PICES-2026

BOOK OF ABSTRACTS

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KEYNOTE SPEAKER

Advancing Actionable Science Advice: PICES collaborations and knowledge exchange in a rapidly changing North Pacific Ocean

Chris **Rooper**

Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada.
E-mail: chris.rooper@dfo-mpo.gc.ca

The North Pacific Ocean is a mosaic of dynamic and interlinked ecosystems. In recent years, ocean conditions have been highly variable, with impacts from warming trends of climate change punctuated by short-term perturbations due to events like El Niño/La Niña cycles and marine heat waves. These trends and variability have downstream effects on the oceanography and biology of the North Pacific Ocean, such as deoxygenation, changes in primary and secondary productivity, expansion and contraction of fish and invertebrate populations, and changes in marine mammal mortality, which have led to unforeseen disruptions in fisheries and sustainable resource management. Projecting ecosystem responses and providing timely science advice that can inform management remains challenging; however, PICES is uniquely situated to coordinate and integrate science across the North Pacific. PICES' science has a broad geographical scope, unique integration of marine disciplines, and inclusive membership. The PICES scientific community has developed products that have already contributed to the discussion and context of domestic decision-making in Canada and in Regional Fisheries Management Organizations, such as the North Pacific Fisheries Commission. This presentation will highlight local and international examples of PICES' collaborations, scientists and expert groups providing actionable science for fisheries in the North Pacific. In addition, it will identify future opportunities to expand the reach of PICES' science to advance new technologies, address transboundary and international fisheries issues, and provide the basis for incorporating ecosystem information into management actions.

PICES-2025 Zhu-Peterson Early Career Scientist Award winner

Oceanic and Atmospheric Drivers of Marine Ecosystem Predictability

Hyung-Gyu **Lim**

Chonnam National University, Yeosu, R Korea. E-mail: hglim01@jnu.ac.kr

Keywords: marine ecosystem, climate variability, predictability

Since September 1997, high quality records in satellite ocean color have continuously revealed spatio-temporal variations in chlorophyll concentration, a proxy for phytoplankton biomass, at a near-global scale. The chlorophyll concentration data set has been a focal point in estimating myriad properties, including but not limited to global marine primary production. Expansion of Global Climate Models (GCMs) by incorporating biogeochemistry to close the carbon cycle, called Earth system models (ESMs), allows simulations of biological and chemical properties in the earth system. With emergences of predictive skills in climate simulations, we currently stand at the horizon of being able to forecast low-high trophic levels of marine ecosystems.

This talk will briefly introduce three research examples about variability and predictability of marine ecosystem using satellite ocean color, earth system model (GFDL-ESM4-COBALT), and its applications to high trophic level of marine ecosystem (FEISTY): 1) Lim et al 2022 JGR-Oceans: Attribution and predictability of climate-driven variability in global ocean color, 2) Lim et al 2022 GRL: Oceanic and Atmospheric Drivers of Post-El-Niño Chlorophyll Rebound in the Equatorial Pacific, and 3) Lim et al in revision.: Skillful multiyear predictability of forage, large pelagic and demersal fish biomass.

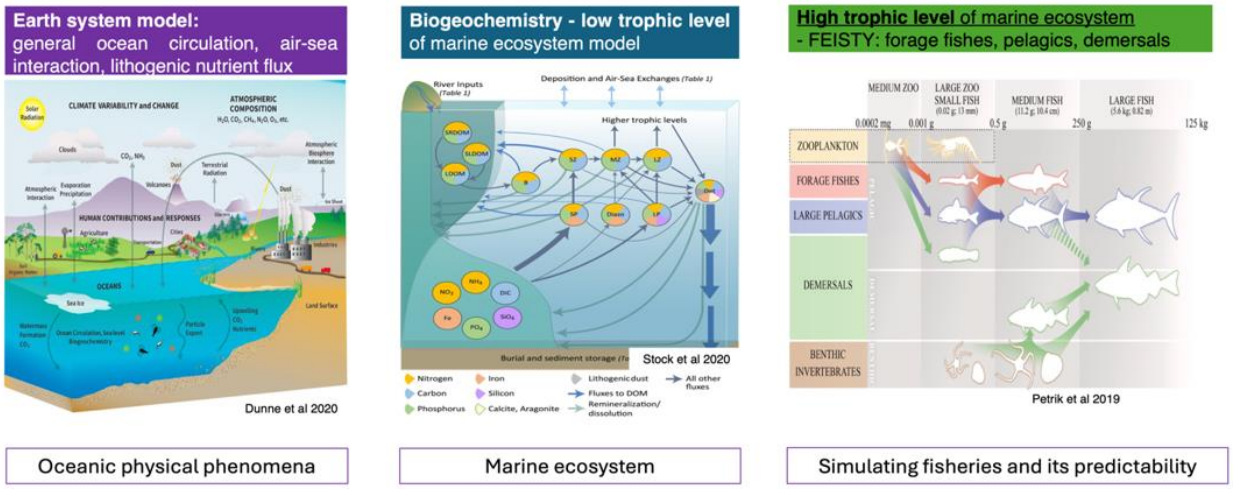


Fig.1. Research outlook for marine ecosystem predictability with earth system model (Dunne et al 2020), marine biogeochemistry (Stock et al 2020), and high trophic level of marine ecosystem (Petrik et al 2019)

SESSION 1: BIO/POC/AP-UNDOS Topic Session

Advancements in Digital Twins applications for evaluating climate change solutions

Oral Presentations

S01, Invited, AbstractID=19121

Digital twin of the ocean as a catalyst for blue economy innovation

Fei **Chai**[1,2], Qiang Deng[1,2] and Xiaoyi Wang[1]

[1]Xiamen University, PR China. E-mail: fchai@xmu.edu.cn
[2]Fujian Ocean Innovation Center, PR China

The global ocean economy is undergoing an urgent transition from an ecologically harmful, profit-driven model to a sustainable blue economy. Yet traditional maritime governance systems still struggle with real-time monitoring, cross-sector collaboration, and efficient decision-making, highlighting a pressing need for advanced digital solutions. The Digital Twin of the Ocean (DTO) offers a promising pathway forward. By creating dynamic, virtual replicas of marine environments, it integrates real-time observations with advanced modeling, supported by AI and supercomputing. Its multi-module architecture, encompassing data, models, analysis, and visualization, enables stakeholders to ask critical questions in the immediate ("What now?"), prospective ("What next?"), and hypothetical ("What if?") scenarios. Advanced DTO systems have the potential to support a wide range of blue economy sectors through full-lifecycle management, including aquaculture, offshore wind energy, shipping, disaster mitigation, blue carbon initiatives, and marine tourism. However, challenges remain in areas such as integrating heterogeneous data, improving model accuracy, and ensuring cybersecurity. Future development should focus on establishing unified mathematical frameworks, hybrid modeling techniques, edge-cloud computing systems, and enhanced interdisciplinary collaboration. With sustained investment and global cooperation, DTOs can become a cornerstone of a sustainable and resilient blue economy.

S01, Invited, AbstractID=19206, (ECOP)

Exploring the application of digital twins in actionable science for adaptive fisheries management

Anna **Sulc**

University of Washington, Seattle, WA, USA. E-mail: sulca@uw.edu

Marine ecosystems are undergoing rapid and unprecedented change projected to continue in coming decades. Shifts in ocean conditions are already altering species distributions and trophic interactions with consequences for the communities that depend on these resources, raising questions about how to sustainably manage marine resources under increasingly uncertain conditions. Scientists and managers are being increasingly challenged to develop adaptive strategies that can accommodate uncertainty while remaining relevant to operational management timescales.

Digital twins or closed-loop simulation frameworks that continuously integrate observational data to mirror a real system and support explicit scenario exploration offer a promising framework to address this challenge. Unlike conventional models, digital twins are designed for iterative updating and flexible decision support, making them well-suited systems that may benefits from real-time adaptive management.

This talk explores the potential application of digital twins to fisheries and marine renewable resource management under climate-driven uncertainty. I review current methods in oceanography and fisheries science and their relevance to digital twin development for marine systems. I then use the Eastern Bering Sea as a case study, using the Alaska Climate Integrated Modeling project as an example of an interdisciplinary coupled modeling framework that could represent early groundwork toward a functional marine digital twin. I conclude by identifying key barriers to implementation and discuss priorities for advancing digital twin frameworks in applied marine science.

S01, Invited, AbstractID=19541

The european ocean digital twin: Innovative approaches for climate-ready fisheries and spatial planning

Patrick **Lehodey**

Mercator-Ocean international, Toulouse, France. E-mail: plehodey@mercator-ocean.fr

Digital Twin methodologies are revolutionizing marine ecosystem management by enabling dynamic, data-driven simulations of complex systems. These tools are developed to allow stakeholders to explore "what if" scenarios, optimize resource allocation, protect biodiversity and evaluate climate adaptation strategies in real time. We present a range of case studies relying on the catalogue of products of the European Marine Copernicus Service and implemented in the Twin Ocean EDITO system, illustrating the versatility and operational feasibility of Digital Twins. This covers modeling of sea turtle movement to inform conservation strategies, monitoring plastic pollution by tracking sources and sinks of macroplastics, forecasting Bluefin tuna spawning habitat in the Mediterranean Sea, or testing tuna fishing scenarios in the context of climate change and spatial management. New applications are being implemented soon, such as the Bay of Biscay anchovy operational model, that could be driven by seasonal forecast. By fostering collaboration among modelers, ecologists, and policymakers, this framework offers a dynamic, inclusive, and efficient approach to addressing the most pressing challenges in marine ecosystems.

S01, Oral, AbstractID=19103

A salmon's eye view: Digital twins for salmon populations and salmon habitats

Lene K. Sortland[1], Eduardo Martins[2], Martin Fore[3], Elvira de Eyto[4], Graeme Diack[5], Colin D. Bull[6] and Scott A. **Akenhead**[7]

[1]Norwegian Institute for Nature Research (NINR), Trondheim, Norway
[2]University of Northern British Columbia, Prince George, Canada
[3]Norwegian University of Science and Technology, Trondheim, Norway
[4]Marine Institute, Furnace, Newport, Co. Mayo, Ireland
[5]Atlantic Salmon Trust, Perthshire, UK
[6]Stirling University, Stirling, UK
[7]Independent, Ladysmith, Canada. E-mail: scott@s4s.com

Digital twins for salmon populations will introduce a new paradigm for fisheries science and management: a shift from coarse-scale correlations to fine-scale mechanisms, as required in the context of climate chaos and (with informative exceptions) world-wide declines of salmon populations. Salmon twins are data-driven simulation models that utilize (1) conventional abundance estimates of salmon at consecutive life stages (parr, smolt, adult landings) (2) in-situ video and sonar observations, (3) data from remote sensing instruments carried by satellites or aerial, surface, and submerged drones, and (4) real-time habitat information. The simulations continuously predict how a salmon is reacting to a real-time prediction of the state of the habitat that the salmon is experiencing: a salmon's eye view. That habitat state is, in turn, output from an ocean digital twin and from twins for coastal zones, estuaries, rivers, and lakes. The result is visibility of the present state of a salmon population, a prediction of its future state, and predictions from what-if scenarios about habitat restoration, extreme weather events, land-use, and effects from fisheries. Among the challenges of moving from 1950's stock-recruit models to individual-based, mechanistic models for salmon will be large-scale mobilization of data, knowledge, and science, and an attendant requirement for better collaboration and communication. The technological foundation for this paradigm shift is facilitated by rapidly-evolving enabling technologies such as AI; how remains to be seen. Salmon twins that use ocean twins and watershed twins will open important opportunities including: (1) a more informed approach to reversing salmon population declines, (2) confronting and and prioritizing knowledge gaps, (3) faster learning from scenarios and experience (adaptive management), and critically (4) improved engagement with decision fora, co-managers, stakeholders, citizen science, and open-source collaborators.

S01, Oral, AbstractID=19389

Artificial intelligence-based image recognition for marine ecological monitoring and assessment

Fang **Zhang**[1,2], Shuo Wang[1,2], Song Sun[1,2], Hongsheng Bi[3]

[1]Institute of Oceanology, Chinese Academy of Sciences, Qingdao, PR China.
E-mail: zhangfang@qdio.ac.cn
[2]University of Chinese Academy of Sciences, Beijing, PR China
[3]University of Maryland Center for Environmental Science, Maryland, USA

Rapid advances in artificial intelligence and marine observing technologies are transforming marine ecological surveys from labor-intensive visual interpretation toward automated, quantitative, and auditable analysis. Major computer-vision tasks provide different ecological outputs. Marine images remain challenging because organisms may be small, transparent, weakly contrasted, densely aggregated, or strongly imbalanced among classes. Differences among regions, seasons, instruments, illumination, and water conditions also cause domain shifts. Model selection should therefore be driven by the ecological question, image structure, required output, annotation cost, and validation design rather than by algorithm novelty alone. Within this framework, three applications are summarized across surface-population, community, and individual scales. The first combines low-altitude unmanned aerial vehicle remote sensing with Mask R-CNN instance segmentation for quantitative monitoring of large surface jellyfish. The second application addresses the large expert workload required to correct ZooScan image classifications. A zooplankton classifier was developed by fine-tuning a pretrained ConvNeXtV2 model. The third application focuses on automated body-length measurement from individual images generated by a plankton imaging instrument. A keypoint heatmap method was developed using a ResNet50 feature extractor and a feature-pyramid network. The three cases represent complementary computer-vision tasks: instance segmentation of surface organisms, transfer-learning classification of laboratory-scanned zooplankton, and key point estimation for individual morphometrics. They show that marine ecological image recognition is best understood as a toolbox linking specific image structures to specific ecological outputs, rather than as a single universal model.

S01, Oral, AbstractID=19481

Potential methods for a machine learning based end-to-end digital twin of regional oceans, fisheries, and management

Albert J. **Hermann**[1,2]

[1]University of Washington, CICOES, Seattle, WA, USA. E-mail: albert.j.hermann@noaa.gov
[2]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA

A wide variety of machine learning (ML) methods have been utilized to either improve or create emulators of dynamical biogeochemical models; these include methods to improve hindcasting and data assimilation, as well as ML-based forecasting trained using dynamical model output. Less well explored is the application of ML-based geophysical model emulators in fisheries management. Here we consider the use of ML approaches in the context of Management Strategy Evaluation, and seek to identify which techniques could be simultaneously skillful and interpretable for this purpose. A successful fully coupled end-to-end (plankton through management) framework could help to optimize oceanographic sampling, and potentially could include agent-based models as digital twins for stakeholders. We explore some of these concepts using methods based on dimensional reduction and Graph Neural Networks, applied to create emulators of downscaling regional models of the Gulf of Alaska and the Bering Sea.

SESSION 1: BIO/POC/AP-UNDOS Topic Session

Advancements in Digital Twins applications for evaluating climate change solutions

Poster Presentations

S01, Poster, AbstractID=19282, PosterID: S01-P1

Development of a 1/60° open-source coupled ocean–sea ice model for the Sea of Okhotsk toward a freely accessible international research platform

Hiroshi **Kuroda**[1], and Takuya Nakanowatari[2]

[1]Hokkaido University, Sapporo, Japan. E-mail: kurocan@lowtem.hokudai.ac.jp
[2]Japan Fisheries Research and Education Agency, Kushiro, Japan

The Sea of Okhotsk is the southernmost seasonal sea-ice region in the Northern Hemisphere and is characterized by high biological productivity, including massive spring phytoplankton blooms. Despite its importance, reanalysis datasets based on ocean–sea ice models that can be applied to oceanographic analyses and interdisciplinary studies in the Sea of Okhotsk remain limited. To address this gap, we have initiated the development of a coupled ocean–sea ice model covering the entire Sea of Okhotsk at 1/60° resolution using open-source tools, with the goal of producing a freely accessible data product for the international research community, covering the period from 1993 to the present. The ocean model is based on the Regional Ocean Modeling System (ROMS), and lateral boundary conditions are provided by GLORYS12 (1/12° global ocean–sea ice reanalysis). The model employs 45 vertical layers, and the vertical coordinate parameters were carefully tuned through trial and error to suppress numerical instabilities. The model successfully simulates coupled ocean–sea ice processes, including sea-ice production and concentrations. The model also visualizes small-scale dynamical features, such as enhanced submesoscale eddies around straits in the northern Kuril Islands and pronounced submesoscale variability around the northwestern Okhotsk Sea shelf polynya and other ice-edge regions. In this presentation, we will share future perspectives on planned routine system operation, and further development toward coupling with lower-trophic-level ecosystem models to support a freely accessible international modeling platform.

SESSION 2: MEQ/ POC/ FUTURE/ AP-UNDOS Topic Session

Climate Extremes and Coastal Impacts in the Pacific

Oral Presentations

S02, Invited, AbstractID=19378, (ECOP)

Marine heatwaves in a warming Pacific: From compound climate–industrial risks to the evolution of subsurface heat stress

González-Espinosa Pedro C[1], Xinru **Li**[9], Marcus Rekha[2], Debus Helena J.[1], Mather Charles[3], Oyinlola Muhammed A.[4,5], Thomas Frölicher[6], Cisneros-Montemayor Andrés M[1], Bloemendaal Nadia[7,8], Reygondeau Gabriel[3,10], Cormier Eric J[2], Singh Gerald G[2]

[1]Nippon Foundation Ocean Nexus, School of Resource and Environmental Management (REM), Simon Fraser University (SFU) Technology and Science Complex 1, Burnaby, BC, Canada
[2]Nippon Foundation Ocean Nexus, School of Environmental Studies, University of Victoria, Victoria, BC, Canada
[3]Department of Geography, Memorial University of Newfoundland and Labrador, St John's, NL, Canada
[4]Changing Ocean Research Unit, Institute for the Oceans and Fisheries, The University of British Columbia, Vancouver, BC, Canada
[5]Institute for the Oceans and Fisheries, University of British Columbia,Vancouver, BC, Canada
[6]Climate and Environmental Physics, Physics Institute, University of Bern, Bern, Switzerland
[7]Institute for Environmental Studies, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands
[8]Royal Netherlands Meteorological Institute (KNMI), De Bilt, the Netherlands
[9]Advanced Institute for Marine Ecosystem Change (WPI-AIMEC), Tohoku University, Sendai, Japan. E-mail: li.xinru.d1@tohoku.ac.jp
[10]Rosenstiel School of Marine, Atmospheric, and Earth Science, University of Miami, Miami, FL, USA

As Pacific continues to warm, Marine Heatwaves (MHWs) have become increasingly frequent and severe, particularly in the boundary current regions and marginal seas. MHWs can profoundly affect marine ecosystems from the surface to subsurface, driving dramatic changes in community composition and species distribution and, in extreme cases, causing mass mortality events. They can also interact with other oceanic properties (e.g., dissolved oxygen) and industrial operations (e.g., mariculture) to generate compound extremes with severe ecological and socioeconomic consequences. However, our understanding remains limited on these dangerous compound extremes and how heat stress evolves below the surface, where many ecologically important processes occur. To provide insights into these two perspectives, we first highlight how developing causal-relationship frameworks between key risk-management decisions and climate extremes can be used to identify climate hazards for salmon aquaculture. Here, spatial analyses and maps of areas at higher and lower risk by 2050 reveal explicit roles of climate extremes in triggering compound climate and industrial events. This information may help guide ocean risk management in a changing world. The second part will present a four-dimensional tracking analysis of the heat stress associated with the unprecedented 2023 Marine heatwave around Japan. In addition to its strong magnitude, this event shows a

prominent subsurface signal, underscoring the need to better understand its spatiotemporal evolutions and driving processes. A clearer understanding on spatiotemporal evolution of this severe subsurface heat stress could help us assess and project its impacts on key migratory fish populations.

S02, Oral, AbstractID=19101

The suppression of harmful algal blooms in spring 2025 off the Zhe-Min coast, China: A consequence of extreme atmospheric and oceanic forcing

Weibo Wang and Haifeng **Gu**

Third Institute of Oceanography, Ministry of Natural Resources, Xiamen, PR China.
E-mail: guhaifeng@tio.org.cn

The Zhe-Min coastal region of China, a principal fisheries area, frequently experiences harmful algal blooms (HABs) driven by the nutrient-rich southward current of the Zhe-Min Coastal Current (ZMCC). In spring 2025, however, routine monitoring (since 2001) recorded an unprecedented absence of large-scale HABs. This study investigates the dynamical mechanisms underpinning this suppression. Our analysis indicates that a persistent, record-breaking anomalous northeastward sea surface current inhibited southward nutrient transport to the Fuzhou–Wenzhou coast. Dynamical decomposition shows that this anomalous current resulted from distinct regional processes: off Fuzhou it manifested as a barotropic response to an anomalous cross-shelf sea-level gradient associated with an extremely weak northeasterly monsoon, while off Wenzhou it was predominantly baroclinic, driven by cross-shelf temperature gradients linked to frequent marine heatwaves. The observed thermal extremes are largely attributable to the record-breaking northward shift of the subtropical high-pressure system during the spring of 2025. Moreover, the interaction between a coastal marine cold spell and offshore heatwaves in March promoted cross-shelf transport that exported coastal nutrients offshore. These findings indicate that climate–related shifts—notably weakened monsoonal forcing and increased frequency of extreme thermal events—can act synergistically to form a compound hazard chain that substantially alters coastal physical–biological coupling, however, in this instance, suppressed large-scale HABs outbreak. Future research should pay more attention to the impacts generated by the coupling processes among such extreme events.

S02, Oral, AbstractID=19123, (ECOP)

Ecological thresholds of marine heatwaves driving redistribution of Japanese flying squid fisheries in the Sea of Japan

Bingqing **Chen**[1,2], Hao Tian[1,2], Yang Liu[1,2], Yulei Zhang[2], Bin Kang[1], Irene D. Alabia[3,4], Sei-Ichi Saitoh[3] and Yongjun Tian[1,2]

[1]Laboratory for Marine Fishery Satellite Application Research, Ocean University of China, Qingdao, PR China. E-mail: Yangliu315@ouc.edu.cn
[2]Deep Sea and Polar Fisheries Research Center, Ocean University of China, Qingdao, PR China
[3]Arctic Research Center, Hokkaido University, Sapporo, Hokkaido, Japan
[4]International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AL, USA

Marine heatwaves (MHWs) are becoming increasingly frequent and intense across the North Pacific under climate warming, causing widespread ecological and fisheries impacts. Although MHW-induced distribution shifts have been documented for many marine species, critical thresholds beyond which fisheries experience abrupt responses remain poorly quantified, limiting the prediction of climate-extreme impacts on marine resources.

To address this gap, we examined the responses of Japanese flying squid (*Todarodes pacificus*) fisheries to MHWs in the Sea of Japan during 2014–2023. Satellite-derived VIIRS boat detection data were integrated with environmental variables and MHW metrics, while random forest models were used to quantify environmental controls on fishing-ground dynamics and identify nonlinear responses to extreme warming.

Results revealed distinct ecological thresholds associated with fisheries redistribution. Core fishing grounds contracted significantly when monthly MHW duration exceeded 16 days or cumulative intensity surpassed 50 °C·days. Exceeding these thresholds triggered pronounced declines in fishing effort and catch, particularly during summer and autumn. Sea surface temperature was the dominant driver of fishing-ground variability, contributing approximately 45% of model explanatory power, with optimal fishing conditions occurring near 17.1 °C. Regional sensitivity differed among exclusive economic zones, with the South Korean EEZ exhibiting the strongest response to MHW characteristics ($R^2 = 0.77$).

These findings provide the first quantitative identification of ecological MHW thresholds for Japanese flying squid and demonstrate how climate extremes can trigger abrupt fisheries redistribution. The identified thresholds improve our ability to predict fisheries responses to future extreme warming events and support climate-adaptive fisheries management in the Northwest Pacific.

S02, Oral, AbstractID=19153, (ECOP)

Seasonal predictions of marine extreme events in the Northeast Pacific

Samuel C **Mogen**[1], Nicole Lovenduski[1], Michael Jacox[2,3], Jessie Liu[3], Allison Cluett[2], James Scott[3], Mercedes Pozo Buil[2], Steven Bograd[2]

[1]Institute of Alpine and Arctic Research, University of Colorado Boulder, Boulder, CO, USA. E-mail: samuel.mogen@colorado.edu
[2]NOAA Southwest Fisheries Science Center, Monterey, CA, USA
[3]NOAA Physical Sciences Lab, Boulder, CO, USA

Marine extreme events, such as marine heatwaves (MHW), can have profound impacts on marine organisms and ecosystems. Alongside physical extremes, there is growing concern about the impacts of biogeochemical extreme events, such as ocean acidification extremes (OAX) and low oxygen extremes (LOX), which may have compounding impacts on marine ecosystems.

Recent work has demonstrated the ability of coarse (~1° horizontal resolution) global model forecast configurations to predict physical extremes and biogeochemical marine extremes. Here we use a regional, high-resolution (~0.1° horizontal resolution) configuration of MOM6-COBALT in the Northeast Pacific to assess forecasts of marine physical and biogeochemical extremes in both surface and bottom waters. Results demonstrate regionally-varying, skillful predictions of surface and subsurface marine extreme events, both physical and biogeochemical. Ongoing work is focused on determining the linkages between climate variability and regional skill, and assessing the ability of this model framework to forecast compound extreme events.

S02, Oral, AbstractID=19159

Storm intensity alters dominant physical controls on coastal ecosystem dynamics

Hongsheng **Bi**[1], Linlin Wang[2], Hui Liu[3], Xianzhong Mao[4], Zhonghua Cai[4], Duansheng Wang[5]

[1]University of Maryland Center for Environmental Science, Solomons, MD, USA.
E-mail: hbi@umces.edu
[2]Shenzhen University, Shenzhen, Guangdong, PR China
[3]Texas A & M University at Gaveston, Galveston, TX, USA
[4]Tsinghua Shenzhen International Graduate School, Guangdong, PR China
[5]Oasis Photobio Tech Ltd, Shenzhen, Guangdong, PR China

Extreme storms are increasingly recognized as major drivers of coastal ecosystem variability, yet their ecological consequences remain difficult to predict because biological responses differ substantially among storm events. Tropical cyclones have been associated with enhanced productivity, negligible ecosystem change, and widespread biomass declines, but the mechanisms underlying these contrasting outcomes remain poorly understood. Here we combine two years of high-frequency underwater plankton imaging observations with atmospheric reanalysis, ocean circulation products, and water-mass analyses to investigate ecosystem responses across five tropical cyclones in the northern South China Sea. Using plankton as high-frequency indicators of ecosystem state, we evaluate how storm intensity modifies the physical processes regulating coastal ecosystem dynamics.

We show that storm intensity alters the balance between two compSeting ecosystem controls: regional connectivity and local disturbance. Under weaker storms, ecosystem variability is primarily regulated by horizontal exchanges among offshore waters, Pearl River plume water, and terrestrial inputs. Changes in water-mass composition closely track biological variability, indicating strong connectivity-driven regulation. As storm intensity increases, enhanced vertical mixing, sediment resuspension, and turbidity progressively weaken the influence of water-mass origin and strengthen the role of local disturbance. Under these conditions, ecosystem dynamics become increasingly decoupled from regional connectivity and dominated by physical disruption. These results demonstrate that tropical cyclones do not generate a single ecosystem response. Instead, storm intensity governs the relative importance of competing physical controls, producing a continuum of ecosystem responses ranging from connectivity-dominated to disturbance-dominated states. We propose a physical framework linking storm intensity to ecosystem regulation that helps reconcile previously contradictory observations and provides a basis for predicting coastal ecosystem responses to increasingly intense storms under climate change.

S02, Oral, AbstractID=19165

A new dynamic regime in the north pacific climate system after 2018: Physical drivers and biogeochemical impacts

Bo **Qiu**, Niklas Schneider, Shuiming Chen, Angelique White and James Potemra

Department of Oceanography, University of Hawaii at Manoa, HI, USA.
E-mail: bo@soest.hawaii.edu

Over the four decades following the 1976/77 climate regime shift, the Kuroshio Extension (KE) in the North Pacific subtropical gyre exhibited quasi-decadal oscillations between stable and unstable dynamic states. These oscillations were facilitated by a delayed negative feedback loop involving wind-forced interior ocean adjustment, its modulation on the KE dynamic state, and the KE's feedback onto atmospheric storm tracks and the wind stress field. After 2018, this feedback loop ceased to function, giving rise to a new dynamic regime, in which the Kuroshio south of Japan assumes a persistent offshore meandering path, while the stabilized KE jet migrates poleward. We identified three key processes responsible for the emergence of this regime: (1) a shift in the external forcing field, characterized by intensified wind forcing over the northern subtropical gyre and weakened forcing over the southern gyre; (2) nonlinear reinforcement between the meandering Kuroshio and the poleward-migrated KE jet; and (3) altered storm track and wind stress responses to the KE's newly established state. The establishment of this regime has significant implications not only on regional mode water properties but also for marine biogeochemical conditions across the broader North Pacific basin. Our analysis suggests that the recent decline in dissolved oxygen observed at Station ALOHA off Hawaii can be quantitatively attributed to changes in wind-forced ventilated thermocline circulation.

S02, Oral, AbstractID=19174

Clustering to characterize extreme marine conditions for the benthic region of the Northeastern Pacific continental margin

Amber M. **Holdsworth**[1], Andrew Shao[2] and James R. Christian[1,3]

[1]Fisheries and Oceans Canada, Victoria, BC, Canada.
E-mail: Amber.Holdsworth@dfo-mpo.gc.ca
[2]Hewlett Packard Enterprise Co, Burnaby, BC, Canada
[3]Canadian Centre for Climate Modelling and Analysis, Victoria, BC, Canada

Anthropogenic CO_2 emissions lead to warming, deoxygenation and acidification of the oceans. Superimposed on these long-term trends are episodic extremes of temperature, pH and oxygen, but the physical and biogeochemical processes that give rise to them are not well understood. To better understand extreme climate events, we present an innovative method for assessing single and multiple stressor extremes using a regional ocean model. The method is applied to a high-resolution model of the Northeastern Pacific Ocean. Focusing on the benthic, we assume that organisms are adapted to local environmental conditions and use an unsupervised clustering approach to isolate regions with similar habitat characteristics. We define extreme thresholds seasonally using a fixed baseline (1996-2020), then quantify the fraction of water in each cluster that has been extreme in the recent past, for both single and compound stressors. A substantial number of single stressor extremes occur annually, but compound extremes are rare, with most of the compound extremes involving dissolved oxygen and acidification. The defined clusters show indicators of control by distinct processes in environmentally similar but not spatially contiguous regions, including mixing with warming near-surface waters and near-bottom advection of corrosive, O_2-depleted oceanic water. The signatures of large-scale climate indices (e.g., NPGO) are apparent from time series showing the influence of these processes on extremes within the clusters. Potential predictability of occurrence of extremes is demonstrated by correlation with basin-scale climate variability.

S02, Oral, AbstractID=19234

Subsurface propagation of surface marine heatwaves and related climate impacts

Antonietta **Capotondi**[1,2], Matteo Wilczak[1], Tongtong Xu[1,2]

[1]University of Colorado, Boulder, CO, USA. E-mail: antonietta.capotondi@noaa.gov
[2]NOAA PSL, Boulder, CO, USA

Marine heatwaves (MHWs) have been extensively studied at the surface but analyses of their subsurface expressions and impacts are still in their infancy. Some studies have assessed statistical properties of subsurface MHWs and have categorized possible vertical structures at different geographical locations. However, an in-depth mechanistic understanding of some of those structures and their impacts on the ocean heat content is still missing. While some subsurface MHWs may exist without any significant surface signal, here we focus on those events that originate at the surface and propagate downward in the ocean interior, as they have the potential to transfer surface properties to the deeper ocean. The Northeast Pacific, where particularly intense MHWs have occurred in recent decades, is chosen as the main study region. We use the diffusion equation as our primary dynamical paradigm for gaining insight on how subsurface properties are shaped by surface MHW characteristics and potentially be inferred by them. Results show that for a given diffusion coefficient, surface MHW intensity and duration are the primary controlling factors of the penetration depth of extreme temperature anomalies, potentially leading to a net oceanic heat gain.

S02, Oral, AbstractID=19241

Long-term trends of heat waves and ecosystem responses in Jiaozhou Bay, China

Xiaoxia **Sun**, Jing Wang, Yongfang Zhao, Shan Zheng, Mingliang Zhu

Institute of Oceanology, Chinese Academy of Sciences, Qingdao, PR China.
E-mail: xsun@qdio.ac.cn

With global warming, extreme weather frequently occurs, yet the consequences remain unexplored. A total of 156 heat waves and their characteristics were detected on the basis of a temperature dataset from 1954 to 2022 in Jiaozhou Bay (JZB). The increment is 0.62 times decade^{-1} for the number of heat waves, 6.65 days decade^{-1} for the sum of participating heat wave days and 0.66 days for the duration of each heat wave. The intensity of heat waves showed regular fluctuations with progressively shorter periods. Based on the dataset of 12 stations in JZB from 2003 to 2022, the zooplankton abundance was significantly greater during heat waves, which was strongly attributed to the greater abundance of copepods and gelatinous zooplankton during heat waves. However, the responses of plankton to heat waves were seasonally heterogeneous. Our study provides new insight into and a scientific basis for understanding the effects of heat waves on offshore plankton ecosystems.

S02, Oral, AbstractID=19257

Modelled changes in extreme environmental conditions within Eastern Beaufort Sea beluga habitat

Nadja **Steiner**[1,2], Tessa Sou[1], Lisa Loseto[1,3], Emma Sutherland[3], and Luke Storrie[3,4,5]

[1]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: Nadja.Steiner@dfo-mpo.gc.ca
[2]Canadian Center for Climate Modelling and Analysis, Victoria, BC, Canada
[3]Center for Earth Observation Science, Clayton H. Riddell Faculty of Environment, Earth, and Resources, University of Manitoba, Winnipeg, MB, Canada
[4]Wildlife Conservation Society Canada, Yukon, ON, Canada
[5]Department of Biology, University of Victoria, Victoria, BC, Canada

To help understand potential climate change related environmental stressors on Eastern Beaufort Sea beluga whales, a key subsistence species for Inuvialuit peoples, we analyzed model simulations of changes, trends and extremes in seasonal beluga habitat (Bering Sea to Beaufort Sea) between 1980-2009 and 2030-2059. The results show decreased ice concentration, warming and advanced ocean acidification. Areas exposed to extremes expand in the future with little difference among scenarios (SSP1-2.6, SSP5-8.5). Changes in sea ice directly impact seasonal habitat and migration. Earlier migration from the Pacific into the Arctic and delayed out-migration is expected. A disappearing sea-ice bottleneck north of Alaska may allow earlier movement into the Inuvialuit Settlement Region. New habitat may open up further offshore, around Banks island and in Amundsen Gulf. Fall conditions are projected to become more similar to the historical summer, encouraging an extended feeding season within the Arctic. Decreases in ice-algal production may negatively impact beluga prey (Arctic cod), however this may be compensated by increases in oceanic production. It is expected that beluga remain tightly connected to the ice edge where ice-algal production is maintained. The offshore Beaufort Sea (fall) and Amundsen Gulf (summer) are highlighted with dual temperature and acidification extremes in the future. The Beaufort shelf and Mackenzie delta, also represent potential areas of increased stress in spring and summer, but may become accessible and frequented earlier in the year, reducing exposure. High interannual variability may allow high-stress years to be followed by low-stress years, and, for the time being, allow recovery.

S02, Oral, AbstractID=19267, (ECOP)

Marine heatwaves influence incidental catch composition in the California commercial halibut trawl fishery

Helen **Killeen**, Armand Barilotti, Cyndi Dawson, Heather Gliniak, Miranda Haggerty, Carlos Mireles, Ken Oda, Dianna Porzio, Kirsten Ramey, Travis Tanaka, and Kim Walker

California Department of Fish and Wildlife, California, CA, USA.
E-mail: Helen.Killeen@wildlife.ca.gov

Marine heatwaves (MHWs) are now a recurring hazard across multiple North Pacific systems, yet their ecological and socioeconomic risks remain underexplored at the spatial and temporal scales relevant for management. The state-managed California halibut trawl fishery provides high-resolution, fishery-dependent data capable of detecting social-ecological-environmental system responses to MHWs. We use a combination of fishery datasets, including logbooks, landing receipts, and third-party observer data to examine shifts in catch assemblages during Eastern Pacific MHWs, including major events spanning 2014-2016 (the Blob/El Niño), 2018, 2019, and 2025-2026 (NEP25A event). Multivariate analysis of catch compositions before, during, and after MHW periods shows that extreme climate event signals are detectable in fishery-dependent data, but effects vary by the physical metrics (surface, subsurface temperatures) and by fishery dataset. Notably, community compositional changes are most pronounced in third-party observer data but damped in landings data, illustrating how effort-standardized observations capture ecological shifts more sensitively than landings influenced by fisher behavior, sorting practices, and market dynamics. By pairing catch-based indicators with concurrent surface and subsurface temperature anomalies, this work contributes empirical evidence of how MHWs propagate through coastal fish communities to impact human communities. These emerging patterns provide biological signals relevant to understanding the mechanisms and predictability of MHW impacts. Ongoing analyses will refine statewide spatial patterns and evaluate the strength of fishery-dependent indicators as tools to assess, compare, and ultimately anticipate ecological responses to future extreme events.

S02, Oral, AbstractID=19272, (ECOP)

Characterizing source-water variability and climate-extreme signatures in the coastal California Current System

Mercedes **Pozo Buil**[1,2], Isaac Schroeder[2], Steven Bograd[3], Antonietta Capotondi[4], Michael Jacox[3,4], Nicole Lovenduski[5], Samuel Mogen[5]

[1]University of South Carolina, Columbia, SC, USA. E-mail: mpozobuil@seoe.sc.edu
[2]University of California Santa Cruz, Santa Cruz, CA, USA
[3]NOAA Southwest Fisheries Science Center, Monterey, CA, USA
[4]NOAA Physical Sciences Laboratory, Boulder, CO, USA
[5]University of Colorado Boulder, Boulder, CO, USA

Climate extremes such as marine heatwaves and El Niño events can rapidly reshape the physical and biogeochemical environment of eastern boundary upwelling systems, with consequences for coastal ecosystems, fisheries, and resource management. In the California Current System (CCS), these impacts are expressed through changes in temperature, oxygen, nutrients, stratification, and the relative influence of distinct source waters. In this talk, I will present a source-water framework for interpreting climate-extreme impacts in the coastal CCS using ocean reanalysis data. We resolve source-water variability across the full coastal domain and examine how major source waters contribute to the spatial structure of extreme-event signatures. This approach allows us to assess how basin-scale climate variability is translated into coastal physical and biogeochemical change. By identifying source-water pathways across the full coastal domain, this work provides a framework for comparing the coastal signatures of different climate extremes and for improving our understanding of climate-driven responses to CCS ecosystems.

S02, Oral, AbstractID=19279

Sea surface pCO_2 in the Eastern North Pacific during the marine heatwave of August 2025

Naohiro **Kosugi**

Meteorological Research Institute, Tsukuba, Ibaraki, Japan. E-mail: nkosugi@mri-jma.go.jp

A marine heatwave (MHW) is a phenomenon in which sea surface temperatures remain significantly above the climatological mean for several consecutive days or longer. In recent years, the increasing frequency and intensity of MHWs have attracted considerable attention because of their impacts on marine ecosystems, fisheries, and weather. With respect to air–sea CO_2 exchange, higher sea surface temperatures increase the partial pressure of CO_2 (pCO_2) in seawater. Therefore, MHWs are generally expected to reduce oceanic CO_2 uptake or enhance CO_2 outgassing. However, observations inconsistent with this expectation have been reported in the equatorial Pacific and the subarctic Eastern North Pacific.

During a cruise of the research vessel "*Hakuhō-Maru*" in August 2025, continuous measurements of sea surface pCO_2 were conducted along 145°W in the Eastern North Pacific, from 55°N to 13°N. At the time of the observations, sea surface temperatures north of 25°N were above the climatological mean, and a significant MHW, with sea surface temperatures more than 2°C above normal, was present between 30°N and 40°N. Climatological data indicate that there is a meridional maximum in surface seawater pCO_2 between 30°N and 40°N in this region. The coincidence of this pCO_2 maximum with the MHW resulted in exceptionally high surface seawater pCO_2 values exceeding 480 μatm (*i.e.*, approximately 60 μatm above atmospheric pCO_2).

S02, Oral, AbstractID=19287

Future projections of the combined impacts of acidification and deoxygenation in eutrophic waters: A case study of Tokyo Bay, Japan

Masahiko **Fujii**[1], Lawrence P C Bernardo[1] and Tsuneo Ono[2]

[1]International Coastal Research Center, Atmosphere and Ocean Research Institute, The University of Tokyo, Iwate, Japan. E-mail: mfujii@aori.u-tokyo.ac.jp
[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan

To predict the risk of combined acidification and deoxygenation in eutrophic waters and evaluate the effectiveness of measures to reduce anthropogenic CO_2 emissions and terrestrial nutrient loads as countermeasures, we developed a high-resolution coupled ocean physical and biogeochemical model for Tokyo Bay, a representative eutrophic water body in Japan. It has been reported that dissolved oxygen (DO) concentrations in the bottom waters of Tokyo Bay occasionally fall below the threshold for adverse impacts on commercially important species such as the coastal demersal fish Sillago japonica, and future projections show that if anthropogenic CO_2 emissions and nutrient loads from rivers remain at current levels, the adverse impacts on these target species will intensify. On the other hand, if nutrient loads from rivers are reduced, the number of days on which DO concentrations fall below the adverse impact threshold for Sillago japonica would actually decrease. It was quantitatively demonstrated that in Tokyo Bay, which receives a high nutrient load, reducing nutrient inflow from rivers would have an effect on future combined acidification and deoxygenation impacts comparable to that of curbing global CO_2 emissions.

S02, Oral, AbstractID=19292

Repeated autonomous underwater glider surveys reveal extreme, near-bottom, shelf hypoxia during the upwelling season off central Washington, U.S.A.

John A. **Barth**, Brian VerWey, and Jace Marquardt

Oregon State University, Corvallis, OR, USA. E-mail: jack.barth@oregonstate.edu

Near-bottom hypoxia has been increasing in both spatial extent and intensity over the United States Pacific Northwest continental shelf. In some years, extremely low dissolved oxygen (DO) concentrations – DO < 22 micromoles/kg and sometimes approaching anoxia or zero oxygen – are observed in the mid to inner shelf in water depths of 25-100 m. While water upwelled onto the continental shelf from depth (source water) is not hypoxic, biological and physical processes on the continental shelf drive near-bottom oxygen levels hypoxic (DO < 61 micromoles/kg). We use a 7-year time series of spatial maps of water-column properties collected by autonomous underwater gliders off the U.S. state of Washington to examine seasonal and year-to-year variability in near-bottom dissolved oxygen. Autonomous underwater gliders are ideal for measuring near-bottom dissolved oxygen over the continental shelf and can provide valuable information to ocean users in near real-time. Each year in late-May/early-June, July, and September we map the central Washington continental shelf over 100 km in the along-shelf direction and from the 25-m isobath to over the continental slope. While summer off the Pacific Northwest is dominated by upwelling-favorable winds, occasional wind reversals and relaxations can lead to onshore surface flows and disruption of upwelling circulation. Repeated cross-shelf glider transects reveal the details of wind-driven upwelling, the effects of wind relaxation, and the occurrence of near-bottom hypoxia. We relate the interannual variability in the intensity and extent of near-bottom hypoxia to external drivers like the cumulative seasonal upwelling and source water DO concentrations.

S02, Oral, AbstractID=19302

Marine heatwaves analyzed using Extreme Value Theory

Charles **Hannah** and Kejia Wang

Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: Charles.Hannah@dfo-mpo.gc.ca

Marine heatwaves are viewed as extreme events, but examples of analysis of MHWs using Extreme Value Theory (EVT) are limited. The primary goal of this work is to experiment with existing EVT frameworks for the marine heatwave metrics 'Intensity' and 'Duration.' We use temperature data from a long-term mooring in 100 m of water, E01, on the west coast of Vancouver Island, Canada, with subsurface temperature records starting in the 1989. We are able to provide robust 100-year return level estimates for both metrics using continuous parametric models. The discrete nature of the duration metric led us to explore how continuous EV models can be extended to evaluate discrete random variables and to search for the underlying sample space from which 'Duration' is drawn. Additionally, the Poisson Point Process is used to model the probability of durations at a given frequency. This provides increased confidence in the return level estimates. We also find differences between the statistical properties of the sea surface temperatures and the subsurface temperatures which may be due to the combination of the prevalence of cloud in our region and the methods used to create gap-free daily datasets.

S02, Oral, AbstractID=19305

Recent physical, biogeochemical, and biological changes in the Prince William Sound pelagic ecosystem

Robert **Campbell**

Prince William Sound Science Center, Cordova, AL, USA. E-mail: rcampbell@pwssc.org

Against the backdrop of a multidecadal warming trend, near-surface temperature anomalies in the Gulf of Alaska and Prince William Sound shifted towards strongly positive in 2014, and remained elevated to present day. Estimates of heat flux suggest that the mechanisms were the same as those observed throughout the GoA: a reduction in winter mixing in 2014 and 2015, and increased heat flux in the summer of 2019. The warming trend has extended to considerable depths as well.

Increased surface temperatures, along with enhanced freshwater inputs, largely from melting ice, have increased near-surface stability, which has resulted in a thinner surface mixed layer and results in less near-surface nitrate (the limiting nutrient in Alaskan coastal waters). Overall phytoplankton productivity has shown a declining trend in the last 23 years; the 4 lowest values in the time series have all occurred in the past 5 years, with the lowest observed in 2023.

Overall zooplankton abundances did not change to a great degree following the marine heat waves, but the species assemblages shifted very rapidly, with the canonical large subarctic taxa declining, and smaller subtropical species more common far to the south (including some previously very rare species) increasing in relative abundance. The observed changes in lower trophic levels can be expected to continue to cascade upwards throughout the food web in the northern Gulf of Alaska. Moving forward, the use of in-site instrumentation to provide rapid snapshots of ecosystem status will give managers the information they need about marine productivity to better manage marine resources.

S02, Oral, AbstractID=19323, (ECOP)

Numerical investigation of the fine-scale features of marine heatwaves occurring along coastal areas of northeastern Japan

Lawrence Patrick C. **Bernardo** and Masahiko Fujii

International Coastal Research Center, Atmosphere and Ocean Research Institute, The University of Tokyo, Iwate, Japan. E-mail: lcbernardo@aori.u-tokyo.ac.jp

As a consequence of global warming, there is increasing concern regarding the impacts of more frequent and intense marine heatwave (MHW) events. From the spring of 2023 to the winter of 2024, the Kuroshio Current flowing south of Japan exhibited an extreme northward meander which led to intense MHW conditions along the coastal areas of Iwate Prefecture, Japan. While satellite data and observations from research cruises and ARGO floats have been used to investigate this phenomenon, few studies have focused in detail on areas closer to the coast. This study describes the development of a numerical modelling approach to help elucidate fine scale features of MHW events along the Iwate coastal area. The Coastal and Regional Ocean COmmunity model (CROCO) system version 2.1.3 (Jullien et al., 2026) is used to run the Regional Ocean Modeling System (ROMS) (Shchepetkin and McWilliams, 2005) to simulate hydrodynamics in the area from October 2022 to April 2025. We used a grid with a spatial resolution of ~1 km and boundary conditions derived from daily outputs of the JCOPE2M model of the entire Japan. Realistic atmospheric, tidal, and river input forcing were also added. Early versions of the model successfully reproduced general trends in observations and identified areas which most frequently experienced extended periods of elevated temperatures during the study period. Elevated seawater temperatures have been partly blamed for decreased catches of important fishery species, and our setup could potentially be used to identify the mechanisms involved to help plan possible mitigation and/or adaptation measures.

S02, Oral, AbstractID=19363

Recent trends in marine biotoxin production in British Columbia coastal waters

Andrew R.S. **Ross**[1,2], Mackenzie Mueller[1,3], Navinder Hundal[1,2], Béatrice Ip[1,4], Nathan Matthews[1,3], Corey Albert[1], Peter McKenzie[5], Brian Nesbitt[5], Isobel Pearsall[1,6], Nicole Frederickson[6], Svetlana Esenkulova[6], Blair Surridge[7], Melissa Hennekes[1] and Akash Sastri[1]

[1]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: Andrew.Ross@dfo-mpo.gc.ca
[2]University of Victoria, Department of Biochemistry and Microbiology, Victoria, BC, Canada
[3]University of Victoria, Department of Biology, Victoria, BC, Canada
[4]University of Ottawa, Department of Biomedical Sciences, Ottawa, ON, Canada
[5]Cermaq Canada, Campbell River, BC, Canada
[6]Pacific Salmon Foundation, Vancouver, BC, Canada
[7]M.B. Laboratories Limited, Sidney, BC, Canada

In 2015 an extraordinary phytoplankton bloom occurred along the continental shelf of western North America including the coastal waters of British Columbia (B.C.), Canada. The bloom contained species of the pennate diatom *Pseudo-nitzschia* that produce domoic acid, a biotoxin that causes illness and mortality in marine mammals and amnesic shellfish poisoning (ASP) in humans. Biotoxins produced by *Alexandrium* species, which cause harm to juvenile fish and paralytic shellfish poisoning (PSP) in humans, are also found in B.C. coastal waters. We have been monitoring these algal biotoxins on a monthly basis since 2020. Highest concentrations of domoic acid are generally observed during spring in the Salish Sea and in summer on the west coast of Vancouver Island whereas PSP toxins peak during late summer or early fall. However, the timing and extent of biotoxin production appear to have changed in recent years. For example, domoic acid peaked later and at higher concentrations that usual in the Salish Sea during 2025. PSP toxins, which have also increased 4-fold since 2020, reached unusually high levels (over 1,000 ng/L) in the Salish Sea during 2024 and spiked at even higher concentrations (almost 6,000 ng/L) on the west coast of Vancouver Island in June 2022. These sudden increases superimposed upon an upward trend resemble the episodic nature of extreme climate events, which can be due to natural causes but are exacerbated by changing background conditions associated with global warming. Our observations suggest that natural drivers of biotoxin production are being influenced by ocean conditions associated with climate change.

S02, Oral, AbstractID=19370

Pelagic harmful algal blooms and climate change: Lessons from nature's experiments with extremes

Vera L. **Trainer**[1], Stephanie K. Moore[1], Gustaaf Hallegraeff[2], Raphael M. Kudela[3], Alexandro Clement[4], Jorge Mardonez[5], William P. Cochlan[6]

[1]University of Washington, Olympic Natural Resources Center, Forks, WA, USA.
E-mail: verat@uw.edu
[2]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia
[3]Ocean Sciences Department, University of California Santa Cruz, Santa Cruz, CA, USA
[4]Plancton Andino, Laboratorio Puerto Varas, Puerto Varas, Chile
[5]Centro de Estudios de Algas Nocivas (CREAN), Instituto de Fomento Pesquero (IFOP), Puerto Montt, Chile
[6]Northwest Indian College, Bellingham, WA, USA

Extreme weather events mimic future climate conditions and provide a "dress rehearsal" for understanding future frequency, intensity and geographic extent of HABs. Three case studies of extreme HAB events are described in detail to explore the drivers and impacts of these oceanic outliers that may become more common in the future. One example is the chain-forming diatom of the genus *Pseudo-nitzschia* on the U.S. Pacific Northwest and its response to the 2015 warm anomaly in the California Current System. The other two are pelagic dinoflagellates. Highly potent *Alexandrium catenella* group 1 blooms during 2012-17 created havoc for the seafood industry in Tasmania. Early evidence suggests that changes in water column stratification during the cold winter-spring season are driving new blooms caused by a previously cryptic species. An expansion of *Pseudochattonella* cf. *verruculosa* to the south and *A. catenella* to the north over the past several years resulted in the convergence of both species to cause the most catastrophic event in the history of the Chilean aquaculture in the austral summer of 2016. Together, these two massive blooms were colloquially known as the "Godzilla-Red tide event", resulting in the largest fish farm mortality ever recorded worldwide, equivalent to an export loss of US$800 million together with shellfish toxicity, together resulting in major social unrest and rioting. Scientists must be poised to study future extreme HAB events as these natural experiments provide unique opportunities to define and test multifactorial drivers of blooms.

S02, Oral, AbstractID=19371

How do offshore marine heatwaves propagate inside Quatsino Sound, BC? A modelling study

Krysten **Rutherford**[1] and Laura Bianucci[2]

[1]Canadian Center for Climate Modelling and Analysis, Environment and Climate Change Canada, Victoria, BC, Canada. E-mail: krysten.rutherford@ec.gc.ca
[2]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada

Marine heatwaves (MHWs) are anticipated to increase in frequency, intensity and duration over the coming decades. While the study of MHWs on the open ocean has gained considerable momentum, less is known about the effect of these extreme events once they reach complex nearshore systems such as fjords. We thus aim to better understand how MHWs propagate into and impact the nearshore environment along the west coast of Canada using a numerical modelling approach. We focus on Quatsino Sound, a traditionally, socially and economically important fjord system on the northwest corner of Vancouver Island (British Columbia) that may be impacted by MHWs in the Northeast Pacific Ocean. Using a high-resolution Finite Volume Community Ocean Model (FVCOM) of Quatsino Sound, we designed a series of nine modelling experiments to explore how theoretical offshore MHWs might affect the Sound at different times of the year. Each experiment had a 3°C temperature anomaly applied at the shelf boundaries of the model for 30 days. This approach revealed a distinct seasonal-dependency of the MHW propagation: our results showed that MHWs entering the fjord system in winter tend to have lower intensity but longer duration, whereas summer MHWs have higher intensity and shorter duration. These seasonal differences are largely attributed to highly variable but slightly downwelling-favourable conditions in fall/winter, versus weak but persistent upwelling-favourable conditions in spring/summer. Overall, our results highlight how MHWs can have lasting and impactful effects in inlet systems, and underscore the importance of extending MHW studies to complex nearshore environments.

S02, Oral, AbstractID=19374

Characterizing ocean temperature extremes in the North Pacific ocean and Bering Sea over the last decade

Emily P. **Lemagie**[1], Shaun Bell[1], and Jacob T. Cohen[1,2]

[1]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA.
E-mail: emily.lemagie@noaa.gov
[2]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA

The impacts of warm ocean temperature extremes resonate throughout the marine ecosystem from ocean chemistry and physics to fisheries and human health. These impacts can be cumulative over subsequent extreme events as well as from persistent warm anomalies. Over the last decade the North Pacific region has experienced a large-scale shift in baseline surface temperatures. Satellite sea surface temperatures are used to characterize the spatial and temporal variability of extremes from the open ocean to the shelf relative to a shifting baseline. These patterns are evaluated in connection to subsurface temperature extremes from long term moorings on the Gulf of Alaska and Bering Sea shelves, from ARGO products, and from Changing Ecosystem and Fisheries Initiative MOM6 model results. The largely persistent marine heat wave status in the western region of the North Pacific and Aleutian Islands is contrasted with interannual variability in the Gulf of Alaska and Bering Sea. Separate metrics are determined for surface and bottom temperature extremes over the continental shelf, where extreme events are not always concomitant throughout the water column. Extremes are considered relative to daily and seasonal climatologies and mechanisms associated with thermal anomalies across these time scales are examined for each region. Finally, connections are made to ecosystem impacts of the observed temperatures. This characterization of ocean temperature extremes across regions of the North Pacific ocean and Bering Sea over the last decade provides critical context to understand habitat changes and cascading effects through the ecosystem into the coming decades.

S02, Oral, AbstractID=19387

Human-induced intensification of sea surface temperature regime shifts threatens global Large Marine Ecosystems

Zihui Gao[1,2], Qinwang Xing[1,2,3,4,5], Shin-ichi **Ito**[2], Haiqing Yu[6], Wei Yu[1,3,4,5], Xinjun Chen[1,3,4,5]

[1]College of Marine Living Resource Sciences and Management, Shanghai Ocean University, Shanghai, PR China
[2]Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan.
E-mail: goito@aori.u-tokyo.ac.jp
[3]National Distant-water Fisheries Engineering Research Center, Shanghai, PR China
[4]Key Laboratory of Sustainable Exploitation of Oceanic Fisheries Resources (Shanghai Ocean University), Ministry of Education, Shanghai, PR China
[5]Key Laboratory of Sustainable Utilization of Oceanic Fisheries, Ministry of Agriculture and Rural Affairs, Shanghai, PR China
[6]Institute of Marine Science and Technology, Shandong University, Qingdao, PR China

Global oceans have warmed markedly and will continue to do so. Superimposed on this trend are abrupt, persistent decadal regime shifts between warm and cold phases that alter ocean–atmosphere dynamics and reshape ecosystem composition and function in addition to marine heat waves. Despite recognition of the increasing risk of irreversible climate tipping points, the past and future evolution of these decadal warm–cold shifts remain unclear. Here, combining observations and simulations, we show a widespread 130–140% increase in the frequency and amplitude of sea surface temperature regime shifts across global Large Marine Ecosystems over the past 150 years, with asymmetries stronger in the Northern Hemisphere. Climate models attribute these trends to anthropogenic warming, which suppresses cold-regime transitions and reinforces warm regimes. Without mitigation, these shifts are projected to rise 130–180% by the late-21st century relative to recent levels, whereas only the lowest-emission scenario could constrain their intensification except in the Arctic oceans. Further analyses reveal close links between intensified temperature regime shifts and abrupt ecological and fishery changes, showing 21–46% synchrony that is rising, potentially amplifying decadal ecosystem instability and socio economic challenges. From a marine perspective, these findings underscore the urgency of achieving the Paris Agreement's target and the Arctic's marked vulnerability. Those results are published in Xing Q., Z. Gao, S. Ito, H. Yu, W. Yu, X. Chen, 2026, Human-induced intensification of sea surface temperature regime shifts threatens global large marine ecosystems. Nature Communications, 17, 4172. https://doi.org/10.1038/s41467-026-70986-z

S02, Oral, AbstractID=19398

Extreme conditions in Dungeness crab habitat across life stages from the pre-industrial to mid-century on the Olympic Coast (northern Washington)

Simone **Alin**[1], Brendan Carter[1,2], Richard Feely[1,2], Jan Newton[2], Samantha Siedlecki[3], John Mickett[2], Jennifer Hagen[4], Ervin Schumacker[5], Jeanette Waddell[6], Katie Wrubel[6], Kathy Hough[6], Amelia Ritger[6], Brandy Cervantes[7], Craig Risien[7], and Melanie Fewings[7]

[1]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA.
E-mail: simone.r.alin@noaa.gov
[2]University of Washington Applied Physics Laboratory (UW/APL), Seattle, WA, USA
[3]University of Connecticut, Avery Point, CT, USA
[4]Quileute Tribe, La Push, WA, USA
[5]Quinault Indian Nation, Taholah, WA, USA
[6]NOAA Olympic Coast National Marine Sanctuary (OCNMS), Port Angeles, WA, USA
[7]Oregon State University, Corvallis, OR, USA

Hypoxic, acidified conditions develop annually during the upwelling season in mid-shelf Dungeness crab habitat along the Olympic Coast, typically peaking in August–September. While natural processes—upwelling, river inputs, primary production, and respiration—fundamentally drive this regional pattern, progressive ocean acidification (OA), deoxygenation, and warming have exacerbated the spatial extent and severity of ocean acidification and hypoxia (OAH) in the region through recent decades. During the last 20 years, OCNMS, UW/APL, and the Quileute Tribe have deployed seasonal to year-round moored subsurface sensors to monitor and study the oceanographic processes driving hypoxia in the region. Using proxy approaches to estimate acidification levels (acidity, CO_2 partial pressures, and calcium carbonate saturation states) at these time-series locations, we have previously characterized how OAH duration and intensity vary across the benthic habitats that sustain important Tribal, commercial, and recreational fishing grounds along the Olympic Coast. Anthropogenic carbon estimates allowed us to project OA conditions into the past (pre-industrial era) and management-relevant future time intervals (to mid-century) across the same habitats, showing spatial complexity in how different OA variables may change across the region. Here we use new Olympic Coast data streams and products to expand these analyses, including a preliminary analysis of how much the availability of water column habitat for pelagic larval Dungeness crab life stages has declined through time due to acidification.

S02, Oral, AbstractID=19418

A warning from the edge: Coral bleaching around the temperate island of Shikine, Japan

Ayaka Umeda Paul[1,2], Jue Alef Lalas[2,3], Sylvain Agostini[4,5,6], Britta Fiedler[2] and James Davis **Reimer**[2,6]

[1]University of Cambridge, Cambridge, UK
[2]University of the Ryukyus, Nishihara, Okinawa, Japan. E-mail: jreimer@cs.u-ryukyu.ac.jp
[3]Academia Sinica, Taipei, Taiwan
[4]Shimoda Marine Research Center, University of Tsukuba, Shimoda, Shizuoka, Japan
[5]ENTROPIE, New Caledonia, Reunion Island, France
[6]International CO_2 Natural Analogues Network (ICONA)

Coral bleaching due to rising seawater temperatures is a serious threat to the survival of coral reef ecosystems as we know them. In recent years, warm temperate coastal ecosystems and their coral communities have been postulated as potential refugia for zooxanthellate corals as a means of escaping lower latitude extreme water temperatures. Such discussion is highly relevant in southern Japan, where global sea surface temperatures are increasing at rates of approximately twice the global average. We report on surveys of warm temperate Pacific coast coral communities around Shikine Island just south of Tokyo, Japan. Our surveys were conducted in October 2024, at peak of the Fourth Global Bleaching Event in the waters around Japan, when the area had reached alert levels of 3 to 5 with above average temperatures for more than three months. Based on our photographic analyses of both comparatively pristine control and stressed (e.g. low pH, ports), we observed disproportionately high bleaching levels in *Porites* and *Montipora* corals when compared to *Acropora* and *Pocillopora* species, which have been thought to be among the most sensitive groups to bleaching. The family Merulinidae was also bleached at comparatively high rates. On the other hand, some coral groups such as *Lobophyllia* appeared to have more bleached colonies in the low pH and port environments when compared to less impacted sites. While overall coral mortality rates were generally low, bleaching was observed across a wide range of coral taxa. Our results suggest that bleaching rates in temperate coral communities, much like in subtropical and tropical reefs, are exacerbated by other stressors such as low pH and/or anthropogenic local effects. While the species identity of many warm temperate corals remains an open question, our results suggest that temperate waters are likely not ideal refugia for lower latitude species, and we discuss the conservation implications of these findings under a warming world.

S02, Oral, AbstractID=19421

Compound extremes: Marine heatwaves and ocean acidification in the Northern California Current System from a 30-year historical simulation

Yifan Zhu[1], Samantha A. **Siedlecki**[1], Felipe Soares[1], Dipti Hingmire[2], Simone R. Alin[3], Richard A. Feely[3], Craig M. Risien[4], Francis Chan[5,6], Jeannette E. Waddell[7], and Jan Newton[8,9]

[1]Marine Science Department, University of Connecticut, Groton, CT, USA.
E-mail: Samantha.siedlecki@uconn.edu
[2]School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada
[3]Pacific Marine Environmental Laboratory, NOAA, Seattle, WA, USA
[4]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA
[5]Department of Integrative Biology, Oregon State University, Corvallis, OR, USA
[6]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, OR, USA
[7]Olympic Coast National Marine Sanctuary, NOAA, Port Angeles, WA, USA
[8]School of Oceanography, University of Washington, Seattle, WA, USA
[9]Applied Physics Laboratory, University of Washington, Seattle, WA, USA

Ocean acidification (OA) is a leading environmental stressor in the northern California Current System (nCCS), where observations documented its impacts on Dungeness crab and oyster larvae. As OA intensifies under climate change, it poses increasing challenges for fisheries and coastal resource management. Meanwhile, the nCCS experiences frequent marine heatwaves (MHWs), which introduce an additional stressor to the ecosystem. MHWs exhibit anomalous biogeochemical signatures and the interactions between MHWs and co-occurring OA conditions remain insufficiently understood.

To investigate historical changes in the occurrence of both extreme events and their interactions, we use the high-resolution LiveOcean model to simulate ocean conditions in the Pacific Northwest's coastal waters. A 30-year hindcast (1993–2022) is analyzed to characterize the spatiotemporal patterns of MHWs, cold spells, and OA-related parameters. We describe regional OA exposure and assess how MHWs (and cold spells) may influence the intensity, duration, or spatial extent of OA events on the continental shelf. This work advances understanding of regional OA dynamics and supports ecosystem-based management and coastal resilience planning.

S02, Oral, AbstractID=19452

Variable impacts of temperature and light on the growth and domoic acid production of the toxigenic diatom *Pseudo-nitzschia multiseries* from the California Current System

William P. **Cochlan**[1,2], Christopher E. Ikeda[2,3], Brian D. Bill[4], Vera L. Trainer[5], David Senn[6] and Charles G. Trick[7]

[1]Salish Sea Research Center, Northwest Indian College, Bellingham, WA, USA.
E-mail: cochlan@sfsu.edu
[2]Estuary and Ocean Science Center, San Francisco State University, Tiburon, CA, USA
[3]Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[4]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, USA
[5]Olympic Natural Resources Center, University of Washington, Forks, WA, USA
[6]San Francisco Estuary Institute, Richmond, CA, USA
[7]Department of Biology, Western University, London, Ontario, Canada

Toxic blooms of the diatom genus *Pseudo-nitzschia* are common in the coastal waters of eastern boundary upwelling systems, including those of the California Current System (CCS) off the west coast of the United States, where ocean warming due to climate change has already been observed. However, the relationship between toxic blooms of elevated domoic acid (DA) and regions of increased water temperature remains uncertain; this relationship has not been examined in conjunction with alterations in light and macronutrient availability. Our study used unialgal cultures of acclimated *P. multiseries* – a toxigenic species isolated from Monterey Bay, a well-known DA hotspot, to examine these relationships in multi-factorial experiments to determine which light and temperature conditions promote the greatest cellular growth and/or DA production under both macronutrient-sufficient and -deficient conditions expected in episodic upwelling regions where silicate limitation of diatom growth is frequently found. The specific growth rate of this diatom increases with higher temperatures and greater irradiance, whereas cellular DA concentrations and rates of DA production only significantly increase with elevated temperature or silicate deficiency. At higher temperatures, the relative proportion of DA present as dissolved DA also increases, although the potential toxic impact of this DA phase shift is unknown. In contrast, the major effect of reduced light is extending the period of substantial DA production throughout the growth cycle. Our results demonstrate that a multi-factorial approach to examine toxigenicity can effectively identify which oceanic conditions are the most valuable predictors of potential DA exposure in coastal ecosystems.

S02, Oral, AbstractID=19484, (ECOP)

Detecting single and compound marine extremes in the California Current Large Marine Ecosystem

Lorenzo R.F. **McCleese**[1], Michael G. Jacox[2, 3], Mercedes Pozo Buil[4], Jessica A. Bolin[5], Mikaela M. Provost[5], Natalie M. Freeman[6], Elliott L. Hazen[2] and Steven J. Bograd[2, 4]

[1]University of Washington, Seattle, WA, USA. E-mail: lorenzoo@uw.edu
[2]NOAA Southwest Fisheries Science Center, Monterey, CA, USA
[3]NOAA Physical Sciences Laboratory, Boulder, CO, USA
[4]University of California Santa Cruz, Santa Cruz, CA, USA
[5]University of California Davis, Davis, CA, USA
[6]NOAA Physical Sciences Laboratory, Boulder, CO, USA

The California Current Large Marine Ecosystem (CCLME) supports rich, biodiverse, and productive fisheries on the U.S. West Coast, yet our understanding of the interactions among multiple ocean stressors affecting living marine resources remains limited. While marine heatwaves have been extensively studied in isolation, far less is known about compound extremes (periods when temperature, oxygen, and productivity anomalies overlap), despite growing evidence that these co-occurring stressors can have synergistic, more severe ecological impacts than any single stressor alone. We develop a methodology to detect and characterize single and compound extreme events across the CCLME using MOM6 ocean model output for the northeast Pacific, following an approach adapted from recent work characterizing compound physical and biogeochemical extremes in this region. We identify extreme events in sea surface temperature, bottom temperature, dissolved oxygen, and primary productivity, as well as compound multi-variable extreme events, across available CMIP6 hindcast and projection output and establish a framework for characterizing events by their frequency, intensity, and duration. This work lays the methodological foundation for a broader effort to identify physiologically grounded climate refugia for marine species, supporting the kind of actionable, management-relevant science that the CCLME's fisheries and coastal communities depend on.

S02, Oral, AbstractID=19507

Red-shifted ocean variability increases the risk of persistent marine heatwaves in the Bering Sea and Gulf of Alaska

Michael A. **Litzow**[1] and Emily R. Ryznar[2]

[1]Alaska Coastal Observations and Research, Kodiak, AK, USA.
E-mail: mike.litzow@alaskacor.org
[2]Alaska Fisheries Science Center, Kodiak, AK, USA

Multi-year marine heatwaves have resulted in unprecedented ecosystem impacts in the Bering Sea and Gulf of Alaska during the past decade. Here, we evaluate the role of red-shifted (autocorrelated) ocean variability as a cause of marine heatwaves in these systems. Using detrended time series of mean winter sea surface temperature (SST), we show that first-order autocorrelation has reached unprecedented levels in recent decades in both systems. This increased autocorrelation is not shared across other boreal and Arctic ecosystems, and is not predicted by a 21-member climate model ensemble, leading us to conclude that increased reddening is not a consequence of climate change. Instead, we show that changes in SST autocorrelation closely track changes in mixed-layer depth (MLD) autocorrelation and interannual variability in Aleutian Low sea level pressure (SLP) anomalies. MLD is an important driver of interannual memory in winter SST, and both MLD and SST anomalies in the northeast Pacific are responsive to Aleutian Low variability. We propose that increasing Aleutian Low variance has resulted in increased autocorrelation in both MLD and SST anomalies. Red-noise variability increases the likelihood of persistent shifts in time series, and we show that the trend in SST autocorrelation that we document has increased the risk of a two-year heatwave by ~50% in the Bering Sea and ~200% in the Gulf of Alaska, independent of the anthropogenic trend. While anthropogenic forcing is the primary cause of marine heatwaves, we propose that transitions between white- and red-noise ocean variability may be an underappreciated contributing factor.

S02, Oral, AbstractID=19530, (ECOP)

Rapid intensification of marine heatwaves in Korean waters: Increasing high-intensity categories

Jin **Yeo**[1,2], Wonkeun Choi[1] and Chan Joo Jang[1,2]

[1]Ocean Circulation and Climate Research Department, Korea Institute of Ocean Science and Technology, Busan, R Korea
[2]Major in Ocean Science, Korea Institute of Ocean Science and Technology School, University of Science and Technology (UST), Daejeon, R Korea. E-mail: cjjang@kiost.ac.kr

Marine heatwaves (MHWs) are extreme ocean warming events in which anomalously high ocean temperatures persist from days to years. MHWs have intensified and become more persistent globally, with this long-term trend accelerating since the 2020s, particularly in Korean waters. However, most previous studies have focused on mean MHW properties, leaving it unclear whether this intensification reflects comparable changes across all intensity categories or is primarily driven by high-intensity MHWs. In this study, we classify MHWs into four intensity categories (I–IV) to investigate category-based spatiotemporal changes, using daily Optimum Interpolation Sea Surface Temperature data over 43 years (1982–2024) in Korean waters. Both duration and mean intensity across all categories showed increasing trends, with the most pronounced increases in the Strong group (Categories III and IV). In the Strong group, the median duration increased by more than 41 days/event, and the median mean intensity increased by more than 0.7 °C in the 2020s compared to the 1980s. Notably, the median duration in the Strong group increased by more than 36 days/event from the 2010s to the 2020s. These results indicate that recent MHW intensification is associated with greater increases in higher-intensity categories. Furthermore, the area without MHW occurrence decreased in the 2020s, while areas experiencing Categories II–IV expanded, indicating an increasing spatial extent of high-intensity MHWs. Our findings provide quantitative evidence that the recent intensification of MHWs is closely linked to the rapid increase of high-intensity events, highlighting the need to understand the mechanisms underlying this acceleration.

SESSION 02: MEQ/ POC/ FUTURE/ AP-UNDOS Topic Session

Climate Extremes and Coastal Impacts in the Pacific

Poster Presentations

S02, Poster, AbstractID=19131, PosterID: S02-P1, (ECOP)

Adaptive fishing behavior and fishery network topology: A structural approach to climate resilience

Gal **Koss**

University of California, Davis, CA, USA. E-mail: gkoss@ucdavis.edu

As climate change reconfigures ocean ecosystems, there is urgency to develop a more complete understanding of the responses of commercial fishers reliant on those ecosystems and the resilience of the fisheries and fishing communities. Research to date has demonstrated that fishers use diversification strategies to mitigate risk associated with both longer-term climate change and shorter-term climate shocks. Individual adaptive fishing decisions impact other vessels in the region, interact with the marine ecosystem, and shape macroscopic decision-making conditions, constituting a complex human-natural system. Network theory provides a useful framework to describe the resilience of a complex system to external perturbations. However, the economic foundations that explain the network topology and climate resilience of commercial fishing communities are not fully understood.

This research connects the micro-foundations of individual decisions with the macro behavior of networks to improve our understanding of resilience in commercial fishery systems. I pair empirically observed fish landings with fishing decisions simulated in a calibrated structural Random Utility Model, mapping the inputs to fishery decision-making to participation choices and, in turn, network outcomes. Vessel fishing decisions are projected into a fishery-fishery network in which fisheries are connected through vessel diversification behavior. Using network measures such as connectance, edge weight, and modularity, I describe how network structures depict climate-adaptive fishing behavior.

I observe that vessels respond to higher costs by choosing to participate in fewer fisheries or choosing a more common fishery strategy. This is depicted in the network structure: the network becomes smaller, less connected, and more modular. While changes in vessel diversification and heterogeneity of fishing strategies in the fleet both arise from the same changes to decision-making conditions, they vary in their impacts on network topology. This implies that a policy that reduces access costs for a fishery will have a different effect on network resilience than one that makes a new fishery available.

Conditional on network connectivity, a reduction in vessel diversification can bring about an entirely different network response: in poorly-connected systems, a decrease in diversification is correlated with a more modular system while the opposite is true in well-connected systems. A large change in fishing costs can reconfigure the network, indicating that network topology is easiest to interpret in response to small changes in decision-making conditions and is therefore regime dependent. I observe that California regions belong to different regimes and, in some

cases, have transitioned through different regimes over time, suggesting that the same reduction in vessel diversification could have qualitatively different resilience consequences depending on a region's current connectivity regime.

S02, Poster, AbstractID=19152, PosterID: S02-P2

Study on northwestern Pacific warming and its role in typhoon genesis and rapid intensification

Kyeong Ok **Kim**, Hong Sik Min, Sunghun Kim, Hyoun-Woo Kang

Korea Institute of Ocean Science and Technology, Busan, R Korea. E-mail: kokim@kiost.ac.kr

The Northwestern Pacific is the most active tropical cyclone basin in the world and a key region for ocean-atmosphere interaction affecting East Asia. This study investigates how Northwestern Pacific warming influences typhoon genesis and rapid intensification, with a focus on the North Equatorial Current (NEC) region and the Eddy Rich Zone (ERZ). Integrated field campaigns conducted by KIOST from 2022 to 2026 combined shipboard, autonomous, and atmospheric observations to capture oceanic and atmospheric conditions before, during, and after typhoon passage. Results indicate that enhanced ocean heat content, warm-core eddies, low-salinity waters, and strong upper-ocean stratification help sustain air-sea heat exchange and favor rapid intensification. Coupled modeling studies are also underway to improve prediction of typhoon rapid intensification and support seasonal typhoon outlooks.

S02, QR-Poster, AbstractID=19196, PosterID: S02-P3, (ECOP)

Bridging the science-policy interface: Actionable frameworks for climate resilience and sustainable fisheries management in coastal West Africa

Michael Adedotun **Oke**

Independent Researcher, Abuja, Nigeria. E-mail: maof2020@gmail.com

Earth's changing climate and escalating environmental stressors pose profound threats to the sustainability of marine ecosystems and the livelihoods of vulnerable coastal communities. Translating marine science into practical, localized policy decisions remains a critical barrier to effective ocean stewardship. This study presents an actionable socio-ecological framework designed to bridge the science-policy interface in coastal West Africa. By integrating regional environmental monitoring tools with socio-economic indicators, we assess the cumulative impacts of multiple climate stressors on small-scale pelagic fisheries. Our findings demonstrate how targeted, data-driven frameworks can empower local fishing communities, non-governmental organizations, and regulatory decision-makers to co-design adaptive management strategies. Crucially, the research outlines explicit pathways for communicating scientific uncertainty and climate risk to policy-makers, transforming baseline oceanographic observations into predictive tools for resource management. Ultimately, this framework provides a scalable model for transboundary collaboration, contributing solution-based science vital for protecting biodiversity and fostering climate resilience in a rapidly changing global ocean.

Keywords: Actionable science, Socio-ecological systems, Climate resilience, Pelagic fisheries, Science-policy interface, Small-scale fisheries management

S02, Poster, AbstractID=19311, PosterID: S02-P4, (ECOP)

Microbial community dynamics in response to typhoon and strong wind disturbances in Jeju aquaculture systems

Haeyoung **Park**[1], Junsang Youn[1], Huijeong Doh[1], Jeonghyeon Kwak[2] and Seong-il Eyun[1]

[1]Chung-Ang University, Seoul, R Korea. E-mail: eyun@cau.ac.kr
[2]National Institute of Fisheries Science, Busan, R Korea

Strong environmental disturbances, such as typhoons and intense winds, can substantially alter bacterial community composition and diversity in coastal ecosystems. However, microbial responses within marine aquaculture systems remain poorly understood despite the high vulnerability of these systems to physical disturbances. In this study, we investigated microbial community dynamics in aquaculture waters (Gosan and Namwon) around Jeju Island, Korea, before and after Typhoon Hinnamnor in 2022 and a strong wind event in 2023. Surface and bottom waters were analyzed using 16S rRNA sequencing. Following a comparative evaluation of taxonomic classification tools and databases, Kraken2 with RefSeq2026 was selected for subsequent analyses because it provided the most consistent taxonomic assignments. In 2022, the genera *Idiomarina* and *Marinobacter* increased markedly after the typhoon, likely driven by elevated organic matter input, suggesting opportunistic growth under disturbed conditions. In contrast, the 2023 strong wind event was characterized by a significant increase in the genus *Woeseia*, indicating sediment resuspension and the enrichment of sediment-associated microorganisms. Virulence factor analysis using VFDB2022 showed that potentially pathogenic *Vibrio* species, including *Vibrio vulnificus*, *V. cholerae*, and *V. parahaemolyticus*, increased post-typhoon in 2022. However, no *Vibrio* species were detected during the 2023 wind event. This disparity suggests that the post-typhoon surge in *Vibrio* species may be associated with enhanced freshwater runoff and nutrient inputs from the accompanying heavy rainfall. Overall, these findings suggest that typhoons and strong winds drive distinct microbial responses through contrasting mechanisms of organic matter enrichment and sediment resuspension.

S02, Poster, AbstractID=19335, PosterID: S02-P5

Predictability of warm core eddies released from Kuroshio Extension in 2024 based on an ice-ocean coupled data assimilation forecast system

Takuya **Nakanowatari**[1], Shoko Abe[2], Taira Nagai[2], Ryu Saiki[1], Hiroshi Kuroda[3], Takeshi Okunishi[4], Takashi Setou[5], Daisuke Hasegawa[4], Hikaru Homma[4], Joji Oida[4], Shigeho Kakehi[4], Taiki Fuji[5], and Satoshi Suyama[6]

[1]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Kushiro, Japan. E-mail: nakanowatari_takuya71@fra.go.jp
[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Niigata, Japan
[3]Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan
[4]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Shiogama, Japan
[5]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan
[6]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Hachinohe, Japan

In recent years, with extreme events under global warming such as marine heatwaves are occurring with increasing frequency, the importance of using numerical models to assess the current state of the marine environment and generate forecasts has grown. In Kuroshio-Oyashio confluences, movements of warm core eddy (WCE) are key elements not only for occurrence of marine heatwaves with mesoscale but also for distribution of water masses and fishery grounds for commercial pelagic fishes such as Pacific saury (Kuroda and Yokouchi, 2017, Miyama et al., 2021). In this study, we evaluated prediction skill of an extremely intense WCE in 2024/2025 detached from extremely northward shifted Kuroshio Extension (Kuroda et al. 2025) by employing a new operational ocean forecast system for mesoscale variability based on an ice-ocean coupled model with 3DVAR data assimilation. A series of reforecast experiments show that the generation timing of WCE in spring 2024 is not skillfully predicted at the lead time of 2 months. On the other hand, the location of WCE in autumn 2025 can be successfully predicted at the lead time of 2 months. The predictability is also likely attributed to the strength of subarctic gyre. In this presentation, we also discuss the importance of in-situ observation for the assimilation data and the possibility of skillful prediction for WCE based on ensemble prediction methods.

S02, Poster, AbstractID=19391, PosterID: S02-P6 CANCELLED

~~**Long-term variability of the Yellow Sea Bottom Cold Water and its implications for fisheries resources in the Yellow Sea**~~

~~Changsin **Kim**[1], Gyeongjae Maeng[1] and Eun-Byeol Cho[2]~~

~~[1]Chonnam National University, Yeosu, R Korea. E-mail: changsin.kim@jnu.ac.kr~~
~~[2]IBS Center for Climate Physics, Busan, R Korea~~

~~The Yellow Sea Bottom Cold Water (YSBCW) is a unique hydrographic feature that forms beneath the seasonal thermocline during summer and plays an important role in shaping thermal habitats and ecosystem dynamics in the Yellow Sea. Previous studies have suggested that variability in the YSBCW influences the distribution, migration, and productivity of major fisheries resources, including Small Yellow Croaker (*Larimichthys polyactis*), Pacific Cod (*Gadus macrocephalus*), Swimming Crab (*Portunus trituberculatus*), and etc.~~

~~This study examined the long-term variability of the YSBCW using multi-decadal bottom temperature datasets and explored its relationship with fluctuations in major fisheries resources. Results showed substantial interannual and decadal changes in the intensity and spatial extent of the YSBCW. Periods of expansion and contraction of the cold-water mass were accompanied by corresponding changes in fisheries catches, suggesting that variability in bottom thermal habitats may influence resource availability and productivity. These findings highlight the potential role of the YSBCW as a key environmental driver of fisheries variability in the Yellow Sea and provide a basis for understanding ecosystem responses to climate change and ocean warming.~~

S02, Poster, AbstractID=19404, PosterID: S02-P7, (ECOP)

Diving and feeding responses of Skipjack tuna to tropical cyclones in the East China Sea

Soya **Sakuma**[1], Hiroto Abe[1], Takayuki Matsumoto[2], Yuichi Tsuda[2], Yoshinori Aoki[2], Hidetada Kiyofuji[2]

[1]Hokkaido University, Hakodate, Japan. E-mail: sakuma.soya.s7@elms.hokudai.ac.jp
[2]Japan Fisheries Research and Education Agency, Yokohama, Japan

The northwestern Pacific Ocean, including the East China Sea (ECS), is the most active region of tropical cyclones (TCs) in the world where they form and pass though. In such regions, epipelagic fish would be affected by positive- or negative-effects induced by TCs with rainfall and strong wind. To reveal the response of epipelagic fish to TCs-induced environmental change leads to better understanding on ecological response and prediction for fishing ground following TC passage. Herein, we focused on skipjack tuna (*Katsuwonus pelamis*), which mainly swim in the top-50 m depth and conducted the release survey in the ECS using electronic tags to reveal the changes in their behavior and feeding induced by TCs.

Using electronic tag data collected in the ECS and reanalysis oceanographic data during the period of 2012-2016, we identified 27 pairs between the 9 fish and 22 TCs based on daily fish and TC positions. For each pair, we calculated changes in swimming depth and estimated energy intake, based on body and ambient temperature change, between the pre- and post-TC periods, and related them to concurrent changes in sea surface temperature (SST), salinity, chlorophyll, as well as TC intensity, speed, and distance to the fish. Correlation analysis indicated that only the change in SST is among the multiple indices that showed a significant relationship with the change in estimated energy intake ($r = 0.496$). Wavelet analysis of the depth data revealed shifts in diving depth and periodicity of tagged skipjack tuna concurrent with TC passage. Furthermore, individuals experiencing a post-TC decline in SST showed reduced feeding. These results suggest that TC-induced upwelling and mixing affected the diving behavior and feeding activity of skipjack tuna. In this presentation, we report a comprehensive analysis of water temperature changes and other variables following TC passage.

S02, Poster, AbstractID=19469, PosterID: S02-P8

Impacts of Ex-Typhoon Merbok on the Bering Sea biophysical environment: Insights from mooring observations and a regional model simulation

Vivek Seelanki[1,2], Wei **Cheng**[2], Phyllis Stabeno[1], Al Hermann[1,2], Liz Drenkard[3] and Charlie Stock[3]

[1]University of Washington, CICOES, Seattle, WA, USA. E-mail: vivek.veelanki@noaa.gov
[2]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA.
E-mail: wei.c.cheng@noaa.gov
[3]NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA

Extreme storms represent some of the most energetic ocean forcing events. Through rapid changes in sea level pressure, intense wind stress, and enhanced air-sea buoyancy fluxes, storms can deepen the mixed layer, erode stratification, and drive circulation anomalies. The Bering Sea is one of the most productive marine ecosystems in the world and supports major commercial fisheries. In recent decades, declining sea ice and changing atmospheric circulation patterns have altered the physical and ecosystem conditions in the Bering Sea. Typhoon Merbok formed over an unusually warm Pacific Ocean in September 2022; on 15 September, it underwent an extratropical transition and intensified into a North Pacific cyclone that impacted western Alaska and the Bering Sea. Merbok generated sustained, strong winds across much of the eastern Bering Sea shelf during the peak seasonal stratification and minimal sea ice. The lack of protective sea ice and the extreme storm surge led to high rates of coastal erosion. This extreme event provides a natural experiment to quantify how late-season storm forcing modifies ocean stratification, circulation, and ecosystem conditions across a broad, shallow shelf. In this study, we investigate the physical and biogeochemical impacts of ex-Typhoon Merbok on the Bering Sea shelf using a regional configuration of the Modular Ocean Model version 6-Northeast Pacific at 10-km horizontal resolution (MOM6-NEP10k), and evaluate the modeled responses to biophysical mooring observations. By combining model diagnostics with *in situ* measurements, we address: (1) how did Merbok modify upper-ocean stratification and mixed-layer structure; (2) what circulation anomalies were generated, and how did they influence vertical and cross-shelf exchange; (3) how did nutrients, oxygen, and chlorophyll respond to the storm forcing; and (4) how well does the regional model reproduce the observed event-scale responses?

S02, Poster, AbstractID=19473, PosterID: S02-P9, (ECOP)

Seasonal and interannual variability of subsurface oxygen in Queen Charlotte Sound

Shannon **McClish**[1], Stephanie Waterman[1], Roberta Hamme[2], Jody M. Klymak[2], Tetjana Ross[3], and Angelica Peña[3]

[1]University of British Columbia, Vancouver, BC, Canada. E-mail: smcclish@eoas.ubc.ca
[2]University of Victoria, Victoria, BC, Canada
[3]Fisheries and Oceans Canada, Sidney, BC, Canada

Seasonal hypoxia has recently been observed in Queen Charlotte Sound, the largest shelf sea in the Canadian Pacific. While decadal decreases in shelf oxygen have been linked to offshore oxygen supply, local processes, including organic matter respiration, shelf circulation, and mixing, can further modulate shelf oxygen content on shorter timescales. Using high-resolution observations from ocean gliders in Queen Charlotte Sound (QCS) from 2020 to 2024 and regional ocean model output, we investigate the seasonal evolution of oxygen on subsurface isopycnals to examine offshore-to-shelf connectivity and identify local processes influencing shelf oxygen in intermediate and deep waters. We find different drivers of seasonal oxygen variability between waters offshore of QCS and on the shelf, whereas interannual variability in subsurface isopycnal oxygen is similar from the coast to offshore waters. In 2022 and 2023, years with previously documented shelf hypoxia, seasonal subsurface oxygen decreases occurred faster than in years without shelf hypoxia. These preliminary results highlight seasonal differences in connectivity between shelf and offshore waters and motivate further investigation of the interaction of local and remote processes and their influence on shelf oxygen content.

SESSION 3: FIS/ POC/ FUTURE/ Topic Session

Ocean and ecosystem predictions to support decision making

Oral Presentations

S03, Invited, AbstractID=19394

Operational seasonal prediction services to support marine end user decision making

Claire M. **Spillman**[1], Alistair J. Hobday[2], Grant A. Smith[1] and Jason R. Hartog[2]

[1]Bureau of Meteorology, Docklands, VIC, Australia. E-mail: claire.spillman@bom.gov.au
[2]CSIRO, Hobart, TAS, Australia

Extreme ocean events, such as marine heatwaves, have implications for many marine systems, industries and coastal communities. Seasonal forecasting has an important role to play in both predicting and understanding these extreme ocean events and providing advance warning for risk mitigation and operational decision support.

Sea surface temperatures were the warmest on record since 1900 for Australian waters in 2024, and then again in 2025. A significant marine heatwave (MHW) occurred around Tasmania in the summer of 2023/24 which led to unprecedented conservation interventions and the development of state-based MHW response plans. In the summer of 2024-25, Western Australia (WA) experienced a severe marine heatwave that led to fish kills and widespread coral bleaching on WA reefs.

The Bureau of Meteorology provides operational sea surface temperature and thermal stress outlooks that are used by a wide range of stakeholders, including marine management agencies, fisheries and Defence. Demand for this information on temperature extremes was high and provided an impetus for setting up coordinated briefings and response plans across sectors over the past three summers. New operational seasonal marine heatwave forecast products were launched in December 2025, in response to customer demand and to support informed decision making across a range of sectors.

The combination of seasonal forecasting capability, inter-agency coordination, strong stakeholder engagement, and effective science communication plays a critical role in improving the understanding of, planning for, and responses to extreme events. Forecasts can provide a 'preparation window' for marine stakeholders to implement proactive management strategies prior to high-risk conditions, noting however that not all sectors have the same level of agility to respond. Sub-seasonal to seasonal forecast tools that are useful, usable and used, provide valuable information to assist marine stakeholders in managing climate risk and vulnerability in a warming climate.

S03, Invited, AbstractID=19578

TBA

S03, Oral, AbstractID=19112, (ECOP)

Development of an operational numerical early warning system for typical marine ecological disasters

Shan Gao, Xuanliang Ji, Jing Yang, Enye He, Jingjing Zheng and Huiqing **Fu**

National Marine Environmental Forecasting Center, Beijing, PR China. E-mail: fuhq@nmefc.cn

Against the backdrop of global warming, extreme marine heatwaves, and increasing pollutant emissions, coral bleaching and estuarine hypoxia have become more frequent and severe, posing a serious threat to marine ecosystems and fisheries resources. This study focuses on the early warning requirements for coral bleaching in the South China Sea and hypoxia in the Yangtze River Estuary. Based on the ROMS-CoSiNE coupled model, and integrating satellite remote sensing and in-situ observational data, we constructed a high-resolution three-dimensional physical-biological dynamic model for the Northwest Pacific by optimizing key ecological parameters. Model validation results demonstrate that this model effectively reproduces the marine ecological processes in Chinese coastal waters. Furthermore, we developed an operational numerical early warning system that integrates data processing, model simulation, and product visualization. This system provides quantitative 5-day forecasts of core hypoxia indicators and coral bleaching risk, offering scientific support for environmental management in the Yangtze River Estuary and the protection of typical coral reef ecosystems.

S03, Oral, AbstractID=19115, (ECOP)

Climate change makes policy and community decisions all the more important and urgent

Elizabeth A, Fulton[1], Rodrigo Bustamante[2], Corrine Condie[1], Michael Fuller[1], Joanna Strzelecki[3], Piers Dunstan[1], Fabio Boschetti[3], Catherine Bulman[1], Scott **Spillias**[1], Rowan Trebilco[1], Javier Porobic[1], Linda Thomas[1], Aysha Fleming[1], Roshni Subramaniam[4]

[1]CSIRO Environment, Hobart, Tasmania, Australia.
E-mail: beth.fulton@csiro.au, scott.spillias@csiro.com
[2]CSIRO Environment, St Lucia, Queensland, Australia
[3]CSIRO Environment, IOMRC, Crawley, Western Australia, Australia
[4]Parks Australia, Department of Climate Change, Energy, the Environment and Water, Tasmania, Australia

Climate change is reshaping marine ecosystems, as well as dependent communities and industries, especially the seafood sector. Australia has begun addressing this challenge in many ways, one of which was a continental-scale modelling of possible futures for marine and coastal ecosystems including not only climate drivers but how marine industries, technology uptake, market and community sentiment and policy change may evolve out to 2040. This ambitious undertaking involved the collation of a comprehensive dataset on all marine uses in Australia over the past 25 years, participatory scenario creation, a mosaic of more than 20 models and a travelling series of workshops to talk through model content, results and the implications for fisheries and aquaculture with seafood producers in every Australian jurisdiction. We found that Australian seafood production is currently on a pathway that will see the industry "struggling" over the coming decades. Shifting to a more favourable pathway will require substantial changes in the system. Regardless of pathway, given current challenges resulting from market, regulatory, technical and social pressures, climate change is certainly making a difficult situation worse, affecting primary production, habitat, species distributions and abundance. Our work suggests that society’s choices in terms of markets and consumer expectations, social perception of seafood production and policy responses are key to ameliorate these impacts.

S03, Oral, AbstractID=19118, (ECOP)

Physiological responses of juvenile Dungeness crab (Metacarcinus magister) to present-day and projected ocean acidification, hypoxia, and warming

Kristofer K. **Bauer**[1], Ella Dreke[1], MacKenna Hainey[2], Jeremy Jennings[2], Nyazia Sajdah-Bey[3], Samantha Siedlecki[4], Felipe Soares[4], Yifan Zhu[4], Samuel Gurr[2], and Francis Chan[1,2]

[1]Cooperative Institute for Marine Resources Studies, Newport, OR, USA.
E-mail: BauerKr@Oregonstate.edu
[2]College of Agricultural Sciences, Oregon State University, Corvallis, OR, USA
[3]Integrative Biology, Oregon State University, Corvallis, OR, USA
[4]Marine Sciences, University of Connecticut, Groton, CT, USA

In recent decades, the Northern California Current (NCC) has emerged as a global hotspot for ocean acidification and hypoxia (OAH), as well as marine heatwaves. These stressors pose a significant threat to regional marine fisheries, particularly benthic species such as Dungeness crab (*Metacarcinus magister*) that are already exposed to hypoxic and corrosive conditions. A key question is whether organisms in upwelling systems that will experience some of the earliest and most severe impacts of OA and ocean deoxygenation will remain resilient to change. As the most economically vital fishery in the region, developing a mechanistic understanding of how vulnerable life stages of *M. magister* respond to OAH is especially important. Little work has been done to determine physiological thresholds of *M. magister* to combined OAH effects under realistic current and future exposure conditions. Here, we leverage new high-resolution system-specific projections of OAH and warming for the NCC to assess the resilience of early lifestage *M. magister* to global change. Focusing on early life stages of *M. magister*, we hypothesize that increasing stress by mid-century will overwhelm compensatory stress response mechanisms. Building on initial experiment results of reduced survival and growth, we predict that stress response to OAH is structured by progressive thresholds of increased oxidative damage, suppressed metabolic rates, and altered protein activity. Together, these findings will establish critical tolerance thresholds for juvenile *M. magister* and provide a framework for anticipating population-level responses to future OAH conditions, providing mechanistic pathways for quantifying resilience in the fishery.

S03, Oral, AbstractID=19132, (ECOP)

Projecting climate-driven distribution shifts of global kelp habitats

Julia **Mayer**[1], Maycira Costa[2], Gabriel Reygondeau[3], Yulia Egorova[3], Scott Bohachyk[4] and William W.L. Cheung[1]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: j.mayer@oceans.ubc.ca
[2]Department of Geography, University of Victoria, Victoria, BC, Canada
[3]Rosentstiel School of Marine, Atmospheric, and Earth Science, University of Miami, Miami, Florida, USA
[4]Ocean Wise, Vancouver, BC, Canada.

Kelp forests support biodiversity, ecosystem functioning, and ecosystem services in temperate and sub-polar regions. However, kelp forests are increasingly threatened by growing pressures from climate change and interacting human stressors, leading to their degradation or total losses in many regions (Wahl et al. 2015; Wernberg et al. 2019). Despite their crucial ecological importance, we currently lack decision-ready tools such as high-resolution global projections of kelp habitat distribution and potential shifts under future climate change. Current global datasets of kelp distributions vary widely in taxonomic consistency and geographic completeness, introducing additional challenges to studying and modelling the biogeography of kelp. Our study addresses this gap by projecting the current and future potential distributions of multiple kelp species at a global scale using the new Aquamaps 2.0 pipeline (AquaX) to assess the changes in suitable habitats under climate change scenarios. First, we developed a standardized, spatially explicit set of global range maps for multiple kelp species by integrating metadata from various sources and occurrence records from biodiversity and expert curated databases. Second, for each of the kelp species with sufficient information, we apply an ensemble of SDM algorithms (AquaX) to project global maps of habitat suitability under present-day environmental conditions and project potential changes under future climate scenarios. Our outputs quantify projected range shifts of kelp species in different ocean regions and identify areas in which their habitats are expected to contract, expand or remain stable over the 21st century. These projections allow us to identify persistent areas of high habitat suitability as well as substantial changes under climate change. We also highlight species-specific sensitivities to climate change linked to species' biological traits, including ecological niches and physiological thresholds. By identifying potential climate refugia under future climate scenarios, our work highlights the use of quantitative species distribution projections to support evidence-based decision-making for kelp restoration and conservation, and to guide site selection for projects aimed at enhancing the long-term resilience of kelp forests.

S03, Oral, AbstractID=19143, (ECOP)

Spatial decision-making and economic efficiency in Korean live-squid offshore jigging fisheries: A bio-economic approach using AIS-derived activity and environmental data

Jisoo **Lee**, Giho Ong, Damin Lee, Sukgeun Jung

Jeju National University, Jeju, R Korea. E-mail: sukgeun.jung@gmail.com

Offshore jigging fisheries are the primary production base for common squid (*Todarodes pacificus*) in Korea. While domestic stock depletion increases import reliance, high-value live squid cannot be imported, sustaining robust domestic demand and premium pricing. Traditional fisheries literature often neglects preservation-dependent selling methods and their influence on fishing ground selection and fuel consumption. This study establishes a bio-economic framework integrating Automatic Identification System (AIS)-derived fishing activity, operational costs, and marine environmental variables to evaluate live-squid harvesting strategies. Fishing activity was identified using vessel speed and fishing duration thresholds. Marine environmental variables derived from satellite and meteorological sources informed habitat suitability, while departure and landing trajectories quantified spatial price differentials and fuel efficiency across landing sea areas (LSAs). Fishing ground distribution was modeled using deep learning trained on AIS records from 438 vessels spanning 2012 to 2026 and habitat suitability indices. Selling price data covering live, fresh, and frozen squid were collected from 2017 to 2025, along with vessel specifications from 100 vessels ranging 10–99 GT and 200–1,200 kW. Results show that vessel operators strategically concentrate fishing activity in specific areas. While the Japan/East Sea (JES) has historically been the primary fishing ground, the Yellow Sea (YS) appears to be gaining relative economic efficiency in recent years. Projections incorporating environmental and market change scenarios further suggest this efficiency gap will persist or widen over varying time horizons. This framework provides practical guidelines for fishing grounds and LSA selection while minimizing trip duration under environmental and market volatility.

S03, Oral, AbstractID=19184, (ECOP)

Developing a Dungeness crab (*Metacarcinus magister*) meat quality forecasting management tool

Julia **Lara Navarrete**[1], Samantha Siedlecki[1], Isaac Kaplan[2], Emily Norton[3], Felipe Soares[1], Kelly Corbet[5], Troy Buell[5], Cathleen Vestfals[5], Dan Ayres[4], Matthew George[4], Chris Biggs[4], Joe Schumacker[5], Al Hermann[3], Jan Newton[6], Simone Alin[7] and Catherine Matassa[1]

[1]Department of Marine Sciences, University of Connecticut, Avery Point, CT, USA.
E-mail: rqw24002@uconn.edu
[2]Conservation Biology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[3]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA.
[4]Washington Department of Fish and Wildlife, Montesano, WA, USA
[5]Quinault Department of Fisheries, Taholah, WA, USA
[6]University of Washington, Seattle, WA, USA
[7]Pacific Marine Environmental Laboratory, NOAA, Seattle, WA, USA

Dungeness crab (*Metacarcinus magister*) is a native species of the Pacific coast and is the most valuable single-species fishery on the West Coast, with the 2024–2025 season harvest valued at $180.6M. In Washington and Oregon, the season historically starts in early December, when the test fishery indicates the meat-to-total-crab-weight ratio, or meat quality threshold, is surpassed. Recently, the fishery has been opening later, presenting challenges to the current management process. Ocean conditions influence the meat quality of crabs, multistressors such as temperature, oxygen, and pCO_2. Managers and end users are interested in having a prognostic tool to forecast when the season will open. Seasonal forecasts of ocean conditions exist in the region (J-SCOPE) and can be used to inform this fishery. Using General Additive Models (GAMs), we observed that the date the meat quality threshold was met was related to oceanographic conditions, which are highly variable and seasonally reach harmful potentially levels in Pacific Northwest crab habitat. The model provided a forecast of the day of the year that the meat quality threshold was surpassed at each sampling station for the entire forecast period (2003–2025). Forecast skill was evaluated outside the calibration period and was found to be skillful. The forecasting products that result are being co-designed with state and tribal resource managers to support healthy fisheries and coastal communities in the face of rapidly changing ocean conditions.

S03, Oral, AbstractID=19223

Improved prediction of tropical cyclone intensity by incorporating ocean waves: An example of a potential PICES science service

Fangli **Qiao**[1], Songlin Li[1], Biao Zhao[2], Qi Shu[1], Vladimir Ryabinin[3], Dong Ji[1], Guomin Chen[4], and Ka-Kit Tung[5]

[1]First Institute of Oceanography and Key Laboratory of Marine Science and Numerical Modeling MNR, Qingdao, PR China. E-mail: qiaofl@fio.org.cn
[2]Department of Earth Sciences, Uppsala University, Uppsala, Sweden. Now with Program in Atmospheric and Oceanic Sciences at Princeton University, New Jersey, USA
[3]Individual Researcher, Geneva, Sweden
[4]Shanghai Typhoon Institute, China Meteorological Administration, Shanghai, PR China
[5]Department of Applied Mathematics, University of Washington, Seattle, WA, USA

All North Pacific rim countries (i.e. PICES contracting parties) have greatly suffered from tropical cyclones, also known as typhoons or hurricanes. Progresses in remote sensing and increasing computing power over recent decades have led to marked improvements in track forecasting. However, a cyclone's destructive power depends on its intensity. Yet operational forecasts continue to severely underpredict the peak intensity of strong cyclones, while overpredict weak ones. Current forecasting models include the coupling between the atmosphere and ocean but ignore the significant energy and momentum transfers from the ocean by breaking waves, and the effect of non-breaking waves on mixed-layer depths. Here we demonstrate that accounting for the dynamic air-sea interface significantly improves the forecast of tropical cyclone intensities. Probability of detection for rapid intensification in the Northwest Pacific increases to 90% compared to 10-50% from existing operational models. A long-awaited breakthrough in predictions of tropical cyclone intensity, especially for strong ones, becomes achievable. As PICES is transforming from research to providing science services to contracting parties, greatly improved tropical cyclone predictions may be one kind of PICES service, as demonstrated here.

S03, Oral, AbstractID=19226, (ECOP)

Integrating forecast modelling into Indigenous fisheries management for the Heiltsuk Nation

Kate J. **Mussett**[1], Kyle L. Wilson[1], Sara Tremblay-Boyer[2]

[1]Simon Fraser University, Burnaby, BC, Canada. E-mail: kate_mussett@sfu.ca
[2]Heiltsuk Integrated Resource Management Department in Bella Bella, BC, Canada

Pacific salmon populations in the Central Coast of Pacific Canada have undergone widespread declines, sparking an urgent need for precautionary fisheries management. Many social and environmental factors contribute to these declines including marine heatwaves and anthropogenic climate changes, watershed and land use changes, and overharvest from coastal mixed-stock fisheries. There is thus an emergent need to better understand and anticipate how salmon and their ecosystems may respond to marine and freshwater changes to inform and empower local management tables in the bioregion. Guided by the Heiltsuk First Nation, our work aims to understand how salmon populations might continue to respond to these environmental drivers across multiple spatial scales, from the ocean to local rivers, under rapidly changing climates. Answering these questions requires novel, mixed methods approaches, where indicators from multiple knowledge systems are brought together to inform forecasting, climate change mitigation, and culturally representative management. Specifically, we aim to identify indicators of salmon productivity and change rooted in both Heiltsuk knowledge systems, as well as quantitative evaluations, to develop a tool for long-term assessments of salmon health. At the outset of this work, we are continuing to explore the ways in which Bayesian hierarchical models and other quantitative approaches may support Heiltsuk fisheries stewardship and management, and how processes may be co-produced to inform novel fisheries management in the Central Coast.

S03, Oral, AbstractID=19259, (ECOP)

Lower trophic level blue food potential of the Canadian Beaufort Sea

Kristen J. **Sora**[1,2], Yulia Egorova[3], Gabriel Reygondeau[1,3], Carie Hoover[4,5,6], Andrea Niemi[4], Lisa Loseto[4,7], Ellen V. Lea[4], C-Jae C. Breiter[4], C.J. Mundy[8], William W.L. Cheung[1], Adam Monahan[2] and Nadja S. Steiner[7]

[1]Institute for the Oceans and Fisheries, The University of British Columbia, Vancouver, BC, Canada. E-mail: ksora@uvic.ca
[2]School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada
[3]Rosenstiel School of Marine, Atmospheric & Earth Science, University of Miami, Miami, FL, USA
[4]Freshwater Institute, Fisheries and Oceans Canada, Winnipeg, MB, Canada
[5]Marine Affairs Program, Dalhousie University, Halifax, NS, Canada
[6]Coastal First Nations/Great Bear Initiative, Vancouver, BC, Canada
[7]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
[8]Centre for Earth Observation Science, University of Manitoba, Winnipeg, MB, Canada

Inuit have always shown exceptional resilience to change, but the current unprecedented rate of climate change jeopardizes coastal ecosystems and threatens the sustainability of traditional food systems and livelihoods. Blue foods include aquatic plants, invertebrates, and fish, and are important to the food security and culture of Arctic communities. To meet future food systems demands, this study aims to evaluate the blue food potential (BFP) that can bolster the resilience and sustainability of Arctic communities and ecosystems. Specifically, we evaluate the diversifying potential of blue food to lower trophic level species (e.g., kelp, crabs, scallops, some fishes) and harvesting mechanisms under climate change in the Canadian Beaufort Sea and Amundsen Gulf. We use species distribution models, led by community-based Inuit Knowledge to assess the biophysical processes driving BFP species' production, spatial trends, and future projections by 2100. We analyze the effects of changing temperature, sea ice cover, salinity, oxygen concentration, and acidity on biomass, production, and distributions under low- and high-emission scenarios. We identify areas projected to face risks and opportunities of BFP, particularly in coastal waters accessed by Arctic communities. The results indicate potential range constriction of Arctic lower trophic level species, decreasing their contribution to the blue food system. Meanwhile, potential migration of emerging lower trophic level species from sub-Arctic waters (i.e., Arctic-boreal species) are important for diversification and resilience of BFP. The combination of Inuit Knowledge with modelling, reveal valuable insights of future BFP relevant for local harvesting, food security, and conservation planning in the Canadian Arctic.

S03, Oral, AbstractID=19270

salmonMSE: A decision-support tool for Pacific salmon linking management objectives with population dynamics and ecosystem drivers

Carrie A. **Holt**[1], Quang Huynh[2], Catarina Wor[1], Brendan Connors[3], Bob Bocking[4], Nick Brown[5], Lian Kwong[6], Wilf Luedke[7], Diana McHugh[7], Michael Thom[6], Amelia Vos[8] and Brendan Zoehner[6]

[1]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada.
E-mail: carrie.holt@dfo-mpo.gc.ca
[2]Blue Matter Fisheries Consulting, Vancouver, Canada
[3]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
[4]LGL Consulting, Sidney, BC, Canada
[5]Pacific Science Enterprise Centre, Fisheries and Oceans Canada, West Vancouver, BC, Canada
[6]Regional Headquarters Fisheries and Oceans Canada, Vancouver, Canada
[7]Southcoast Area Office, Fisheries and Oceans Canada, Nanaimo, BC, Canada
[8]Huu-ay-aht First Nation, BC, Canada

Risk-based decision support tools can link fisheries objectives with population dynamics and ecosystem conditions to inform sustainable management. Pacific salmon are unique among marine fish in their high biological diversity – there are hundreds of genetically distinct populations – and in their vulnerability to environmental conditions in both freshwater and marine environments, requiring distinct decision-support tools. **salmonMSE** is a stochastic, closed-loop simulation tool based on 'management strategy evaluation' (MSE) using a life-cycle based model that can incorporate biological realism of salmon populations and multiple management levers impacting salmon: harvest regulation, hatchery enhancement and habitat restoration. salmonMSE is a generic tool that can be applied across populations and salmon species with varying biological characteristics, data availability and management contexts. Here, we present a case study on Chinook salmon on the West Coast of Vancouver island in the territory of the Huu-ay-aht First Nation, that is exposed to mixed-stock fisheries and subject to hatchery enhancement and habitat restoration. The model is conditioned on available monitoring and tagging data and projections are expanded to include hypotheses about life-history diversity and environmental drivers of freshwater survival. Using this tool, management scenarios can be evaluated under various assumptions about the biology of the fish and ecosystem drivers affecting the stock informed by local understanding of the ecosystem.

S03, Oral, AbstractID=19308, (ECOP)

Projecting climate-driven changes in Canada's ocean resources for blue economy planning

Pedro C. **González-Espinosa**[1], Mohammad Nasir Tighsazzadeh[1], Helena J. Debus[1], Muhammed A. Oyinlola[2,3], William W. L. Cheung[2,3], Gabriel Reygondeau[2,4] and Andrés M. Cisneros-Montemayor[1]

[1]Nippon Foundation Ocean Nexus, School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC, Canada. E-mail: pcgonzaleze@gmail.com
[2]Changing Ocean Research Unit, Institute for the Oceans and Fisheries, The University of British Columbia, Vancouver, BC, Canada
[3]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada
[4]Rosenstiel School of Marine, Atmospheric, and Earth Science, University of Miami, Miami, FL, USA

The Blue Economy depends on marine ecosystems that are being reshaped by climate-driven changes such as temperature, oxygen, acidity, sea level, and circulation patterns. Understanding how these changes may affect the future availability of ocean resources is critical to supporting ecosystem-based management and adaptation planning in Canada. We develop a spatially explicit framework to project changes in marine resource availability supporting key Blue Economy sectors, including fisheries, mariculture, ocean energy, blue carbon, and ecotourism. The framework integrates climate-driven environmental projections with sector-relevant indicators to estimate relative changes across Canada's Pacific, Arctic, and Atlantic bioregions under two emissions scenarios (SSP1–2.6 and SSP5–8.5). Results indicate strong regional heterogeneity in future resource availability. By the end of the century, mean changes range from approximately +1% to +18% under SSP1–2.6, and from −7% to +38% under SSP5–8.5. At a national level, increases from 5.7% and 8.6% could be expected, respectively. However, these patterns mask strong spatial contrasts, with localised declines exceeding 50% projected in parts of the Arctic and Atlantic regions, where dependence on sectors like fisheries and aquaculture is high. These findings highlight the importance of developing adaptive climate policies at local, regional, and national levels. Moreover, such frameworks should secure the long-term sustainability of livelihoods and ecosystems dependent on the ocean, while prioritising support for coastal communities, encouraging inclusive leadership, and promoting equity in benefits and responsibilities.

S03, Oral, AbstractID=19339, (ECOP)

Physics-guided dual-branch networks for global ocean chlorophyll forecasting

Ji-Sook **Park**[1] and Jong-Yeon Park[1,2]

[1]Department of Climate, Environment, and Energy, Jeonbuk National University, Jeonju, R Korea. E-mail: jongyeon.park@jbnu.ac.kr
[2]Department of Earth and Environmental Sciences & Earth Environmental System Research Center, Jeonju, R Korea

Seasonal-to-interannual prediction of phytoplankton biomass is essential for marine ecosystem management and fisheries, yet the Earth System Models that provide such forecasts remain computationally expensive. We present a physics-guided dual-branch neural network that forecasts monthly chlorophyll-a anomalies globally at lead times of 1 to 12 months, at far lower cost. The architecture mirrors the two terms of the chlorophyll tendency equation: a main branch learns biological source–sink processes from past chlorophyll, sea surface temperature, and mixed-layer depth, while a parallel advection branch represents physical transport through semi-Lagrangian advection of past chlorophyll along ocean current anomalies. A soft coupling between the branches separates locally driven biological change from current-driven redistribution. The model is trained on CMIP6 historical simulations and a data-assimilated biogeochemical reanalysis, and forecasts are validated against satellite chlorophyll observations. We benchmark the model against persistence to confirm that its skill exceeds simple autocorrelation, and map forecast skill across six dynamically distinct ocean regions and lead times. To trace where this skill comes from, we compare the forecasts with lead–lag regressions of observed climate precursors and use occlusion sensitivity to locate the regions the network relies on. These diagnostics assess the contribution of physical transport and relate the model's skill to the underlying physical processes.

S03, Oral, AbstractID=19345, (ECOP)

Assessing climate change and potential impacts to Pacific Salmon in Clayoquot Sound, British Columbia

Marilena S. **Geng** and Laura Bianucci

Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: marilena.geng@dfo-mpo.gc.ca

Fjords along the west coast of Vancouver Island form highly productive coastal ecosystems supporting important fisheries and culturally significant species including Pacific salmon. These environments are influenced by regional ocean circulation, river discharge, and seasonal atmospheric forcing, all of which are expected to shift under future climate conditions. Yet global and regional climate projections rarely resolve the fine-scale dynamics of fjord systems, creating a gap between available projections and the spatial scales relevant to local decision-making.

While reliable nearshore projections remain forthcoming, we present a high-resolution modelling framework to help bridge this gap through scenario analyses. Using the Finite Volume Community Ocean Model (FVCOM), we developed a present-day simulation for Clayoquot Sound, British Columbia, that reproduces observed oceanographic conditions well. Based on this, a future scenario for 2055,RCP 8.5, was constructed using a delta approach applied to atmospheric, oceanic, and riverine forcing, maintaining present-day variability on top of a new mean climate.

The future scenario shows overall warming of ~1.15 °C, with the largest increases at the surface during summer. Salinity changes are relatively small and primarily driven by changes in river discharge. To assess ecological implications, we evaluated exceedance of a 17 °C thermal stress threshold for Pacific salmon. Under future conditions, the extent and duration of threshold exceedance increase substantially, particularly in shallower inlets such as Tofino Inlet, where much of the water column exceeds this threshold during late summer. These results demonstrate a tractable, regionally adaptable tool for assessing climate-driven habitat change where high-resolution projections are unavailable.

S03, Oral, AbstractID=19357

High-resolution seasonal forecasts of Northeast Pacific physics and biogeochemistry

Michael G. **Jacox**[1,2,3], Dmitry Dukhovskoy[4], Michael Alexander[5], Jessie Liu[2], Dillon Amaya[6], Liz Drenkard[7], Natalie Freeman[2], Andrew Ross[7], Charlie Stock[7]

[1]Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Monterey, CA, USA. E-mail: michael.jacox@noaa.gov
[2]Physical Science Laboratory, National Oceanic and Atmospheric Administration, Boulder, CO, USA
[3]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, USA
[4]Environmental Modeling Center, National Oceanic and Atmospheric Administration, Boulder, CO, USA
[5]University of Colorado Boulder, Boulder, CO, USA
[6]Marine, Earth, and Atmospheric Sciences Department, North Carolina State University, Raleigh, NC, USA
[7]Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration, Princeton, NJ, USA

Seasonal ocean forecasts offer critical insights for marine resource management, particularly in regions like the Northeast Pacific where ecosystem variability can have profound impacts on fisheries and coastal communities. Under NOAA's Changing Ecosystems and Fisheries Initiative (CEFI), we developed a seasonal ocean forecasting system for the Northeast Pacific based on the Modular Ocean Model version 6 (MOM6) ocean model coupled to the Carbon, Ocean Biogeochemistry, and Lower Trophics (COBALT) biogeochemical model. The model domain extends from south of Baja California to the Chukchi Sea with ~10 km horizontal resolution. To evaluate forecast skill, we produced a ~30-year set of reforecasts (retrospective forecasts) with 10 ensemble members, four initializations per year, and lead times up to 12 months. Forcing for the reforecasts was derived from the GFDL-SPEAR global climate forecast system. Forecasts were assessed using ocean reanalyses and in situ observations, focusing on ecologically- and societally-relevant variables including sea surface temperature, bottom temperature, and bottom oxygen. Forecast skill is dependent on region, variable, season, and climate state, but in many cases significant skill extends out to 3–6 months, comparing favorably to previous downscaled ocean forecasts in the region. These forecasts, which are slated to begin routine real-time delivery in 2026, will support proactive decision making by managers, industry, and coastal communities.

S03, Oral, AbstractID=19375, (ECOP)

Using habitat information to inform reference points for Pacific salmon stocks: New approaches for actionable data-limited science

Tor **Kitching**, Paul van Dam-Bates and Carrie A. Holt

Fisheries and Oceans Canada, Nanaimo, BC, Canada. E-mail: tor.kitching@dfo-mpo.gc.ca

Robust fisheries management advice depends on reliable stock status assessment. For Pacific salmon, assessments are primarily informed by spawning ground surveys. In many cases, the number of these surveys has declined leading to insufficient data for populations across Canada. For data-limited populations, alternative approaches are required to provide evidence-based reference points for management. One approach is to relate habitat-based predictors to reference points using historical spawner-recruit timeseries from data rich stocks in the northeastern Pacific. Specifically, by estimating the relationship between watershed area and the spawner abundance that maximizes recruitment (S_{MAX}). Expanding on previous versions of watershed area models, we develop a Bayesian hierarchical framework to jointly model the different populations, assuming a global productivity. We further develop a relationship between S_{MAX} and productivity to then allow us to predict reference points for data-limited stocks based on watershed area and expert knowledge about local productivity. With a generalized model framework, there are future opportunities to include additional complexity and environmental covariates. We illustrate the application of this model to a group of Chinook salmon, *Oncorhynchus tshawytscha*, populations on the west coast of Vancouver Island, Canada, and highlight the importance of alternative assessment approaches for conservation management.

S03, Oral, AbstractID=19399, (ECOP)

A size-spectrum approach to climate and fishing impacts on North Pacific groundfish communities

Chelsey M. **Beese**[1], Cheryl L. Barnes[1], Jonathan C.P. Reum[2], Carey R. McGilliard[2], Meaghan D. Bryan[2], Alberto Rovellini[3], Martin W. Dorn[2], and André E. Punt[3]

[1]Oregon State University, Newport, OR, USA. E-mail: chelsey.beese@oregonstate.edu
[2]Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, AL, USA
[3]University of Washington, Seattle, WA, USA

Repeated, severe marine heatwaves have altered community structure in the Gulf of Alaska (GOA) over the last decade, driving well-documented declines in groundfish biomass. As further warming brings more frequent, intense marine heatwaves, there is a growing need for climate-ready management tools that anticipate community-level ecosystem responses. Here, we use a multispecies size-spectrum ecosystem model (MSSM) to evaluate how climate and fishing pressure jointly propagate through size- and trophic-structured interactions in the GOA food web. The model is parameterized and calibrated using a combination of survey, stock assessment, and literature data. Climate is incorporated mechanistically via temperature-dependent bioenergetic processes, including temperature-linked metabolism and mortality. Dynamically downscaled projections from ROMS are used to force these rates, allowing us to assess community-level responses to temperature change under various greenhouse gas mitigation scenarios. We expect climate-driven reductions in growth and productivity to decrease spawning stock biomass and mean body size, with cascading effects potentially emerging through altered predator–prey size relationships and reduced predation capacity of large individuals. We anticipate high variability in projected outcomes due to the bottlenecks present in GOA food webs at mid-trophic levels. This lays the groundwork for an updated companion model for the eastern Bering Sea, building on prior size-spectrum modeling efforts there, which will enable direct comparison of climate and fishing impacts across these structurally distinct, adjacent ecosystems. This cross-regional comparison will help clarify whether climate-ready management strategies can be shared across ecological boundaries.

S03, Oral, AbstractID=19414, (ECOP)

Disentangling long-term climate trends and ENSO variability in fish assemblages of the northern South China Sea

Po-Yuan **Hsiao**[1], Kuo-Wei Lan[1] and William W.L. Cheung[2]

[1]Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Keelung, Taiwan. E-mail: 20931002@mail.ntou.edu.tw
[2]University of British Columbia, Vancouver, BC, Canada

Climate warming and increasing climate variability are reshaping marine ecosystems through changes in temperature, productivity, and habitat suitability. However, disentangling the relative influence of long-term environmental trends and short-term climate oscillations on fish assemblages remains challenging. This study investigated how long-term climate forcing and El Niño–Southern Oscillation (ENSO) variability jointly influence fish assemblages in the Northern South China Sea under future warming scenarios. We projected abundance dynamics of 21 representative fish species across four ecological groups from 1951 to 2100 using the Dynamic Bioclimate Envelope Model (DBEM), forced by 10 ensemble members of the GFDL ESM2M Earth System Model. Four environmental variables were reduced using Principal Component Analysis (PCA), with the first principal component (PC1) explaining 89% of total variance. Generalized Additive Mixed Models (GAMMs) with a first-order autoregressive structure were applied to evaluate nonlinear responses to ENSO variability. Results showed that long-term environmental forcing represented by PC1 dominated baseline abundance dynamics, whereas ENSO generated heterogeneous responses among ecological groups. Overall abundance was higher during La Niña phases than during El Niño phases. Aggregate analyses masked important climate signals because benthic and pelagic groups frequently exhibited opposing ENSO responses. Significant nonlinear ENSO sensitivities were detected for benthic and reef fishes and predator fishes, while pelagic groups showed comparatively weaker responses. These findings highlight the importance of ecological heterogeneity in climate-ecosystem assessments under future warming scenarios.

S03, Oral, AbstractID=19422

Dynamics of the Severe Seawater Intrusion Event in November 2024

Liping **Yin** and Fangli Qiao

First Institute of Oceanography, MNR, Qingdao, PR China. E-mail: yinlp@fio.org.cn

During 17–19 November 2024, a severe seawater intrusion event struck six provinces along the southeastern coast of China. Using 1/32°FIO-COM reanalysis sea level fields, we extract a coherent southward-propagating sea level anomaly (SLA) with a phase speed of approximately 10 m/s, originating near Lianyungang and reaching the southern coast within roughly two days. This signal is phase-locked with the alongshore component of wind speed, which propagates southward at a statistically indistinguishable speed, while the cross-shore wind component shows no significant relationship with sea level evolution. A reduced-physics forced coastal-trapped wave (CTW) model, driven solely by alongshore wind stress, is expected to reproduce both the southward propagation speed and the along-coast amplitude growth of the observed SLA. This amplitude growth from north to south is interpreted as evidence of cumulative forcing along the wave-guide, rather than local wind intensification. We further show that the forced CTW surge was superimposed on a seasonally elevated background sea level and coincided closely in time with the spring tide, indicating that the 2024 intrusion event resulted from the constructive superposition of three largely independent processes: a wind-forced coastal-trapped wave, a seasonal background sea level anomaly, and astronomical spring tides. These results identify forced CTWs as a previously underappreciated mechanism capable of producing severe, spatially non-local coastal flooding along the China shelf — including in regions where local wind forcing is comparatively weak — with direct implications for coastal flood early warning along the Chinese marginal seas.

S03, Oral, AbstractID=19432

Skillful seasonal forecasts of blue whale distributions using neural networks

Heather **Welch**[1], Steven J. Bograd[2], Allison Cluett[1], Josh Cullen[1], Elliott L. Hazen[2], Michael Jacox[2,3], Samuel M. Woodman[4]

[1]Institute of Marine Science, University of California, Santa Cruz, CA, USA.
E-mail: hwelch@ucsc.edu
[2]Ecosystem Science Division, NMFS, NOAA, Monterey, CA, USA
[3]NOAA Physical Sciences Laboratory, Boulder, CO, USA
[4]Ecosystem Science Division, NMFS, NOAA, La Jolla, CA, USA

Forecasts of blue whale distribution could inform proactive management interventions to mitigate mortality and serious injury, such as reducing vessel speeds to avoid collisions and removing fishing gear to avoid entanglement. Artificial intelligence (AI) has shown skill in weather forecasting, but its application for anticipating ecological consequences such as shifting wildlife distributions remains untested. Here, we develop AI forecasts to anticipate the future distributions of endangered blue whales (*Balaenoptera musculus*) in the eastern Pacific Ocean. We train neural networks to forecast whale distributions up to 12 months ahead using 30 years of monthly environmental fields and blue whale habitat predictions generated by a species distribution model. Forecasts were benchmarked against a simple persistence forecast. Forecasts of winter/spring distributions had skill above persistence for all leads, while forecasts of summer distributions had skill above persistence for leads of one to three months. Ecological forecasting has traditionally relied on resource-intensive numerical models; these early results suggest AI may offer a complementary approach at a fraction of the cost.

S03, Oral, AbstractID=19455, (ECOP)

Ocean circulation as a missing driver in climate-based marine biodiversity projections

Juliette **Casemajor**[1], Yulia Egorova[1], Elka García-Rada[1], Claire B. Paris[1], Gabriel Reygondeau[1,2]

[1]Rosenstiel School of Marine, Atmospheric, and Earth Science, University of Miami, Miami, FL, USA. E-mail: jxt2618@miami.edu
[2]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada

Climate change is reshaping marine biodiversity by altering the environmental conditions that define species' ecological niches. Species distribution models are widely used to project future habitat suitability, but these projections often indicate where suitable conditions may occur rather than whether species can physically reach them. This distinction is especially important in the ocean, where many species disperse during pelagic early life stages and depend on ocean currents to connect present and future habitats. Future suitable areas may therefore remain outside realized range expansions if they are not linked to current distributions through oceanographic transport. Here, we integrate climate-based habitat suitability projections with ocean-driven connectivity to evaluate how physical dispersal may constrain marine range shifts. Using a standardized global dispersal database, future suitable habitats can be classified as directly reachable, reachable through stepping-stone pathways, or inaccessible within species-specific dispersal capacities. This approach separates environmentally suitable habitat from physically accessible habitat and allows comparison between standard climate-only projections and dispersal-constrained projections. By accounting for both changing environmental conditions and oceanographic connectivity, this workflow provides a more realistic basis for assessing climate-driven marine species redistribution across taxa and climate scenarios. It can help identify where future habitat may support colonization and where suitable conditions may remain unreachable despite becoming climatically favorable.

S03, Oral, AbstractID=19458

Bringing regional ocean model output into Alaska's ecosystem-based management

Kelly **Kearney**[1], Albert Hermann[2,3], Wei Cheng[3], Elizabeth Drenkard[4], Elizabeth Siddon[5], Ivonne Ortiz[2,1], and Bridget Ferriss[1]

[1]NOAA Alaska Fisheries Science Center, Seattle, WA, USA. E-mail: kelly.kearney@noaa.gov
[2]University of Washington, CICOES, Seattle, WA, USA
[3]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA
[4]NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA
[5]NOAA Alaska Fisheries Science Center, Juneau, AK, USA

As part of the Changing Ecosystems and Fisheries Initiative (CEFI), regional ocean-ice-biogeochemical models that cover all US coastal waters are being developed and deployed. The goal of this operational model development is to provide marine resource managers and decision makers with key information necessary to understand and adapt to changing environmental conditions across a variety of time scales. The first hindcast simulations using MOM6 configured for the northeast Pacific at 10-km horizontal resolution (MOM6-COBALT-NEP10k) were released in late 2024, accompanied by an academic publication documenting the model's design and skill across the domain (Drenkard et al., 2025). Since then, active development of the MOM6-COBALT-NEP10k model has continued, with periodic releases of updated hindcast simulations and ongoing development of seasonal, decadal, and multi-decadal forecasts and projections. This successful deployment serves as a fundamental, but not necessarily sufficient, first step in the complex process of bringing regional model output into the fisheries management sphere. Here, we review both the successes and challenges that we have experienced in the Alaska region when incorporating regional model output into the fisheries management process over the past several years. We will highlight experiences related to transitioning between regional model configurations, finding on-ramps to introduce regional model output into existing fisheries management activities, and communicating model performance, capabilities, and limitations to a diverse audience of scientists and managers.

S03, Oral, AbstractID=19470

Do North Pacific climate indices explain groundfish recruitment trends in the Gulf of Alaska?

Bridget **Ferriss**[1], Grant Adams[1], Claudine Hauri[3], Peter Hulson[2], Cole Monnahan[1], Rémi Pagès[3], Kalei Shotwell[1], and Ben Williams[2]

[1]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA. E-mail: bridget.ferriss@noaa.gov
[2]Auke Bay Laboratories, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Juneau, AK, USA
[3]International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA

North Pacific oceanographic indices have been used to explain and predict trends in ecological communities, but these relationships do not always persist through time. The recently developed Northern Gulf of Alaska index and the Gulf of Alaska Downwelling index represent the sea surface height dynamics of the North Pacific subarctic gyre. Here we explore if these more regionally-based indices have the potential to explain and predict recruitment trends in groundfish populations in the Gulf of Alaska. Specifically, we examine mechanistic relationships between these indices and age-0 recruitment of Gulf of Alaska Pacific cod (*Gadus macrocephalus*), walleye pollock (*Gadus chalcogrammus*), northern rockfish (*Sebastes polyspinis*), and arrowtooth flounder (*Atheresthes stomias*). Three mechanistic pathways in which the relationship of climate indices may relate to fish recruitment include transport and retention of larvae in nursery habitat, prey availability, and habitat quality. We use structural causal enhanced stock assessment modelling to determine the ecological significance of these relationships and assess if these indices can reduce recruitment variability in stock assessments using the Rceattle (Climate-Enhanced, Age-based model with Temperature-specific Trophic Linkages and Energetics in R) modeling platform. Results will inform our ability to perform short-term predictions of stock recruitment using regional-based oceanographic indices.

S03, Oral, AbstractID=19476

Seasonal ocean predictions for Canada: Progress and directions

Elise **Olson**[1], Bill Merryfield[1], Parsa Gooya[1], Julia Velletta[1], James Christian[1,2], Krysten Rutherford[1], Natasha Ridenour[1], Jonathan Izett[1] and Woosung Lee[1]

[1]Environment and Climate Change Canada, Climate Modelling Division, Victoria, BC, Canada. E-mail: elise.olson@ec.gc.ca
[2]Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada

Development of global and regional seasonal marine forecasts for ecosystem-relevant variables is underway within Environment and Climate Change Canada (ECCC). We will present an overview of ongoing development, highlighting marine heatwave prediction, biogeochemical forecast initialization, and dynamical downscaling of forecasts. First, we will show that global marine heatwave forecasts based on version 3 of the Canadian Seasonal to Inter-annual Prediction System (CanSIPS) achieve skill levels that are competitive with other systems, and calibration of marine heatwave forecasts for the eastern North Pacific Ocean demonstrates proof-of-concept for improvement of forecast reliability. Second, we will present initial investigations into the suitability of biogeochemical simulations with the physical ocean state nudged toward reanalysis temperature and salinity fields as initial states for biogeochemical forecasts. Finally, we will present plans to apply the Canadian Three-Oceans Downscaling System (CanTODS), currently under development at ECCC, to downscale CanSIPS predictions. This work will enable high resolution regional physical and biogeochemical ocean forecasts for Canadian waters.

S03, Oral, AbstractID=19478, (ECOP)

Recontextualizing climate indices for ecological applications in a warming ocean

Allison A. **Cluett**[1], Michael G. Jacox[1,2,3], Steven J. Bograd[1,2], Mercedes Pozo Buil[1] and Elliott L. Hazen[1,2]

[1]Institute of Marine Sciences, University of California, Santa Cruz. Santa Cruz, CA, USA. E-mail: acluett@ucsc.edu
[2]NOAA NMFS Southwest Fisheries Science Center, Monterey, CA, USA
[3]NOAA OAR Physical Sciences Laboratory, Boulder, CO, USA

Climate indices are widely used to relate large-scale climate conditions to marine ecosystem variability, but interpretation of climate–ocean–ecosystem relationships are grounded in historical associations that may shift under sustained warming. In the North Pacific, the Pacific Decadal Oscillation (PDO) has long served as an indicator of environmental conditions and biological variability in the California Current System and Gulf of Alaska, yet some of these historical relationships have weakened in recent decades. Here, we test whether apparent non-stationarity can be resolved by explicitly representing the warming-related signal alongside the PDO. Using a high-resolution historical simulation of the Northeast Pacific and long-term ecological and fisheries time series, we show that incorporating the Pan-Basin Pattern (PBP), a complementary index of North Pacific warming, improves inference of key physical, biogeochemical, and ecological indicators. Our results provide a framework for reinterpreting climate–ocean–ecosystem relationships in response to the combined influence of variability and warming. Our results suggest that the ecological utility of traditional climate indices remains when interpreting these indices of variability paired with indices of long-term change.

S03, Oral, AbstractID=19508, (ECOP)

A climate vulnerability assessment of fish and invertebrates in the Gulf of Alaska

Isabelle **Galko**[1], Cheryl L. Barnes[1], Paul D. Spencer[2], Alberto Rovellini[3], Albert J. Hermann[3], Thomas P. Hurst[4], Jodi L. Pirtle[5], Mason Smith[5], Marysia Szymkowiak[6] and Benjamin Williams[2]

[1]Coastal Oregon Marine Experiment Station, Oregon State University, Newport, OR, USA. E-mail: isabelle.galko@oregonstate.edu
[2]Alaska Fisheries Science Center, National Oceanographic and Atmospheric Administration (NOAA), Seattle, WA, USA
[3]School of Aquatic and Fisheries Science, University of Washington, Seattle, WA, USA
[4]Alaska Fisheries Science Center, NOAA, Newport, OR, USA
[5]Habitat and Conservation Division, Alaska Regional Office, NOAA, Juneau, AK, USA
[6]Prince William Sound Science Center, Cordova, AK, USA

Recent marine heatwaves and other climate effects have had considerable impacts on marine ecosystems in high latitudes, including species distribution shifts, community reorganization, and fishery collapse. Correspondingly, these climate impacts have direct implications for resource-dependent communities in the Gulf of Alaska (GOA). Understanding how economically and ecologically important species respond to changing environments is critical for developing management strategies that promote long-term sustainability. To evaluate the climate responses of 57 species in the GOA, we conducted a trait-based climate vulnerability assessment (CVA) that combines qualitative expert scoring of species sensitivity (biological and ecological attributes) and quantifying species exposure to future stressors (e.g., warming, ocean acidification). Relying on over a decade of CVAs conducted by the National Oceanic and Atmospheric Administration (NOAA), we augmented commonly used methods to tailor the CVA methodology to a high-latitude system. We mapped spatial variation in exposure across each species' range in the GOA and characterized the potential impacts of future marine heatwaves to understand the cumulative effects of ocean warming. We then produced vulnerability scores (low, moderate, high, and very high) based on species sensitivity and exposure. Most species (n = 50) had low vulnerability, six species had moderate vulnerability, and one species had very high vulnerability. These results provide information for ecosystem-based-fisheries management and can be used to guide fishing portfolios, identify monitoring and research needs, and mitigate socioeconomic risks for resource-dependent communities.

S03, Oral, AbstractID=19514, (ECOP)

HICast: A dynamic ocean management tool for the Hawai‘i longline fishery

Gabriella **Mukai**[1,2] and Justin **Suca**[1]

Presented by Justin Suca on behalf of Gabriella Mukai

[1]School of Ocean and Earth Science and Technology, University of Hawaii at Mānoa, Honolulu, HI, USA. E-mail: gnmukai@hawaii.edu, jsuca@hawaii.edu
[2]Cooperative Institute of Marine and Atmospheric Research, Honolulu, HI, USA

Bycatch across longline fisheries poses a challenge for its fishers and threatens the populations of sharks, turtles, sea birds, and marine mammals. In Hawai‘i, the longline fishery manages bycatch through spatial management, gear/bait requirements, handling and release procedures. However, interactions with bycatch remain an issue with potential fleetwide consequences if bycatch allowances are exceeded. To address this, we developed a near real-time and short-term forecast tool, HICast, to aid deep-set longline fishers in choosing locations that reduce bycatch while maintaining or improving bigeye tuna (*Thunnus obesus*) catch rates. To generate HICast, we developed models utilizing fishery-dependent data and a suite of environmental variables. Our framework included catch rate models for bigeye tuna and presence-absence models for nine bycatch species, including sea turtles, sharks, marine mammals, and seabirds. Predictions for all species were combined to create a summarized spatial map that showed areas with high (low) bigeye tuna catch rate and low (high) probability of bycatch interaction. Overall, presence-absence models for the albatrosses and sharks performed better than remaining bycatch species, such as manta rays (*Mobula*) and false killer whales (*Pseudorca crassidens*). A species-level sensitivity analysis to understand the tradeoffs in bycatch interactions suggested a spatial trade-off, in which using HICast effectively reduced interactions for sharks and turtles while potentially shifting effort toward albatross habitat. Currently, this product provides interactive daily 7-day forecasts to fishers and managers. As additional observer data becomes available, we will update species models and the tool to provide predictions based on the most recent, available data.

S03, Oral, AbstractID=19533, (ECOP)

Projecting future habitat distribution of Undaria pinnatifida under climate change in the Northwest Pacific

Hoyeon **Lee**[1,2], Minkyung Bang[1] and Chan Joo Jang[1,2]

[1]Ocean Circulation and Climate Research Department, Korea Institute of Ocean Science and Technology, Busan, R Korea. E-mail: cjjang@kiost.ac.kr, 1209tim@kiost.ac.kr
[2]Major in Ocean Science, Korea Institute of Ocean Science and Technology School, University of Science and Technology (UST), Daejeon, R Korea

Recent climate change has contributed to poleward shifts in the distribution of many brown macroalgal species worldwide. *Undaria pinnatifida*, a commercially important brown macroalga native to the Northwest Pacific, is likely to undergo similar range shifts under climate change; however, previous studies have mainly focused on physiological responses to environmental stressors, leaving projections of its future habitat distribution relatively limited. In this study, we aimed to assess future changes in the habitat distribution of Sea mustard across the Northwest Pacific under climate change by projecting its habitat distribution for the 2090s using MaxEnt species distribution model under three climate scenarios (SSP1-2.6, SSP2-4.5, and SSP5-8.5). The model was based on Sea mustard presence and five environmental variables: temperature, salinity, nitrate, phosphate at sea surface, and depth. Model projections indicated an overall contraction and poleward shift of suitable habitat, although the magnitude of change differed among scenarios and regions. The latitudinal shift in the habitat centroid was more than twice as large under SSP5-8.5(4.4°) than under SSP1-2.6 (1.7°). Suitable habitat was projected to decline across most of the study region, including the southern Yellow Sea, East China Sea, East Sea, and Kuroshio Current region, whereas it was projected to persist or expand in the central Yellow Sea and northern East Sea. In particular, the central Yellow Sea was identified as a relatively stable habitat for Sea mustard under all climate scenarios. These results may help distinguish climate-vulnerable and persistent habitat regions and prioritize areas for resource management and long-term monitoring.

SESSION 03: FIS/ POC/ FUTURE/ Topic Session

Ocean and ecosystem predictions to support decision making

Poster Presentations

S03, Poster, AbstractID=19247, PosterID: S03-P1, (ECOP)

Development of an integrated coastal big data platform for data-driven coastal management in Korea

Hyeon-Gyeong **Han**[1,2], Hyerin Hwang[1] and Cholyoung **Lee**[1]

Presented by Cholyoung Lee on behalf of Hyeon-Gyeong Han

[1]Korea Institute of Ocean Science & Technology, Busan, R Korea. E-mail: cylee82@kiost.ac.kr
[2]Pukyong National University, Busan, R Korea

Coastal regions are facing multiple pressures from climate change, coastal disasters, marine pollution, and increasing human activities. Effective coastal management requires an integrated data infrastructure that can connect observational data, numerical model outputs, satellite-derived products, and analytical datasets produced by various institutions. This study presents the Coastal Big Data Platform, operated by the Korea Institute of Ocean Science and Technology (KIOST), as a national data infrastructure that supports the integration, distribution, and utilization of coastal and marine data.

The Coastal Big Data Platform collects, standardizes, curates, and distributes high-value coastal datasets produced by public agencies, research institutes, universities, and private companies. Its major data domains include coastal climate and environmental information, ocean observation data, numerical prediction outputs, satellite-based coastal information, ocean current and bathymetric data, wave and storm-surge-related information, sea surface temperature, coastal erosion, marine debris, coastal disaster-risk information, and vessel-position-based analytical data. The platform also provides user-oriented services, including coastal erosion information management, sea temperature monitoring, ship-emission-based carbon analysis, thematic coastal maps, coastal cleanup support, and sea-level-change simulation.

By supporting customized data services, public–private collaboration, and cross-sector data convergence, the platform functions as an operational data ecosystem that supports decision-making in science, policy, industry, and local governments, beyond serving as a simple data repository. This experience can serve as a collaborative model for data-driven coastal management, climate crisis response, and sustainable ocean use in coastal regions.

S03, QR-Poster, AbstractID=19362, PosterID: S03-P2

Problems decision making in remote monitoring ocean ecosystems

Ferdenant **Mkrtchyan**, Evgeny Novichikhin and Maxim Mkrtchyan

Kotelnikov Institute of Radioengineering and Electronics RAS, Fryazino Branch, Moscow region, Russia. E-mail: ferd47@mail.ru

A decision on the level of potential risk of possible change in the ocean ecosystem can be made on the basis of analysis of pre-history of such events and using the methods of prediction of natural events. As a rule, methods of assessing the risk is based on statistical processing of data on parameters of the processes whose interaction can initiate undesirable changes in the characteristics ocean ecosystems. Decision making tool is developed basing on the classical and sequential procedures. Statistical decision model assumes the continuously calculation of the choosen criterion until it is satisfied. With the development of alternative methods of making statistical decisions, the problem of searching an objective estimation of the parameters of the processes taking place in the ocean ecosystems has obtained a new substantiation. This problem can be approached by two methods; on the one hand, a classical one based on the procedure of a-priori limitation of the number of observations, and on the other hand a successive analysis based on the procedure of the step-by- step resolve making. The development of computer technologies enables one to realize both approaches in the form of a single system of making statistical decisions. One prospective approach to the solution of the problems arising here is GIMS-technology (GIMS=GIS+Model). A combination of an environmental acquisition system, a model of the functioning of the typical geoecosystem, a computer cartography system, and a means of artificial intelligence will result in the creation of a geoecological information-modeling system (GIMS) for the typical natural element that is capable of solving many tasks arising in the monitoring ocean ecosystems. This paper discusses the issues of decision making at monitoring ocean ecosystems, monitoring and forecasting of natural disasters, explain and assess the application of the GIMS-technology method to the this tasks.

SESSION 4: HD/MEQ Topic Session

Pathways and process towards sustainable urban oceans where humans and nature co-exist

Oral Presentations

S04, Invited, AbstractID=19256

xaɬəmət ct tə səlilwət / Water Quality Objectives for səlilwət (Burrard Inlet)

Anuradha S. **Rao**

səlilwətaɬ (Tsleil-Waututh Nation), North Vancouver, BC, Canada. E-mail: arao@twnation.ca

In a first-of-its-kind government-to-government initiative, səlilwətaɬ (Tsleil-Waututh Nation) and the Province of BC have co-developed and co-signed an updated marine water quality policy: *xaɬəmət ct tə səlilwət / Water Quality Objectives for səlilwət (Burrard Inlet)*. səlilwətaɬ means "People of the Inlet", demonstrating the deep relationship of səlilwətaɬ to the water body known as Burrard Inlet─səlilwət in the hən̓q̓əmin̓əm̓ language─since time out of mind. The policy weaves together western science and Traditional Indigenous Values and Knowledge, and redefines how clean the Inlet's water, sediment and animal tissue need to be to protect shared Water Values. These Water Values include, among others, shellfish harvesting at rates relevant to coastal Indigenous peoples. Updating the Water Quality Objectives was the first priority action identified in Tsleil-Waututh Nation's 2017 Burrard Inlet Action Plan. The policy contains specific numeric objectives for various water quality parameters, as well as overarching objectives such as the reduction of contamination of any kind in səlilwət. səlilwətaɬ provided leadership in initiating inter-agency collaboration, overall project management, and conducting the required technical assessments. This presentation will describe the collaborative process, lessons learned, interactive and educational materials, and applications of this huge body of work towards restoring a healthy Inlet, and beyond.

*Please note that hən̓q̓əmin̓əm̓ characters appear correctly when using Arial or First Nations Unicode font

S04, Invited, AbstractID=19326

An advanced AI-based approach for spatial mapping and ecological function quantification of macroinvertebrates in tidal flats

Jaehwan **Seo**[1], Chung Ho Kim[2], Keunyong Kim[3], Yeongjae Jang[3], Donguk Lee[3], Hyeong-Tae Jou[2], Joo-Hyung Ryu[3] and Bon Joo Koo[4,5]

[1]Tongyeong Maritime Test & Evaluation Station, Korea Institute of Ocean Science & Technology, R Korea. E-mail: playersjh@kiost.ac.kr
[2]Ocean Climate Response & Ecosystem Research Department, Korea Institute of Ocean Science & Technology, R Korea
[3]Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology, R Korea
[4]East Sea Environment Research Center, Korea Institute of Ocean Science & Technology, R Korea
[5]School of Ocean Science, University of Science and Technology, R Korea

Tidal flat macroinvertebrates play important roles in ecosystem functioning through bioturbation, sediment reworking, nutrient cycling, and carbon sequestration. However, quantifying their ecological functions at landscape scales remains challenging because conventional field surveys are labor-intensive, spatially limited, and often unable to capture the heterogeneity of organism distributions. This study introduces an integrated approach that combines ecological measurements, burrow morphology analysis, drone-based remote sensing, and artificial intelligence (AI) to spatially quantify the ecological functions of macroinvertebrates in tidal flat ecosystems. Field observations demonstrated that dominant macroinvertebrates, including polychaetes, crabs, and mud shrimps, strongly influence sediment dynamics through feeding, burrowing, and sediment reworking activities. These processes regulate sediment characteristics, organic matter turnover, nutrient exchange, and ecosystem functioning. Building upon these ecological findings, high-resolution drone imagery was employed to detect and measure macroinvertebrate biogenic structures across tidal flats. Object-based image analysis and deep-learning algorithms were subsequently applied to identify species-specific burrow openings and associated surface traces. Multi-species detection models based on the YOLO architecture successfully estimated the abundance and spatial distribution of several dominant macroinvertebrate species from centimeter-scale orthophotos. Furthermore, automated measurements of burrow-opening dimensions from drone imagery enabled the spatial estimation of biomass and ecological activity over large areas. This study highlights that integrating ecological measurements, burrow morphology analysis, drone imagery, and AI provides an effective approach for quantifying the ecological functions of tidal-flat macroinvertebrates at landscape scales. By detecting species-specific biogenic structures from high-resolution drone imagery, the abundance, biomass, and ecological activities of dominant macroinvertebrates can be estimated spatially. This approach overcomes the spatial and logistical limitations of

conventional field surveys by enabling accurate and scalable assessments across extensive intertidal areas.

S04, Oral, AbstractID=19108, (ECOP)

Bridging the science and policy interface to enhance marine protected area effectiveness in Taiwan through meaningful stakeholder collaboration

Shu-Chiang **Huang**, Yi Chang and Wenyu Huang

Graduate Institute of Marine Affairs, National Sun Yat-sen University, Kaohsiung, Taiwan.
E-mail: shuchiang.huang92@gmail.com

Developing actionable science to sustain marine ecosystems requires bridging the science and policy interface through interdisciplinary collaboration. Between 2020 and 2022, Taiwan established a management effectiveness evaluation framework to assess marine protected areas (MPAs). This initiated a consulting program integrating continuous ecological surveys with stakeholder engagement. From 2021 to 2024, by combining scientific monitoring with stakeholder workshops, we addressed socioeconomic conflicts and fostered community-led decision-making. Key solution-based actions included spatial zoning, establishing community patrol teams, and integrating indigenous and local knowledge into management practices. Expanding from 2024 to 2026, this actionable science approach continues to yield vital progress. It facilitated the addition of strict no-take zones to enhance existing MPAs. Concurrently, baseline ecological data and the newly enacted Marine Conservation Act are being utilized to designate new seagrass sanctuaries formally. By communicating scientific assessments to policy makers and local communities, this research offers a scalable blueprint for solution-based MPA management in a rapidly changing ocean.

S04, Oral, AbstractID=19122, (ECOP)

Environmental suitability and production efficiency pathways for sustainable oyster aquaculture in urbanized coastal China

Dijing, **Chang**[1], Jiayu Fan[1], Honghong Liu[3], Chunlin Li[1], Fangcheng Han[1], Tianwei Mou[1] and Yang Liu[1,2]

[1]Deep Sea and Polar Fisheries Research Center and Laboratory for Marine Fishery Satellite Application Research, Ocean University of China, Qingdao, PR China.
E-mail: yangliu315@ouc.edu.cn
[2]Fisheries College, Ocean University of China, Qingdao, PR China
[3]School of Management, Guangdong Ocean University, Zhanjiang, Guangdong, PR China

Coastal urbanization and rising food demand are reshaping the links among marine production systems, environmental suitability, and human well-being. Oyster aquaculture is a major shellfish sector in coastal China, but its sustainable development depends on converting socioeconomic inputs into production efficiently while remaining within local environmental constraints. This study developed an integrated decision-support framework for oyster aquaculture across eight major coastal provinces of China from 2002 to 2024. Provincial production and socioeconomic statistics were combined with remote-sensing and ocean reanalysis variables aggregated within 50-km coastal belts, including chlorophyll-a, sea surface temperature, suspended particulate matter, and surface current speed. A two-way fixed-effects model was used to identify average driver associations, while XGBoost and SHAP revealed nonlinear responses and environmentally favorable ranges. These ranges were further incorporated into Pareto-oriented optimization to assess trade-offs between predicted oyster production and composite input intensity. Results showed that oyster production increased from 3.70 million t in 2002–2007 to 6.26 million t in 2020–2024, with growth concentrated in established production centers. Production scale and labor-related inputs dominated predictions, whereas environmental variables mainly defined suitable operating conditions. Pareto analysis indicated diminishing marginal gains at the high-input end, suggesting that moderate-to-high input strategies may be more efficient than extreme intensification. This study provides a socio-ecological decision-support framework for sustainable oyster aquaculture planning in urbanized coastal oceans under climate change.

S04, Oral, AbstractID=19154

Development of an integrated modeling framework for the Puget Sound basin to evaluate cross-ecosystem impacts of environmental change

Hem Nalini **Morzaria-Luna**[1,2], Caitlin L. Magel[3], Joel E. Baker[3], Robert M. Anderson[3], Kevin G. Bogue[3], Allen Brookes[4], Sonali Chokshi[5], Kevin Djang[6], Elizabeth A. Fulton[7], Jonathan J. Halama[8], Chris J. Harvey[9], Marielle Kanojia[3], Isaac Kaplan[9], Tarang Khangaonkar[10], Jiang Long[3], Robert B. McKane[11], Alaia Morell[3,12], Caerwyn Nelson[13], Veronika Polushina[3], Javier Porobic[7], Alberto Rovellini[12], Morgan Thornwell[13], and Su Kyong Yun[10]

[1]Long Live the Kings, Seattle, WA, USA. E-mail: hmorzarialuna@lltk.org.
[2]Visiting Researcher, Conservation Biology Division, Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA, USA
[3]Puget Sound Institute, Center for Urban Waters, University of Washington, Tacoma, WA, USA
[4]U.S. Environmental Protection Agency, Corvallis, OR, USA
[5]Northwest River Forecast Center, National Weather Service, NOAA, Portland, OR, USA
[6]Computer Scientist, Inoventures LLC, subcontractor to General Dynamics Information Technology, McLean, VA, USA
[7]CSIRO Environment, Hobart, TAS, Australia
[8]U.S. Environmental Protection Agency, Corvallis, OR, USA
[9]Conservation Biology Division, Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA, USA
[10]Salish Sea Modeling Center, University of Washington Tacoma, Tacoma, WA, USA
[11]Healthy Watersheds LLC, Philomath, OR, USA
[12]Current address: GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[13]Thornwell Labs, Portland, OR, USA

Linked land-sea urban ecosystems, such as Puget Sound (WA, USA), are regions of high biodiversity, habitat complexity, and ecological, cultural, and economic importance, where interacting human pressures create many challenges. The Puget Sound Integrated Modeling Framework (PSIMF) is a linked environmental and human systems model of the entire basin aimed at exploring how cumulative watershed impacts, including climate change, urbanization, contaminants, and fisheries, affect ecosystem services and species of ecological, cultural, and economic importance, and to use these findings to inform natural resource management. Mechanistic model coupling in PSIMF starts with the Puget Sound Land Cover Change Model (PS-LCCM), which simulates long-term land cover dynamics, forecasts changes through 2100, and transfers land-cover change, impervious surface, and biomass loss, to the Visualizing Ecosystem Land Management Assessment (VELMA) model. VELMA simulates terrestrial ecohydrology at high spatial and temporal resolution and outputs stream discharge, nutrients, and stream temperature that are then used to force the Salish Sea Model (SSM), which simulates hydrodynamic circulation and biogeochemistry. SSM hydrodynamics, biogeochemistry, and

phytoplankton outputs then force the Atlantis Model for Puget Sound (AMPS), a marine food web model. Using a Qualitative Network Model, we will also translate mechanistic model outputs to outcomes related to human health and well-being, and economic impacts. We forced PSIMF under a scenario that assumes the continuation of status quo trends in land-cover change and future climate for 2011-2050. We show that primary productivity increases with ocean warming, raising the system's carrying capacity, which disproportionately benefits species such as jellyfish and small plankton. Some species, such as groundfish and one herring stock, are negatively impacted. We translate the final impacts on the Puget Sound marine food web into Vital Signs that regional managers have identified as key performance metrics. PSIMF demonstrates that a linked modeling approach can project changes in ecological and social outcomes that may be echoed in other urban coastal systems globally.

S04, Oral, AbstractID=19217, (ECOP)

Acoustic telemetry reveals white shark use of Atlantic salmon aquaculture sites

Morgan **Piczak**[1], Ava **Sergio**[1], Marc Trudel[2] and Heather Bowlby[3]

Presented by Ava Sergio on behalf of Morgan Piczak

[1]University of British Columbia, Vancouver, BC, Canada.
E-mail: morgan.piczak@ubc.ca, avasergio13@gmail.com
[2]Fisheries and Oceans Canada, St. Andrews Biological Station, St. Andrews, NB, Canada
[3]Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, NS, Canada

Aquaculture of Atlantic salmon poses substantial threats to coastal ecosystems along Canada's east coast, yet its effects on highly mobile predators remain poorly understood. White sharks (*Carcharodon carcharias*) are increasingly documented in Atlantic Canadian waters, and aquaculture sites may alter their distribution through food subsidies, such as aggregations of wild prey or farmed fish mortalities. Such attraction could increase residency near active sites, with implications for white shark ecology, human-wildlife interactions, and the management of a species of conservation concern. Using acoustic telemetry, we will examine how white sharks use aquaculture sites in Passamaquoddy Bay and how their movement patterns vary among locations. We will assess how site use changes across different phases of the aquaculture cycle (fallow, grow-out, and harvest), offering insight into how white sharks respond to the dynamic nature of aquaculture operations. We will also estimate residency indices at each site and across aquaculture stages, allowing us to quantify white shark exposure to, and interaction with, active aquaculture. Our goal is to determine how aquaculture influences white shark movement and habitat use in coastal ecosystems. This research will provide the evidence needed to identify high-risk interactions between aquaculture and white sharks, informing targeted management actions that reduce ecological disruption and support the conservation of this vulnerable species.

S04, Oral, AbstractID=19281

SATOUMI and other effective area-based conservation measures (OECM) in Japan – Case study in Nanao Bay, Ishikawa Prefecture

Takafumi **Yoshida**

Northwest Pacific Region Environmental Cooperation Center, Toyama, Japan.
E-mail: yoshida@npec.or.jp

"SATOUMI" refers to coastal areas where biological productivity and biodiversity have been enhanced through sustainable human interaction. This concept aligns well with the definition of *Other Effective Area-based Conservation Measures (OECM)*. In Japan, the Ministry of the Environment is promoting *Nationally Certified Sustainably Managed Nature Sites* as part of the national effort to achieve the 30 by 30 target.

To obtain this certification, applicants must accurately document the current environmental conditions and establish a management and conservation framework in collaboration with various stakeholders, including local government, private companies, scientists and fishermen and so on. Local stakeholders in Nanao Bay are currently preparing an application for this certification.

In my presentation, I will introduce the collaborative efforts between local stakeholders and scientists in Nanao Bay in advancing this initiative.

S04, Oral, AbstractID=19318, (ECOP)

Designing interdisciplinary courses for equitable and sustainable leadership in the expanding blue economy

Meaghan **Efford**, Rhea Storlund and Brian Hunt

University of British Columbia, Vancouver, BC, Canada. E-mail: m.efford@oceans.ubc.ca

As the Blue Economy expands, preparing a new generation of professionals to integrate diverse disciplines into the ocean sector is a key challenge. This project focuses on developing four stackable micro-credential courses on the Sustainable Blue Economy (SBE), designed to meet Canada's growing need for a skilled workforce in this rapidly evolving sector. The courses adopt an interdisciplinary approach to ocean science, combining natural sciences, social sciences, and Indigenous knowledge to address pressing ocean challenges. Key topics include Indigenous stewardship, coastal ecology, economics, climate change, and fisheries management, emphasizing practical, real-world applications. These courses provide skill development in science communication, integrating multiple knowledge systems in research, and engaging with policy through hands-on projects and case studies. A reflexive evaluation process, including surveys and skill assessments, is ongoing to gather feedback from learners to refine course content and ensure continued relevance. Preliminary results from the evaluations will be shared. The courses will address the demand for employees with diverse, interdisciplinary expertise to contribute to Canada's Blue Economy, which generates $31.7 billion annually and supports nearly 300,000 jobs. The courses align with Canada's Blue Economy Strategy, which emphasizes the integration of Indigenous and scientific knowledge and the participation of underrepresented groups in decision making. The development and implementation of these courses will support the Blue Future Pathways initiative of the SOI Foundation, our funder, by expanding its resource offerings, growing its audience, and providing youth with valuable tools to pursue educational and career pathways in the Sustainable Blue Economy.

S04, Oral, AbstractID=19419, (ECOP)

Spatial modeling reveals coastal habitat use and anthropogenic overlap of Indo-Pacific bottlenose dolphins around Jeju Island, Korea

Soeon **Ahn**[1], Kyum Joon Park[2], Dongwha Sohn[3] and Hyun Woo Kim[4]

[1]Jeju Bio Research Center, Korea Institute of Ocean Science and Technology (KIOST), Jeju, R Korea. E-mail: soeonahn@kiost.ac.kr
[2]Cetacean Research Institute, National Institute of Fisheries Science, Busan, R Korea
[3]Institute of Mathematical Sciences, Pusan National University, Busan, R Korea
[4]Coastal Water Fisheries Resources Research Division, National Institute of Fisheries Science, Busan, R Korea. E-mail: hyunwoo.kim@korea.kr

The coastal waters of Jeju Island support a resident population of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) within a narrow and intensively used nearshore habitat, part of which was designated as a marine protected area in 2025. Despite this protection, dolphins remain exposed to increasing coastal development, aquaculture, vessel activity, and other anthropogenic pressures. We developed a density surface model using long-term scientific survey data collected between 2007 and 2021 by the Cetacean Research Institute of the National Institute of Fisheries Science. Detection probabilities were estimated separately from vessel-based line-transect and land-based point-transect surveys using distance-sampling methods. Detection-adjusted abundance was modeled using a generalized additive model with a Tweedie distribution, with effective survey area incorporated as an offset. Because the two survey platforms differed in spatial coverage and sampling design, separate spatial smooths were fitted for vessel- and land-based surveys. The model revealed spatial variation in dolphin habitat use around Jeju Island, with higher predicted abundance generally occurring in shallow coastal waters. Dolphin abundance also showed spatial associations with land-based aquaculture intensity and distance from coastal infrastructure during construction periods. The final model explained 26.4% of the deviance. These findings indicate that dolphin distribution around Jeju Island is associated with spatially heterogeneous coastal habitat conditions and their overlap with human activities. The model can help identify important habitat areas and assess potential overlap with human activities and coastal development, supporting spatially explicit conservation and management within and beyond the recently designated marine protected area.

S04, Oral, AbstractID=19433, (ECOP)

From participation to implementation: A co-designed Nature-based Solutions Toolbox for climate adaptation in the Marshall Islands

Naya **Sena** and Mitsutaku Makino

Atmosphere and Ocean Research Institute, The University of Tokyo, Tokyo, Japan.
E-mail: nayacsena@gmail.com

Small Island Developing States, particularly low-lying Pacific atoll nations, are among the most vulnerable regions to climate change. Effective adaptation requires solutions that are not only scientifically robust but also grounded in local priorities, knowledge systems, and governance contexts. Co-design approaches provide an opportunity to bridge these perspectives and support more actionable climate adaptation.

This presentation introduces the development of a co-designed Nature-based Solutions Toolbox as part of a collaborative research project involving universities and research agencies in Japan and the Republic of the Marshall Islands. Adapted from the Fisheries Toolbox framework originally developed in Japan, the NbS Toolbox was designed as a participatory decision-support process that engages local communities, government agencies, academic institutions, and researchers in identifying climate challenges, prioritizing vulnerable areas, and co-developing locally appropriate adaptation pathways.

The presentation focuses on the methodological development of the Toolbox, highlighting stakeholder mapping, iterative workshops, integration of scientific and local knowledge, and strategies for building trust and collaboration across institutions. Preliminary findings illustrate both the opportunities and practical challenges of applying co-design in small-island contexts, including stakeholder representation, communication, resource requirements, and the balance between community expectations and research objectives.

Using the Marshall Islands as a case study, this work demonstrates how co-design approaches can strengthen the connection between science, policy, and local communities, providing a transferable framework for developing actionable and locally owned climate adaptation strategies across Small Island Developing States.

S04, Oral, AbstractID=19443, (ECOP)

Development of a spatial framework for characterizing coastal social-ecological systems in the Sea of Okhotsk, Hokkaido, Japan

Nozomi **Ihara**[1], Takayuki Shiraiwa[2]

[1]Hokkaido University Graduate school of Environmental Science, Sapporo, Japan.
E-mail: Ihara_N@lowtem.hokudai.ac.jp
[2]Hokkaido University Institute of Low Temperature and Science Pan-Okhotsk Research Centre, Sapporo, Japan

Coastal social-ecological systems (SES) provide an important framework for understanding interactions between marine ecosystems and human societies. However, existing spatial analytical frameworks have largely been developed for ice-free coastal regions and cannot be directly applied to seasonally ice-covered seas, where sea ice strongly influences ecosystems, fisheries, tourism, and coastal livelihoods.

This study develops a spatial framework for characterizing coastal SES along the Sea of Okhotsk coast of Hokkaido, Japan. The study area comprises nine coastal municipalities from Shari to Omu. Between 2024 and 2026, literature reviews, field surveys, and semi-structured interviews with fishers, local residents, and government officers identified region-specific environmental and socio-economic characteristics.

Based on these investigations, an existing SES framework was adapted to reflect Sea of Okhotsk characteristics. Marine environmental variables included sea ice, sea surface temperature, salinity, primary productivity, nutrients, and dissolved inorganic carbon, while socio-economic variables included fisheries production, industrial structure, land use, tourism, and protected areas. Qualitative information on environmental change, sea-ice use, and adaptation was also incorporated. Marine environmental variables (within 5 km offshore) and socio-economic variables (within 1 km inland) were integrated at the municipal scale.

The resulting framework provides a region-specific basis for analyzing coastal SES in the seasonally ice-covered Sea of Okhotsk. Statistical analyses are underway. This study proposes a methodological framework for SES analysis in seasonally ice-covered coastal regions, providing a foundation for integrating natural and social dimensions to better understand human–environment interactions and support sustainable coastal management.

S04, Oral, AbstractID=19454

Reconciling coastal development and the land-sea meta-ecosystem in support of healthy and functional coastal marine environments

Brian P. V. **Hunt**[1,2]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. [2]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada. E-mail: b.hunt@oceans.ubc.ca

Coastal oceans are meta-ecosystems that are products of interacting physical, chemical, and biological processes that operate continuously across the land–sea continuum. The flow of freshwater, sediments, organic matter, and nutrients, and movement of organisms, create a network of couplings that define the structure and function of the receiving marine ecosystem. These land-sea connections are a major contributing factor to coastal marine ecosystems being global hotspots for productivity that have attracted human settlement since time out of mind. Today more than 40 % of the world's population lives within 100 km of coastlines. Globally, the services provided by coastal marine ecosystems remain critical to the health of the environment that sustains us, and our subsistence, cultural, and economic needs. The nature of the land—sea connections that maintain these ecosystem services is defined by watershed scale properties, coastal processes, and regional climate. Coastal development re-shapes these connections and in most cases threatens the services that we depend on and, increasingly, these human impacts are being amplified by global climate change. There is no more urgent time than now to incorporate land-sea connectivity into coastal zone planning and management. In support of this agenda, this paper reviews key mechanisms of land–sea connectivity, how these are modified by coastal development and urbanization in particular, and their interaction with climate change. By identifying mechanisms of both operation and change, this paper contributes to a framework for improved inclusion of the land—sea continuum into marine spatial planning. Doing so will not only support the sustainability of coastal marine ecosystems, but provide positive feedbacks to climate change adaptation in urbanized coastal areas.

S04, Oral, AbstractID=19491

Moving toward solutions: Measuring positive change in urban seas

Kathryn L. **Sobocinski**[1], Ginny Broadhurst[2], Mike LeMoine[3], Correigh Greene[3], Heida Diefenderfer[4], Josh Chamberlin[5], Tish Conway-Cranos[6], Jason Hall[7], John Delaney[8]

[1]Western Washington University, Department of Environmental Sciences, Marine and Coastal Science, Bellingham, WA, USA. E-mail: sobocik@wwu.edu
[2]Western Washington University, Salish Sea Institute, Bellingham, WA, USA
[3]Skagit River System Cooperative, LaConner, WA, USA
[4]Pacific Northwest National Laboratory, Sequim, WA, USA
[5]NOAA-Northwest Fisheries Science Center, Seattle, WA USA
[6]Washington Department of Fish and Wildlife, Olympia, WA USA
[7]Cramer Fish Sciences, Issaquah, WA, USA
[8]University of Washington, Oceanography, Seattle, WA, USA

Environmental science is good at problem identification. But once we have identified a problem how we do move toward making positive, restorative change and detecting that change in noisy systems, like coasts and estuaries? Solutions thinking is necessary to alter the environmental trajectory in urban sea systems, like the Salish Sea, where urbanization and climate change create compounding impacts. Calls for improving ecosystem function to improve resilience and benefit species like Pacific salmon have resulted in ecosystem restoration projects that are expanding in size and scope. The need for assessment of conservation actions in estuaries and urban seas with myriad stressors means novel approaches are needed to identify problems, generate solutions, and evaluate change. Cumulative effects evaluation is one approach for bringing disparate data sets together in a new way. Using an example for salmon habitat restoration in we are applying a new hypothesis-based framework rooted in causal analysis to determine effectiveness at the landscape scale for ecosystem restoration. Urban sea systems can benefit from data synthesis, from models to community engagement, and novel approaches are necessary to bring a solutionary lens to current and emerging ecosystem challenges.

S04, Oral, AbstractID=19500, (ECOP)

The effects of urban driven nutrient imbalance on phytoplankton community dynamics and nutritional quality in Vancouver Harbour

Natasha M **Buckiewicz**, Stephanie Moore, Anna McLaskey and Brian PV Hunt

University of British Columbia, Vancouver, BC, Canada. E-mail: n.buckiewicz@oceans.ubc.ca

Urban marine ecosystems are increasingly experiencing shifts in nutrient stoichiometry to receiving waters, largely driven by wastewater inputs, stormwater runoff, and changing hydrology. As primary producers, phytoplankton are essential for their role in synthesizing long-chain polyunsaturated fatty acids (LC-PUFA; e.g., omega-3s), critical for higher trophic level reproduction and development. Phytoplankton functional groups vary in LC-PUFA quantity and type, hence urban-driven shifts in stoichiometry may have implications for nutritional quality. Here, a seasonal survey was conducted in Vancouver, Canada to examine nutrient sources and phytoplankton community composition in a highly industrialized temperate estuary. We assessed NH3, N:P and N:Si ratios and associated community succession using HPLC/CHEMTAX methods and fatty acids in surface waters. F-ratios were analyzed to determine nitrate-driven bloom conditions from NH3 (i.e. wastewater)-supported regenerated production. The link between macronutrient stoichiometry driven by freshwater sources (wastewater, rivers, stormwater) and the relationship to LC-PUFA availability was investigated. Preliminary data indicate diatom dominance during early bloom stages transitions toward small flagellates/cyanobacteria. We hypothesize that these shifts coincide with decreased LC-PUFA content, suggesting potential limitations for trophic transfer. This study highlights how urban-driven nutrient patterns regulate both community composition and the nutritional value of primary production.

S04, Oral, AbstractID=19515

Increasing ocean observation to serve society: What does it take?

Jan **Newton**[1], Roxanne Carini[1], Sheyna Wisdom,[2] and Melissa Iwamoto[3]

[1]University of Washington & NANOOS, Seattle, WA, USA. E-mail: janewton@uw.edu
[2]University of Hawaii & PacIOOS, Honolulu, HI, USA
[3]Alaska Ocean Observing System, AOOS, Anchorage, AK, USA

We know the profound importance of the ocean to society, which is amplified in urban settings but perhaps underappreciated. As leaders of Integrated Ocean Observing System regional associations, we have observed first-hand the payoff to safety, economy, and health from ready access to ocean information in consumable formats, enabling sound decision-making. Yet observing assets continue to be sparse and budgets continue to be constraining. Human-scale equipment, community ownership, and co-design of observing efforts can make a difference. Our experience with Backyard Buoys, fisher-driven sampling, and other community-led programs inspires us to recognize that increasing this element, along with sustained efforts on sophisticated, gold-standard observing assets, gives us a balance of scales leading to increased understanding. Moreover, it leads to increased societal value of the relevance and importance of ocean information. This benefits both participation in community efforts as well as regard for and support for larger scale programs. We have witnessed this engagement and payoff in more rural areas, where ocean dependencies are stronger. We need a vision for how this can translate into urban settings as well. Increased awareness, effective communication, and a strong foundation in science are keys. This presentation will offer ideas and welcome discussion.

S04, Oral, AbstractID=19529, (ECOP)

Characterising the influence of urban inputs on zooplankton communities in a coastal temperate estuary

Stephanie L. **Moore**[1], Natasha Buckiewicz[1], Anna K. McLaskey[1] and Brian P.V. Hunt[1,2]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: s.moore@oceans.ubc.ca
[2]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada

Coastal cities alter nutrient and organic matter inputs from land to adjacent marine ecosystems by modifying existing transport pathways and introducing novel urban material fluxes, such as stormwater and wastewater. Tracing the fate of these nutrient and organic matter inputs is essential for understanding how urbanisation affects marine ecosystem productivity, biodiversity, and food-web structure. This study assessed the uptake of urban and marine organic matter sources by zooplankton communities in Burrard Inlet (British Columbia, Canada), an urban fjord estuary adjacent to Metro Vancouver. In 2025, particulate organic matter and zooplankton stable isotope samples were collected bi-monthly at seven stations. An urban index was derived using caffeine and 6PPD-quinone concentrations as proxy tracers of wastewater and stormwater exposure, respectively. Source signatures were characterised using organic matter stable isotope samples collected from rivers, stormwater, wastewater treatment plants, terrestrial vegetation, marine macrophytes and phytoplankton across Metro Vancouver in 2019, 2023, 2024, and 2025. A Bayesian mixing model is being used to determine the relative contribution of organic matter sources to zooplankton size classes and assess seasonal variation in source use. We hypothesise that zooplankton exposed to higher urban intensity will show proportionally greater assimilation of urban-derived organic matter, and that uptake of these sources will be highest during the wet season, when stormwater runoff is elevated and phytoplankton production is reduced. This study will assess how Metro Vancouver subsidises its coastal pelagic food web throughout the year and provide information for management of cumulative land-based inputs to these rapidly changing urban waters.

S04, Oral, AbstractID=19539, (ECOP)

Neonicotinoid contamination in urbanized coastal systems: Impacts on early life stages of the Dungeness crab

Marine **Uguen**[1,2], Alyssa-Lois M Gehman[1,2], Heather Earle and Christopher D G Harley [1,3]

[1]Department of Zoology, University of British Columbia, Vancouver, BC, Canada.
E-mail: uguen@zoology.ubc.ca
[2]Hakai Institute, End of Kwakshua Channel, Calvert Island, BC, Canada
[3]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada

Anthropogenic impacts on coastal zones are intensifying worldwide, increasing pressure on marine ecosystems. Among these pressures, agricultural runoff contributes to chemical contamination of coastal waters, representing an emerging ecological issue. Neonicotinoids are the most widely used group of insecticides globally, targeting nicotinic acetylcholine receptors and providing high efficacy against arthropods while being considered less toxic to vertebrates. However, their extensive use, persistence, and high water solubility facilitate their transport from terrestrial systems into aquatic environments, where they can persist and expose non-target organisms. Here, we investigate the effects of three neonicotinoids, i.e., imidacloprid, clothianidin, and thiamethoxam, individually and in mixture on early life stages of the Dungeness crab (*Metacarcinus magister*), a key benthic species supporting coastal food webs and major commercial and Indigenous fisheries. Larvae were exposed under controlled laboratory conditions to environmentally relevant concentrations, and both lethal and sublethal endpoints were assessed. Results showed concentration- and compound-dependent effects that can impact larvae survival, dispersal and settlement, with potential consequences for recruitment processes and population dynamics in coastal marine ecosystems. Overall, these findings indicate that neuroactive agricultural pollutants may impair recruitment processes and generate population-level consequences in coastal marine species even at environmentally relevant concentrations. Despite widespread use, monitoring data for neonicotinoids in coastal environments remain limited, hindering comprehensive risk assessment. Strengthening environmental surveillance and integrating these compounds into coastal health indicators is therefore essential to better understand and mitigate their ecological risks in urbanized coastal systems.

SESSION 4: HD/MEQ Topic Session

Pathways and process towards sustainable urban oceans where humans and nature co-exist

Poster Presentations

S04, QR-Poster, AbstractID=19105, PosterID: S04-P1, (ECOP)

Integrated foliar pigment analysis and random forest remote sensing modelling reveals spatially heterogeneous total chlorophyll distribution across Benoa Bay, Bali

I Wayan Gede Astawa Karang and K.K. Basheer **Ahammed**

Udayana University, Bali, Indonesia. E-mail: basheerkk@unud.ac.id

Mangrove ecosystems serve as ecologically indispensable coastal biomes increasingly exposed by anthropogenic pressures and accelerating climate variability. This study presents a rigorous, multi-scale assessment of total chlorophyll content as a primary physiological health indicator in mangrove stands of Benoa Bay, Bali, Indonesia. A total of 169 foliar samples were collected across 11 mangrove species and subjected to spectrophotometric quantification of total chlorophyll (Chlorophyll-a + Chlorophyll-b) using the DMSO-based extraction protocol. A Random Forest Regression (RFR) algorithm was developed and validated to spatially extrapolate total chlorophyll concentrations using multispectral PlanetScope satellite imagery incorporating raw spectral bands and 12 derived vegetation indices. Field-measured total chlorophyll ranged from 0.232 to 2.967 mg g^{-1}, with pronounced interspecific variability. The RFR model achieved strong predictive performance (validation $R^2 = 0.897$; RMSE = 0.278 mg g^{-1}; RMSE% = 22.65%). Spatially predicted total chlorophyll across the study domain averaged 1.28 ± 0.16 mg g^{-1}, with depressed concentrations observed in proximity to coastal development zones, indicative of physiological stress. This integrated framework demonstrates the efficacy of combining field biochemistry with machine learning-driven remote sensing for scalable, evidence-based mangrove health monitoring.

Keywords: Total Chlorophyll; Foliar Pigment Analysis; Mangrove Ecophysiology; PlanetScope; Random Forest Regression; Remote Sensing

S04, Poster, AbstractID=19127, PosterID: S04-P2, (ECOP)

Understanding the cumulative effects of forest harvesting on Pacific salmon in coastal British Columbia

M. D. Hocking[1,2], M. **Kuruvilla**[1,3], J. Braga[2], E. M. Atkinson[4], D. A. Greenberg[5], O. Cornies[3], L. Krichel[3], A. Kamarainen[3], C. Glass[3], J. Speier[6], M. Nicolson[6], B. Connors[7], P. Tschaplinski[8], A.D. Buren[2,9,10], A. W. Bateman[3,11,12], F. J. A. Lewis[2], M. A. Lewis[1], M. Krkosek[3,12]

[1]University of Victoria; Victoria, BC, Canada. E-mail: mariakur@uvic.ca
[2]Trinity Consultants Canada; Victoria, BC, Canada.
E-mail: Morgan.Hocking@trinityconsultants.com
[3]Salmon Coast Society; Simoom Sound, BC, Canada
[4]Biological Sciences, University of Alberta; Edmonton, AB, Canada
[5]Pacific Biological Station, Fisheries and Oceans Canada; Nanaimo, BC, Canada
[6]Musgamagw Dzawada'enuxw Fisheries Group; Kingcome, BC, Canada
[7]Institute of Ocean Sciences, Fisheries and Oceans Canada; Sidney, BC, Canada
[8]Aquatic Ecosystems Branch, BC Ministry of Water, Land and Resource Stewardship; Victoria, BC, Canada
[9]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina
[10]Instituto Antártico Argentino, Argentina
[11]Pacific Salmon Foundation; Vancouver, BC, Canada
[12]University of Toronto, Toronto, ON, Canada

Industrial forest harvesting has altered the functioning of watersheds that support wild Pacific salmon, yet the population-level effects of forestry on salmon are unknown. We reconstructed annual time series of forest disturbance for 1,746 salmon watersheds in coastal British Columbia dating back to 1883, with accumulated disturbance in many watersheds today exceeding 80%. We find strong evidence for a negative effect of forestry on chum salmon productivity with estimated declines of 9.2% to 41.0% for chum conservation units, and effect sizes that are larger than from changing ocean conditions. In contrast, forestry effects appear to be negligible for the more resilient pink salmon. Forestry causes shifts in watershed functioning that can last for decades, leading to salmon population declines and long timescales for recovery.

S04, QR-Poster, AbstractID=19182, PosterID: S04-P3, (ECOP)

Physico-chemical assessment of surface waters in Marchica Lagoon: A tool for environmental risk management

Anas **Bibot**[1], Otman Abida[1], Abdelmourith Laissaoui[2], Imad Kissami[1], Mounia Tahri[1]

[1]Mohammed VI Polytechnic University, Benguerir, Morocco. E-mail: Anas.Bibot@um6p.ma
[2]National Center for Energy, Sciences and Nuclear Techniques (CNESTEN), Rabat, Morocco

The Marchica Lagoon, one of the largest semi-enclosed coastal systems along Morocco's Mediterranean coast, plays a pivotal ecological and socio-economic role while facing escalating pressures from urbanization, agricultural runoff, and natural variability. To establish a robust environmental baseline, we conducted a comprehensive, spatially resolved survey that encompassed lagoon waters, tributary rivers, and wastewater discharges. Key water quality indicators—including salinity, pH, dissolved oxygen, suspended matter, and organic–inorganic carbon fractions—were assessed to capture the interactions between marine and freshwater inputs under anthropogenic influence.

The results revealed clear spatial and temporal gradients, shaped by hydrodynamics, geochemical fluxes, and biological activity. Multivariate statistical analyses, particularly correlation matrices and principal component analysis (PCA), identified coherent clusters of parameters that distinguish zones dominated by seawater intrusion from those influenced by freshwater inflows and organic loading. These findings highlight the lagoon's sensitivity to both seasonal forcing and human-derived pressures.

By integrating physico-chemical profiling with statistical interpretation, this study provides one of the first detailed baselines of Marchica Lagoon's environmental dynamics. The outcomes not only contribute to the broader understanding of Mediterranean coastal systems but also deliver actionable insights for risk assessment, monitoring, and the development of adaptive, science-based conservation and management strategies.

Keywords: Marchica Lagoon; coastal ecosystem; water quality monitoring; anthropogenic pressures; multivariate analysis; Mediterranean Morocco

S04, Poster, AbstractID=19276, PosterID: S04-P4

Informing restoration for better outcomes in the face of climate change and anthropogenic pressures

Nicole **Christiansen**[1], Sarina Clay-Smith[1], Paulina Salinas-Ruiz[1], Nikki Wright[2], and Tim Clermont[3]

[1]Pacific Salmon Foundation, Nanaimo, BC, Canada. E-mail: nchristiansen@psf.ca
[2]SeaChange Marine Conservation Society, Brentwood Bay, BC, Canada
[3]Guardians of our Salish Estuaries (GooSE), BC, Canada

Nearshore and estuarine ecosystems are facing increasing pressures, including human activities and climate change, resulting in widespread habitat degradation, particularly in areas adjacent to urban centres. Important coastal habitats such as eelgrass meadows, tidal marshes, and kelp forests play a critical role in supporting fisheries, biodiversity, coastal communities, and climate adaptation. As recognition of their ecological and socioeconomic value grows, so too does interest in restoring these habitats. Despite this momentum, the effectiveness of nearshore restoration efforts is often hampered by a lack of knowledge about optimal site selection; collated, open-access information on the efficacy of available methodologies; appropriate strategies under worsening climate change scenarios; and guidance on priority areas for restoration.

To address these challenges, the Pacific Salmon Foundation is leading the development of a Restoration Resource Hub: a publicly accessible collection of open-access resources and decision-support tools designed to guide and coordinate adaptive nearshore habitat restoration. The Hub is intended for restoration practitioners, such as Indigenous Guardians and stewardship groups.

Key products include:
State of knowledge reports summarizing recent advances in understanding;
Practitioner handbooks outlining best practices for restoration and monitoring; and
Decision-support tools to assist with restoration site selection and prioritization.

By promoting multidisciplinary collaboration and strengthening education, awareness, and technical capacity, this project aims to improve restoration outcomes and support the long-term conservation of nearshore habitats.

S04, Poster, AbstractID=19285, PosterID: S04-P5

Smart ocean village platform: Integrating education, tourism, industry, and sustainability through marine data

Garam **Yun**, Hyeon-Gyeong Han, Gi-Young Chae and Cholyoung **Lee**

Presented by Cholyoung Lee on behalf of Garam Yun

Korea Institute of Ocean Science & Technology, Busan, R Korea.
E-mail: cylee82@kiost.ac.kr, rkfka9205@naver.com

Marine environments are increasingly affected by climate change, pollution, and growing demands for sustainable resource management. To address these challenges, the Korea Institute of Ocean Science and Technology (KIOST) and the Busan Metropolitan Government developed the Smart Ocean Village (SOV) Platform, a marine data-based digital platform designed to support environmental monitoring, citizen participation, and data-driven decision-making.

The SOV Platform integrates satellite imagery, unmanned aerial vehicle (UAV) observations, CCTV systems, IoT sensors, and in-situ monitoring data to provide real-time marine environmental information. Currently, the platform supports marine debris management, marine air quality monitoring, and marine industry issue analysis through data visualization, AI-assisted analytics, and decision-support services. In addition, citizen engagement activities such as crowdsourcing and coastal cleanup programs contribute to both environmental stewardship and data collection.

Beyond its current functions, the SOV Platform is expanding into education, tourism, industry, and sustainability. Marine environmental data can be utilized to develop digital learning resources and educational programs that improve ocean literacy. The platform also has the potential to support smart marine tourism services by linking environmental information with local tourism resources. Furthermore, marine big data and AI technologies can foster innovation and new business opportunities in the marine sector. By strengthening collaboration among governments, research institutes, industries, and local communities, the platform aims to contribute to sustainable marine management and the achievement of the United Nations Sustainable Development Goals (SDGs).

This study introduces the architecture and current achievements of the SOV Platform and presents its future vision as an integrated marine data ecosystem connecting environmental management, public engagement, economic growth, and sustainability.

S04, Poster, AbstractID=19291, PosterID: S04-P6, (ECOP)

The science behind an urbanized ocean: An ecological review of the Metro Vancouver ocean

Jerry Kwan Ki **Wong**, Grace K. Melchers and Brian P.V. Hunt

Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: kkjwong@student.ubc.ca

Coastal marine ecosystem has been transformed by rising resource use and large-scale urban development from rapid human population growth. Emerging and recurring challenges rooted in spatial-temporal changes of land-sea connections in urbanized regions need to be critically examined to ensure the long-term co-existence and sustainability of people and wildlife in the coastal interface. A Scoping and a Systematic Review were performed in this study to characterize the current ecological and biological state-of-knowledge of the urban marine environment around the Metro Vancouver region. Published scientific literature on marine ecosystems in a pre-defined area around Vancouver were extracted, spanning the years 1921 to 2025. This literature is being examined through qualitative categorization and thematic coding analysis by study discipline, time, location, and other criteria. In this presentation, we will review the history of research development and understanding of human impacts on the Metro Vancouver marine ecosystem across disciplines, and identify critical knowledge gaps through comparison of Vancouver-based evidence with global reviews of urbanization impacts on the marine environment. Based on identified knowledge gaps, recommendations will be made for priority biological and ecological research areas in urbanized coastal marine ecosystems of Vancouver and beyond.

S04, Poster, AbstractID=19304, PosterID: S04-P7

Optimization of a continuous sediment redox potential monitoring system for sustainable prawn aquaculture

Mana **Ito**[1], Taku Sato[1], Md. Khorshed Alam[1], Takuma Sugaya[2], Katsutoshi Ito[1]

[1]Fisheries Technology Institute, Japan Fisheries Research and Education Agency, Hiroshima, Japan. E-mail: ito_mana40@fra.go.jp
[2]Fisheries Technology Institute, Japan Fisheries Research and Education Agency, Oita, Japan

Sediment environment in aquaculture has been affected by organic matter, such as remaining uneaten feed and excreta. Excessive organic accumulation causes eutrophication and leads to a reduced environment, producing bio-toxic hydrogen sulfide. As prawns inhabit the sediments, the sediment environment directly affects their health in prawn ponds. We have therefore implemented a continuous monitoring system focusing on the redox potential in sediment to monitor temporal changes in sediment conditions following aquaculture. Our previous research showed that the sediment conditions were heterogeneous both vertically and horizontally. In the present study, we verified the optimal sensor installation conditions in sediment and then evaluated the sensor's applicability in prawn aquaculture.

First, we evaluated the optimal sediment depth of sensor installation to detect environmental changes in sediment. The redox potential sensors were set at each depth of 2, 5, 10, and 20 mm below the sediment surface. The potential fluctuation following the application of organic matter was continuously monitored. The redox potential at depths of 2 and 5 mm declined rapidly after the application of organic matter, followed by a subsequent recovery. In contrast, no substantial changes were observed in potential values at depths of 10 and 20 mm. These results showed that installing sensors at a depth of 5 mm provides stable and reliable measurements.

Next, a preference test of prawn to sedimental environment was conducted to evaluate the effect of sedimental environment on the spatial distribution of prawn individuals. Nine individuals were simultaneously introduced into a tank subdivided into nine grid cells, each assigned one of three sediment types (low, medium, or high-sulfide concentration). At each observation time point, the number of individuals occupying each grid cell was recorded and aggregated by sediment type. Redox potential of the sediment was monitored at a depth of 5 mm throughout the experiment. Individuals showed a clear preference for low-sulfide and/or medium-sulfide sediment with high redox potential levels. There was no individual who preferred a sediment environment with high sulfide concentrations and low redox potential. These results show that monitoring the redox potential of sediment reveals not only the temporal sediment conditions during aquaculture, but also the prawn’s spatial behavior in the pond in relation to the variable sediment conditions, suggesting the effectiveness of this sensor in prawn aquaculture.

S04, Poster, AbstractID=19474, PosterID: S04-P8, (ECOP)

British Columbia coastal residents' perspectives on ocean contributions to well-being

Luisa **Ramirez**[1], Danielle Perron[2] and Jas Sidhu[2]

[1]Independent Researcher, former DFO Policy Analyst, Victoria, BC, Canada.
E-mail: almantula@gmail.com
[2]Economic Analysis Unit, Policy, Programs, and Partnerships, Fisheries and Oceans Canada, Pacific Region, BC, Canada

Oceans provide economic and ecological services that, together with social and cultural opportunities (learning, social capital, a sense of place, and sharing knowledge), support human well-being. Pressures from human activities and climate change may degrade habitat or biodiversity, motivating management actions which themselves can affect peoples' well-being (positively or negatively).

Recognizing that people rely on and interact with the ocean in different ways, DFO implemented a survey in Fall 2024 to:

- Identify the diverse values coastal residents of British Columbia have for the ocean
- Examine BC coastal residents' perceptions of Marine Protected Areas
- Explore whether a survey is a feasible and effective option to collect social and cultural data to inform marine conservation processes.

Values identified most often include social, cultural, and intrinsic values and are presented by region and demographic. BC coastal residents expressed a high dependence on the ocean for mental and physical health, recreation and social purposes, and for buying seafood locally. The survey data provide a reference point to assess how ocean values and perceptions of MPAs may change through time. This data can also inform the design of monitoring programs that aim to understand conservation outcomes and adaptive management.

S04, Poster, AbstractID=19547, PosterID: S04-P9, (ECOP)

ZooSCAN assessment of temporal and spatial variation in zooplankton assemblage composition in an urbanized coastal ocean

Radhika **Assanie**[1], Stephanie Moore[1], Deniz Coskuner[1], Brian P. V. Hunt[1,2]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: rassanie@student.ubc.ca
[2]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada

Zooplankton occupy a critical position in marine food webs, acting as the interface between primary producers and higher trophic levels. The coastal waters surrounding Metro Vancouver are subject to intense urbanization, and the associated anthropogenic stressors can alter physical, chemical, and biological conditions. Zooplankton respond rapidly to changing conditions such that the assemblage composition throughout Burrard Inlet may reflect the influence that these urban stressors could be having on the coastal food web. To investigate these patterns, the University of British Columbia's Urban Oceans Project sampled zooplankton with Bongo nets during bi-monthly surveys from February to December 2025. Seven stations were sampled across the four major basins of Metro Vancouver, spanning a range of environmental conditions and urban intensity. Preserved samples were analyzed using ZooSCAN imaging software to rapidly identify and quantify major taxonomic groups. ZooSCAN derived biomass and taxonomic diversity data will be used to characterize the temporal and spatial composition of zooplankton assemblages in Burrard Inlet. We predict that zooplankton assemblages will exhibit differences between basins and across seasons, reflecting the interaction of natural seasonal cycles and varying degrees of urban influence. This research will contribute to an essential overview of zooplankton assemblage structure in Metro Vancouver's coastal waters. The observed data can be used as a baseline for long-term ecosystem monitoring in an increasingly urbanized environment to further understand the impact of coastal cities on nearshore zooplankton assemblage composition.

SESSION 5: MONITOR Topic Session

Using ecosystem-scale information and machine-learning modeling approaches to understand climate change impacts on transboundary species in the North Pacific

Oral Presentations

S05, Invited, AbstractID=19347

Consequences of climate-induced range shifts for shared fish stocks: Insights from game theory and Northeast Atlantic fisheries

Mikko **Heino**[1,2]

[1]Department of Biological Sciences, University of Bergen, Bergen, Norway.
E-mail: mikko.heino@uib.no
[2]Complexity Science and Evolution Unit, Okinawa Institute of Science and Technology Graduate University (OIST), Okinawa, Japan

Here I summarize results from two strands of research: theoretical analyses on how range shifts influence management of shared fish stocks with or without sharing agreements, and empirical analyses on how landings data from heterogeneous coastal fisheries in Norway can be used to elucidate stock responses to short- and medium-term climate variability. First, agreements to jointly manage transboundary fisheries are notoriously difficult to reach, and, once in place, may collapse if the circumstances change. To better understand how durable transboundary stock-sharing agreements – designed without considering climate change – are when faced with climate-induced range shifts, we have developed a dynamic game model in which a non-adaptive, cooperative sharing agreement may be formed between two countries sharing a single stock prior to any climate-induced shifts. We use the model to evaluate the countries' incentives to stick to the original agreement as climate-induced shifts start to materialize. We find that the durability of sharing agreements critically depends on the initial ownership and rate of range shift and on whether side payments are used to transfer some benefits from the stock-gaining country to the stock-losing country. Second, landings data are potentially valuable but noisy source of information of fish distribution: many fisheries occur year-round and represent a huge 'sampling' effort, in contrast to fishery-independent surveys that typically have short duration and target specific areas. We are currently investigating how effort standardization and machine-learning based trip classification could be used to derive spatially-resolved CPUE indices from landings data available from 2020 onwards, a period with an overall warming trend and one pronounced marine heatwave.

S05, Oral, AbstractID=19137

Daily, vessel-specific, and species-specific length composition monitoring using the image analysis system FIAS-Deep

Yasutoki **Shibata**[1], Yuka Iwahara[1], Masahiro Manano[1], Daiki, Suzuki[2], Tomoya Nishino[3], Kota Kurosawa[3], Yuka Murayama[4], Tomoyuki Kuwahara[4] and Toru Kitamura[4]

[1]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan. E-mail: shibata_yasutoki20@fra.go.jp
[2]CCS Inc., Kamigyo-ku, Kyoto, Japan
[3]Computermind Corp., Shinjyuku-ku, Tokyo, Japan
[4]Japan NUS Co., Ltd., Shinjyuku-ku, Tokyo, Japan

Length composition is fundamental information for stock assessment and fisheries management. However, fish length measurements often depend on manual work by human measurers, and insufficient measurement capacity can limit the amount of data collected and increase uncertainty in assessment results. Recent advances in deep-learning-based image analysis have made it possible to estimate fish lengths from images and obtain length compositions with reduced dependence on human measurers. In this study, we developed FIAS-Deep (Fish Image Analysis System using Deep Learning), which automatically obtaining daily, vessel-specific, and species-specific length compositions, and introduced it at the Matsuura Fish Market, Nagasaki Prefecture, Japan. We aimed to evaluate the validity of length compositions obtained using FIAS-Deep by comparing them with manually measured length compositions.

A total of five comparison trials were conducted from December 2025 to January 2026. Because mackerels (*Scomber japonicus* and *S. australasicus*) and Japanese jack mackerel (*Trachurus japonicus*) were the species available for validation on the trial days, comparisons were conducted for these species. We compared manually measured fork-length compositions with those estimated using FIAS-Deep. The relative differences in mean fork length ranged from −2.06% to 1.00%, indicating high accuracy when manual measurements were used as the reference. We also present temporal changes in daily, vessel-specific, and species-specific length compositions obtained after June 2026, when the system became able to collect length compositions automatically without human measurers on site.

S05, Oral, AbstractID=19145, (ECOP)

Spatiotemporal prediction of Antarctic krill core habitats using dynamic labeling and U-Net-LSTM

Aike **Huang**, Jialong Wang, Jianchao Li, Yongjun Tian and Peng Sun

Deep Sea and Polar Fisheries Research Center, Ocean University of China, Qingdao, PR China. E-mail: aikehuang123@163.com

Antarctic krill (*Euphausia superba*) is a keystone species in the Southern Ocean ecosystem and an important fishery resource. Accurate prediction of krill core habitats is essential for improving fishery planning and advancing ecosystem-based management. However, krill distribution is strongly affected by rapid environmental change, particularly changes in sea ice, ocean temperature, and primary productivity. At the same time, polar observations remain sparse and unevenly distributed, making it difficult for traditional habitat models to capture the dynamic movement and seasonal development of krill habitats. In this study, long-term krill density observations and ecosystem-scale environmental data were combined to predict monthly core habitats of Antarctic krill. We developed a distribution prediction framework based on dynamic labeling and U-Net-LSTM, using a spatiotemporal prediction model to capture both the spatial structure of krill habitats and the lagged responses of krill distribution to environmental variability. The results showed that the proposed model outperformed traditional habitat prediction approaches overall, and that incorporating historical environmental sequences substantially improved the identification of potential krill habitats. Model interpretation further confirmed that distance to sea ice, chlorophyll-a concentration, and sea surface temperature were the three key environmental factors influencing krill distribution. These findings indicate that integrating ecosystem-scale data with interpretable machine-learning methods can improve our understanding of climate-sensitive habitat dynamics. The proposed framework provides practical and traceable decision support for adaptive management of Antarctic krill fisheries, including the identification of potential fishing grounds, assessment of climate-driven habitat shifts, and recognition of areas requiring precautionary conservation and management under future environmental change.

S05, Oral, AbstractID=19175, (ECOP)

An interpretable deep learning framework for otolith microstructure analysis to automate daily ageing

Jialong **Wang**, Peng Sun, Congxian Chen and Yongjun Tian

Deep Sea and Polar Fisheries Research Center, Ocean University of China, Qingdao, PR China. E-mail: wjljashow@163.com

Understanding fish early life history and recruitment dynamics is critical for regional fisheries management, particularly under climate change. Otolith daily increment analysis provides vital high-resolution data on hatch dates and early growth rates, which serve as sensitive indicators of environmental shifts. However, manual interpretation of otolith microstructures remains subjective, time-consuming, and difficult to scale across large long-term otolith collections. This bottleneck limits the generation of high-resolution data needed for ecosystem-scale analysis and cross-national fisheries assessment. To address this gap, we present an interpretable deep learning framework trained on a dataset of polished sagittal otolith microscopic images with annotations of largehead hairtail (*Trichiurus japonicus*) to automate daily ageing and increment measurement by replicating the manual identification logic. The framework first identifies the optimal reading axis (core-to-edge trajectory) via a deep segmentation model and geometrically transforms the curved trajectory into a standardized 2D ribbon space. Heatmap-based keypoint detection is then employed to localize the dense daily increments within this unrolled projection, followed by an automated decoding step to extract increment positions and estimate their widths. Our results demonstrate that the trained framework enables the rapid identification of both otolith daily age and increments while maintaining high geometric robustness and reducing reading variability. Crucially, this framework can be generalized to other fish species, which enables the efficient generation of early life history datasets necessary for ecosystem-scale assessments of recruitment variability, early growth, and climate-related responses in transboundary populations, thereby strengthening climate-resilient fisheries management.

S05, Oral, AbstractID=19192, (ECOP)

Predicting climate-driven shifts in spawning grounds of common squid (*Todarodes pacificus*) in the western North Pacific by applying species distribution models

Damin **Lee** and Sukgeun Jung

Jeju National University, Jeju, R Korea. E-mail: sukgeun.jung@gmail.com

Common squid (*Todarodes pacificus*) is a commercially important cephalopod species in the western North Pacific. Their recruitment and spatio-temporal variability are sensitive to environmental variability. Climate-driven oceanographic changes are expected to shift their spawning grounds. This study tried to identify the key environmental drivers and predict the shifts by applying Species Distribution Models (SDMs). We compiled occurrence records of mature males, mature females, and paralarvae (<2 mm mantle length) between 1995 and 2015 from past studies. Paralarvae were collected by various plankton nets, whereas mature individuals by jigging. Accessible areas of squid were defined based on their spawning migration speed and hatch dates. We calculated the nearest-neighbor distance (NND) among occurrence records to randomly sample pseudo-absence points outside these buffers. We included sea temperature, salinity, mixed layer thickness, current velocity, and bathymetry as environmental predictors to develop SDMs by applying Generalized Additive Model, Generalized Boosting Model, Random Forest, and Maximum Entropy. To account for spatial autocorrelation and improve model performance, we applied five-fold spatial block cross-validation and integrated the selected high-performing models into an ensemble prediction. Predicted spawning habitats extended from the northern East China Sea northeastward to the coastal waters of Japan, consistent with previously reported spawning grounds. We expected that our ongoing development of the SDM will aid regional squid fishers and policy makers in their adaptation to climate change.

S05, Oral, AbstractID=19211, (ECOP)

Shining light on a cryptic yet commercially valuable family of mesopelagic fishes in the central North Pacific

Justin J. **Suca**[1], Janelle L. Morano[2,3], Jessica N. Perelman[2,3] and Ryan R. Rykaczewski[3]

[1]Department of Oceanography, University of Hawai‘i at Mānoa, Honolulu, HI, USA.
E-mail: jsuca@hawaii.edu
[2]Cooperative Institute for Marine and Atmospheric Research, University of Hawai‘i, Honolulu, HI, USA
[3]NOAA Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, HI, USA

Commercial fisheries throughout the world have traditionally focused on neritic or epipelagic species. However, with the increasing footprint of “deep-set” longline gear targeting 150-500m, mesopelagic predators have become a substantial component of pelagic commercial catch. Here, we focus on understanding the distribution and drivers of catchability for one of the most commonly caught and commercially valuable mesopelagic fish families, pomfrets (Bramidae). We used a 20-year time series of catch records from the Hawai‘i deep-set longline fishery in the central North Pacific. Pomfret catches in this fishery primarily consisted of sickle pomfret (*Taractichtys steindachneri*), followed by keeltail pomfret (*Taractes rubescens*), members of the *Brama* genus, and rough pomfret (*Taractes asper*). Catch records reveal spatial segregation of catches by species, with highest catch rates of sickle pomfrets occurring near the boundary of the oxygen-deficient zone southeast of Hawai‘i, while catch rates of keeltail pomfrets peak nearer to the islands. Regions of high *Brama* and rough pomfret catch rates were largely north of Hawai‘i and associated with the North Pacific Transition Zone. Catch rate models including environmental covariates indicated that surface and subsurface temperature, mesoscale eddies, and the lunar cycle have appreciable effects on the spatiotemporal variability in catch rates of many of these pomfret species. Collectively, this work provides context on the drivers of catch rates at a species-level for this complex, improving our ability to interpret temporal variation in catch rates and setting the stage for generating catch indices for future stock assessments.

S05, Oral, AbstractID=19253, (ECOP)

Otolith biogeochemistry reveals possible impacts of extreme climate events on population connectivity of Japanese Spanish mackerel *Scomberomorus niphonius* in the North Pacific

Xindong **Pan**[1,2] and Yongjun Tian[2]

[1]Fisheries College, Jimei University, Xiamen, PR China. E-mail: panxindong@jmu.edu.cn
[2]Deep Sea and Polar Fisheries Research Center and Key Laboratory of Mariculture, Ministry of Education, Ocean University of China, Qingdao, PR China

Climate change, particularly extreme climate events, is likely to alter the population connectivity in diverse taxa. While the population connectivity for highly migratory species is expected to be vulnerable to climate change, the complex migration patterns has made the measurement difficult and studies rare. However, otolith biogeochemistry provides the possibility to evaluate these climate-induced impacts. Japanese Spanish mackerel *Scomberomorus niphonius* is a highly migratory fish that is widely distributed in the northwest Pacific. Otoliths biogeochemistry of age-1 spawning or spent individuals from three consecutive years (2016–2018), during which a very strong El Niño was experienced (2015–2016), were analyzed to evaluate the temporal variation of connectivity for S. niphonius population along the coast of China. The elemental concentrations of the whole otolith showed that Ba:Ca and Mg:Ca values were found to significantly increase in the El Niño year. The random forest classification and clustering analysis indicated a large-scale connectivity between East China Sea and the Yellow Sea in the El Niño year whereas the local S. niphonius assemblages in different spawning areas were more self-sustaining after the El Niño year. These findings lead to the hypothesis that environmental conditions associated with the El Niño Southern Oscillation (ENSO) events in the Northern Pacific Ocean would likely influence the population connectivity of S. niphonius. If so, extreme climate events can result in profound changes in the extent, pattern and connectivity of migratory fish populations. Our study demonstrates that otolith biogeochemistry could provide insight towards revealing how fish population response to extreme climate events.

S05, Oral, AbstractID=19306

Ecological drivers of Hokkaido pink salmon abundance over four decades: Brood-line structure and marine thermal conditions

Irene D. Alabia[1,2], Sei-Ichi **Saitoh**[1], Takafumi Hirata[1], Yasuyuki Miyakoshi[3], Jorge García Molinos[1], Benjamin Planque[4], Masahide Kaeriyama[1]

[1]Arctic Research Center, Hokkaido University, Sapporo, Japan.
E-mail: irenealabia@arc.hokudai.ac.jp, ssaitoh@salmon.fish.hokudai.ac.jp
[2]International Arctic Research Center, University of Alaska Fairbanks, Alaska, USA
[3]Kitami Salmon Enhancement Program Association, Abashiri, Hokkaido
[4]Ecosystem Processes, Institute of Marine Research, Tromsø, Norway

Understanding the ecological drivers of pink salmon (Oncorhynchus gorbuscha) abundance is essential for explaining recent declines in Hokkaido and for clarifying how brood-line dynamics interact with environmental variability. We analyzed a 42-year brood-year time series of Hokkaido pink salmon abundance from 1982 to 2023, together with freshwater and marine environmental covariates representing key life-history stages, using generalized additive models (GAMs). Brood-line-specific log-linear trend analyses showed that return abundance declined more steeply in the odd-year brood line than in the even-year brood line, with estimated declines of 53.5% and 19.6% per decade, respectively, indicating that the long-term decline was disproportionately concentrated in the odd-year population. Across the study period, all marine covariates retained in the final model increased: May–June coastal SST, May–July feeding-area SST, and August coastal SST rose by 0.50, 0.24, and 0.64 °C per decade, respectively. Among alternative ecological formulations, models that combined brood-line-specific parent abundance with marine temperature covariates outperformed stock–recruit-only, freshwater-only, and environment-only models. Drop-one-term analyses indicated that parent abundance was the dominant predictor of return abundance, whereas May–June coastal SST was the strongest environmental covariate. These findings suggest that recent variation in Hokkaido pink salmon abundance reflects strong brood-line-specific stock–recruitment structure superimposed on warming marine conditions, with the early coastal marine period emerging as the most informative environmental window.

S05, Oral, AbstractID=19353

Environmental drivers of distribution patterns and early growth variability of largehead hairtail in the Northwest Pacific under climate change

Peng **Sun**[1], Aike Huang[1], Congxian Chen[1], Fengming Lv[1], Sukgeun Jung[2], Jisoo Lee[2], Giho Ong[2], Yongjun Tian[1]

[1]Deep Sea and Polar Fisheries Research Center, Ocean University of China, Qingdao, PR China. E-mail: sunpeng@ouc.edu.cn
[2]Department of Marine Life Science, Jeju National University, Jeju, R Korea

Largehead hairtail (*Trichiurus japonicus*) is an important commercial fish species in the Northwest Pacific, characterized by wide distribution, extensive migration and long spawning period. Its spatial distribution, recruitment dynamics, and early growth are likely sensitive to regional environmental variability. Understanding the coupled changes in hairtail distribution patterns and early growth under climate variability is therefore essential for clarifying the mechanisms underlying resource fluctuations and for improving fisheries management. In this study, we focus on hairtail samples collected from Chinese and Korean coastal waters. We use otolith microstructure and age-growth data to reconstruct the early growth patterns of hairtail from different regions. Furthermore, we incorporate environmental variables including sea surface temperature, bottom temperature, salinity, chlorophyll-a concentration, primary productivity, water depth, and ocean currents, and employ machine learning algorithms to identify the key drivers shaping spatial distribution, size structure, and variability in early growth. The results reveal regional differences in suitable habitats and early growth conditions of hairtail under recent climate variability, and clarify the potential mechanisms by which environmental changes affect habitat distribution and early life-history processes, thereby influencing recruitment dynamics. This study provides scientific support for dynamic resource assessment, climate-adaptive management, and regional cooperative conservation of largehead hairtail resources.

S05, Oral, AbstractID=19367

Expanding the case for dynamic ocean management: Models for megafauna and fisheries

Elliott L **Hazen**[1], Josh Cullen[1], Heather Welch[1], Sarah Roberts[2], Gabi Mukai[3], Emily Nazario[1], Justin Suca[3], John Quinlan[4], Cara Wilson[5], Mary Hunsicker[6], Kirstin Holsman[7], Ryan Rykaczewski[5]

[1]University of California, Santa Cruz, CA, USA. E-mail: elhazen@ucsc.edu
[2]CIMAS, University of Miami, FL, USA
[3]JISAO, University of Hawaii, HI, USA
[4]SEFSC, National Oceanic and Atmospheric Administration, FL, USA
[5]SWFSC, National Oceanic and Atmospheric Administration, CA, USA
[6]NWFSC, National Oceanic and Atmospheric Administration, WA, USA
[7]AFSC, National Oceanic and Atmospheric Administration, WA, USA

Dynamic ocean management (DOM) is emerging as a cornerstone of climate-ready ocean management, integrating real-time environmental observations, ecological forecasting, and adaptive governance to align human activities with rapidly shifting marine ecosystems. We synthesize DOM applications across four ecologically and economically important systems: the U.S. West Coast, Gulf of Mexico, Hawaiian Islands, Bering Sea, and Azores. Across these regions, DOM uses satellite oceanography, ecological forecasting, and near-real-time habitat models to reduce fisheries bycatch, support climate-ready harvest strategies, balance conservation and fisheries objectives, and improve ecosystem-based management of highly mobile species. Although the management challenges differ among regions, each demonstrates how dynamic environmental information can complement or potentially replace static spatial measures by tracking ecological change as it occurs. Collectively, these case studies illustrate the growing maturity of DOM as an operational management framework and highlight common requirements for broader implementation, including reproducible environmental data streams, ecological forecasting, cross-jurisdictional governance, and climate-informed management reference points. As climate-driven species redistribution accelerates, DOM provides a scalable pathway to sustain both marine biodiversity and fisheries-dependent communities.

S05, Oral, AbstractID=19409, (ECOP)

An interpretable rule-based framework for defining species-gear management units in multispecies, multi-gear fisheries

Taye **Yoo**[1], Sung Il Lee[2] and Heejoong Kang[1]

[1]National Institute of Fisheries Science, Busan, R Korea. E-mail: yoo.taye7@gmail.com
[2]Pukyong National University, Busan, R Korea

Korea is reforming its fisheries management system toward expanded use of total allowable catch (TAC) controls. However, its coastal fisheries operate as a complex multispecies, multi-gear system in which most species are caught by multiple gears and each gear catches multispecies. This complexity makes it necessary to diagnose appropriate management units before expanding catch-based controls. We ask whether species-gear management units can be defined using national catch statistics aggregated by species and fishery. We reconciled catch records into a consistent 36-year series (1990-2025) and formed a species-by-gear matrix of 87 species groups across 38 fisheries. The overall species-gear structure remained broadly stable across decades while species' shares within it shifted, so units were defined using the most recent, consistent years (2006-2025). Species were classified through a hierarchical rule-based procedure. Targeting-gear coverage, the combined catch share of gears identified as targeting a species, first separated simple structures, where targeting gears covered most of the catch, from complex ones. Single-gear concentration, the largest share taken by any one gear, then further described each structure by whether catch was concentrated in one gear or dispersed across several gears. Each species was also described by whether its catch was landed in a single area or across multiple areas, adding a spatial dimension to the framework. The resulting rule-based framework provides an interpretable basis for diagnosing management units and can support Korea's TAC-centered reform by informing species-specific TACs, vessel-, fishery-, or area-based total-catch limits, and hybrid approaches that combine species and gear dimensions.

SESSION 05: MONITOR Topic Session

Using ecosystem-scale information and machine-learning modeling approaches to understand climate change impacts on transboundary species in the North Pacific

Poster Presentations

S05, Poster, AbstractID=19228, PosterID: S05-P1 CANCELLED

~~Construction of a high-quality dataset for marine disaster prevention and mitigation based on large language models~~

~~Luyao **Han**, Jianfeng Liang and Fangfang Wan~~

~~National Marine Data and Information Service, Tianjin, PR China. E-mail: hlyiocean@126.com~~

~~Aiming at the challenges encountered in the research and development of marine intelligent applications, including insufficient training data reserves, imbalanced category distribution, and uneven data quality, this paper integrates large model-augmented prompt generation and hybrid manual annotation methods to construct a high-quality instruction-tuning dataset dedicated to marine disaster prevention and mitigation. Focusing on six typical marine disasters—storm surges, ocean waves, sea ice, tsunamis, red tides, and green tides—the paper collects high-density domain corpora such as official reports and bulletins, national and industrial standards, as well as policy news documents.First, a hybrid configuration strategy combining data block sizing and text separators is adopted to standardize and segment raw corpora. Next, a knowledge graph for marine disaster prevention and mitigation together with audience-style paired prompts are established to guide the DeepSeek-Chat model to generate question-and-answer (Q&A) samples from multiple perspectives, catering to diverse data requirements during the instruction-tuning phase of large language models.Subsequently, a three-layer prompt architecture consisting of task description, demonstration guidance, and constraint definition is deployed to enable DeepSeek-Chat to automatically annotate domain-specific Q&A samples. Meanwhile, Generative Adversarial Networks (GANs) are introduced to conduct controllable expansion and data augmentation for samples of scarce disaster categories, yielding a final dataset containing 11,220 high-quality Q&A pairs.Instruction tuning is performed on the Qwen2.5-7B-Instruct model using the constructed dataset. Two evaluation paradigms are adopted to compare the model performance before and after fine-tuning: CMMLU for assessing general foundational capabilities, and LLM-as-Judge for vertical domain-specific evaluation. Experimental results demonstrate that the dataset constructed in this work can markedly boost the model's specialized domain Q&A competence while effectively preserving its general fundamental capabilities, which delivers high-quality data support for the research and development of intelligent models in marine sectors.~~

S05, Poster, AbstractID=19232, PosterID: S05-P2, (ECOP)

Environmental drivers of billfish catch rates in the Hawai‘i deep-set longline fishery

Isabella **Kintigh** and Justin Suca

University of Hawai‘i at Mānoa, Honolulu, HI, USA. E-mail: idavila@hawaii.edu

Billfishes are highly migratory predators that support valuable commercial and recreational fisheries throughout tropical and subtropical oceans worldwide. Despite their ecological and economic importance, the environmental factors influencing their distribution and vulnerability to fishing gear remain poorly understood. Fishery observer data of billfish catch and fishing effort from the Hawai‘i deep-set longline fishery (2005–2024) were used to evaluate relationships between catch rates and environmental conditions across the central and western North Pacific Ocean. Analyses focused on blue marlin (*Makaira nigricans*), striped marlin (*Kajikia audax*), shortbill spearfish (*Tetrapturus angustirostris*), and sailfish (*Istiophorus platypterus*). Catch-per-unit-effort (CPUE) was modeled using generalized additive models (GAMs) that incorporated spatial, temporal, operational, and environmental predictors, including sea surface temperature, sea level anomaly, mixed layer depth, light attenuation (Kd490), ocean currents, and subsurface temperature and dissolved oxygen conditions. Preliminary results suggest that billfish catchability is strongly influenced by oceanographic variability, although the relative importance of environmental drivers differs among species. Spatial and seasonal patterns explained substantial variation in catch rates, while sea surface temperature, sea level anomaly, and ocean currents were important predictors of species-specific distributions. Blue marlin catchability was associated with high subsurface dissolved oxygen concentrations, while shortbill spearfish catchability increased in warmer subsurface waters. In contrast, striped marlin catchability increased in areas characterized by positive sea level anomalies, suggesting a link to mesoscale oceanographic features. Improved understanding of billfish habitat associations can help anticipate shifts in bycatch risk under future ocean conditions and support adaptive fisheries management and dynamic bycatch mitigation strategies.

SESSION 6: BIO/POC Topic Session

From Ocean Acidification to Ocean Alkalinity Enhancement: Their relationship and differences

Oral Presentations

S06, Invited, AbstractID=19320

Transition from ocean acidification studies to the ocean negative emission technologies in Japan: A focus on impact assessment

Akira **Iguchi**[1], Atsushi Suzuki[1], Makiko Yorifuji[1,2], Hiroshi Aoki[1], Kazuhiro Sayama[1], Masahiro Hayashi[3], Yoshikazu Ohno[4] and Mayuri Inoue[4]

[1]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. E-mail: iguchi.a@aist.go.jp
[2]Marine Biological Station, Sado Island Center for Ecological Sustainability, Niigata University, Niigata, Japan
[3]Marine Ecology Research Institute, Niigata, Japan
[4]Okayama University, Okayama, Japan

Ocean acidification caused by rising CO_2 levels resulting from human activities is progressing, raising concerns about its impact on marine ecosystems. Our group has conducted numerous experimental studies on marine organisms in Japan to investigate the effects of acidified seawater, clarifying responses in terms of survival rates, growth rates, and gene expression levels. In recent years, we have focused on negative emission technologies (ocean NETs) that maximize the ocean's inherent CO_2 absorption capacity. We are currently conducting a research project that combines precise rearing experiments with environmental impact assessment methods based on metagenomic and environmental DNA analyses. In this presentation, we will provide an overview of our research, spanning from ocean acidification to ocean NETs.

S06, Oral, AbstractID=19434

Understanding the impacts of ocean alkalinity enhancement on the Earth system: A Canadian Earth System Model study

Krysten **Rutherford**[1], Neil Swart[1], James Christian[1,2], and Elise Olson[1]

[1]Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada, Victoria, BC, Canada. E-mail: krysten.rutherford@ec.gc.ca
[2]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada

Ocean alkalinity enhancement (OAE) is increasingly discussed as a geoengineering technology with potential to curb atmospheric CO_2 growth. While OAE needs to be studied across many scales, global Earth system models (ESMs) are unique in their ability to constrain the Earth system feedbacks associated with OAE. We performed OAE experiments with the Canadian Earth System Model version 5.1. Our experiments follow the protocol set out in the Carbon Dioxide Removal Model Intercomparison Project (CDRMIP): 0.14 Pmol of alkalinity is added each year to the entire surface ocean between 60°S and 70°N on the SSP585 emission pathway with interactive atmospheric CO_2. We additionally apply the CDRMIP protocol to emission pathways SSP126 and SSP245. This simple experimental design allows us to compare our results with other ESMs that contributed to this experiment in the Coupled Model Intercomparison Project Phase 6 (CMIP6), which will help elucidate model-based uncertainty in OAE response. The results presented quantify the effectiveness of OAE at limiting climate change signals and will highlight the impacts of OAE on ocean acidification metrics. These results show that Earth system feedbacks need to be considered when evaluating the potential of OAE at regional scales.

S06, Oral, AbstractID=19482

Tipping points and variable sensitivity: Non-linear effects of ocean acidification and complex responses to subsequent acute thermal, hypoxia and predation stress in juvenile shellfish and Dungeness crabs

Iria **Gimenez**[1], Georgia Hall[2], Josh Dyer[3], Carl Ng[1,2,3], Kate C. Rolheiser[1], Jacob M. Etzkorn[1], Sarah Manson[1], Lydia Walton[1], Alex Moore[3,4,5] and Christopher D.G. Harley[2,6]

[1]Hakai Institute, Quadra Island, BC, Canada. E-mail: iria.gimenez@hakai.org
[2]Department of Zoology, University of British Columbia, Vancouver, BC, Canada
[3]Department of Forestry and Conservation Sciences, University of British Columbia, Vancouver, BC, Canada
[4]PSEG Institute for Sustainability Studies, Montclair State University, NJ, USA
[5]Department of Botany, University of British Columbia, Vancouver, BC, Canada
[6]Institute for the Ocean and Fisheries, University of British Columbia, Vancouver, BC, Canada

Ocean acidification (OA) threatens marine invertebrates, yet how it modifies sensitivity to additional stressors — extreme temperatures, hypoxia, and predation — remains poorly understood. Equally unclear is where tipping points lie, where incremental acidification triggers large biological effects. We exposed juvenile Pacific oysters (*Magallana/Crassostrea gigas*), Bay mussels (*Mytilus* spp.), and Dungeness crabs (*Metacarcinus magister*) to a gradient of OA conditions (pH ~7.9, 7.7, 7.5, and 7.3) over ~8 weeks, examining growth, shell integrity, thermal tolerance, predator vulnerability, and responses to acute hypoxia. Oysters and mussels both responded negatively to acidification, with non-linearities and tipping points emerging in some traits (e.g., mussel growth, oyster shell strength) but not others, and at different pH thresholds across traits. OA did not affect critical upper thermal tolerance in either bivalve, but increased mussel vulnerability to predatory sea stars in a predator-size-dependent manner. In Dungeness crabs, growth appeared largely robust to OA, though potential decoupling between growth and development and effects on nutritional status (fatty acid profiles) are still being examined. Preliminary results suggest that OA-exposed crabs mounted a more efficient response to subsequent acute hypoxia, potentially indicating that chronic acidification may prime stress-coping machinery — though the sustainability of this effect and its energetic and physiological tradeoffs require further investigation. These results highlight that OA effects are non-linear, species- and trait-specific, and can modify sensitivity to secondary stressors in unexpected ways, underscoring the importance of multi-stressor, long-duration experimental designs.

S06, Oral, AbstractID=19536, (ECOP)

Observed global-scale biological responses to ocean acidification may constrain ocean alkalinity enhancement efficiency

Reese C. **Barrett**[1], Brendan R. Carter[2,3]

[1]University of Washington School of Oceanography, Seattle, WA, USA.
E-mail: rcbarr1@uw.edu
[2]University of Washington Cooperative Institute for Climate, Ocean, and Ecosystem Studies, Seattle, WA, USA
[3]National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory, Seattle, WA, USA

Ocean acidification, or the decrease in ocean pH caused by oceanic uptake of anthropogenic carbon, has been hypothesized to reduce the ability of calcifying marine organisms to export total alkalinity (A_T) from the surface ocean to depth. This reduction would be a negative feedback on atmospheric CO_2 levels, as increased levels of surface A_T would result in a greater capacity of the surface ocean to buffer additional CO_2. A signature of this "CO_2-biotic calcification feedback," an increase in surface ocean A_T content, has recently been observed for the first time using repeat hydrographic measurements and seawater property prediction algorithms. Over the past thirty years of ocean acidification, our observations indicate that an estimated 20 Tmol of additional A_T has accumulated in the surface ocean due to shifts in biotic calcification, which has increased the ocean's anthropogenic carbon burden by 0.20 PgC. This increase indicates that the CO_2-biotic calcification feedback could reduce the efficiency of ocean alkalinity enhancement (OAE), which act as a "reverse" of ocean acidification by promoting favorable conditions for calcifying marine organisms. In the case of OAE, additional export of surface A_T caused by an increase in biotic calcification would result in a decrease in the ability of the surface ocean to buffer atmospheric CO_2. Constraining this uncertainty in the carbon sequestration potential of OAE will be necessary for both accurate carbon accounting in OAE projects and understanding the impacts of OAE projects on marine ecosystem structure.

SESSION 6: BIO/POC Topic Session

From Ocean Acidification to Ocean Alkalinity Enhancement: Their relationship and differences

Poster Presentations

S06, Poster, AbstractID=19138, PosterID: S06-P1

Sea water alkalinization by calcium hydroxide promotes reproductive growth of young sea urchin *Mesocentrotus nudus*

Tsuneo **Ono**[1], Daisuke Muraoka[2], and Yuki Hosoyama[2]

[1]Fisheries Resources Institute, Fisheries Research and Education Agency, Yokohama, Japan.
E-mail: ono_tsuneo65@fra.go.jp
[2]Fisheries Technology Institute, Fisheries Research and Education Agency, Miyako, Japan

Ocean Alkalinity Enhancement (OAE) technologies have now become important option for ocean-based carbon dioxide removal, but its impacts against marine organisms are still unknown. Here, we carried out a rearing experiment of sea urchin *Mesocentrotus nudus* in alkalinized sea water media, to investigate physiological response of this important marine resources against OAE. Two-years old urchins are reared over one year in the following five different treatment: (1) natural coastal sea water, (2) slightly alkalinized seawater in which total alkalinity (TA) was increased by +20 μmol/kg by continuous addition of Ca(OH)2 solution, (3) highly alkalinized seawater in which TA was increased by +200 μmol/kg by continuous addition of Ca(OH)2 solution, (4) acidified seawater in which pCO2 was increased to 1000ppm by continuous addition of gaseous CO2, and (5) the "restored" acidified seawater in which pCO2 was once increased to 1000ppm by continuous addition of gaseous CO2, and then it was recovered to 400 ppm by continuous addition of Ca(OH)2 solution in a preparation tank before being supplied to the rearing tank. Ten individuals per treatment were reared in separate water tank, and enough amount of *Undaria pinnatifida* blade was fed all through the experiment. Temporal changes of wet weight and body length of each individual were then measured monthly to monitor the growth of urchins.

During the season from October to April, the treatments 2 and 3 showed higher increasing rate of body length compared to the treatment 1. During the season from April to October, however, the treatments 2 and 3 showed lower increasing rate of body length compared to the treatment 1. When we look at wet weight, it was found that only four of 10 individuals in the treatment 1 showed decrease of wet weight During the period from July to October, while all ten individuals showed decrease of wet weight during the same period in the treatments 2 and 3. As the short-time decrease of wet weight of the urchins are usually caused by the spawning of eggs/sperms, we interpreted these results that small addition of Ca(OH)2 in seawater (with +20 ~+200 μmol/kg in TA) have promoted reproductive growth of these 2-3 old urchins. In the treatment 4, on the other hand, showed the lowest increasing rate both for body length and wet weight all through the experiment, suggesting that ocean acidification to 1000 ppm pCO2 arose significant negative impacts in this animal. Urchins in the treatment 5 showed same level of body-length increasing rate with the treatments 2/3, suggesting that addition of Ca(OH)2 is effective for the restoration of acidified seawater.

S06, Poster, AbstractID=19354, PosterID: S06-P2

Observing the biogeochemistry of Alaska's subarctic fjords to detect ocean acidification

Natalie M. **Monacci**[1], Simone R. Alin[2], Jessica N. Cross[3], Seth Danielson[1], Wiley Evans[4], Tyler Hennon[1], Russell Hopcroft[1], Esther Kennedy[5], Kari Lanphier[6], Jennifer Questel[1], Jamie Womble[7]

[1]University of Alaska Fairbanks, College of Fisheries and Ocean Sciences, Ocean Acidification Research Center, Fairbanks, AK, USA. E-mail: nmonacci@alaska.edu
[2]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA
[3]Pacific Northwest National Laboratory, Seattle, WA, USA
[4]Hakai Institute, Heriot Bay, BC, Canada
[5]University of Alaska Southeast, Alaska Coastal Rainforest Center, Anchorage, AK, USA
[6]Southeast Alaska Tribal Ocean Research, Sitka, AK, USA
[7]National Park Service, Juneau, AK, USA

Alaska's coastal waters are naturally more acidified than the global average, with additional pressure as the ocean continues to absorb anthropogenic carbon dioxide. The northeastern Gulf of Alaska receives a significant amount of freshwater input from rainfall and snow and glacial meltwater. Ongoing climate change processes, including increased snow and ice melting, are further expected to enhance corrosive conditions in these coastal ecosystems. Here, we present synthesized biogeochemical observations from 2011 to 2024 across Lingít Aaní, Alaska's southeast region. This data product includes repeated, full water column profile biogeochemical profiles, encompassing carbonate parameters, dissolved oxygen, and macronutrients, from multiple glacially influenced and deglaciated fjords. The dataset complements ongoing research on fjord ventilation physics, zooplankton community structures, and community-led observing programs. Previous studies have identified a contemporary ocean acidification signal in surface waters throughout Lingít Aaní, with indications of emerging biological impacts. By extending publicly available observations through the entire water column, this new product enables assessment of acidification, quantification of air-sea carbon dioxide dynamics, and ecosystem vulnerability. We demonstrate how these observations are used by Tribal, state, and federal decision-makers to inform fisheries and resource management, including the rapidly expanding mariculture industry in the region and building interest in marine carbon dioxide removal.

SESSION 7: MONITOR Topic Session

Spearheading ocean observations using advanced techniques and sensors on the ocean environment and ecosystem

Oral Presentations

S07, Oral, AbstractID=19119, (ECOP)

Utilizing genomic tools to monitor ocean entry year Chinook salmon on the West coast of Vancouver Island

Christoph M. **Deeg**, Arthur L. Bass and Kristina M. Miller

Fisheries and Oceans Canada, Nanaimo, BC, Canada. E-mail: chrdeeg@gmail.com

Genomic tools like environmental DNA (eDNA) and genomic health screening have emerged as essential tools in salmon ecosystem science. eDNA is capable of characterizing the full food web surrounding salmon — from viruses to whales, while genomic health screening ("salmon Fit-Chips") can provide insights into pathogens, disease, and environmental stressor states from minimally invasive gill tissue biopsies. Together these tools provide insights in to the environment salmon inhabit as well as the resulting health and condition on individual level. We deployed both tools as part of a multi-disciplinary multiyear collaborative effort to investigate ocean entry year chinook salmon on the West coast of Vancouver Island. Combining our data with concurrently produced datasets of collaborators we identified multiple factors potentially impacting ocean entry year (OEY) Chinook salmon. Prey availability of OEY Chinook appeared heterogeneous during the outmigration period and Chinook showed strong prey selectivity towards insects and amphipods before shifting to krill and abundant piscine prey during the summer. Over the summer, juvenile Chinook experienced heat stress, showed no indication of malnutrition and did not avoid areas of high concentrations of biotoxin producing algae that resulted in toxin accumulation in individuals. During the same time, we observed spikes in environmental concentrations of the bacterial pathogen *Tenacibaulum maritimum* that coincided with annual epidemics of *T. maritimum* OEY Chinook. Open-net pen salmon aquaculture altered the annual abundance cycles of *T. maritimum* and other salmon pathogens, and significantly altered overall community composition. The observation of oxygen deprivation in OEY Chinook during fall suggests that individuals may not avoid detrimental environmental conditions in favor of high prey abundances. Into the first ocean winter, OEY Chinook foraging hotspots coincided with high predator abundances. Together, we highlight genomic approaches as as a powerful, multifaceted tools for salmon stewardship.

S07, Oral, AbstractID=19173, (ECOP)

A novel approach for monitoring phytoplankton community structure using optical measurements of the particle size distribution

Marta **Konik**[1,2], Rich Pawlowicz[1], and M. Angelica Peña[3]

[1]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada. E-mail: mkonik@eoas.ubc.ca
[2]Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland
[3]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada

Phytoplankton composition is expected to change in response to climate warming in the coming years, making it essential to optimize methods for monitoring phytoplankton assemblages. To observe phytoplankton in areas with low turbidity and low concentrations of colored dissolved organic matter, we propose using a size-based classification scheme based on the particle size distributions provided by the Laser In Situ Scattering and Transmission (LISST) instrument. We defined six size ranges that correspond to the LISST bins and associated these with phytoplankton groups typical of the Salish Sea. Using this method, we detected a shift from a diatom-dominated community to a mixed phytoplankton community in the northern Strait of Georgia. This phenomenon has only been identified previously through pigment analyses, as the differences primarily lie in the composition of the phytoplankton community structure rather than in the total chlorophyll-a concentrations. We suggest incorporating LISST measurements as a screening method to gain an overview of phytoplankton groups, identify blooms that are typically dominated by a few algal types, and target potentially toxic plankton, including mixotrophs. This approach can help optimize resource use by complementing water sampling methods to collect observations, particularly regarding spatial variability that aligns better with drone or satellite data coverage.

S07, Oral, AbstractID=19269, (ECOP)

Ocean glider data reveal physical controls of the Northern Gulf of Alaska spring bloom

Isaac S. **Reister**[1], Seth L. Danielson[1], Suzanne L. Strom[2], Gwenn M.M. Hennon[1], Hank Statsewhich[1], Tyler D. Hennon[1]

[1]University of Alaska, Fairbanks, AK, USA. E-mail: isaac.reister@gmail.com
[2]Western Washington University, WA, USA

The spring bloom in the Northern Gulf of Alaska (NGA) is a key ecosystem feature, and its timing influences upper trophic level production. During the months before the spring bloom, environmental drivers modify water column properties and influence the spring bloom onset timing. Changes in daily conditions initiate or disrupt the bloom, yet the relative importance of daily physical drivers on bloom initiation in the NGA remains unclear. This study examined relationships among four environmental parameters: the potential energy anomaly, the mixed layer depth, light, and chlorophyll-a concentrations. They were assessed in relation to the stabilizing and destabilizing effects of wind, surface buoyancy flux, and tides. Primary productivity was also estimated using a bio-optical model. The pre-spring bloom conditions were observed with 2021-2024 multi-month autonomous profiling (0-120 m) underwater vehicle deployments in coastal and mid-shelf waters. The start of the mid-shelf spring bloom coincided with the mixed layer shoaling above the euphotic zone depth as winds diminished, while temperature primarily drove upper water column stratification. Relative to the mid-shelf, blooms within Prince William Sound were less dependent on changing stratification and occurred earlier due to a more sheltered wind environment. At both sites, stratification was modified primarily through wind forcing, followed by surface buoyancy fluxes. The bio-optical productivity model tracked primary production amongst years and sites as well as synoptic-scale changes. This study improved our understanding of regional marine ecosystem functioning by documenting how the spring bloom onset evolved during the winter-spring transition in response to environmental parameters.

S07, Oral, AbstractID=19239

From lagged forensics to real-time dignosis: A new paradigm of integrated biological observation for marine health assessment

Song **Sun**, Xiaoxia Sun, Zang Wenxiao, Xin Jin, Fang Zhang, Nan Wang, Zhongli Sha

Institute of Oceanology, Chinese Academy of Sciences, Qingdao, PR China.
E-mail: sunsong@qdio.ac.cn

Health assessments of marine ecosystems rely heavily on the real-time diagnosis of biological status and functions. However, the “cognitive lag” of traditional biological observation (i.e., the long period from sample collection to species identification and data output, which makes it difficult to reflect rapid changes in the ecosystem promptly) has become the core bottleneck for the operational application of health assessment. This article systematically analyzes the historical roots and contemporary predicaments of this bottleneck, pointing out that it stems from “technological path dependence,” “verification logic paradox,” and “observation network absence.” To break through this predicament, this article proposes a new biological observation paradigm that will enable the shift from “lagging evidence collection to real-time diagnosis”. This paradigm includes three core dimensions: at the cognitive level, it will survey the “complete species set”, track the “functional fingerprints,” and identify key ecological function signals; at the technical level, it will construct a “real-time perception-quality control verification” collaborative technical system, integrate cutting-edge measures such as environmental DNA, in situ imaging, and intelligent acoustics, and innovatively iterate the verification mode; at the network level, through the development of modular intelligent biological sensing modules, it will embed biological sensing capabilities in the global observation network in an “plug-and-play” manner, achieving automated and continuous perception of biological signals. This paradigm shift aims to upgrade biological observations to a forward-looking information infrastructure that supports real-time health diagnoses and early warnings regarding marine ecosystems.

S07, Oral, AbstractID=19280

Toward realization of autonomous Tow-Yo Observations using an Autonomous Surface Vehicle (ASV)

Daisuke **Hasegawa**, Hikaru Homma, Joji Oida D and Yugo Shimizu

Japan Fisheries Research and Education Agency (FRA), Shiogama, Japan.
E-mail: daisukeh@fra.go.jp

As ocean observations become increasingly automated worldwide, efforts are underway in Japan to develop an autonomous tow-yo observation system for integration with a next-generation Japanese Autonomous Surface Vehicle (ASV) currently under development. As part of this effort, the Fisheries Research and Education Agency (FRA) has been developing a compact multi-parameter environmental sensor package capable of repeated vertical profiling from an autonomous surface platform. The sensor package integrates CTD, chlorophyll-a fluorescence, turbidity, and dissolved oxygen (DO) sensors, enabling comprehensive observations of the upper ocean environment. To evaluate the performance of the sensor system prior to deployment on the intended ASV platform, a commercially available Wave Glider has been used as a test platform. Field experiments have been conducted to assess measurement accuracy, operational reliability, durability, and system integration under realistic ocean conditions. The Wave Glider system has successfully demonstrated repeated autonomous tow-yo observations to depths of 150 m. This presentation introduces the development concept and preliminary results obtained from a series of field tests, including tow-yo experiments using a compact memory-type sensor package and subsequent trials using a dedicated real-time prototype powered by the ASV and capable of transmitting data in real time. Plans for a long-term field deployment scheduled for summer 2026 will also be presented. The developed system provides a practical approach for autonomous, repeated profiling of the upper ocean, expanding the capability of ASV-based marine environmental observations.

S07, Oral, AbstractID=19407

Day-night comparison of acoustically observed organism distributions across the Kuroshio Extension front

Hikaru **Homma**[1], Daisuke Hasegawa[1], Tomohito Imaizumi[2], Tomohiko Matsuura[2], Yoshiaki Fukuda[2], and Yuji Okazaki[1]

[1]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Shiogama, Japan. E-mail: homma_hikaru93@fra.go.jp
[2]Fisheries Technology Institute, Japan Fisheries Research and Education Agency, Kamisu, Japan

Frontal zones are known to be highly productive oceanic regions and often form important fishing grounds. To understand the mechanisms of fishing-ground formation, it is crucial to investigate the relationships between the physical/biogeochemical environments associated with complex frontal structures and the distributions of marine organisms across different trophic levels. For this purpose, acoustic techniques such as scientific echosounders are powerful tools that enable high-resolution measurements of organism distributions. However, as some organisms exhibit diel vertical migration (DVM), it is difficult to determine whether a snapshot of the observed distributions reflects environmental dependence or temporal variability in vertical positions. To separate environmental dependence from DVM-driven variability and achieve a more robust evaluation of the environment-ecosystem relationships, we conducted cross-section surveys during both day and night along the same transect and performed day-night comparisons. The surveys were carried out across the Kuroshio Extension front during the research cruise WK2505G in May 2025 with R/V *Wakataka-maru*. Cross sections of environmental properties (temperature, salinity, fluorescence, turbidity, and oxygen concentration) were obtained at high spatial resolution using the tow-yo profiler BioUCTD (JFE Advantech). Acoustic backscattering was measured using a 38-kHz hull-mounted scientific echosounder KFC-3000 (SONIC Corporation), which detects large zooplankton, micronekton, and pelagic fish. Day-night comparisons of cross sections showed the concentrated biomass in the surface water near the front that was independent of time of day. In addition, the surveys revealed fine-scale spatial variability in DVM patterns across the front. Preliminary results of the day-night comparison will be presented.

S07, Oral, AbstractID=19442, (ECOP)

Characterizing the deep chlorophyll maxima in the NE Pacific using ocean gliders

Lauren **Bannerman-Maxwell**, Roberta Hamme and Diana Varela

University of Victoria, Victoria, BC, Canada. E-mail: lbannermanmaxwell@uvic.ca

Deep chlorophyll maxima are frequently observed in data from profiling gliders in the NE Pacific, as a layer of increased fluorescence beneath the mixed layer. They arise from a true increase in carbon biomass at depth, and therefore substantially contribute to water column primary production. However, deep chlorophyll maxima may also be a product of low light acclimation, leading to excess chlorophyll per cell. Here, we use glider fluorescence and backscatter measurements to classify these maxima, with backscatter acting as a proxy for carbon biomass. This data was collected by the Canadian Pacific Robotic Ocean Observing Facility (C-PROOF) between 2019-2024 and, covers Line P and two relatively inshore transects: Calvert and Southern Line. Data from different regions (inshore, transition, offshore) have distinct annual patterns, most notably the lack of spring bloom in the offshore region delays the formation of said maxima. Rather than forming in spring as seen in transition and inshore, these maxima form in early summer. The maxima are most often ~5m thick and, can be found directly beneath the mixed layer to up to 30m deeper. The most pronounced maxima are found in the inshore and transition regions, specifically carbon biomass maxima occur most frequently in the summer. Additional work will further document spatial and temporal variability and, identify when these maxima represent a significant portion of water column biomass. This research will provide insight into phytoplankton physiological patterns, offer important context for researchers encountering deep chlorophyll maxima, and provide complimentary data to surface limited satellite measurements.

S07, Oral, AbstractID=19456, (ECOP)

A comparison of computer vision-assisted predictions to contemporary dive, ROV, and RUV biodiversity surveys

Talen **Rimmer**[1], Colin Bates[2], Declan Macintosh[1], Alexandra Branzan Albu[1], and Francis Juanes[1]

[1]University of Victoria, Victoria, BC, Canada. E-mail: rimmertalen@gmail.com
[2]Cascadia Seaweed Ltd., Sidney, BC, Canada

Computer vision (CV) techniques are increasingly used in marine biodiversity monitoring, yet few studies have directly compared CV-assisted methods to conventional underwater surveys. This study assessed epipelagic macrofaunal diversity at a seaweed farm and nearby reference site in Barkley Sound, British Columbia, using five approaches: diver transects, remotely operated video (ROV) surveys, and three methods based on footage from unbaited remote underwater video cameras, referred to as 'FishCams'. These FishCam methods included manual annotation of a monthly subset (FishCam Subset), and YOLOv8 model predictions applied to the full FishCam dataset, both with training annotations (YOLO With Annotations) and without (YOLO Only). Over seven months of sampling, preliminary analyses indicate that YOLO With Annotations consistently recorded the highest taxonomic and visually-similar group (pseudo-taxonomic) richness and was most effective at detecting rare pseudo-taxa. Survey methods varied in how they characterized ecological communities: ROVs recorded a higher proportion of gelatinous zooplankton, dive surveys detected several unique mobile fish pseudo-taxa, and high-frequency CV methods yielded higher cumulative abundances than monthly surveys. Pseudo-taxonomic richness was significantly greater at the farm site compared to the reference site ($p = 0.024$). There were also significant differences in community composition at the farm site among the different methods. These results are preliminary and should be interpreted with caution, as they partially reflect the differences in sampling frequency and the uniqueness of the study site. Regardless, our findings show the importance of survey method selection in underwater biodiversity studies, and support the use of high-frequency CV-assisted methods in conjunction with conventional approaches (particularly dive surveys) to monitor epipelagic diversity.

S07, Oral, AbstractID=19505, (ECOP)

Comparison of eDNA and video survey methods to monitor glass sponge reefs

Brighid **Odenthal**[1], Rayne Loeffler[2], Kristen Westfall[2], Emily Rubidge[2], and Natalie Ban[1]

[1]University of Victoria, Victoria, BC, Canada. E-mail: bodenthal@uvic.ca
[2]Fisheries and Oceans Canada, Sidney, BC, Canada

British Columbia's glass sponge reefs are unique ecosystems that provide habitat for many marine species, sequester carbon, and filter large amounts of water. Due to the depths of these reefs, tools to monitor them are limited and the health of most reef area is unknown. Because of this, managers are interested in examining the potential of eDNA metabarcoding to monitor this ecosystem in addition to the method currently used, remotely operated video (ROV) video surveys. Water samples for eDNA and ROV video footage were collected at the same glass sponge reef locations, capturing both live and dead reefs. At these locations, 32 taxa were detected in ROV video and 288 taxa were detected by eDNA. Species richness, number of taxa and species, and taxonomic groups identified were compared between methods, and between live and dead reefs. Species detected by ROV video but not eDNA, which are not in genetic sequence databases, were identified as priorities for future DNA sequencing. Indicator species for live and dead reefs were identified based on video survey data. The ability of eDNA to detect these indicator species and therefore the likely location of reefs with alive sponges was examined, and implications for monitoring glass sponge reefs are discussed.

S07, Oral, AbstractID=19532 (ECOP)

Multi-scale geometric metrics and feature extraction for benthic habitat surveying

Evan **Garcia**[1] and Jeffrey S. **Ellen**[2]

Presented by Evan Garcia on behalf of Jeffrey Ellen

[1]Statistics and Data Science, University of California Los Angeles, Los Angeles, CA, USA
[2]Ulysses Ecosystem Engineering Inc, San Francisco, CA, USA.
E-mail: jeff@ulysses.eco, evan@ulysses.eco

Optical cameras and Structure from Motion (SfM) photogrammetry are widely used to generate detailed 3-D reconstructions of benthic environments. These triangular meshes have been the standard for decades (i.e. video games, virtual reality). Building off of these models, and following Young et al. [1], we implement two new metrics that serve as virtual analogs to real-world measurements used in coral reef surveying: rugosity and vector dispersion. For both metrics, Young et al. showed that computing a digital equivalent retained the accuracy of the in-situ physical measurement (i.e. linear rugosity over a single transect digitally is equivalent to laying links of a chain along the seafloor). In our implementation, we extend rugosity and vector dispersion to be omnidirectional and computed at every point in the mesh. Our algorithm also allows calculation at an arbitrary radius of triangular edges, allowing metrics to be computed at scales (both large and small) that would be intractable in-situ, and show proof of concept on coral reef reconstructions. With the ability to collect these metrics over an entire survey area, we believe that more accurate surveys can be conducted, including habitat classification, organism/object identification, biodiversity mapping, and growth/loss quantification.

Omnidirectional rugosity serves as a foundational proof of concept for extracting 3D-native features backed by existing underwater measurement methods. While our initial testing focused on coral reef environments, these calculations can be applied to any 3D dataset where surface distribution and structural complexity are relevant. We believe these engineered features will significantly aid machine learning classification models, and additional structure-relevant metrics (e.g. branching, porosity, and vector dispersion) would further enhance predictive modeling capabilities on 3D data.

[1] G. C. Young, S. Dey, A. D. Rogers, and D. Exton, “Cost and time-effective method for multi-scale measures of rugosity, fractal dimension, and vector dispersion from coral reef 3D models,” *PLOS One*, 2017, doi: 10.1371/journal.pone.0175341

S07, Oral, AbstractID=19538, (ECOP)

Positive-unlabelled active learning to curate a dataset for *orcinus orca* resident interpretation

Bret **Nestor**[1,2], Bohan Yao[3], Jasmine Moore[4] and Jasper Kanes[5]

[1]University of British Columbia, Vancouver, BC, Canada. E-mail: bret.nestor@ubc.ca
[2]Translacean Research Foundation, Vancouver, BC, Canada
[3]University of Washington, Seattle, WA, USA
[4]University of Calgary, Calgary, AB, Canada
[5]Ocean Networks Canada, Victoria, BC, Canada

This work presents the largest curation of Southern Resident Killer Whale (SRKW) acoustic data to date, also containing other marine mammals in their environment. We systematically search all available public archival hydrophone data within the SRKW habitat (over 30 years of audio data). The search consists of a weakly-supervised, positive-unlabelled, active learning strategy to identify all instances of marine mammals. The resulting transformer-based presence or absence classifiers outperform state-of-the-art classifiers on 3 of 4 expert-annotated datasets in terms of accuracy and energy efficiency. The fleet of WHISPER detection models range from 0.58 (0.48-0.67) AUROC with WHISPER-tiny to 0.77 (0.63-0.93) with WHISPER-large-v3. Our multiclass species classifier obtains a top-1 accuracy of 53.2% (11 train classes, 4 test classes) and our ecotype classifier obtains a top-1 accuracy of 33.6% (4 train classes, 5 test classes) on the DCLDE-2026 dataset.

We yield 919 hours of SRKW data, 230 hours of Bigg's orca data, 1374 hours of orca data from unlabelled ecotypes, 1501 hours of humpback data, 88 hours of sea lion data, 246 hours of pacific white-sided dolphin data, and over 784 hours of unspecified marine mammal data. This SRKW dataset is larger than DCLDE-2026, annotated Ocean Networks Canada, and OrcaSound combined. The curated species labels are available under CC-BY 4.0 license, and the corresponding audio data are available under the licenses of the original owners. The comprehensive nature of this dataset makes it suitable for unsupervised machine translation, habitat usage surveys, and conservation endeavours for this critically endangered ecotype.

S07, Oral, AbstractID=19540

Expanding oceanographic sampling for ports using uncrewed surface vehicles and community observatory programs

Fritz **Stahr**[1], Lucianne Marshall[2], Jason Scherr[3], Dandan Huang[1], Sebastian Deggan[1], Forest McKeating[1], Megan Kot[2], Kristen Meyer[2], and Hannah Kosichek[2]

[1]Open Ocean Robotics, Victoria, BC, Canada. E-mail: fritz@openoceanrobotics.com
[2]Ocean Networks Canada, Victoria, BC, Canada
[3]Prince Rupert Port Authority, Prince Rupert, BC, Canada

Collecting ocean observations can be difficult and time consuming, but it adds immense value to expanding our understanding of the environment for operations and policy enforcement. This is particularly true of coastal communities that include large and small port facilities, as well as cities with significant waterfronts and fishing fleets. This presentation describes a collaboration between a supplier of ocean observing systems - Ocean Networks Canada (ONC) - and a supplier of Uncrewed Surface Vehicles (USVs) - Open Ocean Robotics - working with the Prince Rupert Port Authority (PRPA) to enhance their ability to monitor the Port of Prince Rupert's on-water operational areas. Those include both shorelines and activities there such as construction monitoring, noise data collection (baseline, ship noise, marine mammals), as well as outer areas where ships may encounter whales as they enter or exit the Port, or are at anchor awaiting a berth assignment. PRPA operates a fleet of vessels in order to conduct compliance patrols as well as ocean observations and data collection, the latter of which has been conducted in collaboration with ONC's Community Fishers Program (measuring water profile properties). As part of a provincially funded program to accelerate technology innovation and commercialization (Innovate BC), we will showcase how regional funding can support local collaboration, technology and innovation to advance ocean monitoring capabilities for future applications.

SESSION 7: MONITOR Topic Session

Spearheading ocean observations using advanced techniques and sensors on the ocean environment and ecosystem

Poster Presentations

S07, Poster, AbstractID=19238, PosterID: S07-P1

Five-year satellite monitoring of *Suaeda japonica* aboveground biomass in a Korean salt marsh using a parsimonious model

Seongjun **Bae**, Hye Seon Kim, Chang-Ho Yi, Sung-Uk An and Taek-Kwan Oh

Department of Ecology and Conservation, National Marine Biodiversity Institute of Korea, Seocheon, R Korea. E-mail: sjbae@mabik.re.kr

Salt marshes and other vegetated coastal habitats sequester carbon far out of proportion to their occupied area, and have become central to global climate mitigation efforts. However, quantitative biomass and carbon baseline data for the halophyte *Suaeda japonica*, which forms small fragmented communities, remain scarce, and field sampling is limited due to the inaccessibility of intertidal environments. This study examined the reliability of a deliberately parsimonious framework, based on satellite imagery, for mapping *S. japonica* aboveground biomass (AGB) and carbon stock across Garorim Bay, Republic of Korea, calibrated from only 25 field quadrats. Using Sentinel-2 surface reflectance, a single-band linear regression on blue reflectance (B2) achieved the best predictive performance (r^2 = 0.684, RMSE = 0.056 Mg·ha^{-1}), matching or outperforming all multi-feature and nonlinear alternatives, while a single-feature random forest classifier delineated habitats with 94.12% overall accuracy (F1 = 0.970). Applied to cloud-free growing season imagery for 2021–2025, the calibrated models estimated AGB at 0.339 ± 0.162 Mg·ha^{-1} across a 39.36 ha stable habitat in 2025, equivalent to a carbon stock of 6.27 Mg C (95% CI = 4.13–8.41 Mg C). This study demonstrated that, even with limited data, a model with a single predictor can perform as well as a complex model. A simple pipeline, using a single feature for regression analysis and another for classification, can produce reliable biomass and carbon estimates. The proposed framework requires minimal field calibration and is readily transferable to other small fragmented halophyte stands where extensive field campaigns are impractical.

S07, Poster, AbstractID=19288, PosterID: S07-P2, (ECOP)

Fine-scale vertical habitat organization of *Neocalanus plumchrus* and its light-modulated response in the western subarctic Pacific revealed by Video Plankton Recorder

Yixin **Wang**[1], Takuya Sato[1], Dhugal Lindsay[2], Taketoshi Kodama[1] and Kazutaka Takahashi[1]

[1]The University of Tokyo, Tokyo, Japan. E-mail: Bernice_0571@outlook.com
[2]JAMSTEC, Kanagawa, Japan

Neocalanus plumchrus dominates subarctic Pacific mesozooplankton and drives seasonal carbon transport via ontogenetic migration and lipid accumulation, yet how its upper-layer aggregation is organized at the meter scale during the growth stage remains poorly resolved. Using a Video Plankton Recorder, we obtained 44 high-resolution 1-m vertical profiles across six observations (four daytime, two nighttime) at Station K2 (47°N, 160°E), concurrent with temperature, salinity, chlorophyll *a*, and photosynthetically active radiation (PAR).

Occurrence of *N. plumchrus* was organized within a mixed-layer-depth (MLD)-relative habitat envelope. A binomial GAM identified depth relative to MLD as the dominant predictor (DE = 0.29, AUC = 0.85), with the core layer centered ~6 m above the MLD. Day–night comparison revealed that this core remained anchored to consistent MLD-relative positions (weighted mean depth: −6.1 m day, −6.2 m night) and hydrographic conditions (6.05–7.77 °C; σt 25.62–25.92; 0.64–1.0 μg L^{-1} Chl *a*). In contrast, nighttime distributions were markedly broader and more diffuse: effective vertical width increased 67% (6.1 to 10.2 m), and 21% of nighttime abundance occurred below the MLD versus 0% during daytime. Within daytime profiles, piecewise regression identified a PAR breakpoint of 190 μmol m^{-2} s^{-1}, above which 1-m-bin occurrence frequency dropped sharply from 39.2% to 8.3%, indicating that light constrains surface-layer occupancy.

These results reveal a two-tier habitat organization: an MLD-relative anchor defines the core occurrence layer, while ambient light modulates distribution breadth and surface-layer occupancy. This meter-scale structure provides a behavioral basis for understanding copepod aggregation in the subarctic Pacific.

S07, Poster, AbstractID=19300, PosterID: S07-P3, (ECOP)

Eelgrass fish communities track predicted habitat suitability across a coast-wide eDNA monitoring network: Baseline concordance from Alaska to California

Alejandro **Schmill**[1,2], William W. L. Cheung[1], Matthew A. Lemay[2], Margot Hessing-Lewis[2] and Emily Rubidge[3]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: alexschmill4@gmail.com
[2]Hakai Institute, Quadra Island, BC, Canada
[3]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada

Realizing the potential of environmental DNA (eDNA) metabarcoding as a tool for broad-scale biodiversity monitoring requires evidence that detection patterns carry genuine biogeographic signal rather than reflecting sampling artifact or stochastic detection processes. Here, we present a concordance framework that directly addresses this question using data from the Pacific eDNA Coastal Observatory (PECO), a standardized coast-wide monitoring network spanning Alaska to California that annually samples eelgrass fish communities at over 100 sites using a unified metabarcoding protocol. We ask whether eDNA detections across this network concentrate in sites with higher independently predicted habitat suitability, and whether this signal is consistent across years and taxa. By applying a use-availability resource selection function grounded in inhomogeneous Poisson process theory, we model eDNA detection events against habitat suitability index predictions from the AquaX species distribution modelling platform, with sampled sites forming the availability background. This approach explicitly accounts for the non-random distribution of habitat suitability across the network and does not treat non-detections as confirmed absences. Across four years of monitoring (2021-2024) and 88 species, eDNA detections consistently and significantly concentrated in higher-suitability sites at the community level, with all species returning positive concordance coefficients. The signal was robust across years with differing sampling coverage and community composition, and insensitive to variation in detection thresholds and availability definitions. These findings establish that coast-wide eDNA monitoring captures biogeographically structured occurrence information aligned with independent habitat suitability predictions, providing a validated framework for integrating eDNA data into species distribution modelling and long-term biodiversity monitoring programmes.

SESSION 8: BIO/HD Topic Session

Oceanographic change and predator–prey dynamics: Emerging drivers of human–wildlife conflict

Oral Presentations

S08, Invited, AbstractID=19133, (ECOP)

Predators in a shifting sea

Ciara **Willis**

Monterey Bay Aquarium Research Institute, California, CA, USA. E-mail: cwillis@mbari.org

Pelagic predators depend on dynamic and often poorly observed food webs that link ocean physics, prey availability, and animal behaviour across vast spatial scales. As offshore fisheries and marine infrastructure expand, understanding how predators respond to shifting prey landscapes and human activity is increasingly important for anticipating ecological change and informing ocean governance. This talk explores how human-driven ocean change is reshaping pelagic ecosystems through interconnected shifts in food webs, habitat use, and predator-fishery interactions. A central focus is the role of mesopelagic forage in sustaining predator populations, and how growing interest in exploiting midwater prey resources may alter energetic pathways that support valuable fisheries including for tunas. At the same time, highly mobile predators are adjusting movements in response to changing ocean conditions, creating new patterns of overlap with commercial and recreational fisheries. Observations of swordfish on the hook suggest that vertical behaviour during catch-and-release may reflect behavioural thermoregulation, with implications for survival in a warming ocean. For unfished species, direct observations of predators remain challenging, and direct observations of the prey field around a predator are even more rare. To address these challenges, the *Piscivore* autonomous system was designed to enable persistent, non-extractive surveys of predators and prey across both natural and industrial environments, with exciting potential for future ecosystem monitoring programs. By bringing together knowledge of ocean food web architecture, drivers of animal movement, and dynamics of existing human-wildlife interactions, we improve our ability to anticipate emerging interactions before conflict arises.

S08, Invited, AbstractID=19194

Oceanographic variabilities v.s. the cetacean habitats – What changes might occur in their distribution and trajectories?

Hiroko **Sasaki**

Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan. E-mail: sasaki_hiroko50@fra.go.jp

The Pacific Ocean, the Sea of Japan and the Sea of Okhotsk, which surround Japan, are habitats of many cetaceans. Naturally, the oceanographic environment changes with the season which might affect their habitat. Many baleen whales show the distinct north-south migrations between wintering area and summer foraging area. During the foraging migrations, two closely related rorqual species, sei (*Balaenoptera borealis*) and Bryde's whales (*B. brydei*), are known to show the obvious habitat boundary which are defined by oceanographic features such as sea surface temperature. The abundances of minke (*acutorostrata*), sei and bryde's whale were estimated by using density surface models with their oceanographic range. In contrast, small cetaceans such as dolphins and beaked whales don't show the clear north-south migrations. But, many cases of their habitat have been defined the oceanographic features including the topographic features. Satellite tags study reveal that the habitat ranges of Dall's porpoise (*Phocoenoides dall*) were restricted by water temperature with avoiding warm waters. The sighting data and the recent oceanographic reanalysis data show the habitat of small odontocetes in relation to wide-scale oceanographic structure and the seasonal patterns for 14 species. Recently, we estimated the abundance Baird's beaked whale (*Berardius bairdii*) around Japan. These distribution ranges, particularly northern waters off Japan are susceptible to recent unprecedent ocean warming such as northern shift of Kuroshio Extension and ocean heatwaves. These estimates were compared with the previous abundance estimates in 1980s. The estimated abundance trends will be discussed in relation to long-term oceanographic variability around Japan.

S08, Invited, AbstractID=19208

Avoiding listening space collapse: Ocean noise, prey unprofitability, and reactive vessel management in the Salish Sea

Ruth **Joy**[1], Fabio Frazao[1,2], Lauren Laturnus[3], Teng-Wei Lin[4], Janine McNeilly[5], Bruno Padovese[1], Neil Saxvik[1] and Peter Thompson[1]

[1]School of Environmental Science, Simon Fraser University, Burnaby, BC, Canada.
E-mail: rjoy@sfu.ca
[2]Interdisciplinary PhD Program, Dalhousie University, Halifax, NS, Canada
[3]Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada
[4]Department of Statistics and Actuarial Science, Simon Fraser University, Burnaby, BC, Canada
[5]Raincoast Conservation Foundation, Pender Island, BC, Canada

Decadal-scale increases in underwater sound pressure levels from commercial vessels now pollute the echolocation frequency ranges that Southern Resident killer whales (SRKW) depend on to hunt in the Salish Sea. This chronic noise reduces listening space and echolocation space, forcing whales to be significantly closer to prey to detect returning echolocation clicks, while also impairing communication and navigation. Within a prey field already depleted by declines in Chinook salmon, their preferred prey, high ambient noise further reduces the viability of alternative prey such as sablefish and coho. Recent biologging results show that SKRW experience lower hunting success and may stop foraging altogether in high noise conditions. We show that most prey species become bioenergetically unprofitable under elevated noise conditions, effectively trapping SRKW on Chinook salmon as the only prey whose caloric return exceeds the acoustic cost of detection and capture. To address this predator–prey trap, we are building a near real-time vessel slowdown system for commercial ships en route to the Port of Vancouver when SRKW are present in the Salish Sea. Our approach integrates automated infrared cameras, AI-based detection algorithms, passive acoustic monitoring using hydrophones, trained networks of citizen scientists on both sides of the Canada–U.S. border, eNGO support, First Nation Marine Guardians, and, pending a forthcoming localization trial, fiber-optic cable sensing. Together, these innovations enable the potential for a reactive management infrastructure that reduces vessel noise during critical foraging periods, directly mitigating an emerging form of human–wildlife conflict driven by changing ocean acoustics.

S08, Oral, AbstractID=19144, (ECOP)

Spatial association between anchored fish aggregating devices (aFADs) and endangered, threatened, and protected megafauna in the Celebes Sea

Widhya N. **Satrioajie**[1,2], Achmad Sahri[3], Rr Sekar Mira[3], Imam Prakoso[4], Makoto Tomiyasu[1], Yasuzumi Fujimori[1]

[1]Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Japan.
[2]Directorate for Environment, Maritime, Natural Resources, and Nuclear Policy, National Research and Innovation Agency (BRIN), Jakarta, Indonesia.
E-mail: wi2ed_myunk@yahoo.co.id
[3]Research Center for Biota Systems, National Research and Innovation Agency (BRIN), Cibinong, Indonesia
[4]Indonesia Ocean Justice Initiative (IOJI), Jakarta, Indonesia

Anchored fish aggregating devices (aFADs), locally known as *rumpon*, are central to tuna fisheries in the Celebes Sea, with hundreds of structures deployed across the fishing grounds of North Sulawesi. Despite their prevalence, the ecological footprint of aFADs on marine megafauna remains largely undocumented. We used systematic helicopter aerial surveys from the BRIN-OceanX Expedition (December 2025 to January 2026) to examine whether and how marine megafauna spatially associate with aFADs across approximately 49,000 km² of the Celebes Sea. We recorded 170 georeferenced aFADs and 65 megafauna sightings from over 20 species, including whale sharks, sperm whales, manta rays, beaked whales, and sea turtles. Nearest-neighbour distance analysis and a randomization null model (999 iterations) showed that megafauna occurred significantly closer to aFADs than expected by chance (overall $p<0.001$). Cetaceans showed the strongest spatial association ($p<0.001$), while elasmobranchs were borderline significant ($p=0.054$), likely reflecting the smaller sample size. Over 37% of sightings were endangered, threatened, or protected (ETP) species, indicating systematic spatial overlap between sensitive megafauna and active fishing grounds. We also recorded sperm whales during the Southwest monsoon, a season when their presence in the Celebes Sea was not historically predicted (Sahri et al. 2020). Taken together, these findings provide the first spatially explicit, large-scale documentation of ETP megafauna co-occurrence with aFAD-based tuna fisheries in the region, with direct implications for bycatch risk assessment and Indonesia's compliance with the U.S. Marine Mammal Protection Act Import Provisions.

S08, Oral, AbstractID=19177, (ECOP)

Killer whale movements appear structured by physical oceanographic processes rather than prey density alone

Chuyi **Lin**[1,2] and Andrew W. Trites[2]

[1]Shanghai Ocean University, College of Oceanography and Ecological Science, Shanghai, PR China. E-mail: cyl.charlylane@outlook.com
[2]Marine Mammal Research Unit, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, British Columbia, Canada

The endangered Southern Resident killer whale population is widely considered to be limited by prey availability. However, prey density alone is unlikely to explain the full variability in foraging success. We identified additional mechanisms influencing predator–prey interactions by integrating multi-source biological survey data (including biologging, drone and focal follows) with high-resolution oceanographic models to reconstruct fine-scale movements of northern resident killer whales in Queen Charlotte Strait, British Columbia, and examine their relationship with Chinook salmon habitat proxies. Tidal analysis revealed that semidiurnal tidal constituent (M_2) dominated regional flow dynamics, explaining the majority of current variability. Whale movement trajectories exhibited structured relationships with tidal flow, consistent with both energy optimization and counter-current foraging hypotheses. In addition, whale tracks aligned with persistent thermal and haline fronts, suggesting that whales may actively use these frontal zones as foraging habitats because such features can concentrate prey through aggregation processes. These findings indicate that physical oceanographic processes—particularly tides and frontal structures—likely play a key role in shaping predator movement and foraging opportunities beyond simple prey density effects. Whales appear to preferentially use frontal zones and exhibit behavior consistent with tidal-dependent foraging strategies. This work provides a framework for integrating multi-scale oceanographic and biologging data to better understand predator–prey coupling in dynamic coastal systems, with important implications for the conservation of endangered killer whale populations.

S08, Oral, AbstractID=19179

Distributional changes of marine species in Hawaii using 79 years of commercial catch data

Donald R. **Kobayashi**

Pelagic Research Program, Pacific Islands Fisheries Science Center, NOAA, Honolulu, HI, USA.
E-mail: donald.kobayashi@noaa.gov

Detecting long term changes in distribution and abundance relies on quantitative examination of long term data streams. One such data stream is the commercial catch reporting system in Hawaii administered by the Division of Aquatic Resources, State of Hawaii. Commercial marine licenses in this program and monthly reporting are required for individuals engaged in taking, selling or offering for sale any marine life for commercial purposes. This program started in 1948 and offers 79 years of catch information for a network of statistical areas covering the Hawaiian Islands for a variety of different gears. These data were used to characterize latitudinal patterns over time for taxonomic units (usually species) in the database. The catch data is reported for a variety of organisms including intertidal seaweeds, invertebrates, sharks, and many other fishes. Catch records were screened to yield a subset of daily effort records which could be used to estimate catch rate (e.g., CPUE proxy for abundance). 71 different taxonomic units had a complete 79 year time series and were used in the analysis. Latitudinal patterns were estimated using a catch rate weighted average latitude based on the centroid of the statistical area for that catch. Linear regressions were used to identify significant changes in latitude over time, and dynamic factor analysis was used to cluster similar patterns into groups. Six patterns were found to represent the dataset. These predominant patterns are discussed with respect to long term environmental changes and other factors which contribute to the results.

S08, Oral, AbstractID=19221, (ECOP)

Past and projected overlap between baleen whale forage habitat and a California fixed gear fishery

Danial G **Palance**[1], Nerea Lezama-Ochoa[2], Jarrod A Santora[3], Gemma Carroll[4], Heather Welch[2], Barbara A Muhling[2], Mercedes Pozo Buil[2], Karin A Forney[5,6], Elizabeth A Becker[7], Megan Cimino[2], Briana Abrahms[8], Ryan Bartling[9], Steven J Bograd[10], Roxanne S Beltran[1], Elliott L Hazen[3], Stephanie Brodie[2,11]

[1]Department of Ecology & Evolutionary Biology, University of California Santa Cruz, CA, USA. E-mail: danpalance@gmail.com
[2]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, USA
[3]Fisheries Ecology Division, NOAA Southwest Fisheries Science Center, Santa Cruz, CA, USA
[4]Environmental Defense Fund, Seattle, WA, USA
[5]Marine Mammal and Turtle Division, NOAA Southwest Fisheries Science Center, Moss Landing, CA, USA
[6]Moss Landing Marine Laboratories, San Jose State University, Moss Landing, CA, USA
[7]National Marine Fisheries Service, NOAA, Ocean Associates, Inc., Under Contract to
[8]Center for Ecosystem Sentinels, Department of Biology, University of Washington, Seattle, WA, USA
[9]Marine Region, California Department of Fish & Wildlife, Santa Rosa, California, USA
[10]Ecosystem Science Division, NOAA Southwest Fisheries Science Center, Monterey, CA, USA
[11]Environment Research Unit, Commonwealth Scientific and Industrial Research Organisation, Brisbane, QLD, Australia

We have limited understanding of how highly migratory predators respond to novel prey redistributions and how these shifts may influence human-wildlife conflict. Baleen whales experienced record entanglements with the California Dungeness crab fishery during the 2015-16 large marine heatwave, which have been indirectly related to changes in prey availability and distribution that resulted in increased spatiotemporal overlap with the fishery. Accordingly, there is a need to improve understanding of future overlap between whale foraging grounds and one of California's most economically and culturally important fisheries. We examined predator-prey overlap using species distribution models of humpback whale, blue whale, and northern anchovy habitat and krill density. We compared the spatial area of foraging habitat to historical entanglement rates and proximity to the fishery footprint using a historical re-analysis of ecosystem conditions. Historical (1998-2018) changes in humpback anchovy-overlap mirrored observed entanglements. We then projected habitat suitability under future climate change, from 1980-2100 under RCP8.5. We found a reduction in future humpback overlap with both prey species and a northward expansion in blue whale-krill overlap across the ecosystem. Within each fishery management zone, humpback overlap with both prey declined by century's end though was closer to the fishery footprint, while blue whale-krill overlap expanded north and further

offshore away from the fishery footprint. These findings highlight how different species occupying similar trophic levels within the same ecosystem may have divergent responses to the climate-driven redistribution of prey availability, with the potential to modify the risk of human-wildlife conflict.

S08, Oral, AbstractID=19235

Impacts of marine plastics on sei and Bryde's whales in the western North Pacific

Hiroki **Sakai**[1], Satoko Inoue[1], Tomoe Kuno[1], Atsushi Takahashi[2], Natsuko Kajiwara[3], Tatsuya Isoda[1], Tsutomu Tamura[1], Genta Yasunaga[1] and Yoshihiro Fujise[1]

[1]Institute of Cetacean Research, Tokyo, Japan. E-mail: sakai@cetacean.jp
[2]IDEA Consultants Inc., Yaizu, Japan
[3]National Institute for Environmental Studies, Tsukuba, Japan

Marine plastic pollution has become a global environmental concern, yet its role in contaminant exposure of pelagic large whales remains unclear. We conducted a long-term assessment of marine macro-debris ingestion (2000–2018) in sei whales (*Balaenoptera borealis*) and Bryde's whales (*B. edeni*) from the western North Pacific, a hotspot of floating plastics, and analyzed polybrominated diphenyl ethers (PBDEs) and legacy persistent organic pollutants (POPs) in blubber samples to examine the potential risk of exposure to plastic-associated chemicals released in the stomach. Marine macro-debris was detected in 36.8% of sei whales and 16.2% of Bryde's whales. Most macro-debris consisted of plastics, with a significant temporal increase and latitudinal variation observed in sei whales. PBDEs were detected in all individuals, but concentrations were relatively low (median 6.6 and 5.8 ng/g lipid weight in sei and Bryde's whales, respectively), one to two orders of magnitude lower than legacy POPs in both species, and these concentrations were lower than reported effect thresholds in cetaceans. Principal component analysis revealed species-specific contaminant patterns, suggesting that PBDE exposure may reflect environmental behavior and trophic transfer processes as those observed for legacy POPs. Furthermore, biomagnification factors to their prey items for most PBDE congeners exceeded 1 and were comparable to those of legacy POPs, suggesting efficient trophic transfer via prey. The results suggest that the risk of PBDE exposure from ingested plastics may be low, although sei and Bryde's whales in the western North Pacific are frequently exposed to floating plastic.

S08, Oral, AbstractID=19405, (ECOP)

Environmental drivers of common dolphin (*Delphinus delphis*) occurrence off Ulsan, Korea

Yunji **Noh**[1], Chanhyung Jeon[1], Jae-Hun Park[2], Young-Gyu Park[3], Seongbong Seo[3], Gyeongbin Moon[1,4] and Dong Guk Kim[3]

[1]Pusan National University, Busan, R Korea.
E-mail: jeonc@pusan.ac.kr, yunji0567@pusan.ac.kr
[2]Inha University, Incheon, R Korea
[3]Korea Institute of Ocean Science and Technology, Busan, R Korea
[4]IBS Center for Climate Physics, Busan, R Korea

Opportunistic sightings of common dolphins (*Delphinus delphis*) collected from a whale-watching cruise off Ulsan along the southeastern coast of Korea, revealed clear seasonal and interannual variability during the recording periods between 2013 and 2018. Common dolphin occurrence in this region is closely associated with physical-biological variables such as the upwelling index, upper-layer water temperature, chlorophyll-a concentration, and fisheries catch. During spring and autumn, coastal upwelling enhanced primary productivity and prey abundance, leading to higher sighting rates of common dolphins. In contrast, summer intense upwelling induced a sudden drop in water temperatures, thereby restricting suitable habitats for the common dolphins. In summers of 2015 and 2018, exceptionally high sighting rates were recorded due to the weakened upwelling, probably related to large-scale atmospheric forcing changes, which sustained anomalously warm conditions and provided suitable habitats. Therefore, coastal upwelling would be a key environmental driver for occurrence patterns of common dolphins, operating through both productivity enhancement and thermal habitat constraints.

S08, Oral, AbstractID=19431

Understanding the consequences of range expansion and increasing abundance of California sea lions in B.C. Waters

Sheena **Majewski**, M. Kurtis Trzcinski, Chad A. Nordstrom, Wendy Szaniszlo, Angela D. Schulze, Strahan Tucker

Fisheries and Oceans Canada, Nanaimo, BC, Canada.
E-mail: sheena.majewski@dfo-mpo.gc.ca, strahan.tucker@dfo-mpo.gc.ca

Following protection from commercial harvest and predator control, California sea lions (CSL) have recovered and stabilized near carrying capacity. The stock breeds at rookeries in southern California during May–June, after which some subadult and adult males migrate north to British Columbia (BC), with occasional sightings in southern Alaska during fall and winter. Coastwide aerial surveys show that the number of CSL overwintering in BC has increased substantially in recent years, accompanied by an expansion of haul-out sites and earlier seasonal arrival. The causes remain uncertain but may include shifts in prey distribution and availability associated with ocean warming in the southern portion of their range, and density-dependent processes as the population reached carrying capacity, driving more males northward in search of foraging opportunities. These increases in abundance and distribution have raised concerns about potential ecosystem impacts, including competition for prey with resident pinnipeds (Steller sea lions and harbour seals) and effects on fisheries. To investigate resource use, we quantified the diets of sympatric pinnipeds using DNA metabarcoding and hard-part analysis of more than 6,000 scat samples collected across broad spatial and temporal scales. Results suggest that the three pinniped species currently partition resources sufficiently to coexist. However, substantial niche overlap indicates that competition could intensify in increasingly dynamic marine ecosystems. Rather than viewing pinniped–fisheries conflict solely as a function of predator abundance or simple trophic links, a niche-based framework emphasizes overlap between realized niches and fisheries generating testable predictions about conflict to inform ecosystem-based management in changing ecosystems.

S08, Oral, AbstractID=19509

From bottom up forcing to top down change: Marine heatwaves may have disrupted killer whale–Chinook dynamics in the Salish Sea

Andrew W **Trites**[1], Taryn Scarff[1], Tess McRae[1], Chuck Parken[2], and Jacob E Lerner[1]

[1]Marine Mammal Research Unit, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: a.trites@oceans.ubc.ca
[2]Fisheries and Oceans Canada, Salmon and Freshwater Ecosystems Division, Pacific Biological Station, Nanaimo, BC, Canada

Rapid oceanographic change is reshaping marine food webs, with bottom-up perturbations propagating to top-down predator dynamics and increasing the potential for overlap and conflict between marine mammals and human activities. In the Salish Sea, the endangered southern resident killer whale (SRKW) population has traditionally tracked the seasonal availability of returning Chinook salmon (*Oncorhynchus tshawytscha*), their primary prey. However, recent shifts in whale distribution suggest a possible decoupling of this historically tight predator–prey relationship. We evaluated changes in SRKW–Chinook dynamics using a 14-year time series (2010–2023) of sightings data for all three SRKW pods (J, K, and L) and fishery-based indices of Chinook abundance and run timing from the Albion Test Fishery. Prior to ~2016, SRKW presence was strongly synchronized with seasonal returns of Chinook, particularly during summer and early fall. This synchrony weakened markedly after 2016–2017, coincident with declining returns of early-run, stream-type Chinook and a compression in migration timing of ocean-type Chinook. Post-2016, K and L pods showed substantial declines and increased intermittency in Salish Sea presence, whereas J pod maintained a more consistent, year-round use of the region. The timing of this shift aligns with the 2013–2016 Northeast Pacific marine heatwave (“the Blob”), a basin-scale perturbation that altered lower trophic levels and reduced growth and survival of juvenile salmon. We hypothesize that stream-type Chinook, which enter the ocean at older ages, were disproportionately affected relative to ocean-type life histories. Given typical 2–4 year return lags, these cohort-level impacts would be expected to manifest in adult returns beginning ~2017–2019, consistent with the observed weakening of SRKW–Chinook co-presence. The data further suggest a persistent legacy effect of the heatwave on regional ecosystem structure, which is further compounded by the current heatwave. These results imply that bottom-up, climate-driven reorganization of prey availability may have altered SRKW foraging patterns and seasonal habitat use. Such shifts may increase spatial and temporal overlap between whales and fisheries as predators adjust to changing prey fields, elevating the potential for conflict. Understanding such cascading dynamics is essential for anticipating and mitigating emerging conflicts between humans and marine mammals in rapidly changing ocean ecosystems.

S08, Oral, AbstractID=19518

Marine mammals, fisheries, and a changing climate in the eastern Gulf of Alaska

Szymon **Surma**[1,2], Kerim Y. Aydin[3], Curry J. Cunningham[2], Elizabeth A. McHuron[3,4], Bridget E. Ferriss[3], Beatriz S. Dias[3,4], Alberto Rovellini[3,4], Albert Hermann[4,5], Andy Whitehouse[3], Jamal A. Moss[6,7], and Martin W. Dorn[3,4]

[1]University of British Columbia, Vancouver, BC, Canada. E-mail: szymon.surma@gmail.com
[2]University of Alaska Fairbanks, Juneau, AK, USA
[3]Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[4]University of Washington, Seattle, WA, USA
[5]Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[6]NOAA Fisheries Alaska Region, National Oceanic and Atmospheric Administration, Juneau, AK, USA
[7]North Pacific Anadromous Fish Commission, Vancouver, BC, Canada

In coastal ecosystems, marine mammals (particularly pinnipeds) and fisheries frequently target the same species, creating the potential for competition, depredation, entanglement, and other ecologically and socially problematic interactions. The eastern Gulf of Alaska (EGOA) supports important commercial, recreational, and subsistence fisheries for groundfish, salmon, and herring, as well as recovering populations of federally protected marine mammals (notably Steller sea lion, harbor seal, and humpback whale), and has recently been impacted by several marine heatwaves. This study investigates the ecological connections between marine mammals and fisheries in the EGOA, and the resulting potential for problematic interactions between them, under a changing climate. All analyses were conducted in a mass-balanced food web model fitted to historical time series. Firstly, trophic niche overlap (i.e. similarity in diet or catch composition) was computed for all consumers and fisheries. Secondly, mixed trophic impacts (i.e. instantaneous effects, through all direct and indirect trophic pathways, of a species or fishery on another) were calculated for all food web nodes, including fisheries. Thirdly, mammal biomasses and fisheries catches were projected under three climate scenarios based on ocean temperature trends corresponding to low, medium, and high future carbon emissions. This research was designed to inform policy solutions intended to mitigate problematic interactions between marine mammals and fisheries in the EGOA.

S08, Oral, AbstractID=19521

Using long-term ecosystem observations to understand trophic responses to ocean change in the central California Current

Jaime **Jahncke**[1,2], Meredith Elliott[1], Lala Movsesian[1,2], Pete Warzybok[1], Michael Johns[1], Jan Roletto[3] and Danielle Lipski[3]

[1]Point Blue Conservation Science, Petaluma, CA, USA. E-mail: jjahncke@pointblue.org
[2]Department of Biology, San Francisco State University, Tiburon, CA, USA
[3]Greater Farallones and Cordell Bank National Marine Sanctuaries, San Francisco, CA, USA

The California Current has experienced substantial oceanographic variability over the past two decades, including marine heatwaves, El Niño events, shifts in coastal upwelling, and increasing ocean temperatures. These changes influence marine ecosystems through bottom-up processes that alter prey availability and reshape the distribution, foraging behavior, and habitat use of marine predators. Such shifts can increase spatial overlap between wildlife and human activities, including fisheries and vessel traffic. The Applied California Current Ecosystem Studies (ACCESS) project provides long-term ecosystem monitoring records linking oceanographic conditions, zooplankton communities, seabirds, and marine mammals across the Greater Farallones and Cordell Bank National Marine Sanctuaries and the northern portion of Monterey Bay National Marine Sanctuary.

Using ACCESS observations from 2004–2025, we examined how changing ocean conditions influenced forage communities and marine predators in the central California Current. Warm periods were associated with reduced krill abundance, shifts in zooplankton community composition toward gelatinous taxa, smaller krill size, and increased spatial variability in prey availability. These changes altered predator distributions, shifted seabird foraging patterns, and changed whale habitat use, increasing the likelihood of predator aggregation in areas where human activities are concentrated. In contrast, cooler and more productive periods supported greater krill availability and more consistent predator distributions.

Long-term ACCESS observations provide a fine-scale regional perspective on how climate variability restructures predator-prey relationships in the California Current. Our results demonstrate that sustained ecosystem observations improve understanding of trophic responses to climate forcing and provide an early warning of changing predator distributions that can inform ecosystem-based management and reduce risks of human-wildlife interactions, including whale entanglement and vessel strikes. Long-term monitoring remains essential for anticipating ecosystem responses to future climate extremes and supporting adaptive management that benefits both marine wildlife and coastal communities.

S08, Oral, AbstractID=19550, (ECOP)

Mapping prey-driven habitat and fishery-overlap risk for East Asian finless porpoises with multimodal explainable AI

Peng **Lian** and Xiaomei Wang

Chinese Academy of Fishery Sciences, Beijing, PR China. E-mail: lianpeng@cafs.ac.cn

Climate-driven prey redistribution can draw marine predators into intensively fished coastal waters, yet conventional habitat models often confound ecological preference with unequal detectability. We developed a multimodal explainable artificial intelligence (XAI) framework to identify habitat use and potential fishery exposure of the East Asian finless porpoise (*Neophocaena asiaeorientalis sunameri*) in China's Bohai and Yellow Seas. The framework integrates passive acoustic monitoring of echolocation clicks, environmental DNA, EK80 and DTX hydroacoustic observations of prey fields, unmanned aerial vehicle thermal imagery, hydrographic conditions, and vessel activity. A hierarchical spatiotemporal model estimates latent porpoise occurrence, while sensor-specific observation components account for differences in detection range, sampling effort, weather, and sea state. Spatially blocked SHAP values, accumulated local effects, and counterfactual perturbations distinguish environmental conditions supporting porpoise habitat from factors increasing exposure to fishing activity. Preliminary cross-platform analyses show strongly clustered porpoise use, with recurrent hotspots in the Changdao–Laizhou Bay sector supported by independent acoustic, eDNA, and aerial observations. The joint model links these hotspots to prey-layer structure and hydrographic gradients, while integration with vessel activity identifies locations where productive foraging habitat may also create elevated interaction risk. Cross-sensor agreement provides an internal confidence measure and reduces reliance on any single detection method. This approach moves beyond presence-only habitat mapping by connecting oceanographic change, prey availability, predator occurrence, and human activity within an uncertainty-aware framework. The resulting seasonal risk maps can guide targeted monitoring and spatially explicit mitigation of bycatch and vessel disturbance. The framework is transferable to other data-limited coastal predators across the PICES region.

SESSION 8: BIO/HD Topic Session

Oceanographic change and predator–prey dynamics: Emerging drivers of human–wildlife conflict

Poster Presentations

S08, Poster, AbstractID=19181, PosterID: S08-P1

Beyond statistical proxies: Causal inference replaces environmental driver selection for transferable fishery predictions

Linhui Wang[1], Liming **Song**[1,2], Shun Wang[1], Yuwei Li[1], Shirui Huang[1]

[1]College of Marine Living Resource Sciences and Management, Shanghai Ocean University, Shanghai, PR China. E-mail: lmsong@shou.edu.cn
[2]National Engineering Research Center for Oceanic Fisheries, Shanghai, PR China

Environmental predictors used in fisheries forecasting are typically selected according to statistical correlation with catch data, despite the long-standing recognition that correlation does not necessarily imply ecological causation. This reliance can reduce model transferability and generate habitat predictions that are statistically plausible but ecologically unrealistic. We developed a three-stage causal inference framework, MB-DRC-Tweedie, which combines Markov Blanket learning with regression-based causal validation to identify environmental drivers of catch-per-unit-effort (CPUE) while reducing spurious associations. Using bigeye tuna (Thunnus obesus) in the Western and Central Pacific Ocean as a case study, we demonstrate that causal-driven variable selection yields three advances. First, causal feature sets exhibited greater environmental diversity and vertical representativeness than correlation-matched counterparts, reducing dissolved-oxygen dominance from 81% to 24% and replacing redundant environmental proxies with complementary ecological constraints. Second, causal-driven predictor sets consistently improved predictive performance, achieving a 92% win rate in interannual validation and a 74% win rate in spatial transfer across Exclusive Economic Zones. Third, causal-driven habitat suitability models generated spatial patterns that more closely matched observed abundance distributions and exhibited stronger ecological constraints than correlation-driven alternatives. These findings demonstrate that improving predictor selection may be as important as improving modelling algorithms when forecasting highly dynamic marine ecosystems. By shifting from correlation-based proxies toward causally consistent ecological constraints, the MB-DRC-Tweedie framework provides a more interpretable, transferable, and climate-resilient foundation for fisheries forecasting, habitat modelling, and marine spatial planning.

S08, Poster, AbstractID=19195, PosterID: S08-P2, (ECOP)

Killer whale acoustic presence is associated with Commander squid and greenling catches

Mayuko **Otsuki**[1], Orio Yamamura[1] and Yoko Mitani[2]

[1]Hokkaido University, Hakodate, Japan. E-mail: motsuki@ees.hokudai.ac.jp
[2]Kyoto University, Kyoto, Japan

The coexistence of wildlife and human activities such as fisheries and tourism is an important issue in this changing environment. Killer whales (*Orcinus orca*) have become an important attraction for wildlife tourism in northern Hokkaido, Japan. Off Kushiro, fishermen have reported interactions between killer whales and fisheries, including fishing gear damages and slime flounder (*Microstomus achne*) losses. Off Rausu, where fisheries and whale watching are both popular, fishermen have not reported fishing gear damage associated with killer whales. However, the relationship between killer whale occurrence and fisheries resources remains poorly understood. Here we compare catches of economically important species with the occurrence of killer whale calls recorded off Rausu intermittently from 2012 to 2014. Fisheries catch data were compiled from information provided by the Hokkaido Fisheries Cooperatives and Hokkaido Marinenet. We regressed the monthly occurrence of killer whale calls against the monthly catches of walleye pollock (*Gadus chalcogrammus*), greenling (*Pleurogrammus azonus*), chum salmon (*Oncorhynchus keta*), cod (*Gadus macrocephalus*), Japanese common squid (*Todarodes pacificus*) and Commander squid (*Berryteuthis magister*). We included Commander squid because it belongs to Gonatidae, which have been found in killer whales' stomachs. Killer whale calls were recorded from May to August, whereas fisheries activities were primarily observed from September to January. The occurrence of killer whale calls increased significantly with greenling and Commander squid catches. The catches of other species showed non-significant decreasing relationships with the acoustic presence. Our results suggest that relationships between killer whale occurrence and fisheries catches may be species- and location-specific.

S08, Poster, AbstractID=19366, PosterID: S08-P3 CANCELLED

~~Indigenous-led monitoring reveals seasonal patterns of pinniped use in Pacific salmon rivers on Vancouver Island, BC~~

~~Cypress Hunder~~ **Rookes**[1], ~~Jeremy Ross[2], Sam James[1], Katie Innes[1] and Jamieson Atkinson[1]~~

[1]~~Pacific Salmon Foundation, Vancouver, BC, Canada. E-mail: chunder-rookes@psf.ca~~
[2]~~Simon Fraser University, Vancouver, BC, Canada.~~

~~Pinnipeds are important predators in marine ecosystems and may influence Pacific salmon (*Oncorhynchus* spp.) survival. In response to concerns raised by First Nations partners regarding increased pinniped presence in lower rivers and estuaries, we initiated a multi-method monitoring program in three Vancouver Island river systems to characterize pinniped distribution, abundance, and habitat use in relation to salmon migrations. Monitoring methods included drone-based estuary surveys, in-river visual surveys, and trail cameras, with combined drone and visual surveys providing the most reliable detection. Pinnipeds primarily occupied estuarine environments, with upriver movements increasing in the fall and varying with season, tide, and time of day. Pinniped abundance increased during adult salmon returns, indicating periods of elevated predation risk, whereas responses during juvenile salmon outmigration were weaker, more variable, and differed among river systems. Distinct patterns emerged between Pacific Harbour Seals (*Phoca vitulina*) and sea lions (family Otariidae), with sea lions exhibiting stronger responses to salmon abundance and greater late-fall presence, potentially corresponding to the end of Chinook (*O. tshawytscha*) and coho *(O. kisutch)* runs and peak chum salmon (*O. keta*) returns. These findings improve understanding of pinniped-salmon interactions in lower river environments while contributing to First Nations-led stewardship and collaborative salmon recovery efforts in British Columbia.~~

S08, Poster, AbstractID=19537, PosterID: S08-P4 CANCELLED

~~**Ocean climate change determines seabird-fisheries competition: A problem across systems**~~

~~William J. **Sydeman**~~

~~Farallon Institute, Petaluma, CA, USA. E-mail: wsydeman@faralloninstitute.org~~

~~Seabird-fisheries exploitative or interference competition results from limitations in prey resource availability, and is a vexing problem facing ecosystem and fisheries managers globally. Ocean climate change is likely to make the problem worse, by altering prey abundance and reshaping prey fields that link physical forcing to seabirds and fishing fleet "foraging" behavior. The effects of ocean climate change on forage (fish, krill,) seabirds, and fishing fleets have been well studied in upwelling, temperate shelf, and high latitude spring bloom systems. In all systems, frontal zones may concentrate forage, creating patches that seabirds track to meet high energetic demands, while fisheries target the same aggregations to target "economically accessible" fish. Competition therefore emerges not simply from shared use of resources from the same locale or region, but from overlap in the size, timing, and accessibility of prey under changing ocean conditions. Within systems, inference of seabird-fisheries competition is a challenge as seabirds and fisheries may respond to the same oceanographic driver. Correlations in space may reflect shared habitat selection, rather than direct resource competition, and coarse spatial or temporal aggregation can mask or amplify relationships. A biophysical and experimental framework that explicitly links climate-driven prey redistributions, predator foraging constraints, and fishery effort is presented as the most defensible basis for evaluating how oceanographic shifts may intensify competition, and translate into demographic consequences for seabirds.~~

S08, ORAL, AbstractID=19561 (ECOP) (poster->oral)

Integrating Dynamic Energy Budget theory into a population dynamics model to explore energetic demands of a declining marine mammal, the northern fur seal (*Callorhinus ursinus*), under climate change

Anna **Sulc**[1], Matthieu Veron[2], Bastien Sadoul[2], Liz McHuron[1], Jeremy Sterling[3], Kirstin Holsman[3] and André Punt[1]

[1]University of Washington, Seattle, WA, USA. E-mail: sulca@uw.edu
[2]Institut Agro Rennes Angers, Fisheries and Aquatic Sciences Center, Rennes, France
[3]Alaska Fisheries Science Center, NOAA Fisheries, Seattle, WA, USA

Marine ecosystems globally are changing rapidly and experiencing unprecedented environmental conditions which result in the alteration of their dynamics, leading to a wide scale of impacts on marine food webs, from changes in abundance and productivity of a population to the modification of trophic interactions. The northern fur seal (NFS) (*Callorhinus ursinus)* is a top predator in the Eastern Bering Sea (EBS) marine ecosystem, playing an important ecological and economical role through consumption of large amounts of commercially valuable walleye pollock (*Gadus chalcogrammus*) This creates direct competition with one of the largest fisheries in the United States for the same resource. The NFS is also culturally important, harvested by native communities for subsistence and tradition. Local populations have experienced ongoing declines since the mid-1990s, hypothesized to be driven by food availability, specifically for lactating females whose ability to find food during an energetically intense time period is a strong driver of offspring growth and survival. As pollock distribution shifts under climate change, the potential for conflict between NFS predation demand and fishery removals could intensify.

Most fisheries stock assessments still take a single-species approach that cannot resolve this kind of predator-fishery resource competition. CEATTLE, a climate-enhanced multispecies stock assessment model, considers predator-prey dynamics between different species of groundfish but omits interactions with other predators, such as marine mammals, leaving NFS-fishery interactions unquantified.

Here we develop a Dynamic Energy Budget (DEB) model for NFS, a bioenergetic framework capturing how an individual acquires and uses energy for development, growth, maintenance, and reproduction, focusing on gestation and lactation dynamics given their importance for pup growth and survival. This individual-level model is coupled with an age-structured population framework and forced with projected prey availability from CEATTLE across climate scenarios through 2100, allowing us to evaluate how shifting prey availability affects NFS population trajectories and to quantify the potential for conflict between predation demand and fishery removals.

SESSION 9: BIO/FIS Topic Session

Integrating ecosystem and climate into actionable science for small pelagic forage communities

Oral Presentations

S09, Invited, AbstractID=19224

Decrease in size of small pelagic fish: Bottom-up control and consequences for a top predator and the fishing industry in the Bay of Biscay

Martin **Huret**[1], Aurélien Favreau[1], Clara Menu[1], Fabienne Daurès[2], Mathieu Doray[3], Jean-Baptiste Romagnan[3], Jérôme Spitz[4], Morgane Travers-Trolet[5] and Sigrid Lehuta[5]

[1]DECOD, L'Institut Agro, IFREMER, INRAE, Plouzané, France.
E-mail: martin.huret@ifremer.fr
[2]Ifremer, Univ Brest, CNRS, UMR 6308, AMURE, Unité d'Économie Maritime, IUEM, Plouzané, France
[3]DECOD, L'Institut Agro, IFREMER, INRAE, Lorient, France
[4]Observatoire Pelagis, UAR 3462, La Rochelle Université/CNRS, La Rochelle, France
[5]DECOD, L'Institut Agro, IFREMER, INRAE, Nantes, France

Size of small pelagic fish is decreasing for many stocks worldwide, with ecosystem consequences through trophic cascading, as well as social-ecological consequences on the fishing industries and on food security for communities. This has been the case in the Bay of Biscay over the last two decades, where size- and weight-at-age of anchovy and sardine, as well as their body condition and fat content, have significantly decreased. Within several projects and patnerships involving scientists from various disciplines and stakeholders (fishers, canning industry, managers), we analysed the drivers of these patterns, and the consequences in terms of vulnerability of the fishery and for common dolphin, for which bycatch has significantly increased during the period. Experimental, empirical and modeling studies all pointed to the a bottom-up control, mainly through a decrease in zooplankton size, as an explanation for the decreasing trend in fish quality. The change in size and spatial distribution of the small pelagic fish community, as well as the decrease in its fat content, has modified the energy seascape available to dolphins, which may explain the increase in its bycatch. Our results have also highlighted the strong vulnerability of the fishing fleets that now strongly rely only on sardine, while the canning industry seems more resilient considering their capacity of diversifying their provisioning. Finally, we developed a dashboard with a large set of indicators covering all dimensions of the social-ecological system, as an online tool to build consensus among stakeholders and support decision-making towards securing the future of these fisheries.

S09, Oral, AbstractID=19113, (ECOP)

A model of intermediate complexity to understand predation pressures on the emblematic Prince William Sound Pacific herring

Matheus **de Barros** and Trevor Branch

School of Aquatic and Fishery Sciences, University of Washington Seattle, USA.
E-mail: mdbarros@uw.edu

Forage fish like Pacific herring *Clupea pallasii* serve as important prey to a variety of predators and link lower trophic levels to the food chain. In Prince William Sound, Alaska, USA, Pacific herring have experienced a catastrophic population crash that shut down once productive fisheries for over 2 decades. Pink salmon and humpback whales, recognized as two key herring predators, have consistently increased in PWS whilst herring failed to recover after the collapse, prompting speculations that herring might be in a predator pit. To estimate historical predation rates of these two predators on herring, we developed an integrated Bayesian state-space, age-structured population dynamics Model of Intermediate Complexity (MICE). This model integrates predation mortality as a latent process anchored by bioenergetic priors to circumvent the lack of dietary data common in fully specified multispecies statistical catch-at-age models. Results show that our MICE model with a saturating functional response provides a better fit to data compared to the single-species model currently used to provide herring management advice. Historical predation patterns indicate that pink salmon and humpbacks might be responsible for preventing the recovery of herring after the population crash, as salmon appear to affect young herring, while humpback whales consume large amounts of spawners. These results have direct consequences for the management of PWS herring and suggest predator data should be incorporated into the management process to improve catch advice for fisheries that have just started to reopen.

S09, Oral, AbstractID=19180, (ECOP)

Exploring capelin (*Mallotus villosus*) biomass dynamics on the Newfoundland Grand Banks

Jiaying **Chen**[1], Tyler D. Eddy[1] and Jin Gao[1,2]

[1]Centre for Fisheries Ecosystems Research, Fisheries & Marine Institute, Memorial University, St John's, NL, Canada. E-mail: Jiaying.Chen@mi.mun.ca
[2]Fisheries and Oceans Canada, Stock Assessment & Research Division (StAR), Delta, BC, Canada

Capelin is a key forage species in the Northwest Atlantic, linking primary production to upper trophic levels including commercially important groundfish and marine mammals. However, the nonlinear and state-dependent nature of its population dynamics poses challenges for conventional modelling approaches due to its short life span and the high underlying ecosystem dimensions. Here, we apply the multivariate spatial empirical dynamic modelling (sEDM) framework with Gaussian Process (GP) regression to explore capelin biomass dynamics on the Newfoundland Grand Banks. By systematically evaluating combinations of environmental covariates alongside indices of prey (copepod) and predator (Atlantic cod) abundance, we identify optimal variable configurations that substantially improved predictive skill relative to univariate capelin self-prediction, with a 38% improvement in R^2, and we find that age-2 and age-3 individuals dominate population dynamics, and that sea surface temperature is the strongest environmental driver of capelin biomass. Scenario explorations further quantify the directional and relative influence of each covariate, revealing that capelin biomass is jointly regulated by bottom-up forcing from copepod prey availability and top-down control from Atlantic cod predation. Our results demonstrate the utility of the multivariate GP-sEDM for forage species assessment in data-limited, high-dimensional ecosystems, and advance our mechanistic understanding of capelin as a trophic link and highlight the importance of incorporating multi-trophic interactions and climate variability into ecosystem-based fisheries management. Given that capelin populations in the North Pacific face analogous trophic pressures and climate forcing, this framework may offer a broadly transferable tool for forage fish assessment across ocean systems under ongoing climate change.

S09, Oral, AbstractID=19187, (ECOP)

Comparative feeding ecology of larvae and juveniles of flathead grey mullet and longspine snipefish in the Kuroshio Current region using morphological and metabarcoding analyses

Hikaru **Shimada**[1], Taro Taniguchi[1], Shota Tanaka[1], Mikio Watai[2], Junji Kinoshita[2], Chiyuki Sassa[2], Hiroshi Kuroda[3], Takeshi Okunishi[2], Tohya Yasuda[2] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: shimahika0817@g.ecc.u-tokyo.ac.jp
[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama/ Nagasaki/Shiogama, Japan
[3]Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan

Small pelagic fish may potentially compete for food resources with co-occurring but poorly studied fish species during their early life stages. The Kuroshio Current region provides major spawning and nursery grounds for small pelagic fish. In this region, however, larvae and juveniles of non- or less commercially important species such as flathead grey mullet *Mugil cephalus* and longspine snipefish *Macroramphosus scolopax* are also densely distributed. In the present study, we examined the comparative feeding ecology of larvae and juveniles of these two species in the Kuroshio Current region. Gut content analyses were conducted for the larvae and juveniles (600 individuals) collected by a neuston net during the surveys in the Kuroshio Current region during February–March 2022. The number, mean size, carbon weight, and composition of prey items were examined through morphological observations. Metabarcoding analyses were also conducted to identify prey at lower taxonomic levels and detect prey overlooked by morphological observations. Both species mainly fed on copepods (particularly calanoid copepodites), whereas longspine snipefish mainly fed on planktonic gastropods in some areas. Ontogenetic shifts in prey composition were observed for both species. However, the prey number and carbon weight varied substantially among the species and areas across the Kuroshio axis. Furthermore, metabarcoding analyses revealed the presence of Appendicularia and Chaetognatha, which were not detected by morphological observations. The combined morphological and metabarcoding analyses revealed previously overlooked prey taxa, species-specific feeding patterns, and ontogenetic shifts, providing new insights into potential trophic interactions among fish larvae and juveniles in the Kuroshio Current region.

S09, Oral, AbstractID=19188, (ECOP)

Growth autocorrelation through metamorphosis in small pelagic fish: How long do the effects of early growth persist?

Haruki **Ogata**[1], Shota Tanaka[1], Yasuhiro Kamimura[2], Sho Furuichi[2], Masahiro Nakamura[3], Ryuji Yukami[2] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: lukasan0311@g.ecc.u-tokyo.ac.jp
[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan
[3]Fisheries Technology Institute, Japan Fisheries Research and Education Agency, Kamiura, Japan

Hjort's "critical period" hypothesis postulates that recruitment is determined right after the first feeding, whereas the current understanding holds that recruitment is determined by cumulative mortality throughout early life. To reconcile this apparent dichotomy, our recent studies demonstrated strong growth autocorrelation in small pelagic fish larvae using otolith increment width data. However, growth autocorrelation from larval to juvenile stages through metamorphosis has yet to be studied, and thus the extent to which early growth influences persist is unknown. In the present study, we analyzed growth autocorrelation from larval to juvenile stages of Japanese sardine *Sardinops melanostictus* and chub mackerel *Scomber japonicus*, based on published datasets of otolith increment widths. Both species showed positive growth autocorrelation between a given age and adjacent ages throughout the larval to juvenile stages. However, the correlation coefficient declined with increasing age, and autocorrelation between a given age and ages separated by metamorphosis was negative. This pattern arises because individuals with higher early growth rates undergo metamorphosis earlier than those with slower growth. Since growth rate increases until metamorphosis and declines thereafter, faster early growth leads to an earlier onset of the post-metamorphosis decline. Lastly, we confirmed that post-metamorphosis growth rates differ little among different early growth groups. These findings suggest that growth autocorrelation can be reset through metamorphosis, and that growth after metamorphosis is determined by environmental conditions experienced by an individual. We propose that the effect of early growth on recruitment should be considered separately before and after metamorphosis.

S09, Oral, AbstractID=19189, (ECOP)

Determinants of starvation tolerance in reared Japanese anchovy larvae: Relative roles of somatic size, age, and growth rate

Daichi **Murayama**[1], Shota Tanaka[1], Masahiro Nakamura[2], Michio Yoneda[3] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: ddd70810@g.ecc.u-tokyo.ac.jp
[2]Fisheries Technology Institute, Japan Fisheries Research and Education Agency, Kamiura, Japan
[3]Fisheries Technology Institute, Japan Fisheries Research and Education Agency, Miyako, Japan

Starvation is assumed to be a significant cause of mass mortality for fish larvae, which may influence year-class strength. Although faster-growing larvae are considered to have higher probabilities of survival ("growth–survival" paradigm), some studies suggested a possibility of "growth–survival trade-off". Starvation tolerance has not been well understood in relation to growth characteristics. In the present study, we examined the relative roles of somatic size, age, and growth rate in determining starvation tolerance in reared Japanese anchovy *Engraulis japonicus* larvae. Larvae were obtained from the captive broodstock. The larvae were transferred to 1 L beakers at different timings to cover wide ranges of age and somatic size. They were reared under non-fed conditions and their survival duration was recorded. After starvation experiments, standard length at the onset of starvation and growth rate were estimated by otolith microstructure analysis. In addition, generalized linear models (GLMs) were used to evaluate the effects of somatic size, age, and growth rate on starvation tolerance. Starvation tolerance increased with somatic size and age. In contrast, growth rate per se was not related to starvation tolerance. GLM analyses showed that starvation tolerance was primarily explained by somatic size, whereas the effects of age and growth rate were not significant. These findings support the "growth–survival" paradigm rather than the "growth–survival trade-off," demonstrating that somatic size is the primary determinant of starvation tolerance, whereas the effects of age and growth rate are largely mediated through somatic size.

S09, Oral, AbstractID=19190, (ECOP)

Growth–development patterns shape individual variation in feeding success in anchovy larvae: Laboratory-based hypothesis and field tests

Shota **Tanaka**[1], Shizuna Togoshi[1], Daichi Murayama[1], Etienne Germain[2], Naotaka Yasue[3], Masahiro Nakamura[4], Michio Yoneda[5], Dominique Robert[2] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: shotana0326@gmail.com
[2]Institut des Sciences de la Mer, Université du Québec à Rimouski, Rimouski, QC, Canada
[3]Wakayama Prefectural Fisheries Experimental Station, Wakayama, Japan
[4]Fisheries Technology Institute, Kamiura Field Station, Japan Fisheries Research and Education Agency, Kamiura, Japan
[5]Fisheries Technology Institute, Miyako Field Station, Japan Fisheries Research and Education Agency, Miyako, Japan

Early life history traits, such as growth rate, influence recruitment success in small pelagic fish. Recently, our otolith microstructure analyses showed that Japanese anchovy *Engraulis japonicus* larvae exhibit persistent individual variation in growth rates, leading to strong growth autocorrelation (i.e., faster-growing larvae maintain fast growth, whereas slower-growing larvae maintain slow growth). However, differences in traits among individuals with different growth rates, and their responses to environmental fluctuations remain unclear. In the present study, we examined growth-related variation in morphological development and feeding characteristics through laboratory experiments and field tests. First, we examined variation in morphological traits and feeding characteristics among individuals with different growth rates through 5-minute controlled laboratory feeding experiments. At a given size, faster-growing larvae had smaller jaw and eye sizes and consumed smaller prey items. Hence, we hypothesized that faster-growing larvae would have an advantage in environments with smaller prey sizes. Second, we tested this hypothesis using samples collected by commercial trawls in the field. The field tests revealed that faster-growing larvae achieved higher feeding success and maintained faster growth in samples with smaller prey sizes. Overall, individuals with different growth rates showed different growth–development patterns and feeding characteristics. Our field tests also suggested that fluctuations in environmental prey size may alter the relative advantages/disadvantages in feeding success among individuals with different growth rates. These findings provide a potential mechanism explaining how persistent individual variation in growth rates is generated during the early life stages in small pelagic fish under environmental variability.

S09, Oral, AbstractID=19191, (ECOP)

Environmental and density-dependent drivers of egg-size variability in *Scomber japonicus* and *Scomber australasicus* in the Kuroshio Current system

Koya **Nishihata**[1], Mikio Watai[2], Junji Kinoshita[2], Takeshi Okunishi[2], Hiroshi Kuroda[3], Tohya Yasuda[2] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: koya0169@g.ecc.u-tokyo.ac.jp
[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan
[3]Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan

Small pelagic mackerels *Scomber japonicus* and *Scomber australasicus* are important fishery resources in the Kuroshio Current system, but climate-based fisheries management requires reproductive information beyond spawning stock biomass alone. Egg size is a key reproductive trait that may respond to environmental variability and density-dependent processes, yet species-level analyses for mackerels have been limited because their eggs are difficult to distinguish morphologically. In the present study, we examined environmental and density-dependent drivers of egg-size variability in these two co-occurring mackerels, using a long-term dataset of egg surveys off the Pacific coast of Japan during 2006–2022. In total, 37,546 eggs were classified based on a recently developed temperature-dependent egg-diameter criterion. We analyzed relationships of egg diameter to sea surface temperature, surface salinity, zooplankton wet weight, and spawning stock biomass, using multiple regression analyses and generalized linear mixed models. *S. japonicus* eggs were widely distributed across temperature and salinity ranges, whereas *S. australasicus* eggs were concentrated in warmer, higher-salinity waters around the Kuroshio axis. Egg size decreased with increasing temperature in both species and was positively related to salinity. Zooplankton wet weight showed no clear relationship with egg size. Density-dependent effects differed between species: *S. japonicus* egg size was positively related to conspecific spawning stock biomass, whereas *S. australasicus* egg size was negatively related to *S. japonicus* spawning stock biomass. These findings suggest that environmental variability and interspecific interactions shape reproductive traits of small pelagic fish. Incorporating egg-size information may improve mechanistic understanding of recruitment processes and support future climate-based fisheries management.

S09, Oral, AbstractID=19201, (ECOP)

Ecosystem-based resource assessment and food-web dynamics of Japanese anchovy (*Engraulis japonicus*) in Korean waters

Na-Young **Jung** and Hee-Joong Kang

Coastal Water Fisheries Resources Research Division, National Institute of Fisheries Science, Busan, R Korea. E-mail: nayoungjung3422@gmail.com

Japanese anchovy (*Engraulis japonicus*) is a key forage fish linking lower and higher trophic levels in Korean marine ecosystems. Due to its short life span and sensitivity to predator-prey interactions and environmental variability, anchovy populations exhibit substantial fluctuations under climate change. This study aimed to develop an ecosystem-based assessment framework integrating trophic interactions and environmental variability to evaluate climate-driven changes in anchovy populations. An ecosystem model centered on anchovy was developed using Ecopath with Ecosim (EwE). The model consisted of more than 27 functional groups representing anchovy, its major prey groups, and higher trophic-level predators. To account for bottom-up effects on anchovy dynamics, biomass of copepods and euphausiids was estimated using chlorophyll-a (Chl-a), sea surface temperature (SST), and plankton survey data. In addition, fisheries radio-station records from 2000–2025 were analyzed to investigate spatio-temporal changes in anchovy fishing grounds. Results indicated a northward shift in fishing grounds, particularly after 2016, coinciding with rising SST. CPUE was negatively correlated with SST, suggesting that warming conditions are associated with habitat displacement and reduced productivity. Spatial analyses indicated that changes in anchovy fishing grounds were associated with environmental variability. Ecosystem model analyses suggested that variability in predator productivity substantially affected anchovy biomass, alongside fishing pressure. These findings suggest that climate-driven changes in anchovy productivity and habitat distribution influence major fish population dynamics in Korean waters. This study provides a scientific basis for incorporating environmental information into TAC assessments and supports adaptive ecosystem-based fisheries management in Korean waters.

S09, Oral, AbstractID=19225, (ECOP)

Prey availability of Japanese sardine larvae transported along the Kuroshio Current

Honoka **Ito**[1], Eisuke Tsutsumi[2], Gen Kume[2], Masafumi Kodama[2], Mutsuo Ichinomiya[3], Tomohiro Komorita[3] and Toru Kobari[2]

[1]Graduate School of Agriculture, Forest and Fisheries, Kagoshima University, Kagoshima, Japan. E-mail: k5439114@kadai.jp
[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan
[3]Faculty of Environmental and Symbiotic Sciences, Prefectural University of Kumamoto, Kumamoto, Japan

Small pelagic fishes such as Japanese sardine exhibit large yearly fluctuations of their fishery stock. It has been long argued that their recruitment success is primarily determined by early growth and survival under prey availability. While Japanese sardine larvae hatched in coastal waters are often transported toward the Kuroshio, we have little information about how much prey they encounter on their pathways transported along the Kuroshio. The present study aims to elucidate pathways and prey availability for Japanese sardine larvae transported along the Kuroshio Current. Particle-tracking experiments on a high-resolution ocean model demonstrated that most larvae hatched in the southern Kyushu were transported toward the east and along the inshore region of the Kuroshio path. According to a generalized additive model based on shipboard observatory data, mesozooplankton standing stocks around the Kuroshio front were equivalent to those in the coastal waters. Prey availability encountered along the transport pathway was particularly high around the Kuroshio front, where mesozooplankton standing stocks were comparable to those in coastal waters. These results suggest that Japanese sardine larvae hatched in the northern Satsunan area utilize the favorable prey environment around the Kuroshio front during their transport pathways. We further discuss the implications of prey availability along their transport pathways for early growth and survival of Japanese sardine larvae.

S09, Oral, AbstractID=19240, (ECOP)

Re-emergence of the Satsunan area as spawning and nursery ground of Japanese sardine *Sardinops melanostictus* during the stock-increasing phase

Iara **Torres**[1], Akinori Osawa[1], Haruka Takagami[2], Toru Kobari[2], Masafumi Kodama[2], Mutsuo Ichinomiya[3], Tomohiro Komorita[3] and Gen Kume[2]

[1]Graduate School of Agriculture, Forestry and Fisheries, Kagoshima University, Kagoshima, Japan. E-mail: iaratorrescabrera@gmail.com
[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan
[3]Faculty of Environmental and Symbiotic Sciences, Prefectural University of Kumamoto, Kumamoto, Japan

The Japanese sardine *Sardinops melanostictus* exhibits pronounced multi-decadal fluctuations in stock abundance. During the high-stock period of the 1980s, a major spawning ground existed in the Satsunan area of southern Japan; however, this spawning ground disappeared during the stock decline in the 1990s. Since 2015, we have conducted larval monitoring surveys of small pelagic fishes in this region, and in March 2023 it was detected Japanese sardine larvae for the first time. This study aims to elucidate the processes of spawning and nursery ground formation of Japanese sardine during the current stock-increasing phase. Eggs and larvae were collected at nine stations in the mouth of Kagoshima Bay and adjacent waters from 2023 to 2025, using a twin NORPAC net for eggs and an ORI net for larvae. Abundance of eggs and larvae was estimated for each station, and larval growth, mortality and food requirements were analyzed. Eggs and larvae were consistently observed in the coastal waters in March of each year. The highest abundance was recorded in March 2025, reaching 58,260 and 455 individuals per 1,000 m^3 for eggs and larvae, respectively. The estimated larval mortality rate decreased from 35% in 2023 to 11% in 2024. The weight-specific growth coefficient and ingestion rate were estimated at 0.24 d^{-1} and 85% of body dry weight, respectively in 2024. The high egg and larval abundance, rapid growth, high ingestion rate and good nutritional condition would indicate that the Satsunan area has re-emerged as an important spawning and nursery ground for *S. melanostictus*, providing favorable conditions for early growth and survival.

S09, Oral, AbstractID=19275

Recent anchovy boom-bust dynamics in California: Insights from a climate-to-fish model

Maxwell Seale[1], Jarrod Santora[2], Andrew Thompson[3], Monique Messié[4], Francisco Chavez[4], and Jerome **Fiechter**[1]

[1]University of California Santa Cruz, Santa Cruz, CA, USA. E-mail: fiechter@ucsc.edu
[2]NOAA SWFSC Fisheries Ecology Division. Santa Cruz, CA, USA
[3]NOAA SWFSC Ecosystem Science Division. La Jolla, CA, USA
[4]Monterey Bay Aquarium Research Institute, Moss Landing, CA, USA

We use results from a high-resolution, regional climate-to-fish model to investigate the environmental conditions that led to the recent anchovy boom-bust dynamics in California. This climate-to-fish model includes a regional ocean circulation submodel, a nutrient-phytoplankton-zooplankton submodel, and a full life cycle, individual-based submodel for anchovy. We produced a hindcast for 1998-2023 that captures the observed spatial and temporal variability of the northern anchovy central subpopulation across life stages. Notably, the simulation reproduces two periods of increased adult abundance (2004-2008 and 2016-2023) and a period of decreased abundance in-between, documented by ecosystem surveys from NOAA and CalCOFI. Population variability in the model is attributed to egg production and early life stage survival, whereby boom periods coincide with an expansion of favorable spawning habitat into central California. Increased spawning habitat suitability along central California leads to an extended spawning season and more favorable growth conditions for larvae. This poleward expansion of anchovy spawning habitat coincides with warmer conditions in the central and southern California Current and relates to previously identified habitat compression patterns. As such, our climate-to-fish model simulation not only provides a mechanistic insight into the recent population variability of northern anchovies in California, but proposes a conceptual framework that can inform future management strategies.

S09, Oral, AbstractID=19295, (ECOP) CANCELLED

Otolith stable isotopes indicate partial migration in adult Pacific Herring (*Clupea pallasii*) in the Strait of Georgia

Jessica M. **Qualley**[1], Will Duguid[2], Francis Juanes[2]

[1]Pacific Salmon Foundation, Duncan, BC, Canada. E-mail: jessqualley@gmail.com
[2]University of Victoria, Victoria, BC, Canada

The Strait of Georgia (SOG) Pacific herring (*Clupea pallasii*) population is currently managed as a single migratory stock that moves between spring spawning grounds in the SOG and summer feeding grounds off the continental shelf of West Coast Vancouver Island (WCVI). However, a proportion of adults remain in the SOG year-round, and the prevalence of these non-migratory herring has not previously been quantified. Whole otolith stable isotopes ($\delta^{13}C$ and $\delta^{18}O$) were used to investigate migration life-history diversity by developing a logistic regression model from summer SOG and WCVI baseline fish and applying it to spring SOG spawners collected between 2020 and 2022. Otolith-based classifications estimated that 30–33% of spring spawners were non-migratory (SOG inshore), although many occupied intermediate isotopic space, suggesting migration occurs along a continuum rather than as discrete migratory and non-migratory types. No relationship was detected between first-year growth (proxied by otolith increment distance) and migration strategy, indicating migration decisions likely arise later in life or are influenced by other mechanisms. In contrast, adult migratory herring were longer, heavier, and had lower condition than non-migratory herring, consistent with a potential trade-off between structural growth gained from offshore feeding and the energetic costs of long-distance migration. These findings reveal greater migration life-history diversity than assumed under the current single, migratory stock framework. The otolith stable isotope approach developed here provides a tool for quantifying migration life-history diversity, evaluating fishery impacts on alternative migration strategies, and improving understanding of SOG herring stock structure.

S09, Oral, AbstractID=19325, (ECOP)

Preliminary insights into Atlantic mackerel movement ecology across eastern North America from the largest tracking study to date

Ava J.A. **Sergio**[1], Robert J. Lennox[2,3], Elisabeth Van Beveren[4] and Morgan L. Piczak[1]

Presented by Oscar Notman-Grobler on behalf of Ava J.A. Sergio

[1]University of British Columbia, Vancouver, BC, Canada.
E-mail: avasergio13@gmail.com, oscarn1@student.ubc.ca
[2]Dalhousie University, Halifax, NS, Canada
[3]Ocean Tracking Network, Halifax, NS, Canada
[4]Fisheries and Oceans Canada, Mont-Joli, QC, Canada

Atlantic mackerel (*Scomber scombrus*) are an economically, ecologically, and culturally significant forage fish that link multiple marine trophic levels. In recent years, the stock underwent a high-profile collapse driven largely by overexploitation, leading to the closure of Canadian commercial and bait fisheries in 2022, which remains in effect. This collapse highlighted knowledge gaps in mackerel movement ecology and biogeography, limiting the development of effective management strategies for both the species and fishery. Our objective was to use acoustic telemetry to examine the seasonal distribution of Atlantic mackerel, while identifying migration routes, phenology, and natural mortality as fish move among spawning, foraging, and overwintering habitats. Building on a dataset of more than 800 mackerel tagged throughout Atlantic Canada in 2024 and 2025, we tagged an additional 1000 individuals in 2026 across Nova Scotia, P.E.I., and Newfoundland. Acoustic transmitters were equipped with temperature and acceleration sensors to infer survival and activity patterns, while multi-year battery life enabled tracking across successive years. Preliminary results from fish tagged in 2024 and 2025 indicate size-specific variation in phenology and that endothermic predators are the largest identifiable source of natural mortality among distinguishable thermal profiles. Analyses are anticipated to show that migration routes differ between tagging years depending on resource availability. These preliminary insights and the anticipated findings will provide data-driven estimates to support stock rebuilding and inform the eventual full reopening of commercial and bait fisheries that once contributed more than $25M annually to the Canadian economy.

S09, Oral, AbstractID=19388

Understanding barrier effects of ocean fronts to implement actionable conservation

Qinwang Xing[1,2,3,4,5], Zihui Gao[1,2], Shin-ichi **Ito**[2], Haiqing Yu[6], Bilin Liu[1,3,4,5], Heng Zhang[7], Xinjun Chen[1,3,4,5], Wei Yu[1,3,4,5]

[1]College of Marine Living Resource Sciences and Management, Shanghai Ocean University, Shanghai, PR China
[2]Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan. E-mail: goito@aori.u-tokyo.ac.jp
[3]National Distant-water Fisheries Engineering Research Center, Shanghai, PR China
[4]Key Laboratory of Sustainable Exploitation of Oceanic Fisheries Resources (Shanghai Ocean University), Ministry of Education, Shanghai, PR China
[5]Key Laboratory of Sustainable Utilization of Oceanic Fisheries, Ministry of Agriculture and Rural Affairs, Shanghai, PR China
[6]Institute of Marine Science and Technology, Shandong University, Qingdao, PR China
[7]East China Sea Fisheries Research Institute, Chinese Academy of Fisheries Science, Shanghai, PR China

Marine ecosystems exhibit high spatiotemporal heterogeneity, making it crucial to understand the mechanisms sustaining biological hotspots for appropriate conservation and management. Ocean fronts shape local biogeochemical processes and have long been recognized as biological hotspots aggregating organisms from phytoplankton to top predators and attracting fisheries (hotspot effects). However, fronts also exhibit pronounced environmental differences between their two sides (barrier effects), and how species and fishery distributions respond to these effects remains poorly understood, which is a big obstacle to the implementation of actionable science. By integrating satellite-based front detection with commercial catch records of small pelagic fishes in the western North Pacific, we showed that barrier effects dominate their distribution than hot spot effects, especially in the case seasonal variability is considered. With fishery-independent surveys and global fishing datasets, we also showed that fishery distributions across diverse regions and major commercial stocks worldwide respond strongly to barrier effects, exhibiting 15–70% differences in distribution between the frontal warm and cold zones, driven by species-specific local thermal preferences. In contrast, responses to hotspot effects are generally sporadic with only 5–20% differences between frontal and non-frontal zones, and they emerge only when aggregations on one side of fronts offset avoidance on the other. This offset has led earlier studies to conservatively underestimate front-induced fishery variations by 55–75%. Our findings complement the traditional front-induced hotspot paradigm by clarifying the importance of barrier effects and underscore the need to reassess the role of ocean fronts in marine ecosystems. The correct understanding of frontal effects on fish distribution enables actionable science (e.g. mitigating bycatch of endangered species) with dynamically fluctuating fronts in the ocean. Those results are published in Xing Q., Z. Gao, S. Ito, H. Yu, B. Liu, H.

Zhang, X. Chen, W. Yu, 2026, Underestimated barrier effects of ocean fronts shape global fishery distribution. Nature Communications, 17, 4545. https://doi.org/10.1038/s41467-026-71250-0

S09, Oral, AbstractID=19413, (ECOP)

Mechanistic support for the Trophic Efficiency in Early Life hypothesis in northern anchovy (*Engraulis mordax*)

Luke A. **Bobay**[1,2], Marco Corrales-Ugalde[2], Sean W. Hixon[1], Robert K. Cowen[2] and Su Sponaugle[1,2]

[1]Department of Integrative Biology, Oregon State University, Corvallis, OR, USA.
E-mail: bobayl@oregonstate.edu
[2]Hatfield Marine Science Center, Newport, OR, USA

Because energy transfer across successive trophic levels is inefficient, animals occupying higher trophic positions (TP) can access a smaller proportion of energy made available by primary producers than animals occupying lower TP. This phenomenon has been used to explain inverse relationships between larval fish TP and subsequent growth rates and adult abundance by the "Trophic Efficiency in Early Life (TEEL) hypothesis," although this mechanism has not yet been demonstrated empirically. We sought mechanistic support for the TEEL hypothesis in northern anchovy (*Engraulis mordax*). We collected northern anchovy larvae (> 12 mm TL) from the northern California Current ecosystem (41–47°N) on five two-week research cruises during 2018–2023. We also measured temperature, nitrate concentration, phytoplankton cell diameter, copepod abundance, and the slope of normalized plankton biomass size spectra (NBSS slope; proxy for trophic transfer efficiency) in the same locations where larvae were collected. We estimated the TP of anchovy larvae using compound-specific stable isotope analysis of amino acids. As performance metrics, we measured muscular height at anus (MHA) and recent growth from otolith microstructure of the same individuals. We used a structural equation model to estimate the direction and magnitude of relationships among temperature, nitrate concentration, phytoplankton cell diameter, copepod abundance, NBSS slope, TP, MHA, and recent growth of anchovy larvae. TP had a negative effect on MHA and recent growth of anchovy larvae, suggesting that TP has individual-level consequences. Environmental conditions explain variation in TP, supporting its potential utility as an indicator of future recruitment.

S09, Oral, AbstractID=19429

More than meets the eye: Soft-bodied zooplankton dominate the diet of small pelagic fish larvae

Susana **Garrido**[1], Mariana Carvalho[2], Pedro Fonseca[1], Joana Cruz[3], Catarina Churro[1], Cristina Máguas[2,4], Ana Veríssimo[5,6]

[1]IPMA Instituto Português do Mar e da Atmosfera (IPMA), Lisbon, Portugal.
E-mail: susana.garrido@ipma.pt
[2]Faculty of Sciences, University of Lisbon (FCUL), Lisbon, Portugal
[3]Centre of Marine Sciences (CCMAR), Universidade do Algarve, Faro, Portugal
[4]Centre for Ecology, Evolution and Environmental Change (CE3C), Global Change and Sustainability, Angra do Heroísmo, Portugal
[5]CIBIO – Research Center in Biodiversity and Genetic Resources, InBIO Laboratório Associado, Campus de Vairão, University of Porto, Vairão, Portugal. E-mail: averissimo@cibio.up.pt
[6]BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Vairão, Portugal

Food availability is a major determinant of the survival and recruitment success of small pelagic fish larvae. However, their feeding ecology remains poorly understood because conventional gut-content analyses often overlook soft-bodied prey that are rapidly digested. We used DNA metabarcoding to investigate the diet of European sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) larvae collected during a spring acoustic survey in the northern Canary Current upwelling system off the Iberian Peninsula. To assess whether the high occurrence of soft-bodied prey could reflect methodological bias, we also analysed environmental plankton samples using the same metabarcoding approach. The results showed no preferential amplification of soft-bodied taxa, indicating that their high prevalence in larval stomachs reflects true feeding patterns.

Diet composition varied with species and ontogeny, with pre-flexion larvae exhibiting the greatest prey diversity. Across all developmental stages, soft-bodied zooplankton, particularly hydrozoans, appendicularians and thaliaceans, together with copepods, dominated the diet. These findings reveal that gelatinous prey constitute a major, underestimated food resource for small pelagic fish larvae and highlight the value of DNA metabarcoding for uncovering trophic interactions that are largely invisible to traditional dietary analyses. These findings highlight the need to incorporate soft-bodied zooplankton into ecosystem-based fisheries management, as their availability may influence larval survival, recruitment success, and ultimately the productivity of small pelagic fish stocks.

S09, Oral, AbstractID=19494, (ECOP)

Trait-based vulnerability of pelagic fisheries to extreme and compound temperature and primary production events

Isabella **Morgante** and William Cheung

University of British Columbia, Vancouver, BC, Canada. E-mail: i.morgante@oceans.ubc.ca

Small pelagic fish underpin fisheries and trophic webs worldwide and are sensitive to short-term environmental variability, including anomalously high ocean temperature and low net primary production (NPP) events. Such extremes are expected to become more frequent and intense with climate change, potentially increasing the vulnerability of small pelagic fisheries to extreme low catch events. Biological and ecological traits may modulate species' responses to environmental change, however, how traits shape responses to short-term climate extremes remains poorly understood.

We tested whether maximum body size, trophic level, thermal tolerance window, and latitudinal range breadth mediate the odds of extreme low catch under annual high-temperature and low-NPP extremes using Firth's penalized logistic regression for 120 small, medium, and large-bodied pelagic fish species across 40 Large Marine Ecosystems (LMEs) and reconstructed catch data from 1993-2019. Globally, pelagic fisheries across the size spectrum were significantly and negatively impacted by annual and compound extremes, but trait specific trends showed limited global predictive power. 48% of LMEs exhibited at least one significant trait-environment interaction, with effect direction and strength varying by ecosystem, underscoring that the vulnerability of small pelagic fish to climate extremes is ecosystem dependent rather than universal. Lower trophic level species, a group that includes many forage fish, more showed higher vulnerability particularly under compound extremes, while body size effects were more variable. These findings suggest small pelagic forage fisheries must account for environmental extremes, and that robust management requires regionally calibrated, trait-based vulnerability frameworks rather than globally generalized trait assumptions.

SESSION 9: BIO/FIS Topic Session

Integrating ecosystem and climate into actionable science for small pelagic forage communities

Poster Presentations

S09, Poster, AbstractID=19148, PosterID: S09-P1

Identifying management- and industry-informed research priorities for small pelagic fishes

Matthew **Baker**[1], Susana Garrido[2], Niels Hintzen[3], Minje Choi[4], and Asami Takahashi[5]

[1]North Pacific Research Board, Anchorage, USA. E-mail: Matthew.Baker@nprb.org
[2]Portuguese Institute for Sea and Atmosphere, Lisbon, Portugal
[3]Pelagic Freezer Trawler Association, Zoetermeer, Netherlands
[4]Marine Stewardship Council, Busan, R Korea
[5]Marine Stewardship Council, Tokyo, Japan

Priorities for research in fisheries are often divorced from the insights, perspectives, and interests of commercial industries, fleets, and fishers targeting these resources. As part of the ICES-PICES working group on small pelagic fishes, a recent ICES-PICES symposium workshop brought together fisheries scientists and fishing industry leads and canvassed representatives of industries involved in exploiting pelagic fish stocks worldwide, including the Northwest Pacific (Japan, Korea) Northeast Pacific (US, Canada), Southeast Pacific (Chile, Peru), Northeast Atlantic (US, Canada), Northwest Atlantic and North Sea (UK, EU), and South Atlantic (South Africa). Science is motivated by research questions and management objectives. Industry is often motivated by particular objectives (e.g., maintain exploited stocks, improve gear, access areas). The intent of this workshop was to facilitate productive exchange between these two sectors to inform management. Discussions aimed to determine effective means to translate objectives into research questions and priorities. Participants addressed opportunities, challenges and effective approaches to identify research priorities that reflect the needs, interests, and insights of fisheries managers, fishers, and the fishing industry. Examples identified included fleet assets as oceanographic platforms; implementation of sustainability practices in fishing activities; fishermen's awareness and modern technology; biophysical modeling; sampling programs for fisheries-dependent data; industry data collection efforts; and opportunities for improved dialogue between researchers and fishermen towards the sustainable management of fish resources. Survey results were also compiled from 44 participants engaged in 22 distinct pelagic fisheries across the global oceans. Subsequent analyses outlined strategies to initiate and coordinate further engagement of the fishing industry in setting research priorities, including:

- inventory processes to solicit industry input and identify information gaps and priorities
- review fisheries management forums to synthesize industry testimony and input
- survey fishery managers of small pelagic stocks
- survey fishing industry representatives of small pelagic stocks
- analyze and collate research priorities and needs
- analyze and propose mechanisms to solicit industry priorities for science

Results will be communicated to fishery management councils (US), ICES (Europe) and similar management forums to document existing processes and inform future efforts. In the context of

this session, we draw insights from these discussions and survey responses to develop actionable science for sustainable and informed management small pelagic and forage communities.

S09, Poster, AbstractID=19168, PosterID: S09-P2, (ECOP)

Estimation of total length from images of partially visible fish using generative models

Yuka **Iwahara**, Yasutoki Shibata, Masahiro Manano

Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan. E-mail: iwahara_yuka58@fra.go.jp

In recent years, various studies have been conducted to estimate length composition of fish in commercial catches using deep learning for stock assessment. However, studies on estimating total length of partially visible fish remain limited. In this study, we generated full-body images of fish from partially visible fish images using a generative model to estimate their total length. We prepared 2,226 individual full-body images of Japanese jack mackerel (*Trachurus japonicus*) and 2,298 of chub mackerel (*Scomber japonicus*), which were partially occluded by a white square of varying size for training and evaluation. Palette (Saharia et al., 2022), one of the diffusion models, was used to generate full-body images from partially visible fish images. To evaluate estimation performance, we measured the total length (in pixels) of both the generated and actual fish, calculated the relative difference, and calculated the bias and standard deviation. The overall bias and standard deviation were 4.2 % and 12.3%, respectively, for the two species combined. For Japanese jack mackerel, these values were 0.5 % and 2.6 %, respectively, while for chub mackerel they were 9.7 % and 19.4 %. This interspecific difference in estimation difference may be attributable to differences in the size range in cm of the training data between the species. These results suggest that generative models can be utilized to estimate the total length of partially visible fish.

S09, Poster, AbstractID=19200, PosterID: S09-P3, (ECOP)

Spatiotemporal trends in stomach fullness reflect food availability and feeding behaviour in adult Chinook salmon in southern British Columbia

Nathanael **Tabert**[1], Wesley Greentree[1], Will Duguid[1,2], Francis Juanes[1]

[1]University of Victoria, Victoria BC, Canada. E-mail: nathanaeltabert@gmail.com
[2]Pacific Salmon Foundation, Vancouver BC, Canada

For predators, energy acquisition through foraging is essential to survival, making foraging foundational to predator ecology. In southern British Columbia (BC), Chinook salmon (*Oncorhynchus tshawytscha*) are an important marine predator. They are the primary prey of the endangered southern resident killer whale, they hold cultural significance to indigenous nations, and support a large recreational fishery. Since 2017, the Adult Salmon Diet Program at the University of Victoria has been partnering with recreational fishers to characterize the diets of Chinook salmon via stomach content analysis, with over 7600 stomachs processed to date. Stomach content analysis is a well-established method for investigating predator diets and can be used to understand energy acquisition through stomach fullness. We used geostatistical models to leverage this rich dataset and investigate spatial and temporal trends in Chinook salmon stomach fullness. We found that fullness was highest during the summer months and at sites of known herring aggregations. This highlights high food availability in the summer and the importance of herring as the primary prey of Chinook salmon in this region. Fullness was lower in the winter, likely reflecting lower productivity and therefore food availability. We found that fullness was lowest in fishing locations targeting return migrating salmon in the late summer and fall, reflecting the known behaviour of feeding cessation in mature salmon. This research provides novel insight on spatiotemporal trends in Chinook salmon feeding ecology in BC and a framework for monitoring for changes in these trends.

S09, Poster, AbstractID=19265, PosterID: S09-P4

Prey over temperature: A multi-decadal assessment of how euphausiid availability buffers juvenile pollock against marine heatwaves

Jesse F. **Lamb**[1], David G. Kimmel[2], Lauren A. Rogers[2]

[1]EcoFOCI, Alaska Fisheries Science Center, Seattle, WA, USA. E-mail: jesse.f.lamb@noaa.gov
[2]NOAA Alaska Fisheries Science Center, Seattle, WA, USA

Walleye pollock (*Gadus chalcogrammus*) recruitment in the Western Gulf of Alaska (WGOA) can be highly sensitive to environmental variability during early life history. We analyzed a multi-decadal dataset (2003–2019) to investigate the drivers of age-0 pollock size, diet composition, and energy intake across a wide range of oceanographic conditions. Diet analysis revealed a consistent dominance of large calanoid copepods (LCC) and euphausiids, with a distinct ontogenetic shift toward euphausiids as fish size increased. Linear mixed-effects models indicated that while mean sea surface temperature (SST) three months prior to sampling significantly influenced fish length, adding approximately 8.3 mm per 1°C increase, it had no significant effect on prey energy content. Instead, fish weight was the primary predictor of energy intake, suggesting that larger individuals maintain high-energy diets regardless of thermal trends, provided preferred prey is available. The 2015 marine heatwave emerged as a notable outlier, characterized by anomalously small fish and the lowest consumption of euphausiids in the study, whereas high euphausiid abundance during the 2019 heatwave appeared to buffer the negative metabolic effects of warming. Our findings suggest that age-0 pollock in the WGOA are more dependent on the availability of specific lipid-rich prey than on temperature alone. This highlights the importance of monitoring euphausiid and LCC abundance as critical indicators for predicting pollock overwintering success and recruitment in a changing environment.

S09, Poster, AbstractID=19364, PosterID: S09-P5, (ECOP)

Encrasicholina punctifer: Oceanographic factors behind their rare occurrence in the Hawaiian Archipelago

Kyoko **Suzuki**[1], Andrea Schmidt[2], Jessica Perelman[2], Donald Kobayashi[3] and Justin Suca[1]

[1]Department of Oceanography at University of Hawai‘i at Mānoa, Honolulu, HI, USA.
E-mail: kyokosuz@hawaii.edu
[2]Cooperative Institute for Marine and Atmospheric Research, NOAA Pacific Islands Fisheries Science Center, NOAA, Honolulu, HI, USA
[3]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, USA

Encrasicholina punctifer, also known as the buccaneer anchovy; a congener of the Hawai‘i Nehu (*E. purpurea*), is widely distributed across the Indo-Pacific and typically inhabits pelagic waters. In Hawai‘i, however, fishers have observed that this species appears only occasionally. When present, *E. punctifer* plays an important role in the food web as a forage fish by linking plankton and pelagic predators. These rare events remain largely undocumented in Western science. This study aims to examine the oceanographic drivers of an episodic migration of *E. punctifer* to Hawai‘i in 2023 to better understand how climate variability may influence spawning and migration patterns. The most recent known event began in 2023, when the surge of anchovy larvae appeared around the Kaua‘i, O‘ahu, and Papahānaumokuākea, and disappeared by 2024. Larval anchovy samples were collected across 83 stations throughout the Hawaiian archipelago between July and November 2023. Otoliths microstructure analysis was used to estimate daily larval age and growth. The oldest larvae among the samples were over 20 days old, indicating that the larvae were not only spawned but also survived in favorable environmental conditions in the Northwestern Hawaiian Islands. Larval abundance varied widely across stations, ranging from 0 to over 6,000 individuals. Results indicate that *E.punctifer* larvae were primarily present in regions characterized by relatively high SST. This study will further examine the species’ migration paths by linking temperature variability across Hawai‘i, Northwestern Pacific (Kuroshio Current), and the Indian Ocean.

S09, QR-Poster, AbstractID=19416, PosterID: S09-P6

Climatic anomalies and recruitment variability of Japanese sardine: The 2025 catch crisis in the Northwest Pacific

Aleksandra A. **Sumkina**, Andrey S. Krovnin, Oleg A. Bulatov

Russian Federal Research Institute of Fisheries and Oceanography, Moscow, Russia.
E-mail: sumkina@vniro.ru

Japanese sardine (Sardinops melanostictus) is a unique aquatic bioresource characterized by pronounced multidecadal-scale fluctuations in abundance and biomass. Recent rise of catches has started in 2013 and continued in the first half of the 2020s. However, the 2025 fishing season delivered completely unexpected results—contrary to all projections, actual catches plummeted tenfold possibly due to poor recruitment in previous two years. Investigating the interannual and seasonal variability of sea water temperature in the spawning and larval development areas off the coast of Japan and in the northwestern Pacific Ocean, the authors detected a significant marine heatwave in 2024, with pronounced positive anomalies reaching +4.8 °C. These extreme thermal conditions adversely affected the recruitment success of young sardines, evidently serving as the primary cause for the poor year-classes of 2023–2025, which in turn led to the drastic tenfold decline in landings in 2025. The trend of decreasing thermal background in sardine spawning grounds, which emerged in the spring of 2025, led to a doubling of the number of spawned eggs compared to 2024. The development of negative sea surface temperature anomalies along the Pacific coast of Honshu Island in January 2026 inspired optimism for an increase in spawning volume in 2026 and prospects for its fishery in 2027. The above sharp reversal highlights the critical vulnerability of small pelagic fisheries to short-term climatic extremes that are not adequately captured by conventional stock assessment models. Thus, for sustainable management of the sardine fishery, it is necessary to integrate high-resolution temperature monitoring and ecosystem-based indicators into adaptive harvest strategies.

S09, Poster, AbstractID=19425, PosterID: S09-P7

The recovery and role of coastal pinniped predation on the productivity and dynamics of forage communities in British Columbia food webs

Strahan **Tucker**, M. Kurtis Trzcinski, Chad A. Nordstrom, Sheena Majewski, Wendy Szaniszlo, Angela D. Schulze

Fisheries and Oceans Canada, Nanaimo, BC, Canada. E-mail: strahan.tucker@dfo-mpo.gc.ca

Broad ecosystem changes are occurring in the coastal waters of British Columbia with large increases in several marine mammals since protection in the 1970s. An increase in pinnipeds is likely having both top-down and bottom-up effects on ocean biomass and production as they feed on fish and invertebrates and are preyed upon by transient killer whales. Despite increased predation, spawning stock biomass of herring has increased; primary forage fish and important commercial species. Steller Sea Lions and Harbour seals are year round residents and breed in BC; male California Sea Lion arrive in late summer from southern breeding grounds and remain until the following spring. We quantified the diet of sympatric pinnipeds using DNA metabarcoding and hard part analysis of scat (n>6,000) obtained from broad spatial and temporal sampling efforts. Focus is often given to the direct negative effect of predation on prey populations in tightly coupled predator-prey systems, but we as we show these pinnipeds are generalists predators and forage in a highly connected food web, increasing the potential for important indirect effects as consumption of piscivorous fish often exceeds direct consumption of forage fish. For example, herring may benefit from pinniped predation on hake, particularly if we consider the size distribution of fish consumed. Predation could have an indirect positive effect on juvenile herring, by eating juvenile hake, which results in less hake reaching maturity and thus less predation on juvenile herring. This indirect positive effect of predation on hake-herring also applies to other small pelagic fish.

S09, Poster, AbstractID=19438, PosterID: S09-P8

Recent advances and global collaboration on small pelagic forage communities; their ecology, assessment, management and socio-economics

Rebecca Asch[1], Susana Garrido[2], Chris **Rooper**[3], Motomitsu Takahashi[4]

[1]Department of Biology, East Carolina University, Greenville, North Carolina, USA
[2]Portugese Institute of Sea and Atmosphere (IPMA), Lisboa, Portugal
[3]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada.
E-mail: chris.rooper@dfo-mpo.gc.ca
[4]Pelagic Fish Resources Division, Japan Fisheries Research and Education Agency, Nagasaki, Japan

In May 2026, the joint PICES-ICES Working Group on Small Pelagic Forage Communities convened a symposium; “Navigating Changes in Small Pelagic Fish and Forage Communities: Climate, Ecosystems, and Sustainable Fisheries” in La Paz, Mexico. The symposium brought together a diverse and interdisciplinary community of participants from around the world, including experts in fisheries biology, oceanography, climate science, trophic ecology, ecosystem modeling, socioeconomics, and fisheries management. Here we present a summary of the research themes and recommendations that developed out of the symposium, as well as a brief summary of the ongoing activities of the working group. A key theme of the symposium and working group is study of environmental conditions and variability that are the dominant drivers of small pelagic community dynamics. Turning ecological knowledge into actionable management advice was also a focus, with studies that used analytical tools, novel and developing technologies as pathways to bring ecological research into decision supporting frameworks (e.g. MSE). Communication was also highlighted, in particular trade-offs between complexity (ecological realism), statistical robustness, and our ability to communicate and integrate fisheries management, science, and socioeconomics. One of the most exciting outcomes of the symposium was the number of presentations that integrated studies from across the globe to develop key trends, test widely held hypotheses or simply identify similar or contrasting characteristics of small pelagic forage species in multiple ecosystems. This is a key outcome of the working group which has created a venue for cross-system collaborations among scientists from around the world studying small pelagics.

S09, Poster, AbstractID=19453, PosterID: S09-P9, (ECOP)

Otolith-based size reconstruction of Pacific herring in the diets of juvenile Chinook salmon

Madeleine G. **Thomson**[1], Will Duguid[1], Katie Innes[2], Jessica Qualley[1,2], Bridget Maher[1], and Francis Juanes[1]

[1]University of Victoria, Victoria, BC, Canada. E-mail: maddy.thoms@gmail.com
[2]Pacific Salmon Foundation, Vancouver, BC, Canada

Predator–prey size ratios strongly influence trophic interactions in marine food webs. Studying these ratios requires accurate estimates of prey size, which can be difficult to obtain due to digestion. For piscivorous predators, fish prey sizes are commonly reconstructed from otoliths recovered in diet contents. However, otolith-to-body size relationships can vary with growth rate, with slower-growing fish exhibiting proportionately larger otoliths. If unaccounted for, this variation can decrease the accuracy of prey size reconstructions. In the Strait of Georgia (British Columbia, Canada), age-0 Pacific herring are a key prey resource for juvenile Chinook salmon. However, age-0 herring often approach the upper size limit that juvenile Chinook salmon can consume, potentially constraining their availability as prey. If juvenile Chinook salmon preferentially feed on slow-growing herring, otolith-based reconstructions may overestimate the size of consumed prey. We constructed an otolith-to-body size relationship for Pacific herring in the Strait of Georgia using fish collected during summer by beach and purse seining, as well as intact individuals recovered from salmon stomachs. We evaluated whether the smallest herring sampled at a given time of year had disproportionately larger otoliths than expected for their length, consistent with slower growth. The sizes of digested herring in salmon diets were also reconstructed using otoliths to explore whether larger salmon had access to a broader herring size distribution. These findings improve our understanding of potential biases in otolith-based size reconstruction and clarify how predator–prey size relationships may influence juvenile Chinook salmon foraging in an important rearing habitat.

S09, Poster, AbstractID=19572, PosterID: S09-P11, (ECOP)

Modelling forage fish species distribution in the Canadian Salish Sea

Sammy Alkhalifa[1], Jacqueline **Huard**[1], Cliff Robinson[2], Doug Bertram[3], and Maycira Costa[4]

[1]Comox Valley Project Watershed Society, Courtenay, BC, Canada.
E-mail: Sammy.alkhalifa@gmail.com, jachuard@gmail.com
[2]Fisheries and Oceans Canada (Retired), Nanaimo, BC, Canada
[3]Environment and Climate Change Canada (ECCC), Vancouver, BC, Canada
[4]Spectral Remote Sensing Lab, University of Victoria, Victoria, BC, Canada

Forage fish provide a critical energetic link between lower trophic levels and predators including salmon, seabirds and marine mammals, yet the distribution of many forage species remains poorly understood in the Canadian Salish Sea. This knowledge gap limits our ability to identify areas that may be disproportionately important to pelagic food webs and to incorporate forage fish habitat into ecosystem-based conservation and management.

We developed a multi-species distribution model to identify forage fish hotspots across the Canadian Salish Sea using 2,629 observations from Fisheries and Oceans Canada's long-term juvenile Pacific salmon trawl survey (2000–2023). Focal forage fish included Pacific sand lance, surf smelt, capelin, whitebait smelt and Northern anchovy. Eighteen environmental variables representing oceanographic, biological and geomorphic conditions were evaluated, and occurrence was modelled using a stacked ensemble combining generalized linear mixed-effects, neural network and XGBoost models. The final ensemble achieved an average cross-validated AUC of 0.73, with 98% precision and 72% recall.

Predicted forage fish occurrence was strongly associated with wind-driven surface currents, dissolved organic nitrogen and mesozooplankton biomass. Spatial predictions identified persistent areas of relatively high forage fish occurrence around the Fraser River delta, southern Vancouver Island, the Gulf Islands and several inlet systems, while deep central portions of the Strait of Georgia generally had low predicted occurrence.

By integrating multiple forage species and environmental drivers into a common spatial framework, this work provides a new tool for identifying areas of potential importance to the broader Salish Sea food web. The resulting hotspot map can help inform monitoring priorities, habitat conservation and restoration planning, and provides a foundation for evaluating how forage fish distributions and associated ecosystem functions may respond to changing ocean conditions.

SESSION 10: MONITOR/TCODE/FUTURE/AP-UNDOS

Topic Session

Using long-term ocean observations to understand ocean change and support resilient ecosystems and communities in the North Pacific

Oral Presentations

S10, Invited, AbstractID=19289

From observation to action: Mobilizing long-term ocean biodiversity data through OBIS for a healthy ocean

Silas C. **Principe**, Ward Appeltans, Pieter Provoost

Ocean Biodiversity Information System, International Oceanographic Data and Information Exchange, Intergovernmental Oceanographic Commission, UNESCO, Oostende, Belgium.
E-mail: s.principe@unesco.org

Long-term ocean observations form the backbone of our collective ability to detect change, inform policy, and support the protection of marine ecosystems. Yet the value of sustained observing systems depends not only on the quality of the data collected, but on how effectively that data is mobilized, integrated into standardized and interoperable formats, and translated into actionable knowledge. The IOC Ocean Biodiversity Information System (OBIS) serves as a critical interface between marine biodiversity observations and the international frameworks that depend on them. Through a community of 36 nodes, which collectively publish several millions of new marine species observation records every month, OBIS has become the world's largest open-access repository for marine biodiversity data, aggregating occurrence records from sustained monitoring programs, research cruises, and emerging sources such as eDNA and animal tracking. The North Pacific has been central to this effort: the region has contributed key datasets to OBIS since its inception, and ongoing collaboration with PICES and its member states has helped advance data mobilization and FAIR data practices across the basin. OBIS data flows into major international processes, including those under the Convention on Biological Diversity, the Kunming-Montreal Global Biodiversity Framework, UN World Ocean Assessment, and IPBES assessments and will potentially play a critical role in the BBNJ Agreement. Challenges persist, including uneven data mobilization across regions, taxonomic and temporal gaps, and the need for stronger feedback loops between data providers and (policy) users. Nevertheless, new technologies and an evolving data infrastructure offer significant opportunities to deepen the connection between North Pacific sustained observing efforts and global and regional biodiversity assessments and governance processes.

S10, Oral, AbstractID=19107

Diverse sampling programs highlight pulses of *Velella velella* along the U.S. West Coast

Megan A. **Cimino**[1,2], John A. Conroy[2], Ryan Gasbarro[1], Michael G. Jacox[3,4], Brian Hoover[5], Jarrod A. Santora[6], Danial G. Palance[7], Emily C. Nazario[7], Isaac Schroeder[8], Adena Schonfeld[8], Allison Cluett[8], Mercedes Pozo Buil[1], Nerea Lezama-Ochoa[8], Elliott L. Hazen[3], Eric Bjorkstedt[9], Jaime Jahncke[10], Timothy Jones[11], Mark D. Ohman[12] and Julia Parrish[13]

[1]Institute of Marine Science, University of California Santa Cruz, Santa Cruz, CA, USA. E-mail: mecimino@ucsc.edu
[2]Ocean Sciences Department, University of California Santa Cruz, Santa Cruz, CA, USA
[3]NOAA Southwest Fisheries Science Center, Climate & Ecosystem Group, Monterey, CA, USA
[4]NOAA Physical Sciences Laboratory, Boulder, CO, USA
[5]Farallon Institute, Petaluma, CA, USA
[6]NOAA Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, CA, USA
[7]Department of Ecology & Evolutionary Biology, University of California Santa Cruz, Santa Cruz, CA, USA
[8]Fisheries Collaborative Program, University of California Santa Cruz, Santa Cruz, CA, USA
[9]California State Polytechnic University, Humboldt, Arcata, CA, USA
[10]Point Blue Conservation Science, Petaluma, CA, USA
[11]British Antarctic Survey, Cambridge, UK
[12]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA
[13]College of the Environment, University of Washington, Seattle, WA, USA

Sporadic mass strandings of *Velella velella* along the U.S. West Coast fascinate beachcombers and perplex oceanographers. *Velella* often arrive to the coast in the spring concurrent with a shift in onshore winds, and after winters with warmer water temperatures. Understanding the factors that bring *Velella* to coastal waters provides new information about the ecological impacts of local and basin-scale environmental variability in the northeast Pacific. We summarize several compelling, non-exclusive hypotheses that could explain the recent increase in *Velella*, including increased population size, larger surface patches and enhanced coastward transport. We compiled a comprehensive dataset spanning planktonic larval to colonial adult life stages from ten sources covering ~1900–2025. These sources include multiple decadal long-term monitoring programs that provide the backbone for understanding this species response to climate and environmental variability. We will discuss challenges to integrating diverse sampling approaches, highlight pulses of *Velella* and show an unprecedented number of strandings and at-sea observations since 2014. We found that wind patterns in the central-east Pacific favor transport toward the coast during years of *Velella* presence. However, we found no clear relationship between surface frontal features and *Velella* abundance, nor a consistent association with El Niño. We also identified phalarope abundance as a potential seabird proxy for increased *Velella* abundance at-sea. Finally, we emphasize the value of sustained long-term observations and provide

recommendations for future monitoring efforts to improve long-term assessments to strengthen scientific understanding of ecosystem changes in the North Pacific.

S10, Oral, AbstractID=19172, (ECOP)

Reconstructing conservation unit-level spawner abundance from stream survey data using empirical dynamic modelling

Bruno S. **Carturan** and Stephanie J. Peacock

Pacific Salmon Foundation, Vancouver, BC, Canada. E-mail: bcarturan@psf.ca

Long-term stream spawner survey programs are foundational to Pacific salmon management, providing the escapement data needed to assess conservation unit (CU) status, set harvest limits, and detect population trends. However, these time series are rarely complete: surveys are costly, logistically challenging, and have been inconsistently funded over time, resulting in gaps that undermine their analytical value. Conventional expansion factor approaches fail to consider salmon population dynamics and perform poorly when gaps are extended or data are sparse. Empirical dynamic modelling (EDM) offers a principled alternative grounded in nonlinear dynamical systems theory. Rather than imposing a parametric structure, EDM reconstructs system dynamics directly from observed time series. Building on the recent development of EDM-based gap-filling for ecological time series (Carpenter et al. 2025), we apply multiview cross-mapping (MVCM) to fill gaps in spawner stream surveys across multiple CUs and species. This approach exploits the shared nonlinear dynamics among time series to reconstruct missing values where a focal survey was not conducted and averages across multiple set of predictor time series to optimise prediction. Using spawner survey data from the Pacific Salmon Explorer spanning multiple species and CUs, we compare MVCM performance against conventional expansion factors in reconstructing CU-level abundances. Preliminary results suggest MVCM outperforms expansion factors, particularly in CUs with limited data availability. We discuss the limitations of the MVCM approach and its potential to be integrated into operational CU assessment workflows.

S10, Oral, AbstractID=19213

Long-term observations, real-time action: Southern California Coastal Ocean Observing System

Megan **Medina**[1], Daniel Rudnick[2], Libe Washburn[3], Clarissa Anderson[2]

[1]Southern California Coastal Ocean Observing System (SCCOOS), La Jolla, CA, USA.
E-mail: memedina@ucsd.edu
[2]Scripps Institution of Oceanography, La Jolla, CA, USA
[3]UCSB Marine Science Institute, Santa Barbara, CA, USA

The Southern California Coastal Ocean Observing System (SCCOOS) has operated as the U.S. IOOS Regional Association for Southern California since 2004, delivering sustained, high-quality observations and actionable science across the California Current Large Marine Ecosystem from Morro Bay to Ensenada, Mexico. SCCOOS flagship programs form the backbone of this long-term observing effort: the California Surface Current Mapping Network — the world's largest continuous High-Frequency Radar network — provides real-time surface current observations critical for maritime safety, search and rescue, and ecosystem tracking; the California Underwater Glider Network delivers continuous subsurface physical and biogeochemical profiles across the California Current; Automated Shore Stations sustain high-frequency nearshore measurements of temperature, salinity, ocean acidification, and harmful algal bloom (HAB) indicators; the California HAB Early Warning System — integrating the CalHABMAP monitoring program, the California Imaging FlowCytobot Network, and the operational C-HARM forecast system — serves as a national prototype for a U.S. HAB Observing Network; and the Southern California Acoustic Telemetry Network provides real-time detection of white sharks and other marine species to support beach safety and ecosystem monitoring. New investments are expanding SCCOOS observing capacity into emerging frontiers including environmental DNA, omics, acoustics, and passive acoustic monitoring, enabling next-generation detection of ecosystem change. Together, these platforms deliver Essential Ocean Variables documenting long-term coastal variability and change, including marine heatwaves, ocean acidification and hypoxia, and shifting ecosystem dynamics. Through sustained investment in data management, AI/ML-ready data pipelines, and regional downscaled modeling, SCCOOS translates observations into actionable decision-support tools for maritime safety, public health, fisheries management, and coastal hazard preparedness.

This presentation highlights how SCCOOS long-term observing infrastructure, data user-driven product development, and collaborative governance model support resilient ecosystems and communities across the southern California Current — and offers lessons relevant to sustained ocean observing across the North Pacific.

S10, Oral, AbstractID=19260

Eastern Bering Sea habitat conservation areas support distinct long-term biodiversity and community dynamics

Irene D. **Alabia**[1,2], Megan J. Williams[3], Jorge García Molinos[1], Takafumi Hirata[1], Hiromichi Ueno[1,4]

[1]Arctic Research Center, Hokkaido University, Sapporo, Japan.
E-mail: irenealabia@arc.hokudai.ac.jp
[2]International Arctic Research Center, University of Alaska Fairbanks, Alaska, USA
[3]Ocean Conservancy, Anchorage, AK, USA
[4]Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Japan

Habitat Conservation Areas (HCAs) in the eastern Bering Sea are intended to curtail disturbance and conserve benthic and demersal ecosystems, although their biodiversity value could extend beyond species richness into compositional and functional dimensions. Here, we compared five focal HCAs with matched nearby non-HCA reference cells from 2000 to 2019 and quantified taxonomic, phylogenetic, and functional alpha diversity and interannual beta diversity from a subset of 51 marine taxa comprising 28 mesopredators and 23 apex predators. Diversity indices were estimated based on a published multi-model ensemble of species distributions constructed using species information and relevant environmental covariates. Across Nearshore Bristol Bay, Pribilof Islands HCZ, Red King Crab Savings Area, and Walrus Protection Area, alpha diversity was higher inside HCAs by +4% for species richness and +2% for phylogenetic diversity and functional richness. Beta diversity for all species was also higher in these four focal areas, with mean log response ratios of 0.20 (+22%), 0.13 (+13%), and 0.33 (+39%) for taxonomic, phylogenetic, and functional beta diversity, suggesting stronger interannual compositional dynamics within protected habitats. Positive alpha diversity signals were associated with seals, eiders, and alcids. In contrast, positive beta-diversity signals were more often associated with whales, sharks, and crab taxa. After accounting for spatial structure, HCA status showed a positive association with beta diversity. Disturbance-response analyses further showed that beta diversity generally declined as cumulative disturbance increased. Overall results suggest that reduced habitat disturbance associated with HCAs supports diverse and dynamic marine ecosystems over time.

S10, Oral, AbstractID=19273

Surface ocean pCO_2 trends within coastal British Columbia waters

Wiley **Evans**, Trevor Michalchuk, Lydia Pollock, Katie Campbell

Hakai Institute, Quadra Island, BC, Canada. E-mail: wiley.evans@hakai.org

Resolving ocean acidification (OA) signals requires sustained long-term observations. This constraint can be difficult to realize within many dynamic coastal settings where the time-of-detection for the emergence of OA signals may be many decades. However, sustained observations within these settings enable the identification of processes that may be masking OA signals. The Surface Ocean CO_2 Atlas (SOCAT) is a global compilation of seawater pCO_2 measurements collected over decades that allows for an investigation into the pCO_2 trends within British Columbia (BC) waters. Here, we combine this dataset with additional measurements not included in the compilation to identify trends and their drivers within select areas of BC's coastal ocean. We use data surrounding Ocean Station Papa to define the large-scale North Pacific trend, and contrast this with trends from the Strait of Juan de Fuca, the northern Strait of Georgia, Johnstone Strait, and the central BC coast. The trends and their drivers differ across these coastal sites and from the large-scale North Pacific trend. This analysis highlights competing processes that mask OA signals within BC's coastal regions, which are not only important to consider from an OA context but also would interact with ocean-based interventions to remove atmospheric CO_2.

S10, Oral, AbstractID=19277

Toward coordinated long-term ocean observations for marine ecosystem monitoring: The California Ocean and coastal monitoring inventory & the CalCOFI program

Mark **Gold**[1] and Erin Satterthwaite[2]

[1]Scripps Institution of Oceanography, UCSD, La Jolla, CA, USA. E-mail: m4gold@ucsd.edu
[2]Scripps Institution of Oceanography and California Sea Grant, UCSD, La Jolla, CA, USA. E-mail: esatterthwaite@ucsd.edu

Maintaining healthy, productive marine ecosystems that protect biodiversity, fisheries, the blue economy, and public health in the face of accelerating ocean change requires coordinated and sustained observations of marine biodiversity. Achieving this coordination depends on understanding the scope and capacity of existing monitoring programs, including identifying gaps in spatial and ecosystem coverage and assessing how those gaps align with management priorities and information needs. The California Ocean and Coastal Monitoring Inventory is an effort to address this need by systematically compiling and harmonizing monitoring metadata across ocean and coastal programs. The inventory documents the existing monitoring efforts, including what is measured, where monitoring occurs, how often it is conducted, and by what methods in a unified, searchable view of active monitoring across California's coast. This product enables comparison across programs and highlights redundancies, gaps, and opportunities for integration. Commonly measured parameters across California include temperature, salinity, chlorophyll, dissolved oxygen, and fish abundance. In addition, the coastal discharger community extensively monitors pollutant concentrations in water, sediment and fish. Also, clear spatial and thematic differences in effort exist across regions and program types. However, the California Cooperative Oceanic Fisheries Investigations (CalCOFI), one of the longest-running integrated marine ecosystem monitoring programs in the world, provides sustained quarterly coverage of the Southern and Central California Current System. CalCOFI includes physical, chemical, and biological sampling while increasingly incorporating new tools such as environmental DNA (eDNA) and advanced data systems. Given its long time series, multi-disciplinary sampling, and evolving data systems, CalCOFI serves as a useful microcosm of the challenges faced in achieving large-scale coordination and integration across observing datasets. In this sense, CalCOFI also functions as a practical test case for how broader coordination efforts can be structured. CalCOFI's recent efforts to address the challenge of coordinating and integrating heterogeneous data include developing a comprehensive inventory of observing assets, linking disparate datasets through interoperable systems, and synthesizing and visualizing integrated information in accessible, decision-relevant formats. We hope that the approaches we present can be adapted and extended to support continued progress toward coordinated, comprehensive ocean observations across the North Pacific.

S10, Oral, AbstractID=19309

When the coast remembers: Integrating Indigenous knowledge systems & marine geoscience for tsunami risk assessment

Pieter **Romer**, Soroush Kouhi Anbaran

University of Victoria, Victoria, BC, Canada.
E-mail: promer@oceannetworks.ca, skouhi@uvic.ca

This case study examines the integration of Indigenous Traditional Ecological Knowledge Systems (TEKS) and marine geoscience through a collaborative tsunami risk assessment initiative led by Ocean Networks Canada in partnership with Nuu-chah-nulth and Quatsino First Nations on the northwest coast of British Columbia, Canada. Situated along the Cascadia Subduction Zone, coastal communities face significant risks from earthquakes and tsunamis.

Conventional tsunami hazard assessments rely on bathymetric mapping, LiDAR-derived Digital Elevation Models (DEMs), seismic records, and hydrodynamic modelling. Through sustained engagement with Indigenous knowledge holders, researchers documented oral histories and place-based observations describing historical tsunami events, inundation zones, ecological changes, ancestral settlement locations, and relocation sites.

These accounts showed strong convergence with geological evidence associated with the 1700 Cascadia earthquake and tsunami and provided context for interpreting modelled inundation scenarios. Indigenous knowledge holders identified traditional escape routes, landscape indicators, and high-risk coastal areas that aligned closely with scientific assessments while providing insights unavailable through remote sensing technologies alone.

The project highlights TEKS as a rigorous observational knowledge system grounded in environmental knowledge and intergenerational transmission. Combined with quantitative modelling approaches, these complementary knowledge systems produced a more comprehensive and community-relevant framework for tsunami risk assessment. The collaboration demonstrates how Indigenous Nations and scientists can co-develop hazard assessments that strengthen coastal resilience and preparedness.

S10, Oral, AbstractID=19328, (ECOP)

Linkages between spring bloom seasonality off southeastern Hokkaido and environmental variability in the southern Okhotsk Sea

Joji **Oida**[1], Toru Hirawake[2,3], Youhei Yamashita[4,5], Jun Nishioka[5,6], Hiroto Abe[7], Hisatomo Waga[8,9], Shigeho Kakehi[1], Daisuke Hasegawa[1], Takahiro Tanaka[10], Ryosuke Makabe[2,3] and Amane Fujiwara[11]

[1]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Shiogama, Miyagi, Japan. E-mail: oida_joji94@fra.go.jp
[2]National Institute of Polar Research, Tachikawa, Tokyo, Japan
[3]Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Hayama, Kanagawa, Japan
[4]Faculty of Environmental Earth Science, Hokkaido University, Sapporo, Hokkaido, Japan
[5]Graduate School of Environmental Science, Hokkaido University, Sapporo, Hokkaido, Japan
[6]Pan-Okhotsk Research Center, Institute of Low Temperature Science, Hokkaido University, Sapporo, Hokkaido, Japan
[7]Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, Japan
[8]International Arctic Research Center, University of Alaska Fairbanks, Fairbanks , AK, USA
[9]International Polar and Earth Environmental Research Center, National Institute of Polar Research, Tachikawa, Tokyo, Japan
[10]Graduate School of Integrated Science and Technology, Nagasaki University, Nagasaki, Nagasaki, Japan
[11]Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Kanagawa, Japan

The waters off southeastern Hokkaido, Japan, are highly biologically productive due to a substantial spring phytoplankton bloom. The bloom seasonality, including its magnitude and timing, is known to be influenced by sea surface temperature (SST). In addition, this region is also affected by Coastal Oyashio Water (COW) originating from the Okhotsk Sea. Variability in sea ice extent in the southern Okhotsk Sea can alter the timing of the spring bloom in this region, leading to changes in nutrient supply and influencing the bloom seasonality downstream, off southeastern Hokkaido. However, the impacts of interannual variability in SST and the extent of COW on bloom seasonality have not been sufficiently examined across the entire region off southeastern Hokkaido and over multiple years. In addition, the factors controlling variability in extent of COW remain unclear, and the linkage between environmental variability in the Okhotsk Sea and bloom seasonality off southeastern Hokkaido is not yet well understood.

In this study, we used satellite-derived sea surface temperature (SST), sea surface salinity (SSS), chlorophyll-*a* concentration (chl.*a*), sea ice concentration (SIC), and sea surface height (SSH). We estimated surface water mass distribution, including COW, by combining SST and SSS, and

calculated the COW coverage ratio (R_{COW}). The sea ice coverage ratio (R_{ICE}) in the southern Okhotsk Sea was derived from SIC. We also estimated geostrophic currents from SSH to evaluate the strength of the southward coastal current (East Sakhalin Current: ESC) across 47°N.

In the coastal region off southeastern Hokkaido, the timing of the spring bloom was significantly correlated with SST, with earlier bloom onset in warmer years. In contrast, in the offshore region, bloom magnitude was positively correlated with R_{COW}, and decreased R_{COW} corresponded to reduced bloom magnitude. R_{COW} in April was independently influenced by both ESC strength and R_{ICE} approximately one month earlier. In addition, we present the linkage between bloom seasonality in the Okhotsk Sea and that off southeastern Hokkaido.

S10, Oral, AbstractID=19346, (ECOP)

Using Continuous Plankton Recorder (CPR) data to understand past, present and future changes in Northeast Pacific phytoplankton

Loïck **Kléparski**[1], Clare Ostle[1], Sonia D. Batten[2], Nicolas Djeghri[3], Claudine Hauri[4], Rémi Pagès[4], Suzanne Strom[5]

[1]Marine Biological Association, Citadel Hill, Plymouth, UK.
E-mail: loick.kleparski@hotmail.fr, loikle@mba.ac.uk
[2]North Pacific Marine Science Organization (PICES), Sidney, BC, Canada
[3]Univ Brest, Institut Universitaire Européen de la Mer, IUEM/UBO, Laboratoire des sciences de l'Environnement Marin, UMR 6539 LEMAR, Technopole Brest Iroise, Plouzané, France
[4]International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA
[5]Shannon Point Marine Center, Western Washington University, Anacortes, WA, USA

The Continuous Plankton Recorder (CPR) survey has been sampling phytoplanktonic organisms in the Northeast Pacific since the early 2000s. Although its sampling effort is heterogeneous in space and time, the CPR survey gives an accurate picture of the major changes in the phytoplanktonic community. This talk will demonstrate how this multidecadal dataset can be used to detect important ecosystem changes in response to past extreme climatic events. We explore how phytoplankton morphology and biomass have been affected by long-term environmental variability, how marine heatwaves have caused a shift toward more elongated, high-biomass phytoplankton species, and how this has impacted the carbon cycle. Finally, we will show that the data collected by the CPR can also be used to forecast future changes in phytoplankton abundance, morphology and biomass in response to climatic forcing, therefore enabling us to anticipate important ecosystem reorganization in the decades to come.

S10, Oral, AbstractID=19355

Observing ocean acidification across agencies, knowledge systems, and large marine ecosystems in Alaska

Natalie M. **Monacci**[1], Simone R. Alin[2], Jessica N. Cross[3], Darcy Dugan[4], Jeff Hetrick[5], Esther Kennedy[6], Julie Keister[7], Kari Lanphier[8], Michael Litzow[9], Sierra Lloyd[5], W. Chris Long[10], Matteo Masotti[11], Elizabeth Moeser[5], Celeste Ossowski[12], Darren Pilcher[13], Andie Wall[11], Jared Weems[14]

[1]University of Alaska Fairbanks, College of Fisheries and Ocean Sciences, Ocean Acidification Research Center, Fairbanks, AK, USA. E-mail: nmonacci@alaska.edu
[2]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA
[3]Pacific Northwest National Laboratory, Seattle, WA, USA
[4]Alaska Ocean Observing System, Alaska Ocean Acidification Network, Anchorage, AK, USA
[5]Chugach Regional Resource Commission, Alutiiq Pride Marine Institute, Seward, AK, USA
[6]University of Alaska Southeast, Alaska Coastal Rainforest Center, Anchorage, AK, USA
[7]NOAA Alaska Fisheries Science Center, Seattle, WA, USA
[8]Southeast Alaska Tribal Ocean Research, Sitka, AK, USA
[9]Alaska Coastal and Oceans Research, Kodiak, AK, USA
[10]NOAA Alaska Fisheries Science Center, Kodiak, AK, USA
[11]Sitka Tribe of Alaska, Sitka, AK, USA
[12]Kodiak Area Native Association, Kodiak, AK, USA
[13]University of Washington, Cooperative Institute for Climate, Ocean, and Ecosystem Studies, Seattle, WA, USA
[14]Alaska Department of Fish and Game, Kodiak, AK, USA

The ocean absorbs around 30% of human released carbon dioxide, decreasing seawater pH in a process known as ocean acidification. Alaska's large marine ecosystems are vulnerable to ocean acidification due to natural processes that precondition the water to be near biological thresholds. Physiological response studies show ocean acidification negatively affects marine ecosystems by impacting the survival, growth, and reproduction of sensitive species. Alaska's coastal communities and industries are also at risk, due to the high dependence on marine resources for culture, food security, and economics. Long-term observations monitor the intensity, duration, and extent of ocean acidification in the Gulf of Alaska, Bering Sea, Chukchi Sea, and Beaufort Sea during this time of significant change. We use ship-based, shoreside, and autonomous uncrewed platforms through decadal programs led by academic research centers, federal and state agencies, nonprofits, and Tribal resource offices. Data and information are shared across academic, fishing, and Traditional knowledge systems to strengthen our understanding of the current conditions for future decision making. Our programs include more than 18 years of oceanographic research, 15 years of Indigenous-led initiatives, and 10 years of communication through a statewide network. We will highlight the successes and challenges of sustaining

observations and data management to apply information to fisheries management and climate resilience across Alaska.

S10, Oral, AbstractID=19359, (ECOP)

OceanECO: A new data dashboard, transforming Northeast Pacific long-term monitoring data to information

Yayla **Sezginer**, Taimaz Bahadory, and Jordan Watson

Canadian Integrated Ocean Observing System (CIOOS) Pacific, Victoria, BC, Canada.
E-mail: yayla.sezginer@cioospacific.ca

Long-term ocean observations are essential for understanding and responding to climate-driven challenges in the Northeast Pacific, which is particularly susceptible to marine heatwaves, ocean acidification and hypoxia. The Northeast Pacific is rich in ocean observatories and monitored by some of the longest running oceanographic time series. Yet, the highly multi-institutional nature of the region's ocean observing network, which consists of federal and provincial agencies, first nations, academic institutions, non-governmental organizations, and private industry can lead to a fragmented data landscape that limits the findability of data for researchers, decision-makers, coastal communities, and industry. The Canadian Integrated Ocean Observing System (CIOOS) addresses this challenge through a national data hub that improves the discoverability and interoperability of Canadian ocean observations while enabling CIOOS Regional Associations (CIOOS Pacific, CIOOS Atlantic, CIOOS St Lawrence Gulf Observatory) to develop custom data tools, driven by local concerns. Here, we present OceanECO (Ocean Environmental Conditions Observer), a new CIOOS Pacific data dashboard developed in response to British Columbia's Ocean Acidification and Hypoxia Action Plan, which calls for community-accessible and timely ocean acidification and hypoxia information. OceanECO combines live, in-situ observations from CIOOS Pacific data partners' distributed sensor networks and long-term monitoring programs with regional biogeochemical models to provide near real-time, 3-dimensional visualization of temperature, salinity, dissolved oxygen, pH, and carbonate chemistry throughout the Salish Sea and Vancouver Island region. The platform transforms long-term data records into actionable information by providing model-observation evaluation tools, user-defined threshold analyses, climatological records and long-term trends. OceanECO illustrates how integrated ocean observing systems can bridge the gap between distributed data collection programs and actionable knowledge, supporting resilient coastal communities in a changing ocean.

S10, Oral, AbstractID=19361, (ECOP)

Alternate drivers of primary productivity in the Washington shelf

Nina **Buzby**[1], Jens Nielsen[2,3], Stephanie K. Moore[4], Eric J. Ward[4], Alison Gray[1], and Jodi Young[1]

[1]University of Washington, School of Oceanography, Seattle, WA, USA.
E-mail: nbuzby@uw.edu
[2]University of Washington, Cooperative Institute for Climate, Ocean, and Ecosystem Studies, Seattle, WA, USA
[3]NOAA Alaska Fisheries Science Center, Seattle, WA, USA
[4]NOAA Northwest Fisheries Science Center, Seattle, WA, USA

Primary production forms the energetic foundation of marine ecosystems. Shelf oceans including highly productive upwelling ecosystems are particularly important as they provide essential habitat and an abundance of resources that support a range of biological and economic aspects of coastal ecosystems. The northern region of the California Current System off the coast of Washington sustains notably high production, despite reduced upwelling conditions characteristic of eastern boundary upwelling systems. Several physical mechanisms within the region have been identified as capable of enhancing coastal nutrient supply, though evaluation of their influence on actual primary production metrics remains relatively unexplored. Unlike previous efforts that have employed regional models, this work employs moored in-situ data from the Northwest Enhanced Moored Observatory in tandem with remotely-sensed, observational data products. Using a suite of high-frequency, coastal mooring measurements collected from six years during the growing season in the Olympic Coast National Marine Sanctuary, we calculate net primary production (NPP) to assess primary production dynamics. By investigating mechanistic relationships between NPP and environmental drivers on the Washington shelf, this work contextualizes previously identified production pathways and advances understanding of the processes supporting the region's atypical productivity. Because primary production underpins marine food webs and higher trophic levels in the region exhibit similarly atypical relationships with upwelling, these results provide a valuable framework for ecosystem monitoring and fisheries management.

S10, Oral, AbstractID=19437

Secular range shifts of fishes in the California Current Ecosystem over seven decades

Andrew Richard **Thompson**

National Oceanic and Atmospheric Administration, Southwest Fisheries Science, La Jolla, USA.
E-mail: andrew.thompson@noaa.gov

Elucidating responses of species to climate change is the fundamental task of modern ecology. In the northern hemisphere, many marine species are predicted to shift poleward in response to a warming ocean. Tests of this forecast are somewhat lacking, however, due to limited temporal or spatial time series. We evaluate trends in movement (leading edge, center of distribution and trailing edge) of 178 species from the world's longest fisheries oceanographic monitoring program, California Cooperative Oceanic Fisheries Investigation (CalCOFI)/ Investigaciones Mexicanas de la Corriente de California (IMECOCAL) that have systematically sampled larval fishes and oceanographic conditions quarterly from approximately 150 stations along a ~1500 km stretch between Punta Eugenia, Baja California Sur, Mexico and San Francisco, California, USA from 1951 2019. Depending on adult habitat and geographic distribution, the Center of Gravity (COG) of between 12 and 41% of species significantly shifted northwards in at least one season. COG shifted more frequently for taxa with northern and cosmopolitan geographic ranges than those with southern ranges, but there was no apparent difference between pelagic and benthic taxa. Shifts in distribution for fishes that moved tended to be episodic rather than linear with large, lasting pulses of northward shifts in 1976 and 2015. For taxa that changed COG, the median shift was between ~200 and ~500 km north. On the whole, responses of fish to climate change in the California Current Ecosystem over seven decades were nuanced and highly affected by life history.

S10, Oral, AbstractID=19446, (ECOP)

Physics to fish and beyond: 70 years of subregional ecosystem variability in the California Current

Alison E. **Appelgate**[1], Martin Lindegren[2] and Michael R. Stukel[1]

[1]Earth, Ocean, and Atmospheric Science Dept., Florida State University, Tallahassee, FL, USA. E-mail: aappelgate@fsu.edu
[2]National Institute of Aquatic Resources, Technical University of Denmark, Lyngby, Denmark

From the highly productive onshore to the oligotrophic offshore, the southern California Current Ecosystem (CCE) spans many subregions, each of which is governed by a different combination of physical and biological processes. Physical forcing strongly influences the CCE, with drivers such as El Niño and the PDO often associated with reduced productivity during positive phases. However, despite these well-established trends, how the subregions of the CCE have changed over time is unclear, as time series analyses have historically focused on the region as a whole. Using the high spatial and temporal resolution of the California Cooperative Oceanic Fisheries Investigation (CalCOFI) time series, we split the CCE into four subregions – an oligotrophic offshore region that reaches the outer edge of the North Pacific Subtropical Gyre, an upwelling dominated region around Point Conception and the Channel Islands, a southern section of the SoCal Bight off San Diego, and the core of the California Current. Each subregion is represented by an expansive dataset, from physical forcing and nutrient dynamics, through phytoplankton, zooplankton, fish, marine mammal, and seabird taxa. We then use principal component analyses (PCAs) to analyze the long-term drivers of ecosystem variability within each of these subregions and examine the differences in food web dynamics across the CCE and show how they have varied over time. By understanding the different drivers of ecosystem dynamics across the CCE, we can begin to predict when pelagic ecosystems may be more vulnerable to disturbances and food web shifts within this commercially important area.

S10, Oral, AbstractID=19447, (ECOP)

Deep dive: Analysis of the mesopelagic prokaryotic community in the California Current Ecosystem (2014-2021)

Soo Yoon **Kim**[1,2], Rob Lampe[3], Chase James[4], Bryce Ellman[1,2], Hong Zheng[1,2], Ariel Rabines[1,2] and Andrew Allen[1,2]

[1]Integrative Oceanography Division, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA. E-mail: sok044@ucsd.edu
[2]J. Craig Venter Institute, La Jolla, CA, USA
[3]Woods Hole Oceanographic Institution, Woods Hole, MA, USA
[4]University of Southern California, Los Angeles, CA, USA

The mesopelagic zone (200m-1000m) plays a critical role in the biological carbon pump, yet the prokaryotic communities that drive remineralization and thus carbon and nutrient cycling in this layer remain relatively unexplored in the California Current Ecosystem (CCE). The CCE is a highly productive eastern boundary upwelling system where nitrogen availability and oxygen minimum zones are key regulators of biogeochemical cycling. However, their influence on mesopelagic microbial community structure remains poorly understood. Here, we examine the mesopelagic prokaryotic community diversity in the CCE using samples collected from quarterly CalCOFI cruises from 2014 to 2021. DNA samples from the upper mesopelagic (170m/200m) and lower mesopelagic (515m) along the CalCOFI station grid were subject to 16S V4-V5 marker gene-based sequencing. Alpha diversity was significantly higher in the upper than lower mesopelagic. At 170m, Shannon diversity was strongly correlated with nitrate, nitracline depth, silicate, and oxygen, consistent with a nearshore-offshore productivity gradient, whereas no significant correlations were observed at 515m, suggesting decoupling of lower mesopelagic diversity from local environmental conditions. Bray-Curtis dissimilarity-based PERMANOVA revealed nitrate as the dominant structuring variable for community composition at 170m, while salinity and temperature emerged as top drivers at 515m, suggesting that water mass characteristics play a more prominent role in structuring the lower mesopelagic community. The prokaryotic community was largely dominated by *Nitrosopumilaceae* (34.1 ± 8.2%) across both depth layers, consistent with active ammonia oxidation and nitrification in the CCE mesopelagic. These findings highlight contrasting environmental drivers between depth layers, with the upper mesopelagic strongly responding to nutrient gradients and the lower mesopelagic exhibiting a relatively homogeneous community structure. These patterns further imply differentially altered microbial function and carbon export across the mesopelagic depth layers due to spatiotemporal shifts in upwelling intensity and deoxygenation under future climate scenarios.

S10, Oral, AbstractID=19457, (ECOP)

Multi-trophic-level synchrony in phenological shifts on the western Gulf of Alaska shelf

Lauren N. **Block**[1,2], David G. Kimmel[2], Lauren A. Rogers[2], Jens M. Nielsen[1,2]

[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA. E-mail: blockln@uw.edu
[2]National Oceanic and Atmospheric Administration, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, USA

Shifts in phytoplankton bloom timing, zooplankton reproduction and development, and fish spawn timing have been observed globally. Differences in the relative timing between the three trophic levels can impact the predator-prey temporal match or mismatch with implications for food web dynamics and recruitment. Here, we analyze over two decades of data to examine phenological shifts of phytoplankton, copepod, and larval fish communities on the western Gulf of Alaska shelf using developmental stage and length-based indices of phenological timing. We then compare shifts across the three trophic levels using dynamic factor analysis to identify common trends in phenology over time. Across all three trophic levels, there was a common phenological trend over time. For all trophic levels, cooler conditions between 2007 and 2010 were associated with delayed phenology while warmer conditions between 2015 and 2020 were associated with earlier phenologies. While the absolute magnitude of shifts remains uncertain, the common directionality in phenological shifts from phytoplankton to fishes indicates synchronous responses to environmental change across trophic levels.

S10, Oral, AbstractID=19466, (ECOP)

A community-based approach to monitoring ocean acidification and harmful algal blooms in Alaska's Chugach Region

Elizabeth **Moeser**, Sierra Lloyd, Jana **Wheat**, Riley Thomas Jeff Hetrick and Allison Carl

Chugach Regional Resources Commission, Alutiiq Pride Marine Institute, Seward, AK, USA. E-mail: elizabeth@crrcalaska.org, jana@alutiiqprideak.org

The Chugach Regional Resources Commission (CRRC) is an inter-Tribal natural resources commission serving seven coastal Tribal communities in Alaska's Chugach Region in the Northern Gulf of Alaska. The Chugach Regional Ocean Monitoring (CROM) program was established in response to growing concern for and risk to subsistence resources in the face of ocean acidification and the increased occurrence of harmful algal blooms (HABs). Throughout this region – and much of the state – coastal communities depend on subsistence harvest from the ocean for food security, cultural continuity, and well-being. By training and equipping community-based samplers, the CROM program builds capacity within the Chugach region for long-term ocean monitoring in the near-shore. Samples are processed at the Alutiiq Pride Marine Institute, CRRC's mariculture and marine research facility, in Seward, Alaska. The Chemistry Laboratory has measured continuous carbonate system parameters locally and discrete samples from coastal communities since 2015. The partial pressure of CO_2 (pCO_2) and total CO_2 (TCO_2) are measured using a Burke-O-Lator system, from which all other carbonate system parameters are calculated. Concurrently, the Biology Laboratory analyzes phytoplankton samples to identify toxin-producing *Alexandrium* and *Pseudo-nitzschia* which are responsible for paralytic and amnesic shellfish poisoning. Together, these data can reveal seasonal variability and emerging trends in ocean chemistry and HABs, as well as support informed decisions about subsistence harvest. Continued expansion of the CROM program with the addition of nutrients and environmental DNA analyses will deepen our understanding of local biogeochemical processes and support resilient, community-driven responses to changing ocean conditions.

S10, Oral, AbstractID=19472

Blending local knowledge systems and oceanographic technology to support the restoration of salmonid populations on the West Coast of Vancouver Island

Kiyomi **Holman**[1], Emily **Fulton**[2], Sophie **Vanderbanck**[2], Edward Mason[1] and Lucianne Marshall[1]

[1]Ocean Networks Canada, Victoria, BC, Canada. E-mail: kiyomiholman@uvic.ca
[2]Redd Fish Restoration Society, Ucluelet, BC, Canada.
E-mail: emily@reddfish.org, sophie@reddfish.org

From mountain streams to the open ocean, and everything in between, monitoring the environments that support salmon throughout their lifecycle requires a committed and collaborative approach. Redd Fish Restoration Society is a non-profit organization working in partnership with the nuučaanuł Nations on the west coast of Vancouver Island to engage in ecological restoration, research, and monitoring. By blending traditional knowledge systems with science and technology, Redd Fish seeks to support the restoration of wild salmon habitats and populations.

To better understand the physical conditions of the marine environment and its impact on salmonids and salmonid ecosystems, Redd Fish has formed a partnership with Ocean Networks Canada (ONC), a Major Research Facility in Canada, operated by a not-for-profit society that specializes in oceanographic data collection. ONC's Community Fishers program was established to collect standard oceanographic data in coastal regions by community members. Partners receive training in physical oceanography and the use of scientific equipment provided by ONC, then collaboratively develop and implement a baseline monitoring program based on local needs and objectives. Data are uploaded to ONC's online data repository, Oceans 3.0, where data is processed and managed.

This presentation will illustrate our methods. By combining multiple ways of knowing with many forms of data collected and a community-driven approach, Redd Fish seeks to provide a holistic foundation for understanding ecosystem health, advancing salmon habitat restoration, and supporting the long-term resilience of coastal communities and environments.

S10, Oral, AbstractID=19477, (ECOP)

Abyss to shoreline: Ocean Networks Canada's integrated long-term observing systems for the Northeast Pacific

Moronke K. **Harris**[1], Daniela Loock[1], Desirée Bulger[1], Lucianne Marshall[1], Dwight Owens[1], Jessica Phillips[1], Yayla Sezginer[2], Austen Sorochak[1] and Jordan Watson[1,2]

[1]Ocean Networks Canada (ONC), University of Victoria, Victoria, BC, Canada.
E-mail: moronke@oceannetworks.ca
[2]Canadian Integrated Ocean Observing System (CIOOS) Pacific, Victoria, BC, Canada

ONC operates world-leading ocean observatories providing open access to data from the Pacific, Arctic, Atlantic and Southern oceans, extending from nearshore coastal communities into deep offshore environments. ONC's VENUS coastal network in the Salish Sea has delivered continuous high-resolution measurements since 2006. Operating since 2009, NEPTUNE is an 850-kilometre offshore cabled array spanning the Juan de Fuca tectonic plate and collecting high-resolution multidimensional observations across five unique seafloor environments.

A growing network of Coastal Community Observatories, co-developed with coastal and Indigenous communities across Canada's Pacific, Arctic and Atlantic, provides scaled-down, locally focused systems supplying continuous, real-time ocean monitoring in ecologically and culturally significant areas. Co-managed in close partnership with community members, and deployed, operated, and maintained by small teams using standard vessels, these ocean observing systems complement existing marine research activities, generating locally relevant, accessible ocean data, and providing educational programming opportunities.

Together, these assets deliver freely accessible multi-decadal time series spanning physical, chemical, and biological parameters critical for detecting ecosystem change, monitoring climate extremes, and informing fisheries management. ONC's data infrastructure supports interoperable data sharing through the Oceans 3.0 data portal and national platforms such as CIOOS, alongside AI-assisted processing pipelines and integration with custom data tools. We discuss how this observatory continuum, bridging deep-sea and nearshore environments, scientific and community knowledge systems, and decades-old time series with emerging sensing methods, advances regional ecosystem understanding and the long-term stewardship goals of coastal communities in an era of rapid ocean change.

S10, Oral, AbstractID=19493, (ECOP)

Expanding Oregon's early warning HAB system: Insights from nearly two decades of monitoring harmful algae on the Oregon coast

Rebecca M. **Crawford**, Matthew V. Hunter

Oregon Department of Fish and Wildlife, Astoria, Oregon, USA.
E-mail: rebecca.m.crawford@odfw.oregon.gov

Harmful Algae Blooms (HABs) along the Oregon Coast have been documented since the 1990s and are associated with detrimental impacts to human health, marine life and coastal economies. Neurotoxins produced by the diatom *Pseudo-nitzschia spp.* and dinoflagellate *Alexandrium spp.* accumulate in shellfish tissue and can cause Amnesiac Shellfish Poisoning and Paralytic Shellfish Poising respectively, resulting in shellfish harvesting closures and significant losses to these fisheries. In response to the serious risk blooms of these phytoplankton pose, the Oregon Department of Fish and Wildlife (ODFW), Oregon State University and the National Oceanic and Atmospheric Administration (NOAA) established Monitoring Oregon Coastal Harmful Algae (MOCHA) in 2007. Since 2007, surf zone HAB monitoring has been supported by federal grants from NOAA and the Northwest Association of Networked Ocean Observing Systems and has grown through regional and tribal partnerships. Monitoring includes weekly enumeration and identification of phytoplankton in water samples collected from standardized sites along the Oregon Coast. MOCHA offers timely information on the status of HABS and helps inform the Pacific Northwest HAB Bulletin which provides an early warning of HAB risk to coastal shellfish managers. Beginning July of 2025, ODFW received state funding for the first time to support a coast-wide HAB monitoring program in Oregon. Presented here are data spanning from 2006-2026 showing the spatial and temporal distribution of HABS on Oregon's Coast. Included are preliminary results from the first season of expanded surf and estuarine sampling and how these data are being used to address current gaps in monitoring.

S10, Oral, AbstractID=19513

Combining tradition and innovation: The evolution of CalCOFI in support of Ecosystem-Based Fisheries Management

Noelle M. **Bowlin**[1], Steven J. Bograd[2], Mark Gold[3], Zachary Gold[4], Andrew W. Leising[1], Nastassia Patin[3], Erin V. Satterthwaite[3], Brice X. Semmens[3], Rasmus Swalethorp[3], Andrew R. Thompson[1], William Watson[1] and Edward D. Weber[1]

[1]NOAA Southwest Fisheries Science Center, La Jolla, CA. USA.
E-mail: noelle.bowlin@noaa.gov
[2]NOAA Southwest Fisheries Science Center, Monterey, CA, USA
[3]Scripps Institution of Oceanography, UCSD, La Jolla, CA, USA
[4]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) program has served as a foundational pillar for ecosystem-based fisheries research in the North Pacific for over seven decades. Originally established to investigate the collapse of the Pacific Sardine fishery, CalCOFI pioneered the "ecosystem approach" to fisheries management by integrating physical, chemical, and biological observations to discern the drivers of marine population dynamics. Today, the program is undergoing a significant evolution by combining its robust 75-year time series with cutting-edge technological advancements. Recent initiatives have integrated environmental DNA (eDNA) metabarcoding and the deployment of uncrewed systems alongside traditional ship-based sampling to enhance taxonomic resolution and spatial coverage. These technological augmentations significantly improve monitoring capabilities and data quality, providing a more comprehensive understanding of shifts in community structure and climate-driven ecosystem changes. By bridge-building between historical baseline data and high-resolution modern sensing, CalCOFI continues to provide the essential scientific framework required for resilient fisheries management and better-informed ecological outcomes in the California Current Ecosystem.

S10, Oral, AbstractID=19523

Monitoring and understanding changes in the Northern Bering Sea ecosystem

Julie **Keister**[1], Ryan McCabe[2], Rob Suryan[3], Danielle Dickson[4], Jens Nielsen[5], David Kimmel[1], Jeanette Gann[3], Kelia Axler[1], Heather Tabisola[5], Matthew Baker[4], and Wei Cheng[2]

[1]NOAA Alaska Fisheries Science Center, Seattle, WA, USA. E-mail: julie.keister@noaa.gov
[2]NOAA Pacific Marine Environmental Lab, Seattle, WA, USA
[3]NOAA Alaska Fisheries Science Center, Juneau, AK, USA
[4]North Pacific Research Board, Anchorage, AK, USA
[5]University of Washington, CICOES, Seattle, WA, USA

The Northern Bering Sea (NBS) is one of the world's most rapidly changing marine environments, with its ecosystem highly dependent on the duration and extent of annual sea ice. Sea ice directly controls light penetration, temperature, stratification, the timing and fate of phytoplankton blooms, and the extent of the annual Bering shelf 'cold pool.' Warming results in dramatically reduced ice coverage and duration, leading to fundamental shifts in plankton composition, abundance, and nutrition, with effects on food webs and fisheries. The large impact of warming on the NBS, together with the region's valuable commercial and subsistence fisheries, has motivated increased study and monitoring by NOAA and the North Pacific Research Board (NPRB).

NOAA's EcoFOCI program has been monitoring the NBS using satellite data; annual surveys of the plankton, benthos, fish, and oceanographic variables (>20 years); and an array of biophysical moorings on the Bering Sea shelf at 62°N (M8, >20 years) and 64°N (M14, >5 years). EcoFOCI's multi-decadal observations provide a critical baseline for understanding climate extremes and supporting ecosystem-based fisheries management. A new NPRB-funded Integrated Ecosystem Research Program (IERP), begun in 2026, will explore the mechanisms through which changing sea ice impacts modes of primary production and energy pathways through food webs to better understand how observed changes will affect the ecosystem, and the implications for subsistence and commercial activities in this region. The NBS program seeks to integrate both innovative observing methods and diverse knowledge systems to inform regional adaptation strategies. This presentation will introduce several initiatives planned in this IERP in the context of NOAA's long-term observations of the changing NBS, demonstrating how sustained monitoring directly supports the long-term resilience, sustainability and stewardship of Alaska's LMEs.

S10, Oral, AbstractID=19525, (ECOP)

Trait-based insights into pelagic food webs under climate change in the NE Pacific

Miram R. **Gleiber**[1], Zackary Tandy[1], Natasha A. Hardy[1], Alana Krug-Macleod[1], Zachary Roote[1], Caitlin J. Morganson[1], Iris George[1], Cindy Matuch[1], Cole B. Brookson[1], Elan J. Portner[2], Elizabeth A Daly[3], C. Anela Choy[2], Elliott L. Hazen[4], Michael G. Jacox[4], Steven J. Bograd[4], Barbara A. Muhling[5], Heather Welch[5], Catherine F. Nickels[6], Brian K. Wells[7,8], Richard D. Brodeur[9], Toby D. Auth[10], Jarrod A. Santora[7,11], Owyn Snodgrass[12], Travis Richards[12], Larry B. Crowder[13] and Stephanie J. Green[1]

[1]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada. E-mail: miramgleiber@gmail.com
[2]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA
[3]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, OR, USA
[4]Environmental Research Division, Southwest Fisheries Science Center, NOAA, Monterey, CA, USA
[5]Institute of Marine Sciences, University of California, Santa Cruz, CA, USA
[6]Northwest Fisheries Science Center, NOAA, Seattle, WA, USA
[7]Fisheries Ecology Division, Southwest Fisheries Science Center, NOAA, Santa Cruz, CA, USA
[8]Fish Ecology Division, Northwest Fisheries Science Center, NOAA, Newport, OR, USA
[9]Hatfield Marine Science Center, Oregon State University, Newport, OR, USA
[10]Pacific States Marine Fisheries Commission, Newport, OR, USA
[11]Department of Applied Mathematics, University of California, Santa Cruz, CA, USA
[12]Fisheries Resources Division, Southwest Fisheries Science Center, NOAA, La Jolla, CA, USA
[13]Hopkins Marine Station of Stanford University, Pacific Grove, California, USA

Understanding how predators respond to variations in prey assemblages is critical to forecasting future population dynamics and food-web functioning. Prey traits (habitat, behavior, morphology, nutrition) are emerging as important factors driving predator-prey dynamics.

Integrating trait-based frameworks with long-term, ocean ecosystem monitoring can help simplify complex assemblages and foraging dynamics, highlighting recurring characteristics across diverse taxa consumed by predators. The Pelagic Species Trait Database is an open resource developed to advance trait-based understanding of ecological interactions. With a focus on the NE Pacific Ocean, the database includes lifestage-specific traits for >250 taxa sampled across two decades of pelagic forage community monitoring by multiple annual surveys. These combined resources are facilitating novel analyses of recent changes in prey availability for a top predator (albacore tuna) and projections under future climate scenarios. Identifying hotspots of prey with desirable traits for albacore and relationships with environmental conditions further enables early-season forecasts of prey quality for fishers and management decisions. The

database also highlights monitoring gaps, in particular, nutritional metrics (e.g., lipid, energy content) — key indicators of ecological processes in pelagic systems. Both short-term research and long-term monitoring initiatives can play a key role in filling key trait information gaps to inform analysis of change in pelagic communities and the fisheries they support.

S10, Oral, AbstractID=19534

Long-term observations of seabird density at sea as indicators to shifts in food webs and prey resource availability

William J. **Sydeman**[1,2], Brian Hoover[1], Sarah Ann Thompson[1], Tamara Russell[1,2], Julie Thayer[1], Marisol Garcia-Reyes[3,1], Mark Ohman[2], and Andrew Thompson[4]

[1]Farallon Institute, Petaluma, CA, USA. E-mail: wsydeman@faralloninstitute.org
[2]Scripps Institution of Oceanography, La Jolla, CA, USA
[3]CICESE, Ensada, BC, Mexico
[4]NOAA Fisheries, La Jolla, CA, USA

As conspicuous secondary and tertiary level consumers that respond quickly to changes in prey resource availability, seabirds can be effective indicators of change in marine ecosystems and specifically the structure of coastal-pelagic food webs. However, mechanisms driving variation in seabird population densities at sea (birds/km2) are often non-linear, lagged, and context dependent, leading to uncertainties in using this parameter in ecosystem monitoring. To better understand the use of seabird density at sea and use in ecosystem monitoring, we studied interannual variation in seabird density relative to forage fish and krill availability for 18 species over 38 years. In the most recent decade, both temperate-boreal (e.g., murres, shearwaters) and subtropical (e.g., terns, boobies) piscivorous species have increased, while migrant as well as locally-breeding planktivorous species have declined (e.g., Cassin's auklets, Leach's Storm Petrel complex). Piscivorous species appear to be responding to a major increase in northern anchovy (*Engraulis mordax*) after the 2015-2016 severe El Nino event. Krill and other mesozooplankton prey resources do not appear to have changed, suggesting complex mechanisms of response for the decline in planktivorous seabirds, including potential top-down effects due to growing baleen whale populations in the region.

SESSION 10: MONITOR/TCODE/FUTURE/AP-UNDOS

Topic Session

Using long-term ocean observations to understand ocean change and support resilient ecosystems and communities in the North Pacific

Poster Presentations

S10, Poster, AbstractID=19466, PosterID: S10-P2, (ECOP)

A community-based approach to monitoring ocean acidification and harmful algal blooms in Alaska's Chugach Region

Elizabeth **Moeser**, Sierra Lloyd, Jana **Wheat**, Riley Thomas Jeff Hetrick and Allison Carl

Chugach Regional Resources Commission, Alutiiq Pride Marine Institute, Seward, AK, USA.
E-mail: elizabeth@crrcalaska.org, jana@alutiiqprideak.org

The Chugach Regional Resources Commission (CRRC) is an inter-Tribal natural resources commission serving seven coastal Tribal communities in Alaska's Chugach Region in the Northern Gulf of Alaska. The Chugach Regional Ocean Monitoring (CROM) program was established in response to growing concern for and risk to subsistence resources in the face of ocean acidification and the increased occurrence of harmful algal blooms (HABs). Throughout this region – and much of the state – coastal communities depend on subsistence harvest from the ocean for food security, cultural continuity, and well-being. By training and equipping community-based samplers, the CROM program builds capacity within the Chugach region for long-term ocean monitoring in the near-shore. Samples are processed at the Alutiiq Pride Marine Institute, CRRC's mariculture and marine research facility, in Seward, Alaska. The Chemistry Laboratory has measured continuous carbonate system parameters locally and discrete samples from coastal communities since 2015. The partial pressure of CO_2 (pCO_2) and total CO_2 (TCO_2) are measured using a Burke-O-Lator system, from which all other carbonate system parameters are calculated. Concurrently, the Biology Laboratory analyzes phytoplankton samples to identify toxin-producing *Alexandrium* and *Pseudo-nitzschia* which are responsible for paralytic and amnesic shellfish poisoning. Together, these data can reveal seasonal variability and emerging trends in ocean chemistry and HABs, as well as support informed decisions about subsistence harvest. Continued expansion of the CROM program with the addition of nutrients and environmental DNA analyses will deepen our understanding of local biogeochemical processes and support resilient, community-driven responses to changing ocean conditions.

S10, Poster, AbstractID=19527, PosterID: S10-P1, (ECOP) CANCELLED

~~**Spatial and temporal variability of surface water CO_2, N_2O and CH_4 concentrations in Barkley Sound**~~

~~Maria Amenabar and Reese **Miller**~~

~~University of British Columbia, Vancouver, BC, Canada. E-mail: rmiller@eoas.ubc.ca~~

~~Understanding surface distributions and dynamics of oceanic greenhouse gases is increasingly important in a rapidly changing climate. The west coast of Vancouver Island (WCVI) is known to be a region of active sea-air CO_2 and N_2O exchange and believed to be net source of CH_4 to the atmosphere, particularly in regions overlying hydrothermal seeps. We conducted an oceanographic survey in Barkley Sound, along the WCVI to explore the fine-scale spatial and temporal dynamics of three of the most important greenhouse gases (CH_4, N_2O and CO_2) in near-surface waters. Measurements were conducted using two different cavity ring-down spectrometers (CRDS) each with a gas extraction module. One CRDS, measuring CO_2 and CH_4, was deployed on a 5-day survey in Barkley Sound, continuously measuring gas concentrations at 4 meters depth. These surface water measurements were supplemented by four vertical depth profiles of CH_4 /N_2O collected via CTD Rosette and analyzed on a GCMS. The other instrument collected high-frequency time series data of N_2O and CH_4 concentrations at the Bamfield Marine Science Center (BMSC). Results from the shipboard survey revealed relatively uniform surface concentration of CH4 with the lower concentrations occurring in Alberni Inlet, the warmest, freshest part of the survey. However, depth profiles also show relatively high sub-surface CH_4 and N_2O concentrations, reaching about 40 nM for both at 300 meters depth. It was found during the survey that seasonal deep-water renewal had not yet occurred in Alberni Inlet, potentially explaining high gas concentrations at depth. Preliminary results of the timeseries data indicate strong correlations between CH_4 and N_2O concentrations and sea surface between temperature, salinity, and surface current direction. Indicating a sensitivity of these gases to short term variations in water properties.~~

SESSION 11: FIS/MEQ/AP-UNDOS Topic Session

Approaches to Understanding Population Connectivity and Its Impacts

Oral Presentations

S11, Invited, AbstractID=19130

Considering complex connectivity in a changing ocean for sustainable fisheries

Steven **Cadrin**

University of Massachusetts Dartmouth, School for Marine Science and Technology, New Bedford, MA, USA. E-mail: scadrin@umassd.edu

Traditional fishery science identified unit stocks and relatively simple migration circuits to model population dynamics and sustainable yield by assuming inter-generational connectivity (e.g., a stock-recruit relationship), but those paradigms may need to adapt to new information and climate change. Technological advancements in genomics, electronic tagging, sclerochronology, biophysical models, and spatial analysis have revealed much more complex patterns of dispersal for many marine species. Climate change is also altering ocean circulation, spatiotemporal distribution of habitats or prey, and environmental queues that motivate migration patterns. Several fishery management failures have been attributed to ignoring complex connectivity patterns. By contrast, simulation studies show that stock assessments are more accurate and fishery management is more effective when connectivity patterns are considered. Conventional stock assessment and fishery management models continue to assume unit stocks, so stock identification and delineation of stock boundaries should encompass connectivity patterns – if possible. Alternatively, population models with spatial and seasonal structure may be needed, either for stock assessment or to condition operating models for testing management procedures. Relatively simple spatial management (e.g., spawning closures, protection of nursery habitat, rotational access, catch allocations based on resource distribution) may be robust to complex patterns of connectivity, but more complex spatial management may be needed to sustain productive fisheries. For example, adapting to spatiotemporal shifts in transboundary stocks will require increased interjurisdictional collaboration in science and fisheries management.

S11, Oral, AbstractID=19128

Current dynamics associated with decreased coastal productivity facilitate the northward, inshore expansion of juvenile Pacific hake

Brian K. **Wells**[1,2,3], David D. Huff[2], Jarrod A. Santora[1], Toby D. Auth[2,4], Mary E. Hunsicker[2], Tanya L. Rogers[1], Joseph J. Bizzarro[1,5], Aaron M. Berger[2], Keith M. Sakuma[1], Isaac D. Schroeder[5,6], Rebecca R. Miller[1,5], John C. Field[1]

[1]Southwest Fisheries Science Center, National Marine Fisheries Science, National Oceanic and Atmospheric Administration, Santa Cruz, CA, USA. E-mail: brian.wells@noaa.gov
[2]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Newport, OR, USA
[3]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA
[4]Pacific States Marine Fisheries Commission, Hatfield Marine Science Center, Newport, OR, USA
[5]Institute of Marine Sciences, University of California, Santa Cruz, Santa Cruz, CA, USA
[6]Environmental Research Division, National Marine Fisheries Science, National Oceanic and Atmospheric Administration, Monterey, CA, USA

The California Current Large Marine Ecosystem (CCLME) is an eastern boundary upwelling system characterized by dynamic productivity across biogeographic domains. We investigated the relative influence of environmental preconditioning, transport processes, thermal habitat compression, retention, and Pacific hake (Merluccius productus) spawning stock biomass (SSB) on the regional distribution of young-of-the-year (YOY) Pacific hake, the most abundant finfish in the system. Using a 24-year (2001-2024) dataset of YOY Pacific hake collections and generalized additive models, we characterized the relationships between YOY biomass across CCLME bioregions and identify biophysical drivers. In the southern and northern CCLME, YOY biomass (grams per unit effort) was related to SSB, compressed cool-water habitat (impinged by warmer offshore waters), and onshore current strength following late-winter spawning events. Generally, northward of the primary spawning areas, YOY Pacific hake biomass was increasingly driven by density-independent processes, including transport and preconditioning. Northern models were complex but suggest that SSB, and both onshore and northward transport in the mixed layer were positively related to juvenile occurrence. Central YOY biomass was positively associated with increased undercurrent and onshore current strength. Anomalously high observed YOY juvenile abundances in the northern and central bioregions were associated with lower abundances of age-1 fish the following year (from a different survey), suggesting these juveniles may not contribute to subsequent recruitment. Alternatively, in these cases YOY Pacific hake may act as an environmentally dependent supplemental forage source, potentially offering a compensatory buffer against weak upwelling and reduced biomass of regional forage communities in the central and northern CCLME. This regional variability highlights a potential

mechanism for coastwide mitigation of poor forage production conditions in northern regions, leading insights into the importance of regional processes with respect to recruitment dynamics for this commercially important stock, and providing an alternative perspective on the role of synchronization across a large marine ecosystem.

S11, Oral, AbstractID=19161, (ECOP)

Changes in residency and connectivity of Atlantic cod (*Gadus morhua*) on its southernmost spawning ground

Alison **Frey** and Steven Cadrin

University of Massachusetts Dartmouth, Massachusetts, MA, USA. E-mail: afrey2@umassd.edu

Atlantic cod (*Gadus morhua*) off the coast of Southern New England, are a distinct population with limited connectivity to other cod populations. Beyond the large-scale connectivity studies which lead to the identification of a reproductively isolated Southern New England population, less is known about the fine scale movement and habitat use of cod in this region. Southern New England cod are overfished and vulnerable to habitat change via warming ocean conditions and regional offshore wind farm development sited on important cod spawning grounds. Cod spawning behaviors are sensitive to anthropogenic disturbances, so anthropogenic interference of successful spawning may have population impacts and implications for productivity of the fishery resource. To assess changes in movement and habitat use, we used acoustic telemetry methods to monitor year-round residency and fine-scale connectivity of cod on and around the principal spawning ground, Cox Ledge, which directly overlaps with offshore wind development areas. Through multi-year monitoring and data collection before, during, and after offshore wind farm development activities, we are quantifying changes to spatiotemporal habitat use and movement patterns. Results from this work will be important for fishery managers to promote population rebuilding, resilience, and sustainable coexistence of fisheries and offshore wind farm development.

S11, Oral, AbstractID=19171, (ECOP)

Inside or out? Modeling transboundary connectivity and availability shifts in western Atlantic bluefin tuna

Cole **Carrano**[1], Katie Lankowicz[2], Alex Hansell[3], Steve Cadrin[4], Matt Lauretta[5], and Lisa Kerr[1]

[1]University of Maine, Portland, ME, USA. E-mail: Cole.Carrano@maine.edu
[2]Gulf of Maine Research Institute, Portland, ME, USA
[3]Northeast Fisheries Science Center, Woods Hole, MA, USA
[4]University of Massachusetts Dartmouth, New Bedford, MA, USA
[5]Southeast Fisheries Science Center, Key Biscayne, FL, USA

The rapidly changing ocean environment is driving shifts in fish distribution, altering migration routes, fishing effort, and catch rates. Previous assessments of western Atlantic bluefin tuna have struggled to reconcile conflicting trends in US and Canadian catch per unit effort (CPUE) indices in the northwest Atlantic, a challenge largely driven by climate-mediated changes in bluefin distribution and regional availability across international boundaries. The most recent stock assessment addressed this by using a time series of the Atlantic Multidecadal Oscillation to modulate catchability for these indices within the model. This approach improved model diagnostics and performance, but accounting for dynamic spatial connectivity remains a challenge. We explored an alternative approach, accounting for changes in fish distribution due to environmental factors outside of the model. Using a Vector Autoregressive Spatio-Temporal Model (VAST), we created a joint US/Canada rod and reel CPUE index that integrates key environmental indicators to model trends in abundance across a continuous, large-scale domain. This approach captures shifting stock boundaries and avoids the artifacts of limited spatial stratification. A comparison of approaches suggests improved or similar stock assessment model performance and similar model results in terms of spawning stock biomass and fishing mortality estimates. These results indicate that climate-driven changes in population distribution can be effectively addressed either within an assessment model or through external methods. Ultimately, dynamic spatial connectivity must be explicitly considered in the assessment-management process, and we recommend the use of spatiotemporal methods to support adaptive management strategies under changing ocean conditions.

S11, Oral, AbstractID=19185

Multiple larval sources for Oregon and coastal Washington green crab populations

Sylvia B. **Yamada**[1], Carolyn Tepolt[2] and Alan Shanks[3]

[1]Integrative Biology, Oregon State University, Corvallis, OR, USA.
E-mail: yamadas@oregonstate.edu
[2]Wood Hole Oceanographic Institute, Falmouth, MA, USA
[3]Oregon Institute of Marine Biology, Charleston, OR, USA

The abundance of the green crab (*Carcinus maenas*) in Oregon estuaries falls into two phases: before and after the strong 2015-2016 El Niño. Prior to 2016, recruitment of 0-Age European green crabs to Oregon estuaries was sporadic, with many years of recruitment failure. Ocean indicators of warm surface water and strong north-flowing currents during the winter were followed by good year classes of young green crabs, indicating that larvae were transported from California to Oregon in the Davidson Current. This pattern changed after the 2015-2016 El Niño, when good recruitment occurred every year, and the adult populations in estuaries increased to averages of up to 7 crabs per trap per day. The presence of greater than predicted number of 0-Age crabs after cold winters indicates the existence of additional larval sources. We present evidence for local reproduction and for larval transport from the north. Very early instar larvae were collected in Coos Bay during a mini El Niño from January to March 2010. These larvae had to be locally produced. Genetic evidence suggests that larvae from a genetically distinct population in the Salish Sea were transported south to Washington coastal and northern Oregon estuaries in the Shelf-break current during the summer. Now that the green crab breeding populations have built up along the coast, Oregon estuaries can receive larvae from the south in the winter, from the north in the summer and from local sources. The presence of these multiple larval sources complicates control efforts for this invader.

S11, Oral, AbstractID=19216, (ECOP)

Incorporating population connectivity into operating models for Pacific marine invertebrates

Mackenzie **Mazur**, Sarah de Mendonça, Anna Tigano, and Christine Hansen

Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada.
E-mail: mackenzie.mazur@dfo-mpo.gc.ca

Population connectivity is a critical but often poorly represented component of fisheries assessments and management, particularly for benthic marine invertebrates with dispersive larval stages. Traditional stock assessment frameworks frequently assume closed or locally driven recruitment, despite lack of information on population structure. These gaps present challenges for fisheries management, especially as ocean conditions continue to change. We present an approach that explicitly incorporates population connectivity into closed-loop simulations for a commercially important Pacific invertebrate: Pacific Geoduck (*Panopea generosa*). We revised recruitment assumptions within a spatially explicit simulation framework to include connectivity probabilities among management areas. We compare the performance of current management strategies under connectivity-informed operating models in the closed-loop simulations to those assuming closed populations, illustrating how spatial population structure and altered connectivity may influence management outcomes. Future work will incorporate connectivity results from genomic analyses and biophysical modelling into the closed-loop simulations and apply this approach to two additional species: Giant Red Sea Cucumber (*Apostichopus californicus*) and Green Sea Urchin (*Strongylocentrotus droebachiensis*).

S11, Oral, AbstractID=19218, (ECOP)

Modelling larval dispersal networks among seamounts for connectivity conservation under deep-sea mining

Naoki **Saito**[1], Hiroki Kise[1], Travis W. Washburn[1,2], Eri Ikeuchi[1], Akira Iguchi[1], Hiroko Kamoshida[3] and Atsushi Suzuki[1]

[1]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. E-mail: n.saito@aist.go.jp
[2]Texas A&M University - Corpus Christi, TX, USA
[3]Japan Organization for Metals and Energy Security (JOGMEC), Tokyo, Japan

In the Northwest Pacific, the development of mineral resources such as cobalt-rich crusts on seamounts is under consideration. To conserve spatially isolated marine habitats such as seamounts, it is crucial to maintain ecological connectivity mediated by larval dispersal. In this study, we modelled larval dispersal among 18 seamounts in the Northwest Pacific, including those with potential for future development. The results showed that all seamounts were connected to at least one other seamount by larval dispersal. Several seamounts acted as key nodes for maintaining connectivity across the region. Due to the influence of dominant eastward or westward currents, distant upstream seamounts became important larval supply sources. Comparisons with Argo float trajectories and gene flows of amphipods provided physical and biological support for the modelled dispersal pattern. These findings suggest that understanding larval dispersal networks among seamounts, connected through upstream larval supply, can be important for the development of effective conservation strategies.

S11, Oral, AbstractID=19246, (ECOP)

Connected coasts: Exploring larval connectivity to support marine populations and sustainable fisheries

Sarah N. **de Mendonça**[1], Christine Hansen[1], Mackenzie Mazur[1] and Hauke Blanken[2]

[1]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, Canada.
E-mail: sarah.demendonca@dfo-mpo.gc.ca
[2]Fisheries and Oceans Canada, Institute of Ocean Sciences, Victoria, Canada

Pacific Geoduck, Green Urchin, Giant Red Sea Cucumber and Northern Abalone are four invertebrate species having commercial and/or cultural significance in the Northeast Pacific Ocean (British Columbia, Canada). For example, Pacific Geoduck is one of the highest value invertebrate fisheries (over $ 30 million CAD annual landed value in 2015-2023). Furthermore, Northern Abalone is an endangered species. Biophysical modeling approaches contribute to broad-scale assessments of population connectivity, despite gaps in knowledge and data, and logistical constraints that may restrict empirical approaches. We simulate regional larval dispersal to explore potential connections between nearshore habitats using ocean currents (Coastal Ice Ocean Prediction System for the West Coast of Canada) and biological parameters (e.g., spawning month and pelagic larval duration). Release locations are based on species distribution models for suitable habitat. Connectivity matrices provide insights into patterns and strength, e.g., which areas could be supplying larvae to others (sources contributing to population persistence) and what areas may be isolated (rely more on self-recruitment). We plan to examine changes between years with different environmental conditions (2017, 2021, and 2023), including heatwaves with relevance to climate change. This research will help inform fisheries management and conservation, supporting Fisheries and Oceans Canada mandates related to protection and sustainability in our Pacific Ocean.

S11, Oral, AbstractID=19255

Genomic evidence for the lack of Pacific halibut (*Hippoglossus stenolepis*) population structure in the Northeast Pacific Ocean

Andrew **Jasonowicz**[1], Wes Larson[2], Ingrid Spies[3], Liz Dawson[3], and Josep V. Planas[1]

[1]International Pacific Halibut Commission, Seattle, WA, USA.
E-mail: andy.jasonowicz@iphc.int
[2]NOAA Alaska Fisheries Science Center, Juneau, AK, USA
[3]NOAA Alaska Fisheries Science Center, Seattle, WA, USA

The Pacific halibut (*Hippoglossus stenolepis*) is a key species in the North Pacific Ocean ecosystem that supports important commercial, recreational and subsistence fisheries and is currently managed as a single stock by the International Pacific Halibut Commission (IPHC). The primary objective of the present study is to advance our understanding of Pacific halibut population structure and dynamics in the Northeast Pacific Ocean. We have generated genomic sequences from 727 Pacific halibut collected during the spawning season (winter) from five known spawning areas in the Gulf of Alaska, Bering Sea, and Aleutian Islands using low-coverage whole genome resequencing, a method that enables the characterization of genomic variation at very high resolution. Following alignment to the Pacific halibut reference genome that IPHC generated in 2022, we observed average sequencing depths of ~3x and leveraged this data to identify millions of single nucleotide polymorphisms (SNPs) throughout the Pacific halibut genome. We used principal component analysis and clustering to detect and characterize population structure with approximately 4.6 million SNPs. Additionally, we used estimates of genetic differentiation to identify subsets of SNPs that may be used to assign individuals back to the spawning groups that they were sampled from and used cross-validation techniques to evaluate assignment accuracy. Our results identify a single genetic cluster of Pacific halibut despite the large spatial scale of sampling. Furthermore, we observed low assignment accuracies (<40%) when tracing individuals back to their population of origin. These results suggest levels of connectivity over large spatial scales that are sufficient to homogenize genetic diversity resulting in a single genetic group of Pacific halibut in the Northeast Pacific Ocean. Additionally, these results support IPHC's current stock assessment practices that model the stock as a single coastwide unit.

S11, Oral, AbstractID=19298

Population genomics approaches to characterize levels and drivers of connectivity in green sea urchin and other abundant marine species

Anna **Tigano**, Lyanne Curtis, Mackenzie Mazur and Christine Hansen

Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada.
E-mail: anna.tigano@dfo-mpo.gc.ca

Migration and gene flow, the transfer of individuals and genetic material from one population to another, are strong drivers of evolutionary change and determine how interconnected populations are across their ranges, which in turn determines population structure, levels of genetic diversity, and adaptive potential, all important factors to guide fisheries management and conservation of endangered marine species. Characterizing levels of migration and gene flow, i.e. connectivity, in marine species with historical or current large effective population sizes is challenging because these species often show low levels of genetic differentiation, and weak genomic differentiation can hinder accurate estimates of migration and gene flow, thus overestimating connectivity. Here we will provide an overview of analytical approaches to estimate connectivity from whole genome data in species with large population sizes and show how we applied them in green sea urchin (*Strongylocentrotus droebachiensis*) to reconstruct historical and current connectivity in British Columbia, where the species is ecologically, culturally and economically important. The results of our work will be integrated with biophysical models of dispersal to inform management under different climatic scenarios.

S11, Oral, AbstractID=19330, (ECOP)

Environmental drivers shifting migration timing of pink and chum salmon in the Central Coast of British Columbia

Michelle **Fortier** and Kyle L. Wilson

Simon Fraser University, Vancouver, BC, Canada. E-mail: michelle_fortier@sfu.ca

Pacific salmon migrations drive crucial ecological dynamics throughout the Pacific Northwest and are intrinsically tied to cultural practices and economic opportunity. The seasonal timing of these migrations, known as phenology, has adapted to key environmental cues, creating variability within and among species that forms the foundation of population resilience.

However, as Pacific salmon face increasing cumulative pressures from climate change, habitat degradation, and the legacies of overfishing, this resilience is being tested. As anadromous species that depend on both marine and freshwater ecosystems, understanding how and why salmon phenologies may be shifting requires consideration of drivers across their full migratory range. This research examines how the phenology of adult pink and chum salmon along the Central Coast of British Columbia may be shifting over time and identifying key environmental drivers responsible. These include snow and rain accumulation, stream type (glacial or rain-fed), global ocean oscillation patterns, sea surface temperatures, as well as commercial fishery openings and enhancement practices. Using a Bayesian hierarchical modeling approach across 356 streams with data spanning from the 1950s onward, we analyze long-term trends in phenological shifts. Preliminary findings on changes in peak migration timing and the associated environmental drivers will be discussed along with ecological and management implications in the context of a rapidly changing climate.

S11, Oral, AbstractID=19415

From foundations to fish: Connectivity in offshore wind farm environments

Lauran **Brewster**, Alison **Frey**, Steven Cadrin, Chris Rillahan, Keith Hankowsky, Pingguo He

Presented by Alison Frey on behalf of Mukai Lauran Brewster

School for Marine Science and Technology University of Massachusetts Dartmouth, New Bedford, MA, USA. E-mail: lbrewster@umassd.edu

To meet growing demand for renewable energy, offshore wind farms have expanded into areas that support important fisheries. Turbine foundations introduce hard substrate, often into soft-sediment environments, with potential consequences for fish movement, residency, and habitat connectivity at multiple spatial scales. Our study evaluates the individual and additive impacts of multiple turbines to understand how offshore wind development affects fisheries resources.

We examined species-specific movement and space use at the Block Island Wind Farm, five-turbines spaced approximately 0.5 nautical miles apart located in the northwest Atlantic Ocean off Rhode Island. In collaboration with commercial fishermen to maintain the receiver array and with recreational for-hire fishermen to deploy acoustic tags, we used passive acoustic telemetry to quantify residency, site fidelity, and turbine-to-turbine connectivity for three commercially and recreationally important species with contrasting movement ecologies: black sea bass (*Centropristis striata*, n = 63), striped bass (*Morone saxatilis*, n = 50), and summer flounder (*Paralichthys dentatus*, n = 35). Acoustic detections were used to derive residency indices, spatial distributions, and movement networks, with additional detections shared through regional telemetry networks to support broader-scale inference.

Preliminary results indicate distinct species-specific patterns of local and regional connectivity. Black sea bass and striped bass were detected at multiple receiver locations within the wind farm (median = 3 stations; range = 1–7), indicating movement among turbines and between turbine and adjacent hard bottom habitat. In contrast, summer flounder exhibited lower connectivity (median = 1 station; range = 1–4), suggesting more localized space use. Striped bass exhibited extensive regional connectivity. Planned analyses will extend these results to evaluate connectivity between other wind-farm areas and surrounding regional habitats. These findings highlight species-specific responses and the importance of integrating movement ecology when assessing wind-farm impacts. This research provides stakeholders—including fishers, fisheries managers, and wind-farm operators—with information needed to evaluate how individual turbines and turbine arrays influence fisheries and ecosystems.

S11, Oral, AbstractID=19427

Starvation, thermal stress and dispersal: Disentangling the drivers of small pelagic fish recruitment in an eastern boundary upwelling ecosystem

Susana **Garrido**[1,2], Diogo Lopes[3] and Ana Machado[3,4]

[1]IPMA Instituto Português do Mar e da Atmosfera (IPMA), Lisboa, Portugal.
E-mail: susana.garrido@ipma.pt
[2]Centro de Ciências do Mar e do Ambiente (MARE), Évora, Portugal
[3]Faculty of Sciences, University of Lisbon (FCUL), Lisbon, Portugal
[4]Instituto Dom Luiz (IDL), Lisboa, Portugal

Recruitment of small pelagic fish is highly variable and largely determined by environmental conditions experienced during the early life stages. While starvation and thermal stress are widely recognized as major sources of larval mortality, ocean circulation can also strongly influence recruitment by transporting larvae towards, or away from, suitable nursery habitats. Understanding the relative importance of these processes is therefore essential for predicting recruitment variability and improving fisheries management. We combine a high-resolution hydrodynamic model (ROMS IB2v2), Lagrangian particle tracking and an individual-based model (IBM) to simulate the transport, growth and survival of European sardine (*Sardina pilchardus*) eggs and larvae in the Iberian upwelling ecosystem. The IBM incorporates species-specific temperature-dependent development and growth, feeding success and mortality throughout the egg, yolk-sac and first-feeding larval stages up to 1 month after hatching. To identify the mechanisms driving recruitment variability, we selected years spanning contrasting spawning stock biomass and distribution, recruitment strength and thermal anomalies. For each year, we estimated the relative survival during the spawning season, and compared areas and years, quantifying the three major mortality pathways in the model: starvation, exposure to temperatures outside the larval thermal niche, and dispersal away from favourable nursery areas. By quantifying these processes across spawning grounds, we aimed to identify the dominant mechanisms associated with years of high and low recruitment and assess how their relative importance changes under contrasting environmental conditions. Our results improve the mechanistic understanding of recruitment variability in small pelagic fish inhabiting eastern boundary upwelling ecosystems and provide information to support ecosystem-based fisheries management under a changing climate.

S11, Oral, AbstractID=19462, (ECOP)

Evaluating otolith techniques to identify population structure of myctophid species

Micah J. **Quindazzi**[1], Lydia N. Walton[2], Moira Galbraith[3], Stéphane Gauthier[3], Catherine Stevens[4]

[1]Earth Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada. E-mail: m.j.quindazzi@gmail.com
[2]Marna Lab, Hakai Institute, Quadra Island, BC, Canada
[3]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
[4]Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada

Connectivity between forage fish populations can occur through the migration of adults between marine regions, or through the dispersal of larvae via ocean currents. While tracking adults is feasible through the application of tags, tracking the dispersal of larvae between populations is much more difficult. Understanding the dispersal patterns of these larval fish is important to identify the source of settling larvae, and to understand broader patterns of connectivity within these metapopulations. In British Columbia, the Salish Sea is a large inland sea that is home to hundreds of fish species, including several species of myctophids. While these myctophid species exist both inside and outside of the Salish Sea, it is not clear how much these populations mix. To overcome this challenge, we used otoliths. These structures can provide researchers with insight into oceanographic conditions faced and the physiological condition of the fish through time. Two methods in particular, otolith shape analyses and otolith microchemistry, are useful to study questions of population connectivity. We compared the otoliths of two myctophid species (*Diaphus theta* and *Stenobrachius leucopsarus*) captured inside and outside the Salish Sea. We used otolith shape (Wavelet descriptors) and otolith microchemistry (laser ablation inductively coupled plasma mass spectrometry) to identify population structure and connectivity. Here we show that populations inside and outside the Salish Sea differ in terms of otolith shape, and that the Salish Sea tended to act as a sink population. These methods can be used to highlight population structure and connectivity of forage fish species.

S11, Oral, AbstractID=19479

Model detection of spatial break in Pacific cod stock in the Gulf of Alaska

Rebecca Howard[1,2], Lorenzo **Ciannelli**[1], Steve Barbeaux[2], Pete Hulson[3], and Ingrid Spies[2]

[1]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA. E-mail: lorenzo.ciannelli@oregonstate.edu
[2]Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[3]Auke Bay Laboratories, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Juneau, AK, USA

The spatial structure of a population can be defined in a range of ways, including oceanographic, demographic, ecological, genetic, and socio-economic. Each of these structures influence the way in which resources are surveyed, their abundance is assessed, and their harvest is managed. In the Gulf of Alaska (GOA), Pacific cod (*Gadus macrocephalus*) is assessed and managed as a single stock, but recent genetic, tagging, and oceanographic studies challenge this assumption. To identify potential spatial structure in this stock, generalized additive models were fit to NOAA fishery observer data for three different gear types. Two types of models were developed: those that predicted catch-per-unit-effort for a given size grouping and those that predicted length at a given age. From these models, first derivatives of the spatial smooth term were calculated to detect longitudinal breakpoints within the study region. Our results indicate that there is a consistent spatial breakpoint in the GOA Pacific cod stock near -155°W, persisting through size groupings, gear types, and ages. The potential explanations for this spatial structure are varied. This location is characterized by strong currents circulating through Shelikof Strait, the deep waters of Shelikof Trough, long distances from fishing ports, and frequently unfavorable weather conditions. These indicate that a multitude of reasons may lead to this spatial structuring, and that there may be reason to reevaluate the management scale of the GOA Pacific cod stock.

S11, Oral, AbstractID=19499, (ECOP)

The population structure of Japanese anchovies around Hokkaido estimated by the stable isotopes -seabird as a sampler of pelagic fishes

Tatsuki **Kojima**[1], Yutaka Watanuki[2], Jumpei Okado[3,] Tatsuya Sakamoto[4], Kotaro Shirai[5], Shunsuke Nibe[1], Hikari Ozawa[1], and Motohiro Ito[1]

[1]Toyo University, Asaka, Japan. E-mail: kojima.tatsuki51630@gmail.com
[2]Hokkaido University, Hakodate, Japan
[3]Nagoya University, Nagoya, Japan
[4]The Hakubi Center for Advanced Research, Kyoto University, Kyoto, Japan
[5]The University of Tokyo, Kashiwa, Japan

Pelagic fishes are important prey for marine top predators, and their abundance often fluctuate in response to marine environmental changes. Their distribution pattern and population structure among subgroup level remain unclear due to difficulties of sampling at broad geographic areas. We used the seabird, Rhinoceros auklets *Cerorhinca monocerata,* as a sampler of Japanese anchovies *Engraulis japonicus,* from all around coastal waters of Hokkaido, Japan. This approach enabled us to sample anchovies from a wide spatial range, including the northern Sea of Japan, the Sea of Okhotsk, the Tsugaru Strait, and the northeastern Pacific. We analyzed carbon and nitrogen stable isotopes in muscles and eye lens cores of anchovies sampled from the chick diet of auklets. The isotopic values in muscles (2023-2025) showed slight but significant differences among all regions, probably reflecting different isotopic baselines and food-webs structures among the regions. The isotopic values in eye lens cores did not show clear differences among the northern Sea of Japan, the Sea of Okhotsk and the Tsugaru Strait region. These results suggested that, during those years, the anchovies which from common source of origin (same subgroup) distributed across the waters. However, the isotopic values of muscles sampled at the northern Sea of Japan among 2004–2005 and 2023–2025 differed markedly. This may indicate that the population structure of anchovies and their ecosystem have changed due to the regime shifts that occurred the past two decades. Seabird-delivered samples could provide the local and long-term information of the population structure of pelagic fishes.

S11, Oral, AbstractID=19517

[Re]defining stock structure to support groundfish management along the US West Coast

Cheryl L. **Barnes**[1], Madison Bargas[1], Holland Vernon[2], and Todd Phillips[3]

[1]Coastal Oregon Marine Experiment Station, Oregon State University, Newport, OR, USA.
E-mail: cheryl.barnes@oregonstate.edu
[2]Weber State University, Ogden, UT, USA
[3]Pacific Fishery Management Council, Portland, OR, USA

Effectively balancing harvest and conservation depends on how well management aligns with the spatial scale of key biological and ecological processes. When the degree of population connectivity throughout a regulatory area is unknown or unaccounted for, we risk misidentifying the spatial extent of a "stock" – the population or portion of a population that serves as the basis for assessment and management. We reviewed the scientific literature related to population connectivity for 86 federally-managed groundfish species along the US West Coast. This included compiling information about habitat use, larval dispersal, adult movement, spatial variation in life history traits, and genetic differentiation. We classified the quantity and quality of information as "robust", "limited", or "insufficient" for making inferences about stock structure. We then compared inferred stock structure with the spatial extent of recent stock assessments and management actions. Most federally-managed groundfishes had limited (N = 32) or insufficient (N = 46) information to make informed decisions about stock structure. Of those with robust information (N = 8), misalignments (e.g., an inferred stock boundary but no management distinction) were common at the Columbia River (WA-OR), Cape Mendocino (OR), and Point Conception (CA). Defaulting to single coastwide stocks (e.g., due to limited information about population connectivity), relying on political borders to differentiate management actions, and spatial misalignments between inferred stock structure and assessment or management can increase risks of localized depletion or under-utilization. Regular synthesis of the scientific literature to reevaluate stock-specific boundaries is crucial for ensuring sustainable harvest in the long-term.

SESSION 11: FIS/MEQ/AP-UNDOS Topic Session

Approaches to Understanding Population Connectivity and Its Impacts

Poster Presentations

S11, Poster, AbstractID=19233, PosterID: S11-P1, (ECOP)

Bridging the gap: Leveraging open-access seafloor imagery and hydrodynamic models to inform coral larval connectivity among Hawaiian seamounts

Fanny **Girard**[1], Emily Palmer[1], Jacob Hauʻoli Lorenzo-Elarco[2,3], Justin Suca[1]

[1]Department of Oceanography, University of Hawaiʻi at Mānoa, Honolulu, HI, USA.
E-mail: fgirard@hawaii.edu
[2]Honolulu Community College, Honolulu, HI, USA
[3]Ka Haka ʻUla o Keʻelikōlani, University of Hawaiʻi at Hilo, Hilo, HI, USA

Seamounts in the Pacific often represent hotspots of biodiversity from the surface to the deep benthos. These features are patchily distributed, raising the question of demographic connectivity and the role of seamounts as potential steppingstones for the dispersal of species over large scales. Due to enhanced surface productivity and habitat heterogeneity, seamounts can support large aggregations of commercially and ecologically valuable species, including deep-sea corals, one of the main ecosystem engineers in the deep sea. Understanding connectivity patterns across seamounts is critical to evaluate the resilience of seamount communities to environmental change and human activities and inform area-based management. Here we present a new study that leverages recent field collections and ʻike Hawaiʻi (traditional Hawaiian knowledge) to characterize larval connectivity within and outside Papahānaumokuākea National Marine Sanctuary (PNMS; Hawaiian Archipelago). Relying on Hawaiian language textual resources about coral, publicly available data from > 200 remotely operated vehicle dives and hydrodynamic models (MOM6), we will conduct biophysical model simulations to estimate larval dispersal patterns for three federally-managed precious coral species historically harvested for the jewelry trade. These models will be used to evaluate connectivity between precious coral habitats under variable environmental conditions. Due to uncertainty in tested life history parameters, a sensitivity analysis will also be conducted to evaluate which parameters have the most influence on projected connectivity patterns. By identifying important source and sink habitats, this project will evaluate the efficacy of existing management measures and specifically whether current PNMS boundaries are sufficient for the management of precious corals.

S11, Oral, AbstractID=19485

Characterizing tooth dentine trace element signatures over the lifespans of Northeast Pacific resident and transient killer whales

Nicole **LaForge**, Xiangjun Liao, Nicole Fung, Andrew Ross, Marie Noel and Lisa Loseto

Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: Nicole.Laforge@dfo-mpo.gc.ca

Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) enables the identification and quantification of elements such as trace metals in solids at a microscopic scale, while preserving the temporal record of material deposition. As part of a broader project evaluating life history of environmental contaminant exposure and effects, we analysed trace element patterns in 18 Killer Whale (*Orcinus orca*) teeth dentine growth layer groups (GLGs) from both the resident (fish eating) and transient (mammal eating) populations from the Northeast Pacific. Specimens were provided from archival collections (e.g. museums) of samples obtained from stranded/deceased individuals discovered along the coast of British Columbia between 1947 and 2016. Prior to analysis the teeth were sectioned lengthwise and polished to expose the pulp cavity and all GLGs. For the first time, changes in the concentrations of several analytes across dentine growth layer groups covering the entire lifespan of each individual were measured using LA-ICP-MS. Analytes measured included magnesium (Mg^{25}), manganese (Mn^{55}), copper (Cu^{65}), zinc (Zn^{66}), strontium (Sr^{88}), barium (Ba^{137}), mercury (Hg^{200}) and lead (Pb^{208}). Preliminary results revealed fluxes in zinc concentrations that correlated with the known ages of several specimens, thus supporting the use of Zn to age killer whales, similar to it's use in salmon otoliths. Increases of Mn, Sr and Ba early in the life histories appear to correlate with nursing, as seen in belugas. Elements associated with anthropogenic activity, such as Hg, will be examined in relation to temporal sources and physiological changes at the individual level, among individuals, and across populations to investigate exposure to, and effects of, environmental contaminants.

S11, Poster, AbstractID=19333, PosterID: S11-P3, (ECOP)

Inter-seamount connectivity of deep-sea benthic species in the Magellan Seamounts, northwestern Pacific

Hyeonwoo **Sim**[1,2] and Sook-Jin Jang[1,2]

[1]Ocean Georesources Research Department, Korea Institute of Ocean Science and Technology (KIOST), Busan, R Korea. E-mail: jsookjin@kiost.ac.kr, sty5113@kiost.ac.kr
[2]Ocean Science, University of Science and Technology (UST), Daejeon, R Korea

Seamounts provide relatively isolated habitats characterized by topographic complexity, hydrodynamic conditions and hard substrates, supporting diverse benthic communities. Recent studies have suggested unexpectedly high levels of connectivity in some seamount benthic species. However, knowledge of the biodiversity and connectivity of seamount ecosystems remains limited due to the challenges of deep-sea sampling. In this study, we investigated inter-seamount connectivity of deep-sea benthic organisms across the Magellan Seamounts in the northwestern Pacific Ocean. Three taxa were analyzed: two brittle star species (*Ophioleila elegans, Ophioplinthaca defensor*) and one deep-sea shrimp (*Heterocarpus* sp.). Partial mitochondrial COI sequences were analyzed from specimens collected by ROVs and baited traps during research cruises between 2019 and 2025. Haplotype networks showed that both ophiuroid species shared dominant haplotypes across multiple seamounts, forming star-like patterns with no pronounced genetic differentiation among seamounts. Similarly, the shrimp *Heterocarpus* sp. showed no clear geographic structure. However, unlike the ophiuroid species, its haplotype network exhibited three genetically distinct groups, with inter-group K2P distances of approximately 1.7–3.7%. These results suggest that these groups may represent distinct evolutionary lineages. This study revealed distinct patterns of inter-seamount connectivity among deep-sea benthic organisms in the Magellan Seamounts, likely reflecting differences in life-history traits. Further studies on life-history traits, particularly larval dispersal mechanisms, are needed to better understand the processes shaping connectivity patterns in seamount organisms. These findings provide baseline information on the genetic connectivity of seamount benthic fauna in the western Pacific, contributing to future conservation planning.

This research was a part of the project titled 'Selection of prospective mining area for Co-rich ferromanganese crust in western Pacific seamounts: 3-D resource estimation and environmental impact evaluation', funded by the Korean Ministry of Oceans and Fisheries, Korea (No. RS-2022-KS221644(20220509)).

S11, Poster, AbstractID=19480, PosterID: S11-P4

West Coast Groundfish distribution and ontogenetic overlap analyses in the California Current Ecosystem

Sajna Hussain[1], Lorenzo **Ciannelli**[1], Mary Hunsicker[1], Eric Ward[2], and Owen Liu[1]

[1]Oregon State University, Corvallis, OR, USA. E-mail: lorenzo.ciannelli@oregonstate.edu
[2]NOAA Fisheries, Northwest Fisheries Science Center, Newport, OR, USA

Climate change is reshaping the California Current Ecosystem (CCE) through warming, declining oxygen, and altered stratification, with cascading effects on demersal fish populations. Groundfish shift habitats across life stages as conditions change, yet how climate-driven variability alters spatial overlap among juveniles, sub-adults, and adults remains poorly understood.

We analyzed NOAA West Coast Groundfish Bottom Trawl Survey data (2003–2024) for six representative species—English sole (*Parophrys vetulus*), petrale sole (*Eopsetta jordani*), Dover sole (*Microstomus pacificus*), sablefish (*Anoplopoma fimbria*), longspine thornyhead (*Sebastolobus altivelis*), and shortspine thornyhead (*Sebastolobus alascanus*). We fit size-explicit Boosted Regression Tree models to presence-absence and abundance data, then combined the spatial predictions with Area Overlap (AO) and Biomass Overlap (BO) indices to quantify co-occurrence between successive life stages and tested each index against annual bottom temperature.

Warming was associated with significant shifts in overlap in every species, but the direction depended on the species, life stage, and whether overlap was measured by area or biomass. Co-occurrence among medium and large fish increased with warming in Dover sole, sablefish, and shortspine thornyhead, consistent with mobile adults tracking thermal refugia, whereas several juvenile and adult metrics in English sole, petrale sole, and longspine thornyhead declined with warming, consistent with habitat constraint or compression.

These findings highlight differential vulnerabilities within the groundfish complex and emphasize the need to integrate stage-specific dynamics into ecosystem-based fisheries management. By linking ontogenetic ecology with climate variability, this study provides a framework for anticipating bycatch risk, predator–prey interactions, and adaptive management strategies in the CCE under ongoing environmental change.

S11, Poster, AbstractID=19576, PosterID: S11-P5, (ECOP)

The Pacific Islands Region Ichthyoplankton Survey (PIRIS): A regional platform for investigating larval ecology across the U.S.-Affiliated Pacific Islands

Jessica N. **Perelman**[1,2], Andrea Schmidt[1,2], Justin J. Suca[3], Jonathan Whitney[2], Kisei R. Tanaka[2], Donald Kobayashi[2], Ryan R. Rykaczewski[2,4], Joseph O'Malley, Jennifer Samson[2]

[1]Cooperative Institute for Marine and Atmospheric Research, University of Hawai'i, Honolulu, HI, USA. E-mail: jessica.perelman@noaa.gov
[2]NOAA Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, HI, USA
[3]University of Hawai'i at Mānoa, Department of Oceanography, Honolulu, HI, USA
[4]NOAA Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, CA, USA

Larval survival and transport are fundamental components of recruitment, stock structure, and resilience in marine ecosystems, yet remain poorly understood across the vast and geographically complex U.S.-Affiliated Pacific Islands. Established in 2023, the Pacific Islands Region Ichthyoplankton Survey (PIRIS) was designed to address critical gaps in our understanding of spawning ecology, larval distributions, and the processes that underpin connectivity among federally and jurisdictionally managed pelagic and reef fishes. By integrating standardized nighttime ichthyoplankton and environmental DNA (eDNA) sampling into annual National Coral Reef Monitoring Program (NCRMP) research cruises, PIRIS conducts coordinated surveys spanning Hawai'i Pae 'Āina, the Mariana Archipelago, American Sāmoa, and the Pacific Remote Islands Marine National Monument, creating the most spatially extensive fishery-independent larval fish survey in the Pacific Islands Region. Since its inception, PIRIS has completed more than 300 ichthyoplankton tows across diverse nearshore and offshore habitats, establishing an extensive regional dataset for investigating larval ecology. This presentation introduces the survey framework and highlights how these data support fisheries research through identification of spawning habitats, characterization of larval-environment relationships, integration with biophysical dispersal models, and comparisons with adult fish communities. We will discuss ongoing and planned analyses that leverage PIRIS to evaluate connectivity within and among island regions, improve understanding of recruitment pathways, and provide scientific information to support collaborative marine resource management across the Pacific.

SESSION 12: HD/MONITOR Topic Session

Transboundary Science for a Changing North Pacific Ocean

Oral Presentations

S12, Invited, AbstractID=19178

On detection, attribution, and prediction of species on the move across geopolitical borders

Alexa L. **Fredston**

Department of Ocean Sciences, University of California Santa Cruz, USA.
E-mail: fredston@ucsc.edu

Transboundary science is fundamentally biogeographical in nature: both fields focus on the spatiotemporal distributions of species. Transboundary science especially needs information on range *edges*, in order to understand when (and why) species appear in or disappear from an area. In this talk I will share recent results in each of the three session themes, with an emphasis on range edge dynamics of groundfish. To inform monitoring and data sharing (Theme 1), I will describe the social and technological infrastructure underpinning FISHGLOB (the world's largest open-access dataset of georeferenced marine fish observations [I think]) and introduce a simulation approach that calculates how much data is needed to accurately detect range edge shifts. Range extensions can be identified with just a few observations, but high-precision estimates of range edge shift rates and directions likely require decades of continuous data. Leveraging the bottom-trawl surveys collated in FISHGLOB, I then will share several novel approaches to understanding and predicting the effects of long-term warming and short-term extreme events on fish stocks (Theme 2). These include a theoretical framework for how to build models of species' responses at multiple spatial and temporal scales; and an application of process-based (i.e., mechanistic) modeling to a transboundary stock in the Northwest Atlantic. I will end with a story about communicating near-term forecasts of shifting stocks near jurisdictional boundaries to managers and stakeholders (Theme 3).

S12, Invited, AbstractID=19236

Transboundary large-scale monitoring surveys of small pelagic fishes contributing to international fisheries management

Taiki **Fuji**

Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan. E-mail: fuji_taiki65@fra.go.jp

The North Pacific Fisheries Commission (NPFC) conducts stock assessments and fisheries management for resources distributed in the convention area of the North Pacific Ocean. Among these resources, small pelagic fishes are distributed and migrate not only in the high seas but also across national boundaries. Therefore, surveys limited to the waters of a single country cannot adequately capture their full distribution and population dynamics. Although fishery-derived information is essential for stock assessment, fisheries targeting transboundary resources often differ among members in terms of fishing grounds and fishing methods, making it difficult to obtain a comprehensive understanding of stock status.

Commissioned by the Fisheries Agency of Japan, the Japan Fisheries Research and Education Agency conducts annual surveys targeting small pelagic fishes during June and July, covering waters from the coastal area of Japan to 165°W and encompassing sea surface temperatures between 8 and 20°C. At each sampling station, surface trawl surveys are conducted to collect small pelagic fishes, including Pacific saury and chub mackerel, providing data on their distribution and abundance. Simultaneously, various oceanographic and ecosystem observations are carried out to comprehensively collect information spanning lower trophic ecosystems to pelagic fish communities.

Using these survey data, statistical modeling approaches have been applied to estimate abundance indices for Pacific saury and chub mackerel, which are provided to the NPFC Scientific Committee and its subgroups. These indices constitute essential information for species-specific stock assessments within the NPFC framework. In addition, results from oceanographic observations and NORPAC net sampling have improved our understanding of lower trophic ecosystems in the transition zone at a basin-wide scale.

In this session, I will introduce the role that these surveys have played in international fisheries management within the NPFC framework, as well as recent scientific advances derived from these survey programs.

S12, Oral, AbstractID=19160

Climate-mediated cumulative stressors shape population dynamics of Upper Fraser River Chinook salmon

Eric **Hertz**[1], Rachel Chudow[2], Todd Hatfield[2], Jane Healey[1], Jason Hwang[1], Jane **Pendray**[1], Gord Sterritt[3], Linda Stevens[3], Eric Vogt[2]

Presented by Jane Pendray on behalf of Eric Hertz

[1]Pacific Salmon Foundation, Vancouver, BC, Canada. E-mail: ehertz@psf.ca
[2]Ecofish Research, Campbell River, BC, Canada
[3]Upper Fraser Fisheries Conservation Alliance, Williams Lake, BC, Canada

Pacific salmon populations throughout the North Pacific are experiencing widespread declines, increasing interannual variability, and changing responses to climate forcing. Understanding the environmental drivers of these changes remains a major challenge for the management and conservation of migratory salmon populations that connect freshwater, estuarine, and marine ecosystems across broad spatial scales. Upper Fraser River Spring 5-2 Chinook salmon exemplify these challenges, having undergone substantial declines in abundance while exhibiting increasingly variable annual returns.

We developed an integrated life cycle–based assessment framework to evaluate how climate variability and cumulative anthropogenic stressors interact to influence population dynamics in this highly migratory salmon population. The assessment synthesized population trends, life-history characteristics, environmental conditions, and stressors operating across natal watersheds, the Fraser River mainstem, estuarine habitats, and offshore marine ecosystems. By linking environmental drivers and stressors to life-stage-specific mechanisms of mortality, the framework provides a structured approach for evaluating cumulative effects across ecosystems and identifying factors most closely associated with observed population change.

Results indicate that declines in Upper Fraser Spring 5-2 Chinook salmon are not attributable to a single limiting factor but instead reflect interacting stressors operating throughout the life cycle. Climate-driven changes in marine ecosystems, including shifts in productivity, prey availability, competition, predation, and disease dynamics, appear to play a central role in shaping survival and recruitment. Freshwater habitat degradation, migration barriers, elevated river temperatures, and fisheries-related mortality may further reduce population resilience by constraining the ability of populations to withstand periods of poor marine survival. These cumulative effects likely contribute to increasing variability in adult returns and heightened sensitivity to environmental change. Patterns observed in Upper Fraser Chinook are consistent with broader trends reported across the North Pacific, including declining marine survival, reduced age diversity, and increased sensitivity of salmon populations to marine heatwaves and ecosystem reorganization.

This work demonstrates how integrated assessment frameworks can improve understanding of environmental drivers affecting salmon populations that depend on interconnected freshwater and marine ecosystems. By translating diverse biological and environmental information into a mechanistic understanding of population dynamics, the approach supports climate-informed management, recovery planning, and conservation decision-making. More broadly, the framework provides a transferable approach for evaluating cumulative effects and environmental change in migratory species throughout the North Pacific.

S12, Oral, AbstractID=19176

Identifying a hotspot of euphausiid co-occurrence with low pH and oxygen along the west coast of Canada and United States

Elizabeth M. **Phillips**[1], Chelsea Stanley[2], Hayley V. Dosser[3], Debby Ianson[2], D. Shallin Busch[1], Paul McElhany[1], John E. Pohl[1] and Stéphane Gauthier[2]

[1]NOAA Fisheries Northwest Fisheries Science Center, Seattle, WA, USA.
E-mail: elizabeth.phillips@noaa.gov
[2]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
[3]Environment and Climate Change Canada, Victoria, BC, Canada

Euphausiids (krill) are a critical component of the California Current Ecosystem (CCE) and support numerous ecologically important species of fish, seabirds, and marine mammals. Recent studies in the CCE suggest that krill are sensitive to low oxygen, and may be sensitive to low pH, but the scope of research is limited, particularly for field studies. We leveraged transboundary datasets generated during the joint biennial US-Canada Acoustic Trawl Survey for Pacific hake (hereafter, 'hake survey') to expand the spatial and temporal range of field research on krill populations and ocean acidification (OA). We used acoustic data collected during the hake survey and hydrographic observations of oxygen, temperature, and salinity from co-located vertical CTD casts to estimate adult krill abundance and seawater carbonate chemistry conditions at the time of sampling. We focused our analyses on data from 2023, which enabled us to compare vertical profiles of oxygen from CTD casts and estimates of pH with direct measurements at discrete depths collected in the same area and time period during Fisheries and Oceans Canada's La Perouse Survey. We found greatest krill densities in areas with the lowest dissolved oxygen and pH in the dataset, and will present possible explanations for our results. This research demonstrates the value of transboundary research and coordinated monitoring and data sharing between Canadian and American oceanographic and fisheries surveys to inform monitoring efforts aimed at tracking OA impacts on krill and their predators in the northeast Pacific Ocean. Such work to detect climate-driven change at relevant spatial scales is particularly important as ecosystems respond in rapid and unpredictable ways to changing ocean conditions.

S12, Oral, AbstractID=19199

Integrating US and CA marine data to identify region-specific limiting factors across a transboundary salmon migration

Lisa **Crozier**[1], Cameron Freshwater[2], Brian Burke[1], David Huff[3], Eric Ward[1], Doug Jackson[4] and Eve Pugsley[5]

[1]Northwest Fisheries Science Center, NOAA-Fisheries, Seattle, WA, USA.
E-mail: lisa.crozier@noaa.gov
[2]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada
[3]Northwest Fisheries Science Center, NOAA-Fisheries, Corvallis, OR, USA
[4]QEDA Consulting, Seattle, WA, USA
[5]University of Washington, Seattle, WA, USA

Marine survival for Snake River spring/summer Chinook salmon has long remained well below recovery targets. Although a warming ocean is chronically detrimental for marine survival, a more mechanistic understanding of limiting factors may identify management levers to mitigate population declines. To improve this understanding, we developed a Structural Equation Modeling (SEM) framework that incorporates a wide range of ecosystem data while accounting for complex correlation structures.

We utilized a streamlined model selection approach incorporating size, growth, and catch-per-unit-effort (CPUE) data from NOAA's Juvenile Salmon and Ocean Ecosystem Surveys (JSOES), nested within a smolt-to-adult-return model. The measurement model defines latent variables representing prey, competitors, and predators off the coasts of Washington State, British Columbia, and Alaska.

Our structural model identified robust ecosystem predictors from of growth rates and early ocean survival; we further explored the pathways connecting growth and early survival to adult recruitment. These results facilitate more targeted modeling of age-at-return and help pinpoint the specific management interventions with the greatest potential to improve adult returns in a changing climate.

S12, Oral, AbstractID=19212, (ECOP)

More than bycatch: Understanding catch dynamics of two understudied pelagic fishes across Hawai‘i’s fisheries

Jessica N. **Perelman**[1,2], Janelle L. Morano[1,2], Justin J. Suca[3], Jason Helyer[4], Ryan R. Rykaczewski[2,5]

[1]Cooperative Institute for Marine and Atmospheric Research, University of Hawai‘i, Honolulu, HI, USA. E-mail: jessica.perelman@noaa.gov
[2]NOAA Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, HI, USA
[3]University of Hawai‘i at Mānoa, Department of Oceanography, Honolulu, HI, USA
[4]Hawai‘i Division of Aquatic Resources, Department of Land and Natural Resources, Honolulu, HI, USA
[5]NOAA Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, CA, USA

Despite contributing substantially to Hawai‘i’s commercial and recreational fisheries, many pelagic fish species, such as mahimahi (*Coryphaena hippurus*) and ono (*Acanthocybium solandri*), remain poorly studied in the central North Pacific Ocean. Unlike well-studied and highly managed species such as tunas and billfishes, these economically, culturally, and ecologically valuable pelagic fishes have not been the focus of regional stock assessments or comprehensive catch rate analyses. As oceanographic conditions shift, understanding how the distribution and availability of these species respond across space and time has become increasingly important for Hawai‘i’s fishing communities and industries. This study examines catch rate patterns for mahimahi and ono across Hawai‘i’s near-island troll and offshore longline fisheries. By integrating more than 20 years of fishery-dependent data spanning multiple decades with environmental observations, we evaluate spatial, seasonal, interannual, and basin-scale patterns in catch rates across the central North Pacific Ocean. Our results suggest several common responses to dynamic oceanographic conditions including increased catch rates at higher sea surface temperatures, pronounced seasonality in catch rates, and clear interannual patterns in overall availability across both species and fisheries. Comparisons between fisheries operating at distinct spatial scales further highlight how environmental variability influences pelagic species availability across regions and time. This research highlights the need for greater consideration of important “non-target” pelagic species in a changing ocean that may alter their availability to Hawai‘i’s fishing communities.

S12, Oral, AbstractID=19220, (ECOP)

Disentangling complex dynamics of Pacific hake biomass distribution in the California Current Ecosystem

Olivia M. **Gemmell**[1], Owen R. Liu[1], Mary E. Hunsicker[2], Eric J. Ward[1,3], Jameal F. Samhouri[1,3], Michael J. Malick[4], Michael G. Jacox[5], Julia Clemons[3], John Pohl[3], Aaron M. Berger[3], Kristin N. Marshall[3], and Isaac C. Kaplan[3], Timothy E. Essington[1]

[1]University of Washington, Seattle, WA, USA. E-mail: ogemmell@uw.edu
[2]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Newport, OR, USA
[3]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[4]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Manchester, WA, USA
[5]Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Monterey, CA, USA

Rapid ocean warming, altered circulation, anomalous events, and other changing ocean conditions are disrupting species-environment relationships and leading to novel species distributions. Predicting the spatial distribution of the highly mobile, semi-pelagic Pacific hake is important because of its key role as both predator and prey in the ecosystem, as well as its large transboundary (U.S. and Canada) fishery and commercial importance. In the last five years, hake observations in the Canadian fishery have declined dramatically, despite relatively flat abundance predictions from the coastwide stock assessment model. Here, we use flexible spatiotemporal models to (1) explore Pacific hake biomass distribution across the population's full transboundary range in relation to ocean conditions, (2) incorporate newly available oceanographic drivers from the Modular Ocean Model 6 and (3) systematically evaluate model structures for three age groups including spatial and spatiotemporal correlation structures. We found that oxygen was an important predictor of hake distribution for all age groups. Further, we identified a shift beginning in 2013 characterized by decreased subadult Pacific hake abundance and shifted distribution offshore and south. Despite the specific drivers identified above, we found substantial remaining spatial and spatiotemporal variation. This remaining latent variation challenges current assumptions about Pacific hake distribution drivers, suggesting either a species distribution shift or that more complex processes influence distribution. Although not directly mechanistic, we found moderate to strong spatiotemporal autocorrelation, indicating that distributional changes are not independent year to year but instead reflect persistent, correlated processes, which improved predictive performance and might enable skillful forecasts.

S12, Oral, AbstractID=19222

Disappearing dogfish: Transboundary analyses reveal little evidence for regional redistribution amidst steep population declines

Lindsay N. K. **Davidson**[1], Philina A. English[1], Jackie King[1], Paul B. C. Grant[2], Ian G. Taylor[3], Lewis A. K. Barnett[4], Vladlena Gertseva[3], Cindy A. Tribuzio[4] and Sean C. Anderson[1,5]

[1]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada.
E-mail: lindsay.davidson@dfo-mpo.gc.ca
[2]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
[3]Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA, USA
[4]Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, WA, USA
[5]School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC, Canada

Quantifying broad-scale population trends and distribution change is critical for effective management and conservation of marine species, particularly under climate change. However, fragmented regional survey data often hinder such efforts for transboundary populations. A prime example is Pacific Spiny Dogfish (*Squalus suckleyi*, Squalidae), a small shark with a remarkably slow life history and wide-ranging distribution. Reports on local population trends have conflicted along the coast, suggesting that movement between regions may be responsible. We fit spatiotemporal models integrating data from 10 surveys across Canada and United States (Alaska and western US coast) to synthesise trends in biomass, abundance, distribution and thermal niche for dogfish. Prior to 2003, Alaskan biomass increased through the 1990s whereas California to British Columbia indices were variable and imprecise. However, during 2003–2023, we found a coastwide 51% (95% CI: 38%–61%) decline in dogfish biomass with mature females and immature dogfish showing the largest proportional declines. Regionally, declines were steepest for the US West Coast (71%–85%) and Canada (58%–82%), while Alaska showed less severe declines (13%–54%). Off the US West Coast, dogfish shifted into deeper waters as temperatures in their habitat increased, but these patterns do not explain the coastwide declines. Our results suggest population declines are primarily driven by reduced abundance rather than between-region movement, indicating elevated coastwide conservation concern and helping focus investigations of causal mechanisms.

S12, Oral, AbstractID=19231

The evolving incorporation of ecosystem information into the stock assessment for Pacific Hake in the eastern North Pacific Ocean

Andrew M. **Edwards**[1], Mary E. Hunsicker[2], Kristin N. Marshall[3], Aaron M. Berger[2] and Travis Tai[1]

[1]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada.
E-mail: andrew.edwards@dfo-mpo.gc.ca
[2]Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Newport, OR, USA
[3]Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration,Seattle, WA, USA

Under changing ocean conditions, the governments of Canada and the United States of America are moving towards an Ecosystem Approach to Fisheries Management by incorporating ecosystem information into management advice. Pacific Hake spawn off California and migrate north into Canadian waters, with an estimated female spawning biomass of over 1 million tonnes. Consequently, this transboundary stock is jointly assessed and co-managed by Canada and the United States. This talk will present the evolution of including ecosystem information into the annual stock assessment and advice. Aspects include (a) solid interdisciplinary research, (b) easily accessible ecosystem information, (c) statistical methods to amalgamate diverse information, and (d) a reproducible workflow to convert data into actionable advice for decision makers every year, including the communication of uncertainty. Lessons learned will be presented, including the leveraging of expertise from both countries.

S12, Oral, AbstractID=19294

Assessing the climate-readiness of transboundary fishery assessment frameworks under the Pacific Salmon Treaty

Brendan **Connors**[1], Scott McPherson[2], Catherine **Michielsens**[3], Brian Beckman[4], John Field[3], and Diana Dobson[5]

Presented by Catherine Michielsens on behalf of Brendan Connors

[1]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: Brendan.connors@dfo-mpo.gc.ca
[2]Alaska Department of Fish and Game, Juneau, AK, USA. retired
[3]Pacific Salmon Commission, Vancouver, BC, Canada. E-mail: michielsens@psc.org
[4]Cooperative Institute for Marine Resources Studies, Oregon State University, Newport, OR, USA
[5]Pacific Biological Stations, Fisheries and Oceans Canada, Nanaimo, BC, Canada

Climate change is creating an increasingly uncertain future for the assessment and management of fisheries worldwide. Pacific salmon exemplify this challenge, as both their freshwater and marine habitats are shifting beyond historical ranges of variability. These changes vary across space and time with both negative and positive population-level effects, while also altering abundance, distribution, and life-history timing. Ensuring that stock assessment and management systems remain robust to such changes is particularly difficult for regional fisheries management organizations implementing international agreements like the Pacific Salmon Treaty (PST) between the United States and Canada. The PST supports coordinated transboundary management of marine and select in-river salmon fisheries across the northeast Pacific, from the Yukon River to the mid-Oregon coast. In recent years, many stocks covered by the Treaty have experienced near-record low returns coincident with climate-driven changes in marine and freshwater environments. We review PST assessment frameworks to identify both shared and chapter-specific challenges. We evaluate the extent to which individual management chapters respond to climate-driven change and how they account for the uncertainties it introduces. Overall, we find that Treaty assessment frameworks attempt—directly or indirectly—to account for environmental and climate effects on survival through tools like in-season assessments and, in some cases, inclusion of environmental indicators and sibling information in preseason forecasts. However, not all fisheries are amenable to in-season adjustment, and relationships between environmental conditions and survival are becoming increasingly non-stationary. We identify opportunities to improve how management goals and reference points are defined in light of climate-driven shifts in growth, distribution, survival, and abundance. Greater attention is also needed to explicitly characterize and communicate risk arising from climate-related uncertainty. Our review provides a common foundation to inform ongoing efforts to adapt PST assessment and management frameworks to a rapidly changing climate. More broadly, it

highlights both challenges and opportunities for fisheries governance systems seeking to become more climate resilient.

S12, Oral, AbstractID=19296

The salmon data integration toolkit: Making salmon data reusable across contexts

Brett **Johnson**[1], Graeme Diack[2], Bruno Carturan[3], Gottfried Pestal[4], Tom Bird[5]

[1]Fisheries and Oceans Canada, Cultus Lake, Vancouver, BC, Canada.
E-mail: johnson@psc.org
[2]Missing Salmon Alliance; The Atlantic Salmon Trust, Perthshire, Scotland, UK
[3]Pacific Salmon Foundation, Vancouver, BC, Canada
[4]Solv Consulting, Vancouver, BC, Canada
[5]Fisheries and Oceans Canada, Sidney, BC, Canada

Climate change is reshaping North Pacific salmon ecosystems, increasing the need to combine data across programs, jurisdictions, and organizations. Appropriate reuse of salmon data depends on explicit documentation of context, biological interpretation, methods, provenance, and limits of inference. Without shared tools, these interpretive details often remain embedded in local data structures, terminology, and institutional histories. Broad standards exist for ocean and climate data, yet salmon-specific terms such as stock, run, population, and wild are often conflated or defined differently across contexts. We present the Salmon Data Integration Toolkit: a practical workflow and set of tools for packaging salmon data with the definitions, methods, code lists, provenance, and interpretation constraints needed for reuse. Developed through the Research Data Alliance Salmon Ontology Development Working Group, the Toolkit connects three components. Salmon Data Packages provide an exchange format for tabular data, metadata, data dictionaries, and code lists. The Salmon Domain Ontology provides persistent identifiers and reviewable definitions for salmon data terms, with the goal of supporting open community maintenance. The metasalmon R package scaffolds Salmon Data Packages, validates structure, exports standardized data and metadata, and suggests semantic matches between dataset terms and shared definitions in the Salmon Domain Ontology and related international controlled vocabularies. Self-guided workshop materials in development will guide practitioners through the workflow and tools. Together, these resources support coordinated monitoring, cross-jurisdictional data sharing, and clearer communication of ecosystem information to management and policy.

S12, Oral, AbstractID=19299, (ECOP)

Geography and life history mediate Pacific salmon responses to a warming, crowded ocean

Hannah **Hunter**[1,2], Brendan Connors[3], Dan Greenberg[1], Michael Malick[4], Greg Ruggerone[5], Andrew Munro[6], Marisa Litz[7], Michael Litzow[8], Dylan Glaser[1], Megan Feddern[4], Curry Cunningham[9], Randall Peterman, Stephanie Peacock[2], Eric Ward[4] and Cameron Freshwater[1]

[1]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada
[2]Pacific Salmon Foundation, Vancouver, BC, Canada. E-mail: hhunter@psf.ca
[3]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
[4]Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA, USA
[5]Natural Resources Consultants, Inc., Seattle, WA, USA
[6]Division of Commercial Fisheries, Alaska Department of Fish and Game, Anchorage, AK, USA
[7]Washington Department of Fish and Wildlife, Olympia, WA, USA
[8]Alaska Fisheries Science Center, NOAA Fisheries, Kodiak, AK, USA
[9]College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK, USA

Pacific salmon are typically managed at national and regional scales, but their dynamics are shaped by shared ocean conditions spanning their transoceanic range. Using spawner–recruitment data from 127 populations – three species from four ocean regions spanning six decades assembled in an open-access dataset – we quantify how ocean warming during early marine life and competition with abundant pink salmon later in marine life jointly influence salmon productivity (adults produced per spawner). Warming is associated with reduced productivity at southern latitudes and increased productivity at northern latitudes, though effect sizes vary among species. Critically, these temperature–productivity relationships have shifted since the onset of an unprecedented pan-basin ocean warming period, with intermediate-latitude populations that historically had positive associations with warming now showing negative associations. Competition with pink salmon, whose North Pacific–wide abundance has reached a century-long high, was strongly associated with depressed sockeye productivity at southern latitudes, and across species we found that warming often exacerbated the effects of competition. These results illustrate that climate change and biotic interactions are reshaping salmon productivity in interconnected, non-stationary ways. As conditions in the North Pacific continue to depart from historical norms and past environment–productivity relationships become less reliable guides to the future, managing Pacific salmon across national boundaries will become increasingly complex. Meeting this challenge requires international data sharing and coordinated inference at the scale of the drivers themselves – which our study illustrates is both feasible and necessary.

S12, Oral, AbstractID=19386, (ECOP)

Parallel life-history shifts in geographically separated forefront populations of the tropical sardine *Sardinella lemuru*

Alexanra B. **Regalado**[1,2,5] Daisaku Suda[1,2], Toyoho Ishimura[3], Jeffrey Norriss[4], Wilfredo L. Campos[5], Kaito Inoue[4], Koki Matsuda[4] and Shin-ichi Ito[2]

[1]Department of Aquatic Bioscience, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: regaladoab@aori.u-tokyo.ac.jp
[2]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan
[3]Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, Japan
[4]Fisheries and Sustainability, Department of Primary Industries and Regional Development, WA Fisheries and Marine Research Laboratory, Perth, WA, Australia
[5]OceanBio Lab, Division of Biological Sciences, College of Arts and Sciences, University of the Philippines Visayas, Miagao, Philippines
[6]Miyazaki Prefectural Fisheries Research Institute, Miyazaki, Japan

Climate-driven range expansions are reshaping the distribution of marine fishes worldwide, yet the demographic and life-history characteristics of expanding forefront populations remain poorly understood. We investigated movement patterns and life-history traits of the tropical sardine *Sardinella lemuru* across its core distribution in the Philippines and two geographically separated forefront populations in Japan and Western Australia. Otolith core stable oxygen isotope ($\delta^{18}O$) analyses were used to infer natal origins and movement patterns, while size, growth and reproductive traits were compared to evaluate life-history variation among populations. Otolith $\delta^{18}O$-based habitat assignment in the northern forefront population indicated that some individuals were locally hatched off Japan, whereas others likely originated from warmer southern regions. These results indicate that both local recruitment and long-distance transport contribute to population establishment at the expanding range margin. Both forefront populations exhibited larger body sizes and relatively overweight allometric relationship between body length and weight ($b > 3$) relative to the Philippine core population, which displayed smaller body sizes and relatively skinny allometry ($b < 3$). Among specimens sampled from local fisheries, median standard length was greatest in Japan (17.4 cm), intermediate in Australia (15.0 cm), and lowest in the Philippines (11.6 cm). Reproductive activity in both forefront populations was associated with a similar optimal thermal window (22–24°C), suggesting convergence in reproductive thermal niches at opposite range margins. In contrast, size-at-first maturity was similar between Australia (Lm_{50} = 14.4 cm) and the Philippines (Lm_{50} = 14.3 cm), while Japan population matured at a larger size (Lm_{50} = 16.9 cm). Our results suggest that range expansion in *S. lemuru* is associated with parallel shifts in body size, growth and reproductive thermal niches at both northern and southern distributional limits, while maturation patterns remain region-specific. These findings highlight the combined roles of dispersal and local environmental conditions in shaping life-history responses during range expansion.

S12, Oral, AbstractID=19396, (ECOP)

From passive drift to active migration: Environment-driven spatial pathways shaping chub mackerel dynamics across the Northwestern Pacific

Ziqin **Wang**[1,2] and Shin-ichi Ito[2]

[1]Graduate School of Agriculture and Life Science, the University of Tokyo, Tokyo, Japan.
E-mail: zqwang@g.ecc.u-tokyo.ac.jp
[2]Atomosphere and Oceanography Research Institute, the University of Tokyo, Chiba, Japan

Chub mackerel (*Scomber japonicus*) is an economically important small pelagic fish and a key component of marine ecosystems in the Northwestern Pacific. Its extensive migrations span multiple latitudes, fishing grounds, and management areas; therefore, understanding how its life-history characteristics vary across regions and life stages is important for effective management of this widely distributed stock. The stock has experienced severe long-term fluctuations, including a sharp collapse after 1978 and a renewed decline following a temporary recovery during 2013–2018. These changes coincided with large-scale environmental variability, including ocean warming, marine heatwaves, and the Kuroshio Large Meander (KLM), yet the mechanisms linking environmental change to stock dynamics remain insufficiently understood.

We developed an individual-based model (IBM) of chub mackerel to examine how environment-driven spatial pathways affect population dynamics across the Northwestern Pacific. The simulation reproduced the decline in stock abundance after 2018 and indicated that the KLM negatively affected recruitment of the May and June cohorts, mainly through intensified offshore transport during early life. At the adult stage, individuals exhibited contrasting migration strategies: some migrated seasonally through coastal waters, whereas others followed offshore pathways. Ongoing analyses examine the physiological mechanisms underlying these preferences and their consequences for growth and survival. By linking early-life dispersal and adult migration within a common modelling framework, this study improves understanding of environmental drivers across spatial and temporal scales and provides a mechanistic basis for spatially coordinated assessment and management of widely distributed marine resources.

S12, Oral, AbstractID=19440

Larval sablefish exhibit correlated geographic and phenological shifts spanning national boundaries

Janie Sanborn[1], Katherine E. Dale[2], Martina Van Etten[3], Toby D. Auth[4], R. Ian Perry[5], Mercedes Pozo Buil[6], Lauren A. Rogers[7], Andrew R. Thompson[8] and Rebecca G. **Asch**[2]

[1]University of Virginia, Charlottesville, VA, USA
[2]East Carolina University, Department of Biology, Greenville, NC, USA.
E-mail: aschr16@ecu.edu
[3]University of North Carolina at Pembroke, Pembroke, NC, USA
[4]Pacific States Marine Fisheries Commission, Newport, OR, USA
[5]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
[6]University of California, Santa Cruz, Santa Cruz, CA, USA
[7]Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[8]Fisheries Resources Division, Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration, San Diego, CA, USA

Interannual variability in both local environmental conditions and basin-scale oceanographic patterns is thought to drive larval fish abundance and distribution by affecting the timing and location of spawning. We used an extensive, compiled transboundary dataset of larval fish concentration from 1995-2018 from continental shelf regions off central California to the Gulf of Alaska to model how sablefish (*Anoplopoma fimbria)* shifted larval seasonality and geography in response to environmental and oceanographic variability. The most predictive spatiotemporal model included a monthly term separately calculated across five-year time blocks, with sea surface salinity and sea surface temperature as the most predictive environmental covariates. Sablefish larval distributions were centered in the shelf region of the eastern Gulf of Alaska and exhibited correlated shifts in latitudinal, longitudinal, onshore-offshore, and seasonal centers of gravity. There were few links between geographic and seasonal centers of gravity and average environmental conditions, although modeled larval concentration peaked earlier in the year during warmer average ocean conditions. Phase-specific conditional effects models for the Pacific Decadal Oscillation and Oceanic Niño Index showed that sablefish larvae were uniformly associated with water temperatures between 7-8° C, while having a more variable relationship with sea surface salinity. Our results may indicate that sablefish larvae demonstrate joint geographic and seasonal shifts to maintain a consistent thermal habitat, which has implications for transboundary fisheries management.

S12, Oral, AbstractID=19489

Integrating transboundary survey data using spatiotemporal models: Lessons from the Northeast Pacific

Sean C. **Anderson**

Fisheries and Oceans Canada, Pacific Biological Station, BC, Canada.
E-mail: sean.anderson@dfo-mpo.gc.ca

Analysts are increasingly turning to model-based approaches to join datasets from neighbouring surveys across international borders. These approaches can support whole-stock indices of abundance and improve inference about climate-driven range shifts. Spatiotemporal models are a natural framework for this task because they can account for differences in survey gear, sampling effort, and irregular sampling patterns that do not conform to a single design-based implementation. In this talk, I will introduce the theory behind expanded-domain data integration—joining surveys to estimate a process over their combined spatial footprint—and develop four practical lessons for integrating survey data across borders, drawing on examples from Northeast Pacific groundfish. (1) Assembling transboundary survey data can be challenging, but recent international database initiatives are reducing this burden. (2) Model-based integration requires adequate spatial and temporal sampling proximity; how close is close enough depends on spatial correlation, survey timing, habitat covariates, observation error, and gear similarity. (3) Analysts should generally allow catchability to vary by survey, consider spatially varying catchability, evaluate the assumption of similar length selectivity, and account for differences in survey effort. (4) If sampling is irregular by region, analysts should watch for prediction artefacts due to space-time confounding. These methods open an important opportunity to monitor abundance and distribution shifts under climate change, but they introduce challenges beyond those of single-survey models. I encourage future work that identifies their limitations and establishes best practices for implementation.

S12, Oral, AbstractID=19490

Can YOU do better? Lessons from 3 years of competitive sockeye forecasting for Columbia, Fraser, and Bristol Bay stocks

Gottfried **Pestal**[1], Sean Simmons[2], and the Salmon Prize Community

[1]SOLV Consulting Ltd, Vancouver, BC, Canada. E-mail: gpestal@solv.ca
[2]Angler's Atlas, Prince George, BC, Canada

Effective transboundary science needs to address three fundamental challenges: (1) how to share data from different agencies, (2) how to foster dialog among researchers from different regions and different specialties, and (3) how to test diverse hypotheses in a structured way to support learning over time. The *Salmon Prize* forecasting competitions (https://salmonprize.com/) provide a creative format for addressing these three challenges. In these competitions, teams from around the world try to predict annual returns of major Pacific salmon (*Oncorhynchus* spp.) stocks, starting with a shared data set of spawners and returns by age, then compare performance and debate alternative approaches during a symposium the following spring. So far, 21 teams have competed in 3 full competitions, forecasting sockeye (*O. nerka*) returns to Bristol Bay (8 stocks), Fraser River (5 stocks), and Columbia River (3 stocks) for 2024-2026. We share highlights from the process, discuss spin-off benefits (e.g., streamlined data exchange between agencies, environmental covariates research), and summarize performance of alternative model types across stocks and years. Competition data sets, team forecasts, actual returns and performance diagnostics are being archived in a public GitHub repository (https://github.com/SOLV-Code/SalmonPrize_Diagnostics).

S12, Oral, AbstractID=19503, (ECOP)

Investigating synchrony in fish biomass trends across the West Coast of North America

Robert **Reinsvold**[1], Lauren A. Rogers[2], Eric J. Ward[3], Sean C. Anderson[4], and Jennifer S. Bigman[1]

[1]University of Delaware, Lewes, DE, USA.
E-mail: jennifersbigman@gmail.com , reinsvold.robert@gmail.com
[2]NOAA Alaska Fisheries Science Center, Seattle, WA, USA
[3]NOAA Northwest Fisheries Science Center, Seattle, WA, USA
[4]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada

Environmental change is driving shifts in geographic distributions, size and growth, and phenology of fishes globally. It is less clear how these individual- and population-level responses scale up to influence biomass dynamics. In particular, it remains unknown to what extent broad-scale environmental forcing synchronizes biomass trends across species, regions, and country borders, or whether population-specific vulnerabilities, fishing pressure, and management practices play a larger role. Here, we examine synchrony in biomass trends across fish populations along the West Coast of North America. We fit hierarchical generalized additive models spawning stock biomass time series from stock assessments for ~75 populations to evaluate support for shared trends at multiple levels, including within and across regions, species, and ecological groupings. We then apply Bayesian dynamic factor analysis to identify latent temporal trends for these groupings and quantify the degree to which individual populations associate with each trend. Overall, we find little support for synchrony in biomass trends across all species and regions. Instead, trends in biomass are more similar across stocks within a region, across stocks with similar life histories, and across stocks in functional groupings. Our work suggests that localized conditions, population-specific vulnerabilities, exploitation rates, and management regulations more strongly relate to patterns of biomass over time, and as such, trends are context-dependent. By examining patterns of biomass within and across populations over a large spatial scale, we can begin to tease apart the role that fishing, management regulations, and environmental variability have on the productivity of fisheries.

SESSION 12: HD/MONITOR Topic Session

Transboundary Science for a Changing North Pacific Ocean

Poster Presentations

S12, QR-Poster, AbstractID=19383, PosterID: S12-P1, (ECOP) **CANCELLED**

~~**Body condition of transboundary groundfish in the northeast Pacific**~~

~~Zoe **Khan**[1], Kiva Oken[2], Chantel Wetzel[2], Bridget Ferriss[3], Sean Anderson[4], Lewis Barnett[3], and Eric Ward[2,5]~~

~~[1]Smith College, Northampton, MA, USA. E-mail: zkhan@smith.edu~~
~~[2]NOAA Northwest Fisheries Science Center, Seattle, WA, USA~~
~~[3]NOAA Alaska Fisheries Science Center, Seattle, WA, USA~~
~~[4]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada~~
~~[5]University of Washington, Seattle, WA, USA~~

~~Fish body condition is a measure of an organism's energy reserves, and is often quantified as the residual from the expected weight at an individual's length. Body condition is influenced by factors such as food availability and ocean conditions (e.g. marine heatwaves), and can be used as an indicator of population health and change. While recent work in the U.S. West Coast, British Columbia, and Alaska have examined local patterns of spatial and temporal change of fish condition, few studies have examined these patterns at the ecological scale that matches the full geographic range of fish populations. Across the NE Pacific, there are several commercially important species spanning the California Current to the Aleutian Islands. Recent transboundary data science, including the 'surveyjoin' package, have made trawl survey data from the U.S. and Canada accessible in a standardized format. In this research, we evaluate the application of spatiotemporal models to fish body condition, with the aim of (1) detecting shared spatial or temporal trends among species, (2) identifying environmental covariates that can predict the observed change, and (3) discussing potential implications of these findings on transboundary management of these stocks. The results will be directly applicable to short-term predictions of body condition in response to changing environmental conditions.~~

SESSION 13: MONITOR/TCODE Topic Session

Long-term monitoring of the changing Northeast Pacific Ocean: 70 years of ocean observation at Ocean Station Papa and along Line P

Oral Presentations

S13, Invited, AbstractID=19209

An overview of phytoplankton and nutrient dynamics along Line P in the NE subarctic Pacific

Angelica **Peña**

Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: Angelica.Pena@dfo-mpo.gc.ca

Phytoplankton form the trophic base of nearly all marine ecosystems and play key roles in climate regulation, carbon sequestration and oxygen production. Long-term monitoring of phytoplankton abundance and community composition (as determined by HPLC-derived phytoplankton pigment concentrations) along Line P in the NE subarctic Pacific has contributed to our understanding of how changes in environmental conditions impact phytoplankton community composition and influence biogeochemical cycles. In general, nutrient concentrations are usually high (>5 mmol m^{-3}) and chlorophyll concentrations low (<0.5 mg m^{-3}) year around in the Fe-poor prymnesiophyte- dominated offshore waters of Line P, whereas high seasonal variability in phytoplankton biomass occurs in the nutrient-rich diatom-dominated inshore stations. In between, there is a seasonal nitrate-depleted transition region of variable extent. Significant variations have been observed in recent decades. Unusually high chlorophyll concentrations (~1.3 mg-Chl m^{-3}) were observed at the offshore end of Line P in August 2008 following a natural volcanic Fe fertilization. In addition, the occurrence of marine heat waves in recent years has increased stratification, resulting in a decrease in the flux of nutrients to the upper layer and an increase in light exposure, significantly changing the abundance and composition of phytoplankton. The implication of these phytoplankton changes to food web and biogeochemical cycles, some of which have been documented while others remain to be evaluated, will be discussed.

S13, Oral, AbstractID=19136, (ECOP)

Diurnal variation of sea surface temperature and its influencing factors in mid-latitude seas

Jian **Wang**, Liying Wan and Tiejun Ling

National Marine Environmental Forecasting Center, Ministry of Natural Resources, PR China.
E-mail: wangjian@nmefc.cn

Based on the in-situ observations collected at Ocean Station Papa (OS, 50°N, 145°W) operated by the National Oceanic and Atmospheric Administration (NOAA) from 2014 to 2023, this study investigates the characteristics and influencing factors of the diurnal variation in sea surface temperature (SST). The results reveal that diurnal SST variability is not exclusive to tropical oceans but also occurs in mid-latitude regions, with pronounced seasonal and interannual variations. In summer, the mean amplitude of diurnal SST variation reaches 0.3 °C, and the extreme value can range from 1 °C to 2 °C, which is primarily governed by surface heat fluxes and wind speed. In 2019, a marine heatwave known as "Blob 2.0" broke out in the Northeast Pacific surrounding OSP. It is found that the amplitude of diurnal SST variation was significantly amplified during this marine heatwave, peaking at 2.2 °C in July 2019 — the maximum value recorded throughout the 2014–2023 period. This extreme amplitude occurred under conditions of low wind speed and anomalously shallow mixed layer. The extremely shallow mixed layer confined the heating effect of solar shortwave radiation within a very thin surface water layer. A stronger water stratification and shallower mixed layer lead to a more intense response of diurnal SST variation to atmospheric forcing. Furthermore, diurnal SST variability is modulated by the background state of marine heatwaves; in turn, it may participate in the evolution of marine heatwaves by regulating air-sea heat exchange.

S13, Oral, AbstractID=19149

Time-series observation in the vertical distribution of iron at the Ocean Station Papa and its comparison to the western subarctic Pacific

Jun **Nishioka**[1], Hajime Obata[2], Yoshiko Kondo[3]

[1]Pan-Okhotsk Research Center, Institute of Low Temperature Science, Hokkaido University, Hokkaido, Japan. E-mail: nishioka@lowtem.hokudai.ac.jp
[2]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan
[3]Graduate School of Integrated Science and Technology, Nagasaki University, Nagasaki, Japan

Iron in the ocean plays a critical role as a micronutrient supporting marine primary productivity. Ocean Station Papa (OSP; 50°N, 145°W) is a historically important site where the late J. H. Martin first reported vertical profiles of iron in the North Pacific. Since then, the GEOTRACES program has greatly advanced our understanding of the distribution and biogeochemical cycling of iron in the ocean. However, knowledge of the temporal variability of iron distributions remains limited. In this study, we investigate interannual variations in the vertical distributions of iron at OSP in the eastern subarctic gyre and compare them with those observed at time-series Station K2 (47°N, 160°E) in the western subarctic gyre in the North Pacific. At OSP, in addition to the profile reported by J. H. Martin in 1989, we conducted five vertical profile observations between 1997 and 2025, including several full-depth profiles. At K2, full-depth observations were conducted 11 times between 2008 and 2023. Marked regional contrasts were observed in those vertical iron distributions. At OSP, dissolved iron concentrations showed relatively small temporal variability and remained broadly stable throughout the water column. In contrast, at K2 in the western subarctic North Pacific, dissolved iron concentrations were elevated in the intermediate layer and exhibited pronounced temporal variability, with changes on the order of 1–2 nM during the observation period. We will discuss the mechanisms responsible for these contrasting temporal patterns and their implications for iron supply to the subarctic North Pacific.

S13, Oral, AbstractID=19167

Differences in dissolved iron bioavailability between Ocean Station Papa and Station K2 in the subarctic North Pacific

Yoshiko **Kondo**[1], Jun Nishioka[2], Koki Yamanaka[1], Yudai Sunahara[1], and Hajime Obata[3]

[1]Nagasaki University, Nagasaki, Japan. E-mail: yoshikondo@nagasaki-u.ac.jp
[2]Pan-Okhotsk Research Center, Institute of Low Temperature Science, Hokkaido University, Hokkaido, Japan
[3]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan

Iron (Fe) is an essential micronutrient that often limits phytoplankton growth in high-nitrate, low-chlorophyll (HNLC) regions. Because most dissolved Fe in seawater is complexed with natural organic ligands, its bioavailability depends not only on Fe concentration but also on the chemical properties of Fe-binding ligands. Ocean Station Papa (OSP; 50°N, 145°W) in the eastern subarctic Pacific and Station K2 (47°N, 160°E) in the western subarctic Pacific are HNLC sites with contrasting biological productivity and Fe supply regimes. However, differences in Fe bioavailability between these sites remain poorly understood. Previous studies showed that concentrations of Fe-binding ligands in surface waters are comparable between OSP and K2, although ligand conditional stability constants were higher at OSP. To evaluate Fe bioavailability, we conducted photochemical Fe(II) production experiments and shipboard Fe-enrichment incubations using surface seawater collected from the two stations during the GEOTRACES GP02 cruise. Photochemical experiments showed low Fe(II) production rates at both sites, while little response to light irradiation was observed at OSP, suggesting less reactive Fe-organic complexes. In seawaters used in the incubation experiments, residual nitrate and excess Fe-binding ligands were found at both sites, indicating Fe-deficient conditions. Nevertheless, phytoplankton growth responses to the addition of 2 nM inorganic Fe were greater at K2 than at OSP. These results suggest that dissolved Fe bioavailability differs between OSP and K2 despite similar dissolved Fe and ligand concentrations. Excess natural ligands rapidly complexed with the added Fe but to different extents at both sites. The contrasting responses imply that the properties of Fe-binding ligands and the reactivity of Fe-organic complexes, rather than Fe concentration alone, influence phytoplankton Fe availability.

S13, Oral, AbstractID=19351

Trends in subsurface oxygen in British Columbia waters

Charles **Hannah**[1] and Michaela Maier[2]

[1]Fisheries and Oceans Canada, Sidney, BC, Canada. E-mail: Charles.Hannah@dfo-mpo.gc.ca
[2]University of Victoria, Victoria, BC, Canada

Declining subsurface oxygen concentrations have been reported for several locations in the waters of British Columbia, Canada. It is not clear whether these declines are local phenomena or part of a larger regional pattern. To address this issue we have compiled temperature, salinity, and oxygen time series for 12 locations around British Columbia from the extensive holdings of shipboard observations maintained by Fisheries and Oceans Canada. The locations include P1 and P4 from the Line P program, A few of the time series have data going back to the 1950s but many start in the 1990s. On the shelf and in the inlets, the time series were compiled at 50 m, 150 m, and 300 m (or the bottom). Trends were estimated for the period 1980 to present. The average rate of decline of subsurface oxygen for the 10 locations around the British Columbia shelf and inlets where the trends are statistically different from zero at 95% confidence, is about 5 μmol kg^{-1} $decade^{-1}$ (0.1 ml l^{-1} $decade^{-1}$). This rate is consistent with the declining trends reported for Ocean Station Papa since the 1950s. The declining oxygen trends are not just a near bottom feature. At some locations the declines observed at 50 m are as large, or larger, than the mid depth and near bottom ones, and at some locations there is no suggestion of a trend in the near bottom water.

S13, Oral, AbstractID=19356

Lateral Stirring Statistics in the Northeast Pacific

Lauryn C. Talbot[1], Jody M. **Klymak**[1], Tetjana Ross[1,2], Guoqi Han[1,2]

[1]School of Earth and Ocean Sciences, University of Victoria, BC, Canada.
E-mail: jklymak@uvic.ca
[2]Institute of Ocean Science, Fisheries and Oceans Canada, Sidney BC, Canada

Lateral gradients in the ocean are smoothed out by lateral stirring due to eddies and other mesoscale motions. The observational record of this stirring, particularly underwater, is scant, and hence we have a poor understanding of stirring statistics, and there are few tests of how well ocean simulations represent stirring. Here we present underwater glider data collected along the 1400 km of Line P in the Northeast Pacific in 16 transects and compare to a free running 1/36th degree regional simulation. There is a surprising lack of depth dependence or seasonality to the lateral statistics, but that there is definitive difference between an ``onshore'' and ``offshore'' regime, with the boundary at approximately 500 km from the shelf break. The nearshore California Undercurrent influenced water is a turbulent field that has impressive changes in width from 100 to 400 km wide with no clear time dependence. Comparisons with the numerical simulation show that the model has drifted warm at all depths over the 30-y free run, despite being forced at the boundaries by realistic ocean-state estimates. We are not sure it is related or not, but the simulation also shows a deficit of small-scale variability compared to the observations, and a slight surfeit of mesoscale variability. The simulation also does not show a strong near- and offshore difference in statistics. The results point to a need for more statistics to determine what sets the lateral variability in the Northeast Pacific and to better understanding how to parameterize stirring in submesoscale permitting ocean simulations.

S13, Oral, AbstractID=19461

Integrating altimetry and glider measurements to assess eddy influence on Line P

Tetjana **Ross**[1,2], Bernard Yang[2], Jody M. Klymak[2] and Lauryn Talbot[2,3]

[1]Fisheries and Ocean Canada, Institute of Ocean Sciences, Sidney, BC, Canada.
E-mail: tetjana.ross@dfo-mpo.gc.ca
[2]School of Earth and Oceans Sciences, University Victoria, Victoria BC, Canada
[3]Department of Oceanography, Dalhousie University, Halifax NS, Canada

Mesoscale anticyclonic eddies are a major pathway for transporting coastal water and properties into the offshore Northeast Pacific, yet their aggregate influence along Line P has not been fully characterized. We combine a new 33-year census of Northeast Pacific eddies, derived from blended META3.2 delayed-time and near-real-time altimetry products, with finescale glider observations of a mature Haida eddy sampled in winter 2020 to assess how eddies evolve and modify water masses as they transit the region.

The long-term census shows that ~17 large anticyclones form each year, with roughly half generated near the shelfbreak before propagating westward, many of which then cross Line P. These eddies carry substantial volumes of shelf water offshore along persistent “eddy corridors,” producing a sustained yet intermittent mesoscale influence on Line P hydrography.

Glider observations reveal tendril-like interleaving layers detaching from the eddy core, providing an efficient lateral exchange mechanism between eddy waters and the surrounding Northeast Pacific. Elevated lateral diffusivities inferred from these structures highlight the importance of finescale processes in modifying eddy temperature–salinity structure and water-mass characteristics along Line P, though these processes alone cannot explain observed eddy lifetimes.

Together, the long-term census and glider observations show that mesoscale eddies exert a persistent, evolving influence on Line P hydrography and offshore transport pathways. This integrated perspective underscores the need to combine eddy tracking with finescale process studies to understand how mesoscale dynamics shape the physical environment of the Northeast Pacific.

S13, Oral, AbstractID=19463

The "fresher" got "drier" over 7 decades at Ocean Station Papa in the northeast Pacific

Yolande L. **Serra**[1], Meghan F. Cronin[2], Annika Margevich[3], and Nicholas Bond[4]

[1]University of Washington, Seattle, WA, USA. E-mail: yserra@uw.edu
[2]Pacific Marine Environmental Laboratory (PMEL), NOAA, Seattle, WA, USA
[3]Yale University, New Haven, CT, USA
[4]Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle, WA, USA

Ocean Station Papa, located at 50°N 145°W, is one of the longest oceanic time series, dating back to late 1949. From late 1949 through 1981, two ocean weather ships alternated on station providing a time series of oceanic and meteorological measurements including precipitation. After the weather ship program ended in 1981, oceanographic monitoring continued through regular Line-P cruises to Station Papa (Station "P"), while the meteorological record resumed in 2007 when a National Oceanic and Atmospheric Administration (NOAA) surface mooring was deployed at the same location. This study uses this 7-decade oceanic and meteorological time series at Station Papa to investigate changes in surface precipitation related to previously identified trends in sea surface temperature and sea surface salinity at this location. Climatologies computed for the mooring and for the weather ship data show that rainfall has decreased at Station P over the last 70 years, while no significant trend in evaporation is observed, such that the net precipitation minus evaporation is now smaller than it was during the ocean weather ship era. The decrease in precipitation is coincident with the previously reported decrease in sea surface salinity at this site, suggesting that the mechanisms linking the "fresh gets fresher, salt gets saltier" paradigm to the "dry gets drier, wet gets wetter" paradigm are more complex at this location.

S13, Oral, AbstractID=19464

Reconstructing Line P: A virtual hackathon comparing data-driven methods for imputation

Hayley V. Dosser[1], Emily O'Grady[2], Susan E. Allen[3], James R. Christian[4] and Amber M. **Holdsworth**[5]

[1]Canadian Centre for Climate Services, Victoria, BC, Canada. E-mail: Hayley.Dosser@ec.gc.ca
[2]Fisheries and Oceans Canada, Dartmouth, NS, Canada
[3]University of British Columbia, Vancouver, BC, Canada
[4]Canadian Centre for Climate Modelling and Analysis, Victoria, BC, Canada
[5]Fisheries and Oceans Canada, Victoria, BC, Canada.
E-mail: Amber.Holdsworth@dfo-mpo.gc.ca

In December 2025, the Statistical Downscaling for the Ocean Working Group hosted a two-week virtual hackathon, *Reconstructing Line P*, bringing together 46 participants from seven countries to address gaps in the Line P hydrographic time-series using data-driven imputation. Significant spatiotemporal gaps in the Line P record, combined with seasonal sampling biases, uneven station coverage, and the limited spatial extent of biogeochemical sampling (restricted to five major stations), are typical of hydrographic sampling lines yet limit their full scientific potential. To address this challenge, six interdisciplinary teams applied data-driven methods including quantile mapping, graph neural networks, Fourier neural operators, Gaussian process regression, and transfer learning to reconstruct gap-free monthly-average fields of temperature, salinity, oxygen, dissolved inorganic carbon, and total alkalinity along the transect from 1969 to 2020. These statistical and machine learning methods used fields from high-resolution dynamical models, Global Climate Models, and/or quality controlled observations as inputs, and the resulting models generated skillful results when evaluated against withheld observations. The availability of high-quality inputs with sufficient spatiotemporal resolution was identified as essential for all methods, and reconstructing the early historical record proved the greatest challenge, particularly for biogeochemical variables where both observations and high-resolution model data are sparse. While no single method was identified as superior to the others, the strengths and weakness of each method in an oceanographic context were identified and will be used to guide the development of a peer-reviewed publication and complete imputed dataset, which may serve as a template for reconstructing other long-term hydrographic records.

S13, Oral, AbstractID=19475

An ocean observatory for multidisciplinary studies at Station Papa

Authors: Meghan F. **Cronin**[1], Nathan D. Anderson[1,2], Patrick Berk[1,2], Robert Dziak[3], James Edson[5], Kee Onn Fong[1,2], Catherine Kohlman[4,2], Marie Robert[6], Tetjana Ross[6], Carlos Hernandez Santiago[1,2,7], Yolande Serra[1,2], Adrienne J. Sutton[1,2], Jim Thomson[8], Jie Yang[8], and Dongxiao Zhang[1,2]

[1]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA.
E-mail: Meghan.F.Cronin@noaa.gov
[2]University of Washington Cooperative Institute for Climate, Ocean, and Ecosystem Studies, Seattle, WA, USA
[3]NOAA Pacific Marine Environmental Laboratory, Newport, OR, USA
[4]University of Washington, School of Oceanography, Seattle, WA, USA
[5]Woods Hole Oceanographic Institution's Ocean Observatory Initiative, Woods Hole, MA, USA
[6]Fisheries and Oceans Canada, Institute of Ocean Science, Sidney, BC, CANADA
[7]Bates College, Lewiston, ME, USA
[8]University of Washington Applied Physics Laboratory, Seattle, WA, USA

Station Papa at 50°N, 145°W is one of the oldest ocean observatories in the global oceans. It has provided observations that have grounded ocean mixed layer models used in state-of-the-art general circulation models. Its observations have led to fundamental new understanding of the biological carbon pump, ocean acidification, marine heatwaves, as well as air-sea exchanges associated with the energy cycle, water cycle and carbon cycle. Furthermore, data from passive acoustic sensors deployed at OSP over the last decade have been used to demonstrate 1) the role of wave-generated bubbles in ambient sound, 2) pandemic related reductions in global container-ship traffic significantly reduced ambient sound levels across the north Pacific, and 3) an increased presence of blue whales near OSP during the 2019 marine heat wave potentially due to the increased productivity in the upper ocean there. In this presentation, we will review the current observing network at Station Papa and highlight some of the ongoing studies from the influence of surface wave-generated bubbles on air-sea interactions and ocean acoustics, to the direct measurement of surface fluxes in relation to bulk algorithms.

S13, Oral, AbstractID=19492, (ECOP)

The role of pico-size phytoplankton in the silicon cycle in the Northeast Pacific Ocean

Daniel **Lucyrio**[1], Diana E. Varela[1,2] and Angelica Peña[3]

[1]Department of Biology, University of Victoria, Victoria, BC, Canada. E-mail: lucyrio@uvic.ca
[2]School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada
[3]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada

In the marine pelagic environment, silicon (Si) has traditionally been considered a nutrient primarily associated with diatoms and other silicified plankton. However, it has been recently discovered that picophytoplankton (< 2 µm in size), dominated by cyanobacteria, can utilize Si, suggesting that the ecological role of small phytoplankton in marine Si cycling may have been underestimated. Despite these discoveries, little is known about the magnitude and environmental factors controlling Si use by picoplankton in the oceans, and no studies of Si use by picoplankton have ever been done in the NE Pacific. Here we assess the contribution of different sized phytoplankton (<2 µm, 2-5 µm, 5-20 µm and > 20 µm) to Si cycling in contrasting environments of the NE Pacific. Surface mixed layer Si uptake rates were assessed with the radioisotope ^{32}Si during late summer along the Line P transect in 2025. Other measurements included size fractionated $bSiO_2$ and chlorophyll-a, as well as carbon and nitrogen uptake, phytoplankton taxonomy (microscopy and HPLC), and environmental variables. Silicon was consistently utilized by the <2 µm size-fraction across a gradient of environmental conditions, supporting the hypothesis that Si cycling extends beyond traditionally recognized silicifying organisms such as diatoms. We also explore the relationships between biological and environmental gradients to examine the factors controlling Si use in the NE Pacific. These findings provide new insight into the ecological significance of Si use by very small phytoplankton and contribute to a better understanding of the marine silicon cycle.

S13, Oral, AbstractID=19560

Insights from three decades of zooplankton monitoring along Line P

Akash R. **Sastri**[1,2]

[1]Institute of Ocean Sciences, Sidney, BC, Canada. E-mail: Akash.Sastri@dfo-mpo.gc.ca
[2]Department of Biology, University of Victoria, Victoria, BC, Canada

Zooplankton monitoring has been part of the Station Papa-Line P program since 1956, reflecting the role of zooplankton as sensitive, fast-responding indicators of climate variability, marine ecosystem productivity, and ocean carbon cycling. While early efforts focused on bulk biomass measurements at Ocean Station Papa, the program evolved into a taxonomically resolved time series spanning seven stations from the continental shelf to the offshore Gulf of Alaska. Since 1997, seasonal sampling across this shelf-to-offshore gradient has provided a valuable record of variability in zooplankton biomass and community structure associated with climate forcing and ecosystem change in the northeast Pacific. This presentation reviews the history of the program and highlights key insights from the modern Line P zooplankton time series, including shifts in the timing of peak zooplankton biomass, contrasting patterns of copepod biomass variability in coastal and offshore regions, and the influence of basin-scale climate variability on lower-trophic-level ecosystem dynamics in the northeast Pacific.

BIO PAPER SESSION

Oral Presentations

BIO, Oral, AbstractID=19170

Morphology and phylogeny of *Lepidodinium* spp. (Gymnodiniales, Dinophyceae) from Japanese coastal waters

Yuka **Onishi**[1], Kazuma Nakano[1], Koyo Kuwata[1], Garry A. Benico[2], Kazuya Takahashi[3], Mitsunori Iwataki[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: yukaonishi@g.ecc.u-tokyo.ac.jp
[2]Department of Biological Sciences, College of Science, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines
[3]Institute of Parasitology, Biology Centre, Czech Academy of Sciences, České Budějovice, Czech Republic

The marine unarmored dinoflagellate *Lepidodinium* possesses green plastids of green algal origin, distinct from the peridinin-type plastids common in dinoflagellates. In this study, morphology of two novel strains (KOI328 and Y50) isolated from Japanese coastal water was examined by using LM, SEM and TEM, and their phylogeny was inferred from LSU rDNA sequences. Cells of both strains were ellipsoid with green plastids and a pyrenoid. They were smaller in size compared to known species, with mean lengths of 11.5 ± 1.0 µm (KOI328) and 13.3 ± 1.1 µm (Y50). Nucleus was located in the hypocone in strain KOI328, and in the epicone in strain Y50. For both strains, C-shaped apical structure complex was found by SEM, and a nucleomorph-like structure was found by TEM. In LSU rDNA phylogeny, the two strains formed a robust clade distinct from the clade of two previously described *Lepidodinium* species, *L. chlorophorum* and *L. viride*. Based on their cell sizes and positions of the nucleus, two strains were revealed to represent two undescribed species in the genus *Lepidodinium*.

BIO, Oral, AbstractID=19249, (ECOP)

A population dynamics model incorporating structural and lipid dynamics of copepod *Neocalanus plumchrus* in the subarctic Pacific

Yu-An **Chen** and Hiroaki Saito

Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan.
E-mail: yuan1215@g.ecc.u-tokyo.ac.jp

The biological pump is an essential process for removing carbon from the atmosphere and transporting it to the interior ocean, mitigating the impact of anthropogenic carbon emissions. In the biological pump, zooplankton contribute significantly through vertical migration and production of sinking organic particles. Recent studies have highlighted the significance of carbon export through ontogenetic vertical migration by copepods in high-latitude regions. This process involves accumulating large amounts of lipids in the surface ocean, consuming them for maintenance during dormancy and reproduction in the deep. However, it is difficult to quantify carbon flux through existing observations which mostly capture biomass and physiological processes when copepods are active in the surface layer. To address this gap, we developed a population dynamics model to simulate the life cycle of the dominant copepod species in the subarctic Pacific, *Neocalanus plumchrus*. This model includes eight developmental phases and tracks abundance, structural and lipid carbon weight for each phase, driven by two environmental variables: temperature from the World Ocean Atlas and chlorophyll *a* concentration from NASA's Aqua satellite. The model successfully reproduced long-term copepod population dynamics in three distinct regions (Station A7, K2 and Papa). By applying the model over the North Pacific, it demonstrates regional differences in copepod abundance and carbon export. This research contributes to quantifying the amount of carbon sequestered by dormant copepod species which release carbon through not only respiration but also the mortality of deep-dwelling, stages including C5, adults, eggs, and early nauplii.

BIO, Oral, AbstractID=19263, (ECOP)

Warming enhances protozooplankton top-down controland nutrient competition

Eunbi **Lee** and Yoonja Kang

Chonnam National University, Yeosu, R Korea. E-mail: dldmsqlrjf00@gmail.com

Protozooplankton regulate microbial food webs through top-down control and nutrient cycling, yet their grazing impacst under ocean warming, particularly in subsurface chlorophyll maximum (SCM) layers, remain poorly understood. This study investigated spatial and seasonal variability in protozooplankton grazing in the northern East China Sea, influenced by Tsushima Warm Current (TWC) intrusion and stratification. Thirty in situ dilution experiments were conducted in surface and SCM layers to quantify grazing impacts on dominant diatoms and dinoflagellates across natural temperature gradients. Light limitation was excluded (Zm/Zeu<1), and nutrients were enriched to isolate temperature effects. Grazing impact increased with temperature up to 29°C at the surface and 27°C in the SCM, indicating intensified top-down control even during extreme heat events. Grazing pressure was generally lower on bloom-forming species and in coastal waters, facilitating bloom development. In the SCM layer, elevated grazing rates coincided with high phytoplankton growth under conditions of moderate light availability and nutrient-replete conditions, suggesting rapid turnover and strong trophic interactions. Higher carbon biomass of ciliates and mixotrophic dinoflagellates in the SCM layer also indicated active grazing and nutrient competition with phytoplankton, supported by the lack of significant differences in growth rates between nutrient–enriched and depleted treatments. These findings reveal that warming-driven shifts in protozooplankton grazing and mixotroph-phytoplankton interactions may reshape bloom dynamics and nutrient flows in stratified marine ecosystems. This study highlights the critical role of top-down processes in regulating phytoplankton blooms and provides insights into microbial food web responses under future ocean warming scenarios.

BIO, Oral, AbstractID=19274

Trait variability in zooplankton lipid composition: Implications for energy transfer in Northeast Pacific food webs

Jessica. **Garzke**[1], Akash Sastri[2] and Mary I. O'Connor[1]

[1]University of British Columbia, Vancouver, BC, Canada. E-mail: jessica.garzke@ubc.ca
[2]Fisheries and Oceans Canada, Sidney, BC, Canada

Zooplankton lipid composition is a key functional trait regulating energy transfer to higher trophic levels. Essential fatty acids (e.g., DHA, EPA) are critical for fish growth and development, while lipid classes such as triacylglycerols, wax esters, and phospholipids reflect energy storage strategies and physiological condition. Despite their importance, these biochemical traits remain poorly resolved across taxa and are rarely quantified in marine food web studies.

This study quantifies species-specific variation in lipid traits among dominant zooplankton taxa in the Northeast Pacific using high-resolution lipidomics (comprehensive profiling of lipid molecules), a recently emerging approach in marine ecology. Three key prey taxa, *Euphausia pacifica*, *Calanus marshallae*, and *Neocalanus cristatus,* were analyzed to characterize differences in essential fatty acid content and lipid class composition. Results show pronounced interspecific variability, with DHA and EPA concentrations differing by up to ~2–3-fold among taxa. These differences were structured across lipid classes: DHA was enriched in phospholipids in *E. pacifica* and *C. marshallae*, whereas *N. cristatus* stored a larger proportion of fatty acids in energy-rich triacylglycerols and wax esters. Storage lipid composition varied substantially, with triacylglycerol contributions differing by >50% among species.

These distinct lipid allocation strategies have important implications for prey quality and trophic transfer efficiency. Shifts from large, lipid-rich copepods (*N. cristatus*) to smaller taxa may reduce the availability of essential fatty acids and energy-rich lipids to planktivorous fish, with consequences for growth, survival, and ecosystem productivity.

BIO, Oral, AbstractID=19284, (ECOP)

Quantification of fish bioturbation and predation rates in tidal flats, Yatsushiro Sea, Japan, using UAV imagery and environmental DNA analysis

Risa **Hayashi**[1], Ryutei Inui[2], Ryohei Nakao[3], Yoshihisa Akamatsu[3], Tomoya Yasuda[1], Rikuto Honda[1], Tatsuya Ozaki[1] and Tomohiro Komorita[1]

[1]Prefectural University of Kumamoto, Kumamoto, Japan.
E-mail: g2570010@pu-kumamoto.ac.jp
[2]Fukuoka Institute of Technology, Fukuoka, Japan
[3]Yamaguchi University, Yamaguchi, Japan

Bioturbation by various organisms, including benthic invertebrates, large marine mammals, and fishes, has been recognized as an important process influencing sediment dynamics and ecosystem function. In tidal flats, fish activities often leave conspicuous sediment disturbance traces on the sediment surface. Such traces can be detected from aerial images and used to quantify the spatial extent of fish-induced bioturbation. In the Yatsushiro Sea, predation on commercially important bivalves such as Manila clam (*Ruditapes philippinarum*) by black sea bream *(Acanthopagrus schlegelii*) has been reported, suggesting that fish feeding activities may contribute to bioturbation; however, its seasonal dynamics and the species responsible for these dynamics have not been quantitatively evaluated.

This study aimed to conduct monthly surveys from June 2023 to January 2024 at an intertidal flat off Oshima Island in the Yatsushiro Sea. Fish communities were assessed using environmental DNA (eDNA) analysis, and bioturbation traces extracted from aerial images were used to estimate bioturbation rates by fishes. The bioturbation rate was highest in October ($2.71\pm0.47\times10^{-2}$ m² m⁻² day⁻¹) and lowest in January ($0.875\pm0.596\times10^{-2}$ m² m⁻² day⁻¹). In addition, the mean bioturbation rate from July to October ($2.19\pm0.92\times10^{-2}$ m² m⁻² day⁻¹) was higher than that from November to January ($0.354\pm0.309\times10^{-2}$ m² m⁻² day⁻¹), showing a seasonal pattern consistent with changes in water temperature. eDNA analysis detected seven dominant fish species, among which *A. schlegelii* showed consistent occurrence. These results suggest that *A. schlegelii* likely contributed substantially to the observed bioturbation traces.

To estimate fish predation, a mesh bag experiment was conducted at the same site from April to August 2025. The Manila clam (*Ruditapes philippinarum*), a dominant species and an economically important bivalve in the tidal flat, was selected as the target species. Fish predation was estimated using a one-month mesh bag method. The predation rates were 320 ± 217 inds m⁻² day⁻¹ in May, 260 ± 152 inds m⁻² day⁻¹ in June, and 50.0 ± 57.7 inds m⁻² day⁻¹ in July. This study demonstrates that combining UAV imagery with eDNA analysis enables quantitative evaluation of the seasonal dynamics of fish-induced bioturbation. Furthermore, the results indicate that fish activity traces detected from UAV imagery can be used to estimate fish predation on Manila clam (*R. philippinarum*).

BIO, Oral, AbstractID=19110, (ECOP)

A temperature-driven ecological tradeoff between pathogen replication and inactivation and its impacts on host-pathogen interactions

Sarah **Williamson**[1], Turner DeBlieux[2], Malina Loeher[1,3], Courtney Grady[3], Joe Mihaljevic[2], Paul Hershberger[3], David Páez[3], and Nathan Wolf[1]

[1]Alaska Pacific University, Fisheries, Aquatic Science, and Technology Laboratory, Anchorage, AK, USA. E-mail: smwilliamson@alaskapacific.edu
[2]Northern Arizona University, Mihaljevic Lab, Flagstaff, AZ, USA
[3]US Geological Survey, Western Fisheries Research Center, Marrowstone Marine Field Station, Nordland, WA, USA

Temperature-dependent changes in viral fitness alter virus–host associations. As pathogens respond to warming environments, their geographic ranges may expand beyond historical boundaries, increasing exposures to susceptible hosts. To determine the effects of temperature on kinetics of viral hemorrhagic septicemia virus (VHSV), we conducted *in-vitro* studies to quantify 1) viral replication in *epithelioma papulosum cyrini* (EPC) cells, and 2) virion inactivation in filtered seawater across temperatures (6, 8, 10, 15, and 20 °C). Warmer conditions (15–20 °C) resulted in faster virus replication and inactivation, suggesting a trade-off between increasing replication within hosts and decreasing environmental persistence outside the host. To test whether these temperature effects impacted infectivity, we injected titer-normalized doses of the temperature-treated virus from our inactivation assay into pathogen-free Pacific herring (*Clupea pallasii*). Resulting infection prevalences were similar among the temperature treatment groups, demonstrating that the temperature-mediated viral inactivation appears to only reduce the effective dosage or pathogen density. These findings suggest that, although VHSV is typically considered a cold water–adapted pathogen, it can tolerate warmer temperatures under laboratory conditions. However, this likely reflects the absence of host immune responses and environmental constraints, as warmer temperatures can enhance host immunity and accelerate viral inactivation, together limiting transmission and reinforcing the cold-adapted phenotype.

BIO, Oral, AbstractID=19379, (ECOP)

Species-specific foraging strategies in Pacific salmon revealed by multi-tissue stable isotope analysis

Genyffer C. **Troina**[1], Clarissa R. Teixeira[2], Evgeny Pakhomov[1,3] and Brian P.V. Hunt[1,3]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: g.troina@oceans.ubc.ca
[2]Marine Mammal Institute, Oregon State University, Newport, OR, USA
[3]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada

Understanding individual variation in foraging strategies is central to food web ecology as it shapes species interactions and resource partitioning. This knowledge is needed for ecosystem modelling and management, being particularly important for predicting community resilience to environmental change. Here, we quantified the individual dietary specialization of five Pacific salmon species (*Oncorhynchus* spp.) sampled from the northeast Pacific in late winter (Feb-Apr 2022) during the open-ocean phase of their life cycle. Carbon and nitrogen stable isotopes were measured in tissues with distinct turnover rates (liver and muscle) to quantify individual niche variation relative to population niche. Species differed markedly in trophic niche, spanning broadly generalist populations to those dominated by specialized individuals. Chinook salmon exhibited the strongest individual specialization alongside one of the narrowest population niche widths. In contrast, pink salmon showed spatially structured foraging, with individuals from the same location displaying greater dietary overlap than those sampled farther apart, consistent with flexible, generalist feeding linked to local prey availability. Coho salmon were characterized by high within-individual (65%) relative to between-individual (35%) variability across all models, with no effect of sex or size class. In chum and sockeye salmon, size class significantly influenced between-individual variability, with individuals of similar size exhibiting greater dietary overlap. This highlights the importance of accounting for ontogenetic effects, which can otherwise inflate estimates of between-individual variability. Both speices showed high within-individual variability (Chum = 81%; sockeye = 85%), while chum salmon also displayed the largest population niche width, indicating true generalist foraging behaviour. Overall, our study revealed pronounced ecological differentiation among sympatric, closely related salmon species, facilitating coexistence in the North Pacific open-ocean.

BIO, Oral, AbstractID=19380

Zooplankton community and transport dynamics in the Bering Canyon and Unimak Pass regions of the Bering Sea, Alaska

Colleen E. **Harpold**[1], David Kimmel[1], Carol Ladd[2] and Phyllis Stabeno[2]

[1]Alaska Fisheries Science Center, Seattle, WA, USA. E-mail: colleen.harpold@noaa.gov
[2]Pacific Marine Environmental Laboratory, Seattle, WA, USA

Transport of zooplankton onto the shallow Bering Sea shelf from the deeper, off-shelf basin has been shown to be an important process that provides prey for fish, birds and marine mammals. Basin copepod species tend to be larger and more lipid rich than those originating from the continental shelf, and available evidence suggests basin-origin taxa form an essential part of the prey base. Oceanographic exchange between the basin and the shelf is facilitated through submarine canyons along the Bering Sea slope, providing an advective conduit for zooplankton. Located in the southeast Bering Sea shelf-break, Bering Canyon is thought to be one such conduit; however, seasonal and spatial dynamics of the zooplankton community are not well understood. Whole water column plankton sampling occurred across transects spanning Bering Canyon and the Unimak Pass region in the spring and autumn of 2014 and spring of 2015 to better describe zooplankton species composition, distribution, seasonal patterns and transport. Cluster analyses were used to describe how zooplankton assemblages differed in spring and fall, by year and how they may be influenced by water mass patterns. Key copepod species (*Neocalanus plumchrus*, *N. flemingeri.* and *Calanus marshallae / glacialis*.) were investigated further, as they are important prey for juvenile walleye pollock (*Gadus chalcogrammus*) and other fishes. Results show distinct spring and fall zooplankton communities as well as small scale regional differences. Unimak Pass and Bering Canyon regions clustered differently than the Bering Sea shelf. Of particular note was the unexpected presence of young stages of *N. plumchrus* in autumn of 2014. Zooplankton spatial patterns indicate the influence of several flow patterns in the region, which help resolve mechanisms of transport through Bering Canyon and demonstrate basin-shelf connectivity.

BIO, Oral, AbstractID=19401, (ECOP)

Seasonal variation of *Muggiaea atlantica* (Cnidaria : Siphonophorae) in the coastal water of Sagami Bay, Japan

Atsuhito **Nishikage**, Ryosuke Sakamoto, Shinji Shimode and Yoshiki Takayama

Yokohama National University, Yokohama, Japan. E-mail: nishikage-atsuhito-dp@ynu.jp

Muggiaea atlantica is one of the most abundant siphonophore species in temperate coastal and offshore waters and a major component of planktonic cnidarian communities. To investigate the seasonal variation of *M. atlantica*, monthly surveys were conducted from August 2015 to July 2019 in Sagami Bay. Water temperature, salinity, chlorophyll-a concentration, and M. atlantica abundance were measured. An abundance of potential prey, i.e., calanoid copepods with prosome lengths (PL) of 0.35–0.9 mm, was quantified. *M. atlantica* exhibited a consistent seasonal cycle, with abundance increasing in March–April each year and peaking at 9.8 inds. m^{-3} in March 2017. Abundance declined after the spring peak and remained low or absent during October–February. A significant negative correlation was observed between *M. atlantica* abundance and water temperature. No significant relationship was detected between the abundance of *M. atlantica* and that of the calanoid copepods as potential prey. However, a significant positive correlation was found when the analysis was restricted to CI to CII stages of *Calanus sinicus* within the same PL range. These results suggest that *M. atlantica* abundance is influenced by seasonal changes in water temperature and availability of the specific prey, i.e., CI to CII stages of *C. sinicus.* Our results differed from previous studies, which reported that *M. atlantica* shows no selectivity among calanoid copepod prey species. As the present study only suggested potential predator–prey relationships based on correlation analyses, gut-content analyses and laboratory feeding experiments will be required to identify the prey species utilized by *M. atlantica*.

BIO, Oral, AbstractID=19439, (ECOP)

Larval decapod assemblages of the Northern California Current are modulated by upwelling-driven frontal dynamics

Juan Gerardo **Gutierrez-Bravo**, Rose von Eckartsberg and Lorenzo Ciannelli

CEOAS-Oregon State University, Corvallis, OR, USA. E-mail: gutijuan@oregonstate.edu

We characterize the three-dimensional distribution of larval decapod assemblages from the Northern California Current (NCC) offshore Newport, Oregon, USA, during a period of strong upwelling (May-July 2025). Wind-driven coastal upwelling gradually increased surface salinity, density, and cross-shelf temperature gradients. An upwelling front was apparent 5-10 NM offshore. Three distinct larval decapod assemblages (LDA) were observed across the survey extent: The Inshore (of the upwelling front) LDA was most prevalent in July, characterized by high larval abundances (4.766 larvae m^{-3}) and the highest number of larval forms (44); dominant larvae included *Neotrypaea* spp. and Crangonidae zoeae. The Offshore LDA, present near-surface, and most prevalent in May and June, showed lower larval abundances (0.140 larvae m^{-3}); dominant larvae included brachyurans like *Cancer* spp. Finally, a Subsurface LDA (avg. depth 54 m), also more prevalent in May and June, showcased moderate larval abundances (0.260 larvae m^{-3}) dominated by Hippolytidae, Crangonidae and *Fabia subquadrata*. These results highlight 1) a sharp edge between larval decapod assemblages at the coastal upwelling front, with coastal and estuarine taxa of short pelagic larval duration inshore of the front, and mid-shelf taxa with longer pelagic larval durations offshore of the front, 2) a progressive increase in density and diversity of the coastal assemblage throughout the upwelling season, and 3) a vertical structuring of biological assemblages, especially offshore of the upwelling front. This upwelling-modulated spatiotemporal partition of communities reflects the variability in life history strategies that pelagic spawners display to achieve population persistence in such a highly advective environment.

BIO, Oral, AbstractID=19471

Understanding *Nereocystis luetkeana* gametophyte responses to dynamic stressors

Kate C. **Rolheiser**, Jacob M. Etzkorn, Sarah Manson, Lydia Walton, and Iria Gimenez

Hakai Institute, Quadra Island, BC, Canada. E-mail: kate.rolheiser@hakai.org

Despite strong evidence of kelp species' vulnerability to warming and ocean acidification, knowledge gaps remain regarding climate sensitivities across kelp life-stages. Along the NE Pacific, Bull kelp (*Nereocystis luetkeana*) populations have been declining, primarily attributed to thermal stress on sporophytes. In contrast, experimental evidence suggests certain resiliency to warming on microscopic, gametophyte stages but potential for vulnerability to ocean acidification stress. The interaction of thermal and acidification stress, however, has not been fully explored and evidence to date suggest a complex matrix of additive, synergistic or antagonistic interactions between the two stressors. Nearshore environments exhibit natural, high-frequency temporal variability of both temperature and pCO_2/pH in sub-daily, weekly, and seasonal scales; yet most experimental work relies on constant temperature and/or increased pCO_2, rarely incorporating extreme environmental events like marine heatwaves (MHW). To address the identified gaps in kelp responses to future climate conditions, we focus on two *N. luetkeana* populations near Quadra Island, BC with two temperature and pCO_2 environmental histories. In a series of nested experiments conducted at Hakai Institute's Marna Wet Lab on Quadra Island, we expose gametophytes to MHWs (including recovery time) of varying magnitude and duration and stable versus dynamic pCO_2 treatments in fully-factorial, common-garden experiments. We evaluate growth, survival and reproductive output of the gametophytes. These results will help to elucidate responses of this canopy forming species to changing coastal conditions.

BIO, Oral, AbstractID=19524, (ECOP)

Thermal history reshapes early-life trade offs through mass scaling plasticity in juvenile Dungeness crab

Carl K. H. **Ng**[1,2,3], Iria Gimenez[3], Margot Hessing-Lewis[3,4], Christopher D.G. Harley[2-4] and Alex C. Moore[1,3,5,6]

[1]Department of Forest & Conservation Sciences, University of British Columbia, Vancouver, BC, Canada
[2]Department of Zoology, University of British Columbia, Vancouver, BC, Canada
[3]Hakai Institute, Quadra Island, BC, Canada. E-mail: carl.ng@hakai.org
[4]Institute of the Oceans and Fisheries, University of British Columbia, BC, Canada
[5]Department of Botany, University of British Columbia, Vancouver, BC, Canada
[6]PSEG Institute for Sustainability Studies, Montclair State University, NJ, USA

Climate change is exposing coastal organisms to increasingly frequent and intense thermal stressors, threatening local population persistence and species sustainability even in highly dispersive taxa. Early life stages may be especially susceptible to such climate extremes, creating recruitment bottlenecks that decouple dispersal from successful population replenishment. Phenotypic plasticity provides a major pathway through which organisms may maintain performance under environmental forcing, and is increasingly recognized as important for predicting climate vulnerability and informing adaptive management. Under interacting climate stressors, however, the mechanisms that drive (mal)adaptive plasticity can be difficult to resolve when similar fitness outcomes arise from different underlying pathways. Distinguishing the ecophysiological mechanisms that buffer performance and/or magnify vulnerability is therefore essential, yet their role in mediating early-life fitness across spatial-temporal thermal mosaics remains poorly understood. Here, we use Dungeness crab (*Metacarcinus magister*), a highly dispersive and valuable harvested shellfish resources across the Pacific Northwest, to test how thermal history modifies climate sensitivity and to identify the plastic mechanisms through which press (chronic warming) and pulse (marine heatwave; MHW) stressors jointly alter fitness in juvenile ectotherms.

First-instar juveniles from two Salish Sea populations with contrasting thermal regimes were acclimated to 14°C or 18°C under common-garden conditions, then exposed to a simulated MHW and recovery. Upper lethal limits and oxygen consumption rate was measured across acute assay temperatures, with the metabolic responses partitioned into mass scaling (b) and thermal sensitivity (E) components. These responses were then linked to size outcomes with life history trajectories reconstructed from molt records using a hidden semi-Markov model. Thermal history strongly influenced metabolic plasticity, with population specific response and effect of MHW emerging most clearly on a chronically warmed baseline. Plasticity was driven primarily by compression of b rather than E, indicating that warming altered the relative energetic cost of

accumulating body size more than the acute metabolic cost of warming itself. This shift provides a potential mechanism for the observed life history outcome, whereas warmer conditions accelerated stage progression and increased size-at-age, while reduction in size-at-stage remained comparatively modest. A smaller b may therefore help preserve size-at-stage while buffering the energetic cost of rapid progression through vulnerable early juvenile stages. Upper thermal limits remained comparatively constrained across and within population, suggesting that early juvenile resilience may arise through plastic growth-developmental processes rather than expanded lethal tolerance.

By resolving how thermal history modifies metabolic plasticity and life history trade offs, this study identifies mechanisms that help explain early stage vulnerability in a major harvested coastal species. We demonstrate that even in highly dispersive species, local thermal history can generate divergent plastic responses, underscoring how spatial thermal mosaics and interacting climate stressors jointly shape climate resilience in a warming ocean.

BIO PAPER SESSION

Poster Presentations

BIO, Poster, AbstractID=19129, PosterID: BIO-P2

Comparison of larval growth for bighead beaked sandfish to different prey availability around the Kuroshio Current

Toru **Kobari**[1], Tomoko Kusano[2], Takafumi Azuma[1] and Gen Kume[1]

[1]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan.
E-mail: kobari@fish.kagoshima-u.ac.jp
[2]Graduate School of Agriculture, Forestry and Fisheries, Kagoshima University, Kagoshima, Japan

It has been long thought to be poor prey availability for fish larvae in the Kuroshio due to the low standing stocks of zooplankton under the oligotrophic conditions. Despite a potential risk or disadvantage for their early survival and growth, Kuroshio and its neighboring waters are nursery grounds for crucial life stages of small pelagic fishes including fishery important species. Here, we compare larval growth of bighead beaked sandfish to different prey availability in the Kuroshio based on measurements of conventional and biochemical approaches. Larvae of bighead beaked sandfish widely appeared in the Kuroshio and its neighboring waters where zooplankton standing stocks were different. Higher protein contents, larger body length and older ages were represented for larvae appeared in the Kuroshio path compared with those in inshore of the Kuroshio path. They demonstrated ontogenetic decline of somatic growth represented by mean width of daily otolith increment and metabolic growth shown as protein-specific aminoacyl tRNA synthetase activity. Somatic and metabolic growth indices standardized the ontogenetic decline were comparable between the two regions where prey availability was different. These findings suggest that growth under poor prey availability is achieved for more developed larvae with declined metabolic activity.

BIO, Poster, AbstractID=19163, PosterID: BIO-P3, (ECOP)

Seasonal occurrence variation of *Acartia* species in relation to temperature variation in Suyeong Bay, Korea

Su-Jin **Ju** and Won-Gyu Park

Department of Marine Biology, Pukyong National University, Busan, R Korea.
E-mail: wpark@pknu.ac.kr, jusujin98@gmail.com

Seasonal temperature variation is a key factor influencing zooplankton occurrence and population dynamics in marine ecosystems. We investigated the seasonal occurrence variation of *Acartia* species in relation to temperature change in Suyeong Bay, Busan, Korea. Monthly surveys were conducted at four stations during May–October 2024 and October 2025–May 2026. Water temperature was measured using a CTD. *Acartia* were collected with a conical net (150 μm mesh, 45 cm mouth diameter). Temperature increased from 16.3°C in May to 24.2°C in August 2024 and then decreased to 19.7°C in October. During 2025–2026, it decreased from 20.7°C in October to 11.8°C in January and increased to 18.0°C in May. *Acartia* species showed species-specific occurrence patterns. In 2024, *A. omorii* occurred from spring to early summer, but decreased after August, whereas *A. erythraea* and *A. pacifica* occurred at relatively high abundances during the warm period. In 2025–2026, *A. pacifica* and *A. erythraea* occurred in October, but disappeared with declining temperature. In contrast, *A. omorii* increased after October, became dominant from December, and peaked in March 2026 (785.8 inds. m^{-3}). Although CI–CIV were not species-identified, *Acartia* spp. CI–CIV decreased during the November transition and later increased with high *A. omorii* CV in March, when *A. omorii* dominated. *A. erythraea* and *A. pacifica* were positively related to temperature whereas *A. omorii* was negatively related. These results suggest that seasonal temperature variation is closely associated with species-specific occurrence patterns of *Acartia* in the study area.

BIO, Poster, AbstractID=19202, PosterID: BIO-P4

Effects of water column stratification on summer phytoplankton community structure and dynamics in the East Sea, Korea

Seung Ho **Baek**[1,2], Bora Lee[1], Ji Nam Yoon[1] and Chang Hwan Kim[3]

[1]Ecological Risk Research Department, KIOST (Korea Institute of Ocean Science and Technology), Geoje, R Korea. E-mail: baeksh@kiost.ac.kr
[2]Department of Ocean Science, University of Science and Technology (UST), Daejeon, R Korea
[3]East Sea Research Institute, Korea Institute of Ocean Science and Technology, Uljin, R Korea

We investigated the effects of summer thermal stratification and interannual variations in the East Korea Warm Current (EKWC) on phytoplankton communities and primary productivity in the Ulleung Basin of the East Sea from 2021 to 2024. Our results show that the EKWC acts as a key regulator connecting coastal and offshore waters and facilitating the offshore transport of phytoplankton biomass and productivity. During years with a strong EKWC (2021 and 2023), warm surface waters (26–30°C) moved northward, transporting phytoplankton produced in coastal waters toward offshore regions. In contrast, during years with a weak EKWC (2022 and 2024), coastal phytoplankton tended to remain locally distributed as patches. These patterns were associated with interannual differences in summer wind direction and speed, indicating that EKWC strength and direction strongly influence the offshore transport of coastal primary production. Strong summer stratification limited nutrient supply from deeper layers to the euphotic zone, reducing offshore primary productivity and shaping the vertical distribution of phytoplankton. A subsurface chlorophyll maximum (SCM) developed at depths of 13–47 m, where nutrients were relatively available. Although dominant taxa varied among years, diatoms, including *Chaetoceros* spp. and *Skeletonema* spp., and dinoflagellates, including *Gyrodinium* spp. and *Katodinium glaucum*, generally increased within or near the SCM. Notably, ammonium (NH_4^+) concentrations remained relatively stable (1.75–5.50 μM) in the stratified water column, suggesting active nitrogen recycling associated with the biodegradation of phytoplankton-derived organic matter. This recycled ammonium may have supported the growth of certain dinoflagellates, particularly *K. glaucum*, indicating that ammonium regeneration can continuously influence phytoplankton community structure under stratified conditions. Overall, station-specific differences between years with strong and weak EKWC were clearly distinguishable. As summer stratification intensified, diatoms and dinoflagellates exhibited distinct vertical occurrence patterns, likely reflecting niche separation and different ecological strategies for nutrient utilization. Consequently, even under strongly stratified summer conditions, phytoplankton communities showed clear vertical zonation, which may provide an important food source for higher trophic levels, including zooplankton.

BIO, Poster, AbstractID=19203, PosterID: BIO-P5

Effects of nutrient supply on phytoplankton community dynamics in spring Korean coastal waters: Combined field observations and mesocosm experiments

Ji Nam **Yoon**[1], Young kyun Lim[3], Seongjin Hong[4] and Seung Ho Baek[1,2]

[1]Ecological Risk Research Department, KIOST (Korea Institute of Ocean Science and Technology), Geoje, R Korea. E-mail: jnyoon@kiost.ac.kr
[2]Department of Ocean Science, University of Science and Technology (UST), Daejeon, R Korea
[3]Ocean Climate Response & Ecosystem Research Department, KIOST (Korea Institute of Ocean Science and Technology), Busan, R Korea
[4]Department of Ocean Environmental Sciences, Chungnam National University, Daejeon, R Korea

We investigated the effects of nutrient supply on phytoplankton community dynamics in southern Korean coastal waters during spring 2021 by combining field observations with a 2-week mesocosm experiment. Field surveys were conducted in March and April, and the mesocosm(1000L) experiment was performed using natural seawater control, low-nutrient treatment, and high-nutrient treatment to evaluate phytoplankton responses to different levels of nutrient enrichment. Field observations showed that nutrient concentrations and phytoplankton abundance increased in April compared with March, likely due to enhanced terrestrial runoff after rainfall. Dissolved inorganic nitrogen increased significantly from 6.74 ± 4.02 to 15.18 ± 16.12 μM, and dissolved silicate increased from 5.93 ± 3.97 to 11.95 ± 11.15 μM between March and April (t-test, $p < 0.05$). Total phytoplankton abundance also increased significantly in April ($t = -3.12$, $p < 0.05$). In March, the phytoplankton community was mainly dominated by *Cryptomonas* spp. and *Eucampia zodiacus*, whereas in April, *Cryptomonas* spp. and *Skeletonema* spp. were dominant at stations strongly influenced by riverine inputs. In the mesocosm experiment, nutrient enrichment induced a clear successional pattern in the phytoplankton community. *E. zodiacus* dominated during the early stage, but *Chaetoceros* spp. rapidly increased during the middle stage under nutrient-enriched conditions. The maximum specific growth rate of *Chaetoceros* spp. reached 1.62 ± 0.23 d^{-1} in the low-nutrient treatment and 1.70 ± 0.05 d^{-1} in the high-nutrient treatment, indicating a rapid response to nutrient supply. After nutrient depletion, small diatoms such as *Cylindrotheca closterium* and *Pseudo-nitzschia* spp. became more abundant. Principal component analysis showed that the first two components explained 67.60% of the total variance, and *C. closterium* was negatively associated with nutrient variables, suggesting its adaptability to low-nutrient conditions. Overall, these results demonstrate that rainfall-driven nutrient input and tidal mixing play important roles in regulating phytoplankton community structure and species succession in spring coastal waters. The combined use of field observations and mesocosm experiments provides a useful approach for understanding short-term phytoplankton responses following nutrient loading events.

BIO, Poster, AbstractID=19251, PosterID: BIO-P6

Genetic resources and Deep sea coral biodiversity of seamounts in the Western Pacific

Seonock **Woo** and Sookjin Jang

Korea Institute of Ocean Science and Technology, Busan, R Korea. E-mail: cwoo@kiost.ac.kr

Patterns of genetic connectivity are increasingly considered in the design of marine protected areas (MPAs) in both shallow and deep water. Currently, patterns of genetic connectivity among deep-sea populations throughout West Pacific seamounts are not well understood. Using the mitochondrial *Cytochrome Oxidase I* and *16S rRNA* genes as genetic markers, this study aimed to elucidate patterns of genetic connectivity among populations of two benthic invertebrates with contrasting life history strategies. Populations of the cnidaria, *Bathypathes brook* and the crinoidea, *Thalassometra glacilis* were sampled from continental slope, seamount, and offshore rise habitats on the KC-7, KC-8, KC-9 and KC-4. For the coral, significant population structure was detected among distinct populations on the KC-7, KC-8. Significant genetic differences existed between KC-7 and KC-4. In contrast, no significant population structure was detected across the study area for the crinoid. Patterns of genetic connectivity in *Thalassometra glacilis* are likely influenced by a number of factors including current regimes that operate on varying spatial and temporal scales to produce potential barriers to dispersal. The results of this study are discussed in the context of existing conservation areas that are intended to manage deep-sea benthic communities in the West Pacific region. This study was supported by Marine Biotics project (20210469) and Korea Institute of Marine Science and Technology Promotion (20210646) funded by the Ministry of Oceans and Fisheries.

BIO, Poster, AbstractID=19283, PosterID: BIO-P7

Random forest-based estimation of primary production during *Karenia mikimotoi* red tide using environmental variables

Tomohiro **Komorita**[1], Ryo Sugimoto[2], Saho Kitatsuji[3], Ryoko Yano[3], Kazuo Abe[3], Tatsuya Ozaki[1], Rikuto Honda[1], Yuuka Toya[1], Risa Hayashi[1], Tomoki Tanaka[1], Futaba Nakamura[1], Mutsuo Ichinomiya[1], Katsumasa Yamada[5], Kenji Yoshino[4], Koichi Sugimatsu[3]

[1]Prefectural University of Kumamoto, Kumamoto, Japan.
E-mail: komorita@pu-kumamoto.ac.jp,
[2]Fukui Prefectural University, Fukui, Japan
[3]Japan Fisheries Research and Education Agency, Yokohama, Japan
[4]National Institute for Minamata Disease, Kumamoto, Japan
[5]Kumamoto University, Kumamoto, Japan

The harmful dinoflagellate *Karenia mikimotoi* frequently forms red tides in coastal waters worldwide and causes serious damage to fisheries. Because this species is motile and exhibits diel vertical migration, conventional bottle incubation methods are not suitable for accurately estimating its primary production. In addition, continued growth during advection and spatial expansion of blooms is highly probable. Therefore, a simple and spatially applicable method for estimating primary production is required. This study aimed to develop a predictive model of primary production based on environmental variables (water temperature, salinity, photosynthetically active radiation (PAR), and chlorophyll a concentration (Chl-a)) using field observations from the Yatsushiro Sea where red tides occurred. Furthermore, we applied the model to continuous monitoring data to conduct a nitrogen mass balance analysis and evaluate bloom persistence.

Field surveys were conducted in Minamata Bay from March 2021 to July 2022 and throughout the Yatsushiro Sea in August 2024. A 48-hour continuous observation was carried out in Kusuura Bay Yatsushiro Sea from 5 to 7 August 2024. Water temperature, salinity, Chl-a, and PAR were measured at 1 to 3 hour intervals using an AAQ profiler. Primary production was determined by the ^{13}C method in Minamata Bay (n = 569). In the Yatsushiro Sea survey, primary production estimated by pulse amplitude modulated fluorometry (PAM) was calibrated against the ^{13}C method (n = 3605). During the continuous observation, nutrient concentrations NH_4-N, NO_x-N, PO_4-P, and SiO_2-Si and *Karenia mikimotoi* cell densities were measured from CTD water samples. Regeneration and consumption fluxes of NH_4-N and NO_x-N in both the water column and sediments were experimentally determined and integrated with standing stocks to evaluate daily nitrogen mass balance. A random forest regression model (ranger package R version 4.2.3) was constructed using Chl-a, PAR, water temperature, and salinity as explanatory variables and primary production (μg C L^{-1} h^{-1}) as the response variable.

Primary production measured by PAM showed strong agreement with the ^{13}C method ($n = 12$, $r^2 = 0.853$), allowing correction of PAM based estimates. The random forest model demonstrated high predictive accuracy under both bloom and non-bloom conditions ($r^2 > 0.9$). Chl-a and PAR were identified as the most important variables. During continuous monitoring, a significant positive correlation was observed between Chl a and *Karenia mikimotoi* cell density ($r = 0.573$, $p < 0.0001$), indicating that Chl a served as a proxy for cell abundance during the study period.

Nitrogen mass balance analysis showed that the total standing stock of dissolved inorganic nitrogen DIN (NO_x-N + NH_4-N) was 8.25 mmol N m^{-2}, while nitrogen based primary production was 3.83 mmol N m^{-2} day^{-1}. Dividing DIN standing stock by primary production suggested that bloom growth could become nitrogen limited within approximately 2.7 days. This study established a predictive model capable of quantitatively estimating primary production during red tide events and demonstrated that nitrogen mass balance analysis enables evaluation of bloom persistence. Future work will integrate this primary production model into particle tracking simulations that mimic advection processes to reproduce bloom growth dynamics.

BIO, Poster, AbstractID=19303, PosterID: BIO-P8, (ECOP)

Migratory California gull staging behaviour corresponds with Pacific herring spawn in the Salish Sea

Binyue **Lu**[1], Mark Hipfner[2], Devin R. de Zwaan[2] and Marie Auger-Méthé[1]

[1]University of British Columbia, Vancouver, BC, Canada. E-mail: b.lu@oceans.ubc.ca
[2]Environment and Climate Change Canada, Delta, BC, Canada

Long-distance migration is energetically demanding, and migratory birds often rely on staging areas with abundant, high-quality food resources to refuel during migration. Each spring, migratory California gulls (*Larus californicus*) fly from wintering areas in California to breeding sites in the Canadian prairies, overlapping with Pacific herring (*Clupea pallasii*) spawning events along the Pacific coast. Large quantities of fish and egg biomass are thus available in coastal ecosystems during this time, potentially providing an important seasonal food resource. We examined whether the staging behaviour of California gulls aligns with herring spawning, and whether gull behaviour changes when they overlap with available spawn resources. From 2022-2025, we tracked 20 migratory California gulls using OrniTrack-15 GPS-GSM tags (Ornitela), collecting GPS locations every 30 minutes. We obtained herring spawning time and location data for British Columbia from Fisheries and Oceans Canada. First, we quantified and compared spawn availability during gull residence in the Salish Sea with the average spawn availability in the season. Second, we applied a four-state hidden Markov model to classify gull movement behaviour and assessed whether gulls were more likely to show certain behaviours when overlapping with spawning resources. We found that gulls occurred in the Salish Sea during periods of greater spawn availability than the seasonal average. During periods of overlap with available spawning resources, gull movement characteristics were more consistent with foraging and less consistent with travelling behaviour. These results suggest herring spawn may influence both the timing of stopover and fine-scale behaviours during California gulls' spring migration.

BIO, Poster, AbstractID=19331, PosterID: BIO-P9

Climate change impacts and future management of Manila clam *Ruditapes philippinarum*

Jihong **Zhang** and Yi Liu

Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Qingdao, PR China. E-mail: zhangjh@ysfri.ac.cn

The Manila clam *Ruditapes philippinarum* is the most economically important bivalve in the coastal of eastern Asia, the west coast of North America and the North Atlantic coast, and is one of the most popular bivalves in the world. In recent years, due to the muti-impact of climate change, marine pollution and human activity, the fishery production has experienced significant fluctuations. Global warming will not occur in isolation as it can lead to local oxygen deficiencies and even H_2S increase in the sedimental environment, so these stressors should be considered together. Through on-site investigations, we analyzed physicochemical factors, food availability, and population recruitment in Laizhou Bay, during the summer months when Manila clams are prone to mass mortality, and assessment of the benthic environments by MOM-B. Through controlled experiments, to evaluate the tolerance, behavioral characteristics and tissues damage of the Manila clam to different H_2S concentrations under different temperature conditions, And the combined effects of high temperature and hypoxia on survival, behavioral characteristics, and physiological responses in the Manila clam. These results will help us understand the physiological response strategy of the Manila clam under environmental stress and provide useful information for Manila clam mariculture. We established an individual dynamic energy balance model. By combining the chlorophyll concentration and water temperature data obtained through remote sensing technology with the individual dynamic energy balance model, we studied the changes in the suitable growth areas of Manila clams, providing scientific support for the fishery management of coastal shellfish.

BIO, Poster, AbstractID=19332, PosterID: BIO-P10

Vertical distribution of hydromedusae in the western subtropical Pacific during summer

Minoru **Kitamura**

Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Japan.
E-mail: kitamura@jamstec.go.jp

Hydromedusae are diverse zooplankton that sometimes have great impacts on aquatic ecosystems, but research on them is limited in oceanic area. This study addresses vertical distribution/migration and assemblage structure of oceanic hydromedusae in western part of the North Pacific Subtropical Gyre. Vertically stratified samplings of hydromedusae were carried out through the 0–1000 m water column by using an opening/closing net sampling system, for two summers of 2011 and 2012 at a time-series station S1 (30ºN, 145ºE). Throughout the study, 49 species (46 Siphonophorae, 2 Trachymedusae and a Limnomedusa) were identified and 6 taxa were recognized to genus level. *Abylopsis* spp., *Eudoxoides spiralis*, *Bassia bassensis* and *Diphyes bojani* were numerically abundant, and sum of them occupied 71.1% of the total abundance of hydromedusae. The abundant species except *E. spiralis* were distributed in surface layer, whereas *E. spiralis* showed bimodal distribution whose peaks in abundance were recognized in 0–50 m and 750–1000 m layers. Siphonophores have two phases in their planktonic life cycle: asexual polygastric and sexual monogastric phases, respectively. Vertical distributions of the two phases were generally similar each other for each species. Prominent diel vertical migrations were recognized in polygastric phase of *Eudoxoides mitra*. Detailed descriptions of vertical distribution/migration carried out in the present study will contribute further understanding of hydromedusan ecology.

BIO, Poster, AbstractID=19337, PosterID: BIO-P11, (ECOP)

Behavioural and ecological responses of an intertidal gastropod (*Tegula funebralis*) vary with the number and intensity of subaerial exposures to low temperature

Seojeong **Park**[1], Christopher D. G. Harley[1,2]

[1]Department of Zoology, University of British Columbia, Vancouver, BC, Canada.
E-mail: sjpark@zoology.ubc.ca
[2]Institutions of Ocean and Fisheries, University of British Columbia, Vancouver, BC, Canada

Extreme cold events could cause different low temperature regimes in intertidal systems, changing the air exposure severity to organisms and their ecological interactions during low tide. However, the nature of these relationships, particularly under complex thermal regimes, remain poorly understood. Here we studied the low temperature tolerance of an abundant intertidal snail (*Tegula funebralis*) and how it ecologically responded to single and multiple cold exposures of different intensity. First, we measured supercooling points (SCPs) and lower lethal temperature (LLT_{50}). Next, we tested feeding under different cold intensities and the number of exposure events over nine weeks. Lastly, we simulated a short-term cold snap to investigate predator evasion under different number of exposure events and predator presence. The LLT_{50} for *T. funebralis* was –6.84 °C, which was similar to the SCP (–7.14 °C). In the 9-week experiment, feeding rates and total seaweed consumption were reduced under both extreme and multiple cold exposures. Feeding rates showed suppressed recovery in multiple exposure groups over time. The short-term experiment showed failure of predator evasion under multiple cold exposures. The SCP-LLT50 comparison showed substantial mortality at temperatures overlapping the freezing range, suggesting that *T. funebralis* does not appear to be freeze tolerant. Results from sublethal temperature experiments suggest that fitness of *T. funebralis* could be negatively impacted by cold exposure during low tide, both directly via mortality and indirectly via increased vulnerability to predators. Further, transient cold exposure during low tide had lasting impacts on feeding during subsequent submersion, indicating that cold snaps, particularly when extreme and/or repeated, can have important effects on intertidal trophic dynamics.

BIO, Poster, AbstractID=19342, PosterID: BIO-P12

Monitoring of macrobenthic fouling communities for early detection of non-indigenous species introduced into port environments

Jin-Young Seo, Min-Chul Jang, Kyoungsoon **Shin**

Ballast Water Research Center, Korea Institute of Ocean Science and Technology (KIOST), Geoje, R Korea. E-mail: ksshin@kiost.ac.kr

The introduction pathways of non-indigenous species (NIS) include transportation by vessels, ocean currents, and human activities, among which vessel-mediated transport is recognized as a major pathway for marine biological dispersal. When introduced, organisms establish populations in coastal waters and port environments, causing disturbances to native ecosystems and leading to socio-economic impacts. This study aimed to investigate seasonal recruitment patterns of macrobenthic invertebrates introduced into port environments using artificial settlement plates and to assess the potential introduction of non-indigenous species not previously recorded in Korea through environmental DNA (eDNA)-based metabarcoding. From June 2022 to April 2023, seasonal surveys of fouling organisms were conducted using artificial settlement plates installed near the anchorage area of the research vessel Saebada-ho in Tongyeong, Korea. In addition, next-generation sequencing (NGS)-based metabarcoding analysis was performed to detect the possible introduction of the Asian green mussel (Perna viridis), which the Ministry of Environment of Korea has designated as a species of concern for potential introduction. Species-specific genetic sequences were analyzed to detect P. viridis. The results showed that barnacles were the first organisms to colonize the settlement plates during the summer period and exhibited high dominance throughout all seasons. During autumn, recruitment of bryozoans and the occurrence of colonial tunicates were observed, while attachment of chordate species was detected during winter. In spring, attachment of algae, including bryozoans (*Watersipora subovoidea*) and *Ulva australis,* was confirmed. The analysis of fouling communities around the anchorage area of Saebada-ho revealed that commonly occurring coastal species, including barnacles, bryozoans, and colonial tunicates, were the dominant taxa. No newly introduced species with no previous record of occurrence in Korea were detected. Furthermore, eDNA metabarcoding analysis for Perna viridis did not detect any genetic sequences corresponding to this species. In the future, continuous port-based monitoring systems will be established to facilitate long-term surveillance, and the collected data will be used to develop an early-detection and monitoring framework to improve the management and control of hull-attached organisms.

BIO, Poster, AbstractID=19395, PosterID: BIO-P13, (ECOP)

Mesozooplankton abundance, biomass, and size structure at two seamounts in the Magellan Seamounts, northwestern Pacific assessed by ZooScan imaging: A preliminary comparison (2021,2022,2025)

Yujin **Kim**[1,2], Hyunjin Yoon[1] and Se-jong Ju[1,2]

[1]Korea Institute of Ocean Science and Technology (KIOST), Busan, R Korea.
E-mail: sjju@kiost.ac.kr, ugene@kiost.ac.kr
[2]Department of Ocean Science, University of Science and Technology, Daejeon, R Korea

Seamounts may locally modify oceanographic conditions and zooplankton communities, yet mesozooplankton at northwestern Pacific seamounts remain poorly documented. Here, mesozooplankton communities at two seamounts (KC-2 and KC-8) in the Magellan seamounts, northwestern Pacific were characterized using the ZooScan digital imaging system, enabling rapid quantification of zooplankton abundance, size, and taxonomic composition from preserved net samples. Six vertical net tow samples (0–200 m) collected during 2021, 2022, and 2025 cruises were processed and classified using EcoTaxa. Both seamounts were dominated by Calanoida, followed by Oncaeidae and Oithonidae. Total abundance and dry weight biomass were higher at KC-2 than KC-8 in 2021, whereas this pattern reversed in 2022 and 2025. Size-fractionated biomass analysis and copepod size spectra revealed differences in size structure: KC-2 was characterized by smaller individuals (median ESD = 0.64 mm), while KC-8 exhibited a broader size distribution with larger individuals (median ESD = 0.70 mm). nMDS ordination (stress = 0.012) showed no clear separation between KC-2 and KC-8, with greater variation within each seamount than between them. Surface chlorophyll-a and hydrographic conditions showed no marked differences between seamounts. Because sampling timing differed across years (spring 2021 vs. autumn 2022 and 2025), spatial and interannual effects could not be fully disentangled, and seasonally standardized sampling is needed in future surveys. This study provides baseline information on mesozooplankton communities at northwestern Pacific seamounts and demonstrates that ZooScan-based imaging is an efficient tool for rapid zooplankton assessment in remote oceanic regions.

BIO, QR-Poster, AbstractID=19423, PosterID: BIO-P14, (ECOP)

Influence of ice and wind conditions on spring phytoplankton bloom in the Bering Sea

Aleksandra **Malysheva**[1,2], Kirill Kivva[1] and Aleksandra Sumkina[1]

[1]Russian Federal Research Institute of Fisheries and Oceanography, Moscow, Russia.
E-mail: malysheva@vniro.ru
[2]Department of Oceanology, Faculty of Geography, Lomonosov Moscow State University, Moscow, Russia

Spring phytoplankton bloom (SPB) contributes more than 50 % of annual primary production at high latitudes. SPB timing and intensity may depend on the ice conditions and wind mixing, which is true particularly for the Bering Sea. This study analyzes the impact of wind speed and date of sea ice retreat (DOR) on SPB timing in the Bering Sea and surrounding waters (50–75 °N, 150–210 °E). The phenological characteristics of SPB were calculated using satellite data on chlorophyll-a concentration (Chl-a, mg m^{-3}) from OC CCI database. The initial daily data with spatial resolution of 4 km were regridded onto a polar stereographic grid with a cell size of 25 km. Spatial interpolation was performed using DINEOF with a search radius of 50 km. The SPB onset was determined using a threshold method. The DOR was determined based on daily sea ice concentration from NSIDC CDR (25 km) using a threshold method. Daily mean wind speed cubed (V^3) was used as a proxy of wind mixing (ERA5, 0.25°×0.25°). SPB onset date and DOR had a significant positive correlation (r = 0.5–0.8, $p < 0.05$): the earlier the ice melts, the earlier the SPB begins. We also found a significant difference of V^3 30 days before the bloom onset comparing to 30 days after the onset. We conclude that sea ice retreat plays major role in SPB timing on shelf, and wind mixing largely determines SPB timing in ‘oceanic’ domain of the sea.

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BIO, Poster, AbstractID=19451, PosterID: BIO-P15

Extracellular proteases profile in the subarctic and subtropical North Pacific

Yumiko **Obayashi** and Rikuto Urakubo

Ehime University, Matsuyama, Japan. E-mail: obayashi.yumiko.nn@ehime-u.ac.jp

Heterotrophic prokaryotes play a key role in the degradation of organic matter and the regeneration of nutrients in marine ecosystems. Bio-organic molecules, such as proteins, released into seawater could be a good food for heterotrophic prokaryotes. These polymeric molecules must first be broken down by extracellular hydrolytic enzymes to create smaller molecules that can be taken up by heterotrophic microbes. Proteases are one of the main extracellular hydrolytic enzymes in seawater. Although the subarctic and subtropical regions of the western and eastern North Pacific are known for their distinct nutrient distribution, primary producers and productivity, the characteristics of organic matter processing by heterotrophic microorganisms is not well understood.

We report the activities of extracellular proteases (aminopeptidases and trypsin-type endopeptidases) in surface seawater (0–200 m) in the subarctic and subtropical regions of the western North Pacific in July 2023 and the eastern North Pacific in August–September 2025. At the subarctic stations in both the western and eastern North Pacific, extracellular protease activities were highest in the 0–10 m surface layer and decreased with depth. While, the activity showed subsurface maximum at the subtropical stations. The ratio of trypsin-type endopeptidase activity to aminopeptidase activity (T/A ratio) tended to be higher in the subtropical than in the subarctic region. These differences in the distribution of activities and T/A ratios may indicate different characteristics in the processing of organic matter by heterotrophic microbes in each region. We will discuss the relationship between these extracellular protease profiles and other biogeochemical parameters.

BIO, Poster, AbstractID=19495, PosterID: BIO-P16, (ECOP)

Do methods matter? Evaluating microbiome swab sampling and laboratory workflows for Pacific kelps

Nora **Salland**[1,2], Caroline Chénard[3], Solenn Mordret[3], Colleen Kellogg[1,4], Matthew Lemay[1,5], Evan Morien[1,2], Laura Wegener Parfrey[1,6]

[1]Hakai Institute (Tula Foundation), Heriot Bay, BC, Canada.
E-mail: marinescience@nora-salland.de
[2]Biodiversity Research Center, Department of Botany, University of British Columbia, Vancouver, BC, Canada
[3]National Research Council Canada, Halifax, NS, Canada
[4]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada
[5]Institute for Comparative Genomics, Dalhousie University, Halifax, NS, Canada
[6]Biodiversity Research Center, Department of Zoology, University of British Columbia, Vancouver, BC, Canada

Changing environmental conditions and extreme events, including ocean warming and marine heatwaves, increasingly impact and threaten habitat-forming species like as kelps, the associated communities they support, and the ecosystem services they provide. Climate stressors affect not only kelp growth, development, persistence, and overall health, but also their associated microbial communities, including beneficial symbionts and opportunistic pathogens, potentially influencing host resilience. As the interest in host-associated microbiome research continues to grow, and scientists are faced with numerous methodological choices when designing new studies. However, the extent to which these methodological decisions 'matter' and influence results and biological interpretation remains questionable.

To evaluate the effects of these methodological variations on bacterial communities, we collected surface tissue microbiome samples from two Pacific kelp species (wild *Nereocystis luetkeana* and farmed *Saccharina latissima*) in September 2025 near Saanichton, BC. We compared the results of both species, two swab types, based on three sample preservation methods, tested three DNA extraction kits, and two primer sets for 16S rRNA gene amplicon sequencing to assess their effects on bacterial diversity and community composition.
Our preliminary results show clear differences between the microbial communities of both kelp species, whereas the effects of method combinations are relatively small.

These findings suggest that biological variation among hosts exceeds technical/methodological variations chosen for the sampling design and laboratory workflows. In general, this means that the results of studies using different methods should also be comparable. We think that our results provide practical guidance for marine microbiologists and ecologists designing future studies and monitoring programs, and we think that, within the range of the tested methods, researchers may have a greater methodological flexibility than previously assumed.

BIO, Poster, AbstractID=19510, PosterID: BIO-P17, (ECOP)

Evaluating multiple sources of uncertainty in a global marine ecosystem model from a regional perspective in the Southern Ocean

Denisse **Fierro-Arcos**[1,2,3], Stuart Corney[1,4], Hakase Hayashida[1,5], Petra Heil[4,6], Andrew E. Kiss[7], Amelie Meyer[1,2,3,4] and Julia L. Blanchard[1,3,4]

[1]Institute for Marine and Antarctic Studies, University of Tasmania, Battery Point, TAS, Australia. E-mail: lilian.fierroarcos@utas.edu.au
[2]Australian Research Council Centre of Excellence for the Weather of the 21st Century, University of Tasmania, Hobart, TAS, Australia
[3]Australian Centre for Excellence in Antarctic Science, University of Tasmania, Hobart, TAS, Australia
[4]Australian Antarctic Program Partnership, Battery Point, TAS, Australia
[5]Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Yokohama, Kanagawa, Japan
[6]British Antarctic Survey High Cross, Cambridge, UK
[7]Research School of Earth Sciences, Australian National University, Acton, ACT, Australia

Marine ecosystem models (MEMs) capture physical, biogeochemical, and ecological interactions of marine ecosystems. There are multiple sources of uncertainty influencing the accuracy of MEM outputs. Using the Dynamic Benthic Pelagic Model (DBPM), we investigated the impact of three sources of uncertainty influencing the accuracy of simulated historical fishing catches (1961-2010): (1) coarsening environmental forcings, (2) including a sea-ice mask to limit fishing effort distribution, and (3) using a region-specific, instead of global, fishing effort forcing. We focused on the Southern Ocean (SO), a key player in global climate and biogeochemical cycles that is poorly captured by global MEMs. We found DBPM captured observed spatial catch patterns in the SO with minimal differences across resolutions, suggesting that coarsening inputs from an eddy-permitting ocean model effectively improves MEM performance without increasing computational demands. Both resolutions overestimated catches to a similar degree, likely driven by an unrealistic spatial distribution of fishing effort in the model. Including a sea-ice mask reduced catch overestimation across most of the SO. DBPM closely replicated temporal catch trends prior to the 1990s, but subsequent overestimations suggest fishing effort forcing data are driving these differences and remain a major source of uncertainty hindering global MEM skill improvement efforts. Improvement of simulated fishing catch accuracy is not only a function of higher-resolution inputs, but also better-quality fishing effort data, and a more realistic representation of regional ecosystem and fishing dynamics. These findings although focused on the SO are expected to be transferable to other regions, supporting broader MEM skill improvement.

BIO, Poster, AbstractID=19566, PosterID: BIO-P18, (ECOP)

Global biogeography of multidimensional marine biodiversity hotspots

Yulia **Egorova**[1], Elka Garcia-Rada[1], Juliette Casemajor[1], Kristina Boerder[2], Kristin Kaschner[3], Julia G. Mason[4], Elizabeth P. Pike[5], Kathleen Kesner-Reyes[6], Nicolas Bailly[6,7], William W. L. Cheung[7], Derek P. Tittensor[2], Gabriel Reygondeau[1,7].

[1]Rosenstiel School of Marine, Atmospheric, and Earth Science, University of Miami; Miami, FL, USA. E-mail: egorova.uu@gmail.com
[2]Department of Biology, Dalhousie University; Halifax, NS, Canada
[3]Department of Biometry and Environmental Systems Analysis, Albert-Ludwigs University; Freiburg im Breisgau, Germany
[4]Environmental Defense Fund; New York, NY, USA
[5]Marine Conservation Institute; Glen Ellen, CA, USA
[6]Quantitative Aquatics, Inc.; Los Baños, Laguna, Philippines.
[7]Institute for the Oceans and Fisheries, University of British Columbia; Vancouver, BC, Canada

Efforts to curb marine biodiversity loss have gained momentum through global agreements extending protections across national waters and the High Seas. However, it remains unclear how to capture the multidimensionality of "biodiversity" and prioritize conservation accordingly. Using AquaMaps 2.0 species distribution models for 31,426 marine taxa, hotspots defined from the upper five percent of species richness, range-size rarity and phylogenetic distinctiveness identify largely complementary conservation priorities rather than one shared geography. These hotspots span benthic/demersal and pelagic assemblages in EEZs and the High Seas, forming a continuum from shallow coastal habitats to deep-sea systems. Overlays with cumulative human impact and marine protected areas show uneven exposure and protection, establishing a management-ready framework for locating and protecting irreplaceable concentrations of marine life.

FIS PAPER SESSION

Oral Presentations

FIS, Oral, AbstractID=19169

Asymmetric vulnerability of marine fish to intensifying Ocean thermal extremes

Eun-Byeol Cho, Sharif Jahfer, and Eun Young **Kwon**

IBS Center for Climate Physics, Pusan National University, Busan, R Korea.
E-mail: ekwon957@gmail.com

Marine fish are increasingly exposed to both gradual ocean warming and changes in temperature variability. While many mobile species may adapt or acclimate to long-term warming trends, they remain vulnerable to acute temperature extremes, which can induce range shifts, physiological and behavioral disruptions, reproductive failure, and mortality. In this study, we combine present-day ocean temperature extremes with a global compilation of fish thermal tolerance data to assess species-specific and life-stage-specific vulnerability to both marine heatwaves and marine cold spells within marine protected areas (MPAs) worldwide. Our analyses reveal that approximately 20% of marine fish species already experience thermally unsuitable conditions within at least one of their reproductive MPA habitats. Vulnerability differs markedly across life stages: early life stages are disproportionately susceptible to warm extremes, whereas adults are more vulnerable to cold extremes. In some regions, exposure to thermally unsuitable conditions affects up to 58% of resident species. These highly asymmetric ecological responses contrast with the largely symmetric intensification of warm and cold extremes projected across extensive regions of the global ocean, including major oceanic frontal zones and regions influenced by the El Niño–Southern Oscillation (ENSO). Our findings identify intensifying thermal extremes as an underappreciated and emerging threat to the effectiveness of marine protected areas. They also highlight the need to extend such assessments beyond fish to encompass the broader marine ecosystem, including marine mammals, invertebrates, and microorganisms, to achieve a more comprehensive understanding of future ecosystem resilience and health.

FIS, Oral, AbstractID=19210

Evaluating global and regional marine ecosystem model responses to historical climate and fishing drivers

Kelly **Ortega-Cisneros**[1], Denisse Fierro-Arcos[2], Camilla Novaglio[3], FishMIP regional modelling team and Julia Blanchard[2,4]

[1]Marine and Antartic Research for Innovation and Sustainability, Department of Biological Sciences, University of Cape Town, Cape Town, South Africa.
E-mail: kelly.ortegacisneros@uct.ac.za
[2]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS, Australia
[3]Leibniz Center for Tropical Marine Research, Bremen, Germany
[4]Centre for Marine Socioecology, University of Tasmania, Hobart, TAS, Australia

As the need for more robust climate impact assessments of marine ecosystems grows, understanding how different marine ecosystem models respond to standardised drivers is key to revealing structural differences that influence projections. The Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP) uses ensembles of global and regional marine ecosystem models (MEMs) to project climate impacts on fisheries and marine ecosystems at both global and regional scales. Previous comparisons of global and regional MEMs have revealed that global models tend to project more pronounced biomass declines under future emission scenarios. The sources of this divergence need to be better understood. Here, we apply the ISIMIP and FishMIP 3a simulation protocols, to compare four global MEMs (BOATS, DBEM, EcoOcean, FEISTY), extracted to eight regional domains, with one regional MEM per domain (either Atlantis, Ecopath with Ecosim, Mizer or OSMOSE) forced with standardised climate inputs from GFDL-MOM6-COBALT2 and historical fishing effort data over the period 1961 to 2010.

Regional domains include four Pacific regions (Hawaii, Cook Strait, Chatham Rise, Tasman and Golden Bays) alongside the Baltic Sea, North Sea, southern Benguela, and Prydz Bay. Using simulations with and without fishing to disentangle climate and fishing effects, we examine patterns of agreement and divergence in model responses across ecosystems and discuss the implications for ensemble-based assessments of marine ecosystem change.

FIS, Oral, AbstractID=19293, (ECOP)

Individual-based modeling of early marine growth and survival in a changing ocean

Kelly **Vasbinder**[1], Jerome Fiechter[1], Jarrod Santora[1,2], Nate Mantua[2], David Huff[4], and Brian Wells[2,3]

[1]University of California Santa Cruz, CA, USA. E-mail: kvasbind@ucsc.edu
[2]SWFSC Fisheries Ecology Division, NOAA, Santa Cruz, CA, USA
[3]NWFSC Fish Ecology Division, NOAA, Newport, OR, USA
[4]NWFSC Estuary and Ocean Ecology, NOAA, Corvallis, OR, USA

Survival of juvenile fall-run Chinook salmon depends partially on the time from ocean entry to the end of their first year at sea. We use an ecosystem modeling framework to explore juvenile salmon early marine survival rates and to test freshwater rearing management strategies aimed at improving them. Our ecosystem modeling framework uses a regional ocean circulation model (ROMS) and Nutrient-Phytoplankton-Zooplankton model to drive an Individual-Based Model (IBM) for juvenile Chinook salmon tracking their growth, movement, and predation mortality. The IBM predicts juvenile salmon early marine survival in response to predation by a central-place gape-limited seabird population by combining the impacts of salmon size and the probability of salmon-seabird interactions. We use a hindcast to evaluate model performance against observed marine survival rates for 1998-2020. We also use this modeling system to evaluate freshwater rearing management strategies related to the size and timing of juvenile salmon ocean entry. Our findings indicate that timing and size at ocean entry impact predation experienced by juvenile salmon during their first few months at sea, especially during years when the environment is less favorable to growth. This project integrates multiple models from academic and federal partners and involves collaborations between multiple project teams including rockfish and forage fish specialists, physical oceanographers, salmon ecologists, and seabird experts.

FIS, Oral, AbstractID=19319, (ECOP)

Environmental and spatiotemporal influences on winter ichthyoplankton assemblages of the northern California Current

William R. **McCloskey**[1], Luke A. Bobay[1,2], Nicholas F. Howard[2], Robert K. Cowen[2] and Su Sponaugle[1,2]

[1]Department of Integrative Biology, Oregon State University, Corvallis, OR, USA.
E-mail: mccloskw@oregonstate.edu
[2]Hatfield Marine Science Center, Newport, OR, USA

Winter ichthyoplankton abundance in the northern California Current is a strong predictor of annual recruitment of important fisheries species such as salmon, as juvenile salmon diet at ocean entry is dominated by winter-spawned early juvenile fishes. Yet little is known about the influences of spatiotemporal and environmental factors on the composition of these ichthyoplankton assemblages. To characterize winter ichthyoplankton assemblages and identify the factors that influence their composition, we collected depth-discrete ichthyoplankton samples from across the northern California Current ecosystem (41–47°N) on four two-week research cruises during winter 2018–2023. Temperature, salinity, dissolved oxygen concentration (DO), and fluorescence were measured simultaneously with the ichthyoplankton. Ichthyoplankton were visually identified to the lowest possible taxonomic resolution, and dominant ichthyoplankton assemblages were identified using hierarchical clustering analysis and non-metric multidimensional scaling ordination. Distance-based redundancy analysis was used to estimate the effects of longitude, latitude, year, time of day, sampling depth, seafloor depth, temperature, salinity, DO, and fluorescence on assemblage composition. Finally, generalized linear regression was used to quantify diel differences in the vertical distributions of ichthyoplankton taxa. Dominant ichthyoplankton assemblages included those characterized primarily by *Sebastes* spp., *Parophrys vetulus*, mesopelagics, and Osmeridae. Spatiotemporal and environmental conditions accounted for a significant amount of variation in ichthyoplankton assemblage composition. Vertical distributions of several taxa differed significantly between night and day. Understanding these spatiotemporal and environmental influences on winter ichthyoplankton assemblages will help explain variation and potentially predict the abundance of winter-spawning fishes and subsequent recruitment of fisheries species that prey on them.

FIS, Oral, AbstractID=19360, (ECOP)

Do closures work? Evaluating a gillnet fishery closure with ecological and economic evidence

Lindsay **Begemann**

Simon Fraser University, Burnaby, BC, Canada. E-mail: lindsay_begemann@sfu.ca

Spatial and temporal fishery closures are increasingly used as precautionary tools to protect vulnerable fish populations and habitats. While relatively straightforward to implement, closures are blunt instruments that generate significant socio-economic and cultural trade-offs. Despite their widespread use, rigorous evaluation of closure outcomes remains limited, leaving uncertainty about whether conservation objectives are met and under what conditions closures should be adjusted or lifted. This research assesses indicators of effectiveness for the commercial chum gillnet fishery closure on British Columbia's Central Coast (Pacific Fisheries Management Area, "Area" 8). Following declines in salmon returns, longer-term commercial salmon fishery closures were implemented under the Pacific Salmon Strategy Initiative, including a full commercial closure in Area 8 beginning in 2021. The study combines: (1) empirical bycatch-impact analysis using gillnet scar frequency on Koeye sockeye as a proxy for fishery interaction, alongside qualitative estimates of gillnet scars on steelhead in the Dean River; (2) hierarchical models testing associations between, fishing effort, least cost distance from fishing grounds, and population-specific temporal trends for 25 Central Coast chum and sockeye populations, testing associations between fishing effort, least-cost distance from fishing grounds, and population-specific temporal trends; and (3) historical estimation of fishery revenues, costs, and profits. This work demonstrates how ecological and economic evidence can be used data-limited systems to evaluate closure outcomes and inform more adaptive, evidence-based collaborative management strategies.

FIS, Oral, AbstractID=19373

Supplementing Pacific halibut age determination with deep learning: Covariate integration and uncertainty-guided fine-tuning

Barbara **Hutniczak**

International Pacific Halibut Commission, Seattle, USA. E-mail: barbara.hutniczak@iphc.int

Manual fish age determination from otoliths is accurate but costly, slow, and subject to between- and within-reader variability. The IPHC is developing a convolutional neural network (CNN) to estimate Pacific halibut age from images of break-and-bake otoliths, using transfer learning from a pretrained InceptionV3 backbone adapted for regression. The selected model configuration utilized 11,107 otolith images from the 2019 IPHC fishery-independent setline survey (FISS), with per-sample weighting by number of independent reads and integration of capture covariates (latitude, longitude, day-of-year) through a multi-input architecture. A five-member deep ensemble provided averaged predictions and per-sample uncertainty.

On a held-out test set (n=2,000), the ensemble achieved RMSE 1.68 years, with 35.5% exact and 76.5% within ±1 year of expert ages. Performance degraded under temporal transfer. On a held-out set of 2024 otolith images, RMSE rose to 2.27, an approximate 35% increase over the 2019 test set. Fine-tuning addressed this generalization gap. Adapting the ensemble on a random 20% of new-year otoliths raised within-±1-year accuracy from 59.6% to 66.1%; selecting the 20% with highest ensemble uncertainty for fine-tuning was markedly more effective (RMSE 1.97; 70.0% within ±1 year). These results support a semi-automated workflow routing high-uncertainty otoliths to expert readers for annual, uncertainty-guided fine-tuning, with the potential to improve throughput while controlling the systematic bias critical for stock assessment. Ongoing evaluation of alternative model architectures and training configurations shows further promise.

FIS, Oral, AbstractID=19376

Evaluating the impacts of toxic algae *Alexandrium tamarense* and *Heterosigma akashiwo* on juvenile salmon

Svetlana **Esenkulova**[1,2], Arash Akbarzadeh[3], Andrew Ross[3], Mackenzie Mueller[3], Emiliano Di Cicco[1], and William Bugg[1,4]

[1]Pacific Salmon Foundation, Vancouver, BC, Canada
[2]Island Marine Aquatic Working Group (IMAWG), Nanaimo, BC, Canada.
E-mail: Svetlana@imawg.ca
[3]Fisheries and Oceans Canada, Sidney, BC, Canada
[4]University of British Columbia, Vancouver, BC, Canada

Harmful algal blooms (HABs) are important environmental stressors in coastal ecosystems, with potential implications for fisheries, marine food webs, and aquaculture. Blooms of the harmful algae *Heterosigma akashiwo* and *Alexandrium* spp. are widely distributed in coastal marine ecosystems and have been associated with fish mortality events, yet the mechanisms underlying their effects remain poorly understood. To evaluate short-term physiological and health responses, juvenile Chinook salmon were exposed for 24 hours to *H. akashiwo* and *A. tamarense* under controlled laboratory conditions.

Findings indicate species-specific responses to harmful algal exposure. Behavioural observations suggested reduced activity in fish exposed to *Heterosigma*. Microbial community analyses (based on 16S nanopore sequencing) revealed distinct treatment-specific bacterial assemblages associated with each algal exposure. Toxin analyses indicated no detectable saxitoxin accumulation in gill or liver tissues, while water and filter samples were dominated by decarbamoyl-saxitoxin (dcSTX). Particulate toxin fractions remained relatively stable over time, whereas the dissolved fractions shifted slightly. Histopathological examination indicated higher frequencies of epithelial lifting, inflammation, and epithelial damage in both algal treatments relative to controls. Preliminary transcriptomic analyses of *A. tamarense*-exposed salmon further suggest broad alterations in gene expression associated with mechanosensory and mucosal barrier functions. Ongoing analyses will refine these findings and improve understanding of the pathways through which harmful algae influence salmon health. Final results will be presented in the context of juvenile salmon responses to HAB exposure in a changing coastal ocean.

FIS, Oral, AbstractID=19408

Integrating environmental and socioeconomic drivers for predicting fishery-dependent CPUE of largehead hairtail (*Trichiurus japonicus*) in Korean waters

Dongwha **Sohn**[1], Hee Seok Jung[2], Jihyeon Kim[1], Hwan Sung Ji[3], Sukyung Kang[3], Chan Joo Jang[2], and Sangil Kim[1]

[1]Pusan National University, Busan, R Korea. E-mail: sohndongwha@pusan.ac.kr
[2]Korea Institute of Ocean Science and Technology, Busan, R Korea
[3]National Institute of Fisheries Science, Busan, R Korea

Reliable prediction and interpretation of catch-per-unit-effort (CPUE) are fundamental to sustainable fisheries management. Although CPUE is widely used as an index of relative stock abundance, fishery-dependent data reflect not only fish abundance but also fishing behavior, fishing-ground accessibility, operating costs, and environmental variability, making ecological interpretation challenging. This study develops a monthly grid-based spatio-temporal framework for predicting CPUE of largehead hairtail (*Trichiurus japonicus*) in Korean waters by integrating environmental variables and socioeconomic proxies. The analysis was based on monthly 50 km × 50 km grid records of observed hairtail catches collected from 2010 to 2020. A Long Short-Term Memory (LSTM) model was developed to capture temporal dependencies in monthly CPUE while integrating oceanographic variables (e.g., sea surface temperature, chlorophyll-a, sea surface height, and mixed layer depth) with socioeconomic variables, including fuel prices and distance from landing ports. The model was trained using sequential observations from 2010–2018 and independently evaluated using observations from 2019–2020 to assess its predictive performance for unseen years. Model performance was compared between an environmental-only model and an integrated model incorporating both environmental and socioeconomic variables to evaluate the contribution of human-related factors to CPUE prediction. The integrated model consistently improved predictive performance, particularly during periods of high environmental variability, demonstrating that socioeconomic constraints play an important role in shaping observed CPUE patterns. By integrating environmental and human dimensions within a unified spatio-temporal framework, this study provides a practical approach for improving the interpretation of fishery-dependent CPUE and supports ecosystem-based fisheries management through a better understanding of the interacting biological, environmental, and socioeconomic drivers influencing fisheries resources.

FIS, Oral, AbstractID=19448, (ECOP)

Predators as samplers to develop indicators of prey availability

Peri **Gerson**[1], Cheryl Barnes[1], Jessica Miller[1], Jodi Pirtle[2], Jonathan Reum[3] and James Thorson[3]

[1]Coastal Oregon Marine Experiment Station, Oregon State University, Newport, OR, USA. E-mail: peri.gerson@oregonstate.edu
[2]Alaska Regional Office, National Oceanic and Atmospheric Administration (NOAA), Juneau, AK, USA
[3]Alaska Fisheries Science Center, NOAA, Seattle, WA, USA

Fishery surveys provide valuable information for target species, but we often lack regionwide data to analyze broad-scale trends of lower- and mid-trophic level prey. In the Gulf of Alaska (GOA), stomach samples are collected from a long-term, spatially expansive survey, presenting a unique opportunity to assess data-limited prey. We compared a suite of correlative models to better understand the balance between model complexity and performance when using diet data to estimate the spatiotemporal dynamics of key prey. We modeled the distributions and relative habitat importance of krill (euphausiids), shrimps (Caridea), and forage fishes (Osmeridae, Ammodytidae, Clupeidae, and *Gadus chalcogrammus*) using diet data from arrowtooth flounder (*Atheresthes stomias*), Pacific cod (*Gadus macrocephalus*), and walleye pollock (*Gadus chalcogrammus*). We developed four model structures: 1) single species distribution models (SSDMs) that separately modeled each unique predator-prey combination, 2) joint species distribution models (JSDMs) that separately modeled each prey group using information from several predator species, 3) JSDMs that modeled several prey groups for one predator species at a time, and 4) a JSDM that modeled several prey groups using information from several predator species. We found that SSDMs generally outperformed more complex model formulations during cross-validation. SSDM predictions show recurrent hotspots of krill around Kodiak Island, shrimps in the central GOA, and forage fishes in the mouth of Cook Inlet. Our estimates of prey inform essential fish habitat (EFH) by identifying foraging habitat and conditions for target species and facilitate ecosystem-based fishery management approaches through the creation of ecological covariates.

FIS, Oral, AbstractID=19465, (ECOP)

The role of hatchery origin in early marine residence and survival of Interior Columbia River spring and summer Chinook salmon (*Oncorhynchus tshawytscha*)

Rebecca M. **Forney**[1], Amy A. Wallace[2], Brian J. Burke[3], Cheryl A. Morgan[2] and Jessica A. Miller[1]

[1]Department of Fisheries, Wildlife, and Conservation Sciences, Coastal Oregon Marine Experiment Station, Oregon State University, Newport, OR, USA.
E-mail: forneyr@oregonstate.edu
[2]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, OR, USA
[3]Fish Ecology Division, Northwest Fisheries Science Center National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA

Survival rates for Interior Columbia River spring and summer (ICRSS) Chinook salmon population remain persistently below management targets. Additionally, hatchery fish dominate this population with >90% of yearling migrants originating in a hatchery. For ICRSS hatcheries, marine survival often fluctuates as much within a single year as it does across years. While interannual variation in ocean survival of yearling Chinook salmon has been related to size and timing of ocean entry and marine growth, there is much less information on intra-annual variation in early marine residence. Across eight years, we used genetic parentage-based tagging (PBT) to compare intra-annual variation in survival at nine ICRSS hatcheries. We determined that, after accounting for interannual variability, hatchery of origin explained more of the variation in marine survival than body length or condition at capture, hatchery distance from the ocean, or the number dams passed during migration. We observed similar phenotypic differences in early marine residence traits and variation in marine survival across hatcheries, suggesting that hatchery output remains uniform annually despite shifting ocean conditions. This consistency points to potential carry-over effects associated with hatchery-specific practices. Given that the majority of ICRSS Chinook salmon are hatchery raised, understanding how origin influences survival is critical for the management and recovery of these vulnerable populations.

FIS, Oral, AbstractID=19528, (ECOP)

Minimizing male harvest stabilizes fishery dynamics for a protandrous sequential marine hermaphrodite

Emma M. **Atkinson**[1], Micah Brush[2] and Mark A. Lewis[2,3]

[1]University of Alberta, Department of Biological Sciences, Edmonton, AB, Canada.
E-mail: ematkinson@ualberta.ca
[2]University of Victoria, Department of Mathematics and Statistics, Victoria, BC, Canada
[3]University of Victoria, Department of Biology, Victoria, BC, Canada

Marine invertebrates increasingly underpin commercial fisheries in Pacific Canada, making it critical to understand how management interacts with their unique population biology. The spot prawn (*Pandalus platyceros*) trap fishery in British Columbia has a dynamic history of rising fishing pressure and expanding technology, alongside persistent uncertainty in spot prawn population biology. Spot prawns are protandrous sequential hermaphrodites, transitioning from male to female partway through life. Motivated by observations from the fishing grounds, we investigated whether harvesting males (next year's female spawners) drives variability in annual fishery length at local scales and evaluated the consequences of foregoing male retention in the commercial fishery. We developed a stage-structured population model to simulate (1) whether status quo management generates the hypothesized variability in fishery length dynamics, and (2) how excluding males from harvest affects fishery length and catch. We also analyzed commercial fishery length data to test for the predicted oscillating pattern. Subarea-level fishery length data showed high annual variability, consistent with the prediction that current male harvest creates a feedback loop affecting fishery length. Simulations confirmed that status quo management can drive oscillating dynamics in fishery length. Foregoing male harvest produced, on average, a longer and less variable fishery, though this gain in stability came with a catch trade-off whose magnitude depended on survival rates. Proactively managing male harvest may offer one approach to stabilizing fishery length while balancing economic and ecological trade-offs.

FIS, Oral, AbstractID=19531

Pacific Salmon catch and forecast in Alaska and Eastern Kamchatka (2019–2025)

Albina N. **Kanzeparova**[1], Alexey A. Somov[2]

[1]Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Moscow, Russia. E-mail: kanzeparova@vniro.ru
[2]Pacific Branch of VNIRO (TINRO), Vladivostok, Russia

Alaska (AK) and Eastern Kamchatka (EK) are key regions of Pacific Salmon reproduction. These regions are linked through the Bering Sea, where Asian and north American stocks of salmon feed and growth together. The share of Alaska in the total US catch averaged 92 %, while Eastern Kamchatka comprises 26 % of total Russian catch. The scope of the study is to compare projected and actual catch as well as to assess forecast precision of five salmon species from AK and EK during 2019–2025. AK catch increased from 60 thousand tons in early 1970-th to 500 thousand tons by the 2020s, however in 2024 the catch dropped to 212 thousand tons reaching minimal level 1970-th. In the EK, the catch increased from 7 was thousand tons in 1970-th to 257 thousand tons by the 2020s. A comparison of projections and actual catch for 2019-2025 showed for pink salmon in the EK catch was always higher than projections in odd years (catch-to-forecast ratio was 126 %) and vice-versa in even years (catch-to-forecast ratio was 47 %). In AK catch-to-forecast ratio was high in odd and even years and amounted to 106 and 82%, respectively. Projections for sockeye were the most precise among all species in both regions: catch-to-forecast ratio was 101% in EK and 108% in AK. In contrast, the actual catch of chum, coho and Chinook were systematically lower that forecast in both regions. The average catch-to-forecast ratio for these species was around 70 to 80 % with the lowest value for Alaskan coho – 58 %.

FIS PAPER SESSION

Poster Presentations

FIS, Poster, AbstractID=19230, PosterID: FIS-P1, (ECOP)

Reproductive ecology of skinnycheek lanternfish *Benthosema pterotum* in Kagoshima Bay, southern Japan

Shunta **Omura**[1], Atsuto Uchida[1], Toru Kobari[2], Hiroki Yasuma[3], Masafumi Kodama[2] and Gen Kume[2]

[1]Graduate School of Agriculture, Forest and Fisheries, Kagoshima University, Kagoshima, Japan. E-mail: syunta0810@outlook.jp
[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan
[3]Faculty of Fisheries, Hokkaido University, Hokkaido, Japan

The skinnycheek lanternfish *Benthosema pterotum* is a dominant mesopelagic fish species in Kagoshima Bay, southern Japan, and is considered to play an important role in linking zooplankton production to higher trophic predators in this semi-enclosed bay ecosystem. However, ecological information on this species remains extremely limited. Therefore, this study aimed to clarify the reproductive ecology of *B. pterotum* using specimens (n = 236) collected from Kagoshima Bay between July 2023 and May 2026. In the laboratory, standard length, body weight, and gonad weight were measured. The gonadosomatic Index (GSI) was calculated. The ovaries were embedded in paraffin, sectioned, stained with hematoxylin and eosin, and examined histologically to determine oocyte developmental stages and the presence of postovulatory follicles (POFs). Based on the GSI and histological observation of ovaries, *B. pterotum* spawned throughout the year. The proportion of mature females was high from May to October, and GSI peaked especially in August and September. The POFs were observed only in individuals collected from the surface layer at 23:00, suggesting that *B. pterotum* in Kagoshima Bay would migrate vertically at night and spawn near the surface layer. The minimum size at maturity was 28.0 mm, which was similar to those reported in other regions. The oocytes at different developmental stages were simultaneously observed within the ovaries, indicating that this species is likely a multiple spawner.

FIS, Poster, AbstractID=19245, PosterID: FIS-P2, (ECOP)

Pathogen prevalence in WCVI smolt/post-smolt Chinook

Claudia **Lomax**[1], Sadie Ralph[1], Danielle Naumann[2], Keaton McCallum[3] and Jaime Grimm[1]

[1]University of Victoria, Victoria, BC, Canada. E-mail: claudiatersigni@uvic.ca
[2]Nuu-chah-nulth Tribal Council, Port Alberni, BC, Canada
[3]Ha'oom Fisheries Society, Tofino, BC, Canada

Chinook salmon are an ecologically and culturally important species for First Nations on the west coast of Vancouver Island (WCVI), yet many wild populations continue to experience declines in abundance and marine survival. WCVI Chinook are ocean-type salmon that migrate from freshwater to the marine environment within weeks of emergence and spend their first year at sea in nearshore habitats. This early marine period is considered a critical life stage in the salmon life cycle, as juvenile fish must adapt to rapidly changing environmental conditions while facing a range of biological and ecological stressors. Recent research has highlighted the potential role of pathogens and parasites in influencing salmon health and survival. However, important knowledge gaps remain regarding pathogen prevalence in juvenile Chinook salmon and how pathogen exposure varies seasonally. In Nootka Sound, Fisheries and Oceans Canada's "*Follow the Fish*" project generated valuable information on winter fish health and marine survival, but limited data are available for summer months.

In partnership with Mowachaht/Muchalaht First Nation, Ha'oom Fisheries Society, and the University of Victoria, this project aims to address this knowledge gap by investigating pathogen prevalence and host gene expression in juvenile Chinook salmon during summer and winter periods in Nootka Sound. Sampling builds upon existing monitoring efforts and includes specimens collected from May 2024 through 2026, providing seasonal coverage of early marine migration.

Laboratory analyses are currently underway. This presentation will provide an overview of the collaborative research framework, study design, sampling program, and project progress. While pathogen screening and gene expression analyses have not yet been completed, future presentations will report findings on pathogen prevalence and fish health patterns in juvenile Chinook salmon. This work aims to generate information that supports Indigenous stewardship, salmon conservation, and future management discussions regarding factors affecting early marine survival.

FIS, Poster, AbstractID=19262, PosterID: FIS-P3, (ECOP)

Life history characteristics of the giant mottled eel *Anguilla marmorata* in a temperate river near the northern limit of its distribution

Takeru **Yokogawa**[1], Kai Nishihara[1], Masafumi Kodama[2], Toru Kobari[2], and Gen Kume[2]

[1]Graduate School of Agriculture, Forest and Fisheries, Kagoshima University, Kagoshima, Japan. E-mail: k2234674@kadai.jp
[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan

The giant mottled eel *Anguilla marmorata* is the most widely distributed tropical catadromous eel in the world, and a top predator in freshwater ecosystems. However, no study has revealed life history characteristics of the species in temperate regions near the northern limit of its distribution. In this study, we investigated distribution, migratory histories, age, growth and sex ratio of *A. marmorata* in the temperate river, the Manose River, southern Japan. From May 2022 to April 2026, a total of 7 specimens were collected using fixed nets. Environmental DNA analysis was conducted at 6 sites to determine the distribution of the species in the Manose River. Sagittal otoliths were used to infer migratory histories for 5 specimens by measuring Sr: Ca ratios and to determine age for 7 specimens by counting annual rings. Sex was determined for 6 specimens by histological observation of the gonads. *A. marmorata* was mainly detected in reaches characterized by relatively high water velocity and coarse substrata. In addition, otolith trace element analysis showed no evidence of movement between freshwater and estuarine habitats after recruitment into the river. The maximum total length and age were 1,492 mm and 41 years, respectively. The mean annual growth rate was estimated at 39.9 ± 10.6 mm $year^{-1}$. These results suggest that *A. marmorata* exhibits a longer freshwater residence period and slower growth than populations inhabiting tropical and subtropical rivers. All six sexed specimens were female, suggesting a possible female-biased sex ratio in a temperate river.

FIS, Poster, AbstractID=19278, PosterID: FIS-P4, (ECOP)

Juvenile Pacific cod abundance, diet, and body condition in a warming Bering Sea

Mariela **Brooks**, Emily Fergusson, Lia Domke, Alex Andrews, and Jim Murphy, Robert Suryan

NOAA NMFS Alaska Fisheries Science Center, Auke Bay Laboratories, Juneau, AK, USA.
E-mail: mariela.brooks@noaa.gov

Pacific cod (*Gadus macrocephalus*) are an important species in Bering Sea fisheries and food webs. Recruitment success and population dynamics of fish in general, including cod, are strongly influenced by early life stages, and Fall fish condition can play an important role in over-winter survival. This is particularly true in oceanographic environments like the Bering Sea where seasonal sea ice extent affects ecosystem dynamics, prey availability, and overwinter conditions. We used a time-series of age-0 juvenile Pacific cod data from the eastern Bering Sea shelf to explore relationships between environmental covariates, diet, fish condition, size, and abundance, spanning 2003–2024, including warm and cool stanzas within a region of accelerated warming. Juvenile Pacific cod were more prevalent in the southeastern Bering Sea, with occurrence and abundance varying among years. Diets differed among temperature stanzas, including divergence of warm periods before and after 2014 in the eastern Bering Sea. Fish condition also showed variability among years and a weak negative relationship with summer SST. Identifying factors affecting year class strength of Pacific cod in the Bering Sea will provide an improved understanding of the population dynamics of this commercially and culturally important species in a rapidly changing environment.

FIS, Poster, AbstractID=19301, PosterID: FIS-P5

Changing with the times: Historical shifts in female Pacific halibut maturity-at-age

Colin L. Jones, Ray A. Webster, Ian J. Stewart and Josep V. **Planas**

International Pacific Halibut Commission, Seattle, WA, USA.
E-mail: colin.jones@iphc.int, josep.planas@iphc.int

The maturity status for female Pacific halibut (*Hippoglossus stenolepis*), a key input for estimating female spawning biomass, is currently assessed using macroscopic visual criteria from fish collected on the fishery-independent setline survey (FISS) that is conducted annually by the International Pacific Halibut Commission (IPHC). However, estimates of maturity-at-age for use in the annual stock assessment for Pacific halibut have not been updated in recent years despite uncertainty in the visual method and the apparent stability in maturity-at-age during recent decadal decreases in size-at-age. We recently initiated studies to revise maturity schedules based on histological data for female Pacific halibut throughout its distribution range in the northeastern Pacific Ocean, including the U.S. West Coast, British Columbia, Gulf of Alaska, Bering Sea, and Aleutian Islands. From 2022-2024, we estimated annual histologically based maturity ogives for four distinct geographic regions to examine spatial and temporal trends in maturity-at-age. We then used average abundance estimates across regions to weight regional maturity-at-age estimates to generate a new histological coastwide ogive. The IPHC has visual maturity-at-age data from the FISS going back to 2002 based on current methods. To create a time series consistent with more accurate histological assessments, we developed a calibration between histological and visual maturity ogives from the 2022-2024 data. The historical calibrated time-series indicates a change to older maturing females from 2010-2016 but has shifted to younger maturing females in recent years. A new calibrated coastwide visual ogive from 2002-2024 was developed by averaging across all years and yielded an A50 value of 11.0 years of age, a one-half-year-old decrease from previous estimates. Overall, the results provide the first evidence of spatial and temporal variation in maturity-at-age for female Pacific halibut.

Furthermore, the modeling has led to a more precise and accurate coastwide estimate of maturity-at-age in the northeastern Pacific Ocean that will be used to calculate population-level maturity schedules as an input into the annual Pacific halibut stock assessment.

FIS, Poster, AbstractID=19307, PosterID: FIS-P6, (ECOP)

Co-producing fish recruitment research to support a Native Hawaiian aquaculture system

Lily **Olmo**[1], Keliʻi Kotubetey[2], Shimi Rii[3], Tori Spence[4], Don Kobayashi[4], Jessica Perelman[4] and Jessica Miller[1]

[1]Oregon State University, Corvallis, OR, USA. E-mail: olmol@oregonstate.edu
[2]Paepae o Heʻeia, Kāneʻohe HI, USA
[3]Heʻeia National Estuarine Research Reserve, Kāneʻohe, HI, USA
[4]NOAA Fisheries, Honolulu, HI, USA

Loko Iʻa o Heʻeia is an approximately 800-year-old loko iʻa (fishpond) on the windward coast of Oʻahu, Hawaiʻi. Managed by the nonprofit organization Paepae o Heʻeia and supported by the Heʻeia National Estuarine Research Reserve (NERR), the loko iʻa is currently undergoing restoration to support its function as a productive and culturally significant aquaculture system. The loko iʻa is enclosed by a traditional kuapā (rock wall) and connected to Kāneʻohe Bay through four mākāhā (sluice gates), which regulate tidal exchange and facilitate natural recruitment of larval and juvenile fishes. Despite the importance of recruitment processes in sustaining loko iʻa productivity and nearshore fisheries, the spatial and temporal dynamics of these fish communities remain underexplored. This study engages community partners to co-produce a monitoring protocol for assessing the recruitment of larval and juvenile fish (pua iʻa) at Loko Iʻa o Heʻeia. Sampling approaches include LED light traps, Standard Monitoring Units for the Recruitment of Fishes (SMURFS), and plankton nets deployed within the loko iʻa to establish a baseline dataset on the early life stages of these diverse fish assemblages. Sampling focuses on species of cultural and aquaculture importance identified by community partners, such as ʻamaʻama (striped mullet; *Mugil cephalus*). This real time data will enhance existing research by validating and informing existing fisheries and habitat models. Results will inform place-based restoration and community-led aquaculture management while contributing to broader efforts to integrate Indigenous knowledge and collaborative science into coastal resource management.

FIS, Poster, AbstractID=19382, PosterID: FIS-P7, (ECOP)

Ecosystem risk-based stock assessment of fisheries resources in the East Sea: Biodiversity

Minju **Kim** and Sung-Il Lee

Pukyong National University, Busan, R Korea. E-mail: minjuhappy17@gmail.com

Recently fisheries resource management increasingly requires ecosystem-based assessment and management, rather than relying solely on a single-species approach. Accordingly, research on ecosystem-based fisheries resource management has been actively conducted in Korea. Ecosystem-Based Fisheries Assessment (EBFA), proposed by Zhang et al. (2009), provides a fundamental framework for establishing an ecosystem-based fisheries resource management system. In the EBFA approach, risk score (RS) are first estimated for each indicator and are then used to sequentially calculate the Objectives Risk Index (ORI), Species Risk Index (SRI), Fishery Risk Index (FRI), and Ecosystem Risk Index (ERI). The RS for each indicator is calculated on a scale from 0 to 3 based on the Reference Points of Target (TRP) and Limit (LRP). This study aimed to evaluate ecosystem risk associated with biodiversity, one of the major management objectives (Sustainability, Biodiversity, Habitat quality and Socio-economic benefit), by applying EBFA to fisheries resources in the East Sea. In particular, this study is significant in that moving averages were applied to reduce short-term fluctuations and assessment uncertainty in indicator values that may arise in the conventional EBFA method. In addition, the coefficient of variation (CV) was calculated for each indicator to examine temporal variability and assessment uncertainty.

FIS, Poster, AbstractID=19390, PosterID: FIS-P8

A new research project on the Sakura shrimp (*Lucensosergia lucens*) in Suruga Bay, Japan: Towards recovery from a historic decline in catches

Jun **Nishikawa**[1], Aoba Kojima[1], Akiyuki Kenmochi[2], Junya Hirai[3], Gaël Dur[4], Hiroyuki Matsuura[1], Takashi Yoshikawa[1], Rumi Sohrin[4], Katsuhiko Mineta[2,5,6], Kazuo Amakasu[7], Norihiro Monna[8] and Motoharu Abe[8]

[1]Tokai University, Shizuoka, Japan. E-mail: jun_nishikawa@tokai.ac.jp
[2]Shizuoka Institute of Science and Technology, Shizuoka, Japan
[3]The University of Tokyo, Kashiwa, Japan
[4]Shizuoka University, Shizuoka, Japan
[5]Waseda University, Tokyo, Japan
[6]Marine Open Innovation (MaOI) institute, Shizuoka, Japan
[7]Tokyo University of Marin Science and Technology, Tokyo, Japan
[8]Shizuoka Prefectural Research Institute of Fishery and Ocean, Shizuoka, Japan

Sakura shrimp (*Lucensosergia lucens*) is a small mesopelagic species that occurs abundantly in Suruga Bay, Japan. It has been harvested by commercial fisheries and provide substantial economic benefits to the local community. However, the catch declined abruptly to less than one-tenth of its previous level in 2018 and has remained below half of the pre-2017 level ever since. While several possible causes of this sharp decline in catch have been suggested, the exact cause remains unknown. A new research project examining the biology and ecology of Sakura shrimp has started to clarify current status of the stock, population dynamics including larval stages, reproduction and growth of the shrimp together with environmental conditions and ecosystem processes. By integrating these approaches, the project will provide scientific knowledge to support the sustainable management of the fishery while contributing to the conservation of this important species. An overview of the project will be presented.

FIS, Poster, AbstractID=19406, PosterID: FIS-P9

Unveiling the mesopelagic ichthyofauna in Korean waters: Ecological significance and the need for precautionary management

Dongwha **Sohn**[1], Suam Kim[2], Youn-Ho Lee[3], and Hwahyun Lee[2]

[1]Pusan National University, Busan, R Korea. E-mail: sohndongwha@pusan.ac.kr
[2]Pukyong National University, Busan, R Korea
[3]Korea Institute of Ocean Science and Technology, Busan, R Korea

Mesopelagic fishes (200–1,000 m) account for a substantial portion of global marine biomass and play pivotal roles in marine food webs and the biological carbon pump. Despite their ecological significance, taxonomic baselines and quantitative information on mesopelagic fishes in Korean waters remain limited. Our study establishes a systematic inventory of mesopelagic fishes potentially occurring in Korean waters by cross-referencing international taxonomic literature—including FAO reports and major identification guides from the Atlantic, Pacific, and Indian Oceans—with the domestic fish inventory provided by the National Institute of Biological Resources. We identified 24 species across 13 families as potential inhabitants of Korean waters. Although our results are limited by their reliance on literature review rather than in situ quantitative assessments, this study provides the first comprehensive taxonomic foundation for mesopelagic ichthyofauna in Korean waters. By highlighting their pivotal roles in the biological carbon pump and marine food webs, we emphasize that current research gaps must be addressed through an integrated survey system. Ultimately, this work serves as a foundational step toward establishing a precautionary management framework that aligns with global sustainability goals amidst a changing climate.

FIS, Poster, AbstractID=19428, PosterID: FIS-P10

Comprehensive coastal fisheries resources and habitat evaluation in data-limited situation in Mauritius

Naoki **Tojo**, Takumi Tada, Kazuma Ikegami, Wataru Tabu, Sorachi Watanabe, Yakumo Ozaki Manato Fujimoto and Vanessa Katafono

Hokkaido University, Hakodate, Japan. E-mail: n.tojo.raven@fish.hokudai.ac.jp

Mauritius is a small island nation covering an area of 2,000 km² in the western Indian Ocean, east of Madagascar. In recent years, driven by a paradigm shift toward ecosystem-based fisheries management, the development of a "blue economy", a socioeconomic model premised on sustainability and coexistence with marine ecosystems, has become a goal across the Pacific regions where PICES primarily operates. For Mauritius, a small island states surrounded by the sea, this model is the key for the future. However, implementing it requires the collection of extensive scientific data, a process that often demands immense financial resources, manpower, and advanced equipment. Consequently, many small island states face a situation where they are unable to undertake the necessary surveys and analyses, making it difficult to conduct ideal resource assessments and management. This study explored methods and approaches for comprehensive analysis and assessment of fisheries resources within the constraints, and discussed the validity of the approaches. Size data for several locally important target species, such as *Epinephelus merra* and *Naso unicornis*, were collected in collaboration with local stakeholders; these data were used to estimate von Bertalanffy growth curves, which were then compared with values from existing literature. Based on these estimates, Spawning Potential Ratio was calculated to assess current fishing pressure. Furthermore, the study analyzed ecological factors such as species composition, diversity, and habitat complexity by integrating data, such as drone imagery, snorkeling-based visual observations using adaptive sampling and the empirical knowledge of local fishers, within a Geographic Information System (GIS) framework.

FIS, Poster, AbstractID=19435, PosterID: FIS-P11, (ECOP)

Pacific cod (*Gadus macrocephalus*) larval sources and contribution of nursery habitats to recruitment in the western Gulf of Alaska

Nicholas S. **Strait**[1], Alisa A. Abookire[2], Ben J. Laurel[3], Beth Matta[4], Esther Goldstein[4], Derek Chamberlin[4] and Jessica A. Miller[1]

[1]Department of Fisheries, Wildlife, and Conservation Sciences, Coastal Oregon Marine Experiment Station, Oregon State University, Newport, OR, USA.
E-mail: nick.strait@oregonstate.edu
[2]Alaska Coastal Observations and Research, Kodiak, AK, USA
[3]Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Newport, OR, USA
[4]Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA, USA

Recent marine heatwaves (MHW) in the Gulf of Alaska (GOA) resulted in the closure of the Pacific cod fishery. This led to collaborative efforts to better understand how ocean warming affects Pacific cod reproduction, phenology, growth, and recruitment. Building off these findings, we examined the otolith elemental composition of the early larval period of juvenile Pacific cod from the western GOA from 2018 to 2023 and generated an early larval multi-elemental signature. Using these signatures, we determined there were three to four chemically distinct sources of larvae in the western GOA and juveniles from each nursery share similar elemental signatures from hatch to early larval stages, potentially indicating similar larval dispersal patterns. In addition, we generated nursery mutli-elemental signatures for each of the four nursery grounds juveniles were collected from. We found each nursery ground to have a distinct signature. Our next steps will be to build off these nursery signatures to determine the contributions of Pacific cod from each nursery to older age classes across multiple cohorts. This work links early life history processes to population dynamics and improves our ability to anticipate how future warming events will shape Pacific cod recruitment and inform management decisions within the GOA.

FIS, Poster, AbstractID=19467, PosterID: FIS-P12, (ECOP)

Freshwater growth, habitat use, and survival estimates of Oregon Coast coho salmon

Sammy **Yevak**[1] Wesley Shum[2], Jessica Miller[3]

[1]Marine Resource Management, Oregon State University, Corvallis, OR, USA.
E-mail: yevaks@oregonstate.edu
[2]Oregon Department of Fish and Wildlife, Newport, OR, USA
[3]Department of Fisheries, Wildlife, and Conservation Sciences, Coastal Oregon Marine Experiment Station, Oregon State University, Newport, OR, USA

Accurate estimates of juvenile habitat use are critical for interpreting smolt-to-adult survival (SAR) estimates and informing the management of ESA-listed Oregon Coast coho salmon. Mill Creek, an Oregon Department of Fish and Wildlife Life Cycle Monitoring site, is unique because Mill Creek Reservoir lies upstream of the smolt trap, and smolts from this system are consistently larger than those from nearby watersheds. Recent Passive Integrated Transponder (PIT) tag analyses suggest SAR estimates at Mill Creek may be overestimated, potentially because some juveniles exit the reservoir early and rear downstream in habitats that are not fully represented by current monitoring approaches. We reconstruct early-life habitat histories of returning adults using otolith $^{87}Sr/^{86}Sr$ transects and estimate freshwater growth from otolith daily increment widths. Preliminary results from 39 adults show distinct isotopic signatures among upstream tributaries, the reservoir, and downstream tidally influenced rearing environments. Most fish exhibited reservoir or upstream tributary signatures, while a subset showed evidence of downstream rearing. Ongoing analyses of approximately ~350 archived otoliths linked to PIT-tag data will evaluate habitat-specific growth rates and determine how alternative freshwater rearing strategies influence SAR estimates. These results will improve interpretation of Life Cycle Monitoring data by quantifying how early freshwater rearing variation influence SAR estimates for Oregon Coast coho salmon.

FIS, Poster, AbstractID=19526, PosterID: FIS-P13, (ECOP)

The pelagic species trait database: An open data resource to support trait-based ocean research

Miram R. **Gleiber**[1], Natasha A. Hardy[1], Zachary Roote[1], Zackary Tandy[1], Caitlin J. Morganson[1], Alana Krug-Macleod[1], Iris George[1], Cindy Matuch[1], Cole B. Brookson[1], Elan J. Portner[3], Elizabeth A Daly[2], C. Anela Choy[3], Catherine F. Nickels[4], Barbara A. Muhling[5,6], Brian K. Wells[7,8], Richard D. Brodeur[9], Toby D. Auth[10], Jarrod A. Santora[7,11], Sarah M. Glaser[12], Daniel J. Madigan[13], Elliott L. Hazen[14], Michael G. Jacox[14], Steven J. Bograd[14], Larry B. Crowder[15] and Stephanie J. Green[1]

[1]Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada.
E-mail: miramgleiber@gmail.com
[2]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, OR, USA
[3]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA
[4]Northwest Fisheries Science Center, NOAA, Seattle, WA, USA
[5]Institute of Marine Sciences, University of California, Santa Cruz, CA, USA
[6]Fisheries Resources Division, Southwest Fisheries Science Center, NOAA, La Jolla, CA, USA
[7]Fisheries Ecology Division, Southwest Fisheries Science Center, NOAA, Santa Cruz, CA, USA
[8]Fish Ecology Division, Northwest Fisheries Science Center, NOAA, Newport, OR, USA
[9]Hatfield Marine Science Center, Oregon State University, Newport, OR, USA
[10]Pacific States Marine Fisheries Commission, Newport, OR, USA
[11]Department of Applied Mathematics, University of California, Santa Cruz, CA, USA
[12]World Wildlife Fund, Washington DC, USA
[13]Department of Integrative Biology, University of Windsor, ON, Canada
[14]Environmental Research Division, Southwest Fisheries Science Center, NOAA, Monterey, CA, USA
[15]Hopkins Marine Station of Stanford University, Pacific Grove, California, USA

Trait-based frameworks are increasingly useful for predicting how ecological communities respond to ongoing global change. As species range shifts result in encounters between new predator and prey pairs, identifying prey 'guilds', based on a suite of shared traits, can simplify complex species interactions and assist with predicting food web dynamics. To promote advances in trait-based research in open-ocean systems, we present the Pelagic Species Trait Database, a comprehensive resource synthesizing functional traits of many pelagic fish and invertebrate species in a single, open-source repository. We used literature sources, online resources, and species images to collate traits for 521 pelagic species describing 1) habitat use and behavior, 2) morphology and morphometrics, 3) nutritional quality, and 4) population status information. Species in the database are primarily from the California Current system (CCS) and broader NE Pacific Ocean, but also include globally important pelagic species known to be

consumed by top ocean predators from other ocean basins. We share examples of how the trait database is implemented to better understand the complex foraging dynamics of a highly migratory pelagic predator, albacore tuna. Consistent habitat, morphological, and nutritional quality traits explain taxonomically complex feeding patterns by albacore tuna and are useful for predicting future distributions of highly preferred prey for albacore tuna. This database promotes trait-based approaches in marine ecosystems and for predator populations worldwide.

FIS, Poster, AbstractID=19546, PosterID: FIS-P14, (ECOP)

Stable isotopes uncover the relationship between coastal shelf feeding and juvenile salmon body size

Jaanasheen K. **Bala**, Genyffer C. Troina and Brian P.V. Hunt

University of British Columbia, Vancouver, BC, Canada. E-mail: j.bala@oceans.ubc.ca

It is hypothesized that offshore migrating Pacific salmon (*Oncorhynchus* spp.) must attain a critical size by their first marine winter to survive presumed limited prey availability in the open ocean. High zooplankton biomass in the coastal and shelf waters of the northeast Pacific is expected to provide good conditions for growth during outward migration that may offset lower zooplankton biomass encountered offshore during the winter. However, the contribution of coastal and shelf feeding to juvenile salmon body size remains poorly understood. To address this gap, we used nitrogen and carbon stable isotopes ($\delta^{15}N$ and $\delta^{13}C$) as tracers of coastal and offshore foraging history in chum (*O. keta*) and sockeye (*O. nerka*) salmon sampled at the end of their first marine winter in 2019, 2020, and 2022. Generalised linear models identified $\delta^{15}N$ enrichment, representative of shelf zooplankton consumption, as a significant predictor of fork length and weight in both chum and sockeye, with the direction of this relationship differing between species. Interannual variations in the effect of $\delta^{15}N$ enrichment on body size aligned with shelf foraging conditions during the preceding summer outmigration. Stronger $\delta^{15}N$ enrichment corresponded to larger body size in years of high shelf productivity, but to smaller body size in lower productivity years. $\delta^{13}C$ enrichment showed no significant relationship with either body size metric. Our findings suggest a contingent influence of coastal prey availability on juvenile salmon body size, and highlight the need to understand differential climate change impacts on migration habitats when assessing vulnerability among salmon stocks.

HD PAPER SESSION

Oral Presentations

HD, Oral, AbstractID=19135

Analysis of a two-stage evolutionary game between enterprises and governments under the coastal setback line system

Meng **Su** and Jingmei **Li**

Ocean University of China, Qingdao, PR China.
E-mail: sumengouc@qq.com, 32584626@qq.com

The coastal setback line system is an important guarantee for implementing the land-sea coordination strategy. The system aims to balance the development and protection of coastal zones, which leads to game behaviors between management departments and development entities. To explore the interest equilibrium relationship among game subjects during the system's implementation, this paper constructs a two-stage bilateral evolutionary game model and uses Matlab for numerical simulation. The study finds that: (1)The core factor influencing enterprises' strategy choices is the comparison of profits under different strategies. (2)Environmental risks play a decisive role in enterprises' strategy choices. An increase in environmental risks directly prompts enterprises to shift from an expansion strategy to a non-expansion or relocation strategy. (3)The governments' choice of supervision strategy is jointly affected by supervision costs and the amount of fines. (4)There is a threshold for the impact of fines on corporate decision-making.(5)Fines and relocation subsidies do not play a decisive role in the strategic choices of enterprises. Drawing based on the research conclusions, policy recommendations are proposed to optimize the system's effectiveness: governments can guide enterprises' decisions by providing relocation compensation, reasonably setting fines, strengthening environmental control, supporting technological innovation, reducing tax payments, and increasing policy transparency.

HD, Oral, AbstractID=19139, (ECOP)

Identification of challenges and improvement strategies in sea urchin fisheries using a fisheries self-assessment scheme "Fisheries Management Toolbox (Hama no Dougubako)"

Satomi **Takagi**[1], Natsuki Hasegawa[1], Ryutaro Kamiyama[2] and Shion Takemura[2]

[1]Kushiro Field Station, Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Kushiro, Japan. E-mail: takagi_satomi02@fra.go.jp
[2]Yokohama Field Station, Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan

A fisheries self-assessment scheme "Fisheries Management Toolbox (Hama no Dougubako)" is a coastal fisheries management tool that enables fishers to identify on-site challenges and prioritize key management measures for improvement through self-assessment. In this study, the toolbox was adapted for sea urchin capture fisheries and aquaculture based on interviews with sea urchin fishery practitioners and prefectural fisheries extension officers on the Pacific and Japan Sea coasts of Hokkaido, Japan, where operational contexts differ. This study aimed to identify shared and region-specific challenges and clarify priority issues for adaptation to social and climate-related changes. The results identified fishing-ground maintenance as an important challenge common to both coasts, and the need for measures to adapt to climate-driven changes in sea urchin and kelp resources became evident. Differences in perception between practitioners and fisheries extension officers were less evident where collaboration among fishers was stronger. On the Pacific coast, aquaculture was increasingly regarded as important, indicating the need to secure kelp resources as sea urchin feed. On the Japan Sea coast, where the harvest season overlaps with other domestic fishing areas, initiatives related to sales strategies emerged as high-priority issues. However, implementing these initiatives requires adequate staffing, highlighting the importance of strengthening frameworks for recruiting and onboarding new entrants. In addition, re-evaluating the effectiveness of sea urchin seed releases, improving the socioeconomic foundations of the fishery, and fostering collaboration with neighboring regions and other industries were identified as key measures for bridging the gap between current management approaches and on-the-ground realities.

HD, Oral, AbstractID=19197, (ECOP)

Community engagement and governance of ocean iron fertilization mCDR field research in the Northeast Pacific

Katherine **Roche**[1], Amanda Borth[2], Ken Buesseler[1], Wil Burns[3], Fei Chai[4], Jay Cullen[5], Jessica Drysdale[1], Mara Karageozian[6], Paul Morris[1], Ashwin Murthy[7], Sara Nawaz[3,8], Kilaparti Ramakrishna[1], Sarah Smith[9], Brad Warren[10], Romany Webb[5], Mark Wells[11], and Joo-Eun Yoon[12]

[1]Woods Hole Oceanographic Institution, Woods Hole, MA, USA.
E-mail: katherine.roche@whoi.edu
[2]Association of Science and Technology Centers, Washington DC, USA
[3]Institute for Responsible Carbon Removal, American University, Washington DC, USA
[4]State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, PR China
[5]University of Victoria, Victoria, BC, Canada
[6]Arizona State University, Tempe, AZ, USA
[7]Sabin Center for Climate Change Law, Columbia University, New York, NY, USA
[8]Institute for Resources, Environment and Sustainability, University of British Columbia, Vancouver, BC, Canada
[9]Moss Landing Marine Laboratories, San Jose State University, Moss Landing, USA
[10]Global Ocean Health, Seattle, WA, USA
[11]School of Marine Sciences, University of Maine, Orono, ME, USA
[12]Korea Polar Research Institute, Incheon, R Korea

Global decarbonization efforts are lagging behind international goals, necessitating research into marine carbon dioxide removal (mCDR) strategies that leverage the ocean's large carbon storage capacity. One mCDR approach – ocean iron fertilization (OIF) – harnesses natural ocean processes to stimulate phytoplankton productivity and enhance carbon export to depth. Numerous prior OIF field trials, including three in the North Pacific, were conducted in the 90's and 2000's, but none were designed to assess OIF as a durable mCDR approach or fully examine its potential environmental impacts. The Exploring Ocean Iron Solutions (ExOIS) program is planning the North Pacific Carbon Study (NPCS), a set of next generation OIF field experiments located in the offshore Northeast Pacific, that will examine the carbon storage potential of OIF and its environmental impacts. To responsibly conduct this mCDR research, social and governance aspects must be considered in addition to scientific uncertainties. The NPCS will be permitted in accordance with existing US and international governance frameworks. Alongside the permitting process, field research planning must meaningfully engage domestic and international collaborators, coastal communities, and Indigenous groups, as well as integrate social science research to understand the full societal implications. ExOIS is committed to multidisciplinary engagement of social science and governance experts to ground the research in ethical principles, map affected communities, and adopt frameworks for collaborative research governance. This presentation outlines our approach to aligning mCDR science with the best

practices for community engagement, governance, and permitting in preparation for next generation field trials.

HD, Oral, AbstractID=19219

Behavioral drivers and pathways of public willingness to participate in marine litter governance: Evidence from Qingdao, China

Jingzhu **Shan**[1], Jingmei Li[1,2], and Qing Li[2]

[1]Institute of Marine Development, Ocean University of China, Qingdao, PR China.
E-mail: oucshanjingzhu@126.com
[2]School of Economics, Ocean University of China, Qingdao, PR China

Marine litter is a typical non-point source pollution with scattered sources, complex transport pathways, and unclear responsible parties, making governance highly challenging. From a waste-management perspective, it is also a downstream manifestation of land-based solid waste leakage, insufficient source reduction, and inadequate public participation in waste-management systems. Public participation is therefore essential for preventing waste leakage and improving governance effectiveness. Based on the theory of Complex Environmental Behavior, this study uses Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the driving factors of public willingness to participate (WTP) in marine litter governance. The results show that Individual Motivation (IM), Individual Opportunity (IO), Individual Ability (IA), and Social Guidance (SG) directly affect WTP. Government Attention (GA) indirectly affects WTP through IM; SG influences WTP through IO and IA; and Platform and Facility Construction (PFC) affects WTP through IM and IO. The study further applies fuzzy-set Qualitative Comparative Analysis (fsQCA) and identifies three configurations leading to high WTP: socially guided motivation- and ability-driven, internal individual-driven, and socially guided and platform-facility-supported opportunity-driven pathways. These findings extend the application of Complex Environmental Behavior theory to marine litter governance and provide practical implications for participation-oriented waste-management policies by showing how motivation, opportunity, ability, social guidance, and governance support can jointly promote source reduction, waste leakage prevention, and public participation.

Keywords: Marine litter governance; public willingness to participate; Complex Environmental Behavior; PLS-SEM; fsQCA

HD, Oral, AbstractID=19350, (ECOP)

Opportunities and challenges of Japan's new Anti-IUU Policy: Perspectives from national stakeholders

Toya **Hirokawa**[1,2], Juri Hori[3], Wakao Hanaoka[4], Benjamin Thompson[5], Minako Iue[2,6] and Mitsutaku Makino[6,7]

[1]Graduate School Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: toya910910@g.ecc.u-tokyo.ac.jp
[2]Sailors for the Sea Japan, Tokyo, Japan
[3]Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries, Tokyo, Japan
[4]Seafood Legacy Co., Ltd., Tokyo, Japan
[5]School of Social Sciences, Faculty of Arts, Monash University, Victoria, Australia
[6]Atmosphere and Ocean Research Institute, The University of Tokyo, Tokyo, Japan
[7]Ocean Policy Research Institute (OPRI), The Sasakawa Peace Foundation, Tokyo, Japan

As Illegal, Unreported and Unregulated fishing (IUU fishing) has been one of the major threats to seafood sustainability, Japan implemented the Act on Ensuring the Proper Domestic Distribution and Importation of Specified Aquatic Animals and Plants (Anti-IUU Policy) in 2022. However, there is limited literature examining its effectiveness and challenges. This study aims to summarize stakeholders' experiences and perspectives regarding the effectiveness, challenges and future possibilities of the Anti-IUU policy, and identify similarities and differences in their opinion. Semi-structured interviews were conducted with 19 stakeholders across government, private sector, civil society, researchers, and finance sector. Qualitative data were analyzed using thematic coding, while text mining techniques were used to identify key terms and patterns. Whilst common concerns on verification and digitalization on Catch Documentation emerged across several stakeholder groups, there were different views on species coverage expansion and its timing. To solve the challenges identified, future actions and priorities are suggested, including urgent need of initiating a stakeholder and expert discussion on digitalization and collecting data from overseas cases.

HD, Oral, AbstractID=19402

Portfolio analysis of catch composition in offshore trawl fishing—toward resilient diversification under climate uncertainty

Hiroki **Wakamatsu** and Tomoaki Murakami

Policy Research Institute, Ministry of Agriculture, Forestry, and Fisheries, Tokyo, Japan.
E-mail: hiroki_wakamatsu430@maff.go.jp

This study applies portfolio theory to offshore trawl fishing data from Hyogo and Tottori Prefectures in Japan (2019–2023) to evaluate the risk structure of species-level catch composition. Using vessel-level catch value share by species, we conducted a portfolio analysis of the corresponding fisheries' resilient catch composition towards an external risk under the current uncertainty. The portfolio analysis finds a minimum-variance combination of catch species.

The results show that current fishing income is heavily concentrated in a small number of high-value species, particularly snow crab and a lucrative shrimp, indicating substantial concentration risk towards catch failure due to external shock such as extreme climate events. The optimized minimum-variance portfolio suggests that targeting a broader and more even range of species would reduce this risk.

These findings suggest that diversifying toward moderately valuable species, rather than relying on a narrow set of high-value targets, represents a more resilient strategy for managing income volatility in offshore trawl fisheries. Future work should incorporate demand-side price effects and the practical constraints of multi-species trawl operations into the optimization framework.

HD, Oral, AbstractID=19412, (ECOP)

Bridging society and the sea: Fish finders as a neutral tool in the human–ecosystem feedback of set-net fisheries

Chihiro **Shiga** and Yutaro Sakai

The University of Tokyo, Tokyo, Japan. E-mail: sc-8530-yellowtailer@g.ecc.u-tokyo.ac.jp

The Social–Ecological–Environmental Systems (SEES) approach frames marine systems as coupled feedback linking climate, ecosystems, and human activity, in which fishing communities both depend on and exert pressure on the resources they exploit. Within this feedback, "smart fisheries" using information and communication technology (ICT) are promoted as an adaptive response to resource variability, yet evidence on the causal effects of adoption remains scarce.

This study examined the causal impact of installing fish finders on productivity in Japanese set-net fisheries, using quasi-experimental difference-in-differences designs. We found that real-time information on fish aggregations did not automatically change fishing behavior; its effect on catch was conditional rather than guaranteed.

We interpret this through the SEES lens. Fishing is an indispensable, sea-derived productive activity, while the persistence of marine ecosystems holds value in its own right. These imperatives are inherently difficult to reconcile—herein lies a persistent gap between coastal societies and the resources they depend on. Smart fishing acts on this gap: it renders previously invisible conditions such as resource abundance observable, makes selective harvesting feasible, and allows fishing pressure to be quantified, supplying information missing between social decision-making and resource sustainability.

Its direction, however, is not predetermined: the same technology can intensify fishing pressure by reducing missed catch, or relieve it through more selective, better-timed operations. Smart technologies are therefore best understood not as inherently sustainable or extractive, but as a neutral tool mediating between society and resource—situating fisheries digitalization within the human–ecosystem feedback at the core of SEES.

HD, Oral, AbstractID=19420, (ECOP)

Blue Policy Washing: An early diagnostic framework for marine policy design

Mengyao **Zhu**

Ocean Policy Research Institute, The Sasakawa Peace Foundation, Tokyo, Japan.
E-mail: mengyao-zhu@spf.or.jp

Greenwashing has raised concerns that environmental claims may create symbolic action without substantial effects. This study extends this concern to marine policy and proposes the concept of Blue Policy Washing (BPW): a condition in which marine policies appear to address ocean challenges but lack effectiveness.

Early detection of BPW is crucial for enhancing the effectiveness of policies. However, there are few frameworks for assessing the quality of policy design using policy document data at the pre-implementation stages. Policy documents are open, comparable, and traceable data that connect policymakers, scientists, and civil society. As such, document-based assessment can provide a more open diagnostic for strengthening the science–policy–society interface.

This study aims to develop an early diagnostic framework for BPW based on marine policy documents. Evaluation items are derived through a scoping review and framework synthesis of international guidelines related to policy design evaluation. Policy design elements are extracted when they are relevant to BPW, supported by international standards, observable in policy documents, non-redundant, internationally comparable, and interpretable for assessment. These elements are then synthesized into scorable indicators for quantitatively evaluating BPW.

The framework is preliminarily applied to Japanese and Chinese marine policy documents to compare differences in policy design. This study provides an early diagnostic tool for enhancing transparency, implement ability, and science–policy–society connections in marine governance.

HD, Oral, AbstractID=19436

Networks and human connection are the engines of resilience for the ocean we want

Karen L. **Hunter**[1] and Shion Takemura[2]

[1]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada.
E-mail: karen.hunnter@dfo-mpo.gc.ca
[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan

Human networks—composed of individuals, organizations, and governance bodies—play a central role in shaping outcomes in ocean, coastal, and fisheries science and management. These networks influence how information is shared, how trust is built, how integration emerges across diverse stakeholder groups and programs, and how resource management is delivered. Network structure, including the configuration of nodes (actors) and edges (relationships), and network behaviour, including health and safety aspects, affects connectivity, collaboration, integration, and resilience. Effective networks can accelerate knowledge exchange and adaptive management, while fragmented or hierarchical networks may slow coordination or reinforce imbalances. In marine social-ecological systems, networks with bridging organizations, cross-scale linkages, and strong boundary-spanning actors have been shown quantitatively to support management of complex socio-ecological systems, however, these nodes, nor their qualities, may always be accessible. This presentation will share a set of examples from marine systems to illustrate how networks and their nodes may enable resilience or its components in the context of network structure and behaviour. We will 1) provide an example of integration in fisheries management system networks in relation to system resilience, and 2) share findings from a bibliometric-based assessment to highlight connection and collaboration across a network of research. Networks generated via PICES will be highlighted with future opportunities explored.

HD, Oral, AbstractID=19449

Integrating human dimensions into ecosystem analyses: The Spatial Economics Toolbox for Fisheries (FishSET)

Alan **Haynie**[1], Lisa Pfeiffer[2], and Paul Carvalho[3]

[1]International Council for the Exploration of the Sea (ICES), Copenhagen, Denmark.
E-mail: alan.haynie@ices.dk
[2]NOAA Fisheries, Seattle, WA, USA
[3]Pacific States Marine Fisheries Commission, Portland, OR, USA

Effective fisheries management requires navigating complex decision-making within rapidly changing environments, a challenge that demands integrating human dimensions into ecosystem analyses. To address the methodological and empirical challenges of understanding the relationships between marine ecosystems and the communities and economies that rely on them, we introduce the Spatial Economics Toolbox for Fisheries (FishSET). FishSET is an R package designed for end-to-end economic policy analysis of fishery management measures using discrete choice models. The toolbox serves as a collaborative bridge between disciplines, providing a novel framework to organize fisheries-dependent data, apply cutting-edge econometric models of location choice, and simulate alternative policy scenarios. By standardizing data management and streamlining model selection, FishSET coordinates statistical workflows to ensure transparency and reproducibility. The toolbox aids researchers in understanding how biophysical changes or regulatory shifts impact the well-being and effort redistribution of fishing fleets and communities. We demonstrate FishSET's utility in evaluating diverse challenges, including spatial closures, emerging ocean uses (such as offshore wind and marine protected areas), and climate-driven stock redistributions. FishSET advances the contribution of the social sciences to marine science, a key goal for PICES going forward.

HD, Oral, AbstractID=19545

The approach to optimal management targets under climate change and challenges faced by fisheries

Minling **Pan**[1] and David Tomberlin[2]

[1]NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI, USA.
E-mail: Minling.Pan@noaa.gov
[2]NOAA Fisheries, Office of Science and Technology, Silver Spring, MD, USA

Long-term fishery management targets are typically defined in terms of optimal equilibrium productions (harvests). However, reaching the optimal target is complicated by the fact that most fisheries must pass through a stock-drawdown phase (non-equilibrium harvests), often under shifting socioeconomic and changing climatic conditions. During stock-drawdown phase when initial biomass is higher than the optimal biomass that produces optimal yield, the difference between these two biomass levels (defined as "endowment") is progressively depleted. In this phase, both catch and fishing effort often exceed levels consistent with long-term optimal harvests, leading to substantial and persistent excess capacity. Existing dynamic bioeconomic models largely focus on optimal equilibrium and open access outcomes, providing limited guidance on the length of time it takes to reach optimal targets and how excess capacity emerges during the transition. This study develops a discrete-time dynamic bioeconomic model that explicitly incorporates both drawdown harvests and equilibrium harvests. For a given fishery, the model quantifies important fisheries dynamics, including: (1) the length of time it takes to reach optimal management targets (MSY or MEY); (2) the externality such as the magnitude ("stickiness") and persistence of excess capacity; and (3) the potential time to stock collapse in the absence of management. Through scenario analysis, the model estimates the impacts on fishery dynamics (including economic performance) arising from climate-induced productivity declines, nonlinear catchability driven by technological improvements, shifts in market conditions, and local stewardship in effort controls. This model presents an operational and tractable framework for proactive fishery management.

HD PAPER SESSION

Poster Presentations

HD, Poster, AbstractID=19555, PosterID: HD-P1, (ECOP)

Development of a climate change adaptation indicator system for marine use and development projects: Cases of the port, aquaculture, and marine aggregate extraction sectors

Hansol **Mun**, Seungwon Kang, and Moonsuk Lee

Korea Institute of Ocean Science & Technology, Busan, R Korea.
E-mail: leems@kiost.ac.kr, mhansol@kiost.ac.kr

In Korea, the Marine Use Impact Assessment, which reviews marine use and development projects in advance, is currently confined to evaluating the appropriateness of marine spatial use and the environmental effects on the marine environment, and climate change is not included among its assessment items. Given that projects occupying and using marine space operate over long time horizons and are directly exposed to changing climate conditions, there is a clear need to add a climate change dimension to these two existing axes. This study is an exploratory attempt addressing that gap, and aims to construct an indicator system capable of assessing the climate change adaptation level of marine use and development projects. The indicator system was designed as a dual structure combining risk and resilience. Risk comprises hazard, exposure, and vulnerability, while resilience comprises robustness, rapidity, redundancy, and resourcefulness, so as to capture both the degree of exposure to climate risk and the capacity to respond to and recover from it. After a pool of candidate indicators was compiled, the Analytic Hierarchy Process (AHP) was applied to domestic experts and practitioners to derive the relative importance of each indicator. Three sectors with differing modes of marine space occupation and climate sensitivity were selected for application: ports, aquaculture farms, and marine aggregate extraction. Ports represent fixed infrastructure, aquaculture farms represent biologically based production activities, and marine aggregate extraction represents resource extraction activities.

The results indicate that the key factors differ from scenario to scenario, suggesting that adaptation measures should likewise be approached differentially according to scenario characteristics. The conditions to be addressed as priorities were also found to differ within each of the risk and resilience dimensions. The findings present the adaptation requirements and priorities that marine use and development projects should meet, and can serve as a basis for the future introduction of a Marine Climate Impact Assessment.

HD, Poster, AbstractID=19556, PosterID: HD-P2

Forecasting marine tourism spending at Korea's national fishing ports: Statistical, machine-learning, and deep-learning models compared

Kyu-Won **Hwang**[1,2], Chul-Yong Lee[2] and Moon-Suk Lee[1]

[1]Korea Institute of Ocean Science & Technology, Busan, R Korea.
E-mail: leems@kiost.ac.kr, hwangkw@kiost.ac.kr
[2]Pusan National University, Busan, R Korea

National fishing ports anchor the economies of many Korean coastal communities, and the monthly card-based tourism spending recorded at these ports has become a key indicator for local investment, seasonal operations, and revitalization policy. Reliable forecasts of this spending give port authorities and municipalities a practical planning tool, yet evidence on which forecasting technologies work at this scale has been scarce. We compiled a card-transaction panel of monthly tourism expenditure at 110 national fishing ports (January 2015 to December 2024) and benchmarked 125 forecasting models under one controlled protocol with identical tuning budgets, multiple random seeds, and horizons of 1 to 12 months. Candidates spanned statistical models (SARIMA, SARIMAX), machine learning (Random Forest, XGBoost, LightGBM), deep learning (LSTM, GRU, Transformer, Mamba), graph neural networks, and decomposition- and residual-based hybrids. Overall, seasonal ARIMA ranked first of all 125 models at the 12-month horizon, with a port-level median MAPE of 19.17% (bootstrap 95% CI 17.25 to 22.94), supported by Friedman, Nemenyi, and Diebold-Mariano tests ($p<0.001$); more complex deep and graph-based architectures did not lead the overall comparison. The ranking, however, was far from uniform. The best model and the attainable accuracy varied with each port's spending scale, volatility, seasonality, and other port-specific characteristics, and in 9 of the 101 ports analyzed a graph-based model outperformed every alternative, including a major hub port forecast at 4.31% MAPE. No single model dominated every port, supporting conditional, port-tailored model selection rather than one-size-fits-all deployment. For coastal managers the message is actionable: open-source statistical tools, selectively complemented by advanced models where port conditions favor them, can deliver planning-grade one-year-ahead forecasts of marine tourism spending without costly AI infrastructure.

HD, Poster, AbstractID=19557, PosterID: HD-P3

Economic dimensions of the marine-energy transition: Hidden heterogeneity in public support for actionable marine-energy policy in Korea

Kyu-Won **Hwang**[1,2], Chul-Yong Lee[2] and Moon-Suk Lee[1]

[1]Korea Institute of Ocean Science & Technology, Busan, R Korea.
E-mail: leems@kiost.ac.kr, hwangkw@kiost.ac.kr
[2]Pusan National University, Busan, R Korea

Actionable science for a rapidly changing ocean requires weighing the economic dimensions of the marine-energy transition. Amid a growing need to deploy marine energy under the global energy transition, high upfront costs, grid integration, and the pass-through of these costs to household electricity bills make public acceptance decisive for its success. Among Korean households that already favor marine energy, we ask what this group will pay to scale up renewables. A nationwide contingent-valuation survey fielded by Gallup Korea over roughly two weeks around November 2025 (over 1,000 adults; proportional quota sampling by region, sex, and age) yielded 120 supporters (11.5%), our analysis sample. Rather than the double-bounded dichotomous-choice answers alone, we folded each respondent's open-ended value into the same likelihood function; this joint estimator cut the standard error by roughly 31%. On average, supporters would add about KRW 3,792 (roughly USD 2.72) to their monthly bill. Tariff perception cut both ways: the actual bill and green-tariff awareness pushed willingness up, while feeling that bill heavy pushed it down—so the binding constraint was subjective perception, not objective cost. Latent-class analysis then split this 'homogeneous' segment: a resistant class (32.5%) whose WTP is indistinguishable from zero, and an actively accepting class (67.5%) paying about KRW 6,037 monthly—a divide driven mainly by income and program awareness, not geography. Scaled up, the segment's yearly value—about KRW 116 billion—matches the annual generation cost of Korea's 2030 marine-energy target: a mobilizable base of support, not a full cost-benefit verdict. By turning citizens' preferences into decision-ready evidence, we caution against one-size-fits-all measures and favor transparent disclosure, gain-framed communication on energy security and coastal-economy co-benefits, and a voluntary green-tariff channel converting latent support into funding.

HD, Poster, AbstractID=19558, PosterID: HD-P4

An integrated AHP–IPA assessment of implementation priorities in Korea's marine spatial planning

Seungwon **Kang** and Moonsuk Lee

Korea Institute of Ocean Science & Technology, Busan, R Korea.
E-mail: leems@kiost.ac.kr, seungwon@kiost.ac.kr

Marine spatial planning (MSP) is being institutionalized worldwide, yet whether the formal completion of a plan translates into substantive ecosystem-based management remains an open question. This study applies an integrated assessment framework combining the Analytic Hierarchy Process (AHP) and Importance–Performance Analysis (IPA) to diagnose the implementation status of Korea's MSP. A structured survey was administered to 21 domestic MSP experts and practitioners (mean field experience of 16.9 years), who evaluated the relative importance (weight) and current performance of MSP's six guiding principles and their 30 constituent indicators. The results reveal a marked inversion between the policy importance assigned by experts and actual implementation performance. The strategic principle, which received the lowest weight (0.068), showed high performance across most indicators—such as national–local goal alignment and legal enforcement systems—and clustered in the "keep-up-the-good-work" quadrant. In contrast, the ecosystem-based principle, assigned the highest weight (0.264), exhibited the poorest implementation. Six indicators in particular—ecosystem risk assessment and management, effectiveness of statutory consultative bodies, systematic stakeholder participation, climate change adaptation, and conflict/compatibility management based on marine spatial characteristic assessment—concentrated in the "concentrate-here" quadrant (high importance–low performance). These findings quantitatively demonstrate that Korea's MSP has successfully established the institutional means for plan formulation, yet lags in substantive implementation of its core purposes: ecosystem conservation and science-based conflict resolution. This study offers a reproducible methodology for diagnosing the gap between priority and performance, providing implications for prioritizing MSP advancement in countries at a similar stage of institutional consolidation.

MEQ PAPER SESSION

Oral Presentations

MEQ, Oral, AbstractID=19104, (ECOP)

Direct marking method for the gillnet fishing gear deposit system using a multi-criteria value function

Chae-eun **Shin**[1] and Subong Park[2]

Pukyong National University, Busan, R Korea. E-mail: chaeeun@pukyong.ac.kr

Approximately 44,000 tons of waste fishing gear enter the marine environment each year, causing ghost fishing and pollution; gillnets, with particularly high loss rates, require strengthened management. In Korea, lost gear accounts for a significant share of sea-based marine debris, highlighting the need for systematic control. FAO has proposed international standards for gear marking, and Korea amended the Fisheries Act to introduce a deposit-refund system, later expanding it to gillnets. This study applies an AHP-based multi-criteria value function integrating expert input, fisher preferences, and sea trial results to identify an appropriate direct marking scheme for gillnets. A multi-criteria value function was employed to determine the appropriate marking type. The model consists of weighting coefficients and single-attribute functions, and data were collected through three approaches. First, an AHP analysis was conducted to estimate the weighting coefficients. Second, surveys of coastal gillnet fishers and gear manufacturers were carried out to construct single-attribute functions for social factors. Third, sea trials of the marking methods were performed to develop single-attribute functions for technical factors. The expert priority analysis showed that the label method received the highest weight among marking options, followed by cable ties, special-material fiber integration, stickers, and partial netting with special materials. For the deposit calculation unit, deposits per weight ranked highest, followed by per length, per width, and per price. Ensuring the success of the deposit-refund system requires the adoption of marking methods that do not interfere with fishing operations. Incorporating mixed weights that combine expert judgments with fisher survey results is expected to support the final selection of an appropriate marking scheme.

MEQ, Oral, AbstractID=19141

The next generation of mCDR ocean iron fertilization research studies in the western Gulf of Alaska

Mark L. **Wells**[1,3], Ken Buesseler[2], Paul Morris[2], Fei Chai[3], Jessica Drysdale[2], Kilaparti Ramakrishna[2], Katherine Roche[2], and Sara Smith[4] and Joo-Eun Yoon[5]

[1]University of Maine, School of Marine Sciences, Orono, ME, USA.
E-mail: mlwells@maine.edu
[2]Woods Hole Oceanographic Institution, Woods Hole, MA, USA
[3]Xiamen University, Xiamen, PR China
[4]Moss Landing Marine Laboratories, Moss Landing, CA, USA
[5]Korea Polar Research Institute, Incheon, R Korea

Decreases in greenhouse gas emissions are progressing slowly, and the scientific consensus is that carbon dioxide removal (CDR) from our atmosphere is needed in parallel with increased emission reductions to avoid the most significant consequences of a disrupted climate system. The marine environment offers potential approaches for sequestering carbon at climate relevant scales, with iron-enhanced plankton productivity being the most extensively studied to date. However, past iron enrichment studies were not designed to quantify marine CDR (mCDR), nor can their findings be used to critically evaluate its potential effectiveness or the magnitude of possible negative impacts; a new generation of larger and longer duration field studies are needed to address these uncertainties. Quantifying the amount and durability of CO_2 removal (i.e. 100 years or more) alone is not enough; the environmental and ecological consequences stemming from larger, implementation-scale ocean iron fertilization must also be evaluated. This presentation will describe how the Exploring Ocean Iron Solutions (ExOIS) consortium (oceaniron.org), housed at the Woods Hole Oceanographic Institution, is approaching these research questions, governance challenges, and social engagement in a transparent and responsible manner. Permit application planning has begun for these new pilot-scale field trials. Regular meetings convened by Global Ocean Health provide opportunities for Alaskan communities to provide input, and we look for broader scientific guidance to improve the experimental plan. ExOIS does not endorse ocean iron fertilization for mCDR, but is committed to a responsible code of conduct to provide data-based guidance on whether it is a viable and acceptable approach.

MEQ, Oral, AbstractID=19150, (ECOP)

Vegetation trapping and submarine groundwater discharge regulate microplastic distribution in a muddy tidal flat: Evidence from sediments and porewaters in Suncheon Bay, Korea

Minjun **Kim**[1], Byeongyong Park[2], Taewon Kim[1] and Hyung-Mi Cho[1]

[1]Inha University, Incheon, R Korea. E-mail: chohm@inha.ac.kr, mjk06099@gmail.com
[2]National Institute of Environmental Research, Incheon, R Korea

Intertidal mudflats are critical boundary environments that regulate the transport and exchange of diverse biogeochemical constituents between terrestrial and marine systems. They have also received increasing attention as potential hotspots for the accumulation and transfer of microplastics (MPs). However, despite growing concern regarding MP contamination in coastal sediments, the processes controlling MP distribution within mudflats, particularly in sediment porewaters, remain poorly constrained. In this study, we investigated the abundance, characteristics, and spatial distribution of MPs in intertidal sediments and porewaters across vegetated and unvegetated zones at Suncheon Bay, Korea, in October 2024. MPs in both sediments and porewaters were dominated by white colors (54%) and polypropylene type (53%). MP abundance in sediments was higher in vegetated areas (5.4 MPs g^{-1}) than in unvegetated areas (1.2 MPs g^{-1}). Similarly, porewater MP abundance was higher in vegetated zones (97 MPs L^{-1}) than in unvegetated zones (50 MPs L^{-1}), indicating that vegetation enhances MP retention within mudflats. In addition, MP abundance in groundwater (62 MPs L^{-1}) was approximately 2.8 times higher than in adjacent coastal seawater (22 MPs L^{-1}). This suggests that submarine groundwater discharge (SGD) may act as an important pathway supplying MPs to intertidal and coastal environments. Porewater MP abundance also showed a significant negative correlation with salinity, supporting the influence of SGD inputs. These findings indicate that MP distribution in mudflats is jointly regulated by groundwater-driven inputs and vegetation-associated trapping effects. They also highlight the role of SGD as a previously underrecognized pathway for MP transport to coastal ecosystems.

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Rethinking microplastic exposure in aquatic mammals: Evidence for atmospheric transfer and chemical accumulation

Byeongyong **Park**[1], Taewon Kim[2,3]

[1]Risk Assessment Division, Environmental Health Research Department, National Institute of Environmental Research, Incheon, R Korea. E-mail: quddydsha@naver.com
[2]Program in Biomedical Science and Engineering, Inha University, Incheon, R Korea. E-mail: ktwon@inha.ac.kr
[3]Department of Ocean Sciences, Inha University, Incheon, R Korea

Microplastics (MPs; <5 mm) are increasingly transported among atmospheric, terrestrial, and aquatic ecosystems, creating new pathways for contaminant transfer across environmental compartments. Despite growing concern over MP pollution, exposure assessments in aquatic mammals remain largely focused on ingestion, potentially overlooking inhalation as an important route of exposure and associated ecological risks. Here, we integrated findings from East Asian finless porpoises (*Neophocaena asiaeorientalis sunameri*) and Eurasian otters (*Lutra lutra*) to evaluate multiple MP exposure pathways and their potential environmental consequences. MPs were consistently detected in both digestive and respiratory tissues of aquatic mammals. In finless porpoises, lung tissues contained distinct polymer compositions and higher plastic hazard indices than intestinal contents, indicating that airborne MPs may represent a disproportionately hazardous exposure source. Similar patterns observed in otters suggest that respiratory exposure is not species-specific and may occur across aquatic mammals occupying different habitats. Furthermore, bisphenol A (BPA) concentrations in porpoise blubber increased with MP abundance in stomach contents, suggesting a potential link between MP exposure and contaminant accumulation in aquatic top predators. Collectively, these findings challenge the prevailing ingestion-centered paradigm of MP exposure and highlight atmospheric MPs as a previously overlooked pathway connecting environmental pollution to chemical accumulation in aquatic mammals.

MEQ, Oral, AbstractID=19204

Time-series responses of phytoplankton and periphyton periphytic microalgae to nutrient enrichment in a summer coastal mesocosm

Ji Nam **Yoon**[1], Young kyun Lim[3] and Seung Ho Baek[1,2]

[1]Ecological Risk Research Department, KIOST (Korea Institute of Ocean Science and Technology), Geoje, R Korea. E-mail: jnyoon@kiost.ac.kr
[2]Department of Ocean Science, University of Science and Technology (UST), Daejeon, R Korea
[3]Ocean Climate Response & Ecosystem Research Department, KIOST (Korea Institute of Ocean Science and Technology), Busan, R Korea

We investigated the time-series responses of water-column phytoplankton and plastic-associated periphytic microalgae to nutrient enrichment in large-scale summer coastal mesocosms(1000L). The experiment was designed to simulate the simultaneous input of nutrients and land-based plastic debris into coastal waters after rainfall. Mesocosms were established using natural seawater as a control, low-nutrient treatment, and high-nutrient treatment, and polypropylene(PP) attachment plates were used as artificial substrates representing marine plastic debris. After nutrient addition, dissolved inorganic nutrients in the water column rapidly decreased, accompanied by a marked increase in diatom abundance. The phytoplankton community was initially dominated by the centric diatom *Leptocylindrus danicus*, but the dominant taxa shifted according to nutrient availability. Under nutrient-enriched conditions, relatively large diatoms such as *Chaetoceros* spp. increased rapidly before nutrient depletion. As nutrients became depleted, the community shifted toward smaller diatoms, including *Pseudo-nitzschia* spp. and *Cylindrotheca closterium*, suggesting that species-specific nutrient utilization strongly controlled phytoplankton succession. On the polypropylene attachment plates, periphytic microalgae gradually developed during the experimental period, and *C. closterium*, *Nitzschia longissima*, *Frustulia* sp., and *Navicula* sp. were observed. Among these taxa, *C. closterium* became the dominant attached species during the middle to late stages of the experiment, particularly when nutrients in the water column were depleted. The dominance of *C. closterium* in both planktonic and attached communities indicates that this species may have a competitive advantage under low-nutrient conditions and may readily colonize plastic surfaces. Overall, our results suggest that rainfall-driven nutrient inputs can induce rapid phytoplankton succession in coastal waters, while plastic debris may provide an important substrate for the attachment and potential dispersal of periphytic microalgae. These findings highlight the ecological importance of considering both nutrient loading and plastic debris when assessing coastal microalgal community dynamics.

MEQ, Oral, AbstractID=19244

Functional characterization of algicidal bacteria through polysaccharide degradation and carbon source utilization

Nobuharu **Inaba**, Mizuna Ii, Takuma Matsumoto and Sawako Shirai

Public Works Research Institute, Sapporo, Japan. E-mail: inaba-n@ceri.go.jp

Recent findings suggest that coastal vegetation, including seagrass and macroalgal beds, can serve as reservoirs for algicidal bacteria (AB), indicating their potential role in controlling harmful algal blooms (HABs). However, the ecological factors underlying the high abundance of AB in such vegetated coastal ecosystems remain poorly understood. In the present study, AB isolates targeting the harmful dinoflagellate *Karenia mikimotoi*, found on kelp surfaces and in surrounding environments, were evaluated for their degradative activities against major kelp-derived polysaccharides using agar plates and for carbon-source utilization profiles based on tetrazolium dye reduction. Alginate-degrading activity was not detected in AB strain isolated from sediment in December, when only juvenile kelp was present. In contrast, most AB strains isolated from the kelp surfaces and the surrounding environments during the kelp bed decline period (June to September) showed alginate-degrading activity. Furthermore, laminarin-degrading activities were also observed in several AB strains isolated during the decline period. Through testing the utilization of different carbon sources, several AB strains were found to metabolize carbon sources related to algal-derived organic matter, including D-mannitol, a major photosynthetic product of brown algae, and D-cellobiose, a cellulose-derived oligosaccharide associated with cellulose, which occurs as a structural component of kelp cell walls. Our findings suggest that AB strains detected on kelp surfaces and in the surrounding environment utilize and degrade organic matter abundant in kelp beds, thereby proliferating and contributing to material cycling within kelp-bed ecosystems.

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Degradation rate of *Acartia omorii* faecal pellets based on microplastic size

Gaeun **Kim** and Wongyu Park

Pukyong National University, Busan, R Korea. E-mail: happy526700@naver.com

Zooplankton faecal pellets (FP) are key components of the biological pump. The efficiency of FP export depends on sinking and degradation rates, which are influenced by structural properties, environmental factors and biological interactions. Microplastics (MP) are emerging marine stressor that can be ingested by zooplankton including copepods, and can alter the density and structural stability of FP. This study investigated how MP sizes (0.53, 5.9, and 10.3 μm) affected FP degradation. To distinguish degradation mechanisms, we evaluated environmental degradation across different temperatures (10, 15, and 20°C), and biological degradation mediated by *Acartia omorii* through ingestion (coprophagy) and fragmentation (coprorhexy). MP size affected FP fragmentation and degradation in both environmental and biological degradation experiments. In temperature treatments, the 5.9 and 0.53 μm group exhibited the higher fragmentation and degradation rates than control and 10.3 μm groups. Both fragmentation and degradation rate increased with temperature. On the other hand, under the condition which *A. omorii* was present, fragmentation and degradation rates were higher in the 0.53 and 10.3 μm groups, while the 5.9 μm group exhibited lower rates. Our results suggest that MP size alters structural characteristics of FP and that its effects differ between environmental and biological processes. These differences may imply FP carbon transport efficiency in marine ecosystems.

MEQ, Oral, AbstractID=19348

Development and operational status of the nationwide continuous seawater radioactivity monitoring system in Korea

Jaehong **Park**, Junha Kim and Jong-in Byun

Korea Institute of Nuclear Safety, Daejeon, R Korea. E-mail: pjh@kins.re.kr

Following the Fukushima accident, significant concerns emerged regarding the leakage of radioactive materials into the marine environment caused by nuclear power plant (NPP) incidents. Nevertheless, the demand for nuclear energy has recently increased, driven by global decarbonization and explosive electricity demand from rising hyperscale data center construction.

In particular, China accounts for a significant portion of this expansion, with numerous NPPs currently operating and under construction along its eastern and southern coasts. Consequently, unexpected accidents leading to marine radioactive material discharge could cause catastrophic damage to neighboring countries, including Korea.

Since the Fukushima accident, social concern has prompted the reinforcement of Korea's marine radioactivity monitoring system, including the establishment of the Seawater Radioactivity Monitoring System Network (SeRaNet) which is an on-site continuous monitoring system.

A seawater radioactivity monitor is deployed in seawater directly with a sodium iodide (NaI) scintillator to detect gamma radiation, focusing on ^{137}Cs. Furthermore, volumetric counting efficiency is estimated using MCNP simulations to calculate the radioactive concentration. The minimum detectable concentration derived from the ^{137}Cs ROI from 15-minute gamma-ray spectra is below 5 Bq/L. Separately, we developed an "on-land" type device that continuously detects radioactivity in pumped seawater in coastal areas or on-board with simple lead shielding.

This study aims to introduce the marine radioactivity monitoring system of Korea, the operational status of SeRaNet, its analysis techniques, and device development. It would provide a valuable opportunity to share the case and experience of continuous seawater radioactivity monitoring on a nationwide scale.

MEQ, Oral, AbstractID=19377

Gaps, barriers, and pathways for strengthening shellfish safety monitoring and marine environmental quality through First Nations-led collaboration in British Columbia, Canada

Svetlana **Esenkulova** and Jessica Moffatt

Island Marine Aquatic Working Group (IMAWG), BC, Canada. E-mail: Svetlana@imawg.ca

Shellfish harvesting and aquaculture are important components of food security, cultural continuity, and coastal economies in British Columbia, supporting food sovereignty for many First Nations. Access to these marine resources is influenced by environmental conditions and the capacity of marine environmental quality and seafood safety monitoring systems. Harmful algal blooms (HABs) and associated biotoxins are a recurring feature of coastal ecosystems that influence shellfish harvesting opportunities and monitoring requirements. While the Canadian Shellfish Sanitation Program provides a robust national framework for seafood safety, operational challenges associated with monitoring coverage, laboratory capacity, analytical turnaround times, and information accessibility can affect local harvest opportunities.

The WATCH (We All Take Care of the Harvest) initiative, coordinated by the First Nations-led Island Marine Aquatic Working Group (IMAWG), serves as a platform for engagement on issues related to seafood safety, security, and Indigenous food sovereignty in coastal British Columbia. An integrated review of WATCH-related assessments, workshop outcomes, and Indigenous interview data identified persistent challenges related to monitoring coverage, laboratory capacity, governance, data accessibility, climate preparedness, and integration of Indigenous knowledge. Existing regulatory frameworks remain largely oriented toward commercial production while Indigenous food security, cultural harvesting, and community stewardship priorities may be less well represented.

Findings identified opportunities to strengthen shellfish safety through improved coordination, expanded community-based monitoring, increased transparency, incorporation of long-term environmental datasets, remediation initiatives, and enhanced participation of Indigenous communities within existing monitoring and management processes. This presentation examines how community-based observations and environmental monitoring may complement existing programs and contribute to more locally relevant information to support seafood safety, environmental stewardship, and resilience under changing environmental conditions.

MEQ, Oral, AbstractID=19483, (ECOP)

Uptake of marine biotoxins by blue mussels in an ancestral sea garden

Mackenzie **Mueller**[1], Andrew R.S. Ross[1], Erich Kelch[2], Bryant DeRoy[2] and Erin Slade[2]

[1]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: Mackenzie.Mueller@dfo-mpo.gc.ca
[2]Parks Canada, Sidney, BC, Canada

Sea gardens are a traditional way of managing and enhancing shellfish production in intertidal areas. However, shellfish grown in sea gardens can still be exposed to marine biotoxins produced by harmful algae. The restoration of sea gardens within the Gulf Islands National Park Reserve, British Columbia (B.C.), Canada by Hul'q'umi'num and W̱SÁNEĆ First Nations has been facilitated by Parks Canada who, in partnership with the Canadian Food Inspection Agency and Fisheries and Oceans Canada, have been studying the uptake of algal biotoxins by shellfish at the Russell Island sea garden. Biotoxins capable of harming shellfish or causing amnesic, paralytic or diarrhetic shellfish poisoning were detected in sea water at Russell Island in 2024. Biotoxin concentrations showed seasonal patterns consistent with those previously observed in B.C. coastal waters. Saxitoxins, which can cause paralytic shellfish poisoning, and yessotoxin, which can harm shellfish, were detected in blue mussel tissues. Initial uptake coincided with a significant increase in toxin levels in sea water. However, subsequent reduction in tissue concentrations depended on the toxin with saxitoxin levels falling more quickly that those of the relatively lipophilic yessotoxin. These initial results shed new light on the relationship between biotoxin concentrations in shellfish and those in the surrounding sea water, suggesting that trends in the latter may be used to predict biotoxin exposure and uptake in shellfish.

MEQ, Oral, AbstractID=19520, (ECOP)

Incidence of anthropogenic microparticles in juvenile shortbelly rockfish captured by rhinoceros auklets

Laila A. **SanAhmadi**[1], Ellen Hines[1], Ed Carpenter[1], and Jaime Jahncke[1,2]

[1]Estuary Ocean Science Center, San Francisco State University, Tiburon, CA, USA.
E-mail: lsanahmadi@sfsu.edu
[2]Point Blue Conservation Science, Petaluma, CA, USA

Plastic marine debris has increased since the 1970s and is now one of the most widespread pollutants in marine ecosystems, with documented effects on seabirds through both direct ingestion and trophic transfer. Long-term biological monitoring is needed to understand temporal patterns of plastic exposure and to develop comparable indicators across marine ecosystems. In this study, juvenile shortbelly rockfish (Sebastes jordani; n = 30 per year) collected from rhinoceros auklets (Cerorhinca monocerata) on Southeast Farallon Island were chemically digested to quantify ingested particles across seven years (2012–2017 and 2024). Except for 2012 (73%), 2013 (76%), and 2016 (90%), anthropogenic microparticles were detected in more than 95% of fish using epifluorescence microscopy. Because epifluorescence microscopy may also detect non-plastic materials, these particles are conservatively classified as anthropogenic microparticles. Fourier Transform Infrared (FTIR) spectroscopy was used to analyze one particle per fish, confirming polymer identity and revealing a diverse range of plastic types across years. These results demonstrate that forage fish represent an important pathway for anthropogenic microparticles to enter higher trophic levels while providing a consistent biological indicator for long-term monitoring of plastic pollution in the California Current. Standardized sampling and analytical approaches, combined with sustained time series, can improve comparisons among monitoring programs and contribute to the development of harmonized plastic pollution indicators across the North Pacific.

MEQ, Oral, AbstractID=19535, (ECOP)

Assessment of anthropogenic microparticles in Cassin's auklets on Southeast Farallon Island

Margaret **Shiple**[1,2], Tamara Russell[3], Vance Thomas Vredenburg[1,2], Jaime Jahncke[1,2]

[1]San Francisco State University, San Francisco, CA, USA. E-mail: mshiple@mail.sfsu.edu
[2]Point Blue Conservation Science, Petaluma, CA, USA
[3]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA,

Microplastic ingestion has been associated with gastrointestinal damage, altered gut microbial communities, and reduced reproductive success and survival in seabirds. Despite growing concern over these impacts, microplastic exposure remains poorly characterized for many offshore seabird species within the California Current Ecosystem (CCE). Cassin's auklets (*Ptychoramphus aleuticus*) are abundant planktivorous seabirds that can serve as useful indicators of offshore contaminant exposure through marine food webs. The Southeast Farallon Islands (SEFI), an important breeding colony for seabirds in the CCE, lie downstream of the San Francisco Bay Estuary, where both terrestrial and marine sources may contribute plastic debris to offshore food webs. Despite this potential exposure pathway, anthropogenic microparticle contamination in breeding seabirds on SEFI has not previously been evaluated. This study provides the first baseline assessment of anthropogenic microparticles, including microplastics, in Cassin's auklets breeding on SEFI. Preliminary results from analyses of diet and guano samples are presented to quantify anthropogenic microparticles and characterize the morphology and polymer composition of recovered particles. Regurgitated diet samples and guano provide a minimally invasive approach for assessing recently ingested particles and can be collected alongside ongoing colony monitoring with minimal disturbance to breeding seabirds. These findings provide a practical framework for offshore wildlife-based microplastic surveillance, provide the first baseline estimate of anthropogenic microparticle exposure in Cassin's auklets at SEFI, and inform future source attribution and ecological risk assessment efforts along the California coast.

POC PAPER SESSION

Oral Presentations

POC, Oral, AbstractID=19166, (ECOP)

Formation-based evaluation of mesoscale eddy impacts on primary production in the North Pacific

Hironori **Miyasaka**[1], Hiromichi Ueno[1], Eun Yae Son[1], Hatsumi Nishikawa[1] and Sachiko Yoshida[2]

[1]Hokkaido University, Hakodate, Hokkaido, Japan.
E-mail: miyasaka.hironori.i4@elms.hokudai.ac.jp
[2]University of Hawai‘i at Mānoa, Honolulu, Hawaii, USA

Mesoscale eddies influence marine primary production through nutrient transport and water mass redistribution. Previous studies have primarily evaluated eddy impacts on primary production in regions where eddies are present. However, such existence-based approaches do not reveal where the eddies responsible for large changes in primary production were originally formed. In this study, we focus explicitly on eddy formation regions and aim to identify where eddy formation leads to strong impacts on primary production in the North Pacific using satellite observations.

We analyzed mesoscale eddy trajectories using Mesoscale Eddy Trajectory Atlas Product (META3.2 DT allsat) together with satellite-based NPP estimates from the Standard Vertically Generalized Production Model (VGPM) for the period 2003–2020. To quantify eddy impacts, we calculated a climatological NPP field representing non-eddy conditions at each location. Eddy-induced anomalies are defined as the difference between observed NPP and this baseline within eddy regions. The lifetime-integrated anomalies of individual eddies were aggregated by formation region (formation-based analysis) to identify areas where eddy formation strongly influences primary production.

When eddy anomalies are aggregated in regions where eddies are present (existence-based analysis), as in previous studies, the spatial distribution of eddy-induced NPP anomalies is broadly consistent with reported relationships between sea surface height anomalies and chlorophyll-a concentration, supporting the robustness of the approach. More importantly, the formation-based analysis highlights regions where eddy formation exerts a strong impact on NPP. Pronounced eddy formation regions with strong impacts on primary production are identified in the Kuroshio Extension, the Gulf of Alaska, the California Current System, the Hawaiian region, and the eastern tropical North Pacific.

In particular, the Hawaiian region, the Gulf of Alaska, and the Kuroshio Extension show stronger signals in the formation-based analysis than in the existence-based analysis, indicating that eddies formed there play an important role in modulating NPP, including influences extending beyond their immediate formation areas.

POC, Oral, AbstractID=19248, (ECOP)

Mitigating excessive TC-induced cooling and its negative feedback in an air-sea coupled model with submesoscale parameterization

Huaxin **Wang**[1,2,3], Zhiwei Zhang[1,2,3], Zhouqing Xu[1,2,3], Zhe Feng[1,2,3] and Jinchao Zhang[1]

[1]State Key Laboratory of Physical Oceanography and Frontiers Science Center for Deep Ocean Multispheres and Earth System (FDOMES)/Key Laboratory of Ocean Observation and Information of Hainan Province, Sanya Oceanographic Institution, Ocean University of China, Qingdao/Sanya, PR China. E-mail: wanghuaxin@stu.ouc.edu.cn
[2]SANYA Oceanographic Laboratory, Sanya, PR China
[3]Laboratory for Ocean Dynamics and Climate, Qingdao Marine Science and Technology Center, Qingdao, PR China

Submesoscale processes generate vigorous vertical heat fluxes that are critical for the oceanic thermal recovery of tropical cyclone (TC)-induced cold wakes, yet these processes remain unresolved in most air–sea coupled models, leading to excessive cold-wake cooling and an underestimated upward heat supply.This deficiency weakens air–sea heat exchange and imposes a negative feedback that suppresses the development of subsequent TCs traversing this wake. To address this deficiency, we implement the Zhang23 submesoscale parameterization in an eddy-resolving coupled model to quantify the extent to which submesoscale processes can alleviate this cold-wake-induced negative feedback on a subsequent TC. Compared with the non-parameterized control simulation, the Zhang23 scheme reduces the cold-wake sea surface temperature (SST) cooling bias by over 40%, yielding enhanced net heat fluxes and a greater oceanic heat supply to the subsequent TC. Analysis of the 10-m wind speed and sea level air pressure fields reveals a pronounced response to these SST changes: within a 500-km radius of the TC inner core, approximately 60% of the area exhibits increased wind speeds, while roughly 80% shows reduced sea level air pressure. A diagnostic evaluation of TC intensity further demonstrates that, after transiting the first TC's cold wake, the subsequent TC in the Zhang23 experiment is ~10% stronger than its counterpart in the control simulation. These findings highlight the Zhang23 parameterization can substantially improve the representation of air–sea coupling during TC passages and holds promise for advancing TC intensity forecasts in intermediate-resolution coupled models.

POC, Oral, AbstractID=19250

Submesoscale vertical heat flux accelerates upper-ocean warming

Zhiwei **Zhang**[1,2,3]

[1]State Key Laboratory of Physical Oceanography and Frontiers Science Center for Deep Ocean Multispheres and Earth System (FDOMES)/Key Laboratory of Ocean Observation and Information of Hainan Province, Sanya Oceanographic Institution, Ocean University of China, Qingdao/Sanya, PR China. E-mail: zzw330@ouc.edu.cn
[2]SANYA Oceanographic Laboratory, Sanya, PR China
[3]Laboratory for Ocean Dynamics and Climate, Qingdao Marine Science and Technology Center, Qingdao, PR China

The ocean has absorbed approximately 90% of the excess heat related to anthropogenic greenhouse gas emissions, fundamentally reshaping its thermodynamic structure and modulating global climate change. Although the response of multi-scale ocean dynamics—from basin-scale circulation to mesoscale eddy—to this forcing is increasingly documented, the climatic imprint of submesoscale eddies with horizontal scales of 1–30 km has persisted as a blind spot in climate science due to observational and computational limitations. In this study, by applying an innovative submesoscale parameterization scheme to observational datasets between 1993 and 2024, we find a significant intensification trend of submesoscale vertical heat flux (VHFsm) in the global ocean. The increasing hotspots are concentrated in western boundary currents and the Antarctic Circumpolar Current, where trends reach ~10 W·m-2/decade—an order of magnitude greater than corresponding trends in net air-sea heat flux. This amplification is mechanistically linked to mixed-layer deepening. Heat budget analysis reveals that enhanced VHFsm contribute substantially to the accelerated upper-ocean warming, thereby having broad implications for the climate system. These results highlight the crucial role of submesoscale eddies in upper-ocean warming and underscore the necessity of incorporating submesoscale parameterization into climate models to enhance the accuracy of climate projections.

POC, Oral, AbstractID=19254, (ECOP)

Subsurface submesoscale vortices in the Kuroshio recirculation gyre: Origins and implications for mode water formation

Silvana **Duran** and Takeyoshi Nagai

Tokyo University of Marine Science and Technology, Tokyo, Japan.
E-mail: silvanadg20@hotmail.com

The Kuroshio Extension recirculation gyre is a major formation site of North Pacific subtropical mode water (STMW), where atmospheric forcing during wintertime contribute to the generation of low-potential vorticity (PV) waters. In addition to wintertime deep convection, previous studies in the North Atlantic have suggested that intrathermocline eddies (ITEs), formed through wind-driven driven slantwise convection processes, can subduct and trap low-PV waters beneath the mixed layer, thereby supporting mode water formation and maintenance. However, subsurface coherent vortices (SCVs) in the region may also originate from interactions between the Kuroshio flow and complex topography, particularly around the Izu Ridge, where flow-topography interactions can generate submesoscale vortices and potentially promote the upward transport of deeper waters.

This study investigates the origin and pathways of subsurface submesoscale vortices within the Kuroshio recirculation gyre. Particular attention is given to distinguishing SCVs associated with surface mixing processes from those generated by topographic interactions. To this end, a high-resolution (2-km) ocean model is used to detect and track subsurface eddies below the mixed layer, and the water masses and dynamics within them. This work aims to clarify the role of subsurface submesoscale vortices in mode water formation and in the vertical exchange of properties between the thermocline and upper ocean.

POC, Oral, AbstractID=19297

Local and remote controls on wintertime downwelling and upwelling off Vancouver Island

Shiliang **Shan**[1,2] and Charles Hannah[3]

[1]Royal Military College of Canada, Kingston, ON, Canada. E-mail: dan.shan.rmc@gmail.com
[2]Queen's University, Kingston, ON, Canada
[3]Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada

Winter circulation along the shelf break off Vancouver Island is dominated by downwelling, interrupted by episodic upwelling events. Using multi-year mooring observations and ocean-atmosphere reanalysis fields, we examine along-slope velocity, sea level, and density to distinguish local forcing by winds off Vancouver Island from remote influences originating along the U.S. West Coast, and to assess northward connectivity with Queen Charlotte Sound. Preliminary comparisons suggest that the vertical shear of the along-slope velocity at the southwestern Vancouver Island shelf-break mooring is broadly consistent with the cross-shelf density field through thermal-wind balance and may represent the sign and relative intensity of many winter downwelling and episodic upwelling events. This relationship is less direct when variability in the California Undercurrent modifies the subsurface flow. When local winds are poleward while winds farther south along the U.S. West Coast are strongly equatorward, the locally forced upper-ocean response may be superimposed on a remotely modulated poleward California Undercurrent, so the shear cannot be interpreted from local winds alone. Associated anomalies may extend northward into Queen Charlotte Sound, but their expression may differ between open-shelf and nearshore regions because of local bathymetry and winds. The vertical velocity shear is therefore proposed as a conditional, physically interpretable indicator, with density and sea-level variability providing complementary information on wintertime local and remote connectivity along the continental margin off Vancouver Island.

POC, Oral, AbstractID=19329, (ECOP)

Observed intraseasonal variability of the Kuroshio Current in the East China Sea and its different responses to mesoscale eddies on the offshore and onshore sides of the current path

Minsauk **Kang**[1], Hanna Na[1], SeungYong Lee[2], Hong Sik Min[2], Dong Guk Kim[2], Chanhyung Jeon[3], Jae-Hun Park[4], Hirohiko Nakamura[5], Ayako Nishina[5] and Eisuke Tsutsumi[5]

[1]School of Earth and Environmental Sciences, Seoul National University, Seoul, R Korea. E-mail: kangms124@snu.ac.kr
[2]Ocean Circulation and Climate Research Department, Korea Institute of Ocean Science and Technology, Busan, R Korea
[3]Department of Oceanography, Pusan National University, Busan, R Korea
[4]Department of Ocean Sciences, Inha University, Incheon, R Korea
[5]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan

The Kuroshio in the East China Sea (ECS-Kuroshio) is an important component of the northwestern Pacific circulation system and exhibits pronounced intraseasonal variability. Mesoscale eddies have been recognized as one of the primary drivers of this variability; however, the extent to which the ECS-Kuroshio responds to mesoscale eddies remains poorly understood. This study investigates the spatial differences in the ECS-Kuroshio intraseasonal (50–150-day) variability using 75 kHz ADCP mooring observations at three sites from June 2020 to June 2025. The two offshore sites (KCM3a and KCM4a) exhibited dominant variability in the along-path velocity, whereas the one onshore site (KCM4) showed dominant variability in the cross-path velocity. Composite analyses revealed mesoscale eddies east of Taiwan and south of the Kerama Gap as the primary drivers of intraseasonal variability in the along-path velocity at KCM3a and KCM4a. These velocities are significantly correlated, with KCM3a (upstream) leading KCM4a (downstream) by approximately two days ($r = 0.63$). Meanwhile, the limited along-path but strong cross-path variability at the onshore site (KCM4) suggests that the influence of mesoscale eddies differs between the offshore and onshore sides of the current path over the 50–150-day period. These results highlight that mesoscale eddies are the dominant driver of intraseasonal variability at the offshore side of the ECS-Kuroshio, whereas variability at the onshore side likely reflects a more complex dynamical process.

POC, Oral, AbstractID=19334

Mesoscale cyclonic eddies inject nutrients of the Kuroshio nutrient stream to the Kuroshio recirculation gyre

Takeyoshi **Nagai**[1], Yuki Kaneko[1], Yuki Ikeda[1], Minoru Kitamura[2], Chiho Sukigara[2], Makio C. Honda[2], Naho Miyazaki[1], Otero Huaman Diego Andre[1], Duran Gomez Gloria Silvana[1], Itsuka Yabe[3]

[1]Tokyo University of Marine Science and Technology, Tokyo, Japan.
E-mail: tnagai@kaiyodai.ac.jp
[2]Japan Agency for Marine-Earth Science and Tocology, Kanagawa, Japan
[3]Fukui Prefectural University, Fukui, Japan

Although surface layers of the western North Pacific subtropical gyre, where the Kuroshio Current flows along its northwestern rims, are known to be nutrient-poor, the Kuroshio and Kuroshio Extension regions are one of the most fertile fishing grounds and major net CO_2 sinks for the atmosphere. On the other hand, subsurface layers of the Kuroshio carry nutrients from the south to the Kuroshio Extension region as a nutrient stream, which could be supplied to the euphotic layer to promote the biological pump and CO_2 uptake by the ocean. Previous studies have shown that the high primary production and carbon export flux in the Kuroshio recirculation gyre are attributed to the mesoscale cyclonic eddies. However, it remains unclear how much nutrients can be injected by turbulence near cyclonic eddies and where these nutrients within the cyclonic eddies come from. In this study, data obtained from a tow-yo microstructure profiler within a cyclonic eddy during July 2019 R/V Hakuho-Maru cruise were examined to quantify diffusive nitrate flux. In addition, using a triple-decomposition framework, along isopycnal stirring flux of nitrate near the cyclonic eddy is estimated. Furthermore, mesoscale cyclonic eddies in the Kuroshio recirculation gyre are reproduced by an eddy-resolving numerical model coupled with an ecosystem model and are detected and tracked from which Lagrangian particles are released and traced back in time to discern the origin of nutrients. The results indicate that turbulence is enhanced in the uplifted pycnocline near the center of the cyclonic eddy, where clear subsurface chlorophyll-a maxima appear, resulting in large vertical nitrate diffusive fluxes of 0.1-1mmol N m^{-2} day^{-1}. Along the density surfaces of $\sigma_\Theta < 26.5$, the nitrate concentration is less near the center of the eddy than the edge since it is consumed by phytoplankton near the eddy center, leading to an along isopycnal stirring flux directed to the center of the eddy. The particle tracking back in time indicates most of the nitrate within upper 350 m of the cyclonic eddies originates from the Kuroshio upstream.

POC, Oral, AbstractID=19338, (ECOP)

Seasonal modulation of nitrate availability by eddy fluxes and upwelling-favorable winds at submesoscales in the Eastern Tropical Pacific

Diego A. **Otero Huaman** and Takeyoshi Nagai

Tokyo University of Marine Science and Technology, Tokyo, Japan.
E-mail: otero.diego.andre@gmail.com

The eastern tropical Pacific (ETP) is one of the most productive regions worldwide, with moderately high chlorophyll concentrations sustained by the upward transport of nutrient-rich waters. In this region, upwelling is primarily driven by zonal winds that promote divergence and the vertical supply of nitrate to the euphotic layer. Previous studies have identified several mechanisms that modulate chlorophyll (CHL) variability throughout the year, including tropical instability waves, vertical shear, and turbulent mixing. However, the extent to which the seasonality of upwelling-favorable winds (UFW) influences eddy activity and, consequently, the fate of nitrate in the Northern and Southern Hemispheres remain insufficiently addressed under climatological conditions. Although the strongest UFW occur near 140°W, nitrate concentrations are not necessarily highest along the equator, suggesting that other processes may shape nitrate availability. Considering the clear latitudinal asymmetry of nitrate in the ETP, this raises the question of whether and how much eddy activity is crucial for its spatial and seasonal distribution. Using a submesoscale-permitting CROCO configuration coupled to the BioEBUS biogeochemical model, we find that submesoscale eddy fluxes have a stronger impact in the Northern Hemisphere (NH) than in the Southern Hemisphere (SH), with eddy-driven nitrate subduction within the upper 100 m between 140°W and 100°W, particularly during NH autumn. In contrast, the SH exhibits its strongest nitrate subduction during winter and spring, mainly near the western coast of South America. These results suggest that the seasonal modulation of UFW generates hemispherically asymmetric eddy activity, influencing the fate of nitrate through both vertical subduction and horizontal redistribution in the ETP, reducing the surface nitrate in the NH – ETP more than in SH – ETP.

POC, Oral, AbstractID=19340, (ECOP)

Scale dependency of isopycnal stirring coefficients from observational estimates in the Kuroshio Extension

Yuki **Ikeda** and Takeyoshi Nagai

Tokyo University of Marine Science and Technology, Tokyo, Japan.
E-mail: yikeda3501@gmail.com

Isopycnal stirring strongly influences the transport of tracers in the ocean, and recent studies have highlighted the importance of tracer stirring induced by strain in the resolved flow. However, observational estimates of effective stirring coefficients and their grid-scale dependence remain limited in regions where large-scale strain is important. Here, we evaluate the grid-scale dependence of the isopycnal stirring coefficient, along the Kuroshio Extension by comparing two independent estimates: one derived from mixing-length theory applied to finescale observations and the other based on a refined triple-decomposition framework applied to microscale measurements. To account for double-diffusive mixing, the triple-decomposition framework incorporates the continuous turbulence formulations of Canuto et al. (2008,2010). We find that and within the enstrophy inertial subrange. These scalings are substantially shallower than the dependence predicted for scale-local stirring based on a kinetic-energy spectrum, and are instead close to the 4/3-power scaling associated with shear-dominated stirring, suggesting a contribution from scale-nonlocal stirring by larger-scale flow deformation. Furthermore, the observed three-dimensional anisotropy of Spice gradients is more consistent with the local isopycnal slope associated with the thermal-wind balance of the large-scale baroclinic jet than with the N/f aspect ratio expected from quasi-geostrophic turbulence. Together, these results suggest that isopycnal stirring in the Kuroshio Extension is influenced not only by scale-local eddy motions but also by deformation associated with the large-scale baroclinic flow.

POC, Oral, AbstractID=19352

Mechanisms generating a subsurface temperature minimum in a silled, temperate fjord

Laura **Bianucci**[1], Michael G. Foreman[1], Jonathan Izett[2], Wendy Callendar[1], Jennifer M. Jackson[1], Amber M. Holdsworth[1], Angelica Peña[1], Debby Ianson[3], Cheryl Greengrove[4] and Glenn Gooper[1]

[1]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada.
E-mail: laura.bianucci@dfo-mpo.gc.ca
[2]CanadianCentre for Climate Modelling and Analysis, Environment and Climate Change Canada, Victoria, BC, Canada
[3]University of Victoria, Victoria, BC, Canada
[4]University of Washington - Tacoma, Tacoma, WA, USA

Since the 1960s and even earlier, studies in many fjords of the west coast of Canada have shown the presence of minima or maxima values in subsurface layers for variables such as temperature and oxygen. In particular, a recent study identified low-oxygen (hypoxic) subsurface waters as shallow as 12 meters in Herbert Inlet, a fjord that has also shown evidence of a subsurface temperature minimum. This inlet belongs to Clayoquot Sound, a system of fjords with a very shallow (~5 meters) outside sill, located in the traditional territory of the Ahousaht (ʕaaḥuusʔatḥ) First Nation. Previously, seasonal large-scale wind-driven upwelling had been hypothesized to play a leading role in the generation of the low-oxygen/cold-temperature layer in Herbert Inlet, as it was shown to be the key forcing in other inlets in the mainland of western Canada (e.g., in Rivers Inlet wind-driven upwelling drives the deep-water renewal inside the fjord with saltier, warmer and more oxygenated waters from offshore). Here, we use a high-resolution physical ocean model of the region to study the formation of the subsurface temperature minimum in Herbert Inlet. Our results show that the key dynamics in Herbert Inlet are intense tidal mixing over the shallow sill and the consequent advection of the resulting water mass (saltier, warmer and oxygen-rich) into the inlet at flood tide. While wind-driven upwelling may not be a primary driver, we investigate whether it plays a role modulating the shelf conditions by comparing years with stronger and weaker upwelling seasons.

POC, Oral, AbstractID=19460

Role of wind conditions in sea ice retreat in the Bering Sea

Kirill **Kivva**[1], Aleksandra Malysheva[1,2], Aleksandra Sumkina[1]

[1]Russian Federal Research Institute of Fisheries and Oceanography, Moscow, Russia.
E-mail: kivva@vniro.ru
[2]Department of Oceanology, Faculty of Geography, Lomonosov Moscow State University, Moscow, Russia

Date of sea ice retreat (DOR) is an important indicator of climate state and physical factor influencing many biological processes. We investigate DOR in the Bering Sea and surrounding waters based on CDR NSIDC dataset (daily satellite data on sea ice concentration, spatial resolution of 25 km, 1979–2023). In every grid cell, DOR was accessed as the beginning of the period with sea ice concentration below 0.15. Resulting DOR field was clustered in two stages. Both stages employed DBSCAN method which requires setup of two parameters, minPts (minimum number of points in a group) and eps (radius of point search). The parameters were set using diagrams with number of groups or amount of 'noise' cells. During the first stage, clustering is done for every time window of 20 years with Spearman correlation coefficient as the similarity metric. The results of the first stage (cluster numbers) are used further as categorical variables during the second stage. This allowed to distinguish 6 groups of grid cells within which synchronous DOR variability was observed most often during considered 20-years intervals. 2 of those 6 groups were identified in the Bering Sea, and the rest of them in the Pacific Arctic Ocean. Wind conditions were suggested as the main factor influencing DOR. We tested circular correlation coefficients between DOR and wind direction for every grid cell. Eastern Bering Sea group showed stronger significant correlation between DOR and wind direction comparing to the rest of the groups. DOR variability in the north may be influenced by advective heat flux.

POC, Oral, AbstractID=19496

Using ocean model product to support the State of the Pacific Ocean reporting

Guoqi **Han**

Fisheries and Oceans Canada, Sidney, BC, Canada. E-mail: Guoqi.Han@dfo-mpo.gc.ca

A 1/36-degree ocean model in the northeast Pacific is used to simulate ocean temperature, salinity and currents from 1993 onward. The ocean model is forced by hourly winds and heat flux, major ocean tides and climatological monthly river runoffs. The model monthly temperature, salinity and currents are in approximate agreement with in situ observations. Standardized indices of seasonal surface and bottom temperature are derived for subregions over the continental shelf and slope. Water transport is calculated at selected transects for the major shelf-scale currents: the Vancouver Island Coast Current, the California Undercurrent, and the Davidson Current (the current overlying the California Undercurrent). Standardized indices of seasonal transport are derived for these currents. The standardized indices for temperature and currents are updated and reported annually in the State of the Pacific Ocean Meeting organized by Fisheries and Oceans Canada and published in the Canadian Technical Report of Fisheries and Aquatic Sciences.

POC, Oral, AbstractID=19502, (ECOP)

Lateral stirring and intermittent California Undercurrent influence on the Southern Line

Giuliana **Berden**[1], Jody Klymak[1], Tetjana Ross[1,2], Guoqi Han[1,2]

[1]School of Earth & Ocean Sciences, Department of Physics & Astronomy, University of Victoria, Victoria, BC, Canada. E-mail: gberden@uvic.ca
[2]Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada

The California Undercurrent's signature does not arrive at offshore waters of the NE Pacific shelf-slope system steadily — it pulses, intermittently strengthening and weakening on timescales of days to weeks. This intermittent signature is documented using 38 repeat glider transects ("Southern Line," off Vancouver Island, 2024–2026). The persistent cross-shore thermohaline gradient reflects mixing between the poleward California Undercurrent (CUC), carrying warm, saline Pacific Equatorial Water, and the colder Pacific Subarctic Upper Water of the Gulf of Alaska. On the $\sigma_0 = 26.6$ kg m^{-3} isopycnal — the core depth of CUC influence — temperature is bimodal, separating a nearshore CUC-influenced mode (~6.75°C) from a more mixed offshore mode. Along-transect variability follows a three-part pattern: low at both the nearshore and offshore regions, but elevated in the central section, where CUC influence intermittently strengthens or weakens. Vertical sections reveal coherent mesoscale and submesoscale features — sharp fronts, surface eddies, and subsurface "cuddies" — persisting for ~10 days along the transect. Depth-integrated geostrophic transport averages 0.41 ± 0.97 Sv; both the upper (0–200 m) and intermediate (200–900 m) layers are tied to shifts in the Alaska Gyre–subtropical gyre bifurcation, though this relationship is strongest in the upper layer (77% of variance explained by sea surface height gradients from satellite altimetry) and only partly captured by altimetric gradients at depth (35%). Spectral analysis of thermal anomalies along isopycnals yields slopes near −1.5, with no clear change with depth, and linked to changes in submesoscale and mesoscale variance. Possible drivers of this slope — upwelling-favorable winds, CUC influence, the position of the Alaska Gyre–subtropical gyre bifurcation, and eddy kinetic energy — are explored, without identifying a single, conclusive mechanism.

POC PAPER SESSION

Poster Presentations

POC, Poster, AbstractID=19125, PosterID: POC-P1

A framework for quantifying kinetic energy pathways in the ocean

Lixin **Qu**

Shanghai Jiao Tong University, Shanghai, PR China. E-mail: lixinqu@sjtu.edu.cn

Understanding the complex energy pathways between multi-scale eddies and internal waves is a fundamental issue in physical oceanography, impacting our understanding of the ocean energy budget and its ultimate dissipation. This study develops a framework that separately tracks the kinetic energy of eddy and wave motions across scales and motion types together with a strain-divergence decomposition. The resulting budget equations reveal three distinct classes of energy transfer: cross-scale transfer, which cascades energy to larger or smaller scales; intra-scale transfer, which redistributes energy between eddies and waves at the same scale; and inertial resistance, by which each motion type does work on the other through its resistance to acceleration. Applied to an idealized simulation of co-existing submesoscale eddies and near-inertial waves, the framework uncovers rich dynamical connections within and among the three classes of transfer, revealing how eddies and waves shape each other's energy pathways through both cooperative and competing mechanisms. This proof-of-concept demonstration establishes the framework's utility for quantifying fundamental energy pathways across diverse eddy–wave interaction scenarios.

POC, Poster, AbstractID=19134, PosterID: POC-P2

A direct estimate of horizontal spatial covariance from scalar velocities irregularly sampled at time-varying locations with synchronized time stamps

Hyeong Ji Yoon, Sung Yong **Kim**, and Jinwhan Kim

Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology, Daejeon, R Korea. E-mail: syongkim@kaist.ac.kr

In this study, we examine a direct estimate of the horizontal (isotropic or anisotropic) spatial covariance of two-dimensional orthogonal vector components from the spatial covariance of raw scalar velocities sampled at irregularly spaced, time-varying locations with synchronized time stamps. The conventional covariance estimate is decomposed into the product of radial velocities at spatial lags, composited into evenly spaced bins, and summed over realizations. For a sanity check, the assumed covariance function is used to generate the scalar and vector data, which are sampled irregularly in space and time-varying locations with synchronized time stamps. The estimated covariance is compared with the assumed (true) covariance. This approach will be used to Lagrangian surface drifters and Ocean Dynamics and Surface Exchange with the Atmosphere (ODYSEA) project data, which are sampled at time-varying locations.

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POC, Poster, AbstractID=19214, PosterID: POC-P3, (ECOP)

Season- and depth-dependent steric contributions to rapid sea level rise in the southwestern East Sea (Japan Sea) from 1993 to 2023

Seungsoo **Kim**[1], Young-Gyu Kim[2], KyungJae Lee[3] and SungHyun Nam[1,2,4]

[1]School of Earth and Environmental Science, Seoul National University, Seoul, R Korea.
E-mail: namsh@snu.ac.kr, rlatmdtn78@snu.ac.kr
[2]Future Innovation Institute, Seoul National University, Seoul, R Korea
[3]Department of Marine Science, Incheon National University, Incheon, R Korea
[4]Research Institute of Oceanography, Seoul National University, Seoul, R Korea

Regional sea-level rise (SLR) rates often exceed the global mean (2–4 mm/yr), thereby posing significant threats to coastal communities. Near Ulleung Island in the southwestern East Sea (Japan Sea), SLR rates of 5–7 mm/yr have been observed, but their season- and depth-dependent steric contributions remain poorly quantified. To address this, this study quantified these contributions from 1993 to 2023 by integrating satellite altimetry, tide-gauge records, and repeated CTD profiles. Linear regression was applied to estimate SLR rates, and the Thermodynamic Equation of Seawater - 2010 (TEOS-10) decomposed the upper-500 m steric sea level into thermosteric and halosteric components. Based on vertical temperature and salinity trends, the upper 500 m was divided into three layers: a warming–freshening Layer 1 (0–50 m), a warming–salinifying Layer 2 (50–200 m), and a warming–freshening Layer 3 (200–500 m). During 1993–2023, the annual-mean SLR rates derived from satellite altimetry and the Ulleung tide gauge were 6.29 ± 2.09 and 6.26 ± 1.99 mm/yr, respectively. The upper-500 m steric sea level trend was 3.00 ± 1.80 mm/yr, accounting for nearly 48% of the observed SLR rate. This contribution was dominated by thermosteric expansion (2.95 ± 1.81 mm/yr), with a negligible annual halosteric effect (0.05 ± 0.43 mm/yr). However, the halosteric effect varied seasonally and vertically, becoming more pronounced in autumn and near the Layer 1–Layer 2 interface. The steric contribution explained more than half of the observed SLR rate in winter (57.7%), spring (53.5%), and summer (50.2%), but only 38.1% in autumn. Vertically, steric sea level trends exhibited peaks near 50 and 150 m, with Layer 2 contributing the most. These results highlight the need to better resolve upper-ocean structures and their long-term changes for assessments of steric contributions to regional SLR.

POC, Poster, AbstractID=19215, PosterID: POC-P4, (ECOP)

Synoptic wind-dependent sampling asymmetry biases satellite sea surface chlorophyll-a in subpolar gyres

Qixiang **Wang**[1], Zhaohui Chen[1], Chao Zhang[2], Xiaogang Xing[3], Haihong Guo[1], Haiyuan Yang[1], Dapeng Li[1] and Wenju Cai[1,4]

[1]Frontier Science Center for Deep Ocean Multispheres and Earth System (FDOMES) and Physical Oceanography Laboratory, Ocean University of China, Qingdao, PR China.
E-mail: chenzhaohui@ouc.edu.cn, wangqixiang@stu.ouc.edu.cn
[2]Key Laboratory of Marine Environment and Ecology, Ministry of Education of China, Ocean University of China, Qingdao, PR China
[3]State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou, PR China.
[4]Laoshan Laboratory, Qingdao, PR China.

Satellite observations of sea surface chlorophyll-a concentration (SChl) provide a basin-scale record for interpreting marine productivity and upper ocean biogeochemical variability. However, clouds and other observational limits create gaps in SChl retrieval, which can bias the SChl record, especially in cloud-prone subpolar gyres. Here, we use satellite SChl data from 2010–2019 to quantify sampling bias associated with synoptic-scale wind speed conditions. Compared with low wind speed conditions, high wind speed conditions are often cloudy, yielding fewer valid retrievals of SChl as well as lower observed SChl in subpolar gyres of North Atlantic and North Pacific. The wind-speed-dependent sampling asymmetry biases mean SChl upward; for instance, the largest SChl bias occurs in winter, with local values reaching over 10%. The resulting SChl bias also propagates into satellite-based estimates of ocean productivity.

POC, Poster, AbstractID=19227, PosterID: POC-P5, (ECOP)

Influence of mesoscale eddies on double-diffusive heat fluxes in the East Sea/Sea of Japan

Woo Jin **Lee**[1], Young-Hyang Park[2], Isabelle Durand[2], Kwang Young Jeong[3], Young Taeg Kim[3], Min Su Kim[3], Baek Min Kim[4], Ho Kyung Ha[1]

[1]Department of Ocean Sciences, Inha University, Incheon, R Korea.
E-mail: hahk@inha.ac.kr, dave9901@naver.com
[2]LOCEAN Laboratory, Muséum National d'Histoire Naturelle, Paris, France
[3]Korea Hydrographic and Oceanographic Agency, Busan, R Korea
[4]Department of Environmental Atmospheric Sciences, Pukyong National University, Busan, R Korea

Double diffusion is a vertical mixing process arising from the differing molecular diffusivities of heat and salt, manifesting as salt finger when warm, salty water overlies cool, fresh water. This study examined the distribution of double-diffusive mixing in the East Sea/Sea of Japan (ESSJ) using hydrographic and hydrodynamic observations along the EA transect in November 2021. A suite of diagnostics—Turner angle, density ratio, Richardson number, Thorpe scale, and buoyancy Reynolds number—was applied to identify salt finger-favorable conditions and distinguish them from shear-driven turbulence. Salt finger conditions were predominantly observed within the neutral density layer g^n = 25.0–27.2, beneath the thermohaline structure influenced by the Ulleung Warm Eddy (UWE), where strong stratification and weak vertical shear provided a dynamically stable environment. Salt finger fluxes were estimated following Radko and Smith (2012), yielding downward heat fluxes of −0.34 to −1.05 W m^{-2}. Although group-averaged density ratios (3.58–3.89) indicated a moderate-to-weak regime, elevated buoyancy fluxes were sustained by the strong background stratification of the ESSJ thermocline. Among four hydrographic zones, the UWE core (UWE1) exhibited the highest group-mean fluxes, with heat and salt fluxes 1.7 and 2.1 times background levels. The estimated buoyancy fluxes (~10^{-10}–10^{-9} m^2 s^{-3}) agree with values from the northern ESSJ and Arctic warm eddy cores, suggesting mesoscale warm eddies as preferred sites for salt finger activity. The associated upward buoyancy flux implies a restratifying effect, indicating that double diffusion helps maintain thermohaline stratification in this semi-enclosed marginal sea.

POC, Poster, AbstractID=19266, PosterID: POC-P6

Development of a coupled physical-biogeochemical model of a mid-latitude fjord on Vancouver Island

Kyoko **Ohashi** and Laura Bianucci

Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada.
E-mail: kyoko.ohashi@dfo-mpo.gc.ca

We present a coupled physical-biogeochemical (BGC) numerical ocean model of a mid-latitude fjord system, developed to support local ecosystem-based management and climate-informed decision making. The study area, Quatsino Sound, is located on the Pacific coast of Vancouver Island and holds a productive ecosystem with traditional and economic activities. The modelling framework includes the Finite Volume Community Ocean Model (FVCOM) and the Integrated Compartment Water Quality Model (FVCOM-ICM), used respectively for the physical and BGC components. The model uses an unstructured grid with horizontal resolution varying from ~10 m to ~800 m. In this presentation, we will show the realistic performance of the hydrodynamic model, which is consistent with previous work using an earlier version of the model, as well as a preliminary assessment of the BGC model's performance. Observations made through this project (a collaboration among Fisheries and Oceans Canada, the Quatsino First Nation, and an industry partner) have greatly aided the modelling effort; for instance, these observations have highlighted the existence of severe hypoxic conditions in this fjord, which this model will aim to represent. We also discuss other possible model applications, such as simulating submerged aquatic vegetation to aid in restoration efforts and/or to study their effect on local carbon and oxygen cycles.

POC, Poster, AbstractID=19271, PosterID: POC-P7, (ECOP)

Ocean weather in coastal ecosystems: Wind and tidal controls on near-bottom habitat conditions

Trevor **Michalchuk** and Wiley Evans

Hakai Institute, Merville, BC, Canada. E-mail: trevor.michalchuk@hakai.org

Coastal marine organisms experience a dynamic environmental regime that can be conceptualized as *ocean weather*, where physical and biogeochemical conditions fluctuate across timescales ranging from hours to seasons. In shallow coastal systems, wind forcing and tidal exchange regulate the transport of oxygen, nutrients, heat, and carbonate chemistry throughout the water column, creating alternating periods of environmental stress and favourable growth conditions. Understanding the drivers of this variability is increasingly important as climate change alters patterns of stratification, storm intensity, ocean acidification, and deoxygenation. This study examines high-frequency datasets of physical and biogeochemical properties collected over two time periods (April-November 2018 and June-September 2025) in a shallow coastal environment in Hyacinthe Bay, British Columbia, Canada at 15–20 m depth. Surface measurements, tidal observations, cumulative wind stress, and wind direction were analyzed to investigate the mechanisms linking physical forcing to near-bottom habitat conditions. These datasets exhibited episodes of elevated oxygen and pH at depth during episodes of vertical mixing induced by wind events. These episodes modified the water at depth on the order of a few days and up to a week. In addition, surface conditions exhibited lower pH and increased density during these periods. Wind-driven mixing redistributed nutrient-rich deeper waters toward the surface while transporting oxygenated, higher-pH surface waters to depth. Subsequent periods of reduced wind stress promoted water-column stabilization and enhanced primary production, resulting in biologically mediated increases in oxygen and pH that in some cases extended into near-bottom habitats. Tidal forcing imposed an additional rhythmic influence on temperature, salinity, oxygen, and pH, acting as a persistent background driver of environmental variability. These observations demonstrate how interactions among wind forcing, tidal exchange, nutrient renewal, and biological production create recurring periods of favourable and unfavourable habitat conditions for benthic communities. The resulting ocean weather patterns raise a broader ecological question: does repeated exposure to environmental variability foster resilience in shallow-water communities, while organisms inhabiting deeper, more stable environments are more vulnerable to disturbance when environmental conditions change? As climate-driven shifts alter the intensity and frequency of mixing events, understanding how ocean weather influences habitat quality may be critical for predicting the future resilience of coastal ecosystems.

POC, Poster, AbstractID=19286, PosterID: POC-P8, (ECOP)

Spatiotemporal variability in the hydrographic structure of Wakasa Bay, Japan under the influence of the Kuroshio–Tsushima current system

Katha **Mukherjee** and Takeyoshi Nagai

Tokyo University of Marine Science and Technology, Tokyo, Japan.
E-mail: mukherjeekatha17@gmail.com

Wakasa Bay is one of the largest semi enclosed bays located in western Honshu Island, along the Japanese coast of the Sea of Japan. The bay is strongly influenced by the Tsushima Warm Current, a branch of the Kuroshio Current System, which transports warm and saline water into the Sea of Japan. The seasonal variability of the Tsushima Warm Current plays an important role in biological productivity and marine ecosystems regulating by sea surface temperature, circulation, and water-mass characteristics in Wakasa Bay. However, an integrated analysis of these seasonal physical changes in Wakasa Bay using satellite data remains limited. This study aims to characterize the seasonal hydrographic variability of Wakasa Bay by the influence of the Kuroshio–Tsushima Current System during 2019–2023. Copernicus Marine products will be used to analyze seasonal patterns of sea surface temperature (SST), sea surface height anomaly (SSHA), and surface current velocity. Temperature–salinity (T–S) analysis will be also performed to identify water-mass characteristics and their spatiotemporal variability. The findings are expected to provide a comprehensive overview of the physical conditions in Wakasa Bay that will contribute to the physical oceanographic and fisheries studies in the Sea of Japan and serve as a helpful reference for future studies on regional environmental changes.

POC, Poster, AbstractID=19312, PosterID: POC-P9

Governing factors of Changjiang low-salinity water intrusion toward Korea in Summer: Insight from observations and GFDL-CM4 simulations

Seonju Lee[1], Youngji Joh[2], Young-Gyu **Park**[3], Young-Ho Kim[1] and Myung-Sook Park[3]

[1]Pukyoung University, Busan, R Korea
[2]National Oceanic & Atmospheric Administration/Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA
[3]Korea Institute of Ocean Science and Technology, Busan, R Korea. E-mail: ypark@kiost.ac.kr

The freshwater discharged from the Changjiang into the East China Sea during June and July mixes with ambient ocean water to form the Changjiang diluted water (CDW). During mid- to late-summer, the CDW may reach the western part of Jeju Island (Jeju), causing significant damage to aquaculture and marine ecosystems by lowering salinity and increasing sea surface temperatures (SSTs). Observational and climate model data are used to investigate the driver of CDW transport toward the western part of Jeju and its impact. Both observations and climate models reveal that, when anomalous southwesterly winds prevail, the CDW separates from the coastal zone in June and is subsequently transported toward the western part of Jeju in July, irrespective of the amount of precipitation over the Changjiang basin and the associated river discharge. These southwesterly wind anomalies are driven by an anomalously strengthened western North Pacific subtropical high. In August, the observational data show that the low-salinity water enhances vertical stratification, increasing marine heatwave duration and maximum intensity by approximately 6 days and 1.3 °C, respectively. The model reproduces the same tendency but with weaker intensity, likely because its vertical resolution is insufficient to fully resolve the near-surface stratification that governs this response. Our study generalizes the factor controlling the westward spread of the CDW using observational data and a global climate model, and demonstrates that the spread and its impact may be predictable one to two months in advance.

POC, Poster, AbstractID=19341, PosterID: POC-P10, (ECOP)

Development and sensitivity analysis of a 1D-NPZD biogeochemical model for global climate model coupling

Ji-Hyun **Yoon**[1], Jong-yeon Park [2], Hyun-Chae Jung[2] and Eun-Young Kim[1]

[1]Jeonbuk National University, Jeonju-si, R Korea. E-mail: jh.yoon@jbnu.ac.kr
[2]Department of Earth and Environmental Sciences & Earth Environmental System Research Center, Jeonju, R Korea

Marine biogeochemical cycling directly affects climate-carbon feedbacks as well as marine ecosystems and fishery resources. Therefore, quantitatively understanding and predicting its changes is essential for responding to climate change. However, biogeochemical prediction studies in South Korea have largely lacked independently developed models, limiting region-specific predictions. With this motivation, this study introduces a one-dimensional NPZD (Nutrient-Phytoplankton-Zooplankton-Detritus)-type biogeochemical model capable of simulating the key processes of marine ecosystems and material cycling within a relatively simple framework. The study established the design of core biogeochemical process modules along with their governing equations. Model parameters were further categorized into fixed and tunable parameters, and a framework for collecting marine biogeochemical observational data and evaluating model performance was constructed. Sensitivity experiments on biogeochemical parameters conducted with the developed model revealed that changes in the NPZD state variables respond nonlinearly, driven not only by individual parameters but also by interactions among parameters and varying environmental conditions. These findings suggest that nonliear response may have significant implications for prediction uncertainty in coupled climate models. Future work will pursue the simulation of climate-marine ecosystem interactions and expansion toward a global climate prediction system through coupling with physical processes and improvement of the plankton food-web structure.

POC, Poster, AbstractID=19344, PosterID: POC-P11, (ECOP)

Sedimentary nitrogen regeneration in the Tonegawa River Estuary: Insights from sediment-water observations and a sediment biogeochemical model

Yan **Wang**[1], Toshimi Nakajima[1], Shogo Urakawa[2], Yoshimasa Matsumura[3], and Sachihiko Itoh[1]

[1]The University of Tokyo, Atmosphere and Ocean Research Institute, Chiba, Japan.
E-mail: wangyan@aori.u-tokyo.ac.jp
[2]Meteorological Research Institute, Ibaraki, Japan
[3]National Institute for Environmental Studies, Ibaraki, Japan

Marine primary productivity is frequently constrained by nitrogen, which shapes phytoplankton dynamics and ecosystem structure. Marine primary productivity is frequently constrained by nitrogen, which shapes phytoplankton dynamics and ecosystem structure. We focus on the Tonegawa River estuary on Japan's Pacific margin, where riverine inputs combine with the convergence of the Kuroshio and Oyashio currents to elevate productivity, sustaining one of the country's principal fisheries.

Here the seafloor sediments act as a key reactor for inorganic nitrogen regeneration: deposited organic nitrogen is converted through remineralization and nitrification into dissolved forms that diffuse back into the water column. Pairing bottom-water measurements with a sediment biogeochemical model, we show this benthic pathway supplies a significant fraction of water-column nitrogen, with ammonium accounting for over 80%, a partitioning that identifies ammonium recycling as the principal mechanism.

A sensitivity analysis singled out two controlling parameters: the remineralization rate and the sediment's effective diffusion coefficient. We constrained the latter using radium (Ra) isotopes, whose distribution records wave- and discharge-driven enhancement of sediment–water exchange. The remineralization rate required separate tuning, since a fixed multiple of the settling flux cannot capture the lag between deposition and remineralization. Once calibrated, the model reproduced the observed ammonium-dominated nitrogen split.

Earlier work in this area coupling a hydrodynamic model (MRI.COM) with a pelagic model (NPZD), but omitting sediment dynamics, attributed the regional nitrogen supply chiefly to rivers. Our findings establish benthic biogeochemistry as a meaningful budget term and argue for its routine inclusion in estuarine studies.

POC, Poster, AbstractID=19368, PosterID: POC-P12, (ECOP)

Physical and biogeochemical characteristics of Gulf of Alaska shelf-break eddies

Jacob T. **Cohen**[1,2], Emily Lemagie[2], Zachary Erickson[2], Wei Cheng[2], Albert Hermann[1,2], Maggie Chen[3]

[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA. E-mail: jtcohen@uw.edu
[2]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA
[3]University of Hawaii at Manoa, Manoa, HI, USA

Eddies are a dominant source of spatiotemporal variability in the Gulf of Alaska (GOA). Shelf-break eddies, which form and translate along the continental shelf break, mix properties between the continental shelf and the open ocean basin and can impact higher trophic levels and fisheries through enhanced primary production. Here, we identify and track GOA eddies in output from a regional ocean model hindcast (MOM6). We focus on shelf-break eddies, including subsets of eddies that pass through known regions of high eddy activity, namely Haida, Sitka, Northern GOA (NGOA), and Kodiak. We evaluate the physical and biogeochemical properties of anticyclonic shelf-break eddies to quantify their impact on the GOA region. We examine temperature, chlorophyll, nitrate, and oxygen as a function of distance from the eddy center to understand the properties of eddies relative to their non-eddy surroundings. We then compare eddy properties between shelf-break eddies and GOA basin eddies, and among Haida, Sitka, NGOA, and Kodiak eddies. Finally, we examine the evolution of the physical and biogeochemical characteristics over the lifetimes of long-lived and high-amplitude eddies. This research focuses on understanding the diverse impacts of eddies on the GOA ecosystem.

POC, Poster, AbstractID=19384, PosterID: POC-P13, (ECOP)

Prediction of floating *Sargassum horneri* arrival along the Korean coast: Seasonal readiness and satellite-initialized short-term forecasts

Seongbong **Seo**, Young-Gyu Park, and Kwangseok Kim

Korea Institute of Ocean Science and Technology, Busan, R Korea. E-mail: sbseo@kiost.ac.kr

Floating *Sargassum horneri* has repeatedly affected the Yellow and East China Seas and the Korean coast since 2015, and reliable prediction of its arrival is needed for early offshore response. Previous pathway analyses suggested that Sargassum transported from the northern Yellow Sea can reach southwestern Korea in winter when the December monsoonal flow develops an enhanced eastward component toward the Korean west coast. The present study develops a two-scale prediction framework that links seasonal readiness assessment with satellite-initialized short-term drift forecasts. The seasonal component examines ERA5 atmospheric fields and the Niño3.4 index for 1993–2025 to evaluate whether autumn tropical Pacific conditions are followed by winter circulation patterns favorable for early arrival. The analysis suggests that La Niña conditions can precede a southward-displaced East Asian Trough and a regional pressure-gradient configuration that strengthens the eastward component of December winds over the northern Yellow Sea. Arrival records from 2015–2022 are consistent with the interpretation that early arrivals occur when this regional December transport condition develops. The short-term component initializes a Lagrangian particle model with Geostationary Ocean Color Imager observations and forces particles with operational ocean current and atmospheric wind fields. The combined framework provides a staged prediction chain from seasonal readiness to near-term drift guidance for coastal response.

POC, Poster, AbstractID=19403, PosterID: POC-P14, (ECOP)

Diagnostic comparison of East Sea altimetry-derived geostrophic currents with a wind-adjusted drifter reference

Sung-Won **Cho**, Jae-Ho Lee, Hyung-Ju Park and Yong-Sun Kim

Ocean Circulation & Climate Research Department, Korea Institute of Ocean Science and Technology (KIOST), Busan, R Korea. E-mail: yongskim@kiost.ac.kr, sungwon22@kiost.ac.kr

Gridded satellite altimetry is widely used to describe surface geostrophic currents, but mapped products can smooth narrow boundary currents and frontal variability in marginal seas. This study develops a wind-adjusted drifter-based reference for the East Sea using long-term GDP and regional SVP drifter observations, and applies it to diagnose altimetry-derived geostrophic currents.

Direct wind slip was corrected for undrogued and drogue-lost drifter samples, and several Ekman-current treatments were tested to examine the sensitivity of the adjusted drifter field. The comparison shows that most of the improvement comes from removing direct wind slip, while differences among Ekman treatments are relatively modest at the basin scale.

After adjustment, the largest discrepancies remain along the East Korea Warm Current separation region and offshore frontal pathways. In these energetic areas, gridded altimetry captures the broad circulation pattern but tends to weaken narrow current cores and high variability. Eddy kinetic energy diagnostics and along-track versus gridded altimetry comparisons support this interpretation.

These results suggest that gridded altimetry is useful for basin-scale circulation analysis in the East Sea, but can underrepresent coastal and frontal energetic structures. The adjusted drifter field is therefore best interpreted as a diagnostic comparison reference, rather than a fully independent validation benchmark.

POC, Poster, AbstractID=19410, PosterID: POC-P15

Spatial variations in summer hypoxia and controlling mechanisms in the Changjiang estuary

Qinsheng **Wei**

First Institute of Oceanography, Ministry of Natural Resources, Qingdao, PR China.
E-mail: weiqinsheng@fio.org.cn

Global estuarine hypoxia is among the most acute environmental issues, and the Changjiang Estuary (CE) is well known as one of the largest estuarine hypoxic systems. However, the physical-biogeochemical mechanisms controlling the spatial variability and heterogeneity of summer hypoxia have been rarely examined in this region. Based on observational data, the essential linkages between physical-biogeochemical-ecological processes and spatial variability of hypoxia were revealed off the CE. The hypoxia generally occurred in a transitional region off the CE, presenting to be spatially variable and heterogeneous in its distribution and intensity. The river plume, stratification, front, upwelling and localized high phytoplankton biomass combine to shape the spatial morphology and scope of hypoxia. Notably, a pronounced intermediate-layer hypoxic plume was observed to expand offshore from the bank slope area off the CE. It was bounded by a pycnocline and connected to the seafloor near the foot of bottom front, and a secondary circulation and associated physical-biogeochemical processes are suggested to regulate this unique hypoxic plume. Moreover, the co-occurrence of offshore detached diluted water plume and hypoxia also existed in the northeastern area off the CE, and we demonstrate that the surface patchness of phytoplankton bloom induced by the offshore detached CDW plume may contribute to the formation of this local hypoxia.

POC, Poster, AbstractID=19417, PosterID: POC-P16

Kuroshio-originating warm core rings enhance oxygen supply through wintertime surface heat flux

Hiroto **Abe**

Hokkaido University, Hakodate, Hokkaido, Japan. E-mail: abe@fish.hokudai.ac.jp

Hypoxic water (< 2 mL of O_2 per L), which can cause mass mortality of demersal fishes, is reported to occur in the enclosed coastal area around the world. Funka Bay, a semi-enclosed and cone-shaped bay with a maximum depth of 107 m, located in the southern part of Hokkaido, Japan, also suffers summertime bottom hypoxic water. Previous research successfully developed a model capable of predicting summer near-bottom dissolved oxygen concentrations with an accuracy of 0.26 mL/L six months ahead using only the wintertime heat flux and stratification. However, the detailed mechanisms driving fluctuation of wintertime heat flux remain unclear. Thus, this study aimed to make clear this point. Analysis covering the period from 2010 to 2018, based on prior research, revealed that wintertime water temperatures drop due to the inflow of Coastal Oyashio water originated from Okhotsk Sea, whereas they rise when warm core rings, detached from the Kuroshio Extension, approach Hokkaido and obstruct the cold water inflow. Extending the analysis period up to 2026 showed that an event involving a warm core ring approaching the Hokkaido coast also occurred in 2025. Despite wintertime air temperatures in Hokkaido being 2°C higher than average year, hypoxic conditions did not develop at the following summer. The findings demonstrated that 2025 was a year when the enhanced surface heat flux that subsequently causes convection and oxygen supply, was mainly driven by water temperature rather than the air temperature, highlighting the significant role of the Kuroshio-originating warm core rings on Funka Bay.

WORKSHOP 1: TCODE Workshop

Bridging Global and Regional Marine Ecosystem Modelling:
Connecting the Fish-MIP and PICES Communities under Fish-MIP 2.0

Oral Presentations

W01, Invited, AbstractID=19155

Enhancing the ecosystem modeling cycle: Machine learning approaches for parameter sensitivity and model calibration

Hem Nalini **Morzaria-Luna**[1,2]

[1]Long Live the Kings, Seattle, WA, USA
[2]Visiting Researcher, Conservation Biology Division, Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA, USA. E-mail: HemNalini.MorzariaLuna@noaa.gov

Machine learning can support ecosystem modeling by providing flexible, data-driven approaches that capture the complex, nonlinear relationships among biotic and abiotic factors and offer enhanced predictive accuracy over traditional statistical techniques, while also raising challenges in interpretability and generalizability. I discuss two machine learning applications using models built in the Atlantis modeling framework, a three-dimensional deterministic modeling platform that simulates oceanography, ecology, fisheries dynamics, human impacts, and resource management. Because Atlantis is a deterministic model, the output is completely determined by the input parameters and the model's structure; the only uncertainty affecting the output arises from input variation. We used machine learning to build statistical representations of an Atlantis model, known as “emulators” or “metamodels,” that approximate the complex function linking the model outputs to its inputs. The emulator was built using a 1,000-simulation ensemble and then used to produce summary metrics describing output variance due to input parameter variation. We also used machine learning to develop a semi-automated calibration workflow that enables simultaneous calibration across functional groups and indicators, improving overall model fit and reducing calibration time by a factor of two to four compared to manual approaches. The automated component of the approach uses a multi-objective evolutionary algorithm to optimize a likelihood-based objective function, quantifying the goodness of fit between model outputs and multiple data types (biomass, weight-at-age, and catch). These examples demonstrate how machine learning can accelerate and improve the marine ecosystem modeling cycle.

W01, Invited, AbstractID=19336, (ECOP)

Evaluating AI coding assistants for ecosystem modellers: Translating EwE to Mizer

Scott **Spillias**[1,2]

[1]CSIRO Environment, Hobart, TAS, Australia. E-mail: scott.spillias@csiro.au
[2]Centre for Marine Socioecology, University of Tasmania, Hobart, TAS, Australia

Marine ecosystem models underpin ecosystem-based management but remain time- and expertise-intensive to develop, limiting scalability, comparability, and ensemble approaches across regions. This constrains stronger integration between global initiatives such as Fish-MIP and regionally focused modelling efforts within the PICES community.

This talk examines a progression from AI-generated model components, through AI-assisted implementation, toward integrated human–AI ecosystem modelling systems. I first draw on work demonstrating how AI can help automate key modelling bottlenecks, including the generation of trophic interaction structures and the discovery of interpretable ecological dynamics from time-series data. These approaches move beyond productivity gains by allowing AI to contribute to model structure, parameterisation, and the exploration of structural uncertainty.

I then present results from a prospective, protocol-driven evaluation of AI coding assistants in a realistic modelling task: translating Ecopath with Ecosim models to size-spectrum frameworks under Fish-MIP-aligned workflows. Results highlight heterogeneous productivity gains, with AI most effective for workflow scaffolding, data transformation, and documentation, but requiring expert validation for model logic and numerical implementation.

Finally, I introduce an emerging human-AI ecosystem modelling platform that integrates model-component generation, model translation, automated evaluation, and reproducible workflow management within a unified human-in-the-loop framework. This platform is designed to support interoperability, standardisation, and scalable ensemble modelling across global and regional domains. Together, these developments provide a pathway to better connect Fish-MIP and PICES, enabling more transparent, coordinated, and extensible ecosystem modelling in a rapidly changing ocean.

W01, Oral, AbstractID=19551, (ECOP)

Linking historical fisheries records and modern surveys with explainable AI in China's coastal seas

Peng **Lian**[1], Wenbo Yang[1] and Yunrong Mu[2]

[1]Chinese Academy of Fishery Sciences, Beijing, PR China. E-mail: lianpeng@cafs.ac.cn
[2]Institute of Oceanography, Chinese Academy of Sciences, Qingdao, PR China

Long-term fisheries records are valuable for evaluating regional marine ecosystem models, but historical fishery-dependent data and modern standardized surveys differ in effort, seasonality, and sampling design. We develop an explainable artificial intelligence (XAI) approach to connect these data sources without treating them as a continuous and directly comparable time series. The analysis combines monthly records from 346 fishing grounds in the Bohai, Yellow, and East China Seas during 1972–1982, including catch and catch per unit effort for 30 species, with standardized fishery-independent surveys conducted twice annually during 2014–2024. Historical observations are matched with sea surface temperature, salinity, and upper-ocean heat content. A hierarchical spatiotemporal model estimates shared species–environment relationships while retaining dataset-specific components for fishing effort, survey season, sampling method, and zero inflation. Generalized additive models provide ecological-response benchmarks, while gradient-boosting models capture nonlinear interactions. Spatially blocked SHAP values, accumulated local effects, and bootstrap ensembles are used to identify robust environmental drivers and quantify attribution uncertainty. The 1983–2013 data gap is represented explicitly rather than interpolated. Model evaluation uses spatial blocking, temporal hindcasting, and leave-one-region-out validation to test transferability between periods and regions. The resulting diagnostics describe temporal anomalies, spatial pattern agreement, community turnover, thermal sensitivity, and distribution-centroid shifts.

This framework provides a regional case study of how historical observations can inform marine ecosystem modelling. It also offers standardized and interpretable diagnostics for comparing regional observations with FishMIPoutputs in China's coastal seas.

WORKSHOP 2: BIO Workshop

Beyond boundaries: Understanding epi- and mesopelagic forage communities of the open ocean

Oral Presentations

W02, Invited, AbstractID=19120

Micronekton diets in the North Pacific: Are they competitors of salmon?

Evgeny A. **Pakhomov**[1,2], Alexei Somov[3], Brian P.V. Hunt[2] and Vladimir Radchenko[3]

[1]Earth, Ocean and Atmospheric Sciences Department, University of British Columbia, Vancouver, BC, Canada. E-mail: epakhomov@eoas.ubc.ca
[2]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada
[3]Pacific branch of Russian Federal Research Institute of Fisheries and Oceanography, Vladivostok, Russia

Micronektonic fish and squid are numerous in the North Pacific and by consuming mainly meso- and macrozooplankton may potentially compete for prey resources with foraging Pacific salmon. This may be particularly critical during winter months affecting salmon survival. During the International Year of Salmon (IYS), samples were collected during February-March 2019, March-April 2020 and February-April 2022 to study diets and trophic interactions among abundant micronekton species. This was supplemented by historical winter diet data of micronekton from the western North Pacific. In total, the diets of 13 fish and 9 squid species were investigated through individual analyses of 4334 stomachs. Preliminary analysis of diets showed limited spatial and temporal variability in species specific fish and squid diets. Cluster analysis indicated that all investigated species were combined into three major groups: (a) midwater fish that mainly consumed euphausiids and copepods; (b) coastal micronekton fish ingested mostly copepods, specializing on *Eucalanus* spp.; and (c) squid which generally preyed upon myctophids, smaller squid, amphipods and euphausiids. Average diet similarity indices within groups were high, being 59% for myctophids, 46% for coastal micronekton, and 61% for squid, suggesting a modest competition between species within ecologically similar groups.

However, diet similarity between clusters was low and on average did not exceed 20% pointing to a strong resource partitioning among the main micronekton taxonomic groups in the open ocean. Initial comparison of the main prey items of micronekton and prey size ranges point towards currently unassessed competition between open ocean micronekton (myctophids and squid) and overwintering Pacific salmon.

W02, Pre-RecordedInvited, AbstractID=19506

Spatial structure in dynamic deep pelagic animal communities across the southern California Current

C. Anela **Choy**

Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA. E-mail: anela@ucsd.edu

Quantitative sampling of animal communities that span the oceanic water column is central to understanding the dynamics of deep-sea food web structure, biogeochemical cycling, and resource management. Midwater communities include representatives from nearly all major marine animal phyla – thus, fostering taxonomic expertise and developing sampling and laboratory methods to comprehensively describe these communities is key to drawing food web connections and assessing spatial and temporal dynamics. In the eastern boundary upwelling system of the southern California Current Ecosystem, we have been sampling and quantifying micronekton communities with a $10m^2$ MOCNESS between the surface and 2000 m to understand their horizontal and vertical dynamics. Across five annual cruises, we quantify community composition at seven stations within deep basins, the escarpment, and offshore stations along a 700 km transect. We innovated shipboard processing methods that slow the degradation of fragile animal groups – particularly gelatinous tunicates, coronate medusae, and siphonophores – and identified over 140 families of fishes, crustaceans, molluscs, gelatinous plankton and other invertebrates. Using distance from shore as a proxy for environmental variability along our transect, we quantify the effects of depth, sampling time, and station on community biomass, composition, and vertical distribution and migration. Gelatinous taxa dominated community biomass at most sampling depths and the proportional biomass of fishes and crustaceans peaked at 500-100m, regardless of sampling time. Depth was the strongest driver of family-level composition, and we found that communities were more distinct among stations with increasing depth. We also saw important spatial differences in how much of the community was migrating and to which depths. To understand the biogeochemical connectivity of these communities across epipelagic, mesopelagic, and bathypelagic depth horizons we are also measuring stable carbon and nitrogen isotope compositions of dominant species, migrators, and residents. Our overall goal is to more holistically refine our understanding of the ecological roles of deep pelagic animal communities, and how they shape carbon cycling and dynamically connect species and ecosystems.

W02, Oral, AbstractID=19324

Micronekton and their importance in Northeast Pacific Ecosystems

Richard D. **Brodeur**

Hatfield Marine Science Center, Oregon State University, Newport, OR, USA.
E-mail: ricbrodeur1@gmail.com

The micronektonic fauna of the Subarctic and Transitions zones of the North Pacific has been extensively studied since the 1950s. Although in the 1980s and 1990s, little or no research on micronekton had been conducted. Interest has been renewed in examining the importance of this highly abundant group of organisms in this ecosystem during the last several decades, fueled by the establishment of PICES WG14 (Micronekton of the North Pacific) in 1998. Several historical case studies will be presented that highlight the importance of this group in terms of biomass, production and trophic transfer. Micronekton surveys indicate that mesopelagic fishes represent a high percentage of the total abundance collected and are dominated by the families Myctophidae and Bathylagidae but also include Phosichthyidae, Stomiidae, and Sternopthchidae. In the Northeast Pacific Ocean, four species of myctophids are dominant. The distribution of these species is generally well off the continental shelf though it shifts shoreward during winter and in areas subject to bathymetrically-induced upwelling (undersea canyons). They appear to go through periods of sustained high or low abundance through time. Trophic studies based on stomach and stable isotope analyses indicate that most myctophids feed on copepods, euphausiids, pteropods and hyperiid amphipods and are in turn consumed by many species of fishes, birds and marine mammals. Much less is known about micronektonic crustaceans and cephalopods in this region. Diel vertical migration of micronekton has been shown to contribute significantly to the rapid vertical transport of organic material and pollutants from epipelagic to mesopelagic zones in the North Pacic Ocean.

W02, Oral, AbstractID=19327

Revealing invisible changes in seemingly stable mesopelagic fish community

Vladimir I. **Radchenko**

Pacific Branch of the Russian Federal Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, Russia. E-mail: vladimir.radchenko@tinro.vniro.ru

Lanternfish (family Myctophidae) constitute a significant reservoir of biomass in the pelagic zone while they are minimally affected by the commercial fishery. In addition, lanternfish play a crucial role in food webs and, together with other mesopelagic fishes, maintain the "biological pump" that mediates the vertical transport of nutrients. The species composition and abundance of mesopelagic fishes in the Bering and Okhotsk Seas, as well as adjacent waters of the Pacific Ocean, were estimated using specialized gear during year-round trawl surveys conducted in early 1990s. Stratified sampling targeted the middle and upper pelagic zones from depths of 1000 m to the surface. The total biomass of mesopelagic fishes, primarily represented by two families (Myctophidae and Bathylagidae), was estimated at 15–20 million tons in the Sea of Okhotsk and 15–30 million tons in the Bering Sea. Similar mesopelagic fish biomass censuses have not been repeated since then. Meanwhile, mesopelagic species are caught in significant quantities during annual epipelagic trawl surveys of the Pacific Ocean waters off the Kuril Islands in June and early July. Data accumulated over 21 years of observations suggest that fish communities in the middle layers of the pelagic zone exhibit notable dynamics. The objective of this study is to demonstrate changes in abundance of one of the most abundant families of mesopelagic fishes—myctophids—to hypothesize their underlying causes, and propose approaches for resuming regular studies of mesopelagic fish resources.

W02, Oral, AbstractID=19358, (ECOP)

Vertical structure and long-term change in open-ocean forage fish communities

Tor **Mowatt-Larssen** and Deborah K. Steinberg
Virginia Institute of Marine Science, William & Mary, VA, USA.
E-mail: tmowattlarssen@vims.edu

Fishes comprise a major component of open-ocean forage communities, supporting highly migratory predators while contributing substantially to carbon export through vertical migrations. Yet the relative importance of environmental gradients, life history, and long-term environmental change in structuring these communities remains poorly understood. Using three decades of epipelagic net tows from two long-term ocean time-series (the Bermuda Atlantic Time-series Study and the Palmer Long-Term Ecological Research program), together with depth-resolved sampling across four contrasting ocean ecosystems (Subtropical North Atlantic, Subtropical North Pacific, Subarctic North Pacific, and the Southern Ocean), we examine how open-ocean epi- and mesopelagic forage fish communities vary across space, depth, and time. Long-term observations reveal substantial increases in larval mesopelagic fishes in the Subtropical North Atlantic and along the western Antarctic Peninsula, indicating that open-ocean forage communities are responding to ongoing environmental change. Despite similar long-term increases in abundance, environmental drivers differed between ecosystems. Across ocean basins, epipelagic fish assemblages (0–100 m) varied an order of magnitude in family diversity and were associated with temperature and light structure, whereas deep assemblages were more taxonomically similar despite large geographic separation. Life-stage vertical distributions were conserved across ecosystems, with larvae concentrated in the upper water column and juvenile and adult stages occupying deeper and broader depth ranges. In subtropical systems, taxa such as *Cyclothone* (bristlemouths) exhibited shallow (0–300 m) larval and deep (400–1000 m) adult abundance maxima, whereas *Cyclothone* larvae were absent from high-latitude surface assemblages despite the presence of adults at depth, suggesting spatial decoupling between spawning habitat and adult distributions. Together, these results demonstrate that environmental gradients shape regional differences in forage fish assemblages, while conserved vertical organization links open-ocean forage communities across ocean basins. By integrating long-term ecological observations with cross-ecosystem comparisons, this work provides insight into how climate-driven changes in ocean structure and productivity will reshape pelagic food webs and forage communities.

W02, Oral, AbstractID=19426

Comparative population genetics of seven globally-distributed mesopelagic fish species

Carolyn **Tepolt**, Rayna Hamilton and Sara Shapiro

Woods Hole Oceanographic Institution, Woods Hole, MA, USA. E-mail: ctepolt@whoi.edu

Mesopelagic fish are some of the most abundant vertebrates on the planet. They represent a major food source for other marine species and an important link between the surface and deep ocean. Many mesopelagic species are considered to be globally distributed, though prior genetic research has uncovered apparent barriers to dispersal across widespread ranges. Here, we compare population genetic data for seven mesopelagic fish species across the Atlantic and Pacific oceans: hatchetfish (*Argyropelecus aculeatus*, *Sternoptyx diaphana*), bristlemouths (*Sigmops elongatus*, *Cyclothone microdon*), viperfish (*Chauliodus sloani*), snipe eels (*Nemichthys scolopaceus*), and lanternfish (*Ceratoscopelus warmingii*). For each species, we compared fish from 3-7 distinct geographic regions, using samples collected by a wide network of international collaborators. Fish were initially barcoded with a fragment of the mitochondrial COI gene both to confirm species IDs and to place them in a larger phylogenetic context. Fish were then processed with Restriction-Site Associated DNA Sequencing (RAD), giving us 241-1,509 single-nucleotide polymorphisms per species with which to conduct population genomic comparisons. We found strong divides between the Atlantic and Pacific oceans in all species, with some species showing additional structure within these basins. Mitochondrial barcoding and RAD were congruent in three species, while for four species, RAD identified more subtle structure that was not apparent in mitochondrial sequence data. Our results reinforce the utility of high-resolution genetic tools to better understand the factors that shape dispersal and diversity in highly abundant fish species of the Ocean Twilight Zone.

W02, Oral, AbstractID=19511

Trophic interactions and competition between salmonids and micronekton in the open subarctic Pacific

Szymon **Surma**[1], Evgeny A. Pakhomov[1], Brian P.V. Hunt[1] and Kerim Y. Aydin[2]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: szymon.surma@gmail.com
[2]Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA, USA

The open subarctic Pacific Ocean extends over nearly six million km^2, from Asia to North America and from 45ºN to the Aleutian Islands, providing the primary feeding ground for Pacific salmon. Pelagic foraging is crucial to the growth and survival of these ecologically, economically, and culturally vital species. This paper details the use of mass-balance food web models to investigate trophic interactions and competition between salmon and micronekton (forage fish and small squid) in the open subarctic Pacific. These models were built in Ecopath for the eastern and western subarctic Pacific (ESA and WSA) as defined by PICES. Firstly, prey niche overlap (i.e. similarity in diet composition) was computed as a preliminary assessment of potential competition between salmonids and forage groups. Secondly, mixed trophic impacts (i.e. total instantaneous effects, through all direct and indirect trophic pathways, of a unit change in the biomass of one food web node on another) were calculated for salmonids and forage groups. Sockeye, chum, and pink salmon showed substantial prey niche overlap with all forage groups. However, except for adverse impacts of micronektonic squid on chum salmon (ESA), Pacific saury on steelhead trout (ESA), and Japanese sardine on pink salmon (WSA), there was little evidence of negative effects of forage groups on salmonids. Sockeye and pink salmon (ESA) and chum and pink salmon (WSA) adversely impacted mesopelagic fish, while pink salmon negatively affected Japanese sardine (WSA). These results suggest that while competition may occur between some salmonids and forage groups, its impacts are likely limited.

WORKSHOP 2: BIO Workshop

Beyond boundaries: Understanding epi- and mesopelagic forage communities of the open ocean

Poster Presentations

W02, Poster, AbstractID=19450, PosterID: W02-P8, (ECOP)

Pelagic predator diets as evidence of oceanographic heterogeneity across the central North Pacific

Nan S. Himmelsbach and Justin J. **Suca**

University of Hawai‘i at Mānoa, Honolulu, HI, USA.
E-mail: nhimmels@hawaii.edu, jsuca@hawaii.edu

The central North Pacific Ocean is a mosaic of oceanographic features such as mesoscale eddies, frontal systems, and seasonally shifting water masses. These dynamics structure the distribution and availability of prey across epipelagic and mesopelagic waters available to predatory fishes. Despite their importance to commercial fishing efforts in Hawai‘i, how resources are used and partitioned among top predators such as bigeye tuna (*Thunnus obesus*) across a shifting landscape remains poorly characterized. We examine the stomach contents of bigeye tuna using a hybrid morphological and modified eDNA metabarcoding approach to identify and quantify consumed prey. Stomachs were collected from Hawai‘i's deep-set longline fishery over a 12-month period. Each stomach is paired with georeferenced catch position, depth, and temperature data, allowing for diet composition to be overlain with environmental variables. *In situ* temperature and depth-of-fishing data collected from temperature depth recorders deployed on the mainline of the fishing vessel provides high resolution oceanographic conditions which can be used to confirm the presence of mesoscale eddies. We aim to explore how prey assemblages shift seasonally across ocean features, to better understand whether predators associated with mesoscale features or productive frontal boundaries exhibit differences in diet, reflecting local prey availability. Sustained sampling across a full annual cycle captures seasonal variability of both predator diet and the oceanographic features that drive prey aggregation, offering a temporally resolved view of trophic connectivity across a dynamic pelagic seascape.

WORKSHOP 3: BIO/POC Workshop

Developing a framework for cross-community conversation between natural carbon cycle and marine carbon dioxide removal communities

Oral Presentations

W03, Invited, AbstractID=19444, (ECOP)

Carbon to Sea Canada: Enabling responsible ocean alkalinity enhancement research and innovation

Kohen W. **Bauer**

Carbon to Sea Canada, Victoria, BC, Canada. E-mail: kohen@carbontosea.org

The Carbon to Sea Initiative is a philanthropically funded, science-led non-profit advancing ocean-based carbon dioxide removal (oCDR), with a principal focus on Ocean and River Alkalinity Enhancement (OAE/RAE). Acting as both grant maker and field builder, Carbon to Sea works across two integrated fronts: Science & Technology, which accelerates a portfolio of OAE/RAE pathways toward consensus-based standards of feasibility and desirability, and Policy & Finance, which mobilizes governmental support for high-integrity oCDR strategies built on accountability, scientific rigor, and public trust. In April 2026, the Initiative launched Carbon to Sea Canada, a Canadian non-profit headquartered in Halifax, Nova Scotia, to deepen direct support for Canadian researchers, innovators, and communities advancing oCDR. This builds on more than $15 million already invested in Nova Scotia alone, part of the over 30% of the Initiative's original grant funding that has been directed to Canada to date, funding research, monitoring, and demonstration activity from coast to coast. Here, we present Carbon to Sea Canada's program planning approach and the resulting OAE R&D priorities for Canada, shaped by Canadian expertise, regional priorities, and Indigenous leadership. We highlight concrete examples of how this funding has translated into real-world research capacity and field impact, illustrating a model for responsible oCDR development grounded in scientific excellence, regulatory rigor, and sustained public-private partnership.

WORKSHOP 4: HD Workshop

Connections between the Arctic Gateways and the Central Arctic Ocean – Key research questions for the next 10 years

Oral Presentations

W04, Invited, AbstractID=19459

Biodiversity changes along the Pacific Arctic corridor: From the Bering Sea to the Central Arctic Ocean

Franz J. **Mueter**[1], Katrin Iken[1], Irene D. Alabia[2], Seth L. Danielson[1], Jaqueline M. Grebmeier[3], Russell R. Hopcroft[1], Kaitlyn A. O'Brien[1] and Kathleen M. Stafford[4]

[1]University of Alaska Fairbanks, Juneau, AK, USA. E-mail: fmueter@alaska.edu
[2]Hokkaido University, Sapporo, Japan
[3]University of Maryland, Maryland, MD, USA
[4]Oregon State University, Newport, OR, USA

The Pacific Arctic gateway is undergoing rapid physical and ecological change, with important implications for the future structure and function of the Central Arctic Ocean (CAO). Declining sea ice, earlier seasonal ice retreat, delayed autumn ice formation, and increasing ocean heat transport through Bering Strait have lengthened the open-water growing season across the northern Bering and Chukchi seas. These changes have altered the timing of primary production and are likely influencing zooplankton phenology and the seasonal availability of prey. At the same time, enhanced northward transport is advecting Pacific plankton and other organisms into the Chukchi Sea, strengthening ecological connectivity between subarctic and Arctic ecosystems.

Across the Pacific Arctic, biological communities are responding through shifts in species distributions and community composition. Demersal fish and benthic invertebrate communities on the northern Bering Sea shelf have undergone pronounced borealization as temperate species expand northward. Similar changes are increasingly evident at higher trophic levels, with more frequent occurrences of humpback whales, killer whales, and other boreal marine mammals in the Chukchi and Beaufort seas, while ice-associated Arctic species are retreating or declining in areas experiencing substantial sea-ice loss. Although existing observations in the Chukchi Sea remain too spatially and temporally limited to quantify long-term trends in fish communities, accumulating evidence suggests that ecological change is propagating northward through the Pacific Arctic corridor.

This presentation synthesizes recent observations of physical and biological change across the Pacific Arctic gateway, examines the mechanisms linking ecosystem change from the Bering Sea to the CAO, and highlights key uncertainties and research priorities for understanding how these changes may influence biodiversity, ecosystem functioning, and the future fisheries potential of the Central Arctic Ocean.

W04, Oral, AbstractID=19554

Climate-driven fish community reorganization in the Eastern Bering Sea: Early signals from the Pacific Arctic gateway

Irene D. **Alabia**[1,2], Jorge García Molinos[1], Takafumi Hirata[1], Hiromichi Ueno[1,3], Megan J. Williams[4], Otso Ovaskainen[5], Benjamin Planque[6] and Sei-Ichi Saitoh[1]

[1]Arctic Research Center, Hokkaido University, Sapporo, Japan.
E-mail: irenealabia@arc.hokudai.ac.jp
[2]International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA
[3]Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Japan
[4]Ocean Conservancy, Anchorage, AK, USA
[5]Department of Biological and Environmental Science, University of Jyväskylä, Jyväskylä, Finland
[6]Ecosystem Processes, Institute of Marine Research, Tromsø, Norway

The Eastern Bering Sea (EBS) is an upstream component of the Pacific Arctic gateway, where ecological changes may signal shifts extending through the Bering Strait toward the Chukchi Sea and Central Arctic Ocean. Here, we examined fish community reorganization across the EBS shelf using NOAA bottom trawl surveys conducted from 1993 to 2023. Joint species distribution models integrated occurrence and abundance of 58 fish species with environmental variables, functional traits, phylogeny, and spatiotemporal effects across average, cold, and warm climatic regimes. Environmental filtering and latent spatiotemporal processes contributed similarly to the community structure, although latent effects increased through time. Species responses remained strongly phylogenetically structured, while functional traits explained the greatest share of environmental responses during the recent warm period. Residual species associations peaked during the cold regime and declined under warmer conditions. Taxonomic and functional diversity increased relative to the cold period, consistent with redistribution of boreal and deep-water taxa, while ecological regions and indicator species were also reorganized. These findings identify the EBS as a key observing and modeling system for the Pacific Arctic gateway. Priorities for the next decade include separating locally generated from northward-propagating changes, tracking boreal taxa and traits through the Bering Strait, linking gateway observations to Central Arctic Ocean assessments, and developing coordinated indicators across the EBS–Chukchi Sea–Central Arctic Ocean continuum.

W04, Oral, AbstractID=19559, (ECOP)

Species distribution modeling of fishes in the Central Arctic Ocean

Kristen **Sora**[1,2], Egorova[3], Y., Reygondeau[1,3], G., Hoover[4,5,6], C., Niemi[4], A., Loseto[4,7], L., Lea[4], E. V., Breiter[4], C.C., Mundy[8], C.J., Monahan[2], A., Cheung[1], W. W. L., and Steiner[7], N. S.

[1]Institute for the Oceans and Fisheries, The University of British Columbia, Vancouver, BC, Canada. E-mail: ksora@uvic.ca
[2]School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada
[3]Rosenstiel School of Marine, Atmospheric & Earth Science, University of Miami, Miami, FL, USA
[4]Freshwater Institute, Fisheries and Oceans Canada, Winnipeg, MB, Canada
[5]Marine Affairs Program, Dalhousie University, Halifax, NS, Canada
[6]Coastal First Nations/Great Bear Initiative, Vancouver, BC, Canada,
[7]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
[8]Centre for Earth Observation Science, University of Manitoba, Winnipeg, MB, Canada

Identifying climate-induced spatial variability of Arctic fishes is essential for informing resilient and adaptive management strategies. Marine Protected Areas (MPAs) are a tool established to conserve sensitive Arctic ecosystems and species. Anthropogenic changes both inside and outside of MPAs can restrict the core habitats and distribution of protected or culturally significant species. Species distribution modelling (SDM) was used here to assess the biophysical processes driving Central Arctic fish species' distribution as well as spatial information on trends and future projections of the Central Arctic Ocean under a changing environment. The AquaX framework used in this SDM research includes: (i) standardized species names and taxonomic classification, (ii) a compilation of updated species' ecological and biogeographical information, (iii) verified species occurrence data from public databases, and (iv) expert knowledge to refine the species' mapped habitat suitability. Marine climate layers from Bio-ORACLE v3.0 were used in the SDMs of this study to identify areas that are projected to face large environmental changes leading to decreased habitat suitability of Central Arctic fishes. Climate-induced reductions in sea ice extent and thickness, along with increases in upper ocean temperature and salinity, are likely to reduce the distribution and suitable habitat of ice-associated fish e.g., Arctic cod (*Boreogadus saida*) by 2100 under high-emission scenarios. However, the response of marine fishes to climate change is dependent on the magnitude and timing of the climate stressors, where a species near its tolerance limit may have a reduced tolerance threshold of another environmental variable. Furthermore, the reduced quality and quantity of marine fishes may negatively impact fisheries, and alter the foraging behaviour of higher trophic levels such as birds, and marine mammals. Co-management strategies that include Indigenous traditional and local knowledge and stewardship emerged as crucial components for sustaining Central Arctic fisheries and conserving the marine ecosystem.

WORKSHOP 4: HD Workshop

Connections between the Arctic Gateways and the Central Arctic Ocean – Key research questions for the next 10 years

Poster Presentations

W04, Poster, AbstractID=19126, PosterID: W04-P1

Diet, prey fields, and predatory and competitive interactions in early-stage pelagic fishes in the Chukchi Sea

Matthew R. **Baker**[1] and Natalya A. Kuznetsova[2]

[1]North Pacific Research Board, Anchorage, AK, USA. E-mail: Matthew.Baker@nprb.org
[2]Pacific, Russian Scientific Research Institute of Fisheries and Oceanography, Vladivostok, Russia

In recent years, unprecedented increases in temperature and decreases in sea ice have led to shifts in system phenology, species interactions, and ecosystem interactions in the Pacific Arctic. Understanding the spatial distribution, available prey fields, and competition among the pelagic fish species in this region is critical to assess the persistence, health, and competitive dynamics of these fishes and to understand the transformation of Arctic food webs. An Integrated Ecosystem Research Program launched by the North Pacific Research Board conducted a series of pelagic fish surveys in 2017 and 2019 in the eastern Chukchi Sea. Substantial numbers of Arctic sand lance (*Ammodytes hexapterus*), Arctic cod (*Boreogadus saida*), and juvenile walleye pollock (*Gadus chalcogrammus*) were collected and extensive diet analyses were conducted on these fishes. Analysis of similarity (ANOSIM) metrics suggest high overlap in diets. Non-metric dimensional scaling (nMDS) revealed the importance of physical correlates, latitude, and nearshore-offshore gradients. Latitudinal trends were also noted in prey fields and attributes of foraging success. Results suggest rising temperatures are influencing prey fields and fish distributions – driving extensive range shifts northwards. Our research provides insight into competitive dynamics and prey fields in a transforming Arctic gateway with implications for fishes in the marginal seas of the Arctic and the central Arctic Ocean.

WORKSHOP 5: FIS/POC/FUTURE/AP-UNDOS Workshop

Breaking Barriers, Building Bridges: Communication Strategies to Advance Climate-Informed Fisheries Management

Oral Presentations

W05, Invited, AbstractID=19400

Building climate-smart fisheries in Australia: Insights from climate and ecosystem status reports

Stephanie **Brodie**[1], Laura K Blamey[1], Alistair J. Hobday[2], Éva Plagányi[1], Daniel Corrie[3], Natalie Couchman[3], Alice McDonald[4], Campbell Davies[2], Ryan A. Downie[2], J. Paige Eveson[2], Elizabeth A. Fulton[2], Jason R. Hartog[2], Rob Kenyon[1], Peter Oke[2], Denham Parker[1], Ann Preece[2], Laura Tremblay-Boyer[2], Geoff Tuck[2] and Ashley J. Williams[1]

[1]CSIRO Environment, St Lucia, Queensland, Australia. E-mail: steph.brodie@csiro.au
[2]CSIRO Environment, Battery Point, Tasmania, Australia
[3]AFMA, Canberra, Australian Capital Territory, Australia
[4]FAO, Rome, Italy

Ongoing concerns about the impact of climate change on our oceans has driven a request from fisheries managers for improved science communication to the seafood sector. Despite these concerns, translating climate science into management and industry action at regional and sectoral scales remains a challenge. We developed a reporting structure for communicating climate and ecosystem status to fisheries management, industry, and research stakeholders. Our reports consider historical climate impacts, ecosystem indices derived from scientific observing programs, anecdotal on-the-water observations from industry, and forecast climate outlooks tailored for the upcoming fishing season. Using case studies from 10 Australian fisheries, this talk will describe the reporting structure, the climate and ecosystem indices used, as well as key lessons from the development and dissemination of reports. Key lessons include: (1) Developing tailored environmental indices enhances relevance; (2) Ecosystem observations are essential but remain spatially and temporally patchy; (3) Fishery-independent surveys provide vital data; (4) Remote climate drivers must be considered; (5) Seasonal forecasts offer actionable insights for short-term planning; (6) Fisher observations provide context-rich information that should be systematically incorporated. The lessons and general reporting structure can be applied to the development of other climate and integrated ecosystem reporting activities that are ongoing around the world. We contend that these reports serve as important tools for fostering climate resilience and facilitating the adaptation of the seafood sector to the short and long-term challenges of changing ocean ecosystems.

W05, Oral, AbstractID=19157, (ECOP)

Marine heatwaves and the global distribution of fisheries losses: A *development* gradient

Yujing **Song**[1], Lixin Qu[2], Christopher M. Free[3] and Kaiwen Wang[4]

[1]Peking University, Beijing, PR China. E-mail: yujing.song@pku-iaas.edu.cn
[2]Shanghai Jiao Tong University, Shanghai, PR China
[3]University of California, Santa Barbara, Santa Barbara, CA, USA
[4]Renmin University of China, Beijing, PR China. E-mail: kaiwen.wang@pku.edu.cn

Marine heatwaves are intensifying worldwide, yet their consequences for the fisheries that hundreds of millions of people rely on for food and livelihoods remain unevenly understood. We assemble a long-run, worldwide panel of commercial catch resolved by species, fishing region and year, and pair it with a measure of each fishery's exposure to marine heatwave events. Averaged across the globe, the effect of heatwave exposure on catch is close to zero. However, effects range from sharply negative to strongly positive across specie groups and regions, so that the near-zero global mean is the artefact of offsetting extremes rather than a sign of resilience. Aggregating these responses to the country level reveals a clear and robust pattern: *less-developed countries lose more catch under the same exposure intensity*, and the gradient holds across multiple independent measures of national development. Crucially, it is *not* explained by what these countries catch — differences in the species and ecological composition of national catch portfolios account for little of the gap, pointing instead toward differences in the capacity to manage fisheries under stress. These results reframe marine heatwaves not merely as an ecological disturbance but as a driver of inequality in the global food system, and suggest that adaptation investment in fisheries governance is where the largest equity gains lie.

WORKSHOP 5: FIS/POC/FUTURE/AP-UNDOS Workshop

Breaking Barriers, Building Bridges: Communication Strategies to Advance Climate-Informed Fisheries Management

Poster Presentations

W05, QR-Poster, AbstractID=19313, PosterID: W05-P1, (ECOP)

Breaking operational barriers via localized communication networks: Deploying climate-informed data pathways for mobile-integrated artisanal fisheries management in Nigeria

Michael Adedotun **Oke**

Independent Researcher, Abuja, Nigeria. E-mail: maof2020@gmail.com

Artisanal and inland reservoir fisheries underpin food security for millions across Nigeria, yet these vital socio-ecological systems are increasingly threatened by extreme climate-driven weather anomalies and shifting hydro-acoustic baselines. Empirical literature reviews indicate potential global catch declines of over 50% for Nigeria if climate stress remains unmitigated, highlighting an urgent need for adaptive, climate-informed management. However, a persistent communication barrier exists between top-down meteorological forecasting institutions and ground-level fishers who lack actionable access to localized weather information. This study presents an innovative communication strategy designed to build structural bridges between science and fishing communities. Drawing on data from regional stakeholder interviews, we map out a mobile-integrated advisory framework that translates complex climate indicators into simplified, localized multi-lingual voice alerts. Crucially, this strategy integrates formal institutional forecasts with traditional, flexible community-based management systems to foster mutual trust and operational uptake. By optimizing the transmission of real-time sea surface state and weather data, the framework significantly reduces maritime vulnerability while increasing the adaptive capacity of artisanal cohorts. This scalable approach demonstrates that closing the data-to-user communication gap is a prerequisite for establishing resilient, climate-informed coastal management paradigms worldwide.

Keywords: Science communication, Climate-informed fisheries, Artisanal fishing communities, Nigeria, Mobile data dissemination, Local ecological knowledge

WORKSHOP 6: MEQ/FUTURE Workshop

Toward Harmonized Plastic Pollution Indicators for the North Pacific: Data, Methods, and Action

Oral Presentations

W06, Invited, AbstractID=19124, (ECOP)

Why is measuring little particles such a big problem to harmonize?

Win **Cowger**

Moore Institute for Plastic Pollution Research, Long Beach, CA, USA.
E-mail: wincowger@gmail.com

This talk will explore opportunities to overcome the challenges and barriers to harmonizing data, methods, and action, kicking off the session. The main highlights will be: Microplastics are a diverse suite of materials that require complex, often unstructured data to fully interpret. Study goals and available resources often limit the quality and quantity of data a group can collect. Researchers are not typically trained in best practices for data sharing, leading to a lack of data sharing or critical metadata missing for interpretation. There is no silver bullet method capable of accurately characterizing all types of samples. Policy and management actions often rely heavily on non-scientific evidence unless science is built in from the start. People will walk away ready to participate in the activities and with a more holistic understanding of how to harmonize data, methods, and actions in their future work.

W06, Oral, AbstractID=19102, (ECOP)

A global analysis of microplastics research: Mapping strategic funding, national research capacity, scientific priorities, and policy frameworks

Kazi Belayet **Hossain**[1,9], Xuke Chen[1,9], Md. Faysal Ahammed[2], Shahadat Habib[2], Jarin Tasnim[2,10], Jun Wang[13], Md. Solaiman Hossain[3,4], Seema Rani[10], Hongwei Ke[1,9], Kai Chen[1,9], Leilei Zou[5], Piao Chen[7,8,11,12], Chawalit Charoengpong[3], Md. Kawser Ahmed[2,10], Minggang Cai[1,6,7,8,9]

[1]College of Earth and Ocean Sciences, Xiamen University, Xiamen, PR China.
E-mail: hossain_kb@ymail.com
[2]Department of Oceanography, University of Dhaka, Dhaka, Bangladesh
[3]Department of Marine Sciences, Chulalongkorn University, Bangkok, Thailand
[4]Department of Oceanography, Shahjalal University of Science & Technology, Sylhet, Bangladesh
[5]College of Foreign Languages, Shanghai Ocean University, Shanghai, PR China
[6]College of Ocean and Meteorology, Guangdong Ocean University, Zhanjiang, PR China
[7]College of the Environment and Ecology, Xiamen University, Xiamen, PR China
[8]Coastal and Ocean Management Institute, Xiamen University, Xiamen, PR China
[9]State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, PR China
[10]International Center for Ocean Governance, University of Dhaka, Dhaka, Bangladesh
[11]Guangdong Urban-Rural Planning and Design Research Institute Technology Group Co., Ltd., Guangzhou, PR China
[12]Guangdong Provincial Key Laboratory of Smart and Safety City Planning and Monitoring, Guangzhou, PR China
[13]Department of Marine Biology, Xiamen Ocean Vocational College, Xiamen, PR China

This study examines socioeconomic factors shaping global microplastics research via bibliometric analysis of 18,863 papers (2004–2024), economic data, and a 428-expert survey. It reveals a rapidly growing yet geographically and thematically disparate field, where research output correlates not with immediate pollution burden but with sustained national investment. China, with focused funding, leads at 26.73% of publications, while high-pollution, low-capacity regions in Southeast Asia and Africa are underrepresented, their national R&D spending often below the critical 0.5% of GDP threshold. The survey confirms this divides research focus: wealthier nations prioritize human health, cleanup technology, and advanced modeling, while poorer nations are often limited to basic monitoring. Experts collectively identified cleanup technology (28.90%) and human health effects (28.20%) as top future priorities. The study also flags key methodological barriers like absent standard procedures and poor exposure assessments, impeding reliable risk evaluation. In response, we propose a multi-tiered policy framework targeting the full plastic lifespan. Key proposals include sourcecentric rules (e.g., bans on intentionally added microplastics, extended producer responsibility), mandates for

advanced wastewater treatment, and support for globally consistent monitoring techniques. The analysis demonstrates the current landscape is a product of deliberate policy and investment choices. Thus, bridging major knowledge and capacity gaps in the world's most affected and vulnerable regions is both an equity imperative and a prerequisite for developing effective, evidence-based, and globally.

Keywords: Microplastics; Bibliometric Analysis; Research Trends; Environmental Pollution; Economic Disparities; Global Survey.

W06, Oral, AbstractID=19109, (ECOP)

A decade of collection data reveals fishing-related plastics dominate floating debris in the North Pacific

Sarah-Jeanne **Royer**[1], Wouter-Jan Strietman[2], Peter Puskic[1], Matthias Egger[1,3], Rafael Bergstrom[4], Kevin O'Brien[5], and Laurent Lebreton[1,6]

[1]The Ocean Cleanup, Rotterdam, The Netherlands.
E-mail: sarah-jeanne.royer@theoceancleanup.com
[2]Wageningen Social & Economic Research, Wageningen, The Netherlands
[3]Empaqtify, St. Gallen, Switzerland
[4]Sustainable Coastlines Hawai'i, O'ahu, HI, USA
[5]Papahānaumokuākea Marine Debris Project, Hawai'i, O'ahu, HI, USA
[6]The Modelling House, Raglan, New Zealand

Marine plastic pollution in the North Pacific subtropical gyre represents one of the most persistent environmental challenges of our time, yet the relative contributions of land- versus sea-based sources remain contested. Here we present a decade-long dataset (2015–2025) comprising over 55,893 kg and 272,638 items of floating debris collected across three regions: the North Pacific Garbage Patch (NPGP), the Papahānaumokuākea Marine National Monument, and the Main Hawaiian Islands. Fishing-related gear dominated debris mass across all regions (~71%), with nets comprising the largest fraction by weight. Provenance analysis of 19,768 individually examined items points predominantly to East Asian origin, with Japanese-labelled fishing gear dominating the NPGP as a legacy signal, Chinese-labelled items dominating Hawaiian shorelines consistent with recent fleet expansion, and the near-absence of PET bottles in the NPGP reflecting their high buoyancy, elevated windage, and shorter material lifespan relative to durable polyolefins. Critically, analysis of 174 assessed fishing nets indicates that 87% showed characteristics most consistent with inadequate fishing gear waste management rather than accidental loss, suggesting that net fragments from routine repair and replacement operations are a key pathway by which fishing gear reaches the open ocean. These findings underscore the urgency of targeting sea-based sources, particularly fishing fleet waste management practices both at sea and in port, in international plastic pollution mitigation strategies.

W06, Oral, AbstractID=19242

Occurrence and characteristics of microplastics in jellyfish across China seas

Shan **Zheng**, Xiaoxia Sun, Song Sun, Yaqi Wang

Institute of Oceanology, Chinese Academy of Sciences, Qingdao, PR China.
E-mail: zhengshan@qdio.ac.cn

Microplastics (MPs) have emerged as pervasive contaminants in marine ecosystems, yet their occurrence and retention in jellyfish remain poorly understood. Based on abundance and characteristics of microplastics ingested by jellyfish across three major seas of China, our study shows that microplastics were ubiquitously detected in jellyfish from all regions, and fibers were the dominant microplastic shape, accounting for more than 40% to100%.In the Bohai Sea, microplastic burdens reached 0.117 MP/ind. during the rainy season and 0.056 MP/ind. during the dry season, while a higher annual mean burden was observed in the representative bay of the Yellow Sea (0.298 ± 0.136 MP/ind.). Microplastics in jellyfish contributed most to zooplankton-associated microplastics in the Bohai Sea (39%), followed by the East China Sea (24.8%), with a much lower contribution in the Yellow Sea (3.6%). The abundance was 0.78 MPs/m³ in the Bohai Sea, 0.7460 ± 1.4851 MPs/m³ in the Yellow Sea, and 0.973 MPs/m³ in the representative bay of the Yellow Sea.Correlation analysis revealed that individual microplastic burdens in jellyfish were significantly positively correlated with seawater temperature ($p < 0.05$, $r = 0.684$), and significantly negatively correlated with dissolved oxygen concentration ($p < 0.05$, $r = -0.614$) and microplastic burdens in copepods ($p < 0.05$, $r = -0.682$). These results indicate that jellyfish are important biological vectors of microplastics in China seas, highlighting the potential role of jellyfish in the transport and ecological risks of microplastics.

W06, Oral, AbstractID=19268, (ECOP)

Assessment of anthropogenic microparticles in Cassin's auklets on Southeast Farallon Island

Margaret **Shiple**[1,2], Tamara Russell[3], Vance Thomas Vredenburg[1,2], Jaime Jahncke[1,2]

[1]San Francisco State University, San Francisco, CA, USA. E-mail: mshiple@mail.sfsu.edu
[2]Point Blue Conservation Science, Petaluma, CA, USA
[3]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA

Microplastic ingestion has been associated with gastrointestinal damage, altered gut microbial communities, and reduced reproductive success and survival in seabirds. Despite growing concern over these impacts, microplastic exposure remains poorly characterized for many offshore seabird species within the California Current Ecosystem (CCE). Cassin's auklets (*Ptychoramphus aleuticus*) are abundant planktivorous seabirds that can serve as useful indicators of offshore contaminant exposure through marine food webs. The Southeast Farallon Islands (SEFI), an important breeding colony for seabirds in the CCE, lie downstream of the San Francisco Bay Estuary, where both terrestrial and marine sources may contribute plastic debris to offshore food webs. Despite this potential exposure pathway, anthropogenic microparticle contamination in breeding seabirds on SEFI has not previously been evaluated. This study provides the first baseline assessment of anthropogenic microparticles, including microplastics, in Cassin's auklets breeding on SEFI. Preliminary results from analyses of diet and guano samples are presented to quantify anthropogenic microparticles and characterize the morphology and polymer composition of recovered particles. Regurgitated diet samples and guano provide a minimally invasive approach for assessing recently ingested particles and can be collected alongside ongoing colony monitoring with minimal disturbance to breeding seabirds. These findings provide a practical framework for offshore wildlife-based microplastic surveillance, provide the first baseline estimate of anthropogenic microparticle exposure in Cassin's auklets at SEFI, and inform future source attribution and ecological risk assessment efforts along the California coast.

W06, Oral, AbstractID=19321

Methodology versus data comparability in microplastic research

Chengjun **Sun**[1], Jinfeng Ding[1], Jingxi Li[1], and Wenxi Zhang[2]

[1]First Institute of Oceanography, Ministry of Natural Resources, PR China.
E-mail: csun@fio.org.cn
[2]No. 58 High School of Shandong Province, Qingdao, PR China

Numerous data and reports have been generated on marine microplastics all over the world. Yet large discrepancies exist in the reported abundance of microplastics in different environmental media and biota, making it difficult to accurately assess the current microplastic pollution level, status and bio-environmental impacts. These discrepancies come largely from the different methodologies involved in the research, including but not limited to the sampling methods, sample pretrement methods, volume of the water sampled or number of organisms used, analytical instruments used, quality assurance and quality control standards, and etc. From our own research work, we have found that different water sampling methods can lead to up to six orders of difference in reported microplastic abundance. This talk will focus on comparing results from different methodologies conducted both in our lab and from the literature on seawater and biota in order to help to draw general conclusion and suggest how we should review the reported data.

W06, Oral, AbstractID=19365

Metadata across the plastic continuum: Lessons from marine debris characterization in Hawai‘i

Jennifer M. **Lynch** and CMDR students and staff

Center for Marine Debris Research, Hawaii Pacific University, Honolulu, HI, USA.
E-mail: jmlynch@hpu.edu

Plastic pollution monitoring generates highly diverse datasets, yet metadata requirements vary substantially depending on debris type, environmental context, monitoring objectives, and analytical approach. This challenge becomes particularly evident when research programs work across the full plastic continuum, from abandoned, lost, or otherwise discarded fishing gear (ALDFG) to biological samples and microplastic analyses. The Center for Marine Debris Research in Hawai‘i has generated diverse marine debris datasets through derelict fishing gear recovery, shoreline debris surveys, polymer identification of over 30,000 debris items, source attribution, gastrointestinal tract analyses, recycling feedstock characterization, and targeted microplastic studies. Metadata routinely collected across these efforts include geospatial information, item typology, polymer composition, mass and dimensions, degradation state, source attribution indicators, biological interactions, analytical methods, contamination controls, photographic records, and end-of-life recycling pathways. The diversity of these metadata fields illustrates the complexity of developing interoperable datasets spanning plastic pollution size classes from megaplastics to microplastics. Experience in Hawai‘i demonstrates that harmonizing plastic pollution monitoring requires accounting for highly variable metadata generated across distinct monitoring objectives and debris types. At the same time, long-term microplastic monitoring remains severely underfunded, creating major data gaps despite growing international demand for standardized plastic pollution indicators.

W06, Oral, AbstractID=19381

DeepLitterAI: Automated detection and quantification of deep-sea benthic plastic and macrolitter

Ryota **Nakajima**, Takaki Nishio, Hideaki Saito, Shintaro Kawahara and Daisuke Matsuoka

Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Kanagawa, Japan.
E-mail: rnakajima@jamstec.go.jp

Deep-sea imagery is a non-destructive tool for monitoring seafloor litter, but manual inspection limits its scalability. We developed DeepLitterAI, a YOLOv11x-based detector combined with BoT-SORT tracking, to automatically detect and quantify deep-sea benthic macrolitter. The model was trained with J-Litter, a dataset of 12,029 annotated images extracted from JAMSTEC footage acquired between 1983 and 2025. J-Litter includes small litter objects and non-litter images. To evaluate training-data bias, we compared DeepLitterAI with a model trained only on large, clearly visible litter. On realistic test images containing small objects, DeepLitterAI achieved mAP@0.5 = 0.80 and mean F_1 = 0.73 for plastic films, plastic bottles, and beverage cans; its AP was, on average, 1.6-fold higher than that of the large-object model. In six independent survey videos from 860-5641 m depth, using manual inspection as the reference, DeepLitterAI achieved mean F_1 = 0.77 across categories, and AI-derived total litter density averaged 1.1 times the manual estimate. AI analysis was 2.1-fold faster than manual inspection on average, with a maximum speed-up exceeding threefold. Performance was robust to viewing angle, whereas false negatives increased under low illumination and high turbidity. DeepLitterAI provides a scalable, non-destructive framework for standardized monitoring and mapping of deep-sea macrolitter.

W06, Oral, AbstractID=19543, (ECOP)

Evaluating surf clams as bioindicators of microplastic pollution: Behavioral and physiological responses and interactions with marine heatwaves

Hyojin **Chang**, Yubin Koo and Taewon Kim

Inha University, Incheon, R Korea. E-mail: ktwon@inha.ac.kr, wkdgywls403@naver.com

Microplastic (MP) pollution and marine heatwaves, prolonged periods of anomalously high seawater temperature, are two pervasive environmental stressors that are increasingly co-occurring in coastal ecosystems. The surf clam *Mactra quadrangularis* is a commercially important suspension-feeding bivalve widely distributed in intertidal sandy beaches of East Asia. Therefore, understanding its responses to both MP pollution and marine heatwaves is essential for improving ecological risk assessment under multiple environmental stressors. First, we investigated the biological responses of *M. quadrangularis* following exposure to different concentrations of polystyrene-MPs. Surf clams were exposed to three treatments: a control (no MPs), a low MP concentration (300 particles L^{-1}), and a high MP concentration (15,000 particles L^{-1}) to evaluate concentration-dependent effects. MP accumulation increased markedly with exposure concentration and was predominantly detected in the digestive tissues. Histopathological examination revealed more severe gill damage, particularly under high MP exposure. Burrowing activity was significantly impaired in both low and high MP, whereas valve closure, clearance rate, and condition index remained unaffected. Building upon these findings, we investigated the interactive effects of MP pollution and a simulated marine heatwave (+4°C). Elevated seawater temperature is known to increase metabolic demand and modify feeding physiology in marine bivalves. We expected that combined exposure would alter energetic status (stomach fullness) and behavioral responses (siphon activity and shell-upright behavior), thereby reducing anti-predator performance through decreased burrowing depth. Together, these studies evaluate the potential of *M. quadrangularis* as a bioindicator of MP pollution and examine how marine heatwaves may modify its behavioral and physiological responses to MP exposure.

WORKSHOP 8: MEQ/TCODE/AP-UNDOS Workshop

Weaving knowledge systems to co-design transdisciplinary and actionable solutions

Oral Presentations

W08, Invited, AbstractID=19258

TBA

W08, Invited, AbstractID=19677

What does a place remember? Weaving storytelling, place-based knowledge and science into tsunami risk assessment

Pieter **Romer**

Indigenous Liaison for Ocean Networks Canada at the University of Victoria, Victoria, BC, Canada. E-mail: promer@oceannetworks.ca

Scientific instruments provide critical records of coastal hazards, but they are only part of the story. Across generations, Indigenous communities have observed, experienced and remembered changes in coastlines, ocean conditions and hazardous events—knowledge that can extend scientific baselines and raise questions that conventional datasets may not capture.

This presentation uses *Tsunami: 11th Relative*, a documentary produced by Pieter Romer in collaboration with Ocean Networks Canada, as an entry point for exploring how storytelling can contribute to scientific understanding. Following a screening, we will consider how place-based stories can reveal observations, historical patterns and relationships that may be important to hazard assessment, while asking how these knowledge systems can be brought together respectfully and meaningfully.

The presentation will then move from storytelling to practice, drawing on tsunami risk assessment projects co-designed with Indigenous communities on the British Columbia coast. These projects demonstrate a shift from consultation toward collaboration: communities and researchers working together to identify questions, determine what knowledge is relevant, establish appropriate protocols, interpret information and develop outputs that respond to community priorities.

For scientists, this raises a practical question: What changes when knowledge from a place is not simply collected, but helps shape the research itself?

By weaving Indigenous knowledge, community experience, storytelling and scientific observation, transdisciplinary research can generate a richer understanding of coastal hazards while producing knowledge that is relevant, usable and actionable for the communities and scientists involved.

W08, Oral, AbstractID=19142

Weaving Indigenous and Western knowledge systems across a continuum of knowledge and decision-making spaces

Natalie C. **Ban**[1], Hannah V. Watkins[2,] Robyn E. Forrest[3], Alejandro Frid[1,2], Carrie A. Holt[3], Sierra J. Hall[4], Christina N. Service[4], Luisa Ramirez[5], Daniel L. Curtis[3], Kyle L. Wilson[2], Lawrence Ignace[1], Andrea J. Reid[6], Keshia Moffat[7], Mercedes R. Neasloss[4] and Nicole Marie Burton[8]

[1]School of Environmental Studies, University of Victoria, Victoria, BC, Canada.
E-mail: nban@uvic.ca
[2]School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC, Canada
[3]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada
[4]Kitasoo Xai'xais Stewardship Authority, Klemtu, BC, Canada
[5]Fisheries and Oceans Canada, 401 Burrard Street, Vancouver, BC, Canada
[6]Centre for Indigenous Fisheries, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada
[7]Ugpi'ganjig First Nation, New Brunswick, Canada
[8]Petroglyph Comics, Ottawa, ON, Canada

Researchers and practitioners in many fields are increasingly bringing together (i.e., weaving) Indigenous and Western Knowledge Systems to address intertwined issues of environmental sustainability and social justice. However, varying expectations of what it means to "weave" knowledge systems in practice can reinforce existing power structures, even in well-meaning collaborations. For instance, weaving knowledge systems to generate new insights about a managed ecosystem without simultaneously enabling collaborative decision-making for the management of that system can ultimately serve the dominant Western Knowledge System and undermine Indigenous sovereignty. Building on the growing literature on this topic, we address this ambiguity in expectations by articulating how weaving knowledge systems can happen along separate gradients in both knowledge and decision-making spaces. We present a framework for supporting collaborators in identifying more equitable ways of working along these gradients. We posit that Western researchers and practitioners must engage in an iterative process of deep learning to weave knowledge systems in a good way. Such learning requires Western researchers, practitioners, and institutions to not only question their assumptions about how knowledge can be acquired, but also grapple with the beliefs and values systems in which their knowledge is embedded. Given the plurality of views, experiences, goals, and contexts inherent to weaving knowledge systems, there should not be just one path forward. However, clearly articulating where collaborators find themselves within the knowledge-decision continuums – and where on these continuums they wish to go – can improve the effectiveness of pluralistic collaborations while holding those in power to account.

W08, Oral, AbstractID=19316, (ECOP)

Integrating Indigenous knowledge, archaeological data, and historical records into ecosystem models of marine and coastal change

Meaghan **Efford**

University of British Columbia, Vancouver, BC, Canada. E-mail: m.efford@oceans.ubc.ca

Past environmental conditions and the relationships between social and environmental systems can provide essential insights into how ecosystems have changed due to the impacts of settler-colonialism. They can also illuminate Indigenous stewardship, sustainable management practices, and relationality to place. The integration of past data sets, like those offered by Indigenous Traditional Ecological Knowledge (TEK), archaeology, history, and archival materials, and their translation into metrics that can be used for ecosystem modelling can be a challenge. Research teams encompassing experts with data on and knowledge about past environmental baselines, policy makers, and ecosystem modelers can tackle the wicked problems facing the world's most at-risk ecosystems. Models of past ecological states have the potential to be valuable tools in management decision making and can offer guidance for restoration work. This 'how to' presentation offers a transdisciplinary method for approaching this challenge, with a step-by-step guide on translating valuable information from the past into ecosystem modelling metrics that can track change over time, and ask important questions about the impacts of settler-colonialism, urbanization, and anthropogenic environmental change.

W08, Oral, AbstractID=19487, (ECOP)

A boundary object for Inuit and climate modellers: The case of the Ulukhaktok calendar

Patrick **Farnole**[1], Allen Pogotak[3], Koral Memogana[3], Adam Monahan[1], Mark Stoller[2], Nadja Steiner[1,4]

[1]School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada.
E-mail: pfarnole@uvic.ca
[2]Department of Geography and Planning, Queen's University, Kingston, ON, Canada
[3]Olokhaktomiut Hunters and Trappers Committee, Ulukhaktok, NWT, Canada
[4]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada

Inuit have experienced considerable changes over the past decades. Climate change has been affecting environmental conditions and ecosystem seasonality along with harvesting activities. In this context, investigating past and future climates in the Arctic with scientists could help Inuit communities to better prepare for changes to come. Recent history has raised the bar for meaningful collaborations between southern researchers and Inuit. Building a strong mutual understanding is fundamental for epistemic justice, and presents a challenge with modellers and their specific ontologies. To address this limitation, we co-designed the Ulukhaktok Cultural Calendar, a boundary object between climate modellers and the Inuvialuit community of Ulukhaktok. In this study, we report on the iterative design process and explain how the Calendar contributed to support Inuit knowledge transmission and collective memory, while establishing a common language with climate modellers. From our collaboration emerged unexpected outcomes such as a book, a movie, and school activities. Populating the wide gap between modellers and Inuit with familiar objects, they alleviated the burden, specifically for Elders and youth, to navigate both worlds.

W08, Oral, AbstractID=19512

Braiding Indigenous Knowledge Systems and Western science to inform collaborative fisheries management in the territory of Kitasoo Xai'xais First Nation

Sierra **Hall**[1], Hannah Watkins[2], Kitasoo Xai'xais Marine Working Group[1], Natalie C. Ban[3], Jaclyn S. Cleary[4], Ken Cripps[1], Daniel L. Curtis[4], Robyn E. Forrest[4], Alejandro Frid[5], Carrie A. Holt[4], Douglas Neasloss[1], Luisa Ramirez[4], Robert Rangeley[5], Rebecca Schijns[5], Christina Service[1], and Kyle L. Wilson[2]

[1]Kitasoo Xai'xais Stewardship Authority, Klemtu, BC, Canada. E-mail: research@kxsa.ca
[2]Simon Fraser University, Burnaby, BC, Canada
[3]University of Victoria, Victoria, BC, Canada
[4]Department of Fisheries and Oceans, Nanaimo, BC, Canada
[5]Oceana Canada, Halifax, NS, Canada

Knowledge braiding frameworks, such as Two-Eyed Seeing, bring together the complementary strengths of Indigenous Knowledge Systems (IKS) and Western science to support more equitable and sustainable fisheries management. Although these approaches are increasingly recognized by fisheries managers and policymakers in Canada, practical pathways for implementing them remain underdeveloped.

To address this challenge, the Kitasoo Xai'xais First Nation, in partnership with Fisheries and Oceans Canada (DFO), Oceana Canada, and academic collaborators, established the Git qm̓sistá ("people of the moon tipped over"): *Learning Together to Revitalize Herring* working group. Using Pacific herring (*Clupea pallasii*) as a culturally, ecologically, and economically important focal species, the collaboration aims to co-produce knowledge that supports fisheries decision-making within Kitasoo Xai'xais territory.

The working group is exploring the Kitasoo Xai'xais vision of a healthy herring–human ecosystem by: (1) developing conceptual ecosystem maps informed by Knowledge Holder interviews and focus groups; (2) identifying management levers and ecologically and culturally relevant benchmarks; and (3) co-producing research to address priority information gaps.

Preliminary findings suggest that inclusive Pacific herring management will require adaptations to better reflect Kitasoo Xai'xais values and worldviews, including more explicit consideration of reciprocal relationships between people and the herring ecosystem. This work describes the collaboration, its knowledge-braiding framework, and the challenges of translating braided knowledge into fisheries decision-making. It also shares early insights that will inform the partnership while fostering discussion on practical approaches for operationalizing knowledge braiding in fisheries management.