BOOK OF ABSTRACTS

http://www.pices.int/PICES-2023

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Contents

Keynote Speaker

Focusing Ecosystem-Based Management and Human Engagement Through Tribal First Foods

Eric **Quaempts**

Umatilla tribes (Confederated Tribes of the Umatilla Indian Reservation; CTUIR)
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The Confederated Tribes of the Umatilla Indian Reservation's First Foods Mission and River Vision guide restoration of diverse Tribal First Foods, including Pacific marine anadromous species. The cultural recognition of First Foods is manifest in the ritualistic serving order of native animal and plant species in a traditional meal, but the serving order also identifies key ecological relationships and provides a novel means for engaging diverse communities in collaborative, ecosystem-based management.

Session 1: Science Board Symposium

Connecting Science and Communities for Sustainable Seas

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

Invited Speakers:
Matthew Savoca (Department of Oceans, Hopkins Marine Station, Stanford University, CA, USA)
Vivitskaia J.D. Tulloch (Conservation Decisions Lab, University of British Columbia, BC, Canada)

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

(S1-16678 Invited)

Application of a Social–Ecological–Environmental System Framework to address and manage future climate change impacts on threatened killer whales and their Pacific salmon prey

Vivitskaia J.D. **Tulloch** and Tara G. Martin

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In the Salish Sea, human coastal communities rely on marine resources and species such as killer whales (*Orcinus orca*) to support robust whale-watching and sport-fishing industries. The small population of endangered Southern resident killer whales (SRKW), however, are threatened by impacts from human activities in the region, as well as reduced availability of their Chinook salmon (*Oncorhynchus tshawytscha*) prey. Climate change is expected to affect Chinook salmon growth and migration patterns, which will further reduce the SRKW ability to find sufficient food. Transboundary issues complicate the problem further, as SRKW and Chinook salmon spend most of their time outside the Salish Sea. Ecosystem-based decision-making is needed that considers the interactions between species and across disciplinary dimensions, to effectively understand the social and ecological consequences of a changing world on linked salmon-killer whale ecosystems and connected coastal communities. We apply a Social–Ecological–Environmental Systems (SEES) framework to identify interactions between climate change, salmon-killer whale ecosystems, and human activities, to aid future-focused management strategies across multiple jurisdictional boundaries. We identify positive and negative feedback loops from responsible tourism and fishing industries, which generate income and employment in coastal communities, can aid collection of long-term ecological data, but may continue to negatively affect Pacific salmon and killer whale populations, resulting in reduced socio-economic outcomes for coastal human communities. Our framework highlights the need for more effective climate-informed management strategies that transcend jurisdictional and disciplinary boundaries, and improved compliance and enforcement of legally-binding guidelines to improve resiliency of killer whales and Pacific salmon to future change. These strategies may improve sustainability and resilience of human communities and economies that depend on the sea and marine resources to climate change.

(S1-17011 Invited)

Across the boundary: Internationally coordinated science and action is required to tackle chemical pollution in marine ecosystems

Matthew S. **Savoca**

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Chemical pollution pervades every facet of the biosphere, necessitating monitoring and mitigation to identify and minimize consequences for species and ecosystems. This global anthropogenic stressor demands a concerted and coordinated international response. Harmonized monitoring of marine contamination is paramount as the ocean is the final reservoir for most pollution. I will outline the work that is happening within PICES and the United Nations Decade of Ocean Science, the targets we hope to reach, the obstacles we need to overcome, and our progress to date. Specifically, I will focus on my experience studying plastic pollution and per and per- and polyfluoroalkyl substances (PFAS) in marine food webs. Recent technological advances and international agreements provide hope of a collective commitment to combat chemical pollution via coordinated assessments and actionable solutions. In so doing, we can achieve a cleaner ocean while maintaining sustainable use for all. These efforts are not only vital for safeguarding marine ecosystems, but also contribute to a resilient future for both people and planet.

(S1-16588 Oral)

Toward regional marine ecological forecasting using global climate model predictions from subseasonal to decadal timescales: bottlenecks and recommendations

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We discuss how the research community can promote enhancement of marine ecosystem forecasts using physical ocean conditions predicted by global climate models (GCMs). We review the major climate prediction projects and outline new research opportunities to achieve skillful marine biological forecasts. Physical ocean conditions are operationally predicted for subseasonal to seasonal timescales, and multi-year predictions have been enhanced recently. However, forecasting applications are currently limited by the availability of oceanic data; most subseasonal-to-seasonal prediction projects make only sea-surface temperature (SST) publicly available, though other variables useful for biological forecasts are also calculated in GCMs. To resolve the bottleneck of data availability, we recommend that climate prediction centers increase the range of ocean data available to the public, perhaps starting with an expanded suite of 2-dimensional variables, as several projects are moving in this direction. Allowing forecast output to be downloaded for a selected region, rather than the whole globe, would also facilitate uptake. We highlight new research opportunities in both physical forecasting (e.g., new approaches to dynamical and statistical downscaling) and biological forecasting (e.g., conducting biological reforecasting experiments) and offer lessons learned to help guide their development. In order to accelerate this research area, we also suggest establishing case studies (i.e., particular climate and biological events as prediction targets) to improve coordination. Advancing our capacity for marine biological forecasting is crucial for the success of the UN Decade of Ocean Science, for which one of seven desired outcomes is “A Predicted Ocean.”

(S1-16663 Oral)

Projected abundances of key fisheries in the Pacific Arctic under future climate: potential biological and economic implications

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Marine fisheries resources in the Pacific Arctic have recently experienced considerable climatic impacts, resulting in species abundance and distribution changes with consequences on their availability to commercial fisheries. We project future changes in the relative abundance of eight commercially-important fish and crab species under the different CMIP6 Shared Socioeconomic Pathways that lead to contrasting future (2021-2100) scenarios of warming, sea ice loss, and primary productivity changes. We utilize species-specific abundance models to generate the present predictions and future projections of species relative abundances in the Pacific Arctic. Our results show differential patterns of change in abundance and distribution across species and scenarios, highlighting potential winners and losers under future climate change. Specifically, under the extreme socioeconomic pathway (SSP585), Pacific cod and snow crab abundances are projected to increase and decrease in the region, respectively with concomitant zonal and meridional shifts in the centers of gravity. Importantly, projected changes in species abundance suggest that fishing at the same distance from the major port in the Bering Sea (i.e., Dutch Harbor) could yield declining catches for highly valuable fisheries (e.g., Pacific cod and snow crab) under the SSP585 climate scenario. Albeit the results of this study should be taken with caution due to simplistic model assumptions and projection uncertainties, the projected changes in abundances and shifting distributions could have relevant biological and economic repercussions on the productivity of the Eastern Bering Sea ecosystem, commercial and subsistence fisheries, and effective management of transboundary resources.

(S1-16699 Oral)

"SEAturtle" PICES special research project (2019-2023): What we learned on sea turtles of Jeju Island for the last 5 years and what we should do in future

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PICES special research project "SEAturtle" launched in 2019 to understand the ecology of sea turtles around Jeju Island in relation to environmental stressors. Though COVID 19 had interrupted the project, we had quite a successful outcome over the last 5 years. Until now (June 15, 2023), a total of 12 iridium transmitters were deployed on sea turtles bycaught or rescued in Jeju Island (10 on green sea turtles and 2 on loggerhead sea turtles). Among them, we received the signals successfully from 11 sea turtles. We found that quite a proportion of green sea turtles (N = 4 out of 9, approx. 40%) overwintered in Jeju Island even in the cold sea where the temperature dropped to 15 °C. The diving duration increased to 6 hrs and 50 min with decreasing temperature. Most of migrating green sea turtles (N = 3) traveled toward southern Japan which suggests a strong link to the population in Japan. Our population genetics result on green sea turtles stranded suggests that a subunit of Jeju population also have an affinity to Japan population. On the other hand, one of our loggerhead sea turtles moved westward but the other moved southward from Jeju Island, suggesting that they may also have connectivity to both Japan and China. Our populations genetics and stable isotope analysis on the commensal barnacles support this. We also have actively worked on the threat of plastics on Jeju populations and found that derelict recreational fishing gears might cause more serious problems than commercial derelict fishing gears. Microplastics are other threats to them too. To conserve the population of sea turtles in Jeju Island, we need further extensive research and should keep up international cooperation.

(S1-16721 Oral)

Five actionable pillars to engage the next generation of leaders in the co-design of transformative ocean solutions

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Solutions to complex and unprecedented global challenges are urgently needed. Overcoming these challenges requires input and innovative solutions from all experts, including Early Career Ocean Professionals (ECOPs). To achieve diverse inclusion from ECOPs, fundamental changes must occur at all levels—from individuals to organizations. Drawing on insights from across the globe, we propose 5 actionable pillars that support the engagement of ECOPs in co-design processes that address ocean sustainability: sharing knowledge through networks and mentorship, providing cross-boundary training and opportunities, incentivizing, and celebrating knowledge co-design, creating inclusive and participatory governance structures, and catalyzing culture change for inclusivity. Foundational to all actions are the cross-cutting principles of justice, equity, diversity, and inclusivity. In addition, the pillars are cross-boundary in nature, including collaboration and innovation across sectors, disciplines, regions, generations, and backgrounds. Together, these recommendations provide an actionable and iterative path toward inclusive engagement and intergenerational exchange that can develop ocean solutions for a sustainable future.

(S1-16729 Oral)

Ocean Negative Carbon Emissions: A regional and global effort to mitigate climate change

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Global ONCE (Ocean Negative Carbon Emissions) is an interdisciplinary program of the United Nations Ocean Decade Actions, following the UND calls for restoring a healthy and resilient ocean that is vital for human wellbeing and sustainable development. Global ONCE emphasizes nature and ecosystem-based interventions to optimize organic carbon sequestration capability alongside biodiversity as well as chemical and engineering technologies including seaweed aquaculture, artificial upwelling, water alkalinity enhancement. Additional targeted approaches include land-ocean integrated management through large-scale monitoring and research facilities, as well as capacity building and science education. The ultimate goal is to promote knowledge exchange, develop policies and rules needed to evaluate current negative emission techniques/methods and enhance equitable global governance

(S1-16772 Oral)

Utilizing cooperative fisheries research to better understand harmful algal blooms along the Oregon coast

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Harmful algal blooms (HABs) are a problem for coastal communities, fisher people, and coastal organisms. *Pseudo-nitzschia* spp. is a regularly occurring diatom in Oregon's coastal waters. At times, *Pseudo-nitzschia* spp. can facultatively produce domoic acid, a neurotoxin that can bio-accumulate in the food chain. While regular shore-based sampling provides information on the relative abundance of *Pseudo-nitzschia* spp. and domoic acid concentration, offshore sampling is limited, hindering our understanding of the environmental drivers of blooms and their toxicity. To address this gap, cooperative fisheries research was utilized to frequently and broadly collect surface water samples along Oregon's coast for early detection of HABs. Six commercial and charter fishermen were recruited to collect water samples during regular fishing excursions. The fishermen were equipped with sampling kits to measure temperature and salinity, and collect preserved seawater samples for phytoplankton counts. Samples were later processed with an Imaging Flow Cytobot (IFCB) to quantify the relative abundance and size of *Pseudo-nitzschia* cells. Cooperative sampling revealed a spike in *Pseudo-nitzschia* abundance in late July and early August 2022. These findings agreed well with other regional analyses such as NOAA's Pacific Northwest HAB Bulletin. Sample collection began in June of 2022, and will continue through November of 2023 to get a strong picture of seasonal and spatial variations of *Pseudo-nitzschia* spp. This collaboration with the fishing community showcases an untapped resource that collaborative fisheries research can fill, benefiting both science and fishermen alike. Frequent and regular offshore monitoring allows for early harmful algal bloom detection, providing stakeholders with an advanced warning to make appropriate management decisions.

(S1-16774 Oral)

Ocean changes reflected in oyster biological characteristics through comparison of oyster cultured in Japanese coastal waters between 1990 and 2022

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The Pacific oyster (*Crassostrea gigas*) is a commercially important cultured species worldwide. However, changes in the oyster biological characteristics throughout long-term culturing has not been disclosed. This study focused on the Pacific oyster cultured in the Seto Inland Sea, western Japan over the last half century. Four experimental rafts were set at a distance of 10km in 1990, and three rafts in 2022 in this area. Biological characteristics were obtained from the oysters in each raft, including dorso-ventral height (DVH), shell width (SW), shell depth (SD), total weight (TW), shell weight (SW), dry and wet meat weight (DMW and WMW). Shell thickness index (STI) and conditional index (CI) were calculated for each individual. Higher TW, DMW, WMW and CI were found in 2022 than 1990, while shell shape (SH/SD and SH/SW) showed no remarkable changes. This implies that oyster cultured in 1990 might have experienced poor food conditions and achieved limited growth due to ecosystem degradation. Although SW showed no significant difference between 2022 and 1990, higher STI was found in oysters of 1990. That is, oyster shells become thinner with increased density, which might provide the protection against unfavorable environmental conditions, such as decreased pH or fluctuating salinity. In addition, great raft difference of oyster DVH was found in 2022, which indicates that inland environmental factors might also affect greatly on oyster size, such as freshwater runoff. Local fishing community should raise the awareness of oyster changes, in order to enhance stable oyster production from future challenging ocean changes.

(S1-16805 Oral)

Representing fisheries' footprints in marine spatial planning suitability analyses for offshore wind energy development.

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Offshore renewable energy development is becoming a reality off the U.S. West Coast, and an important goal for selecting the locations of these new ocean-use sectors is to minimize overlap and conflict with current ocean user groups. Two important ocean user groups along the U.S. West Coast are commercial and recreational fisheries. The objective of this research was to identify fisheries data to include in a comprehensive suitability analysis to identify locations within two planning areas that would be most suitable to offshore wind energy development. We used fisheries' logbook and observer program data to summarize annual and cumulative fishing effort (hours fished or amount of gear used) and revenue across the entire planning area and within 2x2-km grid cells within the planning area across a range of years of available data for each fishery. We then ranked, normalized and combined effort and revenue data into a single metric ('ranked importance') for each fishery for each grid cell. Results showed that annual commercial fishing effort and revenue varied widely across the last two decades for many fisheries; however, some fleets showed steadily increasing and decreasing trends in fishing effort across the planning areas. Spatially, the locations of the highest ranked importance values varied among individual fishing sectors, typically corresponding to specific bottom depth contours or habitat features associated with targeted species. Comprehensive marine spatial planning analyses will continue to be a critical component for minimizing conflict among ocean-user groups and for the responsible, sustainable development of new ocean-use sectors.

(S1-16840 Oral)

Contributions of NOAA's EcoFOCI program to climate science and ecosystem-based fisheries management

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Alaskan ecosystems, including the Gulf of Alaska, Bering and Chukchi Seas, are being disproportionately affected by global climate warming. These systems - particularly the Bering Sea - also sustain some of the largest, most valuable, and culturally important fisheries in the world. NOAA's Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI) program has been monitoring Alaskan ecosystems for several decades, providing the foundational science needed to assess climate impacts on these critical fisheries, and providing the data needed to understand fluctuations in fishery production in support of Ecosystem-Based Fisheries Management. EcoFOCI is a collaborative effort among physical, chemical, and biological oceanographers, fisheries biologists, and modelers. Together, they combine long term moorings, oceanographic surveys conducted from spring to fall, annual fish surveys, and advanced technologies to study the ecosystem dynamics from physics to fish, with a focus on lower trophic level variability. Long-term data provide models with concurrently-measured multidisciplinary information that permits prediction of climate impacts on future ecosystem and fishery dynamics in Alaskan waters. Zooplankton and ichthyoplankton indicators developed from field observations aid in predictions of future fishery yields. Huge climate-driven changes such as reductions in sea ice, delayed spring production, and shrinkage of the Bering Sea "cold pool" have been observed in recent years, leading to dramatic changes in plankton, pollock, cod, and crab. Going forward, the EcoFOCI program may be challenged with expanding farther into the newly-opening central Arctic while maintaining its historical coverage to support commercial fisheries, fishing communities, and native villages that depend on a healthy and productive ecosystem.

(S1-16854 Oral)

How will China's stressed marine fisheries respond to climate change impacts? A social-ecological analysis of vulnerability and risk

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Climate change is a new disrupter to the global fisheries systems and their governance frameworks. This presents a particular challenge in China where fisheries play a significant role in food security, livelihoods, economy and culture, while experiencing multiple issues including overfishing, habitat loss, and inadequate management. As climate change continues to intensify in the region and climate awareness grows within the country's ocean policy, it becomes increasingly crucial to comprehend the capacity of China's fisheries, ecologically and socioeconomically, to address the climate crisis. To address this issue, we conducted an interdisciplinary analysis that examines the ecological and socioeconomic risk of China's marine capture fisheries to climate change. The study uses a spatially-explicit, indicator-based approach with a modified social-ecological vulnerability and risk assessment framework. By integrating climatic, ecological, economic, societal and governance indicators and data, we elucidate the factors influencing vulnerability across species, taxa and coastal regions, and identify fisheries at risk to climate change impacts. Our analysis reveals existing data and research gaps that may hinder a comprehensive understanding of a climate risk and suggest future research directions to address these gaps. This study underscores the management challenges posed by climate change and emphasizes the imperative to develop various climate-ready approaches for fisheries adaptation. The scientific basis provided by this study can help identify specific needs of priority for management and adaptation, enabling evidence-based solutions that foster the development of climate-resilient fisheries within China and beyond.

(S1-16886 Oral)

Pathways to good research: partnerships on equal footing

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Coast Salish Peoples have been caretakers of the Salish Sea since time immemorial. Many tribes in Washington State have tribal resources departments, to manage and care for the land and the sea. The Indigenous people who rely on seafood for subsistence, cultural, recreational, and commercial purposes are some of the most vulnerable to climate change impacts, especially living in coastal communities. The UN decade of Ocean Science specifically tasks researchers to work with Indigenous communities, to empower the next generation of ocean leaders through providing equitable access to marine science. Our approach is to begin research projects on equal footing as partners with Indigenous researchers. In 2018, The Northwest Indian College was awarded a Tribal Colleges and Universities Enrichment Achievement (TEA) Center for Community Marine Research. The purpose of the TEA Center is to collaborate with Indigenous communities to advance the research goals, needs, and interests regarding food sovereignty and healthy water issues in the Salish Sea. To date we have developed projects that study a culturally important forage fish, built a harmful algae monitoring program that has identified freshwater biotoxins in marine seafood, and designed genetic primers to investigate invasive European green crab and other harmful species. These projects were decided as priority tasks in collaboration with our tribal partners and include detailed data management plans. Through partnerships and collaboration with the Indigenous community, shared research goals can provide space and support for diverse narratives, specifically those that are Indigenous, and of different genders, ages, and career stages.

(S1-16505 Poster) S1-P1 (ECOP)

Presuming the pathways of sea turtles by using $\delta^{18}O$ values from commensal barnacle shells

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To develop an effective conservation plan for endangered sea turtles, it is crucial to understand their movement patterns. Although various methods such as mark and recapture, satellite telemetry, and genetic analysis have been employed, they have certain limitations, such as high cost, low resolution, or low return rates. As an additional method, the use of epibiotic barnacles can be considered. The shells of commensal barnacles on sea turtles provide an isotopic history that reflects the temperature and $\delta^{18}O$ of the seawater the host has encountered. This study measured the chronological isotopic history on the shell surface of commensal barnacles by utilizing secondary ion mass spectrometry (SIMS). The weekly $\delta^{18}O_{calcite}$ values were analyzed from barnacle shells collected from four sea turtles (two *Caretta caretta*, one *Chelonia mydas*, and *Eretmochelys imbricata*) stranded on Jeju Island. Sea turtles are considered to have been introduced to Jeju Island through the Taiwan Strait, the Ryukyu Islands, and Kyushu Island. Analysis using SIMS was able to extract more information from a smaller amount of sample than conventional isotope analysis methods. However, there is a need to develop in terms of resolution and reliability, so it is necessary to use auxiliary indicators such as $\delta^{13}C$ and trace metals for calibration in future research.

(S1-16510 Poster) S1-P2 (ECOP)

Examining the socioeconomic vulnerability of coastal Alaskan communities to temperature dependencies in Pacific cod's spatial distribution

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The Eastern Bering Sea (EBS) supports a highly productive commercial and subsistence Pacific cod (*Gadus macrocephalus*) fishery and is projected to experience accelerated oceanic warming. Temperature drives life history traits of Pacific cod and warming temperatures have initiated a large-scale northward redistribution of the stock in the EBS. This shift in the spatial distribution of Pacific cod poses potential threats to both sustainable fishery management and the economies of coastal Alaskan communities reliant on this resource. Our approach incorporates 40 years of field collections in the EBS to: 1) assess the vulnerability of Pacific cod to temperature across two life history stages, and 2) use these results within an exposure-vulnerability assessment to analyze the socioeconomic risk facing coastal Alaskan communities to changes in the distribution of the stock. We spatially fit data on EBS Pacific cod abundance, temperature, and community socioeconomic values for each coastal Census area. We used statistical models to enable predictions of landings based on available temperature-related biomass. Community vulnerability was quantified by considering the economic value of Pacific cod (exposure) and the communities' adaptive capacity and reliance (sensitivity). Elements of community vulnerability were then combined within a risk assessment framework, and categorized as having high, moderate, or low risk. Our preliminary results indicate temperature-driven shifts in Pacific cod distribution pose a challenge to coastal Alaskan communities, particularly those with historically high reliance and current socioeconomic strains. Understanding these vulnerabilities is crucial for effective management and mitigating socioeconomic impacts related to changes in Pacific cod stock.

(S1-16527 Poster) CANCELLED S1-P3 (ECOP)

~~Vulnerability assessment of costal urban expansion and modelling green spaces to quantify extreme weather events~~

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~~Current growth simulations indicate that by 2050, nearly 6.3 billion people out of an estimated global population of 9.1 billion will live in costal urban territories. Karachi is largest city of Pakistan, and highly vulnerable to extreme weather events due to costal rise. The aim of this study is to assess the vulnerability of the Karachi urban inhabitants to heat stress and to identify the role of ecosystem services in mitigating the future impacts of heatwaves as well as the estimation of landscape functions to urbanization. GIS/RS techniques are used to estimate the suitability of forest scenario projection models and to identify the current status of urban green spaces in the city. Long-term meteorology dataset (1989–2018) is also analyzed to quantify the frequency of heat waves, along with downscaling of rise in temperature under future scenarios. The results indicate that heat waves are linked with climate warning and extreme weather events, aggravated by rapid urbanization, industrialization, deforestation, emission of~~ $\cancel{CO_2}$~~, degradation of Mangrove Forest, and shift of land use etc. Moreover, findings revealed that there is significant drop-off in urban green spaces and increase in build-up areas of the city during the 1984–2016. In addition, the model projected that forest area around the city has the ability to absorb~~ $\cancel{CO_2}$ ~~emissions up to 55.4 million tons. This study provides initial assessment and specific policy implications in meteorological predictions to establish early warning heat waves alerts and promote smart sustainable cities plans among residents and planners.~~

(S1-16528 Poster) S1-P4 (ECOP)

A model for evaluating links between salmon smolt ocean entry size and timing and early marine predation risks in a dynamic ocean

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Survival of fall run juvenile Chinook salmon depends partially on the time from ocean entry to the end of the first year. In this key period, an ecosystem modeling approach is a useful framework for exploring the impact of spatial and temporal variability on predation pressure and testing management strategies that can be taken during the freshwater period directly preceding ocean entry. Our ecosystem model incorporates a ROMS submodel for hydrodynamics, a Nutrients-Phytoplankton-Zooplankton (NPZ) submodel for generating prey fields, and an individual based model (IBM) for juvenile Chinook salmon. The salmon IBM consists of a series of modules representing growth, mortality, behavioral movement, and predation interactions. The mortality submodel includes size-based predation by a central-place seabird predator that is based on both salmon size and the probability of salmon-seabird interactions, scaled by the seabird population size and distribution. Temperature and krill fields from the ROMS and NPZ submodels are used in the IBM for calculating juvenile salmon growth and inform behavioral movement. Because growth is driven by the environment and our approach to predation mortality is based on size-dependence, the environment is also a driver of the interaction between salmon and their seabird predators. Our modeling framework predicts that environmental factors are largely responsible for survival during low predation, but when predators are abundant they become important in determining survival. We explore a range of freshwater juvenile salmon production scenarios and predict that the timing and size of ocean entry impacts early marine predation risk for Central Valley Chinook salmon.

(S1-16532 Poster) S1-P5 (ECOP)

Remote impacts of low-latitude oceanic climate on coastal upwelling in a marginal sea

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Upwelling plays an important role in the physical processes and biological variability of coastal regions. Using 40-year-long coastal hydrographic and climate data, the remote impacts of low-latitude oceanic climate on the coastal upwelling along the east coast of Korea were investigated. During El Niño, the development of anomalously enhanced anti-cyclonic circulation over Northwestern Pacific resulted in relatively strong southerly winds (~1.1 m s^{-1}), compared to La Niña. During El Niño, the mean upwelling index was 402±106 kg m^{-1} s^{-1}, and 10°C isotherm was located at a depth of 32.7 m. During La Niña, they were 368±95 kg m^{-1} s^{-1} and 39.9 m, respectively. During El Niño, in the approximation, the offshore Ekman transport by wind-induced upwelling and the vertical transport by isotherm were 3.3×10^{-8} Sv and 5.6×10^{-8} Sv higher than those during La Niña, respectively. This suggests that El Niño might cause strong coastal upwelling. This finding can be explained by the increased SSH difference and subsequent enhanced geostrophic current and decrease in onshore SST during El Niño. The strong (weak) upwelling tended to be more prevalent when El Niño (La Niña) and PDO were in phase. These results suggest that low-latitude climate change could affect the coastal upwelling in mid-latitude marginal sea through the teleconnection.

(S1-16608 Poster) S1-P6 (ECOP)

The governance systems different, but biological diversity connected and challenges common: exploring potential cooperation of MPAs using Japan, the Philippines, and Palau as case studies

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With a goal to protect 30% of the ocean by 2030, marine protected areas (MPAs) are now one of mainstreams of both marine conservation and fisheries management. Yet, there is still limited effort on regional cooperation in the MPA management. In our case studies, we examine current situations of the MPA governance in Japan, the Philippines, and Palau with an aim to explore potential areas of cooperation among the three countries connected through the Kuroshio Current. Each of them has its unique MPA governance systems; however, they have similar governance frameworks. They manage coastal MPAs through either community-based or co-management systems: Japan designating common fishery right areas as MPAs managed by fishers; and the Philippines and Palau adopting co-management systems for MPAs at the municipal and state levels, respectively. On the other hand, offshore MPAs are mainly managed nationally. Despite their efforts on MPAs, Japan and the Philippines are facing a challenge of meeting the 30% goals whereas Palau is struggling with the effective enforcement of its vast national MPA. Being connected through the Kuroshio Current, the three countries may benefit from managing MPAs at larger ecological scales to address these challenges. For example, they may share the same indicators and data of joint monitoring such as the catch and biomass of species that inhabit the three countries, but at different ages or life stages. Such cooperation may assist the three countries in the implementation of MPAs, allowing them to ensure the substantive conservation of their oceans.

(S1-16642 Poster) S1-P7 (ECOP)

Effects of ocean acidification on growth and body compositions of Snow Crab *Chionoecetes opilio* assessed by indoor culture experiments

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Ocean acidification (OA) is a phenomenon of reduction in seawater pH, caused by uptake of atmospheric carbon dioxide, and thus threatens marine life by changing the properties of seawater. In particular, crustaceans are vulnerable to OA because they have carbonate minerals as a main component of their exoskeleton. Since less is known about the responses of snow crabs to OA, this study is designed to investigate the effects of OA on snow crabs, the major fishery resources in Korea. Juvenile snow crabs were raised for 35 days in OA incubation system formulated at three pH levels: control, pH 7.5, pH 7.0. To determine the impact of OA on crabs, the survival rate, growth rate, and respiration rate, etc. were measured. After the experiment, the number of surviving individuals was 4 in control, 3 in pH 7.5, and 1 in pH 7.0, indicating that OA had a negative effect on survival. The growth rate calculated as the change in total weight, decreased in all conditions, but the most decreased at pH 7.0. The oxygen consumption rate under pH 7.0 had a minimum value of 0.025 mgO2/hr/gweight, which is suggested that juvenile snow crabs reduced energy consumption by respiration in a poor condition like OA. The contents of calcite and Ca of carapace were decreased with pH. Protein and lipid contents of soft tissue were also lower in acidified conditions. This suggests that organisms use them as potential energy sources due to high energy consumption in OA environment.

(S1-16666 Poster) CANCELLED S1-P8 (ECOP)

~~Evaluating the effects of embankments and polder systems on community well-being and coastal ecosystems in mitigating tidal floods in Jakarta~~

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~~Jakarta, the capital city of Indonesia, plays a significant role in the global economy. With its large population and its position as the centre of politics, business, and finance in Indonesia, Jakarta has become one of the largest economic hubs in Southeast Asia. Tidal floods, also known as tidal surges or coastal floods, are a frequent occurrence in Jakarta's coastal areas due to rising sea levels caused by tidal variations. This condition has significant impacts on the economy, particularly in the coastal regions of Jakarta. Tidal floods also result in infrastructure damage, disruptions in transportation and logistics, adverse effects on the tourism sector, and significant implications for the livelihoods of fishermen and coastal residents. The Jakarta government has implemented various measures to control tidal floods, including the construction of a giant sea wall and the implementation of polder systems as part of the National Capital Integrated Coastal Development (NCICD) project. These measures have significant implications, including restricted access to the sea and changes in water flow and tides that lead to alterations in the structure and abundance of fishery resources. This research employs qualitative methods, including interviews, participatory observations, content analysis, and focus group discussions, to examine how these projects have influenced the behaviour of the community and the surrounding ecosystems. The findings highlight that embankments and polder systems are the most effective mitigation measures currently available. To minimise their impact on the community, participatory approaches should be adopted, promoting environmentally-friendly practices such as green polder systems and eco-drainage.~~

(S1-16752 Poster) S1-P9

Toward a less plastic ocean: connecting science and communities

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Increasing microplastics is a new emerging issue to marine ecosystem and many studies have been conducted. The Atmosphere and Ocean Research Institute is also undertaking research on the dynamics of microplastics in the ocean. One of the projects is targeting development of a numerical model to represent historical marine microplastic variabilities. Another project supported by the Nippon Foundation is targeting elucidation of microplastic behaviors in the ocean and impacts on marine ecosystems, and development of policy options to reduce plastic litter. Under these projects, we are trying to engage social communities to understand the current science status and cooperate to reduce, re-use and recycle plastics to achieve less plastic ocean. As a program to incorporate children and parents, a workshop was held to create a 3D model of a bivalve mollusk to learn about the role of marine filter-feeders and to consider the effects of microplastics on the filter feeders. In another program, a core group of about 10 people, ranging from high school students to adults, is developing the discussion on the three sacred tools for reducing the use of plastics. The core group held workshops to extend the discussion to a wider audience. We will introduce those programs and discuss the difficulties to engage social communities. This research was partially supported by the Environment Research and Technology Development Fund (JPMEERF20221001) of the Environmental Restoration and Conservation Agency of Japan.

(S1-16881 Poster) **CANCELLED** S1-P10

~~FishSCORE: Fisheries Strategies for Changing Oceans and Resilient Ecosystems – Building global resources and networks for climate-resilient fisheries~~

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~~Building climate-resilient fisheries is essential for ensuring the continued flow and equitable distribution of benefits, such as nutritious foods, economic benefits, and cultural traditions, that are necessary for achieving many of the global sustainable development goals. As a programme endorsed by the UN Decade of Ocean Science for Sustainable Development, FishSCORE (Fisheries Strategies for a Changing Ocean and Resilient Ecosystems) will form a network of collaborators – including interdisciplinary scientists, fishery stakeholders, resource managers, community practitioners, and policy makers – from across the globe to co-develop scientific information and approaches to sustain resilient marine fisheries in changing oceans. This programme will integrate transdisciplinary knowledge into new understandings of how climate change will affect marine fisheries at local to regional scales, and moreover, how healthy marine ecosystems and resilient fisheries can be achieved in the context of these changes. FishSCORE will rely on ongoing collaborations between scientists and practitioners to improve scientific products, ensure they are tailored for applied needs, and support their use in real-world fishery systems. This approach will strengthen partnerships and build capacity for forward-looking resilience planning in marine fisheries across the globe, including in industrial and artisanal fisheries as well as in developed and developing countries. By advancing collaborations among diverse types of fisheries, FishSCORE will contribute to equity of knowledge and capacity for climate resilience efforts, which will be needed to achieve sustainable development goals associated with eliminating hunger and poverty, enhancing well-being, protecting marine ecosystems, and reducing climate goals.~~

(S1-16901 Poster) CANCELLED S1-P11

~~**Marine ecosystems and sustainable development**~~

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~~The search for ways of sustainable development of marine ecosystems is associated with the development of information technologies that make it possible to predict the consequences of the implementation of anthropogenic projects, without which it is impossible to improve the living conditions of the population. Many of the problems that arise in marine ecosystems require the development of decision-making procedures in order to solve them, allowing the search for acceptable strategies for sustainable development. Sustainable development indicators are usually used to assess the overall state of the system or process under study. This paper discusses the issues of sustainable development of marine ecosystems. The main global problems of the dynamics of marine ecosystems and the analysis of the importance of environmental and socio-economic factors in the formation of global changes in these systems are considered. The decision on the level of potential risk of possible changes in the marine environment can be made on the basis of an analysis of the prehistory of such events and using methods for predicting natural phenomena. As a rule, risk assessment methods are based on statistical processing of data on process parameters, the interaction of which can initiate undesirable changes in the characteristics of the marine environment. The decision tool is developed on the basis of classical and sequential procedures. The statistical decision model assumes the continuous calculation of the selected criterion until it is satisfied. It is assumed that the process under study is evaluated on the basis of a specific indicator, and a set of its values is formed from various sources of information.~~

(S1-16927 Poster) S1-P12 (ECOP)

Engaging Early Career Ocean Professionals (ECOPs) in East Asia: Insights from 2022-2023 surveys in China, Japan and South Korea

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The Early Career Ocean Professional Programme (ECOP Programme) is a Global Network Programme endorsed by the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) in June 2021. It has experienced remarkable growth in its geographical reach, evolving into a dynamic 'network of networks' comprising five regional nodes (Africa, Asia, Caribbean, Central America and Europe) and 24 different national hubs. The ECOP communities in East Asia are particularly active, with 120, 54 and 101 registered members in China, Japan and South Korea, respectively.

The national coordinators of the ECOP Programme in Asia have played an integral role in its success. They have conducted video interviews, organized ECOP-centered symposia, sessions and workshops, curated dedicated communication and networking channels, engaged with key ocean stakeholders and partners of the UN Ocean Decade, and took stock of the needs, priorities and challenges faced by their respective ECOP audiences. To gain a comprehensive understanding of the latter, four regional and national surveys have been disseminated since mid-2022, gathering crucial socio-demographic statistics and identifying the barriers ECOPs encounter, and the resources required for their professional growth. These bilingual online surveys capture cultural nuances and provide tailored actionable insights, particularly in areas such as funding, awareness-raising, networking and capacity building.

In this context, PICES assumes a pivotal role in effectively engaging and fostering meaningful relationships with ECOPs in East Asia. By doing so, PICES will contribute to the development of synergistic and transformative partnerships that drive progress and innovation in ocean science and sustainability.

(S1-16967 Poster) CANCELLED S1-P13

~~Towards a respectful and sustainable long-term marine monitoring program in Gwaii Haanas, a cooperatively managed protected area in northern British Columbia, Canada~~

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~~Coastal marine ecosystems are complex and interrelated ecological, cultural and social systems, particularly within the traditional territories of Indigenous Peoples. Learning from decades of working together as cooperative management partners in Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve (NMCAR), and Haida Heritage Site (hereafter Gwaii Haanas), the Haida Nation and Canada are developing a long-term marine monitoring program for Gwaii Haanas with guiding principles grounded in Haida ethics and values from Haida law, and consistent with the ecological sustainability monitoring framework for Parks Canada NMCARs. To be sustainable and comprehensive, this monitoring is being implemented in collaboration with the Haida Nation, other government departments, non-government organizations, academia and industry partners. Haida knowledge, local knowledge and scientific knowledge are being woven together in the development, implementation and evaluation of marine monitoring surveys and metrics. For Gwaii Haanas and other NMCARs in Canada, these metrics include key environmental stressors, species and habitats, and marine uses most relevant to each place. Using Gwaii Haanas as a focal place, we provide our perspectives and lessons learned to date as discussion points with the broader marine monitoring community to contribute to future development of respectful and sustainable long-term marine monitoring programs.~~

(S1-16992 Poster) S1-P14

Implementation and strategic planning for connecting science and communities for sustainable seas: case studies in dissemination of Ciguatera Fish Poisoning (CFP) in Gili Matra Lombok, Indonesia

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Dissemination of science and technology to the community to increase their knowledge, understand, accept, adopt and apply it in various related activities, requires a holistic strategy and planning. A bottom-up and top-down approach involving community leaders from various related groups as well as decision-maker at both the local and national levels including experts from various research institutions, universities and NGOs is a very strategic approach to be implemented in Indonesia. The socialization model to bridge the application of knowledge to society like this is expected to become a model that can be applied in other countries. As is known, Ciguatera Fish Poisoning (CFP) has become a global problem in several parts of the world, both in tropical and sub-tropical regions. Indonesia, as the largest archipelagic country in the world with an area of 39,583 km^2 consisting of coral reefs about 45.7% of the total 86,503 km^2 of coral reefs in the Coral Triangle region, and biodiversity of up to 590 species of rock coral and reef fish, must be prepared to face this problem. Gili Matra is an area of small islands in the Northwest of Lombok Island which has the potential to face damage to coral reefs due to very intense tourist activity both from the number of tourists and boats that gather at dive tourism objects in coral reef areas. For this reason, PICES collaborates with various stakeholders in Indonesia such as ITI - Institute of Technology of Indonesia, BRIN - National Research and Innovation Agency, UI - University of Indonesia, and UNRAM - Mataram University, Ministry of Maritime Affairs and Fisheries, as well as the Provincial Government of West Nusa Tenggara (NTB). has been and is working to socialize various marine environmental health monitoring technologies (Hydro-colour Technology, Fish GIS, Plankton Scope, etc) in the area. This activity is in line with the Ocean Decade Program and the UN's 2030 Sustainable Development Goals: Building Good Health and Well-Being (No. 3), Climate Change (No. 13), and Improving Life Underwater (No. 14).

Session 2: BIO/POC/TCODE Topic Session

Applications of Deep Learning Systems in Marine Science

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

Invited Speaker:
Jean-Olivier Irisson (Laboratoire d'Océanographie de Villefranche, Sorbonne Université, France)

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

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

(S2-16571 Invited)

Increased usage of deep learning systems in marine ecology

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Over the last four years, the Working group on Machine Learning in Marine Science of the International Council for the Exploration of the Sea set itself to map the use of machine learning approaches in marine ecology, to highlight working solutions and trends. We will first present the general process of machine learning and the anatomy of recent deep learning systems. Then we will take a historical perspective to describing the evolution of the use of machine learning for various input data types (images, acoustics, remote sensing, etc.) based on a collaborative database of >1000 peer reviewed references, which we tagged according to the task achieved (classification, regression, etc.) and the machine learning method used. We find that machine learning is most often used for classification problems, is pervasive on images, and that deep learning systems are becoming dominant for all data types. We also highlight papers that can serve as reference for newcomers and/or have proved influential for the community. Beyond classification, we will also highlight how deep learning systems can be used to reduce the dimension of complex ecological data and provide new views of oceanic ecosystems. Finally, we underline which bottlenecks still exist for a wider, routine application of deep learning approaches and propose ways forward.

(S2-16508 Oral)

Fourier transform near infrared spectroscopy of otoliths coupled with deep learning to improve age prediction

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We explore advanced technologies using Fourier transform near infrared (FT-NIR) spectroscopy coupled with machine learning to estimate fish age more rapidly and with greater efficiency than traditional approaches. Traditional microscopic age estimation methods of fish otoliths are expensive, labor-intensive, and often subject to poor repeatability. FT-NIR spectroscopy measures the absorption of light in the near infrared region and records an otolith spectrum. This technology has recently been applied to the otoliths from northern rockfish (*Sebastes polyspinis*) and red snapper (*Lutjanus campechanus*) collected in the Bering Sea and Gulf of Mexico, respectively. Deep machine learning explores the underlying relationships between an otolith spectrum and fish age along with other biological and geospatial data that have an effect on fish growth. Coefficients of determination (R^2) for the best northern rockfish model are 0.92 and 0.92 for the training and test data, respectively. Root mean square errors (RMSE) of training and testing data sets are 3.37 and 3.36 years, respectively. R^2 for the best red snapper model are 0.91 and 0.89 for the training and test data, respectively. RMSE of training and testing data sets are 1.01 and 1.13 years, respectively. Since FT-NIR spectroscopy method is about ten times faster than traditional age estimation methods, these results suggest that FT-NIR spectroscopy of otoliths coupled with deep machine learning can predict fish age more rapidly, with greater efficiency, and with comparable precision.

(S2-16518 Oral)

Rapid plankton biomass assessment in coastal waters

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Plankton plays a crucial role in understanding the health and dynamics of marine ecosystems. Traditional methods for measuring plankton biomass are often laborious and time-consuming. We deployed an imaging system coupled with an end-to-end deep learning (DL)-based image processing procedure for real time plankton biomass assessment in coastal waters. The imaging system can capture high-resolution images of plankton in coastal waters with suboptimal imaging conditions caused by high turbidity and complex water movements. The DL-based fast plankton identification system can extract and classify different plankton groups near real time. Results from our deployment demonstrate the effectiveness of the proposed system which provides real-time monitoring and tracking of plankton biomass. High-frequency time series observations capture the fine-scale temporal variability, reveal phenological patterns, detect impacts of episodic events and ecosystem responses, and support adaptive management strategies. The fine-scale spatial distribution of plankton facilitates our understanding of trophic interactions, physical-biological coupled processes, and impacts of environmental changes. The combination of imaging systems and DL techniques presents a promising solution for rapid plankton biomass assessment which offers a time-efficient and automated approach and contributes to our understanding of ecosystem dynamics and enables adaptive sampling and adaptive ecosystem management practices.

(S2-16583 Oral)

Estimation of total length composition of fish detected as non-occluded using a smartphone application and deep learning techniques

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Length composition of landed fish is a fundamental data for stock assessment, although a lack of measurers directly leads to a decrease in precision of estimates. Image analysis techniques such as deep learning can be used to obtain length composition from fish images independent of the number of measurers. On the other hand, the fish length of the underlying individuals may be underestimated due to overlap among multiple individuals (hereafter referred to as occluded). The purpose of this study was to evaluate the accuracy and precision of the total length composition obtained from images including both occluded and non-occluded fish. The lengths of four fish species landed at Matsuura fish market in December 2022 were measured one by one. Multiple fish were then placed randomly per species in a fish box (70 x 40.5 cm) and photographed through a newly developed smartphone application (ToroCam). Estimated total length compositions were compared to the true composition both occluded and non-occluded individuals. The total length compositions of occluded individuals were invariably more different from the observed mean than that of non-occluded individuals. A difference of total length compositions of non-occluded individuals differed only ±3% from the observed mean. It was suggested that total length composition could be generated automatically from the catch in occluded condition at the fishing port site simply by photographed images with a smartphone.

(S2-16597 Oral)

Fish identification through deep learning using only non-occluded fish

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Length composition of landed fish by species is important for stock assessment. In this study, we examined if a fish with non-occluded by other fish body in the image would improve the accuracy of fish species identification, in order to determine length by species from images of catches. Cameras were set on the conveyor belts for sorting fish at several fish ports in Japan and fish images were obtained. The training data were pre-cropped images of each individual fish. The target fish were the following four groups and 16 classes: group Carangidae (6 classes), group Scomber (3 classes), group Sphyraena and Promethichthys (4 classes), and group Auxis (3 classes). Fish identification model was trained to classify each group. The model was Convolutional Neural Network using ResNet18, and the ratio of training, validation, test data was 8:1:1. From the test data, non-occluded fish were selected and compared for accuracy with all test data. In most groups, the accuracy of the test data with only non-occluded fish was better than that of all test data for group Carangidae, group Scomber, and group Sphyraena and Promethichthys. On the other hand, the accuracy decreased for group Auxis. Group Auxis tend to be photographed with their ventral or dorsal side up due to their large body width, which might make it difficult to identify the fish class. However, it is probably effective to select non-occluded fish to improve the accuracy of most fish class identification.

(S2-16600 Oral)

Automated video processing to support commercial fishing innovation in the walleye pollock (*Gadus chalcogrammus*) fishery in Alaska

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Bycatch reduction devices (BRDs) are used in the walleye pollock (*Gadus chalcogrammus*) fishery in Alaska to reduce Pacific salmon (*Oncorhynchus* spp.) bycatch. The performance of BRDs is often studied by recording videos during fishing. There is also active research to develop BRDs that use live-feed video. The live-feed and recorded video need people to review or monitor the footage, which is tedious and costly. These impediments can slow BRD development. A possible solution for expediting this process is to use deep learning, a widely applied tool for automating the analysis of imagery. We investigated the possibility of automating the review of videos collected in the pollock trawl by fine-tuning a pre-trained deep learning model to detect salmon and pollock. We annotated 17,659 video frames that included 219 salmon and 3,041 pollock. These annotations and five-fold cross validation were used to fine-tune and evaluate the detection model EfficientDet. Models were evaluated across 10 different background and camera situations that included krill presence, three rankings of fish density, camera occlusions, low lighting, and combinations of these conditions. The best fine-tuned model detected 85% of salmon and pollock (mean Average Recall of 0.85 ± 0.01) and 57% of the detections were correct (mean Average Precision of 0.57 ± 0.04) for detections with 50% or greater overlap with our annotations. Model performance varied across different situations, and the greatest variability occurred during camera occlusions. Our study showed that these models can automatically detect fish in-situ in high volume fisheries and illustrated challenges that exist.

(S2-16628 Oral)

Microplanktonic assemblages in the spring East China Sea: An approach with a frugal plankton imaging system coupling with EcoTaxa

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Imaging analysis of plankton coupling with automatic classification would be potentially beneficial to monitor the dietary condition of commercially important fish by fast and traceable observation of dietary species, yet there are only a few examples. This could be partly due to the high cost of implementation and the high programming skills requisite to archive good identification with deep learning. Here we introduce our recent attempt to examine the spatial distribution of microplanktonic assemblages using PlanktoScope, an open-source frugal imaging system, and EcoTaxa, an open-source web platform for plankton classification. After several modifications with the PlanktoScope, images of microplankton were taken and segmented in ca. 1 hour. The segmented images were easily uploaded, predicted, and validated on EcoTaxa. From the test analysis using NORPAC net samples taken around the shelf edge of the East China Sea from February to March 2021 (63 µm mesh; vertical hauls from 50 m to the surface), we observed that the major microphytoplankton including *Chaetoceros*, *Thalassionema*, and *Thalassionsira*, had opposite distribution patterns against chlorophyll *a* concentration, which implies of high contribution of pico- and nanoplanktonic species to the chlorophyll *a*. Contrastively, copepod copepodites and nauplii, mainly calanoids and cyclopoids, showed a similar distribution to the chlorophyll *a*, which could be a manifestation of their preferential to the pico- and nanophytoplankton, or a result of their active grazing on diatoms.

(S2-16630 Oral)

A novel approach to retrieve vertical profiles from PIES data using a deep neural network and its application to the northwestern Pacific Ocean

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Timeseries of vertical acoustic travel time (VATT) from the sea floor to the sea surface can be measured using the bottom-moored pressure-recording inverted echo sounder (PIES), which is a simpler observing instrument when compared to the traditional tall mooring with thousands of meters of rope and heavy ankers. The VATT reveals characteristics of main thermocline at the PIES site since it provides integrated information of water properties. Based on the VATT, various types of gravest empirical modes have been developed to estimate the profile of water properties. Here, we present a novel technique based on a deep neural network, which is called as artificial intelligence-PRO (AI-PRO). Based on the WOA annual mean temperature profile, the AI-PRO is conditioned to estimate the temperature profile from the VATT and satellite-derived data, such as sea surface height and temperature. The satellite-derived sea surface data can give spatial and temporal information, and the sea surface height data can be considered as another proxy for vertically integrated water properties. The network is trained using about 15,000 profiles of ARGO data in the northwestern Pacific and tested at the PIES-moored sites. The network's performance is evaluated by changing input days and variables to find the optimal parameters. The performance evaluation confirms that our novel AI-PRO technique can produce quantitatively improved water-property profiles when compared with the state-of-the-art data-assimilated numerical simulation outputs.

(S2-16664 Oral)

Habitat classification in the Gulf of Alaska based on acoustic surveys using deep learning

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Abundance and productivity of marine life are often strongly influenced by seafloor habitats, and therefore, high resolution mapping of the seafloor is essential. Underwater imagery can capture high resolution data on seafloor types and features, but the sampling footprint of cameras is small and therefore of limited use for mapping shelf-scale marine areas. Acoustic instruments can capture reflections from the seabed over large areas, but relating these data to seafloor habitat types is challenging. We set up a machine learning framework to associate seafloor habitat with the acoustic data by training on a small subset of acoustic data where concurrent high resolution camera imagery is available. A random forest model was used to semantically segment the benthic images collected over the Gulf of Alaska. The derived substrate composition and rugosity from stereo reconstruction were used as training outputs for a convolutional neural network. The acoustic backscatter at five frequencies (18, 38, 70, 120 and 200 kHz), recorded over a 30 m distance and the seabed depth, were the inputs provided to the network. The image-acoustic pairing data were well-distributed over the seabed classes – sand, coarse, cobble, boulders, and bedrock. The present talk will discuss the considerations of the input to the network for handling the acoustic data collected over a wide range of measurement conditions, vessel speeds and bottom depths. The network structure and interpretations of the important features learned by the machine learning based classifier will also be presented.

(S2-16725 Oral)

Semantic segmentation of Pacific hake aggregations in water column echograms

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Pacific hake supports the largest fishery of the U.S. west coast and is a keystone species in the northern California Current ecosystem. Obtaining biomass estimates of hake relies on a key step of identifying water column echo returns induced by hake in months-long acoustic survey data. This is a time consuming task, requiring fisheries acoustics expertise and substantial field experience associating echogram patterns with hake trawls. In

this work we leverage existing annotations to develop a semantic segmentation framework to detect hake aggregations in echograms from ship surveys. Semantic segmentation has been shown to successfully extract fish aggregations from echograms for species such as herring and sandeel. However, hake poses a unique challenge since its aggregations typically do not have well-defined boundaries and can have a large spatial span. Further, hake appearance may differ depending on age, depth of occurrence, or co-occurrence with other species. Despite these variations, the algorithm can successfully identify several types of hake aggregations, and detects potential hake regions not identified by annotators but having acoustic signatures consistent with hake echoes. The algorithm thus can serve as an initial screening tool to allow focusing expert annotation efforts on the more ambiguous identification cases.

(S2-16773 Oral)

Advancing mussel habitat mapping in rocky intertidal ecosystems using high-resolution UAV Imagery and deep learning techniques

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Mussels (*M. edulis*, *M. trossulus*, and *M. galloprovincialis*) are vital inhabitants of rocky intertidal habitats, contributing to habitat formation, biodiversity, nutrient cycling, and providing food and shelter for various other organisms. However, climate change impacts such as sea-level rise, ocean acidification, and shifting environmental conditions pose significant threats to mussels and their habitats. Consequently, monitoring these species becomes crucial to assess the health of the ecosystem and devise effective conservation strategies.

Conventional methods for mapping mussel habitats often suffer from limitations such as high costs, hazards, and impracticality for monitoring changes over time. This talk introduces an innovative approach that harnesses the power of high-resolution Unmanned Aerial Vehicle (UAV) imagery and advanced deep learning techniques, specifically Convolutional Neural Networks (CNNs) and Vision Transformer Networks (VTNs), to enable large-scale mapping of mussel habitat while reducing image labeling costs.

The presentation focuses on a comparative analysis of various neural network models for semantic segmentation of mussel habitat, evaluating their performance against meticulously hand-labeled image datasets. By integrating deep learning methods, our objective is to enhance the accuracy and efficiency of mapping efforts significantly. Furthermore, we discuss the challenges associated with this approach and outline potential directions for future research, emphasizing the need for continued innovation in this field.

(S2-16798 Oral)

Big data mining and fusion towards resources evaluation of deep-sea polymetallic nodules

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Polymetallic nodules is a kind of strategic marine mineral resources with potential economic values for it is rich in critical metallic elements like Cu, Co, Ni, Mn, REEs and Pt, and the spatial distribution rules and resources potentials evaluation of which are the research hotpots in marine earth science. Limited to conventional data and traditional evaluating methods, the whole spatial correlation of multi-source heterogeneous data and complicated nonlinear spatial distribution mode are difficult to realize. In order to improve the polymetallic nodules resources evaluating accuracy and efficiency, it is necessary to mining and fusing the information from multi-source heterogeneous data based on big data analysis methods. The major research contents and methods are: (1) Knowledge pedigree analysis for Polymetallic nodules resources; (2) Metallogenic characteristics mining methods based on data science; (3) Fusion and integration methods based on spatial decision-making model with big data; (4) Application test of quantitative prediction and evaluation on polymetallic nodules resources. Through creatively mining and analysis on conventional/unconventional resources evaluating data and the correlation with ore deposit, and establishing the spatial decision-making model with geological constraint and big data, the technology solution based on big data can be supplied to deep-sea mineral resources evaluation.

(S2-16867 Oral)

Enhanced climate downscaling for the Northeast Pacific using deep learning methods

Albert J. **Hermann**[1,2], Kenneth O. Coyle[3], Emily L. Norton[1], Wei Cheng[1,2], Kelly A. Kearney[1,4], Darren J. Pilcher[1,2], Martin Dorn[4] and Kirstin K. Holsman[4]

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Elevated temperatures in both the Gulf of Alaska (GOA) and the Bering Sea have recently been associated with profound changes in the abundance and distribution of commercially important fish species. The duration and intensity of such "heat waves", with associated changes in biogeochemistry, are anticipated to shift under global climate change. Using deep learning methods (specifically, the long short-term memory method [LSTM]), applied to output from dynamically downscaling hydrodynamic-biogeochemical models of the Northeast Pacific, we examine the histograms and spectra of historical and projected future regional properties under multiple global greenhouse gas emission scenarios. The LSTM method is used to expand our dynamical ensemble of regional projections, to include a broader range of global model realizations and possible socio-economic pathways; this provides improved estimates of means and uncertainties for their use in management applications. Forcing of the downscaling models includes surface winds and air temperatures, inter-annually varying runoff with associated iron, and lateral ocean boundary conditions with hydrographic, macronutrient, and carbonate variables. Internal model dynamics include iron, tides, sea ice, and multiple plankton categories. We include a broad range of environmental variables in the LSTM analysis, but focus in particular on projections of bottom temperatures in the northern GOA and the Bering Sea shelf. Overall findings include a larger increase in bottom temperatures of the Northern GOA and the Bering Sea, relative to the Eastern GOA.

(S2-16895 Oral)

Fine-scale spatial patterns of gelatinous zooplankton in the Northern Gulf of Alaska

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The logistic constraints of plankton net sampling limit our ability to collect high-resolution zooplankton data that captures the high spatiotemporal variability of the marine environment. In particular, abundances and distributions of gelatinous and fragile-bodied organisms can be poorly resolved by nets due damage inflicted during collection. Advancements in computational power are enabling us to overcome many of these challenges by combining *in situ* pelagic imaging and machine-learning technologies. In the Northern Gulf of Alaska (NGA), we are deploying an *In Situ* Ichthyoplankton Imaging System Deep-Focus Particle Imager (ISIIS-DPI), a towed vehicle with mounted instrumentation and an imaging array. Its 3 line-scan, shadowgraph cameras image ~250 liters/second while conserving the scale of particles and plankton. Each hour of deployment collects ~1 TB of data and millions of images, necessitating automated processing. Our pipeline uses a semi-convolutional neural network (sCNN) to segment and classify these images. Simultaneous collection of imaging and environmental data enables us to describe fine-scale distribution patterns of gelatinous zooplankton in the context of surrounding biophysical drivers. Ctenophores are the most fragile gelatinous zooplankton and are virtually missed by traditional sampling methods. Here, we demonstrate their prominence in the NGA and present first records of previously undetected species. Results suggest that their aggregations are concentrated around frontal features and associated with elevated densities of known prey species (eg. copepods). These high-resolution distribution patterns would be entirely obscured if relying solely on traditional plankton net sampling methods.

(S2-16932 Oral)

Beyond transfer learning: an implementation guide to optimally leveraging ancillary images in automated classification of plankton

Jeffrey S. **Ellen** and Mark D. Ohman

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We assess the efficacy of a supervised Machine Learning algorithm, specifically a Convolutional Neural Network, on planktonic image classification when including non-planktonic and ancillary planktonic images in the training set. Transfer learning, or cross-domain adaptation, is a decades old machine learning concept intended to reuse an existing algorithm and model that worked well on an existing task to initialize a new model for a new task in order to reduce the annotation burden, or boost results given a small number of initial annotations. There are recent publications applying transfer learning to plankton with ambiguous results. We focus on the use case of optimizing the CNN for a single planktonic image source and we consider ancillary images to be plankton images from other instruments. We conducted two sets of experiments with three different types of plankton images (from a Zooglider – 1.2M images, Underwater Vision Profiler 5 – 145k images, and Zooscan – 2.1M images). We combined all three plankton image types into a single dataset with 3.3 million images (despite their differences in contrast, resolution, and pixel pitch) and conducted a multi-stage Transfer Learning assessment. We executed a Transfer Learning stage from ImageNet to the merged ancillary plankton dataset, then a second Transfer Learning stage from that merged plankton model to a single instrument dataset. We found that multi-stage Transfer Learning resulted in additional accuracy gains. We believe this technique should generalize to other underwater vision classification tasks, but is especially useful for novel instruments without large, annotated corpora.

(S2-16936 Oral)

Using Ecotaxa to assess phenological variability of winter predator-prey dynamics between ichthyoplankton and zooplankton in Beaufort Inlet, North Carolina, USA

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As temperatures increase over time, it is important to learn how cyclic or seasonal patterns in the marine environment are changing. This is especially true for ichthyoplankton that are expected to successfully recruit to a fishery and sustainably contribute to the spawning stock biomass of a given fishery. The degree of seasonal match or mismatch between larval fish and zooplankton abundance may help explain variability in recruitment. This project aims to assess potential mismatches between predator abundance and prey availability as a response to temperature. This was examined using historical data from NOAA's Beaufort Inlet Ichthyoplankton Sampling Program and zooplankton samples collected by East Carolina University. Zooplankton taxonomic groups were identified using Ecotaxa, a machine learning program, that utilizes a random forest algorithm. Both seasonal and general learning sets will be used to test which learning set results in more true positive readings. This analysis will aid in understanding how to streamline and increase the accuracy of the classification process using Ecotaxa. We examined how the abundance of adult copepods and nauplii coincided with the peak estuarine ingress timing of spot (*Leiostomus xanthurus*) and Atlantic croaker (*Micropogonias undulatus*) larvae in the winter. Adult copepods and nauplii of both copepods and barnacles had coinciding blooms. There were no significant differences between the degree of mismatch for both fish species between winters. However, mismatches between predator and prey were more offset for spot than Atlantic croaker. This analysis will inform future methods examining predator-prey dynamics of multiple fish species and prey taxa.

(S2-16545 Poster) S2-P1 (ECOP)

An integrated deep learning-based approach for fishing vessel classification using AIS data

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Effective fisheries management is important for achieving sustainable development of marine resources, in which the monitoring of fishing vessels is an essential element. Mining data from the Automatic Identification System (AIS) is a powerful method to monitor marine fishing activities. In this talk, we proposed a novel ensemble deep learning model based on the AIS data to accurately classify five types of fishing vessels, i.e., gillnetter, troller, trawler, transport vessels, and trapper, further improving the performance of fishing vessels classification. Firstly, the model utilized the geometrical, static and dynamic features of the vessels to extract the latent information from the AIS data, which more effectively explained the differences in various types of fishing vessels. Secondly, the integrated model of two-dimensional bidirectional long short-term memory and convolutional neural network with attention mechanism (2D-BiLSTM-CNN-Attention) was selected to gain highly accurate classification results. Ultimately, the final predictions of the five fishing vessel types were obtained through the fully connected layer. The experimental results indicated that this approach achieved a superior performance and can be used to increase the accuracy of fishing vessels classification using AIS data.

(S2-16786 Poster) S2-P2 (ECOP)

Automating the acoustic detection of Arctic ringed seal vocalizations using deep learning

Karlee **Zammit**[1], William Halliday[2], Fabio Frazao[3] and Stan Dosso[1]

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Arctic ringed seals are designated as a species of Special Concern in Canada. The critical habitat of ringed seals is sea ice, which is thinning and forming later each year due to climate change. Completely ice-free summer conditions are projected to occur by 2050, which will likely lead to increased shipping presence in a historically acoustically pristine environment. Increased anthropogenic sound levels from shipping can cause behavioural disturbance, hearing damage, and persistent stress in marine animals. Passive acoustic monitoring (PAM) is in many cases the only feasible method to obtain year-round information on marine species in harsh, remote environments. Acoustic detections of marine mammal vocalizations aid in the creation of conservation regulations to protect marine species by indicating the presence, absence, and behaviour of a species. Employing a human expert to manually analyze PAM data is prohibitively time-consuming and costly, which has motivated the development of automated analysis methods. In this work, deep learning architectures which have shown success for other marine species are trained to classify spectrograms as containing ringed seal vocalizations or without. The spectrograms are generated from terabytes of PAM data which have been collected in the Arctic since 2014. Once trained, the network is used to detect ringed seal vocalizations in unseen data to create the first reliable ringed seal acoustic detector in existence. The pre-processing steps and trained deep learning architecture will be available as an open-source tool for researchers to use as the basis for further development of new automated detectors.

(S2-16900 Poster) S2-P3

Analysis and projection of long-term sea level change around the Korean Peninsula

Gwang ho **Seo**[1], Kwang-Young Jeong[1], Hyun-Ju Oh[1], Yang-Ki Cho[2] and Yu-Kyeong Kang[2]

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We focus on regional sea level change around the Korean Peninsula. In this study, we analyze the sea level record from tide gauges to better understand regional sea level change. The sea level record from tide gauges is an important indicator of the evolution and impact of climate change. For 33 years (1989 to 2021), the rates of sea level rise were 3.53 ± 0.26 mm/yr on the east coast of Korea, 3.08 ± 0.23 mm/yr on the west coast of Korea, and 2.55 ± 0.22 mm/yr on the south coast of Korea (including Jeju). Ulleungdo had the highest rate of sea level rise, at 5.29 ± 0.46 mm/yr.

We also studied sea level rise using the results of high-resolution models to project future sea level rise in the marginal seas around the Korean Peninsula. High-resolution regional ocean climate models (RCMs) that consider tides and rivers were used to address the limitations of global climate models (GCMs) in the Northwestern Pacific (NWP) marginal seas through dynamical downscaling. Four GCMs were selected for dynamical downscaling based on a performance evaluation of sea surface temperature (SST) and sea surface height (SSH) along the RCM boundaries. A regional model with high resolution (1/20°) was simulated to project spatially non-uniform changes in sea level under two CMIP6 scenarios (SSP1-2.6 and SSP5-8.5) from 2015 to 2100. Sea level rise in the NWP marginal seas was approximately 82 cm under the SSP5-8.5 scenario and approximately 47 cm under the SSP1-2.6 scenario.

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

Responses of Small Pelagic Fish to Extreme Events in Pacific Ecosystems

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

Invited Speakers:
Sukgeun Jung (Jeju National University, Korea)
Toru Miyama (Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan)

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

(S3-16716 Invited)

Significant impact of ocean current variability on marine heatwaves: case studies in the Northwestern Pacific Ocean

Toru **Miyama**, Yasumasa Miyazawa, Hakase Hayashida, Yu-Lin K. Chang, Sergey Varlamov and Ruochao Zhang

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This presentation will explore the significant impact of ocean current variability on marine heatwaves in the Northwestern Pacific Ocean. Marine heatwaves have been rapidly increasing and intensifying in this region in recent years, like other parts of the world. One of the unique features in this region is that the western boundary current system of the North Pacific, including the Kuroshio, Oyashio, and Tsushima Warm Current, exerts a strong influence on the region and plays an important role in the occurrence of marine heatwaves. We have conducted investigations using ocean prediction systems developed by the Application Laboratory (APL) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) to examine the role of ocean currents in the occurrence of marine heatwaves. Particular attentions were given to the impacts of the Kuroshio Large Meander and the recent weakening of the southward intrusion of the Oyashio. Marine heatwaves can have a negative impact on the ecosystem and fisheries, as changes in the distribution and abundance of marine organisms can result in an abrupt decrease or increase in catches and have economic impacts on fishing communities. In addition, marine heatwaves can affect the atmosphere and increase the likelihood of heavy precipitation, leading to natural disasters. It is essential to gain a better understanding of the relationship between ocean currents and marine heatwaves to develop an efficient strategy to mitigate the negative effects of this phenomenon. Therefore, this presentation aims to explore different aspects of the western boundary current System in the North Pacific.

(S3-17008 Invited)

Recent population explosion and mass killing of Pacific sardine in the western North Pacific in relation with climate change and fisheries management

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Annual fluctuation of the abundance of Pacific sardine (*Sardinops sagax*) has shown cycles of ~50 years in the western North Pacific. Recently, the population seemed to explode again in 30 years. In Korea, the sudden population increase and mass killings in 2022 drew public interest and concern. I hypothesized that all of the dead sardine bodies found at 9 sites along the coast of Masan bay were discarded ones from the fishing vessels targeting anchovy, because of the fisheries regulations on bycatch. To test my hypothesis, I contacted fishers and was confirmed that they indeed discarded them within Masan bay. Later, however, the Korean government announced that the mass killings were caused by hypoxia, but I contended that the dissolved oxygen concentrations were all normal in the surface layers where sardine swim. Later, the government changed the cause of mass killing to the aggregation of sardine to the coast and the subsequent lack of dissolved oxygen. I proposed that the Korean government should allow fishermen to catch and land sardine to avoid further mass killings. The government now allows the bycatch. Similar mass killings were also reported in Japan, and I speculate the cause was either the discard from the nearby set nets (e.g., Toyama bay) or by unusually cold water (e.g., Mutsu Bay). Developing stories on sardine in the region will be shared and discussed in relation with further research and fisheries implications.

(S3-16489 Oral)

Trophoscapes of predatory fish reveal biogeographic structuring, spatial dietary overlap, and inform fisheries bycatch patterns

Brian K. **Wells**[1,2,3*], Jarrod A. Santora[1,4], Joseph J. Bizzarro[5], Alicia Billings[6], Richard D. **Brodeur**[2], Elizabeth A. Daly[7], John C. Field[1], Kate E. Richerson[6] and James T. Thorson[8]
(*Presented by Richard D.* ***Brodeur***)

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Trophic interactions are proximate drivers of ecosystem function, including predator-prey dynamics, and their spatio-temporal variability may reflect ecosystem shifts and changes in trophic transfer. We investigated biogeographic structuring of trophic interactions by analyzing multi-decadal time series of diet for Pacific hake (*Merluccius productus*) and Chinook salmon (*Oncorhynchus tshawytscha*) from a large marine ecosystem. We compared our predictions for spatio-temporal variability of hake and salmon trophoscapes (i.e., spatially-explicit predictions of trophic relationships) to inform ecosystem dynamics and fishery bycatch patterns. We have three inter-related findings pertaining to the spatial coherence of the trophoscapes and the potential consequences to juvenile and sub-adult (i.e., after the first year at sea but prior maturation) salmon when sharing foraging areas with Pacific hake. First, the spatial scale of Pacific hake diet variability represents coastwide variability and spatial variability of Chinook salmon diets varies across regions and demonstrates a broad diet. Second, the expectation for increased diet and spatial overlap of Pacific hake and Chinook salmon during low productivity periods (e.g., periods with low krill biomass, suboptimal upwelling) can inform fishery management challenges. In this regard, we explore the role of shared foraging habitats on increased predation, and consequentially reduced recruitment, by Pacific hake on juvenile salmon during sub-optimal upwelling conditions. Third, we show above-average bycatch of sub-adult Chinook salmon was associated with later spring transition, potentially as a result of both Pacific hake and salmon sharing foraging areas and prey species on the shelf and shelf-break.

(S3-16530 Oral)

Trophic shifts and energetic responses in small pelagic fishes during prolonged marine heatwaves in the Northern California Current

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The U.S. west coast marine ecosystem has recently experienced unprecedented ocean warming due to anomalous marine heatwaves (MHWs) lasting several years. The MHWs led to profound changes in species composition, spatial distribution, and food web structure throughout the California Current ecosystem (CCE). A key unknown that warrants attention is how MHWs may impact marine food web interactions, and particularly the trophic interactions of small pelagic fishes. Previous diet studies indicated that crustaceans were the dominant prey item of forage fishes in cool or normal periods, but gelatinous species were the dominant prey during the marine heatwave. Our goal is to use stable isotope signatures in forage fish muscle tissue combined with a Bayesian mixing model to determine if we detect similar changes in their feeding during warm ocean conditions. We measured the stable isotopic signatures ($\delta^{13}C$, $\delta^{15}N$) of forage fish and their invertebrate prey during 10 oceanographically variable years (2000,2002, 2015-2022) including several anomalous MHWs. Most species fed on a narrower diet and had a higher trophic position during the MHW, and the proportion of gelatinous material in the diet increased during the heatwave compared to normal ocean conditions. We also found differences in the energy content of both the forage fishes and their prey between normal and MHW conditions. Overall, our results corroborate the findings from the stomach content analyses, providing further support of a shift in forage fish feeding habits from a crustacean to a gelatinous dominated diet in the CCE during warm conditions.

(S3-16607 Oral)

Should I stay or should I go? Participation, species target, and landing location choices in the U.S. West Coast Coastal Pelagic Species fishery

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In this study, we analyze how historical changes in the forage species distribution affected Coastal Pelagic Species (CPS) vessel participation and target decisions in the U.S. West Coast fishery over the 2012-2017 period. To do so, we develop discrete choice models for the choice of species targeted: Pacific sardine (*Sardinops sagax*), market squid (*Doryteuthis opalescens*), Northern anchovy (*Engraulis mordax*), Chub (*Scomber japonicus*) and Jack (*Trachurus symmetricus*) mackerels, Pacific Herring (*Clupea pallasii*) or other Non-CPS species, and landing port during a specific day. We estimate separate models by fleet segments (obtained from cluster analysis results). Using a mixed logit, we capture heterogeneous responses by vessels within a fleet. An environmentally informed species distribution model (SDM) is used to compute expected revenue for forage species. We then conduct a simulation experiment to assess the impact on vessel participation of alternative forage distribution scenarios that assume abrupt changes in species distribution. This allows us to understand how fishers targeting decisions and landing location choices would change under extreme events. The simulations also allow us to compute the fishers' willingness to pay to avoid extreme events by comparing fishers' utility estimated from the observed data to that from the simulated scenario.

(S3-16829 Oral)

Influence of extreme cold and warm oceanographic events on larval fish assemblages in the southern region of the California Current off Mexico

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The fish larvae community in the southern region of the California Current (CC) was analyzed to test the hypothesis of a northward expansion of tropical species for the summer-fall seasons of La Niña (LN) 2010-2011, The Blob 2014 and El Niño (EN) 2015-2016. Interannual temperature anomalies (-5 °C to 2 °C), as well as a decrease in Chl-a (68%), and zooplankton density (71%), originated dramatic changes in the larval fish community, such as an 82% decline in larval fish density unprecedented for the CC. Tropical species richness increased in the north by 46% and decreased by 65% for temperate species in the south. The mesopelagic species richness increased in the north by 53%, as well as their relative abundance (92%). In the south, the species richness of the demersal component increased up to 39%, although they were co-dominant with mesopelagic species, accounting 47% of the relative abundance against. 49% of the mesopelagic species. The magnitude of the changes in the community was unparalleled when compared with other warming events, such as EN 1983-1984 or EN 1997-1998. The differences were probably related to the presence of The Blob, which favored the transport of oceanic species into the neritic region of the CC region. In both cold and warm years, fronts and mesoscale eddies in the middle part of the Peninsula represented barriers to the latitudinal distribution of species, even during intense tropicalization processes since no latitudinal extensions in species distribution occurred.

(S3-16875 Oral) **RECORDED**

Predicting abundance distribution of *Vinciguerria lucetia* larvae during extreme thermal scenarios in the southern portion of the California Current System

Rubén Esteban **García-Gómez**[1], Gerardo Aceves-Medina[1], Héctor Villalobos[1], Sylvia Patricia Adelheid Jiménez Rosenberg[1] and Reginaldo Durazo[2]

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Vinciguerria lucetia is a mesopelagic fish with a frequent presence in the southern portion of the California Current System. Due to their sensibility to environmental changes, it is considered an indicator of water masses and interannual variability in this area. Fish larvae abundance registered from 1997 to 2015 as part of the Investigaciones Mexicanas de la Corriente de California program were used to predict the abundance distribution of *V. lucetia* larvae under two extreme thermal conditions (2000 La Niña and 2015 El Niño) using the novel machine learning algorithm eXtreme Gradient Boosting (XGBOOST). Data were partitioned into COLD and WARM groups using the mean sea surface temperature recorded for each sampling point as a split threshold and compared to an unpartitioned TOTAL group. Models trained from each group were created with 12 environmental and biological predictor features. Root mean squared logarithm error (RMSLE) was used as a measure of predictive performance for internal (train versus test samples) and external (predicted versus observed data) validation. COLD model showed the best performance for the internal validation with a lower RMSLE value, while TOTAL model presented the lowest RMSLE value for the coldest and warmest external validation. Models showed accurate spatial prediction, but no model was able to predict the same magnitude as observed abundance in both extreme thermal conditions. Nevertheless, XGBOOST is a promising algorithm for describing the distribution traits of *V. lucetia*.

(S3-16918 Oral) **CANCELLED**

~~Capelin condition and abundance through multiple heatwaves in Alaska~~

~~Robert **Suryan**, Johanna Page, Fletcher Sewall, Jacek Maselko, Edward Farley, Ellen Yasumiishi, James Murphy, and Alexander Andrews~~

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~~Changes in the condition and abundance of small pelagic forage species have been linked to ocean conditions, particularly warm and cool periods in temperate to arctic oceans. Capelin (*Mallotus spp*.) are pelagic forage fishes that can be especially abundant in sub-arctic marine ecosystems and important prey for upper trophic-level consumers, including commercially important groundfishes, seabirds, and marine mammals. The distribution and abundance of capelin have been linked to ocean temperature, but the direction of change varies depending on region and relative change in temperature. We used 11 years of data spanning nearly two decades from trawl surveys in Alaskan waters, including the Gulf of Alaska, Bering Sea, and Arctic, to determine how capelin condition and abundance responded to the initial and subsequent heatwaves that occurred over a 5 year period. Length-adjusted mass and energy density was initially highest at lower latitudes, but rate of change with size was greatest at higher latitudes; with potential temperature-mediated threshold effects. Capelin condition during heatwaves varied by size and regionally, with multi-year declines and recovery in some regions, but not others. The abundance of capelin varied markedly with abrupt declines during heatwave years. Additive effects of changes in abundance and condition indicate that energy available to capelin predators was greatly reduced throughout Alaska during marine heatwave years.~~

(S3-16948 Oral)

Archived DNA reveals marine heatwave-associated shifts in fish and zooplankton assemblages

Zachary **Gold**[1,2*], Ryan P. Kelly[3], Andrew Olaf Shelton[2], Andrew R. Thompson[4], Kelly D. Goodwin[4,5], Ramón Gallego[2], Kim M. Parsons[2], Luke R. Thompson[5,6], Dovi Kacev[7], Paul H. Barber[8], Erin V. Satterthwaithe[9], Noelle Bowlin[4], Rasmus Swalethorp[7], Nastassia Patin[7], Susanna Theroux[10] and Brice X. Semmens[7]

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Marine heatwaves can drive large-scale shifts in marine ecosystems, but studying their impacts on comprehensive assemblages across multiple trophic levels is difficult. In this study, we paired microscopy with environmental DNA (eDNA) metabarcoding of the ethanol preservative of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) ichthyoplankton biorepository spanning a 23-year time series. This biorepository captures major and sometimes unexpected changes to fish and zooplankton assemblages in the California Current Large Marine Ecosystem during and after the 2014–2016 Pacific Marine Heatwave. Using both data sources, we modeled patterns of tropicalization in the California Current, with increases in southern, mesopelagic species and associated declines in commercially important temperate fish species (e.g., North Pacific Hake [*Merluccius productus*] and Pacific Sardine [*Sardinops sagax*]). Our results show shifts in fisheries assemblages (e.g., Northern Anchovy, *Engraulis mordax*) even after the return to average water temperatures, corroborating ecosystem impacts found through multiple traditional surveys of this study area. We further provide novel insights into both larval Rockfish (*Sebastes* sp.) assemblages that largely lack the distinctive morphological characteristics necessary for species level identification. Likewise, we successfully characterized hundreds of large zooplankton (>505μm) species from CalCOFI preserved samples, allowing for the identification and characterization of key fisheries target larvae, imperiled species (sea stars), and key foundational zooplankton taxa (e.g. copepods, krill) within the longest running paired biological and carbonate chemistry time series. This work demonstrates effective, low cost methods for reconstructing the historical dynamics of biodiversity from modern and archived samples worldwide.

(S3-16958 Oral)

Spatial distribution of arctic sand lance related to the physical environment

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Sand lance or sand eels (*Ammodytes* spp.) are small planktivorous forage fishes that play an integral role in pelagic ecosystems in the Northern Hemisphere. Arctic sand lance is prevalent in the North Pacific in the Sea of Okhotsk, northern Bering Sea, Chukchi Sea, and Beaufort Sea. Few studies have focused on this species despite its critical position in energy transfer and trophic food webs. Recent surveys in the Chukchi Sea and Beaufort Sea have noted an increase in the prevalence of this species in concert with reduced ice extent. We use comprehensive surveys conducted throughout the Chukchi Sea shelf over multiple years to evaluate spatial distribution and abundance relative to oceanographic variables in the water column and sediment composition on the seafloor. We applied logistic regression and generalized additive models to investigate presence and relative abundance of Arctic sand lance and to evaluate spatial distribution, as a function of oceanographic and benthic environmental variables. Spatial distribution shifted considerably between years in response to environmental conditions. Arctic sand lance presence was influenced by surface water mass and positively associated with Alaskan Coastal Water. Relative abundance was positively associated with high surface temperature, low surface salinity, and coarser substrates. Evidence is mounting that the distributions of many boreal species are expanding on the margins of the Arctic. Our research reports increased aggregations of Arctic sand lance in the Chukchi Sea and at the highest latitude on record for this species, at the shelf break of the Arctic Basin.

(S3-16844 Poster) S3-P1 (ECOP)

Predicting larval northern anchovy (*Engraulis mordax*) abundance across space and time

Luke A. **Bobay**, Moritz S. Schmid, Robert K. Cowen and Su Sponaugle

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Changes in habitat availability caused by climate change are likely to influence the abundance of many species. During recent warm years, larval northern anchovy (*Engraulis mordax*) distributions in the northern California Current shifted north and shoreward. Accurately predicting larval northern anchovy abundance distributions could allow estimation of their overall abundance under a changing climate. However, recent work demonstrates that larval northern anchovy distributions in the California Current are difficult to predict under novel environmental conditions. This may be because accurate predictions require that species abundance distribution models move beyond correlations to capture mechanistic drivers that underpin species responses to the environment. Yet, traditional net sampling methods integrate larval fish catches over the length of a tow and may mask relationships between environmental conditions and larval fish abundances. Together with depth-discrete net sampling, we collected fine-scale larval northern anchovy abundance data using the *In Situ* Ichthyoplankton Imaging System (*IS*IIS), which simultaneously records environmental conditions including temperature, dissolved oxygen, chlorophyll a, salinity, and depth. *IS*IIS was towed continuously along two cross-shelf transects (>120 km) off Trinidad Head, CA, and Newport, OR, during winter and summer 2018-2019. The resulting larval northern anchovy abundance data were modeled using environmental conditions as predictors, and spatially blocked cross-validation was used to assess model performance. Results reinforce that fine-scale plankton imagery data are useful for characterizing relationships between larval fish abundances and environmental conditions to enhance the prediction of future larval fish abundances.

Session 4: FUTURE/MEQ/MONITOR Topic Session

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

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

Invited Speakers:
Guebuem Kim (School of Earth and Environmental Sciences, Seoul National University, Korea)
Jorge I. Mardones (Center for Harmful Algal Studies, Instituto de Fomento Pesquero, Chile)

Climate drivers have and continue to strongly influence the physical and biogeochemical properties of ocean surface waters, and these effects become magnified during extreme events. Coastal regions are particularly sensitive to extreme events. In addition to being affected by the onshore movement of anomalous oceanic water, coastal regions are subject to rapid fluctuations in precipitation-driven runoff as well as mixing associated with nearshore wind patterns. The increasing occurrence of extreme change in nearshore waters can intensely influence nutrient supply, dramatically altering ocean ecology in ways that can cause extensive socioeconomic stress. The outcomes of these integrated processes vary widely given the complexity of drivers, magnitudes and dynamics of change, making it difficult to proactively identify problems in time to take steps towards mitigation. Nevertheless, better understanding of past extreme events, and the nature of associated ecological and socioeconomic impacts, will provide the foundation for developing prediction and response strategies. This topic session will help to inform the Working Group 49: Climate Extremes and Coastal Impacts in the Pacific by helping to develop a census of historical climate extreme events around the Pacific Rim to describe their characteristics, identify potential climate and ocean drivers, and catalog the ecological and socioeconomic consequences (ToR#1). The session also addresses the UN Decade of Ocean Science for Sustainable Development goal towards developing a common framework for improving conditions for sustainable development of the Ocean. We welcome papers that address the oceanographic, ecological, and socioeconomic outcomes associated with extreme events in coastal oceans and particularly encourage papers that seek linkages among two or more of these aspects that help to illustrate the underpinnings of ecological and socioeconomic responses to extreme events.

(S4-16523 Invited)

Evolution of nutrient structure and associated changes in harmful algal blooms in coastal waters off Korea Peninsula over the last few decades

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In the marginal seas neighboring the Korean Peninsula (except the Yellow Sea), the concentrations of dissolved inorganic nitrogen (DIN) and phosphorus (DIP) have decreased significantly, mainly due to water stratification. Korean coastal waters within ~10 km from the coastline showed more significant decreases (~50%) in nutrient concentrations since 1995, mainly due to the decline of anthropogenic sources from the land. However, interestingly, the concentrations of dissolved organic nitrogen (DON) maintained relatively high concentrations (>8 μM) in this region. In this study, we focus on the changes in nutrient structure and associated harmful algal blooms (HAB) in two regions: (1) the southern sea of Korea off Tongyeong and Yeosu, where *Margalefidinium polykrikoides* blooms often occur in summer, and (2) Jinhae Bay where paralytic shellfish poisoning by *Alexandrium* sp. often occur in spring. We consistently observed that the timing of the HAB outbreak is determined by depleted DIN, which limits the growth of diatoms. More importantly, in both regions, the intensity of the HAB outbreak is found to be dependent on the levels of DON and fluorescent dissolved organic matter, which fuel HAB under depleted DIN. Thus, the nutrient structure of coastal waters off Korea has evolved to become more favorable for the growth of dinoflagellates competing with diatoms. However, the overall decline in nutrient concentrations in both regions weakens the intensity of HAB. Our study displays that the change in nutrient structure in coastal waters by climate change and human activities significantly alters the health of coastal ecosystems.

(S4-17014 Invited)

Patagonian fjords dealing with extreme Harmful Algal Blooms (HABs): Lessons and challenges in a changing climate

Jorge I. **Mardones**

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The southern Chilean coast is widely known for suffering the most severe Harmful Algal Blooms (HABs) that affect one of the world's most productive aquaculture regions. Climate change is newly adding to the unpredictability of such fast HABs and puts further pressure on seafood security for an ever-increasing human population. Since the first massive human intoxication due to Diarrhetic Shellfish Poisoning (DSP) in 1970, Chile has faced several world records, such as the extremely high shellfish toxicities in 2018, with an extraordinary world record of 143,130 µg STXeq. 100 g^{-1}. Adding to these known phycotoxins that affect human health, new emerging species have shown an increase in the frequency of detection and intensity of outbreaks. For instance, the massive *Pseudochattonella verruculosa* bloom in 2016, resulting in the most extensive fish farm mortality ever recorded worldwide (equivalent to an export loss of USD$800 M) evidenced that the Chilean salmon industry was not prepared for this unexpected bloom. The mitigation strategies attempted at salmon farms during the *Pseudochattonella* bloom were not successful. On the other hand, oceanic HAB events not previously monitored in the area are currently a new threat for local aquaculture and artisanal benthic fisheries. For example, *Alexandrium catenella* is rapidly showing an apparent further expansion to the north of the country by the oceanic coast, and the Kareniaceae family is producing massive offshore mortalities of both marine invertebrates and vertebrates. The discovery for the first time of Pinnatoxin-G (PnTx G) in the southern Chilean fjords calls for new strategies for HABs monitoring. Regional drivers that lead to these HABs are still speculative but potential scenarios are discussed.

(S4-16562 Oral)

Spatio-temporal variation of large-scale harmful algal blooms with *Karenia selliformis* in Pacific Coastal Waters off southeast Hokkaido, Japan after marine heatwaves

Satomi **Takagi**, Hiroshi Kuroda, Yukiko Taniuchi, Takuya Nakanowatari, Hiromi Kasai, Takuya Ohnishi, Natsuki Hasegawa, Tsuyoshi Watanabe and Tomonori Azumaya

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Large-scale harmful algal blooms (HABs) dominated by *Karenia selliformis* occurred off the southeastern coast of Hokkaido, Japan, from late September to early November 2021, about a month after intense and extensive marine heatwaves (MHWs) had subsided. Takagi et al. (2022, Front Mar Sci 9, 939393) have developed one-dimensional NEMURO+, a lower trophic-level ecosystem model, by including a new compartment "PK" with *K. selliformis* characteristics to NEMURO, and revealed the environmental factors involved in the HABs development. The present study investigated the spatio-temporal variation of the HABs by a three-dimensional NEMURO+ along the Pacific shelf waters off the Hokkaido coast. The model successfully reproduced the occurrence and horizontal distribution of the HABs. The PK expanded gradually from northeast to southeast Hokkaido along the Coastal Oyashio (CO) and Oyashio stream (OY), within the area east of Cape Erimo, during mid-July to mid-September in association with the horizontal advection of PK. PK concentration increased in late September, and the high concentration was then persisted until early November. Meanwhile, a subtropical Tsugaru Warm Current (TW) water, warmer and higher-salinity than waters transported by the CO and OY, would have suppressed PK production in the area west of Cape Erimo where TW water occupied. These indicate that the CO and OY would have allowed PK to reach southeast Hokkaido, and the temperature and salinity of them in autumn, which was suitable for *K. selliformis*, involved PK increment, resulting in the HABs outbreak.

(S4-16573 Oral)

Ecosystem impacts of record-breaking 2020 summer marine heatwaves in the South China Sea

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Marine heatwaves (MHW) are a recurrent phenomenon in the South China Sea that impact regional ecosystems and are expected to intensify in the future. Record-breaking MHW occurred in the South China Sea during the summer of 2020. In this work we use a biogeochemical model coupled to a three-dimensional hydrodynamic model, which allowed the simulation of some of the physical and biological consequences of the anomalous warm 2020 period. Model results indicated that the shortwave radiation and the ocean advection jointly contributed to the development of the MHW in the South China Sea. In July 2020, the eastern South China Sea experienced the strongest MHW, surface nitrate concentration was significantly reduced by 51%, which was associated with weakened advection and vertical mixing. Reducing the supply of nutrients resulted in a 71% decrease in the surface chlorophyll concentration. In August, when the MHW dissipated, the nitrate concentration increased by 38%, due to the enhanced nitrate advection and mixing. Moreover, the enhanced horizontal advection was the main mechanism for the increase in the chlorophyll concentration. These findings may contribute to the understanding of phytoplankton dynamics in response to the MHW.

(S4-16593 Oral)

Development of an operational forecasting system for marine ecosystem in the China seas

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The coastal ecological environment is rapidly deteriorating due to human activities and climate change, posing a serious threat to the sustainable development of marine economy. Hence, the construction of a high-resolution ecological operational forecasting system is of great significance. In 2019, the National Marine Environmental Forecasting Center (NMEFC) has constructed a high-resolution ecological environment forecasting system using ROMS coupled with CoSiNE model, which covers the Bohai Sea, the Yellow Sea, and the South China Sea. The forecasting system operates with stability, automatically running once a day. The process entails data collection and processing, data assimilation, model forecasting, interpretation, and application analysis of predicted data, as well as product creation. The primary predictions consist of hourly temperature, salinity, ocean currents, nitrate, ammonium, phosphate, silicate, chlorophyll-a, and dissolved oxygen for the next 120 hours. Additionally, based on the above predictive elements, warning predictions are generated for marine disasters, including hypoxia, ocean acidification, eutrophication, red tide, and green tide. Therefore, the marine ecological forecasting system we have established plays a significant role in both scientific research and ocean disaster prevention and reduction.

(S4-16610 Oral)

Analyzing oceanographic data to understand possible impacts to BC salmon: focus on *Heterosigma akashiwo* and climate factors

Svetlana **Esenkulova**[1], Vera Pospelova[2,3], Rich Pawlowicz[4], Nicola Haigh[5], Jayaprabandh Pudota[5], Chrys Neville[6], and Isobel Pearsall[1]

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The coastal region of British Columbia (BC), Canada, is a crucial rearing ground for Pacific salmon, which holds particular importance to the province due to economic value and cultural significance. In recent decades, many BC salmon populations have experienced dramatic declines. To address this concern, the Pacific Salmon Foundation (PSF), a non-profit organization dedicated to conserving and restoring Pacific salmon in BC and Yukon, has supported programs focused on understanding factors affecting salmon survival. Since 2015, the PSF Citizen Science (CitSc) Oceanography Program has undertaken an unprecedented data collection effort in the Strait of Georgia (SoG), with hundreds of measurements and samples (CTD, nutrients, phytoplankton) collected annually. In this presentation, we explore the impacts of climate variability (ENSO, PDO, and NPGO) on temperature, salinity, and summer chlorophyll-a concentration in the SoG, using eight years of CitSc data. Given the specific importance to salmon, we also present data on the dynamics of *Heterosigma akashiwo*, a fish-killing algae species that is known to impact farmed and potentially wild salmon. Relationships between *H. akashiwo* concentrations from 1999 to 2022 (combined data from the Harmful Algae Monitoring Program, funded by the BC salmon aquaculture industry, and PSF CitSc datasets) and hydrographic, weather, and climate data are investigated. Understanding environmental drivers for *H. akashiwo* will enhance our ability to predict blooms and mitigate negative impacts on BC salmon. This knowledge contributes to broader ecological, environmental, and economic studies by uncovering the connections between algae and weather/climate patterns.

(S4-16629 Oral) CANCELLED

~~Large-scale drivers of Northeast Pacific Marine Heatwaves~~

~~Antonietta **Capotondi**[1,2], Matthew Newman[2], Tongtong Xu[1,2] and Emanuele **Di Lorenzo**[3]~~
~~(*presented by Emanuele Di Lorenzo on behalf of Antonietta Capotondi*)~~

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~~The Northeast Pacific Ocean has experienced episodes of intense and persistent abnormally warm conditions, also known as marine heatwaves (MHWs), with devastating ecological impacts. Being able to predict these extreme events a few seasons in advance is therefore very important, but has proven elusive. While the intensity of Northeast Pacific marine heatwaves (MHWs) has been related to local stochastic atmospheric forcing with limited predictability, their evolution and persistence may be controlled by large-scale climate influences. Here we use a multi-variate statistical approach to identify these large-scale drivers, as well as the initial states that optimally develop into a MHW at a later time in this region. Results indicate that a decadal mode of variability related to the Pacific Decadal Oscillation plays a key role in creating conditions favorable to the development of Northeast Pacific MHWs. This decadal mode is also associated with the development of Central Pacific El Niño events, which appear to contribute to the persistence of the Northeast Pacific warm anomalies.~~

(S4-16730 Oral)

Advancing an integrated understanding of land-ocean connections in shaping the marine ecosystems of Coastal Temperate Rainforest ecoregions

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Land and ocean ecosystems are strongly connected and mutually interactive. As climate changes and other anthropogenic stressors intensify, the complex pathways that link these systems will strengthen or weaken in ways that are currently beyond reliable prediction. In this review we offer a framework of land-ocean couplings and their role in shaping marine ecosystems in Coastal Temperate Rainforest (CTR) ecoregions, where high freshwater and materials flux result in particularly strong land-ocean connections. Using the largest contiguous expanse of CTR on Earth, the Northeast Pacific CTR (NPCTR), as a case study we integrate current understanding of the spatial and temporal scales of interacting physical, geochemical and biological processes across the land-ocean continuum, and examine how these processes structure marine ecosystems from nearshore to offshore domains. We do so through the lens of three interconnected aspects of marine ecosystems — circulation dynamics, biogeochemical cycling, and food webs — with emphasis on the fate and effects of freshwater discharge and its associated terrestrial materials. We look ahead to the potential effects of climate and other anthropogenic changes on the coupled land-ocean meta-ecosystem. Finally, we review key data gaps and provide research recommendations for an integrated, transdisciplinary approach that we hope will guide future evaluation of ongoing impacts in marine ecosystems of the NPCTR and other CTRs globally. In the light of extreme events, including heatwaves, fire and flooding that are occurring almost annually, this agenda is not only necessary but urgent.

(S4-16810 Oral)

Southern Salish Sea (U.S.) ocean acidification and hypoxia extremes in response to major heat and runoff anomalies during a seasonal 2014–2018 cruise time-series: multi-stressor implications for sensitive species

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Anomalies in regional air and water temperature, precipitation, and river runoff resulted in physical and biogeochemical extremes in the southern Salish Sea during 2014–2018. The peak temperature anomaly associated with the 2013–2016 northeast Pacific marine heatwave–El Niño event was observed in boundary waters during October 2014, but Puget Sound experienced the largest temperature increases during 2015–2016. The most extreme ocean acidification and hypoxia (OAH) measurements to date were recorded in Hood Canal (which consistently has the strongest OAH conditions) during the same period, but occurred earlier in the year than previous events. After the heat anomaly, a distinct carbonate system anomaly with unprecedentedly low Ω_{arag} and high fCO_2 occurred in parts of the southern Salish Sea that are not normally so acidified. This extreme CO_2 event appears to have been driven by anomalous river discharge earlier in 2017, which resulted in enhanced stratification and inferred primary productivity anomalies. Unusually, this CO_2 anomaly was decoupled from O_2 dynamics compared to past Salish Sea OAH events. The complex interplay of weather, hydrological, and circulation anomalies revealed distinct multiple stressor scenarios that will potentially affect regional ecosystems under a changing climate. The frequencies at which Salish cruise observations crossed known or preliminary species sensitivity thresholds illustrates the relative risk landscape of temperature, hypoxia, and acidification anomalies in the southern Salish Sea in the present-day, with implications for how multiple stressors may combine to present potential migration, survival, or physiological challenges to key regional species in the future.

(S4-16828 Oral)

Community informed social indicators for the California Dungeness Crab Fishery under whale entanglement mitigation regulations

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A 2013-2016 large marine heatwave in the Pacific Ocean brought about changes in natural and social systems that created social and economic challenges for fishing communities and decision-makers on the US West Coast. A particular societal impact that arose and persists through effects of this extreme event is an increase in reported whale entanglements in the California Commercial Dungeness Crab Fishery. Resource managers, together with the fishing community, continue to develop strategies to balance marine mammal protection with maintaining a productive fishery. Thus far, regulations enacted have been successful at reducing whale entanglements, but fishery delays and closures have had substantial and heterogeneous impacts on ex-vessel revenues across the fishery. This research uses information from semi-structured interviews with fishery participants to first understand how and why actions taken to mitigate whale entanglements affect the fishery. This information was used to develop a set of stakeholder-informed considerations that could help guide decision-making. Second, the interview was used to identify social indicators that can be used to monitor the social and economic health of the fishery in the context of this regulation change. Beyond extreme climate events, building partnerships with stakeholders is an important process in finding solutions to conflicts with wildlife which can also occur due to marine mammal population growth or distribution change. These social indicators, together with ecological indicators developed for this fishery, will enable managers to evaluate the impact of regulatory changes on both social and ecological objectives as management responses continue to evolve.

(S4-16866 Oral)

Harmful algal species in the East China Sea and their possible respondence to climate change via a global vision

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Climate change pressures are influencing marine planktonic systems globally, and it is conceivable that harmful algal blooms may increase in frequency and severity. The Yangtze River Estuary (YRE) is the most severely affected sea area for harmful algal blooms (HABs) in China. *Karenia mikimotoi*, *Margalefidinium polykrikoides*, *Prorocentrum donghaiense* and *Heterosigma akashiwo* are the main HABs species in East Asian Sea. The four HABs species were detected and quantified via quantitative real-time PCR (qPCR) in this study. Estimated maximum cell abundance of *K. mikimotoi*, *M. polykrikoides* (East Asian Ribotype, EAR), *P. donghaiense* and *H. akashiwo* were 1.6×10^5, 1.3×10^5, 1.6×10^5 and 1.2×10^7 cells·L^{-1}, respectively. HABs dominated by *H. akashiwo* and *P. donghaiense* occurred at station S27 on July 22, 2020. In the studied sea area, turbidity, pH and salinity may be the main factors affecting the blooms of *K. mikimotoi*, *M. polykrikoides* (EAR) and *P. donghaiense*, while temperature may be the main factor affecting the blooms of *H akashiwo*. The results reveal a distributive pattern of the four HABs species in the YRE under the different ecological status. We also analyzed the blooms distributions of these four bloom species globally. All of these results will help us to understand the HAB expansion via a global vision.

(S4-16892 Oral) CANCELLED

~~Spatio-temporal variation in zooplankton community composition in the southern Salish Sea: Changes during the 2015–2016 Pacific marine heatwave~~

~~Amanda **Winans**, BethElLee Herrmann and Julie E. Keister~~

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~~The 2015-2016 Pacific marine heatwave (MHW) strongly affected zooplankton in the Salish Sea; however, the patterns differed compared to the outer coast, suggesting that the unique oceanography of the Salish Sea imposed different forcing mechanisms on their communities. Mesozooplankton were collected in the southern Salish Sea during an ongoing time series that began in 2014. We examine patterns along a north-south latitudinal gradient, from the San Juan Islands to South Sound to look at spatial and temporal variability of communities during the MHW. Zooplankton biomass increased in all regions in 2015 and remained high through 2017 in central and southern basins. The northern, more oceanic, site experienced its highest biomass in later, cooler years. Many crustaceans and molluscs increased during MHW years, especially at central stations. Puget Sound resident warm-water copepod species were found in higher biomass in Puget Sound and increased during the MHW. Cold-water and subarctic copepods were in higher biomass at northern sites and generally decreased during the MHW. Gelatinous zooplankton were more common at southern, retentive sites, with mixed patterns around MHW years. These results contrast with MHW observations in the California Current System (CCS), which generally had decreased crustaceans and increased gelatinous zooplankton. While reduced upwelling, depleted nutrients and advection of offshore and tropical/subtropical waters during the MHW were major drivers of observed changes in the CCS, the Salish Sea was likely more affected by local drivers, such as heat retention and increased nutrients and production due to changes in ocean inputs.~~

(S4-16912 Oral) CANCELLED

~~Bottom marine heatwaves along the continental shelves of North America~~

~~Dillon J. Amaya[1], Michael G. **Jacox**[1,2], Michael A. Alexander[1], James D. Scott[1,3], Clara Deser[4], Antonietta Capotondi[1,3], and Adam S. Phillips[4]~~

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~~Recently, there has been substantial effort to understand the fundamental characteristics of warm ocean temperature extremes – known as marine heatwaves (MHWs). However, MHW research has primarily focused on the surface signature of these events. While surface MHWs (SMHW) can have dramatic impacts on marine ecosystems, extreme warming along the seafloor can also have significant biological outcomes. In this study, we use a high-resolution (~8 km) ocean reanalysis to broadly assess bottom marine heatwaves (BMHW) along the continental shelves of North America. We find that BMHW intensity and duration vary strongly with bottom depth, with typical intensities ranging from ~0.5˚C-3˚C. Further, BMHWs can be more intense and persist longer than SMHWs. While BMHWs and SMHWs often co-occur, BMHWs can also exist without a SMHW. Deeper regions in which the mixed layer does not typically reach the seafloor exhibit less synchronicity between BMHWs and SMHWs.~~

(S4-16942 Oral)

Using otoliths to understand how marine heatwaves affect fish growth

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The increased frequency and intensity of global marine heatwaves in the past century have led to greater awareness of how these extreme events can shape aquatic ecosystems. While the lethal impacts of these acute warming events are well-described, the sub-lethal impacts, such as growth, are poorly understood and play a critical role in shaping ecosystem and fishery production. We aim to assess the impact of marine heatwaves by examining the immediate and legacy effects of exposure to extreme heat on fish growth, using species from Southeast Australia as a case study for this approach. Specifically, we identified patterns in fish growth responses to heatwaves among species groups and life stages. We used satellite-derived daily sea surface temperatures from 1981-present to identify heatwaves and calculate a suite of physical parameters describing each event. Then, we related these heatwave attributes to individually-resolved estimates of fish growth from otoliths. Effect sizes from all 15 taxa were then combined in a meta-regression to determine which heatwave event attributes best explained juvenile and adult growth variation. Overall, we found that many species experienced depressed growth in response to marine heatwaves, with this effect most pronounced in juvenile life stages. In particular, the acute intensity and the number of sequential heatwaves in a year were most related to growth depression. Our ability to anticipate the sensitivity of fish growth to heatwaves is critical for predicting responses under future climate events and understanding legacy effects which may alter food webs and assemblages well after the event subsides.

(S4-16971 Oral)

Non-stationary relationships between climate and fisheries in the California Current and Gulf of Alaska

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An emerging challenge in ecosystem based fisheries management is that many relationships used to understand climate-ecosystem dynamics are changing over space and time. Recent examples include shifting spatial distributions of fish populations, changing meanings of environmental indices (e.g., Pacific Decadal Oscillation) and changing demographic-climate relationships with environmental drivers (e.g., sea surface temperature and sea level pressure). Working with a diversity of assembled oceanographic and biological datasets, we investigate and synthesize dynamic climate-biology relationships that are relevant to management in the California Current and Gulf of Alaska marine ecosystems using Bayesian linear modeling, dynamic linear modeling, and self organizing maps. First, we examined changing relationships between atmospheric forcing (sea level pressure), climate conditions (SST, upwelling) and environmental indices (PDO, NPGO, ENSO) from 1940 - 2023 with an emphasis on dynamics since prominent marine heat waves (2013 - 2023). Next, we will identify if these changing relationships are reflected in protected and commercially important species (Pacific salmon, groundfish, rockfish) in the California Current. Finally we will identify whether incorporating these relationships may be useful in improving short-term (1-2 years) forecasts of population dynamics.

(S4-16975 Oral)

Comparison of biodiversity of ARMS installed in Jeju Island through metabarcoding technique and morphological classification assay

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Global warming driven by climate change has negative impacts on marine biodiversity. Jeju Island has been suggested as an area capable of supporting the high biodiversity of its geographical position and the different currents influencing the marine environment around the island. Jeju is located within temperate latitudes but borders to environmental changes, providing an ideal testbed for assessments of life under rapid climate change. However, a significant limitation of monitoring programs is the difficulty in comparing and quantifying results generated by different methods. The MarineGEO program developed a quantitative, standardized method of sampling monitoring data called Autonomous Reef Monitoring Structures (ARMS). We deployed ARMS units in Jeju (Kangjung, Bomok, and Seongsan) in 2018. After 12 months, the ARMS were retrieved, and DNA and morphological assay conducted a taxonomic analysis determining the marine biodiversity. Through genetic analysis and morphological classification of each site, 158~265 and 104~130 species were classified, respectively. So far, we found new Osctracoda species and unrecorded gastropod species from the ARMS units. We expect this baseline data will provide further information to detect “climate refugees,” i.e., newly extended species due to climate change and species new to the science of understudied taxa. These “climate refugees” would disturb marine ecosystems as they compete with indigenous marine organisms. Besides investigating changes in marine ecosystems caused by climate change and detecting invasive marine species, this standardized monitoring method (ARMS) is applied to understand the role of biodiversity in sustaining resilient coastal marine ecosystems under climate threat.

(S4-16499 Poster) CANCELLED S4-P1 (ECOP)

~~**Climate risks on blue foods value chain of Bangladesh: Impacts and responses**~~

~~M Minhazul **Islam**[1] and Md. Tariqul Alam[2]~~

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~~Climate variability and change are projected to profoundly affect blue food (from aquatic animals, plants, and algae) value chain- from local to global scale. Based on key informant interviews and focus group discussion, this study aims to assess the impacts of climate change and variability on the blue food supply chain of Bangladesh and respective responses. The findings suggest that blue food processing, storage, marketing, and export are vulnerable to various climatic risks, including cyclones and other extreme events, extreme heat, floods, and increased saline water intrusion. Rapid onset events cause loss of blue food production, disruption of distribution and market access, price taker risks of small-scale holders, and increased waterborne disease and pollutants in the supply chain. Different slow onset events such as increased soil and water salinity cause deteriorated environmental situations leading to disease outbreaks and reduced growth performances of the cultured species. As income from blue food production and subsistent consumption of local livelihoods are tightly connected, thus any disturbances in the supply chain can readily translate into local poor income and a cash-strapped economy, creating food insecurity and reducing well-being. Identifying impacts and responses of key processes and actors in the supply chains would inform policymakers towards better business decisions, thereby can facilitate adaptive transformation (through an endowment with socio-economic capitals, strengthening market linkage process and provision of insurance, for example) within the blue food system to climatic risks.~~

NEW – S4-P4

Coastal oceans are potential RDOM production hotspots

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(S4-16525 Poster) S4-P2 (ECOP)

Monitoring nutrients and Fluorescent Dissolved Organic Matter (FDOM) to predict the outbreaks of Paralytic Shellfish Poisoning (PSP) in Jinhae Bay, Korea

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Recent field observation studies showed that paralytic shellfish poisoning (PSP) generally occurred under low concentrations of dissolved inorganic nitrogen (DIN) and high concentrations of dissolved organic nitrogen (DON) and humic-like fluorescent dissolved organic matter ($FDOM_H$) in Jinhae Bay, Korea. To verify the link between this environmental condition and PSP outbreaks, we deployed a real-time monitoring system with nitrate sensor (ISUS V3) and $FDOM_H$ sensor (ECO-fluorometer) in spring 2021 at the mouth of Jinhae Bay. In addition, we utilized the data obtained from field observations in the entire bay and the automatic water quality measuring systems positioned at the upstream sites of the bay from 2018 to 2021. The Field observation data showed that the streams near the upstream sites mainly supplied the DIN to the entire bay, which was almost fully converted to DON before entering the PSP outbreak sites. Our results show that the PSP outbreak timing is determined by the conversion of DIN to DON, which is affected by precipitation periodicity, and the PSP intensity by the concentrations of DON and $FDOM_H$. We verified that the real-time monitoring data at the mouth of the bay well reflected the nutrient and $FDOM_H$ conditions by comparing them with the field observation data. The real-time monitoring data predicted unfavorable conditions for the PSP outbreak in 2021, as observed in the field. Thus, our results suggest that this real-time monitoring system deployed in the PSP outbreak area can be successfully utilized to predict PSP outbreaks in the ocean.

(S4-16894 Poster) CANCELLED S4-P3 (ECOP)

~~Vulnerability assessment of Korean fisheries to Climate Change~~

~~Moo-Jin **Kim**[1], In-Seong Han[2], Joon-Soo Lee[2] and Do-Hoon Kim[1]~~

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~~Climate change is expected to cause changes in marine biota and ecosystems, thereby directly affecting fishery production. To establish policies to respond to climate change, the importance of climate change vulnerability assessments is growing. In South Korea, annual fishery production has been decreased since 1986, and climate change has caused changes in compositions of species and the ecological structure. Therefore, we assess the vulnerability to climate change for 36 species with sensitivity and exposure. Based on this result, the vulnerability of 24 fisheries to climate change was evaluated. In this study, as exposure factors, we consider relationship between future seawater temperatures and spawning/habitat temperature of each species. Species with high scores both in sensitivity attributes and climate exposure factors are evaluated as highly vulnerable species and fisheries with high catch ratios of such species are assessed to be relatively more vulnerable. Hence, it is required to prioritize fisheries with high catch ratios of relatively vulnerable species when establishing policies to manage offshore and coastal fisheries in Korea.~~

Session 5: POC/MONITOR Topic Session

Multi-scale ocean processes and their impacts on marine ecosystems

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

Invited Speakers:
Changming Dong (School of Marine Sciences, Nanjing University of information Science and Technology (NUIST), China)

Oceanic processes exhibit distinct characteristics on different temporal and spatial scales, spanning from chaotic turbulence, intense internal waves, complex fronts and filaments to energetic mesoscale eddies and basin-wide circulations. The unique properties of different processes impact the distribution, transport, and conversion of various biogeochemical tracers as well as the microscopic marine organisms that form the base of the marine food web. In recent decades, many studies have been devoted to this interdisciplinary field, especially focusing on the oceanic meso- and submeso-scales, but there are still knowledge gaps in understanding how these multi-scale oceanic processes configure marine ecosystems, i.e., building the connection between the physical environment and sustainable use of the marine resources, which is in alignment with the UN Decade's SDG 14. We invite general studies providing new insights on multi-scale physical processes, scale interactions, and their impacts on the marine ecosystem. Biogeochemical studies related to the physics are also strongly encouraged in this session.

(S5-16996 Invited)

Submesoscale processes-induced vertical heat transport modulated by oceanic mesoscale eddies

Changming **Dong** and Qingyue Wang

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Oceanic submesoscale processes mainly arise from phenomena such as jets, density fronts, and mesoscale eddies. Previous studies suggest that the overall submesoscale processes transport heat vertically upgradient, i.e. from cold to warm. However, it is not clear whether the submesoscale processes-induced vertical heat transport (VHT) in mesoscale eddies remains upgradient. The present study focuses on submesoscale-induced VHT modulated by mesoscale eddies. A high-resolution oceanic numerical model product is applied to examine the VHT induced by submesoscale processes associated with cyclonic and anticyclonic mesoscale eddies in the Kuroshio Extension (KE) region in different seasons. Frequency-wavenumber spectra, Rossby numbers, and strain rates in eddies reveal the existence of submesoscale motions surrounding mesoscale eddies. The variables are decomposed into monthly mean meso- scale and submesoscale components to calculate submesoscale VHT at low-frequency (LF) and high-frequency (HF). The analytical results reveal how submesoscale processes affect the VHT modulated by mesoscale eddies in detail.

(S5-16511 Oral)

Feedbacks between bottom boundary biogeochemistry and ecosystem metrics in a regional biogeochemical model intercomparison in the Bering Sea

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Traditional biogeochemical models have mostly been developed with an eye toward deep-water, open-ocean environments. However, when these models are applied to shallow coastal environments, the influence of physical processes related to this shallow geometry can play an outsized role in controlling ecosystem behavior. Here, we present the results of a biogeochemical model intercomparison in the Bering Sea. In this intercomparison, three biogeochemical models of varying structural complexity are coupled to a single 30-year simulation of the same ocean/ice regional ocean model. We demonstrate that across the wide eastern Bering Sea shelf, differences in the way that these three models handle bottom boundary processes lead to large disagreements across common metrics of ecosystem function, such as the ratio of new to regenerated production and the timing and magnitude of production within phytoplankton and zooplankton communities. These often-overlooked physical/biogeochemical interactions are important to consider when using regional models like this one to investigate the impact of climate variability on living marine resources in coastal regions.

(S5-16536 Oral)

Mesoscale eddies regulate habitat distribution of neon flying squid in the Northwest Pacific Ocean

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Mesoscale eddies are ubiquitous in global oceans yielding significant impacts on marine life. As a short-lived pelagic squid species, neon flying squid *Ommastrephes bartramii* is extremly sensitive to changes of ambient oceanic variables. However, a comprehensive understanding of how mesoscale eddies affect *O. bartramii* stocks in the Northwest Pacific Ocean is still unknown. In this study, a 10-year squid fisheries data with eddy tracking and high-resolution reanalysis ocean reanalysis data were combined to evaluate the impact of mesoscale eddies and their induced changes in environmental conditions on the abundance and habitat distribution of *O. bartramii* in the Northwest Pacific Ocean. A weighted-based habitat suitability index (HSI) model was developed with three crucial environmental factors: sea surface temperature (SST), seawater temperature at 50-m depth (T_{50m}) and chlorophyll-a concentration (Chl-a). Results indicated that the abundance of *O. bartramii* were significantly higher in anticyclonic eddies (AEs) than that in cyclonic eddies (CEs). This difference was well explained by the distribution pattern of suitable habitats in eddies derived from the HSI model. Enlarged ranges of the preferred SST, T_{50m} and Chl-a for *O. bartramii* within AEs were the main causes of more squids to occurring inside the warm-core eddies, whereas highly productive CEs matching with unfavorable thermal conditions tended to form unsuitable habitats for *O. bartramii*. Our findings suggest that with an unstable KE background, suitable thermal conditions combined with favorable foraging conditions within AEs were the main drivers that yielded the high abundance of *O. bartramii* in the warm eddies.

(S5-16554 Oral)

Role of submesoscale cyclonic eddies generated at the south of Yaku Island, Japan

Gloria Silvana **Duran Gomez**[1], Takeyoshi Nagai[1], Toru Kobari[2] and Hirohiko Nakamura[2]

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The Kuroshio carries a large amount of nutrients in dark subsurface layers as a nutrient stream. In the region off the southern coast of Japan, previous studies showed that the flow of the Kuroshio over seamounts could provide very efficient mixing hotspots, enhancing the nitrate vertical flux, thus, the biological production toward downstream. In addition to diapycnal mixing, eddies generated from the topographic features may induce intense nutrient upwelling. Although high-resolution model studies have showed submesoscale nutrient upwellings associated with generated eddies from the front or flow-topography interactions, quantification of the net upwelling is still unclear. Also, while it is reported that submesoscale eddy activity is enhanced during winter, the seasonality for the submesoscale eddies generated by the flow-topography interactions is largely unknown.

In this study, in-situ high-resolution tow-yo observations and numerical simulations were conducted to ascertain the seasonality and the role of submesoscale cyclonic eddies. Surveys were conducted in the Tokara Strait off south of Yaku Island, by using a state-of-the-art twin tow-yo profiling system for turbulence and biogeochemical parameters (chlorophyll-a and nitrate) on the R.T.V. Kagoshima-Maru in November-December. Our observations show for the first time the submesoscale nitrate upwelling structures along isopycnals of the cyclonic eddies, formed by the Kuroshio behind Yakushima. High-resolution nested simulations, coupled with an ecosystem model, reproduce the observed cyclonic eddies behind Yakushima. The model nitrate vertical advective flux shows, however, both subduction and upwelling on the western and eastern side of model cyclonic eddies, respectively, with an enhanced chlorophyll-a response.

(S5-16556 Oral)

Role of submesoscale and microscale mixing processes in the Kuroshio flowing south of Kyushu

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In contrast to the surface oligotrophic waters, the Kuroshio subsurface layers carry a large amount of nutrients. Although these subsurface nutrients could play a role to sustain high biodiversity and biological production in the regions south of Japan, it has been elusive whether and how these nutrients become available for phytoplankton before they reach the downstream Kuroshio Extension. In this study, a series of high-resolution tow-yo microstructure and nitrate observations and nested high-resolution simulations were carried out in the regions south of Kyushu. The results indicate that the Kuroshio constantly flows over seamounts in the Tokara Strait that induces 100-1000-fold enhancement of turbulent kinetic energy dissipation rates on average over 100-200 km along the Kuroshio. Further observations show that intense turbulence is associated with the negative potential vorticity (PV) generated on the steep slope of the seamount. Nitrate diffusive flux at $\sigma_\theta = 25$ (~200 m depth) is 3 mmol m^{-2} day^{-1} on average over 200 km, that could induce biological responses in further downstream. In addition, when the Kuroshio in the Tokara Strait shifts northward, the warm Kuroshio water can intrude into north of Yakushima and Tanegashima Islands and the Ohsumi Strait, where depth is about 100 m at most. When this occurs, our observations and numerical simulations show that the enhanced turbulence and associated nitrate diffusive flux spread further to the downstream in the streak of negative and low PV generated on the slope of Tanegashima Island, that merges to the Kuroshio east of Kyushu.

(S5-16557 Oral)

Asymmetry in seasonal mixed layer transitions with respect to coastal upwelling strength between northern and southern hemisphere and its influence on marine ecosystem

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The Eastern Boundary Upwelling Systems (EBUSs) in the eastern boundaries of the ocean basin including Pacific Ocean are important sites for oceanic ecosystems due to their intense upwelling that allows the blooming of phytoplankton and consequently, an abundant biomass which can feed migratory fishes including yellowfin tuna (YFT), one of the most important species around the world because of its large biomass and high commercial values. It is reported that ocean submesoscale eddies, which are often formed by the mixed layer eddies, exhibit strong seasonality. When the Ocean Surface Mixed Layer Depth (MLD) becomes deeper and surface stratification is destroyed during winter, the mixed layer eddy activity is intensified. On the other hand, the upwelling is strengthened during summer and winter in the Northern and Southern Hemispheres, respectively. Many studies have suggested that the phytoplankton growth is largely controlled by the seasonal MLD changes, and changes in the stratification caused by eddies, and hence it is highly probable that they influence on ecosystem. However, the impacts of across hemisphere asymmetry in timing of the mixed layer deepening with respect to the coastal upwelling have neither been discussed nor analyzed so far. In this study, using the ocean reanalysis, GLORYS12V1 (1/12° horizontal resolution, 50 vertical levels and 1993 onwards), chlorophyll provided by Global Ocean Satellite Observations, YFT CPUE data (IATTC), and idealized submesoscale permitting simulations, we attempt to elucidate what is the consequence of the across hemisphere asymmetry of mixed layer eddy activities in the upwelling systems.

(S5-16565 Oral)

Effects of seasonal variation of mesoscale eddy off the central coast of Peru on the distribution of anchovy eggs and larvae

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Various mesoscale structures, such as eddies, filaments and upwelling fronts, influence marine organisms. In the case of eddies, several studies have shown that they can redistribute suspended particles including fish eggs and larvae of different species, and alter their survival. In the Humboldt Current System, eddies off the central coast of Peru exhibit seasonal variability. The seasonal changes in their activity would directly or indirectly affect fisheries of the most important species in this area, the Peruvian anchovy (Engraulis ringens). It is reported that anchovy egg hatching occurs over 2 days between 14-17°C and from surface to 70 m depth approximately, and the larvae have to feed within the next 4-5 days to survive. Thus, how these eggs and larvae can be advected by eddies is a key to understand their survival and growth, which is currently unclear off Peru. In this study, data from Global Ocean Physics Reanalysis (GLORYS12V1) are used to characterize the physical properties and seasonality of eddies and to simulate how they transport anchovy eggs and larvae using the Lagrangian particle tracking. Further, the analyses on how the interannual variabilities of mesoscale eddies affect on the larvae transport are provided to understand the impacts over a longer time scale. Defining the role of eddies off Peru in anchovy larval transport could help to have better accuracy of the state estimate for anchovy stocks, that could also be very useful to other species in other similar environments as the California Current System.

(S5-16619 Oral)

Distribution of acoustically detected marine organisms across Kuroshio Extension front associated with physical and biogeochemical environments

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Frontal zones are known to be highly productive regions in the ocean. Understanding the links between physical processes, biogeochemical environments, and ecosystem at frontal zones has been an important issue. To address this, simultaneous field observations of environmental properties and the distribution of marine organisms were carried out across the Kuroshio Extension front. A cross-section survey was conducted during the research cruise WK2205G in May 2022 with R/V *Wakataka-maru* along the north-south transect from 37.5°N to 40.5°N on 150°E. Cross sections of environmental properties (temperature, salinity, fluorescence, turbidity, and oxygen concentration) down to ~400 m depth were collected by using the tow-yo profiler BioUCTD (JFE Advantech). Acoustic backscattering strength, as a proxy of biomass of fish, micronekton, and/or zooplankton, was measured down to ~600 m depth by using the scientific echosounder KFC-3000 (KAIJO) with the transducers of 38 and 120 kHz. High volume backscattering strength (S_v) was detected in the surface water at the south of the front, implying high productivity at the frontal zone. A layer with high S_v distributed widely in the mesopelagic zone (below 200 m depth), which is known as the deep scattering layer (DSL). Another high-S_v layer extended from the DSL to the productive surface water along the tilted isopycnals near the front. This distribution was detected during nighttime and thus did not represent diel vertical migration occurring at twilight. The relationships between the tilted scattering layer, physical processes, and biogeochemical properties will be presented in this talk.

(S5-16627 Oral)

How the Kuroshio Extension entrains the surrounding water masses off Sanriku

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In recent years, the Kuroshio Extension (KE) has been extremely northwardly polarized off the coast of Sanriku. The influence of the KE northerly bias is remarkable, such as a rise in temperature along the Sanriku coast and changes in fish species caught. On the other hand, the KE water denatures by taking in nearby water masses such as the coastal water, Oyashio water, and Tsugaru warm water. In addition, the uptake of coastal water and the Oyashio water leads to the supply of nutrients to the KE, suggesting an impact on the downstream ecosystems. The purpose of this study is quantitatively clarifying the process of the Kuroshio Extension entraining the surrounding water masses. In May 2023, we conducted high-resolution observation from the coast to the KE frontal region using the R/V *Wakataka-maru* with ADCP, UCTD, and turbulence profiler. In this presentation, we report the preliminary results of the survey.

(S5-16670 Oral)

Potential predictability of environmental drivers in Community Earth System Model Decadal Prediction Large Ensemble for a fisheries size and functional type model

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Fishes provide diverse values for human cultures as economical, food resources and social environments. Predicting fishes as marine living resources are rarely devoted for the near future despite of its importance. This presentation will share the preliminary result of ongoing project that investigates potential predictability of environmental drivers, pelagic temperature, bottom temperature, carbon flux, zooplankton biomass and mortality simulated in a Community Earth System Model Decadal Prediction Large Ensemble (CESM-DPLE) for offline simulation of a fisheries size and functional type model (FEISTY) compared to CESM Forced Ocean-Sea Ice (CESM-FOSI) for offline simulation of FEISTY. We note that all drivers in lead year (LY) 1 to 3 is highly predictable globally, that decreases as increasing LY. However, most of global ocean has higher potential predictability skills of CESM-DPLE forecast than persistence skill via calculating autocorrelation from by assuming "tomorrow is the same as today". Globally averaged environmental drivers in CESM-DPLE are showing highly correlated skills (r=0.6~0.8). In the regional timeseries averaged in Large Marine Ecosystems (LMEs) domain, environmental drivers of CESM-DPLE are highly predictable in most of LMEs of LY 1 to 3, but decreasing their predictability as increasing LY. Potential predictabilities of environmental drivers in LMEs are generally higher than persistence skill of CESM-FOSI in LMEs. In this sense, decadal prediction systems based on earth system models become valuable for simulating environmental drivers and sources for predicting fishes in interannual and decadal timescales.

(S5-16697 Oral)

Impact of warm eddy on sea level rise in the frontal region of the East/Japan Sea

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Understanding the dynamics of sea level rise (SLR) in frontal regions is of increase importance, as these areas often exhibit significantly higher or lower SLR rate compared to the global average. In this study, we focused on investigating the dynamics of SLR in the Subpolar front in the East/Japan Sea, where the SLR rate is nearly twice as high (~6 mm year^{-1}) as the global mean (3 mm year^{-1}). To achieve this, 28 years (1993-2020) of satellite altimetry data and in-situ hydrographic data are used.

Our analysis reveals that the presence of warm eddies, specifically the Ulleung warm eddy (UWE), has played a substantial role in driving the high SLR observed in this region. The temperature and thickness of the UWE have experienced notable increases, contributing to 33% and 67% of the SLR, respectively. Two potential factors are identified as the underlying causes for these changes. First, there has been an increase in the temperature of inflowing water through the Korea Strait. Second, the subsurface (100-300 m) temperature gradient across the Subpolar front has intensified, leading to greater instability in the subsurface layer which subsequently results in deepening of the lower boundary of eddies.

By comprehending the mechanisms behind SLR, particularly the influence of warm eddies such as the UWE, we can enhance our understanding of the complexities involved in regional SLR patterns and their implications in frontal regions.

(S5-16737 Oral)

Observations of upstream-downstream connectivity of the Kuroshio Current variability in the East China Sea

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The spatial and temporal variability of the Kuroshio Current in the East China Sea (ECS) was investigated based on the measurement from four moorings of the Acoustic Doppler Current Profile (ADCP) in the Okinawa Trough from June 2020 to June 2022. The four ADCP moorings were located southwest (upstream and onshore), southeast (upstream and offshore), northwest (downstream and onshore), and northeast (downstream and offshore), respectively. The time-mean current profiles are northeastward following the steep continental slope of the Okinawa Trough, and the current speeds decrease with depth. Their temporal variations also decrease with depth at the two offshore sites close to the deepest part of the Trough. However, they are larger between 200 m and 300 m, where the mean speeds are faster, at the two onshore sites over the shelf slope. The dominant modes of the observed Kuroshio Current variability were identified through the cyclo-stationary empirical orthogonal function analysis. The most dominant mode exhibits surface-intensified variability at the offshore sites, propagating from the upstream to the downstream. Regression analysis suggests that this propagation is associated with mesoscale eddies entering the ECS from the North Pacific, resulting in the sea level anomaly (SLA) along the Okinawa Trough. However, the velocity anomalies in the deeper (> 200 m) layers of the two onshore sites exhibit opposite signs compared to the two offshore sites. This result presents observational evidence for the connectivity of the Kuroshio variability in the ECS between upstream and downstream areas.

(S5-16756 Oral)

Submesoscale stirring as a crucial mechanism maintaining subsurface chlorophyll maxima within cyclonic eddies

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The interaction between physical and biological processes strongly influences the phytoplankton production in the upper ocean, yet our understanding of this relationship remains limited. Here, we use a combination of satellite and targeted in situ observations conducted during summer in the South China Sea to investigate the biophysical interplay that shapes and maintains the subsurface chlorophyll maxima (SCM) within cyclonic eddies. The results reveal a dome-shaped high chlorophyll distribution in the subsurface of a coherent cyclonic eddy. It is found that the doming of density surfaces increased light exposure, favorable for phytoplankton production at the eddy core. Importantly, we demonstrate that submesoscale stirring along slantwise isopycnals disrupted the mesoscale coherence and drove significant vertical exchange of tracers. Notably, compared to diapycnal mixing, the submesoscale isopycnal stirring serves as the primary driver of vertical nutrient flux, crucially resupplying the elevated phytoplankton biomass in the core of the coherent cyclonic eddy with nutrients. These findings provide a dynamical explanation for the formation and maintenance of local SCM within cyclonic eddies, highlighting the important role of submesoscale dynamics in structuring marine ecosystems.

(S5-16826 Oral) CANCELLED

~~Processes that influence bottom temperatures along the west coast of the US and Baja Peninsula~~

~~Michael **Alexander**[1], James Scott[1,2], Michael **Jacox** [1,2,3], Dillon Amaya[1] and Leah Wilczynski[4]~~
~~(*presented by Michael Jacox on behalf of Michael Alexander*)~~

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~~Temperatures on the ocean bottom strongly influence marine ecosystems along the US and Mexican west coast. While observations of bottom water temperature are very limited in both space and time, the recent development of high-resolution ocean reanalyses enable a detailed three-dimensional view of coastal oceanography. Here we use the GLORYS 1/12° (~9 km) reanalysis during 1993-2019 to examine processes that influence bottom temperature (BT) along the west coast of North America from 23°N-48°N. Locally, there are positive correlations (r> 0.4) between BT and indices of the vertical temperature structure, including the mixed layer depth, thermocline depth (TD) and the vertical temperature gradient near the bottom, where the correlation between BT and TD exceeds 0.8 in the southern part of the domain. The BT is also correlated (r > 0.5) with the local sea surface height (SSH) with a maximum at ~5-day lag. On subseasonal timescales, the coherence between SSH at the southern tip of Baja and both SSH and BT anomalies northward along the coast increase with lag on timescales consistent with the northward propagation of coastally trapped waves. Like SST and SSH, BT anomalies are coherent along the entire west coast on interannual time scales, reflecting the influence of ENSO on the eastern North Pacific. In contrast to SSH, the influence of the local wind-driven Ekman transport on BT anomalies increases with latitude. The relative roles of wind-driven and ocean processes as a function of latitude are confirmed using sensitivity experiments with a regional ocean model.~~

(S5-16837 Oral) CANCELLED

~~Subsurface nutrients, not upwelling strength, control projected productivity changes in the California Current System~~

~~Michael G. **Jacox**[1,2*], Michael Alexander[2], Dillon Amaya[2], Steven Bograd[1], Nathali Cordero Quiros[1,3], Dianne Deauna[4], Hui Ding[2,5], Jerome Fiechter[6], Mercedes Pozo Buil[1,3] and Ryan Rykaczewski[7]~~

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~~A number of mechanistic hypotheses have been offered to describe physical and chemical responses of eastern boundary upwelling systems to climate change. In terms of their impacts on primary production, these mechanisms may reinforce or oppose each other – enhanced nutrient concentrations in source waters would support higher productivity, increased stratification would tend to limit nutrient supply and productivity, and increased upwelling could enhance productivity to a point but limit productivity if it is too strong. There is no clear consensus on which mechanism(s) will predominantly drive future productivity changes, with various retrospective and forward-looking studies suggesting dominant roles for wind, stratification, and source water nutrient concentrations. Here we use an ensemble of regional ocean projections for the California Current System (CCS), forced by three different earth system models, to disentangle the sometimes-competing factors of wind forcing, water column structure, and remotely-driven nutrient content. Some trends are consistent among models (e.g., decreased mixed layer depth and increased upwelling in the northern CCS) while for others there is a lack of agreement between models (e.g., nitrate concentration in upwelled waters, upwelling in the central/southern CCS, chlorophyll concentration). However, despite the disagreement between models on whether productivity will increase or decrease, there is agreement that productivity changes are predominantly driven by changes in subsurface nitrate concentrations, not by changes in upwelling strength. Given that much of the focus to date has been on changes in upwelling or upwelling-favorable winds, our results suggest the need for more attention to the role of subsurface changes.~~

(S5-16861 Oral)

Seasonal cycle of the confluence of the Tsugaru Warm, Oyashio, and Kuroshio currents east of Japan

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The Sanriku Confluence east of Japan is the region of confluence of the Tsugaru Warm Current from the Sea of Japan, the Oyashio Current from the western subarctic gyre and the Sea of Okhotsk, and Kuroshio water that has detached from the subtropical gyre. It is a field of vigorous stirring driven by variability in current systems, but transition processes between water masses have yet to be clarified. High-resolution underwater conductivity–temperature–depth observations were undertaken during each of the four seasons to test a hypothesis that the water- mass gradient in the Sanriku Confluence is set without full stirring. Analyses in isopycnal coordinates indicate the seasonal occurrence of prominent fronts of both salinity and displacement, related to the emergence of various water masses. After fitting error functions to frontal features, the seasonally emerging isopycnal salinity fronts often became extremely sharp with widths typically narrower than 3 km, supporting the hypothesis. Disturbances distinguished from frontal structures indicate variance peaks with ranges similar to or slightly greater than the baroclinic Rossby radius, likely stirring the large-scale tracer gradient at this scale. Elevated variances in isopycnal salinity were often observed around the fronts, and variances caused by isolated patches with salinity anomalies were also large. By determining the horizontal scales at which the effects of internal wave heaving becomes dominant, we were able to calculate the potential vorticity (PV) of the balanced flow field. As the PV becomes negative or near zero around the fronts, symmetric instability might have developed.

(S5-16887 Oral)

Effects of tidal forcing on the frontal dynamics of the Changjiang River plume

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Tidal forcing is a key driving factor in the frontal dynamics of the Changjiang River plume and plays a significant role in coastal ecosystem dynamics. In this study, hydrodynamic models of the Changjiang River plume with tides and without tides were developed based on the Regional Ocean Modeling System. The model results were used to estimate the gradient of density and the divergence and vorticity of velocity. Lagrangian Coherent Structures (LCSs) were applied to analyze the horizontal dispersion and mixing of the plume water.

The LCSs results show that tidal forcing could enhance the horizontal dispersion in the frontal regions. The horizontal gradient of density indicates that the stratification is stronger during the neap tide than that during the spring tide. The horizontal dispersion is stronger (weaker) at the surface (bottom) during the neap tide than during the spring tide. The strength of the horizontal divergence and vorticity are stronger in the frontal region during the spring tide than that during the neap tide in the frontal region north of 31°N where the plume mainstream is located, while the strength of the horizontal divergence and vorticity are weaker in the frontal region during the spring tide than that during the neap tide in the frontal region south of 31°N. Strong convergence always occurs at the slack water. The horizontal divergence evolution analysis reveals that the during the spring/neap tides, greater effect of deformation induced by the velocity shear, the smaller divergence in the frontal regions.

(S5-16902 Oral)

Velocity structure functions derived from submesoscale surface currents over marginal seas

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Observational platforms for submesoscale phenomena have developed rapidly since the advent of remote sensing. Space-based observations can resolve features smaller than submesoscales, thereby enhancing our understanding of intricate oceanic and atmospheric processes. While ocean colors have facilitated the detection and quantification of ephemeral and localized processes, monitoring Eulerian submesoscale surface currents over areas comparable to, or larger than, marginal seas, remains challenging with conventional submesoscale observational platforms. In this study, we implemented a Convolutional Neural Network (CNN) to evaluate the accuracy of ocean color-based submesoscale surface currents. Through this network, we filtered out low-accuracy vectors that could potentially be affected by weather conditions and the strength of scalar magnitude and its gradient. We applied these filtered surface currents to calculate the Eulerian velocity structure function in the marginal seas such as the Yellow Sea, East China Sea, and East/Japan Sea around the Korean Peninsula. Subsequently, we compared these satellite-derived structure functions with those derived from ocean models and Lagrangian drifter observations. The findings illuminate the capability of ocean color to investigate submesoscale turbulence across diverse regions governed by various physical processes, and aid in evaluating the reliability of ocean models.

(S5- 17431 Oral)

A Regime Shift of the Kuroshio Extension System after 2018

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The Kuroshio Extension (KE) system constitutes the western boundary current outflow after the Kuroshio separates from the coast of Japan. In the past 40 years following the 1976/77 climate regime shift in the North Pacific climate system, the KE system has been observed to vascillate between a stable and an unstable dynamic state with a preferred period of ~10 years. This decadal modulation has been argued to result from a delayed negative feedback process involving the KE variability, its impact upon the overlying stormtracks, the basin-scale wind-forced main thermocline adjustment, and the response of the KE system to the westward-propagating thermocline anomalies. In August 2017, the Kuroshio south of Japan developed a large meander (LM) path which has persisted over the past 6 years. By analyzing eddy-resolving sea surface height data and by adopting a wind-forced linear vorticity model, we demonstrate that the on-going persistent LM is maintained by an exceptionally stable dynamic state of the KE that is both forced by wind stresses across the Pacific basin and by the occurrence of the Kuroshio LM. Through the nonlinear mutual enhancement between the KE and its upstream LM, the KE system has entered a new regime with a super dynamic stability.

(S5-16522 Poster) S5-P1

Surface chlorophyll and temperature anomalies induced by mesoscale eddies and geostrophic strain in the Arctic Norwegian Sea

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The northern Norwegian Sea is an important area for fisheries in the Nordic Seas, and its high productivity is strongly associated with mesoscale eddy activities. Mesoscale eddies affect biogeochemical cycling in the upper ocean through horizontal and vertical transport-mixing of nutrients and phytoplankton, as well as modulation of eddy structures by eddy-wind interactions. To quantitatively assess mesoscale eddy induced ocean surface chlorophyll-a concentration (CHL) anomalies and modulation of eddy-wind interactions in the region, we constructed composite averaged CHL and wind anomalies from 3,841 anticyclonic eddies (ACEs) and 2,727 cyclonic eddies (CEs) over the period 2000-2020 using satellite altimetry, scatterometer and ocean color products. Statistical results indicate that both ACEs and CEs have positive or negative CHL anomalies; of particular importance is that eddy-induced Ekman upwelling plays a key role in the unusual positive CHL anomalies within the ACEs. This process is critical for the vertical transport of nutrients and phytoplankton and for sustaining high productivity of the region. Seasonal shallowing of the mixed layer depth (MLD) result in greater irradiance levels available for phytoplankton growth, thereby promoting spring blooms, which in combination with strong eddy activity leads to high CHL anomalies in May and June. The combined processes of wind-eddy interactions and seasonal shallowing of MLD play a key role in generating surface CHL anomalies and is a major factor in the regulation of phytoplankton biomass in the northern Norwegian Sea.

(S5-16555 Poster) S5-P2 (ECOP)

The formation of the T-S relationship in the Kuroshio Extension region

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A triple decomposition framework was applied to the temperature variance equation to assess each temperature variance budget term, diapycnal mixing production by small-scale turbulence, isopycnal stirring production by mesoscale eddies and temperature variance dissipation in the Kuroshio Extension (KE) region.
In the surface, diapycnal mixing dominated variance production.
The vertical eddy diffusivity was not so high value ($K_\rho \sim 10^{-6} - 10^{-4}$) in the upper 200m, but variance production was dominated by diapycnal mixing because the vertical component of potential temperature gradient was high.
In contrast, isopycnal production of temperature variance was dominant in mid-depth(200-450m). Although the water in this depth is characterized by low PV, its density is greater than that of NPSTMW (North Pacific Subtropical Mode Water), suggesting that low PV water formed in the northern region (such as Central Mode Water) may have advected into this region mixing with other seawater. The effect of double-diffusive convection should also be considered since thermal variance dissipation in the KE is found to be much active than that of TKE dissipation that are previously considered to be caused solely by double-diffusive convection. In this study,
the effective thermal diffusion coefficient derived from two models is used to separate the role of double diffusion from lateral stirring on the temperature variance budget.

(S5-16575 Poster) S5-P3 (ECOP)

Spatiotemporal characteristics of the cyclonic eddies generated between the Kuroshio and the coast of Japan during 2000 – 2020

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Submesoscale cyclonic eddies formed between the currents and the coasts, known as the frontal eddies, play a key role in promoting exchanges of matters between offshore and coastal ocean and nutrient rich deep and sunlit surface layers, while retaining fish larvae within the eddies that improves the juveniles' survival rate. Although the previous studies reported that the Kuroshio can also generate frontal eddies that were suspected to enrich the downstream regions, it is still unclear how the activity of frontal eddies can modulate interannually in relation to the Kuroshio path modulations. In this study, ocean reanalysis product and satellite chlorophyll a data are analyzed to elucidate where and when these submesoscale cyclonic eddies can be generated in relation to the Kuroshio path variabilities and their impacts on the phytoplankton.

(S5-16813 Poster) S5-P4

Vertical changes in phytoplankton size structure assessed through in-situ measurements, a profiling crawler and random forest modeling

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Phytoplankton community size structure is a key attribute that influences pelagic trophic energy transfer and the vertical flux of organic matter to benthic food webs. Phytoplankton assemblages dominated by small cells, commonly have low trophic transfer efficiency and high internal recycling, which contrast with food webs dominated by large phytoplankton. In the Bering Sea, a highly productive spring bloom is followed by summer periods characterized by strong stratification and nutrient depleted surface waters. Here, we explore how such contrasting oceanographic conditions in the southeast Bering Sea influence phytoplankton size structure. We analyzed the dynamics of phytoplankton size structure both seasonally and vertically throughout the water column. This was accomplished, by developing a random forest model using multi-year discrete water sample measurements of total and large fraction (>10 µm) chlorophyll-a concentrations (Chl-*a*), and then apply this model to a vertically integrated moored profiler (Prawler). Our results, of both in-situ water sample and modeled Prawler data, show that the proportion of large fraction Chl-*a* increases with water depth. Large cells have proportionally higher abundance below the mixed layer depth throughout most of the summer, while small cells (<10 µm) comprise 70-80 % of phytoplankton community near the surface. Our findings highlight the stable vertical partitioning of phytoplankton size structure for much of the summer growing season. The seasonal and vertical differences in phytoplankton size structure likely influence feeding behavior of both micro and meso zooplankton, as well as the structure and energy transfer of the southeastern Bering Sea planktonic food web.

(S5-16830 Poster) S5-P5

Seasonal and interannual variation of Atlantidae heteropods off the western coast of Baja California, Mexico.

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Ocean acidification can affect the Atlantidae holoplanktonic gastropods because of their aragonitic shell and their epipelagic habitat. In the southern California Current System, the strongest seasonal changes in zooplankton species composition and environmental conditions occur between winter and spring. ENSO and marine heat waves are the main drivers of interannual scale environmental changes. Our aim was to infer the effect of the seasonal (winter-spring) and interannual (2012-2016) environmental variability on the diversity, distribution, and abundance of atlantid species off the Pacific coast off Baja California, Mexico. Atlantidae diversity was higher during winters than during springs, with maximum species diversity associated to the 2013-2015 marine heat wave and El Niño 2015-2016. Atlanta californiensis was the most abundant species, mainly during spring, and its relative abundance decreased during periods with warm anomalies, while tropical/subtropical species increased theirs. Atlantid distribution recorded during winter was correlated with temperature, salinity, and the distribution of seawater masses, and during spring their distribution was mostly associated with the depth of hypoxic conditions and Ω aragonite saturation horizon. Differences in the species community structure, the rapid response to Ω aragonite undersaturated waters and hypoxia, and their seawater mass affinity showed that atlantids are robust indicators of environmental changes and potential biological indicators of acidification and deoxygenation.

(S5-16848 Poster) CANCELLED S5-P6

~~Characterization of the fish larvae community off ENSENADA in the southern California Current, and its interaction with local and interannual variability~~

~~Sylvia P. A. **Jiménez-Rosenberg** and Gerardo Aceves-Medina~~

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~~Fish larvae communities in the Southern California Current have been studied regarding to species composition and community structure on seasonal and inter-annual scales. According to this, the region can be divided in three zones: Ensenada, Bahía Vizcaíno, and South Punta Eugenia. Off Ensenada, larvae of mesopelagic fishes rank among the first in abundance. Demersal species larvae exhibit the highest richness, except during winter, were the meso and bathypelagic species richness increase. Being meso-bathypeagic and demersal the most remarkable fish larvae off Ensenada year-round, the objective of this work is to find out if the variations in these two communities are attributed to local seasonal variability or to larger-scale variability in the area, or both. Fish larvae were sorted out of zoplankton samples of 63 IMECOCAL cruises realized during a 20-year period (1997-2017), representing almost in equal proportion the four seasons of the year, in addition to various interannual scale events Preliminary results show that larvae of meso-bathypelagic species tend to be synchronized with local and large-scale variability, reporting abundances in direct relation to positive and negative thermal anomalies, attributed to both sea surface temperature and El Niño and La Niña events. However, no related change is observed in the presence dominant species of this group. The larvae of demersal species, in terms of their abundance, tend to be directly related to strong El Niño events and prolonged cooling events. However, something that is notable in this community is the variability of species richness, both on a seasonal and interannual scale.~~

(S5-16876 ~~Poster~~) **CHANGED TO ORAL (OCT. 24)** ~~S5-P7~~ (ECOP)

Using pollock larvae distributions to explore ocean processes in the Western Gulf of Alaska

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Understanding the processes that influence fish larval distributions is a key aspect in assessing population dynamics, survival and recruitment. Past studies have shown that local wind forcing influences Walleye pollock (*Gadus chalcogrammus*) larval dynamics in the Gulf of Alaska, but the mechanisms and year-to-year variability are not fully resolved. Walleye pollock is a key trophic linkage in the Gulf of Alaska food web as both a predator and prey resource, as well as an important target of the commercial fishery. Pollock larvae are spawned in Shelikof Strait and transported southwestward into the Shelikof Sea Valley by the Alaskan coastal current. Larval drift varies due to processes and forcing across many spatial scales such as due to eddies within Shelikof Strait which can retain pollock in patches, baroclinic gravity-driven exchange across the sea valley, mesoscale eddies over the slope, and the strength, direction, and shear of the wind stress–including from gap wind events funneled by local topography. NOAA's EcoFOCI program has sampled larval pollock distributions since the 1980s, allowing us to revisit hypothesized relationships between oceanographic processes and pollock larval dynamics including how marine heatwaves influence larval distribution. We analyze 34 years of larval data to estimate interannual changes in distribution and abundance using spatiotemporal models to infer how oceanographic conditions, multi-scale processes, and climate variability impact spring distributions. Preliminary analyses show shifts in the larval center of gravity of up to 100 km among years, driven by multiple processes.

Session 6: MEQ Topic Session

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

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

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

Invited Speakers:
Adrianne Akmajian (Makah Fisheries Management, Makah Indian Tribe, WA, USA)
Bobbie Buzzell (Lummi Natural Resources Department, Lummi Indian Business Council, WA, USA)
Joshua Charleson (Coastal Restoration Society, BC, Canada)
Crysta Stubbs (Coastal Restoration Society, BC, Canada)

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

(S6-16677 Invited)

Bringing back ecological balance through an indigenous perspective

Joshua **Charleson**

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Since time immemorial Indigenous peoples living on the West Coast of what is now known as Canada and the United States have had an intimate relationship with all living and non-living species in our coastal waters. For thousands of years balance was created naturally between all living and non-living species in our coastal waters and gave abondance to the Indigenous peoples. This balance has been disrupted over the past 150 years through rapid climate change, over harvesting, and the introduction of invasive species. Indigenous peoples are the stewards of these territorial lands and waters and have witnessed these changes and imbalances firsthand. In order to understand the full scope of these changes happening at an accelerated rate; we must look back into our history and what has led us here to where we are today. Traditional Ecological Knowledge blended with modern science and technology is the key to unlocking the past and returning ecological balance into the future. Engagement, co-development, and implementation of AIS programs in partnership with Indigenous peoples have never been more important. Understanding and building relationships with Indigenous Nations is the first step to understanding and building a balanced future in our lifetimes and for the generations that come after we are gone.

(S6-16787 Invited)

South Coast European Green Crab Control Project

Crysta **Stubbs**

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The South Coast European Green Crab Control Project investigates the efficacy of industrial style trapping as a method to deplete and control populations of the invasive European green crab (EGC) on the coast of Vancouver Island. Since November 2021, Coastal Restoration Society, the Ahousaht First Nation, the Tla-o-qui-aht First Nation and T'Sou-Ke First Nation in partnership with the Department of Fisheries and Oceans Canada have been collaborating on EGC trapping programs in Clayoquot Sound and Sooke Basin within critical juvenile salmon habitat. Integral information regarding the logistics, engagement pathways, operational costs, trap types, variety in catch per unit effort based on trapping variables, bait selection, etc has been collected and will guide the development of a coast wide management plan for European green crab in BC. As of June 20, 2023, over 560,000 European green crabs have been removed from Canadian waters through the South Coast European Green Crab and Control Project. This Project not only highlights the complexities associated with performing aquatic invasive species management, but also demonstrates the importance of meaningful collaboration to ensure efforts are cost-effective, done in a mutually informed and respectful way amongst partners, and involve thorough risk assessment and management.

(S6-16800 Invited)

Increasing trapping capacity to address invasive European green crab (*Carcinus maenas*) in Lummi Sea Pond and Lummi Nation Tidelands

Bobbie **Buzzell**, Nicholas Jefferson and Shawn Evenson

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In 2021, Lummi Natural Resources Department (LNR) staff led a high intensity trapping effort to remove invasive European green crab (Carcinus maenas; EGC) from Lummi Sea Pond (LSP), a 750-acre manmade aquaculture pond located in Lummi Bay on Lummi Nation tidelands. By years' end, nearly 86,000 EGC were captured and removed from LSP and prompted Lummi Indian Business Council to declare an EGC disaster (Resolution #2021-158), which was soon followed by an emergency order enacted by Washington state. Both measures set in motion increased funding and resources for Lummi Nation to respond to the EGC population increase in LSP appropriately. Over the next year, LNR staff quickly built capacity to increase trapping within LSP. LNR staff are also continuing to assess the extent of EGC spread into Lummi Bay and Lummi River and monitor other areas of potential establishment on Lummi Nation tidelands. Increased trapping efforts revealed some spread of EGC in Lummi Bay; however, LNR collaboration with Washington Department of Fish and Wildlife, Lummi-owned vendors, and Lummi fishers have successfully stagnated EGC trapping densities in LSP. The slowing population growth of EGC in LSP allows for time to develop long-term strategies for EGC research and management on Lummi Sea Pond (beyond trapping) and reduces the likelihood of EGC in LSP serving as a source population for the greater Puget Sound and Salish Sea. In this presentation, we will discuss implementation strategies, hurdles, and outcomes over the last couple years to appropriately address the EGC invasion on Lummi Nation tidelands.

(S6-16945 Invited)

Management, monitoring, and research on European green crab (Carcinas maenas) on the Makah Reservation

Adrianne **Akmajian**

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Since first detecting European green crab (*Carcinas maenas*; hereafter green crab) on the Makah Reservation in 2017, the Makah Tribe has implemented a variety of strategies to remove and monitor the invasive crabs within their waterways. Removal trapping for the past six years has revealed complex and unexpected findings in their distribution not only spatially and temporally, but also by size, sex, and environmental variables. While the population appears to be established and, at least partially, self-recruiting, settlements of new recruits throughout the trapping season suggest there are likely multiple sources. Monitoring and research to look at their impacts on the native species reveals both the potential for biotic resistance by some species and seeming declines of others. Mark-recapture studies reveals the complex nature of attempts to estimate true abundance and study their movements.

(S6-16604 Oral)

The transition from resistance to acceptance: Controlling a marine invasive species in a changing world

Abigail **Keller**[1], Perry de Valpine[1], Tim Counihan[2] and Carl Boettiger[1]

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Invasive species managers face novel challenges allocating limited control resources under a changing climate, particularly in aquatic habitats where organisms can disperse broadly and rapidly. Managers must identify the level of control effort sufficient to mitigate ecological impacts, or decide when to shift from a "resist" to "accept" management framework when high rates of non-local or density-dependent recruitment outstrip the pace of suppression activities. To support control decisions, we develop a size-structured model of invasive European green crab population dynamics on the U.S. west coast that describes how size-selective control actions alter the population. We then identify optimal allocations of species control effort, including conditions when removal resources should be surrendered from a given location. Finally, we quantify the relative contribution of different sources of uncertainty to overall decision uncertainty, which can be used to guide future research efforts. This decision support framework provides a path forward for optimizing invasive species management strategies under non-stationary marine conditions.

(S6-16680 Oral)

Challenges, lessons learned, and advantages of large-scale collaborative management actions targeting the European green crab, *Carcinus maenas*, in Washington state

Brian Christopher **Turner**, Chelsey Buffington and Lennah Shakeri Mohar

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Managing marine non-indigenous species (MNIS) is a challenging undertaking, even for small, isolated populations where one entity has jurisdictional authority. As management actions' geographic scope increases, the complexity of MNIS management increases exponentially. Natural variation between geographical locations requires careful consideration of management actions on a site-by-site basis, both in terms of efficiency and safety. The larger management area complicates the transportation of gear and personnel but can result in localized bottlenecks in management capacity due to labor and resource shortages. In addition, geographic expansion of management efforts often incorporates multiple jurisdictions, requiring coordination and collaboration among various entities. While cooperation between entities can yield great benefits, differences in priorities, goals, and internal procedures must be navigated. As the number of individuals/entities increases, variation in fieldwork and data collection/management practices can quickly complicate reporting and assessment of management actions. The ongoing statewide management of the European green crab (*Carcinus maenas*) in Washington is a case study of the challenges and benefits of a large-scale collaboration between various co-managers, tribes, and partners to manage MNIS. This presentation will review the challenges, lessons learned, and advantages of large-scale collaborative management actions for MNIS.

(S6-16769 Oral)

Multiple larval sources for Oregon and coastal Washington green crab populations

Sylvia **Behrens Yamada**[1], Carolyn Tepolt [2] and Alan Shanks[3]

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Prior to the 2015-2016 El Nino, recruitment of Young-Of-The-Year European green crabs to Oregon and coastal Washington estuaries was closely linked to ocean conditions experienced by their larvae during the previous winter. The primary larval source during this period was the Davidson Current transporting larvae north from breeding populations in California. Ocean indicators of warm surface water temperatures and strong northward water transport during winter were followed by good year classes of young green crabs, while the reverse produced recruitment failure. This pattern changed after the 2015-2016 El Nino, when good recruitment occurred every year, indicating the presence of additional larval sources. Evidence for local reproduction was found in Coos Bay, Oregon during the winter of 2010 (a mini El Nino year) when first instar green crab larvae were found in plankton samples. Larvae can also arrive from the north after the Davidson Current dissipates and the Shelf-break Current brings water masses from the north during the summer. One isolated population on Vancouver Island, in Sooke Basin, developed a unique genetic fingerprint that differs from the well-mixed populations on the open coast. Some crabs from Makah, Grays Harbor, Willapa, Tillamook and Netarts Bays carried this unique genotype, suggesting that they must have arrived from Sooke as larvae carried in the Shelf-break Current. Oregon and coastal Washington estuaries now 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 the control of this invader.

(S6-16779 Oral)

Genomic tracking during the earliest stages of a marine invasion

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Marine invasive species are often widespread and highly dispersive, presenting a challenge for effective management and spread prevention. Understanding where new introductions are coming from, and how they are dispersing in their introduced range, can help to concentrate resources on the highest-risk vectors and to design management strategies at an appropriate spatial scale. The emergence of cost-effective high-throughput genetic sequencing permits us to examine sources and connectivity directly using a much higher-resolution, genome-wide perspective than traditional population genetics approaches. We will discuss the utility of genomic tools for better understanding and managing marine invasions, using the European green crab (EGC) in the northeastern Pacific as a case study. Green crabs have spread rapidly in the northeastern Pacific since their first detection in 1989, with increasing recruitment and accelerating spread since 2017 likely due in part to warming waters. EGC in this region have lost substantial genetic diversity and traditional population genetic markers have provided little resolution; we will present genomic data from ~5,000 transcriptome-derived single nucleotide polymorphisms. This improved genomic resolution demonstrates overall extensive dispersal in the region, with distinct genetic signatures developing rapidly in embayments where dispersal is restricted. Using these distinctive populations as tracers, we have identified complex patterns of regional dispersal and spread, especially in the Salish Sea, with multiple sources and recent introgression between them. Genomic data can be an excellent tool for understanding dispersal and spread in the earliest stages of invasion, and can inform management decisions to predict, prevent, and manage marine invaders.

(S6-16839 Oral)

Top-down control of invasive European green crabs by Southern sea otters in central California

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Can recovering populations of native apex predators increase the resistance of coastal ecosystems to invasions by non-native species? Elkhorn Slough estuary in central California is habitat for several keystone species including the Southern sea otter (*Enhydra lutris nereis*) and several invasive invertebrates including the European green crab (*Carcinus maenas*). We investigated whether predation by sea otters has suppressed abundance of green crabs in Elkhorn Slough. We analyzed monitoring data tracking both otter and green crab abundances since the early 2000s. We found that as sea otters have steadily increased over the past decade, green crabs have declined. Sea otters consume a variety of prey including green crabs, which we quantified with field observations. Our analysis showed increasing sea otter density resulted in a significant reduction of relative green crab abundance at multiple sites. However, tidally restricted sites that impeded access by sea otters maintained higher densities of green crabs, highlighting the importance of restoring natural hydrology. We also compared green crab population trends across California estuaries and found green crabs have remained consistently low only in Elkhorn Slough over the past decade. We suggest that focusing efforts to maintain populations of native apex predators can have similar effects on invaders elsewhere.

(S6-16888 Oral)

Community science for the early detection of European green crab (*Carcinus maenas*)

Lisa **Watkins**[1], Jeff Adams[1], Emily Grason[1], Aina Hori[1], P. Sean McDonald[2], Staci McMahon[1], Kate Litle[1], Benjamin Rubinoff[1,2], and Alex Stote[1]

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European green crab, *Carcinus maenas*, was first detected in the Salish Sea in 2012. Since that time, management efforts have focused on early detection and rapid response to proactively address population expansion across the region. In support of these management efforts, Washington Sea Grant launched a new program in 2015 called Crab Team, a community science early detection monitoring network. Crab Team protocols generate baseline data on ecosystem composition across the region and establish a systematic observation network sensitive to range expansion and preferences of European green crab. The network engages over 200 volunteer, tribal, and agency monitors in consistent data collection at nearly 70 sites. Its monitoring efforts have successfully resulted in several first detections of European green crab in new waterbodies. In 2023, Crab Team launched a complementary program called Molt Search to more broadly engage the public in surveying for European green crab across wider swaths of Salish Sea shoreline. To add value to these programs, Crab Team staff prioritize partnership building and advise regional groups on cohesive data collection and interpretation, ensuring the community-sourced data remains valued in management decision-making. In this talk we share how Crab Team's programs are designed to generate management relevant data and give a few examples of its measurable utility thus far.

(S6-16897 Oral)

Introduced subtropical ship hull seaweed, *Colaconema formosanum* (Rhodophyta): species description and ecophysiological characterization

Hyung Woo **Lee**[1], Ye Rim Kim[1], Ju-Hyoung Kim[1], Young Jun Song[2], Young Sik Kim[2], Eun Ju Kang[1], Min Gui Jung[1], Kyungsoon Shin[3], Jung-Hoon Kang[4], Seung Ho Back[4] and Bonggil Hyun[3]

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The fouling of ship hulls by international maritime interactions is significant vectors that poses a threat to local coastal biosecurity. Despite antifouling treatments, numerous barnacles form communities on the hull surfaces and spread along the maritime routes worldwide. These fouling barnacles can serve as hidden vector for tiny epizoic seaweeds. We collected a very tiny filamentous red algal individual from the barnacles attached on the hull surface of a commercial vessel and incubated its biomass to describe its taxonomic and ecophysiological characteristics. Using the molecular approach (*rbc*L, COI-5P and SSU markers), we identified our collection as a subtropical red seaweed, *Colaconema formosanum* M.-C. Lee & H.-Y. Yeh, newly reported as a negative epi- or endophytic species to inhibit the growth of *Sarcodia suae*, one of the economic seaweeds in Taiwan. We measured the growth rates of fragment of *C. formosanum* under various temperature (10, 15, 20, 25, and 30℃) and light (20, 50, 80, and 100 μmol photons $m^{-2}s^{-1}$) conditions for 10 days to identify their ecophysiological characteristics and invasive potential. The optimal growth was observed at higher temperature (approx. 25°C) and higher light condition (100 μmol photons $m^{-2} s^{-1}$). Consequently, *C. formosanum*, which thrives in warm environments, is likely to establish easily along the Korean coast if introduced through the ship hull, particularly during the summer. Additionally, barnacle, which provide substrates for seaweed, could be significant as a potential source for invasive seaweed.

(S6-16899 Oral)

Investigating the basis of thermal tolerance of a rapidly spreading crab

Yaamini R. **Venkataraman[1]**, Sara Shapiro[1], Sarah Zuidema[1], Julia Kelso[2], Mikayla Newbrey[3], Lauren Stephenson[4], and Carolyn Tepolt[1]

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European green crabs (*Carcinus maenas*) are one of the world's most successful marine non-indigenous species (NIS). On the North American West Coast, *C. maenas* negatively impact species important for tribal food sovereignty and commercial shellfish production through competition with native crabs, predation of juvenile shellfish, and destruction of nursery eelgrass beds. Crab populations in this region are characterized by substantially lower genetic diversity than in their native range. Recent discovery of a supergene (block of genes inherited together) with amino acid-changing mutations strongly associated with thermal tolerance suggests a genetic basis for population thermal tolerance. However, the low overall genetic diversity and high thermal plasticity exhibited by crabs presents a genetic paradox: how is thermal tolerance maintained with seemingly low adaptive potential? This talk will explore how genetic and environmental factors contribute to an individual crab's thermal tolerance. Crabs were exposed to cold (5ºC), ambient (14ºC), or warm (25ºC) temperatures for one month. Individual crab responses to temperature were assessed using time-to-right and respirometry. Thermal tolerance phenotype was compared between supergene genotypes and temperatures to determine how genotype and environment shaped individual performance. This work illustrates the importance of understanding factors that contribute to within-population stress tolerance, as individual variation may improve overall population fitness and influence spread of NIS.

(S6-16925 Oral)

Identifying Management Needs for European Green Crab in British Columbia, Canada

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The European Green Crab (Carcinus maenas - EGC) is a high-risk global invader that can devastate coastal marine ecosystems by displacing native species, degrading and disturbing native habitat, and altering food webs. Despite being known from Canadian waters of the Pacific Ocean for more than two decades, management efforts have only recently been initiated. As the invasion isn't uniform and there are locations that have only recently been invaded while others have been invaded since the late 1990s. This greatly complicates management activities and means that a single solution will not be applicable coast-wide. Where EGC have not yet been reported then early detection is the priority while in locations where EGC have been present for decades management efforts are aimed at reducing populations levels. Also, there is considerable context-dependency that must be factored into decision making and successful management requires considerable engagement with coastal First Nations, stakeholders, industry, and Canadians. Here we discuss the challenges, solutions, and gaps around EGC management needs. Although there are no "silver bullets" there are areas where science can inform and improve decision making. These will be discussed in the context of early detection, monitoring, short-term intervention, and longer-term removals. For example, can management thresholds be identified whereby managers know when to engage in control efforts, when they know efforts are working or when they are not and management needs to adapt or cease. Finally, we will discuss how advances have been made through early engagement both domestically and with colleagues in the United States.

(S6-16940 Oral)

Developing a quantitative basis for management targets for non-indigenous marine species

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Non-indigenous species (NIS) have continued to increase in marine systems over the past decade driven by expanding globalization and climate change. Among the primary goals of managing NIS is to reduce or mitigate the ecological and economic damage they cause including the loss of biodiversity, and the reduction of ecosystem functions and services including fisheries productivity. A critical aspect of developing management actions for to reduce these damages is to define the functional relationship between the abundances and distribution of NIS and the damage they create. Defining this relationship permits the development of quantitative targets for harvest reduction. Too often harvest management programs invest substantial capital without clearly defined targets for reducing or eradicating marine NIS, although eradication is extremely difficult. In this presentation, I start with examples using the European green crab and their bivalve prey and then summarize what we know broadly about the relationship between NIS abundance and the resulting damage to specific ecosystem functions and values. Functional eradication is an approach that uses the non-linear relationship between NIS abundance and the ecosystem value at risk to develop targets for management harvest. The degree to which this relationship applies to other NIS and the ecosystem values that they put at risk will determine the utility of this approach for providing similar targets for managing other NIS. I also discuss how this approach could be implemented by multiple jurisdictions over larger spatial scales involving locally variable NIS densities and ecosystem values.

(S6-16969 Oral)

Science to support management of marine bioinvasions; a case study of invasive European green crab (*Carcinus maenas*) in Washington

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Effective management of marine bioinvasions frequently hinges on rapid deployment of best available science to address urgent concerns. To do so, managers and scientists must work together closely, and infrastructure and processes should be aligned for efficient implementation. We use the example of European green crab (*Carcinus maenas:* henceforth green crab) management in Washington State as a case study. The green crab was first detected in Washington waters in 1998 after warm El Niño currents spread larvae of California populations as far north as Vancouver Island. Because of perceived risks to coastal resources, the green crab was designated a deleterious species in Washington State, which among other actions, mandated monitoring and control of the species in state waters. Over the past decade, green crab abundance and distribution has increased throughout the region, as has coordinated management in many jurisdictions. In this presentation we highlight how knowledge transfer and collaboration have developed among managers, scientists, and other stakeholders and how management has evolved to build regional response capacity. In particular, we emphasize the importance of integrating new scientific understanding into management. This has enabled a robust and responsive regional strategy, rooted in effective communication and science-informed decision-making.

(S6-16978 Oral)

Ecological impacts of the invasive European green crab (*Carcinus maenas*) in Washington

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The European green crab (EGC) was first detected in Washington, USA in 1998, and since then, has expanded in numbers and spatial extent across coastal and inland waters. Ecological impacts of EGC have not yet been recorded at this early stage of invasion, but as populations continue to grow, they are likely to become increasingly detectable/apparent. We analyzed Washington Sea Grant's Crab Team monitoring data to determine how EGC populations vary over space and time and to identify species showing negative population correlations with green crab abundance. Native hairy shore crab (*Hemigrapsus oregonensis*) showed the strongest negative relationship with green crab abundance, aligning with documented impacts in other locations. We then conducted a tethering experiment during the summer of 2023 to investigate whether green crab abundance across multiple invaded sites show a positive correlation with the number of tethered hairy shore crab consumed. In this talk, we will present the results of our tethering experiment and discuss how they align with documented impacts of EGC in other locations. We will conclude by suggesting how our monitoring and experimental results can best be utilized by managers in coastal Washington.

(S6-16768 Poster) S6-P1

Research outcomes on core elements to establish biological risk assessment protocols for in-water cleaning of ships' biofouling

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This study covers the scientific basis for managing hull fouling of ships entering a port. It can also be used to diagnose biological risks that may occur when in-water cleaning systems remove hull fouling. The development of the protocol for biological risk assessment is primarily divided into two sections: system design of Korea-infection Modes and Effects Analysis (K-IMEA), including the selection of core elements and scenario design for in-water cleaning, and K-IMEA response experiments. The K-IMEA evaluation index of hull fouling was designed by considering the inoculation pathway of attaching organisms in all processes to the ships which enter the port for in-water cleaning; R1: Introduction/Establishment of alien species before in-water cleaning, R2: Establishment of alien species escaped during in-water cleaning, R3: Introduction/ Establishment of alien species after in-water cleaning, R4: Establishment of alien species in the effluent water. K-IMEA response experiments using the in-water cleaning wastes sampled during in-water cleaning (R2, R4) and AFC plates (R1, R3) were performed, and its results showed that the attachment and regrowth of prokaryotes, microalgae, and macroalgae confirmed. In particular, prokaryotes and some microalgae passed through a 5 μm mesh. Notably, organisms were observed in the samples filtered through a 5 μm mesh of the in-water cleaning effluent even at a low fouling rating (Lv. 1-2). As a result of the biological risk assessment based on the K-IMEA conditions, it seems necessary to consider the secondary treatment method along with the primary filtration method for the treatment of in-water cleaning effluents.

Session 7: BIO/POC/MONITOR Topic Session

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

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

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

(S7- 16534 Oral)

Coastal hypoxia in Pearl River estuarine waters: why isn't it worse?

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Coastal hypoxia is believed to be due to nutrient enrichment, but the degree of coastal hypoxia varies widely among estuaries. The Pearl River, the 2nd largest in China, discharges into the oligotrophic South China Sea and plays a dominant role in determining nutrient concentrations and eutrophication processes in the Pearl River estuary and adjacent coastal waters (PREC). The Pearl River is highly enriched in nitrogen (N), ca. 100 uM, but low in P. However, eutrophication hypoxia, is not as severe as expected from this high N enrichment. The PREC ecosystem appears to have a buffering capacity for the N enrichment. Two major buffering mechanisms are hypothesized to be responsible: physical dilution processes and P limitation. In winter, northeast monsoon dominates in the region and Pearl River discharge is minimal and in summer, southwest monsoon prevails and river discharge reaches the maximum in July. Winter monsoons induced downwelling bring offshore waters onshore and serve as an annual flushing mechanism; and summer monsoons induce upwelling and onshore movement of bottom deep water, serving as a within-season flushing mechanism. As
the N:P ratio is much higher (>50N:1P) than 16:1 in the estuarine influenced water, P is potentially the most limiting nutrient and likely places a limit on chlorophyll biomass production. In addition, frequent wind events also often interrupt the formation of coastal hypoxia. Therefore, the mechanisms of physical mixing and P limitation work together as the ecosystem capacity buffering against the seasonal formation of hypoxia in the bottom water getting severe.

(S7-16667 Oral)

The diel and seasonal heterogeneity of carbonate chemistry and dissolved oxygen in three types of macroalgal habitats

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As concerns about ocean acidification continue to grow, the importance of macroalgal communities in buffering coastal seawater biogeochemistry through their metabolisms is gaining more attention. However, studies on diel and seasonal fluctuations in seawater chemistry within these communities are still rare. Here, we characterized the spatial and temporal heterogeneity in diel and seasonal dynamics of seawater carbonate chemistry and dissolved oxygen (DO) in three types of macroalgal habitats (UAM: ulvoid algal mat dominated, TAM: turf algal mat dominated, and SC: *Sargassum horneri* and coralline algae dominated). Our results show that diel fluctuations in carbonate parameters and DO varied significantly among habitat types and seasons due to differences in their biological metabolisms (photosynthesis and calcification) and each site's hydrological characteristics. Specifically, carbonate parameters were most affected by biological metabolisms at the SC site, and by environmental variables at the UAM site. Also, we demonstrate that macroalgal communities reduced ocean acidification conditions when ocean temperatures supported photosynthesis and thereby the absorption of dissolved inorganic carbon. However, once temperatures exceeded the optimum ranges for macroalgae, respiration within these communities exceeded photosynthesis and increased CO_2 concentrations, thereby exacerbating ocean acidification conditions. We conclude that the seawater carbonate chemistry is strongly influenced by the metabolisms of the dominant macroalgae within these different habitat types, which may, in turn, alter their buffering capacity against ocean acidification.

(S7-16736 Oral)

Skillful multiyear prediction of marine habitat shifts jointly constrained by ocean temperature and dissolved oxygen

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The ability to anticipate marine habitat responses to climate variability has high socioeconomic value. Here we quantify interannual-to-decadal predictability of habitat shifts by combining trait- based aerobic habitat constraints with a suite of initialized retrospective Earth System Model forecasts, for diverse marine species in the North American Large Marine Ecosystems. We find that aerobic habitat viability, defined by joint constraints of temperature and oxygen on organismal energy balance, is potentially predictable in the upper-600 m of the ocean, showing a substantial improvement over a simple persistence forecast. The skillful multiyear predictability is dominated in most regions by the oxygen component, yielding habitat predictions with longer lead time than previously estimated based on temperature alone. Notable predictability differences exist among species differing in temperature sensitivity of hypoxia vulnerability, especially along the northeast coast. This tool will be critical in predicting marine habitat shifts in face of a changing climate.

(S7-16762 Oral)

Effects of ocean acidification on plankton in the Salish Sea

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(*Recorded talk; questions handled by co-authors Simone Alin and Jan Newton*)

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Ocean acidification (OA) may have substantial impacts on the planktonic food web. We used a three-dimensional coupled biogeochemical-physical model of the Salish Sea to examine the impacts of OA on phytoplankton and zooplankton model classes in pre-industrial and present-day scenarios. Diatom growth rates show strong consistent responses to OA in lab and field studies. As such, in the model these rates were manipulated based on literature estimates. Results showed that present-day surface pH is, on average, 0.2 pH units lower than pre-industrial surface pH in the Salish Sea. Depth-integrated diatom biomass increased in the spring (March) and summer in response to increasing OA, whereas flagellate biomass decreased in the summer due to competition with diatoms. Present-day total microzooplankton grazing was higher in March and during the summer months compared to the pre-industrial scenario, while mesozooplankton grazing showed only a slight increase in the present-day scenario. We observed less CO_2 limitation in the present-day scenario, particularly in the summer, meaning that present-day diatom growth is less inhibited by CO_2 than during pre-industrial times. Regional variability in our results showed that the largest OA impacts occurred in the Central Strait of Georgia, Central Basin in Puget Sound, and the Juan de Fuca Strait. Altogether, these results provide insight into the potential impacts that OA-related changes in lower trophic level dynamics may have on juvenile salmon and herring in both the Canadian and US waters of the Salish Sea.

(S7-16775 Oral)

Spatiotemporal variability of exposure to low pH conditions in the central California Current region

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The nearshore environment of the California Current System (CCS) is known to experience natural exposure to low pH and reduced oxygen in response to coastal upwelling. Anthropogenic impacts further decrease pH and oxygen below biological thresholds, making the CCS particularly vulnerable to ocean acidification and hypoxia. We use a high-resolution (~3 km) historical simulation from a coupled physical-biogeochemical model to examine alongshore and temporal variability of exposure to low pH conditions. Our results indicate strongly heterogeneous alongshore patterns of nearshore pH in the central CCS, explained by a complex interplay between local upwelling intensity, alongshore transport, primary production, and onshore-offshore meandering of the regional ocean circulation. An event-based analysis further demonstrates that the duration, intensity, and severity of exposure to low pH conditions in bottom waters along the central CCS shelfbreak is explained by a combination of coastal upwelling intensity and DIC content in upwelled source waters. Our findings suggest that while the interannual variability of aragonite undersaturation events is primarily determined by the intensity of upwelling-favorable winds, this response is substantially modulated by low-frequency basin-scale variability (i.e., Pacific Decadal Oscillation) and resulting changes in water mass composition near the source depth of upwelled waters. The mechanistic description of spatiotemporal exposure to low pH conditions proposed here provides important context for monitoring the progression of ocean acidification in the central CCS and identifies conditions leading to increased vulnerability for ecologically and commercially important species.

(S7-16790 Oral)

High-resolution climate projections of ocean acidification for the main Hawaiian Islands

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Anthropogenic carbon emissions have resulted in increased concentrations of dissolved inorganic carbon in the world's oceans, reducing the availability of carbonate ions. This has negative implications for the physiological performance of calcifying organisms and heightens their vulnerability to additional stressors, such as elevated water temperature and coastal runoff. The Hawaiian Islands, steep mountains in the central Pacific, rise from the deep ocean to over 4 km above sea level. They disrupt the northeast trade winds and surrounding ocean currents, giving rise to robust submesoscale features. The water mass around the main Hawaiian islands is characterized by gradients between oligotrophic waters over the abyssal plain and the biologically active coral reef ecosystems in the shallow waters, which are inadequately resolved by global climate models.

We present regional ocean projections generated by a coupled physical/biogeochemical model at a 4 km horizontal resolution, spanning three CMIP6 scenarios from 2000 to 2100. Our assessment focuses on distribution, variability, and future evolution of widely used ocean acidification (OA) proxies (pH, aragonite saturation, and substrate-to-inhibitor ratio). Across all three scenarios (SSP1-2.6, SSP2-4.5, and SSP3-7.0), we observe an unprecedented increase in OA in the first half of the century followed by scenario-specific outcomes. Regional differences emerge for trends as well as natural variability, which are linked to submesoscale features and the latitudinal temperature gradient. These differences highlight contrasts between the OA proxies.

(S7-16812 Oral)

Buffering capacity minima in coastal–estuarine waters: implications for ocean acidification trajectories and ecosystem management

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Northeast Pacific marine ecosystems experience naturally high CO_2 conditions as a result of subsurface respiratory CO_2 accumulation during global ocean circulation. Subsurface water masses upwelled into coastal and estuarine environments thus have naturally low buffering capacities, which are eroded further by global ocean acidification (OA) and local respiration processes. Bottom-water residence times vary in the northern California Current System and through the Salish Sea to create a mosaic of biogeochemical conditions in the present-day, with varying susceptibility to further acidification across habitats. Here we present estimates of changes in buffering capacity and carbonate chemistry in Washington coastal and estuarine waters from the pre-industrial to the present-day and compare these to projections of near-future acidification. Projected rates of acidification depend on present-day buffering capacity levels and anthropogenic carbon content. Less acidified regional benthic habitats are projected to see equal or greater change by 2030–2040 in acidification than has occurred between pre-industrial and present-day estimates. In contrast, the currently most acidified habitats may see less change in saturation states over the near future but an acceleration of $p\mathrm{CO_2}$ increase as the carbonate system is depleted of carbonate ions. Differential rates of change across OA metrics have implications for how the multi-stressor seascape will evolve over the coming decades, and its relevance to potential biological impacts. While impacts of declining Ω values on marine calcifiers have been an early focus of OA research, the biological effects of $p\mathrm{CO_2}$ increase may require more research attention in coming decades with accelerating rates of change.

(S7-16832 Oral)

A century of change in the California Current: Quantifying the impact of anthropogenic climate change on ocean acidification

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Over the past century, oceanic uptake of anthropogenic CO_2 has caused seawater to become more acidified through a process known as ocean acidification. The California Current System (CCS), which historically experiences more acidified conditions compared to the open ocean because of upwelling, serves as an indicator of ecosystem response to acidification. However, predicting the pace of acidification in the CCS is complicated because the anthropogenic contribution is intertwined with other natural sources of acidification and variability. A central and contested question is whether acidification in the CCS will follow the pace of increasing atmospheric CO_2, or if dynamical climate effects or other processes will act to either accelerate or attenuate acidification. Here we apply the boron isotope pH proxy to cold-water orange cup corals to establish a historic baseline for acidification in the CCS, a productive upwelling system, and the Salish Sea, an associated coastal estuary. Through a combination of modeling and geochemical approaches, we show that the CCS and Salish Sea have experienced accelerated acidification over the industrial era driven by equilibration of atmospheric CO_2 and a thermodynamic response in the carbonate system that amplifies biogeochemical changes in high-carbon regimes. From this foundation, we make projections for future acidification in the CCS under continued high CO_2 emissions. The change in $p\mathrm{CO}_2$ over the 21st century will continue to outpace atmospheric CO_2, posing a severe threat to marine ecosystems of biological, cultural, and economic importance. Acidification of this magnitude is predicted to have profound impacts on eastern boundary current systems in the coming century.

(S7-16846 Oral)

Inshore hypoxia alters abundance and distribution of zooplankton in the northern California Current

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In the northern California Current, hypoxia occurs on the shelf seasonally as a result of oceanographic and biogeochemical processes. With the frequency of these hypoxic events increasing, marine hypoxia threatens planktonic organisms through the reduction of oxygenated water column habitat, and can result in altered abundances and vertical distributions. Despite the potential for these drastic changes, there have been few studies that look at the fine-scale effects of hypoxia on plankton abundances and distribution, in this region and globally. We used a towed *in situ* plankton imager (In Situ Ichthyoplankton Imaging System, ISIIS) with concurrent environmental sensors (e.g., dissolved oxygen, pH) to sample plankton in normoxic and hypoxic inshore regions of the northern California Current in 2016, and 2018-2022. These six years showed substantial variation in the extent and severity of hypoxia. Decision tree based machine learning was used to describe the relationships between environmental variables and abundances of plankton groups of interest (appendicularians, *Oithona* copepods, larval fishes, hydromedusae, copepods, and non-copepod crustaceans) and to identify values of oxygen that are thresholds to reduced abundances. In order to determine whether these waters were avoided by different plankton groups within the region, these thresholds were then used in presence/absence models. Understanding how plankton abundances and distributions change with hypoxia is important for contextualizing the influence of hypoxia in this dynamic ecosystem, and in marine systems facing deoxygenation globally.

(S7-16851 Oral)

Impacts of ocean acidification and deoxygenation on zooplankton communities in an estuarine fjord

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Zooplankton form a crucial link in marine food webs, transferring energy from primary producers to forage fish and juvenile fisheries fish. Many laboratory studies have documented lethal and sub-lethal impacts of ocean acidification and deoxygenation on individual zooplankton species, but the ways in which these impacts translate to zooplankton communities *in-situ* are not well understood. Species-level differences in sensitivity to these stressors may lead to shifts in community composition, favoring less sensitive taxa like gelatinous zooplankton. However, these shifts are difficult to predict in coastal environments where temperature, food availability, and other co-occurring factors vary. Additionally, zooplankton in coastal environments that regularly experience low pH and dissolved oxygen may be adapted to environmental stressors, leading to more subtle shifts. Community-level studies examining multiple environmental stressors are needed to tease apart subtle shifts related to pH and oxygen concentrations. Puget Sound is a complex, fjord-like estuary that offers a diverse range of habitats including Hood Canal, which experiences persistently low pH and dissolved oxygen. Here, we examine how mesozooplankton community composition varies with changes in pH and dissolved oxygen at seven locations in Puget Sound from 2014-2022, a period of large environmental variability. Variation in temperature, salinity, and phytoplankton are also considered as potential drivers of community composition. Understanding responses of zooplankton communities to changing environmental conditions will be essential to predicting the quality of prey available to culturally and economically important fish species.

(S7-16884 Oral)

Modeling ocean acidification in the Bering Sea to support long-term planning and management of the largest U.S. fishery

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Seasonal manifestations of OA are already occurring in the Bering Sea, in the form of late summer bottom water conditions that are undersaturated with respect to aragonite. Although these more acidic conditions are generated by natural processes, OA is projected to increase their duration, magnitude, and spatial extent. It is therefore critical to develop skillful predictions and projections of these more acidic water conditions in order to support sustainable fisheries management over long- and short-term time scales. This work describes ongoing efforts to provide historical, present, and future water carbonate chemistry conditions to fisheries stakeholders using a regional biogeochemical ocean model. Multi-decadal projections provide spatio-temporal information for how OA conditions may evolve throughout the Bering Sea shelf and highlight key differences between climate emissions scenarios, providing a regional perspective for the impact of climate mitigation strategies. Meanwhile, near-term products provide fisheries stakeholders with updated environmental information for annual stock assessment and the fisheries management process. Furthermore, these model products identify episodic events which modify coastal shelf conditions, such as a recent intrusion of off-shelf low pH, low oxygen water onto the outer Bering Sea shelf. Lastly, longterm (i.e. 50+ year) hindcasts provide historical context for changing carbonate chemistry conditions and help fill in gaps prior to our observational record. Our vision is to continue developing and refining this approach and to expand available products, including the addition of seasonal forecasts, in order to support evidence-based decisions in sustainable marine resource management for the largest U.S. fishery.

(S7-16904 Oral)

***In situ* observations of zooplankton show changes in abundance and swimming speed in response to environmental stress**

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Zooplankton exhibit a range of swimming behaviors to reposition themselves in the water column, feed, find mates, and avoid predation. Behavioral responses to environmental stress can therefore have cascading effects on population distributions and predator-prey interactions.
Understanding zooplankton population dynamics is challenging, largely because traditional methods for quantifying zooplankton distributions are costly, limited in scope, and require extended analysis by trained investigators. A combination of two rapidly-developing technologies—remotely deployed profiling camera systems and Artificial Intelligence-based identification of individual zooplankton from *in situ* imaging—promises to change the type and amount of data available to quantify zooplankton populations. To quantify copepod and amphipod responses to environmental stress, we deployed a camera system in a seasonally hypoxic fjord and recorded *in situ* swimming behaviors. Preliminary analysis of *in situ* behaviors indicate that in hypoxic (<2 mg/L DO) waters the abundance of copepods increased and copepods of all sizes swam on average 7.5 mm/s faster than copepods in non-hypoxic waters. Additionally, copepods exhibited less frequent escape responses, with copepods 1-2 mm in length being 67% less likely to exhibit a "jumping" behavior in hypoxic conditions than in non-hypoxic conditions. In contrast, the abundance of amphipods significantly decreased in hypoxic waters relative to non-hypoxic waters, but the average "darting" speeds did not differ between environmental conditions. With advances in ocean technology, *in situ* behaviors may become useful proxies in monitoring impacts of climate change on coastal ecosystems.

(S7-16914 Oral)

Acidification effects on Dungeness crab: experiments, models and population uncertainty

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Dungeness crab, the most valuable fishery on the U.S. West Coast, show mixed response to ocean acidification and other climate change stressors. Through species response experiments in controlled aquaria, we explore CO_2 sensitivity by looking at a variety of metrics, including those that drive demographic processes (e.g. survival and growth rate) and those that provide insight into the physiological mechanisms underlying the response (e.g. metabolic pathways and calcification). We observe negative effects of high CO_2 on the larval stage, but, surprisingly, higher survival of juvenile crabs raised high CO_2 compare to those reared in ambient conditions. We hypothesis that the higher survival may be the result of a cryptic CO_2-senstive pathogen. Experiments we also used to evaluate which carbonates system parameters (e.g. pH or calcite saturation state) drive lower survival in zoea. Results show an interactive effect of multiple parameters. The experimental data were input to models that explore population level processes related to management issues, such as environmental thresholds. The differing sensitivities of different life stages and uncertainties about the factors driving population dynamics complicate predictions of climate change effects on Dungeness crab.

(S7-16972 Oral)

Oceanographic observations in and around Gwaii Haanas, Haida Gwaii, British Columbia from 2016 to 2022

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Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage site is a marine protected area that is collaboratively managed by the Council of Haida Nation and the Canadian government. Starting in 2017, regular oceanographic surveys that measured the physical, chemical and biological properties were conducted in Gwaii Haanas coastal waters. In addition, near-continuous temperature, salinity, oxygen, and current data have been collected in coastal waters via moored instruments. Oceanographic data showed that the Gwaii Haanas coastal waters were lighter and had more oxygen than the surrounding waters in Queen Charlotte Sound and Hecate Strait. Indeed, 2017 to 2022 data showed a lack of hypoxia in Gwaii Haanas, even down to waters that are 300 m deep. For this research, we use atmospheric and oceanographic data to explain why the water properties in Gwaii Haanas are different than most regions on the British Columbia coast. We discuss why these unique ocean properties may enhance marine life in Gwaii Haanas.

(S7-16983 Oral)

A coupled circulation-biogeochemical model to study deoxygenation in the Canadian Pacific continental margin

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Marine ecosystems are increasingly impacted by warming temperatures, declining oxygen and acidification. There is a growing need to assess the state of the ocean to support climate and marine environment policies. Here, we present a multi-year hindcast simulation from a high-resolution coupled circulation and biogeochemical model of the British Columbia continental margin (BCCM) and evaluate the ability of the model to reproduce the mean state and seasonal and interannual variability of subsurface oxygen, temperature and relevant physical processes. The BCCM model is an implementation of the Regional Oceanic Modeling System at 3 km resolution and 42 vertical layers coupled to 9-compartment biogeochemical model. The model is forced by ERI-5 atmospheric model and by lateral open boundary conditions taken from GLORYS 12. We show good agreement between in situ observations and simulated subsurface oxygen, temperature and current patterns over the 1993 to 2020 period. Finally, the impact of using climatological oxygen fields at the open boundary to realistically represent oxygen distribution is assessed.

(S7-16529 Poster) S7-P1

Observing ocean acidification for Alaska's fisheries

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During the past decade, ocean acidification has become one of the most critical marine resource conservation issues in Alaska, as the state's unique vulnerability is being realized with the onset of actualized effects. The projected spatial expansion and shallowing of acidified waters with continued absorption of anthropogenic carbon dioxide from the atmosphere poses a direct threat to marine calcifiers and an indirect threat to other species through trophic interactions. Alaska's coastal margins are sites of active biogeochemical cycling with tremendous productivity. We co-locate current fishery and ecosystem monitoring with marine carbonate chemistry observations on recent NOAA Alaska Fisheries Science Center surveys. Annual field campaigns alternate between the southeastern Bering Sea (2022) shelf and the northern Gulf of Alaska (2023). Our project links current and forecasted impacts of changing ocean chemistry on marine ecosystems that may inform sustainable fisheries management for these two large marine ecosystems.

(S7-16754 Poster) S7-P2

Mapping of deoxygenation trend in the subsurface waters of the East China Sea

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Several studies have reported deoxygenation trend in the East China Sea (ECS), but most of the deoxygenation signal was detected in the continental shelf areas along the Chinese coasts. Ono [2021], however, detected rapid decrease of oxygen in the Tsushima Strait, the eastern area of the ECS, suggesting that deoxygenation had actually been occurred in the wide area within this sea. To capture exact distribution of deoxygenated area in the ECS, historical oxygen data recorded after 1950 in World Ocean Database 2018 were extracted from the whole area of ECS.

ECS was then divided to 29 subareas, and temporal variation of oxygen as well as related hydrographic properties were investigated in each subarea. Significant decreasing trend of oxygen was detected in the latitudinal bands from 30^{o} N to 34.5^{o}N in summer time, which roughly corresponds to the area of the seasonal occupation of low-salinity Changjiang diluted water. Vertically, deoxygenation signal showed two peaks, one located just above the seafloor while the other peak located at 30m - 50m. Detailed analyses indicated that the lower deoxygenation peak was constructed by the enhanced decomposition of organic materials that was provided by the increased primary production along the Chinese coast (Ning et al., 2011), while the shallower peaks has generated by the upward shift of pycnocline caused by the ocean warming. The present study suggested that ECS is now facing hybrid effect of "ocean deoxygenation" and "coastal deoxygenation," and hence international cooperation is needed to cope with socio-economic problems arose from this phenomenon.

(S7-16847 Poster) CANCELLED S7-P3

~~Vertical distribution of fish larvae, in the oxygen minimum zone off southern México (December 2020)~~

~~Sylvia P.A. **Jiménez-Rosenberg**[1], L. Sánchez-Velasco[1]; F.J. García-De León[2]; E.D. Ruvalcada-Aroche[3]; E. Beier[3]; V.M. Godínez[4]; E.D. Sánchez-Pérez[5]; F. Contreras-Catala[3]; A. Mnich[6]; N. Verma[6] and M. Altabet[6]~~

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~~The distribution of fish larvae in the Oxygen Minimum Zone off southern Mexico (December 2020) was analyzed. A hydrographic section of five sampling stations was made in the confluence of Transitional Water and Tropical Surface Waters. Horizontal zooplankton trawls on three different dissolved oxygen conditions (~100, < 44 and < 4.4 µmol kg^{-1}) were carried out by a MOCNESS net (333 µm). The 100 µmol kg□ 1 oxypleth (oxic condition) was ~60 m depth along the section, but the 4.4 µmol kg^{-1} oxypleth (suboxic) rose southward from Transitional Water (~ 150 m) to Tropical Surface Water (~ 90 m), approaching the well oxygenated layer. The distribution of the zooplankton biomass and fish larvae showed statistically significant differences ($P < 0.01$) between the oxic (100 µmol kg^{-1}) and the deeper suboxic conditions. The larvae of typically dominant fish species such *Vinciguerria lucetia*, *Diogenichthys laternatus*, *Diaphus pacificus* and *Cubiceps pauciradiatus*, were present only in the oxygenated depths in the Transitional Water, and were almost absent from all depths in the Tropical Surface Water, where the oxycline shoaled. These differences in larval fish abundance indicates that the oxycline is a limiting factor for the fish larvae. The fish larvae results contrast with previous observations from the mouth of the Gulf of California, where some species have distributions independent of water column dissolved oxygen conditions, probably as a consequence of coastal processes. Overall, our results show that even within the OMZ, variations in oxycline depth have biological implications, particularly on meroplanktonic organisms.~~

Session 8: MEQ Topic Session

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

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

Invited Speaker:
Hyo-Bang Moon (Human & Ecology Analytical Laboratory (HEAL), Marine Science and Convergence Engineering, Hanyang University, Korea)

United Nations Decade of Ocean Science for Sustainable Development (2021-2030) make "Clean Ocean" one of its priority development areas, which includes identifying, quantifying and reducing pollution sources and removing pollutants from the ocean. The Session on the Occurrence and Ecological Impact of Emerging Pollutants (Persistent Toxic Substance, Resistance Gene and Marine Debris, et al.) in the Coastal Marine Environment has the following 2 objectives: First, to review the situation and to discuss the information gap and deficiencies in occurrence and evaluation on the emerging pollutants and its impact on marine ecosystem in the North Pacific. Second, to exchange the new technique and methodology for monitoring and assessment of emerging pollutants, and to discuss the development trends and research priorities. The main topics of the Session include the following: (1) The current situation of emerging pollutants on marine ecosystems in North Pacific. (2) The new technique for the analysis of emerging pollutants in marine environment. (3) The assessment on the ecological impact of emerging pollutants. The Session will invite experts in the relevant field, and welcome the reports on the research and progress in the above topics.

(S8-16991 Invited)

Paradigm shift for environmental and biological monitoring with a focus on the OPFRs

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Organophosphate triesters (tri-OPEs) have been widely used as flame retardants and plasticizers in industrial and consumer products. With the increasing demand of flame retardants, tri-OPEs have been contaminated to the environment, wildlife, and humans. Despite numerous studies on the distributions of tri-OPEs in various environmental compartments, few studies are investigated on the occurrence of organophosphate diesters (di-OPEs). In the present study, tri- and di-OPEs were simultaneously determined for water and sediment from highly industrialized coastal waters of Korea to understand the environmental distribution and degradation processes of OPEs in coastal environment. We also assessed the suitability of types of OPEs for environmental and biological monitoring tools. All di- and tri-OPEs were detectable in almost water and sediment samples, indicating widespread contamination in aquatic environments. The concentrations of tri-OPEs in water were similar to those of di-OPEs, whereas tri-OPE concentrations in sediments were higher than those of di-OPEs. Predominant tri- and di-OPEs were different depending on the coastal waters and environmental compartments surveyed in our study. Di-OPEs, degradation products of tri-OPEs, were not matched with major parent OPEs in water and sediment samples, indicating the possibility of use for di-OPEs as parent. The occurrence of chemical types of OPEs may be influenced by impact of source, chemical properties, and degradation conditions of aquatic environments. Recent studies have reported that di-OPEs elicit comparable or greater adverse health effects with tri-OPEs. Our findings suggest that the present environmental and biological monitoring tools should be revised for accurate assessment of OPEs.

(S8-16494 Oral)

Identifying the external N and Hg inputs to the Geum Estuary along the Yellow Sea in Korea

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Estuaries receive N and Hg inputs from both riverine and atmospheric sources; therefore, quantifying the contribution of both sources to estuaries is important. In this study, the external inputs of N and Hg to the Geum Estuary in the Yellow Sea, northwestern Pacific Ocean, were determined by estimating the relative contributions of atmospheric, riverine, and marine N and Hg inputs and identifying N pollution sources using isotope values. We found that the relative contributions of riverine N and Hg inputs to the Geum Estuary were greater than those of atmospheric deposition. However, an opposite trend was noticed when the distance from the estuary dam increased, with atmospheric N inputs becoming more significant. Based on isotopic information, fossil fuel combustion and vehicle exhaust were identified as the main sources of atmospheric N deposition while septic waste, manure, and soil organic matter were the main sources of riverine N contamination. The isotope information and [NO3-] contents indicated that assimilation and nitrification occurred, emphasizing that the combination of isotope and flux methods could quantify and qualify the external N inputs and identify the biological N processes. The atmospheric total mercury (THg) contribution to the estuary region was less significant than the riverine inputs, which was consistent with the findings for N deposition. However, the relative percentage of atmospheric THg to the total flux was relatively higher (23%) than that of the N. Thus, the management of anthropogenic N and THg should differ based on the relative contributions of external sources.

(S8-16572 Oral)

Distribution and sources of microplastics in the Beibu Gulf using in-situ filtration technique

Zuhao **Zhu**[1, 2], Kazi Belayet Hossain[3, 5, 6,], Huihua Wei[1, 2], Renming Jia[1, 2], Xiaofeng Gao[7], Haiyan Jin[1, 2, 8], Xingyong Xu[1] and Minggang Cai[3, 4, 5, 6]

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The Beibu Gulf is a vital link between China and the ASEAN nations, and microplastic contamination is rising due to fast growth, coastal life, fisheries, and mariculture. The abundance, distribution, and source analyses were conducted at 25 sample points for this study. According to this study, the average MPs was 0.25 ± 0.05 items/m^3, ranging from 0.01 items/m3 to 0.89 items/m^3. Fibers, white, cellulose, and 0.33–1 mm were abundant in shape, color, composition, and size, respectively. Multi-statistics-based source analysis indicated land-based inputs (packing materials, textile materials, fisheries, and mariculture) were dominant in the Beibu Gulf. In this study, we also acknowledged a comprehensive comparison and convenience between plankton pumps and other conventional designs to collect microplastic samples from water. We suggested that using a uniform design could elevate the data quality of microplastics.

(S8-16645 Oral)

An overview of microplastic pollution in the North Pacific region

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With the increasing production of plastic products and generation of mismanaged plastic wastes, the oceans are receiving more plastic wastes and microplastic from land-based sources. Marine microplastics are now ubiquitous across the global oceans. They are present in all types of media including the seawater, sediment, biota and atmosphere. This talk will give an overview of the current microplastic pollution status in the North Pacific region and call for further actions. The North Pacific region was most actively monitored for microplastics and showed comparatively high levels of microplastic pollution in a global context. Literature reviews show that the North Pacific harbor the highest amount of microplastics in the seawater, shoreline, and biota. Roughly half of all fish and seabird specimens and more than three-quarters of sea turtles and bivalve specimens examined in this region had consumed plastic. PICES WG42 has conducted a comprehensive review on all published literature in the Pacific Ocean region and proposed a series of guidelines with regard to standardizing microplastic and marine debris monitoring, bioindicator selection and achieving target goals in the North Pacific regions. As the Pacific Ocean is constantly receiving plastic waste and microplastic from the land and secondary microplastic coming from the fragmentation of large plastic debris is a potential large source of microplastic in the ocean, a long-running program for monitoring microplastic in the PICES region is necessary. Related work will serve the sustainable development goals of the UN as well.

(S8-16655 Oral)

Arctic Ocean sediments plays a role as important current and future sinks for marine microplastics missing in the global microplastic budget

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Global marine plastic inventory still remains uncertain, including unexpectedly low plastic loads in ocean surface compared with their input. Therefore, finding the missing marine plastics—where, how much, and in what form they are stored—remains a fundamental challenge to balance the global plastic budget and to better identify the negative impacts of plastic accumulation. We demonstrate that Arctic Ocean sediments serve as important current and future sinks for microplastics (MPs) missing from the global budget by presenting the first MP budget for multiple compartments (sea ice, seawater, and sediment) in the western Arctic Ocean (WAO). Relatively elevated MP abundances were found in seawater and surface sediments around the summer sea ice retreat region, implying enhanced MP accumulation and deposition facilitated by the ice barrier. We identified an increase of 3% year^{-1} in MP deposition from sediment core observations. High nonfiber-to-fiber ratio together with an exponential increase in MP burial suggests that the WAO sediments can provide an archive enabling us to trace historical plastic usage on the planet. We estimate 15.7 ± 2.30 × 1016 N and 0.21 ± 0.14 million metric ton as total MP loads in the WAO, of which 90 % (in mass) may have been buried in upper 10-cm sediment accumulated since 1930s. The WAO MP loads exceed the global average of the current marine MP load. Also, the slower increase plastic burial versus production implies a lag in plastic delivery to the Arctic, indicating more pollution in the future. Therefore, globally concerted vigorous action to substantially reduce the plastic ocean input is urgently needed to protect Arctic environment.

(S8-16672 Oral)

Toxic effects of single and combined exposures to nanoplastics and bisphenol A on the marine medaka

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Nanoplastics (NPs) as emerging contaminants have become a global environmental issue due to their small size and high bioavailability. However, there are still knowledge gaps regarding effects of co-existing pollutants on NPs toxicity to marine organisms at their respective environmentally relevant concentrations. Herein we investigated developmental toxicity, histopathological alterations caused by co-exposure of polystyrene nanoplastics (PS-NPs) and bisphenol A (BPA) to marine medaka, *Oryzias melastigma* and potential molecular mechanisms were explored. Embryos at 6 hours post-fertilization were exposed to 50-nm PS-NPs (55 μg/L) or BPA (100 μg/L) or co-exposed to a combination of both. Results showed that PS-NPs exhibited decreased embryonic heart rate, larval body length, and embryonic survival as well as larval deformities such as hemorrhaging and craniofacial abnormality. When co-exposed, BPA mitigated all the adverse developmental effects caused by PS-NPs. PS-NPs also led to an increase in histopathological condition index of liver with early inflammatory responses, while co-exposure of BPA with PS-NPs did not. Our data suggest that the toxicity reduction of PS-NPs in the presence of BPA might result from the decreased bioaccumulation of PS-NPs caused by the interaction between BPA and PS-NPs. This study unveiled the impact of BPA on the toxicity of nanoplastics in marine fish during early developmental stages and highlight the need of more research on the long-term effects of complex mixtures in the marine environment by applying more omics approaches to better understand the toxicity mechanism.

(S8-16706 Oral) CANCELLED

~~**Behavior of antibiotic resistance genes in the pristine environment: A case study in Ny-Alesund of Arctic**~~

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~~Antibiotic resistance genes (ARGs) are considered environmental pollutants. Comprehensive characterization of the ARGs in pristine environments is essential towards understanding the evolution of antibiotic resistance. The present study characterized the ARGs in feces, soil and sediment samples collected from the relatively pristine Arctic using a metagenomic approach, and the source of ARGs in multi-environmental media was also analyzed. The results showed that a total of 33 ARG types and 1325 subtypes were identified. Resistance genes for multidrug resistance, β-lactam, and MLSB were the most important ARGs. The average abundance of ARGs in bird feces was higher than other samples. As for the detected ARG types, multidrug resistance genes were present at the highest abundances in the range of~~ 2.33×10^4 ~~to~~ 3.18×10^5~~. The relative abundances of *macB*, *RanA*, *tetA(48)*, *evgS*, *Txr*, *bcrA*, and *PvrR* were the most abundant ARG subtypes. Proteobacteria was identified as the dominant phylum across all samples, and a significant correlation between the ARG profiles and bacterial composition was observed. The result of FEAST indicated that animal waste contributed a lot to the presence of ARGs in the Ny-Alesund, and the migration of birds may influence the ARGs profiles significantly. These data and analyses are very valuable for filling data gaps related to ARGs in the Arctic and describing antibiotic resistance in the pre-antibiotic era.~~

(S8-16728 Oral)

Emerging contaminants of concern, new Persistent Organic Pollutants and Polycyclic Aromatic Hydrocarbons (PAHs) in endangered southern resident killer whales (*Orcinus orca*) from the Northeastern Pacific

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Killer whales (*Orcinus orca*) are one of the most contaminated cetacean species in the world. Concentrations and potential health implications of contaminants of emerging concern (CECs), new persistent organic pollutants (POPs) and polycyclic aromatic hydrocarbons (PAHs) in endangered southern resident killer whales (SRKWs) have been scarcely documented. Here, we contribute with the first assessment of CECs [alkylphenols (APs), triclosan, methyl triclosan, and per- and polyfluoroalkyl substances (PFAS)], new POPs (including hexabromocyclododecane [HBCCD], PFOS, PFOA, PFHxS), and PAHs in skeletal muscle and liver samples of SRWK and investigate *in utero* transfer of these contaminants. Samples were collected from stranded, necropsied individuals from 2006-2018 in British Columbia, Canada. AP and PFAS were the most prevalent compounds; 4-nonylphenol (4NP) was the predominant AP (median 40.84 ng/g ww), and interestingly, 7:3-fluorotelomer carboxylic acid (7:3 FTCA) was the primary PFAS (median 66.35 ng/g ww), followed by PFOS and PFOSA. For PAHs, C3-phenanthrenes/anthracenes (mean: 632 ng/g lw), C4-dibenzothiophenes (mean 334 ng/g lw), and C4-phenanthrenes/anthracenes (mean: 248 ng/g lw) presented the highest concentrations across all tissue samples. PAH diagnostic ratios indicated a dominant petrogenic-sourced contamination for SRKWs. A mother-fetus skeletal muscle pair revealed evidence of CECs, POPs, and PAH maternal transfer. Maternal transfer ratios indicated 4NP as the most transferred contaminant from mother to fetus (95%), while low molecular weight PAHs (C3-fluorenes, dibenzothiophene, and naphthalene) also exhibited higher maternal transfer rates. Our contaminant data serve to inform regulation and mitigate pollutant sources and contamination of SRKWs’ critical habitat and prevent oil spills by improving hydrocarbon emission regulations.

(S8-16946 Oral)

Global Eutrophication Watch: a cost-effective interactive assessment of coastal eutrophication on the cloud

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Human activities are increasingly contributing to the proliferation of eutrophication that results in significant negative impacts on coastal ecosystems. The appearance of red tides and/or dead zones, or the decline in fishery products can be a manifestation of the effects of eutrophication. Therefore, monitoring the eutrophication status is crucial for effective preventive management. Recognizing the global significance of this issue, the United Nations Environment Programme (UNEP) has introduced an index of coastal eutrophication as an indicator to track progress towards achieving Sustainable Development Goal (SDG) Target 14.1. This index established a link between the global reporting system and each country's national eutrophication monitoring programme.

We developed an interactive tool for the assessment of coastal eutrophication potential (CEP)—the Global Eutrophication Watch—using Google Earth Engine (GEE). The tool uses a regional eutrophication assessment methodology, the NOWPAP Eutrophication Assessment Tool (NEAT), designed for coastal eutrophication assessment based on satellite-derived chlorophyll-a (satellite Chl-a) data. Thus, the Global Eutrophication Watch provides a means for any user around the world to conduct a cost-effective assessment of CEP using satellite Chl-a information stored in the cloud. The Global Eutrophication Watch currently includes satellite Chl-a data set from MODIS/Aqua (Level 3, Global), SeaWiFS (Level 2, West Pacific), SGLI (Level 2, Northwest Pacific), YOC (Level 2 blended, Regional) and a combination of the YOC and SGLI (YOC+SGLI).

(S8-16515 Poster) S8-P1

Green tide development associated with submarine groundwater discharge and land-based aquaculture farm effluent in the Bangdu bay, Jeju, Korea

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The coast of Jeju island is rapidly change marine environment by affected global climate change and subtropicalization is in progress. Recently, increases in coastal pollutants, reduction of resources, damage to fisheries, and disturbance of marine ecosystems have frequently occurred. In the coast of Jeju Island, green tides of *Ulva* spp. have occurred annually since the early 2000s. It is affecting the coastal ecosystem disturbing and seriously damaging the coastal fishery and tourism industry. In the Bangdu bay, submarine fresh groundwater discharge (SFGD) and land-based Aquaculture farm effluent (LAFE) are flowing into the bay. The mouth of bay is narrow due to the construction of a seawall, so the circulation of seawater is very slow in inner bay. SFGD and LAFE have high concentration of nitrate, and stagnant current in inner bay increase the residence time of seawater, contributing to the growth of *Ulva* spp. Nitrogen and phosphorus contents in *Ulva* were in the range of 1.8% to 3.1% and 0.11% to 0.20%, respectively, and nitrogen and phosphorus contents were particularly high around the inflow of LAFE. It is estimated that the green tide in Bangdu Bay is more affected by LAFE than SFGD.

(S8-16591 Poster) S8-P2

Timing of changes in phytoplankton communities and attachment to plastic plates after nutrient addition in mesocosm experiments

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Anthropogenic pollutants, such as excessive nutrients and marine plastic debris (MPD), can significantly affect marine ecosystems, but the timing and combined effects of these pollutants are poorly understand. We established six 1000-L mesocosms and performed experiments for 15 days during November to examine the effects of nutrient enrichment and MPD. The mesocosms (2 replicates per group) had natural seawater (control), low nutrient (LN) seawater, or high nutrient (HN) seawater with polypropylene (PP) plates to mimic the effect of MPD. We recorded the timing of changes in nutrients and other abiotic factors and in phytoplankton in the water column and in the periphyton communities on the PP plates. *Cryptomonas* spp. was initially dominant in all three groups, but the LN and HN groups shifted to chain diatoms, such as *Pseudo-nitzschia* spp., and then to *Cylindrotheca closterium*. Due to significant nutrient uptake by bloom-forming diatoms, most of the nitrate+nitrite and phosphate were consumed within 4 days in the LN group. In contrast, the some nutrients remained in the HN group until day 15, and this was related to the nutrient requirements of other small solitary diatoms, such as *C. closterium*. Analysis of the PP plates showed that although small numbers of the planktonic diatom *Chaetoceros* spp. were present from day 4, there was a shift to the attached diatom *C. closterium* during the middle and end of the experiment, indicating that *C. closterium* in the water attached to the PP plates even when nutrients levels were low. Notably, the percentage of total Chl. *a* in the periphyton community, which was associated with nutrient uptake in the HN group, was higher than in the phytoplankton community. This implies that the periphyton biomass in the HN group effectively utilized the remaining nutrients.

(S8-16661 Poster) S8-P3 (ECOP)

Weathering extent and further fragmentation potential of microplastics in environmental samples

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The amount of microplastics (MPs) accumulated in the marine environment is estimated to have increased in proportion to the increase in environmental discharge of plastics. By natural weathering (particularly UV exposure), marine MPs can experience changes in physicochemical properties, and can be further fragmented into smaller sized MPs. Therefore, these marine legacy MPs could be a source of much smaller MPs, including nanoplastics (NPs), and thereby the abundance of marine MP/NPs would increase. The generation of secondary products by MP weathering depends on the weathering degree of the parent MPs; however, that is little known in natural conditions. To determine the weathering extent of legacy MPs (i.e., environmental samples) and thereby the possibility of secondary particle generation, we analyzed both field-collected samples (i.e., legacy MPs) and laboratory MPs exposed to accelerated UV. For environmental samples, we measured the physicochemical properties including carbonyl index (CI) for floating MP particles (≥330 μm in size) collected from upstream to downstream water of river as well as inner- and outer-bay seawater of the river-discharged coastal region. We found significant differences in physicochemical properties of legacy MPs in environmental samples according to polymer-type (between PP, PE, and PS) and according to the collected space (between upstream vs downstream river and inner- vs outer-bay). From laboratory experiment, we also found the CI change in pure parent MPs and the generation of secondary products with UV exposure. By coupling the two experiments, we expect to assess how many secondary particles could be generated from weathered MPs.

(S8-16739 Poster) S8-P4

Fate and mass budget of microplastic in the Beibu Gulf, the Northern South China Sea

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Beibu Gulf is an essential region of the microplastic fluxes in the northwest part of the South China Sea and therefore in the Indo-China peninsula due to different coastal activities such as industry, tourism, urban development, intensive fishing, and loads of riverine discharge. Multiple samples from surface water, bottom water, and surface sediment were taken for this investigation. The results showed that in surface and bottom seawater, MP concentrations were 0.25 ± 0.25 items/m^3 and 0.29 ± 0.29 items/m^3, respectively, while 74.99 ± 37.53 items/kg in surface sediment. Statistical analysis and geographical abundance showed vise-versa phenomena as surface water and sediment had similar features while statistical analysis showed a negative relationship between these two. The mass balance of the box model showed that riverine discharge and atmospheric deposition account for a substantial portion of MPs (50%) whereas the South China Sea (SCS) receives 49% of MPs discharged from Beibu Gulf, and just 1% is deposited in sediment annually, which could explain the vise-versa phenomena between statistical analysis and geographical distribution of microplastics. Nonetheless, it is revealed that human activities and coastal influence have a more significant impact on microplastic abundance and distribution in the Beibu Gulf.

(S8-16855 Poster) S8-P5 (ECOP)

Assessing potential drivers for microplastic ingestion by myctophids caught near the Columbia River mouth

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Due to their small size, microplastics (< 5mm) in the marine environment are bioavailable to pelagic fishes and have been shown to cause a suite of harmful effects when consumed. With an estimated biomass of one to ten billion metric tons, the largest migratory mass on the planet occurs nightly by fishes from the family Myctophidae (lanternfishes) and associated communities. Known as diel vertical migration, these small-bodied fishes travel further than a kilometer under the cover of night to feed on zooplankton at the ocean's surface. Buoyant microplastics are also concentrated at the surface and are presumed to be mistakenly ingested during feeding events. When the myctophids return to the deep, they are key prey for many mesopelagic predators; and thus act as a massive biological carbon, nutrient, and potentially microplastic pump. Riverine systems transport much of the inland plastic debris to the ocean and these particles disperse far offshore in a plume. Three species of myctophids (*Tarletonbeania crenularis, Diaphus theta, and Stenobrachius leucopsarus*) caught at varying distances from the Columbia River mouth were processed for microplastics with the expectation that those nearest to the proposed source contain the highest levels. While we found that microplastic ingestion was similar across the region sampled (~44% of fish contained 1 or more particles), black and blue microfibers were the predominant microplastics identified, likely originating from textiles. Other oceanographic and biological variables will be explored to improve our predictions of susceptibility to microplastic consumption by myctophids off of the Oregon coast.

(S8-16933 Poster) S8-P6

Integrated numerical modeling of multi-fraction sediment and radioactivity transport in the West Sea of Korea

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The West Sea of Korea, combined with the East China Seas, form a confined marine basin with the Western Pacific serving as its offshore boundary. The presence of suspended sediments strongly influences the characteristic marine environment of this region. In the past, various numerical models, such as the ECOMSED model combined with wind-wave data from WAM cycle 4 were utilized to calculate fine-grained sediment transport driven by wind and tidal currents. Another previous attempt involves the ROMS circulation model coupled with the SWAN spectral wave model to investigate the formation of sediment pathways from river discharge. In this study, an integrated numerical model is presented that is capable of addressing sediment and radioactivity diffusion in different virtual scenarios occurring in the Western Pacific region by incorporating suspended sediment concentration data from the Korea Maritime Environment Management Corporation (KOEM), Korean National Institute of Fisheries Science (NIFS), and Geostationary Ocean Color Imager (GOCI). The calculated results are meticulously compared with GOCI data for total suspended sediment concentration (TSC). The findings indicate that incorporating wave effects into the model has a significant impact, as the spatial distribution of TSC closely aligns with the satellite data. The validated integrated model is subsequently employed to simulate several scenarios of 137Cs releases from the Sanmen, Hanbit, and Hongyanhe Nuclear Power Plants, providing comprehensive insights into dispersion and diffusion within the Western Pacific Ocean.

(S8-16977 Poster) S8-P7 (ECOP)

Establishment of a safety management system for marine biotoxins: tetrodotoxin

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As rising sea temperatures, the range of occurrence of marine biotoxins is expanding worldwide. This has prompted extensive research to detect and assess marine toxins within the marine environment and organisms, as well as evaluate contamination levels and associated risks, globally. In Korea, tetrodotoxin (TTX) presents a significant threat to public health as the predominant naturally occurring marine toxin responsible for food poisoning. Our research focuses specifically on TTX, commonly identified in pufferfish, and aims to achieve three main objectives. Firstly, we aimed to monitor and identify hybrid pufferfish resulting from changes in breeding areas, as the distribution of toxins in hybrids is unclear, leading to potential food poisoning risks. Secondly, we aimed to monitor the invasion of toxic subtropical species, such as the blue-ringed octopus, which contains TTX. Its presence was first discovered in Jeju, Korea in 2005, and it has since expanded its distribution along the southern coast of Korea. Lastly, we aimed to monitor the toxification of endemic marine organisms. According to Roggatz (2019), ocean acidification has the potential to increase the bioavailability of TTX. Several European countries have reported an increased occurrence of TTX detection in bivalves, which are extensively cultivated in shellfish aquaculture. The management of these TTX-related issues for marine ecosystems and human health are crucial. Therefore, it is important to establish a safety management system and continuous monitoring for marine biotoxins. The Ministry of Food and Drug Safety provided support for this research through grant number 20163MFDS641 in 2023.

Session 9: BIO/FIS Topic Session

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

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

Invited Speaker:
Max Lindmark (The Institute of Marine Research, Swedish University of Agricultural Sciences, Lysekil, Sweden)

Everyone loves photos of the big fish that didn’t get away. However, warming oceans often mean that young fish grow more quickly but reach smaller adult sizes. This equates to a loss of yield in commercial fisheries. Scientists are working together to assess the magnitude of the shrinking fish problem in different regions and determine what this means for sustainable fisheries management now and in the future. Warming seas can affect fish body sizes, with major implications for size-structured marine ecosystems, species interactions and fisheries productivity. Synchronous shifts toward smaller adult body sizes in marine fish have already been detected in several rapidly warming areas. Yet, the mechanisms underpinning the temperature size rule (TSR; higher temperatures result in smaller body sizes) remain debated and most fisheries models do not routinely account for the expected temperature-dependent trends in growth. Understanding the impacts of temperature-driven changes in body size on reproduction and maturity is critical if we want to predict shifts in stock productivity. Novel monitoring programs are needed to provide managers with the appropriate information to detect and quantify any body size change that is occurring. Lastly, fisheries management plans need to adequately account for the implications of shifting fish body sizes and ensure harvest strategies are flexible enough to ensure stock productivity in a rapidly changing world. We propose a session that will: 1) synthesise ecological and empirical knowledge about trends in fish and other ectotherms' growth rates and body sizes, and how this can be incorporated into monitoring programs; 2) explore the utility of new assessment models that allow for time-varying and environmentally driven trait parameters 3) assess the potential impacts of temperature-induced body size change on fisheries yields in the future ocean 4) Discuss management options to addressing the impacts of rapid temperature-induced changes in stock productivity.

(S9-16669 Invited)

Non-linear growth-temperature relationship leads to opposite response to warming in cold versus warm populations

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Ectotherm growth and body size are unimodally related to temperature. Hence, both the rate at which growth changes with temperature, and the sign of the temperature-effect depends on current temperatures in relation to the species' optimum growth temperature. We analyze spatiotemporal growth data to understand how climate warming has affected growth in Eurasian perch (*Perca fluviatilis*). We compiled data sets of length-at-age from annuli rings on operculum bones (213,338 measurements across 40,908 individuals) from 12 monitoring areas along the Baltic Sea coast, from 56.1–65.9° Latitude, with the longest time series starting in 1953. To these data, we fit von Bertalanffy models to individuals and analyze the effect of temperature on cohorts' growth coefficients. Temperatures were acquired by fitting GLMMs to data from three complementary sources: ERRS, temperature at fishing, and temperature loggers. Two of the areas have in turn been artificially warmed by nearby nuclear power plants, introducing an unusually large temperature gradient (growth season temperatures ranging from 1–18°C across areas and cohorts). Body growth in the coldest area is positively related to temperature and, and in the warmest area it is negative, and their average growth rates are in fact similar despite a difference in 11°C. The growth rates are lower than in areas with intermediate temperatures. Our study shows that warming already has negative effects on growth in several of the warmest areas and climate change will continue this negative trend. Improving our understanding of temperature-effects on growth is critical for making predictions about future ecosystems.

(S9-16520 Oral)

Fish grow faster to a smaller size under intense exploitation and warming waters with mixed impacts on fishery productivity in China

Cody **Szuwalski**[1], Alice Lee[2], Lee Qi[3] *et al.*

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China's marine populations have experienced intense fishing pressure and exist in seas for which temperatures have risen over the past 50 years. We catalogue changes in life history based on ~1500 records from the Chinese scientific literature over this period. Increasing growth rates, smaller maximum sizes, and increases in natural mortality have been reported for important commercial species. These changes have resulted in increases in productivity as seen through yield per recruit for some stocks and decreases for others. Chinese fisheries management reform is underway, but we demonstrate the outcomes of reform could depend upon whether or not life history changes are plastic or selection-based and how life history may change with changes in fishing pressure and climate.

(S9-16540 Oral)

Spatiotemporal trends in weight and its potential implications for stock assessments

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Changing ocean conditions challenge the management of living marine resources. As the climate shifts, changing ocean conditions are driving biological responses that affect key vital rates in marine fishes. However, despite evidence that vital rates such as somatic growth vary through time and space, stock assessments often assume they are time- and space-invariant.
EWAA is one way to account for variability in somatic growth when estimating population status. Previous work has shown that this method can lead to more accurate estimates of spawning biomass compared to when growth is parameterized mechanistically. However, challenges in specifying model and data structure when using EWAA can introduce inaccuracies in spawning biomass estimates, especially for populations with strong spatiotemporal variability in growth. To address these concerns, I explore spatiotemporal trends in weight-at-age for Pacific Hake (*Merluccius productus*) on the west coast of North America and the consequences for the stock assessment that uses an empirical weight-at-age approach (EWAA). In this talk, I will evaluate the sensitivity of EWAA for Pacific hake to how well spatiotemporal variability in weight-at-age is represented in the data. I use geostatistical models to identify spatiotemporal trends in weight-at-age data and simulation testing to diagnose its misspecification in EWAA. Results suggest that monitoring and assessment may need to account for seasonal variability and persistent spatial patterns to ensure the stock assessment model produces unbiased estimates of spawning biomass. I will discuss the broader implications of these results to monitoring programs for species that exhibit spatiotemporal trends in growth in the face of climate change.

(S9-16544 Oral)

Effects of faster growing on fisheries management reference points

Fan **Zhang** and Jiangfeng Zhu

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With climate change, many areas of global oceans are experiencing warming water temperature, which may lead to faster growing of harvested fish species. Higher body growth rate and earlier maturation further affects the reference points derived from population dynamics models, casting important implications to fisheries management. In this study, we use simulations of bigeye tuna (*Thunnus obesus*) to study effects of increased body growth and earlier maturation on MSY-based reference points (B_{MSY} and F_{MSY}), unexploited reference points (B_0) and yield-per-recruit reference points (F_{MAX}). Results indicated that different types of reference points had heterogeneous responses to increased body growth rate. When faster growing is associated with earlier maturation, they had synergic and non-additive effects on management reference points. Our study highlights the importance to consider changing population vital rates and non-stationary population dynamics when implementing reference points in fisheries management.

(S9-16603 Oral) CANCELLED

~~Emerging changes in size structure and overwintering success for juvenile Pacific cod (*Gadus macrocephalus*)~~

~~Benjamin J. **Laurel**[1], Mary Beth Rew Hicks[1], Steven Barbeaux[2], and Louise A. Copeman[1]~~

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~~Climate-driven changes in phenology and growth in the first year of life of fish will likely alter mortality schedules and recruitment to the adult population. Such processes are particularly important at higher latitudes where fish must accumulate sufficient size to survive long winters of low productivity. We present several recent studies demonstrating how temperature-dependent processes in the spring and summer have led to an ~50% increase in the average individual size of age-0 Pacific cod (*Gadus macrocephalus*) in the Gulf of Alaska since 2006. In a follow-up live animal experiment, we then examine the degree to which size predicts overwintering success with varying degrees of fall and winter environmental information (food and temperature). Several key results from these experiments were that: 1) fish size alone is a poor predictor of overwintering survival, 2) fall growth environments are highly influential on overwintering success through the regulations of the fish's lipid reserves, and 3) winter warming will still be a major source of mortality even when pre-winter environments are optimal for lipid allocation. Collectively, these results suggest that warm-related size shifts in juvenile cohorts are not necessarily positive for the population, and that forecasting recruitment will become increasingly difficult to predict from the early life stages in the absence of fall and winter information.~~

(S9-16609 Oral)

Implications of changing body size in Chinook salmon for population productivity and fishery management

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Many populations of Pacific salmon along the west coast of North America have experienced declines in mean body size of adult fish since at least the 1970s. Changes in body size are of concern because they may reduce population productivity and bias estimates of biological reference points used to inform fishery management. We show that Chinook salmon have experienced widespread changes in population demographic structure throughout their North American range that have led to declines in mean body size and spawner reproductive potential. To evaluate potential management implications of size declines, we simulated populations with demographic trends, selective or unselective fishery harvests, and periodically updated harvest policies based on assessment methods that differed in whether and how they accounted for demographic changes when estimating biological reference points used to set management goals. We show that expected mean harvests and returns were reduced when demographic trends toward smaller adult fish were present in the population. Decreased abundances and increased conservation risks to the populations could partially be mitigated by accounting for demographic trends in the stock assessment, specifically by using a stock-recruitment model based on egg production instead of spawner abundance. Our results suggest that accounting for demographic trends in stock assessments can reduce conservation risks and that preserving population demographic structure may be critical for sustaining productive fish populations and their benefits to ecosystems and people.

(S9-16646 Oral)

Climate, fish body growth, mortality, and fisheries management for Korea chub mackerel

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It is well recognized that global warming, caused by the increased amount of carbon dioxide, has changed aquatic ecosystems. The effect of temperature on fish can be summarized as the temperature size rule (TSR), where they mature at smaller body sizes under warmer temperatures. Body size is a product of growth rate (increase in weight per time) and development rate (increase in life stage per time). However, yield-per-recruit, one of the key metrics in fisheries management is not only affected by fish body size but also by mortality. Also fish mortality is also linked to body size. The major objective of our study is to examine the effect of body growth as a climate index proximately on mortality and ultimately on fisheries management. Previous study on fish says that temperature-acclimated adults show a greater temperature-size response than do acclimated progeny (e.g., eggs) whereas early larval stages of many species suffer from higher mortality than adults. The specific objectives include investigating body size dependent effects, hypothesizing that fish body growth affects both the mortality and the management key metrics and that the mortality also affects those metrics. We illustrate our analysis using data on Korea chub mackerel (*Scomber japonicus*).

(S9-16668 Oral)

Fish weight reduction due to intra- and interspecific competition altered by climate change

Zhen **Lin** and Shin-ichi Ito

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Fish size is thought to be reduced under global climate change with warmer temperature based on temperature-size rule paradigm in which fish living in a warmer temperature grow faster while ends up with a smaller body size. However, the body size change of fish communities in the western North Pacific, where one of the most active fishery grounds, remains unclear. We investigated fish weight data of 6 populations of 4 species during 1978–2018 and those of 17 populations of 13 species during 1995–2018. Weight reduction of fish assemblage was observed in the 1980s associated with the biomass peak of Japanese sardine (*Sardinops melanostictus*), indicating the effect of inter- and intra-species competition. Another weight reduction was found in 2010s associated with the biomass increase of Japanese sardine and chub mackerel (*Scomber japonicus*). However, the biomass of Japanese sardine and chub mackerel was much lower in 2010s than that in the 1980s, which poses a question why inter- and intra-species competition emerged in the 2010s. Our analyses indicated stronger stratifications in the surface layers during the 2010s potentially reduced nutrient supply to the surface layer from the subsurface layer, limited carrying capacity, and forced inter- and intra-competition with moderate increase of fish biomass.

(S9-16713 Oral)

Mechanisms of change in weight-at-age in Gulf of Alaska groundfish and forage fish under warming: Insights from an ecosystem model

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Increased temperature is an important driver of altered ecological processes and population dynamics in marine ecosystems, and changes in weight-at-age of marine fishes are expected for many stocks under global warming. While the size of adult fish has been observed to shrink in some warming areas, the mechanisms that mediate changes in weight-at-age, as well as the ensuing effects of such changes on the rest of the ecosystem, are often not well understood. Integrating key mechanistic linkages between temperature and biology into ecological models is critical when using these models to investigate climate scenarios. In recent years, the Gulf of Alaska (GOA) has experienced climate events that have altered ecosystem productivity, ultimately cascading into changes in fish body condition. Here we use a deterministic end-to-end simulation model (Atlantis) to explore the mechanisms of change in weight-at-age of GOA species under regimes of warmer water and decreased plankton productivity. We focus on key commercially targeted groundfish (Pacific cod, arrowtooth flounder, walleye pollock, and Pacific halibut) and forage fish (capelin, Pacific sand lance, eulachon, and Pacific herring). Model results show that temperature-driven metabolic mechanisms mediate increases in weight-at-age under warm conditions, but that food limitation from decreased plankton productivity has is a potential driver of decreases in weight-at-age. We highlight that model specification is important when exploring temperature-driven changes in population dynamics. Finally, we demonstrate that ecosystem models can help disentangle the mechanisms that mediate changes in weight-at-age, and how such changes propagate through the food web and ultimately to fishing.

(S9-16740 Oral)

The potential role of enhanced selective mortality during marine heatwaves

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The occurrence of marine heatwaves is increasing globally. Evidence indicates that, early in life, size-at-age increases at warmer temperatures, resulting in earlier age-at-maturity at smaller sizes ("Temperature-Size Rule") although mechanisms remain unclear. Accelerated growth due to warming is cited as a factor but increased size-selective mortality could contribute to observed changes. We examined changes in growth and size of juvenile Pacific Cod collected in Alaska before (2007, 2009, 2010, 2012, 2013) and since MHWs (2015 to 2019). We combined field and otolith data to compare attributes of fish captured in July ("settlers") with those in August ("survivors"). Using linear mixed models, we compared 1) length and mass at capture and 2) back-calculated size and growth during early July before and since MHWs. Before MHWs, survivors were 22 mm longer and 2.36 g heavier at capture than settlers. Since MHWs, those differences increased by 32% for length and >200% for mass (survivors were 32 mm larger and 6.13 g heavier than settlers). Size and growth differences between settlers and survivors in early July also increased since MHWs. Before MHWs, survivors were 15 mm longer and grew faster (0.014 mm/mm/d) than settlers in early July. Since MHWs, survivors were 26 mm longer in early July than settlers, yet their growth rates were slower (0.011 mm/mm/d) than before the MHWs. These differences indicate greater size-selection likely occurred during heatwaves, contributing to observed increases in size. Change in selection intensity is a potential mechanism contributing to changes in age and size associated with warming.

(S9-16765 Oral)

Can the temperature size rule help us predict fisheries productivity in a changing climate?

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The temperature size rule is nearly ubiquitous yet is not well understood. In particular, changes in size and growth with temperature are uneven across life stages – faster growth under warmer temperatures may result in a larger size-at-age for earlier life stages but a smaller size-at-age for later life stages. However, we lack an understanding of whether this pattern is common across species (and regions) and how fisheries will be affected. Here, we bridge macroecological theory with fisheries science and examine how the interaction of size, growth, and temperature will affect fisheries productivity in a changing climate. To do so, we combine fisheries survey data and time series of temperature from regionally downscaled global climate models to assess how size-at-age of commercially important fishes in Alaska's large marine ecosystems has changed over time. We then assess how these effects vary with oxygen (also from global climate models) to understand how both temperature and oxygen may relate to patterns of growth. Finally, we predict how changes in adult size may confer changes in reproductive output. Observations indicate that the strength and direction of size, growth, and temperature relationships depend on size class (and thus change along the ontogenetic growth trajectory) and that these dynamics allow for predicting stage-structured population dynamics based on future environmental conditions. This work highlights the complexity in the temperature size rule and applies this complexity to predict fisheries productivity, thus connecting theory with empirical data and models to uncover the intricate dynamics between the environment and life histories.

(S9-16776 Oral)

Marine Heatwaves alter the size, age, diet, and growth of juvenile Pacific Cod in Gulf of Alaska nursery habitats

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Pacific Cod (*Gadus macrocephalus*) abundance declined dramatically following recent marine heatwaves (MHWs) in the Gulf of Alaska. Early life stages of Pacific Cod may be particularly susceptible to MHWs, including age-0 juveniles during periods of rapid summer growth in coastal nursery habitats. We assessed the size and age, diet composition, and recent growth both inter- and intra-annually of post-settled age-0 juveniles collected from Kodiak Island, AK in July and August before (2006-2013), during (2014-2016, 2019), and between (2017-2018) MHWs to evaluate their potential consequences. Fish were larger and older during MHWs, with a large increase in size and moderate increase in age between July and August that did not occur in other years. Even when accounting for size, diet shifted to larger prey items during MHWs, yet diet composition did not influence growth rates. July growth rates were moderately faster during MHW conditions compared to other years, although growth showed a clear negative relationship with temperature and age across all heatwave classes, including during MHWs. By August, growth was influenced by a 3-way interaction of size, temperature, and heatwave class. Before MHWs, patterns in August growth were like July's. However, during and between MHWs, growth did not show a clear relationship with temperature or body size, with fastest growth during MHWs and slowest growth between them. Even when accounting for growth variation, fish were larger than expected by August, thereby indicating that size was likely influenced by additional factors including earlier hatch dates and size-dependent selection in the nursery.

(S9-16806 Oral)

Operationalizing the impact on stock assessments of size-selective fishing's effect on body size

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Size-selective fishing generally causes more mortality on faster-growing individuals, which reduces the average growth rate and body size of the survivors. This has been known for over 100 years as Rosa Lee's phenomenon. Despite the recognition of this general pattern, treatment of time-varying body size in fishery stock assessments tends to be principally by tracking changes empirically. McGarvey and Feestra (2007) developed a slice approach to incorporating size-survivorship in assessment calculations. Subsequently, Taylor and Methot (2013) introduced this phenomenon to the Stock Synthesis (SS3) assessment program by subdividing the modeled population into a set of platoons that have different average body size, so encounter differing degrees of fishing mortality, just as happens to wild fish experiencing size-selective fishing. An important aspect of modeling this phenomenon is capturing the degree to which fast-growing vs slow-growing fish maintain fidelity to their natal growth pattern. Here we demonstrate recent advancement to SS3 that allows for this degree to be represented by a model parameter that is estimable given suitable data. We also show how failure to recognize and account for this phenomenon causes mean asymptotic size (L_∞) to be underestimated. With incorporation of the phenomenon, the SS3 approach is able to estimate the correct average L_∞ of fish in the population, while also estimating the realized average size after the effect of size-selective fishing. With this capability, SS3 is then able to incorporate size-selective mortality as one of the dynamic factors influencing estimation of fishery reference points.

(S9-16834 Oral)

Modeling spatial and temporal growth patterns with single- and multi-area fisheries stock assessment models

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Stock assessments models often assume a single area with constant size-at-age. However, temporal patterns in size-at-age can occur and may show complicated interactions with spatial processes that necessitate more refined stock assessment methodologies. For example, Gulf of Alaska (GOA) Dover sole size-at-age has increased over time and also exhibit ontogenetic movement between habitats, resulting in higher proportions of fish small for their age in deeper waters. Here we compare how complex spatial growth patterns can be accounted for with either spatially-structured assessment models which internally estimate growth parameters (used for GOA rex sole and GOA northern rock sole), or simpler one-area models in which spatially-averaged estimates of size at age are estimated outside the model (used for Bering Sea Aleutian Islands (BSAI) northern rockfish). Spatial and/or temporal patterns in size-at-age appear for many Alaskan stocks with a variety of life-history patterns, including long-lived rockfish and flatfish with moderate longevity. Therefore, we compare the one-area models (with spatially averaged estimates of size-at-age) and two-area models for a series of stocks, including GOA Dover sole, GOA rex sole, BSAI northern rockfish, and GOA northern rock sole. Evaluation criteria for model performance includes fit to the observed data, uncertainty in estimated parameters and management quantities such as harvest recommendations and reference points. We hypothesize that simple patterns of spatial size-at-age might be addressed with one-area models using spatially averaged size-at-age data, whereas complex interactions between spatial and temporal patterns may be better addressed with multi-area models.

(S9-16835 Oral)

Deciphering the molecular basis of temperature-induced growth changes in Pacific halibut (*Hippoglossus stenolepis*) to improve our understanding of growth variation in a changing North Pacific Ocean

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Our understanding of the potential causes for the long-term variability in the size-at-age (SAA) of Pacific halibut (*Hippoglossus stenolepis*) is limited. Although several factors could contribute to this variability, it is hypothesized that temperature variation could be a contributing factor to the observed changes in SAA. According to its ecothermic nature, Pacific halibut growth has previously been shown to be affected by temperature. However, in order to study how temperature can affect growth patterns, not size, suitable growth markers need to be identified and validated to monitor growth patterns in the wild. To that effect, we have conducted experimental growth manipulations in juvenile Pacific halibut through temperature acclimation to generate growth suppression and growth stimulation phenotypes. Using white skeletal muscle samples from growth-suppressed and growth-stimulated juveniles we have conducted RNA sequencing and proteomic analyses to identify genes and proteins that change their mRNA expression and abundance levels, respectively, in accordance to the direction of the growth change. In addition, we have conducted stable isotopic analyses of white skeletal muscle from growth suppressed and growth-stimulated juveniles to further characterize the molecular responses to temperature-induced growth manipulations. Finally, we have validated a subset of the identified molecular growth markers using white muscle samples from wild-caught Pacific halibut to detect the presence of growth differences among age-matched adult fish. The results from this study will help identify potential differences in growth patterns in Pacific halibut under variable environmental, dietary and intra- as well as inter-specific conditions.

(S9-16841 Oral)

Changes in copepod size in response to warm and cold conditions during spring in the Eastern Bering Sea

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Large marine ecosystems of Alaska are experiencing significant warming, and one response to warming predicted by ecological theory is a decline in organism body size. Here we report preliminary results for NPRB Project 2008: The effect of global warming on long-term changes in copepod size in the Bering Sea. We used an archive of preserved specimens to measure body size (prosome length) of copepods across warm and cold periods in the eastern Bering Sea. Average prosome length for large copepods (*Calanus* and *Neocalanus*) was lower during the warm years, whereas prosome length for smaller copepods (*Acartia, Oithona*, *Pseudocalanus,* and *Metridia*) did not show differences. The differences in body size translate to differences in individual mass and lipid content. For example, the average size of *Calanus* C5 during cold years was 0.27 mm larger than during warm years. Based on length-weight regression, this translates to C5 *Calanus* being ~20% heavier and having 10% more lipid content during cold years. This suggests that the fewer *Calanus* observed during warm conditions are smaller and less lipid rich compared to cold years. This has implications for the eastern Bering Sea food web as many species rely on *Calanus* as an important forage item, including Walleye pollock, seabirds, and the critically endangered North Pacific right whale. We hypothesize that warming in Alaska ecosystems has caused copepod body size to decline over time. Should such a decline be detected, it would suggest a shifting relationship with higher trophic levels with ecosystem wide consequences.

(S9-16850 Oral)

Best practices for modeling time-varying growth in state-space stock assessments

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Time-varying growth can contribute to biomass fluctuations, and its incorporation in assessment models has received more attention in recent years. State-space assessment models (SSMs) have garnered more attention recently due to their ability to estimate time variation in biological and fisheries processes, but their use has been mostly limited to fish stocks that rely on age-specific data. Recently, new features in the Woods Hole Assessment Model (WHAM) platform have expanded the applicability of SSMs by including size-specific data and modeling mean size and weight-at-age. However, it is still unclear what data type or growth modeling approach to use in an SSM under diverse circumstances. In this study, we used WHAM in a simulation-estimation framework to compare the performance of the currently available methods to model growth in SSMs. Specifically, our operating models were based on a generic groundfish (cod-like) and had time-variation in different growth parameters, driven either by random noise or linked to an environmental covariate. We then evaluated the performance of parametric, semi-parametric, and non-parametric estimation models when using marginal length composition, conditional age-at-length, or weight-at-age data of varying quantities. Our results are a first step to identifying estimation strategies that are accurate and reliable, and inform best practices for modeling time-varying growth in SSMs. Our findings will be valuable for stocks where length data are a key source of information, variation in growth is an essential part of the dynamics of the assessed stock, or when linking climate variables to growth in hindcasts or forecasts is relevant.

(S9-16616 Poster) CANCELLED S9-P1 (ECOP)

~~**Unveiling unselective fishing in China: A nationwide meta-analysis of multispecies fisheries**~~

~~Ming **Sun**[1,2], Yunzhou Li[1, 2], and Yong Chen[1, 2]~~

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~~Understanding and managing fishery selectivity to target species and desirable size is instrumental to fisheries management. China, as the world's largest producer of marine capture fisheries, has been widely perceived to possess unselective domestic fisheries. To date, this perception remains largely anecdotal and conjectural, hindering the development of evidence-based and effective management solutions. This study presents a literature review to examine the magnitude and scale of unselective fisheries in China. By collating and analyzing 140 fishery-level and 807 species-level records from 66 peer-reviewed publications from 2010 to 2021, we found that primary target species were absent in 59% of fisheries, while unidentifiable low-value and juvenile mixed catch were universal. Key commercial taxa were subject to nationwide multi-gear and multispecies fisheries, each involving an average of 3.33 types of gear and accounting for less than 25% of catch individually. The "permissible gears" defined by the national gear regulatory catalog were selective over target species and caught negligible by-products, though they were used less frequently, representing only 24% of catch records. While unselective fishing can provide seafood supplies for China's large population and potentially facilitate balanced harvest, management actions are needed to control the fishing pressure on primary target species and by-product species. Amid the ongoing fisheries management reform in China, we proposed management recommendations tailored to China's needs and social contexts, including accounting for the trade-off between socioeconomic and ecological goals, contemplating impacts of unselective fishing when implementing TAC programs, and strengthening fisheries monitoring to inform management at multiple scales.~~

(S9-16684 Poster) S9-P2 (ECOP)

Development of a bioenergetics and population dynamics coupled model: A case study of chub mackerel

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Pacific chub mackerel (*Scomber japonicus*) is a small pelagic fish that widely distributes in temperate zones in the waters around Japan, which showed large stock fluctuations in the western North Pacific with other small pelagic fishes like Japanese anchovy, Japanese sardine, and Pacific saury. For clarifying the mechanism of the stock fluctuations, we developed a coupling model of bioenergetics model and a population dynamics model of chub mackerel, in which influence of temperature and prey plankton on growth and hence population can be included. Body growth is calculated by the bioenergetics model and mortality of early life stages depends on body size and growth rate. However, the dependencies of mortality on size and growth rate were not explicit for chub mackerel. Therefore, two types of mortality functions were employed in the model to figure out a better pattern of dependencies of parameter by comparing the reproducibility between two types of mortality functions. Influences of sea surface temperature (SST) and chlorophyll-a were also evaluated separately by using the climatological values for one of the forcings. The model results revealed that the stock fluctuations of chub mackerel during 1998–2018 were mainly controlled by chlorophyll-a, whereas the increasing stock during 2010–2014 was strongly influenced by chlorophyll-a, and that after 2014 was influenced by SST. Furthermore, importance of the fishing pressure on the recovery of the chub mackerel stock was evaluated by analyzing cases with different fishing pressure and two sub-cases of growth overfishing and recruit overfishing.

(S9-16931 ~~Poster~~) **ORAL PRESENTATION OCT. 26** ~~S9-P3~~ (ECOP)

Comparison of juvenile pacific salmon abundance, distribution, and body condition between Western and Eastern Bering Sea using spatiotemporal models

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Recent changes in climate have had different impacts on salmon stocks in the eastern and western Bering Sea (WBS). Eastern Bering Sea (EBS) salmon stocks periodically experienced reduced productivity, size, and survival, whereas salmon stocks in the Bering Sea (WBS) have more stable and generally positive trend in abundance. This difference could be partially attributed to the different habitats that juvenile salmon occupy during their first marine year. Salmon surveys in the EBS and WBS are used to compare the status of juveniles in these two large marine ecosystems. We applied a spatio-temporal VAST models to adjust for differences in timing, vessels and trawl gear used, and to compare the density and body condition indices (length, weight, and Fulton's condition factor) of three juvenile salmon species (*Oncorhynchus gorbuscha, O. keta, and O. nerka*) between the WBS and EBS from 2002 to 2022. Juvenile salmon in WBS exhibited a consistent trend of larger size, higher Fulton's condition factor than EBS populations with greater abundance during even years compared to EBS. A clear even-odd year pattern, which is believed to be driven by pink salmon (*O. gorbuscha*), occurred in all species' density and body condition in the WBS with a limited impact of interannual temperature changes. Conversely, temperature had a significant impact on EBS salmon and much of the variation in density and body condition occurred between warm and cold periods. We detected different WBS-EBS migration patterns with EBS juveniles dispersing from nearshore habitats earlier than WBS juveniles, but migrate offshore later.

Session 10: MONITOR Topic Session

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

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

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

Forage species serve an important intermediate trophic role in marine ecosystems, yet an understanding of how they drive trophodynamics in the North Pacific remains poorly known. The species composition, condition, and availability of forage species to predators can be sensitive to physical and biological changes and variable production at lower trophic levels. Forage populations are prone to large variations in production, which can affect their availability to predators. North Pacific forage species include both commercially and non-commercially exploited taxa including small pelagic fishes (e.g. herring, sardines, anchovies, smelts, and sand lance), early life stages of groundfish, salmon, and crabs, mesopelagic fishes, and other important invertebrates (e.g. squids, euphausiids). In marine ecosystems where the most abundant forage species are unexploited taxa or life stages, detecting changes in species composition, abundance, and distribution is often particularly challenging due to a lack of directed monitoring, and may have profound ecological and socio-economic impacts at the ecosystem level. An improved understanding of how changes in the abundance and distribution of unexploited forage species impacts exploited species and other predators is critical for commercial interests, as well as for economic and food security of Indigenous and coastal communities in the North Pacific. This session welcomes contributions focused on: 1. Improvements in monitoring and data synthesis of forage species – particularly unexploited taxa and life stages – such as integrating multiple data sources (surveys, predator diets), gear modifications for improved retention of forage species, advances in monitoring tools (biogeochemical and genetic analyses, autonomous vehicles), and inclusion of traditional or local ecological knowledge; 2. Describing changes in forage communities and impacts on predators; 3. Advances in knowledge about interspecific interactions and bottom-up and top-down processes that affect forage species used to inform ecosystem-based fisheries management or reduce uncertainties in stock assessments and population forecasts of exploited species.

(S10-16719 Invited)

Persistent spatiotemporal patterns between seabird and small pelagic fish communities provide early indications of ecosystem change

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Predator-prey interactions may contribute substantially to spatiotemporal variability in pelagic food webs. However, concurrent information on both predators and their prey is often lacking in marine systems. Seabird densities at sea are relatively easily assessed using standardized survey methodology, whereas targeted and timely survey data for small pelagic fish are particularly challenging to obtain. We assessed seabirds and forage fish densities using coupled marine bird surveys and acoustic-trawl surveys in Cook Inlet, Alaska across ten survey years. We used multispecies VAST models to identify persistence in spatial correlations among seabird and prey communities and to contrast ecosystem states during and after record-breaking El Niño conditions in 1997-1998 and the multiyear Blob - El Niño events nearly 20 years later. We also explored drivers of spatiotemporal variability among predator and prey communities to better understand factors that may predispose certain seabirds to greater sensitivity in food supply. Modeled densities of transient (non-breeding shearwaters) and certain pelagic-feeding breeding seabirds (common murres, Kittlitz's murrelets) were more strongly tied to food supply than others (black-legged kittiwakes, pigeon guillemots). We show that persistent upwelling areas in lower Cook Inlet provide thermal refugia in the northern Gulf of Alaska, thereby increasing local abundance of seabirds and small pelagic fish (age-0 walleye pollock, capelin, sand lance) during some years. Our findings suggest that using multispecies distribution models that include the seabirds most sensitive to food supply as a proxy for small pelagic fish distribution can provide early indications of food web perturbations and ecosystem change.

(S10-16823 Invited)

Consideration of the population dynamics of sardines in the western and eastern North Pacific on the basis of isotope chronologies

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Small pelagic fish populations worldwide have fluctuated by several orders of magnitude at multidecadal scales, although the mechanisms connecting physical forcing with fish populations remain unclear. One of the major limitations in this field is the difficulty in observing when and where the free-ranging fish have been and what environmental conditions they have experienced, which could be solved by reading the chemical signals in the fish body. Here, I review our recent studies using stable isotope analyses on incrementally growing and metabolically inert tissues, i.e., otoliths and eye lenses, to understand the population dynamics of sardines around the world. High-end oxygen stable isotope analysis of otoliths combined with numerical simulations were able to reproduce the migration history of sardines at about half a year of age. Extensive chemical and microstructure analyses of otoliths revealed that sardine populations in the western and eastern North Pacific have different metabolic and growth rates in the early life stage that respond contrastingly to temperature variations, which could explain the puzzle that the populations increased during periods of opposite temperature anomalies. Massive carbon and nitrogen stable isotope analyses in eye lenses suggested that the sardine population in the Sea of Japan does not form a self-sustaining subpopulation, as has been conventionally assumed, but is largely dependent on immigrants from the western North Pacific. Although understanding the dynamics of the underwater world is still exceedingly difficult, technical developments will allow stepwise improvements necessary to resolve the impacts of climate change and variability on marine populations.

(S10-16498 Oral)

Gelatinous zooplankton prey is important for supporting early survival and growth of skipjack tuna in the western North Pacific Ocean

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Subtropical waters in the western North Pacific Ocean are known to be feeding grounds for early life stages of skipjack tuna, despite of a potential risk or disadvantage for their survival and growth under the poor food availability. For understanding these inconsistencies, however, there is limited information on trophic sources to support early survival and growth through the bottom-up processes in the complicated food web. Here, we investigate zooplankton prey of skipjack tuna larvae and juveniles in the western North Pacific Ocean based on metabarcoding analysis of their gut content DNA. We obtained 5,020,207 reads of zooplankton prey, composed 1.6% of total sequence reads from gut content DNA. Major zooplankton prey of larvae and juveniles were maxillopods including calanoids, foraminifers, hydrozoans, appendicularians and chaetognaths. The most contributed prey of the larvae demonstrated geographical differences, maxillopods in the tropical Pacific, hydrozoans in the subtropical Pacific and appendicularians in the Kuroshio and Kuroshio Extension. The most frequently appearing prey was maxillopods including calanoids, molluscans and hydrozoans. Frequently appearing prey was more for juveniles than larvae. Non-metric multi-dimensional scaling on their prey compositions allocated the different geographical patterns among the four regions. These findings suggest that gelatinous zooplankton prey being underestimated is important trophic source for supporting early survival and growth of skipjack tuna in the western North Pacific Ocean.

(S10-16509 Oral)

Alternative management strategies for forage fish communities: Implications for dependent predators and fishers under climate change uncertainty

Pierre-Yves **Hernvann**[1,2], Isaac C. Kaplan[2], Barbara Muhling[1,3], Stefan Koenigstein[1,3], Robert P. Wildermuth[1,3], Elizabeth A. Fulton[4], Felipe Quezada-Escalona[3], Nerea Lezama-Ochoa[1], Peter Kuriyama[1,3], Owen R. Liu[5], and Desiree Tommasi[1,3]

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Managing forage species comes with multiple challenges, particularly under a changing climate. As highly productive, short-lived organisms feeding on low trophic levels, forage species display extreme recruitment and abundance fluctuations in response to the environment. They also support a wide diversity of predators including protected or commercially exploited species which may be negatively impacted by forage species fisheries or, conversely, exert top-down control on forage species. Ecosystem-based fisheries management must therefore balance trade-offs between catch of forage species and their ecological role regarding dependent predators. To explore those trade-offs under different management rules and climate change scenarios, we establish the foundations of a climate-informed ecosystem management strategy evaluation of the forage species fisheries in the California Current using an Atlantis end-to-end ecosystem model. Atlantis represents oceanography, biogeochemistry, food web and fisheries dynamics, and is designed to simulate management strategies. We tested the robustness of alternative harvest control rules (HCR) for forage species to future climate change through 2050 with respect to both economic and conservation objectives. Atlantis was driven by projections of (i) oceanography derived from downscaled models to predict changes in biological production fueling the food web, (ii) species distribution models developed for individual forage and predator species, and (iii) anchovy (*Clupea pallasii*) and sardine (*Sardinops sagax*) recruitment variation derived from other ecological models. Our simulations demonstrate that climate vulnerability of forage fish and fisheries can be reduced by adjusting harvest rates to ecosystem productivity, predators' status, and employing guild-based harvest rules.

(S10-16541 Oral)

Metabarcoding analysis on trophic sources of mesozooplankton during spring phytoplankton bloom in the neighboring waters of the Kuroshio Current

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Coastal sites neighboring the Kuroshio Current have been known as nursery grounds for early life stages of small pelagic fishes. It is believed that their early growth and survive are supported by mesozooplankton standing stocks and production during spring phytoplankton bloom with colonial diatoms and large dinoflagellates in the coastal sites. However, since these diatoms and dinoflagellates are too large for small copepods predominating in the Kuroshio to feed, such general paradigm should be re-considered. Here, we explore trophic sources and linkages of mesozooplankton in the coastal sites neighboring the Kuroshio based on metabarcoding analysis of gut content DNA for major taxonomic groups. We obtained 728,250 reads of prey organisms, composed 21.1% of total sequence reads from their gut content DNA. Copepods represented by calanoids were major prey items, and gelatinous mesozooplankton taxa and phytoplankton were the supplementary prey. Copepods were the most frequently appeared prey taxa, and gelatinous mesozooplankton taxa represented by molluscans, appendicularians and polychaetas exhibited the second frequency. Non-metric multi-dimensional scaling on their prey compositions allocated different groups among feeding habits, such as large and small omnivores, and carnivores. Trophic networks based on the contribution and appearance frequency of prey demonstrated that copepods were the major nodes with multiple linkages among their prey and predators. These findings suggest that copepods were important hubs of trophodynamics in the food web and many omnivorous mesozooplankton groups are not strongly dependent on diatoms and dinoflagellates even in spring phytoplankton bloom in neighboring waters of the Kuroshio Current.

(S10-16551 Oral)

It is worse than you think: Implications of spatial and trophic overlap between juvenile salmon and sablefish in the inshore surface waters of the Northern California Current

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Interactions between protected and commercial species remains an area of concern for management agencies. An unusually high abundance of juvenile sablefish in nearshore marine waters in the northern California Current in 2020 were in spatial and trophic overlap with protected populations juvenile salmon, which created an unexpected ecological interaction during a critical phase of both their early life histories. The 2020 index of abundance of juvenile sablefish showed an 8.6-fold higher relative to any of the other 24 years and there was an overall positive relationship between encounter rates of sablefish and temperature. The sablefish were more abundant than the juvenile salmon for which the survey was designed, and sablefish were caught at the most inshore stations and along all transects. Sablefish ate similar prey taxa as the salmon, such as juvenile rockfish, crab larvae, and krill, though there were notable diet differences. Juvenile sablefish had significantly higher feeding intensity than juvenile salmon, with 7% of sablefish consuming greater than 10% of their body weight, while none of the salmon had a stomach fullness higher than 7.2%. Juvenile salmon caught in the presence of sablefish had lower feeding intensity than at stations where there were no sablefish present. Climate driven increases in coastal ocean temperatures could be changing juvenile sablefish distributions, resulting in higher spatial and trophic overlap that could negatively impact Pacific salmon. Juvenile salmon, in direct competition for food resources, would be the loser relative to the more numerous juvenile sablefish that ate similar, larger, and more prey.

(S10-16601 Oral)

Integrating survey data to explore if Pacific hake diets reflect variation in the prey community of the California Current Ecosystem

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Indices of lower trophic level productivity can provide important insights for ecosystem based fisheries management. However, information about prey abundance, and relationships between prey consumption and recruitment of fish populations are not fully understood. Pacific hake, *Merluccius productus*, a commercially important groundfish on the west coast of the U.S. and Canada, consume euphausiids, or krill, as a key prey item. Using stomach contents of hake sampled from midwater trawls during the biennial Pacific Hake Ecosystem and Acoustic Trawl Survey between 2007-2019 (n = 8 years; odd years inclusive, and 2012) in combination with a recently developed acoustic index of coast-wide krill abundance, we tested the hypothesis that hake diets reflect changes in the availability of krill. We found that krill dominated the diet of hake aged 1-7, whereas hake aged 8+ consumed a more piscivorous diet. Krill consumption was greater when they were abundant in the ecosystem, particularly during 2011-2013, and 2017. During 2015, when krill abundance was the lowest in the time series, hake diets were more diverse and contained proportionately greater alternative prey, including Pacific sardine and Northern anchovy. These results indicate that the proportion of krill occurring in hake diets is positively correlated to krill abundance, and that dietary diversity increases as krill become less abundant. Our results have important implications for utilizing predator diets to monitor prey populations. Furthermore, krill abundance may be an important link to hake growth and recruitment, which could inform stock assessment models.

(S10-16665 Oral)

Sampling North Pacific forage fishes with midwater trawls: behavior observations, retention, and other considerations

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Forage fishes, including smelts, herring, and juvenile groundfish, are often encountered in midwater trawl samples during acoustic-trawl surveys in Alaska waters. Innovations in scientific trawling, such as trawl-mounted cameras and recapture nets, provide information on the efficiency and potential biases in trawl sampling associated with forage fish capture. We present observations from a stereo-camera system on species-specific behavior patterns in the trawl, including 3D analysis of fish positions, orientations, and movement. Estimates of size-dependent forage fish retention by the trawl are also presented using recapture net data from two surveys. Retention values are used to compute trawl selectivity, which is used to correct catches for escapement in order to allocate backscatter to multiple species using the selectivity-corrected trawl data. Pocket nets also provide data on directional escapement, which can aid in the design of trawl gear specific to forage fish sampling. Examples of behavior observations and retention characteristics are presented for Pacific capelin (*Mallotus catervarius*), eulachon (*Thaleichthys pacificus*), Pacific herring (*Clupea pallasii*), and juvenile walleye pollock (*Gadus chalcogrammus*). These findings are critical for correct interpretation of catch-based abundance and size composition data for these important components of the ecosystem.

(S10-16681 Oral)

A model-based approach to improve estimates of distribution and abundance for data-limited forage species

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Forage species (small pelagic fishes, juvenile fishes, and important invertebrates) serve a key, intermediate trophic role in Northeast Pacific marine food webs. Although directed fisheries for forage species are prohibited in U.S. waters off Alaska, information on the distribution and population dynamics of key species are requested by fisheries managers due to their ecological value as prey to seabird, marine mammal, and commercially important fish species. Accurate indices of abundance are needed to monitor how fluctuations in the availability of forage species impact managed predators under an ecosystem-based approach to fisheries management. Existing monitoring surveys are not designed to sample these species, as the spatial coverage and sampling gear used may not be appropriate, so the use of data from such surveys has thus far been limited. However, improved monitoring of forage species can be achieved in the absence of directed surveys by integrating multiple, independent data sources while compensating for their individual limitations in spatiotemporal models. For example, advances in these models allow multiple surveys with different data types (e.g., presence/absence, biomass density) to be incorporated within a single, joint modeling framework to estimate shifts in habitat use and abundance trends. Here, an example index standardization model for Pacific capelin (*Mallotus catervarius*) in the Gulf of Alaska is presented. Using encounter data from bottom trawl and biomass density measurements from acoustic-trawl surveys, the joint model provides improved distribution and abundance estimates for capelin when compared with individual models for each survey.

(S10-16718 Oral) **CANCELLED**

~~Ecosystem models to evaluate the role of trophic vertical exchange processes on forage and predator productivity within oceanic ecosystems~~

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~~Understanding the trophodynamics of forage and predator species in open ocean ecosystems is hampered by lack of quantitative estimates of connectivity between epipelagic, mesopelagic, and bathypelagic depth zones. We developed vertically-resolved ecosystem models (*ECOTRAN*) of the oceanic central North Pacific and oceanic Gulf of Mexico that include major pathways of vertical connectivity: the sinking of detritus and the diel vertical migration of zooplankton, micronekton, and fish. Net and acoustic survey data were used to parameterize vertical distributions and diel migration behavior within different oceanic regions. Models were run at high temporal resolution to capture sub-daily changes in vertical migration and quantify trophic connectivity within and between depth zones. Independent estimates of the oceanic *f*-ratios were used to constrain detritus recycling rates via microbial metabolism. For both ecosystems, vertical connectivity was dominated by detritus sinking. An imbalance of consumption gains and predation losses within each depth zone among vertically migrating groups also contributed to a net flux of biomass from the epipelagic to the mesopelagic (the "biological pump"). Migration-driven flux accounted for 12% to 27% of the total biomass flux between depth zones in the central North Pacific and the Gulf of Mexico, respectively. Flux mediated by migrating crustacean zooplankton was more than an order of magnitude higher than that mediated by migrating fish and squid. Simulations were run to estimate how changes to vertical exchange processes and to food web structures within each depth zone propagate throughout the water column, effecting the foraging environment of piscivorous fish.~~

(S10-16720 Oral)

Toward identifying the critical ecological habitat of larval fishes: an environmental DNA window into fisheries management

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Marine larvae are important to marine ecosystems and fisheries, but predicting recruitment remains a fundamental challenge in fisheries science. Previous work has focused on characterizing physical conditions that defines critical oceanic habitats for important fisheries as well as key groups of prey, but the complex network of species associations that define larval ecological habitat is unexplored. Now, ecological aspects of the larval habitat can be examined through biomolecular techniques. Using anchovy larvae (*Engraulis mordax*) as a case study, the goal of this study was to examine how eDNA data can be coupled with traditionally sampled larval fish abundance data to develop ecological co-occurrence networks that provide insight into the larvae's microscopic world and work toward elucidating communities, species, and mechanisms that control larval dynamics. We correlated the presence/absence (P/A) of ASVs from biomolecular 16S and 18S data with visually enumerated counts of larval fishes to create a correlation matrix that we visualized as an ecological co-occurrence network. We found that ‘anchovy water’ can be characterized by eDNA analysis to reveal potential prey field, predators, microbiome associates, or a general fingerprinting of anchovy ecological habitat. Biomolecular approaches provide insight into the larval habitats of important fisheries species and provide working hypotheses to explore through future research. Thus, there is great potential for eDNA methods coupled with ecological network analyses to provide a holistic understanding of community composition and species interactions and to develop indicators for fisheries and ecosystem-based management.

(S10-16726 Oral)

Assessing the influence of starvation relative to advective losses across El Niño and La Niña years for an ecologically important fish of the California Current System

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Understanding biophysical drivers of year-to-year changes in the replenishment of marine fish populations (i.e., recruitment) is crucial for effective ecosystem-based fisheries management (EBFM). For more than 100 years, fisheries oceanographers have tried with varying success to attribute cause to observed recruitment fluctuations. Mechanistic models grounded in first principles (i.e., physiology) when coupled to ocean circulation models are useful to retrospectively test recruitment hypotheses and to elucidate the relative influence of starvation mortality vs. advective losses to year-class success or failure. Here I develop a coupled biophysical individual-based model for Shortbelly Rockfish (*Sebastes jordani*), a non-commercial, yet ecologically important species of the California Current System (CCS). Shortbelly Rockfish in the central CCS are a significant component of the forage fish assemblage and exhibit sporadic fluctuations in early life survival that have effects on higher trophic level predators. Leveraging biological data from a fisheries-independent survey along with model output, I show that starvation is most prevalent during low productivity (El Niño) years while retention over the continental shelf is the bottleneck to recruitment during high productivity (La Niña) years. The preponderance of recruitment variability being differentially driven by food web-dependent and transport-dependent processes amongst a backdrop of contrasting environmental conditions may explain why correlations between the environment and recruitment break down over time and emphasizes the importance of context-dependency when studying mechanisms of recruitment variability. I conclude by putting these results into a broader ecosystem context, highlighting the role Shortbelly play as forage and the challenges they pose to EBFM.

(S10-16731 Oral)

Tradeoffs between shifts in phenology and geography among early life history stages of fishes in response to environmental changes in the Eastern Pacific

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In response to changing ocean conditions, marine fishes may shift where they are (geography) and/or when they are present (phenology) during climatically-sensitive periods, such as spawning. Understanding the distribution and seasonal timing of larval and juvenile fish occurrence is especially important, as small changes in mortality rates during the early life stage can lead to large changes in subsequent recruitment. In a changing ocean, these effects can become even more stark. We examined how fish with three life-history strategies (groundfish, coastal pelagics, and mesopelagics) balance the tradeoff between shifting their geography or phenology during their early life history. We assembled larval and juvenile fish abundance data from seven long-term sampling programs covering the region between Baja California Sur, Mexico and the Gulf of Alaska. A unique aspect of this work is that it allows for range-wide modeling even though no single survey covers the range of many of the target species. We modeled species distributions using a generalized linear mixed effects model that considers spatio-temporal autocorrelation (i.e., sdmTMB). Models examined salinity, sea surface temperature, sea surface height, and distance from shore as environmental covariates. Preliminary analyses indicate that fish tend to vary their geography more than their phenology, particularly among mesopelagics and coastal pelagic species. With these results, we build capacity to assess climate vulnerability of marine fish species and to determine the adaptive distributional capacity of commercially exploited and ecologically important fish to changing ocean conditions.

(S10-16789 Oral)

Genetic identification of early larvae of grenadiers (family Macrouridae) in the Bering Sea and Gulf of Alaska and spatial modeling of larval transport in the Bering Sea

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Grenadiers (Macrouridae) represent a taxonomic fish group of ecological importance in the North Pacific Ocean and several species occur in the Bering Sea and Gulf of Alaska. In Alaskan waters there are no directed commercial fisheries for grenadiers, nevertheless some are retained as by-catch in Sablefish (*Anoplopoma fimbria*) and Greenland Halibut (*Reinhardtius hippoglossoides*) Bering Sea fisheries. The North Pacific Fisheries Management Council has indicated that collection of life history information on data-poor species such as grenadiers is a research priority in Alaskan waters (NPFMC 2016). Early larvae collected from the large marine ecosystems in Alaska are not identifiable morphologically despite previous attempts. In this study, Macrourid larvae collected during ichthyoplankton surveys conducted in Alaska over a 40-year period by the Alaska Fisheries Science Center were examined and three species of grenadiers were identified from several specimens using genetic techniques. Additionally, output of a Bering Sea ocean circulation model is used to simulate possible larvae transport. The simulated drifters are seeded at the larva collection locations and tracked backward using modeled ocean currents from different depths, over time periods determined by larvae growth rates inferred from their sizes at the capture locations. Simulations suggest that where fish were spawned makes a big difference in transport distances and deep current differences likely reflect transport from spawning habitat. Future continuation of this work of drifter tracks guided by discrete spatial sampling may find that shifts in ocean currents as a consequence of changes in Aleutian low-pressure systems would likely impact larval transport patterns.

(S10-16811 Oral)

Expanding perspectives in marine mammal research: Leveraging eDNA metabarcoding for enhanced understanding of three-dimensional species distribution

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Marine mammals are rare and elusive, making them difficult to study. Distribution studies have traditionally relied on acoustic and visual methods, which are each subject to a set of biases. However, the emergence of environmental DNA (eDNA) metabarcoding has opened new possibilities for assessing species' presence in three spatial dimensions in marine ecosystems and may offer complementary data to traditional analyses to improve our understanding of marine mammal distributions. eDNA reflects marine mammal species and their prey, and recent advances in quantitative eDNA analysis may revolutionize ecological research. Here we will present results on eDNA metabarcoding analysis targeting marine mammals, cephalopods, and fishes aimed at deciphering the 3D (0 and 50m depth) spatial distribution of marine mammals in the northern California Current (Washington and Oregon) by evaluating the influence of prey species' distributions, as well as geographic and environmental parameters. This investigation illustrates the potential of eDNA metabarcoding to improve our understanding of the broad scale distributions of marine mammals and their prey in marine ecosystems.

(S10-16836 Oral)

Widespread shifts in phenology of fish early life stages associated with warming in Alaska

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Changes in the timing of fish spawning and early life stage development will affect their match or mismatch with production of preferred prey, as well as their availability to predators, with potential consequences for recruitment success and food-web dynamics. Using four decades of observations from spring ichthyoplankton surveys in the Gulf of Alaska and Bering Sea, we investigated long-term changes in the phenology of early life stages for over 30 fish species. Larval size-at-date was used as a proxy for larval developmental timing in spring, reflecting a combination of changes in spawn timing (larval age) and growth. Spatio-temporal models were used to account for variable sampling effort in space and time in order to isolate thermal effects on larval size. With a few exceptions, interannual variation in size obtained by June 1 was significantly and positively related to temperature, demonstrating widespread effects of warming on phenology of fish early life stages. However, the strength of response varied by species, which reflected differences in life history and ecology as well as analytical constraints associated with assessing some species only partly available to the survey. Long-term trends in size-at-date were uncommon, despite the clear thermal effects detected, which was not unexpected given the temperature variability observed in recent decades in these regions. We demonstrate an analytical method to assess long-term changes in phenology from larval size observations sampled at variable locations and times, and detect phenological shifts that were not necessarily identifiable from larval abundance data alone.

(S10-16862 Oral)

Using environmental DNA to reveal the influence of environmental factors on the forage fish community compositions

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Forage species are particularly sensitive to environmental fluctuations. However, the environmental effects on forage fish distribution have been investigated mainly in each species separately, leading to a limited understanding of the relationship between environmental factors and the community composition. Here, a multiplex real-time quantitative PCR approach was used to efficiently quantify environmental DNA in six forage species including Japanese anchovy (*Engraulis japonicus*), Japanese sardine (*Sardinops melanostictus*), chub mackerel (*Scomber japonicus*), blue mackerel (*Scomber australasicus*), Japanese jack mackerel (*Trachurus japonicus*), and Pacific saury (*Cololabis saira*). A total of 29 sampling sites data were collected from Noto Peninsula to Tsushima Island in Sea of Japan. The result of non-metric multidimensional scaling (NMDS) ordinations showed that the community structure of all samples can be divided into Group I (Japanese anchovy dominating), Group II (Japanese anchovy, chub mackerel and/or blue mackerel dominating), Group III (Japanese anchovy and Japanese sardine dominating) and others. The best-fit GAMs for the ordinations, determined by AIC, included temperature, bottom depth, dissolved oxygen, chlorophyll-a and salinity as the environmental explaining variables ($P < 0.05$). Distance-based redundancy analysis (db-RDA) provided evidence of salinity, temperature and bottom depth as the main influencing factors of community structures. Group I and Group III are positively correlated with salinity and bottom depth, indicating that they were more likely to distribute in high salinity and offshore areas. Our study demonstrates the complex response of fish communities to environmental variables, which implicates the importance of ecosystem-based fisheries management.

(S10-16871 Oral)

Mapping the distribution of forage fish in coastal British Columbia using environmental DNA

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Forage fish play crucial roles in coastal marine food webs in the North Pacific Ocean by transferring a significant amount of energy from lower trophic levels to high trophic predators. Despite the importance of forage fish in marine food webs, information on fish species distribution and habitat use are deficient and critical to implement efficient management strategies to maintain healthy populations. Compared to conventional biomonitoring tools, environmental DNA (eDNA) shows several complementary advantages, such as being non-intrusive, easy to implement on the field and having high rate of species detection. Our research aims to evaluate the potential of eDNA in monitoring fish biodiversity and addressing the existing gaps in understanding the distribution of forage fish species in BC coastal ecosystems. We compiled 12S eDNA data collected during the Canada C3 expedition in summer 2017, archived data collected by the Hakai Institute (Quadra Island, BC) along the BC coastline in summer 2019 and 2022, as well as data collected at multiple depths in five BC fjords in the winter and spring of 2023. To optimize species-level assignments and reduce misclassifications, the MIDORI 12S database was curated for the region of interest using species distribution information from the Ocean Biodiversity Information System (OBIS). Mapping the relative abundance of fish provided new insights on the horizontal and vertical distribution of these species and informed on the role of fjords as critical habitats and refugia for culturally and commercially important forage species such as herring, eulachon and capelin.

(S10-16874 Oral)

How accurately and precisely can fisheries-independent surveys assess phenological change among forage fishes?

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Changes in phenology of forage fishes can impact higher trophic levels that prey upon them. Understanding and projecting phenological change requires long time series, such as fisheries-independent surveys. However, few surveys sample frequently enough to detect phenological changes. Using surveys with suboptimal timing or frequency can bias phenology estimates, while variability in fish abundance can complicate phenological trend detection. We explore sampling impacts on phenology estimation using Monte Carlo simulations to model changes in seasonal occurrence of early-life stages of sardine and anchovy from surveys in the California Current System (CCS). Phenological shifts of 1-15 days decade^{-1} were simulated, and resulting distributions were sampled mimicking survey designs to produce design- and model-based estimates of phenological metrics. Design-based change estimates were most precise for the seasonal centroid and least precise for season duration. Fitting a variable-coefficient generalized additive model to survey data produced similar estimates of phenological change. In southern California, changes in sardine phenology could be accurately assessed, but with half the precision of anchovy. Biases emerged for anchovy when assessing rapid changes (>9 days decade^{-1}). In Baja California, simulated phenological change among summer-spawning sardine was under- or over-estimated based on survey timing, which also lead to erroneous estimates of trends in population size. In the northern CCS, the 2015-2016 marine heat wave led to abrupt changes in phenology and abundance of several forage fish taxa. In this region, variations in abundance throughout the time series obscured detectability of phenology trends to a greater extent than in the southern CCS.

(S10-16878 Oral)

Patterns in nutritional traits across environmental conditions in the North Pacific

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Nutritional composition can vary significantly within and among marine species. A few studies have associated variability in nutritional composition of small pelagic species with upwelling, sea surface temperature, seasonality, and location. We examined variation in nutritional traits across and within species of prey important for top predators in the California Current, including albacore tuna. Specifically, we evaluated energy density, and percent lipid and protein in fishes, squids, and tunicates from northern and southern regions of the California Current, collected during regional and NOAA research surveys in 2021. Overall, fishes had higher lipid and energy density values than squids (inter-specific variation) and showed more nutritional variability for all nutritional metrics (intra-specific variation). These patterns were consistent between the two oceanographically distinct regions of the California Current. To explore whether these overall patterns were conserved not only across natural oceanographic gradients, but also as environmental conditions rapidly changed within sub-regions, we compiled a literature-based nutritional dataset. We then assessed variation by comparing i) average lipid, protein, and energy density values for 25+ species to identify changes in rank among species as sea surface temperatures, chlorophyll levels, and El Niño–Southern Oscillation conditions varied over 40 years (inter-specific variation), and ii) variation in nutritional traits within each of those 25 species as the environmental conditions fluctuated over that timespan (intra-specific variation). Analyzing combined data sources on albacore tuna prey allows us to identify patterns in nutritional differences that may predict adjustments in the foraging behaviour of top predators encountering environmental changes.

(S10-16919 Oral)

Pacific salmon trophic interactions in the subarctic gyres

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The pelagic phase of Pacific salmon life cycles is crucial to the growth and survival of these species of vital ecological, economic, and cultural importance. However, interactions among salmon and with their predators, prey, and competitors in the open Pacific Ocean have hitherto received little attention. This paper presents the results of an investigation into these interactions using models of the subarctic gyre ecosystems of the northeastern and northwestern Pacific built in Ecopath with Ecosim. A suite of ecological metrics was computed in each model to quantify salmon trophic interactions. Firstly, trophic level, omnivory index, primary production required, ascendency, and keystoneness were calculated for individual food web nodes. Secondly, mixed trophic impacts, similarities in trophic level and diet composition, and predation mortality rates were evaluated for node pairs. Results suggested top-down impacts on salmon by sharks as well as intra- and interspecific competition among salmon. The latter finding is somewhat paradoxical considering the low predation mortalities inflicted by salmon on micronekton and zooplankton. Large squid and marine mammals are the main consumers of micronekton in the eastern and western gyres, respectively, while ctenophores and chaetognaths are the dominant predators of zooplankton in both ecosystems. The apparent paradox likely results from high pelagic food web complexity, omnivory, and ascendency, indirect competition among salmon for production at trophic levels below their prey, and apparent competition mediated by differential predation on salmon species. These findings advance our understanding of Pacific salmon pelagic ecology and will be further refined and tested using ecosystem simulations.

(S10-16920 Oral)

Species composition of mesopelagic fish catches in the coastal NE Pacific Ocean and the presence of potentially indigestible lipids

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Total marine fish biomass is thought to be dominated by mesopelagic species. The ecological importance of mesopelagic fish to ecosystem function has been established in some marine systems, but in others, our knowledge is rudimentary. In the NE Pacific Ocean, we lack information on the biochemical properties of mesopelagic species and their suitability as prey for higher trophic levels. The purpose of this ongoing study is to identify and catalog mesopelagic species caught off the west coast of Canada and the US, and to characterize their diets and condition using lipids. A total of 22 species from 10 families were identified using a combination of traditional taxonomic methods and COI barcoding. The digestive tracts and otoliths were removed before whole fish were freeze-dried, ground, and their lipids extracted. The myctophid *Diaphus theta* generally dominated the mesopelagic portion of catch biomass, except when trawls were conducted below 300 m. In deeper trawls, stomiids and the myctophids *Lampanyctus regalis* and *Stenobrachius leucopsarus* dominated the biomass. On a mass basis, myctophids contained more total lipid than any other fish family. Of the eight myctophid species analysed, four contained triacylglycerol (*D. theta*, *Tarletonbeania crenularis*, *Notoscopelus* sp., *Lampadena urophaos*) as their primary storage lipid, and four contained wax esters (*L. regalis*, *L. ritteri* and *S. leucopsarus*, *S. nannochir*). Ingestion of large amounts of wax esters by a variety of predators is associated with poor growth and digestibility.

(S10-16921 Oral)

Dietary and spatial overlap among jellyfish and small pelagic fish in the eastern Bering Sea during warm ocean conditions

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Populations of scyphozoan jellyfish in the eastern Bering Sea (EBS) can grow rapidly within a single season and have fluctuated widely over recent decades. Understanding the role of jellyfish in the EBS ecosystem is required for fishery and ecosystem management, however we lack direct measurements of the impact that changes in jellyfish abundance have had upon this ecosystem and its fish populations. We examined the role of jellyfish as competitors of juvenile forage fishes (herring and gadids) and juvenile salmonids by (1) examining the diets of the dominant scyphozoan jellyfish in the region, *Chrysaora melanaster*, and (2) estimating the dietary and spatial overlaps among jellyfish and major planktivorous pelagic fish taxa. Ocean sampling for diet analyses occurred in two contrasting years: 2014 (high jellyfish biomass but cooler temperatures) and 2016 (low jellyfish biomass but warmer temperatures). Jellyfish diets were very diverse and contained primarily small copepods and pteropods but showed mostly low overlaps with small pelagic fishes, which consumed mainly euphausiids and small fishes. Fishery research data were used to examine the spatial overlap of small pelagic fish and jellyfish within the EBS during the summers of 2014 and 2016. Generally, jellyfish and the small pelagic fishes showed low spatial overlap, but there were some high spatial overlaps among the small pelagic fish and salmonids. Spatial overlap and trophic relations are not uniform throughout the EBS nor across years, however, regions of high overlap do occur, which could result in resource competition in low productivity years or areas.

(S10-16922 Oral)

Effects of distribution and abundance of small pollock on fish predators and northern fur seals

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Within the eastern Bering Sea shelf, northern fur seals (NFS), Pacific cod, arrowtooth flounder and walleye pollock can jointly consume over a million tons of pollock per year. A large proportion of the pollock consumed is 30 cm or less in length. We look at pollock ≤30 cm, their distribution from acoustic (2004 -2018 non-continuous) and bottom trawl (1991-2021) surveys, the predators diets and distribution to evaluate the potential competition between NFS and fish predators. The populations of these pollock consumers have changed significantly in biomass and location since the early 1990's. Cod, pollock, and arrowtooth flounder are three of the main commercial species in the eastern Bering Sea. We evaluated the overlap of small pollock, fish predators, and NFS, using year-specific summer distribution maps of small pollock and fish predators (pollock, cod, arrowtooth flounder) overlapped with multi-year aggregated foraging ranges for NFS. Prey size preference and diets for fish predators were estimated from stomach samples collected during the bottom trawl surveys. In addition to the interannual variability of fish distribution and abundance, the overall distribution of pollock, cod and arrowtooth has shifted northward and towards the middle shelf which in turn has changed the overlap with NFS lactating females. The diets of the fish predators also show changes over time within the foraging range of NFS lactating females. This study helps inform ecosystem based management of pollock, its fish predators and NFS by providing insights into the effects of environmental conditions on their feeding interactions, distribution shifts and overlaps.

(S10-16929 Oral)

Using marine fatty acid data to estimate the nutritional quality of micronektonic organisms in the British Columbia coastal ocean

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The nutritional quality of prey species is critical to consumer health in terrestrial and aquatic food webs. Fatty acids (FAs) provide an effective measure of nutrition as they are transferred from prey to predator throughout the food web and promote the health of an organism. In marine ecosystems, small pelagic fish (i.e., micronekton; between 20-300 mm total length) occupy the middle trophic levels and are thus the conduit between the lower (zooplankton) and higher (nekton) trophic levels. In this study, we examined variation in micronekton prey quality in British Columbia coastal waters. Specifically, we 1) compared nutritional quality among a diverse group of micronekton at a single region and, 2) compared nutritional quality of micronekton species across adjacent coastal areas with different oceanographic conditions. Micronekton were sampled in the summer of 2019, from the Strait of Georgia, Queen Charlotte Strait, Queen Charlotte Sound, and Strait of Juan de Fuca. Fatty acid (FA) profiles were measured, and total fatty acid content, essential fatty acid content, and DHA:EPA were used as nutritional metrics. There was considerable nutritional variability among species within regions and within species across regions. Species differences indicate the relevance of distinct feeding habits and species-specific metabolic pathways for FA composition. Within species differences in FA metrics at small spatial scales highlight the importance of local ocean conditions in determining prey quality. Overall, our work provides evidence that food web nutrition will change in response to shifts in community composition or environmental conditions.

(S10-16959 Oral)

Using predator diets to inform forage fish distributions and interannual trends

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(*Presented by Matthew Baker on behalf of Kayla Gunther*)

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Forage fishes comprise an integral part of marine food webs in the highly productive ecosystems of the North Pacific. Standardized bottom trawl surveys are critical to stock assessment of groundfish but lack the gear and protocols to quantitatively evaluate populations of small pelagic fish. Significant knowledge gaps exist related to the status of forage fish, their life histories, and how populations may react to future climactic shifts. Where diet data are available, predators may be used as an indirect method of collecting forage fish data. We used a comprehensive dataset on predator-prey interactions in the eastern Bering Sea to analyze the distribution of five forage taxa over a 34-year time series (1985-2019). Using four dominant groundfish, we constructed forage fish and predator depth and temperature habitat profiles and used center of gravity analysis and global index of collocation to examine predator-prey overlap. Results provide insight on habitat partitioning and competitive interactions between forage species and dynamics between predators and prey. Interannual center of gravity analyses indicated recent periods of cooling (2007-2013) and warming (2014-2019) had significant effects on the distribution of forage fish populations and suggest differences in the relative resilience of forage fish populations to climate change in this region. Population shifts were particularly evident in recent periods of anomalous warming, highlighting the need to understand how future periods of prolonged warming may affect predator-prey dynamics. Results also demonstrate the importance of predator diet timeseries and how these data might inform multi-species models and management strategies.

(S10-16553 Poster) S10-P1 (ECOP)

Growth and food requirement of chub mackerel *Scomber japonicus* larvae in the northern Satsunan area, southern Japan

Hiroki **Oba**[1], Toru Kobari[2], Taichi Shigemura[3], Kazuhiro Shiozaki[2], Mutsuo Ichinomiya[4], Tomohiro Komorita[4] and Gen Kume[2]

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The northern Satsunan area, southern Japan is used as an important spawning and nursery ground for chub mackerel *Scomber japonicus* during a high-stock period. We estimated growth and food requirement of *S. japonicus* larvae in the study area. Larvae were collected using the ORI net at 15 stations in the mouth of Kagoshima Bay and adjacent area to analyze growth in 2018, 2019, and 2022, and to estimate predation impacts on mesozooplankton in 2021. Prior to growth analysis, *S. japonicus* larvae were identified by PCR-RFLP method. The effects of temperature and mesozooplankton biomass on the recent growth rate (RGR) were analyzed using a generalized linear mixed model, which showed that only temperature positively affected the RGR of larvae. To estimate predation impacts on mesozooplankton, food requirement was estimated for *Scomber* spp. larvae (*S. japonicus* and *Scomber australasicus*). The weight-specific growth coefficient (Gw) was 0.14 d^{-1}. Based on the reported relationship between Gw and ingestion rate of the larval fishes, the daily ration was calculated to be 51.6% of body dry weight. Predatory impact of *Scomber* spp. larvae on the production rate of mesozooplankton was estimated to be approximately 0.08–1.1%. These results suggest that the northern Satsunan area a would be a favorable nursery ground to support early growth of *S. japonicus*.

(S10-16724 Poster) CANCELLED S10-P2 (ECOP)

~~Did Southeast Alaska provide refuge for juvenile salmon during recent marine heatwaves?~~

~~Mariela K **Brooks**, Emily Fergusson, Matthew Rogers, Wesley W Strasburger and Robert M Suryan~~

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~~Pacific salmon (*Oncorhynchus* spp.) play an important ecological role and provide important subsistence, commercial, and recreational fishery opportunities. Juvenile salmon growth and survival have been linked to marine trophic ecology and oceanographic conditions. Recent marine heatwaves in the North Pacific have created notable ecosystem effects. It is important to place observations of trophic ecology and fish condition into context within the increasing prevalence of ecosystem changes and stressors during these heatwave events. Juvenile salmon samples were collected from 2010-2019 in Icy Strait, a major fish migration corridor in the northern Southeast Alaska archipelago. We analyzed morphometrics, energy density, stomach contents and bulk $\delta^{13}C$ and $\delta^{15}N$ stable isotopes in four juvenile salmon species (chum (*O. keta)*, coho (*O. kisutch*), pink (*O. gorbuscha*), and sockeye (*O. nerka*)). We used stable isotopes and diet composition to assess variability in relative isotopic niche and trophic overlap and evaluate effects on body condition during a period that included significant and persistent warm periods. Despite observed interannual variability in isotopes and diet over the 10-year record, late summer juvenile condition showed less variability across species and did not appear to be clearly related to offshore marine temperature anomalies, suggesting that the inside waters of Southeast Alaska may provide temporary refuge to juvenile salmon prior to migration into the Gulf of Alaska.~~

(S10-16838 Poster) S10-P3 (ECOP)

Shifts in the distribution, size structure, and feeding of Arctic cod early life stages in a changing Pacific Arctic

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Arctic cod (*Boreogadus saida*) are the most abundant fish in the Arctic Ocean and a key prey resource linking upper and lower trophic levels of the Arctic marine food web. However, the impacts of Arctic warming, sea ice loss, and changing sea ice phenology on this ice-associated species is challenging to predict due to a lack of early life history data in the Pacific Arctic. We compared the distribution, size structure, and feeding of the early life stages of wild-caught Arctic cod from warm (2017-2019) and cold (2012-2013) climate conditions in the Chukchi Sea to assess potential impacts of the rapid ecosystem change observed in the Pacific Arctic in recent years. The highest abundances of Arctic cod larvae in late summer were found during cold years in the northeastern Chukchi Sea. While Arctic cod larvae showed similar size-frequency distributions in cold years, the size of fish captured in warm years was more variable. Preliminary diet data indicate a shift in prey composition with ontogeny and the availability and abundance of zooplankton prey. Zooplankton prey dynamics are tightly linked to shifting sea ice phenology and prevailing oceanographic conditions and may account for inter-annual differences in Arctic cod feeding and growth. These data highlight important relationships between sea ice and oceanographic variability and the distribution, feeding, and survival of Arctic cod early life stages in a rapidly changing Pacific Arctic ecosystem.

Session 11: BIO Topic Session

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

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

Invited Speakers:
Brianna Abrahms (University of Washington, Department of Biology, Center for Ecosystem Sentinel, USA)
Nick Bond (University of Washington, Cooperative Institute for Climate, Ocean and Ecosystem Studies (CICOES), USA)
Kaoru Hattori (Fisheries Resources Institute, Fisheries Research and Education Agency (FRA), Japan)
Barbara Muhling (NOAA, University of California Santa Cruz, USA)
Yutaka Watanuki (Faculty of Fisheries Sciences, Hokkaido University, Japan)

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

(S11-16488 Invited)

Climate conditions mediate the costs and benefits of migration strategies in a North Pacific marine top predator, the northern elephant seal

Briana **Abrahms**[1], Elliott L. Hazen[2,3], Steven J. Bograd[2], Justin S. Brashares[4], Patrick W. Robinson[2], Kylie L. Scales[5], Daniel E. Crocker[6] and Daniel P. Costa[2]

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As climate change impacts ecosystems, research advancing understanding of how climate variability influences the trade-offs of behavioral strategies is critical to anticipating species' responses to future change. Site fidelity, the tendency to return to repeated sites for foraging, breeding or shelter, is a widespread strategy observed across many taxa and is theorized to confer a fitness advantage in unpredictable environments over long timescales. However, such rigid behavior could become maladaptive in environments undergoing rapid change. Here, we combine a decade of satellite tracking data on migratory northern elephant seals (*Mirounga angustirostris*), measurements of individual mass gain, and oceanographic data to examine the relative costs and benefits of site fidelity under different Pacific Decadal Oscillation (PDO) phases. Contrary to expectation, strong and weak site fidelity strategies performed similarly over 10 years, but the success of each strategy varied interannually and was strongly mediated by climate conditions. Individuals with strong site fidelity performed best under neutral PDO phases, had lower interannual variation in mass gain, and used areas that had relatively stable resources over time. Individuals with weak fidelity performed best during anomalous PDO phases, had higher variation in mass gain, and foraged in areas with less habitat stability. Such results suggest that the evolutionary benefits of site fidelity may be upended by increasing climate variability predicted in the North Pacific. Our study offers insight into the adaptive responses of marine predators to new climate regimes and highlights how individual behavioral variation may modulate the adaptive capacity of species to climate change.

(S11-16636 Invited)

Future changes in habitat suitability, foraging grounds, and energy dynamics of North Pacific albacore

Barbara A. **Muhling**[1,2], Stephanie Snyder[3], Jong-Yeon Park[4], Catherine F. Nickels[1,2,5], Rebecca Whitlock[6], Charles A. Stock[7], Elliott L. Hazen[8], Heidi Dewar[2], Desiree Tommasi[1,2] and Barbara A. Block[9]

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Long-distance migrations can allow marine animals to optimize their use of seasonal prey resources. These behaviors are frequently shaped by evolutionary history, and may be adapted to maximize energy gain through time. However, as climate change impacts the productivity and phenology of ocean ecosystems, migratory strategies which were beneficial in the past may become less advantageous. Juvenile albacore tuna (*Thunnus alalunga*) migrate extensively between the California Current System and the offshore North Pacific. During these migrations, they are targeted by fisheries in the territorial waters of multiple countries, as well as on the high seas. Previous research suggests that albacore movements and energy gain are partially predictable based on water temperature and secondary productivity. In this study, we use projections from an earth system model (GFDL ESM4.1) to examine how the spatial distribution of albacore foraging grounds and migratory corridors may change into the future. In addition, we show how their ability to gain energy from coastal and offshore ecosystems may be impacted. Our results demonstrate how climate change can shift the energetic balance of foraging migrations in pelagic species, as well as redistributing thermally suitable habitat. These shifts in favorable habitat of top predators can impact the trophic structure of ecosystems, as well as the availability of commercially important species such as albacore to fishing fleets from different nations.

(S11-16648 Invited)

Climate change in NW Pacific and prey and reproductive performance of surface feeding and diving seabirds

Yutaka **Watanuki**, Risa Sakai, Aya Kumagai, Jumpey Ookado and J.B. Thiebot

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Climate change drives shift of forage fish community, which affects diet, foraging area, and reproductive performance of seabirds. To understand these processes in surface feeding black-tailed gulls *Larus crassirositris* (BTGU) and underwater feeding rhinoceros auklets *Cerorhinca monocerata* (RHAU), we monitored their diet and breeding performance for more than 30 years, and measured their at-sea movements using GPS data-loggers in 3 years of contrasting prey species. BTGU showed good performance in the periods of sand lance *Ammodytes* spp., but RHAU showed good and poor performance in the periods of anchovy *Engraulis japonicus* and juvenile greenling *Pleurogrammus azonus*, respectively. Foraging distance of BTGU was short in a year of juvenile anchovy and that of RHAU was long in a year of juvenile greenling and short in a year of juvenile anchovy; reflecting the habitats of these forage fish species. Day feeding-day provisioning BTGU increased trip duration as they fed in the distant locations within 30 km and day feeding-night provisioning RHAU showed step-wise increase of trip duration when foraging distance was longer than 150 km. The energy value of prey and food-packaging of predators in relation to prey species and the linear/non-linear relationships between foraging distance and trip duration may induce species difference in the breeding performance under the shift of prey species. Small parental energy reserve of RHAU may also constraint their behavioural flexibility. This study highlights the importance of species-specific constraints that affects breeding performance of seabirds in the recent unconventional climate change.

(S11-16687 Invited)

Long-term changes in the spatial distribution of Steller sea lions around Hokkaido Island, Japan

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Hokkaido Island is located at the southern limit of the Steller sea lion (*Eumetopias jubatus*) Asian population distribution range and is used as a wintering ground. Their seasonal movement is considered to be easily affected by prey availability and oceanographic conditions. Here we provide a brief review of the long-term changes in the spatial distribution of sea lions wintering in Hokkaido along with the backgrounds. In early 20th century, when the Kuril Islands were the main breeding grounds in the Asian population, many migrated to the nearby Nemuro Strait and the Pacific coast of Hokkaido Island, but the wintering population almost disappeared from the Pacific coast along with the decline in their breeding population. Since the late 1980s, on the western side of the Sea of Okhotsk, Tuleny Island was established as a permanent breeding ground and the population began to grow rapidly. As a result, migration to the Sea of Japan side of Hokkaido increased, and its distribution range extended to southern Hokkaido. Analysis suggested that the early timing of sea ice breakup contributed to the increase population on Tuleny Island. This may have been mediated not only by Steller sea lions and climate change, but also by competition with the sympatric northern fur seal (*Callorhinus ursinus*). In recent years, the massive aggregations of sea lions has been observed at the northern end of Hokkaido. This concentration might be due to changes in prey availability during the wintering season.

(S11-16714 Invited)

Observed and projected changes in the North Pacific relevant to marine ecosystems

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The North Pacific Ocean is responding to global climate change. Some aspects of this transition have already emerged above the natural variability, and other elements are expected to be manifested as the climate continues to warm. Is the warm anomaly that has been prominent in the central North Pacific over about the last 5 years liable to become a more-or-less permanent feature of its atmosphere-ocean system? Does the onset of El Nino in 2023 herald the end of a prolonged period with a preponderance of La Nina conditions in the tropical Pacific? How well do the climate indices developed based on historical records represent the present (and projected) state of the North Pacific? These issues are explored from an ecosystem perspective considering their linkages to phenomena such as marine heat waves (MHWs), upper ocean stratification/mixing, and ocean chemical properties.

(S11-16612 *Waitlisted for oral presentation*) **CANCELLED**

~~Generalists, specialists, and shifting seas: phenological match and mismatch, diet diversity, and anthropogenic change in seabirds~~

~~Amy **Miles**[1*], Thomas P. Hahn[1], John Wingfield[1], Marcel Holyoak[1], Michael Johns[2], Heather Major[3], Anthony Diamond[3] and Joshua Hull[1]~~

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~~Conservation of marine top predators is a critical component of maintaining ocean health. By studying the interaction between phenotypic traits, we can both improve understandings of life-history ecology and identify at-risk species under anthropogenic environmental change. In this study, we investigated the interaction between two traits, diet flexibility and variation in reproductive phenology, in seabirds through global meta-analysis. We discovered that flexibility in diet is correlated with flexibility in reproductive timing, with generalists more variable in timing than specialists. We also found that reproductive success is more variable in specialists, suggesting that although they may not be adjusting their breeding timing to match with resource pulses, trophic matches and years with favorable conditions are particularly beneficial to specialist species. Despite these effects of diet flexibility on phenology and productivity, we found no evidence of differences in changing phenology across a generalist-specialist spectrum. Seabird breeding phenology is growing later globally, among generalists and specialists alike. We also found global declines in reproductive productivity and suggest that generalists and specialists are suffering from the effects of human-induced rapid environmental changes equally.~~

(S11-16703 Oral)

Modeling resilience and its limits from phytoplankton to salmon: Learning from Atlantic–Pacific comparisons at four trophic levels

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Our empirical understanding of plankton and fish has been built up incrementally through intercomparison of detailed regional studies: more like anthropology than theoretical physics. Ecological modeling benefits from the same approach: here we outline ongoing efforts to transfer insight back and forth between Atlantic and Pacific case studies at four trophic levels. (1) A simple nutrient-phytoplankton-zooplankton (NPZ) framework originally tuned using Bering Sea observations is being applied to the Barents Sea spring bloom, in an ensemble approach that systematically addresses uncertainty in the dynamics of bloom growth and termination. (2) A trait-based model of large copepods has been run along a California–Chukchi coastal gradient and a matching subtropical–Arctic gradient in the Eastern Atlantic. Results suggest a highly adaptable growth/development/timing "recipe" for the *Calanus* species complex that predicts high resilience and replaceability in some areas of rapid climate change (the Barents Sea) but simultaneously predicts hard environmental limits in others (like the warming Southeastern Bering Sea). (3) An optimality-based model of sandeel prey selection and growth accurately describes patterns of resilience and decline in the North Sea, and is being generalised into a trait-based framework for "forage fish growth potential" in other oceans. (4) Inspired by past Salish Sea projects, a new life-cycle model for wild Atlantic salmon integrates bottom-up changes in ocean energetics with carryover effects from the freshwater phase in an interactive decision-support tool. This brief overview is intended as an invitation to new UK–Pacific collaborations.

(S11-16733 Oral)

The Thermal Corridor Hypothesis: an experimental oceanographic approach to understanding the effects of ocean warming to North Pacific loggerhead sea turtles

Bianca S. **Santos**[1*], Dana K. Briscoe[1,2,3], George H. Balazs[4], Jeffrey J. Polovina[5], Jeffrey A. Seminoff[6], Alberto Abreu-Grobois[7], Masanori Kurita[8], Masanori Mori[8], Denise M. Parker[9], Marc R. Rice[10], Tomomi Saito[11], Calandra N. Turner Tomaszewicz[6], Noah Yamaguchi[11] and Larry B. Crowder[1]

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The North Pacific loggerhead sea turtle, *Caretta caretta*, undergoes one of the greatest of all animal migrations, entering the sea as hatchlings from nesting beaches in Japan and appearing years later along foraging grounds off Baja California Sur, Mexico after spending several years or more living in the Central North Pacific (CNP) high seas. The mechanisms that connect these distant habitats have remained poorly understood but are crucial for managing this endangered species. This is especially true given recent spatial shifts associated with warm water events. Our research group analyzed 15 years of data from satellite-tagged juvenile loggerheads released in the Western and Central North Pacific and proposed the Thermal Corridor Hypothesis (TCH) based on observations that turtles in the CNP transition eastward to the North American coast as a function of ocean variability. To test this hypothesis, we have initiated the first-of-its-kind experimental oceanographic approach for a top marine consumer, deploying satellite tags on cohorts of 25 juvenile loggerheads in the Eastern North Pacific high seas across four years with variable environment conditions (2023-2026). Here, we discuss the anticipated movements of loggerheads from the 2023 cohort, with the expectation that turtles will move eastward towards the North American coast given the forthcoming El Niño conditions, which will likely result in the opening of a thermal ‘corridor’ of warm water bridging these two regions. The outcome of this work has critical implications for conservation and management. As the North Pacific continues to undergo unprecedented changes in the Anthropocene, understanding how sentinel species such as sea turtles will respond and adapt to climate variability is imperative to effectively maintaining and managing healthy ecological connections across their entire North Pacific habitat.

(S11-16764 Oral)

Understanding factors influencing species sentinel ability for climate change, pollution and human health

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We are already experiencing the rapid pace of environmental change in the Anthropocene, necessitating the development of new tools and techniques for measuring changes in ecosystem dynamics. Sentinel species from birds to invertebrates, have been used to provide insight into ecosystem function, leading indicators of risk to human health, and as harbingers of future change, with possible implications for human health as well. Here we offer an update to our previous research identifying marine top predators as an indicator of ecosystem change, to also examine terrestrial sentinels and the latest research on sentinels of pollution and human health. Using ecosystem sentinels enables rapid response and adaptation to ecosystem variability and environmental change in part because they may be easier to observe, and in part because they may serve as leading indicators of ecosystem change. We update with the latest research on climate and ecosystem sentinels, including a metanalysis of publications that have claimed their species as a useful sentinel. While there may not be a given taxa that is best suited as sentinels, we highlight the factors that make the most effective sentinels including examples of when sentinel species have been incorporated in mammals. Choosing a suite of appropriate sentinels will both give insight into ecosystem processes and can help manage changing ecosystems into the future.

(S11-16788 Oral)

Projections of climate change impacts on California Current predators and food webs

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The California Current off the US West Coast has experienced recent heatwaves as well as long term increases in temperature. Future projections under climate change suggest continued warming, deoxygenation, and acidification, which may affect predators both directly (due to physiological constraints) and indirectly (due to forage abundance and distribution). In the context of the “Future Seas” and “GC5” projects, our research group has refined an Atlantis ecosystem model to understand two relevant aspects of climate change. First, we benefit from a new generation of species distribution models (SDMs) that include environmental covariates such as temperature, oxygen, and chlorophyll. The SDMs define environmental niches for predators and prey, and subsequently the Atlantis model tests the implications of these niches and associated spatial shifts in terms of trophic dynamics. Second, we force Atlantis with downscaled oceanography, driven by Earth System Models under a high emissions scenario interpolated to match hindcasts from a data-assimilative global ocean reanalysis (GLORYS). These high resolution temperature fields drive consumption, mortality, and growth rates of all species within Atlantis, and downscaled currents advect forage including plankton. For both demersal and pelagic predators, we find that shifting distributions drive stronger ecosystem responses than do physiological responses to temperature alone. Also, in part due to higher magnitudes of predicted spatial shifts, we find pelagic predators to be more impacted in future projections than demersal species. However, these impacts are not universally negative, and in some cases predators (especially highly mobile pelagic predators) do benefit from anticipated ocean change.

(S11-16803 Oral)

Applying traits to explore climate-driven variability in albacore tuna resource use in the California Current Large Marine Ecosystem

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As global climate change drives reorganization in marine communities, understanding how predators respond to variations in prey assemblages is critical to forecasting future population dynamics and, at a wider scale, food-web functioning. While prey availability is an important factor driving predator consumption, biological traits (e.g. habitat, behavior, morphology, nutrition) are key aspects mediating predator-prey dynamics. In particular, trait-based frameworks can help simplify complex foraging dynamics, highlighting recurring characteristics across diverse consumed taxa, and elucidate potential mechanisms governing interactions between prey and predators. Here, we used such a framework to understand resource use by albacore tuna (*Thunnus alalunga*), a highly migratory species targeted by pelagic fisheries globally. Applying traits to historical (2005-2019) juvenile albacore diet data and prey community composition reveals that consistent trait forms are selected across time and space in the California Current Large Marine Ecosystem. We use these insights into traits that inform albacore feeding as a tool to facilitate predictions of prey resource use under climate-driven change. First, by applying these traits to datasets on forage community composition, we aggregate across shared functional roles relevant to the predation process, to identify hotspots of highly suitable prey for albacore and relationships with environmental conditions. We ultimately explore the capacity of traits for predicting patterns in albacore feeding, using statistical modeling to evaluate how traits of available preyscapes and environmental conditions explain long-term variability in diets. This enhanced understanding of albacore resource use will enable us to better anticipate the impact of changes in prey assemblages on predator productivity and distribution as pelagic communities are altered by climate change.

(S11-16822 Oral)

Comparing functional diversity and redundancy with species diversity and turnover across scenarios to identify climate refugia for marine megafauna in the Northeast Pacific

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In the face of escalating pressures from climate change, we need to properly understand how marine organisms are responding. Current approaches in ocean management and conservation planning typically aim to identify and protect climate refugia defined as i) areas with persistent species taxonomic diversity over space and time, and/or ii) areas with stable climatic conditions (i.e., climate analogs). However, this approach critically overlooks complex shifts in functional diversity of community assemblages driven by climate-induced turnover of species and related functional traits. Here, we innovatively define climate refugia as areas where functional diversity persists over space and time, independent from persistence in species taxonomic diversity and/or climate analogs. We performed a scenario analysis by modelling the functional space of marine megafauna in the Northeast Pacific using 19 functional traits. We analyzed functional diversity and redundancy in relation to species diversity and turnover. Although moving northwards, some ecoregions' functional diversity changed at lower rate than taxonomic diversity, meaning that the turnover of species did not correspond to a similar functional diversity shift. Moreover, With the combined analysis of taxonomic and functional diversity patterns we also identified areas where their relative change will place to new systems, including areas with increased functional diversity and redundancy. This novel approach to climate refugia will help shape future protection and goals of conservation while considering the capacity of these new systems to provide functions and related ecosystem services in the future.

(S11-16859 Oral)

Northward habitat expansion of whale shark (*Rhincodon typus)* in the Western Pacific region

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Climate change has shifted the global distribution of marine organisms. According to the International Union for Conservation of Nature (IUCN), whale shark (*Rhincodon typus*) is widely distributed between approximately 30°N and 35°S, with occasional seasonal migration to the north and south. Recently, changes in the spatial distributions of whale shark were detected; the Ishikawa coast near 36.5°N in Japan was recorded as the northernmost limit of the distribution for whale shark in the western Pacific Ocean, but recently, this species has been observed occasionally near 38.4°N in the coastal sea off the east coast of Korea. In this study, using 16 years (2004–2019) of whale shark presence only data in the Indian and Pacific Oceans, we applied both the Gradient Boosting Machines model and the Generalized Additive Model to assess whether the occurrence of whale sharks in Korean waters was an accidental event or whether the suitable spatio-temporal habitat was formed in Korea waters. Environmental predictors in the full model included chlorophyll-a, model-estimated net primary productivity, sea surface temperature, water depth, and distance to shore. Habitat suitability was mainly driven by the spatial variation in bathymetry and sea surface temperature, although these effects differed slightly by season, with overall range expansion. These results provide insight into possible geographic variation of whale shark and the potential suitable habitat of the endangered and vulnerable species for their conservation under a rapidly warming climate.

(S11-16873 Oral)

Examining distributional shifts of spawning and feeding migrations of Pacific cod in Alaska with Satellite popup tags

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Pacific cod (*Gadus macrocephalus*) is a key component of the Eastern Bering Sea ecosystem. Warming in recent years has resulted in dramatic shifts in the distribution of Pacific cod in Alaskan waters. Particular concerns include a northward shift from the Eastern Bering Sea to the Northern Bering Sea and seasonal movement between the Gulf of Alaska and Bering Sea management areas.
This study examines the changes in seasonal distribution patterns with Satellite popup tags. These tags provide information on the location of the fish at time of popup as well as light, temperature, and depth data. We estimate movement paths with a hidden Markov model (HMM) and reconstruct the travel paths of individual fish and produce monthly maps of tagged cod distributions. Results from tags released in the summer in the Northern Bering Sea show that fish migrated south to spawn in previously observed spawning locations of the Eastern Bering Sea, suggesting that the Northern Bering Sea summer population is a northward expansion of Eastern Bering Sea and Gulf of Alaska Pacific cod stocks. Results from tags released in the winter in the Western Gulf of Alaska indicate that a high percentage may move north into the Bering Sea, including the Northern Bering sea, Russia, and the Chukchi Sea during the summer months. These northward shifts in Pacific cod distribution and the seasonal movement across management boundaries pose challenges for stock assessment and results from this study have provided valuable information for spatial management of Pacific cod stocks.

(S11-16930 Oral)

Changes in North Pacific ocean conditions and seabird productivity understood through comparison to other northern hemisphere ecosystems

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As top predators, seabirds are both critical to marine ecosystem structure and function, and are considered to be excellent near-real time sentinels of key changes in pelagic food webs and other anthropogenic factors. Long-term monitoring programs around the world have shown that seabird demographic rates are in decline, heralding the widespread and profound influence of climate change. However, rates of environmental change vary both among and within geographic regions with differing consequences for ecological communities including top predator species. Comparison of seabird demographic data across regions can thus provide insight into how spatial variability of environmental stressors, such as ocean warming and stratification, influence marine ecosystems. Using a recently expanded and updated database on seabird breeding success, we examine geographic variability in breeding productivity trends and relationships between breeding success and high-resolution stratification, sea surface temperature (SST) and primary productivity (chl-a) data from the European GLORYS12 model. While seabird breeding success has declined over the past half-century throughout the northern hemisphere, rates of decline are among the highest in the Arctic where SSTs are warming rapidly. Conversely, the eastern and western sides of the North Pacific are regions of relative stability in seabird breeding success. Comparison of seabird demographic rates across geographies reveals not only where species are most at risk, but also helps to identify patterns and processes that may confer either climate resilience or vulnerability to North Pacific seabirds.

(S11-16984 Oral)

Assessing seabird distributional shifts in response to climate change in the Gulf of Alaska and Bering Sea

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Marine climate has shifted sharply in the North Pacific over the last 40 years, which may be driving distributional and demographic shifts in marine communities. Using the recently updated North Pacific Pelagic Seabird Database (NPPSD v.4) and a Vector Autoregressive Spatiotemporal Modeling (VAST) framework, we quantified shifts in seabird distribution during the summer-fall (May-October) from 1981-2021, and asked whether these movements match physical shifts in marine habitat. To do this, we applied an Empirical Orthogonal Function (EOF) spatial temporal model to a multi-species assemblage of seabirds (10 taxa groupings) on a decadal scale throughout the Gulf of Alaska, Bering Sea, and southern Chukchi Sea. Seabird distribution shifts, calculated as Center of Gravity, leading edge and trailing edge metrics per decade, were correlated with the Velocity of Climate Change (VoCC; i.e. isothermal shifts calculated as km/yr) within the study region. Preliminary results suggest East-West movement for most seabird taxa in the Gulf of Alaska over this time frame, and North-South movement in the Bering Sea. VoCC patterns were relatively mixed during the 1980's and 1990s, followed by a cooling period in 2002-2011 and a strong positive shift in 2012-2021. These results potentially corroborate the hypothesis of northerly isothermal shifts causing an increase in seabird density in the northern sector of the Bering Sea. Seabirds are acknowledged indicators of ecosystem processes, and identifying the spatial linkages between seabirds and VOCC contributes to a broader understanding of how marine communities are responding to hydrographic change in the North Pacific.

(S11-16988 Oral)

Impacts of global warming on transport and dispersal of the Pacific bluefin tuna in early life stages

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Climate change-induced variations in ocean conditions such as water temperature and ocean currents can have significant impacts on the early life growth and survival of marine fish species. By using high-resolution particle tracking methods, this study investigated the effects of global warming on the transport and survival of Pacific bluefin tuna *Thunnus orientalis* eggs and larvae in the two spawning grounds (the Pacific Ocean and the Sea of Japan). Particle simulations under the present-day climate (1976–2000) and the future climate (2076–2100) showed no significant difference in the transport routes of the bluefin eggs and larvae in both spawning grounds. The increased velocity of the Kuroshio Current and the Tsushima Warm Current in the future climate transported the particles to more distant nursery areas, but not necessarily resulted in an increase in an overall arrival rate. The survival rate, on the other hand, decreased significantly by 60% in the Pacific Ocean and 25% in the Sea of Japan due to exposure to higher water temperatures. The simulation results of both advanced and northward spawning scenarios mitigated the effects of such a warming climate, suggesting these adaptive responses could be effective strategies for bluefin survival in future climate warming.

(S11-16537 Poster) S11-P1 (ECOP)

The effects of climate change-induced environmental variability and fishing operation on the spatiotemporal distribution of bigeye tuna in the Pacific Ocean

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Climate change-driven environmental variability and fishing pressures impact the distribution and population of bigeye tuna in the Pacific Ocean. Deciphering the causal relationships between these factors is complex. A multi-output neural network model was developed, using data from four types of bigeye tuna fisheries and marine environmental data from 1995 to 2019. This model analyzed the response of bigeye tuna to natural and anthropogenic influences in the Pacific Ocean. Input layer weights gauged environmental variable importance, while output layer weights assessed fishing operation contributions, helping map out the spatiotemporal distribution and population dynamics of bigeye tuna. The model revealed a strong correlation between major bigeye tuna habitats and ENSO events, suggesting the bigeye tuna's population dynamics are responsive to climate variability intensity. During El Niño events, suitable conditions trigger an eastward expansion of the primary habitats, while La Niña events, characterized by enhanced westward advection, cause contraction of these habitats. Interestingly, the model predicts a higher bigeye tuna resource abundance during moderate to weak El Niño events compared to strong ones. Purse seine and longline fisheries showed distinct distribution patterns under varying ENSO events, reflecting different environmental preferences at each bigeye tuna life stage. With increasing climate variability and fishing pressures, our findings provide valuable insights for sustainably managing bigeye tuna in the Pacific Ocean.

(S11-16538 Poster) S11-P2

Climate-projected ecosystem responses in the Northern California Current Ecosystem: Insights from a climate and eco-physiology linked end-to-end model

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Physics-to-fisheries ecosystem models (or end-to-end models, E2E) are important for providing spatially explicit ecosystem forecasts to further implementation of ecosystem-based management under climate change. Few studies have considered reorganizations in food webs arising from distinct physiological responses amongst the component model units (species or species complexes) given anthropogenic climate change forcing. Given projected changes in oceanographic conditions, characterization of eco-physiological responses of different taxonomic groups within an E2E model is necessary for understanding the potential impact that climate change may have upon fish stocks and fishery yields, protected species, and large-scale ecosystem dynamics. In this study, we incorporated physiological temperature coefficients into a 3D E2E ecosystem model of the Northern California Current upwelling system (*NCC-3D-ECOTRAN*). Here we present results of the E2E model for the Northern California Current ecosystem under downscaled regional climate projections forced by three Earth System Models (ESMs). Model simulation scenarios indicate that, for most commercially valuable or protected species under most climate change projections, production rates declined substantially by 2050 relative to the baseline period (1980-2010) under the projected changes in temperature, circulation, and phytoplankton biomass. Relative increases or decreases in species' production rates were only evident when eco-physiological parameterization (effects of temperature on metabolic rate and consumption rate both independently and in combination) was included in the model. This newly developed eco-physiological and downscaled projected biophysical forcing functionality within *ECOTRAN* provides a comprehensive platform for simulating how an eastern boundary current upwelling ecosystem might respond to mid-term climate change.

(S11-16548 Poster) CANCELLED S11-P3 (ECOP)

~~Evaluating trade-offs between management actions to prevent the decline of endangered resident killer whales and their salmon prey using multi-species ecosystem models~~

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~~Pressures threatening biodiversity are intensifying, driving species loss globally. In the northeast Pacific, Southern resident killer whale populations are threatened by multiple factors including human activities, insufficient Chinook salmon prey and small population size. Numerous uncertainties exist in our understanding of the system, especially how climate change may affect fish populations and propagate up food webs, hindering decisions for management. Ecosystem models can improve our understanding of the complex predator-prey-competition interactions among resident killer whales and their prey, and help to advance recovery of threatened species through proactive management of multi-use areas. We developed, calibrated and applied a multi-species ecosystem model for coastal British Columbia that included killer whales, Pacific salmon, seals, sea lions and Pacific herring to assess the response of threatened species and the community to alternative management actions given climate change. We brought together experts from both Canada and the USA including scientists, resource managers, conservation agencies, and linked to First Nations, to help inform the model and develop future scenarios. By predicting species' abundance, productivity and interactions, we provide a single framework for understanding ecosystem processes and evaluating trade-offs between population status and community structure. Initial findings suggest that community dynamics following changes in management regimes were driven by complex interactions among species, including competition and predation. The project is ongoing, with stakeholder engagement ensuring the greatest possible impact from outputs benefiting both conservation efforts for highly threatened resident killer whales, as well as informing resource management strategies for economically and culturally important salmon stocks.~~

(S11-16587 Poster) S11-P4 (ECOP)

Connectivity of sea turtles in Jeju Island of Republic of Korea to the populations in the Western Pacific

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Sea turtles are expected to expand their range due to the rise in water temperature driven by climate change. However, there is still limited information available about sea turtle populations in the Republic of Korea, the northern boundary for many sea turtle species in the Western Pacific area. Among 39 sea turtles which were bycaught or found dead in Jeju Island of Korea, four species were identified: 25 greens (*Chelonia mydas*), 9 loggerheads (*Caretta caretta*), 2 hawksbills (*Eretmochelys imbricata*), 2 olive ridleys (*Lepidochelys olivacea*), and 1 leatherback sea turtle (*Dermochelys coriacea*). Our mixed stock analysis using mitochondrial DNA haplotypes revealed that the Korean green turtles primarily originated from the southern islands of Japan. Similarly, the genetic composition of loggerhead turtles in Korea and southern islands of Japan suggests a high level of connectivity between the two regions, corroborated by our iridium tracking data. Notably, given that 60% (6 out of 10) of the tagged green sea turtles stayed around Jeju, with most overwintering, it appears that some green sea turtles are transitioning from migratory to territorial status on Jeju Island. Additionally, our study presents the genetic sequences of the three species, hawksbill, olive ridley, and leatherback turtles, much of which remain to be discovered in Northwestern Pacific. These data provide a crucial foundation for understanding the behavior in the expanding area. Our findings suggest that Jeju Island serves as a significant habitat for turtles in the Northwestern Pacific region.

(S11-16613 Poster) S11-P6 (ECOP)

Juvenile Albacore Tuna (*Thunnus alalunga*) diet variability and resilience in the northern California Current Large Marine Ecosystem

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Juvenile Albacore Tuna (*Thunnus alalunga*) are important predators in the California Current Large Marine Ecosystem (CCLME), where they support both commercial and recreational fisheries. Albacore diet composition data have been collected off Northern California, Oregon, and Washington since 2009, covering a period of several extreme climate events. We used this time-series to investigate environmental drivers of diet variability and to evaluate whether differences in diet composition affect total energy intake. We used classification and regression tree (CART) analysis of diets characterized by percent weight to identify distinct dietary modes that recur over time and the environmental conditions associated with their occurrence. Northern Anchovy (*Engraulis mordax*) was the most important prey taxa during the first half of the time series when temperature and upwelling were low. During the second half of the time series, a high diversity of prey with Euphausiids (Order: Euphausiidae) as the most important contributor was consumed in years with low chlorophyll-*a*, while Pacific Saury (*Cololabis saira*) was the most important prey when chlorophyll-*a* was high. Despite these differences in prey composition, the total energy content of prey per stomach was not significantly different between modes. We found that Albacore are opportunistic foragers that maintain a stable energetic intake through time as their diets change in association with shifting environmental conditions. Further work will investigate the impact of diet composition on predator condition, with implications for future suitability of the CCLME as an albacore foraging ground.

(S11-16656 Poster) S11-P7

Challenges to monitor cetacean abundances in changing ocean environment

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Cetaceans are apex predators, which directly and/or indirectly related to middle and low trophic levels through food-web interactions. Abundance estimates for cetaceans are keys to understand the ecosystem structures because those constrains the parameters of other consumers in the ecosystem. Since 1980s, dedicated sighting survey programs have been conducted to monitor cetacean abundances off Japan (Japan Fisheries Research and Education Agency Cetacean Sighting Survey, JAFRACSS). However, abundance estimation of cetaceans is generally challenging because of their wide distributions which cannot be sufficiently covered by limited survey efforts. In addition, their distribution patterns could change through dynamic changes of ocean environment and ecological processes. In the western North Pacific, cetacean distributions are affected by path patterns of Kuroshio Current and related changes in physical and biological environments. We demonstrate three modeling approaches that can effectively estimate long-term abundance trends for cetacean species: 1) the random-effects model accounting for year-by-year distributional changes, 2) the habitat models to explain the relationship between cetacean density and dynamic environments, and 3) the population dynamics model with the inter-specific competitions among the species potentially sharing similar niches. The abundance and distribution of Risso’s dolphins, the small cetacean species inhabiting the waters along the Kuroshio, were investigated through these three approaches. For these results, the abundance of the Risso’s dolphins tended to increase for the last few decades. Possible causes for such trends will be discussed in relation to habitat shift due to impact of climate change and reduction in abundance of competitors.

(S11-16686 Poster) S11-P8

Improving population dynamics modellings for small cetaceans in the western North Pacific with biological information

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Cetacean populations are susceptible to short- and long-term environmental changes as well as anthropogenic activities. To evaluate those effects, long-term trend analyses on cetacean abundances are needed. Our research group has developed the population dynamic models for small cetaceans inhabiting the western North Pacific using long-term time series abundance trend data. Although several biological parameters, such as calf and non-calf survival rate, age at sexual maturity, and fecundity rate, were used in those models, most of them were based on literature values previously published outside of North Pacific and some important parameters related to reproductive senescence in females observed in some species were not explicitly modelled. Because biological parameters are closely related to the population status and environmental conditions, e.g., the population with decreasing abundance tends to show younger maturation and higher proportion of young animals, integrating both abundance and biological parameters through population dynamic models greatly helps us understand the past and current population trends and quantify the effects of environmental and anthropogenic activities. Here, we analyzed the relationship between age and maturity status and estimated age at sexual maturity and survival rate for common bottlenose dolphins and short-finned pilot whales in western North Pacific using Bayesian framework. Those biological parameters are particularly important for age-structured population dynamics models and can be easily combined by Bayesian hierarchal modelling approach. We will discuss the long-term population trends of two small cetacean species and future direction to improve population dynamics modelling.

(S11-16698 Poster) S11-P9 (ECOP)

Overwintering behavior of green sea turtles in a temperate habitat

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Green sea turtles (*Chelonia mydas*) are tropical or subtropical species with a thermal limit entering dormancy at a sea surface temperature (SST) of 14 °C of seawater. Overwintering green sea turtles benefit from warm currents in the coastal waters surrounding Jeju Island, although the seawater temperature approaches the thermal limit during the winter season. In previous research, they are observed year-round in the Sea of Jeju Island, the southern part of the Republic of Korea, and it was confirmed that some juveniles spend winter around the Jeju coast. In this research, we used Iridium GPS transmitters to observe the movements and diving behaviors of four overwintering individuals (SCL 67.58 ± 11.5 cm) from late August to February 2019-2022. Their movements were limited during winter with total habitat area (95% KDE) between 0.021 and 6.411 km^2 (1.907 ± 3.025 km2) and core habitat (50% KDE) from 0.001 to 0.942 km^2 (0.264 ± 0.454 km^2). Their maximum dive duration increases with decreasing temperature, including the longest one ever reported in green sea turtles (367.4 min). Our results suggest that the coast of Jeju Island could function as a seasonal feeding ground for sea turtles of various ages, and as a potential residence and wintering ground for green sea turtles.

(S11-16825 Poster) CANCELLED S11-P10 (ECOP)

~~**Climate and fishery effects on the size spectrum for an ever-changing food web in the Gulf of Alaska**~~

~~Cheryl L **Barnes**[1], Martin W Dorn[2], Timothy E Essington[2], Carey R McGilliard[3], André E Punt[2], and Jonathan CP Reum[4]~~

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~~With climate-driven shifts in population and community dynamics, there is a clear need to consider broader ecological contexts when developing management strategies for marine resources. It is difficult, however, to quantify the mechanistic underpinnings of ecosystem structure and function. Multi-species size spectrum models (MSSMs) are a class of simulation models that are intermediate in their complexity and use individual body size to represent food web dynamics. Specifically, MSSMs relate size to processes like growth, reproduction, and mortality to estimate steady states of ecosystems and simulate temporal changes due to climate and fishing. We constructed an MSSM (‘mizer’ package in R) for the demersal fish assemblage in the Gulf of Alaska (GOA) – a large marine ecosystem that has recently undergone changes in environmental forcing and ecosystem reorganization. We synthesized available information from stock assessments, scientific publications, and standardized surveys to calibrate the model and retrospectively assess nonlinear and non-local effects on size-based metrics (e.g., maximum size, trophic level, predation mortality, biomass density). We then simulated these metrics under various climate and fishing scenarios to evaluate future population- and community-level impacts on the size spectrum. This project is part of the Gulf of Alaska Climate Integrated Modeling (GOACLIM) project, which represents a multi-model evaluation of the GOA food web. Continued development of these ecosystem models is designed to support ecosystem-based fisheries management in this predator-dominated system.~~

(S11-16831 Poster) S11-P11 (ECOP)

Increased temperature decreases starvation resiliency in first feeding Sablefish (*Anoplopoma fimbria*)

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Waters in the Gulf of Alaska have recently experienced anomalous warming and are expected to continue to warm as climate change progresses. This warming has been shown to influence spawning phenology in some fish species and may create mismatches between when fish larvae start feeding and when their zooplankton prey are available. In this study we reared sablefish larvae (*Anoplopoma fimbria*) in the laboratory under a temperature typical for the spring and at an elevated temperature (6 and 9°C, respectively), and two feeding conditions (fed and starved) to measure the time to the point of no return – the time when larvae are unable to physiologically recover from starvation. We also measured larval length and weight daily to monitor how condition varied among treatments. We found that sablefish larvae reached the point of no return 11 days earlier in the warm treatment than the cold treatment and that body condition was dramatically different between starved and fed larvae in the warm treatment, but did not differ in the colder treatment during the duration of the experiment. These findings suggest that, under future warming scenarios, sablefish larvae may be much more susceptible to starvation-associated mortality under variable prey match/mismatch feeding conditions.

(S11-16965 Poster) S11-P12 (ECOP)

Understanding what drives marine lipid accumulation in Chinook salmon

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Chinook salmon (*Oncorhynchus tshawytscha*) accumulate large amounts of lipid during their time at sea. This stored marine energy is necessary for their long spawning migrations, but also makes them a high value prey for resident killer whales. Despite the significance of their lipid accumulation, little is known about its ocean or trophic drivers. In this study, we sought to resolve this question with an inter- and intra-annual analysis of lipid levels of four populations of Fraser River (British Columbia, Canada) Chinook salmon with known differences in mean lipid content (Fall-4_1, Summer-4_1, Summer-5_2, Spring-5_2). First, we measured lipid content of returning adult Chinook salmon over three years (2020-2022). A subsample of Chinook from 2020 and 2021 were collected for bulk carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) and compound specific amino acid (CSIA-AA) stable isotope analysis. All sampled Chinook were genetically stock identified. We analysed the effect of size, bulk isotope signatures, and CSIA-AA calculated trophic level on lipid levels between and within each of the four Chinook populations for 2020 and 2021. We then measured mean population lipid over the three-year study and correlated these data with large scale climatic variables.

Our presentation will examine the interannual comparison between 2020-22. Preliminary results from the intra-annual comparison indicate no effect of size or trophic level on Chinook salmon lipid content. Lipid content was negatively correlated with $\delta^{13}C$, implying high lipid Chinook resided in colder or more offshore waters. Our results may have important implications for Chinook marine energy accumulation in a changing ocean climate.

Session 12

Shining Light on Essential Fish Habitat in Data-Limited Pacific regions

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

Invited Speakers:
Yun-Wei Dong (Fisheries College, Ocean University of China, China)
Narea Lezama Ochoa (University of California Santa Cruz (UCSC) and Environmental Research Division (NOAA, Monterey), USA)
Jessica Perelman (Cooperative Institute for Marine and Atmospheric Research (CIMAR) and NOAA Pacific Islands Fisheries Science Center (PIFSC))
Xu Zeng (School of Oceanography, Shanghai Jiao Tong University, China)

Essential Fish Habitat (EFH) is a key ecosystem-based fishery management component required to be described and identified in all fishery management plans. As habitat degradations often lead to declines in overall abundance and diversity of living marine resources (LMRs), one of the main areas of emphasis in current ecological research is the delineation and refinement of EFH toward higher levels of detail, from presence-absence of certain species (Level 1; the lowest) to production and vital rates by habitat (Level 4; the highest). The central and tropical Pacific regions contain commercially and recreationally important bottom fishes (e.g., snappers, groupers), pelagic fishes (e.g., billfish), crustaceans, and coral reef-associated taxa. Field research and in situ data collection efforts are often limited due to the region's vast size and small-scale spatial complexity. This paucity of data, particularly relating to spatio-temporal trends of LMRs, is effectively hindering the delineations of EFH beyond species presence and density (Levels 1 & 2). This session invites presentations highlighting approaches to inform EFH delineations, specifically in regard to fish density, growth and reproductive dynamics, and habitat-specific production rates in a data-limited environment. We particularly welcome types of research that 1) use quantitative and statistical approaches to generate relative abundance maps using multiple data sources, 2) support tactical EFH relevant decision-making and longer-term strategies (e.g., harvest control rules, marine protected areas), 3) evaluate the robustness of methods that forecast changes in LMR productivity and distribution, and 4) attempt to integrate environmentally heterogeneous habitats, species domains, and species' interactions into understanding EFH-relevant processes (e.g., density, reproduction, and productivity) at multiple scales. We encourage both application case studies and theoretical and integrated modeling approaches to improve EFH delineations.

(S12-16495 Invited)

Zoning effects on fish populations in a multi-use marine protected area

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Multi-use marine protected areas (MMPAs), including zones with differing protection levels, are a widely used management tool, yet comparatively little is known about their ecological effects. Here, we examined the ecological impacts of the Shengsi Marine Park zonation, a typical MPPA located in the Yangtze River Delta of China with high human-sea interaction within it. Assessing its impact on fish allows us to understand whether the MMPA is effective in an area of high human activity. The abundance, biomass, mean size, and total richness of fishes in response to zones and habitat factors within the MPPA were analyzed using generalized additive models (GAMs). Boosted Regression Trees (BRTs) were used to explore the relative importance of key drivers of fish populations. Results indicated that zoning significantly influenced the biomass of high and moderate commercial value fish, the mean size of moderate commercial value fish, and the total richness of all fish. The trend of increasing biomass and total richness of high commercial value fish were more pronounced in the key protected zone than in the lower protection level zones. Adjacency to a high protection level zone enhanced the ecological impacts of lower protection level zones, while the effect of high protection level zones was less sensitive to the presence of adjacent high protection level zones. These findings suggest that (1) zoning management in the MMPA significantly impacts commercially exploited fish populations, and (2) zoning that strictly limits human activity can yield conservation benefits. Both the GAMs and BRTs indicated that habitat factors cannot be ignored when quantifying the effectiveness of zoning management. This study provides novel data on the ecological effects of MMPAs and further highlights their utility as a spatial management tool in conservation and fisheries management.

(S12-16535 Invited)

Evaluating the sensitivity of mariculture species to heatwaves and mapping aquaculture areas using species distribution models

Yu-Yang Zhang, Shuang-En Yu, Chao-Yi Ma, Xiao-Lu Zhu, Liang Zhang, Lin-Zuan Ma and Yun-Wei **Dong**

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Ongoing global warming and more frequent heatwaves have caused devasting impacts on mariculture in China and around the globe. It is urgent and important to evaluate the sensitivity of mariculture species to these thermal stressors, and then map the appropriate aquaculture areas for these species. This talk will address the following three aspects: firstly, the sensitivity of major mariculture species, including macroalgae, fish and shellfish, to extreme temperatures in China evaluated using thermal safety margins (i.e. the difference between species' thermal limits and environmental temperatures), and listed the more sensitive species to both low and high temperature; Secondly, mapping of the appropriate aquaculture areas for mariculture species (e.g. salmon and rainbow trout) in North China using both correlative and mechanistic species distribution models; Finally, mapping the aquaculture areas for major commercially important species around the globe with mechanistic species distribution model. These studies provide useful information for understanding the impacts of climate change, especially heatwaves, on mariculture, and shed light on the importance of species distribution models in mapping mariculture areas.

(S12-16675 Invited)

The use of Species Distribution Models for projecting future distributions of marine species: strengths, limitations and future perspectives

Nerea **Lezama-Ochoa**[1,2]; Heather Welch[1,2]; Stephanie Brodie[3]; Barbara Muhling[1,4]; Owen R. Liu[5]; Megan Cimino[1,2]; Mercedes Pozo Buil[1,2]; Michael Jacox[2,6]; Jerome Fiechter[1]; Scott Benson[7,8]; Karin Forney[7,9]; Elizabeth Becker[1,10]; Heidi Dewar[4]; Dan Palace[1]; Pierre-Yves Hernvann[11]; Isaac Kaplan[11]; Nima Farchadi[12]; Camrin Braun[13]; Rebecca Lewison[12]; Steven Bograd[2,1] and Elliott Hazen[2,1]

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Projecting the future distributions of marine species has become highly useful for marine managers and practitioners to understand, prepare, and adapt to the potential impacts of climate variability and change. Species Distribution Model (SDM) projections harness a multitude of different data sources with their own inherent uncertainty, and when coupled with uncertainty derived from earth system models can lead to divergent and variable projections of species patterns. Here, we outline the strengths and limitations of SDM projections using marine case study species across three guilds (coastal pelagic species, groundfish and migratory species). We highlight examples that describe future predator-prey dynamics, and scenarios where climate impacts will influence fishery target and protected species overlap. Key factors that affected the strengths and limitations of projecting SDMs depending on the study domain included the choice of SDM algorithm and covariates selected, and the data quality of the species observations used to build the SDMs. Finally, we provide a number of applications where species projections could be used in marine ecosystem management and stakeholder engagement.

(S12-16738 Invited) CANCELLED

~~Modeling spatial trends in coral reef fishery resources across the Pacific Islands Region~~

~~Jessica N. **Perelman**[1,2], Kisei R. Tanaka[2], Justin J. Suca[1,2], and Thomas A. Oliver[2]~~

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~~Reef fishes are a critical component of local fishery resources for Pacific Island communities. They provide numerous ecosystem services that include helping to maintain coral reef health. Understanding the distribution and status of various reef fish species is therefore essential for ensuring their sustainable management and conservation. As part of the NOAA Pacific Islands Fisheries Science Center's efforts to identify areas of Essential Fish Habitat (EFH), we use fishery-independent diver survey data collected across the Pacific Islands Region to model local and regional biomass trends of numerous culturally and ecologically important reef fish species. Using a machine learning approach, we identify environmental and human drivers underlying patterns in species' distributions. These species distribution models are augmented by temporally summarized satellite oceanographic data to identify the timescales at which various environmental drivers are relevant to species' distributions. Our results indicate variability in habitat use across species and provide insight into potential shifts in coral reef fishery resources across the U.S. Pacific Islands. This work supports NOAA's partnerships with managers across various U.S. Pacific Islands to develop dynamic species management plans in the face of changing oceans.~~

(S12-16673 Oral)

Advancing Essential Fish Habitat in Alaska using an ensemble approach to species distribution modeling

Jodi L. **Pirtle**[1], Ned A. Laman[2], Jeremy Harris[3], Megsie C. **Siple**[2], Jim T. Thorson[2], Skylar R. Bayer[1], and Mason J. Smith[1]

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Describing Essential Fish Habitat for management requires spatial information about species distributions, which is increasingly generated from species distribution models (SDMs). Predictions from these SDMs are then processed to identify occupied habitat. Existing SDMs have different strengths and, in many cases, provide different types of information about species distributions (e.g., presence/absence, density). In some cases, data quality or quantity can dictate which SDMs can be feasibly fit. To describe habitat for 208 species/life stage combinations in three marine ecosystems in Alaska, we fit a suite of five SDMs to data from bottom trawl surveys, ensuring that they all estimate a "common currency" of numerical abundance. We then calculated out-of-sample predictive performance to weight these constituents in an ensemble SDM. Results from this work show that an ensemble approach can mitigate bias that would normally arise from *a priori* specification of individual SDMs, and provide a better fit to survey data. We also explored different ways of estimating occupied habitat area from SDM predictions, and found systematic differences in the estimates of area occupied between two different potential methods. We will share the framework we developed for model selection and communication with managers and stakeholders, and demonstrate how this advances the process for describing Essential Fish Habitat for Alaska.

(S12-16784 Oral)

Using archival tags and mechanistic movement models to estimate habitat utilization for mobile species

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Fisheries policy and management requires understanding species habitat utilization to identify Essential Fish Habitat (EFH) and track changes in EFH over time. However, many fisheries worldwide target species that occur where resource surveys are infeasible or prohibitively expensive. Archival tags provide a known start and end location for individual animals, and can measure that individual's environment between these locations. In contrast to resource surveys, archival tags provide information that is (1) not restricted to national jurisdictions and (2) not impacted by changes in catchability over space and time, where (3) sampling designs can be rapidly matched to available budgets by changing the number of tags deployed. They therefore provide information that complements conventional surveys. Previous studies have applied track-reconstruction models to archival tags to infer movement for individual animals, but these typically do not estimate population-scale habitat utilization. Here, we show how archival tags can be analyzed to infer habitat utilization and associated uncertainty, either in isolation or in combination with other data. We specifically introduce an advection-diffusion model representing habitat preferences (taxis) and exploratory movement (diffusion), and fit this model to data from two examples involving Pacific cod. The first involves a single tagged individual, where we fit a Hidden Markov Model to estimate a nonlinear preference for depth and estimate population-scale habitat utilization in the Aleutian Islands. The second estimates seasonal habit utilization across the eastern Bering Sea using both tags and resource surveys. We conclude by recommending research to identify EFH using low-cost tagging deployment and analysis.

(S12-16819 Oral)

Projecting future catch distributions of chub mackerel (*Scomber japonicus*) in Korean waters under the CMIP6 forcing scenarios

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Changes in environmental condition in marine ecosystems induced by climate change significantly affect distribution and abundance of fish species. Understanding species-specific responses to environmental variability is critical for managing commercially exploited fish. In Korean waters, chum mackerel (*Scomber japonicus*) is one of the most commercially and ecologically important fish species. In this study, to assess future changes in seasonal catch distributions of this species in Korean waters, (1) we constructed species distribution models using a Generalized Additive Model (GAM) and Boosted Regression Trees (BRT) based on historical fisheries dependent data and ocean environmental data from 1998 to 2015 and then (2) we projected their catch distribution in the 2050s using the CMIP6 under three future climate change scenarios (Shared-Socio-economic Pathways (SSP)1-2.6, SSP2-4.5, and SSP5-8.5). Our results shows that there are changes in their seasonal catch distributions between the period 1998-2015 and future projections. Our results can be used to provide scientific basis for planning sustainable fisheries management strategies for fish stocks in Korean waters.

(S12-16934 Oral)

Projecting future seasonal distribution of chub mackerel (*Scomber japonicus*) under continued ocean warming in the Yellow and East China Seas

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Chub mackerel (*Scomber japonicus,* hereafter mackerel) is a commercially important small pelagic fish in Korea and is highly sensitive to environmental change, shifting its spatial distribution due to climate change in recent decades. Although environmental changes are projected to be significant in Korean waters, few studies have explored potential future shifts in mackerel distribution. In this study, we examined future seasonal changes in mackerel distribution in the Yellow and northern East China Seas (hereafter YECS) in the 2050s by using three species distribution models—Maximum Entropy model, Generalized Additive Model, and Boosted Regression Trees—based on the three CMIP6 future scenarios (SSP1-2.6, SSP2-4.5, and SSP5-8.5). Seasonal distribution models were fit using mackerel presence in Korean fisheries and five skillful environmental variables (temperature, salinity, current speed at the surface, mixed layer depth, and chlorophyll concentration) for 18 years (1998~2015). All the three models project a decrease in mackerel distribution in the YECS across all seasons: 3.8~9.8%, 16.9~25.7%, 8.8~13.1%, and 2.5~10.5% from spring to winter, respectively. This contraction is mainly driven by predicted temperature increases and salinity decreases. In addition, this distribution contraction contributes to the contraction in the spawning habitat (mainly in the northern East China Sea in spring), which could considerably change the abundance and timing of the spawning habitat and in turn fisheries productivity. Our findings suggest that the future seasonal changes in the mackerel distribution and their potential effects on fishing communities should be considered to effectively plan future management strategies, particularly for environmentally susceptible species, including mackerel.

(S12-16979 Oral)

Delta downscaling as a tool to create flexible, high-resolution climate change projections for the global ocean

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Rapid changes in the ocean are prompting growing interest in accurate projections of future climate change, in order to facilitate adaptation and promote resilience. However, although climate projections exist for the ocean, spanning decades into the future for multiple emissions scenarios, these projections are coarse and often do not appropriately capture coastal bathymetry and nearshore processes that are key to the functioning of many of the most important and vulnerable ecosystems in the world. Here, we present a straightforward framework for downscaling projected global climate data that can help bridge this gap, by translating coarse (1°) Earth System Model (ESM) outputs onto a higher resolution (1/12°) GLobal Ocean ReanalYsis and Simulation (GLORYS) grid from Copernicus Marine Environment Monitoring Service (CMEMS). This “delta downscaling” approach calculates the difference between ESM projections and a historical climatology, then applies those differences (the “deltas”) to a GLORYS climatology to produce high-resolution projections. We show an application of this method to the California Current ecosystem, including a comparison with an alternative, dynamically-downscaled ocean projection model, then discuss its caveats and applications in building species distribution models for key species and as oceanographic forcing for an Atlantis ecosystem model. Although an imperfect tool, the delta-downscaling approach is theoretically applicable in any region of the global ocean to produce long-term and high-resolution climate projections, and represents an important bridge towards the next generation of ocean climate models.

(S12-16487 Poster) CANCELLED S12-P1 (ECOP)

~~**Mapping the potential for offshore aquaculture of salmonids in the Yellow Sea**~~

~~Shuang-En **Yu**[1], Shuang-Lin Dong[1,2], Zhi-Xin Zhang[3], Yu-Yang Zhang[1], Gianluca Sarà[4], Jie Wang[1] and Yun-Wei Dong[1,2]~~

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~~Mariculture has been one of the fastest-growing global food production sectors over the past three decades. With the congestion of space and deterioration of the environment in coastal regions, offshore aquaculture has gained increasing attention. Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) are two important aquaculture species and contribute to 6.1% of world aquaculture production of finfish. In the present study, we established species distribution models (SDMs) to identify the potential areas for offshore aquaculture of these two cold-water fish species considering the mesoscale spatio-temporal thermal heterogeneity of the Yellow Sea. The values of the area under the curve (AUC) and the true skill statistic (TSS) showed good model performance. The suitability index (SI), which was used in this study to quantitatively assess potential offshore aquaculture sites, was highly dynamic at the surface water layer. However, high SI values occurred throughout the year at deeper water layers. The potential aquaculture areas for *S. salar* and *O. mykiss* in the Yellow Sea were estimated as 52,270 ± 3275 (95% confidence interval, CI) and 146,831 ± 15,023 km^2, respectively. Our results highlighted the use of SDMs in identifying potential aquaculture areas based on environmental variables. Considering the thermal heterogeneity of the environment, this study suggested that offshore aquaculture for Atlantic salmon and rainbow trout was feasible in the Yellow Sea by adopting new technologies (e.g., sinking cages into deep water) to avoid damage from high temperatures in summer.~~

(S12-16793 Poster) CANCELLED S12-P2 (ECOP)

~~Sensitivity in uku (*Aprion virescens*) larval dispersal patterns to simulated spawning location and environmental conditions throughout the main Hawaiian Islands~~

~~Justin J. **Suca**[1,2], Andrea L. Schmidt[1,2], Johanna L.K. Wren[1], Donald R. Kobayashi[1], Jonathan L. Whitney[1], Kisei R. Tanaka[1], and Gabriella N.M. Mukai[1,3]~~

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~~Uku (green jobfish; *Aprion virescens*) are a commercially, recreationally, and culturally important species throughout the main Hawaiian Islands. Despite uku's importance, very little is known about the biology and ecology of this species throughout the region – particularly the early life stages. This project aims to approximate larval dispersal patterns of uku using bio-physically coupled Lagrangian particle tracking models from a Regional Ocean Modeling System (ROMS) Reanalysis for the main Hawaiian Islands from 2008-2020. Newfound information on adult uku habitat and the historical vertical distribution of uku larvae are used to appropriately parameterize particles to simulate uku spawning locations and larvae. Our releases indicate that there is a moderate degree of interannual variability in dispersal patterns, with retention representing the most common pathway for 'settled' larvae. However, this pattern appears sensitive to inter- and intra-annual environmental conditions and release location. Specifically, trade wind patterns alter simulated dispersal pathways in variable fashion, decreasing retention in many areas while enhancing inter-island connectivity from certain simulated spawning locations. Understanding either the compensatory or enhancing effects of variable oceanographic and atmospheric conditions on uku larval dispersal can better elucidate the role dynamics such as wind patterns may ultimately play on recruitment processes. These results can identify regions of particularly high sensitivity and productivity in generating larvae that are likely to find suitable habitat and recruit – important information for effective habitat management of this species.~~

(S12-16795 Poster) S12-P3

Essential fish habitats in the Western Bering Sea

Vladimir **Kulik**, Dmitry Sokolenko, Mikhail Goryunov, Viktor Nadtochy and Aleksey **Somov**
(*Aleksey Somov presenting on behalf of Vladimir Kulik*)

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Random forest in the multiple imputation by chained equations procedure (MICE) was used to interpolate abundance of 30 benthos taxa in the equal area grid with hexagons of 3.5 km of width and 3 km of height each. The base predictor variables were ground types, statistical properties of water near the bottom extracted from Bio-ORACLE, and bottom morphology (depth, aspect, slope, curvature, and its difference) calculated from GEBCO bathymetry. The number of all layers prepared for fish habitats estimation was too high (167), thus it was reduced to 55 dimensions during Principal Components (PC) analysis. Those 55 PCs accumulated 95% of variance. They were used to run MICE for abundance interpolation of 38 fish species. At first, we averaged fish abundance by periods of 1977-1990, 1991-1995, 1996-2005, 2006-2010 and 2011-2022. The out-of-bag (OOB) R^2 increased for many species from 1977 to 2010, but the last period of research had the lowest OOB R^2 for all species. Secondly, MICE of fish abundance used 55 PCs by years in addition to month and period covariates. It was successfully run by years for grenadiers and halibuts, but surprisingly it wasn't better than a simple average for skates. Poor performance in the same procedure was also noticed for pelagic fish (salmon, pacific herring) and sharks, but the abundance of flatfish and demersal species from Gadidae and Cotidae families wasn't very well approximated by MICE every year. Thus, we suggest that our 55 PCs could be used as essential fish habitats for grenadiers and halibuts.

(S12-16842 Poster) S12-P4 (ECOP)

Evaluating the impact of temperature on hindcasting and forecasting shrimp distributions in British Columbia

Mackenzie **Mazur**

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Environmental variables impact species distributions. Indeed, temperature changes have resulted in poleward movements, suitable habitat variability, and phenology changes for many marine species. As a result, environmental variables should be considered in hindcasting and forecasting species distributions, which can provide valuable insights for fisheries management. Additionally, modeling species distributions becomes difficult with gaps in survey data. Shrimp off the coast of British Columbia (BC) present an interesting case study for evaluating the impact of temperature on hindcasting and forecasting species distributions. First, the consistency of data collection varies among shrimp management areas (SMAs). Some SMAs are surveyed every year whereas others have gaps of one or several years of data. Second, shrimp exhibit cyclical patterns in biomass not explained by fishing but may be influenced by temperature, which is known to strongly influence ectotherms, such as shrimp. Given the variability of data collection among BC SMAs and the potential impact of temperature on shrimp distributions, the objective of this study was to evaluate the impact of temperature on hindcasting and forecasting shrimp distributions in BC. Here, spatiotemporal modeling is proposed as a method for estimating shrimp distributions. sdmTMB, an R package that implements predictive-process stochastic partial differential equation based spatiotemporal models, was used to estimate smooth pink, spiny pink, and sidestripe shrimp distributions. The ability of a spatiotemporal model with and without a temperature covariate to hindcast and forecast shrimp distributions was evaluated. This study highlights the importance of considering environmental variables and nonstationarity in modeling species distributions.

(S12-16957 Poster) CANCELLED S12-P5

~~Assessing reef fish abundance and diversity in the Mariana Archipelago: Insights from a spatiotemporal model and NOAA's National Coral Reef Monitoring Program~~

~~Kisei R. **Tanaka**[1], Jessica N. Perelman[1,2], Justin Suca[1,2], and Tye L. Kindinger[1]~~

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~~Understanding the ecological patterns of reef fish diversity is crucial for effective coal reef management and conservation. This study utilized fisheries-independent surveys from National Coral Reef Monitoring Program (NCRMP) conducted between 2009 and 2022. A spatiotemporal model generated abundance estimates for over 150 fish species in the shallow waters surrounding 13 islands. Results showed high agreement between estimated and observed reef fish abundances, validating the model's effectiveness in capturing local reef fish biogeography. Reef fish diversity generally increased with depth in nearshore waters, but this relationship varied among islands due to local factors influencing species composition and abundance. We observed a significant decline in reef fish diversity with increasing latitude across the archipelago, indicating lower species richness and variety on higher latitude islands. This trend may be influenced by varying island sizes and fewer surveys conducted at smaller northern islands. The study also identified higher diversity in select marine protected areas (MPAs) within the study domain, emphasizing their importance in preserving biodiversity and promoting ecological stability compared to non-protected areas. Our research highlights the value of ongoing NCRMP survey efforts in remote and data-poor locations. These surveys provide continuous data collection, enabling the development of useful fisheries management tools. By integrating long-term monitoring data with advanced modeling techniques, our study addresses information gaps and supports evidence-based decision-making for effective fisheries management and conservation strategies in the nearshore waters of the Mariana Archipelago. These findings provide valuable insights for sustainable management and conservation efforts in this ecologically diverse region.~~

Session 13

Operational forecasts to improve recruitment prediction in fish stock assessments

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

Invited Speaker:
Carrie Holt (Pacific Biological Station, Fisheries and Oceans Canada, DFO, BC, Canada)

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

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

(S13-16711 Invited)

Evaluating new computational methods for detecting non-stationarities and forecasting recruitment with applications to Pacific salmon

Carrie **Holt**[1], Brendan Connors[2], Andrew Edwards[1], Lyse Godbout[1], Dan Greenberg[1], Luke Rogers[1], Catarina Wor[1] and Yi Xu[1]

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Non-stationary population dynamics are pervasive in fisheries and can impact the performance of population forecasts and the robustness of management decisions. As a result there is growing interest in accounting for non-stationarity in forecasts and assessments. However, identifying reliable signals in noisy data is a common challenge. To address this gap, we used closed-loop simulation to evaluate the reliability of commonly used analytical methods for detecting non-stationarity in stock-recruitment relationships. The reliability of detection was generally poor across underlying 'true' scenarios in parameter variability, and depended on the parameter being estimated, magnitude and frequency of variability (annually or periodically in step-wise regime shifts), data quality, and the model selection criterion used. Importantly, model selection criteria relevant for short-term forecasts tended to favor stationary models over those with time-varying parameters. These results urge caution when seeking to identify non-stationarities for forecasting and management advice. An alternative approach to incorporating non-stationarity in forecasts is to include environmental covariates directly. In some cases, forecast models that include biological covariates related to underlying mechanisms can outperform status quo forecasts. Where mechanisms are unknown, non-parametric approaches (e.g., Empirical Dynamic Modelling and Boosted Regression Trees) offer potential improvements for forecasting. We illustrate the application and evaluation of parametric and non-parametric forecasting methods to Fraser River Sockeye Salmon, Canada. We suggest that generating accessible code to easily implement a variety of analytical methods in a transparent and reproducible way is key to facilitating robust evaluation and selection of stationary and non-stationary forecast models.

(S13-16521 Oral)

Integrating climate effects in multiple population processes for fisheries projections: an example with snow crab in the eastern Bering Sea

Cody **Szuwalski**[1], Baptiste Alglave[1,2], Maxime Olmos[1,2], Andre Punt[2] and Matthieu Veron[1,2]

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Climate change is projected to impact life history processes of harvested marine species. Analyses often focus on incorporating climate effects on a single process (e.g. recruitment or mortality), but it is possible that multiple population processes will be impacted by climate change. Here we examine the impact of incorporating a varying number of climate drivers in projections for eastern Bering Sea snow crab on the trajectories of mature male biomass and commercially exploitable male biomass. Relationships to environmental drivers have been reported in the literature for recruitment and natural mortality of eastern Bering Sea snow crab. Environmental drivers of the probability of having undergone terminal molt have been reported in Canadian stocks. We present a factorial consideration of non-stationarity in these processes to understand the potential implications of excluding a non-stationary process in projections under climate change.

(S13-16569 Oral)

Non-stationary environmental indicators related to Pacific Northwest Chinook and coho salmon marine survival

Neala W. **Kendall**[1], Benjamin W. Nelson[2], Mike Haggerty[3], Mike Crewson[4], Dave Beauchamp[5], Diego Holmgren[4], and Casey Ruff[6]

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Conserving and recovering anadromous fish requires understanding limiting factors both in freshwater and the ocean. Past relationships between survival and ecosystem factors are often used to guide future conservation and management efforts, despite work suggesting non-stationarity in these associations. We gathered and updated marine survival data from the early 1970s-2010s from Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon from US and Canadian coastal rivers and those draining into a large, semi-enclosed estuary (the Salish Sea). We found that relationships between pink salmon (*O. gorbuscha*), which are present and highly abundant as juveniles in the Salish Sea (but not the coast) only in even-numbered years, and Chinook and coho salmon marine survival were inconsistent in magnitude and direction over time. Other ecosystem indicators, including NPGO index, sea surface temperature, harbor seal abundance, and hatchery salmon release abundance, were more related to marine survival trends than were pink salmon for some regions and time periods. An interaction between pink salmon and hatchery releases was found for Salish Sea Chinook and coho salmon (but not coastal stocks); it varied over time for coho but not for Chinook salmon. Our results support findings that large-scale climate indicators and harbor seal predation matter for Pacific salmon marine survival. We add to the story showing that pink salmon and hatchery salmon release abundance also matter. Projecting long-term relationships forward may produce faulty expectations, so further work exploring the mechanisms behind relationships and why they change over time is necessary.

(S13-16614 Oral)

Revealing climate impacts on recruitment drivers through application of Dynamic Factor Analysis, a coastal pelagic fish case study

Robert P. **Wildermuth**[1,2], Desiree Tommasi[1,2], Charles Hinchliffe[1,2], Stefan Koenigstein[1,2], Peter Kuriyama[2], Isaac Kaplan[3], Andrew Thompson[2], Noelle Bowlin[2], Mercedes Pozo Buil[1,4], Michael G. Jacox[4,5], Steven J. Bograd[1,4], and Barbara Muhling[1,2]

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Small pelagic fishes exhibit boom-bust cycles driven by interannual fluctuations in recruitment success likely linked to environmental forcing. These drivers remain poorly understood and are rarely accurately predicted. Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*) in the California Current Ecosystem are well-monitored small pelagic stocks that are understood by fisheries management to respond to the environment. Without a mechanistic understanding of these environment-recruitment linkages, the risks to managing these stocks may increase as the climate changes and the underlying linkages shift or break down. We developed an approach to identify, test, and project the influence of multiple drivers of recruitment success on these two pelagic fishes. Recruitment, or the culmination of parental fecundity and early life stage growth and survival, is influenced by 1) behavioral and physiological responses to oceanographic conditions, 2) maternal condition, 3) forage availability, and 4) predation. Based on literature review and expert elicitation, we identified indicators of sardine or anchovy recruitment success for each of these general drivers. Using these process-based indicators and Dynamic Factor Analysis, we derived composite indices for each species from the 1990s to 2019 and test model skill for prediction of future recruitment success. We then projected the indices through the end of the century under multiple climatic and predation scenarios using downscaled earth system model products to understand potential climate impacts on these coastal pelagic stocks.

(S13-16727 Oral)

Evaluating the utility of pre-recruit abundance indices of year-class in stock assessments of West Coast rockfishes

John **Field**[1], Vladlena Gertseva[2], Toby Auth[3], E.J. Dick[1], Melissa Haltuch[4], Mary Hunsicker[5], Tanya Rogers[1], Keith Sakuma[1], Jarrod Santora[1] and Nick Tolimieri[5]

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Over the last four decades, the National Marine Fisheries Service (NMFS) has conducted an annual midwater trawl survey for pelagic young-of-the-year (YOY) rockfish in the coastal waters of the California Current, with the primary goal of informing recruitment estimates in stock assessment models. Rockfish and many other groundfish stocks in this ecosystem exhibit tremendous variability in cohort strength, with infrequent strong year-classes often driving substantial swings in abundance and catch rates for key species. However, there is a multi-year lag in the ability of both fisheries catch data and survey data collections to detect these large changes in abundance due to the delayed selection of many rockfish to different gear types, often several years depending on the species. The spatial footprint of the survey expanded in the early 2000s from a regional to a coast-wide scale in an effort to improve the detection of year-class strength by the YOY indices. Here, we investigate how well the YOY indices compare to realized recruitments from stock assessment models, and evaluate the benefits and challenges of using YOY indices for early determination of year-classes in stock assessments in the absence of other data to inform year-class strength.

(S13-16782 Oral)

Evaluating the short- and long-term performance of six forecasting methods on West Coast and Alaska groundfish recruitment

Emily L. **Sellinger**[1], André E. Punt[1], Cody Szuwalski[2], Mark Scheuerell[1] and Richard Methot[3]

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Recruitment, often defined as the number of age-0 fish, can be influenced by a variety of biological and environmental factors. Due to the number of factors that can influence recruitment, providing consistently accurate forecasts has proved elusive. Despite the challenges associated with forecasting recruitment, it continues to be a major area of research. Improved recruitment forecasts could allow for better predictions of stock biomass, which are used to evaluate the status of stocks and set harvest limits. Forecasting methods that are robust to changing environments, which are expected under climate change, will be important for fishery scientists and managers in the near future. Identifying forecasting techniques that perform well within systems that undergo regime shifts could also allow for more sustainable harvest. We evaluated short- and long-term recruitment forecast performance of six forecasting methods: 1) Beverton-Holt stock-recruitment relationship, 2) an autoregressive-1 function, 3) mean recruitment, 4) a hidden Markov sampling procedure, and 5) simplex projection, 6) a PELT changepoint sampling procedure for data-rich groundfish stocks managed by the Pacific Fishery Management Council (PFMC) and the North Pacific Fishery Management Council (NPFMC). These stocks differ in their time series length, exploitation history and the age of recruitment to the fishery. Our study seeks to determine how the accuracy of a forecast method is related to these key biological and historical characteristics.

(S13-16791 Oral)

Introducing a Novel Stock-Specific Indicator of Salmon Survival in the Marine Environment

Brian J. **Burke**

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Salmon populations face numerous challenges during their migration from freshwater rivers to the open ocean, making accurate assessment of their survival critical for effective conservation and management strategies. Sea surface temperature (SST) and sea level height (SLH) have often been used in correlative models to estimate marine survival. This often takes the form of standard indices, such as the Pacific Decadal Oscillation or the North Pacific Gyre Oscillation, or time series of SST or SLH at a specific location, such as near the mouth of the river from which salmon are migrating. However, from satellite data and earth systems models, we now have rich data sets with complete spatial and temporal coverage to use for these applications. Here, we introduce a novel method for extracting information from these data sets to inform salmon survival modeling efforts. We outline the methodology used to construct this new indicator and highlight the key metrics and variables incorporated. We also delve into the benefits and practical applications of this new indicator, such as informing policy decisions, guiding fisheries management practices, and facilitating targeted conservation efforts. Importantly, and unlike standard indices such as PDO, this new metric is tailored for the specific stock of salmon one is interested in. As a result, this can be applied to other marine species such as rockfish, squid, and sablefish. By employing this innovative tool, researchers, policymakers, and conservationists can gain deeper insights into salmon survival patterns, enabling more informed and effective strategies for the sustainable management of these iconic species.

(S13-16821 Oral)

Environmental conditions at Chum salmon feeding and wintering grounds: potential effects on survival at sea

Irene D. Alabia[1], Sei-Ichi **Saitoh**[1,2,4], Takafumi Hirata[1], Yasuyuki Miyakoshi[3], Fumihiro Takahashi[4] and Masahide Kaeriyama[1]

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Chum salmon (*Oncorhynchus keta*) is the most abundant Pacific salmon species in Japanese waters and is produced through artificial hatchery programs. In the last two decades, however, its abundance has dramatically declined. Here, we examined the marine environmental conditions during its seaward migration from 1998 to 2017 and related these changes to the annual total catch data of Chum salmon in Japan from 2001 to 2020. We computed the area within the optimal feeding (8°-13°C) and wintering (5°-7.5°C) temperatures for each brood year (1998-2017) across its putative migration-based oceanic habitats. During its feeding migration (June-November) in the Okhotsk and Bering seas, we computed the average zooplankton biomass in areas within its optimal temperatures. We then developed a generalized additive model using these data to elucidate the relative importance of environmental conditions at each feeding and wintering ground before its average return migration at age-3. The full model captured 83.1% of the overall variance in Chum salmon catch in the last 20 years. It also highlights the significant partial effects of the environmental conditions during its first wintering (western subarctic gyre; deviance explained: 8.14%), initial feeding in the Bering Sea (22.7%), second wintering (Gulf of Alaska; 15.9%), and hindmost feeding in the Bering Sea (36.3%) migrations in predicting the annual total catch fluctuations. Hence, our results shed some light on the impacts of changes in the oceanic environment on the potential survival of Chum salmon at sea, which is likely to regulate its subsequent availability to fisheries.

(S13-16915 ***Backup for an oral presentation in case of cancellation*****)**

Leveraging ecological indicators improve fisheries recruitment forecasts

Mary Hunsicker, Kristin Marshall, Kiva Oken, Brice Semmens, Melissa Haltuch, John Field, Andrew Thompson, Nick Tolimieri and Eric **Ward**

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Interest in ecological forecasting has rapidly increased over the last decade, with both data and methodologies evolving to meet the complex challenges of making predictions in a non-stationary world. Predicting future fish productivity or recruitment has been a focus of forecasting efforts in fisheries for the last century; this remains inherently difficult because recruitment time series are often short, they are produced from model estimates that are subject to error, and mechanistic understanding of drivers is often limited. In this talk, we present several new approaches for linking environmental drivers with estimated recruitment deviations in stock assessments. We assembled a dataset of 30 U.S. west coast groundfish stock assessments, and performed a short term forecasting comparison across statistical models and predictor variables to predict future recruitment deviations. Predictor variables included larval fish indices from CalCOFI and the Rockfish Recruitment and Ecosystem Assessment Survey, ROMS oceanographic model outputs, and derived ecosystem state indices. Including a wide range of assessed species allows us to identify populations with skillful recruitment forecasts. Similarly, comparing statistical models or predictor variables is useful for identifying the most robust approaches for performing forecasts. Our results show that for 10 populations in our analysis, recruitment deviations can be forecast with some degree of skill ($R^2 > 0.7$). We find that for the majority of these populations, larval fish indices from the CalCOFI survey offer the best predictive skill (lowest RMSE) – and in all cases, multivariate linear models outperformed more complicated approaches. Finally, we discuss caveats of this overall approach, as well as future research with international datasets to better link these approaches with assessment tools.

(S13-16916 ***Backup for an oral presentation in case of cancellation*****)**

Environmentally-driven recruitment forecasts for Pacific Hake

Kristin N. **Marshall**[1], Eric J. Ward[2], Mary Hunsicker[2], Kiva Oken[2], Aaron Berger[3], Kelli Johnson[2] and Cathleen Vestfals[4]

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Novel analytical approaches and forward-looking management solutions are needed as climate change threatens to increase conflicts in fisheries. Improved understanding of environmentally-driven recruitment variability would greatly reduce prediction uncertainty and improve advice for managers in tactical decision-making and long-term climate risk planning. Pacific Hake (*Merluccius productus*) is the most abundant groundfish on the U.S. West Coast and the target of the largest groundfish fishery by volume in the region. Pacific Hake population dynamics are strongly influenced by environmentally-driven recruitment variability, with infrequent large cohorts supporting the fishery. Recent analyses have identified several potential environmental drivers of recruitment from Regional Ocean Modeling System output over the historic period 1980-2010. Here, we extend those analyses to the present decade and explore empirical survey data on larval and juvenile fish on the U.S. West Coast to inform indices of operational forecasts of recruitment for use in setting catch advice and long-term risk planning using management strategy evaluation. We found high forecast performance skill for recruitment indices using surveys of juvenile abundance. Importantly, models with the best forecast skill were obtained by fitting models that included other species, not data on early life stages of Pacific Hake themselves, which collectively appear to be indicators of favorable ocean conditions linked to strong cohorts of Pacific Hake. We will discuss the opportunities and challenges these approaches and results present for management of the Pacific Hake fishery.

(S13-16964 Poster) S13-P3 (ECOP)

Using environmental drivers to improve the accuracy of fisheries population models

Rachael Ren[1], Kiva L. **Oken**[2] and André E. Punt[3]

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The environment strongly influences annual recruitment variability in fish populations. However, it is not common practice to use environmental drivers to refine recruitment estimates within most production stock assessments used for fisheries management. This is increasingly important as climate change leads to both long-term productivity shifts and increasing variability. Scientific effort in recent years has made strides in incorporating environmental drivers into stock assessment models more regularly. This is generally done by using oceanographic time series to inform recruitment deviation estimates within the stock assessment model. One ongoing challenge is determining which environmental drivers have potential to actually improve recruitment estimates. We asked how correlated an environmental driver time series must be to historical recruitment deviations to improve key outputs of stock assessment models– recruitment deviations and depletion– in terminal model years for a range of species. We simulated environmental driver time series with varying correlation levels to recruitment deviations and then compared errors in estimates between stock assessment models fit with and without simulated environmental data. The more correlated an environmental driver was to historical recruitment deviations, the more accurate estimates of both recruitment deviations and population depletion. However, correlation levels necessary for environmentally-driven models to consistently produce more accurate estimates than the original model varied across species. These correlation thresholds were also generally higher than those observed in actual fish populations. Simulation experiments can help to determine which real environmental drivers have the potential to improve stock assessment models and provide improved advice for managers.

Session 14: BIO Topic Session

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

Co-sponsor:
NPFC

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

Invited Speaker:
Ashley Rowden (Victoria University of Wellington, School of Biological Sciences, New Zealand)

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

(S14-16561 Invited)

Methods and challenges for identifying VMEs and monitoring biodiversity on seamounts: a personal perspective from the South Pacific Ocean

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Vulnerable marine ecosystems (VMEs) face a continued threat from fishing, a likely threat from climate change, and a potential threat from deep-seabed mining. Seamounts are considered an example of a topographical feature that can potentially support VMEs. However, despite the publication of guidelines and criteria to assist in the identification of VMEs, and scientific studies that have attempted to operationalise these definitions, it is often practically difficult to identify or predict the occurrence of VMEs with a high degree of certainty. As such there is a degree of contention in discussions and actions aimed at effectively protecting VMEs from the threats they face. This presentation will draw on personal experiences from the seas around New Zealand and the wider South Pacific Ocean to illustrate this issue. The first part of the presentation will focus on identifying VMEs and assessing the impact of the threats they face. Successes and failures to practically identify and protect VMEs will be highlighted to identify potentially useful avenues for future research, and the challenges that remain. The second part of the presentation will focus on the research conducted in the South Pacific to assess and monitor biodiversity on seamounts, which will exemplify the methods and challenges faced in studying their sometimes complex benthic communities, as well as predicting their response and resilience to human impacts. The presentation will conclude with reflections on how we can perhaps better integrate current and future understanding of VMEs and seamounts for their management in the Pacific Ocean.

(S14-16491 Oral)

Coral biodiversity and genetic resources of West Pacific seamount, Godin Guyot

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Seamounts are underwater mountains that rise abruptly hundreds or thousands of meters from the seafloor. Scientists estimate that there are at least 100,000 seamounts >1000 m in height around the world, and seamounts of ~14,000 m have been found recently. These provide hard foundations upon which deep-sea life can settle and grow. Seamounts are important locations that maintain a high diversity of pelagic organisms and sessile benthic invertebrates, including suspension feeders. Deep-sea corals, primarily from Octocorallia (soft corals), Scleractinia (stony corals), and Antipatharia (black corals), represent one of the most common groups observed on seamounts studied worldwide. Deep-sea corals form a megafauna within the benthos, together with Porifera, Annelida, Echinodermata (crinoids and ophiuroids), and Tunicata. In this study, we explored seamounts in West Pacific, approximately 400km northeast from Guam, using ROV (remotely operated vehicle) and RV *ISABU* to investigate the deep-sea fauna and biodiversity around the seamounts. We aimed construction of the ecological map and discovery of biological resources, particularly from cnidarian. First of all, we collected samples of deep-sea coral species and extracted its RNA and DNA. We constructed transcriptomic assemblage of 3 deep sea corals (Rohdanirdogorgia. Sp., Chrysogorgia stellate, Calyptrophora lyla) after de novo RNA sequencing to investigate further gene expressions in abiotic extreme environment and also to discover differentially expressed genes comparing between deep-sea environment and shallow water species or cold water and trophic coral species.

(S14-16579 Oral)

Association analysis of Seamount benthos for identifying the validity of VME indicator taxa based on scientific sampling survey

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We analyzed the benthos samples collected by R/V Kaiyo-maru to identify effective indicators of benthic community diversity in the Emperor Seamounts area. The benthos samples were identified to family or order levels, and their occurrences in sampling locations were determined. Using the occurrence frequencies of benthic taxa in sampling locations as multivariate data, we calculated Jaccard index as a metric of the co-occurrence tendencies of pairs of taxa. Then, we classified the benthic taxa into clusters according to Ward's method based on the Jaccard distance (1 – Jaccard index) to characterize the benthic community in the study area. Finally, association analysis, which is commonly used for discovering hidden relationships among purchased items in market transaction data, was applied to the haul-by-haul occurrence data to explore the association rules for benthic taxa that represent strong relationship like **"**A habitat where taxa **A** occur is also inhabited by taxon **B"** are extracted. It has not been applicate to ecological studies.

(S14-16634 Oral)

Bathyal biogeography of North Pacific seamounts

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With recent advances in the use of remotely operated vehicles (ROVs) throughout the North Pacific Ocean, it has been possible to compile large datasets of the presence of megafaunal morphospecies identified from the video recorded during numerous dives. For this study, data were obtained from ROV dives conducted along the central Aleutian Ridge (NOAA Alaska Fisheries Science Center), Emperor Seamounts (Schmidt Ocean Institute & University of Hawaii at Manoa), and Hawaiian Ridge and several seamount groups in the central part of the North Pacific (NOAA Office of Exploration and Research) courtesy of the University of Hawaii Deep Sea Animal Research Center. In addition, records of octocoral occurrences obtained from the Ocean Biogeographic Information System (OBIS) and several other sources were used to assess Upper Bathyal biogeographic patterns and OBIS records of all anthozoans were used to supplement data from ROV dives in the Lower Bathyal. Data were analyzed using cluster analysis and network analysis methods. Five Upper Bathyal and three Lower Bathyal provinces were delimited from those data. North Pacific seamounts reach Upper Bathyal depths mainly in the NE Pacific and eastern part of the Subarctic provinces, but there are numerous seamounts in all three of the Lower Bathyal provinces. In fact, most of the octocoral data in the Lower Bathyal are from seamounts.

(S14-16679 Oral)

Monitoring cold-water corals and sponges in changing ocean conditions: A case study in the Canadian Pacific

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Understanding the mechanisms which constrain the distribution patterns of vulnerable marine species underpin ocean change predictions and Marine Protected Area (MPA) strategies. The Canadian Pacific contains some of the lowest oxygen levels in the global ocean, where a mid-water oxygen minimum zone (OMZ) is losing oxygen rapidly. Additionally, this area is transected by a dense collection of seamounts which support abundant long-lived habitat-forming cold-water corals and sponges (CWCS). The offshore MPAs within the Canadian Pacific aim to maintain and restore CWCS given a backdrop of rapid ocean change. Seven long-term monitoring sites (LTMS) were established on Dellwood Seamount in 2018 at depths identified as vulnerable to further oxygen depletion. 3D reconstructions of these LTMS were created to characterize abiotic and biotic factors and establish abundance and condition baselines for future monitoring. Three years later five of these LTMS were revisited, enabling the first CWCS time-series in the MPAs. Contrary to our expectations, we found evidence of changes in the abundance and condition of CWCS within the relatively short interval. Based on 3-D mosaic image analysis, we observed decreases in the number of coral branches, increases in the amount of visible dead tissue on sponges, and an overall decline in the total number of individuals per LTMS. Our findings highlight the importance of (1) ecological studies to identify drivers of biodiversity change, and (2) annual monitoring to monitor MPA effectiveness and facilitate strategic management in Canadian Pacific MPAs to support CWCS conservation objectives.

(S14-16683 Oral)

Using visual surveys and distribution models to identify vulnerable marine ecosystems on seamounts in the North Pacific Fisheries Commission Convention Area

Devon R. **Warawa**[1], Janelle M. R. Curtis[1], Chris N. Rooper[1], Samuel Georgian[2], Jessica Nephin[3], Jackson W. F. Chu[3], Sarah Dudas[3] and Anders Knudby[4]

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The United Nations General Assembly called upon States to manage fisheries sustainably and protect vulnerable marine ecosystems (VMEs) from destructive fishing practices when they adopted Resolution 61/105 in 2006. The North Pacific Fisheries Commission (NPFC) identifies four taxa of corals and two taxa of sponges as indicators of potential VMEs. The NPFC has yet to use these taxa to develop quantitative methods to identify VMEs, but it does support the use of the best available data to identify them. To date no VMEs have been identified in the northeast part of the NPFC Convention Area in part due to the sparse information available, including limited visual data and coarse resolution predictions of the suitable habitat for VME indicator taxa. We propose a quantitative method for VME identification that maximizes the value of existing data, integrating both visual data and model predictions in a manner that aligns with the precautionary approach, the Convention, and the research plan of the NPFC's Scientific Committee. We use data from Cobb Seamount to illustrate our proposed methodology. This preliminary application of our approach identified 58 areas of 50 m^2 that are VMEs on Cobb Seamount based on visual data. We further predict areas likely to be VMEs in the Cobb–Eickelberg Seamount chain using distribution models of VME suitability.

(S14-16691 Oral)

Application of environmental DNA metabarcoding approach to reveal biodiversity of seamounts in the northwestern Pacific Ocean

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Seamounts play an important role as biodiversity hotspots in deep-sea ecosystems. While studies on the biodiversity of seamounts can provide invaluable information for their effective resource management and conservation, it has been challenging primarily because of insufficient specimen numbers and low accessibility for exploration. As a cost-effective and non-destructive method, environmental DNA (eDNA) metabarcoding was here applied to analyze the eukaryotic diversity of seamounts in the northwestern Pacific Ocean. Seawater samples were collected across two seamounts (11 sites from KC-2 and one site from KC-8) at different water depths, as well as from abyssal plains (3 sites) at the bottom depth. Four liters of seawater were collected from each sample site and depth, and were analyzed using universal primers targeting the 18S rDNA gene by the Illumina MiSeq platform. As the result of eDNA metabarcoding analysis from 48 seawater samples, a total of 4,572 eukaryotic amplicon sequence variants (ASVs) were generated from 4,066,087 merged reads, which were assigned to 32 phyla and 81 classes. Among them, the Unidentified eukaryote was the most dominant, followed by the phyla Radiozoa, Euglenozoa, and Myzozoa. Similarity analysis based on ASVs showed that eukaryotic communities in the seamounts clearly differed from those in the abyssal plains and were clustered by depth rather than sample site. These results suggested that eDNA metabarcoding can be an effective tool for determining deep-sea eukaryotic communities and their spatial variation. However, the presence of a high percentage of unidentified eukaryotes in deep-sea water samples underscores the need of constructing a reference sequence database for precise species identification and establishment of long-term monitoring and assessment of the deep-sea biodiversity.

(S14-16692 Oral)

Environmental DNA as a potential tool for the understanding of demersal ichthyofauna in seamounts: a case study from the Emperor Seamounts area

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Environmental DNA is increasingly becoming popular as a tool to investigate biological communities in a wide range of habitats. In this study, we conducted an environmental DNA survey in the Emperor Seamounts area, an international fishery ground located in the high seas of North Pacific, to examine its effectiveness as a tool to investigate distributions of demersal animals in oceanic seamounts, using R/V Kaiyo-maru. By conducting environmental DNA and visual (drop camera) surveys at the same localities, we were able to compare the results of the two methods. In addition, there are a plenty of information on the fauna in this area owing to scientific surveys by research vessels and scientific observer programs on fishing vessels, providing the basis to evaluate the plausibility of detected species. In this presentation, we report the preliminary results on fishes, for which well-established sets of primers are available. By comparing species detected by environmental DNA against the list of species observed or collected, we demonstrated the possible effectiveness of environmental DNA survey as an efficient and non-invasive method to complement visual surveys and sample collection.

(S14-16751 Oral)

Spatial distribution and community structure of benthic megafauna from two seamounts in the northwest Pacific

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Underwater images have been considered a suitable tool for analyzing megafaunal diversity and distribution in various deep-sea habitats. Seamounts, in particular, are an appropriate habitat for a non-destructive image survey, as they are vulnerable marine ecosystems (VMEs) with an abundance of slow-growing and fragile organisms such as sponges and corals. Furthermore, the northwest Pacific has a high concentration of seamounts nearby, which means that connectivity between seamounts is likely to exist and could be affected by potential human activities in the future, making it necessary to understand the biodiversity of the region for monitoring and environmental management. In order to understand the spatial distribution and community structure of benthic megafauna in the northwest Pacific seamounts, seven and eight transects were surveyed in the Gordin and Hemler guyots using a deep-sea camera (HDR-CX700, Sony) from 2019 to 2022. Obtained images and multibeam echo sounder (EM120, EM121S) were utilized for terrain analysis to classify the habitat types. The major taxa represented were sponges, cnidarians, arthropods, and echinoderms. Megafaunal community structure varied by seamounts and transects, with sessile fauna decreasing with depth in the steeply sloping Hemler guyot but not in the relatively gently sloping Gordin guyot. These results show the biogeography and diversity of benthic megafauna in the northwest Pacific seamounts that can be used to plan environmental management.

(S14-16758 Oral)

Bathyal megafaunal assemblages of the Musicians Seamounts

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The Musicians Seamounts are a group of about 25 underwater mountains in the central Pacific Ocean north of the Main Hawaiian islands and bordering the eastern boundary of the Papahānaumokuākea Marine National Monument in the Northwestern Hawaiian Islands. The individual features are named for famous European composers, such as Mendelssohn, Tchaikovsky, Gershwin, Beethoven, Verdi, etc. The Musicians Seamounts are extrusive constructional volcanic features, with ages of 95 Ma in the north and 75 Ma in the south. These seamounts apparently were formed along the Euterpe hot spot track, which is now extinct. Fifteen remotely operated vehicle (ROV) dives were conducted as part of the NOAA CAPSTONE project in the central North Pacific. Morphospecies of sponges and octocorals were identified from the recorded video and compiled by the University of Hawaii at Manoa Deep Sea Animal Research Center. Those count data were aggregated at the family level due to the high number of unknown species and genera and analyzed using standard cluster analysis methods. At bathyal depths the seamount megafaunal assemblages could be divided into two groups, those with high density of megafauna vs. those with low density. There was also a faunal break between 2000 and 2100 m in the high density group. The deep (2600-2900 m) Lower Bathyal dives at Shostakovich Seamount were most similar to the abyssal dives throughout the seamount group.

(S14-16766 Oral)

Variability in zooplankton biomass and nutritional quality above Northeast Pacific seamounts, with application to marine conservation efforts

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Zooplankton are a major food source for many fish, marine mammals, and sea birds, representing a key link between primary producers and larger consumers in the open ocean. Due to the natural patchiness of plankton in marine ecosystems, prey quantity and quality are highly variable. Understanding the variability of zooplankton biomass and macronutrient composition can aid in measuring energy flow into marine environments, such as seamount ecosystems. My research aims to characterize zooplankton as a food source to Canadian seamounts and to determine whether these seamounts influence zooplankton distribution. This was completed using size-fractionated zooplankton biomass and taxonomy data collected during three oceanographic surveys in 2017, 2019, and 2021. Additionally, biomass samples were used for the determination of energy density, lipid content, and protein content of the zooplankton community. We found zooplankton energy density and nutrient content does differ between the seamounts and is largely due to differences in taxonomic assemblage. For example, in 2017 a higher proportion of zooplankton sampled at Union seamount were gelatinous, resulting in a community 1.5x less energy dense than other seamounts sampled. We have also determined this variation is likely due to natural mesoscale variability and not seamount effects, per se. Our data demonstrates the variability of zooplankton in the NE Pacific and how this can lead to quantitative differences in energy and macronutrients supplied to seamount ecosystems. I will also discuss how this variability in allochthonous energy flow to seamounts may impact the conservation and monitoring of Canadian offshore Pacific Marine Protected Areas.

(S14-16863 Oral) CANCELLED

~~Fish biodiversity monitoring in extreme environments: a case study of fish in the Southern Ocean~~

~~Yehui **Wang**[1], Chunlin Liu[1], Mi Duan[1], Wenchao Zhang[1], Shuyang Ma[1], Jianchao Li[1], Jianfeng He[2] and Yongjun Tian[1]~~

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~~Antarctica has attracted wide attention due to the unique biodiversity and vulnerable ecosystem, but its remote and extreme environment also poses challenges for ecosystem monitoring. Environmental DNA (eDNA) metabarcoding has been demonstrated by many studies to be an effective tool for resource investigation, especially for difficult-to-sampling regions. Here, we used eDNA to investigate the species composition and fish community structure across the Southern Ocean, including the Prydz Bay, Cosmonaut Sea, East Antarctic Peninsula Sea and Amundsen Sea. We collected 125 eDNA samples from 66 stations in four sea areas. A total of 43 species, belonging to 7 orders, 13 families and 31 genera, were detected in the Southern Ocean. The highest alpha diversity was found in the East Antarctic Peninsula Sea and Amundsen Sea, followed by the Cosmonaut Sea and Prydz Bay. The Principal Co-ordinates Analysis for fish assemblage revealed significant differences among the four sea areas, and the cluster analysis showed stations located in the seamount of the Cosmonaut Sea were separated from other stations. The analysis of horizontal distribution indicated that there is higher biodiversity in the nearshore area. In addition, the results of different sampling layers showed that the species detection rate is higher in the surface and bottom layer. Our study provides overall information on the fish community of the Southern Ocean, and demonstrates that eDNA as a supplement to traditional sampling will contribute to ecosystem-based fisheries management in the region.~~

(S14-16890 Oral)

Patterns of deepsea coral and sponge monitoring groups on Northeast Pacific seamounts: management implications

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Off the Pacific coast of Canada, Marine Protected Areas (MPAs) safeguard more than 135,000 km2 of deep-sea habitats, including at least 50 seamounts (i.e., SGaan Kinghlas-Bowie Seamount MPA and Tang.ɢwan-ḥačxʷiqak-Tsigis MPA). Current MPA management plans prioritize the conservation of cold-water corals and sponges (CWCS). However, given the size of the MPAs and number of seamounts, efficient and cost-effective monitoring is necessary. Current methods are time-consuming and require significant expertise (e.g., characterizing only surveyed areas and identifying CWCS to lowest taxonomic level). To streamline monitoring processes, extrapolating distribution patterns to unsurveyed areas and grouping CWCS species into larger monitoring groups (MGs) are being considered. Here we use benthic imagery from nine seamounts to assess the correlation of CWCS diversity and density patterns across seamounts with similar environmental characteristics. We adopt a national framework, based on taxonomy and morphological traits, to investigate if these MGs exhibit patterns comparable to their representative species. Preliminary findings reveal a lack of correlation in density and diversity patterns across seamounts. Moreover, monitoring for the nine MGs may obscure species-level distribution responses to environmental variables, including highly vulnerable species. The absence of correlation among seamounts, even with similar characteristics, challenges the suitability of using observed patterns to infer about unsurveyed seamounts. We highlight that low-resolution classifications can impact our understanding of how vulnerable species respond to changing ocean conditions, making them potentially unsuitable for monitoring MPAs based on conservation objectives. Here we provide recommendations for long-term monitoring plans in deep and remote MPA settings.

(S14-16926 Oral)

Flow around seamounts and larval retention: revisiting the Taylor cone

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One mystery in deep-sea ecology is how larvae of benthic organisms, many of which spend weeks or months in the pelagic before settling, are retained (or delivered) to maintain populations on isolated seamounts. A long-standing, and also controversial, idea is that a Taylor cone circulation is present and helps to retain larvae over many seamounts. With this in mind, we observed an Argo float circling the shallow SGaan Kinghlas-Bowie seamount in the Northeast Pacific, off the coast of British Columbia, for over 4 months starting in Fall 2020. Here, we assess the presence of a Taylor cone over SGaan Kinghlas-Bowie seamount using a combination of Argo trajectory and hydrographic data and remotely operated vehicle (ROV) imagery of sessile organisms. Some coral species, such as *Primnoa pacifica* and *Parastenella* spp., provide natural current meters. They are known to orient across the mean-flow direction --like catcher's mitts-- and the degree of curvature across the organism is related to the flow strength. While we find little evidence for a consistent Taylor cone, we do find evidence that Haida eddies visit the seamount regularly and may pause, providing a similar rretentive circulation Finally, we discuss the larval retention paradigm relative to a competing idea that SGaan Kinghlas-Bowie seamount is simply a stop on the larval highway and strongly connected to the continental slope.

(S14-17009-Oral)

Distribution, abundance and size structure of deep-sea corals and sponge communities on seamounts in international waters of the NE Pacific Ocean

Christopher N. **Rooper**[1], Pamela Goddard[2], Christina Conrath[2], Cynthia Wright[3], Kim Rand[2], Vanessa Lowe[2]

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Many seamounts in international waters are unexplored due to their remoteness and relative inaccessibility. Seamount communities face threats from historical and on-going fishing activity, as well as climate change impacts. In 2022, Canada and the USA conducted a survey of five seamounts in the Cobb Seamount chain using an underwater stereo camera system. Oceanographic data, eDNA and bird and mammal observations were also collected. This joint survey was designed to study deep-sea coral and sponges and their associated taxa. In total 77 camera transects were completed, with a high proportion of them observing glass sponges and corals, particularly those transects below 600 m. Species distribution models were developed predicting both presence and abundance of coral and sponge taxa. Densities of sponges and corals were relatively low and appeared to be related to the oceanographic and geological conditions at the sites. The sizes of sponges and corals were generally large indicating a mature community. The fish fauna was dominated by rockfishes and pleuronectids that are found in the adjacent shelf and slope ecosystems. The communities appeared to be largely organized by depth. Evidence of both historical and present day fishing activity was observed on most of the seamounts. Comparisons were made with shelf and slope systems around the Gulf of Alaska to gauge the uniqueness of the seamount ecosystems. The data collected during this survey will be useful for the regional fisheries management organization responsible for assessing the risks and sustainability of the Canadian sablefish fishery conducted at these seamounts.

(S14-16492 Poster) S14-P1

The microbial communities associated with the deep sea stalked barnacle

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Hydrothermal vent fields are an important component of deep-sea vent microbial ecosystems. To understand the ecology, physiology, and function of microbial groups distributed throughout the pelagic deep sea, the hydrothermal vent microbial communities and the processes possess the huge significance in biogeochemistry and the distributions of seafloor hydrothermal vent microbes between vents sites. All animals on Earth form associations with microorganisms, including protists, bacteria, archaea, fungi, and viruses. In especially deep-sea ocean, marine animal–microbial relationships has not been studied much like as terrestrial animals because the studies about the deep-sea or the hydrothermal vents have been limited due to the requirement for research vessels and remotely operated vehicles (ROVs). Despite the well-recognized importance of microorganisms in the biogeochemistry of hydrothermal vents and plumes, few studies have characterized microbial communities that inhabit them. The stalked barnacle, *Neolepas marisindica* from the Central Indian Ridge (CIR) was recently classified as Arthropoda; Crustacea; Hexanauplia; Scalpellomorpha; Eolepadidae; Neolepas and was collected various sites of Indian Ocean Central Ridge to compare its microbiome and plan to be compared with samples of West Pacific seamounts area. These biogeographic differences in bacterial composition may have been due to varying environmental conditions among study locations, or because of host responses to prevailing environmental conditions. This study provided a baseline for future studies of *Neolepas marisindica* microbiomes, and assessment of functions of host metabolites and *N. marisindica* holobionts.

(S14-16898 Poster) S14-P2

Habitat mapping to understand deep sea benthic communities and ecosystem

Won-Gi **Min**[1], Min-Su Woo[1] and Dongsung Kim[2]

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Deep sea areas support unique ecosystems and are sources for energy and minerals. Particularly deep-sea hydrothermal vents on the seafloor are dynamic environments with steep gradients of nutrient and physicochemical conditions resulting from both volcanic and tectonic events. Despite the extreme conditions, hydrothermal vent communities are characterized by a large biomass, predominantly composed of vestimentiferan tube worms, bathymodiolin mussels, vesicomyid clams, and shrimps. After the discovery of the Kairei hydrothermal vent field, an active hydrothermal vent, in 2000, only five hydrothermal vent communities (Dodo, Edmond, Kairei, Longqu, and Solitaire) were known in the Indian Ocean. However, the new hydrothermal vent, the Onnuri Vent Field (OVF), located on the northern Central Indian Ridge, was recently discovered by the Korea Institute of Ocean Science and Technology (KIOST) during a 2017–2018 research expedition. In this chemosynthesis-based ecosystem, the commonest species are the scaly-foot gastropod *Chrysomallon squamiferum* , the shrimps *Rimicaris kairei* and *Mirocaris indica*, the stalked barnacle *Neolepas marisindica*, and the mussel *Bathymodiolus marisindicus*. Species of bathymodiolin mussels are conspicuous and dominant taxa in the Indian hydrothermal vent fields and play an important role in providing energy and habitats for various animals. Exploring and mapping the deep sea around hydrothermal vent area help us fill gaps to better understand planetary-scale processes including tectonics and marine hazards; energy, mineral and biological resources; and other large-scale Earth systems.

(S14-16943 Poster) S14-P3 (ECOP)

The first report of deep-sea scallop *Propeamussium investigatoris* (E. A. Smith, 1906) from the seamount OSM 9-1 in the Western Pacific.

Jong-Seop **Shin**[1], Ki-Seong Hyeong[2], Kwang-Sik Choi[1]

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Recently, more than 14,500 seamounts have been identified from the world oceans, which are formed mainly by uplifting of the submarine volcano with 1,000 to 4,000 m height. In this study, the RV Onnuri of Korea Institute of Ocean Science and Technology visited the seamount OSM 9-1 in the West Pacific Ocean to explore the minerals and biotic resources. To collect the megabenthic organisms, we towed the Epi-Benthic Sledge at depth of 1,200 m on the slope near the top of OSM 9-1 (149˚56.3'E - 149˚53.6'E, 17˚05.0'N - 17˚02.2'N). We were able to collect two live intact scallops during the expedition. Size of the live scallop specimen collected in this survey were identical, as 2.0mm in shell length, 2.0mm in shell width, and 0.1mm in shell thickness. The shell was translucent and oval with distinct calcific ribs on the inner surface of the shell. Unlike other scallops, the deep-sea scallops collected in this study exhibited no apparent byssal notch on the right valve, suggesting that this scallop belongs to the family Propeamussiidae. Members in the family Propeamussiidae are known to distribute in deep sea mud bottom in the Indo-Pacifc Ocean. Moreover, it was revealed through the phylogenetic tree constructed using the 18s rRNA gene that the collected scallops show a close phylogenetic relationship with *Propeamussium investigatoris* (E.A. Smith, 1906). In addition, this study analyzed the complete mitochondrial genome of *P. investigatoris*, which is 18,132 bp, and it is expected to provide important information for future research on deep-sea scallop phylogeny.

BIO Contributed Paper Session

Convenors:
Akash Sastri (Canada)
David G Kimmel (USA)

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

(BIO-P-16574 Oral)

Dominance of the naked ciliates in the microplankton community during the post-bloom season in the Oyashio region, western subarctic Pacific

Mutsuo **Ichinomiya**[1], Yuichiro Nishibe[2], Yuji Okazaki[3], Mitsuhide Sato[4, 5] and Kazutaka Takahashi[5]

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The biomass and community structure of the microzooplankton were investigated during the post-bloom season when mesozooplankton forms an annual biomass peak, in the Oyashio region, the western subarctic Pacific. NO_3 and SiO_2 remained in the euphotic layer, while the chlorophyll concentration was low, indicating a high nutrient and low chlorophyll (HNLC) like condition. The microzooplankton biomass was 1.1–4.6 times higher than the phytoplankton biomass in the surface layer. Naked ciliates dominated the microzooplankton community (40–87%). The growth rates of naked ciliates at the *in situ* bottle incubation experiments were significantly positive at 0.23–0.99 d^{-1}. The mesozooplankton biomass was 6.4–10.0 times higher than the microzooplankton biomass. This inverted biomass pyramid with relatively low microzooplankton biomass and high mesozooplankton biomass would be explained by the high production of microzooplankton. Among the phytoplankton community pennate diatoms, picoeukaryotes and nano-flagellates were dominant with low biomass of chain-forming centric diatoms. The ratios of phytoplankton growth to grazing mortality by microzooplankton (m / μ) were relatively low at 0.26–0.44 at the dilution experiments. These low m / μ values of phytoplankton indicate that microzooplankton grazing does not regulate phytoplankton growth, suggesting that alternative nutritional sources, such as heterotrophic prey items or mixotrophy, fulfil the food requirement for microzooplankton growth. Overall, this study showed that during the post-bloom period in the Oyashio region, it is important to evaluate mechanisms sustaining dominance and production of microzooplankton, especially naked ciliates, under the HNLC-like condition.

(BIO-P-16649 Oral)

Differentially expressed genes associated with food availability and field expression levels in *Neocalanus plumchrus* (Calanoida: Copepoda)

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Neocalanus plumchrus is a prominent copepod species in the subarctic North Pacific and its adjacent seas, playing a crucial role as a food source for various organisms. Understanding the population dynamics of *N. plumchrus* is essential due to its ecological significance, with food availability being a key factor affecting copepod growth, reproduction, and survival. This study aimed to investigate the effects of food availability on the physiological condition of *N. plumchrus* through gene expression analysis. Culturing experiments involving two treatments, feeding (FED) and fasting (FAST), were conducted for 72 hours. The RNA-seq analysis identified 44,726 expressed genes, of which 6,133 genes showed significant differences in expression between the FED and FAST. Pathway enrichment analysis revealed that under the FAST condition, oxidative phosphorylation (OXPHOS), lysosome, and peroxisome exhibited higher expression levels, while DNA replication showed lower expression levels. Enhanced OXPHOS suggests that *N. plumchrus* maximizes the efficiency of converting stored nutrients into energy during food restriction. Activation of lysosomes, involved in intracellular substance degradation and recycling, and peroxisomes, involved in lipid metabolism, indicates efficient recycling of intracellular substances for energy sources under food restriction. Additionally, peroxisomes act as antioxidant systems, potentially serving as a response to reactive oxygen species generated by enhanced OXPHOS. The suppression of DNA replication suggests a potential growth inhibition associated with food restriction. Genes related to these pathways could serve as indicators of food limitation and potential growth in copepods. The presentation will also explore the relationship between gene expression levels in the field and environmental conditions.

(BIO-P-16732 Oral)

Rapid Zooplankton Assessment: developing a tool to apply zooplankton information to ecosystem-based fisheries management

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Zooplankton information is useful to apply to fisheries management as an ecosystem indicator. However, fisheries management often occurs on an annual cycle and zooplankton samples require significant time to process in order to produce useful data. This mismatch in timing has resulted in limited application of zooplankton information within an ecosystem-based fisheries framework as data are not typically available in time. Here we describe a rapid shipboard counting approach called Rapid Zooplankton Assessment (RZA) that does not require taxonomic expertise. RZA data from multiple surveys across three large marine ecosystems (LME) and two time periods were analyzed using a Bayesian, hierarchical modeling approach to determine how well RZA counts matched those of fully processed samples. The models revealed good agreement between RZA counts and processed counts for three coarse zooplankton categories important in fish diets. Random effects of sorter and survey had the most impact on the models, whereas fixed effects of LME and time period had no impact. The Bayesian approach allows prediction of final counts to be estimated with a credible interval, thus providing an estimate of uncertainty. Finally, we show how zooplankton time-series that include RZA estimates are used as indicators of ecosystem condition in Alaska's LMEs.

(BIO-P-16814 Oral)

Variations in phytoplankton biomass, size structure, and primary production in a warming Arctic

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Marine phytoplankton size structure, biomass, and primary production are important to carbon cycling and consequently also the quality (e.g., nutritional composition, size of phytoplankton particle) and quantity of dietary resources for higher trophic level consumers. Phytoplankton population dynamics can vary considerably between spring and summer, nutrient deplete and replete water masses, and between surface and subsurface depths in Arctic seas. We quantified spatial variations of total and size fractionated chlorophyll and primary production for 4 surveys conducted during late spring (June) and late summer (August-September) 2017-2019 in the northern Bering and Chukchi seas. We also compared seasonal changes in phytoplankton blooms in the upper mixed layer and at the subsurface maximum, and estimated the factors limiting phytoplankton growth (e.g., nutrients, light, and temperature). Our results indicate that chlorophyll biomass and production of the small (< 5 µm) and large (> 5 µm) size fractions differed between seasons and years. The relative abundance and production of the small size fraction was higher in summer than in spring, and in summer 2019 (the warmest year) compared to summer 2017. Initial data analyses indicate sub-surface blooms were more common in summer than in spring, particularly in regions with low surface nutrients. The reductions in phytoplankton size are likely to result in longer less efficient food webs with negative ramifications for higher trophic levels in this region.

(BIO-P-16869 Oral)

Opposite responses in chlorophyll-a in the Yellow Sea and East Sea LME

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A long-term analysis of the COBE SST in the North-western Pacific region, the Yellow Sea, East Sea, and East China Sea LMEs shows a clear indication of recent warming starting in the late 1980s. However, the exact trends in SST of the three LMEs were somewhat different. Furthermore, the chlorophyll-a time series from MODIS show that the biological responses were very different among the three LMEs. To understand why they were different spatially, dynamic time warping is used to classify the response patterns spatially. Here I discuss the possible causes of the opposite responses in the chlorophyll field in the Yellow Sea and East Sea LMEs.

(BIO-P-16917 Oral)

Inter-specific differences outweigh seasonal variability in zooplankton trophic markers, revealing distinct roles within a complex food web

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Zooplankton link primary producers and the microbial food web to higher trophic levels, forming a critical but complex connection within marine food webs. They consume an array of prey species using various feeding techniques and respond to shifts in phytoplankton and microbial communities, with subsequent effects on their consumers. Despite their importance, food web pathways to zooplankton remain poorly defined for many taxa, especially during winter. We investigated seasonal shifts in fatty acid and stable isotope trophic markers of ten key mesozooplankton taxa—including copepods, amphipods, mollusks, and an euphausiid—over an annual cycle in the Strait of Georgia, Canada. Seasonal diet shifts occurred in most species, but differences among taxa were the greatest source of variability. *Calanus* and *Eucalanus* had consistently elevated diatom fatty acids, as did late summer-fall *Euphausia*. In contrast, bacteria and pico-phytoplankton markers were high in *Limacina*, *Clione*, *Metridia*, and in *Euphausia* during late fall and winter. In all species, carnivory was greatest in March (high δ^{15}N, DHA:EPA), likely influenced by the abnormally short spring diatom bloom in February. Transient summer and fall diatom blooms contributed more to zooplankton, evidenced by persistent occurrence of diatom markers through summer for *Eucalanus* and *Calanus*, and peak diatom signal during late summer/fall for *Euphausia*, *Metridia*, and *Primno*. Although taxon fatty acid signatures generally remained distinct over the year, seasonal differences in fatty acid content (mg gDW^{-1}) and the nutritional factor DHA:EPA were very large within most species, highlighting the importance of seasonality for the nutritional quality of zooplankton.

(BIO-P-16935 Oral)

Geographical and seasonal variation of mesozooplankton community around Japan

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There are two major ocean currents on the Pacific side of Japan: the Oyashio, which is a cold current, and the Kuroshio, which is a warm current. Additionally, Japan is surrounded by marginal seas such as the Sea of Japan, Okhotsk Sea, and the Seto Inland Sea. These geographical features create diverse and complex oceanographic conditions around Japan, which, in turn, are significant factors affecting the zooplankton community structure. Due to the diverse oceanographic conditions, a wide variety of zooplankton communities is believed to exist around Japan, supporting diverse fish production. However, the community structure of zooplankton in this region has not been thoroughly understood. To obtain insights into the community structure and its geographical and seasonal variations, we analyzed zooplankton samples collected at stations established by Japan Fisheries Research and Education Agency and the prefectural institute in 2012 and 2017. The zooplankton communities were classified into four groups through cluster analysis. Group 1 is considered the cold water community, as it mainly comprises cold-species. Group 2 represents the transition community, consisting of both cold and warm species. While both Group 3 and Group 4 are considered warm water communities, Group 3 exhibits a higher abundance of neritic species. Clear seasonal shifts in the zooplankton communities were observed in the waters around Japan. In the Oyashio waters, Group 1 predominated from winter to summer, followed by Group 2 in autumn. In the Kuroshio waters, Group 3 was dominant from winter to spring, while Group 4 prevailed from summer to autumn. In the Sea of Japan, Group 3 mainly appeared from winter to summer in the southern part, while the northern part exhibited a prevalence of Group 2. In conclusion, this study sheds light on the shift of zooplankton communities and their relationships with environmental conditions. Further discussions will focus on the implications of these findings.

(BIO-P-16938 Oral)

Epipelagic zooplankton dynamics during International Year of the Salmon winter surveys of the NE Subarctic Pacific (2019, 2020, & 2022)

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The International Year of the Salmon High Seas Expeditions provided a rare opportunity to better understand winter to early spring zooplankton dynamics across the NE Subarctic Pacific. As part of the Gulf of Alaska Expeditions, bongo samples were collected north of 47.5 °N and east of 147.5 °W in February – March, 2019, and March – April, 2020. For the Pan-Pacific Expedition in 2022, the survey area was expanded westward to 172 °W and sampled over February – April from American, Canadian, and Russian vessels. To describe zooplankton dynamics, we identified communities using on a cluster analysis of genus abundances from 196 samples and interpreted variation in zooplankton taxon presence and abundance according to life history, behaviour, and regional oceanography. A cluster analysis divided samples largely according to SST, with clusters dominated by subarctic taxa occurring where SST was below 7 °C and clusters with high occurrence of transition zone and/or California Current species occurring with higher SST. The area covered by 'warmwater' clusters varied between years, and was largest in 2020. In addition, a region of low zooplankton abundance was observed in the area of the central Alaska Gyre. We discuss these findings in relation to zooplankton community size structure, biomass, and foraging opportunities for higher trophic levels.

(BIO-P-16950 Oral) CANCELLED

~~Exploring the temporal and spatial dynamics of zooplankton in the Salish Sea using environmental DNA~~

~~Andreas **Novotny**[1,2], Colleen Kellogg[2], Matt Lemay[2], and Brian P. V. Hunt[1,2]~~

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~~Being the primary trophic link between primary production and fish, understanding the temporal and spatial distribution of zooplankton is critical to comprehend the dynamics of marine ecosystems. While traditional sampling methods have limitations in capturing the complete picture of heterogenous zooplankton communities, environmental DNA (eDNA) has emerged as a promising tool to enhance sampling intensity. In this study we aimed to evaluate the efficiency of eDNA as a complementary approach to microscopy in capturing zooplankton community dynamics. Our results revealed the importance of sampling design when studying zooplankton communities. We observed higher agreement between DNA extracted from traditional net tows and microscopic observations compared to eDNA filtered from water samples collected across multiple depths in parallel with net sampling. However, despite these limitations, the eDNA analysis provided valuable insights into the temporal dynamics of individual zooplankton taxa when sampled with high frequency. Furthermore, our study detected significant differences in community composition among various sites in the northern Strait of Georgia, highlighting the spatial heterogeneity of zooplankton assemblages. Additionally, we identified variations in the timing of the occurrence of certain zooplankton taxa between years, suggesting potential associations with alterations in oceanographic properties and water mass structure. These findings underscore the potential of integrating eDNA analysis to complement and enhance the resolution of traditional zooplankton community monitoring.~~

(BIO-P-16542 Poster) BIO-Paper-P1 (ECOP)

Lipid acids contents of zooplankton community in the Kuroshio and its neighboring waters

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Kuroshio and its neighboring waters have been known as nursery grounds for early life stages of small pelagic fishes, despite of a poor food availability under the oligotrophic conditions. Recent findings suggest that plankton standing stocks increased by nutrients supply around the archipelagic sites provide good prey availability for these fish larvae. However, there is limited knowledge on qualitative evaluation of zooplankton community as the larval prey. Here, we demonstrate spatial and temporal variations in lipid acids contents of zooplankton community from the transect lines across the Kuroshio in the two different seasons for evaluating their nursery grounds in the Kuroshio and its neighboring waters. We detected 4 or 5 saturated (SFA), 4 mono-unsaturated (MUFA) and 11 or 12 poly-unsaturated fatty acids (PUFA) from zooplankton community. Multivariate analysis demonstrated that lipid acids contents to zooplankton dry mass were changed between the seasons and the regions. The temporal change was associated with SFA. Major PUFA represented by arachidonic (ARA), eicosapentaenoic (EPA) and docosahexaenoic acids (DHA) were increased during fall in the Kuroshio. These major PUFA contents exhibited significantly positive correlations to genetic abundance of Eucalanidae and molluscans determined with metabarcoding analysis and to contents of representative lipid acids for diatoms, dinoflagellates and haptophytes. These findings suggest that major PUFA contents of zooplankton community in the Kuroshio were equivalent to those in the Inshore of the Kuroshio due to the specific zooplankton groups and their feeding on major phytoplankton groups.

(BIO-P-16543 Poster) BIO-Paper-P2 (ECOP)

Feeding impacts of micro- to mesozooplankton on phytoplankton community in the Kuroshio and its neighboring waters

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Small pelagic fishes spend their vulnerable life stages around the low food availability in the oligotrophic Kuroshio. Although micro- and mesozooplankton are likely their energy source, there is limited measurements on their trophodynamics of plankton food web in the Kuroshio. Here, we demonstrate feeding impacts of micro- and mesozooplankton on phytoplankton community in the Kuroshio and its neighboring waters using onboard dilution experiments of micro- and mesozooplankton. Grazing mortality of phytoplankton was estimated with dilutions in standing stocks of microzooplankton (i.e., seawater without mesozooplankton) and micro- plus mesozooplankton (i.e., ambient seawater). Grazing rates were variable ranged from 0.22 to 1.82 day^{-1} for microzooplankton and from 0.10 to 0.97 day^{-1} for micro- plus mesozooplankton. Grazing impacts of microzooplankton and micro- plus mesozooplankton on primary production were significantly increased with the ambient chlorophyll *a* concentrations. In the Kuroshio, whereas primary production was almost consumed by microzooplankton in the experiment bottles removed mesozooplankton, grazing impacts of micro- plus mesozooplankton corresponded to half of primary production. Based on the size-fractionated dilution experiments, microzooplankton grazing mortality exceeding micro- plus mesozooplankton were always evident for pico-autotrophs, indicating trophic cascading effects of microzooplankton predated by mesozooplankton. These findings suggest that mesozooplankton controls microzooplankton grazing down primary production and yields predominance of pico-autotrophs in the Kuroshio through their trophic cascading effects.

(BIO-P-16550 Poster) BIO-Paper-P3 (ECOP)

A new species of copepod, *Mesocalanus* n. sp. (Calanoida, Calanidae), from the Coastal Waters of Korea

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Mesocalanus spp. appear in the coastal water of Korea and have been identified so far as two species: *Mesocalanus tenuicornis* and *M. lighti*. A recent molecular analysis suggested the specimens identified as *M. tenuicornis* was a new species. Morphological analysis was additionally performed for the accurate identification of this new species. *Mesocalanus* sp. samples were collected in April, May, and August 2022 in the East Sea by a Bongonet (80 cm mouth diameter, 330 μm mesh). The body shape, total length (prosome and urosome), and the ratio of cephalothorax length (CL) and depth (CD) were analyzed. The appendages were dissected and measured. The body shape was similar to that of *M. tenuicornis* in the species' sharp and stubby form. Total length (TL) ranged from 1.5 to 2.1 mm. Prosome length (PL) ranged from 1.1 to 1.65 mm. Appendages of *Mesocalanus* n. sp. were mostly similar to *M. tenuicornis*, and *M. lighti*, but different in the fifth leg of male. The right exopodite of the fifth leg of *Mesocalanus* n. sp. has five spines and three setae while those of *M. tenuicornis* and *M. lighti* do of seven spines and no setae. With this study, we report three *Mesocalanus* species in the coastal water of Korea.

(BIO-P-16581 Poster) BIO-Paper-P4

An underwater glider observation of phytoplankton photosynthetic activity using a Fast Repetition Rate Fluorometer (FRRF)

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An underwater glider (Sea Explorer, Alseamar) equipped with a FRRF (FastOcean FRRF3, Chelsea Technologies) was deployed in May 2022 to monitor the phytoplankton photosynthetic activity off the east coast of Japan where warm Kuroshio and cold Oyashio waters confluence. While TS properties were classified as the Oyashio water during the entire mission, seawater in the latter half of the mission has higher salinity, lower nutrient, and lesser chlorophyl fluorescence and has a subsurface salinity maximum, indicating the influence of Kuroshio. The subsurface maximum of mean daytime photosystem II (PSII) photochemical efficiency under ambient light (*Fq'/Fm'*) was reduced from 0.4 to 0.3 in the latter period possibly due to the low nutrient availability of seawater affected by Kuroshio. The nighttime mean absorption cross section of PSII photochemistry in darkness (σ_{PSII}) was also reduced in the surface layer. Since our FRRF only consisted of the light chamber, the phytoplankton productivity was estimated via a formula of Kolber and Falkowski (1993) assuming the vertical profile of daytime σ_{PSII} was the same as the nighttime mean σ_{PSII} profile. The resultant productivity was comparable to those from incubation experiments made by a past study in the Kuroshio-Oyashio transitional area in spring. In contrast to the lower *Fq'/Fm'* and smaller σ_{PSII} in the latter period, the estimated productivity was larger than the former period due to the stronger solar irradiance. These results suggest that the phytoplankton production in the Kuroshio-Oyashio transitional area may be primarily controlled by the light intensity and secondary by seawater properties.

(BIO-P-16585 Poster) BIO-Paper-P5

Metavirome profiling and dynamics of the DNA viral community in seawater in Chuuk State, Federated States of Micronesia

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Despite their abundance and ecological importance, little is known about the diversity of marine viruses, in part because most cannot be cultured in the laboratory. Here, we used high-throughput viral metagenomics of uncultivated viruses to investigate the dynamics of DNA viruses in Chuuk State, Federated States of Micronesia tropical seawater sampled in March, June, and December, 2014. Among the identified viruses, 71–79% were bacteriophages belonging to the families *Myoviridae, Siphoviridae*, and *Podoviridae* (*Caudoviriales*), listed in order of abundance at all sampling times. Although the measured environmental factors (temperature, salinity, and pH) remained unchanged in the seawater over time, viral dynamics changed. The proportion of cyanophages (34.7%) was highest in June, whereas the proportion of mimiviruses, phycodnaviruses, and other nucleo-cytoplasmic large DNA viruses (NCLDVs) was higher in March and December. Host species were not analysed, but the dramatic viral community change observed in June was likely due to changes in the abundance of cyanophage-infected cyanobacteria, whereas changes in NCLDVs was likely due to the abundance of potential eukaryote-infected hosts. These results can serve as a basis for comparative analyses of other marine viral communities and guide policy making when considering marine life care in Chuuk State.

(BIO-P-16594 Poster) BIO-Paper-P6

Covariance of marine nucleocytoplasmic large DNA viruses with eukaryotic plankton communities in the sub-arctic Kongsfjorden ecosystem: a metagenomic analysis of marine microbial ecosystems

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Nucleocytoplasmic large DNA viruses (NCLDVs) infect various marine eukaryotes. However, little is known about NCLDV diversity and their relationships with eukaryotic hosts in marine environments, the elucidation of which will advance the current understanding of marine ecosystems. This study characterises the interplay between NCLDVs and the eukaryotic plankton community (EPC) in the sub-Arctic area using metagenomics and metabarcoding to investigate NCLDVs and EPC, respectively, in the Kongsfjorden ecosystem of Svalbard (Norway) in April and June, 2018. *Gyrodinium helveticum* (Dinophyceae) is the most prevalent eukaryotic taxon in the EPC in April, during which time *Mimiviridae* (31.8%), *Poxviridae* (25.1%), *Phycodnaviridae* (14.7%) and *Pandoraviridae* (13.1%) predominate. However, in June, the predominant taxon is Aureococcus anophagefferens (Pelagophyceae), and the NCLDVs, *Poxviridae* (32.9%), *Mimiviridae* (29.1%), and *Phycodnaviridae* (18.5%) appear in higher proportions with an increase in Pelagophyceae, Bacillariophyceae, and Chlorophyta groups. Thus, differences in NCLDVs may be caused by changes in EPC composition in response to environmental changes, such as increases in water temperature and light intensity. Taken together, these findings are particularly relevant considering the anticipated impact of NCLDV-induced EPC control mechanisms on polar regions and, therefore, improves the understanding of the Sub-Arctic Kongsfjorden ecosystem.

(BIO-P-16622 Poster) BIO-Paper-P7 (ECOP)

Hypoxia tolerance of *Calanus marshallae*: Implications for its future distribution in the Northern California Current System

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The increasing severity of hypoxia every summer throughout the Northern California Current System has resulted in large mortality events across multiple commercially important fishery species. In response to this, a significant amount of work is being done to better understand the impact of low oxygen conditions on these species. However, little work has been done to determine the impacts of seasonal hypoxia in species at the base of marine food webs. The calanoid copepod *Calanus marshallae* is a major prey item for fish throughout the coastal North Pacific, but nothing is known about how hypoxia impacts its availability and distribution. In this study, we quantify the lower thresholds of hypoxia tolerance in *C. marshallae* through respirometry trials carried out at multiple temperatures. Hypoxia tolerance is measured via the calculation of the P_{crit} value for each individual, which is defined as the partial pressure of oxygen at which basal metabolic rate can no longer be sustained. Temperature-specific P_{crit} values are then compared to conditions in the field, to determine the extent of metabolically stressful or viable space throughout the water column for *C. marshallae*. Assuming that hypoxia increases in both spatial extent and intensity on the Oregon coast throughout the upwelling season, tolerance to hypoxia in *C. marshallae* will likely vary significantly throughout the upwelling season as time of exposure and temperature increase. This study will mark the first to quantify the tolerance to hypoxia in *C. marshallae*, as well as how that tolerance likely fluctuates throughout the upwelling season.

(BIO-P-16651 Poster) BIO-Paper-P8 (ECOP)

Exploring the impact of harmful algal bloom species *Karenia selliformis* on the survival and grazing of copepods from the Pacific region of southeastern Hokkaido, Japan

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In autumn 2021, a large-scale harmful algal bloom (HAB) dominated by the dinoflagellate *Karenia selliformis* was observed along the Pacific coast of southeastern Hokkaido, Japan. HABs occur in unprecedented areas, and their effects on marine ecosystems, particularly on lower trophic levels, in such areas are poorly understood. In this study, we investigated the effects of a HAB on the survival and grazing habits of copepods distributed in southeastern Hokkaido. We conducted survival and grazing experiments on six copepod species (*Acartia tumida*, *Centropages abdominalis*, *Eurytemora herdmani*, *Metridia* sp., *Neocalanus plumchrus*, *Paracalanus* sp.) exposed to varying cell densities of *K. selliformis*. Results showed that the presence of *K. selliformis* significantly reduced copepod survival, with higher cell density of *K. selliformis* leading to a more pronounced effect. Interestingly, copepod survival was also reduced when reared in seawater from which *K. selliformis* cells had been removed using a syringe filter. Since copepod survival was reduced even without physical contact with or grazing on *K. selliformis* cells, *K. selliformis* may release toxic chemical compounds extracellularly. The grazing experiment shows that *Neocalanus plumchrus*, the largest body-size copepod species in this study, can ingest *K. selliformis*, although its intake is inhibited at a high algal cell density. Large copepods with the small surface-to-volume ratio may have a higher tolerance than smaller species. The study suggests that *K. selliformis* blooms negatively impact marine ecosystems by affecting copepod survival and grazing behavior. These findings have important implications for understanding impacts of HAB on marine ecosystems.

(BIO-P-16676 Poster) BIO-Paper-P9

Preliminary results of multi-year diet analysis project of Walleye Pollock (*Gadus chalcogrammus*) in the Western Gulf of Alaska, USA

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Walleye Pollock is a fish of high commercial value in the north Pacific Ocean.
As such, the environmental and biological factors that influence their early life history and contribute to overwinter survival and eventual recruitment are of considerable interest.
One factor that potentially plays a large role in pollock early life history is diet. For example, availabilty of low caloric (small or lipid poor copepods) versus high caloric (large lipid rich copepods and euphausiids) prey has a direct influence on growth rates and potential predator avoidance. Here we present a preliminary analysis of interannual variability within Walleye Pollock diets sampled every other year in the western Gulf of Alaska from 2003 – 2019. We tracked interannual shifts in diet composition using Prey-specific Index of Relative Importance (PSIRI), a metric used to determine prey importance within a diet. We then linked diet composition to a total energetic value per stomach. Ultimately, we will explore the oceanographic and biological drivers of spatial and interannual variation in diet quality to further understand how changes in the Gulf of Alaska ecosystem affect conditions for juvenile pollock growth and survival.

(BIO-P-16695 Poster) BIO-Paper-P10

Developing a fiberization process for the common cordgrass from salt marsh plant

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The common cordgrass (*Sporobolus anglicus*) is a salt marsh plant that is naturally found in the North Atlantic region. In recent years, it has significantly expanded its habitat along the coasts of Korea and China. Researchers and governments have shown great interest in understanding the impact of these environmental changes on the existing salt marsh ecosystems and in developing policies for the effective management of the common cordgrass. The Korean government has designated the common cordgrass as an invasive species and has implemented a policy of annual removal followed by disposal through landfill or incineration. However, since the common cordgrass has not yet demonstrated potential as an industrial or medical material, disposal through landfill or incineration remains the only available method, which leads to secondary environmental issues.
This study aims to develop a process for obtaining fibers from cordgrass stems and evaluate their characteristics as a fiber material. The optimization conditions for degumming the cordgrass fiber were determined, and the morphology of fibers after carding and combing was examined. Additionally, physical properties such as tensile strength, moisture content, and photostability were measured and compared with those of hemp fiber to evaluate the potential of cordgrass as a fiber material. The findings are expected to propose various applications for common cordgrass fibers and enhance its value as a carbon storage plant.

(BIO-P-16700 Poster) BIO-Paper-P11 (ECOP)

Immediate and gradual effects of typhoons on the blooms of harmful dinoflagellate *Margalefidinium* (=*Cochlodinium*) *polykrikoides* in Korean coastal waters

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Typhoons passage has significant effects on the blooms of harmful dinoflagellate *Margalefidinium* (=*Cochlodinium*) *polykrikoides* in Korean coastal waters (KCWs). This study aimed to investigate the immediate and gradual effects of typhoon passage on these blooms. First, in terms of immediate effect, in September 2019, typhoon *Lingling* triggered the accumulation of red tide, but typhoon *Tapah* immediately terminated the bloom. Comparison of physical parameters of typhoons that affected the Korean peninsula during blooming periods over the past 20 years revealed that typhoons *Bolaven* and *Tapah* with high cumulative wave energy, were potentially responsible for bloom termination. Second, in terms of gradual effect, to investigate the gradual effects of typhoon passage, microcosm experiments using sediments from different KCWs sites simulated the effect of suspended sediment-based diatoms on *M. polykrikoides* blooms. This dinoflagellate grew well under control conditions and exhibited a maximum abundance of 985 cells mL^{-1} on day 10, but all treatment groups had decreased abundances by day 4 and fewer than 50 cells mL^{-1} on day 10. As *M. polykrikoides* declined, two diatoms (*Skeletonema* spp. and *Chaetoceros* spp.) dominated in the three treatment groups. In addition, sediment addition led to a high proportion of Verrucomicrobiales, affecting the bacterial community. Overall, our microcosm experiments suggest that the proliferation of sediment-based diatoms following the passage of a typhoon, decreases blooms of *M. polykrikoides* and affects the bacterial community.

(BIO-P-16735 Poster) BIO-Paper-P12

Differential response of the copepods, *Calanus glacialis* and *Pseudocalanus* spp. to recent warming in the Chukchi Sea

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It has been hypothesized that the Alaskan Arctic is undergoing borealization due to rapid warming. Under historical conditions, *Calanus glacialis* grazed on ice-associated phytoplankton to fuel spring reproduction and accumulated biomass and lipid over the summer that provided forage to fish, mammals, and seabirds. However, recent warming has resulted in declines in *C. glacialis* biomass and increases in smaller body sized *Pseudocalanus* spp. advected from the Bering Sea. Here we present an analysis of 11 years of biomass data focused on these two copepods in the Chukchi Sea. We used a species distribution model to investigate spatiotemporal changes in response to physical conditions. We found that changes in physical conditions coincided with movement of the center of gravity for *C. glacialis* and *Pseudocalanus* spp. Locations of increased biomass (“hot-spots”) also shifted in response to physical conditions. Sea ice extent was positively correlated to *C. glacialis* biomass and advection from the Bering Sea was positively correlated to *Pseudocalanus* spp. biomass. We also found that colder years had much higher biomass of *C. glacialis* overall, but that during warm years, *Pseudocalanus* spp. biomass was equal to or exceeded *C. glacialis* biomass, though was reduced overall compared to cold years. These results suggest a change in trophic dynamics is likely to occur in the Chukchi Sea in the face of continued warming, altering ecosystem structure and function.

(BIO-P-16741 Poster) BIO-Paper-P13 (ECOP)

Assessment of CO_2 removal potential of *Neopyropia* aquaculture beds

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The global seaweed aquaculture beds (SABs) play a positive role in carbon sequestration. Among cultivated seaweeds, *Neopyropia* (or *Pyropia*) accounts for approximately 8% of global seaweed production and has the potential to remove a significant amount of CO_2 from the ocean's surface layer. In this study, we evaluated potential CO_2 removal efficiency of *Neopyropia* SABs by measuring photosynthesis. Samples of *Neopyropia* were collected from *Neopyropia* SABs located on the South and West coasts of Korea from 2016 to 2019 (December to March), and photosynthetic light-response curves were measured. The maximum rates of CO_2 uptake ranged from 9.99 to 21.39 mg CO_2 g^{-1}ww h^{-1} with a P/R ratio (photosynthesis to respiration ratio) of 16.15 to 58.56, demonstrating a potent availability of carbon sequestration of *Neopyropia* SABs. To quantify the CO_2 removal potential (i.e., carbon-based primary productivity) in the coastal areas of Korea peninsula during the cultivation period (December to March), we extrapolated the CO_2 uptake rates using the total area of *Neopyropia* SABs and meteorological light data. The highest CO_2 removal potential was observed in the Southern Sea in December, with a value of 2,823 tons CO_2 $month^{-1}$. When considering all productivity data from the entire cultivation period, approximately 9,679 tons of CO_2 were removed through the *Neopyropia* SABs. Our study indicates that *Neopyropia* SABs possess a significant potential for CO_2 removal through primary production. Also, harvesting and effectively utilizing macroalgal primary productivity could contribute to reducing greenhouse gas emissions.

(BIO-P-16746 Poster) BIO-Paper-P14 (ECOP)

Assessment of carbon storage capacity of oyster, *Magallana gigas* in Korean aquaculture farms

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More than 90% of bivalve shells are composed of calcium carbonate, and are formed through biogenic calcification, absorbing carbon within the ecosystem to create the shell. Furthermore, as bivalves grow, the discarded shells settle on the seabed and become sequestration. The aim of this study is to estimate the carbon storage in Pacific oyster aquaculture farms along the southern coast of Korea. *Magallana gigas* were monthly collected at aquaculture farm over the period from August in 2022 to April in 2023. Sediment core samples were also collected at the beginning of the study. Total percentage of inorganic carbon based on the monthly growth in the shells were not significantly different and oyster shell contained 11.5 ± 0.07% carbon individually. Total annual oyster products, based on the study area, is 303 tons a year which indicated that 26 tons of carbon is sequestrated annually. In terms of carbon sequestration of sediment, the sediment from aquaculture farm was 17 t C/ha. whereas 6.5 t C/ha. in the non-farming area. This result indicated that oyster shells themselves and oyster farming area can play an important role as a carbon sink in the ocean.

Spatiotemporal distribution of subtidal meiofaunal and macrofaunal assemblages along the southern coast of Korea

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This study was conducted to investigate the spatiotemporal variability in subtidal macrofaunal and meiofaunal assemblages off the southern coast of Korea at local scales. Abiotic (e.g. temperature, Salinity, pH, DO, grain size, TOC, TN, heavy metals) and biotic (e.g. density, diversity, assemblages composition) samples were collected at nine sites over 6 years (2015-2020). The species richness, density, and composition of the macrofaunal and meiofaunal assemblages differed significantly among sites. Nematoda and Annelida were the most dominant meiofaunal and macrofaunal taxa, respectively, although dominant taxa differed among sites and years. The dominant species among the meiofauna assemblages is the nematode species *Dorylaimopsis*, *Terschellingia*, and *Parodontophora*, while dominant species are *Diopatra bilobata* and *Cirrophorus furcatus* in macrofaunal assemblages. A distance-based multivariate multiple regression analysis revealed that the mean sediment grain size, and heavy metals concentrations were key environmental variables determining the variation of both assemblages. This study can provide basic ecological data for understanding the spatiotemporal distribution of benthic assemblages along the south coast of Korea and aid in the development of management strategies to mitigate marine pollution in the region.

(BIO-P-16763 Poster) **CANCELLED** BIO-Paper-P16 (ECOP)

~~Understanding the mechanisms linking large-scale climate indices to zooplankton biomass in the Strait of Georgia, Canada, using a modelling approach~~

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~~The North Pacific Gyre Oscillation (NPGO) is a climate pattern that emerges as the second dominant mode of variability in sea surface height in the Northeast Pacific. Previous studies have linked NPGO to variations in phytoplankton and zooplankton in the Strait of Georgia, Canada. While the exact mechanisms by which this climate pattern affects lower trophic levels remain unclear, there is a strong correlation between Salish Sea temperature and NPGO. Here, we used a three dimensional biogeochemical model, SalishSeaCast, to compare physical drivers and lower trophic level dynamics between NPGO positive (cool-phase) and NPGO negative (warm-phase) years over a 14-year period from 2007 to 2020. In addition, we ran model experiments trading individual warm and cold year physical parameters to determine the mechanistic drivers of modelled changes to the food web. Our results showed that spring diatom biomass peaked earlier during warm-phase years. Moreover, lower diatom biomass during the summer months of warm-phase years resulted in zooplankton grazing on a higher proportion of small flagellates in the model. The model experiments revealed that local wind-driven upwelling had the strongest influence on nitrate concentrations and, ultimately, the food available to zooplankton. These findings help us to better understand mechanisms of interannual zooplankton variability and implications of future warming scenarios in terms of the quantity and quality of prey available to zooplankton, and the potential impact on energy transfer to higher trophic levels.~~

(BIO-P-16770 Poster) BIO-Paper-P17 (ECOP)

Population structure of *Caprella scaura* (Amphipoda: Caprellidae) on *Sargassum thunbergii* at Cheongsapo, Busan in Korea

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Sargassum thunbergii is a common species in the Korean intertidal zone and numerous invertebrates live on the species. *Caprella scaura* inhabits dominantly on *S. thunbergii*. The population structure of *C. scaura* on *S. thunbergii* was investigated from November 25, 2021 to November 25, 2022. *S. thunbergii* was biweekly collected in the intertidal area of Cheongsapo, Busan in Korea. The dry weight (g) of *S. thunbergii* was measured. The density of *C. scaura* was calculated by algal dry weight. Life stages of *C. scaura* were categorized and counted. The size of *C. scaura* was measured, and the size group was classified into 0.5 mm intervals. Eggs and juveniles were separated from the brood pouch of the ovigerous females. They were counted and measured by sizes. The density of *C. scaura* was highest on August 3, 2022. The size range varied from 0.5 to 17.5 mm. The sex ratio was mainly skewed towards males. The range of egg size was from 0.100 to 0.458 mm. The number of eggs ranged from 2 to 97 eggs. The size of the eggs was mostly similar regardless of female sizes, but the number of eggs was closely related with female lengths. The density of *C. scaura* was not related with temperature, salinity, and dry weight, but the size was significantly related to temperature and salinity. The recruitment ratio was highest in late spring. We estimate that the life span of *C. scaura* is two to three months.

(BIO-P-16817 Poster) BIO-Paper-P18

Research on development of macrobenthic community analysis through genetic classification

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This study was conducted to develop and apply the benthic community analysis methods using eDNA. The samples were collected in Gamak and Deukryang Bay on the southern coast of Korea from Aug. 2021 to May 2022; the morphological and genetic classification was carried out simultaneously to establish a species identification system. A species identification system based on NGS (next-generation sequencing) was established to develop a genetic information reference for each species, and species were determined through DNA analysis. A total of 106 species of macrobenthic fauna appeared in Gamak and Deukryang Bay during the study period. After morphological identification, CO-I analysis was performed on 31 arthropods and 51 annelids. After completing the PCR, sequencing was performed for the species in which the resulting band was identified. Some of the sequenced samples were identified to the genus level. However, most species were identified as species with entirely different ecological information. The only species with consistent morphological and genetic classification results were *Paraprionospio cordifolia* of annelids, *Monocorophium acherusicum*, and *Xenophthalmus pinnotheroides* of arthropods. *P. cordifolia* is one of the three species isolated from *Paraprionospio pinnata*, and its genetic information has been registered relatively recently. As such, information on species must still be sufficient to perform community analysis of macrobenthos by DNA analysis. Therefore, it is judged that preparing a species composition and database suitable for the domestic situation is necessary to form a community analysis study using the eDNA method for marine invertebrates.

(BIO-P-16827 Poster) BIO-Paper-P19 (ECOP)

Origin and distribution of the floating *Sargassum* in the Yellow and East China Sea

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Using particle tracking modeling and satellite data, the origin and pathway of the floating *Sargassum* reaching southwestern part of Korea were investigated. The study revealed that the *Sargassum* was not only from the Zhejiang coast of the East China Sea (ECS) but also from the northern coast of the Yellow Sea (YS). Particles from the northern coast of the YS origin showed two paths, reaching Jeju Island and the southwestern part of the Korean Peninsula due to the influence of monsoon and coastal currents in winter or moving to the ECS and reaching the area through southerly wind in spring. The timing of arrival at the coast of the Korean Peninsula varies from year to year, but the early arrival of each year was greatly influenced by the westerly wind in December of last year. In relation to the growth of *Sargassum*, the study highlights the importance of temperature. Between 2010–2022, the surface temperature trend on the coast of China and the ECS was about 10 times higher than that of the past 30 years and 5–6 times the global surface average, indicating that accelerated algae growth and warming of coastal and sea areas are related, and continuous monitoring is necessary.

(BIO-P-16845 Poster) CANCELLED BIO-Paper-P20

~~Spatio-temporal shifts in copepod communities in the southern Salish Sea, 2014-2022~~

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~~The southern Salish Sea in Washington State, USA supports diverse zooplankton communities influenced by oceanic and estuarine waters. Within these populations, copepods contribute >50% of the abundance and biomass of zooplankton available to critical fisheries. Their sensitivity to environmental stressors makes them a vital level to monitor in the marine food web. This study analyzed copepod species throughout Puget Sound and northern Washington from 2014-2022, a period which included the marine heatwave of 2015-2016. While increased temperatures were associated with positive responses in abundances of many zooplankton, copepods were multifaceted, showing anomalous highs at northern stations during 2019 and 2020, while previously highest at southern stations in 2017, indicating mechanisms beyond temperature controlled abundances. NMS ordinations show distinct copepod clusters exist in more ocean exposed regions compared to groups within Puget Sound. These northern communities may be responding to seasonal fluctuations driven by circulation dynamics, such as advection from the coast through the Strait of Juan de Fuca and Admiralty Inlet, apart from those in the more isolated southern regions of Hood Canal and South Sound. Furthermore, Indicator Species Analysis showed species-specific aggregates that included northern boreal species (*Acartia longiremis* and *Pseudocalanus mimus*) and sub-Arctic species (*Eucalanus* spp. and *Neocalanus* spp.) separated from the resident warm water species of Puget Sound (*Ditrichocorycaeus anglicus*, *Calanus pacificus*, and *Paracalanus* spp.). These findings contribute to a better understanding of the drivers of zooplankton communities and how they relate to varying conditions in a complex fjord ecosystem on the brink of shifting climate regimes.~~

(BIO-P-16849 Poster) BIO-Paper-P21 (ECOP)

Using two biochemical methods to characterize *in situ* secondary production in the waters around Vancouver Island

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Zooplankton represent a critical link in marine food webs, allowing energy produced via primary production to be transferred to ecologically and economically important organisms at higher tropic levels. Despite this, field measurements of the rate at which zooplankton production ("secondary production") occurs *in situ* remain rare. Two advances in measuring secondary production, the chitobiase method and the aminoacyl-tRNA synthetase (AARS) method, use biochemical measures to enable *in situ* production rate estimates in less time and with less effort than traditional incubation-based practices. Pairing these two methods in a field setting provides the opportunity to compare their limitations and to measure *in situ* zooplankton production rates at a higher resolution than previously attainable. Chitobiase and AARS sampling was conducted at various stations off the west coast of Vancouver Island and in the Strait of Georgia from September 2021 to September 2022 to characterize spatiotemporal variability in rates of secondary production. Ocean Network Canada's "Community Fisher" project was used to supplement this data. Initial results indicate a positive relationship between the secondary production rates estimated by both biochemical methods and growth rates estimated by the widely accepted Huntley and Lopez temperature-dependent growth model. Here we share the preliminary results of the first simultaneous use of these biochemical methods in the field and provide insights into the spatiotemporal variability in secondary production in the waters surrounding Vancouver Island.

(BIO-P-16910 Poster) BIO-Paper-P22 (ECOP)

Red tide events promote an increased zooplankton biodiversity?

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Over seven years (2013-2019), we explored the zooplankton biodiversity using the metabarcoding approach in Tongyeong, located on the southern coast of Korea. This region is known for the active aquaculture industry. To investigate the impact of the red tide events on zooplankton dynamics, we performed a comparative analysis of biodiversity. This involved the samples taken before, during, and after red tide events as well as a comparison between samples collected in years with red tide occurrences and those from years without red tide. Out of the 519 taxa identified, 374 taxa (72%) were classified as zooplankton. Among them, copepods were the most abundant taxa comprising an average of 57.34%. During the red tide periods, species richness (α-diversity) either increased or remained relatively similar when compared to before their occurrence and same periods (mostly July-August) in no-red tide years. The cluster structure (β-diversity) exhibited notable differences during the red tide periods compared to no-red tide years. The dissimilarities showed a significant correlation with the density of red tide species (*C. polykrikoides*) and SST. During HAB, we observed a decrease in the proportion of calanoid copepods and an increase in various invertebrate zooplankton. This suggests that massive red tide outbreaks have the potential to temporarily increase zooplankton diversity. Overall, this study presents a comprehensive and detailed analysis of the shifts in the zooplankton community during red tide events, providing valuable insights into their dynamics. The findings contribute to our understanding of red tide ecology and offer novel perspectives in this field.

(BIO-P-16961 Poster) BIO-Paper-P23 (ECOP)

Host-specificity of the *Roseobacter* clade towards *Margalefidinium polykrikoides* blooms: Insights from field studies

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Roseobacter clade and Flavobacteria are known to have species-specific interactions with phytoplankton blooms. In recent, it is suggested that *Roseobacter* may have more highly specific interactions with phytoplankton than Flavobacteria in laboratory experiment. However, there is no study for their interaction through field study. To investigate species-specific interactions in fields, bacterial communities were identified from four distinct *Margalefidinium polykrikoides* bloom events via next generation sequencing (NGS) assay and bloom associated bacterial OTUs were analyzed. As a result, the predominant shared free-living (FL) and algae/particle-associated (PA) bacterial communities were similar among the four distinct bloom events, but the FA and PA bacterial communities clearly differed. In FL bacterial communities, the Rhodobacteraceae and Flavobacteriaceae families were the predominant taxa, whereas Flavobacteriaceae and a few members of the Gammaproteobacteria were prevalent in PA bacterial communities. Thus, at higher taxonomic levels (the family level), these bacterial taxa were relevant and had species-specific interactions with *M. polykrikoides* blooms. In NMDS analysis, operational taxonomic unit (OTU) communities within the Flavobacteriaceae and Vibrionaceae were not well clustered and were dissimilar among bloom events. However, in the *Roseobacter* clade, OTU communities were not only well clustered by FL and PA bacteria, but also OTUs #17 and 842 were commonly predominant in distinct *M. polykrikoides* bloom events. These results newly show that the *Roseobacter* clade had more species-specific interactions with *M. polykrikoides* blooms than did Flavobacteriaceae in fields.

(BIO-P-16985 Poster) BIO-Paper-P24 (ECOP)

Changes in distribution of detectable environmental DNA of cetaceans in hydrodynamic models due to shedding rate representation

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The environmental DNA (eDNA) of rare species such as cetaceans in open marine environments is distributed heterogeneously in space and time, posing challenges to detection. Previous studies have used hydrodynamic models to predict the distribution of eDNA using Lagrangian tracers, but eDNA shedding rates are simplified due to lack of observations. Here we quantify the error introduced by shedding rate simplification using observed eDNA concentrations near an enclosure of non-native dolphins in Hood Canal, Washington, measured hourly for two days and found to vary in time by three orders of magnitude. To demonstrate the implications of time-varying DNA shedding in a time-varying flow field, the difference in detectable eDNA distribution between realistic (time-varying) and simplified (constant or pulse) shedding rates was modeled using Lagrangian tracers in a high resolution hydrodynamic model of the dolphin enclosure. The effect of sampling effort is explored because averages of highly time-variable data are sensitive to the length and frequency of observations. To demonstrate this, we calculated the total area of near-surface waters with detectable eDNA predicted by models with constant shedding rates derived from averages over different subsamples of the observed data. These results provide margins of error when model simplification is necessary due to limited observations, helping to better understand and utilize eDNA as a biomonitoring tool.

(BIO-P-16989 Poster) BIO-Paper-P25 (ECOP)

Winter marine predator community structure in the northern Antarctic Peninsula ecosystem

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The Antarctic Peninsula marine ecosystem is highly productive, with large populations of ecologically and commercially important species such as Antarctic krill (*Euphausia superba*), Adelié penguins (*Pygoscelis adeliae*), and crabeater seals (*Lobodon carcinophagus*). It is also rapidly changing due to accelerating climate change and fisheries pressure. Understanding ecosystem variability and potential climate change impacts is enhanced through developing stronger syntheses across seasons to better account for phenology shifts and carry-over effects across trophic levels. Due to difficulty from adverse weather conditions during winter, systematic ecosystem surveys have largely focused on austral spring/summer, leaving an information gap on winter ecosystem dynamics. Using data from five consecutive synoptic ecosystem surveys, we quantified the composition and distribution of winter predator communities and investigated the physical and biological influences on community structure. Seabirds and marine mammals formed three communities: an ice-associated community represented by Adelié penguins and crabeater seals; a marginal ice zone community of snow petrels (*Pagodroma nivea*) and Antarctic petrels (*Thalassoica antarctica*); and an open water community indicated by Southern fulmars (*Fulmarus glacialoides*). At the mesoscale, these communities fell along an environmental gradient from icy, cold, saline waters to ice-free, warmer water with greater chlorophyll/phaeopigment concentrations. Predator communities also associated with different macrozooplankton communities: ice-associated predators with large euphausiid/*Metridia* spp communities and open water/marginal ice zone predators with small euphausiid/amphipod communities. The composition and distribution of the winter predator communities differ from those in spring/summer and fill data gaps that currently hinder ecosystem projections and management decisions in this rapidly changing region.

FIS Contributed Paper Session

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

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

(FIS-P-16606 Oral)

Sex- and maturity-specific distributions of eastern Bering Sea snow crab (*Chionoecetes opilio*)

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Bering Sea snow crab (*Chionoecetes opilio*) support a valuable commercial fishery and play an important ecosystem role as food for species such as Pacific cod. The population of snow crab in this region has declined in recent years, resulting in closures of the fishery. This decline followed a period of low sea ice concentrations and higher bottom temperatures in the Bering Sea, possibly implicating changing ocean conditions. To further investigate how both ocean conditions and biological interactions impact the distribution of snow crab, we aimed to develop sex- and maturity-specific species distribution models (SDMs). We explored the use of several SDM methods and parameterized models for use in short-term forecasts. These models incorporate both survey and fishery data, disease prevalence, predator abundance, and physical data. We found that boosted regression trees performed best when compared to generalized additive models, and that the relationships with the selected covariates varied by sex and maturity. For both sexes, distributions of less mature individuals were found to extend further northeast compared to mature individuals. For all stages and sexes, temperatures above approximately 3°C had a negative effect on abundance. However, in cases where winter ice concentrations were high, temperatures below 0°C had a negative effect on legal-sized male snow crab abundance. Earlier maturity stages had peaks in abundance at shallower depths than later stages and in all cases, smaller grain sizes had a positive effect on abundance. Our results illustrate the value of specifying different life stages when modeling species distributions.

(FIS-P-16611 Oral)

Size-explicit species distribution models for marine fishes

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Different fish life stages have different sensitivities to changes in water temperature and occupy different habitats, which have their own unique temperature variations. This results in temperature effects that are likely to vary over both space and ontogeny. In this study we develop and implement a framework for size-explicit species distribution models and compare results with size-aggregated models. We implemented the framework on data from Pacific cod in the eastern Bering Sea and Dover sole in the California Current System, two ecosystems which have been the stage for extreme warming events during the last decade. We found that for both species, the effect of temperature changes over different size groups and spatial locations. However, there are notable differences. Pacific cod has pronounced ontogenetic habitat shifts, while Dover sole does not; however, Dover sole exhibits changing responses to temperature over space and stages. Accordingly, a species distribution model that includes size-specific spatial terms performed well for Pacific cod, while for Dover sole models with stage- and spatially-explicit temperature terms were most effective. Further, Bering Sea models performed poorly when extreme cold or warm years were not included in the calibration, indicating that extreme conditions can result in non-stationary species-habitat relationships. Collectively, these results indicate that size-specific data can provide useful information for climate-vulnerability assessment. Data and modeling requirements needed for size-specific distribution analysis are greater than for traditional aggregated approaches, so it is important to assess the life history traits of species that can benefit from the application of size-structured models.

(FIS-P-16799 Oral)

Decadal-scale variation in juvenile salmon growth in the Northern California Current (2000 – 2022)

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Early summer indices of growth for juvenile coho and Chinook salmon collected in the Northern California Current underwent a step-change between 2009 and 2012. Mean insulin-like growth factor 1 (IGF1) levels (an indicator of growth) differed significantly over succeeding decadal intervals (2000 – 2009 vs 2011 – 2022) with IGF1 levels since 2010 being consistently higher than found before 2010. Across the time series, IGF1 levels were correlated with a prey index for juvenile salmon derived from plankton samples collected in the upper water column during juvenile salmon surveys. There are no apparent correlations between juvenile salmon growth and basin-scale oceanographic indictors including the PDO, NPGO or ONI. Neither is there a correlation between juvenile salmon growth and upper water column temperatures concurrent with the survey. These data don't easily fit with current paradigms suggesting that variation in juvenile salmon growth and survival is correlated with California Current ecosystem productivity driven by variation in basin-scale ocean processes indexed by the PDO or ENSO. Indeed, the highest IGF1 level measured in the time series was found during the 2016 El Nino. Ecosystem processes underlying decadal-scale increases in growth of juvenile salmon since 2010 are not yet apparent.

(FIS-P-16820 Oral)

An example of Digital Twin of the Ocean: build and utilize a digital representation of the fish behavior in a fish farming cage

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Digital Twins of the Ocean (DITTO) are a virtual representation of the real ocean and have a two-way connection with it. Observations from the real ocean change and refine the twin; manipulating the twin can highlight regions of the real ocean in need of better or different observations. Digital Twins empower ocean professionals, citizen scientists, policymakers, and the general public alike to visualize and explore ocean knowledge, data, models and forecasts. However, since the DITTO is a very new idea, there are few examples of how to utilize the DITTO for fisheries. We introduce a digital twin of a fish farming cage that is installed a few kilometers off the coast. One of the important problems of marine culture is the difficulty of monitoring. Since the farmed fish is exposed to the abrupt environmental change, e.g., harmful algal blooms, oxygen deficit water and so on, the fish number sometimes decreases abruptly. There is a large demand for the real-time monitoring of the fish number and abnormality detection. We have tried to solve these problems by using a digital twin. Our digital twin of a fish school in a fish farming cage is comprised of the fish behavior under the normal condition. From this digital twin, we can obtain echoes for any number of farmed fish. By comparing these results with echoes obtained in actual fish cage, it becomes possible to estimate the number of individuals and detect abnormality. We present our findings on individual number estimation this time.

(FIS-P-16843 Oral)

Expanded measurements of bottom temperatures aid predictions of Pacific cod spawning habitat in the Bering Sea

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The eastern Bering Sea ecosystem is sensitive to global climate warming. While sea ice in the Bering Sea has large year-to-year variability, the underlying trend (especially on the southern shelf) is reduced sea-ice extent and duration. This, in turn, impacts ocean temperatures, in particular the size of the “cold pool”, the area of bottom water that remains < 2°C throughout the spring and summer. The cold pool impacts the distribution of both arctic and sub-arctic fish and shellfish. Bottom temperatures are especially important for Pacific cod (*Gadus macrocephalus*), as experimental results show that egg survival is constrained by temperature. Warming bottom temperatures, therefore, can be expected to change spawning success and location of Pacific cod and other fish species. While long-term moorings (M2, M4, M5 and M8) provide data for the last 2-3 decades on the 70-m isobath, spatial variability across the shelf is poorly resolved. Temperature measured alongside groundfish surveys provide spatial patterns across the shelf, but are limited to asynchronous summer snapshots. Lack of spatially- or temporally-resolved data leads to uncertainties in modeled hindcasts/forecasts of temperature, and limits their utility for studies of winter-spring ecology, including spawning. To resolve this, during the last several years we have expanded bottom-temperature observations through year-long deployments of low-cost temperature sensors (pop-up floats). The data from these instruments are used to examine the evolution of the cold pool and to validate the Regional Ocean Modeling System (ROMS) with respect to cold pool dynamics, providing multiple benefits to fishery management.

(FIS-P-16868 Oral)

Otolith microchemistry profiles revealing the life history and population connectivity of Pacific saury (*Cololabis Saira*) in the Northwest Pacific Ocean

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Pacific saury *Cololabis saira* is one of the most commercially important small pelagic fish species in Asian-Pacific countries. Identification of stock composition is essential for fish stock assessment and management. Previous studies suggested the mixed stock composition of Pacific saury in the Oyashio water, but their natal origin and connectivity remain largely unknown. Otolith microchemistry analysis is a powerful tool to elucidate the life history and population connectivity of fish, providing important insights to the natal origin and population structure. Here, based on 45 samples collected in the North Pacific Ocean during the fishing season (July – November) in 2019, the micro-chemical compositions of otoliths were analyzed using laser ablation inductively coupled plasma mass spectrometry to produce continuous life history profiles from otolith core to edge. Li/Ca, Na/Ca, Mn/Ca, Cu/Ca, Ba/Ca, and Sr/Ca ratios were determined. The gradient forest analysis identified Ba, Mg, Li, Sr, as the most important variables in reflecting the chronological ‘signature’. **Two sources were identified** by unsupervised random forest clustering analysis using near core chemistry. Generalized additive mixed models (GAMM) was used to reconstruct the micro-chemical composition over the whole life history of both groups. Significant differences in chemical signals only at early life stages and no significant differences in hatching dates suggesting the existence of two spawning grounds and large-scale connectivity in the following life history. This study can assist with better understanding the spawning grounds, population connectivity, and provide valuable information on the assessment and management of Pacific saury.

(FIS-P-16877 Oral)

Estimating the abundance and uncertainty of multiple species in an acoustic-trawl survey using a spatially informed Bayesian inverse approach

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For many years, active acoustics have been used to monitor the abundance of pelagic animals, typically in conjunction with direct trawl sampling. Acoustic surveys have major advantages, giving a synoptic view of the water column quickly and non-extractively. However, identification of animals from acoustic backscatter remains a challenge, and the scale mismatch between remotely sensed acoustic data and in-situ trawls used for ground truth means it is difficult to obtain comprehensive uncertainty estimates. Here, I demonstrate how a recently developed inverse approach for multi-frequency acoustic data can be combined with research trawls and other forms of direct sampling in a spatial framework. Applying this approach to an acoustic-trawl survey for Alaska pollock (*Gadus chalcogrammus*) in the Gulf of Alaska yields a better-constrained estimate for pollock abundance, but also enables estimates to be made for other, weaker scatterers often ignored in surveys, such as squid, zooplankton, and myctophids. I will also speculate on the future promise of such an approach. By bridging the analytic gap between the trawl, transect, and survey scales, it should be able to constrain the uncertainty inherent in acoustic-trawl surveys, ultimately producing more holistic and reliable information about the state of pelagic ecosystems.

(FIS-P-16908 Oral)

Juvenile snow crab habitat and changes in distribution, density, and thermal occupancy during a period of ocean warming in the Chukchi Sea.

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Juvenile snow crab (*Chionoecetes opilio*) are considered to be stenothermic, yet little is known about their distribution during their first four years on the bottom. Juvenile snow crab distribution, density, habitat, and thermal occupancy in the Chukchi Sea were studied during a period of ocean warming. During a cold year (2012), >90% of surveyed juveniles of all size classes inhabited cold (<2 °C) areas. In warmer years (2017 and 2019), catch rates of the smallest crab size classes (presumably age-1) declined by two orders of magnitude, and a habitat model indicated that catch rates of these crab declined sharply at temperatures greater than 2 °C. In the warmer years, larger juvenile crab inhabited areas with bottom temperatures up to 8 °C. The centers of distribution of the larger juvenile crab also shifted to the north between the cold and warm years. The strong observed correlation between temperature and densities of the earliest benthic stages suggest that they are the most stenothermic and could limit how the species responds to climate change. The effects of warmer thermal occupancy on the condition and vital rates of larger juveniles are unknown. The observed temperature- and ontogeny-dependent distribution of snow crab will continue to impact the Chukchi Sea benthos with continued warming. Increased knowledge of the habitat requirements of sensitive early juvenile stages could help with predictive models that aim to link crab physiology to observed species distributions throughout in the Alaska Arctic region.

(FIS-P-16966 Oral)

Do fishers go where the fish go? A retrospective analysis on the pollock fishery in the Eastern Bering Sea

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Effective fishery managers consider the needs and behaviors of the people they manage. As fish distributions shift over time and space, it is often assumed that fishers will simply follow the resource. However, this is not always the case, as fishers also have to consider economic variables such as travel costs and shifting management regulations. Furthermore, fish distributions are often best described using annual scientific surveys, whereas fishers need to make their fishing decisions in real-time. A better understanding of how fishers have adapted to changes in resource distribution and in management will allow us to better prepare for future changes in fisheries, and modify management objectives and strategies accordingly. Using the catcher-processor fleet of the Eastern Bering Sea pollock fishery as a case study, we aim to understand the drivers behind their decisions on where and when they choose to fish. This analysis takes a retrospective look at the location choices made by the fishers, fitting a discrete choice model to data from both the scientific survey and observers on board the fishing vessels. The fine-scale model of fishing behavior can be used to test and inform potential spatial management measures such as area or seasonal closures for bycatch avoidance in the future.

(FIS-P-16502 Poster) FIS-Paper-P1

Interannual variability of the pollock stock, spatial differentiation and fisheries in the northern Bering Sea

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Annual environmental condition variability in the Subarctic and Bering Sea affects zooplankton community, recruitment, abundance, behavior and seasonal spatial distribution of Bering Sea pollock. This in turn influences fisheries management strategies. Understanding the changes caused by these annual environmental variations on the pollock population is important for improving predictions of the assessed population, thereby having positive effects on recreational fishing and commercial harvest as accurate predictions are critical for fishery planning. Understanding the variability within the ecosystem is especially important for the development of environmental- enhanced pollock fisheries in northern Bering Sea and Russian waters, where pollock migrate only in summer and autumn periods. Significant annual differences in pollock seasonal migration and spatial distribution are related to the variability of population abundance, temperature conditions, zooplankton species composition and distribution in the Bering Sea. Current research demonstrates that annual changes in the Bering Sea physical oceanographic conditions, zooplankton species composition and productivity greatly influence differences in pollock seasonal distribution, reproduction, abundance of year classes and total population biomass.

(FIS-P-16514 Poster) **CANCELLED** FIS-Paper-P2 (ECOP)

~~An assessment of the historical population trends of Crassostrea tulipa at the coast of West Africa~~

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~~This study conducted a comparative assessment of the shellfish fishery in four water systems: Densu and Anyanui in Ghana, Ouidah in Benin, and Lagos in Nigeria. The study assessed historical trends in the growth of the species, their ages, their growth performance, and the possible pressures influencing the change by comparing data estimated from fossilized shells to the modern population. Radiocarbon dating was used to determine the year of death for excavated fossilized shells and stable isotope analysis was conducted on fossilized and modern shells to determine past and present temperature and salinities. The mean shell heights (L) recorded for the fossilized populations in Densu, Anyanui, Ouidah, and Lagos were between 6.58 ± 1.10 cm 9.69 ± 2.33 cm, whereas in the modern populations, the mean shell heights recorded in the same regions were 5.18 ± 0.92 cm 6.38 ± 0.30 cm. Ages of the oysters were estimated using the thin section technique (counting of annual growth rings deposited at the hinge section of the oyster shells) and was validated by fitting the von Bertallany growth function into the length at age data to estimate their various growth parameters to calculate their growth rates, mortality, and exploitation rates. Ages estimated in these regions ranged from 2 25 years, while the highest recorded fossilized age was recorded in Anyanui (25) and the highest in the modern shells was 14 from Nigeria. The growth coefficient (K) values ranged from 0.13 1.4 for all the sites, showing that for both populations, K values were lower, except for Anyanui, which recorded 1.4 for the older population. The growth performance index recorded were all below 3 for both populations in all the sites. The oysters were determined to be slow growing and with long life spans. This study provides important insights into the historical trends and current status of the shellfish fishery in four water systems in West Africa. The results suggest that the fishery is under pressure from overfishing and other human activities, and that this is leading to a decline in the size and growth of the oysters. These findings highlight the need for sustainable management of the shellfish fishery in this region. Differences in temperatures and salinity over time also shows the impact of climate change on the shellfisheries decline in growth.~~

(FIS-P-16552 Poster) FIS-Paper-P3 (ECOP)

Feeding habits of skinnycheek lanternfish *Benthosema pterotum* larvae, metamorphosing larvae, and juveniles in the semi-enclosed Kagoshima Bay, southern Japan

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The skinnycheek lanternfish *Benthosema pterotum*, which belongs to the order myctophiformes, is numerically dominant in the semi-enclosed Kagoshima Bay, southern Japan. This study aims to examine feeding habits of larvae, metamorphosing larvae, and juveniles of the species in semi-enclosed Kagoshima Bay. Larvae, metamorphosing larvae and juveniles were collected by an ORI and LC nets in 2015, 2021, and 2022. In the laboratory, the body length was measured. The prey composition was analyzed by microscopic and DNA metabarcoding analyses for their gut contents, and the nutrition sources and trophic level were estimated by stable isotope analysis (SIA). By microscopic observation, feeding incidences of larvae, metamorphosing larvae, and juveniles were 24%, 3%, and 84%, respectively. A significant positive correlation was observed between larval body length and prey size ($P < 0.05$). Larvae fed mainly on various copepods including nauplii. Meanwhile, metamorphosing larvae and juveniles fed mainly on poecilostomatoid copepods. DNA metabarcoding analysis detected a high percentage of calanoid copepods for larvae (29%), metamorphosing larvae (53.8%) and juveniles (26%), and the importance of poecilostomatoid copepods (4.3%), bivalves (26%), and appendicularians (19%) increased in juveniles. SIA strongly suggested that calanoid copepods would be main nutrition sources throughout larval and juvenile stages, and poecilostomatoid copepods would be important prey for metamorphosing larvae and juveniles. The ontogenetic variation in trophic level would be influenced by the difference in size of calanoid copepods which they feed on.

(FIS-P-16564 Poster) FIS-Paper-P4 (ECOP)

Complete mitochondrial genome of *Deima validum* and *Oneirophanta mutabilis* (Holothuroidea: Synallactida: Deimatidae): Insight into deep-sea adaptation in the sea cucumber

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The deep-sea is the most extensive ecosystem on Earth with constant darkness, hundreds of bars of hydrostatic pressure, low temperature, and low oxygen. Mitochondria plays a key role in energy metabolism and oxygen usage, thus it may undergo adaptive evolution in response to pressures from extreme harsh environments. In this study, we present the mitochondrial genome sequences of the sea cucumbers *Deima validum* and *Oneirophanta mutabilis* collected from the deep South China Sea. To our knowledge, they are the first reported mitogenomes from the family Deimatidae. Similar to other sea cucumbers, both mitogenomes contain 13 PCGs, 22 tRNA genes, 2 rRNA genes and 1 non-coding region. We compared the order of genes from the 13 available holothurian mitogenomes and found a novel gene arrangement in *D. validum*. Phylogenetic analysis revealed that *D. validum* clustered with *O. mutabilis*, forming the deep-sea Deimatidae clade. Positive selection analysis showed that four residues were positively selected sites with high posterior probabilities. By comparing these features with shallow sea cucumbers, we predict that *nad2* and *nad5* may be the important candidate genes for the further investigation of the adaptive evolution of Deimatidae to the deep-sea environment.

(FIS-P-16566 Poster) FIS-Paper-P5

Community structure of demersal fishes off the Okhotsk coast of Hokkaido in relation to environmental forcing

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The southern Okhotsk Sea is one of the most productive areas of the northern Pacific. Based on the 349 bottom trawl surveys conducted in the northeastern Hokkaido coasts during 14 consecutive springs, to monitor the dynamics of dominant specie, we explored the factors affecting the structure of the demersal fish community in the 100-300 m depth zone. Fish density was calculated for each species and station, and a principal component (PC) analysis was conducted based on square root transformations of the densities at each station. The first and second PCs were then modeled as annual averages using environmental parameters such as mean bottom water temperature and salinity, mean sea ice density for the entire Sea of Okhotsk (SIOS) and the coastal region (SICA), and teleconnection indices (PDO, NPGO and Western Pacific). The top-five species in biomass were walleye pollock, Pacific cod, blackfin flounder *Glyptocephalus stelleri*, Opilio crab and Pacific herring in decreasing order. The average biomass fluctuated between ca. 100 to 450 kg/km^2. NPGO and SICA were selected for explanatory parameters for PC1 while only NPGO was significant for PC2. The correlation between PC1 and the biomasses of gadids and herring suggested that SICA has a positive impact on their abundance.

(FIS-P-16617 Poster) FIS-Paper-P6

The Fisheries Integrated Modeling System: a collaborative approach to stock assessment model development

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Fisheries stock assessment models are used worldwide to provide crucial management advice, and therefore, increasing their accuracy and efficiency is a global goal. To increase accuracy, methods are being developed to incorporate new data types, such as tagging and genetic data, and climate forecasts. To ensure efficiency, modeling platforms should scale to incorporate new techniques using open and reproducible development practices. These practices, pioneered by the open-source software community, require a collaborative and cyclical approach to development. In response to this need, NOAA Fisheries is investing in a Fisheries Integrated Modeling System (FIMS), a modular and collaborative stock assessment software system. FIMS is developed by a team of regional experts working with dedicated programming staff to ensure the system meets regional needs while remaining interoperable with other frameworks and modules. The overall FIMS project is guided by a Council that includes representatives from outside NOAA Fisheries, including domestic and international partners and stakeholders. The FIMS process is designed to consolidate fish stock assessment model development across regions to reduce the number of duplicate and parallel operational models and to transition stock assessment best practice research and development into operation. The development cycle iteratively incorporates feedback from reviewers and stakeholders from the beginning. The approach is also designed to widen the pool of experts who can develop, maintain, test, and support user needs of the system. We have completed the first software development cycle, concluding with a benchmark simulation study comparing the FIMS to several widely used operational models.

(FIS-P-16625 Poster) FIS-Paper-P7

Adaptive improvement of habitat suitability index (HSI) model for skipjack tuna in the western North Pacific using real-time ocean forecast and AIS vessel position data

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An accurate estimate of a potential habitat of fish species enables us not only to understand the response of species to environmental changes but also to utilize it for an efficient use of fish resources. Skipjack tuna (*Katsuwonus pelamis*) is a highly migratory pelagic species inhabiting all tropical and subtropical waters of the world’s oceans. It is commercially important, and a significant portion of the catches are from the Pacific Ocean, which has one of the most productive fisheries in the world. We developed a habitat suitability index (HSI) model for this species in the western North Pacific by using fishing points data estimated from AIS fishing vessel position and MOVE/MRI.COM-JPN ocean reanalysis dataset produced by MRI-JMA, which can provide realistic fields of 3-dimensional ocean environments. In this study, we developed a method of an adaptive improvement of HSI model by using real-time AIS position data of fishing vessels. The HSI model constructed in advance was sequentially modified by updating the AIS data. We investigate the HSI model performances before and after modification and compare them. The remarkable improvement can be seen in the sequentially modified HSI model in which the information of ocean environments in the actual fishing ground was reflected. The results suggest that the adaptive modification of the HSI model could be practically useful for the accurate estimate of the potential fishing ground.

(FIS-P-16637 Poster) FIS-Paper-P8 (ECOP)

Effects of the Oregon offshore wind energy project and temperature-driven population distribution shifts of Pacific hake on Oregon's hake fishery

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Pacific hake (*Merluccius productus*) is the most plentiful and commercially harvested groundfish (by volume) of the U.S. and Canadian West Coast. A distinguishing attribute of hake is its annual migration between wintertime spawning grounds in Southern California/Mexico and summertime feeding grounds off the northern U.S. and Canadian West Coast. Ocean temperature has been observed to have a linear but spatially varying effect on the migration patterns and distribution of hake. Therefore, there is a growing interest in the impacts of climate on the hake fishery. Additionally, the groundbreaking Oregon Offshore Wind Energy (OWE) project is a quickly developing undertaking that is gaining a lot of attention over its potential environmental impacts on ocean resources. The Bureau of Ocean Energy Management (BOEM) has chosen two "call areas" on which to put floating wind turbines, one located off the coast of Coos Bay and the other off Brookings, both of which overlap with present and historic hake fishing grounds. We are investigating potential short-term effects of this offshore wind energy by analyzing the historical fishing footprints of hake inside and outside these proposed call areas. We are also investigating the potential long-term effects by analyzing the overlap of the call areas and the predicted temperature-driven hake distribution under different climate scenarios (i.e. increases in ocean temperature). Here we present preliminary findings on both components of this project.

(FIS-P-16640 Poster) CANCELLED FIS-Paper-P9

~~Trophic life histories of sablefish from birth through maturation as inferred by eye lens stable isotopes.~~

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~~Sablefish (*Anoplopoma fimbria*) are a commercially important catch in Alaska, yet we do not have a full understanding of the mechanisms underpinning recruitment in this species. The trophic life history of sablefish may play an important role in growth and survival and may lead to strong recruiting classes or differences in fitness across individuals. Sablefish are opportunistic feeders and are known to prey on many different species of forage fish as well as squid, euphausiids, and jellyfish. In this study we explore the first use of stable isotope analysis in sequentially grown eye lens layers to infer the trophic life history of individual sablefish from birth through maturation. The eye lens is formed in layers which are inert after synthesis and store dietary stable isotopic information over the entire period of fish growth. We sampled eye lenses from sablefish caught in the annual NOAA longline survey in the Gulf of Alaska. Individual eye lenses were dissected into ~40 layers and the individual layers were analyzed for their stable isotope signatures. We found substantial variability in eye lens isotope patterns among the individuals surveyed, particularly in carbon stable isotope signatures. Further work is in progress to experimentally determine trophic discrimination factors relating diet to eye lens isotopic signatures. Eye lens carbon isotope data patterns in conjunction with trophic discrimination factors may reveal differing timing of ontogenetic shifts in diet or habitat use and may be useful in helping to determine which trophic life history patterns lead to greater fitness and survival.~~

(FIS-P-16671 Poster) FIS-Paper-P10 (ECOP)

Using simulation studies to inform threshold detectability in the California Current System

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Ecosystem thresholds are points at which ecosystem properties change rapidly from one state to another, sometimes arising as a result of novel environmental conditions or changing relationships. Knowledge of the existence of thresholds and the processes that drive them is critical for our ability to predict ecosystem responses to anthropogenic activities and natural environmental variability. However, use of thresholds in fisheries management is often hindered by questions about their detectability and ability to improve decision making. In this study, we address these issues by using simulations to explore the utility of ecosystem thresholds for fisheries management, with a focus on the California Current System (CCS) in the eastern Pacific. We apply threshold detection methods to time series simulated with and without known threshold responses. Simulations are repeated with various complicating factors (e.g., observation error, nonstationary dynamics, model mis-specification) to determine the conditions under which thresholds can be accurately detected as well as the detection methods' robustness to different forms of uncertainty. We will apply our findings to an empirical case study of commercially important species in the CCS to investigate the feasibility and potential benefits of incorporating thresholds into management decisions for these species. Overall, this work will help to quantify the performance of threshold detection methods under different scenarios and provide insight into the extent to which thresholds can support sustainable management of CCS fisheries.

(FIS-P-16785 Poster) CANCELLED FIS-Paper-P11 (ECOP)

~~Visualizing species distribution changes with the NOAA Fisheries Distribution Mapping and Analysis Portal (DisMAP)~~

~~Melissa A **Karp**[1], Roger Griffis[1], Patrick Lynch[1], Tim Haverland[1], John Kennedy[1], Venkat Sunkara[1], Kevin Craig[2], Elliott Hazen[3], Isaac Kaplan[4], Don Kobayashi[5], Scott Large[6], Wendy Morrison[7], Hassan Moustahfid[8], Malin Pinsky[9], and Phoebe Woodworth-Jefcoats[5]~~

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~~Marine species are moving in response to climate change, with impacts reaching far beyond the individual species moving to affect entire ecosystems, fisheries interactions, and coastal economies. Robust information on past, current, and expected future distributions of marine species is critical for effective ecosystem-based management and decision-making in all ocean use sectors. In general, information on species distributions is dispersed across multiple sources and regions and therefore not easily accessible across fisheries governance boundaries. In response to this need, NOAA Fisheries launched a new state-of-the-art mapping portal to consolidate information on species distributions into one easily accessible, interactive website called the Distribution Mapping and Analysis Portal (DisMAP). The current version of the portal displays data from fishery-independent surveys for six US regions (Northeast, Southeast, Gulf of Mexico, West Coast, Hawaii, and Alaska) and includes a map viewer and graphing capabilities to explore the distributions of over 400 marine fish and invertebrate species caught during the surveys. The portal is being developed in phases, with plans for future releases to include additional data types, model outputs, and functionalities. The interactive website will improve data sharing and collaboration, help fisheries managers and the fishing industry better plan for and respond to changes, and increase overall knowledge of species distributions. User-friendly tools like this play a critical role in decision-making for a climate-ready future.~~

(FIS-P-16801 Poster) FIS-Paper-P12 (ECOP)

Improving species distribution models through a physiologically based approach: oxygen and temperature effects on groundfish distributions

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Species distribution modeling is increasingly being used to describe and anticipate consequences of a warming ocean. These models often identify associations between distribution and relevant environmental conditions such as temperature and oxygen, but rarely consider the mechanisms by which these environmental variables affect metabolism. Oxygen and temperature jointly govern the rate of oxygen supply to oxygen demand, and theory predicts thresholds in these rates below which species densities are diminished. However, parameterizing models with this joint dependence is challenging because of the paucity of experimental work for most species, and the limited applicability of experimental findings *in situ*. Here we ask whether the joint effects of temperature and oxygen can be reliably inferred from species distribution data, using the U.S. Pacific Coast as a model system. Through simulation testing, we found that our statistical model—which applied an Arrhenius equation to jointly consider oxygen and temperature and used a non-linear threshold function to link oxygen and temperature to fish distribution—could reliably estimate the temperature-oxygen relationship and predict fish densities. These estimates were robust to misspecification of the prior on the temperature-oxygen relationship. Our model provided a better fit to sablefish (*Anoplopoma fimbria*) spatial distribution than previously used model structures. The inclusion of environmental-physiological relationships can advance our ability to effectively explain groundfish habitat use and predict future distributions under climate change.

(FIS-P-16804 Poster) FIS-Paper-P13 (ECOP)

The pelagic species trait database, an open data resource to promote trait-based fisheries research

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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 and broader NE Pacific Ocean, but also includes globally important pelagic species known to be consumed by top ocean predators from other ocean basins. The aim of this database is to promote the use of trait-based approaches in marine ecosystems and for predator populations worldwide.

Regional and annual variation in the lipid storage of juvenile Bering Sea snow crab during a recent period of environmental warming

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A marine heat wave occurred in the Bering Sea during 2018 and 2019. Since then, billions of snow crab (*Chionoecetes opilio*) have vanished from the region and the fishery closed in 2022. In recent decades, the geographic range of snow crab has contracted to the north in response to warming near-bottom temperatures and reduction of the cold pool, a < 2 ^{o}C body of bottom water that is highly associated with annual sea ice extent. During heat wave years, the cold pool was completely absent from the Bering Sea shelf, yet the causal mechanisms linking declining crab populations to the shrinking cold pool are not fully resolved. Here we present data supporting the hypothesis of reduced nutritional condition occurring in southeastern Bering Sea snow crab prior to the stock collapse. We compare region-specific (southeastern and northern Bering Sea) crab condition in the 2019 heat wave year to that in two subsequent years (2021 and 2022), using moisture content and fatty acid concentrations in crab hepatopancreas tissue as a new and rapid condition metric. Finally, we present specific fatty acid trophic markers that link decreasing crab energetic condition in southern regions to a higher level of carnivory (18:1n-9/18:1n-7) and a decrease in diatom-sourced fatty acids (16:1n-7/16:0) fluxing to the benthos, during the warm year. The level of diatom-sourced lipids in crab tissue was highly correlated with a region-specific spring bloom index, indicating that a reduction in the occurrence of ice-edge blooms may have negatively impacted juvenile crab nutritional condition.

(FIS-P-16808 Poster) FIS-Paper-P15 (ECOP)

International Year of the Salmon Ocean Observing System

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Data mobilization, which involves making data available for appropriate re-use, continues to be a significant obstacle in the effective management of salmon populations. The process of data mobilization enables data sharing, discovery, and reutilization, leading to increased citations, the development of synthesis data products, meta-analyses, and the creation of robust management decision-support tools. The International Year of the Salmon (IYS) High Seas Expeditions conducted in 2019, 2020, and 2022 presented both a challenge and an opportunity for data mobilization efforts, given the extensive scale, volume, diversity of data, and involvement of numerous nations. Considering the global nature of this project, we undertook the mobilization of salmon ocean ecology data in accordance with the United Nations' Global Ocean Observing System and the Decade of Ocean Science for Sustainable Development. Within this framework, we catalogued datasets using metadata records, assigned digital object identifiers, and made them accessible through a web-based data catalogue available at https://iys.hakai.org. Whenever feasible, we adopted existing community-developed and international data and metadata standards, and we ensured that the data were published in globally accessible open-access repositories. The implementation of both sociocultural and technical solutions has significantly enhanced the impact of the IYS. Furthermore, it has established a foundation and a clear path forward for institutions, commissions, foundations, or projects involved in salmon and oceanographic data production and interested in contributing to international data-intensive salmon and oceanographic sciences.

(FIS-P-16818 Poster) FIS-Paper-P16

Pacific anchovy (*Engraulis japonicus*) dispersal during the early life stages in the coastal areas in Korean waters using Lagrangian simulations.

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Global climate change can significantly influence the biophysical dynamics of coastal marine environments. Variations in ocean circulation induced by climate change likely influence the trajectories of many marine species during their early life stages, and consequently impact their recruitment and connectivity between spawning grounds and recruitment areas. Pacific Anchovy (*Engraulis japonicus*) is an ecologically and commercially important fish species in Korean waters as it accounts for approximately 20% of Korean catch production since the 2000s. This small pelagic fish is sensitive to environmental conditions and ecosystem changes. The coastal area of Korea, especially the South Sea, provides important spawning and nursery areas for this species. We assume that retention towards coastal areas is expected to be more favorable for their survival and development during early life stages. To investigate interannual variability in dispersal pathways and connectivity of anchovy in relation to changes in currents of the coastal area in South Sea, we conducted passive Lagrangian particle tracking simulations using the Lagrangian TRANSport model (LTRANS) with the Regional Ocean Modeling System (ROMS) from 2006 to 2015. Our results showed that larvae highly maintain along the coastal areas when they are released close to inshore areas. Also, when eggs were released in the western part of the coastal areas in the South Sea, some of them advected to the Yellow Sea in some years. Our results from this study can be used to provide scientific basis for developing sustainable fisheries management for fish stocks characterized by high vulnerability of early life history.

(FIS-P-16870 Poster) FIS-Paper-P17 (ECOP)

Effects of sedimentation during early-life rearing on phenotypic outcomes and gene expression in coho salmon (*Oncorhynchus kisutch*)

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Pacific salmon (*Oncorhynchus* spp.) populations have exhibited drastic reductions and face numerous threats. In particular, the increased input of fine sediment into streams and rivers leads to the degradation of salmon spawning habitat and reduces the availability of dissolved oxygen to incubating eggs. However, the impacts of these poor early-life conditions on an individual's phenotype and the subsequent implications for declining populations remain unclear. Here, we present the results of an experiment evaluating the effects of sediment stress during early-life development on phenotypic outcomes and gene expression in coho salmon (*O. kisutch*). We obtained *O. kisutch* eggs from Sugsaw Hatchery on the west coast of Vancouver Island, BC, Canada, and reared them in a high quality (no fine sediment), medium quality (10% fine sediment), or low quality (20% fine sediment) substrate treatment (n=180 eggs per treatment) until the alevin stage. Data were collected for multiple phenotypes including survival, condition factor, and yolk sac area. Furthermore, RNA was extracted from 30 head tissue samples per treatment to determine the influence of sedimentation on the expression levels of several genes associated with hypoxic stress. Preliminary results demonstrate that average survival was lowest in low quality substrate, though no significant difference was detected among treatments. Our findings will help to further elucidate the physiological and molecular impacts of sedimentation on early-life salmonid fish, and their potential long-term fitness consequences into adulthood.

(FIS-P-16906 Poster) **CANCELLED** FIS-Paper-P18

~~Understanding and predicting the spatiotemporal overlap of Pacific Hake and constraining species in the hake fishery~~

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~~Pacific hake (*Merluccius productus*) comprise the largest groundfish landings by volume in the commercial groundfish fishery on the U.S. west coast. Over the past five years, the U.S. fleets attained on average about 71% of the allocated quota. The proportion of the quota that is harvested is partially influenced by regulatory and voluntary management measures that aim to minimize incidental catch of other species, such as salmon and rockfishes. Because the fishery is actively avoiding incidental catch of several species, each with unique and dynamic distribution patterns, fishery participants often face difficult trade-offs in finding clean, productive fishing areas and avoiding non-target species. The spatial and temporal incidental catch patterns, especially for rebuilt rockfish, have been atypical in recent years and the fishery has expended more time and resources avoiding species of concern. Here we present some preliminary work that aims to better understand and predict the spatiotemporal overlap between Pacific hake and constraining species in the northern region of the California Current ecosystem. We expect the outcomes of this work to improve the fishing industry's ability to avoid incidental catch under increasingly common warm ocean conditions that affect fish spatial dynamics. Our findings may also inform discussions about whether the siting of Oregon Wind Energy call areas could hinder the fishing industry's ability to avoid constraining species and fish productively in the near and long-term.~~

(FIS-P-16909 Poster) **CANCELLED** FIS-Paper-P19 (ECOP)

~~**Approaches to stock enhancement in crab trap by comparing different light-emitting diode and baits**~~

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~~The high economic value and market demand for Portunidae, coupled with the costly crab bait, have spurred the need for exploring novel alternatives to lure Portunidae into traps. Moreover, the advancements in fishing technologies, particularly the adoption of LEDs, have provided significant advantages. LED usage offers benefits such as lower energy consumption and longer lifespan compared to conventional lighting sources. This allows crab fishermen to reduce their harvesting costs while simultaneously minimizing their environmental footprint. This study conducted offshore experiments along the coasts of Terengganu, Johor, Taiping, and other areas in Malaysia, comparing the catch rates of crab traps using different bait types (mackerel, chicken head) in combination with light-emitting diode (LED) lights. The results showed that in Terengganu, the combination of blue LED lights with mackerel bait achieved the highest catch per unit effort (CPUE) of 0.084 no./traps. The group with only green LED lights had the lowest CPUE of 0.009. In Johor, the highest CPUE of 0.05 was obtained using mackerel bait alone. The groups with green LED lights combined with mackerel bait and the groups with only red or blue LED lights in the traps did not yield any catches. In Taiping, the highest CPUE of 1.0504 was observed with chicken head bait. The groups with only red or blue LED lights in the traps did not yield any catches. It was also noted that the CPUE of groups using only LED lights was lower than those using bait.~~

(FIS-P-16923 Poster) FIS-Paper-P20 (ECOP)

The characterization of viral hemorrhagic septicemia virus in marine fishes

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This research proposal aims to investigate the occurrence and factors driving the presence of Viral Haemorrhagic Septicaemia Virus (VHSV) in common marine fish species. The study will focus on *Gasterosteus aculeatus* and *Clupea pallasii* sampled from multiple locations along the Pacific coast of Canada. The objective is to understand the extent of VHS in these species and its association with environmental factors such as water temperature and the spring spawning season. It is hypothesized that VHSV occurrence will be similar in both species, with higher viral loads in longer-lived herring species. The methods involve capturing the fish and recording their characteristics. Stickleback will be caught using minnow traps, while live herring will be purchased from fishermen. Phenotypic symptoms will be diagnosed through external and internal examinations, followed by necropsies to extract liver tissues for the high viral loads. RNA isolations, cDNA conversions, and quantitative PCR (qPCR) will be performed to detect and further quantify VHSV using viral disease development biomarkers. This research is significant as it addresses the lack of empirical evidence on the prevalence and frequency of VHSV in marine fish populations, particularly in Canada. The development and testing of effective biomarkers will provide valuable insights into the reservoir status of VHSV and its cross-species transmission potential. This knowledge can inform regulatory requirements for quarantine and transmission risk, as well as enhance our understanding of the ecological dynamics of VHSV in marine fish species all in a single study.

(FIS-P-16947 Poster) CANCELLED FIS-Paper-P21 (ECOP)

~~Exploring the effects of harvest pressure on fish growth across an environmental gradient~~

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~~Fishery harvest selectively targets individuals which display a particular trait (e.g., boldness) or certain body size, effectively changing the size structure and behavioral trait diversity of the remaining population. Similarly, environmental conditions also impact fish populations both directly, via temperature effects on metabolism and physiological stress, as well as indirectly by driving changes in productivity and prey availability. Independently, these phenomena are well-documented but the interactive effects of harvest and climate are comparatively understudied. We aim to assess the direct and indirect effects of climate variability on fish growth under varying levels of fishing pressure, using a Yelloweye rockfish, a long-lived, cosmopolitan species as a model taxon. We used archival otolith collections from fishery-independent surveys throughout the US west coast to calculate individually resolved estimates of fish growth and generate region specific biochronologies. We then assessed the spatio-temporal variation of climate across the timeseries using satellite-derived sea surface temperatures and a suite of harvest metrics to characterize fishing pressure. Preliminary results indicate that yelloweye growth was strongly driven by combined impacts of harvest pressure and temperature, with the greatest depression in growth rates occurring during anomalously warm conditions experienced by heavily fished population. By examining drivers of fish growth, both naturally occurring and anthropogenic, we can develop a more mechanistic understanding of the processes underlying fish population dynamics and help inform future management decisions.~~

(FIS-P-16952 Poster) FIS-Paper-P22

Spatial growth variability in marine fish: example from Northeast Pacific groundfish

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Marine fish populations exist in a complex environment, with oceanographic and fisheries factors affecting their dynamics. It has been shown that life history characteristics of marine fish vary in space and time. We examined spatial variability in growth of eight groundfish species in the Northeast Pacific Ocean to identify shared spatial patterns and hypothesize about common mechanisms behind them. Growth parameters were estimated in different areas over the latitudinal range of the species, and several hypotheses were tested as to how these parameters vary along the US west coast. Clear differences in spatial growth variability emerged among the species examined. Shelf species exhibit the highest growth rate between Cape Blanco and Cape Mendocino, which may, in part, be attributed to area-specific upwelling patterns in the California Current ecosystem, when nutrient-rich deep water is brought to the surface south of Cape Blanco and is uniquely distributed throughout this area, providing favorable conditions for primary productivity. Slope species showed a cline in asymptotic size (L_∞), with L_∞ increasing from south to north. This cline, previously attributed to fishery removals, also fits a specific case of the widely described Bergmann's rule, and we explore specific potential ecological mechanisms behind this relationship.

(FIS-P-16960 Poster) FIS-Paper-P23

Diel vertical migration in a pelagic forage fish associated with benthic substrates

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Diel vertical migration (DVM) in marine organisms is an evolved response to maximize foraging opportunities and minimize predation risk. This pattern in vertical distribution is a widely observed phenomenon and common in pelagic forage fish species. Modelling these dynamics has important relevance to understanding marine ecosystem dynamics, predator–prey interactions, and marine food webs. We examine DVM in sand lance—an ecologically important taxa of forage fishes throughout northern hemisphere marine systems and target of commercial fisheries. Much remains unknown about their diurnal emergence from sediments. We apply data from autonomous stereo-camera deployments and tank observations to provide new insight to DVM patterns in Pacific sand lance (*Ammodytes personatus*). We model emergence curves using beta regression models with random effects, depicting important differences in the shape of ascent and descent. Our observations and analyses document crepuscular movement patterns, suggesting pelagic foraging occurs primarily at dawn and dusk. Results suggest critical light thresholds are necessary to initiate and maintain pelagic foraging. Results also suggest the importance of seasonality and life stage, such that adult fish exhibit reduced pelagic foraging in the fall relative to juvenile fish. These results constitute a comprehensive evaluation of DVM in this species, better define the physical drivers, and mathematically depict the pattern and shape of emergence timing.

(FIS-P-16973 Poster) FIS-Paper-P24 (ECOP)

The impacts of the Pacific marine heatwave on recruitment of fish species

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This poster will be covering my research project I completed as part of my internship with NOAA INFISH. The project was centered around the impacts the pacific marine heatwave from 2014-2016 possibly had on recruitment of a variety of fish species including groundfish, coastal pelagic and highly migratory species. I will provide background information, methods, the results, and the final findings and suggestions of the project.

HD Contributed Paper Session

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

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

(HD-P-16503 Oral)

Fishers' perception on armored catfish (*Pterygoplichthys spp*.) invasion: ecologic and socioeconomic impacts in an estuarine protected area in Guatemala

María A. **Schoenbeck**[1], Emily Pineda[1], Yasmin Quintana[2] and Fernando Castillo-Cabrera[1]

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Armored catfishes from the genus *Pterygoplichthys* spp. (family Loricariidae) have established populations in tropical and sub-tropical regions worldwide. The negative impacts caused by these catfishes have been studied in various ecosystems, especially in Mexico and the United States. Nevertheless, the impacts of invaded aquatic ecosystems and fisheries on the Pacific Coast of Guatemala remain undocumented. This study brings novel evidence about the impacts of this invasive species using local fishers' perceptions in an estuarine ecosystem on the Pacific coast of Mesoamerica. During the rainy season of 2021 at Monterrico Multiple Use Natural Reserve, we conducted participatory activities with fishers. The study found that fishers perceived economic, social, and ecological impacts, including damage to fishing gears, ghost fishing, and habitat modification due to armored catfish nesting, among others. Fishers' perceptions indicate that controlling the invasive species is necessary to reduce the damage to local fisheries and fishers' livelihoods.

(HD-P-16546 Oral)

Methods and application of marine ecological product accounting in China

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In order to promote the work of marine ecological product accounting (MEPA) and realize the value of marine ecological products, this paper summarizes and sorts out the accounting methods and application progress of marine ecological products, and analyzes the related research of marine ecological products through analogy analysis method. The analysis of the theoretical research, methods, and application progress of MEPA shows that the theoretical research of MEPA is not mature, and the definition and classification are not yet unified; There is still a lack of unified accounting methods and systems for MEPA; The feasibility and effectiveness of the accounting results need to be further improved. Based on the existing research results, the index system and method of MEPA including supply, support and cultural products were established and applied in Hepu Dugong National Nature Reserve of Guangxi Zhuang Autonomous Region of China. According to the current research results and the applied accounting results of this paper, the following suggestions are proposed: A unified theoretical and methodological system for marine ecological product accounting should be established by combining multiple disciplines in the future researches; The application practice of MEPA urgently needs to be further developed, and periodic accounting should also be emphasized at the same time. The paper provides a series of accounting methods and a case study for MEPA, and provides technical reference for the establishment and promoting of the value realization mechanism of marine ecological products.

(HD-P-16654 Oral)

Understanding local residents' perceptions of blue carbon-based marine park in the context of long-term management and its feasibility

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Climate change brings with it increased pressure on terrestrial and marine ecosystems. There has been considerable interest in blue carbon as strong impacts on carbon storage and sequestration, which have been found to harness environmental and social benefits in newly emerging blue carbon-based marine park (BCMP). However, there is less evidence on the long-term positive effect of BCMP based on local residents' willingness to be involved in keeping BCMP in light of the context of governance-based practices. This paper calls on empirical data collected via questionnaire surveys with local residents around marine areas in South Korea. The findings show that overall, BCMP long-termly managed by local residents' involvement as a key stakeholder was considered feasible by such residents' groups particularly age groups under 50s in governance-based practices but to a lesser extent by all age groups in residents/ community-led income generation. In addition, interestingly there are strong positive correlations between the dimensions (governance, partnership, income generation, monitoring and maintenance) based on the concepts of place-keeping which pursue long-term management. The results highlight the overarching importance of local residents' willingness to be involved in the practices regarding how they inform an awareness of governance, which is increasingly dependent on governance arrangements and partnerships, to contribute to a BCMP's maintenance, which is monitored through evaluation. Concluding remarks suggest a variety of feasible, context-specific BCMP practices which may help stakeholders to address pragmatically the current challenges of making and keeping BCMPs. This will ultimately be an overriding contribution to climate change adaptation.

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(HD-P-16659 Oral)

Transition of consumer preference for seafood sustainability in Japan

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Various fields put efforts towards sustainable development, and the fisheries sector is also expected to contribute to sustainable development. Seafood consumers have a strong influence on fisheries by their strong purchasing power, and their demand for sustainable seafood is important to divine the future of fisheries resource. In this study, we estimate the willingness to pay for bluefin tuna *Thunnus orientalis* sashimi to Japanese seafood consumers through four choice experiments over seven-year periods in 2017, 2019, 2021, and 2023 to investigate the extent to which consumers are willing to pay for sustainability, including eco-labeling. The results showed that Japanese consumers increased the value of sustainable seafood until 2019, but that this value became a phenomenon after 2021.

(HD-P-16750 Oral)

Economic and environmental evaluation of kelp fishery with Hakodate City, Hokkaido Prefecture as a case study

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Kelp is a fishery resource in Japan, and a resource for coastal and marine ecosystems and biodiversity because it is a habitat for fish and marine life and is responsible for carbon sequestration called blue carbon. In Japan, a system to generate carbon credits for activities that contribute to the conservation and restoration of natural macroalgal beds and the sustainability of cultivated macroalgae has been demonstrated. In the future, it is essential to develop and implement initiatives and policies that support the sustainable continuation of the local kelp industry by utilizing new funding sources using the blue carbon credits. However, when kelp production is promoted, kelp-related industries emit CO_2, and the net carbon sequestration effect is not clear. To further promote kelp fisheries as an ecologically and economically sustainable industry, a comprehensive evaluation of the net carbon sequestration and economic impact is necessary. Therefore, we apply the Social-Ecological-Environmental System Framework with Hakodate City, Hokkaido Prefecture as a case study. We combine natural science knowledge to assess carbon sequestration effect and social science knowledge of the environment and general types of Input-Output tables to evaluate the carbon emission and economic impact of the kelp fishery. We obtained results showing that net CO_2 emissions per one unit of economic effect is less in natural kelp fisheries than in aquaculture kelp fisheries, thus concluding that natural kelp fisheries would bring more sustainable ecological and economic profits than aquaculture kelp fisheries.

(HD-P-16885 Oral)

Human-centered data management for a prevalent type of fisheries data

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To support efficient and effective information flow, data management tools must fit within a larger web of human activities and organizational processes. We present a recent stock assessment data review for Yukon River Chinook salmon (*Oncorhynchus tshawytscha*) as a case study of a robust, human-centered data management approach. The approach is robust for a specific setting: situations where a few people try to maintain annual estimates for a group of stocks, with source data coming from many different assessment programs and organizations and important context for interpretation spread out over many different reports, spreadsheet notes, and e-mail exchanges. Conceptually, the approach focuses on documenting estimates, major changes in each assessment project, and potential issues with individual records. Computationally, the approach replicates the basic components of relational data bases like MS Access, which store data in individual tables that are linked through queries, except that the tables here are individual csv files, the queries are *R* scripts that merge and summarize the source files into computer-friendly data sets, and changes are tracked through *git*. This de-centralized and people-friendly structure avoids many of the practical hurdles encountered when parts of the source data are maintained by many different people across multiple fisheries organizations. This approach also has clear advantages over the still-common "data management by spreadsheet" approach, where workbooks used to manage fundamental data have grown over decades, have dozens of interconnected tabs, and include important information in text boxes and pop-up comments. A worked example is available at https://github.com/SOLV-Code/UltraLite-Fisheries-Data-System

(HD-P-16944 Oral)

Framework for regional downscaling of climate modelling based on a co-designed traditional seasonal calendar, with the community of Ulukhaktok.

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In Ulukhaktok, NWT, the effects of a warming marine environment are experienced by local Inuit in a variety of ways. These effects, which include seasonal shifts and increased inter-annual variability, influence the occurrence and location of subsistence species and the associated harvesting patterns and methods of local hunters. The ability to document and share knowledge of these changes is one of several steps towards adapting to the challenges of changing oceanic conditions.

Responding to a request from community members of Ulukhaktok, and moved by the desire to bring together Inuit knowledge with Western scientific research methods, we co-designed a seasonal calendar documenting observations of current seasonal arrivals and harvesting of subsistence species by local hunters. We then linked these ecosystem timings with the major environmental drivers, and analyzed past and future changes with the community using a regional model coupling ocean-sea-ice physics and biogeochemistry.

In this presentation we will review the methods and learnings from this 18-months project, highlighting the benefits of starting with a specific community request (a calendar) mixed with open-ended scientific questions - as opposed to the other way around. We will go through the 4 co-design phases that led to the actual calendar now used by the community. Finally, we will review ways in which this combination of tools can support the generation of climate projections from the perspective of the community of Ulukhaktok.

(HD-P-16970 Oral)

The role of local organizations in community participation in marine ecosystems management: a perspective from Small Island Developing States

Naya **Sena** and Mitsutaku Makino

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Small Island Developing States (SIDS) coastal communities face unique challenges when it comes to sustainable management of their marine ecosystems. Apart from being heavily dependent on the marine resources for their livelihoods, SIDS coastal communities' bond with the ocean through important social and cultural ties. As we progress in the Decade of Ocean Science, in which we seek to integrate all stakeholders in producing ocean knowledge, in co-designing solutions and in decision-making processes, it is important to promote local communities' participation in marine ecosystems management, especially in SIDS context. Therefore, in this study we analyze and describe the role and importance of local environmental organizations in promoting community empowerment and participation in marine ecosystems management. First, using Cabo Verde archipelago as a model, we surveyed different coastal communities from three islands and collected the perceptions of 347 local stakeholders, from community people, local leaders, business people, to governmental and non-governmental organizations members. Second, using literature review, we examined the successful cases of local stakeholders' participation in marine ecosystems management in Japan and in the Solomon Islands. We analyze the benefits and challenges of community participation in marine ecosystems management in SIDS and island nations, and we discuss the role of local organizations in promoting multi-stakeholders' collaborations. Finally, we debate on the possible contributions that international organizations, like the North Pacific Marine Science Organization, can have in promoting community participation, shedding a light on the relevance of inter-regional collaborations and exchange of knowledge.

(HD-P-16519 Poster) **E-POSTER** HD-Paper-P1 (ECOP)

Assessing the benefits of mangroves in flood reduction in coastal communities using InVEST Coastal Vulnerability model

Chinomnso C. **Onwubiko**, Frederick Ato Armah and Denis Worlanyo Aheto

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Coastal ecosystems play a significant role to reduce the impacts of coastal hazards on society. This study assessed the role mangrove ecosystems play in reducing floods in coastal communities by employing the InVEST Coastal Vulnerability. The InVEST CV model is an integrated tool used to visualize disaster risk under different ecosystem conditions by analyzing the role of each data input and assigning relative numbers, ranked 1 to 5 signifying lowest to highest exposure. The results from this study show that the mangroves in River State provide minimum protection against coastal flooding, this could be as a result of the deplorable state of the mangrove ecosystems. Therefore, this study suggests climate financing of mangrove restoration and afforestation, indigenous tree planting projects, and climate education and awareness of the benefits of the coastal ecosystem which will aid in changing the perception of coastal communities to conserve mangrove ecosystems.

(HD-P-16526 Poster) **CANCELLED** HD-Paper-P2 (ECOP)

~~**Assessment of environmental degradation in two coastal communities of Ghana using Driver Pressure State Impact Response (DPSIR) framework**~~

~~Charles Abimbola **Faseyi**, Michael K. Miyittah and Levi Yafetto~~

~~University of Cape Coast, Cape Coast, Ghana. Email: charles.faseyi@stu.ucc.edu.gh~~

~~In this study, Driver Pressure State Impact Response (DPSIR) framework was employed to assess the drivers of environmental degradation and their implications on Anlo and Sanwoma coastal communities in the Western Region of Ghana. Pollution Index (PI) and Environmental Risk Factor (ERF) were estimated in Pra and Ankobra estuaries, respectively, in Anlo and Sanwoma communities to complement the qualitative assessment in the studied communities. The state and condition of the coastal ecosystems are critical to the well-being and livelihood of the residents of the two coastal communities. Therefore, it was important to assess the drivers of environmental degradation and their consequences on the coastal communities. The findings showed that the coastal communities were severely degraded and were in a vulnerable state due to the impact of drivers such as gold mining, farming, improper waste disposal, and illegal fishing that pressurize the environment. Also, PI and ERFs showed that the estuaries in Anlo and Sanwoma coastal communities were contaminated with metals such as arsenic, lead, zinc, and iron. Some of the impacts of the environmental degradation on the communities included flooding, reduction in fish catch and health-related ailments among the residents of the two communities. Unfortunately, regulatory policies by government and efforts of non-governmental organisations and members of the two coastal communities to address the environmental issues have not yielded the desired results. It is recommended that there should be urgent interventions by policymakers to stop further degradations in the coastal communities to enhance the well-being and livelihoods of the residents.~~

(HD-P-16570 Poster) **CANCELLED** HD-Paper-P3 (ECOP)

~~Studies on the use of locally available (Coxs Bazar and Saint Martin) renewable seaweed wastes as compost organic fertilizer resources.~~

~~Durlave **Roy**~~

~~Bangladesh Open University, Dhaka, Bangladesh. Kdr2021@gmail.com~~

~~Marine red algae from the Bangladesh Bay of Bengal *Hypnea Sp* have been used as organic materials due to the presence of a number of plant growth-stimulating compounds. The effect of various seaweed species on plant growth and development with an emphasis on the use of this renewable bio-resource in sustainable agriculture of northern fertilizers raw materials system. Organically made fertilizers play an important role in increasing crop yield and the quality of crops promises improvements considering climate adaptation. Seaweed wastes compost was put in evaluation trials at Sreemangal, Bangladesh to evaluate its efficacy and find out the optimum dose for profitable Betel leaf production. This part of the study is directed toward the analysis of the future trend and performances of composting seaweed wastes. The science of seaweeds explores, how analysis of the future trend and performances of composting seaweed wastes. A field study was conducted at three sites at Khasia farmers of Sreemangal Khasia betel leaf cultivation community area of Bangladesh. Seaweed wastes mixed with compost organic fertilizer dose of 50g per support tree. The highest betel leaf yield was obtained from seaweed wastes mixed with compost organic fertilizer applied to plants. Table 1. (2880 leaf). Two people have not used it, but the one who has used it has had good results. This study suggests that seaweed wastes mixed with organic fertilizer are suitable for betel leaf cultivation. Area-based conservation is a key tool for delivering the SDG goal of responsible production and consumption and climate action.~~

(HD-P-16657 Poster) HD-Paper-P4 (ECOP)

Synergies between gender equality and sustainability in coastal fisheries resource use

Hana **Matsubara** and Mitsutaku Makino

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While an international agreement to promote gender mainstreaming has been made, efforts in the fisheries sector tend to fall behind. One of the reasons would be the gap in motivations among stakeholders: while those in the development sector prioritize gender equality as a matter of human rights, those in the fisheries sector tend to expect contribution to sustainability in marine resource utilization through the promotion gender equality. To bridge this motivational gap and promote a Nexus approach to simultaneously achieve Sustainable Development Goals 5 and 14, it is crucial to identify factors that can create synergies between gender equality and sustainable marine resource use. This presentation aims to showcase an example of such synergy in a coastal community, specifically the case of Oarai in Ibaraki Prefecture, Japan. In Oarai, the Women's Group of the Fisheries Cooperative Association operates a local restaurant. Through conducting semi-structured interviews with community members, it was indicated that the contribution to sustainability through value addition on the local catch and the contribution to gender equality through the activities by diverse gender human resources are synergistically reinforcing each other. Key factors contributing to this synergy include a geographically and temporally convenient working environment for women and a shared understanding of the restaurant's value among local stakeholders. To promote gender equality effectively, it is required not only to increase the investment on women’s activities, but also to enhance cooperation among different gender groups so that all human resources can overcome difficulties based on gender-differentiated environment.

MEQ Contributed Paper Session

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

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

(MEQ-P-16496 Oral)

Allelopathic effect on the harmful bloom-forming microalgae: insights into the inhibitory allelopathic compounds of extracts from *Pyropia haitanensis*

Vishal **Patil**[1], Lu Huang[1], Junrong Liang[1], Lin Sun[2], Dazhi Wang[1,2], Yahui Gao[1,2] and Changping Chen[1]

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Various approaches have been conducted to control harmful algal bloom (HAB). The chemical and physical approaches have been used to control microalgal growth, but their adverse effects on the ecosystem remained for a long duration. The macroalgae are part of the ecosystem; hence in detail, we are revealing the antialgal potential of macroalga *Pyropia haitanensis* extracts to prevent microalgal bloom. Initially, the growth-inhibition effect of solvent and aqueous extracts from *P. haitanensis* was tested on five bloom-forming microalgae. The growth of all five microalgal species was significantly reduced by solvent and aqueous extracts. Comparatively, the methanol extract was more effective and hence further fractioned with petroleum ether (PE), ethyl acetate (EA), n-butanol (NB), and milli-q water (W) to test on *Skeletonema costatum* and *Pseudo-nitzschia pungens*. Methanol fractions significantly affected these strains, where both the microalgae were completely dead after 96h of exposure to PE, EA, and NB extracts. 49 confirmed compounds were detected from methanol extract and its fractions using Gas Chromatography-Mass Spectroscopy (GC-MS). The eicosapentaenoic acid, arachidonic acid, palmitic acid, pyridine 3-(1-methyl-2-pyrrolidinyl), α-D-Galactopyranoside, glyceryl-glycoside, and phytol were abundant in most inhibitory extract phase of *P. haitanensis*, which can be majorly responsible for microalgal inhibition. Our results, therefore, suggest that *P. haitanensis* extracts have the potential to control HAB.

(MEQ-P-16504 Oral) CANCELLED

~~**Comprehensive assessment of eutrophication in Xiamen Bay and its implications for management strategy in Southeast China**~~

~~Yang **Luo**[1], Jinwen Liu[1], Jianwei Wu[1], Zheng Yuan[1], Jiwei Zhang[1], Chao Gao[1] and Zhiyu Lin[2]~~

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~~The eutrophication of coastal water has been a critical environmental problem in China's offshore areas. How to effectively assess the status of coastal waters is key for pollution treatment and environmental protection. In recent years, eutrophication symptom-based and multi-indicator methods, termed "phase II" methods, have been gradually adopted to assess the eutrophication status in some coastal waters in China and have achieved success. The cumulative quantile is typically selected to determine the characteristic value of an indicator in "phase II" methods. The influence of small-scale damaged water bodies on eutrophication assessment may be exaggerated, which often leads to the overassessment of the eutrophication status. In this study, the area ratio method was integrated into the assessment of the estuarine trophic status (ASSETS) method in order to assess the eutrophication status of Xiamen Bay in 2016. The results indicated that, in 2016, the eutrophication status of Xiamen Bay coastal waters was moderate and exhibited spatio-temporal variation. The area ratio method can effectively reduce the effect of small-scale coastal waters with extremely high eutrophication on the overassessment of eutrophication at the broader scale, allowing the eutrophication status to be better reflflected, even with limited observation data. The centralized distribution of pollution sources and poor hydrodynamic conditions are the main reasons for the aforementioned phenomenon. Controlling the pollution discharge from the Jiulong River in flood seasons is key to reducing eutrophication in Xiamen coastal waters.~~

MEQ-P (new talk)
Andrew Ross
Harmful algal biotoxins in British Columbia coastal waters

(MEQ-P-16531 Oral) **CANCELLED**

~~Emerging trends in harmful algal blooms: Insights from distribution patterns along Pakistan's coastline and adjacent areas.~~

~~Sonia **Munir**[1], Jun Sun[2,3]*, Steve L. Morton[4] and Zunaira Shahzad[5]~~

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~~This study provides an overview of the emerging trends in harmful algal blooms (HABs) along Pakistan's coastline and adjacent areas, focusing on their distribution patterns. HABs pose increasing concerns globally due to their detrimental effects on marine ecosystems and human health. In recent years, HAB occurrences have risen in Pakistan's coastal waters, presenting significant challenges to coastal communities and industries. HABs can also lead to the closure of beaches and the loss of revenue for the fishing and tourism industries.~~

~~A comprehensive review of relevant studies conducted from 1990 to the present was conducted to analyze HAB distribution patterns. Phytoplankton composition and abundance, particularly HAB species, were determined using microscopic techniques. Concurrent measurement of environmental parameters, such as temperature, salinity, nutrient concentrations, and hydrographic conditions, provided valuable context and played a crucial role in HAB distribution and dispersion such as *Prorocentrum*, *Ceratium*, *Scrippsiella*, *Gyrodinium*, *Katodinium*, *Noctiluca*, *Gymnodinium*, *Akashiwo*, and *Gonyaulax* and Dinophysis spp., Alexandrium spp., Gambierdiscus, *Pseudo-nitzschia pungens*, and Cochlodinium spp., known for toxin production. Distribution patterns varied spatially and temporally, with certain regions and seasons experiencing higher prevalence and abundance.~~

~~Implications of HABs on local ecosystems and human activities are significant, leading to fish and shellfish mortalities, fisheries closures, disruptions to aquaculture, and risks to public health from consuming contaminated seafood. Further research such as monitoring, application of molecular technique, and role of Pharmaceutical in treatment of HABs caused diseases should be focused for implementing effective monitoring and management strategies.~~

(MEQ-P-16589 Oral)

Effects of wastewater from the in-water cleaning of ship hulls on planktonic and attached microalgae

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Wastewater from the in-water cleaning of ship hulls (hull cleaning wastewater, HCW) can negatively impact aquatic ecosystems. Using microcosm experiments, we examined the effects of HCWs containing heavy metals and biocides on the growth of microalgae. HCW samples were obtained using four different treatments: 5% or 10% HCW obtained by cleaning with a soft sponge, and 5% or 10% HCW obtained by cleaning with a hard brush. In the control, planktonic microalgae grew rapidly on day-2 (maximum chlorophyll *a* (Chl. *a*), 34.1 ± 0.8 μg L^{-1}). For the soft and hard cleaning groups, however, the maximum Chl. *a* was 12.6 ± 4.3 μg L^{-1}, indicating a negative effect of HCW on growth of unattached microalgae. Conversely, the Chl. *a* concentration on plastic plates in the HCW groups was up to 50-fold higher than that in the control (maximum 46.0 ± 3.7 μg cm^{-2} from 10% HCW in hard cleaning), indicating the reattachment and growth of potentially fouling microalgae. The biomass of attached microalgae increased with increasing HCW level from 5% to 10% ($p < 0.01$), although cleaning intensity had no impact. The highest concentration of dissolved Cu (an inhibitor of microalgal growth) was 130.9 ± 28.2 μg L^{-1}. Our findings suggest that HCW can negatively impact aquatic micro-ecosystems, with this effect differing between unattached and attached microalgae. The management of HCW runoff is an important consideration when performing the in-water cleaning of ship hulls.

(MEQ-P-16647 Oral)

Distribution and fate of microplastics in the coastal marine environment, South Korea

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The coastal environment can be exposed to microplastic pollution due to various pollutants such as rivers, atmosphere and so on. We identified the horizontal and vertical distribution of microplastics in the coast of Incheon/Kyeonggi bay, South Korea, which are affected by point sources and non-point sources. To investigate the horizontal distribution of microplastics, surface seawater (0 - 0.2 m) was collected using a stainless-steel bucket at 11 stations. To understand the vertical distribution, the CTD profile was investigated for 4 stations (two stations at inner and outer bay, respectively) wherein six layers of seawater, including air-sea interface layer, were collected. In the horizontal distribution, the average abundance of microplastic was 16,182 ± 14,748 particles/m^3, and a slightly higher microplastic abundance was confirmed in the inner bay (28,960 ± 17,986 particles/m^3) than in the outer bay (8,880 ± 5,451 particles/m^3). The mass contribution of microplastics was 13 times higher in the inner bay. The vertical distribution showed the relatively high abundance of microplastic (28,990 ± 19,322 particles/m^3) in the air-seawater interface layer, but there was a vertically uniform distribution (6,340 - 12,010 particles/m^3) throughout all subsurface layers. These results indicate that microplastics sink due to interactions with other environmental factors and thus their substantial amounts can be present in water column. In this study, samples of biological environmental factors that can affect the vertical behavior of microplastics were additionally analyzed. After further analysis, the relationship between marine environmental factors and microplastic behavior will be presented in detail.

(MEQ-P-16682 Oral)

Evaluation of special representativeness of microplastic sampling methods using a non-hydrostatic particle tracking model

Ziqin **Wang**, Yoshimasa Matsumura and Shin-ichi Ito

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Unmanaged microplastics (MPs) released from land into ocean have received widespread public attention widely. While much effort has been devoted to understanding the transport mechanism of marine MPs, field sampling of MPs is still in its infancy and many problems remain. MPs sometimes show characteristic spatial distributions at various scales because of a wave-induced Stokes drift, Langmuir circulation, and wind-induced turbulence, which requires an appropriate assessment of those physical effects on sampling methods to improve the spatial representativeness of sampling. Therefore, particle tracking was conducted to mimic MPs within a non-hydrostatic circulation model, and particle collection characteristics were evaluated for three representative sampling methods (neuston net, Niskin bottle, Large Volume Water Transfer System). For the neuston net, the effect of the relative angle between wind direction and the net tow direction on sampling was evaluated. The results showed that the standard deviation of the collected number of particles was higher and the spatial representativeness became lower when the net was towed in the same directions as the streak of the Langmuir circulation, which is formed by tilting to the right in the downwind direction. Collected particles by Niskin bottles are likely to reflect the dominant vertical profile of MPs which occupies over 80% of the total. Besides, there is a risk of reflecting a vertical profile that is less spatially representativeness of the remaining 20%. This research was performed by the Environment Research and Technology Development Fund (JPMEERF20221001) of the Environmental Restoration and Conservation Agency of Japan.

(MEQ-P-16694 Oral)

Occurrence, source, and transfer fluxes of organophosphate esters in the South Pacific and Fildes Peninsula, Antarctic

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Organophosphate esters (OPEs) are widely used as flame retardants, plasticizers, and antifoaming agents due to their excellent flame-retardant properties and low production cost. In this study, concentrations of 11 OPEs were investigated in surface water and atmosphere samples collected from the South Pacific and Fildes Peninsula. TEHP and TCEP were the dominant OPEs in South Pacific dissolved water, with concentration range of nd–106.13 ng/L and 1.06–28.97 ng/L, respectively. The total concentration of $\sum_{10}$OPEs in the South Pacific atmosphere was higher than that in Fildes Peninsula, ranging from 216.78-2033.97 pg/m^3 and 161.83 pg/m^3, respectively. TCEP and TCPP were the most dominant OPEs in the South Pacific atmosphere, while TPhP was the most prevalent in the Fildes Peninsula. The air-water exchange flux of $\sum_{10}$OPEs at the South Pacific was 0.04-3.56 ng/m^2/day, with a transmission direction of evaporation totally determined by TiBP and TnBP. The atmospheric dry deposition dominated the transport direction of OPEs between air and water, with an flux of S$_{10}$OPEs at 10.28–213.62 ng/m^2/day (mean: 85.2 ng/m^2/day). The current transport flux of OPEs through the Tasman Sea to the ACC (2.65´10^4 kg/day) was significantly higher than the dry deposition flux over the Tasman Sea(493.55 kg/day), indicating the Tasman Sea’s importance as a transport pathway for OPEs from low latitude areas to the South Pacific. Principal component analysis and air mass back-trajectory analysis provided evidence of terrestrial inputs from human activities that have impacted the environment in the South Pacific and the Antarctic.

(MEQ-P-16865 Oral) **Talk cancelled, will present POSTER instead (MEQ-P6)**

Phytoplankton community and HABs species in the Beibu Gulf detected by metabarcoding approaches

Junjie **Zheng**[1], Jiarong Hu[1], Pengbin Wang[1,2], Ruoyu Guo[1], Ruifang Wang[1,2], Xinfeng Dai[1] and Douding Lu[1]
(presented by colleagues on behalf of Junjie Zheng)

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The marine environment is affected by human activities and climate change, leading to the increase of harmful algal blooms (HABs) caused by microalgae fast growing, which pose serious threats to public health, tourism, fisheries and ecosystems in coastal areas. This study focused on the Beibu Gulf, and used high-throughput sequencing technology analyzed the microalgal community structures, especially on the HAB species, of 62 stations from both deep and shallow waters during summer and winter cruises. The results revealed that 261 microalgal species were detected, among which 66 species were HAB species and 24 species were new records of HAB species in the Beibu Gulf, such as *Alexandrium fraterculus*, *Margalefidinium fulvescens*, etc. The microalgal community structures showed obvious seasonal and regional differences, and the biodiversity was the highest in the deep water area in summer. In deep water area, there were more HAB species than in the shallow water area, but the group of HAB species were similar between summer and winter. Among the HAB species, in the shallow water area, *Cyclotella cryptica* was the dominant species in winter, while *Chaetoceros tenuissimus* was the dominant species in summer, with their relative abundances exceeding 40%. This study disclosed the diversity and complexity of the microalgal community in the Beibu Gulf, and discovered a rich variety of HAB species, which laid a foundation for studying the formation mechanism of HABs in the Beibu Gulf. Furthermore, this study also suggested the potential HABs in Beibu Gulf.

(MEQ-P-16963 Oral)

Investigating the distribution of *Azadinium* (Dinophyceae) species responsible for shellfish poisoning in two distinct Pacific regions: Korean coastal waters and Puget Sound, WA, USA

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The discovery of a new group of toxins called azaspiracids (AZAs) in 1995, which were found to be responsible for human illnesses after shellfish consumption along the Irish west coast, has prompted research into the global distribution of these toxins and the species of the dinoflagellate genera *Azadinium* and *Amphidoma* known to produce them. In this study, a genus- and species-specific qPCR assay was employed to detect *Azadinium* spp. in sediment samples collected from sixteen stations in the East Sea, West Sea, and South Sea, including Jeju Island in Korean coastal waters, as well as fifteen stations in Puget Sound, WA, USA. The results revealed a positive signal in almost all stations using the SYBR green qPCR assay for Amphidomataceae and the Taq-man probe qPCR for *A. poporum* in Puget Sound. Furthermore, clonal isolates of four *Azadinium* species, namely *A. cuneatum*, *A. obesum*, *A. dalianense*, and the AZA-producing species *A. poporum*, were obtained from incubated sediment samples collected during this study. The identification of these *Azadinium* species was based on morphological characteristics, which were further confirmed through molecular phylogeny analysis. This research significantly contributes to our understanding of the distribution patterns of *Azadinium* species, including those that produce AZAs, in Korean coastal waters and Puget Sound. The findings provide valuable insights into the prevalence and potential ecological implications of these harmful algae species in the investigated Pacific regions.

(MEQ-P-16517 Poster) MEQ-Paper-P1

Risk of the superposition of *Phaeocystis globosa* and *Pleurobrachia globosa* on cold source water of nuclear power plant

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The biomass of *Phaeocystis globosa* increased abnormally in the cold source water intake area of the nuclear power plant in the eastern Liaodong Bay in November, 2020. And the biomass of *Pleurobrachia globosa* was also higher than that in previous years. *Phaeocystis globosa* and *Pleurobrachia globose* are risk organisms that can affect the cold source water intake system of nuclear power plant. The marine biological monitoring and early warning project team launched a field investigation to assess the risk from the superposition of *Pleurobrachia globosa* and *Phaeocystis globosa* on the cold source water system. The monitoring results showed that the density of *Phaeocystis globosa* and *Pleurobrachia globose* tended to decrease with the method of field sampling by shallow water plankton nets, remote sensing of red tide, beach patrol and the situation investigation in pelagic sea. As well as the overall biomass and risk tended to decrease. The abnormal increase of *Pleurobrachia globose* and its delayed disappearance were probably cause by the relative cold summer and the apparent delay in cooling water temperatures in November, 2020. Meanwhile, the hysteresis of decreasing water temperature provided suitable conditions for the deviant raising of *Phaeocystis globosa* in November. The nuclear power plant reserve modified clay over the years to eliminate *Phaeocystis globosa* . Furthermore, the nuclear power plant has formulated a prevention plan for eliminating *Phaeocystis globosa* with modified clay to fully cope with the influence of its red tide on cold source water system.

(MEQ-P-16626 Poster) MEQ-Paper-P2 (ECOP)

Effects of microplastics on different developmental stages in *Acartia omorii* (Copepoda, Calanoida)

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Microplastics (MPs) are distributed widely in all marine environments and have been known to affect a wide range of marine organisms. MPs have the potential for ingestion and accumulation by organisms and can make harmful conditions to them. *Acartia omorii* is a copepod found widely over the world. MPs toxicity tests on *A. omorii* have been conducted before, but most of them are limited to acute tests on adults. This study describes the effects of MPs on *A. omorii* and their naupliar stages. Experimental groups were exposed to polystyrene MPs (diameter: 10 μm). Experimental conditions were set up differently depending on life stages. Those were set to (1) Filtered seawater (control), (2) 1 μg/L(MP1), (3) 10 μg/L (MP10), (4) 100 μg/L (MP100) for the adult and (1) Filtered seawater (control), (2) 10 μg/L (MP10), (3) 100 μg/L (MP100), (4) 1,000 μg/L (MP1000) for the naupliar stages. Adults were exposed to MPs for 48 h as an acute toxicity test, and 13 days in the case of the naupliar stages. In the adult experiment, mortality was highest in MP100 and lowest in the control group. However, the control group and all experimental groups survived more than 80% at the end of the experiment. Thus, LC50 could not be obtained. In the naupliar stage experiment, mortality was highest in MP10 and lowest in the control group. Developmental time was fastest in MP10 and slowest in the control group, and also copepodid stages appeared first in MP10 and last in the control. Unlike previous studies, MPs were not toxic in this study. This is probably because the experimental concentrations covered in this study were lower than those of previous studies. However, the development of the naupliar stages was affected by MPs.

(MEQ-P-16783 Poster) MEQ-Paper-P3

The Olympic Region Harmful Algal Bloom (ORHAB): a powerful partnership to mitigate HABs

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In 1999, regional scientists and public health officials concerned about the impacts of harmful algal blooms (HABs) along the Washington State, USA, outer coast gathered together to form Olympic Region Harmful Algal Bloom (ORHAB), a partnership of federal, state, tribal and local management and research agencies, marine resource-based businesses, and academic institutions that determine where and when harmful algal blooms occur on the Washington State, USA, coast and explore methods to reduce HAB impacts on humans and the environment. Beginning in 2000, this partnership was funded by a 5-year federal grant, then transitioned to State funding in 2003, when the Washington State legislature created a permanent source of funding through a shellfish license surcharge. The University of Washington's Olympic Natural Resources Center (ONRC) in Forks, Washington became the scientific lead for ORHAB, responsible for distribution of supplies to partners, and planning training exercises and workshops. The ONRC provides field sampling and lab protocols, HAB species taxonomy expertise, and coordination of event response. Tribal partners, including the Makah, Hoh, Quileute and Quinault tribes, now monitor HABs and test for seawater toxins at their own labs, resulting in rapid sample analysis and decision-making at locations coastwide. In 2023, ORHAB created a centrally-located HAB lab at ONRC to increase the ability to respond rapidly to coastwide HAB events, such as the 2015 "Bloom-Blob". Additionally, ONRC is developing the ability to establish phytoplankton cultures and begin offshore HAB sampling using autonomous vehicles, taking HAB monitoring and mitigation to the next level.

(MEQ-P-16955 Poster) MEQ-Paper-P4 (ECOP)

Can the *sxtA4* gene diversity be associated with variation in paralytic shellfish toxin production in the toxic dinoflagellate *Alexandrium pacificum*?

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It is unclear how the genus *Alexandrium* exhibits high intraspecific physiological variability, resulting in variations in production of paralytic shellfish poisoning toxins (PSTs) depending on the strains. Thus, we investigated the intraspecific variation in PST production of the eight *A. pacificum* strains depending on the four different temperature conditions (15 °C, 20 °C, 25 °C, and 30 °C). As a results, PST content was clearly different depending on *A. pacificum* strains irrespective of temperature conditions, and the level of PST content in each strain was higher under unfavorable growth conditions. There was a clear difference in PST composition between the two strains (KM2 and KM5): PST components in strain KM5 were more diverse than those in strain KM2. To examine whether or not this difference might be derived from intraspecific genetic diversity between the strains, we investigated the sequences of the *sxtA4* gene which is a core gene for PST production using a cloning method. Interestingly, the *sxtA4* gene in strain KM5 (88 single nucleotide polymorphisms; SNPs/615 bp) had more SNPs than that in strain KM2 (54 SNPs/615 bp). Given these findings, the number of SNPs might be positively associated with the level of PST diversity in *A. pacificum*.

(MEQ-P-16962 Poster) CANCELLED MEQ-Paper-P5 (ECOP)

~~**Comprehensive understanding of the life history of *Heterosigma akashiwo* (Raphidophyceae): Integrating *in situ* and *in vitro* observations**~~

~~Joo-Hwan **Kim**[1,3], Jin Ho Kim[2], and Bum Soo Park[1]~~

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~~*Heterosigma akashiwo* (Raphidophyceae) is a globally recognized harmful algal species responsible for harmful algal blooms. Despite its diverse morphological variations observed during cell cultivation, understanding its life history has been limited due to challenges in observing transitions between life cycle stages *in vitro* and *in situ*. This study combined laboratory-based (*in vitro*) and field-based (*in situ*) observations to define the life cycle stages of *H. akashiwo* and investigate their transition pathways. For the first time, novel homothallic sexual reproduction processes involving hologamete fusion and zygote formation were observed *in vitro*. These zygotes demonstrated two pathways: division into vegetative cells (Pathway I) or enlargement to form multiple cells with multiple nuclei (Pathway II). Additionally, field observations documented large cells and cell clusters, including cytokinazed large cells that act as intermediate stages bridging the gap between the two cell types. The zygotes observed *in vitro* exhibited a large size and multinucleated characteristics, similar to the large cells and cell clusters observed *in situ*. This suggests that large cells observed in the field are zygotes undergoing cell division to form cell clusters (Pathway III). Moreover, based on the similarities in cell morphology and nuclear size between the cell cluster and the cyst cluster, along with synchronized germination characteristics of cyst clusters, it is proposed that the cell cluster serves as the precursor to cysts. By integrating *in situ* and *in vitro* observations, this study provides a comprehensive understanding of the previously unknown life history of *H. akashiwo*.~~

POC Contributed Paper Session

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

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

(POC-P-16493 Poster) POC-Paper-P1

Impact of mesoscale eddies on particulate organic carbon flux in the western subarctic North Pacific

Ryo Dobashi[1], Hiromichi **Ueno**[2], Nozomi Matsudera[2], Isao Fujita[2], Tetsuichi Fujiki[3], Makio C. Honda[3] and Naomi Harada[3,4]

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The mechanism that controls particulate organic carbon (POC) flux in the deep sea differs depending on the season and sea. The POC produced in the western subarctic North Pacific are known to be transported to the deep sea efficiently, but the direct relationship between the POC flux and physical processes is still unclear. In this study, we evaluated the effect of mesoscale eddies on POC flux in the western subarctic North Pacific. The seasonal and interannual variabilities of POC flux were investigated using data from a time-series sediment trap deployed at 4,810 m at station K2 (47°N, 160°E) from 2005 to 2018. POC flux was high during May–November, appearing to reflect spring and fall blooms at the ocean surface. POC flux also showed interannual variability, with twelve peaks that were mostly affected by enhanced bloom just before the peak. Nine peaks of the twelve peaks were affected by mesoscale eddies, which enhanced bloom around K2 by extending the area with a high chlorophyll-a concentration along the coastal region into the offshore region, suggesting that mesoscale eddies strongly impact the interannual variability of POC flux at K2.

(POC-P-16599 Poster) POC-Paper-P2

An imporoved estimate of submesoscale surface kinematic and dynamical properties obtained from concurrent Lagrangian surface drifter observations

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We evaluate the surface kinematic and dynamical properties, including instantaneous surface currents and deformation rates of surface currents, obtained from at least 70 concurrent Lagrangian surface drifter observations. We introduce another step to map these properties from systematic combinations of multiple Lagrangian drifters and compare the previously conducted direct mapping approach on an Eulerian grid within a temporal and spatial range. Since the oceanic submesoscale processes have variability at O(1) km spatial scale and less than O(1) hour time scale, the newly introduced mapping approach can (1) provide raw estimates at submesoscale, (2) minimize the potential smoothing in space and time in direct gridding (3) maintain the submesoscale features. We evaluate the consistency and performance of the mapping by formulating optimal interpolation in gridding instead of a linear-squares fit.

(POC-P-16685 Poster) (E-poster, Access from Whova) POC-Paper-P3

Seasonal and interannual variability of the latent heat flux in the northwestern Pacific Ocean according to ERA5 reanalysis data

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The monthly average latent heat flux (LHF) values (1998 – 2022) in the northwestern part of the Pacific Ocean (NWPO) and the Far Eastern seas are considered. The highest LHF values were found in autumn and winter in areas with the highest SST values, in the zone of influence of the warm Kuroshio and Tsushima currents. Most likely, this is due to the action of the winter monsoon, which is characterized by high wind speeds that carry drier air from the mainland than the summer monsoon brings from the central Pacific Ocean. The positive values of the parameter in the areas of quasi-stationary upwellings also have a simple physical explanation, since moisture condensation can occur in them due to the lower temperature of the ocean surface. These features can also be seen in the spatial distribution of the first EOF mode. The time function of the first EOF mode is characterized by low-frequency modulation, which is most pronounced for winter maxima, with a period of about 6 years. An analysis of unidirectional trends showed that the most intense interannual changes were revealed in autumn. Significant negative trends were found in the area of the Sangara Strait and, in general, off the coast of Japan, while positive trends were found in the Amur Estuary, near the Shantar Islands, and in the Pacific Ocean along the southern boundary of the area under consideration.

(POC-P-16753 Poster) POC-Paper-P4

Wintertime marine extreme temperature events modulate phytoplankton blooms in the North Pacific through subtropical mode water

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Marine extreme temperature events (METs), including marine heatwaves (MHWs) and cold spells, have recently gained much attention owing to their vital influence on the marine ecosystem and social economy. Since METs can alter the upper ocean stratification and wintertime convective mixing in the northwestern North Pacific subtropical gyre (NPSG), their activities may modulate phytoplankton blooms by regulating entrainment of the subtropical mode water (STMW) with high NO^{-3}. Furthermore, because STMW formed in the previous winter reemerges east of its formation site in the following winter, the METs activities imprinted in STMW affect phytoplankton blooms remote from its formation site. Here, we examined the relationship between the MET activities, STMW volume, and phytoplankton blooms using satellite observations and a data-assimilative coupled physical-biogeochemical model dataset. MET activities appearing in the STMW formation region during winter regulate the formation of STMW and the supply of NO^{-3} from the subsurface, with the latter controlling the spring/autumn blooms in that region under NO^{-3}-limited conditions. Subsequently, this water mass is transported eastward in the subsurface within the northern flank of the NPSG before reemerging east of the STMW formation site the following spring. This process results in a negative lag-correlation between MET activities and surface chlorophyll in the reemergence region; for example, MHWs in winter at the STMW formation site tend to lower the surface chlorophyll concentration one year later in the reemergence region. Our study suggests that the oceanic processes allow one year of predictability of the marine ecosystems by monitoring METs in the STMW formation site.

(POC-P-16792 Poster) CANCELLED POC-Paper-P5

~~**The source of the summertime shelfbreak current off the west coast of North America**~~

~~Charles G. **Hannah**, Roy Hourston, Richard E Thomson, and Hauke Blanken~~

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~~The ocean off Vancouver Island, British Columbia is viewed as the northern end of the California Current System. An important feature of the system in the summertime is the southward flowing shelf break current that extends south to California. Surface drifters, moored current measurements, and a circulation model are used to examine the question, 'Where does the water come from?' The source is a westward current in southern Queen Charlotte Sound which has its origins in Queen Charlotte Strait. This simple observation has several important consequences: in the summer, freshwater entering the coastal ocean from Washington and southwestern BC must eventually go south, not north; the water in the Vancouver Island Coastal Current must get absorbed into the shelf break current; and the westward flow in southern Queen Charlotte Sound may be a barrier to coastal transport of aquatic invasive species from southern to northern BC in the summer.~~

(POC-P-16794 Poster) POC-Paper-P6

Evaluation of mixed layer depth simulation performance in the Korean waters using numerical models

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The mixed layer depth (MLD) is a significant contributor to climate regulation, as it determines the thickness at which momentum, heat, and moisture incoming through the atmosphere are stored and thus has a critical influence on climate forecasts and predictions. In this study, we evaluate the model performance of MLD simulations for February, the month with the deepest mixed layer, calculated from numerical models (HYCOM and MERCATOR ocean) for the 25 years (1994–2018) compared to the observation. The spatial distribution of the mean MLD simulated by the numerical models was generally similar to the observation but was underestimated by about 25% in the Ulleung eddy and the Yellow Sea warm current region. In the linear trend of the MLD, while the observed MLD has increased over most Korean waters during the 25 years, the MLD simulated by the numerical model has changed negligibly or become shallower, except for the East/Japan Sea. The variability of the MLD is underestimated in the numerical model, but the interannual variation trend is similar to the observation. These MLD biases in the numerical model appear to be mainly associated with the performance of the wind, temperature, and Korean Strait transport simulations.

(POC-P-16797 Poster) POC-Paper-P7 (ECOP)

Evaluation of marine heatwave biases in the North Pacific Ocean simulated by the CMIP6 model

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Climate models are the primary tool for projecting marine heatwaves (MHWs). Although model performance should be evaluated before projecting into the future, the causes of MHW bias in climate models are poorly understood. In this study, we aimed to evaluate the MHW characteristics (total days, frequency, and mean intensity) in historical simulations from 30 Coupled Model Project Intercomparison Phase 6 (CMIP6) models in the North Pacific Ocean (NPO) compared to OISST reanalysis data for 33 years (1982–2014), and to analyze the causes of bias by clustering to CMIP6 models with similar bias patterns. The CMIP6 models overestimated the annual mean total days of MHW in the NPO by approximately 25 days compared to the OISST, while the frequency was underestimated by approximately 0.8 events per year. This suggests that the CMIP6 model overestimates the duration of MHWs. In the mean MHW intensity bias, over 80% of the CMIP6 model showed a dipole pattern in the Kuroshio extension. This bias pattern is likely due to the simulation of the Kuroshio Current further north, known as the Kuroshio overshooting. We will evaluate the model performance in simulating the Kuroshio Current and investigate its association with the MHWs intensity bias. Furthermore, we plan to divide CMIP6 models into two groups based on spatial bias patterns using clustering to compare the bias causes.

(POC-P-16939 Poster) POC-Paper-P8 (ECOP)

Asymmetries between phases of Atlantic multi-decadal variability in the CMIP6 model

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The Atlantic Multidecadal Variability (AMV) is a slowly varying Sea surface Temperature (SST) fluctuations, centered in the subpolar North Atlantic, extending to lower latitudes, of which the exact mechanism or the temporal characteristics are poorly understood. A recent study suggested the possibility of asymmetric responses in the tropics to the two opposite phases of AMV, prompting us to conduct a comprehensive analysis of the asymmetry between these phases using the preindustrial experiments with 49 different models from the WCRP Coupled Model Intercomparison Project 6 (CMIP6).
To quantify the asymmetry, we compared the tropical SST response during positive AMV phases to that during negative phases. As for the tropical SST response to each AMV phase, the mean SST anomalies in the Tropical North Atlantic during one phase was normalized by the mean subpolar North Atlantic SST anomalies during the corresponding phase.
The AMV asymmetry is found to be highly model-dependent, both in terms of strength and direction. Some models show greater sensitivity in Tropical North Atlantic to the negative AMV while the other models prefer the positive AMV. The modeled asymmetries are found preferring slightly positive with the mean located at +0.08, with 67% of the range falling within ±0.4.
In seeking for the possible sources of the inter-phase asymmetry of the AMV patterns, we examined the climatological characteristics of the surface conditions in both the atmosphere and ocean within the models. This analysis includes surface winds, net heat fluxes as well as the upwelling of cold water. Larger asymmetry is found in models with the steeper zonal mean decrease in the global surface mean temperature with latitude. Additionally, cold water upwelling is found reducing the Tropical sensitivity to the positive AMV in a group of models.

Satellite-data temperature-salinity framework to characterize the California Current System

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Characterizing temperature and salinity (TS) conditions is a widely used framework to describe deep water masses and their dynamics. At the surface and in coastal areas, TS conditions are not usually analyzed because salinity sampling is expensive, and other processes, such as air-sea-land interactions impact TS values at faster scales than can easily be monitored. In addition, sea surface salinity data lags behind sea surface temperature monitored, largely due to its lower resolution, shorter time span, and biases near the coast. Still, the spatial and temporal coverage achieved with satellite data is unsurpassed and has the potential to be used in areas where no other data is available.

To test this approach, we focus on the California Current System (CCS), a highly dynamic region in which salinity plays an important role, and where validation data is largely available - in this study, from 12 Saildrone cruises during the summers of 2018-2019. Through a clustering analysis on Saildrone data we identify CCS regions that show similar TS characteristics, and apply that characterization to remote sensing data. Both satellite and Saildrone data clearly identify the Northern and Southern CCS regions, and two regions within what is traditionally considered the Central CCS. Saildrone data goes further to identify differences between nearshore, coastal and offshore data, which satellite data has problems disentangling due to biases nearshore. Despite these differences, the satellite-data TS framework shows potential as a tool to identify characteristics and variability that traditional *in-situ* monitoring or temperature-only analysis might miss.

GP: General Poster Session

Convenor:
Sanae Chiba (PICES Secretariat)

Posters from any workshop or science sessions that do not fit the workshop or session scopes are welcome.

(GP-16560 Poster) GP-P1 (ECOP)

Emergent constraint for future decline in Arctic phytoplankton concentration

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In recent decades, the Arctic Ocean has experienced continuous warming and freshening, affecting biogeochemical factors such as nutrient supply, light availability, chlorophyll, and productivity. While Arctic marine productivity is projected to increase due to the expansion of the open ocean and increased chlorophyll concentration, uncertainties related to chlorophyll and nutrients may distract the fidelity of productivity in current Earth system models (ESMs). Here, we analyze the existing uncertainty in the Arctic chlorophyll projections using the 26 ESMs participating in Coupled Model Intercomparison Projects 5 and 6 (CMIP5 and CMIP6). We found that the uncertainty in the Arctic chlorophyll projections in the CMIP6 ESMs is greater than in the CMIP5 ESMs due to increasing uncertainty in the background nitrate concentration. A significant relationship between background nitrate and projected chlorophyll ($r = 0.86$) is demonstrated using the observational climatology of nitrate. Based on this strong relationship, the emergent constraint is applied to reduce the uncertainty of future chlorophyll projections. Declines in chlorophyll concentration based on emergent constraint are estimated to be further decreased in the future ($44.9 \pm 29.1\%$ to $50.9 \pm 27.6\%$) than at present, which is about three-fold larger than the multi-model mean projection ($-13.5 \pm 48.7\%$). Comparing cumulative density functions before and after the emergent constraint, the probability of the decreasing chance of chlorophyll is increased by approximately 36% from 60% in prior CMIP5,6 to 93-96% after constraint. Our results imply that reducing the uncertainty in background nitrate concentration can improve the fidelity of future projections of the Arctic ecosystem in the ESMs.

(GP-16595 Poster) GP-P2 (ECOP)

An assessment of sessile benthic communities in Jeju Island off the south coast of Korea using Autonomous Reef Monitoring Structures

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The composition of coastal benthic communities in temperate regions is shifting owing to climate change. We utilized artificial reef monitoring structures (ARMS) as a standardized tool for assessing the biodiversity of sessile benthic communities. ARMS units were deployed at depths of 12–15 m in shallow subtidal sites (Gangjeong and Bomok) in Jeju Island, Korea. After 1 and 3 years, we evaluated benthic communities by analyzing the images for 17 plate-faces and conducted metabarcoding analysis for each ARMS unit. The image analysis identified 13 orders and 24 families of sessile benthic organisms, while metabarcoding had high sensitivity in detecting dissimilarities among benthic communities, identifying 39 orders and 95 families. Furthermore, metabarcoding identified crustose coralline algae (CCA) at a lower taxonomic rank, which was not discernible from image analysis. Nevertheless, metabarcoding did not detect some species identified in the image analysis, including *Isognomon* sp. (mollusca), *Herdmania* sp. (tunicate), *Amphiroa* sp., and *Jania* sp. (geniculate coralline algae). ANOSIM analysis indicated that deployment period and plate-face significantly affected benthic community composition. The use of ARMS as a benthic ecosystem monitoring tool provides insights into the biodiversity of benthic communities, contributing to an understanding of these ecosystems in response to regional and environmental changes. This study provides as a foundation for integrating complementary approaches, such as image and metabarcoding analyses, to explore the composition of benthic communities along the coast of Jeju Island.

(GP-16641 Poster) GP-P3

Dietary analysis of the ducks flying to Japanese tidal flats in winter and evaluation of impact on the ecosystem

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Wataerfowls feed on various species of animals and algae in shallow water environments, including tidal flats, and are top predators in the food web, having a huge impact on the marine ecosystem. We used carbon and nitrogen stable isotope ratios to analyse the feeding habits of ducks on the mouth of the Mirodikawa River facing the Ariake Bay in southern Japan. In addition, we deployed unmanned aerial vehicles to estimate the duck population and body size, and calculated energy requirements per unit area in the tidal flats. The survey was conducted by the Kawaguchi Fisheries Cooperative Association in collaboration with the Jonan Hunting Club as part of a project to exterminate ducks for five times from December 2021 to March 2022. A total of 41 ducks were sampled for testing. Using an elemental analyzer and an isotope ratio mass spectrometer, samples of duck muscle and dietary resources were analyzed for carbon and nitrogen content and their stable isotope ratios. The stable carbon isotope ratios ($d^{13}C$) of mallard, which were present in the highest number of ducks samples, widely varied from –25.6‰ to –17.6‰. When prospective food resources were divided into marine ($d^{13}C$: from –21 to –14‰, $d^{15}N$: from 7 to 12‰) and terrestrial ($d^{13}C$: –27.9‰, $d^{15}N$: 6.6‰) sources, we observed that there were individuals who fed on terrestrial sources. Therefore, our data indicates that ducks migrating to this region do not necessarily rely exclusively on marine food resources.

(GP-16650 Poster) GP-P4

Can satellite image detect seabirds and waterfowls on waters?

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Clusters of feeding flocks of seabirds are believed to indicate marine biological hot spots. To explore feasibility of detecting feeding flocks using satellite image, we examined 9 Pleiades (0.5 m resolution) and 86 SPOT7 (1.5 m resolution) satellite images of the sea around Teuri island, the colony of black-tailed gulls and rhinoceros auklets in Japan, sampled in summers of 2012-2021, though apparent signs of feeding flocks were not detected. We further requested 4 Pleiades images in April - June 2022 where we did the land survey simultaneously as well, but no feeding flocks were detected. In 108 out of 233 Pleiades images of 38 lakes in winters of 2012-2021 where waterfowls were wintering, white spots, an indicator of swan, were detected but black ones, an indicator of geese and duck, were not. We further requested 11 Pleiades images over Utonai lake in December 2022-April 2023, and found white spots in 5 images. Number of white spots in a single image was identical to the number of swans observed from the land, while the number of those in the other one did not match with the number of swans observed from the land. Swans on the ice and ducks and geese on the water were not detected in the satellite images. Our preliminary study indicates that flocks of large white seabirds such as albatross species can be detected using Pleiades satellite images on the calm water.

(GP-16662 Poster) GP-P5 (ECOP)

Reduction of atmospheric N deposition to the Yellow Sea of Northeastern Pacific Ocean for COVID-19 period

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Rapid population growth and industrialization in Northeast Asian countries have caused the excessive input of atmospheric N to the Yellow Sea of the Northeastern Pacific Ocean. Since the Yellow Sea is located between Northern China and Korean Peninsula, the abundant atmospheric N has been deposited to the Yellow Sea with 71% of total new N input, implying an increase in marine primary productivity. We monitored atmospheric N deposition and analyzed isotopic values of [NO_3^-] and total carbon, nitrogen, and sulfur concentrations for COVID 19. During COVID-19, The depositions of [NO_3^-] and [NH_4^+] decreases by 38% and 68.7% for summer and 49.5% and 49.6% for winter, respectively. The deposition of [NO_3^-] for COVID-19 indicated that the fossil fuel combustion and vehicles were main sources for atmospheric N depositions for winter and summer, respectively. These trends were not different from those of pre-COVID-19, implying the reduction of N deposition and no change of N pollutant sources for COVID-19. The concentrations of total carbon, nitrogen, and sulfur also reduced 21.6%, 13.6%, and 45.2% for winter, respectively. However, the isotope values showed different trends such in $\delta^{13}C$ and $\delta^{34}S$, unlike N depositions. Thus, we will further investigate the mechanisms of isotope changes of $\delta^{13}C$ and $\delta^{34}S$ during COVID-19. This work was primarily supported by the National Research Foundation of Korea (NRF) grants (2022R1A2C3008402) funded by the Ministry of Science and ICT (MOIT) of the Korean Government as well as a grant from the National Marine Biodiversity Institute of Korea (2023M00300).

(GP-16781 Poster) GP-P6 (ECOP)

A traits-based approach to assess aquaculture's contributions to food, climate change and biodiversity goals

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Aquaculture has the potential to support a sustainable and equitable food system in line with the United Nations Sustainable Development Goals (SDG) on food security, climate change and biodiversity (FCB). Biological diversity amongst aquaculture organisms can drive diverse contributions to such goals. Yet there is a lack of knowledge connecting underlying biological traits of the cultured species to their potential influence on FCB. Existing studies have assessed the performance of a limited number of taxa in the general context of improving aquaculture production, but few explicitly consider the biological attributes of farmed aquatic taxa at the FCB nexus. Through a systematic literature review we identify key traits associated with FCB and evaluate the potential of aquaculture (54 major species) to contribute to FCB goals using a fuzzy logic model. Our results reveal taxonomic differences in FCB contribution potential. While finfish and crustaceans show relatively low potential for all three FCB goals, algal species have relatively high FCB potential, and molluscs have high potential for food and biodiversity goals. We find that the most influential traits to predict a species' FCB potential are trophic level, growth rate, absolute fecundity, and temperature, phosphorus and latitudinal range. The intertwined nature of FCB challenges and opportunities in aquaculture emerged as a prominent theme during our synthesis and is supported by the trait overlap and correlations across food, climate and biodiversity categories. Possible FCB synergies in aquatic farming could be explored through co-culture, regenerative aquaculture and livelihood transitions. Research on the socio-economic opportunities and barriers for aquaculture transitions could further stimulate the development of equitable pathways toward FCB-positive aquaculture across nuanced regional contexts. This study provides decision-makers with a biologically informed assessment of desirable aquaculture traits and species while illuminating possible transition pathways to increase support for FCB goals.

(GP-16860 Poster) GP-P7

A study on revision of regulations to promote bio-materialization of the Fishery Processing Industry's residue

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Despite many seafood processing by-products (scales, heads, bones, and shells of fish, shellfish, crustaceans etc.) being discarded in Korea, these raw materials could be used as the ingredients for pharmaceuticals, cosmetics, and health-functional foods. Fortunately, the Fisheries By-products Recycling Promotion Act (officially unnamed, hereinafter referred to as FBRPA) was enacted in July 2021, providing a legal basis for the recycling of fisheries by-products. But only shells from six shellfish species are treated as fishery by-products while others from fish and crustaceans are not included as fishery by-products in the Enforcement Decree of FBRPA. In this study, we attempted to find the relevant rationale for why fish by-products should be treated as fishery by-products under the FBRPA. According to the Ministry of Oceans and Fisheries in Korea, it is estimated that a total of 1,121,000 tonnes of fisheries by-products is generated, equivalent to one-third of fisheries production in 2020. The number of fish by-products generated in 2020 was 1.3 times higher than that of shellfish by-products, and also the recycling rate of fish by-products was also higher than shellfish by-products. In addition, shells are mostly used as raw materials for fertilizers in Korea, but fish by-products for bio-materials sold at an added value of more than 27 times the price of fertilizers. Based on our study, to decrease fishing processing waste and to increase utilization of fish by-products, we propose that fish by-products are included in fishery by-products under the Enforcement Decree of FBRPA.

(GP-16872 Poster) CANCELLED GP-P8 (ECOP)

~~Ringed seals' (*Pusa hispida*) exposure to underwater shipping noise in the Canadian Arctic~~

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~~Climate change is driving unprecedented changes in sea ice coverage throughout the Arctic, and as the duration and extent of ice-free periods has increased, so has vessel traffic and underwater vessel noise. Marine mammals, who use sound for foraging, communication, and mating strategies, are among the species most impacted by vessel noise, which can mask and diminish the effective range of their acoustic signals, cause behavioural disturbance, and even contribute to hearing damage. Integral to both Arctic ecosystems and Indigenous communities, ringed seals (*Pusa hispida*) are an ice-obligate species adapted to quiet underwater soundscapes. They are currently listed as a COSEWIC species of special concern, but little is known regarding the extent to which ringed seal behavior and movement patterns are influenced by increases in Arctic shipping activity. A critical first step to answering this question is to determine how often ringed seals are exposed to shipping vessel noise. Using data from ringed seals equipped with satellite tags in the eastern Canadian Arctic, we implement a continuous-time movement model to improve location estimates derived from error-prone Argos data. Corrected seal relocations are then compared with the tracks of large commercial vessels derived from satellite Automated Identifier System (AIS) data. Our results are the first to illustrate how often ringed seals and commercial vessels overlap in space and time in the eastern Canadian Arctic and provide valuable insight needed for developing informed vessel management plans in a changing Arctic.~~

(GP-16880 Poster) GP-P9

Introduction to the Ieodo Ocean Research Stations (Ieodo-ORSs) and Korea Hydrographic and Oceanographic Agency (KHOA) research activities

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The Ieodo Ocean Research Station (Ieodo-ORS), a steel-framed tower-type platform has been constructed in the vicinity of a submarine rock called Ieodo in June 2003 to improve our understanding of oceanic and atmospheric phenomena and their interactions in the East China Sea. The station is characterized by an internationally unique station due to the open-sea location which is about 149 km away from Jeju Island. The Ieodo-ORS was initially established by KIOST as part of the R&D project of the Ministry of Oceans and Fisheries, control of the Ieodo-ORS was transferred to the KHOA in 2007. It has 29 Pieces of equipment installed for collecting oceanographic, meteorological, and environmental data. In order to promote studies based on the Ieodo-ORS, the KHOA has actively pursued projects categorized into three key areas: the development of observation techniques, enhancement of observational data utilization, and the monitoring of oceanic and atmospheric environments. In addition, the KHOA has run a program of 'Ieodo ORS field research trip' since 2014, supporting a dedicated ship to service the Ieodo-ORS and use of Ieodo-ORS's facilities. The KHOA ultimately aims to establish the Ieodo-ORS as an international scientific station through a variety of academic research.

(GP-16905 Poster) GP-P10 (ECOP)

Vocal behaviour of ringed seals (*Pusa hispida*) in the western Canadian Arctic

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Ringed seals produce a variety of underwater sounds, but their vocal behaviour remains poorly studied. The goal of this work is to quantify different ringed seal vocalizations and investigate temporal variations in sound emission. Data collection occurred in May 2022 near Ulukhaktok in the western Canadian Arctic. Three acoustic recorders (SoundTrap 300 STD) were deployed in five cracks in the sea ice that were regularly used by ringed seals as haul-out areas. Recordings were carried out continuously throughout the day with a sampling rate of 96 kHz. Spectrograms were inspected visually by an experienced observer using Raven Pro 1.6 (Hanning window, window length 7000 samples, 50% overlap) and all ringed seal sounds were counted and classified into one of three categories: yelps, barks and growls. For every hour of the day, the average number of emitted sounds was also quantified. In total, 357.4 hours of recordings were analyzed and 14,698 vocalizations identified. The most common vocalizations were yelps (81.4%), followed by barks (14.3%) and growls (4.3%). Ringed seals vocalized throughout the day, but more frequently at night from 19:00 to 05:00, decreasing their calling rates in the morning and afternoon. The average vocalization rate of the quietest hours (06:00 to 18:00) was 18.6 sounds per hour compared to 64.2 sounds per hour during the night. Determining commonly-produced sounds and temporal variation in sound production is essential to characterize patterns in ringed seals acoustic behaviour and can help detect their presence in long-term passive acoustic data.

(GP-16907 Poster) CANCELLED GP-P11 (ECOP)

~~Indicators of pelagic forage community shifts related to the abundance of tropical tunas by climate effect in the Western Indian Ocean~~

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~~Most studies exploring the relationship between tunas and their prey focused on the Pacific and the Atlantic Oceans, but few studies on the Indian Ocean. Therefore, in this study, the standardized catch per unit effort (CPUE) of tunas was calculated for yellowfin tuna (YFT) and Bigeye tuna (BET) from longline fisheries data from Indian Ocean Tuna Commission. Then the pelagic forage community data was collected from Sea Around Us Project Website to further used to compare the CPUE trend and their prey affected by climate change and fishing exploitation between YFT and BET. For the spatial distribution, the high CPUE overlapping areas (>60% grids) for YFT and BET (Area A), and the high CPUE of YFT with lower overlapping occurred in Arabian Seas (Area B). The cross-wavelet result showed that YFT and BET had 4-10 years positive correlation periodicity from 1980 to 2000, then using Non-metric multidimensional scaling and canonical correlation analysis to divide tuna and their prey into different groups in two areas, Carangidae and Scombridae are the same group with YFT and BET in area A are affected by PDO, ENSO, DMI and effort. Loligindae, Decapoda, Carangidae and Scombridae are in the same group as tuna in area B affected by PDO, ENSO and effort. Furthermore, the relationship between the pelagic forage community and tunas revealed a negative correlation with crustaceans but showed a positive correlation with other species in two areas. Thus, we suggested that the impact of fishing exploitation and climate effect may change the species density of fish populations and be conditioned through top-down control processes in Area A and B.~~

(GP-16951 Poster) GP-P12 (ECOP)

Regional assessment of sustainable development goal 14 in the North East Asia: focusing on its implications and impacts on the semi-enclosed seas

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Sustainable development goal 14 (SDG 14) for healthy oceans and seas is considered as one of the most challenging goals among others. This study examines the current status and trends of SDG 14 in the North East Asian countries including China, Democratic People's Republic of Korea (DPRK), Japan, Republic of Korea, and Russia. Based on dimensional and developmental comparisons across the countries, it analyzes vulnerable areas for implementing SDG 14 within the region, its impacts on the semi-enclosed seas such as the Yellow Sea and the East Sea, and related implications. Materials are drawn from *Sustainable Development Report 2023* by the Sustainable Development Solution Network, *Voluntary National Reviews* by respective countries, and various sources reporting domestic and cross-regional issues. This study conducts cross country comparisons of performances by indicators, discusses dimensional impacts on the Yellow Sea and the East Sea, and suggests future responses based on the results and discussion. Current SDG assessment and VNR tools are examined by respective countries so that cross-boundary and regional issues, which are inevitable but important in SDG 14, could be marginalized. This study contributes to raising awareness on such issues and highlighting blind spots in regional wide and worldwide implementation of SDG 14.

IPHC Special Session

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

Co-sponsor:
IPHC

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

Invited Speakers:
Piera Carpi (Institute of Marine Research (IMR), Bergen, Norway)
Barbara Hutniczak (International Pacific Halibut Commission, Seattle, WA, USA)
David T. Wilson (International Pacific Halibut Commission, Seattle, WA, USA)

In 1923, the Convention for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and Bering Sea was signed by Canada and the United States of America (U.S.A) in response to conservation needs. The International Pacific Halibut Commission (IPHC), initially named the International Fisheries Commission, was established as an intergovernmental organisation by this Convention that came into effect on 21 October 1924, constituting the first international agreement for joint management of a marine resource. Therefore, for the last 100 years, the IPHC has been successfully managing the Pacific halibut resource for Canada and the U.S.A. through the application of rigorous science, innovation, and the implementation of international best practice. This session is intended to celebrate the first 100 years of the IPHC by highlighting past and current scientific activities that have supported the management of the Pacific halibut fishery in the Northeastern Pacific Ocean.

(IPHC-16559 Invited)

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

David T. **Wilson**

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The International Pacific Halibut Commission (IPHC) is an international organization established by a Convention between Canada and the United States of America. The IPHC Convention was signed in 1923 and entered into force on 21 October 2024. The Convention has been revised several times since, to extend the Commission's authority and meet new conditions in the fishery. In October 2024, the IPHC will turn 100, making it the oldest regional fisheries management body in existence. The IPHC conducts an annual stock assessment that includes the Pacific halibut resource in the IPHC Convention Area, covering the Exclusive Economic Zones of Canada and the United States of America. Data sources used for stock assessment include data from the fishery-independent setline survey, the commercial Pacific halibut sector and other fisheries sectors, as well biological information on migration and population dynamics, maturity, growth, mortality and discard survival assessment of Pacific halibut (*Hippoglossus stenolepis*) contemplated in the IPHC 5-Year Program of Integrated Research and Monitoring (2022-2026). These data sources for stock assessment are updated each year to reflect the most recent scientific information available for use in management decision making. Furthermore, the IPHC is also conducting a Management Strategy Evaluation process to evaluate the consequences of alternative management options.

(IPHC-16563 Invited)

Migration, MSE and management: the wonder world of Pacific halibut.

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Pacific halibut is one of the most extensively studied species worldwide, as well as one of the most valuable fishery resources in the North Pacific Ocean. The International Pacific Halibut Commission (IPHC) has dedicated a century to the management of this stock, conducting ground-breaking research to understand its biology, life-history, and population dynamics. This research has provided invaluable insights into the Pacific halibut's highly migratory nature, paving the way for the unique management of the stock along the Pacific Northwest coast of the United States and Canada.

The understanding of Pacific halibut migration has culminated in the development of a conceptual model that describes the movement of Pacific halibut from southern California through the Bering Sea. This has been extremely helpful to describe and visualise the complicated migratory pattern of this species.

The abundance of high-quality time series data on Pacific halibut has been instrumental in the development of an Area-Based Management Strategy Evaluation (Area-Based MSE). Designed to assess various management procedures at different levels of fishing intensity, the MSE framework aims to identify strategies that safeguard the spatial distribution of the spawning component across the management area. This approach is key for the conservation and sustainable utilisation of the Pacific halibut stock, and has been a joint process together with the stakeholders involved in the fishery.

This keynote speech will delve into the world of Pacific halibut, exploring its migratory behaviour, the ground-breaking research conducted by IPHC, and its unique MSE framework.

(IPHC-16632 Invited)

Hundred years of Pacific halibut management in the context of global events

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The Convention for the Preservation of the Halibut Fisheries of the Northern Pacific Ocean was signed on 2 March 1923 and ratified on 21 October 1924. This action established the International Fisheries Commission, renamed in 1953 the International Pacific Halibut Commission (IPHC). It was the first international agreement for joint management of a marine resource and a major milestone for development of modern standards for marine conservation.
The IPHC's centennial year is an opportunity to celebrate a remarkable history of the Commission, but also reflect on challenges that shaped its mission. Born from alarms about overfishing during the World War I, the Commission gradually gained more authority to additional conservation measures through established public confidence in its basis for decisions. Pacific halibut regulations have been shaped by not only the changing conditions of the stock and growing demand for seafood, but also global events and trends in fisheries management.

In this project, I look at the evolution of management measures applied to Pacific halibut in the context of global events relevant to fisheries, including rapid commercialization of fisheries driven by growing population and the introduction of a number of technological improvements in the industry, United Nations Convention on the Law of the Sea that established exclusive economic zones and altered access to fishing grounds, and adoption of Agenda 21 at the United Nations Conference on Environment and Development held in Rio de Janeiro, which highlighted the importance of balancing environmental, economic, and social aspects in fisheries management.

(IPHC-16602 Oral)

International Pacific Halibut Commission Fishery-Independent Setline Survey (FISS)

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The International Pacific Halibut Commission (IPHC) has conducted a fishery-independent setline survey (FISS) since 1963 with the primary objective being to collect standardized, fishery-independent data for the Pacific halibut stock assessment and stock distribution estimation. The information collected during the FISS is used to study aspects of the Pacific halibut stock, such as growth, distribution, area-wide biomass, age composition, sexual maturity, and relative abundance of associated by catch species. The IPHC FISS of the Pacific halibut stock is conducted annually during the summer months on chartered commercial fishing vessels, and currently has a full design standard grid of 1,890 stations spanning Northern California, through the coast of British Columbia, Gulf of Alaska, Bering Sea slope, and out to the western points of the Aleutian Islands. Standardized longline gear as well as bait is used to ensure consistent data collection coastwide. The IPHC collaborates with several domestic government agencies in both Canada and the United States of America to collect additional data throughout the FISS, such as Pacific Cod and Spiny dogfish lengths, and dockside rockfish biological sampling.

(IPHC-16631 Oral)

Biological and ecological research at the International Pacific Halibut Commission

Josep V. **Planas**

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The International Pacific Halibut Commission (IPHC) has been conducting biological and ecological research on Pacific halibut (*Hippoglossus stenolepis*) since its inception in 1923. Historically, the first scientific investigations on Pacific halibut were initiated in 1925 to provide information on migration rates between “banks”. Between 1925 and 1927, more than 10,000 Pacific halibut were tagged from British Columbia to Kodiak Island in Alaska. Tagging efforts by the IPHC have continued to date. Furthermore, early life history characteristics of Pacific halibut in relation to oceanographic features of the North Pacific Ocean were already described by Thompson and Van Cleve in a scientific report published by the IPHC in 1936. This seminal work set the pace for subsequent decades of scientific research at the IPHC. At the present time, IPHC research has evolved to incorporate state-of-the-art scientific approaches that include individual-based biophysical models, spatiotemporal models, population genomics and physiological analyses that provide robust information on key life history characteristics and population dynamics of Pacific halibut with the aim to reduce uncertainty in the stock assessment.

(IPHC-16638 Oral)

Fishery-dependent data collection at the International Pacific Halibut Commission

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The International Pacific Halibut Commission (IPHC) collects fishery-dependent landing and biological data which are an integral part of the annual Pacific halibut stock assessment. Landing (logbook) data date back to 1888 and are provided directly from fishers to the IPHC. Biological data collection by the IPHC from commercial landings began with length and age information in 1933 and now include length, age, weight and sex as well as tagging data. Sampling protocols are reviewed annually and are designed to ensure that the sampled Pacific halibut are representative of the population of landed Pacific halibut throughout the Convention Area. Data collected in the field are entered into remote data entry applications developed by the IPHC to optimize data-entry and editing. IPHC secretariat are stationed throughout the Convention area to accomplish statistically sound data collection objectives. In 2023, the IPHC Secretariat staff are stationed in Port Hardy and Prince Rupert (Canada), in Newport, OR and Bellingham, WA (West Coast U.S.A), and in Dutch Harbor, Kodiak, Homer, Juneau, Petersburg, Seward, Sitka and St. Paul (Alaska).

(IPHC-16639 Oral)

The long path to ensemble-based stock assessment

Ian **Stewart**

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The International Pacific Halibut Commission (IPHC) transitioned from decades of ‘single best model’ stock assessments to the explicit use of multiple models (an ensemble) in 2013. This talk will trace our historical motivation for and recent development of ensemble-based assessment analyses. The method naturally integrates both estimation and structural uncertainty while providing more stable results over time than a single model. We discuss developments in model weighting. The IPHC’s experience with multiple models highlights that clear communication, including presentation the results of individual model results as well as probabilistic risk-benefit trade-offs, remains the biggest challenge in conducting all stock assessments. Ensembles have provided the IPHC with a logical bridge toward management strategy evaluation operating models.

(IPHC-16717 Oral)

The IPHC's fishery-independent setline survey: an historical review and a look to the future

Ray **Webster**

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The International Pacific Halibut Commission (IPHC) began conducting fishery-independent surveys in 1961, initially with a trawl survey before switching to longline gear in 1963. Surveys were intermittent over the next 30 years and generally focused on high-density regions in the core of the stock in the Gulf of Alaska and British Columbia. An annual setline survey began in 1993, expanding to all management areas by 2000 and providing the most important data input to the Pacific halibut stock assessment. The current fishery-independent setline survey (FISS) is based on a fixed-station grid design established in 1998. From 2011 to 2019, the footprint of the FISS was expanded to fill in gaps in historical coverage, ultimately encompassing the full geographic range of the US/Canada stock: 1,890 stations located at the intersections of a 10 x 10 nmi square grid from California to the northern Bering Sea. Because not all stations can be sampled each year, annual FISS designs are rationalized through a process that selects a subset to sample with the goal of maintaining precise estimates and low risk of bias in a model-based index of relative abundance. The FISS design process includes scientific review, stakeholder input and cost-optimization, and provides us with a flexible survey that is responsive to current and future challenges, including cost constraints and rapid distributional shifts due to factors such as climate change.

(IPHC-16760 Oral)

More than fifty years of management strategy evaluation at the International Pacific Halibut Commission

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The International Pacific Halibut Commission (IPHC) has a long history of Management Strategy Evaluation (MSE) and there are many lessons to be learned. Many notable fisheries scientists have contributed to this history, and stakeholders have been involved in various ways. From a 1968 report on simulating management strategies to the recent formation of an advisory body to the Commission, this talk explores the history of MSE at the IPHC as well as the benefits and challenges of involving stakeholders in the process. In 2013, the IPHC's Management Strategy Advisory Board (MSAB) was formed to oversee the MSE process and to advise IPHC staff on the development and evaluation of harvest policies. The MSAB formally meets at least once each year and includes representatives from commercial, sport, processing, Tribal/First Nations, and management sectors. Defining goals and objectives was a first step to developing performance metrics, followed by specifying the management procedures for evaluation. Overall, a cooperative and successful environment has been created by educating stakeholders on the MSE process, explaining that it is a process and not a product, and defining how they fit into the process.

Workshop 1: TCODE/FUTURE/HD Topic Workshop

Creating Concise and Compelling Fact Sheets to Amplify your PICES work

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

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

Fact sheets, which are similar to Pamphlets, are an effective communication tool that can be used to describe the accomplishments and future plans of PICES Expert Groups in a clear and concise format. Preparation of these would provide an excellent opportunity to deliver an outstanding first impression, educate community members and target audiences and increase organizational recognition about the value and relevance of scientific work being conducted under PICES. Moreover, creating fact sheets will challenge PICES scientists to analyze the goals and objectives of their Expert Groups, and to efficiently describe their achievements concisely and clearly. With informative fact sheets, the interest in PICES Expert Groups will be aroused and end users will understand the key ideas and achievements of the Expert Groups, providing opportunities to promote and celebrate the science being conducted by PICES. It will also provide a simple way to communicate PICES science to potential collaborators and aid them in identifying with which Expert Groups they are most closely aligned, while at the same time sparking interest and encouraging them to ask for more information.

The proposed workshop builds upon the 2-day Science Communications workshop at PICES 2022 that had the primary goal of developing videos that describe the accomplishments, needs, and future plans of PICES Expert Groups. An expert writing coach and a visual layout expert will provide instruction to PICES members on:
Strategic design of unique fact sheets
Creating compelling headlines to highlight the value of your PICES work
Honing your result statements to a few key short bullet-points
Including and selecting testimonials about your work
Leverage visual information design and aesthetics to attract audiences, clarify the value of your work; spread your message, provide recommendations that can help decision-makers make informed decisions about our marine ecosystems
Communicate effectively to an international audience.

Participants will work together to develop summaries of PICES Expert Group work, highlighting primary accomplishments and their importance,without overwhelming the reader. Attention will be given to using appropriate language that is understandable and appealing to all participating PICES countries. In addition, the workshop provides an opportunity for participants to build their science communication skillset which they can take to their own work outside of PICES, thereby advancing the promotion of ocean science more broadly. These skills will be an asset to all participants.

The goal will be for completed/approved fact sheets to be posted on the PICES website.

(W1-16578 Invited)

From research to fact sheet – a case study of how to turn your research into a fact sheet

Sayaka **Sogawa**

Japan Fisheries Research and Education Agency, Yokohama, Kanagawa, JPN. E-mail: sogawa_sayaka51@fra.go.jp

This talk will address a case study of making a fact sheet -a simple science story- using ABT strategy (And-But-Therefore), including a discussion of current situation on science communication in Asian country (Japan). This case study will be an example to the workshop participants of the following PICES WG 1 meeting, a working group that will undertake creating concise and compelling fact sheets to amplify work of each expert group.

A science story presented here is an ongoing research project to propose resolution to social issue. Semi-closed sea area, inner bays and inland seas, are known as highly productive area for fisheries and aquaculture. During the high economic growth period, water pollution such as eutrophication has also progressed due to a large amount of water discharged from living or industry activities. Since then, measures to reduce the pollutants have been promoted, and water quality have been improved significantly. But there are some arguments that water quality improvement is going too far recently to maintain fisheries production. It has also been pointed out that rising water temperatures associated with climate change will affect fishery products and their environment. Therefore, it is desired to clarify the long-term trend of changes in water quality and low-trophic level marine ecosystem in inner bays and inland seas. A project is underway for the formation of a rich fishing ground environment using a prediction model based on the results obtained.

(W1-17012 Invited)

Honing your message for fact sheets

Julie **Claussen**

Fisheries Conservation Foundation, Champaign, IL, 61820, USA. E-mail: jclaussen@fishconserve.org

Fact sheets are an excellent method to provide an overview of current research and educate others about the goals and key points of a project. Successfully engaging fact sheets should follow the goldilocks approach: not too little text or sharing too much information but rather providing just the right amount of detail. How to best accomplish the “concise yet compelling’ goal? This workshop presentation will familiarize participants with the proven ABT framework for communicating science and explore how to present information in a logical and inviting manner so that readers pay attention to, understand, and remember the information presented.

(W1- 17016 Invited)

The power of the visual: What is accessible communications?

Marjorie **Mooney-Seus**

NOAA/National Marine Fisheries Service/Alaska Fisheries Science Center, Seattle, WA, USA : E-mail: Marjorie.Mooney-Seus@noaa.gov

Communication is vital to everything we do — from sharing science to building relationships with friends and family. However, to do it well takes training. To be an oceanographer, biologist or social anthropologist requires that you learn the foundational principles and scientific method for each scientific discipline. For communications, there are five key stone skills to help ensure your content standouts in the content ecosystem. In this workshop, we will explore ways to use visuals to communicate persuasively and effectively. Visuals highlight the main points you are trying to communicate in an efficient and interesting way. If used effectively, they can help your reader connect with the main points you are trying to make with contexts that are relevant in their own lives so they remember what they read.

Workshop 2: TCODE/FUTURE/HD Topic Workshop

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

Co-sponsor:
ICES

Convenors:
Steven Bograd (USA), *corresponding*
Kirstin Holsman (USA)
Hannah Lachance (USA)
AP-SciCom, AP-ECOP members from western Pacific TBA

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

The UN Decade of Ocean Science for Sustainable Development (UNDOS; 2021-2030) addresses challenges associated with ecosystem health, food security, and climate change through international Programmes, Projects and Activities. PICES, in partnership with ICES, leads the UNDOS-endorsed Programme called 'SUSTAINABILITY OF MARINE ECOSYSTEMS THROUGH GLOBAL KNOWLEDGE NETWORKS' (SmartNet), which aims to leverage ICES and PICES infrastructure and long-term collaborations to advance global marine ecosystem research and sustainability. Related UNDOS-endorsed Programmes include SUPREME (advance ocean forecasts and projections to guide climate-informed resource management); FishSCORE (sustain fisheries, protect ocean ecosystems, and enhance equitable benefits); Marine Life 2030 (coordination to deliver actionable knowledge of ocean life and ecosystem restoration); and ECOP (empower early career ocean professionals and incorporate new thinking into ocean sustainability and stewardship). We propose a 2-day hybrid topic session and workshop to share knowledge and capacity amongst UNDOS programs, to establish collaborative networks to advance UNDOS goals, and to co-design transformative actions. On the first day, oral and poster presentations will highlight recent science advances within the climate-fisheries nexus, including developments in climate and marine ecosystem predictability and social-ecological-environmental systems. On the second day, participants will engage in open discussion to identify opportunities for developing scientific products for societal benefit and sharing capacity with developing nations. We encourage participation from those not currently associated with an UNDOS action, and especially from early career ocean professionals.

(W2-16558 Invited)

Operational climate and ocean forecasting at the Application Laboratory, JAMSTEC

Hakase **Hayashida**, Yuya Baba, Swadhin Behera, Takeshi Doi, Shoichiro Kido, Toru Miyama, Yasumasa Miyazawa, Yushi Morioka, Masami Nonaka, Sergey Varlamov and Ruochao Zhang

Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan. E-mail: hakaseh@jamstec.go.jp

Short-term (week-to-decade) predictability of the climate and ocean state estimates has been central to the research and development activities of the Application Laboratory at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) over the past twenty years. In this presentation, we provide an overview of the operational forecast products and services and a vision for expanding our capability during the UN Ocean Decade (2021-2030). Specifically, the seasonal climate ensemble prediction system SINTEX-F has been operational since 2005 and has disseminated the prediction information and contributed to the global effort in the multi-model ENSO and IOD predictions. The regional ocean prediction system JCOPE has been routinely providing two-month forecasts since 2001 and has successfully predicted the occurrences of the past two Kuroshio Large Meander events that affect local climate and marine industries. The results from both systems are transformed into various communication formats that are readily accessible to stakeholders and the public. Both systems are evolving to improve predictability and expand capability. One key aspect is the implementation of ocean biogeochemistry for marine ecosystem sustainability. As the host institution for the West Pacific and Marginal Seas of South and East Asia regional team of the Decade Collaborative Centre for Ocean Prediction (DCC-OP) of the UN Ocean Decade, we seek opportunities for collaborations and providing services to the PICES community.

(W2-17010 Invited)

Ocean Sustainability through collaboration: SmartNet, SIDS and Early Career Ocean Professionals perspectives

Khushboo **Jhugroo**

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The UN Decade of Ocean Science for Sustainable Development (UNDOS) underscores the importance of international collaboration and transdisciplinary insights. Building upon last year's discourse, this presentation will revisit the ECOP's perspective from Small Island Developing States (SIDS) and delve further into the potential communication and collaboration with SmartNet. The talk will emphasize the pivotal role of early career ocean professionals in the western Indian Ocean. Our initial interactions with Daniel Marie from the Mauritius Oceanography Institute have sparked insightful conversations and opened avenues for more comprehensive and inclusive initiatives. These communications have gained interest from the Indian Ocean Commission and the Western Indian Ocean Early Career Scientists Network (WIO-ESCN). The WIO-ECSN is open for discussion and is seeking to work with different partners to tackle existing challenges. Some of the actions they are focusing on involve enhancing hydrographic and oceanographic observations, sustainable ocean management, institutional capacity building towards the sustainability of ocean science, ocean literacy and citizen science, amongst others. As SmartNet is increasingly embracing SIDS' unique perspectives and challenges in its approach, this talk will be a starting point for discussions on how collaborative efforts among ECOPs, SIDS, and SmartNet can be established. By weaving these voices into this network, we hope to inspire more actionable knowledge and transformative actions.

(W2- 17019 Oral and Poster W2-P3)

UNDOS Implementation Research Group, a new born program of Korea MOF for international cooperation.

Wonho **Yih**[1,2], Juna Kim[1]

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[2]Kunsan National University, Gunsan, Republic of Korea E-mail: ywonho@kunsan.ac.kr

UNDOS Implementation Research Group of Korea (UNDOS-K-IRG) was launched in April 2023 as a new born program of the Korea Ministry of Oceans and Fisheries to promote international cooperation, particularly by conducting UNDOS-related scientific research. The first component of the UNDOS-K-IRG, Research Outreach and Program Management Team (ROPMT), was formed in April, followed by 2023 selection processes of two research projects with themes related to the 10 challenges of UNDOS. As the second component of UNDOS-K-IRG (a total of 10 research projects), biennial research projects selected annually from 2023 to 2027 will be eligible for funding through ROPMT, which will support some research aspects of the 10 topics for UNDOS challenges. Each of the project research was designed to be conducted by one mentor scientist and two related early-settlement scientists, which could concurrently lead to the first attempt at a Korean next-step scientist training program after post-doctoral researches in ocean sciences. The structure and function of both components of UNDOS-K-IRG and their contribution to UNDOS will be introduced to the participants in Session 01 of Seattle Pices-2023. Further discussion on the Action-Contribution by UNDOS-K-IRG to international UNDOS network is expected to take place during the session and the Pices-2023.

(W2-16777 Poster) W2-P1

Collection and utilization of fisheries and environmental information on small scale fisheries in Indonesia: a preliminary analysis to estimate fish body size using a smartphone app and AI

Shion **Takemura**[1], Shigeharu Kogushi[2] and Mitsutaku Makino[3]

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[2]Green Front Laboratory Inc., Okazaki, Japan
[3]Atmosphere and Ocean Research Institute, University of Tokyo, Kashiwa, Japan

In recent years, the marine environment has been changing dramatically throughout Japan, and recently there have been also changes in the distribution of catches and fish species composition. In taking flexible adaptation measures to changes in the marine environment, major challenges are to detect changes and signs in the marine ecosystem, and to share this information promptly among relevant stakeholders. Therefore, tools such as smartphones and AI, represented by the rapid evolution of ICT, will be able to contribute to solving these challenges. Therefore, in this presentation, we will report the preliminary results to estimate the fish body size of from images of fisheries catch using a smartphone application (FishGIS) and AI. Both ICT tools were developed through the PICES Special Project (FishGIS and Ciguatera). In this study, from the 26 images collected in Lombok, Indonesia, the four coordinates of their bounding boxes including several morphological body parts (anterior-most part of the fish and the tip of the longest caudal fin rays) of the fish in the images were recorded, and the total length was calculated from the coordinates. Then, an AI for fish recognition was developed using 19 images (338 individuals), and the remaining 7 images (88 individuals) were used to verify the accuracy of the AI. The AI was developed using CoreML, a free machine learning application for PCs provided by Apple Inc. The results showed that with a confidence threshold of 0.5, the AI was able to reproduce human measurement results, except for images taken under peculiar conditions. However, in order to improve the accuracy of the developed AI for fish recognition, a future challenge is not only an accumulation of training data but also establishment of a mechanism for local stakeholders to actively participate in data accumulation.

(W2-16778 Poster) W2-P2

What are the characteristics of marine science and human networks in the north Pacific Ocean?

Shion **Takemura**[1] and Mitsutaku Makino[2]

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[2]Atmosphere and Ocean Research Institute, University of Tokyo, Kashiwa, Japan

For more than 30 years, PICES has initiated international research projects that provide a link between various institutions, countries, and cultural spheres in the North Pacific Ocean. This leadership position gives PICES an advantage to make progress towards the goals outlined for the UN Decade of Ocean Science (2021-2030). However, the characteristics of marine science and human networks in the North Pacific are not well understood. Therefore, this study applied text analysis and co-authorship network analysis to abstract books of PICES annual meetings (1993-2019) to identify characteristics of the science and human networks of PICES. The results of the text analysis revealed that researchers in the northeast Pacific were more likely to present on “Biology”, “Ecosystem Based Management” and “Fisheries Management”, while researchers in the northwest Pacific were more likely to present on “Biology”, “Oceanography”, and “Marine Environmental Quality”. The results of the co-authorship network analysis also showed that the simple network consisting of a limited number of institutions when PICES was established (1990s) changed to a more complex network with a larger number of institutions and higher cohesiveness in the 2000s and 2010s. These results reveal that although the research topics in PICES community differ significantly between northeast and northwest Pacific Ocean, the network of research institutions in the PICES member countries has evolved into a highly cohesive international through interdisciplinary research projects. Further research is needed to detect new research topics and hub institutions that bridge the gap between research topics on the west and east coasts of the north Pacific Ocean.

Workshop 3: TCODE/MEQ Topic Workshop

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

Co-sponsors:
GlobalHAB
NOWPAP
SCOR

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

Invited Speakers:
Nobuharu Inaba (Chemicals Evaluation and Research Institute, Japan)
Jorge Mardones (Center for Harmful Algal Studies, Instituto de Fomento Pesquero, Chile)
Tae Gyu Park (National Institute of Fisheries Science (NIFS), Korea)
Kathryn Coyne (University of Delaware, USA)
Heather Raymond (College of Food Agricultural and Environmental Sciences, Ohio State University, USA)
Zhiming Yu (Key Laboratory of Marine Ecology & Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences (IOCAS), China)

Harmful algal blooms (HABs) are a ubiquitous problem that affect marine and estuarine waters around the world. Advances in our understanding of bloom dynamics, improved HAB detection, and increased monitoring in many regions have enabled explorations of promising approaches to prevent and mitigate coastal blooms at multiple geographical scales. However, only a few approaches are available and most have not been fully tested for cost effectiveness and unintended environmental impacts. Therefore, effective and scalable marine and estuarine HAB control remains an elusive goal for many global regions. For example, spraying clay from ships has been used as a physical mechanism to control active Margalefidinium (Cochlodinium) blooms in Korea, as well as Phaeocystis, Aureococcus and other HAB species in China, and the use of naturally occurring bacteria or their exudates is being explored as a biological/chemical method to control raphidophyte blooms and some dinoflagellates in the United States. Some other examples of control include the use of oxidizing agents such as peroxide, percarbonate, ozone, and UV irradiation, as well as direct biomass removal, water column mixing, native seagrass or macroalgal planting, barley straw application, and direct application of algaecides, mostly in smaller-scale freshwater systems.

The societal desire to have access to a greater variety of safe and effective bloom control options has become more urgent given the continued development of coastal regions for aquaculture, tourism, and other uses that are impacted by HABs. An international workshop to explore approaches to HAB control in marine and estuarine waters will stimulate an international dialogue, foster in situ experimentation, and support assessments of social, economic and environmental costs and benefits of various approaches. A discussion of different strategies for navigating environmental compliance will highlight the processes used in different countries to overcome the complexities of rules and regulations and may highlight ways that national regulatory policies could be adjusted to quicken the pace of developing safe and effective HAB control approaches.

The workshop will specifically focus on HAB control mechanisms that have been tested in the field, and not prevention or mitigation. The following definitions are provided for clarification. Control efforts focus on the organisms themselves, either killing them or removing cells and/or toxins from the water. An example is the use of clay spray to control fish-killing HABs. Prevention approaches focus on stopping blooms from occurring or minimizing and limiting their extent. An example is reducing nutrient inputs to water bodies to reduce HAB growth. Mitigation focuses on relieving the impacts of blooms. Examples of mitigation are the use of phytoplankton monitoring and forecasts to provide early warning of HABs. Early warning allows multiple actions to minimize the impacts, such as closure of shellfish harvesting before they become too toxic for human consumption or identifying whether red tide conditions are expected to be present on particular beaches.

The international workshop will engage participants with expertise in research, development, and implementation of promising estuarine and marine HAB control approaches. We encourage the participation of early career ocean professionals and scientists from under-represented communities. Participants will discuss technical, environmental compliance and public perception challenges and explore solutions to these common barriers. In depth discussions of existing control methods and strategies used in different regions/countries will be fostered. The workshop findings will summarize the worldwide approaches in HAB control as a scientific report or as a collection of papers in a special issue of Harmful Algae.

However, only a few approaches are available and therefore effective and scalable marine and estuarine HAB control remains an elusive goal for many global regions. For example, spraying of clay from ships has been used as a physical mechanism to control active Margalefidinium (Cochlodinium) blooms in Korea, as well as Phaeocystis, Aureococcus and other HAB species in China, and the use of naturally-occurring bacteria or their exudates is being explored as a chemical method to control raphidophyte blooms and some dinoflagellates. Some other examples of control include the use of oxidizing agents such as peroxide, percarbonate, ozone, and UV irradiation, as well as direct biomass removal, water column mixing, native seagrass or macroalgal planting, barley straw application, direct application of algicides.

The societal desire to have access to a greater variety of safe and effective bloom control options has become more urgent given the continued development of coastal regions for aquaculture, tourism, and other uses that are impacted by HABs. An international workshop to explore approaches to HAB control in marine and estuarine waters will stimulate an international dialogue, foster in situ experimentation, and support assessments of social, economic and environmental costs and benefits of various approaches. A discussion of different strategies for navigating environmental compliance will highlight the processes used in different countries to overcome the complexities of rules and regulations and may highlight ways that national regulatory policies could be adjusted to quicken the pace of developing safe and effective HAB control approaches.

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explore solutions to these common barriers. In depth discussions of existing control methods and strategies used in different regions/countries will be fostered. The workshop findings will summarize the worldwide approaches in HAB control as a scientific report or as a collection of papers in a special issue of Harmful Algae.

(W3-16533 Invited)

Enhancing the supply capability of growth-limiting bacteria against HAB species through artificially introduced macroalgal beds

Nobuharu **Inaba**

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Recently, growth-limiting bacteria (GLB) kill and/or inhibit the growth of HAB species have been found in various macroalgal and seagrass biofilms in Japan and overseas at densities of ca. 10^5 to 10^8 CFU per gram of wet weight, and the density of GLBs in seawater and on the seafloor is often higher in areas with that vegetation than in those without. In a microcosm experiment using seawater at a seagrass bed, GLBs increased even in the presence of bacterial predators and other competing organisms, and the *Chattonella* red tide was effectively suppressed in a short period. According to these results, macroalgae and seagrasses can be used to improve the supply capability of GLBs, creating a more favorable environment for reducing HABs. In this workshop, the results of a survey aiming to improve the supply capability of GLBs through artificially introduced *Ulva pertusa* bed using their zoospores will be mainly referred to, and related laws, permits, and procedures to successfully conduct these field experiments will also be discussed.

(W3-16621 Invited)

Technology and progress of using modified clay to control HABs in China

Zhiming **Yu**, Xiuxian Song, Xihua Cao and Yongquan Yuan

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Flocculation is an essential approach to control Harmful Algal Blooms (HABs) in the ocean. However, the application of traditional flocculants in marine environment is limited, as the insufficient aggregation and slow settlement of them to HAB organisms caused by hydrodynamic influence, wave disturbance, etc. Such limitations can be overcome by Modified Clay (MC) technology. Using natural clay particle as a carrier, the surface of which is physically modified as to enhance the electrical neutralization, to strengthen the function of absorption bridging and sweep netting, and to improve the algicidal ability. As a result, the HAB organisms can be aggregated effectively and settled down to the bottom rapidly. Comparing with traditional methods, MC shows the great potential controlling HABs in the ocean. In China, it is the most accepted method and widely used technology in such area. A MC based comprehensive technology system for HAB control has been established, including development of functional MC products and supporting equipments, eco- and environmental evaluations of MC, standards and protocols for on-site applications, etc. Within this presentation, the research, development, and application of MC technology in China would be generally introduced, focusing on the principle and theory, safety assessments, and application cases.

(W3-16702 Invited)

Control of *Margalefidinium polykrikoides* blooms using clay dispersal in Korea

Tae Gyu **Park**, Moon Ho Son, Min Ji Lee, Hyung Chul Kim and Seok Hyun Youn

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Numerous control methods have been examined in Korea, including yellow clay, marine bacteria, microscreen filtration/ozone, ultraviolet radiation, parasitic dinoflagellates, and zooplankton predators. Nevertheless, no other control methods have been used extensively in the sea except yellow clay. Due to the effectiveness and practicality of clay, clay dispersal has become the prime control technique for *M. polykrikoides* blooms in Korea. The clay dispersal resulted in decreasing *M. polykrikoides* densities near the surface and about 80% decline in fish mortalities compared to non-controlled areas. However, some critical problems remain with the clay dispersal method in terms of negative ecological impacts, particularly on the benthos. In order to reduce the amounts of clay used, a third generation (3G) clay dispenser has been developed combining an electrolytic water generator and a clay dispenser, significantly reducing the amount of clay used. Also new red tide control agents were formally approved for dispersal in the sea. Component analysis and evaluation of practical application (removal efficiency, effects on environments and organisms, practicality and costs) were conducted against more than 100 substances. Approved four substances are natural clays mixed with palm oil, oyster shells, natural microorganisms, or sophorolipid. So far, only natural clay-based substances are allowed to use in the sea because long-term side effects on marine organisms and environments are unclear. The clay dispersal method is very labor intensive and requires a large number of vessels. Accordingly, clay is only dispersed in Korea when *M. polykrikoides* density exceeds 1000 cells mL^{-1} and fisheries damages are imminent.

(W3-16949 Invited)

Lessons learned from freshwater harmful algal bloom mitigation and control strategies

Heather A. **Raymond**[1] and H. Dail Laughinghouse IV[2]

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There are a variety of mechanical, chemical, and biological freshwater harmful algal bloom mitigation and control strategies that have been employed to various degrees of success. Control strategies focus primarily on treatment of active blooms and less on longer term bloom prevention, which targets sustained nutrient reduction at the watershed scale. Although a plethora of strategies exist, only a handful of treatments have been demonstrated as effective, and effectiveness can vary based on lake dynamics, phytoplankton community, weather fluctuations, nutrient input, and other factors. In general, treatment of smaller waterbodies has been more successful, but there are some cases where blooms on larger lakes have been controlled. Larger scale examples, as well as emerging innovative treatments, could provide insight on bloom control in marine systems. In the United States, federal regulations often apply to use of control strategies and individual states may have additional rules and requirements. These safeguards are often put in place to protect against potential impacts to non-target organisms, but they can create barriers to implementation and hinder trials and adoption of newer, more innovative, strategies. Harmful algal blooms in marine systems often cover multiple regions and international waters with variable regulations, and implementation of control strategies faces further complexities.

(W3-16981 Invited)

Evaluation of novel mini *in-situ* algicidal bioreactors (DinoSHIELD) to control red tide: Moving from the bench to the field

Kaytee Pokrzywinski[1], Yanfei Wang[2], William C. Holland[1], Alexandria Hounshell[1], Kathryn **Coyne**[2] and Alan Kennedy[3]

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Blooms of harmful dinoflagellates occur globally. Specifically, *Karenia brevis* presents a major human health and economic threat to coastal communities in the Gulf of Mexico. Previous research investigated an algicidal bacterium, *Shewanella* sp. IRI-160, which exhibited algicidal activity against dinoflagellates, including *K. brevis*, while having no negative impacts on other phytoplankton tested. Additionally, previous research indicated that this bacterium secretes a group of water-soluble algicidal compounds to control the growth of dinoflagellates without the requirement of direct bacteria-algae contact. However, high-dose repeated application of the bacteria or algicidal filtrate may raise concerns about biosafety. Recent research demonstrated the algicidal activity of *Shewanella* sp. IRI-160 and the algicidal filtrate in surface water deployable and retrievable alginate hydrogels (designated as "DinoSHIELDs") as an effective alternative to direct application of the bacteria or product. Furthermore, at concentrations required to kill *K. brevis*, DinoSHIELDs were recently demonstrated in *in situ* mesocosms (766 gallons) to have a negligible effect on the microbial community with respect to non-target species. Current research is focused on scaling-up production to conduct a field demonstration (up to 1 acre) on the west coast of Florida, USA. The study will use plots with barriers (i.e., shoreline, turbidity curtains, and/or a bubble curtain) to confine the trial in the native environment. The overall goal of the field study is to optimize delivery of the algicide from DinoSHIELDs containing either the immobilized *Shewanella* sp. IRI-160 or cell-free algicidal product and demonstrate the utility of this technology for continuous red-tide management in the Gulf.

(W3-16986 Invited)

Mitigation of harmful algal blooms by the Chilean salmon industry revisited

Jorge I. **Mardones**, Ana Flores-Leñero, Marco Pinto Torres, Maximiliano Vergara and Javier Paredes-Mella

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Harmful algal blooms (HABs) pose significant challenges to the Chilean salmon aquaculture industry as they can lead to severe economic losses and environmental impacts. For instance, in 2016, the dictyochophyte Pseudochattonella verruculosa was responsible for the largest recorded mortality of farmed fish worldwide, resulting in losses of approximately US$ 800 million for the Chilean salmon industry. Mitigating HABs at fish farms is generally not considered an urgent matter until a major fish-killing bloom or a sequence of toxic outbreaks occurs. Despite an increase in phytoplankton monitoring as a mitigation strategy in southern Chile over the past decades (e.g., from approximately 2,200 water samples in 2000 to about 14,000 in 2016), salmon mortality cannot be completely prevented during severe HAB events. Various mitigation methods have been attempted at salmon farms during HAB contingencies, but only a few have demonstrated some degree of effectiveness. The use of bubble curtains, for example, is a HAB control approach that is widely employed in the Chilean fjords, albeit with low efficiency. The apparent rise in the detection of ichthyotoxic HAB events, coupled with the impact of ongoing climate change on the hydrodynamic conditions of the Patagonian fjords, has made predictions and management more challenging. To address these challenges, a multidisciplinary approach that integrates scientific research, industry collaboration, and governmental support is essential.

(W3-16802 Oral)

"Turning back the harmful red tide" revisited

Donald M. **Anderson**

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In 1987, I published a Commentary in Nature about the status of research on harmful algal bloom (HAB) control, entitled "turning back the harmful red tide". This was an attempt to encourage workers in the HAB field to put much more effort into laboratory and, in particular, field studies of marine HAB suppression or control. At that time, having just returned from a recent international HAB conference where there was only a single contribution addressing direct control of marine HABs out of more than 400 papers and posters from 58 countries, I couldn't help but wonder how different it would have been if the conference had been on agricultural pests or on algal blooms in freshwater, where control efforts are far more common and advanced. Now, more than 25 years later, it seems appropriate to re-examine the state of research and applications on marine HAB control, and to consider whether an update of the commentary would be a worthwhile output from this PICES workshop. This talk will thus examine the current situation with marine HAB control efforts, and will once again examine the successes and failures, as well as the barriers to progress. Hopefully, this can motivate discussions that can not only advance the field, but also contribute to a new, and more optimistic commentary.

(W3-16976 Oral)

Practical application of virus-based biological control against the harmful dinoflagellate *Heterocapsa circularisquama* bloom

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The marine dinoflagellate *Heterocapsa circularisquama* is one of the most harmful bloom-forming microalgae, specifically killing bivalves, such as oysters and pearl oysters. The Lake Kamo in Sado Island, northern Japan, is a major oyster culture site and experienced its first bloom of *H. circularisquama* in 2009. The aquaculture oyster industry in the lake suffered serious economic losses estimated at over US $2 million. We developed and applied a biological control method using the algal virus HcRNAV contained in marine sediments owing to the urgent need for developing preventive approaches. The method involves spraying autochthonous sediment containing a high density of HcRNAV when the *H. circularisquama* blooms. Due to the high virus–host specificity, the risk of this low-cost, incredibly effective technique to adversely affect the ecosystem is limited. However, field testing was an essential prerequisite for the practical application of such biological methods, and it was difficult to obtain approval from stakeholders and regulatory authorities due to the concerns about its potential ecological impact. Since Lake Kamo is used for oyster farming, field trials using viruses or bacteria had to be carefully implemented to achieve public acceptance. Therefore, in 2014, following lengthy negotiations, permission for a field experiment was obtained from both the local government and fisheries cooperative, and the first field trial was conducted in 2016. The results were accepted by the local government and fisheries, and the method was applied in Lake Kamo in 2019. Last year, we worked with locals to spread sediments containing HcRNAV.

(W3-17013 Oral)

Logistical considerations in mesocosm and field studies of *Karenia brevis* red tide control in Florida

Donald M. **Anderson**[1], Emily Hall[2], Kristy Lewis[3], Vincent J. Lovko[2], Richard H. Pierce[2], Jennifer Toyoda[2], Kate Hubbard[4], Matt Garrett[4], James Javaruski[2], Victoria Roberts[3], Jessica Frankle[2], Ari Nissanka[2], Zhiming Yu[5], Xiuxian Song[5], Xihua Cao[5], and Yongquan Yuan[5]

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Of the numerous approaches under investigation for marine HAB control, clay flocculation is the most globally advanced, scalable, and widely used. It has been employed for decades in China and Korea, but is still the subject of research in the US, as many knowledge gaps remain with the use of this strategy on a toxin-producing organism. Accordingly, a multi-year study is underway exploring the use of several modified clays to flocculate *Karenia brevis* cells and remove or destroy toxins. This work has progressed from laboratory flasks to 1,500 L mesocosms to pilot-scale studies in canals covering ~1000 m². This talk will describe logistical challenges associated with these efforts, including problems maintaining viable *Karenia* populations in mesocosms containing benthic animals that rapidly deplete oxygen and increase ammonia during experiments. For field studies, challenges include permitting requirements at local, state and federal levels, as well as the logistics of working in small canals using turbidity booms and portable spraying equipment, with tidal movement of *Karenia* cells and treated or untreated water a major constraint. Some clays have been shown to effectively remove *Karenia* cells, but with significant toxin release during treatment. This led to the testing of clay formulations with oxidizing agents or other modifiers that can destroy or sequester toxins. The most effective modified clay removed 95% of the *Karenia* cells in 3 hours, and 75% of the toxin after 24 hours. Progress towards meaningful field experiments has thus been significant but major challenges remain before large-scale treatments can be attempted.

Workshop 4: FUTURE/HD/POC Topic Workshop

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

Co-sponsor:
NOWPAP

Invited Speaker:
Hiroaki Saito (AORI, Tokyo University, Japan)

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

The western North Pacific, one of the areas of the global ocean most affected by climate change and anthropogenic activities, consists of several marginal seas. Many international programs initiated in this area including CREAMS (Circulation Research of East Asian Marginal Seas) have contributed to significant advances in understanding of physics and biogeochemistry of North East Asian Marginal Seas. The UN Decade however requires comprehensive research programs connecting science and communities for sustainable seas. We expect this workshop would provide a forum to discuss all aspects of marine science (physical, chemical, biological oceanography and fishery science) focusing on the North East Asian Marginal Seas and its changing social-ecological-environmental system. It is especially important to identify links between marine sciences and socio-economic requirements in the area to develop an integrative program for future research in this region to correspond the UN Decade targets. Presentations covering success of integrative marine science approach in other regions of the World Ocean are welcomed. The workshop outcome should clarify a vision of international comprehensive marine research in the North East Asian region that meets the current needs of society.

(W4-16586 Invited)

Marine ecosystems in Southeast Asia: Status, emerging issues and scientific contribution for the sustainable use

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In Southeast Asia (SEA), more than 60% of the population lives in 60 km from sea and the human society has benefited from diverse and fertile marine ecosystems. The marine ecosystems are, however, under the serious pressures of human activities due to the rapid growth of the population and economy as well as global warming. Impacts of anthropogenic perturbations are now obvious, such as marine heat waves, coral bleaching, plastic pollution, decreasing fishery production, and harmful algal blooms. These are looming threats for the sustainability of our society. In spite of the importance, our understanding on the structure and dynamics of SEA marine ecosystems is still limited, partly due to the limited human resources. Scientists are requested to prepare best scientific knowledge to develop solutions for societal issues related to the marine ecosystem services. From 2020, scientists of SEA and Japan conducted Collaborative Research and Education Project in Southeast Asia for Sustainable Use of Marine Ecosystems (CREPSUM). The goals of CREPSUM is 1) establish an international science and educational network for the Southeast Asian marine ecosystem, 2) progress marine ecosystem studies on emergent issues for conservation and sustainable use of marine ecosystem services in SEA, and 3) contribute to the UN Decade of Ocean Sciences and UN SDG 14 “Life below water” by compiling the best scientific knowledges. In the presentation, I will present the products from the CREPSUM and remaining issues for the sustainable use of marine ecosystem services in SEA.

(W4-16755 Oral) CANCELLED

~~**Exploring potential strategy for highly exploited multispecies fisheries management**~~

~~Guankui **Liu**, Peng Sun, Runlong Sun and Yongjun Tian~~

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~~Sustainable fishing is a paramount concern encompassing the exploitation of fishery resources and marine conservation. As human activities increasingly impact the marine ecosystem, issues such as resource depletion, ecological degradation, and declining profits have become more severe, particularly evident in the China Seas. The East China Sea (ECS) is currently experiencing significant changes in community structure and diversity due to overfishing. To address these challenges, a balanced harvest (BH) approach has emerged as a potential strategy for ecosystem-based fisheries management. In this study, we developed the Ecosystem-Based OSMOSE-ECS model to assess the long-term impacts of fishing and explore potential management strategies that achieve a balance between ecological and economic considerations, while also considering social welfare. By incorporating various ecological processes, mechanisms, and the overall structure and functionality of the ECS ecosystem, the OSMOSE-ECS model provides a realistic representation of ecosystem dynamics. Our research emphasizes that the implementation of ecosystem-based management through the BH approach can enhance ecosystem resilience, protect vulnerable species, ensure long-term fisheries sustainability, and safeguard social welfare.~~

(W4-16815 Oral)

Unraveling the types and dynamics of marine heatwaves in the East Sea (Japan Sea)

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Extremely warm seawater temperatures (beyond the 90th percentile threshold) conditions known as marine heatwaves (MHWs) have profound biogeochemical impacts on marine ecosystems and affect humanity. MHWs in the East Sea (Japan Sea) have been happening at an unprecedented rate. However, the ecosystem consequences and evolutionary patterns of these MHWs are still poorly understood, despite their increasing frequency and severity. This study utilized ocean reanalysis/model data (SODA, HYCOM, GLORYS, and ECCOVr4) to gain deeper insights into the dynamics of MHWs. Long-term time-series observations collected from the East Sea Real-Time Ocean Buoy (ESROB) between 2000–2015 were used to validate the observed MHWs. The findings revealed a rising frequency of annual mean and summer (JJA) MHWs throughout the entire East Sea from 1982–2019. Using unsupervised machine learning clustering techniques, *K*-means and Hierarchical clustering, the study identified three distinct types of MHW evolutions within six sub-regions of the East Sea— Type-A (surface-confined and short-lived), Type-B (surface to subsurface evolution up to a few meters), and Type-C (deeper layer evolution). Factors such as increased shortwave radiation, low wind speed, and mixed layer shallowing contribute to the formation of MHW types, while heat penetration into deeper layers and dissipation mechanisms involve mixed layer deepening, heat release to the atmosphere, and interactions with deeper layers. This study offers crucial insights into the characteristics and subsurface evolution MHWs, emphasizing the importance of understanding MHWs to predict and mitigate their ecosystem consequences in the rapidly warming East Sea.

(W4-16824 Oral) **CANCELLED**

~~**Gross ecosystem product (GEP) accounting**~~

~~Shang **Chen**, Shuai He, Wenwen Li and Yuemei Jin~~

~~First Institute of Oceanography, Ministry of Natural Resources of China (FIO, MNR), Qingdao, China. E-mail: qdcs@163.com~~

~~Gross Ecosystem Product (GEP) is proposed based on ecosystem service theory to assess the sustainability of coastal ecosystem and its contribution to socio-economic system. GEP is defined as the total value of final ecosystem goods and services used directly and indirectly by human per year in a given region. GEP does not include the ecosystem services with existence value, bequest value, optional value and other intrinsic values. The accounting methods of GEP is proposed. GEP composes of three groups of ecosystem products: (1) The biophysical products, including agricultural products, forest products, pastoral products, fishery products, bioenergy products, biomaterial products, oxygen product etc. (2) The regulating products, including carbon sequestration, climate regulation, air purification, sewage treatment, water conservation, flood control, soil retention, coastal protection etc. (3) the cultural products, including leisure and recreational service, and landscape-added value etc. The GEP in Yancheng city, a coastal city in the western Yellows Sea was assessed. The total area of Yancheng city is 3580 kilo ha including sea (1890 kilo ha), cropland (774.5 kilo ha), wetland (486.8 kilo ha), forest (59.3 kilo ha), grassland (9.4 kilo ha), orchard (4.7 kilo ha) and urban green space (0.90 kilo ha). The GEP of Yancheng increased from 780.65 billion CNY in 2019 to 890.79 billion CNY in 2021, the annual increasing rate: 7.05%. Regulating products account 75 % of GEP, while biophysical products account 20% of GEP and cultural products account 5% of GEP. GEP is an integrated index to assess ecological performance of ecological and environmental projects.~~

(W4-16883 Oral)

Climate change alters social-ecological trade-offs in achieving ocean futures' targets

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Climate change effects on marine ecosystems are causing cascading impacting on livelihood, food security and culture through fisheries. Such impacts interact and exacerbate the effects of overfishing on marine social-ecological systems, complicating the rebuilding of ecosystems to achieve desirable and sustainable ocean futures. Developing effective pathways for ecosystem rebuilding requires consideration of the co-benefits and trade-offs between ecological and social dimensions and between fishing sectors. However, the effects of intensifying climate change on such co-benefits or trade-offs have not been well understood, particularly in regions where ecosystem rebuilding is urgently needed. We apply a numerical optimization routine to define the scope for improvement towards the Pareto-frontier for ecological and economic benefits of the northern South China Sea (NSCS) and the East China Sea (ECS) ecosystems, representing over-exploited low- and mid-latitude systems, respectively, from the current status through fisheries management. We find that the ECS ecosystem has the possibility of increasing the economic benefits generated by the fisheries it supports under the impacts of climate change by 2050. Nevertheless, climate change is projected to reduce the scope to restore biodiversity and ecosystem structures for both the SCS and the ECS ecosystems. This study highlights the contrasting impacts of climate change and the co-benefits/trade-offs in ecosystem rebuilding across and between different fishing sectors even in neighboring ecosystems.

(W4-16896 Oral)

The effects of selective harvest on exploited population and economic benefits

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Long-term selective harvest induces the change in biological traits and economic value of exploited population. Stow net is the main fishing gear to capture commercially important fish species small yellow croaker (*Larimichthys polyactis*) in Haizhou Bay, China. Long-term stow net selective harvest affects both the biological traits and economic benefits of small yellow croaker. Therefore, an appropriate harvest scenario that can achieve the high economic benefits and the sustainable use of resource needs to be explored. In this study, we develop a bio-economic model for small yellow croaker and focus on different harvest scenarios for obtaining maximum economic benefit and sustainable utilization of resource. Our results indicate that the increase in mesh size has positive effects on the protection of small yellow croaker population, and optimal harvest scenario achieves the short- or long-term economic benefits to different stakeholders. Fishing with small mesh size gets high economic value in short-term, while fishing with large mesh size achieves better economic value and effectively protect small yellow croaker resource under long-term fishing pressure. This study provides evidence to balance the long-term economic benefits and sustainable utilization of fishery resource, and it also offers a basis for the scientific formulation of fishery policy.

(W4-16924 Oral)

Potential predictability of skipjack tuna (*Katsuwonus pelamis*) catches in the Pacific Island countries

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The Pacific Island countries have a crucial dependency on the fishery industry to maintain their economy. Collecting access fees to the exclusive economic zone from foreign fishing fleets contributes considerably to these countries' financial resources, and the fish processing industry also provides employment to local people. Many of the Pacific Island countries, including the Federated States of Micronesia, the Marshall Islands, Kiribati (or the Gilbert Islands), Nauru, and Tuvalu, are located in the Western Central Pacific (WCP), a subdivision (statistical area 71) assigned by the Food and Agriculture Organization of the United Nations. This region exhibits a spatio-temporal variability influenced by ocean conditions, mainly the El Niño- Southern Oscillation. This talk will present the relationship between skipjack tuna catch amounts in the Pacific Island countries and ocean environmental variables in the equatorial Pacific during 1990–2019 and discuss the potential predictability of the catches based on their statistical relationship. Applications of this result to other species could have broad implications for the fishery industry in the WCP.

(W4-16937 Oral) CANCELLED

~~Land and sea changes and the ecological impacts of land reclamation projects: ecological restoration or monetary compensation?~~

~~Jingmei Li[1,2] and Jingzhu **Shan**[1]~~

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~~Land reclamation permanently alters the natural properties of coastal resources and environment and thus has caused significant damage to the marine ecosystem services. The selection of scientifically and operationally feasible standards is the key to establishing an effective marine ecological damage compensation system. This research proposes that marine ecological damage compensation standards can be classified into two types: monetary compensation and ecological restoration. On this basis, this research compares and analyzes the differences between monetary compensation and ecological restoration in terms of theoretical basis, compensation contents, and evaluation methods and summarizes the advantages and limitations of the two types of compensation standards. Furthermore, based on survey data from decision-makers and experts in the field of marine science and management in China, the social acceptance of different compensation standards is tested. The results show that the differences in implementing entities and conditions as well as economic and ecological efficiency lead to different application conditions and scopes for the two standards. When selecting compensation standards, specific issues such as the type of damage event and affected object, the responsible party, and the accessibility of evaluation parameters should be comprehensively considered.~~

(W4-16990 Oral) CANCELLED

~~**Spatial and temporal differentiation of the coordination and interaction among the three fishery industries in China from the value chain perspective**~~

~~Meng **Su**~~

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~~The efficiency change, mutual cooperation, and interaction among the three fishery industries in China can accurately reflect the level of economic development within the industry. Studying the relationships between the three fishery industries under the existing structural system is conducive to enhancing the endogenous power and steady progress of the industry. Using the DEA-Malmquist model, gray correlation, impulse response, and variance decomposition methods, this paper focuses on the specific value appreciation process of the three fishery industries, namely, fishery capture and aquaculture (primary industry), aquatic processing (secondary industry), and recreational fishery activities (tertiary industry), in order to analyze the synergy and interactive response relationship among the three fishery industries during the period of 2003 to 2020 based on the value chain. We propose specific policy suggestions regarding the overall efficiency level and integration degree of the three fishery industries. The results show the following: (1) the efficiency of fishery capture and aquaculture (primary industry) and aquatic processing (secondary industry) show significant regional differences, and the change in trend in the efficiency of recreational fishery activities (tertiary industry) is better than that of the other two. (2) Most of the synergy degrees of fish capture and aquaculture efficiency, aquatic processing efficiency, and recreational fishing efficiency, are medium and above. (3) The interactions among the efficiencies of the three fishery industries in the country and that in different regions vary. From a national perspective, the efficiency of the fishery industries can be dependent on economic inertia. There is a regional heterogeneity among the interactive responses to the efficiency of the three fishery industries in China; the interaction of fishery value chain efficiency in the four economic regions differs in both strength and direction. Exploring the synergy and interactive response among the three fishery industries in China from the value chain perspective can provide a basis for the precise governance of different regional characteristics and help to modernize the fishery industry.~~

(W4-16490 Poster) CANCELLED W4-P1

~~Stable Isotope (δ18O- δ13C) signatures of modern Mollusk shells as proxies of Coastal pollution, part of South East Coast of India~~

~~Jayaraju **N**[1], Lakshmanna B[2], Sreenivasulu G[3], Madakka, M[4], Vijayanand P[1] and Upendra B[5]~~

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~~In the tropical to subtropical marine ecosystems, we carried out stable isotope analyses (δ18O- δ13C) on 5 serially-sampled modern Mollusk shells collected from coastal sediments in parts of East Coast of India. Certain physico-chemical parameters viz., pH, Temperature, EC, Salinity, Dissolved oxygen (DO) and Organic matter (OM) were recorded . Shell samples reveal variations in temperature and/or seawater δ18O in their δ18O profiles. Unusually high or low δ18O values measure the intensity of seasonal upwelling or freshwater input, respectively. To quantify marine environment, baseline δ18O values have been calculated from average temperatures. Analyses of stable oxygen isotopes from Mollusk shells (Venus clam shells) indicate a significant change in sea surface temperatures (SST; 2 ^{0}C). Baseline-normalized δ18O profiles reveal little or no fresh freshwater input in study area. The shell δ18O range (Δ18O) and δ18O-δ13C (O-C) were integrated for correlation to further identify marine environments and thus nutrient source and status. Eutrophic environments are characterized by high Δ18O and low O-C correlation. In contrast, the oligotrophic environments are low to moderate Δ18O and non-significant to positive O-C correlation. It is believed that application of these studies to fossil Mollusk shells, can characterize the nutrient status of ancient ecosystems. This work is considered to be first of its kind from marine environments of Indian coasts.~~

Keywords: ~~Stable Isotopes, Mollusk shells, Physico-chemical parameters, Marine Environment, South East Coast of India~~

Workshop 5: BIO/MEQ Topic Workshop

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

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

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

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

(W5-16707 Invited)

Seabird Tissue Archival and Monitoring Project (STAMP) as an example of a long-term standardized specimen collection

Jennifer C. **Hoguet** and Rebecca S. Pugh

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Seabirds play an important role in the monitoring of environmental pollutants. Specifically, eggs from alcid seabirds (e.g., murres, puffins, etc.) have been identified as key tissues for monitoring persistent organic pollutants (POPs) in the circumpolar arctic (Arctic Monitoring and Assessment Programme (AMAP). In 1999, the Seabird Tissue Archival and Monitoring Project (STAMP) was initiated as a collaboration between the National Institute of Standards and Technology (NIST), the US Geological Survey Biological Resources Division (USGS-BRD), the US Fish and Wildlife Service (USFWS), the Bureau of Indian Affairs (BIA) and other partners. This long-term project was designed to systematically identify and track pollutants in Alaskan seabird eggs while simultaneously archiving homogenous subsamples for retrospective analysis. The standardized protocols for collecting, processing, and archiving eggs were designed to 1) provide sufficient material for multiple analyses, 2) ensure sample integrity by minimizing potential contamination, 3) protect long-term sample stability by enlisting cryogenic techniques and archival, and 4) keep and maintain records of sample history. Over these last 20 years, STAMP has amassed approximately 1850 individual eggs from 5 Alaskan seabird species (i.e., common murre (*Uria aalge*), thick-billed murre (*U. lomvia*), black-legged kittiwake (*Rissa tridactyla*), glaucous gull (*Larus glaucescens*), and glaucous-winged gulls (*L. hyperboreus*)) spanning 45 colonies. Following significant collection and processing efforts by collaborating partners, eggs are shipped to and are cryogenically archived at the NIST Biorepository. Through their use in many research endeavors, the STAMP collection has proven an invaluable resource and will remain so for years to come.

(W5-16653 Oral)

Feather mercury of a pelagic seabird can be useful indicator of marine pollution

Hikaru Odagiri[1], Yutaka **Watanuki**[1], Mayu Iwasaki[1], Sarara Azumi[1], J-B Thiebot[1], Hideshige Takada[2], Mayumi Ishizuka[3], Yoshinori Ikenaka[3], Yoshito Chikaraish[4], and Ken Yoda[5]

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Mercury concentrations (Hg]) in the feathers of seabirds equilibrate with blood [Hg] when the feathers are replaced, making feathers a useful indicator of mercury pollution in the marine ecosystem. To accurately use feather [Hg] for understanding the spatial variation of mercury pollution, however, we need to know where birds replace these feathers and standardize for biases in relation to sex and trophic levels. We studied individual variation of [Hg] in the outermost tail-feathers of Streaked Shearwaters *Calonectris leucomelas* breeding in Japan, which replace the feathers in their wintering locations. We used geolocators to track their wintering locations and measured [Hg] and bulk $\delta^{15}N$ in the tail-feathers. We also subsampled the tail-feathers and measured compound-specific $\delta^{15}N$ to understand their trophic levels. We found that tail-feather [Hg] was higher in males than females and in individuals with higher bulk $\delta^{15}N$. Within the observed range, the trophic level did not affect the feather [Hg]. Using these findings, we developed a new technique to map the level of mercury pollution over tropical-subtropical NW Pacific.

(W5-16994 Oral)

Assessing plastic debris ingestion of seabirds using invasive and non-invasive methods in Korea

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Plastic debris is a global environment concern. Seabirds have been used as indicator for investigating marine plastic pollution. We investigated marine plastic debris ingestion using non-invasive samples (pellets and regurgitates) and invasive samples (carcasses) in Republic of Korea. Total 156 pellets and 70 carcasses of Black-tailed gulls (*Larus crassirostris*) were collected from breeding colonies between 2016 and 2022. 35 regurgitates and 148 carcasses of Swhinhoe's storm petrels (*Hydrobates monorhis*) were collected from Chilbaldo Island between 2013 and 2022. Frequency of occurrence (%) were differed according to sample types. In Black-tailed gulls, 10.25% of pellets contained marine plastic debris and 12.8% of carcasses contained plastic debris in stomach contents. Black-tailed gulls may remove plastic debris through pellets. In Swinhoe's storm petrels, 99.7% of carcasses contained marine plastic debris in stomach contents. While plastic debris in regurgitates had much less (11.4%). Swhinhoe's storm petrels may accumulate plastic debris in stomach. These results suggested that we need to consider sample types for assessment of plastic ingestion depending on species. This study was supported by the grant "Development of technology for impact assessment of marine plastic debris on marine ecosystem (PEA0114)" of Korea Institute of Ocean Science and Technology.

(W5-16995 Oral)

External morphology monitoring of wild marine mammals using photo-ID and UAVs

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Photo ID is a method that has traditionally been widely used to identify an individual in marine mammal research. In recent years, more remarkable progress has been made in identifying changes in their morphological characters due to the development of UAV technology. These techniques are particularly useful for identifying extrinsic injuries and manifestations of disease, whether natural or anthropogenic, or determining the severity of an injury. In researching the habitat and behavior of the Indo-Pacific bottlenose dolphin population in Jeju since 2015, we have identified individuals undergoing or underwent body mutilation by entanglement every year. Tumors or skin diseases of some individuals have also been observed. In the case of physical amputation, it can sometimes have a fatal effect on the individual's survival, including calves and juveniles. Identifying the morphological changes, such as injuries and skin mark patterns in certain dolphin populations in specific areas, might indicate changes in environmental conditions, the spread of infectious diseases, and the degree of interactions between individuals. In addition, we could evaluate the marine mammal population's health by assessing the exposure to negative anthropogenic impacts, including scars caused by boat strikes or fishing tools, the effect of pollutants, or interactions with fisheries. Although such monitoring method has to be continuously conducted for an extended period, it is possible to indirectly identify and manage changes in the marine environment and anthropogenic effects and sequentially an effective way to evaluate the health of the local marine ecosystem.

(W5-16999 Oral)

Towards a North Pacific Ocean long-term monitoring program for plastic pollution: A review and recommendations for plastic ingestion bioindicators

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Marine debris is now a ubiquitous component of the Anthropocene global ocean. Plastic ingestion by marine wildlife was first reported in the 1960s and since that time, roughly one thousand marine species have been reported to consume this debris. This study focuses on plastic ingestion by marine invertebrates and vertebrates in the North Pacific Ocean. Specifically, we reviewed the scientific literature to assess the scope of the problem, identified key bioindicator species, and proposed guidelines for future monitoring of plastic debris in North Pacific marine ecosystems. Our meta-analysis confirmed that the North Pacific is among the most polluted ocean regions globally; roughly half of all fish and seabird specimens and more than three-quarters of sea turtles and bivalve specimens examined in this region had consumed plastic. While there are not enough standardized data to assess if these ingestion rates are changing, sampling standardization and reporting of methods are improving over time. Using a rubric-evaluation approach, we evaluated 352 species for their potential to serve as bioindicators of the prevalence of plastic pollution in the North Pacific. This analysis revealed a suite of 12 bioindicator species candidates which sample a variety of ecosystem components and cover a wide range of plastic size classes. Thus, we contend that these bioindicator candidates provide a key foundation for developing a comprehensive plastic monitoring program in the region. To enhance the utility of these bioindicators, we developed a framework for standardized data collection to minimize methodological variability across different studies and to facilitate the assessment of temporal trends over space and time. Tracking plastic ingestion by these bioindicators will help to assess the effectiveness of mitigation actions in the region, a critical step to evaluate progress towards sustainability and improved ocean health in the 21st century.

(W5-17000 Oral)

An ecosystem-scale litter and microplastic monitoring plan under the Arctic Monitoring and Assessment Programme (AMAP)

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Plastic pollution is a global problem that the Arctic region is not immune to. While there are more and more reports of litter and microplastics across the Arctic, currently there is a lack of coordination of monitoring of plastic pollution in the region. We considered 11 environmental compartments – atmospheric deposition, water, shorelines, aquatic sediments, terrestrial soils, seabeds, snow/ice, invertebrates, fish, seabirds and mammals. We recommend the immediate monitoring of litter and microplastics monitoring in the Arctic in four Priority 1 compartments - water, aquatic sediments, shorelines and seabirds. The other compartments may be useful to detect trends in the future, but methods need to be refined before widespread monitoring is implemented. Monitoring activities should focus on both local and international needs, and include community-based local components where possible.

(W5-17003 Oral) CANCELLED

~~An improved standardisation method for characterising plastics ingested by marine megafauna and those in their environment~~

~~Fernanda **Ferreira Paula Landim**[1], Peter Puskic[1], and Lauren Roman[1,2]~~

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~~Marine plastic pollution poses danger to marine life and ecosystems, as marine species, including seabirds, often mistakenly consume plastic debris, particularly microplastics and mesoplastics, due to visual cues. However, the lack of harmonisation in studies on plastic in the ocean and those consumed by marine animals seabirds, due to diverse research methods, poses difficulty for comparability across the world. Although global efforts have emerged to standardise these methodologies, the consideration of discrete standard protocols to characterise the many physical characteristics of plastic, including colour standardisation are overlooked in many leading protocols. My research aimed to address some of these limitations by introducing an improved standardisation method using a new technology for characterising plastics, building on previous efforts. We utilise the Saturna imaging system and machine learning algorithms developed by Ocean Diagnostics to automate the process of characterising plastic, saving researchers time and enabling comparability across samples. Here I present a updated standard methodology protocol was developed for reporting the size, shape, colour, and item category of meso and microplastic ingested by marine megafauna and those found in the environment. Furthermore, the flexibility of this updated standard methodology was investigated to adapt to multiple compartments by characterising the above-mentioned characteristics of meso and microplastics on beaches and those ingested by two seabird species (genus *Ardenna*). Lastly, changes in the characteristics of plastic ingested by these seabird species were examined using the updated standard methodology developed in the first objective, across 10 years of sampling efforts.~~

(W5-17004 Oral) CANCELLED

~~**Harmonisation in the context of management – Reporting on marine debris in the environment and interactions with megafauna**~~

~~Lauren **Roman** and Denise Hardesty~~

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~~As scientists and decision makers the world over come together seeking to understand the impacts of plastic pollution on economies, environment and society, standards for reporting information become increasingly important. Plastic pollution is a multinational, transboundary problem that necessitates multinational, transboundary solutions. Intergovernmental, civil society and scientific institutions are having the similar conversations about standardisation and harmonisation of different types of plastic pollution data to strengthen informed decision making. I have been fortunate to be part of the CSIRO Marine Debris Team's Global Plastics Losses Project, where the team has worked with intergovernmental bodies such as the United Nations Environment Programme, and international partners on every continent, with whom we have worked together to collect marine debris data on the ground in more than 20 countries. The discussions we have had with NGOs, governments and universities around the world highlight issues of disconnect between the types of information scientists are collecting, and what policy makers require as evidence to drive change within their jurisdictions. This talk aims to discuss some of the lessons learned through these collaborations, recent advancements in CSIRO's Global Plastics Leakage Project, reporting on marine debris in the environment and interactions with megafauna. Furthermore, we discuss how we are harmonising data across multiple sources including citizen science, government data collection and scientific studies to assess risk to the risk that plastic pollution poses to threatened species in Australia and tangible opportunities for interventions to reduce marine megafauna mortality.~~

Workshop 6: MEQ Topic Workshop

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

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

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

Coastal oceans are global hotspots for marine productivity, reflected in high primary producer biomass and fisheries yields. Contributing to this productivity is land-ocean connectivity, including freshwater and material contributions from land that can modify hydrodynamics and enhance micro and macronutrients concentrations. Among marine environments, coastal oceans are also uniquely vulnerable to human impacts. Approximately 40% of the human population lives within 100 km of the coast. The anthropogenic impacts associated with human settlement and development can disrupt critical land-ocean linkages. Urbanization, a pervasive form of land use change, has wide ranging effects, including shoreline modification, pollution, and changes to freshwater runoff and the quantity and quality of material flux to the ocean. However, while localized studies have examined specific urban impacts, a unified concept of urban oceans is lacking. Such a concept needs to take into account the interacting effects of the geographic, climatic and oceanographic setting of the urban environment, history of urbanization and associated impacts, and the backdrop of climate change and sea level rise. In this workshop we aim to: 1) review the state of the knowledge of urban oceans through presentations from diverse knowledge holders that specifically address the interactions between cities and coasts, focusing on case studies from the North Pacific; 2) discuss and develop an integrated conceptual framework for urban ocean ecosystems that is inclusive of different knowledge types. Such a framework is envisioned to allow for strategic solutions to healthy urban oceans, and improved communication and connection between science and communities; 3) initiate development of an urban oceans concept paper that builds off the workshop discussions. We broadly welcome presentations and participation in discussions, particularly by those whose research focuses on the ocean impacts of urbanization, whose communities are affected by coastal degradation, or whose management efforts center on mitigating these effects.

(W6-16997 Invited)

Introducing the Puget Sound Stormwater Heatmap: a foundational tool for visualizing stormwater interventions

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Urban stormwater pollution is a widely recognized threat to coastal cities, freshwater rivers and streams, and nearshore marine ecosystems. Yet, stormwater retrofit planning remains an opportunistic, locally-focused endeavor. First, we examine stormwater loading along the western coast of the United States, where we estimate that hundreds of billions of kilograms of suspended solids flow off the land surfaces and enter the Northern California Current system. However, 70% of this pollution could be addressed by treating only 1.35% of the land area. Determining how to prioritize treatment of stormwater in this region requires a clear articulation of objectives- the spatial distribution of appropriate management actions is dependent on the life histories of species, and management schemes optimized for one species may not achieve desired objectives for other species. We highlight that the scale of urban stormwater interventions must match the ecological scale relevant to species targeted by management. Second, we introduce a decision support tool developed for the Puget Sound region to help management broaden the scale at which stormwater management can assess high impact interventions. The Puget Sound Stormwater heatmap includes: 1) a high resolution land cover spatial dataset for Puget Sound; 2) a process-based hydrology model drawing from downscaled climate data; and 3) a suite of statistical models relating local water quality data to Puget Sound spatial datasets. When combined with social-ecological data, adoption of tools such as this can allow better prioritization of urban stormwater investments and lead to more rapid recovery of freshwater and coastal ecosystems.

(W6-17015 Invited)

Sea2City Design Challenge: An example of value based coastal adaptation planning

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The Sea2City Design Challenge (Sea2City) was an innovative 12-month collaborative planning and design competition that reimagined the False Creek shoreline in response to rising sea levels while accommodating urban development, fostering ecological revitalization, and addressing decolonization and reconciliation with Host Nations. This was the first time in Canada that a competition model was used to conduct a planning and adaptation project.

Sea2City asked two multidisciplinary teams to reimagine five "Challenge sites" located in Vancouver's False Creek floodplain, a highly urbanized area in the heart of the city that is home to over 38,000 people, dozens of community facilities, and critical infrastructure. The project generated a positive and bold future vision for False Creek, dramatic but achievable site concepts, decolonized adaptation language and shorter-term pilot projects designed to test new ideas, build the City's collective coastal adaptation understanding, increase public awareness, and support the next steps of the City's adaptation journey.

At the heart of Sea2City was bold leadership. The project tested new ways of public engagement and invited a diverse range of practitioners to work on the 'wicked problem' of sea level rise. The City also tested 2 m of sea level rise on designs, which had not been done before. As climate change accelerates, so are the impacts it is generating. Sea2City was a collaborative competition model that sought to break the mold of conventional coastal adaptation planning for floodplain communities.

(W6-16618 Oral)

Living shoreline and sustainable saltmarsh planting in the Green-living tech, South Korea

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The Ministry of Oceans and Fisheries in Korea has recognized the significance of "Blue Carbon (BC)" as a promising solution for naturally reducing carbon in marine environments. Recently, we have proposed a new initiative, called the "Coastal New Deal (CND)," which expands on the BC concept and incorporates the perspectives of the US "Living Shorelines" approach. This project aims to address the challenges posed by rapidly changing climates by enhancing marine biodiversity, mitigating coastal erosion, and buffering sea-level rise. The Korean CND project encompasses three key techniques. Firstly, "Green Living" involves the planting of halophytes and seagrasses to increase carbon sinks. Secondly, "Blue Living" focuses on constructing oyster reefs and other structures to prevent coastal erosion. Lastly, "Soft Living" aims to adapt to rising sea levels by softening coastal grey infrastructure. As part of the Green Living approach, we are implementing active biomass utilization of native reed and invasive cordgrass. Our goal is to maximize carbon sequestration by utilizing above-ground biomass in blue carbon ecosystems, specifically salt marshes. To achieve this, we will assess the potential reduction of organic carbon through the conversion of reed and cordgrass materials. Additionally, we will develop products using salt marsh plant fibers to safeguard coastal ecosystems and measure their contribution to on-site carbon storage in sediments. Through the promotion of sustainable salt marsh management, our study strives to contribute to the achievement of Net-zero 2050.

(W6-16715 Oral)

Effect of multiple pressures on early marine survival of juvenile salmon in Puget Sound

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Marine systems are at increasing risk from the cumulative impacts of human activities, including population growth, urbanization, shoreline development, pollution, increases in nutrient and sediment inputs, and climate change. Pacific salmon have suffered drastic declines in recent decades and multiple populations are in danger of extinction in the Pacific Northwest region of the USA. Cumulative human impacts have likely contributed to declining trends in juvenile marine survival of Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) in Puget Sound, a fjord estuary in Washington State. We used an ecosystem model ensemble for Puget Sound built on the Atlantis ecosystem modeling framework to identify the main drivers of salmon survival. Atlantis is a marine 'end-to-end' model that integrates oceanographic, geochemical, ecological, and anthropogenic processes in a three-dimensional, spatially explicit domain. The model ensemble was initialized to represent recent conditions (c. 2011) and simulates food web dynamics using 74 functional groups, including 21 salmon groups. We examined expert-selected scenarios of bottom-up (production limited) versus top-down (predation-mediated) drivers. We assessed the relative impact of these drivers on salmon survival in 30-year forward projections. We found a strong effect of bottom-up drivers, including increased gelatinous zooplankton production and a decrease in forage fish. Contrary to expert expectations, top-down effects like predation by marine mammals was less influential on early marine survival. Our scenario approach can help rank past drivers of salmon decline, this information can be used to identify management actions that are likely to produce improvements in salmon survival.

(W6-16968 Oral)

Does the luxury effect occur in urban marine ecosystems?

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The "luxury effect" is a term used in urban ecology to describe the phenomenon where wealthier neighborhoods have a higher diversity of plants and animals. It has been widely documented in terrestrial environments but remains to be thoroughly examined in the marine realm. This study examined whether there was evidence for the luxury effect in the urbanized estuary – the Puget Sound. Publicly accessible biological and socioeconomic were used to assign relative index values for biodiversity and wealth to public shore access points throughout the estuary. Findings indicated a slight positive relationship between biodiversity and wealth. However, the relationship was nuanced, complex, and likely the result of mechanisms distinct from those in terrestrial urban ecosystems. In this talk, I will present key findings from preliminary analyses, highlighting linkages between marine biodiversity and a suite of different socioeconomic characteristics that are important for us to consider as we move towards developing an integrated, inclusive, conceptual framework for urban marine ecosystems.

(W6-16998 Oral)

The Salish Sea Marine Survival Project – a model program for evaluating challenges in marine resource stewardship in an urbanizing coastal marine ecosystem

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Survival patterns of Puget Sound and Strait of Georgia Chinook and coho salmon and steelhead trout populations vary independently from coastal populations and indicate that early marine conditions within the rapidly urbanizing Salish Sea are important to overall marine survival. In 2021, the Pacific Salmon Foundation (PSF) and Long Live the Kings (LLTK) released the final report on the findings of the Salish Sea Marine Survival Project (SSMSP): a 6-year US-Canada research collaboration of over 60 federal, state, tribal, nonprofit, academic, and private entities focused on identifying the primary factors affecting the survival of juvenile Chinook, Coho, and steelhead in the Salish Sea marine environment. The evidence from more than 90 individual studies supports the conclusion that many different factors are important in marine survival, and that no single change is driving the decline. However, there were two primary factors affecting early marine survival trends: food supply and predation. Feeding conditions, specifically the quantity, quality, and type of prey, have changed and are impacting growth and survival. And an increase in predation, primarily from pinniped predators, has been linked to increased mortality in the Salish Sea. Evidence also indicates that local factors contribute significantly to salmon health and survival in specific populations. Habitat degradation, especially in crucial estuary and nearshore marine habitats, impacts marine survival for juvenile wild Chinook. Toxic contaminants near urban areas and hotspots of infectious agents exceed fish health thresholds. And climate change poses an overarching threat that has and will continue to exacerbate existing conditions. We will summarize the primary findings and recommendations of this groundbreaking effort and examine the potential value for evaluating and managing other coastal systems.

(W6-17002 Oral)

Urban seas are hotspots of stress in the Anthropocene ocean

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Coastal seas and estuaries are highly productive ecosystems that have long attracted human activity. With increasing populations throughout the world centered in coastal areas, urbanization pressures are intense and are compounded by accelerating climate stresses. Urban seas are now hotspots of stress in the Anthropocene ocean. The Salish Sea stands out as one of a few highly functioning urban seas in the world, boasting ecological riches and thriving coastal communities and industries, including tourism. For thousands of years the region has supported Indigenous peoples; now it is home to a growing population of almost nine million people, concentrated in and near the major cities of Seattle, Washington, and Vancouver, British Columbia. Increasing urbanization combined with intensifying climate stress is degrading the Salish Sea and acutely affecting communities already experiencing marginalization. Current environmental impacts include acidifying waters, hypoxia, and intense heat waves, all of which have had measurable impacts within the ecosystem. Yet, the oceanography of the Salish Sea also mitigates many anthropogenic problems, which in other regions are exacerbated by slow circulation and/or shallow and turbid waters. While many problems within urban coastal ecosystems are shared, the manifestation of these problems within a given system will be unique. Nevertheless, developing actionable solutions for people and the biota of coastal seas is imperative to continue to profit from the ecosystem services in this region. The Salish Sea serves as a global example of a sustainably managed urban sea with transferable insights to other urban seas in need of revitalization around the world.

(W6-17005 Oral)

Tsleil-Waututh Nation's approach to understand urban impacts on Burrard Inlet

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Tsleil-Waututh Nation (TWN) is a distinct Coast Salish Indigenous nation whose territory has been centered on Burrard Inlet since time out of mind. Today, TWN territory also includes the city of Vancouver, Canada's busiest port, extensive industrial development, innumerable contamination sources, legacies of destructive fishing, and other impacts related to colonial development. The cumulative effects of these impacts have left TWN with almost no opportunities to harvest marine foods from their territory, thereby infringing TWN's inherent and constitutionally protected rights. This degradation is in breach of TWN law and requires concerted, pragmatic and strategic action. However, Canadian governments' departmental mandates and jurisdictional boundaries at federal, provincial and municipal levels impede their own ability to adequately assess and consider an entire ecosystem in decision-making, management and governance processes. Therefore, TWN is uniquely positioned to comprehensively analyze urban and industrial impacts on Burrard Inlet. The nation has studied impacts of fisheries, contamination, shoreline development, invasive species, marine vessel traffic, and other aspects of colonial development, and is working to develop a framework to understand how these combine to affect TWN's ability to harvest marine foods from the ecosystem.

(W6-16524 Poster) W6-P1

Significant contribution of fish-farm activities to the distributions of nutrients and trace elements in the coastal water off Jeju Island, Korea

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The concentrations of nutrients, dissolved organic matter (DOM), and trace elements in coastal waters off Jeju Island, Korea, are known to be influenced mainly by submarine groundwater discharge. However, the influence of effluents from densely located fish farms, which use groundwater, has been poorly understood. In this study, we measured the concentrations of nutrients, fluorescent DOM (FDOM), and trace elements (Mn, Fe, Co, Ni, and Cu) in seawater, fresh groundwater (FGW), and farm water in two coastal areas off Jeju Island, in May and August 2021. The concentrations of humic-like FDOM ($FDOM_H$) and NH_4^+ were greatly enriched owing to organic matter decomposition in the farm waters. Based on the end-member mixing model using salinity and $FDOM_H$ as tracers, we found that FGW contributed about 73% of NO_3^-, whereas the farm effluent contributed about 95% of NH_4^+ and 71% of $FDOM_H$ in the coastal waters. In addition, the concentrations of all trace elements in coastal waters were significantly correlated with NH_4^+, suggesting that trace elements were produced inside farm waters. Although trace elements were found to be partially scavenged onto particles in the fish farms, as shown by the intensive removal of Ce, these particles would be discharged into the coastal waters and release the trace elements back into the water columns eventually. Thus, our result suggests that fish-farm effluents can be an important source of anthropogenic nutrients, DOM, and trace elements in coastal waters.

(W6-16928 Poster) W6-P2 (ECOP)

Using fatty acids to profile organic matter from urban sources and measure its uptake into the food web in Vancouver, B.C

Dilan **<u>Sunthareswaran</u>**[1], Anna K. McLaskey[1,3], Chris Harley[1], Kate Menzies[2] and Brian P.V. Hunt[1,3]

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Our research uses organic matter to investigate land-ocean connectivity in the context of Vancouver, British Columbia's urban landscape. Organic matter forms a critical component to the base of the food web and originate from a variety of sources. Studies have shown that water bodies have organic matter pools with a unique range of contributions from different sources. Urban oceans – watersheds near urban development – face considerable amounts of runoff from urbanized areas (e.g., stormwater and wastewater) that can introduce organic matter to the food web. The ongoing research project is guided by two key objectives: 1) utilize fatty acid analysis to measure and characterize urban and non-urban sources of organic matter and 2) measure the urban uptake by the marine food web. The objectives are being approached through collections of urban (stormwater and wastewater) and non-urban sources of organic matter (phytoplankton, freshwater, and macrophytes). To measure food web uptake, zooplankton, mussels, and clams are being collected across a range of urbanization intensities. Here we present fatty acid data for particulate organic matter (urban and non-urban sources) and key primary consumer species collected from March 2023 to August 2023. This library of data across varying urban intensities will provide insight into how the base of the food web may respond to the rapid rise of urbanization.

(W6-16941 Poster) W6-P3 (ECOP)

Using stable isotopes to distinguish between naturogenic and anthropogenic source of organic matter to the urban ocean in Burrard Inlet, Vancouver B.C.

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Particulate organic matter (POM) has been neglected from discourse on novel inputs to the marine environment originating from urban landscapes. In the marine environment, these inputs could be altering productivity, food web structure, and nutrition. Understanding the basal resources in the marine environment and the fate of this material, broadens our understanding of the connectivity between terrestrial and marine environments and the impact of urban landscape. Moreover, determining whether anthropogenic inputs are significantly contributing to POM, either fueling or hindering productivity, is crucial for planning and managing an ever growing human-ocean interface. The poster will present on-going work in Burrard Inlet, Vancouver, B.C. to characterize and distinguish the organic matter contributions of anthropogenic inputs (stormwater and sanitary waste) from naturogenic inputs (river, phytoplankton, and macrophyte) to the POM. POM of urban stormwater is widely uncharacterized, particularly for the Pacific Northwest, with unknown impacts on the coastal ocean. Though assumed to be unimportant, treated and untreated sanitary waste offers pathways for novel organic matter to enter the ocean. Burrard Inlet experiences large inputs from river sources, marine phytoplankton blooms, and marine macrophytes growth, all well-established contributors to oceanic POM. In this study, we are using carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and sulfur ($\delta^{34}S$) isotopes to distinguish between POM sources, and MIXSiar Bayesian modelling to estimate relative contributions of anthropogenic and naturogenic material to POM across an urbanization gradient. Here we will present methodology and preliminary data focused on the ocean impacts of urbanization; one of the goals of PICES Workshop 6.

(W6-17001 Poster) W6-P4 (ECOP)

Coastal warming heightens direct impacts of seawater temperature on nutrients near aquaculture farms in Korea

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The potential roles of temperature and phytoplankton in nutrient cycling throughout the water column were investigated nearby aquaculture farms. Using the convergent cross mapping (CCM) model, we examined the relative strength of phytoplankton and temperature effects on nutrients. High $\delta^{15}N$ values of particulate organic matter in the inner bay were detected compared to those in the outer bay. $\delta^{15}N$ values greater than 5 ‰ throughout the bay indicate that nitrogen influxes from the aquaculture farms are the critical nitrogen source in the study region. Our CCM model revealed that temperature positively and strongly affected the potential regeneration of nutrients, associated with PO_4^{3-} while phytoplankton utilized nutrients as soon as available. The temperature–driven nutrient regeneration was higher in the bottom layer than that in the surface layer, indicating that temperature was a more important controlling factor in nutrient fluxes from the surface sediments.

Workshop 7: FIS Topic Workshop

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

Co-sponsor:
IPHC

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

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

The North Pacific Ocean is a large and productive ecosystem that is characterized by strong interdecadal climate variability. This Ocean basin supports a number of flatfish species of great ecological, cultural and economic importance. Many of these species have wide distribution ranges and undergo significant ontogenetic and seasonal migrations, and, therefore, are particularly susceptible to climate and environmental variability. In order to address key issues related to flatfish species, from basic aspects of their biology to population management and conservation efforts at an international level, two FIS-sponsored PICES workshops have been held at PICES Annual Meetings. The first workshop was co-sponsored by the International Pacific Halibut Commission (IPHC) at the 2019 PICES Annual Meeting (W2) and focused on important topics on the biology and fishery of Pacific halibut and interacting species by bringing together researchers, scientists and managers from countries that are invested in this resource (highlighted in PICES Press, 2020, Vol. 28(1)). This workshop highlighted the need to apply integrative approaches to improve our understanding of the biology and management of widely-distributed flatfish species in the North Pacific Ocean, requiring a high level of cooperation at the international level. One of the deliverables of this workshop was the publication of several papers as part of a special issue in the journal Fisheries Research edited by the convenors. The second workshop will take place at the 2022 PICES Annual Meeting (W5) and will focus on addressing emerging issues in key flatfish species with broad distribution across the North Pacific Ocean related to their biology, environmental impacts on their distribution, and management. In order to capitalize on the gains of the first two workshops, the convenors are proposing a third workshop during the 2023 PICES Annual Meeting that will aim at 1) devising strategies for data sharing on fishing efforts and management of flatfish species across the North Pacific Ocean, and 2) promoting international collaborative studies to improve our knowledge on movement of flatfish populations and potential distribution changes of flatfish and other interacting species in the face of climate variability.

(W7-16497 Invited)

Conservation engineering approaches for mitigating Pacific halibut (*Hippoglossus stenolepis*) bycatch: biology, behaviour, and technology

Noëlle **Yochum**

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Capture of non-target animals in fishing gear is influenced by the efficiency of fishing practices and gear. Therefore, bycatch mitigation efforts include spatio-temporal approaches for reducing overlap with target animals and conservation engineering approaches for preventing entry and retention of non-target animals. Efficacy of the latter hinges on an understanding of fish biology and behaviour, and of fishing technology and gear performance. This presentation will discuss how these elements have been used to address Pacific halibut (*Hippoglossus stenolepis*) bycatch in Alaska and U.S. west coast trawl fisheries, and the innovative approaches and technology that will be used to further enhance bycatch mitigation.

(W7-16723 Invited)

Identifying the impacts of warming waters on British Columbia groundfish productivity

Philina A. **English**, Sean C. Anderson, and Robyn E. Forrest

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Effectively managing fisheries in the face of climate change is a key challenge facing decision makers. A key step towards achieving this is understanding the relationships between environmental conditions and the productivity of fish stocks. Historically, such relationships have often been hard to detect, or have not held up over time. However, improvements in data quality, time series length, spatiotemporal modeling techniques, and accelerating environmental change are all likely to enhance the detectability of relevant relationships. We develop spatiotemporal statistical models that assess how juvenile and adult fish biomass distributions and body condition have been shaped by changes in bottom temperature over the past two decades. Using a multi-species approach, we will assess the potential for opposing temperature effects at different life stages and overall generalizability of relationships between temperature and productivity across species. Our results show that warming is often associated with declines in biomass in the warmest locations, and with stable or increasing biomass in the coolest locations. While fish movement and scale mismatch make it difficult to detect changes in body condition in response to local temperature, our spatial models still allow for more representative weighting of annual condition indices for both juveniles and adults. We then investigated the extent to which any of these temperature associated changes in distribution and body condition can be scaled up to help predict annual recruitment and productivity estimates from stock assessments for a variety of British Columbia's flatfish and will compare these results with rockfish and other groundfish species.

(W7-16767 Invited)

Managing the Pacific halibut (*Hippoglosssus stenolepis*) fishery while considering historical and future changes in the environment

Allan C. **Hicks**, Ian J. Stewart, Josep V. Planas, Ray Webster, Barbara Hutniczak and David T. Wilson

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The International Pacific Halibut Commission (IPHC) has managed Pacific halibut fisheries in U.S. and Canadian waters for one-hundred years. Throughout this time, variable productivity of this stock has been observed, including periods of high and low weight-at-age, average recruitment, movement rates-at-age, and changes in the distribution of age-0 recruits. Some of these processes have been linked to the Pacific Decadal Oscillation (PDO). The successful management of this wide-ranging fish stock has been a result of cooperation and collaboration between stakeholders, managers, and scientists along with integrating biological research, stock assessment, and management strategy evaluation (MSE), thus spanning the continuum of broad conceptual understanding, tactical decision-making, and strategic planning. Conceptual models use available data to determine life-history strategies, such as ontogenetic movement, and its relationship with the environment. Tactical models use this information and integrate data to determine current trends, stock status, and uncertainty in historical predictions. An operating model in an MSE is parameterized with this information to make long-term projections that can be used to determine optimal harvest strategies and understand responses to fishing and the environment. Considering these three categories has resulted in a better understanding of the response to fishing and the effects of the environment on the Pacific halibut stock and each category informs the research needed in other categories. We provide an example of how these three categories interrelate and were integrated to predict region-specific responses of the Pacific halibut stock to PDO cycles.

(W7-16539 Oral)

Whole-genome sequencing to investigate population structure and dynamics of Pacific halibut in the northeast Pacific Ocean

Andrew **Jasonowicz**[1], Wes Larson[2], Ingrid Spies[3], Liz Dawson[3], and Josep V. Planas[1]

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[3]NOAA Alaska Fisheries Science Center, Seattle, WA, USA

The Pacific halibut (*Hippoglossus stenolepis*) is a key flatfish species in the North Pacific Ocean ecosystem that supports important commercial, recreational and subsistence fisheries and that is managed as a single stock by the International Pacific Halibut Commission (IPHC) within IPHC Convention Waters. The primary objective of the present study is to advance our understanding of Pacific halibut population structure and dynamics through the use of whole-genome sequencing to inform fishery management. To improve our current understanding of stock structure among spawning groups of Pacific halibut in IPHC Convention Waters, we have generated genomic sequences for 570 adult Pacific halibut collected during the spawning season from five different areas including the Gulf of Alaska (2), Bering Sea (1), and Aleutian Islands (2) using low coverage whole genome resequencing (lcWGR). By leveraging the recently sequenced Pacific halibut genome, lcWGR is currently being conducted to characterize genomic variation within the Pacific halibut population at the highest resolution possible. We have identified over ten million single nucleotide polymorphisms throughout the Pacific halibut genome, establishing a baseline of Pacific halibut genetic diversity. These whole genome sequences are currently being used to examine population structure and local adaptation on spatial and temporal scales. The results from this study will inform on the delimitation of management units. Furthermore, these data may be leveraged in the future to aid the development of genomic tools aimed at understanding the genetic composition of the commercial fishery and monitoring changes in distribution associated with climate change.

(W7-16567 Oral)

Will a warming subarctic Bering Sea favor yellowfin sole production?

Cynthia **Yeung**, M. Elizabeth Matta and Louise A. Copeman

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The southern Bering Sea (SBS) sustains the valuable yellowfin sole (*Limanda aspera*; YFS) fishery. Following recent record-high water temperatures, the biomass of YFS has increased in the subarctic northern Bering Sea (NBS). Summer bottom temperatures were anomalously warm from 2016 to 2019, except for 2017 when temperatures returned to near the 2010-2019 average. The abundance of juvenile YFS (age-5 and younger) has increased steadily in the NBS since 2017. Juvenile YFS inhabit depths of less than 50 m (inner shelf) and historically were concentrated in the SBS. We divided the inner shelf latitudinally into three areas – north, central, and south – to assess the implications of a northward habitat shift on juvenile growth potential. Faster growth and larger length-at-age were associated with warmer temperatures. As the Bering Sea warms, the summer bottom temperatures in the north are becoming increasingly warmer than those in the south. In 2019, the highest concentration of juveniles was in the north. They were also younger in the north (age-1 and age-2) than in the south (age-3). The estimated growth rate (2018-2019) based on otolith increment width was higher in the north. Growth was lowest in the central area, which typically had the lowest summer bottom temperatures among the three areas. It appears that conditions in the NBS in the summer are favorable to juvenile growth, and a northward shift in habitat may increase productivity of the stock. However, negative effects on the growth and condition of this cold-adapted species may occur if warming continues.

(W7-16568 Oral)

Delineating yellowfin sole (*Limanda aspera*) reproduction in the northern Bering Sea provides information across the eastern Bering Sea continental shelf

Todd **TenBrink**

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Yellowfin sole (*Limanda aspera*) is an abundant, commercially harvested flatfish that ranges across the northern and southeastern Bering Sea continental shelf. In recent years, the summer bottom trawl survey of the southeastern Bering Sea (SEBS) conducted by the National Marine Fisheries Service's Alaska Fisheries Science Center (AFSC) extended into the northern Bering Sea (NBS) in August. This opportunity allowed for describing yellowfin sole reproductive parameters in the NBS, such as female length and age at maturation, reproductive status, and sex ratio distribution. Estimates of 50% sexual maturity were 10.11 years (A50; 95% CI: 9.47–10.76 years; n = 209) and 28.47 cm (L50; 95% CI: 27.16–29.68 cm; n = 212). Histology indicated much of the mature population was approaching the end of spawning. Yellowfin sole spawning timing appears to be synchronous across the NBS and SEBS. There is evidence that part of the yellowfin sole spawning population in the NBS is connected to a recognized spawning migratory group from the SEBS. A higher proportion of females than males was observed, which varied by year and stratum. This was negatively related to warmer bottom temperature and positively related to location (western longitudes and northern latitudes). Yellowfin sole females in the NBS exhibit a similar size and age of maturation, depth of spawning, and sex ratio proportions with those females inhabiting the SEBS. These results provide information for fisheries managers on the yellowfin sole stock throughout this region. Spatial and temporal aspects of reproduction, however, should be more thoroughly investigated.

(W7-16633 Oral)

Gear-based approaches to protecting Pacific halibut captured on longline gear from removal by marine mammal depredation.

Claude L. **Dykstra**, Ian J. Stewart, and Josep V. Planas

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Whale depredation of captured fish is a growing problem among many hook and line fisheries worldwide. In the North Pacific Ocean, both Killer (*Orcinus orca*) and Sperm (*Physeter macrocephalus*) whales are involved in depredation behavior in the Pacific halibut (*Hippoglossus stenolepis*), sablefish (*Anoplopoma fimbria*), and Greenland turbot (*Reinhardtius hippoglossoides*) longline fisheries. Whale depredation leads to increased costs to fishers, challenges to estimating removals for fisheries managers, and can lead to potential risks to whales including physical injury due to being near vessels and gear, disruption of social structure, and developing an artificial reliance on non-primary food items. The IPHC hosted an international workshop in 2022 to explore and identify cutting edge methods to protect catch, with a specific focus on Pacific halibut, from removal by marine mammals. From this work, two catch-protection device concepts were selected and developed for pilot testing in the field: (1) an underwater shuttle designed to remove longline catch from the hooks near the ocean floor, and to securely transport the catch to the surface inside the device, and (2) an underwater shroud designed to slide down branch lines of 10 hooks, clustering the hooks and cover captured fish as they are brought to the surface. We will present results of pilot testing of these devices which focused on investigating (1) the logistics of setting, fishing, and hauling the two devices, and (2) the basic performance of the protected gear on catch rates and fish size compared to unprotected gear in the absence of depredators.

(W7-16635 Oral)

Environmental conditions on the Pacific halibut fishing grounds obtained from a decade of coastwide oceanographic monitoring, and the potential application of these data in stock analyses

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In 2009, the International Pacific Halibut Commission (IPHC) commenced an annual coastwide environmental monitoring program spanning the continental shelf from southern Oregon to the Bering Sea and Aleutian Islands. At each station surveyed during the IPHC's fishery-independent setline survey (FISS), water column profilers were deployed to collect pressure (depth), conductivity (salinity), temperature, dissolved oxygen, and fluorescence (chlorophyll *a*) data. These data for the years 2009-2018 are synthesized to provide geographically distinct near-bottom oceanographic baseline information about the north American continental shelf in the northeastern Pacific Ocean and Bering Sea in summer, as global climate change is expected to result in future increased variability in these areas. Four Biological Regions have been developed by the IPHC as a tool to help maintain Pacific halibut stock bio-complexity, and this analysis provides evidence that environmental variables can also be logically grouped into these four geographic regions. Such a grouping may allow for the use of environmental co-variates in future analyses of demersal stocks in the region. Oceanographic monitoring has enabled the ability to detect annual anomalies such as seasonal hypoxic events that can greatly affect local Pacific halibut density. Incorporation of environmental covariates into IPHC's spatio-temporal modelling of density indices allows for the exploration of relationships between Pacific halibut distribution and environmental variables. As an example, we present results from modelling of the relationship of catch rates and near-bottom dissolved oxygen and temperature data collected on the FISS off the west coast of the United States of America. In this example, modeling shows that hypoxic events can have a clear impact on Pacific halibut distribution during the FISS.

(W7-16759 Oral)

Testing of a semi-demersal longline to reduce yelloweye rockfish bycatch in a U.S. West Coast Pacific halibut longline fishery

Mark J.M. Lomeli[1,2], Jon McVeigh[3], W. Waldo Wakefield[2,4], Bent Herrmann[5,6,7], Claude L. Dykstra[8], Ian J. Stewart[8], and Gregory C. **Christie**[2]

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[8] International Pacific Halibut Commission, Seattle, WA, USA

In Pacific halibut (*Hippoglossus stenolepis*) longline fisheries in the eastern North Pacific Ocean bycatch of yelloweye rockfish (*Sebastes ruberrimus*) is a concern as their stock status along the U.S. West Coast is “rebuilding” from being “overfished”, the southeast Alaska stock has shown a ~60% decline since at least 1994 and through 2015 where it stabilized, and the Canadian stock has been recently declared “threatened”. Thus, identifying, developing, and testing techniques (including gear modifications) to reduce yelloweye rockfish bycatch in commercial and recreational fisheries would be beneficial to the conservation of yelloweye rockfish, support management objectives, and contribute to sustainable fishery practices. In the summer of 2023, we will conduct a catch comparison study to determine how changing from a conventional demersal longline to a semi-demersal longline with section of its groundline elevated off bottom affects the catch rates of Pacific halibut and yelloweye rockfish. We will also estimate probabilities for modes of capture (e.g., hooking locations) for Pacific halibut and yelloweye rockfish for the longline configurations tested, and determine by using hook timers if there is a temporal component in the catch between Pacific halibut and yelloweye rockfish between the two longline configurations tested. Results from this study and future research recommendations will be presented.

(W7-16761 Oral)

Update of maturity-at-size and -age for Pacific halibut (*Hippoglossus stenolepis)* using histological analysis

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Each year, the IPHC fishery-independent setline survey (FISS) collects biological data on the maturity of female Pacific halibut that are used in the annual stock assessment to estimate spawning stock biomass. Currently used estimates of maturity-at-age using macroscopic visual criteria collected in the FISS indicate that the age at which 50% of female Pacific halibut are sexually mature is 11.6 years on average. However, female maturity schedules have not been revised in recent years and may be outdated. In addition, the currently used macroscopic visual criteria used to score female maturity in the field have an undetermined level of uncertainty and need to be contrasted with more accurate microscopic (i.e. histological) criteria. In previous studies examining the annual reproductive cycle of Pacific halibut, it was determined that the time when gonad samples can be collected on the FISS (June-August) is an appropriate temporal window during which Pacific halibut females that are developing towards the spawning capable reproductive phase can be identified as mature for stock assessment purposes. In 2022, the IPHC Secretariat initiated studies to revise maturity schedules by histological characterization of maturity throughout the distribution range of Pacific halibut in the northeastern Pacific Ocean, including the U.S. West Coast, British Columbia, Gulf of Alaska, Bering Sea, and Aleutian Islands. A total of 1,025 Pacific halibut ovarian samples were collected on the FISS coastwide. An update on our efforts to generate maturity ogives by size and age, as well as a potential revision to our current macroscopic visual criteria used in the field, will be provided.

(W7-16780 Oral)

Exploring the relationship between diet and size-at-age in Pacific halibut

Nathan **Wolf**[1], T. Scott Smeltz[1], Anita Kroska[1], Sarah Webster[1], Brian Ritchie[1], Bradley P. Harris[1], Ian J. Stewart[2], and Josep V. Planas[2]

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Observed changes in the average size-at-age of Pacific halibut (*Hippoglossus stenolepis*) in the Gulf of Alaska raise questions about possible influences to growth. We provide a synthetic perspective on the relationship between size-at-age and one potential influence – diet – guided by the results of a series of controlled experiments and analyses of data from the IPHC's setline survey. By demonstrating 1) segregation in dietary resource use among different size-at-age classes of fish, 2) spatial patterns in dietary resource use that mirror those in size-at-age, and 3) a mechanistic connection between resource availability and growth, our work provides insight into the potential role of diet in driving changes in the average size-at-age of Pacific halibut in the Gulf of Alaska and the potential implications of shifts in the distributions of prey species associated with global environmental change.

(W7-16833 Oral)

Exploring the relationship of *Ichthyophonus* exposure to infection prevalence and severity in wild-caught Pacific halibut

Anita C. **Kroska**[1], Sioned Sitkiewicz[2], T. Scott Smeltz[1], Paul Hershberger[3], Claude L. Dykstra[4], Jake Gregg[3], Bradley P. Harris[1], and Nathan Wolf[1]

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Ichthyophonus is a highly pathogenic mesomycetozoan parasite that has been associated with mass mortality events in populations of wild marine fishes. In Southcentral Alaska, we found the prevalence of *Ichthyophonus* infections in sport-caught Pacific halibut increased steadily from 2011-2020, but individuals displayed uniformly low infection levels during the same period. Further, there has never been a documented mass mortality event nor indications of significant health impacts from *Ichthyophonus* in Pacific halibut. Previous work has suggested that Pacific halibut are exposed to *Ichthyophonus* through ingestion of infected prey; however, the impacts of exposure level on pathogenesis is currently not understood. Here we detail the results of an experiment designed to test the potential effects of exposure level on host prevalence and parasite density through repeated exposures with infected tissue. Wild-caught halibut were separated into three groups by exposure duration: 1 day, 6 consecutive days, and an *Ichthyophonus*-negative control. Based on in vitro heart explant culture, *Ichthyophonus* prevalence was high (70-86%) across all groups, including the negative controls, and was similar to the average prevalence observed in field surveys. Regardless of treatment group, only 11% percent of the fish had infection levels that could be detected by qPCR. Our work confirms the unique nature of the relationship between *Ichthyophonus* and Pacific halibut and provides foundational information for future studies focused on ecological and immunological influences on this host-pathogen dynamic.

(W7-16956 Oral)

Investigating food web and groundfish community structure in the eastern Gulf of Alaska

Szymon **Surma**[1,2], Kerim Y. Aydin[3], Bridget Ferriss[3], Curry J. Cunningham[2], Jamal Moss[3], Albert J. Hermann[4], Alberto Rovellini[5], and Martin Dorn[5]

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The highly productive Gulf of Alaska (GOA) ecosystem hosts a diverse community of abundant groundfish supporting regionally and nationally important fisheries. However, the western and eastern GOA (WGOA and EGOA) differ in important aspects of their physical and biological oceanography, ecology, and fisheries. Here we present a quantitative analysis of food web and groundfish community structure and dynamics in the EGOA, which has received markedly less research attention than the WGOA. An EGOA ecosystem model, built in Ecopath with Ecosim (EwE), was employed to evaluate food web and groundfish community structure and dynamics. A suite of ecological metrics was computed in EwE to investigate EGOA trophic structure and interactions. Firstly, trophic level, omnivory index, primary production required, ascendency, and keystoneness indices were calculated for individual food web nodes. Secondly, mixed trophic impacts, prey niche overlap, and predation mortality rates were evaluated for node pairs. All these indices were employed to investigate patterns of predation and competition in the EGOA food web and groundfish community. In addition, time series of EGOA groundfish species biomass and diet composition estimates were assembled using NOAA Alaska Fisheries Science Center bottom trawl survey data, collected since 1984. These data allowed trends in groundfish biomass and biodiversity to be evaluated in the context of the destructive marine heatwaves of 2014-16 and 2019. This novel research highlights the importance of groundfish as predators, prey, and competitors in the EGOA food web and the need for ecosystem-based fisheries management strategies accounting for the ecological roles of commercial groundfish.

(W7-16796 Poster) W7-P1

Management of Greenland turbot (*Reinhardtius hippoglossoides*) and the Pacific halibut (*Hippoglossus stenolepis*) using JABBA in Russian Far-East

Vladimir **Kulik**[1], Igor Glebov[1], Nadezhda Aseeva[1], Roman Novikov[2] and Aleksey **Somov**[1]
(*Aleksey Somov presenting on behalf of Vladimir Kulik*)

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Just Another Bayesian Biomass Assessment (JABBA) was used in 2023 for total allowable catch (TAC) setting of Greenland turbot or black halibut, *Reinhardtius hippoglossoides*, and the Pacific halibut, *Hippoglossus stenolepis*, in the Western Bering Sea (WBS) fishing zone of Russia and for Greenland turbot in the Okhotsk Sea (OS), and for the Pacific halibut in the Eastern Sakhalin fishing subzone where it's retained catch is negligible. Nowhere TAC was increased. The worst status was estimated for the Pacific halibut in the WBS, where it was overfished (0.75 probability) due to high bycatch during the Pacific cod, *Gadus macrocephalus* targeted fishery. Greenland turbot is not overfished (0.91 probability) in the WBS, where it is retained during the Giant grenadier, *Albatrossia pectoralis*, targeted fishery. Both halibuts sometimes were fished as the primary target in the WBS, but the most part of the catch was retained as a bycatch. In the OS black halibut was the primary target for many years and it was overfished. Therefore, the Giant grenadier became a target more often there and its catch increased in two folds for the last 4 years. Abrupt decline of catches of Greenland turbot in the OS stopped its biomass decrease though the probability of $B_{2022} < B_{MSY}$ was equal to 1, while $F_{2022} > F_{MSY}$ was equal to 0.35. So, we see that fishers have to go deeper to catch grenadiers instead of halibuts. This is the result of opposing trends in abundance: increasing for grenadiers and decreasing for halibuts.

Workshop 8

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

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

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

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

(W8- 17017 Invited)

Sustainability management of plankton fishery resources of Asian waters in preserving the marine environment

Nadiah Wan **Rasdi**[1], Hidayu Suhaimi[1], Amirah Yuslan[1] and Atsushi Hagiwara[2]

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Research development and collaboration between universities, industry and society are vital to lead curriculum design and delivery through partnership models which include apprenticeships, hands-on training, real-life simulations, and specialized employer training programs. The aim of our studies is to ensure the sustainability of plankton production by exploring their ecosystem, variation in diversity, species compositions, adaptability, and abundance to assess the potential for future use by industries and society. Current research development on zooplankton study had emerged from finding potential zooplankton species, its adaptability, and potential for future culture purposes. Results, from our studies on the exploration of potential plankton, dietary manipulation, and developments in the low cost enrich-technology and bio-encapsulated of plankton culture by utilized feeding from waste to wealth formulation, had improved the growth and sustain the production of fish and crustaceans' larvae. Current research output in Malaysia, from several marine and freshwater area in Malaysia, found good potential species candidate of zooplankton from fisheries resources such as *Alonella nana, Moina macrocopa, Ceriodaphnia cornuta, Oithona rigida, Apocyclops ramkhamhaengi and Mesocyclops leuckarti,* which were discovered can be future use for applied science (aquaculture). Next, studies on feeding manipulations techniques are important to develop live feed species that have high nutrient content. Nutritional enhancement of zooplankton as live feed candidate can be a great instrument to measure growth and development of fish and crustaceans' larvae. We highlight all the latest research of zooplankton study that can clearly embark a new form of knowledge from this tiny, but beneficial organism. Our research output would contribute to the applied use of zooplankton explored through various aquatic environments in Asian countries for effective use in early feeding of aquaculture organisms.

(W8-16507 Oral)

Light wavelength and intensity effects on phototactic behavior of pediveligers in the Pacific oyster *Crassostrea gigas*

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A particular ontogenic characteristic of oysters is an eyespot, which appears during the last planktonic stage larvae called the pediveliger. Regarding this phenomenon, this study investigated the effects of light wavelengths and intensities on the phototactic behavior i.e., phototaxis and light-modulated attachment of pediveligers associated with the function of an eyespot. Early and late eyed pediveligers were employed to monitor the aforementioned parameters under different light conditions established by the combination of 6 light wavelengths (i.e., near ultraviolet, blue, white, green, red, near infrared) and 4 intensities [0 (control), 5, 15, 25 W/m^2]. To characterize the pediveligers' eyespot, the wavelength-dependent light absorbance of the larvae on two developmental stages was measured by a microspectrophotometer system. There were no significant differences in the light absorbance of eyespot between the two stages and a higher light absorbance was detected at red light wavelength (620 - 638 nm). The major propensity of phototaxis in the early-stage eyed pediveliger was positive phototaxis under the red light where the highest eyespot absorbance was observed. Meanwhile, negative phototaxis was determined under the blue light. These proportions were varied with light intensity. The attachment behavior of late eyed pediveligers were activated under the red and the near infrared. These results may explain the mechanisms behind water depth regulation and utilization of light conditions by larvae of the Pacific oyster to search for optimal locations of attachment. This expected mechanism can be applied to improve oyster seed production by using a certain light condition to activate larval attachment.

(W8-16624 Oral)

Improvement of groundwater flow and benthic environment in tidal flat by application of granulated coal ash

Hee Eun **Woo**[1], Jun Myoung Choi[2], Kyunghoi Kim[2] and Tadashi Hibino[3]

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Tidal flats, known for their low permeability, create an environment prone to the accumulation of contaminants in the sediment surface rather than their dispersion into the open sea. This concentration of pollutants causes significant problems for the surrounding ecosystem, has detrimental effects on marine life, and interferes with important food chains, damaging the overall health of the coastal environment. In order to comprehensively examine changes in groundwater flow and the benthic environment within deteriorated tidal flat sediment, a pilot test utilizing granulated coal ash (GCA) was conducted in the Ota River of Hiroshima Bay, Japan. The experimental site demonstrated an observed increase in dissolved oxygen, indicating enhanced sediment permeability and improved groundwater flow following the application of GCA. Notably, the pore water surrounding the granulated coal ash exhibited a reduction of up to 70% in ammonia concentration, while nitrite and nitrate concentrations increased, suggestive of stimulated nitrification processes. The presence of calcium within the GCA contributed to a decrease in phosphate concentration within the sediment. Additionally, a significant decrease in chemical oxygen demand (COD) was observed at the experimental site, with a maximum removal ratio of 50%. The experimental site exhibited dominance by annelids, indicating an increase in both the number and diversity of benthic organisms. These findings affirm the efficacy of granulated coal ash application as an effective technique for improving the benthic environment of contaminated tidal flat sediment.

(W8-16690 Oral)

Investigating coastal tourism demand in the COVID-19 era through big data analytics: Focusing on Korean beach tourists' trip

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Beach is one of the most important tourism attractions in coastal tourism. Coastal tourism in Korea was on the rise with its geographical characteristics, increased national income and increment in demand for marine leisure activities. Due to the outbreak of the COVID-19, tourism industry has been considerably shrunk. The purpose of this study is to analyze the tourism demand in the COVID-19 era. In this study the numbers and sizes of national beach visitors of the beaches were collected through public data. Based on the R project for statistical computing, we visualized geographic information and performed the time series analysis by using big data and visualization related packages such as ggplot2, ggmap, rgdal, rgeos, maptools and sf. The result showed that the number of each beach tourists showed a big deviation. The places with the most visitors in 2016 still have the most visitors in 2021, such as beaches in Busan and Daecheon beach in Chungcheongnam-do. However, some beaches along the east coast were in halt during the COVID-19 era. The study implies that implement of government policies and guidelines during the COVID-19 era, had negative effect on marine tourism. However, the fact that 27.2 million people have found beach as the tourist destination in 2020, suggests that there was a demand for touring coastal sites during the epidemic, in the shape of small trips of less than four people and low-population density tourism.

(W8-16696 Oral)

Stock assessment and management strategies of Small yellow croaker (*Larimichthys polyactis*) in the Northwest Pacific region using CMSY and BSS models

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This study aimed to evaluate the stock status of Small yellow croaker (*Larimichthys polyactis*) caught in the Northwest Pacific region and to seek strategies for management. In this study, the following three points were considered as differences from previous stock assessment studies. First, data of fishing types targeting Small yellow croaker in Korea was maximally utilized. Second, in addition to the GLM (Generalized Linear Model) method, which is widely used as a standardization for fishing efforts, as an alternative, the total amount of horsepower by fishing type was used to standardize fishing efforts. Third, since Small yellow croaker migrates the North Pacific region, the stock assessment was conducted by including all catch data of China, Japan, and Taiwan, which are neighboring countries that jointly catch. For these research objectives, CMSY (Catch-Maximum Sustainable Yield) model and BSS (Bayesian state-space) model, which are based on catch and resilience data were used. In addition, the scenario analysis was conducted according to the fishing type, period, and fishing effort standardization method. Result showed that the current biomass of the Small yellow croaker was predicted to be generally on the decline and be lower than the biomass of maximum sustainable yield (B_{MSY}) level. As a management strategy, if the TAC (Total Allowable Catch) would be set at a minimum of 17,326 tons and a maximum of 31,114 tons for the next 10 years, it was predicted that the biomass would be able to recover to the B_{MSY} level.

(W8-16757 Oral)

Estimating factors affecting to fishing boat transaction prices using an hedonic price model in South Korea

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This study is aimed to estimate factors affecting to the fishing boat transaction price. In recent, as the aging of fishing workers, trading of fishing boats is increasing. However, the transaction price varies greatly depending on characteristics of the fishing boat. In this study, we estimated the economic value of each factor affecting to fishing boat price, using an hedonic price model. Result showed that tonnage, age, engine type, and abundance of fishing grounds had a significant effect on its transaction price. In particular, as the CPUE (catch per unit effort) of the fishing ground would increase by one ton, the marginal price was analyzed to be KRW 1,903,426.

Workshop 9: TCODE/HD Topic Workshop

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

Co-sponsors:
ICES, PSC

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

Coastal communities are on the frontline of climate change. Supporting resilience and community determined climate adaptation requires strong relationship building, trust, and collaborative knowledge production that bridges multiple knowledge systems. The UN Decade of Ocean Science (2021-2030, UNDOS) has a major emphasis on co-design of science and co-production of knowledge to achieve the "ocean we want", weaving traditional western science, with local and Indigenous knowledges to arrive at sustainable solutions for the challenges facing the oceans and coastal communities. The North Pacific and Arctic have long histories of Indigenous and Community leadership in promoting and defending coastal resilience, fisheries and ecosystem management, ecosystem health and protection of species at risk. Drawing from these experiences, this workshop and session aim to provide space for dialogue and knowledge sharing.

The workshop has three main objectives: 1) Bring together marine and coastal knowledge holders (including climate scientists, Indigenous and traditional knowledge holders, resource managers, and ocean practitioners) to showcase examples of successful partnerships, as well as new opportunities, and ongoing challenges in community-led approaches to support climate ready decision-making and ecosystem resilience. 2) Identify lessons learned from transdisciplinary and community-led work rooted in co-production. 3) Facilitate a cross regional knowledge network of coastal community leaders and ocean practitioners to provide continued support outside of the PICES annual meeting.

The first one-day agenda will include invited Indigenous speakers and transdisciplinary science practitioners. The structure will allow for interactive discussion, topical breakout sessions, and time allocated for collaborative creation. We will support a dialogue with participants to address the following questions:

Q: What are some examples/ways that communities and scientists are weaving Indigenous knowledge and western science to inform climate adaptation and coastal and ocean stewardship?

Q: What are the challenges and opportunities to bridge the gaps between community-based knowledge and management/decision making?

Q: What are some lessons learned for co-designing and co-producing knowledge with communities to foster locally determined and resilient and coastal ecosystems?

The following half-day workshop will provide an opportunity for reflection on the workshop and individual presentations on key points that emerged in the workshop. We will also invite experts from outside of the North Pacific and Arctic region to participate in this workshop to extend our scope within the Ocean Decade.

Outcomes of the workshop will include a report highlighting examples and lessons learned. Additionally, this work will inform a peer-reviewed publication on diverse methodological approaches to transdisciplinary work. Other outcomes based on discussion among participants on ways to bring together multiple ways of knowing and multiple types of knowledge, expertise, and experience to inform decision-making will be decided collaboratively by workshop participants. This interactive workshop and session build on the ongoing work from several related working groups including: Joint ICES/PICES WG44; SICCME, and GMRI, and complements a proposed S-CCME open meeting and both the S-CCME and Joint ICES/PICES WG44 business meetings at the 2023 Annual Science meeting in Seattle.

(No Abstracts Submitted)

Workshop 10: FIS/BIO/POC/TCODE/FUTURE Topic Workshop

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

Co-sponsor:
ICES

Convenors:
Kirstin Holsman (S-CCME; USA, AFSC - NOAA), *corresponding*
Alison L. Deary (NOAA, USA), *corresponding*
Lewis Barnett (NOAA, USA)
Xiujuan Shan (S-CCME. China)
Kathy Mills (ICES, SICCME, USA, GMRI)
Alan Baudron (ICES, SICCME, Scotland)
Sukgeun Jung (Jeju National U, Korea)

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

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

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

The 1.5 day workshop will include a mix of spark presentations and discussion sessions on the following topics:

- Case studies of accounting for climate impacts in management measures & showcasing policies applied 'in practice'

- Best practices and approaches for considering large-scale and long-term climate impacts
- Reconciling long-term projections and short-term tactical management
- Advances needed for climate-ready fisheries management to be widely adopted
- Data standardization, its application to ecosystem-based management, and the optimization of sampling platforms to monitor climate change across a variety of ecosystems and trophic levels
- This workshop will provide an opportunity to showcase how climate-informed EBFM can be implemented in practice and actions needed to get there. Outcomes of the workshop will include two peer-reviewed publication and report on best practices and example case studies of climate-informed EBM and a decade of change paper that brings together biological, physical, and socio-economic datasets.

(W10-16882 Invited)

Approaches for climate-informed ecosystem-based fisheries management

Katherine E. **Mills**[1], Kirstin Holsman[2], and Alan Baudron[3]

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[3] Marine Scotland, Aberdeen, Scotland

Climate change is profoundly impacting marine ecosystems and fisheries, yet accounting for climate effects in fishery management plans and policies remains challenging. Ecosystem-based fishery management approaches are emerging that (1) account for external drivers, including physical factors and ecosystem conditions affected by climate change and (2) incorporate diverse forms of stakeholder knowledge. This presentation will synthesize contributions to a session at the ICES Annual Science Conference that demonstrated examples of how climate-related changes in spatial distribution, population productivity, and other effects on fish populations are being incorporated into scientific processes, ecosystem information products, fisheries advice, and strategic planning to support fisheries management in the context of climate change. This synthesis will introduce a framework for categorizing approaches for climate-informed fisheries management in the North Atlantic, which will be expanded and refined based on approaches used in the North Pacific that are contributed during this workshop.

(W10-16987 Invited)

Adapting the ecosystem and socioeconomic profile framework to include climate ready indicators for informing next generation stock assessments

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Ecosystem-based science is a forefront component of effective marine conservation and resource management; however, a gap remains between ecosystem research and integration with stock assessments. Primary obstacles are a lack of a consistent approach to deciding when and how to incorporate ecosystem and socioeconomic information into a stock assessment and how to test the reliability of this information within a changing climate. Over the past several years we have developed a standardized framework called the Ecosystem and Socioeconomic Profile (ESP) for operationalizing the integration of ecosystem and socioeconomic factors within NOAA Fisheries' stock assessment system.
The ESP uses data collected from a variety of sources in a four-step process to generate a set of standardized products that create a meaningful communication of potential drivers on a given stock. The ESPs also inform conversations regarding the use of climate science in fisheries management decisions. The North Pacific Council recently recommended focusing climate change modifications on short-term responses to climate change effects for tactical management and that the ESPs in particular can be used or adapted to achieve our climate ready goals. We describe the success of the ESP framework for informing management decisions using the Alaska sablefish and Pacific cod stocks as case studies and identify avenues for including climate information within the ESP process. The adaptability and responsiveness of the ESP framework allows for timely and streamlined products that will increase the readiness of our stock assessment enterprise as we respond to a rapidly changing climate.

(W10-16598 Oral)

Ecological and carbon cycling response to the climate change in the South China Sea: a three-dimensional physical-biogeochemical modeling study

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The South China Sea (SCS) exhibits strong variations on seasonal to interannual timescale, and the climate change has direct impacts on the nutrients and phytoplankton dynamics, as well as carbon cycle. A three-dimensional physical-biogeochemical model is established for SCS, with a high resolution of 1/30° to compensate for the limited temporal coverage and limited spatial resolution of the observations and numerical models. The model is driven by daily air-sea fluxes (wind stress, long wave radiation, short wave radiation, sensible heat and latent heat, freshwater fluxes) that derived from the National Centers for Environmental Prediction (NCEP) reanalysis2 from 1992 to 2021. The coupled model is capable of reproducing the observed seasonal variation characteristics over the same period in the SCS. The model results showed that the SCS serves as an atmospheric CO2 source from March to October and a sink from November to February, and the temporal variation was positively correlated with the variation of sea surface temperature (SST). The first EOF mode is positively correlated with the Niño 3 index with a correlation coefficient of 0.51 when the Niño 3 leads 5 months, and the second EOF mode is correlated with the PDO index when the PDO leads 7 months, which suggests an influence of climate variability on the carbonate system.

(W10-16745 Oral) **CANCELLED**

~~**Climate resilience in blue sustainable fisheries: inclusion and ecosystem-based management for short and long-term success**~~

~~Isa O. **Elegbede**~~

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~~Climate change poses significant challenges to marine ecosystems and fisheries, necessitating proactive measures for sustainability. This research emphasizes the importance of understanding climate impacts, incorporating climate projections, modeling, and scenario planning in blue sustainable fisheries. The study explores the role of inclusive approaches, ecosystem-based management, and local engagement in enhancing climate resilience. Inclusive approaches play a crucial role in climate-resilient fisheries, with particular emphasis on local engagement. By involving local communities, fishers, scientists, policymakers, and Indigenous groups, collaboration and integration of diverse perspectives and traditional knowledge can be achieved. Ecosystem-based management is essential for sustainable fisheries, ensuring the preservation of ecosystem integrity through the consideration of species interdependencies, habitats, and the environment. This involves protecting critical habitats, managing fishing activities sustainably, and preserving biodiversity to enhance adaptive capacity. Both short and long-term climate impacts must be addressed to develop comprehensive climate adaptation plans. Immediate impacts, such as extreme weather events and shifting species, require adaptive management strategies. Long-term impacts, including sea-level rise and ocean acidification, call for proactive measures like habitat and ecosystem restoration, as well as policy interventions. Accounting for climate impacts in blue sustainable fisheries requires the adoption of inclusive and ecosystem-based management approaches. By understanding climate effects, engaging local communities, and integrating adaptive strategies, resilience can be built. This research provides insights for effective fisheries management, ensuring the sustainability of marine resources in the face of climate change.~~

(W10-16623 Poster) W10-P1

Numerical study on decadal-scale change in primary production in the subarctic North Pacific and the Sea of Okhotsk

Takuya **Nakanowatari**[1], Tomohiro Nakamura[2], Humio Mitsudera[2], Jun Nishioka[2], Hatsumi Nishikawa[3], Hiroshi Kuroda[1], and Keisuke Uchimoto[4]

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The subarctic North Pacific is characterized by High Nutrient and Low Chlorophyll region in which decoupled micronutrient of dissolved iron as well as macronutrient is essential for controlling the primary production. In this study, we evaluate the impact of the decadal-scale change in the thermohaline and wind-driven ocean circulation on the primary production in the subarctic North Pacific by using an ice-ocean coupled model with a simple biogeochemical cycle model including iron limitation. We performed the hindcast experiments forced with ERA-interim for the past decades (1979-2016). The linear trend analysis based on the model outputs shows that the remarkable decrease in the net primary production (NPP) in the subarctic frontal region (SAF) has occurred since 1990s, although the NPP in the Sea of Okhotsk oppositely has increased due to the local sea ice reduction. The decrease in the NPP in the SAF is prominent in spring, and highly related to worse light availability as well as the decrease in the dissolved iron concentration. The diagnostic analysis for the model outputs indicates that these environment changes are highly caused by the poleward shift of subtropical gyre which induces more saltier and oligotrophic water to the subarctic area. We discuss that the subtropical water occupation has the significant impact on the primary production in the subarctic North Pacific through the combination effects by the deepening of wintertime mixed layer depth (i.e., springtime stratification is delayed) and the depletion of iron-rich water.

Workshop 11: SB

Science advances needed to understand our "new ocean"

Convenors:
Francisco Werner (NOAA Fisheries, USA), corresponding
Shin-ichi Ito (Japan)
Salvador E. Lluch Cota (Mexico)

Invited Speakers:
TBA

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

Our oceans have also become more crowded through the growing presence of multi-sectoral uses (e.g., commercial and recreational fisheries, aquaculture, renewable energy, etc.). As such, we are at a point where not only do we need to study and understand our "new ocean", but we also need to develop novel ways of sampling, observing, and quantifying it. Fortunately, significant advances in our ability to sample and quantify our ocean's new states have resulted from a robust evolution in observational (e.g., uncrewed systems, molecular approaches, satellite/remote sensing) and analytical (e.g., high performance computing, artificial intelligence/machine learning, etc.) capabilities. Such advances provide an opportunity to reevaluate the questions and approaches our scientific communities have undertaken and reassess (global and regional) science efforts as appropriate.

The workshop will focus on framing questions that can help define the next levels of understanding of our "new ocean", as well as identifying the challenges in doing so. We aim to prioritize (e.g., a "top 5") questions that we need to take on as a scientific community, and discuss our capabilities to address these. Included in our discussions (and implied in a prioritization or a triage) are foreseeable challenges that we might not be able to address given present or even future capabilities. Questions guiding the discussion include:

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

The workshop will be one full day. The first half-day will be (4 to 5) invited presentations on the state of our science to help identify and focus future questions and needs. The second half-day will build on opening discussions and aim to identify science priorities, supporting rationale, and needed next steps.

Outcome: a perspectives/white paper for peer-reviewed publication TBD.

(W11-16722 Poster) W11-P1

Global capacity development as a prerequisite to fully understanding our new ocean

Alexis **Valauri-Orton**, Kaitlyn B. Lowder, and Lily Rios-Brady

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To fully contend with rapid changes in oceanic environments, novel tools, instruments, quantifications, and approaches are not wholly sufficient. Developing the requisite spread of human capital, institutional support, and capacity sharing is necessary to address the ongoing global changes that impact the people who border every ocean basin. The Ocean Science Equity Initiative (EquiSea) of The Ocean Foundation aims to increase the equitable distribution of ocean science capacity by providing administrative, technical, and financial support to on-the-ground partners. Specific support provided by EquiSea to improve the ability of more researchers to conduct this important research has included funding to launch a training and support center staffed by local experts, design and distribution of GOA-ON in a Box ocean acidification monitoring kits, provision of online and in-person training, and direct funding of research. EquiSea is currently working with the U.S. government to build ocean acidification monitoring programs around the Pacific Islands, support ocean observation capacity development in the Federated States of Micronesia and to establish a Women in Ocean Science Fellowship program for the Pacific. The scientific community working on the cusp of ocean science advances can make substantial contributions to growing the distribution and diversity of colleagues in their field by partnering with capacity development leaders, such as EquiSea, and sharing their expertise in trainings, writing practical methodologies, and developing lower-cost approaches that enable more data to be collected, analyzed, and contributed towards better understanding our shared ocean.

(W11-16734 Poster) W11-P2

Building an open-source software toolbox for integrating fisheries and plankton acoustic data into our study of the new ocean

Wu-Jung **Lee**, Emilio Mayorga, Valentina Staneva, Landung Don Setiawan, Soham Butala
Dingrui Lei and Caesar Tuguinay

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Scientific echosounders are an efficient observing tool that can provide fish and zooplankton distribution and abundance information across time and space for fisheries and marine ecological research. The recent fast growth of echosounder deployment on various ocean observing platforms has created unprecedented opportunities to systematically observe these animals at an ecosystem scale. However, there remains a need for open, scalable workflows that adapt well to the rapidly increasing data volume, so that information embedded in echosounder data streams can be easily incorporated into integrative analysis across multiple ocean variables to understand our "new ocean." To address this need, we have been building an open-source data processing pipeline that transforms raw acoustic data into biological information, such as biomass estimates of different taxonomic groups. Here we present our ongoing work on developing software building blocks and the associated workflow-orchestrating infrastructure aimed at achieving this goal. These include software elements that handle data parsing and organization, identify target echogram regions using analytical methods, and incorporate fine-grained biological data from net trawls in echo interpretation, all operating on a scalable cloud cyberinfrastructure with a set of clearly specified data product levels. We will demonstrate current capabilities using publicly available echosounder data archives and discuss our next stages of development objectives.