# 2024

# Book of Abstracts


https://meetings.pices.int/meetings/annual/2024/pices/program#future

# Table of Contents

# Future Symposium

Hanna Na, Corresponding, (Korea)

Steven Bograd, Corresponding, (USA)

FUTURE SSC

Email FUTURE Symposium Corresponding Convenors

**FUTURE Symposium does not call for abstracts.**

PICES has provided leadership in developing a more thorough understanding of the structure, function, and changes of North Pacific marine ecosystems with the support of its flagship scientific programs. The current scientific program on 'Forecasting and Understanding Trends, Uncertainty, and Responses of North Pacific Marine Ecosystems' (FUTURE) has been promoting investigations of North Pacific ecosystems with an emphasis on the synergy of social, ecological, and environmental systems (SEES) and processes. Within this SEES framework, FUTURE is focused on developing a better understanding of the combined consequences of climate change and anthropogenic pressures on marine ecosystems, ecosystem services, and marine-dependent social systems. The FUTURE symposium plans to review its past, assess the present, and discuss the future of FUTURE to better observations, improved awareness of mechanisms of change, and ultimately science for sustainability along with the United Nations Decade of Ocean Science for Sustainable Development and the mission of developing "the science we need for the ocean we want".

**(FUTURE 18001 Oral)**

**PICES's Science Program, FUTURE: advanced knowledge and future research**

Jennifer L. Boldt[1], Saeseul Kim[2], Stephen Bograd[3], Sukyung Kang[4], Thomas Therriault[1], Emanuele Di Lorenzo[5], Daisuke Hasegawa[6], Oleg N. Katugin[7], Vyacheslav B. Lobanov[8], Mitsutaku Makino[9], Shion Takemura[10], Mackenzie Mazur[1], Hanna Na[11], Hitomi Oyaizu[12], Fangli Qiao[13], Ryan R. Rykaczewski[14], Erin Vera Satterthwaite[15], Seongbong Seo[16], Chengjun Sun[17], Sinjae Yoo[18] and Hanna **Na**[11]

[1]Fisheries and Oceans Canada, Nanaimo, BC, Canada. E-mail: Jennifer.Boldt@dfo-mpo.gc.ca

[2]PICES

[3]Environmental Research Division, NOAA Southwest Fisheries Science Center, Monterey, CA, USA

[4]National Institute of Fisheries Science, Busan, Republic of Korea

[5]Earth, Environmental, & Planetary Sciences, Brown University, Providence, RI, U.S.A.

[6]Transition Zone and Coastal Area Research Group, Japan Fisheries Research and Education Agency, Shiogama, Miyagi, Japan

[7]Pacific Scientific Research Fisheries Center, Vladivostok, Primorsky Kray, Russia

[8]V.I. Il'ichev Pacific Oceanological Institute, Vladivostok, Primorsky Kray, Russia

[9]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan

[10]Japan Fisheries Research and Education Agency, Yokohama, Kanagawa, Japan

[11]Seoul National University, Seoul, Republic of Korea

[12]Fisheries Resources Institute, Japan Fisheries Research and Education Agency (FRA), Yokohama-shi, Kanagawa-ken, Japan

[13]First Institute of Oceanography, Qingdao, People's Republic of China

[14]Pacific Islands Fisheries Science Center, NOAA National Marine Fisheries Service, Honolulu, HI, U.S.A.

[15]California Sea Grant & Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, U.S.A.

[16]Korean Institute of Ocean Science and Technology, Busan, Republic of Korea

[17]First Institute of Oceanography, Qingdao, People's Republic of China

[18]Korea Institute of Ocean Science and Technology, Gyeonggi-do, Republic of Korea

A goal of PICES's integrative Scientific Program, FUTURE, is to understand and forecast how North Pacific marine ecosystems respond to climate change and human activities. To address this

goal, three scientific questions (with 18 sub-questions) were identified as the basis of FUTURE-directed research. The goal of the current study was to summarize the sub-questions that have been addressed and to identify areas for potential future research. Publications from 2010 to 2020, including peer-reviewed papers, PICES Special Publications, and PICES Scientific Reports, were systematically reviewed. There were 35 published special issues within scientific journals (293 scientific papers), 22 PICES Scientific Reports, and 3 PICES Special Publications. Generally, after 2014, there was an increase in the number of references with answers to the 3 main FUTURE questions. Each reference addressed between 1 and 11 of the sub-questions. Each sub-question was addressed by between 2 and 44 references. FUTURE-directed research improved our understanding of the processes that underlie the structure and function of ecosystems and how changes in those processes affect ecosystems. Also advanced by FUTURE-directed research was knowledge about how ecosystems respond to pressures, including human activities, how ecosystems might change in the future, and how societies are affected by these changes. Focal areas for potential future research include: how changes in ecosystem structure and function affect an ecosystem's resilience or vulnerability to pressures; thresholds, buffers, and amplifiers that are associated with maintaining resilience; the effects of multiple and cumulative pressures; and resulting implications about the ability to predict future ecosystem states.

**(FUTURE 17854 Poster)** FUTURE-P1

**Generating Responsible Environmentally Effective Networking (GREEN)**

Vera L. **Trainer**[1], Hiroya Sugisaki[2], Sung Yong Kim[3], Jae-Hyoung Park[4], Robin Brown[5], Jeanette Gann[6], and Pengbin Wang[7]

[1]University of Washington, Forks, WA, USA. E-mail: verat@uw.edu

[2]Japan Fisheries Research & Education Agency, Yokohama, Japan

[3]Environmental Fluid Mechanics Laboratory, Daejeon, Republic of Korea

[4]Pukyong National University, Busan, Republic of Korea

[5]PICES Secretariat (advisor), North Saanich, British Columbia, Canada

[6]NOAA Alaska Fisheries Science Center, Juneau, USA

[7]Second Institute of Oceanography, People's Republic of China

Part of the vision for the "ocean we want" is for PICES members to consider how best to engage with fellow climate scientists. At PICES-2023 and over the months that followed, the Study Group: Generating Recommendations to Encourage Environmentally- Responsible Networking (SG-GREEN), with the help of the Human Dimensions Committee, conducted an online survey to query the PICES membership about their interest in changing how we meet, purchasing carbon credits to offset the cost of meeting in person, and participating in beach clean-up and other environmental activities. The responses to surveys show an overwhelming interest in changing the way that we do business. Approximately 158 members completed the survey with 53% female and 46% male, with 36% identifying as ECOPs. Most respondents felt that they would be allowed to attend the Annual Meeting in person, even if there was a virtual option.

There were strong feelings about carbon offsets, including 67% stating that PICES should provide recommendations on purchase of reliable carbon credits. A strong majority (74%) would participate in a beach cleanup or other restoration activity as part of the PICES Annual Meeting. Most respondents (88%) are in favor of PICES eliminating plastic products at the Annual Meeting. Over 72% felt that PICES member nations should contribute an annual fee toward carbon offsets or another green project, such as habitat restoration. These and other results from the survey and information collected from other international scientific organizations will be discussed with recommendations for how to incorporate these suggestions into future PICES activities.

# Session 1: FUTURE/HD/POC Topic Session

Climate Extremes and Coastal Impacts in the Pacific

Convenors:

Antonietta Capotondi, *Corresponding* (USA)
Chan Joo Jang, *Corresponding* (Korea)
Charles Hannah (Canada)
Helen Killeen (USA)

Invited Speakers:

Neil Holbrook (University of Tasmania, Australia)
Ce Bian (Ocean University of China, China)

Over the past several decades, extreme climate events (ECEs) have generally become more frequent and intense, resulting in devastating, long-lasting ecological and socio-economic impacts on both global and regional scales. ECEs include both rapid or intermittent physical events (e.g., marine heatwaves, tropical cyclones, and storm surges) and imbalances initiated by biogeochemical responses to climate change (e.g., ocean acidification, deoxygenation, HABs, bleaching). These events affect marine ecosystems at all trophic levels mainly through shifts in habitat distribution, biodiversity, and communities, resulting in the destruction of coastal biogenic habitats.

There is a clear need to better understand and predict these events in different Pacific regions. Advances needed include an updated statistical characterization of ECEs (e.g., in terms of intensity, frequency, duration, and three-dimensional evolution), identification of their driving mechanisms, a refined assessment of their ecological impacts, and improvements in our ability to predict and project future changes in extremes. Improved characterization and understanding of compound events, i.e., the co-occurrence of different types of physical and/or biogeochemical extremes, is also needed.

This session provides a platform to compare physical and biogeochemical processes and the statistics of ECEs in different regions by inviting case studies in the Pacific.

In this session, we welcome contributions on ECEs and related compound events on the following topics: 1) the physical and biogeochemical processes of extremes, 2) the ecological and socio-economic consequences, and 3) the prediction or projection of extremes.

**(S01 17849 Invited)** (ECOP)

**Physical Drivers of Global Marine Heatwaves**

Ce **Bian**, Zhao Jing, and Lixin Wu

Frontiers Science Center for Deep Ocean Multispheres and Earth System and Key laboratory of Physical Oceanography, Ocean University of China, Qingdao, China. Email: cecbian@outlook.com

Global warming has exacerbated occurrence of extreme events, threatening the environment of human living. Marine heatwaves (MHWs) are prolonged extreme warm water events in the ocean, exerting devastating impacts on marine ecosystems. Comprehensive knowledge of physical processes controlling MHW life cycles is pivotal to improving MHW forecast capacity, yet it is still lacking. Here, we use a historical simulation from a global eddy-resolving climate model with an improved representation of MHWs, and innovatively show that heat flux convergence by oceanic mesoscale eddies acts as a dominant driver of MHW life cycles over most parts of the global ocean. In particular, the mesoscale eddies make an important contribution to growth and decay of MHWs, whose characteristic spatial scale is comparable or even larger than that of mesoscale eddies. Moreover, our results proved that features of global MHWs are scale dependent. The primary drivers of MHWs shift from oceanic advection to atmospheric forcing as their spatial scale becomes larger. There is evident geographic heterogeneity in the transition scale between these oceanic and atmospheric dominated regimes. Our study reveals the crucial role of mesoscale eddies in controlling the global MHW life cycles and highlights that using eddy-resolving ocean models is essential for accurate MHW forecasts. Another contribution is we clarified the transition scale of global MHWs, which is essential for parameterization of MHWs forecasting in a warmer future.

**(S01 18008 Invited)**

**Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities**

Neil J. **Holbrook**[1,2], Vanessa Hernaman[3], Shirley Koshiba[4], Jimaima Lako[5], Jules B. Kajtar[6], Patila Amosa[7] and Awnesh Singh[8]

[1]University of Tasmania, Hobart, TAS, Australia. Email: neil.holbrook@utas.edu.au

[2]ARC Centre of Excellence for Climate Extremes, Hobart, TAS, Australia

[3]CSIRO Oceans and Atmosphere, Aspendale, VIC, Australia

[4]Palau International Coral Reef Center, Koror, Palau

[5]Fiji National University, Suva, Fiji

[6]National Oceanography Centre, Southampton, United Kingdom

[7]The National University of Samoa, Apia, Samoa

[8]The University of the South Pacific, Suva, Fiji

Marine heatwaves (MHWs) can have devastating impacts on marine species and habitats, often with flow-on effects to human communities and livelihoods. This is critical for Pacific Island countries and communities who rely on coastal and ocean resources. Here, we investigate MHWs in the tropical western and central Pacific Ocean region, focusing on observations, impacts, and future projections using Coupled Model Intercomparison Project phase 6 (CMIP6) simulations under low (SSP1–2.6) and high (SSP5–8.5) greenhouse gas emissions scenarios. Documented impacts from Moderate mean intensity MHW events in Fiji, Samoa, and Palau, that were categorised as Strong at their peak, included fish and invertebrate mortality and coral bleaching. Based on CMIP6 multi-model mean estimates, and relative to current baselines, Extreme category MHWs range from <1 day per year under the current climate to >50 days per year projected under the high emissions scenario by 2050. In contrast, Extreme MHWs are projected to increase to <5 days per year by 2050 under the low emissions scenario. This highlights the imperative for Pacific Island nations that global emissions are substantially reduced to follow no more than the low emissions scenario trajectory.

**(S01 17773 Oral)**

**Modeling decisions in Hawaii's deep-set longline fishery: fishing under spatial closures and climate variability**

Kristy **Wallmo**[1], Hing Ling Chan[2], Lisa Pfieffer[3], and Paul Carvalho[3]

[1]National Marine Fisheries Service, Headquarters, Silver Spring, MD email: kristy.wallmo@noaa.gov

[2]National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu, HI

[3]National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA

Hawaii's bigeye tuna fishery is an important high profile, high value fishery, accounting for over 85% of U.S. bigeye landings and revenue every year between 2008 and 2019. Effort has expanded over the last 20 years and the fishery's footprint currently spans over 13 million $km^2$ in the central North Pacific ocean. The fishery is governed under the West and Central Pacific Fisheries Commission and regulated domestically by the U.S. National Marine Fisheries Service. The fishery is subject to quotas, permanent and ephemeral closures, and is predicted to experience climate-driven biomass changes in the next 50 years. Given these conditions, understanding the drivers of fishing location choice can help predict fishing effort and effort redistribution under a variety of environmental and regulatory scenarios. In this paper we present a utility-theoretic spatial location choice model to examine fishing location under hypothetical yet plausible scenarios involving area closures and climate variability. Model results show that expected catch, sea surface temperature, cost, and potentially a social network among vessels, are all significant predictors of a vessel's decision of where to fish. We use our model to illustrate effort redistribution and welfare changes to industry under various scenarios, and then demonstrate the potential of FishSET, a fisheries management tool, to facilitate the development and integration of datasets for spatial models similar to the one discussed here. Our paper should have broad appeal among researchers, industry, and managers interested in the effects of climate variability and other changing conditions on fishing decisions and fisheries management.

**(S01 17782 Oral)** (ECOP)

**Relationship between subtropical Indian Ocean Dipole and phytoplankton blooms**

Seongsik **Park** and Kyunghoi Kim

Pukyong National University, Busan, South Korea. E-mail: hoikim@pknu.ac.kr

The Subtropical Indian Ocean Dipole index (SIODI), which measures the difference in sea surface temperatures between the western and eastern subtropical Indian Ocean, showed a significant negative correlation with the affected area of phytoplankton blooms globally ($r = -0.52$; $P < 0.05$) and with bloom frequency ($r = -0.41$; $P < 0.1$). Particularly, SIODI exhibited a strong negative correlation with the annual number of red tide occurrence days in South Korea ($r = -0.70$; $P < 0.05$). To elucidate how SIOD influences winds and ocean currents around South Korea, thereby increasing red tide occurrences, we developed a method to calculate and represent the correlation between scalar and vector quantities. A preceding negative SIOD from November to January resulted in intensified humid high-pressure systems around South Korea in the following August, leading to increased rainfall. Additionally, SIOD affected ocean currents around the South Sea of South Korea, bringing seawater temperatures closer to the optimal range for red tide occurrences. Thus, a preceding negative SIOD from November to January led to increased rainfall in the following August and changes in seawater temperature, resulting in more frequent red tide occurrences along the coastal waters of South Korea. This significant correlation between SIOD and phytoplankton blooms was also observed in the Malvinas Current region, where phytoplankton bloom frequency is highest globally. The SIODI showed a significant negative correlation with the phytoplankton bloom frequency in the Malvinas Current region ($r = -0.61$; $P < 0.05$).

**(S01 17816 Oral)** (ECOP)

## Disturbance in benthic sediment and primary production in tidal flat by extreme meteorological events (typhoons Maysak and Haishen) in 2020

Seong Woon **Jeong** and Ho Kyung Ha

Inha University, Incheon 22212, Republic of Korea. E-mail: hahk@inha.ac.kr

A typhoon with strong wind and heavy precipitation, is a substantial hazard to coastal regions. This meteorological extremity usually occurs during the fall, when the tidal flat productivity is lowest. However, the resuspension mechanism of benthic sediments and chlorophyll-a (Chl-a) fluctuation in tidal flat has not been evident. In this study, in-situ mooring for measuring the current velocity, suspended sediment concentration (SSC), and Chl-a were conducted at the upper and lower tidal flats in the Muui Island from September 1-23, 2020. Chl-a maintained low (<3 mg/l) during the typhoons because of high SSC and low surface solar radiation (SSR). During the typhoons, when the northerly prevailed, SSC and SSR maintained low. During the post-typhoons with the westerly, SSC increased up to 614 mg/l. The westerly during post-typhoons could reinforce ebb current and cause high SSC. This time lag caused low Chl-a during the typhoons. After the typhoons, Chl-a drastically increased up to 18 mg/l, which was 5 times higher than that of typhoon period. One of the possible reasons of drastic Chl-a increase is nutrient input from offshore, which was increased by typhoon-induced vertical mixing. Sea surface temperature decreased after the typhoons, at the same time, Chl-a increased at the study area. The results from this study suggested that the effect of typhoon-induced vertical mixing could reach to nearshore such as tidal flats. With the growing interest directed toward tidal flats in Korea, the outcome of this study may serve as a guideline for the effective management of these environments.

**(S01 17821 Oral)** (ECOP)

**Impact of ocean heat changes induced by the Pacific Decadal Oscillation (PDO) on typhoon intensification in the Philippine sea**

Kiduk **Kim**, Jeong-Yeob Chae, Hajin Song, Eun-Joo Lee and Jae-Hun Park

Inha University, Incheon, Korea. E-mail: slidell@naver.com

Typhoons significantly impact ecosystems and human activities in the Northwestern Pacific, leading to numerous studies on their behavior and effects. Many studies have shown that ocean heat intensifies typhoons, though most focus on specific case studies. For better understanding of the effects of ocean heat to typhoon intensification for long periods of time, we conducted an analysis spanning around 30 years. We compared tropical cyclone heat potential (TCHP) data derived from both numerical model and an AI model with the best track data from the JTWC. In the Philippine Sea, we found higher TCHP values during the periods of negative phase of PDO. To examine the relationship between TCHP and typhoon intensification, we analyzed the Vmax gradient as an indicator of its intensification. The result indicates that the Vmax gradient of typhoons has correlation with TCHP. Further analysis was undertaken by categorizing strong PDO cases, showing a stronger correlation between Vmax gradient and TCHP during periods of strong negative PDO phases. Moreover, during these phases, the average Vmax exhibits a notably higher value compared to periods of strong positive PDO. Background changes in TCHP during the passage of typhoons along their tracks indicate higher values in strong negative PDO periods, suggesting typhoons absorb more oceanic heat to fuel their intensification in such conditions. This study demonstrates the crucial impact of negative-PDO induced warming in the Philippine Sea on the intensification of typhoon, implying the need for high-quality TCHP data for precise analysis or prediction of typhoon intensification events.

**(S01 17822 Oral)** (ECOP)

**A transition at twilight: the declining diel vertical migrators in a warming shelf sea**

Lingyun **Nie**[1,3], Jianchao Li [*1,2,3], Yang Liu [1,3], Peng Sun [1,3], Zhenjiang Ye [1,3], Honghai Zhang [4], Liyan Zhu[5], Shuyang Ma [1,3], Wenchao Zhang [1,3] and Yongjun Tian [1,2,3]

[1]Deep Sea and Polar Fisheries Research Centre, Ocean University of China, Qingdao, China. E-mail: lijianchao@ouc.edu.cn

[2]Frontiers Science Center for Deep Ocean Multispheres and Earth System (FDOMES), Ocean University of China, Qingdao, China

[3]College of Fisheries, Ocean University of China, Qingdao, China

[4]College of Chemistry and Chemical Engineering, Ocean University of China, Qingdao, China

[5]College of marine Life, Ocean University of China, Qingdao, China

The diel vertical migration (DVM) of plankton and nekton plays an important role in the energy flow and material cycling of marine ecosystems. This migration between deep and shallow water, occurring in twilight, happens almost daily in coastal areas, yet little is known about the relationship between its migration patterns and environmental changes. Therefore, we employed multi-frequency acoustics, coupled with underwater video and biological sampling, to conduct comprehensive observations across different seasons in the Eastern China Shelf Sea between 2019 and 2023. The results show that (1) there are two distinct groups of migrators: gas-bearing (GB, swimbladder fish, jellyfish, etc.) and fluids-like (FL, zooplankton, crustaceans, etc.), and that their geographic distributions are closely related to temperature. (2) Migratory behavior is influenced by multiple environmental factors, such as moon phases, spring and neap tides, and fronts. For example, during the full moon, GB will end upwards deeper and the FL shallower, compared to the new moon. (3) Migration in the East China Sea is weakening under ongoing warming, especially for FL species. This is a potential bottom-up control mechanism, and this weakening migration is projected to intensify further in the future. Changes in DVM could trigger a series of ecological effects, including the alteration of predation strategies and consequently affect the survival of organisms, and impact coastal carbon and nutrient fluxes. The resilience of vertical migrators to ongoing and future climate change remains a critical area for continuous study.

**(S01 17844 Oral)** (ECOP)

**Spatial variability in multivariate climate vulnerability produces mosaic of risks and tradeoffs for four California Current shellfish species**

Esther G. **Kennedy**[1, 2], Sara L. Hamilton[3], Ben Walker[4], Meghan Zulian[1, 2], Kristy Kroeker[4], Eric Sanford[1, 2], Brian Gaylord[1, 2] and Tessa M. Hill[1, 2]

[1]University of California Davis, Davis, CA, USA. E-mail: egkennedy@alaska.edu

[2]Bodega Marine Laboratory, Bodega Bay, CA, USA

[3]Oregon Kelp Alliance, Port Orford, OR, USA

[4]University of California Santa Cruz, Santa Cruz, CA, USA

Shellfish in the California Current System face layered threats from warming, deoxygenation, and acidification. These stressors interact in complex ways in space and time, leading to multivariate hotspots and refugia that are distinct from patterns of univariate stress. Here, we use a newly available compilation of coastal temperature, dissolved oxygen, and pH observations from the U.S. West Coast to evaluate spatial patterns of exposure to stress at three different depth horizons. We combine these exposure patterns with species-specific sensitivities for each stressor to develop high-resolution maps of vulnerability for red abalone (*Haliotis rufescens*), red urchin (*Mesocentrotus franciscanus*), North Pacific krill (*Euphausia pacifica*), and Dungeness crab (*Metacarcinus magister*). We couple this with an analysis of the effects that uncertainty in species vulnerability has in identifying climate refugia and hotspots. We find that multivariate vulnerability varies substantially along the coast for each species, that temperature stress is most dominant in the Southern California Bight while deoxygenation and acidification stresses are most impactful further north. This work underscores the importance of considering interactions between oceanographic stressors, as avoidance of one stress may mean increased exposure to another.

**(S01 17890 Oral)**

**Marine Heatwaves and Pyrosome Blooms: Are these the new normal for the Northern California Current?**

Richard D. **Brodeur**[1,2], Kelly R. Sutherland[3], Kim S. Bernard[2], Dylan G.E. Gomes[1,4], Laura E. Lilly[4], Elizabeth A. Daly[4], Samantha M. Zeman[4], Moira Galbraith[5], R. Ian Perry[5,6], Douglas L. Draper[1], James J. Ruzicka[7], Eric P. Bjorkstedt[8], and Roxanne R. Robertson[9]

[1]Northwest Fisheries Science Center, NOAA, Hatfield Marine Science Center, Newport, OR, USA. E-mail: ricbrodeur1@gmail.com

[2]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA

[3]Oregon Institute of Marine Biology, University of Oregon, Eugene, OR USA

[4]Cooperative Institute for Marine Resources Studies, Oregon State University, Hatfield Marine Science Center, Newport, OR, USA

[5]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, CA

[6]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, CA

[7]Pacific Islands Fisheries Science Center, NOAA, Honolulu, HI, USA

[8]Southwest Fisheries Science Center, NOAA, Trinidad, CA, USA

[9]Cooperative Institute for Marine, Earth, and Atmospheric Systems, Cal Poly Humboldt, Arcata, CA, USA

Marine heatwaves (MHWs) have increased in intensity and duration globally as a result of sustained carbon emmissions. The North Pacific Ocean witnessed multiple strong and prolonged MHWs since 2014 leading to many ecosystem anomalies. Pelagic urochordates (salps and appendicularians) are dominant components of oceanic, low productivity waters globally and have been studied with some regularity in temperate ecosystems. However, colonial pyrosomes are generally restricted to oceanic tropical seas and far less studied. The subtropical cosmopolitan species, *Pyrosoma atlanticum*, has priodically been sampled off Southern California. With the advent of anomalously warm conditions due to the severe MHW in 2014, *P. atlanticum* started appearing in the Northern California Current (NCC), north of its known range, and following a strong El Niño in 2016, became the dominant component of pelagic surveys by 2017. These massive blooms impaired commercial fisheries and contanimated beaches, prompting public concerns. Due to the paucity of information on this species north of its normal range, we compiled existing and new data on horizontal and vertical distributions, habitat preferences, feeding ecology and grazing rates, and utilization by higher trophic levels. This information was assimilated into an end-to-end ecosystem model to examine impacts to the pelagic and benthic food webs and human utilization of this system. Since this tropical invader may become established in the productive coastal ecosystem of the NCC with predicted future

warming of the North Pacific, understanding its ecology and potential impacts will fill critical gaps in our knowledge of the importance of this hitherto understudied species.

**S01, Oral, AbstractID=17908, (ECOP)**

**Interannual variability of the marine heat waves in the Western North Pacific Ocean and its marginal seas**

Hyung-Ju **Park** and Hanna Na

School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea. E-mail: hanna.ocean@snu.ac.kr

Marine Heat Waves (MHWs) denote anomalously warm seawater events that can persist for several months, adversely affecting marine ecosystems. This study examines the spatio-temporal variations of MHWs in East Asia, utilizing 41 years of satellite-based sea surface temperature data. The results indicate that MHWs predominantly occur in the East Korea Bay (EKB), the East China Sea (ECS), and the Western North Pacific (WNP) for longer than 25 days annually. MHWs in the EKB and WNP exhibit relatively longer durations but are less frequent than those in the ECS. Despite the distinct characteristics, the time series of MHW days across these regions have significant inter-correlations, suggesting a collective response to large-scale climate phenomena. Spectral analysis indicates the separation between interannual-scale variability (shorter than six years) and the long-term warming trend. The relationship with peak years of the interannual component and well-known climate variability is presented. Nearly half of the peaks align with the El Niño to La Niña transition. During this period, MHWs occur along with both intensified ocean currents and warm and moist air inflow induced by anomalous anticyclonic circulation near the surface. On the other hand, during the peaks without the El Niño to La Niña transition, MHWs are driven by enhanced downward shortwave radiation associated with an anticyclonic system over the mid-to-upper troposphere, embedded in the circum-global teleconnection pattern. Our study provides an integrated understanding of the relationships between the East Asian MHWs with various climate modes, offering basic mechanistic insights: ocean advection-driven or heat flux-driven.

**(S01 17932 Oral)** (ECOP)

**A dipole pattern bias in marine heatwave intensity in the Kuroshio Extension simulated by the CMIP6 models**

Wonkeun **Choi**[1,2], Heeseok Jung[1] , Zhenya Song[3,4] and Chan Joo Jang[1,2]

[1]Korea Institute of Ocean Science and Technology, Busan, Republic of Korea. Email: cjjang@kiost.ac.kr

[2]Korea University of Science and Technology, Daejeon, Republic of Korea

[3]First Institute of Oceanography, and Key Laboratory of Marine Science and Numerical Modeling, Qingdao, China

[4]Laboratory for Regional Oceanography and Numerical Modeling, Qingdao, China

While the spatial distribution of marine heatwave (MHW) characteristics varies among individual climate models, certain models show similar bias patterns in specific regions. Therefore, clustering the climate models with similar bias patterns can help to identify representative biases of climate models in those regions. In this study, we employed hierarchical clustering to group the 30 CMIP6 models into five clusters based on their spatial distribution of MHW characteristics bias in the North Pacific Ocean compared to OISST reanalysis data for 33 years (1982–2014). Except for one cluster, the four clusters of CMIP6 models show a dipole pattern of the mean MHW intensity bias in the Kuroshio Extension region. In order to identify the cause of these biases, the simulation performance of ocean currents grouped with the same cluster as the mean MHW intensity clusters was evaluated. The four clusters with a dipole pattern simulate a relatively wide width of the Kuroshio Current compared to observation. Furthermore, in three of these clusters, the Kuroshio Current tends to overshoot. The sole remaining cluster without a dipole pattern does not show both Kuroshio overshooting and an expansion of the Kuroshio Current width. These two simulation biases can result in relatively warmer water flowing at higher latitudes compared to observation, thereby contributing to a dipole pattern bias in the mean MHW intensity. Our finding suggests that the performance of ocean current simulations in climate models has a significant impact on the simulation of MHW intensity, especially in the western boundary current regions.

**(S01 17980 Oral)**

**Tropical and North Pacific decadal variability promotes the occurrence of Northeast Pacific marine heatwaves**

Antonietta **Capotondi**[1,2], Tongtong Xu[1,2], Matthew Newman[2] and Emanuele Di Lorenzo[3]

[1]University of Colorado, Boulder, CO, USA. antonietta.capotondi@noaa.gov

[2]NOAA PSL, Boulder, CO, USA

[3]Brown University, Providence, RI, USA

Interannual variations associated with El Niño Southern Oscillation in the tropical Pacific are viewed as key drivers of Northeast Pacific marine heatwaves (MHWs), and important sources of their seasonal predictability. However, studies have also shown that Northeast Pacific marine heatwaves are strongly influenced by decadal variability in the tropical and North Pacific, with tropical anomalies contributing to the persistence of these events. In this study, we make use of a Linear Inverse Model (LIM), i.e., an empirical model trained on observations, to examine the relative role of tropical interannual variability and tropical/North Pacific decadal variability in the development of Northeast Pacific MHWs. The dynamical eigenmodes of the LIM operator include both tropical interannual modes, capturing canonical ENSO, and a decadal mode that spans both the North Pacific and the central equatorial Pacific ("NP-CP" mode). By selectively "filtering" these modes out of the data, we assess their relative influence on MHW characteristics. Our results indicate that the NP-CP mode was key to the growth of the 2014-16 MHW in the Northeast Pacific, and significantly impacts the intensity of MHWs in this region, while the interannual tropical ENSO modes only influence MHW intensity in the tropical Pacific. These results provide insights on tropical-extratropical interactions at decadal timescales and on the primary sources of Northeast Pacific MHW predictability.

**(S01 1800 Oral)** (ECOP)

**Pan-basin warming now overshadows robust Pacific Decadal Oscillation**

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

[1]NOAA Southwest Fisheries Science Center, Monterey, CA, USA. E-mail: allison.cluett@noaa.gov

[2]NOAA Physical Sciences Laboratory, Boulder, CO, USA

[3]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, USA

The Pacific Decadal Oscillation (PDO) has historically described the leading mode of North Pacific sea surface temperature (SST) variability on interannual-to-interdecadal timescales, providing a popular index connecting basin-scale physical processes to impacts on marine ecosystems. However, declining reliability of PDO-ecosystem relationships within the past decade has called into question the stability of the mode and its continued utility as an index. Here, we show that PDO has neither changed in spatial pattern nor weakened relative to its historical expression. However, pan-basin warming of the North Pacific now overwhelms PDO-related SST variability, recently producing the first prolonged period in which a negative ('cold') PDO phase failed to produce cool SSTs in the eastern North Pacific. We present the pan-basin pattern (PBP) as a new index describing the shifting baseline of North Pacific SSTs. Future use of the PDO index demands distinguishing the impacts derived from PDO dynamics from those produced by anomalous SSTs, and should be coupled with consideration of the non-stationary PBP baseline. Furthermore, quantifying internal variability is necessary to determine the potential for extremes (e.g., +PBP/+PDO as in 2014-2021) and no-analog ocean regimes (e.g., +PBP/–PDO) arising from interactions between internal variability and anthropogenic warming.

**(S01 18023 Oral)**

**Improved ocean-related forecasting ability has been paving the way for providing decision-making actionable information**

Fangli **Qiao**

First Institute of Oceanography, Ministry of Natural Resources, Qingdao, China email: qiaofl@fio.org.cn

Accurate forecasting of ocean and climate can provide actionable information for decision-making or ocean governance, which should be one of main tools transferring ocean science to sustainability. However, huge common model biases of the ocean, tropical cyclone (TC) and climate models have hindered our forecasting ability. With huge heat content, ocean controls the evolution of TC and climate. In this regards, ocean should be the key to improve forecasting ability. The programme of "Ocean to climate Seamless Forecasting system (OSF), approved by UN Ocean Decade in 2022, may provide us a solution. This presentation will introduce the OSF structure, projects, highlights and its vision. To improve the ocean, TC and climate prediction ability through considering surface wave-related physical processes is the main task of OSF. As the time and spatial scales of surface waves are several seconds and hundreds meters, which are much smaller than those of ocean circulation and climate, months and thousands kilometers or even bigger. As a result, ocean surface wave models are separated from ocean circulation models and climate models. Through the Through our untiring efforts during the past 2 decades, we find that surface waves play dominant role in the vertical mixing of the upper ocean, and heavily modulate the air-sea momentum and heat fluxes both of which are keys for ocean prediction. (1) By including surface waves into ocean general circulation models (OGCMs), the ever-standing simulation errors of shallow mixed layer and over-estimated sea surface temperature (SST) especially in summer faced by nearly all OGCMs are dramatically reduced by about 80% in different OGCMs; (2) Although the forecasting error of TC track is reduced by about half during the past decades, the forecasting of TC intensity has no much progress during the past decades. By including surface waves, the TC intensity error is reduced by about 40%; (3) SST is a crucial parameter in climate system. Climate models have huge SST simulation bias which has last for half century. By including surface wave, the SST bias can be reduced by about 60%. All above suggests that surface waves shed new light on ocean, TC and climate forecasting, and then improve our ability on providing decision-making accurate and actionable information.

**(S01 18053 Oral)**

**Structure of Marine Heatwaves in the Southern Java and Karimata Strait, Indonesia**

Young-Gyu **Park**[1], Mochamad Riza Iskandar[2] and Ahmad Bayhaqi[2]

[1]Korea Institute of Ocean Science and Technology, Busan, South Korea. E-mail: ypark@kiost.ac.kr

[2]National Research and Innovation Agency of Indonesia, Jakarta, Indonesia.

The marine heatwaves (MHWs) have been reported to occur globally, but their structures within the Indonesian Maritime Continent (IMC) have not been fully explored yet. Here, we explore the genesis and statistics of the MHWs in two prominent locations within the Maritime Continent. Specifically, we focus on South Java and the Karimata Strait, which have exhibited strong MHWs during the period from 1982 to 2021. In the 10 days prior to the events, both in South Java and the Karimata Strait, MHWs were primarily driven by the reduced latent heat loss from the ocean to the atmosphere due to decreased wind speed. Additionally, the increased solar radiation caused by reduced cloud cover served as an additional contributing factor. These two factors explain about 70% of the genesis and the oceanic factors the remaining 30%. Overall, the strongest and longest-lasting MHWs in the South Java have occurred during the negative phase of the Indian Ocean Dipole, while in the Karimata Strait during El Niño events.

**(S01 18055 Oral)** (ECOP)

**Variation of commercial pelagic species under ENSO and Climate Change in the Northern South China Sea**

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

[1]National Taiwan Ocean University, Keelung, Taiwan. E-mail: 20931002@mail.ntou.edu.tw

[2]University of British Columbia, Vancouver, BC, Canada

The El Niño/Southern Oscillation (ENSO) is known to significantly impact marine ecosystems and fisheries, particularly pelagic species. ENSO events influence environmental factors, leading to variations in fish abundance. However, the processes driving ENSO remain complex and not fully understood. The Northern South China Sea hosts a diverse range of fish species, many of which are of commercial and ecological importance. Some studies suggest that climate events significantly affect the annual ocean-atmosphere cycle in the South China Sea, causing changes in the abundance of small pelagic species. Meanwhile, climate change is also another important factor influencing ecosystems and biomass. To understand how these species are affected by El Niño and La Niña events under future climate change conditions, we selected important and top-landing commercial species. We used the Niño 3.4 index to study ENSO-like events and applied the environment data from GFDL ESM2M ensemble model in conjunction with the Dynamic Bioclimatic Envelope Model to assess fish biomass. Using Lasso Regression, examined the significant impacts of extreme and compound ocean events on ENSO-like events and fish abundance. Correlation tests indicate that some species increase during La Niña due to lower sea surface temperatures and other environmental factors, while others show the opposite trend. Changes in biomass during the ENSO period are mostly influenced by multiple factors rather than a single environmental factor Overall, ENSO is part of a complex set of conditions that affect marine ecosystems, rather than being the sole or primary factor.

**(S01 18134 Oral)**

**Unraveling the formation mechanism of Marine Heatwaves in the Northeast Pacific**

Fei **Chai**[1], Yuntao Wang[2] and Huan-Huan Chen[2,3]

[1]Xiamen University, China. E-mail: fchai@maine.edu

[2]Second Institute of Oceanography, Ministry of Natural Resources, China

[3]Zhejiang University, China

The Northeast Pacific Ocean, a global hotspot for marine heatwaves (MHWs), has witnessed frequent extreme MHWs in recent years. Our study explores the driving forces of the 2013/14 extreme MHW event known as the Blob, and the role of Arctic warming in winter MHWs in the region. The results revealed that the Blob primarily resulted from reduced air-sea heat flux and horizontal advection of cold water associated with an abnormal high-pressure system. The abnormal high-pressure system played a significant role in this event by influencing air temperature and wind intensity. In detail, the anomalous air-sea heat flux was mainly induced by the increase in air temperature and the decrease in wind speed. However, the anomalous horizontal advection is mainly due to the weakened Ekman transport caused by the reduced wind stress. Based on numerical model sensitivity experiments, the role of the anomalous air temperature and wind intensity in the formation of the Blob is confirmed, with the increase in air temperature having a more significant impact. In addition, we revealed the potential link between Arctic warming and the winter ocean temperature variability in the Northeast Pacific by combining multi-source observations and the CAM5 model. Specifically, Arctic warming can contribute to the formation of an anomalous high-pressure system over the study region. This system can significantly weaken the intensity of the prevailing westerlies, resulting in reduced upper ocean cooling in the Northeast Pacific during winter. As a result, sea surface temperatures have risen, favoring the occurrence of MHWs.

**(S01 17894 Poster)** S01-P2

**Regional variations of water transparency in the Yellow Sea using MODIS data**

Young Baek **Son**[1], Sun Kyeong Choi[1] and Don-Hyug Kang[2]

[1]Korea Institute of Ocean Science & Technology (KIOST), Jeju Research Institute, Jeju, Korea. E-mail: sonyb@kiost.ac.kr

[2]Korea Institute of Ocean Science & Technology (KIOST), Pusan, Korea

Water transparency are important optical parameters as understanding the spatial variability of the water properties. To understand the temporal and spatial variations of water transparency distribution in the Yellow Sea(YS), we conducted linear trend and K-means analyses of satellite-derived transparency data and satellite products(MODIS sea surface temperature(SST), Chlorophyll-a concentration(Chl), colored dissolved organic matter(CDOM), total suspended matter(TSM)) the region during 2003~2023 periods. Water transparency showed a typical seasonal pattern of increasing in summer and decreasing in winter. Increasing water transparency was related by decreasing Chl, CDOM and TSM during summer and decreasing water transparency was related by increasing CDOM and TSM during winter. The increasing trend was correlated with increasing SST and decreasing Chl, CDOM and TSM trends. The spatial variations of five regional areas using K mean method showed the regional different impact factors. The coastal areas of Korea and China displayed a relatively lower increasing water transparency and it was associated with increasing SST and decreasing Chl and CDOM. The southern Yellow Sea was associated with the changes in TSM. The central Yellow Sea showed the highly increasing trend in the study area. The inter-annual variations in the western YS were associated with the changes in SST, Chl and CDOM, while these in the eastern YS was related to the changes of SST, Chl and TSM.

**(S01 17920 Poster)** S01-P3 (ECOP)

**Impact of super typhoon on subtropical Ulva green tides in Korean coast**

Sun Kyeong **Choi**, Seul Yi and Young Baek Son

Jeju Research Institute, Korea Institute of Ocean Science & Technology (KIOST), Jeju, Korea.
E-mail: choisk@kiost.ac.kr

Not only is Korean coast experiencing a rapid rise in water temperature, leading to increased activity of subtropical species and extreme fluctuations in coastal ecosystems, but the impact of typhoons is also increasing. In this study, we investigated the macroalgal bloom using drone photo images that has become a problem in the Jeju coast and the impacts of typhoons. The study area was found to be severely covered by subtropical Ulva in every August 2020-2022. Jeju Island were affected by super typhoons in September each year during the study period, with strong winds. In 2020 and 2022, the green tides were found to have mostly disappeared from study area after the typhoon. This is an ironic result of the dissipation of subtropical Ulva biomass, which is increasing in biomass due to climate change, by super typhoons, which are becoming more frequent. However, there was no significant difference in the area of the Ulva blooms despite the impact of super typhoon in 2021. This may be due to the fact that the strong winds of the typhoon in 2021 blew in the opposite direction of the open sea and therefore did not affect the distribution of the Ulva bloom. These results suggest that the wind direction of typhoons that occur each year may determine whether or not the green tide outbreaks is resolved.

**(S01 17941 Poster)** S01-P4

**Long-lasting marine heatwaves in the East Korea Bay, East/Japan Sea: Characteristics and mechanisms**

Chan Joo **Jang**[1,2], Subi Lee[1], Wonkeun Choi[1,2], Minkyoung Bang[1] and Heeseok Jung[1]

[1]Korea Institute of Ocean Science and Technology, Busan, Republic of Korea. E-mail: cjjang@kiost.ac.kr

[2]Korea University of Science and Technology, Daejeon, Republic of Korea

Marine heatwaves (MHWs) have become more intense, frequent, and prolonged in recent decades, devastatingly affecting marine ecosystems and subsequent socio-economic consequences. In the East Korea Bay (EKB), located in the northwestern East/Japan Sea (EJS), the duration of MHWs is 32% longer (16.8±24.0 days/event) than in the entire EJS. Notably, the EKB has experienced two exceptionally prolonged MHWs lasting over four months each. In this study, we investigated the distinct characteristics of the long-lasting MHWs in the EKB and their possible driving mechanism using satellite and reanalysis data. During the long-lasting MHWs, enhanced ocean surface cooling mainly driven by a latent cooling and a negligible solar radiation anomaly suggest a predominant influence of oceanic processes. Spatial and temporal reveal of sea level anomalies reveals that the long and strong anticyclonic eddies with higher amplitude is associated with extremely long-lasting MHWs. A heat budget analysis further supports the dominant role of advection by the anticyclonic eddies for maintaining long-lasting MHWs. Our findings suggest that the ocean processes including eddies can contribute to driving extremely long-lasting MHWs in the EKB in the EJS.

**(S01 17953 Poster)** S01-P5 (ECOP)

**Observations on the delayed genesis of Marine Heatwaves on the East coast of the Korean Peninsula by near-inertial waves after the passage of typhoon Hinnamnor**

Saranya. **J. S**[1], Panini Dasgupta[2] and SungHyun Nam[1,3]

[1]School of Earth and Environmental Sciences, College of Natural Sciences, Seoul National University, Seoul, Republic of Korea email: saranyaozhoor@gmail.com

[2]Future Innovation Institute, Seoul National University, Siheung 15011, Republic of Korea

[3]Research Institute of Oceanography, College of Natural Sciences, Seoul National University, Seoul, Republic of Korea

Typhoons and marine heatwaves (MHWs) interact in a way that significantly influences each other. Typhoons can rapidly intensify by drawing energy from MHWs, which are characterized by extremely high sea surface temperatures. Conversely, MHWs can either form or dissipate following a typhoon's passage due to alterations in upper ocean heat content and stratification. A notable example is Super Typhoon Hinnamnor, which originated in the subtropical northwest Pacific and weakened in the East Sea (Japan Sea) region. About a week after this weakening, MHW conditions emerged on the western side of the typhoon's centre off the Korean east coast. Continuous oceanographic and meteorological data were collected using a fixed surface mooring located 8 km off the coast and approximately 300 km from the typhoon's centre. This data revealed that combined with near-inertial internal gravity waves (NIWs) influenced by sub-inertial background conditions, caused a one-week delay in the appearance of MHWs. Despite favourable conditions such as typhoon-induced coastal downwelling, increased surface net heat flux from the atmosphere to the ocean and higher upper ocean heat content, the development of MHW conditions was delayed. This delay was due to vertical mixing and stratification affected by the NIWs, which prevented the sea surface temperature from rising. This research highlights the ongoing impact of typhoons on post-typhoon MHWs through changes in vertical thermal structure caused by internal waves, providing insights into their combined effects on coastal environments and marine ecosystems.

**(S01 17957 Poster)** S01-P6 (ECOP)

**Representing annual marine heatwave characteristics using the monthly sea surface temperature datasets**

Gyundo **Pak**

Korea Institute of Ocean Science & Technology, Busan, Korea. E-mail: gdp@kiost.ac.kr

The marine heatwaves (MHWs) are periods of prolonged elevated sea surface temperature (SST). The long-term variability of the MHW characteristics is typically measured by frequency (the annual count of discrete MHW events), duration (average event length), intensity (mean SST anomaly during MHW events), and total MHW days (annual cumulative MHW days). The widely used MHW detection technique, relying on over 30 years of daily SST data, is unsuitable for investigating MHW characteristics prior to 1981 due to the absence of global daily SST data. Alternatively, global monthly SST datasets, which extend over a century, offer the potential for analyzing MHW characteristics on multi-decadal to centennial scales. However, detecting individual MHW events from monthly SST is not feasible since the minimum timescale of the MHW (5 days) is shorter than a month. Nevertheless, annual MHW characteristics can be represented using monthly SST. This study introduces new proxy indices derived from four monthly-averaged long-term daily SST datasets. These indices enhance the representation of annual MHW characteristics compared to previously suggested proxies. A direct comparison between daily SST-derived MHW characteristics and the new proxies suggests their superior performance in capturing the interannual variability of MHW characteristics. The robustness of these proxies is further assessed using an extended analysis period with earth system model data, highlighting their potential for multi-decadal to centennial scale estimation of MHW characteristics. Additionally, the assessment results for proxies based on the machine-learning technique will be also briefly introduced.

**(S01 18010 Poster)** S01-P7 (ECOP)

**Sensitivity of extreme events detection to satellite data resolution in coral reef habitats**

Jessica N. **Perelman**[1,2], Hui Shi[1,2], Ryan R. Rykaczewski[1], and Justin J. Suca[1,2]

[1]Cooperative Institute for Marine and Atmospheric Research, University of Hawaii Honolulu, HI USA. Email: jessica.perelman@noaa.gov

[2]NOAA Pacific Islands Fisheries Science Center, Honolulu HI USA

Satellite ocean color measurements are a valuable tool for evaluating water quality parameters relevant to coral reef habitats. However, low earth orbiting satellites offer a limited number of observations for detecting episodic, extreme events to which coral reefs are sensitive, and the spatial resolution of most sensors is too coarse for fine scale processes in optically shallow nearshore environments. Here, we assess whether high-resolution satellite ocean color measurements from the first geostationary satellite ocean color sensor (GOCI) can improve our understanding of coral reef habitat conditions and monitoring capabilities for potential reef changes. Using ten years (2011-2021) of GOCI ocean color measured eight times per day at a spatial resolution of 500 m around the Okinawa Prefecture region, we simulate a range of coarsened spatiotemporal grid configurations to replicate existing sensor resolutions and assess the sensitivity of coral reef-relevant indices to satellite data resolution. We find that the high-resolution grid increases the coastal areas that are retained along coastal reef habitat by 55% where waters are otherwise masked at coarser resolutions (i.e. 4 km) to avoid optical reflectance in shallow waters. The increased spatial resolution decreases the distance between the coastline and useful ocean color measurements to 1/3 of the original distance. We also find that the ability to detect episodic, extreme chlorophyll blooms increases significantly with increasing spatiotemporal resolution and that the locations of these events become much more refined at higher resolutions. Finally, over the ten years examined, the highest resolution chlorophyll data captured up to 600 episodic events that were missed by the commonly used 4 km 8-day resolution in any given grid cell around Okinawa Island. High-resolution ocean color data may enable us to assign significantly more reliable risk to coral reef tracks that could be affected by frequent episodic events and allows us to assess the development and persistence of such events in waters much closer to coastal habitat.

**(S01 18013 Poster)** S01-P8

**Identification and delineation of key control area of storm surge disaster in Zhoushan City based on loss perspective**

Yang **Luo**, Ziyan Guo, Jianwei Wu, Jinlong Jiang and Quanyi Xiang

Third Institute of Oceanography (TIO), Ministry of Natural Resources (MNR), Xiamen, China.
E-mail: luoyang@tio.org.cn

Typhoon storm surge disasters are characterized by wide distribution areas, high frequency, high intensity, and great human and economic losses, and its resistance and control is a worldwide management problem. Currently, the common prevention and control method is to conduct regional management through the risk assessment results formed by superposition of storm surge hazard and carrier vulnerability, which can better identify high-risk areas, but these areas are difficult to be valued due to low economic value, and thus will not enhance the disaster preparedness capacity. This study proposes a method for identifying and delineating key control areas for storm surge disasters based on the loss perspective. The method is based on simulating the storm surge inundation range under the 100-year return period scenario in Zhoushan City, Zhejiang Province, using the ADCIRC model, calculating the number of affected population, direct and indirect economic loss for each standard statistical unit, and then determining the classified eigenvalues of the three loss indicators by K-means cluster analysis method, so as to identify the key control areas through geospatial technology. The results show that the classified eigenvalues of population and direct and indirect economic loss for the standard statistical unit are 102 people/km$^2$, 3.744 million yuan/km$^2$ and 0.926 million yuan/km$^2$, and the area of the key control area divided accordingly accounts for 32.8% of the inundated area. The results are conducive to formulate a more scientific and reasonable strategy for disaster prevention based on the comprehensive consideration of disaster losses and input gain/loss analyses.

**(S01 18022 Poster)** S01-P9 (ECOP)

**Multiproxy analysis for understanding ecosystem shifts in coastal Louisiana under environmental and climatic stressors**

Junghyung **Ryu**[1], Kam-biu Liu[2], Terrence A. McCloskey[3], and Jeogyun Kim[1]

[1]Department of Oceanography, Division of Earth and Environmental System Sciences, Pukyong National University, 45 Yongso-ro, Nam-gu, Busan, 48513, Republic of Korea. email: jryu@pknu.ac.kr

[2]Department of Oceanography and Coastal Sciences, College of the Coast and Environment, Louisiana State University, Energy, Coast & Environment Building, Baton Rouge, Louisiana, 70803, United States of America.

[3]Independent Researcher, St. Margarets Village, Mile 32 Hummingbird Highway, Belize, Central America.

Containing one of the world's largest deltas, coastal Louisiana has undergone extreme environmental changes due to natural and anthropogenic impacts, including climate change, sea level rise, and land subsidence, resulting in a significant land loss of 5,197 $km^3$ since the 1930s. The standard environmental progression in such locations is predictable. However, the timing and rapidity of these ecological changes and identifying the relative importance of the various external factors controlling the ecosystem shifts over time is extremely difficult. This study proposes that a multiproxy-based paleo-environmental study can be employed to help distinguish natural and anthropogenic factors and identify the relative importance of various external forcing agents such as sea level rise, land subsidence, hurricane landfalls, and coastal flooding. We integrated methodologies (geological, chemical, ecological) for assessing various coastal environmental stressors affecting coastal environmental conditions by analyzing multiple deep cores along the salinity gradient (n-s) in the coastal wetlands of Louisiana; an intermediate marsh, a brackish marsh, and a mangrove swamp. Concentrations of Barium (Ba) and Bromine (Br), along with six elemental ratios (Calcium/Rubidium, Zirconium/Rubidium, Titanium/Rubidium, Potassium/Titanium, Manganese/Rubidium, and Sulfur/Rubidium), were used to infer proxies for various environmental conditions (such as waterlogging and redox levels), depositional processes (including fluvial versus marine or in situ), and sediment characteristics (like grain size). Six successive ecosystem shifts were identified, associated with various environmental changes, influenced by local (anthropogenic activities), regional (delta lobe switching), and global (sea level rise) factors. An elemental ratio (Zr/Rb) was used to determine a continuous (2 cm resolution) estimate of grain size along the length of the cores. By correlating the identification of environment types, inferred depositional processes, and the historical Mississippi Delta cycle with ecosystem reconstruction, we increase insight into how ecosystems respond to various stresses. This knowledge can be used to better understand and predict current and future responses to ongoing stresses.

**(S01 18149 Poster)** S01-P10 (ECOP)

**Basin-scale events to coastal impacts (BECI) project**

Kathryn **Berry**, Vivitskaia Tulloch, Devon Wawara, and Sonia Batten.

North Pacific Marine Science Organization, Sydney, Canada. E-mail: Kathryn.berry@pices.int

The effects of climate change are impacting ocean processes and systems globally. The North Pacific Ocean has experienced marine heatwave events at increased frequency since 2013. Such events can span across the basin, with implications for ocean and coastal ecosystems. While some marine organisms are responding by shifting their distributions, reductions in health and productivity have been measured. Extreme consequences of recent heat waves include the mass mortality event of Alaskan snow crab in the Bering Sea in 2021. A better understanding of what conditions and mechanisms are driving these changes is required to inform adaptive management strategies. Wholistic ocean science, management, and policy development are currently hindered by inaccessible data and siloed research efforts. Multinational collaborative efforts are necessary to evaluate, forecast, and adapt to climate change effects at large scales, across national and international jurisdictions. The Basin-scale Events to Coastal Impacts (BECI) project is a multinational interdisciplinary project that aims to improve ocean and coastal management under increasing climate variability, by supporting transboundary collaboration and forward-looking decisions for marine ecosystems and fisheries in a changing climate. The BECI project will build on the existing international partnerships of PICES to bring people together to work as a collective, building on each other's strengths to address complex climate change and ocean science challenges. This poster will outline the goals and objectives of the major themes of BECI: Data Integration, Ecological Modelling, Targeted Research, Decision Support, and International Partnerships. Each theme consists of transboundary initiatives that will function via multinational collaborations. We hope that PICES scientists will find a theme or initiative where their expertise can be applied, and partner with us to achieve our goals.

# Sessions 2: FUTURE/BIO/HD/POC Topic Session

S-CCME/SICCME session on innovation in using integrated approaches to detect and manage for the effects of climate change tipping points and critical thresholds in marine ecosystems

Convenors:

Kirstin Holsman (USA), *corresponding*
Elliott Hazen (USA)
Kathy Mills (USA)
Xiujuan Shan (China)

Invited Speakers:

Mary Hunsicker (NOAA NWFSC, USA)
Camilla Sguotti (Department of Biology, University of Padova, Italy)

Climate change and extreme events are rapidly altering marine ecosystems worldwide, impacting ecosystem productivity, structure, and stability and the livelihoods and wellbeing of people that rely on sustainable marine resources. Understanding if and when climate-driven changes will push systems and species past tipping points (critical points where a small change in a pressure or driver can induce a disproportionate change in system dynamics) has profound implications for management decisions and climate adaptation planning and response. The goal of this session is to follow on findings from our ECCWO5 workshop on tipping points and threshold analyses and to integrate across PICES and ICES working group efforts to synthesize findings and outputs from recent integrated modeling projects across the globe. In particular, the session will include presentations that (1) explore methods for detecting tipping points in marine ecosystems, (2) provide evidence and case studies for historical and future physical, biological, and social-economic tipping points and thresholds in marine systems, and (3) review progress towards inclusion of such information in actionable advice to support climate-informed Ecosystem Based Management.

**(S02 17830 Invited)**

**Approaches to detect tipping point and estimate the resilience of marine populations and communities**

Camilla **Sguotti**[1]

[1]University of Padova, Department of Biology, Via U.Bassi, 35100 Padova, Italy. E-mail: camilla.sguotti@unipd.it

In the face of global changes, resilient populations and ecosystems are necessary to maintain the critical service they provide to humanity. Yet it is still unclear how many impacts an ecosystem or a population can take before they are irrevocably changed. The increasing evidence of irreversible tipping point has brought the resilience concept to the spotlight in ecology. However, detecting tipping point and estimating resilience from empirical data of ecological systems is still complex and can be done by few methodological approaches. Here I show the application of CUSPRA to estimate resilience and detect irreversible tipping points. We developed CUSPRA as an extension of the stochastic cusp model, which models cusp bifurcations of a state variable depending on two interactive drivers. CUSPRA has three main characteristics: i) it provides estimates on how likely a system is to cross a tipping point, ii) it assesses resilience depending on multiple external pressures, iii) it provides straightforward results for ecosystem-based management. I apply CUSPRA to the Adriatic Sea community to estimate the resilience of the community to fishing pressure and temperature increase. The results show the impact of fishing and climate change on the resilience of ecological systems and are fundamental from an ecological but also socio-economic perspectives. While methods to estimate and understand the resilience of natural community exist, a step forward needs to be made to integrate them to be able to apply more efficient and useful management measures. This is crucial to adapt to present and future global changes.

**(S02 17847 Oral)**

**Revisiting bias correction of earth system models for climate-informed ecosystem based management**

Kelly A. **Kearney**[1] and Jennifer Bigman[2]

[1]NOAA Alaska Fisheries Science Center, Seattle, WA, USA email: Kelly.kearney@noaa.gov

[2]NOAA Office of Science and Technology, Seattle, WA, USA

Earth system models (ESMs) are increasingly being used to provide climate forecast information for ecosystem based management. While ESMs can fill in spatiotemporal gaps in observations and project changing conditions into the future, they are inherently imperfect representations of reality. Ecological systems are often constrained by specific environmental thresholds, and also respond nonlinearly to physical drivers such that small changes in environmental conditions can lead to substantial impacts on the ecosystem. Therefore, even small biases in ESM output can complicate interpretation of forecasted environmental change in a management context. Many methods for bias correction have been proposed, but there is no 'one size fits all' method that performs equally well across model variables and uses, correcting for problematic biases while preserving key aspects of the climate change signal. Here, we demonstrate this by exploring the impact of bias correction when deriving annual environmental indices for use in climate-informed management contexts. We explore the biases present in three variables extracted from a regional downscaling suite for the southeastern Bering Sea shelf: bottom temperature, primary production, and ice coverage. We then apply a suit of bias correction methods and examine the resulting annual index values derived from these three variables. Finally, we investigate the potential impact of bias correction choices through two case studies: 1) forecasting thermal spawning habitat for Pacific cod and 2) predicting observed zooplankton abundance from sea ice extent. Overall, we show that these biological models are sensitive to the choice of bias correction method.

**(S02 17868 Oral)**

**Preliminary study on the Artificial Intelligence-based climate change and marine environmental predictions**

Guimei **Liu**

Key Laboratory of Research on Marine Hazards Forecasting, National Marine Environmental Forecasting Center, Ministry of Natural Resources, Beijing 100081, China. Email: liugm@nmefc.cn

Marine ecosystems in the China Seas exhibits strong variations from seasonal to interannual timescale, and the climate change shows its direct impacts on the nutrients and phytoplankton dynamics. Climate change and marine environmental predictions mainly rely on numerical models. To enhance prediction skills and inter-predictability, we propose to use Artificial Intelligence methods to integrate numerical model forecast results, observation and reanalysis data for ENSO, SST, Chl-a etc. predictability study. The strength and trend changes of numerical model forecast results can assist in correcting errors in Artificial Intelligence, facilitating better integration and utilization of numerical model forecast and reanalysis data. ENSO intelligent prediction model is combined with numerical model forecast data. Deep Residual Network is used as the basic structure of deep model, that are substantially deeper than those used previously. These residual networks are easier to optimize, and can gain accuracy from considerably increased depth. This enables the extraction of effective ENSO forecast information from these two types of data. Focusing on ecological parameter predictions, particularly sea surface temperature (SST) and chlorophyll-a concentration, our review underscores the transformative impact of Artificial Intelligence (AI) in modeling complex, nonlinear relationships inherent to marine ecosystems. Principal Component Analysis (PCA) coupled with Back Propagation Neural Networks (BP), forming a PCA-BP model, specifically for nearshore SST forecasting is employed in Rongcheng coastal waters, Shandong Province. Implemented in 2021, this model outperformed traditional numerical and empirical forecasts, reducing errors and extending the prediction horizon. By leveraging deep learning's capability to distill essential features, it achieved higher temporal resolution, reduced computational demands, and better captured the dynamics relevant to marine weather and climate events. Moreover, a double-layered artificial neural network (ANN) for chlorophyll-a concentration forecasting, surpassing single-layered models in both accuracy and generalization is applied.

This work highlights the efficiency of refined data handling integrated with AI models, resulting in substantial enhancements to forecasting quality. These studies exemplify AI's potential to revolutionize marine forecasting, employing sophisticated statistical techniques to unravel complex ecological phenomena.

**(S02 17879 Oral)**

**Projected climate change and variability of krill population in California Current**

Jerome **Fiechter**[1], Megan Cimino[1,2], Monique Messié[3], Michael Jacox[2,4], Mercedes Pozo Buil[1,2] and Jarrod A. Santora[5]

[1]University of California Santa Cruz, Santa Cruz, USA. E-mail: fiechter@ucsc.edu

[2]NOAA Southwest Fisheries Science Center, Monterey, USA

[3]Monterey Bay Aquarium Research Institute, Moss Landing, USA

[4]NOAA Physical Sciences Laboratory, Boulder, USA

[5]NOAA Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, USA

We present results from a "super-ensemble" of downscaled regional climate projections for krill population dynamics in the California Current region. The super-ensemble encompasses three representative warming rates under a high-emissions scenario and three vastly different krill model formulations: an Eulerian biogeochemical model (NPZD-type), a Lagrangian growth-advection model, and a statistical species distribution model (SDM). Based on the 9 ensemble members (3 projections x 3 krill models), we present dominant modes of climate variability and long-term change that can be reliably identified across all model solutions. We also characterize whether uncertainty in identifying these responses is due to spread in projected future conditions (i.e., projection uncertainty) or spread in krill model formulation (i.e., model uncertainty). Our results indicate that krill concentrations will progressively decrease through the 21st century but pinpointing the exact rate of decline as a function of latitude is limited by projection uncertainty. In contrast, identifying the dominant modes of climate variability in different part of the California Current region is mainly limited by model uncertainty, although latitudinal patterns and links to basin-scale processes are generally consistent across ensemble members. We synthesize these findings by quantifying when future krill concentrations in various subregions of the California Current will become significantly different from historical conditions considering projection and model uncertainty.

**(S02 17936 Oral)** (ECOP)

**Red-shifted temperature variability in Alaskan marine ecosystems: implications for climate tipping points**

Emily R. **Ryznar** and Michael A. Litzow

Alaska Fisheries Science Center, NOAA Fisheries, Kodiak, USA. E-mail: emily.ryznar@noaa.gov

Red-noise (autocorrelated) variability increases the likelihood of abrupt, persistent shifts in physical and biological time series, so understanding the causes of red-shifted climate variability is important for understanding the potential for climate-forced ecosystem tipping points. Here, we evaluate the role of red-shifted variability as a cause of historical tipping points in the Eastern Bering Sea and Gulf of Alaska, evaluate possible causes of changing reddening over time, and discuss the implications for future physical-biological-social tipping points in these systems. Using time series of annual mean sea surface temperature (SST) from 1960-2023, we found that first-order autocorrelation (AR1) and interannual standard deviation (SD) have reached unprecedented high levels in recent years in both systems. This upward trend in AR(1) and SD values is not shared across other boreal and Arctic ecosystems, and is not predicted by a 21-member climate model under Shared Socioeconomic Pathway 2-4.5, leading us to conclude that increased reddening is not a consequence of climate change. Instead, we show that increased red-noise variability in these ecosystems can be explained by increasing interannual variability in the Aleutian Low. Recruitment to crab and groundfish stocks in these systems is often responsive to SST variability, and we show how historical ecosystem tipping points were triggered by large-magnitude, persistent shifts in SST that have become more likely with increased reddening and variability. We propose that improved understanding of the factors contributing to reddening of climate variability may provide a useful perspective on the likelihood of tipping points as ecosystems warm.

**(S02 17944 Oral)**

**Interacting impacts of prey availability and climate warming on future California sea lion reproductive success in the California Current System**

Barbara A. **Muhling**[1,2], Stefan Koenigstein[3], H. William Fennie[4], Rachel Seary[1,5], Steven J. Bograd[5], Megan A. Cimino[1], Alexandra Curtis[2], John Field[6], Elliott L. Hazen[5], Pierre-Yves Hernvann[1,7,8], Charles Hinchliffe[1,2], Michael G. Jacox[5,9], Isaac Kaplan[7], Elizabeth A. McHuron[10], Mercedes Pozo Buil[1,5], Sharon Melin[4], Jarrod A. Santora[7], Julie A. Thayer[11], Desiree Tommasi[1,2] and Andrew R. Thompson[2]

[1]University of California Santa Cruz, Santa Cruz, CA, USA. Email: barbara.muhling@noaa.gov

[2]NOAA Southwest Fisheries Science Center Fisheries Resources Division, La Jolla, CA, USA

[3]Leibniz Centre for Tropical Marine Research, Bremen, Germany

[4]NOAA Alaska Fisheries Science Center, Seattle, WA, USA

[5]NOAA Southwest Fisheries Science Center Ecosystem Science Division, Monterey, CA, USA

[6]NOAA Southwest Fisheries Science Center Fisheries Ecology Division, Santa Cruz, CA, USA

[7]NOAA Northwest Fisheries Science Center, Seattle, WA, USA

[8]DECOD, IFREMER, INRAE, Institut Agro, Nantes, France

[9]NOAA Earth System Research Laboratory, Boulder, CO, USA

[10]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA

[11]Farallon Institute, Petaluma, CA, USA

As climate change leads to novel environmental conditions and changes in trophic dynamics, top predators may be increasingly vulnerable to shifts in the forage base that they rely on. Small pelagic fishes such as northern anchovy (*Engraulis mordax*) are important prey for several top predators in the California Current System. During times when these energy-dense forage species are less abundant, predators may shift their diets to focus on prey that are lower quality or less energy-efficient to capture, reducing the energy available for reproduction. Previous work has shown that an indicator of anchovy spatial availability (the Anchovy Ecosystem Indicator: AEI) can predict reproductive success and pup weights for California sea lion (*Zalophus californianus*) in the central California Current. In this study, we combined the existing AEI with a temperature indicator to examine drivers of past reproductive success and pup weights in California sea lions. We then applied these models to future projections of anchovy biomass

derived from a process-based Model of Intermediate Complexity, and ecosystem conditions from multiple downscaled earth system models. Our results highlight the importance of interactions between climate-driven shifts in prey availability and ocean warming on future sea lion reproductive dynamics. In addition, model projections show changes in the future frequency and severity of "tipping points", where the combined impacts of prey availability and ocean conditions may drive sea lion pup mortality events. Due to their sensitivity to these drivers, California sea lions can act as "sentinel species" for ecosystem monitoring in the California Current. Their continued observation will be particularly valuable as climate change continues to drive shifts in ocean conditions and prey fields in the region.

**(S02 17985 Oral)**

**Climate Change and Marine Food Webs: Navigating Structural Uncertainty and its Impact on Salmon Survival**

**Crozier**, L.G, D. G. E. Gomes and D. D. Huff

Northwest Fisheries Science Center U.S.A. email: lisa.crozier@noaa.gov

Effectively modeling the impact of climate change on any population necessitates careful consideration of potential changes in interactions with other species. As communities reassemble and abundance and distribution shifts reverberate throughout ecosystems, cumulative impacts on species of conservation concern need to be explicitly examined. Furthermore, deliberate qualitative exploration of alternative responses to climate change from multiple components in a food web can inform the design and interpretation of quantitative models. Using salmon marine survival as a case study in a qualitative network analysis, we showed that the highest risks for salmon come from increased consumption by multiple competitor and predator groups. This scenario is consistent with observations during a recent marine heatwave. By testing 54 plausible representations of strong interactions within the marine food web, our work emphasized the importance of structural uncertainty in climate impact studies, paving the way for more targeted and effective research.

**(S02 17992 Oral)**

**Marine heatwaves disrupt ecosystem structure and function via altered food webs and energy flux**

David D. **Huff** [5], Dylan G. E. Gomes [1,2,6], James J. Ruzicka [3], Lisa G. Crozier [4], Richard D. Brodeur [5], and Joshua D. Stewart[1]

[1]Ocean Ecology Lab, Marine Mammal Institute, Department of Fisheries, Wildlife & Conservation Sciences, Oregon State University, Newport, OR 97365, USA.

[2]National Academy of Sciences NRC Postdoctoral Research Associateship, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA 98112, USA. [3]Ecosystem Sciences Division, Pacific Islands Fisheries Science Center, National Marine

[3]Fisheries Service, National Oceanic and Atmospheric Administration, Honolulu, HI 96822, USA.

[4]Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA 98112, USA.

[5]Presenter Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Newport, OR 97365, USA. Email: david.huff@noaa.gov

[6]Present address: Forest and Rangeland Ecosystem Science Center, United States Geological Survey, Seattle, WA 98195, USA.

Marine heatwaves are increasingly prevalent and intense globally, causing disruptions in local environmental conditions. While individual and population-level impacts on marine species have been documented, whole-ecosystem consequences remain largely unexplored. This study leverages time series abundance data of 361 taxa, grouped into 86 functional groups from six long-term surveys, diet data from a new database, and previous modeling efforts to build two food web networks using the Ecotran framework, an extension of the Ecopath ecosystem model. We compared ecosystem models parameterized before and after recent marine heatwaves to assess cascading effects on ecosystem structure and function in the Northeast Pacific Ocean. Significant changes were observed in the ecosystem-level contributions of most functional groups, with gelatinous taxa experiencing the largest transformations, highlighted by the northward expansion of pyrosomes. These altered trophic relationships and energy fluxes suggest profound implications for ecosystem structure and function, raising concerns for both threatened and harvested species.

**(S02 17997 Oral)**

**An updated end-to-end ecosystem model of the Northern California Current reflecting ecosystem changes due to recent marine heatwaves**

Jim **Ruzicka**[3], Dylan Gomes[1,2], Lisa Crozier[4], David Huff[5], Elizabeth Phillips[4], Pierre-Yves Hernvann[6], Cheryl Morgan[7], Richard Brodeur[5], Jen Zamon[8], Elizabeth Daly[7], Joseph Bizzarro[9], Jennifer Fisher[5] and Toby Auth[10]

[1]National Academy of Sciences NRC Research Associateship Program, Northwest Fisheries Science Center, Seattle, WA, USA

[2]Current address: Forest and Rangeland Ecosystem Science Center, United States Geological Survey, Seattle, WA, USA. Email: dylan.ge.gomes@gmail.com

[3]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, USA

[4]NOAA Northwest Fisheries Science Center, Seattle, WA, USA

[5]NOAA Northwest Fisheries Science Center, Newport, OR, USA

[6]Institute of Marine Sciences, University of California, Santa Cruz, Santa Cruz, CA, USA

[7]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, OR, USA

[8]NOAA Northwest Fisheries Science Center, Hammond, OR, USA

[9]Fisheries Collaborative Program, University of California, Santa Cruz, Santa Cruz, CA, USA

[10]Pacific States Marine Fisheries Commission, Newport, OR, USA

The Northern California Current is a productive upwelling ecosystem and home to both commercially harvested species and species protected under the U.S. Endangered Species Act. Recently, there has been a global shift from single-species fisheries management to ecosystem-based fisheries management, acknowledging that complex dynamics can reverberate through a food web. Here, we have integrated new research into an end-to-end ecosystem model (physics to fisheries) using data from long-term ocean surveys, phytoplankton satellite imagery paired with a vertically generalized production model, a recently assembled diet database, fishery catch information, species distribution models, and literature. This spatially-explicit model includes 90 living and detrital functional groups ranging from phytoplankton, krill, forage fish to salmon, seabirds, and marine mammals, and nine fisheries. This model was updated from previous regional models to account for recent changes occur off the coast of Washington, Oregon, and Northern California (increases in market squid and gelatinous zooplankton such as pyrosomes and salps); to increase spatial resolution; to include data from previously unincorporated surveys; and to improve characterization of endangered species, such as Chinook salmon (*Oncorhynchus tshawytscha*) and southern resident killer whales (*Orcinus orca*). Our model is ecologically plausible, without extinctions, and stable over 150-year simulations. Nutrient dynamics, primary production, and model-derived phytoplankton time series are within realistic ranges. As we move towards ecosystem-based fisheries management, we must continue to openly and collaboratively integrate disparate datasets and collective knowledge to solve the intricate problems we face. As a tool for future research, we provide the data and ecosystem model code.

**(S02 18014 Oral)** (ECOP)

**Data integration improves model performance in a changing climate**

Nima **Farchadi**[1], Camrin D. Braun[2], Martin C. Arostegui[2], Elliott L. Hazen[3,4], Barbara A. Muhling[4,5], Andrew Allyn[6], Kiva Oken[7], and Rebecca L. Lewison[1]

[1]San Diego State University, San Diego, CA email: nimafarchadi@gmail.com

[2]Biology Dept, Woods Hole Oceanographic Institution, Woods Hole, MA

[3]Environmental Research Division, NOAA Southwest Fisheries Science Center, Monterey, California, USA

[4]Institute of Marine Sciences, University of California Santa Cruz, Monterey, California, USA

[5]Fisheries Resources Division, NOAA Southwest Fisheries Science Center, La Jolla, California, USA

[6]Gulf of Maine Research Institute, Portland, Maine, USA

[7]Fishery Resource Analysis and Monitoring Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA 98112

Predicting shifts in species distribution in response to changing climate is essential for effective management and conservation decision-making. However, species distribution models (SDMs) have shown to have limited capacity to produce robust predictions under novel environmental conditions as they are typically trained with only one data source. With greater access to diverse data sources, integrated SDM (iSDM) approaches that leverage disparate data sources have shown to enhance model performance. Yet we have limited understanding of how robust iSDMs are to climate extremes. Here, we compare the performance of iSDMs with traditional SDM approaches that model each data source individually under Marine Heatwave (MHW) conditions for an important fishery resource, albacore tuna (*Thunnus alalunga*), in the Northeast Pacific. We contrasted traditional SDMs, trained on fishery-dependent vessel logbook data, with iSDMs that incorporated fishery-independent archival tag data, evaluating them across two dimensions: *predictive skill* and *ecological realism*. Models were trained on data from 2003 to 2013 and validated against albacore occurrences from 2014 to 2019, a period marked by multiple pronounced MHW events in the Northeast Pacific. Additionally, we investigated the relationship between *predictive skill* and *ecological realism* with environmental novelty and examined how it varies between iSDM and traditional SDM approaches. As access to diverse data sources continues to grow, maximizing our ability to leverage available data for accurate predictions of

species distributions will support the development of proactive, climate-ready management and conservation strategies in the face of climate extremes.

**(S02 18024 Oral)**

**Environmental drivers of species shift in Dokdo coastal waters**

Seokjin **Yoon**, Youngsun Song, Eunho Kim and Jung Hwa Choi

Dokdo Fisheries Research Center, National Institute of Fisheries Science, Pohang, Republic of Korea. E-mail: seokjinyoon@korea.kr

The coastal waters of Dokdo have experienced a notable shift in dominant fish species, transitioning from Ditrema temmincki to Chromis notata around 2017. This study aims to analyze the underlying environmental factors driving this species shift using an integrated approach. By combining environmental monitoring data, fish population surveys, and advanced AI modeling techniques, we investigated the relationships between environmental changes and species distribution. The AI models employed in this study identified and quantified the relative importance of various environmental factors, providing insights into complex interactions driving the species shift. Our findings indicate that this shift results from multiple environmental variables acting together rather than a single causative factor, underscoring the importance of a holistic, integrated approach to marine ecosystem management. Understanding these dynamics is crucial for ensuring the sustainability of marine resources in Dokdo and similar coastal regions. Our research highlights the necessity of ongoing monitoring and adaptive management to address the impacts of environmental changes on marine ecosystems. This includes the development of predictive models to forecast future shifts in species composition under various climate scenarios. These efforts align with the goals of climate-informed Ecosystem Based Management as discussed in the session, supporting the development of strategies to enhance the resilience and sustainability of marine ecosystems in the face of climate change.

**(S02 18025 Oral)**

**Evaluating climate-robust management strategies for environmentally-driven recruitment in transboundary fisheries: avoiding tipping points for Pacific Hake**

Kristin N. **Marshall**[1], Aaron Berger[2], Kelli Johnson[3], Eric J. Ward[3], Nick Tolimieri[3], Mary Hunsicker[2], Michael Jacox[4] and Mercedes Pozo-Buil[4]

[1]National Marine Fisheries Service, Northwest Fisheries Science Centers, Seattle, WA, USA. E-mail: kristin.marshall@noaa.gov

[2]National Marine Fisheries Service, Northwest Fisheries Science Centers, Newport, OR, USA.

[3]National Marine Fisheries Service, Northwest Fisheries Science Centers, Seattle, WA, USA.

[4]National Marine Fisheries Service, Southwest Fisheries Science Centers, Monterey, CA, USA.

Novel analytical approaches and forward-looking management solutions are needed as climate change threatens to push species across thresholds and 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 develop future projections of recruitment variability in Pacific Hake to inform long-term risk planning using management strategy evaluation. We explored recruitment scenarios forced by oceanographic models and conceptual scenarios informed by expert knowledge and investigated the robustness of the current harvest policy for Pacific hake. Recruitment projections suggest that shifting ocean conditions can shift the scale and frequency of strong cohorts of Pacific Hake, with implications for meeting sustainability objectives and avoiding tipping points. We will discuss the opportunities and challenges these approaches and results present for management of the Pacific Hake fishery, and transboundary fisheries more broadly.

**(S02 18046 Oral)** (ECOP)

**Exploring the impacts of warming timescales on top predator distributions in the California Current**

Meghan L. **Kaschner**[1,4], Nerea Lezama-Ochoa[1,2], Steven J. Bograd[1,2], Heather Welch[2,1], Michael Jacox[1,2,3], Allison Cluett[2,1], Andrew D. Barton[4], C. Anela Choy[4], Joshua A. Cullen[1] and Elliott L. Hazen[1,2]

[1]NOAA Southwest Fisheries Science Center, Ecosystem Science Division, Monterey, CA. USA.

E-mail: meghan.kaschner@noaa.gov

[2]Institute of Marine Science, University of California Santa Cruz, Santa Cruz, CA, USA.

[3]NOAA Physical Science Laboratory, Boulder, CO. USA.

[4]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA. USA.

Global long-term warming trends will intersect with internal climate variability in our future ocean in novel ways. Warming signals include the long-term, basin-wide trend; natural, low frequency variability, such as the Pacific Decadal Oscillation (PDO); and high-frequency marine heatwaves (MHW). When a warm PDO phase coincides with reduced upwelling on top of an increasing long-term warming trend, marine species can encounter extremely enhanced temperatures. Conversely, cool PDO phases may mitigate, or even hide, long-term warming trends. Previous studies have considered responses of Northeastern Pacific top predators to long term warming trends and MHWs independently, yet impacts of interactions between different warming timescales have not been explored. Here, we evaluate select top predators' responses to projected secular warming and variability using downscaled global climate CMIP5 model output between 1980 and 2100 in the California Current. We found long-term warming trends responsible for part of marine species' redistribution; high- and low-frequency natural variability were influential, too. While climate change has gradual long-term consequences, evaluating what happens during extreme events (e.g. periods when internal variability amplifies the warming trend) can give us a better understanding of future top predator distributions and how they could vary from past MHWs. Further, analyzing how climate change is likely to affect marine environments is important for proactive and effective ecosystem-based management.

**(S02 17901 Poster)** S02-P1 (ECOP)

**Ecosystem observations and evolving technology in Central & Northern California**

Alex R. **Harper**, Henry Ruhl, Amy West and Jason Adelaars

Central & Northern California Ocean Observing System (CeNCOOS), MBARI, U.S.A. email: AHARPER@MBARI.ORG

Biology and ecosystem variables are at the heart of many monitoring requirements for the marine environment, including for protected species and understanding natural hazards, as well as for managing fisheries, offshore energy, and mineral industries. Increasingly, biology and ecosystem information can be readily collected across a wide range of organism sizes in conjunction with physical and biogeochemical oceanographic data. This maturation of technologies, including Passive Acoustic Monitoring (PAM), environmental DNA (eDNA), tagging and imaging and efficient data processing technologies, presents a great opportunity to address information gaps by producing solutions with biogeochemical (BGC), biological, and ecosystem-level information required by stakeholders. The Central and Northern California Ocean Observing System (CeNCOOS) is revolutionizing traditional observing efforts through the incorporation of ecosystem monitoring techniques, including moorings and gliders to assess water properties and circulation; BGC and BioEco EOVs to address national, climate-mediated concerns, such as marine heatwaves, HABs, ocean acidification (OA); and animal movement, PAM, eDNA, and imaging to understand changing habitats of marine organisms to deliver information relevant for fisheries and ecosystem management. This work includes the launch of Synchro in 2023, a technology testbed in Monterey Bay, to accelerate technology solutions for ocean research and monitoring.

**(S02 17933 Poster)** S02-P2 (ECOP)

**Relevance of international trends in EBFM to Japanese fisheries management systems**

Hitomi **Oyaizu**

Japan Fisheries Research and Education Agency, Yokohama, Japan. E-mail: oyaizu_hitomi09@fra.go.jp

In recent years, ecosystem-based fisheries management (EBFM), which considers fisheries as one component of ecosystems and aims to manage fisheries to maintain the health and sustainability of marine ecosystems, has gained widespread acceptance in fisheries management policy. EBFM is a concept derived from the ecosystem approach proposed in the 1992 Convention on Biological Diversity and is a framework that provides a comprehensive "place-based" management framework for the whole ecosystem, as opposed to traditional single-species management. International trends in EBFM are therefore related to those in the ecosystem approach to fisheries and oceans. Following these international developments, studies related to EBFM have been actively conducted since 2000, in aspects such as defining the concept, examining frameworks for implementation, developing quantitative ecosystem indicators and evaluating integrated approaches. In particular, there has been much interest of recent studies in evaluating the methodologies and institutionalisation used to date. However, only a few cases have been evaluated on the development of the Japanese fisheries management system in relation to the development of international trends and research focusing on EBFM. In this study, through a literature review based on the collected bibliographic information, we present the development of Japanese fisheries management systems in relation to international trends and research on EBFM.

**(S02 17983 Poster)** S02-P3

**Widespread marine predator culls will not recover salmon populations**

Lisa G. **Crozier,** Dylan G.E. Gomes, James J. Ruzicka, David D. Huff and Joshua D. Stewart

Northwest Fisheries Science Center, U.S.A. email: lisa.crozier@noaa.gov

Pacific salmon are severely depleted due to historical and modern impacts, and management strategies have struggled to recover populations. Consumption of salmon by predators such as pinnipeds and seabirds has been suggested as a barrier to recovery, leading to calls for predator culls. However, no studies have evaluated the whole-ecosystem impact of removing predators or estimated the direct and indirect effects of these culls on salmon. We use an end-to-end ecosystem model to assess the efficacy of culls and other potential interventions. We find that culls have little to no positive effect on salmon, due to the indirect food web effects of predator reduction and the relatively low biomass of specialist top predator groups. Instead, more abundant fish predators, northward-expanding competitors, and temperature-sensitive prey have the largest effects on salmon.

**(S02 18066 Poster)** S02-P4 (ECOP)

## The ecological responses of tunas to Marine Heatwaves based on explainable artificial intelligence

Peng **Lian**[1,2], Wenbo Yang[1,2], Jing Zhao[3,4] and Xiong Zhang[5]

[1]Chinese Academy of Fishery Sciences, Beijing, China. E-mail: lianpeng@cafs.cn

[2]Experimental Station for Remote Sensing Scientific Observation of Fisheries, Ministry of Agriculture and Rural Affairs, Beijing, China

[3]State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing, China

[4]National Earth Observation Data Center, Beijing, China

[5]Sun Yat-sen University, Shenzhen, China

The sustainable use of marine biological resources is facing severe challenges from extreme marine heat events. Marine heatwaves(MHWs), as widespread and frequent marine ecological disasters, pose a significant threat to tuna populations. The Pacific Ocean, as the origin of warm pools and El Niño events, is a crucial region for studying global climate changs and is also an important fishing ground for tuna fisheries. Currently, it is unclear how MHWs modulate the dynamics of tuna fishing grounds. This study, based on spatiotemporal grid datasets of global tuna production in the Western and Central Pacific from 2000 to 2022, high-precision production datasets, and multidimensional marine environmental datasets, employs a lightweight tuna fishing ground disaster prediction model using partial dependence plot (PDP) Transformer to explore the response of three major tuna species to MHWs and the sensitivity of their spatiotemporal modes to different MHWs indicators. The study found that MHWs have a significant spatiotemporal modulation effect on tuna, with the spatial modes of fishing grounds exhibiting four main distribution types corresponding to different heatwave intensities and durations. Furthermore, high-frequency heatwave events accelerate the fragmentation of tropical Pacific tuna habitats and the polarization of fishing ground centroids. This study provides important insights into the ecological impacts of MHWs on highly migratory fish species.

**(S02 18145 Oral)** (ECOP)

**North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME) to inform fisheries management under climate change**

Vivitskaia **Tulloch**[1], Kathryn Berry[1], Julia Blanchard[2], Cheryl Harrison[3], Kelly Ortegas-Cisneros[4], and Robin Brown[1]

[1]North Pacific Marine Science Organization, Victoria, Canada. Email: Viv.Tulloch@pices.int

[2]University of Tasmania, Tasmania, Australia.

[3]Louisiana State University, Baton Rouge, United States.

[4]University of Cape Town, Cape Town, Africa.

Climate change could irreversibly modify ocean ecosystems. Marine ecosystem model (MEM) ensembles can assist policy making by projecting future changes and allowing the evaluation and assessment of alternative management approaches. However, projected future changes from Earth System Models (ESMs) and MEMs highlight an uncertain future for the Pacific Ocean, indicating the need for improved region-specific ensemble modelling frameworks that address some of these uncertainties, particularly at lower trophic levels. To build confidence in regional MEMs as ecosystem-based management tools in a changing climate, we are developing a North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME) linked to climate change. The framework builds on a Southern Ocean Marine Ecosystem Model Ensemble (SOMEME) simulation protocol that contributes to the Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP) global and regional model intercomparison initiatives. As a first step, we propose a NOMEME simulation protocol based on regional pilot projects in the eastern North Pacific, where ecosystem models are becoming more prevalent to solve problems for fisheries under climate change, that includes: skill assessment of environmental forcing variables for Pacific Ocean regions; extension of the global fishing forcing data to include regional fisheries catches; and new simulations that assess ecological links to climate processes in an ensemble of candidate regional MEMs that include key fisheries stocks, addressing future climatic variability and uncertainty. Standardizing ecological and fishery-related outputs across ecosystem models facilitates comprehensive analyses, aiding management efforts and informed policy-making in response to climate challenges across North Pacific Ocean ecosystems.

# S3: FUTURE/FIS/HD/MONITOR Topic Session

**Advanced tools to monitor, observe, and assess small pelagic fish populations in support of ecosystem based fisheries management and maintaining ecosystem services**

Convenors:
Jennifer Boldt (Canada), *corresponding*
Rebecca Asch (USA)
Matt Baker (USA)
Chris Rooper (Canada)
Dongwha Sohn (Korea)
Kresimir Williams (USA)

Invited Speakers:
Vaneeda Allken (Institute of Marine Research (IMR), Bergen, Norway)
Minkyoung Bang (Korean Institute of Ocean Science and Technology (KIOST), Korea)

Small pelagic fish are important components of fisheries and marine ecosystems worldwide. Yet for many species, there is limited information on the consequences of climate change and multiple stressors. Information on pelagic fish distribution, habitat use, and the pressures that affect them is required for sustainable and ecosystem based approaches to fisheries management. Recent advances in technologies, empirical analytical tools, and models can lead to better observations and improved understanding of pelagic fish. In this session, we invite presentations that elucidate the effects of climate change and other pressures on the distribution and productivity of small pelagic fish through advanced technologies in sampling and observational tools (e.g., optics, eDNA, modified trawls, autonomous vehicles), analytical tools (e.g., automated image and acoustics analyses, advances in processing remotely collected data, using diet analyses to develop indices of abundance and distribution), and modeling techniques (e.g., artificial intelligence, spatio-temporal and other statistical methods, incorporating the environment into ecosystem models and ecosystem considerations into stock assessments). Advances in tools used for monitoring, observing, and assessing will improve our ability to predict and manage small pelagic fish populations, which is critical for both ecosystem-based fisheries management and communities that rely on marine resources. This will address the United Nations Decade of Ocean Science’s mission of developing the “science we need for the ocean we want”.

**(S03 17842 Invited)**

**A deep learning-based method to identify and count small pelagic and mesopelagic fishes from trawl camera images**

Vaneeda **Allken**, Shale Rosen, Nils Olav Handegard and Ketil Malde

Institute of Marine Research Norway email: vaneeda.allken@hi.no

Environmental monitoring of marine life is typically done via acoustic-trawl surveys but it can be challenging to assign the acoustic signal to the correct species or group of species. Some trawls are now equipped with camera systems that can provide high-resolution ground truth for the presence of species through the examination of images captured at known positions in the trawl track. We trained a deep learning algorithm (RetinaNet) to automate the process of image-based fish detection and identification and focus on the detection of small pelagic fishes (blue whiting, Atlantic herring, Atlantic mackerel) and mesopelagic fish from images collected in the Norwegian sea. To address the need for large amounts of annotated data to train these models, we used a combination of real and synthetic images, and obtained a mean average precision of 0.845 on a test dataset of 918 images. Regression models were used to compare predicted fish counts, which were derived from our model predictions in the individual image frames, with catch data collected at trawl stations. This method yields estimates of species distribution at fine scale for better interpretation of acoustic results, can detect fish that are not retained in the catch due to mesh selection and could enable trawl surveys to operate without extracting fish from their habitat.

**(S03 18107)** (ECOP)

**Projecting future seasonal distribution of small pelagic fishes under continued ocean warming in Korean waters**

Minkyoung **Bang**[1], Dongwha Sohn[2], Jung Jin Kim[3], Wonkeun Choi[1,4], Elliott Lee Hazen[5,6], Sukyung Kang[4], and Chan Joo Jang[1,4,7]

[1]Korea Institute of Ocean Science and Technology, Busan, Korea. Email: cjjang@kiost.ac.kr

[2]Institute of Mathematical Sciences, Pusan National University, Busan, Korea

[3]National Institute of Fisheries Science, Busan, Korea

[4]University of Science and Technology, Daejeon, Korea

[5]Southwest Fisheries Science Center, National Oceanographic and Atmospheric Administration, Monterey, California, USA

[6]University of California Santa Cruz, Santa Cruz, California, USA

[7]Ocean Science and Technology School, Korea Maritime and Ocean University, Busan, Korea

Small pelagic fishes are a commercially and ecologically important component and are highly sensitive to environmental changes, shifting their spatial distribution due to climate change in recent decades. Although environmental changes are projected to be significant globally, it is still required to explore potential distribution shifts in the future. In this study, we investigated future seasonal changes in the distributions of anchovy (*Engraulis japonicus*) and mackerel (*Scomber japonicus*) in Korean waters in the 2050s by using species distribution models with climate model (CMIP 5 & 6). Seasonal distribution models were fitted using species 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). The distribution models projected future changes in mackerel habitat in Korean waters with high seasonal and regional variability, showing an increase from winter to spring, and a decrease in summer and fall in the future. The habitat gains and losses of both species were mainly driven by predicted temperature increases and salinity decreases. In addition, contractions in the potential distributions in each spawning season could lead to contractions in the spawning habitat, which could considerably alter the abundance and timing of the spawning habitat and in turn fisheries productivity. Our findings suggest that the future seasonal changes in the two species distribution and their potential impacts on fishing communities should be considered in order to effectively plan future management strategies, particularly for small pelagic fishes—environmentally sensitive species.

**(S03 17736 Oral)**

**The role of upwelling fronts in structuring trophic dynamics and ecosystem function.**

Brian K. **Wells**[1,2], Jarrod A. Santora[1], David Huff[2], Meredith Everett[3], and Jack Barth[4]

[1]SWFSC, Fisheries Ecology Division, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Santa Cruz, CA, USA. E-mail: brian.wells@noaa.gov

[2]NWFSC Fish Ecology Division, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Newport, OR, USA

[3]NWFSC Conservation Biology Division, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA

[4]College of Earth, Ocean, and Atmospheric Sciences, Corvallis, OR, USA

Ecosystem function and structure are defined by biophysical pressures at multiple spatial and temporal scales. Namely, basin conditions prepare the coastal system of the California Current Ecosystem for productivity and larger-scale transport strength. Embedded in the larger system are regional systems defined by coastal promontories that, in concert with larger wind patterns, define the upwelling dynamics (e.g., timing and strength). At this scale, forage communities are defined relative to their assemblage and abundance. At the finer scale, the fronts associated with upwelling plumes can aggregate forage and predators. Hence, fronts may act to increase trophic interactions and, therefore, are a primary determinant of ecosystem functioning. Ultimately, salmon, a prey and predator, could use these fronts where they can potentially interact with more prey but also with predators (e.g., seabirds). There is support that the presence of fronts increases the likelihood of increased population survival. Specifically, the occurrence of fronts that are present during out-migration timing is correlated to the survival and recruitment of salmon to the fishery. We argue it is critical to quantify the role of fronts and upwelling plumes in structuring ecosystems such that we can inform ecosystem-level models to improve salmon and ecosystem management. The research we present has four primary goals: 1. Characterize ecosystem structure around fronts including physical and biological data (e.g., eDNA, trawls, passive acoustics, and CTDs) 2. Define how salmon and predators interact with fronts, and 3. Examine the utility of Slocum gliders for diagnosing and examining these smaller-scale features within a larger-scale survey. To address the goals, we develop a strategy employing NOAA Fisheries Survey Vessels and a small boat-based design combined with a Slocum glider program. In doing so, we used the ship to quantify regional-scale dynamics while the glider, within that region, diagnosed ecosystem structure around fronts and within and out of the upwelling plume.

**(S03 17738 Oral)** (ECOP)

**Random forest regression models in ecology: accounting for messy biological data and producing predictions with uncertainty**

Caitlin **Allen Akselrud**

Southwest Fisheries Science Center, NMFS, NOAA, La Jolla, California. E-mail: caitlin.allen_akselrud@noaa.gov

Machine learning methods such as random forest regression models are increasingly useful tools in ecology when applied correctly, although features inherent to ecological data sets can lead to over-fitted or uncertain predictions. Here, a set of methods is outlined to account for temporal autocorrelation, and sparse, short, or missing data for random forest predictions. Methods are also provided for estimating prediction uncertainty due to the inherent randomness in the random forest algorithm.

This research focuses on methodological improvements to using the random forest algorithm to produce numerical predictions from ecological data, employing the example problem of forecasting fishery catch for the California market squid fishery (Doryteuthis opalescens) using relative indices of abundance, a prey index, previous catch, and environmental indices. The methodology is generalized into six components: data structuring, cross-validation implementation, model tuning with training data, assessing epistemic uncertainty of the fitted model, model application to testing data, and model selection. The market squid example includes applying a cross-validation method to the training data to account for temporal autocorrelation, and temporally structuring the testing data to reflect short-term predictions. Expanded hyperparameter testing methods and a new method for ascertaining the epistemic uncertainty of the training set are developed due to the limited and sparse data. There is also a comparison among several models with data lags structured differently to reflect possible life history strategies of market squid, and a comparison to a simple regression. These methods improved model stability under the limitations of actual fisheries data.

**(S03 17743 Oral)**

**Automated stereocameras to assess movement in a pelagic forage fish**

Matthew R **Baker**, TS Smeltz, Kresimir Williams, Casey Greufe, Megan Ewing, Jonathan Chapman, Julia Glassy, Eva Hasegawa, Kathleen Cieri, Sofia Matson, Rick Towler

North Pacific Research Board (NPRB), U.S.A email: Matthew.Baker@nprb.org

Much of what is known about movement in fishes comes from fisheries acoustic vessel-operated surveys, archival tags, net surveys, commercial fisheries harvest, or observational studies. Increasingly, autonomous instrumentation has been applied to collect data through remote means. In collaboration with NOAA Midwater Assessment and Conservation Engineering, we applied stereocamera arrays to observe movement patterns and vertical distribution of sandlance – an ecologically and commercially important forage fish in northern hemisphere marine systems. Specifically, we used these instruments to characterize diel vertical migration – an evolved response to maximize foraging and minimize predation. Modelling these dynamics has relevance to marine ecosystem dynamics, predator–prey interactions, and marine food webs. Stereocamera arrays were deployed using custom-built system of Chameleon-3 machine vision cameras, reduced instruction set computer (RISC, Acorn Computers Ltd.), system computer (ODroid XU4), and power circuit and strobe. We combine these data with tank observations and applied beta regression models to define mathematical functions of emergence curves, patterns in ascent and descent, and response to light and seasonal cues. Results document crepuscular movement patterns and critical light thresholds necessary to initiate and maintain pelagic foraging. Results also suggest the importance of seasonality and life stage. Stereocameras have been demonstrated to provide cost-effective and accurate data on species identity, abundance, size, and other factors. Application in this study allowed us to better characterize behavioral patterns and availability of this forage fish to marine predators and provide greater insight to patterns in diurnal emergence, potentially relevant to other small pelagic fishes.

**(S03 17781 Oral)** (ECOP)

**Length estimation of curved fish using zero shot learning**

Yuka **Iwahara**[1], Yasutoki Shibata[1], Masahiro Manano[1], Tomoya Nishino[2] and Hiroki Yaemori[2]

[1]Fisheries Resources Institute, National Research and Development Agency, Japan Fisheries Research and Education Agency, Yokohama, Kanagawa, Japan, E-mail: iwahara_yuka58@fra.go.jp

[2]Computermind Corp., Nishi-Shinjyuku, Tokyo, Japan

Deep learning for fish images has been used to estimate the length composition of fish in commercial catches for stock assessment in recent years. However, studies on the total length of curved fish are limited. In addition, deep learning requires a large amount of training data to detect fish, which makes it difficult to adapt deep learning to various measurements. In this study, we detected curved fish using a zero-shot model and estimated their total length using the image thinning. We manually measured the total length one for each of the five species, Sphyraena pinguis, Sardinops melanostictus, Lepidotrigla microptera, Lateolabrax japonicus, and Trichiurus lepturu. Fish bodies were intentionally bent for the experiment and photographed several times. Fish areas were masked in two ways; manually and with GroundedSAM. The total length curved fish was estimated using image thinning by detecting the centerline of the fish body. The average of the error from the actual total length was calculated to evaluate accuracy. Average estimation errors were 1.4% for manually masked fish. The error for L. japonicus was the largest among the species. They have larger fins compared to other species, which caused distortions in the detection of the centerline of the fish body. The average estimation error using the fish bodies detected by GroundedSAM was -0.9%. Although the length estimation was 0.5% shorter than that of manually masked fish, the estimation accuracy is almost equal to that of manual masking. Our method is useful for length estimation of curved fish without learning.

**(S03 17784 Oral)** (ECOP)

**Distribution of Fish Communities Around Japan: Insights from eDNA Methods**

Yuan **Lin**[1,2], Zeshu Yu[1], Sk Istiaque Ahmed[1,2], Xueding Wang[1,2], Tomihiko Higuchi[1], Itsuka Yabe[1], Sachihiko Ito[1], Eisuke Tsutsumi[3], Hiroaki, Saito[1], Kosei Komatsu[1], Atsushi Tsuda[1], Yusuke Kawaguchi[1], Eitarou Oka[1], Kyoko Okino[1], Hajime Obata[1], Yuki Minegishi[1], Hideki Fukuda[1], Marty Kwok-Shing Wong[1], Jun Inoue[1], Susumu Hyodo[1] and Shin-Ichi, ITO[1]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo, Japan.

E-mail: linyuan@g.ecc.u-tokyo.ac.jp

[2]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Japan

[3]Faculty of Fisheries, Kagoshima University, Japan

The Northwest Pacific, with its abundant fisheries resources, significantly supports the global fisheries economy. In the Northwest Pacific, small pelagics showed dominated biomass and large fluctuations in their populations. But, the fluctuation mechanism is still unclear. One of the lacks of information is fish community structure surrounding small pelagics. Environmental DNA (eDNA) provides a non-invasive, high-throughput approach to monitoring biodiversity and fish community structure surrounding small pelagics.

We analyzed nearly five years of eDNA data from 17 surveys around Japan, from coastal to open ocean. Sampling 193 stations at 0-200 meters depth, we collected 1031 samples. The detected species are dominated by pelagic or mesopelagic species including major small pelagics. Hierarchical clustering divided these into eight groups based on species presence/absence. Detected species number was the highest in the cluster located in warm waters around southern Japan, and the lowest in the cluster located in the Oyashio-Kuroshio Inter-frontal Zone. Statistical tests indicated significant differences in Shannon and Simpson indices among groups and the tendency is similar to that of the detected species number. However, the sampling efforts were different between the clusters. Therefore, species accumulation curves were compared and the results showed the highest biodiversity in the southern Japan, but the Oyashio-Kuroshio Inter-frontal Zone ranked second. NMDS based on Jaccard index also highlighted distinct fish communities between the clusters and the potential influence of environments. Monitoring not only small pelagics but also surrounding fish community structure is essential to manage small pelagic fish populations sustainably under future climate change.

**(S03 17785 Oral)** (ECOP)

**Applications of Computer Vision in Underwater Ecology: A Case Study from the Northeast Pacific**

Talen K.L. **Rimmer**[1], Declan Mcintosh[1], Colin R. Bates[2], Tom Zhang[1], Alexandra Branzan Albu[1], and Francis Juanes[1].

[1]University of Victoria, B.C., CAN. E-mail: trimmer@uvic.ca

[2]University of British Columbia, B.C., CAN

The world's oceans are undergoing rapid changes due to climate change and other anthropogenic impacts, affecting marine species' distribution, abundance, and behavior. Ecological monitoring methods often struggle to keep pace with these transformations, especially in underwater habitats. Recently, computer vision techniques have emerged to enhance the efficiency of video and image-based underwater monitoring, though adoption has been slow due to its inaccessibility to ecologists, and the lack of easily adaptable tools for ecological monitoring.

This study investigates the application and validation of computer vision techniques for monitoring underwater pelagic macrofaunal diversity, using a case study from coastal British Columbia. Over 9000 hours of underwater video were collected from four sites over 18 months, using mounted cameras programmed to record five minutes of video every hour. A supervised computer vision model (YOLOv8) was trained with approximately 240,000 annotations to assess the presence and abundance of marine species at these sites. This approach provided high-resolution temporal data on the diversity and abundance of pelagic fish and gelatinous zooplankton at these sites.

We detail our process of employing computer vision techniques for long-term underwater ecological monitoring, emphasizing accessibility for ecologists. An iterative stepwise method for adapting supervised computer vision models to achieve biodiversity monitoring objectives is presented, and the strengths and limitations of our approach are discussed. Finally, we propose future directions for integrating these technologies into new and existing monitoring programs, and suggest priority areas for future research to advance the use of computer vision in underwater ecological monitoring.

(S03 17809 Oral)

**Estimation of length composition by species from images of catches obtained using a fish image analysis system using deep learning (FIAS-Deep)**

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

[1]Fisheries Resources Institute, National Research and Development Agency, Japan Fisheries Research and Education Agency, Yokohama, Kanagawa, Japan, E-mail: shibata_yasutoki20@fra.go.jp

[2]CCS Inc., Kamigyo-ku, Kyoto, Japan

[3]Computermind Corp., Shinjyuku-ku, Tokyo, Japan

[4]Japan NUS Co., Ltd., Shinjyuku-ku, Tokyo, Japan

The length composition of fish catches is fundamental information for stock assessment, but a shortage of measurers directly increases uncertainties of the result. Using image analysis technologies such as deep learning, length composition can be obtained from fish images without relying on the number of measurers. However, Japan has a larger number of small vessels compared to overseas, making it difficult to obtain images of catches on board, as seen in many previous studies. This study aims to evaluate length composition by species estimated using a fish image analysis system (FIAS-Deep) which is designed to capture images of fish catches onshore.

We developed an image analysis system, FIAS-Deep, which comprises two subsystems: a training and inference subsystem capable of executing learning using deep learning and inference with newly provided images, and an image capture subsystem that acquires images from cameras installed on such as conveyors. Over 10,000 fish images, including those obtained from the capture subsystem installed at Matsuura fish market, Nagasaki, in October 2023, were used to train a model with Mask R-CNN. For comparison, the total lengths of some species including Japanese jack mackerel Trachurus japonicus landed by purse seine fishing at Matsuura fish market were measured individually. At the same time as the manual measurements, images were captured through the image capture subsystem. Subsequently, length compositions by species were obtained using the training and inference subsystem. This report presents the results of comparing the length compositions by species obtained through manual measurements with those obtained through FIAS-Deep.

**(S03 17871 Oral)** (ECOP)

**Biogeographic patterns of two typical mesopelagic fishes in the Cosmonaut Sea through a combination of environmental DNA and trawl survey**

Yehui **Wang**[1], Chunlin Liu[1], Mi Duan[1], Peilong Ju[2], Wenchao Zhang[1], Shuyang Ma[1], Jianchao Li[1], Jianfeng He[3] and Yongjun Tian[1]

[1]Ocean University of China, Qingdao, China. E-mail: yjtian@ouc.edu.cn

[2]School of Fishery, Zhejiang Ocean University, Zhoushan, China

[3]Polar Research Institute of China, Shanghai, China

The Antarctic lanternfish (Electrona antarctica) and the Antarctic deep-sea smelt (Bathylagus antarcticus), as two representative and dominant mesopelagic fishes in the Southern Ocean, play an important role in connecting different trophic levels and maintaining ecosystem stability. However, due to the limitations of remote and extreme environments on traditional sampling, there are still gaps in our knowledge of the habitat and distribution of these mesopelagic fishes. In this context, environmental DNA provides a promising choice. Here, we investigated the biogeographic patterns of these two typical mesopelagic fishes using 20 midwater trawl samples and 187 eDNA samples collected in the Cosmonaut Sea during two cruises in 2021-2022. Two sets of species-specific primers and probes were developed for quantitative eDNA analysis of two fish species. Both eDNA and trawl results indicated that the two fish species are widely distributed in the Astronaut Sea, with no significant difference in eDNA concentration, biomass and abundance between stations. However, the E. antarctica tended to be distributed in shallow waters, while the B. antarcticus tended to be distributed in deep waters. Vertically, the E. antarctica was more abundant above 500m, while the B. antarcticus had a wider range of habitat depths. Both species exhibited a distribution pattern affected by nutrients, with the distribution of E. antarctica additionally affected by chlorophyll, indicating that their distribution is influenced by food resources. Our study provides a broader insight into the biogeographic patterns of the two fish species, contributing to future ecosystem studies and fisheries management in the region.

**(S03 17925 Oral)** Non-Scheduled Pre-Recorded

**Assessment of pelagic fish density using a stereo camera**

Kresimir **Williams**[1], Christopher Rooper[2], and Matthew Phillips[1]

[1]Alaska Fisheries Science Center, Seattle, WA, USA. E-mail: kresimir.williams@noaa.gov

[2]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada

Pelagic fishes are traditionally sampled using acoustic instrumentation, scientific trawling or a combination of these methods. While these methods are effective, they require large investments in survey operations and equipment and are potentially limited by gaps in information on trawl selectivity and acoustic reflectance of individual species and sizes of fishes. Cameras can provide more direct observation data on fish presence, although they have a substantially smaller sampling coverage than trawls or acoustics. Cameras usually only provide indices of relative abundance based on counts, including metrics such as the maximum number seen in any image. The use of stereo cameras enables estimation of fish size, but also provides fish range from the camera in absolute units, which can be leveraged to estimate density of fish around the cameras. Here we demonstrate a method for estimating volumetric density for several groups of small pelagic fishes, including young-of-the-year walleye pollock (*Gadus chalcogrammus*), Pacific capelin (*Mallotus catervarius*), and Pacific herring (*Clupea pallasii*). Species-specific range-dependent detection functions are computed for each species, and applied to estimates of imaging volume based on the stereo camera calibration. The results show a direct estimate of density that is comparable between species and deployments, and standardized across different calibrated stereo camera setups. In addition, a method for camera deployment that minimizes camera platform movement in the water is shown. This approach can improve image quality and reduce fish avoidance reactions, which can cause biased observations.

**(S03 17979 Oral)**

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

Jim **Ruzicka**[1], Stacy Calhoun-Grosch[2], Jesse Van Der Grient[3], Jacob Snyder[4] and Réka Domokos[1]

[1]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, USA. Email: james.ruzicka@noaa.gov

[2]University of Louisiana, Lafayette, LA, USA

[3]South Atlantic Environmental Research Institute (SAERI), Stanley, Falkland Islands

[4]Penn State University, State College, PA, USA

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.

**(S03 17799 Oral)** (ECOP)

**Automatic detection and measurement of otolith using zero-shot learning**

Masahiro **Manano**[1], Yuko Hiraoka[1], Yasutoki Shibata[1], Yuka Iwahara[1] and Daisaku Masuda[2]

[1]Fisheries Resources Institute, National Research and Development Agency, Japan Fisheries Research and Education Agency, Yokohama, Kanagawa, Japan, E-mail: masahiro_manano94@fra.go.jp

[2]Nagasaki Prefectural Institute of Fisheries, Taira, Nagasaki, Nagasaki, Japan

The body length (BL) composition of prey is important for studying target fish stocks. This is often determined by measuring the otolith length (OL) from stomach contents and using the known OL-BL relationship. However, measuring OL is time-consuming and involves both inter- and intra-measurer error. Although automated measurement using supervised deep learning has been attempted in fisheries studies, it still requires significant effort and time to prepare the training data. Recently, a deep learning technique called "zero-shot learning" has been developed that does not require any training data. In this study, aiming to reduce labor and improve repeatability in obtaining size composition from otoliths, we used zero-shot learning to automatically detect otoliths from images and estimate OL. We measured OL of 121 Japanese anchovies (Engraulis japonicus; 35.65-128.54 mm BL) and photographed multiple otoliths with a scale. We then used the Grounded-Segment-Anything model to detect scales and otoliths and create masks. Minimum bounding boxes were assigned to the masks, taking the length of the longer side as OL estimates. Relative biases were calculated for measured and estimated OL to evaluate estimation accuracy. The model successfully detected all 121 otoliths without prior training. Relative bias was about -1.4% for OL estimates. It is thought that OL was underestimated because the longer side of the bounding box was shorter than actual OL due to distorted masking. More accurate masking with few-shot learning could improve OL estimate accuracy.

**(S03 18018 Oral)** (ECOP)

**Eye lens isotopes reveal different migration ecology of European sardine and anchovy**

Tatsuya **Sakamoto**[1,2] and Susana Garrido[2]

[1]The Hakubi Center for Advanced Research, Kyoto University, Kyoto, Japan. E-mail: sakamoto.tatsuya.3p@kyoto-u.ac.jp

[2]Instituto Português do Mar e da Atmosfera, Lisboa, Portugal.

Small pelagic fish such as sardines and anchovies play an important role in energy transfer in productive coastal ecosystems. While their movements can significantly influence trophodynamics and biogeochemical cycles in habitats, their migration ecology has been difficult to understand due to their small size, which makes artificial tagging difficult. In this study, we introduced stable isotope analyses of carbon and nitrogen in eye lenses to understand the population structures and migration ecology of the European sardine Sardina pilchardus and anchovy Engraulis encrasicolus. Adult and juvenile specimens of both species were collected during cruises between 2016 and 2022 off the north, west and south coasts of the Iberian Peninsula, the western Mediterranean and north-west Africa. The isotopes in the muscles of the anchovies showed significant geographical differences, probably due to different isotope baselines. Accordingly, the isotopes in the eye lens cores of juvenile sardines and anchovies showed similar geographical differences: higher $\delta^{15}N$ off the Portuguese south coast, lower $\delta^{15}N$ in the Mediterranean and lower $\delta^{13}C$ off the Portuguese west coast. The eye lens isotopes of adult anchovy showed similar geographical differences to those of juvenile anchovy, suggesting limited movements of adult anchovy. In contrast, adult sardine eye lens isotopes in each region showed a variety of values that differed significantly from the pattern observed in juvenile sardine, demonstrating that sardines are more likely to leave their nursery area and move freely between regions. These results have important implications for fisheries management as they contradict current stock boundaries, and suggest that the change in dominance of sardines and anchovies may have a significant impact on biogeochemical cycles and energy flows across ecosystems in European waters.

**(S03 18020 Oral)** (ECOP)

**Using lower trophic levels to identify habitat for small pelagics in the Bering Sea, 2002-2023**

Jens **Nielsen**, Margaret Siple, Alex Andrews, Cheryl Barnes, Lewis Barnett, Lisa Eisner, Jeanette Gann, Jeremy Harris, David Kimmel, Calvin Mordy, Jodi Pirtle, Lauren Rogers, Sean Rohan, Elizabeth Siddon, Genoa Sullaway and Ellen Yasumiishi

NOAA Alaska Fisheries Science Center email: margaret.siple@noaa.gov

Small pelagic fishes (SPFs) and zooplankton transfer energy from phytoplankton to piscivorous predators in large marine ecosystems. In the Bering Sea, Alaska, interannual and long-term climate variation drives ice cover, wind, and sea surface temperature, which in turn influence phytoplankton population dynamics and interactions with higher trophic levels. Previous studies indicate differences between warm and cold years in the total abundance and distribution of SPFs. The mechanism for this may be related to spatial and temporal mismatches between SPFs, their zooplankton prey, and the phytoplankton base of the food web.

We examine the distributions of three SPFs: Age-0 walleye pollock (*Gadus chalcogrammus*), capelin (*Mallotus villosus*), and Pacific herring (*Clupea pallasii*) relative to *in situ* measurements of chlorophyll *a* (Chl-*a*) concentration and zooplankton density (*Calanus* spp., *Neocalanus* spp., and *Pseudocalanus* spp.). We fit spatial generalized linear mixed models to data from the Alaska Fisheries Science Center's Bering Arctic Sub-Arctic Integrated Surveys.

The spatiotemporal analyses suggest that Chl-*a* is associated with higher densities of all three SPFs. Our results are also consistent with earlier studies that found higher densities of capelin and lower densities of age-0 pollock and herring in "cold" years with later ice retreat and cooler overall temperatures.

This work shows how climate affects SPF and their prey. Our results suggest that higher abundances of SPFs occur in high-productivity areas where primary producers are also abundant. This result has implications for ecosystem-based fisheries management of small pelagics, including a step towards describing habitat for prey of Essential Fish Habitat species.

**(S03 18054 Oral)**

**Coupling small pelagic fish distribution models to complex ecosystem models: tools and choices to support ecosystem-based fishery management and climate assessment**

Isaac C. **Kaplan**[1], Elliott L. Hazen[2,3], Stefan Koenigstein[2,3], Nerea Lezama Ochoa[2,3], Mariana Hill Cruz[4], Pierre-Yves Hernvann[1,3,5], Owen R Liu[1], Dylan G.E. Gomes[1,15], Sebastian I. Vásquez[6,7], Criscely Lujan[8], Stephanie Green[10], Matthew R. Baker[11,13], Ricardo Oliveros-Ramos[8,12], Alberto Rovellini[13], Rebecca G. Asch[14], and Barbara Muhling[2,3]

[1]Northwest Fisheries Science Center, National Marine Fisheries Service, NOAA, Seattle, WA, USA. E-mail: Isaac.Kaplan@noaa.gov

[2]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, USA

[3]Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA, La Jolla, CA, USA

[4]GEOMAR Helmholtz Centre for Ocean Research, Kiel, Schleswig-Holstein, Germany

[5]DECOD (Ecosystem Dynamics and Sustainability), IFREMER, INRAE, Institut Agro, Nantes, France

[6]Instituto de Investigación Pesquera, Talcahuano, Chile

[7]Universidad de Concepción, Concepción, Chile

[8]Instituto del Mar del Perú (IMARPE), Callao, Perú

[10]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada

[11]North Pacific Research Board, Anchorage, AK, USA

[12]Marine Biodiversity, Exploitation and Conservation (MARBEC), Univ. Montpellier, IRD, IFREMER, CNRS, Montpellier, France

[13]School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA, USA

[14]Department of Biology, East Carolina University, Greenville, NC, USA

[15]Current address: Forest and Rangeland Ecosystem Science Center, United States Geological Survey, Seattle, WA, USA

Spatial distribution modeling of small pelagic fish and other marine species is well developed, with tools such as generalized additive models, machine learning approaches such as boosted regression trees and neural networks, and spatio-temporal approaches, such as VAST and sdmTMB. Species distribution models (SDMs) allow us to track changes in species' ranges seasonally and over the past decades, to understand how these ranges respond to ocean

conditions and to project how distributions will evolve under climate change. Recently, we have begun to couple SDMs to complex multispecies and end-to-end-ecosystem models, such as Ecospace, Ecosim, Atlantis, and OSMOSE, enabling the incorporation of predator-prey and population dynamics. However, small pelagic fish offer unique challenges in modeling because their population dynamics and spatial distributions are driven by both bottom-up and top-down ecological drivers. Coupling small pelagic fish SDMs to multispecies and ecosystem models requires multiple choices and approximations. In this talk, we identify best practices related to these choices. Focusing on small pelagic fish, we discuss case studies in the California Current and Peru Current ecosystems, the Celtic Sea, and the Gulf of Alaska. We discuss decision points related to the handling of foraging movement; whether SDMs should include realized versus fundamental environmental tolerance niches; handling gaps in SDMs when information is lacking for seasons, areas, or life history stages; choices of covariates to include in the SDM; and approaches for handling uncertainty. These case studies offer solutions to support ecosystem-based fishery management with projections of species distributions and ecosystems under climate change.

**(S03 18062 Oral)**

**Predicting of future changes in the distribution of Spanish mackerel habitat in the waters surrounding Korea**

Dongwha **Sohn**[1], Minkyoung Bang[2], Jung Jin Kim[3], Chan Joo Jang[2] and Sangil Kim[1]

[1]Pusan National University, Busan, South Korea E-mail: sangil.kim@pusan.ac.kr

[2]Korea Institute of Ocean Science and Technology, Busan, South Korea

[3]National Institute of Fisheries Science, Busan, South Korea

As the environmental conditions of marine ecosystems change due to climate change or global warming, shifts in the spatial distribution of aquatic resources can occur. In the sustainable use and management of fish species, it is important to understand the species-specific responses to these environmental changes. In Korean waters, the Spanish mackerel is one of commercially important fish species. In this study, in order to examine future changes in the seasonal distribution of Spanish mackerel in Korean waters, three species distribution models were constructed using (1) a generalized additive model, a boost regression tree, and a maximum entropy model based on fishery-dependent data (1998–2015) and marine environment data (temperature, salinity, current speed at the surface, mixed layer depth, and chlorophyll-a concentration). Then, three CMIP6 model outputs were used in each best-fitted model and ensemble modeling approaches to predict the occurrence probability of Spanish mackerel in the Yellow Sea, the Korea Strait/the northern East China Sea and East Sea/Sea of Japan in the 2050s in the future climate change scenario (Shared Socio-Economic Pathway (SSP1-2.6, SSP2-4.5, and SSP5-8.5)). Each models predicts a decrease in Spanish mackerel distribution across all seasons in the Yellow Sea and the Korean Strait/the northern East China Sea, while forecasting an increase in the East Sea/Sea of Japan. Changes in their spatial distribution were primarily influenced by sea surface temperature, with slight variations across different seasons. Our findings offer a scientific foundation for developing sustainable fisheries management strategies for fish stocks in the waters surrounding Korea.

**(S03 17756 Poster)** S03-P1

**Ocean forecast for fishermen: Information technology for exploring fishery grounds of natural juveniles for yellowtail farming using ocean big data**

Toru **Kobari**[1], Eisuke Tsutsumi[1], Gen Kume[1], Ayako Nishina[1], Hirohiko Nakamura[1], Hirofumi Sumoto[1], Hikaru Endo[1], Masafumi Kodama[1], Yuji Sakuno[2], Shin-Ichiro Kako[3] and Toru Yamashiro[3]

[1]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan. Email: kobari@fish.kagoshima-u.ac.jp

[2]Graduate School of Advanced Science and Engineering, Hiroshima University, Hiroshima, Japan.

[3]Faculty of Engineering, Kagoshima University, Kagoshima, Japan.

Yellowtail farming is the most important for aquaculture production in Japan. It is typical for supply chain business but vulnerable for ambient risks difficult to predict or avoid, such as harmful algal bloom and fish disease. Meanwhile the fisherman population has been aging and declined, the increasing costs of fuel and aquaculture feed make them to require technologies improving labor and cost efficiency for yellowtail farming, especially for finding fishing grounds of the farming juveniles to follow floating algae in the East China Sea. Here, we report information technology to explore fishing grounds of natural seeds for yellowtail farming based on high-resolution regional ocean model and some options. In our website (https://nagaremo.fish.kagoshima-u.ac.jp/), the two major information is now available for local fishermen, daily maps demonstrating their fishing ground conditions and maps indicating migration of floating algae followed by yellowtail juveniles. Moreover, the further optional information is available, reports of shipboard observations of floating algae and remote observations of GPS drifting buoy attached with floating algae. Since fishermen can predict the geographical distributions of floating algae followed by yellowtail juveniles based on the information, the labor and cost efficiency for exploring their fishing grounds would be improved by the decreases of wasted working days and fuel expenses.

**(S03 17900 Poster)** S03-P3

**Passive acoustic monitoring of Pacific herring (Clupea pallasii) spawning aggregations**

Frances **Juanes**[1], Philina A. English[2], William Halliday[1,3], Dana Haggarty[2], Sarah Dudas[2], Jennifer Boldt[2], Jaclyn Cleary[2], Darienne Lancaster[1,2] and Stephanie K. Archer[4]

[1]University of Victoria, Victoria, BC, Canada email: juanes@uvic.ca

[2]Fisheries and Oceans Canada, Nanaimo, BC, Canada

[3]Wildlife Conservation Society Canada, Whitehorse, YT, Canada

[4]Louisiana Universities Marine Consortium, Chauvin, LA, USA

Pacific herring are an ecologically and culturally important forage fish. These small pelagic schooling fishes aggregate each spring in coastal embayments to spawn. These spawning events provide feeding opportunities for predators and provide important fisheries opportunities for coastal fishers, and for scientists to monitor herring populations. The remote nature of much of Canada's Pacific coast represents a challenge for effective monitoring of herring spawning activity. Pacific herring are soniferous, but unlike Atlantic herring, have not yet been documented in the wild. Production of species-specific sounds suggests that passive acoustic monitoring may be an effective tool to document the occurrence of herring spawning in remote locations. We deployed autonomous hydrophones at 3 suspected spawning sites in the Strait of Georgia, BC, manually identified sounds, and calculated acoustic complexity indices and sound pressure levels for biologically relevant frequency bands. Herring spawned at two of three locations where we deployed recorders, but we detected herring sounds at all sites. These sounds are short, averaging 0.09 seconds, ranging from 2-4 kHz with a median peak frequency of 2.70 kHz. Herring sounds were more prevalent between dusk and dawn. We also detected bird calls and sea lion vocalizations at both sites where herring spawned. This is the first time Pacific herring sounds have been documented in the wild and the first description of the overall soundscape of Pacific herring spawning aggregations. Ultimately, this represents the first step towards developing a passive acoustic monitoring system for herring spawning in the northeast Pacific.

**(S03 17946 Poster)** S03-P4

**Using eDNA to study Longfin Smelt in the Nooksack River Estuary, WA**.

**Steffan Michael Francis Kinley**[1], **Na'ta'ne Morning-Song Miles**[1], **Justice Marie Black-Williams**[1], Andrés Lopez[2], Megan Schulz[1], Kira Walters[1] and John Rombold[1]

[1]Northwest Indian College, Bellingham, WA. E-mail: jrombold@nwic.edu

[2]University of Alaska, Fairbanks, AK.

The Longfin Smelt (*Spirinchus thaleichthys*) is an anadromous forage fish that is sporadically distributed from San Francisco Bay, California, USA to Prince William Sound, Alaska. The Lummi People—who value this fish for subsistence and to maintain cultural practices—describe a decline of the local Longfin Smelt spawning run. This study uses a TaqMan quantitative PCR (qPCR) assay to detect environmental DNA (eDNA) of Longfin Smelt. We are using this assay to investigate the habitat use and spatiotemporal distribution of Longfin Smelt in riverine and marine environments near the Lummi Indian Reservation, WA. Based on our results, we hypothesize that: 1) the species is present in the Nooksack River estuary throughout the year, with higher concentrations being found near the mouth of the river during spawning season, 2) the nearshore environments of the Nooksack River estuary are important for juvenile rearing, and 3) the Nooksack River Delta may be an important Longfin Smelt spawning habitat. Information regarding Longfin Smelt spawning, rearing, and migration dynamics will help to inform management practices of this culturally important population.

**(S03 17991 Poster)** S03-P5 (ECOP)

**The pelagic species trait database, an open data resource to support trait-based ocean research**

Miram R. **Gleiber**[1], Natasha A. Hardy[1], Caitlin J. Morganson[1], Catherine F. Nickels[2], Barbara A.Muhling[3,4], Elan J. **Portner**[5], Pierre-Yves Hernvann[2], Brian K. Wells[6,7], Richard D. Brodeur[8], Toby D. Auth[9], Jarrod A. Santora[6,10], Sarah M. Glaser[11], Daniel J. Madigan[12], Elliott L. Hazen[13], Michael G. Jacox[13], Steven J. Bograd[13], Zachary Roote[1], Alana Krug-Macleod[1], Zackary Tandy[1], Iris George[1], Cindy Matuch[14], Cole B. Brookson[1], Elizabeth A Daly[15], C. Anela Choy[5], Larry B. Crowder[16] and Stephanie J. Green[1]

[1]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada.

Email: miramgleiber@gmail.com

[2]Northwest Fisheries Science Center, NOAA, Seattle, WA, USA

[3]Institute of Marine Sciences, University of California, Santa Cruz, CA, USA

[4]Fisheries Resources Division, Southwest Fisheries Science Center, NOAA, La Jolla, CA, USA

[5]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA

[6]Fisheries Ecology Division, Southwest Fisheries Science Center, NOAA, Santa Cruz, CA, USA

[7]Fish Ecology Division, Northwest Fisheries Science Center, NOAA, Newport, OR, USA

[8]Hatfield Marine Science Center, Oregon State University, Newport, OR, USA

[9]Pacific States Marine Fisheries Commission, Newport, OR, USA

[10]Department of Applied Mathematics, University of California, Santa Cruz, CA, USA

[11]World Wildlife Fund, Washington DC, USA

[12] Department of Integrative Biology, University of Windsor, ON, Canada

[13]Environmental Research Division, Southwest Fisheries Science Center, NOAA, Monterey, CA, USA

[14]California State University, Monterey Bay, California, USA

[15]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, OR, USA

[16]Hopkins Marine Station of Stanford University, Pacific Grove, California, USA

Trait-based frameworks are increasingly useful for predicting how ecological communities respond to ongoing global change. As species range-shifts result in encounters between new predator and prey pairs, identifying prey ‘guilds’, based on a suite of shared traits, can simplify our understanding of complex species interactions and assist with predicting food web dynamics. To promote advances in trait-based research in open-ocean systems, we present the Pelagic Species Trait Database, a comprehensive resource synthesizing functional traits of many pelagic fish and invertebrate species in a single, open-source repository. We used literature sources, online resources, and species images to collate traits for 521 pelagic species describing 1) habitat use and behavior, 2) morphology and morphometrics, 3) nutritional quality, and 4) population status information. Species in the database are primarily from the California Current system (CCS) and broader NE Pacific Ocean, but also include globally important pelagic species known to be consumed by top ocean predators from other ocean basins. We share examples of how the trait database is implemented to better understand the complex foraging dynamics of a highly migratory pelagic predator, albacore tuna. Consistent habitat, morphological, and nutritional quality traits explain taxonomically complex feeding patterns by albacore tuna and are useful for predicting future distributions of highly preferred prey for albacore tuna. This database promotes trait-based approaches in marine ecosystems and for predator populations worldwide.

**(S03 18016 Poster)** S03-P6

**Species composition and assemblages of ichthyoplankton of small pelagic fishes around the Korean waters using DNA barcodes**

Hwansung **Ji**, Hyojae Yu and Sukyung Kang

National Institute of Fisheries Science, Busan, Republic of Korea. E-mail: nise9@korea.kr

Marine environmental features surrounding the Korean waters have an important role in formation of distinct ecosystems or population structure of small pelagic fish. In order to clarify species composition and assemblages of ichthyoplankton, we collected from coastal and offshore waters in the Yellow Sea, Korea Strait, East Sea and the East China Sea, which surround the Korean waters. Ichthyoplankton samples were taken 127 station with a bongo net (80 cm, 330 μm) during the 2017-2023, as part of the National Institute of Fisheries Science (NIFS) cruises by the research vessel TAMGU 21-23. We performed PCR experiments using universal primers for mitochondrial DNA COI or the 16S rRNA sequences. A total of 61,734 eggs and 44,743 larvae were collected and identified using combined DNA barcording and morphological methods. Eggs were classified into 30 taxa including 22 species in February, but 53 taxa including 39 species in July. Assemblage analyses divided the eggs into two and four groups, and the larvae into three and four groups in February and July, respectively. The geographical separation of these groups was clearer in July than in February. We found that the ichthyoplankton assemblages were differentiated among the water masses in different seas (East Sea, Yellow Sea, and East China Sea) around the Korean waters, suggesting the hydrographic boundaries may hinder the dispersal of ichthyoplankton between the seas.

**(S03 18093 Poster)** S03-P7

## Trends in the reproductive phenology and thermal sensitivity of thirteen populations of small pelagic fishes across North American waters

Rebecca G. **Asch**[1], Katherine Dale[1], Sarah Weisberg[2], Toby D. Auth[3], Gerardo Aceves-Medina[4], Richard D. Brodeur[5], Rubén Esteban García Gómez[4], Sylvia P.A. Jiménez-Rosenberg[4], Hannah Murphy[6], Neil McNeill[7] and R. Ian Perry[8]

[1]Department of Biology, East Carolina University, Greenville, NC, USA. Email: aschr16@ecu.edu

[2]School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY, USA

[3]Pacific States Marine Fisheries Commission, Newport, OR, USA

[4]Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas, Baja California Sur, Mexico

[5]Hatfield Marine Science Center, Oregon State University, Newport, OR, USA

[6]Fisheries and Oceans Canada, St. John's, NL, Canada

[7]Southeast Fisheries Science Center, National Oceanic and Atmospheric Administration, Beaufort, NC, USA

[8]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada

The seasonal timing when small pelagic fishes (SPF) reproduce can influence recruitment via synchrony with plankton blooms. Multiple studies have shown the seasonality of SPF reproduction is shifting under climate change, but no global synthesis has assessed variations by species, ocean basins, or latitude. As part of a PICES/ICES working group on sustainable pelagic forage communities, 57 times series were identified for synthesis. These time series represent 24 species from 28 ecoregions with data from ichthyoplankton and spawning migration surveys, maturity stages and gonadal development, otolith estimation of hatch dates, and historical documentation of spawning runs. Open-source code is being developed to analyze weekly-to-annual time series uniformly. An initial analysis demonstrates our approach using seven species from both coasts of North America. We detected a trend for fall/winter spawning species to reproduce later and spring spawners to reproduce earlier, with notable exceptions. For nine out of thirteen populations, the phenological signal-to-noise ratio exceeded one, indicating long-term climate trends have a greater influence on spawning time than interannual variability. No distinct latitudinal trends were identified, but species-specific patterns were detected. Sardine and sand lance often displayed larger variations in phenology than co-occurring species. Despite rapid warming in the Northeast United States, its SPF populations exhibited low phenological sensitivity to temperature. Consequently, we identified a statistically significant, inverse relationship between rates of warming and thermal sensitivity of reproductive timing. The inverse relationship suggests that SPF could have a high adaptive capacity to handle changes in temperature without falling victim to phenological mismatches.

# S4: FUTURE/BIO/MONITOR/TCODE Topic Session

**Observational frontier and new studies for understanding of ocean and ecosystem**

**Convenors:**
Sung Yong Kim (Korea), *corresponding*
Jack Barth (USA)
Kiyoshi Tanaka (Japan)
Akash Sastri (Canada)

**Invited Speakers:**
Maria Kavanaugh (Oregon State University, USA)
David Kimmel (NOAA Fisheries, USA)
Chris Rooper (Pacific Biological Station, DFO, Canada)

Advanced technology has helped our sampling efforts and increased our understanding of oceanography and ecosystem processes over the last two decades. Various sampling sensors, platforms, and ways of sensor fabrication have been developed, such as physics, biology, biogeochemistry, underwater communication, bioacoustics, bio-optics, and autonomous vehicles. These observational frontiers and new studies can be combined with building a seamless data integration and sharing system, which can relay information to artificial intelligence technology. We invite contributions on recent ocean observational approaches to obtain primary ocean variables and unprecedented measurements for physical, biological, and biogeochemical ocean properties and integrated efforts using different platforms. We also welcome contributions of low-cost ocean observations and new approaches by citizen scientists using new and existing sensors and platforms. These advanced technology and accessible approaches will support our goal of understanding the ocean sustainably.

**(S04 18128 E-Poster)** (S04-P1) (ECOP)

## Species diversity assessment and Above-ground biomass estimation of mangrove ecosystem using remote sensing and field observation data: a deep-learning approach in in Bali Province Indonesia

K. K. Basheer **Ahammed**[1,2], I Wayan Gede Astawa Karang[1], I Wayan Nuarsa[1], I Gede Hendrawan[1], Arvind Chandra Pandey[3] and Gede Surya Indrawan[1]

[1]Faculty of Marine Science and Fisheries, Udayana University, Jimbaran, Bali 80361 Indonesia email: basheer.kk@cuj.ac.in

[2]International Union for the Conservation of Nature (IUCN), Commission on Ecosystem Management (CEM), South Asia

[3]Department of Geoinformatics, Central University of Jharkhand, Cheri Manatu Rachi, 835 205 India

Mangrove ecosystems play significant role in carbon storage and carbon fixation in the global coastline. However, it faces an equilibrium between development and ecological integrity in recent years. Aboveground biomass (AGB) inventory provides several baseline information for different applications, for instance, regional carbon and bio-energy policies towards the sustainable ecosystem management. In the present study focus on Bali's mangrove ecosystems, particularly in the Tahura Ngurah Rai (Benoa bay) mangrove area, brings attention to the localized challenges and opportunities for climate justice. The integration of sophisticated field sampling and advanced remote sensing techniques reflects a cutting-edge technology for the management of the coastal ecosystem. The use of deep learning approach demonstrates a proactive approach to monitor and assess mangrove above-ground biomass with higher prediction accuracy (>$R^2$0.7), contributing to both scientific understanding and practical conservation efforts. The study utilised 12 different remote sensing indices derived from the spectral band combination such as EVI, LAI, NOAC, NDVI, NDWI, NDMI, SR, MNDWI, NDBaI, CMRI, NDBI, and NBR, and developed a prediction model using Random Forest Regression (RFR) model reviled that L8 derived models provides a better result in comparison to S2 models. The study collected a total of 77 field quadrats of 10×10 m size in which recoded a total of 8384 specimens consisting of 12 tree species which the DBH is laying between 0.95 – 95.49 cm. the average density of the mangroves in the Tahura Ngurah Rai (Benoa bay) exhibited 10906 specimens'/ $ha^{-1}$ and basal cover 533.57 $m^2ha^{-1}$. The highest AGB was contributed by ***Sonneratia alba J.E. Smith*** with 2.22 Mg $specimen^{-1}$ followed by ***Rhizophora mucronata Poir*** (0.91 Mg $specimen^{-1}$) whilst an average of 78.99 Mg $ha^{-1}$ biomass ranging from 13.3 254 Mg $ha^{-1}$ to 254 Mg $ha^{-1}$ is recorded in the studied mangrove forest. The present study provides a significant contribution to the scientific community by unravelling the intricate connections between mangrove ecosystems, blue carbon dynamics, and climate change. The study's findings serve as an example for policymakers, scientists, and conservationists alike, guiding efforts towards a more resilient and just environmental future.

**(S04 17913 Invited)**

**Novel approaches to monitor zooplankton in the large marine ecosystems of Alaska**

David G. **Kimmel**

Alaska Fisheries Science Center/NOAA, Seattle, WA, USA. E-mail: david.kimmel@noaa.gov

Zooplankton are diverse group of organisms that exist at the base of marine food webs and understanding variability in their populations provides information on ecosystem status. As such, zooplankton are the target of ongoing monitoring programs throughout the north Pacific. These programs often collect samples using nets, a traditional method that has remained unchanged for decades. Samples must be preserved for later sorting and organism identification in the laboratory; however, this process takes significant time and expertise, resulting in a delay in the production of relevant ecosystem information. Here I present ongoing work to assess the efficacy of both laboratory and in situ plankton imaging systems for zooplankton monitoring in Alaska waters. While the application of imaging to zooplankton ecology has a long history, only with the recent advances in artificial intelligence/machine learning have imaging platforms begun to show real promise as monitoring tools. I present an overview of several different technologies used to assess zooplankton in the large marine ecosystems of Alaska. The first case study shows the deployment of PlanktonScope, an in situ shadowgraph imaging system in order to assess copepod and euphausiid populations in the Bering Sea. The second shows a recent deployment of a glider equipped with a shadowgraph imaging system, in the Gulf of Alaska. In each case, I will highlight the promise and pitfalls of deploying new technology to monitor marine ecosystems.

**(S04 18129 Invited)**

**Marine Biodiversity Observation Network in the Northern California Current: technological integration, ecosystem science, and management applications**

Maria T. **Kavanaugh**[1], Jennifer L. Fisher[2], Su Sponaugle[1], Robert Cowen[1], Nicolaus Adams[2], Jan Newton[4], Stephanie Moore[2], Laurie Juranek[1], Jenny Waddell[5], Kym Jacobsen[2], Anna Bolm[3], Kelly George[1] and Samantha Zeman[3]

[1]Oregon State University email: maria.kavanaugh@oregonstate.edu

[2]Northwest Fisheries Science Center, NOAA Fisheries

[3]Cooperative Institute for Marine Ecosystem Resource Studies (CIMERS)

[4]Northwest Association of Networked Ocean Observing Systems (NANOOS)

[5]Olympic Coast National Marine Sanctuary

Biodiversity is a key indicator of ecosystem health and can affect primary production, food quality, and ecosystem resilience. In the NE Pacific, shifting ocean conditions and extreme events (e.g. marine heat waves) have affected plankton community composition, a component of biodiversity, with repercussions throughout the food web. Understanding the regional to global effects of climate on planktonic assemblages requires a dynamic geographic framework to track changes in ecosystem extent and location; quantify mechanistic relationships between habitat quality, community structure, and ecosystem functioning; and ultimately determine the vulnerability or resilience of ocean organisms or systems to multiple stressors. As part of the US Marine Biodiversity Observation Network, the Northern California Current node is a multisector collaboration that monitors phytoplankton, zooplankton, and ichthyoplankton across broad spatial scales using various tools, including nets, spectroscopy, imaging systems (such as the Imaging FlowCytobot and the In-situ Ichthyoplankton Imaging System with machine learning image analysis), acoustics, and eDNA. We demonstrate how these sampling and analytical tools can be integrated with synoptic habitat indicators to examine spatio-temporal changes in plankton community composition and ecosystem function. Ultimately, this suite of tools, observations, and analytical concepts will be used to create ecosystem indicators to inform marine ecosystem management and early warning systems.

**(S04 17753 Oral)** (ECOP)

## Long-term changes in demersal community structure of an urban bay: Transition from bottom-heavy to top-heavy pyramids

Shujuan **Xia**[1], Takashi Yamakawa[2], Mari Kuroki[2], Toshihiro Horiguchi[3], Keita Kodama[3], Hiroaki Shiraishi[3], Makoto Shimizu[4], Jun'ya Takakura[1], Kiyoshi Takahashi[1]

[1]Social Systems Division, National Institute for Environmental Studies, Tsukuba, Japan.

E-mail: xia.shujuan@nies.go.jp

[2]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan

[3]Health and Environmental Risk Division, National Institute for Environmental Studies, Tsukuba, Japan

[4]Emeritus Professor, The University of Tokyo, Tokyo, Japan

Human activities such as pollution and fishing are altering ecosystem functioning throughout the world's oceans. The urban bay, positioned at the interface between land and sea, is one of the most impacted areas of the world's oceans. Fish community structures in urban bays have changed over time because of anthropogenic activities, leading to changes in species richness, diversity, fish assemblage composition, and abundance. Tokyo Bay, one of Japan's most eutrophic urban bays, experiences changes in environmental conditions and/or anthropogenic stressors. Consequently, the demersal community in the bay has seen significant shifts in taxonomic composition over the past several decades. We analyzed data from a 35-year bottom trawl survey to examine long-term changes in the body size spectra slopes of the demersal community in Tokyo Bay, a reliable indicator of shifts in community structure. Our findings indicate a transition from bottom-heavy pyramids in the earlier period (1977–1995) to top-heavy pyramids in more recent years (2003–2019), driven by a decline in the biomass of small-sized crustaceans and an increase in the biomass of large-sized elasmobranchs. This study contributes to a broader understanding of the impacts of environmental changes on marine fish communities. Additionally, fish are also a critical resource for many coastal communities, providing food and livelihoods, thus this study may also help guide the development of policies to mitigate negative impacts on human communities that depend on fisheries.

**(S04 17795 Oral)** (ECOP)

## Genomic signatures of natural selection in *Calanus marshallae* in response to geographic variation in oxygen and temperature

Kristofer K. **Bauer**[1], Sam Zeman[2], Jennifer Fisher[2], John Nelson[3], Moira Galbraith[3], Colleen Kellogg[4], Jesse Lamb[5] and Felipe Barreto[1]

[1]Integrative Biology, Oregon State University, Corvallis, OR, USA. E-mail: BauerKr@Oregonstate.edu

[2]Cooperative Institute for Marine Resources Studies, Newport, OR, USA

[3]Institute of Ocean Science, Sidney, BC, Canada

[4]Hakai Institute, Campbell River, BC, Canada

[5]NOAA/AFSC, Seattle, WA, USA

Marine plankton species are well known for their extensive geographic ranges, spanning across regional and sometimes even global oceanographic current systems. These distant but highly connected populations were long thought to lack notable interpopulation genetic divergence from one another (i.e. panmixia) making processes such as local adaptation unlikely. However, recent work has shown that the heterogenous environments that plankton species may experience can result in strong selective pressures driving divergence between even highly connected populations, thus challenging long held hypotheses. This study will present recent tests of environmental selection on the calanoid copepod species, *Calanus marshallae*, an ecologically important species that extends from Northern California to the Bering Sea. We sequenced nearly 200 individual *C. marshallae* transcriptomes spanning from Northern California to the Queen Charlotte Sound, British Columbia, and we will genotype single nucleotide polymorphisms (SNPs) in protein-coding genes. While analysis is still currently underway, we hypothesize that natural selection throughout the North Pacific has driven significant levels of divergence in areas of the *C. marshallae* transcriptome responsible for responding to environmental stress. We predict that recent episodes of intense hypoxia off the coast of Washington and Oregon may have left a signature of natural selection on allele frequencies across the transcriptomes of local populations in this region compared to those elsewhere. This study marks the first large-scale investigation of natural selection and potential adaptation in this species and will provide a useful framework for similar work to be done on other species of marine plankton throughout the North Pacific.

**(S04 17817 Oral)**

## Ten years of PSF Citizen Science Oceanography monitoring in the Strait of Georgia, Canada.

Svetlana **Esenkulova**[1], Nicole Frederickson[1], Rich Pawlowicz[2], Deniz Coskuner[2], Brian Hunt[2], Andrew Ross[3], and Isobel Pearsall[1]

[1]Pacific Salmon Foundation, Vancouver, BC, Canada. E-mail: sesenkulova@psf.ca

[2]University of British Columbia, BC, Canada

[3]Fisheries and Oceans Canada, Sidney, BC, Canada

The Strait of Georgia (SoG), Canada is one of the most biologically productive ecosystems in the world, supporting significant commercial and recreational fisheries. In recent decades, many SoG 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, has supported programs aimed at understanding the factors affecting salmon survival. Since 2015, the PSF Citizen Science (CitSc) Oceanography Program has undertaken an unprecedented data collection effort in SoG, with hundreds of measurements and samples collected annually. This high-resolution (~55 stations sampled bi-monthly) sampling is conducted by trained volunteers, with data and samples analyzed by PSF, the Department of Fisheries and Oceans Canada (DFO), the University of British Columbia (UBC), and Oceans Network Canada. The program produces datasets on physical parameters (temperature, salinity, depth, dissolved oxygen, turbidity, chlorophyll), nutrients (nitrates, phosphates, and silicates), harmful algae and (since 2020) marine algal biotoxins. The data are freely accessible via the Strait of Georgia Data Centre (https://sogdatacentre.ca/), with annual summaries provided at the DFO State of the Pacific Ocean and in the digital Atlas of oceanographic conditions in the Strait of Georgia (https://sogdatacentre.ca/atlas/). Additionally, zooplankton samples are collected at three stations. The first 2.5 years of samples were analyzed at DFO using traditional light microscopy techniques, while subsequent samples are being analyzed at UBC using ZooSCAN. ZooSCAN is an advanced system that integrates specialized scanning hardware and image processing software to rapidly analyze zooplankton samples. The development of semi-automated imaging may provide accessible tools for other organizations interested in conducting zooplankton monitoring. Zooplankton results will be assessed for inter- and intra-annual dynamics and their relationship to environmental conditions. The overall goal of the PSF CitSc program is to provide essential data for ecosystem research and salmon studies, contributing to the conservation and restoration efforts of Pacific salmon populations.

**(S04 17864 Oral)** (ECOP)

**Impact of the mining process on the near seabed environment of a polymetallic nodule area**

Bowen **Li**[1], Yonggang Jia[2,3], Zhihan Fan[3], Kai Li[3] and Xuefa Shi[4]

[1]College of Oceanography and Space Information, China University of PetroleumQingdao, China email: 20200111@upc.edu.cn

[2]Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

[3]Shandong Provincial Key Laboratory of Marine Environment and Geological Engineering, Ocean University of China, Qingdao, China

[4]First Institute of Oceanography, MNR, Qingdao, China

The exploitation of deep-sea polymetallic nodule minerals has garnered global attention due to the depletion of terrestrial metal resources. Consequently, the environmental impact of deep-sea polymetallic nodule mining cannot be overlooked. In this study, a field disturbance and observation device integrated with multiple sensors was utilized for the first time to simulate the mining-induced disturbance process on seabed sediments in the 5700 m deep polymetallic nodule area of the western Pacific Ocean. The impact of mining activities such as stroke and drawing on bottom sediment in the polymetallic nodule area is estimated to be 30 times greater than that caused by waves or currents. Turbidity takes approximately 30 minutes to return to normal levels after disturbance, with an influence distance of about 126 meters on turbidity from a single disturbance event. Density returns to normal levels within about 4 hours, with an influence range extending up to approximately 1000 meters. Additionally, resuspension of bottom sediment results in increased density anomalies and salinity. Reciprocating currents were observed during the monitoring period, which may lead to suspended sediment clouds near the seabed in the mining area due to continuous operation of mining vehicles. This could result in elevated nutrient levels and decreased dissolved oxygen near the seabed, significantly impacting local ecological environments. Therefore, it is crucial to consider that mining vehicle operations involving digging and washing can have substantial implications for marine ecosystems.

**(S04 17883 Oral)** (ECOP)

**Diapycnal mixing and isopycnal stirring in the Kurohsio Extension front and Izu ridge**

Yuki **Ikeda** and Takeyoshio Nagai

Tokyo University of Marine Science and Technology, Tokyo, Japan. E-mail: yikeda3501@gmail.com

Understanding how water masses, heat, salt, organic and inorganic constituents are stirred and mixed is critical for better predicting how the ocean responds to ongoing climate changes. The development of microstructure profilers has allowed us to quantify the vertical eddy diffusivities. Using these vertical eddy diffusivity estimates, several previous studies attempted to quantify isopycnal diffusivities. However, despite a fact that isopycnal stirring causes lateral thermohaline intrusion, the double-diffusive convection has been ignored. In this study, we have attempted to estimate the isopycnal stirring coefficient taking into account the temperature variance generation due to double-diffusive convection. The results indicate that isopycnal stirring by mesoscale eddies and submesoscale flows is active in the Kuroshio Extension region with the isopycnal stirring coefficient ranging from O($10^3$-$10^4$ $m^2s^{-1}$) which reflects the interleaving structures of different water masses. In such areas, double-diffusive convection actively produces microscale temperature variances. On the other hand, in Izu-Ridge, turbulence is dominantly responsible for active diapycnal diffusivity and generates microscale temperature variances that acts on large-scale temperature gradients rather than mesoscale and submesoscale temperature gradients. The distinct characteristics of isopycnal stirring and diapycnal mixing and therefore temperature variance generation in these two regions implicate the differences in modification process of the water masses.

**(S04 17907 Oral)** (ECOP)

**Toward discerning Submesoscale Coherent Vortices originating from Tokara Strait in the Upstream Kuroshio**

Gloria Silvana **Duran Gomez** and Takeyoshi Nagai

Tokyo University of Marine Science and Technology, Tokyo, Japan.
E-mail: silvanadg2095@gmail.com

Submesoscale Coherent Vortices (SCVs) are characterized as lends of distinct low PV water with small horizontal scale found in the subsurface layers, below the mixed layer depth. SCVs transport huge volumes of water for long distances with a significant lifespan up to years. As they pose challenges to their identifications due to small spatial scales, there have only been a few studies that have managed to resolve them in-situ. On the other hand, recent studies, using mooring data and Argo data, attempted to map the distribution of SCVs in many regions around the global ocean, including the Kuroshio Extension region, where the origin of some of them was hypothesized as the southern coast of Japan through flow-topography interactions. At the south of Japan, the Kuroshio Current, a western boundary current in the North Pacific, interacts with many islands generating topographic wakes, which could be the source of the flow-topography-induced SCVs. However, there is still lack of studies of SCVs in the upstream Kuroshio. In this study, we use in-situ tow-yo high-resolution multidisciplinary observations and numerical simulations to discern the presence and/or generation mechanisms of SCVs in the Tokara Strait. The preliminary results from the numerical simulations suggest that while topography-islands interaction in the Tokara Strait near Yakushima Island dominantly sheds surface intensified submesoscale cyclonic eddies, submesoscale anticyclonic eddies are more dominant in subsurface layers generated from small islands in the farther south, Nakanoshima, Kuchinoshima, and Suwanosejima Islands. Furthermore, SCVs may also enhance diapycnal mixing, thus, bringing nutrient-rich waters to surface layers. In the presentation, we will show details of the influences of SCVs on the nutrient supply.

**(S04 17931 Oral)** (ECOP)

**Consequences of physical and biogeochemical processes for ecosystem: preliminary results from in-situ environmental and acoustic measurements**

Hikaru **Homma**, Daisuke Hasegawa, Takahiro Tanaka, Yuji Okazaki and Takeshi Okunishi

Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Shiogama, Japan. E-mail: hhomma@affrc.go.jp

Understanding the links between ocean climate, physical processes, biogeochemical environment, and ecosystem has been a key issue of oceanography. To address this, we have been working on developing the methods of simultaneous high-resolution in-situ measurements of different aquatic properties and integrative analysis of interdisciplinary dataset. Active acoustic instruments are useful tools to monitor the distribution of aquatic organisms in wide areas with high spatial and temporal resolutions. Moreover, the acoustic instruments can be operated in parallel with the surveys of ocean environments, which allow investigating the consequences of physical and biogeochemical processes for higher trophic levels of ecosystem such as zooplankton, micronekton, and fish. In this talk, the preliminary results of in-situ measurements of acoustic and environmental data will be presented. The field surveys were carried out at the Kuroshio-Oyashio Transition Area, which is known to be a highly productive zone with complicated physical structures and important fishing ground, during the research cruises with R/V Wakataka-maru. We employed a hull-mounted scientific echosounder KFC-3000 (KAIJO) with the transducers of 38 and 120 kHz. The tow-yo profiler BioUCTD (JFE Advantech) was used to collect high-resolution cross sections of environmental properties (temperature, salinity, fluorescence, turbidity, and oxygen concentration). The discussion about the influences of ocean environments on the aquatic organisms will be presented in this talk.

(S04 17937 Oral)

**Attitude and heading measurements with inertial measurement unit for tow-yo type observation system**

Terubumi **Saito**, Hikaru Homma, Takahiro Tanaka, Daisuke Hasegawa and Takeshi Okunishi

Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Japan. E-mail: saito_terubumi62@fra.go.jp

Tow-yo type observation systems, such as the Underway Conductivity-Temperature-Depth (UCTD) instruments, are essential for collecting high-resolution oceanographic data, which are crucial for understanding complex marine environments. Unexpected change in attitude and heading of the probe may bring motion-induced errors or noise in the measurement results. Analyzing the motion also enables us to develop new tow-yo techniques to stabilize the instruments, to reduce the impacts of vessel speed, winds, and waves on measurements. For this purpose, we attached an inertial measurement unit (x-IMU3, x-io Technologies) inside the probe of the tow-yo profiler (BioUCTD, JFE Advantech). A cast of tow-yo measurement was made using the UCTD winch system during the R/V Shunyo-maru cruise SH2405G in May 2024 in the Kuroshio stream off the east coast of Japan, and the data including the attitude and heading information down to 480 m depth were successfully taken from the deployment until recovery of the profiler. The preliminary analysis shows that prominent periodic rotation and oscillation around the tow line was clearly observed, as anticipated, especially while the probe was towed down. It should be also noted that magnetic field produced by the electric current for the circuit of the probe influences the magnetometer in the x-IMU3. This shows that calibrations are necessary. Details of the field experiment and the calibrations are to be given in the presentation.

**(S04 17948 Oral)**

## Using passive and active acoustics from an underwater glider over the Pacific Northwest continental shelf

John A. **Barth**[1], Anatoli Erofeev[1], Steve Pierce[1], Otavio Mendes[1], Brian Wells[2], and David D. Huff[3]

[1]Oregon State University, Corvallis, OR, U.S.A. E-mail: jack.barth@oregonstate.edu

[2]Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration

[3]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration

Understanding the spatial and temporal relationship of zooplankton and fish assemblages to coastal ocean fronts and phytoplankton distributions requires contemporaneous, high spatial resolution measurements. While much has been learned using traditional ship- and often multi ship-based sampling, we explore the utility of using an underwater glider to measure these relationships off the coast of Washington. Sampling occurred in late spring/early summer across both coastal upwelling and river-driven currents and fronts. We added passive and active acoustics sensors to an electric Slocum glider equipped with a CTD, bio-optical sensors for chlorophyll fluorescence, CDOM fluorescence and light backscatter, and an optode for measuring dissolved oxygen. A passive 69-kHz VEMCO receiver was mounted on both the top and bottom of the glider and a downward-looking Acoustic Zooplankton and Fish Profiler from ASL Environmental Sciences was mounted on the bottom of the glider, angled so that the acoustic beams pointed straight down during the glider's dive. Acoustic backscatter at three frequencies (67-, 120- and 200-kHz) were collected only during the glider dive. We describe a series of cross-front glider transects of fronts off the Washington coast during spring and summer 2022-2024. These include a weak Columbia River-driven front and a strong, wind-driven, coastal upwelling jet and front. Multiple cross-front glider transects were conducted over 1-2 weeks, with one cross-shelf transect sampled alongside the R/V Bell Shimada equipped with multi-frequency active acoustics. We analyze glider-based physical, chemical, bio-optical, and bioacoustics measurements in relation to these coastal fronts.

**(S04 17981 Oral)**

**Resolving submesoscale and microscale mixing processes using a tow-yo microstructure profiler**

Takeyoshi **Nagai**[1], Gloria Silvana Duran Gomez[1] and Miku Okawa[2]

[1]Tokyo University of Marine Science and Technology, Tokyo, Japan. E-mail: tnagai@kaiyodai.ac.jp

[2]ANA Systems Co., Ltd., Tokyo, Japan

Recent studies have pointed out the importance of submesoscale processes near ocean fronts for energy dissipation and diapycnal mixing that occur at microscale. At the top and the bottom boundaries of the ocean, friction induced destruction of potential vorticity caused by downfront wind and frontal jets over steeply sloping bottom topography can alter the sign of potential vorticity, leading to inertial and symmetric instabilities. As these submesoscale instabilities can trigger onset of microscale turbulence, the sign alteration of potential vorticity should have profound implications to mixing and nutrient diffusive flux. However, their small spatiotemporal scales pose a challenge to resolve them in-situ. In this study, we developed a tow-yo microstructure profiling scheme that can measure turbulent kinetic energy dissipation rates at 1-2 km lateral resolutions down to 250-300 m depth. A series of intensive surveys, using this technique in the Tokara Strait where the Kuroshio Current quasi steadily flows over seamounts, revealed the 100-1000-fold enhancement in turbulent kinetic energy dissipation rates observed over 100-200 km along the Kuroshio. This long-lasting strong turbulence is found to be fueled by inertial instability associated with negative potential vorticity generation on the bottom slope of seamounts. By combining a biochemical profiler, this turbulence was found to provide nitrate diffusive flux of O(1 mmol $m^{-2}$ $day^{-1}$) on average over 200 km. Furthermore, by measuring also microscale thermal dissipation rates, an average mixing coefficient in the Tokara Strait is 0.4, twice as much as the conventional value, 0.2.

**(S04 17986 Oral)** (ECOP)

**Leveraging 4-dimensionally mapped ocean biogeochemistry data products to inform species distribution modeling**

Mary Margaret **Stoll**[1], Andrea Fassbender[2], Barbara Muhling[3], Paige Lavin[4], Mar Arroyo[5], Steve Bograd[3], Hartmut Frenzel[6] and Jon Sharp[6]

[1]University of Washington, Seattle, WA, USA. Email: mmstoll@uw.edu

[2]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA.

[3]NOAA Southwest Fisheries Science Center, La Jolla, CA, USA.

[4]University of Maryland Cooperative Institute for Satellite Earth System Studies, College Park, MD, USA.

[5]University of Santa Cruz, Santa Cruz, CA, USA.

[6]University of Washington Cooperative Institute for Climate, Ocean, and Ecosystem Studies, Seattle, WA, USA.

Despite recent advances in biologging and monitoring technologies to inform fisheries species distribution models (SDMs), limitations remain in understanding migratory patterns in the context of a 4D ocean. The Biogeochemical Argo (BGC-Argo) array has revolutionized our spatiotemporal view of subsurface biogeochemistry, providing a new perspective on the linkages between species migratory patterns and environmental conditions. The four-dimensional biogeochemical landscape imposes critical constraints on suitable fish habitat through oxygen and hypoxia, $pCO_2$ and hypercapnia, temperature thresholds, and feeding behavior. Given that these biogeochemical characteristics bound physiologically suitable habitat, their inclusion in SDMs provides a basis for more reliable, mechanistic relationships between species and their environment. To assess the utility of depth-resolved information in SDMs, we leverage archival tags datasets, mapped ocean biogeochemistry data products, and machine learning to examine the extensive migratory behaviors of North Pacific albacore tuna (*Thunnus alalunga)*, a commercially important fishery species. Our model predicts habitat suitability from 4D biogeochemical predictor variables with high skill across space and time. Furthermore, subsurface information improves our understanding of species migrations within their desired habitat zones through a refined view of regions with high primary productivity and biomass. The synthesis of fisheries abundance data and four-dimensional biogeochemical information offers new avenues to study species distributions and inform fisheries management by incorporating interior ocean biogeochemical information.

**(S04 17990 Oral)** (ECOP)

**Resource partitioning among pelagic predators in the southern California Current remains stable despite temporal variability in diet composition**

Barbara A. Muhling[3,2,] Elan J. **Portner**[1], Antonella Preti[3,2], Owyn Snodgrass[2], Travis Richards[3,2], Catherine F. Nickels[3,2,4], Heidi Dewar, Elliott L. Hazen[5], and C. Anela Choy[1]

[1]Scripps Institution of Oceanography, University of California San Diego, San Diego, CA, USA email: eportner@ucsd.edu

[2]Fisheries Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, CA, USA

[3]University of California, Santa Cruz, Institute of Marine Sciences' Fisheries Collaborative Program, Santa Cruz, CA, USA

[4]Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, WA, USA

[5]Ecosystem Science Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Monterey, CA, USA

Observations of feeding habits are critical for describing dietary niches and food web structure. However, timeseries required for assessing variability in resource partitioning are limited. Here, we examine a diet timeseries (1998-2018) representing 2,749 stomachs from ten pelagic predators in the southern California Current (SCC): albacore tuna (*Thunnus alalunga*), bluefin tuna (*Thunnus orientalis*), swordfish (*Xiphias gladius*), blue shark (*Prionace glauca*), shortfin mako shark (*Isurus oxyrinchus*), thresher shark (*Alopias vulpinus*), bigeye thresher shark (*Alopias superciliosus*), short-beaked common dolphin (*Delphinus delphis*), long-beaked common dolphin (*Delphinus capensis*), and northern right whale dolphin (*Lissodelphis borealis*). Although each predator had distinct diets across the timeseries, clustering analyses based on Schoener's Index indicated five pairs of predators with similar feeding patterns based on the taxonomy, size, vertical habitat, and horizontal habitat of their prey. From 1998-2015, pairwise annual Morisita-Horn diet dissimilarity for predators feeding in epipelagic habitats (<200 m; *T. albacares, T. orientalis, A. vulpinus, D. capensis*) was more variable within species than between species. This suggests that although their diet compositions varied over this period, resource partitioning among predators remained stable. Following increased abundance of northern anchovy (*Engraulis mordax*) starting in 2016, the dietary niches of *T. orientalis* and *X. gladius* converged, with both predators feeding more heavily on prey from shallow nearshore waters. This work provides a comprehensive assessment of resource partitioning among pelagic predators in the SCC and represents a unique opportunity to compare observations with fundamental hypotheses on the stability of resource partitioning under variable conditions.

**(S04 18006 Oral)**

**Integration of novel ocean observing technologies to advance NOAA EcoFOCI's monitoring of Alaska marine ecosystems**

Heather M. **Tabisola**[1], Julie E. Keister[2], Phyllis J. Stabeno[3], Calvin Mordy[1], Zach Gold[3], Natalie Monacci4, and Catherine Berchok[2]

[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA. E-mail: hnmac@uw.edu

[2]NOAA, Alaska Fisheries Science Center, Seattle, WA, USA.

[3]NOAA, Pacific Marine Environmental Laboratory, Seattle, WA, USA.

[4]University of Alaska Fairbanks, College of Fisheries and Ocean Sciences, Fairbanks, AK, USA.

NOAA's Ecosystems & Fisheries-Oceanography Coordinated Investigations (EcoFOCI) program was established in 1984 to examine the physical and biological factors that affect the pollock fishery in Alaska. Since that time, the program has evolved to meet emerging scientific questions and needs of NOAA, stakeholders, and communities throughout Alaska's ecosystems. The program uses a wide variety of observing tools, including research vessel surveys, mooring arrays, and ocean observatories. New technologies are continually incorporated to advance the observing capacity.

Since the first biophysical mooring (M2) was deployed on the southeastern Bering Sea shelf in 1995, 10 additional sites have been established from the southern Bering Sea to the northern Chukchi Sea. At M2, observations include CO2 surface measurements, passive acoustics, and a PRAWLER system. Two observatories include eDNA, nutrients, and sediment flux. On EcoFOCI cruises, eDNA is integrated with plankton net tows and cameras to measure changes in composition and diversity, from microbes to fish, alongside high-resolution hydrographic data. Low cost pop-up floats, designed at NOAA PMEL, are used to understand under-ice and spring ice melt dynamics. Uncrewed systems have also played a key role in the observing tool box, with experience testing saildrones and shallow-water gliders. In 2023, the first known transit through the Bering Strait was led by EcoFOCI scientists and PMEL engineers. The real-time data from these observatories and technologies are integrated into regional forecasts and models.

We will highlight the programs' integrated multidisciplinary ocean observations, how these novel technologies contribute to decade-long observations, and the innovative technologies currently being developed.

**(S04 18126 Oral)**

**Backyard Buoys: meeting coastal Indigenous community needs for wave data through co-design and co-production**

Jan **Newton**[1], Sheyna Wisdom[2], Melissa Iwamoto[3], Roxanne Carini[1], Jordan Watson[3], Sebastien Boulay[4], Duncan Mactavish[5], Jennifer Hagen[6], Joe Schumacker[7], Dua Rudolph[8], Dolores Kattil-Debrum[8], Pua Tuaua[9], Eric Brown[9], John Hopson Jr[10], and Jenny Evans[10]

[1]University of Washington & Northwest Association of Networked Ocean Observing Systems, Seattle, WA, USA. E-mail: janewton@uw.edu

[2]Alaska Ocean Observing System, Anchorage, AK, USA

[3]Pacific Islands Ocean Observing System, Honolulu, HI, USA

[4]SouthSeas Consulting, Raglan, New Zealand

[5]formerly Sofar Ocean, San Francisco, CA, USA

[6]Quileute Tribe, La Push, WA, USA

[7]Quinault Indian Nation, Taholah, WA, USA

[8]Marshal Islands Conservation Society, Majuro, Republic of Marshall Islands

[9]National Park of American Samoa, Pago Pago, United States Territory of American Samoa

[10]Alaska Eskimo Whaling Commission, Utqiagvik, AK, USA

The Backyard Buoys™ project (www.backyardbuoys.org) enables Indigenous and coastal communities to gather and use wave data, enhancing their blue economy and hazard protection. These communities have been historically underserved, and climate change is making weather and wave predictability even harder. Leveraging low-cost, scalable marine technology in partnership with regional ocean observing networks, Backyard Buoys offers a system for community-managed ocean buoys and data access to complement Indigenous Knowledge. Through co-design of an implementation and stewardship plan, as well as apps tailored to transmit data in low-bandwidth scenarios and render data easy to access and understand, we are revolutionizing the status quo. By using lower-cost tools and deepening the human and data connections, collectively our system is addressing needs within the hyper-local scale – sorely lacking in the design of existing ocean observing systems – while assuring it is within a globally-connected network. The Indigenous communities involved are now the stewards of the wave buoys within their own waters, with a plan for sustaining beyond the project in an ongoing partnership with the U.S. Integrated Ocean Observing System (IOOS) regional ocean observing systems. While the need for wave data from lower-cost, more-easily serviced buoys was a clear motivation, this project focused on working together to overcome barriers and challenges as communities deployed buoys in the water, addressed permitting requirements, and fostered autonomous stewardship into the future. We are preparing materials to enable knowledge transfer of procedures and keys to success beyond the project.

**(S04 17859 Pre-Recording)**

## Combining advanced technologies to monitor and assess forage fish temporal distribution and abundance

Chris **Rooper**[1], Jennifer Boldt[1], Stéphane Gauthier[2], Xiamao Wang[3] and Kresimir Williams[4]

[1]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, British Columbia, Canada. E-mail: chris.rooper@dfo-mpo.gc.ca

[2]Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, British Columbia, Canada

3University of Victoria, Department of Environmental Sciences, Victoria, British Columbia, Canada

[4]National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Washington, USA

Forage fish comprise an important link between zooplankton and predatory fishes, birds and mammals. In the Salish Sea, adult Pacific herring (Clupea pallasi) are the dominant forage species. They spawn in the spring and, after hatching, juveniles occupy nearshore habitats. In 2021 a project was initiated to use advanced sampling technologies (acoustics, optics and spatial modeling) to assess and compare multiple methods of estimating herring abundance and to improve our understanding of juvenile herring residency in nearshore areas. Acoustic data were collected at transects to compare with seine net catches. The seasonal residency of herring was assessed by deploying upward looking autonomous echosounders at two sites over 15 continuous months. Species composition and size distributions of fish observed in the acoustics were verified using stereo cameras deployed monthly at the two sites. Herring were observed throughout the year, with a distinct seasonal pattern of higher abundance in the summer. Other portions of the pelagic community (gadids, marine mammals, rockfishes, etc.) were observed throughout the year. The acoustic-optic surveys were combined with net survey data in species distribution models to determine patterns in nearshore habitat use. This research has the potential for broader application, especially with recent advances and easier attainability of consumer robotics and its associated programming. In addition to the Pacific herring work, examples of ongoing applications utilizing low cost and DIY optic and acoustic technology will be presented. These applications provide solutions that have the potential to monitor fisheries and survey catches, as well as deep sea fish and habitat.

**(S04 17754 Poster)** S04-P2

**Seasonal turbulent characteristics in physical and spectral domains obtained from multiple Lagrangian surface drifters**

Sung Yong **Kim**, Changhoon Ko, and Jinwhan Kim

Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology Daejeon, Republic of Korea E-mail: syongkim@kaist.ac.kr

We present seasonal turbulent characteristics of the surface ocean. We deployed multiple Lagrangian surface drifters in a coastal region of the East Sea for up to 90 days in the summer of 2023 and winter of 2024. The relative dispersion exhibits three regimes of non-local, Richardon, and diffusive, characterized by exponential function (et), cubic function (t3), and linear function (t) in theory, respectively. To examine the regional turbulent characteristics of the surface ocean, we examine the kinetic energy spectra of surface currents in the wavenumber domain to elucidate the transition between Richardson and diffusive regimes and investigate the relative dispersion of synthetic surface drifters to find a proper parameterization of random walk simulation using regional submesoscale resolving numerical model outputs.

**(S04 17823 Poster)** S04-P3

**Comparison of carbon storage capacity and physiological activity of 8 halophytes in the West Sea of Korea**

Sunwoo **Park** and Eun Ju Jeong

Department of GreenBio Science, Gyeongsang National University, Jinju, Republic of Korea

E-mail: jeong.ej@gnu.ac.kr

Blue carbon, the carbon absorbed by the marine ecosystem mainly halophytes, has recently attracted attention in order to expand carbon sinks. Marine ecosystem is known to absorb more than 50 times faster than land ecosystems, and numerous projects to create halophyte colonies are being actively carried out. Therefore, we compared the carbon assimilation abilities of eight species of halophytes living in the West Sea of Korea, and studied the physiological activity of halophyte resources. In order to verify the carbon storage capacity, photosynthesis-related genes, rbcL, psbA, psbB, psbD, and petA, were detected in eight species of halophytes (the Leymus mollis, Calystegia soldanella, Zoysia sinica, Suaeda glauca, Vitex rotundifolia L., Salsola collina, Atriplex gmelinii C. and Limonium tetragonum). Based on the expression level of the Leymus mollis, the mRNA level of all genes was significantly higher in the Calystegia soldanella, Suaeda glauca, and Vitex rotundifolia L. Among them, 20 ug/ml of Calystegia soldanella and Vitex rotundifolia L. reduced cellular activity of colon cancer cells HCT116, and especially, Calystegia soldanella promoted late apoptosis of HCT116. In addition, 50 ug/ml of Vitex rotundifolia L. reduced the cell viability of ihOESCs, immortalized human ovarian endometriotic stromal cells, and increased the autophagy activity of ihOESCs. These results proved that the efficiency of Calystegia soldanella, Suaeda glauca, and Vitex rotundifolia L. for carbon storage, Moreover, Calystegia soldanella and Vitex rotundifolia L. showed physiological activity against proliferative diseases, proving that they are plants with high value of additional use.

**(S04 17903 Poster)** S04-P4 (ECOP)

**Artificial Intelligence (AI) literacy for ocean professionals is needed for a sustainable future**

Erin **Satterthwaite**[1] and Matthew Robbins[2]

[1]CalCOFI & California Sea Grant, Scripps Institution of Oceanography, University of California, San Diego (UCSD) email: esatterthwaite@ucsd.edu

[2]Bren School of Environmental Science and Management, University of California Santa Barbara (UCSB) & Robbins Research

The increasingly widespread use of artificial intelligence (AI)-based tools in society and ocean sectors, is accompanied by an increasing need for AI literacy. AI literacy is a relatively new concept informed by interdisciplinary research from various fields, and is generally agreed to include the suite of knowledge, skills, and values learners need to navigate in an increasingly AI-influenced society. It involves an exploration of foundational AI concepts related to and AI technologies and techniques, practical applications, critical thinking and evaluation of AI, understanding the impact of AI on society and the attendant philosophical and ethical implications. AI literacy can be implemented through formal classes for those who are still in a formal learning setting (e.g., undergraduate and graduate students), but for individuals already in the workforce, professional development and other learning opportunities are needed. Achieving AI literacy will require engagement across a diverse range of people who can engage, develop, support, and incentivize it, including employees, employers, organizational leaders, educators, funders, and policy makers. AI technologies can facilitate transformative solutions, but achieving their potential relies on ethical and meaningful individual participation. Thus, AI literacy is essential for a vibrant, resilient, and sustainable future.

**Combined effect of polystyrene microplastics and dibutyl phthalate on the microalgae *Chlorella pyrenoidosa***

Zhaochuan **Li**[1] and Xianliang Yi[2]

[1]National Marine Environmental Monitoring Center, Dalian, Liaoning, China. E-mail:

zcli@nmemc.org.cn

[2]Dalian University of Technology, Panjin, Liaoning, China

The combined effect of polystyrene (PS) microplastics and dibutyl phthalate (DBP), a common plastic additive, on the microalgae *Chlorella pyrenoidosa* was investigated in the present study. The 96 h-$IC_{50}$ value of DBP was 2.41 mg $L^{-1}$. Polystyrene microplastics exhibited size-dependent inhibitory effect to *C. pyrenoidosa*, with the 96 h-$IC_{50}$ at 6.90 and 7.19 mg $L^{-1}$ for 0.1 and 0.55 µm PS respectively, but little toxicity was observed for 5 µm PS. The interaction parameter $\rho$ based on the response additive response surface (RARS) model varied from −0.309 to 5.845, indicating the interaction pattern varying with exposure concentrations of chemical mixtures. A modified RARS model (taking $\rho$ as a function of exposure concentration) was constructed and could well predict the combined toxicity of PS and DBP. More than 20% reduction of DBP was observed at 20 mg $L^{-1}$ PS, while 1 mg $L^{-1}$ PS had no significant effect on the bioavailability of DBP at different sampling time points. Volume, morphological complexity and chlorophyll fluorescence intensity of microalgal cells were disturbed by both DBP and PS. The antagonistic effect of high concentrations of PS might be partially attributed to the combination of hetero- and homo-aggregation and the reduced bioavailability of DBP. The overall findings of the present study profiled the combined toxic effects of PS and DBP on marine phytoplankton species which will be helpful for further evaluation of ecological risks of PS and DBP in marine environment.

**(S04 17974 Poster)** S04-P8 (ECOP)

**Implementing the UN Ocean Decade: Climate change response through research on marine ecosystem and marine toxins in Korean coastal waters**

Eunyoung **Yoon**[1], Jaeyeon Park[1], Jungrae Rho [2] and Wonho Yih [3,4]

[1]Advanced Institutes of Convergence Technologies, [2]Kunsan National University email: journal04@snu.ac.kr

[3]Korean Academy of Marine Science, [4]Geosystem Research

This study aims to analyze the impact of climate change on the marine ecosystem and marine toxins in Korean coastal waters. Aligned with the goals of the UN Ocean Decade, this research conducts investigation of the changes in marine ecosystems and the distribution and concentration of marine toxins in response to climate change in various coastal areas of Korea. The rate of sea surface temperature (SST) increase in Korea exceeds the global average, leading to the influx and spread of Ciguatera-causing dinoflagellates. Tropical or subtropical species transported into temperate waters by ocean currents due to global warming are now able to overwinter in their new environments. Consequently, the abundance of toxin benthic dinoflagellate species such as *Gambierdiscus* spp. and *Ostreopsis* spp. has increased since their first report in Jeju Island, South Korea, in 2008. Recently, four species of *Gambierdiscus* producing ciguatera toxin and three species of *Ostreopsis* producing palytoxin were reported in Korean coastal waters. This study involved long-term monitoring of ciguatera-toxic dinoflagellates based on region, season, and water depth to confirm the distribution status and changes in South Korea. The results will provide a crucial scientific foundation for developing climate change response strategies for Korean coastal marine ecosystems and offer practical data contributing to the goals of the UN Ocean Decade.

**(S04 18032 Poster)** S04-P9 (ECOP)

## Temporal dynamics of nearshore zooplankton communities in the Strait of Georgia: implications for ecosystem health

Deniz **Coskuner**[1], Svetlana Esenkulova[2], Isobel Pearsall[2] and Brian Hunt[1]

[1]University of British Columbia, BC, Canada. Email: d.coskuner@oceans.ubc.ca

[2]Pacific Salmon Foundation, Vancouver, BC, Canada.

In recent decades, zooplankton communities in the Strait of Georgia (SoG) have shown pronounced inter-annual variability linked to large-scale climate oscillations. Nevertheless, understanding of local drivers remains limited due to infrequent sampling characteristic of many monitoring programs. Additionally, zooplankton in nearshore habitats, which are vital for juvenile salmon and other forage fish, have been largely overlooked. To address this, zooplankton data collected by Pacific Salmon Foundation's (PSF) Citizen Science Oceanography program are being leveraged in conjunction with ZooSCAN technology, a semi-automated image processing system, to assess the seasonal and interannual dynamics of the nearshore zooplankton assemblages in the SoG, and their relationship to oceanographic properties. PSF's ongoing program uses trained citizen scientists to collect zooplankton, temperature, salinity, depth, dissolved oxygen, turbidity, chlorophyll, nutrients, and harmful algae at three nearshore sites in Malaspina Strait, a key juvenile salmon migration pathway in the SoG. Samples have been collected approximately one to two times a month since 2015. ZooSCAN captures and processes high-resolution images of zooplankton samples and image analysis uses deep learning to rapidly identify major taxonomic groups. In addition, several metrics are calculated that are highly relevant to ecological studies and studies on fish diets, including organism size, organism biovolume, and community size spectra and biomass. Here we present preliminary results of the seasonal dynamics of zooplankton assemblages from three nearshore sites in Malaspina Strait over one year and their relationship to oceanographic drivers; one site is then selected for analysis of interannual variability.

**(S04 18039 Poster)** S04-P10

## Comparison of environmental DNA and imaging methods for monitoring deep-sea fishes on a seamount

Akira **Iguchi**[1,2], Miyuki Nishijima[1], Eri Ikeuchi[1], Hiroyuki Yokooka[3], Hideki Sugishima[3], Kazumasa Ikeda[4], Ryuichi Miwa[5], Yoshiro Sekido[6], Nozomu Iwasaki[7], Masahiro Suzumura[8], Ayumi Tsukasaki[8], Yuichiro Tanaka[1], Shogo Kato[9], Jumpei Minatoya[6], Nobuyuki Okamoto[9], Taiga Kunishima[1,10], Yuji Ise[11] and Atsushi Suzuki[1,2]

[1]Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. E-mail: iguchi.a@aist.go.jp

[2]Research Laboratory on Environmentally-conscious Developments and Technologies [E-code], National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan.

[3]IDEA Consultants, Inc., Yaizu, Japan.

[4]Okamoto Glass Co., Ltd., Kashiwa, Japan.

[5]Kaiyo Engineering Co., Ltd., Taito, Japan.

[6]Marine Biological Research Institute of Japan Co., Ltd., Shinagawa, Japan.

[7]Rissho University, Kumagaya, Japan.

[8]Environmental Management Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan.

[9]Japan Organization for Metals and Energy Security (JOGMEC), 2-10-1 Toranomon, Minato, Tokyo 105-0001, Japan.

[10]Setsunan University, Hirakata, Japan.

[11]Kuroshio Biological Research Foundation, Otsuki, Japan.

In this study, environmental DNA analysis (seawater and sponge samples) was compared with image analysis using a free-fall deep-sea camera lander called Edokko Mark I and an ROV (Remotely Operated Vehicle) at a seamount of the Northwest Pacific, with the aim of improving efficiency in understanding fish communities around seamounts. The results showed that a total of 18 fish taxa were identified at the family level and that detection patterns differed significantly between environmental DNA analysis and image analysis. This may be due to differences in the sensitivity of environmental DNA analysis and image analysis to detect specific fish groups. No significant differences in fish composition were found in the environmental DNA analysis of seawater and sponge samples, but significant differences were found between the Edokko Mark I and ROV analyses. The latter was considered to be due to the high sensitivity of some fish groups to ROV. Although there is room for improvement with regard to environmental DNA analysis, such as the amount of samples taken, it would be possible to obtain a more comprehensive picture of the fish community when combined with image analysis. Our trial of environmental DNA analysis using seawater and sponge samples around seamount should prove

useful in facilitating environmental baseline studies and environmental impact assessments in future deep-sea surveys.

**(S04 18042 Poster)** S04-P11 (ECOP)

## Spatial distribution of deep-sea megabenthos around cobalt-rich ferromanganese crusts on seamounts in the northwestern Pacific

Hiroki **Kise**[1], Akira Iguchi[1,2], Shogo Kato[3], Hideki Sugishima[3], Shota Mitsui[7], Jumpei Minatoya7, Ryuichi Miwa[4], Nozomu Iwasaki[5], Masahiro Suzumura[6], Ayumi Tsukasaki[6], Yuichiro Tanaka[1], Keigo Yanagita[8], Shohei Kikuta[8], Hiroko Kamoshida[9] and Atsushi Suzuki[1,2]

[1]Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. E-mail: h.kise@aist.go.jp

[2]Research Laboratory on Environmentally-conscious Developments and Technologies [E-code], National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan.

[3]IDEA Consultants Inc., Yaizu, Japan.

[4]Marine Biological Research Institute of Japan Co., Ltd., Shinagawa, Japan.

[5]Kaiyo Engineering Co., Ltd., Taito, Japan.

[6]Rissho University, Kumagaya, Japan.

[7]Environmental Management Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan.

[8]Science and Technology Co., Ltd., Minato, Japan.

[9]Japan Organization for Metals and Energy Security (JOGMEC), Minato, Japan.

In this study, we aimed to comprehend spatial distribution patterns of deep-sea megabenthos on flat tops of seamounts off southeastern Minami-Torishima Island in the North Pacific. We used towed cameras and remotely operated vehicles to examine spatial distributions of substrates and marine organisms in our study area. Using this data, we constructed habitat maps. We identified various sessile taxa (e.g., Porifera, Crinoidea) and nekton (e.g., fishes), and estimated the densities of these taxa. We also categorized the observed substrates into four types based upon the percentage of hard substrate and compared the distribution of these substrate types against organism distributions. Sessile organisms were frequently observed not only in sites with a high percentage of hard substrates but also those rich in rubble-like ones. Depth appeared to limit the distribution of several taxa. We also detected significant aggregation in many taxa. Aggregation of sessile organisms was observed at numerous sites where may be affected by resource exploitation. Future observations to understand source–sink relationships among these sites could contribute to the establishment of preservation reference zones.

**(S04 18076 Poster)** S04-P12

**Detailed observations of the Kuroshio Extension Front**

Daisuke **Hasegawa**, Takahiro Tanaka and Okunishi Takeshi

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

Our research group has been carrying out detailed observations of the Kuroshio extension front using research vessels and underwater gliders. For the shipboard observations, the BGC sensors (CTD, DO, chlorophyll and turbidity) are integrated into the UCTD (Underway CTD) system and the UTA (Undulating Towed sensor Array), while for the gliders, the BGC sensors (CTD, DO, chlorophyll, turbidity, CDOM, PAR, nitrate and turbulence intensity) are equipped to measure a wide range of environmental parameters. The results of these measurements indicate that entrainment and subduction of surrounding water masses (the Oyashio and coastal waters) and the associated transport of biological particles (high chlorophyll and high turbidity water) occur in the Kuroshio extension front. Furthermore, during the subduction of the entrained water masses in the front, enhanced turbulence at the boundaries of the subducting layers has also been observed. In this talk the detailed processes observed in the Kuroshio extension front will be presented.

**(S04 18082 Poster)** S04-P13 (ECOP)

**Study on the difference characteristics of spring and autumn in Tie Bay ecosystem**

Minbo **Luo**[1], Tianxiang Li[1,2], Yunlong Wang[1] and Mei Jiang[1]

[1]East China Sea Fisheries Research Institute, China Academy of Fishery Sciences, Shanghai 200090, China. E-mail: luomb@ecsf.ac.cn

[2]College of Marines Science, Shanghai Ocean University, Shanghai 201306, China

In order to better understand the structural function and energy flow changes of the Tie Bay ecosystem in spring and autumn, the present study constructs two ecological energy channel models of Tie Bay in different seasons using Ecopath with Ecosim (EwE6.5) based on the data of the Tie Bay fishery resources and ecological environment survey in Spring and autumn 2021. According to the data of fishery resources, 16 functional groups are set for spring and 20 functional groups for autumn, basically covering the whole process of energy flow in the Tie Bay ecosystem. The results showed that the energy conversion efficiency in autumn was much higher than that in spring, and the nutrient level and nutrient conversion efficiency of all functional groups also increased. The total energy flow of the ecosystem in spring and autumn was $11419.57 t \cdot km^{-2} \cdot a^{-1}$ and $7314.99 t \cdot km^{-2} \cdot a^{-1}$, respectively. The trophic levels of each functional group ranged from 1-3.66 and 1-4.34, respectively, and the grazing food chain was the main energy channel. In spring and autumn, the energy utilization rate of the Tie Bay ecosystem was low, and there was still a lot of surplus production that was not fully utilized, which was in an immature development stage.

**(S04 18084 Poster)** S04-P14

**An overview of SynObs UN Decade Project and preprimary results of its flagship observing system experiments**

Shoichiro **Kido**[1], Yosuke Fujii[2], Ichiro Ishikawa[2], Yasumasa Miyazawa[1], Elisabeth Remy[3], Drew Peterson[4], and Jennifer Waters[5]

[1]Application Lab, Japan Agency for Marine-Earth Science and Technology, Japan email: skido@jamstec.go.jp

[2]Meteorological Research Institute, Japan

[3]Mercator Ocean International, France

[4]Environment and Climate Change Canada, Canada

[5]UK Met Office, United Kingdom

Accurate estimation and prediction of oceanic conditions such as currents and water temperature are crucial not only from the perspective of physical oceanography and climate science but also for understanding variability of marine ecosystems and management of fishery resources. For these reasons, research institutes around the world have been developing ocean nowcasting and forecasting systems to provide estimates of ocean states. While various types of observational data, such as the satellite altimetry and temperature/salinity profiles from ships and Argo floats, are used to ocean state estimates, the relative importance of information derived from individual platforms is yet to be quantified in a comprehensive manner.

Given the paramount importance of systematic evaluations of the impact of ocean observation, the SynObs project (Synergistic Observing Network for Ocean Prediction), was launched as part of the United Nations Decade of Ocean Science for Sustainable Development. This project is aimed at maximizing the utility of diverse ocean observation platforms for predicting ocean behavior, and involves a series of coordinated Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs) conducted with multiple operational ocean forecasting systems to evaluate the impact of different types of ocean observations. The results of these multi-system experiments will be compiled into a database resembling an ocean digital twin, facilitating analysis by the broader oceanographic community.In this presentation, we will outline the experimental designs of the SynObs Flagship OSEs and present their initial findings using our ocean nowcasting/forecasting system, mainly focus on the results for the North Pacific.

**(S04 18089 Poster)** S04-P16 (ECOP)

**Anomalous Edge Warming and High Biomass in High-Latitude Oceanic Eddies Driven by Submesoscale Ageostrophic Motions**

Huizi **Dong**[1], Meng Zhou[1], Roshin Raj[2], etc.

[1]School of Oceanography, Shanghai Jiao Tong University, Shanghai, China. E-mail: huizidong@sjtu.edu.cn

[2]Nansen Environmental and Remote Sensing Center, Norway and Bjerknes Center for Climate Research, Norway

The warm and saline Atlantic Water has long been recognized as being subjected to a substantial heat loss along its poleward transit as it passes through the Nordic Seas. In particular, the Lofoten Basin, a region of abundant eddy activity and strong air-sea interactions, plays a crucial role in the transformation of Atlantic Water. Vertical heat transport due to submesoscale dynamical processes is likely to be a key link in the transfer of ocean heat to the atmosphere in this region. By using a combination of satellite altimeters, radiometers, multi-year Seaglider observations, and finite size Lyapunov theory, we diagnose the oceanic vertical heat transport in the Lofoten Basin. The results demonstrate how geostrophic strain drives VHT associated with submesoscale ageostrophic motions along the edges of eddies on spatial scales smaller than 10 km and at depths below the mixed layer. The strain-induced submesoscale vertical motions along the edges of both the cyclones and anticyclones drive heat transport from the ocean interior back to the surface, leading to a 0.4°C increase of sea surface temperature. The long-neglected submesoscale heat transport exceeds other contributors to vertical heat transport and is likely the key reason for the substantial heat loss in the Atlantic Water in the Lofoten Basin.

**(S04 18097 E-Poster)** S04-P17

**Limited Genetic Connectivity of Precious Corals on Fisheries Impacted Seamounts of the North Pacific**

Amy R. **Baco-Taylor**[1], Nicole B. Morgan[1], and E. Brendan Roark[2], Peter Beerli[1] and Tara Khodaei[1]

[1]Florida State University, Tallahassee, Florida, USA E-mail: abacotaylor@fsu.edu

[2]Texas A&M University, College Station, Texas, USA

Deep-sea precious corals in the octocoral family Coralliidae are among the dominant benthic megafauna at depths of 300-600m on the high-seas seamounts of the Northwestern Hawaiian Ridge and lower Emperor Seamount Chain. These seamounts have experienced some of the heaviest fisheries impacts of any seamounts in the world for both finfish and for precious corals. Coralliids still occur on the heavily fished seamounts but at lower abundances than at unfished sites. Since fishing continues on the seamounts outside the US EEZ, it is imperative to understand the connectivity of these species. A total of 481 individuals for one of the targeted species, Hemicorallium laauense, were collected from 25 populations divided into 3 fishing treatments, Still Trawled, Recovering, and Never Trawled. Data from 9 microsatellite loci showed extremely high levels of variation, with 17-82 alleles per locus. All loci also showed significant departure from Hardy-Weinberg equilibrium, with the observed heterozygosity lower than the expected. FIS values ranged from 0.11-0.27 suggesting self-recruitment is common at most locations. The Still Trawled and Recovering Seamounts had higher heterozygote deficits and higher FIS values compared to unfished seamounts. The overall G’ST value was 0.17, indicating moderate genetic structure among populations. Among the treatments, mean pairwise G’ST values for Still Trawled sites vs Never Trawled sites was 0.23, which is much higher than the comparison of Still Trawled to Recovering sites of 0.12. A pattern of isolation by distance was present across the Archipelago. Additional metrics support these results and indicate that the Still Trawled seamounts are more well connected to the Recovering sites than either is to the Never Trawled sites, suggesting protecting recovering sites from additional fishing pressure will be critical for recovery of actively trawled areas. However, the high FIS values indicate local recruitment from remnant populations will also need to be a critical consideration in high seas conservation and management.

**(S04 18101 Poster)** S04-P18

**High-rate, near-surface foraging of Rhinoceros Auklets revealed by depth and video data loggers**

Jean-Baptiste **Thiebot**[1,5], Mindaugas Mitkus[1,2], Kozue Shiomi[1,3, 4], Jumpei Okado[5,6], Ui Shimabukuro[1,7], Yutaka Watanuki[5] and Akinori Takahashi[1,3]

[1]National Institute of Polar Research, Tokyo, Japan email: jbthiebot@fish.hokudai.ac.jp

[2]Institute of Biosciences, Life Sciences Center, Vilnius university, Vilnius, Lithuania

[3]Department of Polar Science, SOKENDAI (The Graduate University of Advanced Studies), Tokyo, Japan

[4]Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, Sendai, Japan

[5]Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Japan

[6]Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan

[7]Meiji Institute for Advanced Study of Mathematical Sciences, Nakano, Tokyo, Japan

Seabirds, as abundant predators in marine ecosystems, can be used as bio-indicators of the distribution and abundance of regional prey resources in the marine environment, through their diet and foraging behavior. However, in this context, it is needed to examine the birds' foraging habitat, prey items, and feeding rate, in order to reliably quantify the relationships between environmental conditions and the observed birds' response. In this study, we examined the at-sea foraging behavior of chick-rearing Rhinoceros Auklets (*Cerorhinca monocerata*) from Teuri Is. (Hokkaido, Japan), using bird-borne video and depth data loggers. Data available from four birds (990 dives) showed that auklets performed very short and shallow dives (median dive duration: 15.0 ± 4.2 s; median depth: 2.6 ± 0.9 m, on average) during which they captured 1120 prey items at an unexpectedly high rate of 1 capture per 14 s spent underwater (up to 15 captures per dive). The visible prey captures were identified as 0-year sandlance (*Ammodytes sp.*) and constituted 97.0 ± 1.8 % of the total catch close to the surface, on average. Concomitant colony-based diet monitoring confirmed the importance of sandlance for the studied auklet population at that time, with >50% of bill loads consisting exclusively of that prey. Our study shows that the predominance of juvenile sandlance in the diet of auklets at that time reflected the availability of this prey at very shallow depths and that the birds were able to exploit it with low effort and at high feeding rate.

**(S04 18119 Poster)** S04-P19

## Consistent seabird habitat use across years and populations reveals key areas for marine conservation in the North-western Pacific

Jean-Baptiste **Thiebot**[1,2], Ui Shimabukuro[3,4], Jumpei Okado[2,5], Nobuo Kokubun[1,3], Yutaka Watanuki[2] and Akinori Takahashi[1,3]

[1]National Institute of Polar Research, Tokyo, Japan email: jbthiebot@fish.hokudai.ac.jp

[2]Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Japan

[3]Department of Polar Science, SOKENDAI (The Graduate University of Advanced Studies), Tokyo, Japan

[4]Meiji Institute for Advanced Study of Mathematical Sciences, Nakano, Tokyo, Japan

[5]Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan

Identifying key marine habitats is essential to develop adequate and meaningful ecosystem conservation strategies. Marine predators such as seabirds may help indicating ecologically important areas, through their at-sea distribution and habitat use. However, it can be costly and logistically challenging to examine repeatability in the utilization of said key habitats, both among years and populations, which may limit our full understanding of those critical areas to protect. In this study, we used light-based geolocation loggers to track rhinoceros auklets (*Cerorhinca monocerata*) during their annual migration, from three islands located in the Sea of Japan and the Western Pacific Ocean, across one to eight years. We examined spatial overlap in the core areas used by the birds across years and colonies. Finally, we built a predictive model of habitat suitability to evaluate whether other areas could also be suitable for the birds. We found a remarkable spatial consistency in the auklets' wintering distribution across years: in the Sea of Okhotsk (in autumn), then in the southern Sea of Japan (in winter). Moreover, the three populations had similar at-sea distribution core areas. Modelled habitat suitability suggested that there was no other major suitable area for the birds in their flying range. In conclusion, our study shows that these areas reflect key habitats because they were consistently used by auklets, across years and populations. In the context of the U.N. Convention on Biological Diversity, this study provides a robust scientific basis to flag these areas as ecologically significant for regional marine conservation.

**(S04 18120 Poster)** S04-P20

**Seasonal resilience of temperate estuarine fish in response to climate change**

Zhaopeng **Zhang**[1,2], Yuanchao Wang[1,2], Cui Liang[1,2], Lei Zheng[1,2] and Weiwei Xian[1,2,3]

[1]Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China. E-mail: wwxian@qdio.ac.cn

[2]Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

[3]Center for Ocean Mega-Science, Chinese Academy of Sciences, Qingdao, China

To date, the intricacies and efficacy of how periodic seasonal environmental fluctuations affect fish populations in biogeography in the context of profound climate change remain to be elucidated. Collected monitoring data on fish resources in the Temperature Estuary provide an excellent opportunity to assess the effects of seasonal environmental fluctuations on populations and functional assemblages under climate change. We first developed a framework for predicting habitat suitability under different climate change scenarios (SSP1-2.6 and SSP5-8.5) for 12 fish populations in the Yangtze estuary by examining the seasonal environmental affinities of temperate estuarine fishes. We then summarized the multidimensional habitat suitability responses (HSRs) of populations and functional assemblages and discussed the possible drivers and mechanisms underlying these changes. The results suggest that the acidity of the Yangtze estuary may decline in the future as the climate warms, endangering the ecosystem that many fish species depend on. Prospective climate change may have an impact on fish population HSRs through redistribution, area changes, and centroid migration of suitable habitats; nevertheless, affinity for environmental factors may be limited to distinguishing patterns of population response in the spring. Fish (5 populations) and functional assemblages (11 assemblages) may exhibit robust adaptations or non-adaptations to climate change when seasons change, given their suitable habitat area. Furthermore, projections indicate that the majority of fish habitat centroids exhibit seasonal responses, migrating northeast in the spring and southeast in the autumn. By decentralizing climate risk to seasonal scales, seasonal resilience in the multidimensional HSRs of several fish populations (5/12) and their functional assemblages (11/16) is revealed for the first time. Efforts to mitigate climate risks and safeguard resources should take these seasonal forecasts and indicative information into account.

**(S04 18123 Poster)** S04-P21

**An overview of the US Biogoechemical Argo program in the North Pacific**

Yuichiro **Takeshita**[1], Kenneth S. Johnson[1], Andrea Fassbender[2], Alison Gray[3], Todd Martz[4], David Nicholson[5], Sarah Purkey[4], Stephen Riser[3], Lynne Talley[4] and Susan Wijffels[5]

[1]Monterey Bay Aquarium Research Institute, Moss Landing, CA, USA. E-mail: yui@mbari.org

[2]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA

[3]University of Washington, Seattle, WA, USA

[4]University of California San Diego, Scripps Institution of Oceanography, La Jolla, CA, USA

[5]Woods Hole Oceanographic Institution, Falmouth, MA, USA

The main objective of this talk is to provide an update on the status of the US Biogeochemical (BGC)-Argo effort, which aims to deploy and sustain 500 BGC floats globally, which is equivalent to half of the target global array size of 1,000 BGC floats. These floats are equipped with sensors to measure oxygen, pH, nitrate, chlorophyll-a fluorescence, optical backscatter (proxy for phytoplankton biomass), and a subset of floats also carry downwelling radiometers. They collect data from 2,000 m to the surface every 10 days. Over 200 BGC floats have been deployed worldwide through programs such as GO-BGC, NOAA, and SOCCOM over the past 3 years, with at least 90 more scheduled to be deployed by the end of 2024. Funding exists to deploy over 250 more floats through 2026. In particular, over 50 BGC floats now operate in the North Pacific, and the array size is expected to continue growing. Adjusted, science quality data from GO-BGC are made publicly available in near-real time, typically within 24 hours of collection. Furthermore, we provide a snapshot of delayed-mode quality-controlled data twice a year with an associated doi on the dataset, on the UCSD library website. There are open source tools to access and visualize the BGC-Argo dataset as well. These data are starting to be used for a variety of scientific applications, as well as developing gridded data products that can help tie environmental conditions to biological and ecosystem data.

# S6: FUTURE/MONITOR/TCODE Topic Session

**Past, Present and Future of CREAMS program: 30 years of international research in North East Asian Marginal Seas**

**Convenors:**
Vyacheslav Lobanov (Russia), *corresponding*
SungHyun Nam (Korea)
Fei Yu (China)
Jing Zhang (Japan)

**Invited Speaker:**
Seongbong Seo (Ocean Circulation & Climate Research Department, Korean Institute of Ocean Science and Technology (KIOST), Korea)

International program on Circulation Research of East Asian Marginal Seas (CREAMS) started in August of 1993. It was the first international program in this area and it significantly promoted collaboration between marine scientists of bordering countries as well as their colleagues from other parts of the world. North East Asian Marginal Seas are one of the most affected areas in the global ocean by climate changes and anthropogenic impacts. There have been considerable advances in exploring these seas over the 30 years. Being initially focused on research of water circulation and ventilation, the CREAMS program evolved into biogeochemical and ecosystem research and now is seeking a way to be a more socio-economic oriented program. This session would summarize and share the knowledge and experience in water dynamics, biogeochemistry, ecosystem and their variability at multi-scales, and discuss the future directions of research in the area moving toward a multidisciplinary science. 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 to the UN Decade targets. Participation of ECS is especially welcomed to involve them into the CREAMS activity. The session outcome should clarify a vision of international comprehensive marine research in the North East Asian region that meets the current needs of society.

**(S06 18136 Invited)** (ECOP)

**Estimation of vertical eddy diffusivity over the southwestern East/Japan Sea**

Seongbong **Seo** and Young-Gyu Park

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

Over the southwestern East/Japan Sea (EJS), the vertical diffusivity of the upper ocean was indirectly estimated using the Thorpe scale analysis, calculated from approximately 1000 CTD profiles. The results from the Thorpe scale were comparable to those obtained from microstructure measurements conducted at selected locations. The mean vertical eddy diffusivity in the southwestern EJS was found to be within the range of $O(10^{-5})- O(10^{-2})^{m2s-1}$. A density-layer-based analysis revealed that the strongest mixing occurred over the southwestern EJS, where strong internal tides are generated. The internal waves are known to propagate primarily normal to the isobaths and secondarily along the isobaths. The vertical diffusivity was stronger not in the main direction of the internal tides, but along the isobaths. This observation suggests that the internal tidal energy mainly dissipates along the continental shelf near the generation site. Enhanced values of vertical diffusivity were also found near the coast and islands.

**(S06 17802 Pre-Recorded Oral)**

**The Tsushima Warm Current and its connection to sea surface temperature and winter rainfall along Japan**

Shinichiro **Kida**[1], Cocoro Yokomatsu[2], and Hiromi Matsuura[2]

[1]Research Institute for Applied Mechanics, Kyushu University, Kasuga, Japan. E-mail: kida@riam.kyushu-u.ac.jp

[2]Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, Kasuga, Japan

The Tsushima Warm Current (TWC) plays a crucial role in setting up the atmospheric and oceanic environment surrounding the Japan Sea. In this study, we investigated its impact on rainfall and the mechanism behind the rapid warming of the sea surface temperatures (SST) over the past few decades. Based on the long-term observations of the transport through the Tsushima Strait, we find a dramatic shift in recent connections between the autumn TWC transport and winter rainfall along Japan's northern coast. The correlation is high before 2005 but becomes absent after 2006. This abrupt shift in correlation is attributable to transport variability dominated by that through the western channel as well as enhanced surface cooling induced by stronger northwesterly continental winds and lower temperatures. The impact of the TWC on the SST is overwhelmed by that forced by the atmosphere. For the long-term SST, we find TWC to act to weaken the warming trend of the Japan Sea. This is opposite to its role on the seasonal time scale. By bringing SST with a weaker warming trend in the East China Sea and Kuroshio region, a region of weak warming trend is established. The role of TWC is, therefore, to mitigate the SST warming trend while the atmosphere acts to warm the SST from above.

**(S06 17737 Oral)** (ECOP)

**Long-term sediment trap study in the Northwest Pacific (Ulleung Basin): Insights from organic and inorganic tracers**

Minkyoung **Kim**[1], Young-Il Kim[2], Sun A Lee[1], Ho Jung Kim[1], Otosaka Shigeyoshi[3], Michael Bollen[4], Patrick Blaser[4], Samuel L. Jaccard[4], Negar Haghipour[5,6], Timothy I. Eglinton[6]

[1]Department of Oceanography/ KNU LAMP Research Center, Kyungpook National University, Daegu, South Korea. E-mail: minkyoung@knu.ac.kr

[2]East Sea Research Institute, Korea Institute of Ocean Science & Technology, Uljin, South Korea

[3]Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, 2778564, Japan

[4]Institute of Geological Sciences, University of Lausanne, Lausanne, Switzerland

[5]Geological Institute, Swiss Federal Institute of Technology Zürich (ETHZ), Zürich, Switzerland

[6]Laboratory for Ion Beam Physics, ETHZ, Zürich CH-8093, Switzerland

This talk will address 10-years of sinking particle data collected by conical-type sediment traps deployed at 300, 1000, and 2000 m depths in the Ulleung Basin, southwestern part of the East/Japan Sea (EJS) to understand the carbon cycling in the EJS. Beginning with the introduction of the previous studies, (i.e., i) seasonal variations of biogeochemistry and radiocarbon contents of sinking particles and ii) influence of sediment resuspension), preliminary data of on-going studies will be presented. The surface area of sinking particles, long-term trend of radiocarbon compositions of sinking particulate organic carbon, and the neodymium isotopic value (eNd) as an inorganic tracer will be discussed. Overall, this presentation will cover various aspects of sinking particles by using organic- and inorganic- tracers to understand the carbon cycling in the deep ocean interior, especially focusing on particle dynamics.

**(S06 17977 Oral)** (ECOP)

**Feasible sketch of the nitrogen cycling process and N2O production pathways using bacterial biomarker genes in the East Sea**

Hyo-Ryeon **Kim**[1], Seo-Young Kim[1], Hae-Kun Jung[2], Ju-Hyoung Kim[3], and Il-Nam Kim[1]

[1]Department of Marine Science, Incheon National University, Incheon, South Korea. E-mail: ilnamkim@inu.ac.kr

[2]Environment and Fisheries Resources Research Division, East Sea Fisheries Institute, National Institute of Fisheries Science, Gangneung, South Korea.

[3]Department of Aquaculture and Aquatic Science, Kunsan National University, Gunsan, South Korea.

Nitrogen (N) is a fundamental element for maintaining marine ecosystem stability. Additionally, various N transformation processes mediated by microbial metabolism determine N availability and produces potent greenhouse gas nitrous oxide (N2O) as a by-product or final product during nitrification and denitrification processes. The East Sea (ES) is a semi-enclosed marginal sea, often referred to as a miniature ocean due to its multiple ocean dynamic processes. Recent studies have shown that the ES is undergoing significant environmental changes due to climate change, greatly impacting its biogeochemical cycles. Thus, understanding N cycling and N2O production pathways in the ES by using N-associated biomarker genes, coupled with bacterial community composition, offers insights into future biogeochemical cycles and climate change impact. During the study period (April, August, and October in 2021), both seasonally affected and unaffected zones showed an increasing trend in the abundance of genes and compositions related to ammonification and nitrification from April to October. Furthermore, the correlation analysis between excess N2O and apparent oxygen utilization confirmed that N2O was produced by nitrification. In particular, the genes and compositions involved in the nitrifier denitrification (the oxidation of NH3 to NO2– is followed by the reduction of NO2– to N2O and N2), a process belonging to nitrification and carried out by NH3 oxidizers, were highly abundant across the entire water-column. This finding indicates the significant contribution of nitrifier denitrification to N2O production. This research is anticipated to serves as an initial baseline, contributing to a better understanding of N cycling in the ES.

**(S06 17994 Oral)**

**Coincidental increase in the primary productivity and sardine catch in the East Sea in response to the warming after 2014**

Sinjae **Yoo**[1,2] and Sukgeun Jung[1]

[1]Marine Life Science, Jeju National University, Jeju-Si, South Korea email: sjyoo@kiost.ac.kr

[2]Korea Institute of Ocean Science and Technology, South Korea

LMEs in the western North Pacific has experienced warming starting around 2014. In response to this, the primary productivity in the Yellow Sea, East China Sea and Kuroshio LMEs has decreased. On the contrary, the primary productivity in the East Sea LME has increased. Here, the long-term trends of chlorophyll-a, primary productivity and environmental variables in four LMEs in the western North Pacific are analyzed using satellite and in-situ data. Our analysis indicates the increase in the wind stress in the East Sea is likely to have induced the increase in the primary productivity. On the other hand, the catch of sardines in the region has also increased in the similar time frame. We discuss the potential relationship between these two events.

**(S06 18130 Oral)**

**Learning outcomes from the CREAMS 30th-anniversary workshop**

SungHyun **Nam**

Seoul National University, Seoul, Republic of Korea. E-mail: namsh@snu.ac.kr

In this talk, I will share learning outcomes from recent CREAMS (Circulation Research of the East Asian Marginal Seas) 30th-year anniversary workshop held in Seoul on July 25–26, 2024. Since the launch of the first international program in this area in the early 1990s, there have been remarkable progress in international collaboration as well as scientific findings over the past 30 years. During this session, I will provide a personal review of the past 30 years of CREAMS research based on presentations and conversations among the workshop participants. Collaborative efforts among the countries and with other international programs have advanced our understanding of water dynamics, biogeochemistry, ecosystem and their variability on different scales in these marginal seas. The insights gained from the workshop could have significant implications for the future direction of the next phase CREAMS (Creative Research of the East Asian Marginal Seas) research, as well as other relevant programs such as the UN Decade of Ocean Science. This shift aims toward a more data-driven and socio-economically linked multidisciplinary and integrative approach to marine sciences.

**(S06 18138 Oral)**

**Intraseasonal variability of the Deep Scattering Layer observed by subsurface mooring deployed east of Taiwan Island**

Fei **Yu**[1,2], Bei Wang[1,2], Ran Wang [1], Zhencheng Tao[2,3], Qiang Ren [1,2], Xingchuan Liu [1], Zifei Chen[1] and Feng Nan[1,2]

[1]Key Laboratory of Ocean Circulation and Waves, Institute of Oceanology, Chinese Academy of Sciences, Qingdao266071, China. Email: yuf@qdio.ac.cn

[2]University of Chinese Academy of Sciences, Beijing 100049, China.

[3]Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China

The Deep Scattering Layer (DSL), a stratum of marine Diel Vertical Migration (DVM) organisms inhabiting the mesopelagic ocean, plays a crucial role in transporting carbon and nutrients from the surface to depth through the migration of its organisms. Here, using 18 months in-situ observations and altimeter sea level data, we observed for the first time the intraseasonal variation of the DSL and the DVM of zooplankton and micronekton to the east of the Taiwan Island, and revealed the underlying mechanisms. The extraordinary vertical speeds acquired from the Acoustic Doppler Current Profiler are used to investigate the distribution and variation of the DVM. Innovatively, results of power spectrum analysis of the scattering intensity indicate that the DSL exhibits a significant intraseasonal variability (ISV) with an 80-day period, while the variation of the DVM is linked to the DSL, and also shows an 80-day ISV during the observation. Dynamically, the ISV of the DSL east of the Taiwan Island is correlated with the westward-propagating mesoscale eddies. When anticyclonic (cyclonic) eddies move towards the Taiwan Island, the local isotherms bend downward (upward), resulting in warming (cooling) in the DSL, and thus the upper boundary layer of the DSL gradually deepens (rises). These findings highlight the significant influence of mesoscale eddies on biological activity in the mesopelagic ocean.

**(S06 18144 Oral)**

**Study on the Yellow Sea warm current and Yellow Sea cold water mass in spring**

Xinyuan **Diao**, Fei Yu and Guangcheng Si

Key Laboratory of Ocean Observation and Forecasting and Key Laboratory of Ocean Circulation and Waves, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China. E-mail: diaoxinyuanl@qdio.ac.cn

The Yellow Sea is an important continent shelf region connected Bohai Sea and open sea. There are two typical phenomena in this area, which are the Yellow Sea Cold water mass and Yellow Sea warm current. Although many scientist have done good study on these, the research on the seasonal transition period is relatively lacking. Use the investigated data in the past ten years, scientist from IOCAS have obtained some new understandings of these two phenomena. In some year, the Yellow Sea warm current is still exist and the reason is well researched. The cold water from Chengshantou area and the residual water from the Yellow Sea warm current have contribute to the formation of the Yellow Sea Cold water mass.

**(S06 18146 Oral)** (ECOP)

**Unravelling Phytoplankton bloom in the subarctic western North Pacific Marginal Seas**

Yi **Xu**, Xinyuan Diao, Yansong Liu, Jianzhong Ge and Fei Yu

East China Normal University, SKLEC, China, PR email: xuyi@sklec.ecnu.edu.cn

The subarctic western North Pacific where a permanent halocline prevents surface water from sinking, the exchange of heat and nutrients is limited by this salinity-driven stratification. This region is also an important exception to the dominance of the Subantarctic Mode Water (SAMW) influence, which is the main source of nutrients for the thermocline in other oceans. This suggests that the nutreint source in the thermocline in the North Pacific should be assocated with certain strong vertical mixing that tap thermocline directly into the high-nutrient waters of the deep ocean. The North Pacific Intermediate Water (NPIW, σθ=26.8$\sigma\ \theta$ =26.8) is a distinct water mass found in the thermocline in the North Pacific Ocean. Given the importance of NPIW for the thermocline nutrient cycle, we need to understand the property of the NPIW water types and the processes that determine it. In the North Pacific, there exists a significant discrepancy between most models and observational estimates of primary production. The question then arises: is the model's failure to generate high nutrients during wintertime due to its inability to mix up nutrients from sufficient depths, or is it that the water mass being mixed up lacks an adequate amount of nutrients, or an insufficient lateral supply of high-nutrient water e.g. from river and atmopheric depostitions. Considering significant temporal shifts in physical processes, with implications for biogeochemistry, factors determine nutrient source and phytoplankton bloom phethology are investigated in the subarctic western North Pacific.

**(S06 18143 Poster) S06-P1** (ECOP)

**Role of the Yellow Sea Cold Water Mass in Modulating Winter Sea Surface Temperature**

Xingchuan **Liu** and Fei Yu

Key Laboratory of Ocean Observation and Forecasting and Key Laboratory of Ocean Circulation and Waves, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China. E-mail: liuxc@qdio.ac.cn

The Yellow Sea Cold Water Mass (YSCWM), a seasonal bottom-layer water mass in the Yellow Sea (YS) most prominent in summer, has always been ignored in previous studies investigating variations in the winter sea surface temperature (SST). Here, using observations and high-resolution numerical modeling, we reveal for the first time the significant contribution of thermal stratification associated with the YSCWM to the sea surface cooling and the formation of the westward-shifted Yellow Sea Warm Water Tongue (YSWT) in early winter. Heat budget analyses indicated that the impact of the YSCWM to surface cooling manifests in two aspects. Firstly, the upward mixing of bottom cold water from the remnant YSCWM triggers cooling in the mixed layer. Secondly, the shallower local mixed layer above the YSCWM facilitates more pronounced cooling processes compared to the YSWT region under similar heat flux. Hence, in one way, the previous winter SST anomaly signal could reemergence in next early winter through the intermediate role of the YSCWM. In the other way, the formation of the westward-shifted YSWT is the result of intensified surface cooling in both the coastal shallow waters and the YSCWM region in the central YS. During the formation process of the YSWT, its main axis aligns with the western boundary of the YSCWM. As the YSCWM dissipates, the YSWT shows an eastward apparent displacement and eventually stabilizes near approximately 123°E. This study enriches our understanding of the transition from stratification to vertical homogeneity in the water temperature structure of the YS during early winter.

# S7: BIO/HD Topic Session

**Social, economic and ecological implications of recoveries, range expansions and shifting distributions of marine birds, mammals and fish**

**Convenors:** **Invited Speakers:**
Andrew Trites (Canada), *corresponding* *Harold Levrel (AgroParisTech University and the University of Paris-*
Elliott Hazen (USA) *Saclay, France)*
Kaoru Hattori (Japan) Hiroto Murase(the Tokyo University of Marine
Science and Rolf Ream (USA) Technology, Japan)

Reports of fish, seabirds, and marine mammals occurring in regions of the North Pacific where they infrequently or were not known to previously occur are on the rise. In some cases, the arrival of newcomer-species may reflect re-establishments of historic ranges following protection from over-exploitation. In other cases, range expansions and shifting distributions of the newcomer-species may be responses to bottom-up processes related to changing ocean conditions or may reflect top-down behavioral responses to predation.

Documenting and understanding the drivers of new appearances of species is needed to assess the ecosystem impacts, including consequences that increasing numbers of new arrivals may have on other species. Similarly, assessments are needed to evaluate the social, economic and ecological benefits and threats that such newcomer-species pose. This type of information is needed to help guide future social and fisheries policies.

This topic session invites papers that address 1) decadal changes in the distributions of marine birds, mammals and fish—and their implications and underlying causes, 2) direct and indirect effects that the changes in species distributions are having on other species and community compositions, 3) social and economic consequences that changing distributions and ranges of species have on coastal communities, 4) unique observations of newcomer-species as a result of extreme-events, and 5) how newcomer-species can help inform ecosystem status reports and other management needs.

This session contributes to FUTURE, BIO, S-CCME and MBM goals to document ecosystem response to climate-driven (and other) changes.

Presenters will be encouraged to link their work to other PICES expert groups. If there is enough interest, we will plan a special issue of such examples of newcomer-species and rapid-range shifts that interested presenters could participate in.

**(S07 17892 Non-Scheduled Pre-Recorded Oral)** (ECOP)

## Understanding jellyfish proliferations and their implications for coastal fisheries: insights from Cameroon

Gisèle Flodore Youbouni **Ghepdeu**[1,2], Durane Chougong Tchatchouang[2], Andre Carrara Morandini[3], Felix Meutchieye[4], Anselme Crépin Mama[5], Emmanuel Henock Kwambe Dicka[2], Ulrich Joël Felicien Bilounga[2] and François Tchoumbougnang[1].

[1]Fisheries Resources Laboratory, Institute of Fisheries Science, University of Douala, P.O.Box : 24157 Douala-Cameroun email: ggiseleflodore@yahoo.fr

[2]Laboratory of Fisheries Research SSRECOMA IRAD-KRIBI, P.O.Box : 219 Kribi-Cameroun,

[3]Center for Marine Biology (CEBIMar), University of São Paulo - Department of Zoology, Institute of Biosciences, University of São Paulo

[4]Department of Animal Production, Faculty of Agronomy and Agricultural Sciences, Biotechnology and Bio Informatics Research Unit, University of Dschang, P. O. Box 188, Dschang, Cameroon

[5]Department of Oceanography, Institute of Fisheries and Aquatic Sciences, The University of Douala, Cameroon

Jellyfish proliferations have emerged as a global concern due to their adverse socio-economic and environmental impacts. These proliferations are anticipated to increase, and the feeding habits of jellyfish—specifically their ichthyoplanktophage and zooplanktophage tendencies—pose a serious threat to other commercially and socially valuable fisheries in coastal regions. Efforts are underway to establish sustainable measures that transform this nuisance into a fisheries resource, aligning with Sustainable Development Goals 14 and 2. In a pioneering study in Cameroon, researchers unveiled jellyfish diversity, ecology, and perception along the Kribi coastal area. Four main taxa—*Chimaerus palmatus*, *Chrysaora sp*., *Cyanea sp*., and *Catostylus tagi* along with four additional morphotypes—were identified. These taxa were prevalent in selected sampling stations, exhibiting temporal variations in abundance and size. Notably, an interspecific relationship revealed a positive, strong, and statistically significant correlation between *Chimaerus palmatus* and *Cyanea sp*., as well as an overlap between jellyfish abundance and certain high socio-economic value species in the artisanal maritime fishing industry. Despite this and high coastal urbanization, there remains limited awareness among sea users, fishers and management authorities regarding jellyfish proliferations and the drivers. These findings lay the groundwork for future research, emphasizing the need for an ocean literacy program in this coastal region to foster a shift in perception and fishing practices, all while safeguarding well-being. Urgent research on the relationship between jellyfish (both polyps and medusae stages) and other marine resources in the region is essential for developing effective conservation strategies.

**(S07 17788 Invited)**

**Social-economic impacts of rewilding: the case of the pinniped population boom along the California coast**

Harold **Levrel**

Université Paris-Saclay, AgroParisTech, UMR Cired, Avenue de la Belle Gabrielle, 94130, Nogent-sur-Marne, France. E-mail: Harold.Levrel@agroparistech.fr

This talk explores the dynamics of change and reorganization of coastal California socio-ecosystems over the past 30 years in response to the regional population boom of two pinniped species: the California sea lion Zalophus Californianus and the harbor seal Phoca Vitulina.

The work presented focuses on four very different types of socio-ecosystem - urban beaches, harbors, a river, the coastal marine ecosystem (continental shelf). The strong dynamics of rewilding led local stakeholders to looking for solutions for managing these new social-ecological interactions. Over the years, innovations have been adopted in a more integrated way and have demonstrated some successes, offering avenues of reflection for managing the rewilding of ecosystems controlled by humans. In this communication we describe institutional, organizational and technical innovations which have supported coexistence between human populations and pinnipeds for the last 20 years. These innovations were very heterogeneous, depending on the types of socio-ecosystem, the commercial activities in place, the articulation between private ownership, common property rules and public law.

**(S07 17804 Invited)**

**New wintering ground for humpback whales that have appeared around Hachijojima Island (33°06'N, 139°47'E), Tokyo Metropolis, Japan since 2015: Their ecology and positive impact on the local tourism**

Hiroto **Murase**[1], Taiki Katsumata[2], Gen Nakamura[1], Hidehiro Kato[1,2], Taro Kato[3], Shingo Tamura[4] and Tadashi Yamakoshi[5]

[1]Laboratory of Cetacean Biology, Tokyo University of Marine Science and Technology, Minato-ku, Tokyo, Japan. E-mail: hmuras0@kaiyodai.ac.jp

[2]Institute of Cetacean Research, Chuo-ku, Tokyo, Japan

[3]Nature Kikaku Co.,Ltd., Hachijo Town, Tokyo, Japan

[4]Hachijojima Island Tourism Association, Hachijo Town, Tokyo, Japan

[5]Hachijo Town Office, Hachijo Town, Tokyo, Japan

Okinawa (26°13'N, 127°41'E) and Ogasawara (27°04'N, 142°13'E) islands have been documented as wintering grounds of humpback whales around Japan. They suddenly appeared around Hachijojima Island (33°06'N, 139°47'E), Tokyo Metropolis, Japan since 2015 which locates further north of two known wintering grounds. Shipboard surveys have been conducted since 2016. Survey items are sighting, detection of song, Photo-ID and biopsy sampling. The analyses using these data and samples provided new ecological insights on this species around the island: (1) they are mainly distributed near the coastline where bottom depth is less than 200 m, (2) songs were continuously identified each year, (3) the mean rate of return of individuals in consecutive years from 2016 to 2020 was 4.8%, (4) mtDNA analysis indicated that individuals around the island were more closely related to Ogasawara than Okinawa and (5) age estimation based on DNA methylation frequency revealed dominance of young adult males (around 10 years old). After the survey confirmed that humpback whales consistently migrated to the island in the winter, commercial whale watching by a single vessel was initiated in 2020. The whale watching was featured as a model in a famous Japanese animated film in 2023 and contributed greatly to the promotion of tourism on the island. Ongoing research is important for the conservation and management of this species as well as for the sustainability of the tourism.

**(S07 17746 Non-Scheduled Pre-Recorded Oral)**

**Ecological and Social Dynamics of Shifting Marine Species Distributions and the Role of Non-State Initiatives in the Blue Economy**

Isa Olalekan **Elegbede,**

Lagos state university, DOSI E-mail: isaelegbede@gmail.com

The blue economy, fueled by marine resources, stands as a pivotal force in global sustainability endeavors. However, the intricate dynamics of shifting marine species distributions within this framework present multifaceted challenges to ecosystem stability and resource management. This study aims to investigate the multifaceted dynamics of changing marine species distributions, assess their socioeconomic and ecological consequences, and explore the effectiveness of non-state initiatives such as coastal communities, NGOs (Non-governmental Organization) in addressing associated challenges. Through a review assessment of various data, analysis, and stakeholder perceptions, this research seeks to provide insights into the key drivers behind shifting marine species distributions, the potential risks, and opportunities they entail, and the role of non-state actors in mitigating these impacts. This research reveals the value of key drivers behind shifting marine species distributions and elucidate their interconnected impacts on ecosystem structure and function. By assessing the socioeconomic consequences of these changes, including their effects on coastal communities and fisheries-dependent livelihoods, the research highlight the importance of incorporating social considerations into marine resource management strategies. Moreover, the study further shed light on the role of non-state initiatives in promoting resilience and adaptive capacity in the face of changing marine ecosystems, thereby contributing to the broader discourse on governance and sustainability within the blue economy. The study therefore offer practical recommendations for policymakers, stakeholders, and safeguard the health and integrity of our marine environments for future generations.

**(S07 17767 Oral)** (ECOP)

**Evaluating marine fish migratory strategies and subsequent effects on distribution and ontogenetic process using an individual based model developed for Pacific chub mackerel (*Scomber japonicus*)**

Ziqin **Wang** and Shin-ichi Ito

The University of Tokyo, Chiba, Japan. Email: zqwang@g.ecc.u-tokyo.ac.jp

There are substantial uncertainties in response of marine ecosystems to climate change and those increased challenges of fishery resources managements. While immense effort has been put into unravelling the mechanism of fish stock fluctuation, many processes are still mysterious for us. “Regime shift”, a phenomenon that depicts large and abrupt change of climate and ecosystem in northwest Pacific Ocean, has been observed for many decades since last century, which resulted in decadal species alternation among dominant economic species. Optimal temperature hypothesis for growth was proposed to explain the species alternation. However, fish can alter the migration route including spawning grounds adjusting their habitat temperature to their optimal temperature in the real ocean. Therefore, the real fish responses to “Regime shift” and climate change is still undetermined. To clarify how migratory strategies influence on fish distribution and growth, this study developed a Lagrangian migratory module integrated with a bioenergetics model to decipher the migratory strategies of chub mackerel (*Scomber japonicus*). Potential drivers for change of distribution were tested with different migratory strategies using the model. Landings, growth, spawning grounds, and regional connectivity observed and described in previous studies were compared with the simulations in order to assess the migration strategy of chub mackerel and the effect of migration strategy on their ontogenetic process. In the future, we plan to develop a two-species model further discussing the effect of prey-predator relationship on stock fluctuations typically due to underway global warming based on this model.

**(S07 17806 Oral)**

**Temporal changes in distribution and prey species of common minke whales in Sendai Bay off the Pacific coast of Japan**

Tsutomu **Tamura**[1], Kenji Konishi[1], Tatsuya Isoda[1], Hidehiro Kato[1,2], Mitsuhiro Saeki[3] and Kazushi Miyashita[4]

[1]Institute of Cetacean Research, Tokyo, Japan. E-mail: tamura@cetacean.jp

[2]Tokyo University of Marine Science and Technology, Tokyo, Japan

[3]Miyagi Prefecture Fisheries Technology Institute, Miyagi, Japan

[4]Hokkaido University, Hakodate, Japan

The common minke whale, Balaenoptera acutorostrata, is a frequently sighted whale species around Japanese coastal water. The distribution of this species around Japan is highly dependent on the availability of prey species, which is associated with oceanographic conditions. Historically, Sendai Bay has been an important feeding ground for this species in spring. However, in recent years the sightings of this species have decreased. This study investigates the possible causes of the decrease behind the changes observed in temporal distribution of common minke whales in Sendai Bay through the analyses of whale sightings, stomach contents and oceanographic conditions obtained by research under special scientific permit between 2003 and 2019 (JARPNII and NEWREP-NP), and by commercial whaling since 2019. The density index of common minke whales (number of animals found per 100 miles of sighting surveys) decreased rapidly since 2003, which coincided with surface temperature rise around the study area. Major prey shift of common minke whales occurred from sand lance to Japanese sardine since 2015. The limited sightings of common minke whales could be due to both the changes in oceanographic conditions by global warming and the 2011 East Japan Earthquake. This huge Earthquake caused changes in the marine bottom sediments in Sendai Bay, it was causing significant damage to sand lance spawning ground. The commercial fisheries catch of sand lance has decreased from 10,000 tons in the 2000's to almost zero in recent years. Based on the results of this study may suggest that Sendai Bay is no longer be a captivate feeding ground for common minke whales.

**(S07 17827 Oral)**

**Multi-decade northward shift of loggerhead sea turtle pelagic habitat as the eastern North Pacific Transition zone becomes more oligotrophic**

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

[1]Stanford University, Woods Institute for the Environment, Stanford, California, United States email: dbriscoe@stanford.edu

[2]University of California Santa Cruz, Institute of Marine Sciences, Santa Cruz, California, United States

[3]Golden Honu Services of Oceania, Honolulu, Hawaii, United States

[4]NOAA-Southwest Fisheries Science Center, La Jolla, California, United States

[5]Laboratorio de Genética, Unidad Académica Mazatlán, Instituto de Ciencias del Mar y Limnología,Universidad Nacional, Autónoma de México, Mazatlán, Sinaloa, Mexico

[6]Port of Nagoya Public Aquarium, Minato-ku, Nagoya, Japan

[7]Golden Honu Services of Oceania, Newport, Oregon, United States

[8]Hawaii Preparatory Academy, Kamuela, Hawaii, United States

[9]Usa Marine Biological Institute Kochi University, Usa Tosa, Kochi, Japan

[10]Marine Biology Program, University of Hawaii at Manoa, Honolulu, Hawaii, United States

The North Pacific Transition Zone (NPTZ) is known as a global marine hotspot for many endangered and commercially significant highly mobile marine species. In the last few decades, the region has undergone unprecedented physical and biological transformations in response to climate variability and change. Although it is anticipated that many highly mobile species will need to adapt and shift their distributions, current predictions have relied on short-term data sets or modeled simulations. This has left a critical gap in our understanding of long-term (decadal or longer) change and species' responses within the NPTZ. Here, we integrate nearly 3 decades of satellite tracking data from a climate sentinel, the North Pacific juvenile loggerhead sea turtle (*Caretta caretta*), with concurrent observations of sea surface temperature (SST) and chlorophyll concentrations to examine higher trophic level response to climate-induced changes within the eastern bounds of the NPTZ. Between 1997-2024, the NPTZ has warmed by 1°C and experienced a 29% decline in mean surface chlorophyll concentration, corresponding to a loss of approximately 1 million km$^2$ of productive habitat. Over the same period, the average latitude of loggerhead sea turtle foraging habitat in the NPTZ has shifted northwards by 400-600 km, tracking the movement of the NPTZ in the same direction. This distributional shift rate (200km/decade) greatly exceeds the global average. Our findings reveal substantial physical and biological change to the NPTZ over the last quarter century and the first empirical evidence

illustrating the substantial spatial response of a highly mobile apex species.  As the NPTZ continues to undergo significant change, these insights can provide vital information for dynamic conservation and management strategies within this critically important ecosystem.

**(S07 17851 Oral)**

**Drivers of variability in the Transition Zone Chlorophyll Front and its linkage to the Hawaii shallow-set longline fishery**

Hui Shi[1,2], Ryan **Rykaczewski**[1], Justin Suca[1,2], Johanna Wren[1], Réka Domokos[1], Joseph O'Malley[1] and Phoebe Woodworth-Jefcoats[1]

[1]NOAA Pacific Island Fisheries Science Center, Honolulu, HI, USA. Email: hui.shi@noaa.gov

[2]Cooperative Institute for Marine and Atmospheric Research, University of Hawai'i at Mānoa, Honolulu, HI, USA

The Transition Zone Chlorophyll Front (TZCF) is considered a foraging corridor for many commercially important predator species in the North Pacific, including tunas and swordfish, as well as for protected turtles. Here we use nearly three decades of satellite remotely sensed ocean color data to characterize the variability and trends of the TZCF properties, investigate their relationships with large-scale atmosphere-ocean patterns, and explore their linkages with the fisheries. We found that over the past 26 years, there has been a significant northward movement of the TZCF as defined by the 0.2 $mg/m^3$ chlorophyll contour. The interannual variability of the latitude of the front, its west/east slope, the degree of its meandering, and the annual range in its latitude are generally associated with the El Nino-Southern Oscillation (ENSO), especially in the winter months. TZCF properties are also related to the Pacific Decadal Oscillation and North Pacific Gyre Oscillation. The ENSO-driven changes in TZCF location are associated with a shift in fishing effort of the Hawaii-based shallow-set longline fishery targeting swordfish; changes in the TZCF meandering and slope can potentially explain the changes in catch per unit effort. Data from the international swordfish fleet suggest that swordfish life history likely plays a role in the contrasting responses of catch to ENSO in comparison to the Hawaii-based fleet. The study provides insights on the impacts of large-scale climate variability on longline fisheries via the TZCF in the North Pacific.

**(S07 17865 Oral)** (ECOP)

**Inter-decadal assembly processes shaping fish community in the Eastern Bering Sea**

Irene D. **Alabia**[1], Jorge García Molinos[1], Takafumi Hirata[1], Hiromichi Ueno[2], and Sei-Ichi Saitoh[1]

[1]Arctic Research Center, Hokkaido University, Sapporo, Japan. Email: irenealabia@arc.hokudai.ac.jp

[2]Faculty of Fisheries Sciences, Hokkaido University, Hakodate Japan

Community processes shape the identity and abundance of species within ecological communities and are important for conserving biodiversity under the pervasive threat of climate change. Here, we inferred the influence of environmental and spatial drivers of fish community assembly in the Eastern Bering Sea (EBS) across three decadal periods (1993-2023) using joint species distribution models (JSDMs). This model-based approach interrelates species occurrence data, environmental factors, functional traits, and phylogenetic relationships of 58 fish taxa in the EBS with community assembly processes across decades. Our preliminary findings showed that 20-25% of the variation in species occurrences across decadal periods were accounted for by the environmental covariates, while 65-74% were attributed to the spatial latent structure. The influence of traits on the species responses to temperature and productivity was lowest in the first (1993-2002; 1%) and comparably high during the second (2003-2012; 24%) and last (2013-2023; 26%) decades. Across the decades, our results showed phylogenetically structured responses of species to inter-decadal environmental changes, suggesting phylogenetically related taxa exhibit shared environmental responses. Further, residual species-to-species associations showed higher non-random co-occurrences beyond those explained by environmental covariates in the later than the early decade. Hence, the rich ecological insights from JSDMs could provide useful information for managing and conserving biodiversity and its ecosystem services.

**(S07 17866 Oral)** (ECOP)

**Eastern Pacific fish spawning patterns demonstrate mixed spatiotemporal tradeoffs in response to environmental changes**

Katherine **Dale**[1], Lorenzo Ciannelli[2], Jerome Fiechter[3], Mercedes Pozo Buil[3], Rubén Esteban García Gómez[4], Sylvia P. A. Jiménez-Rosenberg[4], Gerardo Aceves-Medina[4], Andrew Thompson[5], John C. Field[6], Toby Auth[7], R. Ian Perry[8], Lauren Rogers[9], Rebecca Howard[2] and Rebecca Asch[1]

[1]East Carolina University, Greenville, NC, USA. Email: dalek22@ecu.edu.

[2]Oregon State University, Corvallis, OR, USA

[3]University of California, Santa Cruz, Santa Cruz, CA, USA

[4]Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas, Baja California Sur, Mexico

[5]Fisheries Resources Division, Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration, San Diego, CA, USA

[6]Fisheries Ecology Division, Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Santa Cruz, CA, USA

[7]Pacific States Marine Fisheries Commission, Newport, OR, USA

[8]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada

[9]Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA, USA

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 fish occurrence is especially important, because 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 adult habitat use patterns (groundfish, coastal pelagics, and mesopelagics) balance the tradeoff between shifting their geography or phenology in response to oceanic conditions during their early life history. We assembled larval fish abundance data from six 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 distribution range of many of the target species. We modeled species distributions using a generalized linear mixed effects model that considers spatiotemporal autocorrelation (i.e., sdmTMB). Models examined salinity, sea surface temperature, spiciness, sea surface height, and bottom depth as potential environmental covariates. Analyses indicate that species tend to either: (1) shift both their spatial distribution and timing, or; (2) shift neither aspect of their spatiotemporal distribution. Groundfish demonstrate the most diverse set of tradeoff strategies. Using multifactor analysis, we found no

links between several life history characteristics and tradeoffs. With these results, we build capacity to assess climate vulnerability of marine fish species and determine the adaptive distributional capacity of commercially exploited and ecologically important fish to changing ocean conditions.

**(S07 17870 Oral)** (ECOP)

**Evaluating the uneven impacts of ENSO events on pacific tunas**

Hongyu **Lin** and Fan Zhang

Shanghai Ocean University, Shanghai, China. E-mail: linbojun99@gmail.com

Climate change has led to increasingly frequent and interacting variability events, notably affecting the distribution patterns and availability of Pacific longline fisheries targeting tuna. However, understanding the nonlinear relationships between major tuna species and marine environmental variables, as well as the adaptability of different fish species to various ENSO events, remains challenging. This paper utilizes primary data from Pacific longline fisheries combined with marine environmental data to build a species distribution model, analyzing the responses of key Pacific longline tuna species to ENSO events from 1993 to 2020. The model results expose the varied responses of different tuna species to various types of ENSO events. Centroid analysis indicates that, unlike other tuna species, the North Pacific albacore shows no significant longitudinal distribution patterns across different ENSO events, and no significant latitudinal centroid shifts were observed for any of the four tuna species. Time series analysis of abundance shows that the correlation between the relative abundance of temperate albacore and the Multivariate ENSO Index (MEI) is not significant, a finding corroborated by cross-correlation function (CCF) analysis. Spatial-temporal mapping illustrates the distinct distribution patterns displayed under different types and intensities of ENSO events, emphasizing the importance of distinguishing between types of ENSO events. This comprehensive approach highlights the complex dynamics influenced by ENSO and underscores the necessity of nuanced analyses to understand the impacts on key tuna species in the Pacific.

**(S07 17876 Oral)** (ECOP)

**Can Dynamic Ocean Management tools prove useful for a fishery set to disappear?**

Rachel **Seary**[1,2], Elliott Hazen[2], Steven Bograd[2], Helen Bailey Olde[3], Rebecca Lewison[4], Austin Sell[5], Emily Nazario[1], Dan Lawson[6] and Amber Rhodes[7]

[1]Institute of Marine Sciences, University of California, Santa Cruz email: rseary@ucsc.edu

[2]Ecosystem Science Division, NOAA Southwest Fisheries Science Center

[3]Blue Wave Consulting, LLC

[4]Department of Biology, San Diego State University

[5]Evans School of Public Policy and Governance, University of Washington

[6]NOAA Fisheries West Coast Region, Protected Resource Division

[7]NOAA Fisheries West Coast Region, Highly Migratory Species Branch

Dynamic ocean management is an adaptive strategy for the management of the marine environment under a changing climate. By providing near real-time information on the probable distribution of protected and unwanted as well as target catch species, dynamic ocean management can be a useful tool in fisheries where there is a need to manage human-wildlife conflict. This is especially true in highly migratory species fisheries where protected and unwanted or target species distribution is driven by ocean conditions that are affected by a changing climate, and novel social, economic and ecological challenges may arise as a result. EcoCast, a near-real time dynamic ocean management tool, was initially developed with an aim to reduce bycatch of protected species and improve fishing opportunities for the drift-gillnet fishery in California. Since the enactment of the Driftnet Modernization and Bycatch Reduction Act (2022), the California drift-gillnet fishery in its current configuration is set to become fully prohibited before 2028. As a result, fishery participants must learn to use new fishing configurations while striving to avoid the protected and unwanted species the regulations of the former drift gillnet fishery were implemented to conserve. Moreover, with target species projected to shift outside of current fishing grounds, managers and fishermen alike, will be challenged to adapt. Using a program evaluation approach, we investigate the efficacy of this dynamic ocean framework to support a sustainable evolution of this fishery and to generate positive social impact in the face of challenges exacerbated by climate-related changes in Pacific Ocean ecosystems.

(S07 17887 Oral)

**Multiple scales for multiple whales: management-inspired ecological models**

Elliott L. **Hazen**[1,2], Nerea Lezama Ochoa[1,2], Stephanie Brodie[3], Michael Jacox[1,2], Steven Bograd[1,2], and Heather Welch[1,2]

[1]Southwest Fisheries Science Center - Ecosystem Science Division, Monterey, CA 93940, USA email: elliott.hazen@noaa.gov

[2]University of California Santa Cruz - Fisheries Collaborative Program, Monterey, CA 93940, USA

[3]Environment, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Brisbane, Queensland, Australia

We have developed a skillful suite of prediction systems at multiple timescales for use in assessing weather, storm tracks, and long-term change to maximize human safety and minimize storm repair costs. Here we propose a similar framework for the ocean, from physics to fisheries to help maximize sustainable uses of the oceans while minimizing impact on protected species from sharks, turtles, seabirds to marine mammals. The different timescales of prediction carry different skills and different management applications including nowcasts on where species are most likely distributed, forecasts of indices such as habitat compression and temperature thresholds to reduce and avoid entanglements, and projections of species distribution for use in long term planning (e.g. sanctuaries and wind energy planning). This suite of prediction scales can be used to create a holistic approach towards marine resource management, with the goal of reducing risk and rewarding opportunity in the face of climate variability and change. As species recover from past exploitation and shift their distribution with changing ecological resources, new risks arise that stress existing management frameworks.

**(S07 17914 Oral)** (ECOP)

**Biological hotspots under threat: Quantifying climate impacts to sentinel features in the California Current**

Danial G. **Palance**, Nerea Lezama-Ochoa, Stephanie Brodie, Heather M. Welch, Jarrod A. Santora, Barbara A. Muhling, Briana Abrahms, Elizabeth A. Becker, Scott Benson, Megan A. Cimino, Karin A. Forney, Michael G. Jacox, Mercedes Pozo-Buil, Steven J. Bograd, Conner M. Hale, Z. Premo, Gemma Carroll, Kristy J. Kroeker, Roxanne S. Beltran and Elliott L. Hazen

UC Santa Cruz, Ecology & Evolutionary Biology, U.S.A email: danpalance@gmail.com

Marine hotspots have been proposed as critical sentinel features for the detection of climate change effects on marine ecosystems including species range shifts, spatiotemporal mismatches between predators and prey, and increased conflict with human activities. However, a clear framework for marine hotspots is missing. We provide a robust conceptual framework for marine hotspots that we then operationalize to examine how climate change may impact the distribution of a sentinel predator species (humpback whales) and prey (northern anchovy) in the California Current. We projected changes in overlap of core habitat hotspots from 1980-2100 at a 0.1° scale using boosted regression trees and three earth system models downscaled to the California Current System. We show a system-wide decrease in habitat overlap from 1980-2100, with seasonal patterns most pronounced in summer and fall. On a finer scale, our findings highlight how the timing, location, and persistence of overlap may shift in response to climate change within and outside of marine protected areas and how these patterns compare to coastwide analyses. These results demonstrate how hotspots containing sentinel species and their prey may help detect ecosystem level changes in both space and time for predator-prey dynamics, alterations to the delivery of ecosystem services, and the potential for increased conflict with human use of the ocean such as fishing and shipping.

**(S07 17945 Oral)** (ECOP)

**Impacts of whale population recovery on pelagic ecosystems of the subarctic Pacific**

Szymon **Surma**[1], Evgeny A. Pakhomov[1,2], Brian P.V. Hunt[1,2], Andrew W. Trites[1,3], and Kerim Y. Aydin[4]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: s.surma@oceans.ubc.ca

[2]Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada

[3]Department of Zoology, University of British Columbia, Vancouver, BC, Canada

[4]Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA, United States of America

Whales are the largest animals in the world, and the massive size and mammalian metabolic rates of these consumers may enable abundant whale populations to exert top-down trophic control over their prey, including cephalopods, forage fish, and zooplankton. While North Pacific whale populations were depleted by commercial whaling in the 20$^{th}$ century, many of these populations are showing signs of recovery. Full recovery of North Pacific whale populations could re-establish top-down control over many prey groups, some of which (e.g. large squid and many forage fish) are targeted by commercial fisheries. Other whale prey groups (e.g. myctophids, small squid, and zooplankton) are consumed by both whales and by many ecologically, commercially and culturally important species (e.g. large squid, salmonids, and forage fish). Estimates of biomass production and consumption rates, recent and unexploited abundances, and diet compositions for North Pacific fin whales (*Balaenoptera physalus*), sei whales (*B. borealis*), and sperm whales (*Physeter macrocephalus*) were used to parameterize species-specific surplus production models for North Pacific whale populations, as well as models representing subarctic North Pacific ecosystems in the PICES ESA and WSA areas in Ecopath with Ecosim. These models were employed to simulate past and future whale recovery trajectories and their impacts on ecosystem structure and dynamics under several future scenarios for commercial whaling. This research illuminates the potential for competition and coexistence of whales and commercial fisheries in the pelagic ecosystems of the subarctic Pacific, as well as the past, present, and future impacts of whaling on these ecosystems.

**(S07 17947 Oral)** (ECOP)

**Climate change impacts on the distribution of seabirds within National Marine Sanctuaries and offshore wind areas in the California Current Ecosystem**

Ryan P. **Gasbarro**[1,2], Nerea Lezama-Ochoa[1,2], Adena Schonfeld[1,2], John Field[2], Jarrod A. Santora[1,2], Megan Cimino[1,2], Elliott L. Hazen[2], Steven Bograd[2], Kelly S. Andrews[3] and Heather Welch[2]

[1]University of California, Santa Cruz email: ryan.gasbarro@noaa.gov

[2]NOAA NMFS Southwest Fisheries Science Center

[3]NOAA NMFS Northwest Fisheries Science Center

Marine species are predicted to undergo notable distributional changes in response to climate change, where shifting environmentally suitable habitat may alter the timing of migrations and locations of occurrence. These distributional changes are likely to affect the efficacy of spatial management, such as marine protected areas, and should be considered when siting areas for offshore resource development. Species distribution models (SDMs) are useful tools to investigate and project spatiotemporal changes in species occurrences under scenarios of climate change that can be used for proactive management. Here, we develop SDMs for five of the most abundant seabirds in the California Current Large Marine Ecosystem (CCLME) using shipboard and aerial surveys from 1980-2017. We project the distribution of these species from 1980-2100 using three downscaled high-resolution (0.1º) numerical ocean models in a high-emissions scenario (Representative Concentration Pathway 8.5). These projections reveal notable shifts in the location and intra-annual timing of suitable biophysical habitat that vary by species, and we discuss these changes in the context of species ecology (e.g. resident versus seasonal visitor species). We then assess changes in the percentage of overall suitable habitat in the CCLME represented within four offshore wind planning areas and five National Marine Sanctuaries. These inferences can help identify the risk of habitat loss as offshore wind development is poised to begin in the region and facilitate improvements in climate-ready monitoring and management plans for seabird taxa that are both vulnerable and play an important role in the wider marine ecosystem.

**(S07 17995 Oral)**

**Arctic Ecosystem Update: a 20-year Synthesis**

Elizabeth **Logerwell**[1], Silvana Gonzalez[2], Jens Nielsen[3], David Kimmel[1], Adam Spear[1], Ellen Yasumiishi[4], Dan Cooper[1], Katrin Iken[5], Lewis Barnett[1], Jackie Grebmeier[6], Lee Cooper[6], and James Thorson[1]

[1]NOAA Fisheries, Alaska Fisheries Science Center, Seattle, WA, USA. Presenting author email: Libby.Logerwell@noaa.gov

[2]Institue of Marine Research, Bergen, Norway

[3]CICOES, University of Washington, Seattle, WA, USA

[4]NOAA Fisheries, Auk Bay Laboratory, Juneau, AK, USA

[5]College of Fisheries and Ocean Sciences, University of Alaska, Fairbanks, AK, USA

[6]Center for Environmental Science, University of Maryland, MD, USA

This presentation is a result of the North Pacific Research Board's Arctic Integrated Ecosystem Research Program Synthesis. One of our goals for the synthesis was to examine whether there has been a re-organization of the Northern Bering (NBS)-Chukchi Sea (CS) ecosystem resulting from a decrease in pelagic-benthic coupling. We synthesized data on oceanography, phytoplankton, zooplankton, pelagic fish, benthic epifauna, benthic infauna, and benthic fish from 2000-2021. We generated biomass time series using a spatiotemporal model implemented with the vector autoregressive spatiotemporal (VAST) package. We compared pelagic and benthic time series to test the prediction that pelagic time series have increased and benthic time series have decreased due to a breakdown in the flux of production from the pelagic to the benthic. The prediction that pelagic time series increased was not supported by the data. Neither was the prediction that benthic time series decreased supported over all. Instead, most of the typically Arctic taxa showed declines and most of the typically boreal taxa showed increases. In summary, the changes in the pelagic and benthic communities we observed were not consistent with a breakdown in pelagic-benthic coupling, but instead supported the hypothesis of borealization.

**(S07 18011 Oral)** (ECOP)

**Oceanographic partitioning of catch and by-catch rates in Hawai‘i's longline fisheries**

Justin J. **Suca**[1,2], Johanna L.K. Wren[3], Ryan R. Rykaczewski[3], Robert Ahrens[3], Donald Kobayashi[3], Phoebe A. Woodworth-Jefcoats[3], Heather Welch[4], and Elliott Hazen[4]

[1]Department of Oceanography, University of Hawai‘i at Mānoa, Honolulu, HI USA Email: jsuca@hawaii.edu

[2]Cooperative Institute for Marine and Atmospheric Research, University of Hawai‘i at Mānoa, Honolulu, HI USA

[3]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI USA

[4]NOAA Southwest Fisheries Science Center, Monterey, CA USA

Ocean conditions have long been known to influence the abundance and distribution of fished species throughout the globe. However, a holistic view of how these conditions drive the distribution and catchability of large pelagic species in the North Pacific remains unresolved. We use fisheries observer data on catch rates for more than 20 species caught in the Hawai‘i shallow-set and deep-set longline fisheries to identify how environmental variables drive the occurrence and catch rates of these species. Specifically, we model the associations between environmental variables and catch rates of each species using ensemble machine learning techniques geared toward out-of-sample predictions. Models for the shallow-set swordfish fishery generally had higher skill than those for the deep-set ‘ahi (bigeye tuna) fishery, primarily due to catch rates being more clearly partitioned by the North Pacific Transition Zone in the shallow-set fishery. Results also indicate catchability for species with diel vertical migratory behavior is impacted by the lunar cycle in the case of the nighttime shallow-set fishery, whereas current properties had higher importance for the deep-set fishery. Year effects (interannual variability in catch rates not attributable to other environmental or fishing properties) were pronounced for a handful of species, indicating that understanding population dynamics—such as recruitment and mortality—will be essential for accurately forecasting bycatch in future years. Collectively, these models provide baselines for how oceanography drives catch rates, allowing us to move toward projections of shifts in occurrence and catch rates of these taxa in a changing climate.

**(S07 18073 Non-Scheduled Pre-Recorded Oral->POSTER)** **S07-P2** (ECOP)

**The climatic impacts of Marine Heatwaves on tropical tuna resources**

Yurong **Mu**[1,2], Yuxiang Qiao[2], Peng Lian[3] , Xiong Zhang[4] and Zelin Chen[5]

[1]Institute of Oceanography, Chinese Academy of Sciences, Qingdao, China. E-mail: muyurong@qdio.ac.cn

[2]Joint Graduate School of Agriculture, Kagoshima University, Okinawa, Japan

[3]Chinese Academy of Fisheries Research, Beijing, China

[4]Sun Yat-sen University, Shenzhen, China

[5]University of Essex, Colchester, UK

As one of the world's most important economic fishery resources, tuna fisheries have always been a focal point for countries globally. In recent years, with the increasing effects of internal oceanic climate variability and external human-induced pressures, the security of tuna biological resources has faced severe challenges. Notably, the long-lasting ocean temperature anomalies have had a significant impact on the living environment of tuna. Based on ocean satellite remote sensing data and the spatio-temporal distributions data of three tuna species, we investigated the impact of marine heatwaves (MHWs) on the spatio-temporal distribution and resource dynamics of tuna in various global waters from 1992 to 2020. By establishing interpretable deep learning models and causality analysis models, this study explored the non-stationary relationships between MHWs and tuna resources in different oceans. And we also examined the time series relationships between MHWs and tunas to determine the response mechanisms of tuna to MHWs in various waters. The findings showed both commonalities in time series and heterogeneity in spatial distribution. Between 1992 and 2020, the global tropical tuna population shifted an average of 7% towards the poles. The high-frequency signals of MHWs accelerated the fragmentation of tuna habitats in the tropical oceans. Furthermore, MHWs reduced the connectivity between tuna populations across different oceans, exacerbating the risk of resources decline.

**(S07 18095 Oral)**

**Recent changes in larval, juvenile, and adult Pacific sardines in the northern California Current**

Elizabeth A. **Daly**[1], Toby D. Auth[2], Kym C. Jacobson[3], Cheryl A. Morgan[1], Brian J. Burke[4] , Miram R. Gleiber[5], Barbara Muhling [6,7], Catherine Nickels [4], and Antonella Preti[6,7]

[1]Cooperative Institute for Marine Resources Studies, Oregon State University, Newport, OR, USA. Email:  Elizabeth.Daly@oregonstate.edu

[2]Pacific States Marine Fisheries Commission, Newport, OR 97365, USA.

[3]NOAA, Northwest Fisheries Science Center, Newport, OR, USA.

[4]NOAA, Northwest Fisheries Science Center, Seattle, WA, USA.

[5]Department of Biological Sciences, University of Alberta, Edmonton, AB, T6G 2R3, Canada.

[6]Institute of Marine Sciences, University of California, Santa Cruz, CA 95064, USA.

[7]Fisheries Resources Division, NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, CA 92037, USA.

Mass spawning of the northern sub-population of Pacific sardine in the SoCal Bight has not been observed since 2014. Historically, the population would then migrate into the northern California Current (NCC; Oregon, Washington) in summer. Since 2015, newly-hatched larvae have been sampled in winter/early-spring along the Oregon coast (1-25 nm from shore) with highest abundances observed in 2015-16. This pattern appears persistent, and strengthening, based on January-March 2024 samples. Pacific sardine juveniles have been sampled in coastal waters of the NCC in May of 2017-18, and 2021-24, suggesting substantial growth and survival of the winter/spring-spawned larvae. These unusual occurrences of larvae and juveniles represent both a latitudinal and cross-shelf phenological shift in reproduction into the NCC, with potential to contribute to increases in adult abundance. Since 2016, adult Pacific sardines sampled in large trawl net in the NCC have been smaller (< 160 mm FL) than many of the earlier years. This increased abundance of juvenile and small adult Pacific sardine in the NCC appears to translate to enhanced prey for top predators, as albacore tuna present offshore of Oregon and Washington in fall 2022 and 2023 had a high prevalence of Pacific sardine (30-135 mm SL) in their diets. Lastly, in March 2024, when Pacific herring came into Yaquina Bay Newport, OR for their annual spawning in the estuary, many small adult Pacific sardine were simultaneously caught by fishers within schools of herring. The co-occurrence of Pacific sardine and herring could potentially signal increased competition for resources between them.

**(S07 17803 Oral)** (ECOP)

**Balancing Marine Mammal Protection and Fisheries Sustainability: Social Indicators in California's Dungeness Crab Fishery**


Alexis **Hadinger**[1], Steven Bograd[1], Elliott Hazen[1], and Rachel Seary[1,2]

[1]Ecosystem Science Division, NOAA Southwest Fisheries Science Center, Monterey, CA, USA.
E-mail: alexis.hadinger@noaa.gov

[2]Institute of Marine Sciences- University of California, Santa Cruz, USA.



In recent years, a series of marine heatwave events in the North Pacific Ocean have impacted the California coastal ecosystem, posing social and economic challenges for fishing communities and decision-makers. A significant consequence has been increased whale entanglements within the California Commercial Dungeness Crab Fishery, partly due to shifting whale populations. Balancing marine mammal protection with maintaining a financially viable fishery presents a critical challenge. This research explores whether social indicators can capture the socio-economic impacts of disturbances on the fishery. While indicators of coastal community vulnerability exist for the US West Coast, we hypothesize that fishery-specific indicators, developed in partnership with its participants, will provide deeper insight into how environmental and regulatory changes affect the fishery and its stakeholders. We identified potential local indicators through semi-structured interviews with fishery participants to examine how regulatory actions impact stakeholders. By identifying social indicators from these interviews, we aim to monitor the fishery's socio-economic resilience to regulatory changes. These indicators offer insights into the fishery's adaptability to various disturbances, including changes to mitigate whale entanglements and environmental stressors. While ecological indicators have traditionally guided fishery management, this project aims to integrate social data into coastal fisheries decision-making processes. Our objective is to identify variables serving as effective indicators of fishery health, facilitating more adaptive management strategies amid dynamic environmental and regulatory conditions. We expect fishery-specific social indicator development to provide richer information than solely relying on state-level fishery data for assessing the Dungeness crab fishery's wellbeing.

**(S07 17832 Oral)** (ECOP)

## Quantifying the socioeconomic risk of Alaskan fishing communities to climatic-driven changes in Pacific cod spatial distributions

Sarah **Stone**[1], Lorenzo Ciannelli[1], Sarah Wise[2], Michael Harte[1], and Kirstin Holsman[2]

[1]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA. Email: stonesar@oregonstate.edu
[2]NOAA Alaska Fisheries Science Center, Seattle, WA, USA

The Eastern Bering Sea (EBS) supports a highly productive commercial Pacific cod (Gadus macrocephalus) fishery and is projected to experience accelerated oceanic warming. Warming temperatures have initiated a large-scale northward redistribution of Pacific cod in the EBS, posing potential challenges to both sustainable fisheries management and the economies of Alaskan fishing communities reliant upon this resource. Our approach combines a theoretical risk assessment framework with statistical modeling and regional downscaled ocean models to 1) quantify the relationship between Pacific cod distribution and bottom temperature, and 2) use these results within an exposure-vulnerability assessment to analyze the risk of Alaskan fishing communities to changes in the distribution of the Pacific cod in the EBS. We spatially fit data on Pacific cod abundance and bottom temperature with fisheries engagement and reliance indicators for seven Bering Sea census areas. We used statistical models to enable predictions of distribution under two climate scenarios (SSP1-2.6 and SSP5-8.5) and three Earth System Model ensembles. Risk was calculated as a function of a hazard (redistributions of Pacific cod), exposure (community engagement with the fishery), and vulnerability (community reliance and adaptive capacity). These elements were combined within a theoretical risk assessment framework and categorized as having high, moderate, or low risk. Climatic-driven shifts in Pacific cod distributions pose the greatest risk to census areas with historically high economic reliance upon and engagement with the fishery. The results of this study are directly relevant to fishers experiencing changes in resource availability and community managers actively developing adaptation strategies.

**(S07 17898 Poster)** S07-P3 (ECOP)

**Deep-sea fish fauna in the Sea of Japan off Niigata Prefecture.**

Akinori **Teramura**[1,2], Atsushi Suzuki[1], Hiroki Kise[1], Shusaku Goto[1], Masahiro Suzumura[3], Akira Iguchi[1]

[1]Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. E-mail: teramura-akinori@aist.go.jp

[2]Tokai University, Hakodate, Japan.

[3]Environmental Management Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan.

Fish species diversity of deep-sea in the Sea of Japan is markedly lower compared to the Pacific Ocean, with most recorded species usually distributed cold shallow waters. However, there are few studies on the ecology and community structure of these fish species. Additionally, the Sea of Japan is noted for its methane hydrate deposits, and it is essential to document and describe species diversity to assess potential impacts on ecosystems and environments during future resource development. This study aims to elucidate the characteristics of deep-sea fish communities in the Sea of Japan, off the coast of Niigata Prefecture. Firstly, we capture fishes by the ROV. As a result, we collected Malacocottus gibber (Psychrolutidae), Liparis ochotensis (Liparidae), Careproctus rastrinus (Liparidae), Lycodes nakamurae (Zoarcidae), and Bothrocara hollandi (Zoarcidae). Next, video was taken by navigating three transects at an altitude of 1.5 meters and a speed of 0.5 knots. Fish species were identified based on the collected specimens, and the number of individuals per species was counted at five-minute intervals. Finally, hierarchical cluster analysis and nMDS analysis were used to compare community structures within the survey area. The results revealed that the survey area could be divided into two distinct fish community clusters, likely explained by the presence or absence of carbonate rocks forming reef or gravel zones on the seabed. This study was conducted as a part of the methane hydrate research project funded by METI (the Ministry of Economy, Trade and Industry, Japan.

**(S07 18114 Poster)** S07-P4 (ECOP)

**Assessment of the habitat characteristics of salmon predation locations of southern resident Killer Whales**

Sophia **Hemsi**, Jennifer Tennessen, Marla Holt, Bradley Hanson, Candice Emmons and Deborah

U.S.A email: sophia.hemsi@gmail.com

A primary threat to endangered Southern Resident killer whales (SRKW) is the limited availability and accessibility of preferred salmonid prey in their core critical habitat. A key limitation to protecting foraging opportunities is a shallow understanding of the environmental characteristics associated with foraging. Our study aimed to characterize the most pertinent aspects of the marine habitat associated with SRKW foraging. We used foraging data derived from (1) high-resolution sound and movement tags ('DTAGs') suction cup-attached to SRKW during September 2010, 2012 & 2014, and (2) concurrent focal follows of tagged whales, to identify locations of foraging events. Next, we computed environmental data including bathymetry, distance to shelf, slope, and substrate matched to whale location data on a dive-by-dive basis. We built statistical models to identify environmental factors that predicted foraging. These insights advance our understanding of the foraging habitat of SRKW, as well as their spatiotemporal distribution patterns. Additionally, these findings improve our understanding of SRKW ecology and behavior, particularly in relation to habitat use and seasonal occurrence. Finally, identifying key habitat features associated with SRKW foraging areas can better inform conservation and management efforts to protect these endangered marine mammals.

# S8: BIO/POC Topic Session

**Changing ocean carbon cycle and its consequences for the ocean environment: Detection, prediction and mitigation**

**Convenors:**
Tsuneo Ono (Japan), *corresponding*
Alex Kozyr (USA)

Ocean carbon cycles have been perturbed critically by human activities, with consequences for the ocean environment as well as the world's climate already emerging both at regional and global scales. Prompt detection of such perturbations and accurate projection of future consequences are essential for adequate social planning and implementation of countermeasures. However, our skills require further development to support society's needs for timely, accurate information on ocean conditions. Especially in coastal areas, anthropogenic signals are often masked by large, complex natural perturbations, and our ability to accurately predict future natural variation is also limited. Interaction of coastal and open ocean ecosystems and biogeochemical cycles are also important, but many processes and interactions require further investigation.

In addition to these advances needed for understanding changing ocean carbon cycles, marine carbon dioxide removal (CDR) is emerging as a rapidly expanding issue in ocean sciences and industries. The 6th IPCC assessment report clearly stated that implementation of negative emission technologies is unavoidable to limit warming to less than 2 °C by the end of this century, and ocean CDR is one such option. However, estimation of the efficiency of each CDR technique still has large uncertainties, and understanding of potential side effects of each technique on marine ecosystems and global biogeochemical cycles is limited.

Capacities required to fill critical knowledge gaps on ocean CDR overlap with those needed for prompt detection of natural/anthropogenic perturbations and accurate projection of their future consequences. This session aims to showcase our current knowledge, and knowledge gaps, regarding detection of natural and anthropogenic perturbations of the carbon cycle including ocean CDR, and accurate projection of their future consequences. We welcome submissions across all disciplines that address these issues in both open and coastal ocean.

**(S08 17810 Oral)** (ECOP)

**Global Dynamics of Fossil-Derived Brown Carbon in Wet Atmospheric Deposition**

Min-Young **Lee** and Tae-Hoon Kim

Department of Earth Systems and Environmental Sciences, Chonnam National University, Gwangju, 61186, Republic of Korea E-mail: thkim80@jnu.ac.kr

In order to comprehensively understand the global dynamics of fossil-derived brown carbon (BrC) in wet atmospheric deposition and its implications for the oceanic carbon cycle, it is imperative to consider both the source-specific fluxes of organic carbon (OC) and BrC into the ocean. We calculated the concentration of BrC using the optical intensity of organic matter and the global wet depositional flux of fossil fuel-derived BrC for the first time. Our analysis revealed that the global wet depositional flux of fossil fuel-derived BrC is approximately 2.0 ± 0.6 Tg C $yr^{-1}$, a value derived from the ratio of humic-like substances to OC fluxes. Significantly, this study finds that the flux of fossil-derived refractory DOC into the oceans, which constitutes about 53 ± 35% of the total global wet depositional OC flux, amounts to 0.7 ± 0.2 Tg C $yr^{-1}$. This is equivalent to 1.6% of the production rate of refractory DOC in the ocean (43 Tg $yr^{-1}$), suggesting a potentially underestimated yet disproportionately important role of fossil fuel-derived BrC in oceanic carbon cycles. Thus, our findings indicate that the fossil fuel-derived refractory DOC flux from the atmosphere into the ocean, which is not properly represented in current models of global DOC cycling, may play a disproportionately important role in oceanic carbon cycles.

**(S08 17810 Oral)** (ECOP)

**Alkalinity pumping by coastal macroalgal forests**

Chnag-Ho Lee[1], Kitack **Lee**[1], Miok Kim[1], Ju-Hyoung Kim[2], Yong Woo Choi[3] and Jin Woo Kang[3]

[1]Pohang University of Science and Technology, Pohang, Korea. E-mail: ktl@postech.ac.kr

[2]Kunsan National University, Gunsann, Korea

[3]Korea Fisheries Resources Agency

Macroalgal habitats are extensive, covering a vast area of 6.06-7.22 million km2 along coastlines worldwide, and are highly productive with a net primary production of 1.32 Pg C yr-1, surpassing the NPP of all other coastal primary ecosystems combined. However, the carbon sequestration potential of macroalgal ecosystems is poorly constrained because of uncertainties regarding the pathways and fates of macroalgal carbon. Experimental investigations into macroalgal oxidation have shown that half of the assimilated carbon is discharged as bicarbonate ions (HCO3-) rather than as $CO_2$. This phenomenon, characterized by concurrent increases in alkalinity and total dissolved inorganic carbon, represents a unique mechanism of bicarbonate pumping into coastal environments. Our observations, from a macroalgal habitat in Korea to a natural macroalgal bloom in the Yellow Sea, demonstrate the global universality of this mechanism. With only 0.5% of released bicarbonate projected to transform into $CO_2$ per degree ocean warming, bicarbonate ions serve as a stable carbon reservoir, less likely to be respired back into $CO_2$.

**(S08 17857 Oral)**

**Standardization of Ocean Negative Carbon Emission Technologies and Carbon Neutrality**

Yanli **Lei**

Institute of Oceanology, Chinese Academy of Sciences, Add. Nanhai Road 7, Qingdao 266071, P.R. China; ISO/TC8/WG15 Manger&Convenor; E-mail: leiyanli@qdio.ac.cn

In response to the imminent climate crisis and in alignment with the global goals of carbon neutrality and the objectives of the Paris Agreement, the United Nations has recently approved the Global Ocean Negative Carbon Emissions (Global-ONCE). This initiative aims to protect marine biodiversity and ensure the sustainable development of the oceans by harnessing the pivotal role of oceans in regulating greenhouse gas absorption. Within this context, Global ONCE has applied to establish ISO/TC8/WG15, Ocean Negative Carbon Emissions and Carbon Neutrality, under the International Organization for Standardization. The technical scope of this working group encompasses the standardization of technologies and engineering related to ocean negative carbon emissions and carbon neutrality. These standards will facilitate the quantification and assessment of carbon in the marine environment, marine biological carbon, sedimentary carbon, and the application of negative carbon emission technologies in areas such as ocean ranching, alkalization of wastewater treatment, and artificial upwelling. ISO/TC8/WG15 warmly welcomes scientists from around the world to join in international cooperation, aiming to develop innovative technologies, methods, and best practices for harnessing the potential of ocean carbon negative emissions. The ultimate goal is to transform these advancements into international standards and share advanced experiences, technologies, and scientific ideas with humanity at large. Through collaborative efforts, overcoming challenges, and promoting public engagement, this initiative seeks to maximize the role of oceans in mitigating climate change and achieving global carbon neutrality targets.

**(S08 17880 Oral)**

**A negative emission application based on floating integrated system**

Fengjun **Duan**

The Canon Institute for Global Studies, Tokyo, Japan. E-mail: fengjun.duan@canon-igs.org

Since the IPCC report noted that removing large amounts of $CO_2$ from the atmosphere are essential to achieve the climate change mitigation target, methods based in the ocean area have obtaining more and more attentions because of their high potential. This study examines the capability of a proposed integrated system as one of these approaches. The system combines a 12.5MW OTEC (Ocean Thermal Energy Conversion) facility, microalgae cultivation bioreactors, and fish aquaculture cages on an offshore floating structure. During the operation process, the cultivated microalgae will be fabricated into fish food for aquaculture, the resident biomass will be used to produce biofuel, and all the necessary energy will be provided by the OTEC. Being independent both in energy and material, the system has no carbon emission. Therefore, it can realize a negative emission effect through absorbing $CO_2$ from the atmosphere by microalgae cultivation and biological productivity enhancement, which is generated by the artificial upwelling along with the OTEC process. The life cycle carbon footprints were calculated for assumed system applications in tropic and sub-tropic areas in East to Southeast Asia. The results showed that annual negative emissions of the system were estimated to be from 5,000 to near 100,000 tones of $CO_2$ in different locations. At meanwhile, the system outputs fish stock and energy products, thereby could also contribute to maintain the food, especially the protein security, and improve the sustainability of the local community. A comprehensive assessment was also carried out to evaluate the sustainability of the system itself.

**(S08 17934 Oral)** (ECOP)

**Dissolved organic carbon cycle in the Yellow Sea and the East China Sea: Insights from radiocarbon analysis**

Yeongjin **Ryu**[1], Heejun Han[1,2], Taehee Na[1], Guebuem Kim[1] and Jeomshik Hwang[1]

[1]School of Earth and Environmental Sciences/Research Institute of Oceanography, Seoul National University, Seoul 08826, Republic of Korea. E-mail: jeomshik@snu.ac.kr

[2]Marine Environmental Research Department, Korea Institute of Ocean Science and Technology (KIOST), Busan, Republic of Korea

The Yellow Sea and the East China Sea are the continental shelves of the Northwestern Pacific. Dynamic organic matter cycling occurs here due to high marine primary production, input of terrestrial organic matter through rivers and the atmosphere, and resuspension of sedimentary organic matter. Radiocarbon has been used to study dissolved organic carbon (DOC) inputs to the region, but has rarely been applied to understanding DOC cycling within the continental shelf. Studies on DOC using radiocarbon ratio ($\Delta^{14}C$) can provide better insights into DOC cycling, including the influence of various pre-aged DOC sources entering the Yellow Sea, DOC distribution in the water column, and excessive DOC fluxes to open ocean. In this study, we measured the concentration and $\Delta^{14}C$ value of DOC in the Yellow Sea and East China Sea in August 2020 and November 2021. We then synthesized them with the results of a radiocarbon study of DOC reported in the East China Sea in February 2017. Subsequently, we investigated the processes that regulate DOC cycling on the continental shelves of the Northwestern Pacific.

**(S08 17982 Oral)** (ECOP)

**Amplified subsurface signals of ocean acidification and the implications for interior ocean ecosystems**

Andrea J. **Fassbender**[1], Brendan R. Carter[2,1], Jonathan D. Sharp[2,1], Yibin Huang[3,4,1], Mar C. Arroyo[5,1] and Hartmut Frenzel[2,1]

[1]NOAA/OAR Pacific Marine Environmental Laboratory, Seattle, USA. Email: andrea.j.fassbender@noaa.gov

[2]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, USA

[3] Department of Marine Chemistry, Xiamen University, Xiamen, China

[5]Cooperative Institute for Marine and Atmospheric Research, University of Hawai'i at

Manoa, Honolulu, USA

[4]Department of Ocean Sciences, University of California Santa Cruz, Santa Cruz, USA

Ocean Acidification (OA), caused by the air-to-sea transfer of anthropogenic carbon ($C_{ant}$), is intuitively thought to be a surface-intensified process. However, this is not the case across both coastal and open ocean regions and for multiple OA metrics, including the partial pressure of carbon dioxide gas ($pCO_2$) and the hydrogen ion concentration ($[H^+]$). Although $C_{ant}$ concentrations are largest at the surface, smaller amounts of $C_{ant}$ at depth can induce larger $pCO_2$ and $[H^+]$ changes due to greater sensitivities of these parameters in weakly buffered subsurface waters that have experience significant organic matter respiration. As a result, subsurface $pCO_2$ (and $[H^+]$) changes exceed surface water changes by >100% throughout large expanses of the ocean, outpacing the atmospheric $pCO_2$ change that drives OA itself. Re-emergence of high $pCO_2$ waters at the sea surface could cause elevated $CO_2$ evasion rates and reduced carbon storage efficiency in regions where waters do not have time to equilibrate with the atmosphere before subduction. The elevated signal-to-noise ratio associated with subsurface $pCO_2$ and $[H^+]$ changes could prove useful in the assessment of environmental impacts associated with some marine carbon dioxide removal (mCDR) strategies. Similar subsurface amplified signals were not found for pH or aragonite saturation state. This talk will convey where and why these signals are occurring, how the signals are anticipated to progress across a range of shared socioeconomic pathways, and how these changes contribute to a landscape of multiple stressors in the ocean interior.

**(S08 18019 Oral)** (ECOP)

**Investigation of concentrations and fluxes of potent greenhouse gases ($N_2O$, $CH_4$, and$CO_2$) in the port and harbor seawaters of Jeju Island (Korea)**

Seo-Young **Kim**[1], Hyo-Ryeon Kim[1], Ju-Hyoung Kim[2] and Il-Nam Kim[1]

[1]Department of Marine Science, Incheon National University, Incheon, South Korea. E-mail: ilnamkim@inu.ac.kr

[2]Department of Aquaculture and Aquatic Science, Kunsan National University, Gunsan, South Korea.

Understanding greenhouse gas (GHG) dynamics is crucial for preparing future climate scenarios. Semi-enclosed port and harbor environments are vulnerable to nutrient accumulation from anthropogenic activities, leading to GHG emissions. However, previous studies in these areas have primarily focused on atmospheric pollution. Jeju Island, which is experiencing increased nutrient discharge into its coastal environment, is well-suited for studying GHG emissions from port and harbor environments. Thus, we investigate, for the first time, the concentrations and air-sea fluxes of potent greenhouse gases ($N_2O$, $CH_4$, and $CO_2$), which account for over 88% of radiative forcing, in the port and harbor seawaters of Jeju Island during the summer of 2021. We categorized Jeju Island into four groups based on dominant industries: Urban, Aquaculture, Nature tourism, and Agriculture. Significant differences in GHG concentrations and fluxes were found among these regions. In particular, the ports and harbors in urban and tourist areas showed relatively higher concentrations due to intensive human activities, compared to those in other areas. Overall, during the summer of 2021, the Jeju ports and harbors acted as a source region of $N_2O$, $CH_4$, and $CO_2$ to the atmosphere, with average fluxes of 1.67±1.41 μmol m-2 day-1, 10.30±10.24 μmol m-2 day-1, 0.15±0.75 mmol m-2 day-1, respectively. Our results highlight the need for a deeper understanding of port and harbor environments as potential sources of GHG emissions.

**(S08 18029 Oral)** (ECOP)

**Ocean acidification and compound extreme events in the northern California Current System during 1993–2023: A modeling study**

Yifan **Zhu**[1], Samantha Siedlecki[1], Felipe Soares[1], Dipti Hingmire[2], Parker MacCready[3], Simone R. Alin[4], Richard R. Feely[4], Craig M. Risien[5] and Jeannette Waddell[6]

[1]University of Connecticut, Groton, CT, USA. E-mail: yifan.zhu@uconn.edu

[2]University of Victoria, Victoria, BC, Canada

[3]University of Washington, Seattle, WA, USA

[4]Pacific Marine Environmental Laboratory, NOAA, Seattle, WA, USA

[5]Oregon State University, Corvallis, OR, USA

[6]Olympic Coast National Marine Sanctuary, NOAA, Port Angeles, WA, USA

Due to strong seasonal upwelling, the northern California Current system (nCCS) is highly productive, supporting diverse fisheries; however, it is also a hotspot prone to persistent ocean acidification and hypoxic events. On the continental shelf, intensive rates of subsurface and benthic respiration increase over the summer, often reducing oxygen to extremely low levels such that hypoxia or anoxia occur. Corrosive ($\Omega Ar<1$) and acidity extremes co-occur in the late summer/early fall. Additionally, the nCCS experiences marine heat waves (MHWs), representing an additional environmental stressor impacting marine species and ecosystems. These compound extreme conditions stress the surrounding biota, particularly affecting Dungeness crab and calcifying organisms. To examine the historical change in the occurrence of these compound events, we use an existing local forecast system (LiveOcean) to simulate the historical ocean conditions spanning 1993–2023. Using a suite of observations, we analyze the spatiotemporal patterns and trends of MHWs and ocean acidification-related parameters in the simulations over the three decades and identify gaps in our observing needed to monitor and support changing conditions. Finally, we will describe the potential impact of MHWs on ocean acidification events on the shelf.

**(S08 18099 Oral)** (ECOP)

**Seasonal forecasts of bottom water pH conditions for the Bering Sea shelf**

Darren J. **Pilcher**[1,2], Natalie Monacci[3], Kelly Kearney[4], Albert Hermann[1,2], Wei Cheng[2], Linquan Mu[1], Jessica N. Cross[5], and Elizabeth Siddon[4]

[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA. E-mail: Darren.pilcher@noaa.gov

[2]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA

[3]Ocean Acidification Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA

[4] NOAA Alaska Fisheries Science Center, Seattle, WA, USA

[5]Pacific Northwest National Laboratory, Sequim, WA, USA

Seasonal manifestations of ocean acidification (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. Previous model work has tracked these conditions over historical timeframes and projected changes on multi-decadal timeframes under climate emissions scenarios. A major gap in the current portfolio of products is forecasting conditions on seasonal timeframes. This project describes recent efforts to test the ability of an existing ocean biogeochemical model to predict bottom water pH and carbonate saturation states 4-5 months in advance. These forecasts are initialized as three-member ensembles on April 1st and May 1st. These start dates are chosen based on previous research illustrating that model forecast skill of bottom water temperatures is increased when initializing after the start of sea ice retreat. Here, we specifically target the prediction of the OA index, an established metric of summertime corrosive bottom water conditions. Initial results illustrate promising model forecast skill, with the model accurately predicting several substantial year-to-year increases in corrosive conditions. These forecasts could, therefore, provide advance notice prior to the fisheries survey season of relatively more acidic water conditions expected later that summer. With sufficient skill, these forecasts will join our suite of ongoing products used to support evidence-based decisions in sustainable marine resource management for the Bering Sea large marine ecosystem.

**(S08 17805 Poster)** S08-P1

**Observing marine carbon dioxide in Alaska's coastal oceans**

Natalie M. **Monacci**[1], Simone Alin[2], Roman Battisti[3], Randy Bott[2], Jessica Cross[4], Wiley Evans[5], Stacy Maenner-Jones[2], Linquan Mu[3], Sylvia Musielewicz[3], John Osborne[3], Darren Pilcher[3], Phyllis Stabeno[2], Adrienne Sutton[2], and Hongjie Wang[6]

[1]Ocean Acidification Research Center, College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK, USA. E-mail: nmonacci@alaska.edu

[2]Pacific Marine Environmental Laboratory, NOAA, Seattle, AK, USA

[3]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA

[4]Pacific Northwest National Laboratory, Seattle, WA, USA

[5]Hakai Institute, Campbell River, British Columbia, Canada

[6]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, USA

The global surface ocean is absorbing ~25% of anthropogenic carbon dioxide released to the atmosphere, which results in decreasing seawater pH, known as ocean acidification. High latitude regions and coastal areas in the North Pacific are experiencing some of the fastest rates of ocean acidification due to natural local processes such as cold waters, high freshwater input, and high biological productivity. We employ ship-board observations and autonomous platforms to monitor the ocean carbon cycle in Alaska's large marine ecosystems. The northern Gulf of Alaska and eastern Bering Sea are affected by coastal processes and exhibit significant natural variability. This presentation will highlight data from two high-frequency, autonomous time series to demonstrate the air-sea interaction of carbon dioxide at long-term mooring sites in the northern Gulf of Alaska (GAKOA) and southeastern Bering Sea (M2). At GAKOA, we are beginning to detect the anthropogenic trend outside the seasonal and annual variability. Additionally, we will summarize five years of surface carbon dioxide observations from an uncrewed surface vehicle project in the Pacific Arctic Region in context with the subsurface marine carbonate system on the Bering Sea shelf. Alaska's coastal oceans can act as a significant seasonal sink of carbon dioxide and have been identified as a potential site for marine carbon dioxide removal. We will relate our observations and mission to monitor marine carbon dioxide in Alaska with efforts to identify and characterize potential sites for future marine carbon dioxide removal projects.

**(S08 17846 Poster)** S08-P2 (ECOP)

**Studies on the use of locally available (Coxs Bazar and Saint Martin) renewable seaweed wastes as compost organic fertilizer resources**

Durlave **Roy**

Durlave Roy School of Agriculture,Bangladesh Open University,Dhaka,Bangladesh, email: 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 treatments 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). 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 Sustainable Development Goal of responsible production and consumption and climate action.

# S9: MEQ Topic Session

**Recent advances in plastic pollution research in the North Pacific**

**Convenors:**
Matthew Savoca (USA), *corresponding*
Chengjun Sun (China)

**Invited Speaker:**
Jinfeng Ding (First Institute of Oceanography (FIO), China)

The North Pacific and its marginal seas are heavily polluted with meso- and microplastics. The science to understand and tackle this problem is moving quickly. This session will highlight recent advances in plastic pollution science in the North Pacific and its marginal seas, covering issues such as how we are monitoring plastic pollution in the ecosystem, harmonization of methodologies and how this standardization is driving novel insights, trends in plastic pollution in the abiotic and biotic components of the ecosystem, and how science is informing risk assessments and mitigation of this mounting global threat. We are also interested in how science in the PICES region aligns with global coordination of plastic pollution research. Along this theme, there is also interest in how researchers in the PICES community are interfacing with scientists, managers, and policymakers from other regions. These interactions with members of the global community are supported by the UN Decade of Ocean Science for Sustainable Development and will be increasingly necessary to empower science-guided decision-making for plastic usage and litter management, as well as assessing threats to environmental and human health.

**(S09 17962 E-Poster)** S09-P1 (ECOP)

## Development of analytical procedures to investigate the environmental occurrence of micro to nano-sized plastics in Asian urban cities


Tamaki **Morioka**[1], Shuhei Tanaka[1], Akiko Kohama-Inoue[1], and Ibukun Oluwoye[2]

[1]Kyoto University, Kyoto, Japan. E-mail: morioka@eden.env.kyoto-u.ac.jp

[2]Curtin University, Perth, Australia



Asian countries contribute over 60% of the world's mismanaged plastic waste, which transforms mostly into marine plastic debris. A few microns- and nano-size plastics can easily be suspended in the atmospheric environment and may be contributing to global water pollution. Plastic particles having a few μm diameter may pose ecological risks to aquatic species due to their potential for long-term persistence in the body. However, there are no developed analytical standards to investigate a few microns down to nano plastic due to the limitations of conventional analysis such as FTIR. In this study, we developed analytical procedures to quantify plastics with diameters ranging from 0.43 μm to 11 μm in the urban outdoor atmosphere using pyrolysis-gas chromatograph-mass spectrometry (pyro-GC/MS) and applied the technique to investigate outdoor airborne plastics in the major cities in Nepal, Thailand, and Japan. We collected aerosol on the heat-resistant quartz wool filters in seven different size fractions using an Andersen air sampler (AN-200). Each filter was punched out and placed in a sample cup before analysis. When compared to single-shot analysis, in which polymers are pyrolyzed at a constant temperature, double-shot analysis, in which volatile compounds are thermally desorbed before pyrolysis, may be more effective because this procedure detected relatively more polymer compounds in the test sample. The concentration of some polymers, such as PE, tended to be relatively high mass concentration at sizes under 1 μm, indicating that these polymers can be easily finer down to nano-size and pose higher ecological risks.

**(S09 17863 Invited)**

## Occurrence and migration rules of seawater microplastics in the Pacific sector of the Arctic Ocean

Jinfeng **Ding**, Chengjun Sun, Wei Cao, Jingxi Li and Fenghua Jiang

Marine Bioresource and Environment Research Center, First Institute of Oceanography, Ministry of Natural Resources, Qingdao, China. E-mail: csun@fio.org.cn

Some researchers have proposed that the Arctic seafloor is a "sink" for microplastics based on microplastic data from the surface water in the Atlantic sector of the Arctic Ocean. The ocean current model shows that the Arctic Ocean is affected by pollution transmission from the North Pacific Current and North Atlantic Current. However, there is limited data on microplastics in the Pacific sector of the Arctic Ocean. This study focuses on microplastic pollution in surface, subsurface, and column water in the Pacific sector of the Arctic Ocean to explore the horizontal and vertical migration rules of seawater microplastics. The results showed that the Bering Sea surface seawater is an important source of microplastic pollution in the surface seawater of the northern Arctic Ocean in the horizontal direction, which is consistent with the surface current data. In addition, the correlation between the microplastic features in different water layers in the northern Arctic Ocean is weaker than that in the Bering Sea Basin and the Bering Sea Shelf, which is closely related to the complex structure of water masses from different sources in this sea area. This study evaluated the transport mechanism of seawater microplastics in the Pacific sector of the Arctic Ocean in both horizontal and vertical directions, providing basic data for the prevention and control of Arctic microplastic pollution and the formulation of relevant policies, and also providing comparable data for the establishment of a global marine microplastic pollution database in the future.

**(S09 17766 Oral)** (ECOP)

**Estimating the biological removal timescale of microplastics in the North Pacific**

Haodong **Xu**[1,2], Yoshimasa Matsumura[1], Hideyuki Nakano[3], Kazutaka Takahashi[2], Kentaro Miyazono[2] and Shin-ichi Ito[1]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan Email: goito@aori.u-tokyo.ac.jp

[2]Graduate School of Agricultural and Life Science, The University of Tokyo, Tokyo, Japan

[3]Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, Japan

In the decades investigating the microplastics in the ocean, the distribution characteristics, sources and local pathways have been elaborated and corroborated. Towards ocean science for sustainability, the removal process, along with other physical processes, are the keystones for the comprehensive understanding of marine microplastics, to reach the predictability and cleanness of ocean (UN Decade goals). Some of these processes have been calculated by comparing observation data and basin-scale simulation, which facilitated the holistic knowledge of ocean microplastics. Based on concepts from pioneering researches, we would like to further evaluate one of most significant parameters, removal timescale, which can explain the 'missing plastics', a term describing the budgetary imbalance between plastic emission model and surface plastics estimation. By comparing particle tracking model and long-term observational neuston net samples, removal timescale was calculated as 4.4 months in average and 2.9 years at maximum. In the model, up to 94 % of particles would be removed within 1 year. Moreover, the sea areas where floating microplastics were removed were also computed. The distance to release points, chlorophyll concentration are 2 important factors that can explain the distribution that removal occurred. For instance, coastal sea areas are vibrant in particle removing due to high chlorophyll concentration and high particle density. Nonetheless, under this timescale, the particles couldn't be transported to remote seas. In coming step, an unfixed timescale that can be varying based on different sizes, will be analyzed to better reflect the real scenario.

**(S09 17834 Oral)** (ECOP)

**Recent advances in macroplastic risk assessments**

Erin **Murphy**[1,2,3], Britta Baechler[1], George Leonard[1], Nicholas Mallos[1], and Chelsea Rochman[2]

[1]Ocean Conservancy, Washington, DC, U.S.A Email: elmurph1@asu.edu

[2]University of Toronto, Toronto, Canada

[3]Arizona State University, Tempe, Arizona, U.S.A

Plastic ingestion has been documented in nearly 1,300 marine species, including in every family of seabird and marine mammal, and all seven species of sea turtle. Acute mortality from plastic ingestion has also been determined via necropsy in all three taxa due to obstruction, perforation, or torsion of the gastrointestinal tract. Growing concern about the possible ecological implications of plastic-induced mortality has motivated calls for risk assessments (i.e., how much ingested plastic is too much?) to inform regulatory actions. Here, we will share qualitative and quantitative risk assessment approaches we have developed to better understand the risk macroplastic poses to marine mammals, sea turtles, and seabirds. The qualitative risk assessment approach we developed uses species trait data to rank the relative vulnerability of marine populations to macroplastic ingestion and entanglement. We exemplify the value of this approach through the development of a vulnerability index for species found in the Hawaiian EEZ. The quantitative risk assessment approach we developed predicts the likelihood of mortality for individuals based on macroplastic ingestion. These tools can provide critical information about the effects macroplastic pollution has on marine biota, and actions we may take to address it. Moving forward we aim to expand on these approaches to further elucidate the relationship between environmental macroplastic concentrations and harm to marine biota.

**(S09 17867 Oral)**

**The alteration of toxicity in marine organisms by micro and nanoplastics, co-existing with typical organic chemicals**

Ying **Wang**, Mingxing Zhang, Fei Jin, Fuwei Yu and Juying Wang

National Marine Environmental Monitoring Center, Ministry of Ecology and Environment, Dalian, China. E-mail: wangying@nmemc.org.cn

Micro and nanoplastics (MNPs) 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 their toxicity to marine organisms. 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. 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. Furthermore, the presence of polystyrene microplastics (PS-MPs) significantly decreased benzo[a]pyrene (B[a]P) accumulation in soft tissues of Mytilus galloprovincialis by approximately 6.7%. Single exposure of PS-MPs or B[a]P decreased the mean epithelial thickness of digestive tubules and enhanced reactive oxygen species levels in haemolymph. The co-presence of PS-MPs down-regulated the mRNA expression of NF-κB in gills compared with of B[a]P alone. Adverse outcomes for the co-existence of marine emerging pollutants under long-term conditions remain to be further validated.

**(S09 17909 Oral)**

## Benthic marine litter in the Hawaiian Archipelago: evidence from a citizen science initiative

Pierpaolo **Consoli**[1], Gaia Grasso[1], Valentina Costa[2], Valentina Sciutteri[1], Danilo Malara[1], Fabio Figurella[3], Ian Campbell[4], Emily Deery[4] and Franco Andaloro[5].

[1]Stazione Zoologica Anton Dohrn, Sicily Marine Centre, Messina, Italy. E-mail: pierpaolo.consoli@szn.it

[2]Stazione Zoologica Anton Dohrn, CRIMAC - Calabria Marine Centre, Amendolara, Italy

[3]PADI EMEA Ltd, Bristol, United Kingdom

[4]PADI AWARE Foundation, Bristol, United Kingdom

[5]Stazione Zoologica Anton Dohrn, Sicily Marine Centre, Palermo, Italy

Over the past decade, the exponential increase in marine debris in the world's oceans has led to an ever-increasing interest in this issue by marine scientists and governing agencies. Finding time-efficient, cost-effective and standardized data collection methods is a challenge when addressing aquatic litter pollution. Citizen science initiatives can provide valuable tools for better understanding and quantifying marine litter pollution. In this study, we analysed data on aquatic benthic debris collected in the Hawaiian Archipelago by volunteer scuba divers through Dive Against Debris®, a worldwide citizen-science program carried out by PADI Aware Foundation. From 2006 to 2021, a total of 453 survey dives were conducted in the archipelago, collecting data on quantity, typology and distribution of benthic litter. In the region, the average litter density was 236.98 items/100 m2 and plastics represented 50% of the total abundance, followed by metal at 30% and glass/ceramic at 14%. Single Use Plastics constituted 6%. The top ten marine litter items identified in the dataset contributed to 83% of the total litter abundance, with fishing lines as the most abundant items (34%), followed by fishing sinkers/lures/hooks (22%). Overall, fisheries emerged as one of the main sources of litter since lost fishing gear accounted for 59% of the total litter. The outcomes gained can be utilised to improve waste management policies, keeping in mind that awareness-raising activities could be major tools in tackling this problem and should go closely together with government policies to contain the problem.

**(S09 17949 Oral)** **(**ECOP)

**Thirteen years of sea turtle plastic ingestion monitoring in the Central Pacific**

Rachel M. **Nakamoto**[1], Katherine R. Shaw[1,2], Raquel N. Corniuk[1], Melissa R. Jung[1], George H. Balazs[3], T. Todd Jones[4], Thierry M. Work[5], Summer Martin[4], and Jennifer M. Lynch[1,2].

[1]Hawai‘i Pacific University Center for Marine Debris Research, Waimanalo, United States email: rnakamoto@hpu.edu

[2]National Institute of Standards and Technology Waimanalo, United States

[3]Golden Honu Services of Oceania, Honolulu, United States

[4]The National Oceanic and Atmospheric Administration, Honolulu, United States

[5]United States Geological Survey, Honolulu, United States

The Biological and Environmental Monitoring and Archival of Sea Turtle Tissues (BEMAST) project is a long-term pollution trend monitoring for sea turtles in the Central Pacific. Five out of the seven species of sea turtles can be found in the Central Pacific Ocean, and their proximity to the Eastern Pacific Garbage Patch increases the threat of plastic interactions, making them an ideal bioindicator. Plastic pollution is an increasingly common threat to sea turtles through plastic ingestion, which can have lethal or sublethal effects. Lethal effects from plastic ingestion can include obstruction, perforation, and torsion of the gastrointestinal tract, while sublethal effects can include the nutrient dilution and harmful chemical exposure. The gastrointestinal tracts of 97 longline bycaught and 20 stranded sea turtles collected between 2016 and 2014 were examined for plastic ingestion. The ingested plastics were categorized by count, type (fragment, sheet, line, foam, nurdle, or whole item), color, length, width, depth, and mass. Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy (ATR-FTIR) was used to chemically identify the plastic polymers. An average of 57 pieces of plastic were found per turtle. Green sea turtles ingested more plastic than the other species. Continuing to monitor sea turtle plastic ingestion over a long period allows us to see trends, and knowing which types of plastic are ingested can help us to take action and prevent more plastic from entering the ocean.

**(S09 17952 Oral)** (ECOP)

## The role and impact of salp blooms on the removal of floating small microplastics in the Kuroshio, south of Japan

Kengo **Egami**[1], Kentaro Miyazono[1], Rei Yamashita[2], Gajahin Gamage Nadeeka Thushari[3], Akinori Takasuka[1], Mikio Watai[4], Tohya Yasuda[4], Taketoshi Kodama[1] and Kazutaka Takahashi[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Bunkyo, Tokyo, Japan. E-mail: kenegapple46@g.ecc.u-tokyo.ac.jp

[2]Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Chiba, Japan.

[3]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.

[4]Japan Fisheries Research and Education Agency, Yokohama, Kanagawa, Japan.

Information on the dynamics of microplastics <330 µm (SMPs), which cannot be collected by conventional net samplings, is still lacking on a worldwide basis. This study focused on the role and impact of salps, non-selective filter-feeding tunicates, on the removal of floating SMPs around the Kuroshio, south of Japan. We examined 98 neuston-net samples to determine the distribution of Salpa fusiformis. No specimen was collected during the daytime (0/50), while it occurred in 75.0% of samples collected at night (36/48) with a density of 0.0026–0.82 individual/m3, suggesting that they exhibited an active diel vertical migration. SMPs were found in 97.9% of guts of S. fusiformis (n=48) with an average of 5.23±4.40 particle/individual. The size mode of SMPs in salp gut was 70 µm, and they remarkably varied in color and polymer type. Furthermore, with the aid of previously known allometry relationships regarding filtration and evacuation rates, we estimated in-situ distribution of floating SMPs based on the abundance and composition of SMPs in salp gut. The results showed that SMP density in the study area ranged between 194±138 to 7093±923 particle/m3; notably, they were abundant at stations with weak current speed. The estimated populational ingestion rates by S. fusiformis on SMPs ranged from 0.0188 to 34.5 particle/m3·day, and they were particularly higher around the edge of the cold-core ring where salps bloomed, suggesting that S. fusiformis significantly contributed to the mass transportation of floating SMPs to the depth, owing to their mass occurrence, non-selective feeding habit, and large fecal-pellet production.

**(S09 18002 Oral)**

## An overview of marine debris removal, sourcing, and recycling in the Hawaiian archipelago

Jennifer M. **Lynch**[1,2], Mafalda de Freitas[2], Katherine A. Stevens[2], Cara Megill[2], Mandy Brinkmann[2], Paige White[2], Eric Kingma[3], Eileen Nalley[4], and Darren Lerner[4]

[1]National Institute of Standards and Technology, Chemical Science Division, Waimanalo, HI, USA. E-mail: jennifer.lynch@nist.gov

[2]Hawaii Pacific University, Center for Marine Debris Research, Honolulu, HI, USA

[3]Hawaii Longline Association, Honolulu, HI, USA

[4]University of Hawaii, Hawaii Sea Grant, Honolulu, HI, USA

The marine habitats of the Hawaiian Archipelago are threatened by a large magnitude of plastic pollution, originating from multiple industries and countries around the Pacific Rim. This talk will summarize the goals and accomplishments of the Center for Marine Debris Research's Megaplastics Program, which seeks to reduce plastic pollution in the North Pacific Ocean. The three-prong approach is to accelerate marine debris removal, source the debris to recommend the most effective targeted prevention strategies, and mechanically recycle the debris to create long-lasting, locally necessary infrastructure products. Currently, our removal project pays commercial fishers a bounty to remove derelict fishing gear (DFG) found at sea to prevent nearshore coral habitat damage when the DFG washes towards the shoreline in Hawaii. Together with the other largest marine debris removal organizations in Hawaii, we seek to remove 200 metric tons per year from the archipelago. Our sourcing projects have determined that the far majority of the debris is plastic and approximately 75% is DFG. Twenty percent of the debris is trawl netting made of high-density polyethylene (HDPE), as determined using our two-step polymer identification methods (ATR FTIR and DSC). Very little of the debris is nylon; however, we have partnered with the 150 vessels in the Hawaiian longline fleet to receive and recycle their spent monofilament nylon line. The HDPE and nylon are the biggest feedstocks available for mechanical recycling in our Plastic Recycling Research Facility (PRRF), which is equipped with an industrial shredder. The first recycling project paved an asphalt road on Oahu with 0.1% HDPE fishing nets into the pavement. The mechanical performance of the pavement is being tested currently, and we are testing microplastic and plastic additive chemical leaching from the pavement. We are committed to undertaking projects that have the most environmentally friendly process; thus, we are conducting comparative life-cycle assessments (LCAs) to empirically determine which process or option is best for the environment.

**(S09 18009 Oral)** (ECOP)

**Big fish, little plastics: investigating microplastic accumulation and trophic transfer in salmon sharks**

Maddie **English**[1], Alexandra McInturf[1], Bonnie Hamilton[2], Olivia Boisen[1], Reilly Boyt[1], Matthew Savoca[3], Susanne Brander[1], and Taylor Chapple[1]

[1]Oregon State University, Corvallis, OR, USA. E-mail: maddie.english@oregonstate.edu

[2]Environment and Climate Change Canada, Toronto, ON, Canada

[3]Stanford University, Stanford, CA, USA

Anthropogenic microparticle ingestion, including microplastics, in marine organisms—especially fish—is a growing concern. Yet, its prevalence in sharks of the Northeast Pacific remains largely unexplored. One species ideally suited to address this knowledge gap is the salmon shark (*Lamna ditropis*). Salmon sharks are regionally endothermic and have a high metabolic rate, and their food consumption rates and energetic requirements are higher than those of most shark species. In addition to contributing to their ecological impact as consumers, these traits may also influence how frequently they encounter plastics and other particles. In this study, we use a combination of methods including stomach content analysis, high-resolution microscopy, and micro-Fourier-transform infrared spectroscopy to investigate anthropogenic microparticle (natural or synthetic particles < 5 mm) quantities and types in salmon sharks and their prey off the Oregon Coast. We aim to quantify the amount of microparticles consumed by these predators along the Oregon Coast and determine whether there is sufficient evidence to suggest that trophic transfer occurs through comparison of ingestion levels and particle characteristics in sharks and their prey. Our preliminary findings indicate a high presence of ingested microparticles of diverse morphologies in salmon shark stomachs, highlighting the need for further investigation into the impact of microparticles on salmon sharks as well as other elasmobranch species.

**(S09 18033 Oral)**

**Unraveling the effects of climate change and microfibers from textiles on coastal food webs via a critical prey species**

Lauren M. **Kashiwabara**, Patrick Reece, Clarissa B. Raguso, Lisa Hildebrand, Leigh Torres and Susanne M. Brander

Hatfield Marine Science Center, Oregon State University, Newport, OR USA. Email: lauren.kashiwabara@oregonstate.edu

Mysid shrimp are an important prey item in many marine food webs, including those containing predators such as salmonids and Pacific gray whales. Gray whales are ecosystem engineers requiring up to 75 million zooplankton, including mysid shrimp (Holmesimysis sculpta), daily. Gray whales, recently found to have reduced overall size compared to historic measurements, and mysid shrimp are subject to multiple stressors including climate change and pollution. Field measurements from H.sculpta and gray whale scat indicate consumption of up to 21 million microparticles (primarily microfibers) from prey and potential additional microplastic sources due to their benthic feeding behavior. Sediment was recently collected from gray whale foraging grounds for microplastic analysis and will highlight mysids' susceptibility to microplastic pollution. After a 14-day exposure to a weathered treated blend of cotton, spandex, and polyester, laboratory mysids, Americamysis bahia showed hypoactivity as a response to a stimulus. Field-collected H. sculpta were shown to 48h ingest similarly weathered polyester after just 48 hours of exposure. Future research will investigate longer exposures, textiles from across manufacturing stages (from greige (untreated) to fully chemically treated), and climate conditions. A. bahia and H. sculpta will be exposed to estuarine acidification or increased ocean temperatures, respectively, with treated or untreated weathered microfibers. Analyses of behavior, growth, reactive oxygen species, and caloric value will explore physiological responses to these stressors. Changes in the quantity and quality of these prey items due to climate change and microplastics may have substantial individual and population-level impacts on this North Pacific food web.

**(S09 18050 Oral)**

**Abundance and vertical distribution of microplastics in the epipelagic waters of the Kuroshio region**

Yuichiro **Nishibe**, Lingfeng Guan and Rei Yamashita

Atmosphere and Ocean Research Institute, the University of Tokyo, Kashiwa, Japan Email: ynishibe@aori.u-tokyo.ac.jp

The distribution of microplastics in the world's oceans has been extensively studied, primarily focusing on surface waters. However, it is also crucial to understand their distribution in the water column below the surface to have a comprehensive view of marine plastic pollution. This study investigated microplastic abundance, size and polymer composition at the surface and three depths between 10 and 150 m in the Kuroshio region. We concentrated particles in 50 L of seawater from each depth onto a 5 µm membrane filter and then identified microplastics using micro-FT-IR after digestion and density separation treatments. Microplastic abundances ranged between 320 and 4230 pieces m-3, with most particles smaller than 300 µm. The vertical distribution of microplastics did not show a consistent pattern with increasing depth among stations. Additionally, there was no clear relationship between microplastic abundance and the vertical profiles of seawater density. The dominant polymers found were polyethylene (PE), polypropylene (PP), and PE-PP copolymer, collectively constituting over half the total on average. Even though PE, PP, and PE-PP copolymer have a specific density lower than seawater, we found them throughout the epipelagic water column. The integrated-mean microplastic abundance in the water column between 10 and 150 m ranged from 550 to 980 pieces m-3, corresponding to about 20% of the surface microplastic abundance. These findings indicate that microplastics are also present in high concentrations in the water column below the surface in the Kuroshio region.

**(S09 18051 Oral)**

## Modelling seafloor deposition of heavy microplastics in the North Pacific over the past 65 years

Haodong Xu[1,2], Yoshimasa Matsumura[1], Rei Yamashita[1], Hideyuki Nakano[3] and Shin-ichi **Ito**[1]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan. E-mail: goito@aori.u-tokyo.ac.jp

[2]Graduate School of Agriculture and Life Sciences, University of Tokyo, Tokyo, Japan

[3]Meteorological Research Institute, Ibaraki, Japan

Increasing microplastics is a new emerging issue to marine ecosystem and many studies have been conducted. However, the distribution of microplastics on the seafloor has not yet been understood because of the difficulties of observation and analyses. In addition, most of modelling studies have focused on floating microplastics which observational data coverage is better than that of microplastics on the seafloor. Therefore, we developed a particle tracking model for microplastics which density is heavier than seawater. The model was integrated from 1951 to 2015 in the North Pacific. We included 7 categories of microplastic sinking velocity and riverine emission scenarios were applied to the simulation. It is not surprising that 78 % of the heavy microplastics were deposited within 100 km from their discharged locations. However, strong currents such as the Kuroshio and Equatorial Counter Current advected the heavy microplastics to the offshore over 100 km. The seafloor was categorized into six clusters regarding origin of seafloor microplastics, which reflects advection effects on the heavy microplastic transportation. The seafloor was clustered into four clusters regarding sinking velocity category of the seafloor microplastics which demonstrating the combined effects of geographical distribution of discharge points, geographical distribution of microplastic mass load, and relative position of discharge points to ocean currents. This research was partially supported by the Environment Research and Technology Development Fund (JPMEERF20221001) of the Environmental Restoration and Conservation Agency of Japan.

**(S09 18075 Oral)**

**Long-term changes in the abundance, size, and morphotype of marine plastics in North Pacific**

Kazutaka **Takahashi**[1], Kentaro Miyazono[1], Kazuaki Tadokoro[2], Gagame G. N. Thushari[1,3], Hiroomi Miyamoto[4], Akinori Takasuka[1], Mikio Watai[4], Tohya Yasuda[4], Takuya Sato[1,5], Rei Yamashita[6] and Taketoshi Kodama[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Bunkyo, Tokyo, Japan. E-mail: kazutakahashi@g.ecc.u-tokyo.ac.jp

[2]Japan Fisheries Research and Education Agency, Shiogama, Miyagi, 985-0001, Japan.

[3]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.

[4]Japan Fisheries Research and Education Agency, Yokohama, Kanagawa, Japan.

[5]Bioinformatics Center, Institute for Chemical Research, Kyoto University, Uji, Kyoto, Japan.

[6]Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Chiba, Japan.

This study presents a long-term empirical dataset on floating marine plastic debris collected from 1949 to 2020 around Japan in the western North Pacific, covering the early stages of plastic pollution up to the present. We observed three phases: 1) a period of increase (0–104 pieces/km2) from the early 1950s to the late 1970s; 2) a stagnation period, with high abundance (104–105 pieces/km2), from the 1980s to the early 2010s; and 3) a period of re-increase (>105 pieces/km2), from the mid-2010s to the present. The shift from film to fragmented plastic in the 1980s and the continuous downsizing may have caused the expansion of the offshore polluted area, resulting in the stagnation period by enhancing the removal process. Importantly the size of the plastic debris continuously decreased from the beginning of the discharge to the present regardless of morphotypes except for filamentous type, suggesting the increasing contribution from pollution sources that efficiently produce microplastics, such as beaches. While the size reduction may have facilitated the removal of plastic debris from the surface layer and caused the stagnation period over 35 years, the recent increase in microplastics suggests that plastic discharge is outpacing its removal possibly due to the global increase of plastic use and climate change.

**(S09 17771 Poster)** S09-P2

**Insights into diversity and plastic substrate specificity of potential pathogenic bacteria**

Hyun-Jung **Kim**[1,2], Sang-Hen Lee[2] and Seung Won Jung[1]

[1]Library of Marine Samples, Korea Institute of Ocean Science & Technology, Geoje, Republic of Korea. E-mail: diatomas@kiost.ac.kr

[2]Department of Oceanography and Marine Research Institute, Pusan National University, Busan, Republic of Korea

To understand the diversity and the substrate specificity of potentially pathogenic bacteria (PPB) in floating marine plastic debris off the Southern coastal waters of South Korea, a total of 600 pieces of plastics were collected from the coastal waters and bacterial diversity was analyzed through 16s rDNA metabarcoding. Additionally, as a control, ambient seawater around plastic litter was collected and analyzed. The dominant bacterial community in the seawater was Alphaproteobacteria, while there was Gammaproteobacteria in the plastisphere. The bacterial community in the plastisphere showed no significant differences by investigated areas and plastic materials (ANOVA, $p>0.05$). However, it was significantly divided into four groups according to the temperature of the ambient seawater ($p<0.01$). PPB appeared at 157 ASVs, 2.9% in the total bacterial community, on means of 16.2% in plastispheres and 4.8% in seawater. When Venn diagram analysis was performed, the core PPB that commonly appeared in all four plastic materials (PE, PP, PET, and EPS) was 72 ASVs and mostly composed of Pseudoalteromonas and Vibrios. In addition, PPB showed a higher proportion during lower water temperature periods. These litters may act as vectors for pathogen transport, and core PPB may play a core role in pathogenicity during low-temperature periods in the plastisphere.

**(S09 17955 Poster)** S09-P3 (ECOP)

**Investigating the spatial and temporal patterns of microplastics in the Fraser River and Burrard Inlet (British Columbia, Canada)**

Nicole **McHugh**, Roger Francois, Maureen Soon, and Maite T. Maldonado

University of British Columbia, Vancouver, BC, Canada. E-mail: nmchugh@eoas.ubc.ca

In the absence of long-term monitoring, microplastics have become the forefront of concern regarding the health and well-being of major marine ecosystems. Despite their persistence in oceanic habitats and potential impacts, few investigations exist on microplastics contamination in marine environments of British Columbia. Microplastics' spatial and temporal variability within highly dynamic riverine systems and shallow-sided marine fjords is not yet well understood. To address these concerns, we targeted sampling at multiple depths in the Fraser River and Burrard Inlet, two receiving water bodies with a variety of microplastic sources. We will use modeling to decipher the contribution of various sources. We built a multichannel sampling apparatus and utilized McLane large-volume pumps to investigate the vertical distribution of microplastics ($>50\mu m$) in the Fraser River and Burrard Inlet. A novel extraction method was developed to advance the ability to quantify microplastics from such organic-rich and brackish environmental matrices. This monthly, multi-depth, one-year time series will help broaden our understanding of the sources, dispersion and distribution of microplastics in BC.

**(S09 18047 Poster)** S09-P4

**Effect of different sampling methods on microplastic abundance and composition in marine surface waters**

Rei **Yamashita** and Yuichiro Nishibe

Atmosphere and Ocean Research Institute, the University of Tokyo, Kashiwa, Japan Email: ryamashita@aori.u-tokyo.ac.jp

Over the past decade, a significant amount of data has been collected on the distribution of microplastics in the ocean. However, most studies have focused on plastic particles larger than 300 µm, collected by surface tows of neuston nets or manta trawls. Since plastics degrade into smaller pieces due to environmental factors, it is likely that smaller microplastics, which conventional sampling nets cannot detect, are more prevalent than larger ones. This study aims to compare the abundance, size, and polymer composition of microplastics collected by filtering surface waters and neuston net tows at six different sites in coastal and offshore waters around Japan. To collect microplastics, we concentrated particles in 100 L of surface water on a 5 µm membrane filter and then analyzed them using micro-FT-IR after digestion and density separation treatments. Additionally, we used a neuston net with a 315 µm mesh to sample microplastics on the sea surface and identified them using ATR-FT-IR. Most (>97%) of microplastics in surface water samples were smaller than 300 µm, whereas those in neuston net catches were from 1 to 6 mm. We found that the microplastic abundances determined by filtering techniques were 2–4 orders higher than those concurrently sampled with neuston net. The polymer composition differed between the samples collected using different methods at the same site. These results suggest that the conventional net sampling method underestimates the presence of smaller microplastics in marine surface waters.

**(S09 18108 Poster)** S09-P5 (ECOP)

**Effect of Harmful microalga *Heterosigma akahiwo* on Aggregation and Sinking of Microplastics in Marine Environments**

Young Kyun **Lim**[1], Chung Hyeon Lee[1], Kyun-Woo Lee[2,3], Sang Hee Hong[1,2], and Seung Ho Baek[1,2]

[1]Ecological Risk Research Department, KIOST (Korea Institute of Ocean Science and Technology), Geoje 53201, Republic of Korea email: limyk0913@kiost.ac.kr

[2]Department of Ocean Science, University of Science and Technology (UST), Daejeon 34113, Republic of Korea

[3]Marine Biotechnology & Bioresource Research Department, Korea Institute of Ocean Science & Technology (KIOST), Busan 49111, Republic of Korea

The vertical distribution and behavior of microplastics (MP) in the marine environment are significantly influenced by attachment and aggregation processes mediated by microalgae. This study investigated the aggregation and sinking characteristics of four types of MP particles (low/high-density polyethylene [PE] spheres and small/large polypropylene [PP] fragments) induced by the harmful algal bloom (HAB)-forming *Heterosigma akashiwo*. Aggregates of MP and *H. akashiwo* began forming from day 3 due to the secretion of extracellular polymeric substances (EPS) rather than direct attachment to *H. akashiwo* cells. The sinking ratio of buoyant MP exponentially increased, with low-density PE particles saturating at 28% (half-saturation: 9 days). In contrast, the maximum sinking ratios of PP particles with a density of 0.91 g/cm³ were very low, with small (45-75 µm) PP particles reaching 2% (half-saturation: 24 days) and large (150-500 µm) PP particles being less than 0.1%. This indicates the limited sinking abilities of *H. akashiwo* based on the density and size of buoyant MPs. The sinking velocities of aggregates were significantly slower for low-density PE particles (0.63 mm/s) compared to high-density PE particles (0.81 mm/s) and small PP particles (0.74 mm/s) ($p < 0.05$). Additionally, the number of MPs in the settled aggregates remained constant even after 60 days under dark and cold water conditions (12°C), suggesting a low possibility of MPs re-suspension due to the decomposition of aggregates in the deep-sea environment. These findings represent the first experimental study reporting the influence of the harmful microalga *H. akashiwo* on the environmental behavior of various MPs, offering vital insights for modeling the distribution of MPs in real marine environments when integrated with field observations.

**(S09 18152 Poster)** S09-P6 (ECOP)

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

Zuhao **Zhu** [1,2,9*], Kazi Belayet Hossain [3,4,5,9], Huihua Wei [1,2], Jie Chen [2], Renming Jia [1,2], Xiaofeng Gao [7], Haiyan Jin [1,2,8] and Minggang Cai [1,2,3,4,5]

[1]Guangxi Key Laboratory of Beibu Gulf Marine Resources, Environment and Sustainable Development, Fourth Institute of Oceanography, Ministry of Natural Resources, Beihai 536000, PR China E-mail: zhuzuhao@4io.org.cn

[2]Key Laboratory of Tropical Marine Ecosystem and Bioresource, Fourth Institute of Oceanography, Ministry of Natural Resources, Beihai 536000, PR China

[3]State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, PR China

[4]College of Ocean and Earth Science, Xiamen University, Xiamen 361102, PR China

[5]Coastal and Ocean Management Institute, Xiamen University, Xiamen 361102, PR China

[6]College of Environment and Ecology, Xiamen University, Xiamen 361102, PR China

[7]Key Laboratory of the three Georges Reservoir Region's Eco-Environment, Ministry Education, PR China, College of Environment and Ecology, Chongqing University, Chongqing 400045, PR China

[8]Key Laboratory of Marine Ecosystem Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou 310000, PR China

[9]Fourth Institute of Oceanography, Beihai, China.

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/m3 and 0.29 ± 0.29 items/m3, respectively, while 74.99 ± 37.53 items/kg in surface sediment. Statistical analysis and the abundance of MP between surface water and sediment showed vise-versa phenomena. Both had similar features, in contrast, statistical analysis showed a negative relationship between these two. The mass balance of the box model showed that riverine discharge account for a substantial portion of MPs (42 %), whereas the South China Sea (SCS) receives 49 % of MPs discharged from Beibu Gulf. Just 1 % is deposited in sediment annually, which could explain the vise-versa phenomena between statistical analysis and the geographical distribution of microplastics. Nonetheless, it is revealed that human activities and coastal influence have more influence on microplastic abundance and distribution in the Beibu Gulf.

# S10: MEQ Topic Session

**East meets West and West meets East: Past, current and future implications of Non-Indigenous Species (NIS) in the North Pacific**

**Convenors:**
Thomas Therriault (Canada), *corresponding*
Joseph Krieger (USA)
Aibin Zhan (China)

**Invited Speakers:**
**Stanley Burgiel**
(National Invasive Species Council, USA)
**Brian Hauk**
(NOAA/NOS/ONMS/PMNM, USA)
**Christy Martin**
(University of Hawaii, USA)
**Nikolai Maximenko**
(University of Hawaii, USA)

PICES will provide leadership to the United Nations Decade of Ocean Science for Sustainable Development and its mission of developing "the science we need for the ocean we want" through its science programs. The current FUTURE scientific program promotes investigations of North Pacific ecosystems with an emphasis on the synergy of social, ecological, and environmental systems and processes. Within this framework, PICES is focused on developing a better understanding of the combined consequences of climate change and anthropogenic pressures on marine ecosystems and services, and their marine-dependent social systems. Globally, non-indigenous species (NIS) are recognized as major ecosystem stressors which can cause ecological and economic damage to 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 such as climate change. An increased awareness about the threats NIS pose has resulted in a recognition for better management and policy in order to achieve sustainability goals. From aquaculture imports to commercial shipping to the catastrophic consequences of the Great East Japan Tsunami, there are many examples of NIS movements between the eastern and western Pacific and between the Pacific and all world oceans. In order to mitigate the risks posed by NIS to achieve greater sustainability of North Pacific ecosystems we must first learn from the past and present in order to make informed decisions about the future. The goal of this session is to share experiences around understanding, forecasting, assessing, and mitigating NIS that will inform future priorities on NIS for PICES member countries.

**(S10 17761 Invited)**

**An overview of *Chondria tumulosa* in Papahānaumokuākea Marine National Monument and the development of preliminary biosecurity protocols**

Brian B. **Hauk**[1]; Heather L. Spalding[2]; Taylor M. Williams[3] and Randall K. Kosaki[1]

[1]NOAA, Papahānaumokuākea Marine National Monument, 1845 Wasp Blvd., Bldg. 176, Honolulu, HI 96818, U.S.A. Email: brian.hauk@noaa.gov

[2]Department of Biology, College of Charleston, 66 George St, Charleston, SC 29424, U.S.A.

[3]Department of Biology, University of Alabama at Birmingham, 1720 2nd Ave S, 35294, U.S.A

*Chondria tumulosa* was first observed and collected in 2016 after it was found in small patches overgrowing coral reefs around the northeastern backreefs of Manawai (Pearl & Hermes Reef) in the Papahānaumokuākea Marine National Monument (PMNM). It was not until a research expedition in 2019 that the seriousness and extent of *Chondria* reef overgrowth and spread came to light. At that time, preliminary lethality experiments were conducted to inform management of the biosecurity protocols required to mitigate the risk of inadvertently spreading this cryptogenic species elsewhere in the PMNM or inhabited Hawaiian Islands. Further trials were conducted in 2022 to better expand managers' biosecurity mitigation options after the alga was discovered at the adjacent atoll of Kuaihelani (Midway Atoll) in 2021. In 2023, the species was identified at Hōlanikū (Kure Atoll) growing cryptically and is now considered to be present at the last three atolls of the Hawaiian Archipelago. It is imperative that managers understand the options available to prevent further spread of this species through vectors associated with anthropogenic activities and natural occurrences.

**(S10 17855 Invited)**

**New connections across marine ecosystems facilitated by spread and accumulation of floating anthropogenic debris**

Nikolai A. **Maximenko**[1], Clara Benadon[2], James T. Carlton[3], Luca Centurioni[4], Fiona Chong[5,6], Mary Crowley[7], Jan Hafner[1], Linsey E. Haram[2], Rebecca R. Helm[8], Verena Hormann[4], Cathryn C. Murray[9], Andrey Shcherbina[10], Cynthia Wright[9], Gregory M. Ruiz[2], and Chela J. Zabin[2,11]

[1]International Pacific Research Center, School of Ocean and Earth Science and Technology, University of Hawaii, Honolulu, HI, USA. E-mail: maximenk@hawaii.edu

[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

[3]Williams College–Mystic Seaport Coastal and Ocean Studies Program, Mystic, CT, USA

[4]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, USA

[5]Energy and Environment Institute, University of Hull, Hull, UK

[6]School of Environmental Sciences, University of Hull, Hull, UK

[7]Ocean Voyages Institute, Sausalito, CA, USA

[8]The Earth Commons, Georgetown University, Washington, DC, USA

[9]Institute of Ocean Sciences, Fisheries & Oceans Canada, Sidney, BC, Canada

[10]Applied Physics Laboratory, University of Washington, Seattle, WA, USA

[11]San Francisco State University, Tiburon, CA, USA

Increasing production and discharge in the environment of persistent anthropogenic pollutants have diverse and often poorly understood impacts on marine ecosystems. Floating marine debris provides a substrate for many species which quickly form a mini-ecosystem. Recently, the abundance of plastic debris exceeded the amount of natural materials on the ocean surface and such debris can drift over longer distances without critical degradation compared to natural objects. This creates new connections across ocean basins and challenges the historical balances of local ecosystems. An unprecedented number of Asian coastal species arriving on North American shorelines was documented after the 2011 tsunami in Japan. Furthermore, our studies in the North Pacific “garbage patch” revealed a “neopelagic” ecosystem dominated by species native to coastal areas which were able to survive and reproduce due to high concentrations of plastic debris habitat. The change is not limited to fouling species but affects all levels of the ecosystem. Marine debris accumulating in the same areas as freely floating neuston changes the biochemical balance sustaining these species. Some species of western fish propagate to the eastern North Pacific. Unknown response of dispersing species to changes in environmental parameters along the trajectories of debris opens unique opportunities for multi-disciplinary research. The relative global and regional impacts of debris from disasters, accidents, and “normal” activities require further investigations. Results can help to understand the

vulnerabilities of marine ecosystems to ongoing climate change, which is expected to both modify the baseline and increase the frequency and amplitudes of extreme events.

**(S10 17910 Invited)**

**Coordination of invasive species at various scales: Experiences of the U.S. National Invasive Species Council**

Stanley W. **Burgiel**

National Invasive Species Council (US), Washington, D.C. USA. Email: stanley_burgiel@ios.doi.gov

The National Invasive Species Council (NISC) is an interagency body that helps coordinate work across the U.S. Federal Government. This presentation will provide an overview of NISC and its thematic activities on invasive species (e.g., climate change, early detection and rapid response, islands). Discussion will also focus on how these are addressed with other partners at various scales including regional, national, and international. The presentation will conclude with some considerations for addressing invasive species in the North Pacific.

**(S10 18135 Invited)**

**Marine invasive species in Hawai‘i: pathways, pests, and policies**

Christy **Martin**

Pacific Cooperative Studies Unit-University of Hawaii at Manoa-Coordinating Group on Alien Pest Species, Honolulu, HI, USA. E-mail: christym@hawaii.edu

Healthy marine ecosystems are important for biodiversity and the goods and services people rely on, and they are crucial for meeting climate resilience and adaptation goals. Now and into the foreseeable future, healthy coral reefs are the best and only protection that Hawai‘i and many other islands have against increased storm frequency and intensity. Yet the health of marine and coastal ecosystems and the myriad benefits and services they provide are at significant risk from marine invasive species. Once introduced and established, invasive species such as the pathogen that causes Stony Coral Tissue Loss Disease (SCTLD), soft corals like *Unomia stolonifera*, and seaweeds such as the cryptogenic *Chondria tumulosa* are true phase-shifters, diminishing biodiversity, goods, and services. These and similar species underscore the urgency and preeminence of addressing marine invasive species via a “pathway” approach where laws and programs focus on minimizing or mitigating pathway risk, high-risk areas such as harbors are monitored for incursions, and response and control programs are in place to prevent spread and greater losses. These and other species will be used to illustrate pathways and gaps in prevention and response systems, as well as possible solutions. These and other marine invasive species and their pathways must be addressed to meet Hawaii’s climate resilience and adaptation goals, food resilience targets, and maintain biocultural resources.

**(S10 17786 Oral)** (ECOP)

**Reef fish community changes along a gradient of invasive macroalgae cover in Papahānaumokuākea Marine National Monument**

Chelsie W. W. **Counsell**[1] and Heather Ylitalo-Ward[2]

[1]Cooperative Institute for Marine and Atmospheric Research, Honolulu, HI, USA. E-mail: chelsie.counsell@noaa.gov

[2]Division of Aquatic Resources, Lihuʻe, HI, USA

The balance between coral and macroalgae within reef ecosystems is of particular interest with phase shifts in the dominant benthic cover occurring on some reefs. Chondria tumulosa is a red macroalgae that can form mat-like structures covering other substrates including corals. Chondria tumulosa was not previously known; however, in the last eight years, it has been found to dominate some reefs within the northern region of Papahānaumokuākea. Using SCUBA based fish surveys paired with 3D models of the reef habitat (created from structure for motion benthic photos), we assessed changes in the reef fish community along a gradient of C. tumulosa cover around Manawai Atoll. In total, we surveyed reef fishes at 28 sites with depths ranging between 10 and 17 meters. All surveys were conducted by the same two divers over the course of five days in July 2023. On average, sites with higher C. tumulosa cover had a lower abundance and a lower diversity of reef fishes. We observed unique trends for different functional groups of reef fishes, and explored the relative importance of C. tumulosa cover in driving patterns in reef fishes compared to other habitat characteristics. Understanding the impacts of C. tumulosa on reef fishes is key to informing management on the broader impacts of this invasively-behaving macroalgae in Papahānaumokuākea.

**(S10 17833 Oral)** (ECOP)

**NOAA's response to novel and emerging marine invasive species threats**

Joseph R. **Krieger**

National Oceanic and Atmospheric Administration, MI, USA. E-mail: joseph.krieger@noaa.gov

Invasive species have been described as one of the most pervasive and ecologically significant threats to marine and coastal communities, second only to climate change. This has been well documented in a series of recently published white papers produced by the US Invasive Species Advisory Committee, which also highlight that invasive species can have disproportionate impacts on underserved and indigenous communities. Although there is substantial knowledge about the impacts of terrestrial invasive species, our understanding of marine invasive species remains comparatively limited. In the US, the National Oceanic and Atmospheric Administration (NOAA) is congressionally designated as a co-chair of the Aquatic Nuisance Species Task Force and is executively appointed a co-chair of the National Invasive Species Council. In these roles, NOAA plays a critical part in addressing the threats of marine invasive species within Federally-managed waters and in helping to prevent their spread to neighboring jurisdictions and communities. Recently, several marine invasive species have been identified in the Pacific and Caribbean that could impact mission critical operations for US military, federal and state agencies, and local communities. If these are not addressed and accounted for, there's a substantial risk that these species could be unintentionally spread to other US regions, potentially causing escalating and compounded economic and ecological damage. This presentation will provide some specific examples of marine invasive species around the Hawaiian Islands and in the Caribbean; highlighting NOAA's work in helping coordinate collaborative efforts to prevent the introduction and spread of marine invasive species in these regions

**(S10 17942 Oral)**

**Fine-scale larval dispersal dynamics in an expanding invasive crab population**

Carolyn **Tepolt**[1], Weifeng (Gordon) Zhang[1], Jiabi Du[1,2], Rayna Hamilton[1], Sara Shapiro[1], Yan Jia[1], Emily Grason[3] and P. Sean McDonald[3,4]

[1]Woods Hole Oceanographic Institution, Woods Hole, MA, USA. E-mail: ctepolt@whoi.edu

[2]Texas A&M University at Galveston, Galveston, TX, USA

[3]Washington Sea Grant, Seattle, WA, USA

[4]College of the Environment, University of Washington, Seattle, WA, USA

The European green crab (Carcinus maenas) is a high-profile invasive species, with populations spanning a broad range of temperate environments. It has been especially successful in the northeast Pacific, where it spread across >2,200 km of coastline since its initial detection in 1989, largely through larval dispersal. While overall population structure is minimal, a few sites have developed distinct genetic signatures due to high larval self-recruitment. One of these sites exports larvae, providing a distinctive genetic "tracer" for directly measuring dispersal. Using targeted population genomics and oceanographic modeling, we examine differences in dispersal over time and space with a focus on expansion in Washington, USA and British Columbia, Canada. We find that the species' recent expansion into the Salish Sea is complex, with multiple larval sources and subsequent interbreeding in its first few years. We also find evidence that individual larvae may be dispersing at least 400 km south along the coast, and explore differences in dispersal distance and magnitude from year to year. This system offers a powerful window into fine-scale larval dispersal dynamics in a highly-dispersive invasive species, and illustrates the potential utility of a coupling modeling and genomics for understanding gene flow and spread in the sea.

**(S10 18139 Oral)**

## Monitoring and seasonal succession of invasive ascidians and predicting their distribution shifts under climate change scenarios in South Korean waters

Seongjun Bae[1] and Keun-Hyung **Choi**[2]

[1]Department of Ecology and Conservation, National Marine Biodiversity Institute of Korea, Seocheon 33662, Republic of Korea

[2]Department of Ocean Environmental Sciences, College of Natural Science, Chungnam National University, Daejeon 34134, Republic of Korea email: keunhchoi@cnu.ac.kr

Invasive marine species present a significant threat to global biodiversity, necessitating effective management strategies such as early detection and quantitative estimation of their environmental impact. This study evaluates the efficacy of environmental DNA (eDNA) analysis via quantitative PCR (qPCR) as a potential substitute for traditional visual surveys in monitoring two prominent invasive ascidians, *Ciona robusta* and *Didemnum vexillum*, in South Korean waters. Over a 16-month period at sites in Gunsan and Yeosu, visual surveys and eDNA collection were conducted concurrently. Specific eDNA markers were validated to ensure reliable detection limits and minimize false positives. Results indicated a positive correlation between species coverage and eDNA copy numbers for C. robusta, suggesting that eDNA-based methods could complement or replace morphological surveys. Additionally, succession patterns of fouling communities on artificial substrates were studied to understand the temporal dynamics influencing species dominance. While initiation timing minimally impacted succession in Gunsan, it significantly influenced community structure in Yeosu, highlighting the variable response of fouling organisms to temporal factors. Furthermore, habitat suitability models using MaxEnt predicted current and future distributions of *C. robusta* and *D. vexillum* under climate change scenarios. Chlorophyll-a emerged as a critical factor influencing species presence, with *D. vexillum* exhibiting broader suitability ranges than *C. robusta*. Future projections indicated potential shifts in distribution patterns due to increasing temperatures, emphasizing the dynamic impacts of climate change on invasive ascidians. This comprehensive assessment underscores the importance of integrating species-specific ecological data for accurate predictive modeling and effective management of invasive marine species in a changing environment.

**(S10 18030 Poster)** S10-P1

**Development of Biological Risk Assessment Protocols for Evaluating the Risks of In-Water Cleaning of Hull-Fouling Organisms**

Bonggil Hyun, Pung-Guk Jang, Min-Chul Jang, Jin-Young Seo, Woo-Jin Lee and Kyoungsoon **Shin**

Ballast Water Research Center, Korea Institute of Ocean Science & Technology, Geoje 53201, Republic of Korea email: ksshin@kiost.ac.kr

We evaluate the scientific basis for managing hull fouling of ships entering Korean ports, diagnose biological risks that may occur when in-water cleaning (IWC) systems remove hull fouling, and present a protocol for evaluating these risks (the Korean Infection Modes and Effects Analysis; K-IMEA). Protocol development included the selection of core elements and scenario design for IWC and the evaluation of regrowth experiments. The K-IMEA index was designed by considering the inoculation pathway of attaching organisms in all processes to ships that enter a port for in-water cleaning. A number of risk indices were defined: 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; and R4—Establishment of alien species in effluent water. K-IMEA regrowth experiments (R2 and R4) using the in-water cleaning effluent showed that the attachment and regrowth of prokaryotes, microalgae, and macroalgae were successfully detected. In particular, prokaryotes were observed in samples filtered through a 5 µm mesh of the in-water cleaning effluent, even at a low fouling rating (Levels 1–2). These experiments suggest a necessity to consider a secondary treatment method in addition to the primary filtration method for the treatment of in-water cleaning effluents.

# S11: FIS Topic Session

**Impacts of warming-induced changes in body sizes on marine fish ecology and their consequences for ecosystems and associated fisheries**

**Convenors:**
Shinichi Ito (Japan), *corresponding*
Chenying Guo (China, ECOP)
Christine C. Stawitz (USA)
Paul Spencer (USA)

**Invited Speaker:**
**Julia Indivero** (University of Washington, USA)

As sea temperatures keep rising, warming impacts on marine fisheries have become increasingly prevalent. For example, temperature-induced changes in fish distribution and movement across management boundaries impact management of multi-jurisdictional fisheries. Additionally,, changes in phenology can lead to mismatch between larva abundances and plankton blooms, thereby affecting recruitment and fish stocks productivity. In contrast, warming-induced changes in fish body sizes have been increasingly documented but their potential impacts have received comparatively less attention.

Changes in body size can impact other life history traits such as maturity, fecundity, diet, habitat preferences, and predator-prey interactions; all of which can alter the functioning of size-structured ecosystems and commercial fisheries. While research has thus far mainly focused on understanding how warming seas affect fish growth, the magnitude of the consequences of changes in body size and what it could mean for ecology, fisheries and ecosystems is yet to be explored.

As global warming is likely to lead to further changes in fish body sizes there is a need to assess the possible consequences facing marine ecosystems and fisheries in order to understand the challenges that lie ahead. This session aims at assessing the future consequences of changing fish body sizes occurring in warming seas. We are seeking contributions on (but not limited to) the following topics:

1. Interrelations between fish growth and other life history traits
2. Impacts of fish body sizes on species mobility, use of habitat, and migrations/distributions
3. Evidence of changes in fish body sizes affecting predator-prey interactions and their consequences on size-structured food webs.
4. Impacts on commercial fisheries, including changes in yield, fishery practices, and management measures

5. Examples accounting for changes in fish body sizes in fish stocks assessment and management
6. Impacts on markets and fish sales, changes in nutritional value, and implications for food security

**(S11 17739 Invited)** (ECOP)

**Incorporating distribution shifts and spatio-temporal variation when estimating weight-at-age for stock assessments: A case study involving the Bering Sea pollock (Gadus chalcogrammus)**

Julia **Indivero**, Timothy E Essington, James N Ianelli and James T Thorson

University of Washington, Aquatic and Fishery Sciences, USA email: jindiv@uw.edu

Environmental conditions can create spatial and temporal variability in growth and distribution processes, yet contemporary stock assessment methods often do not explicitly address the consequences of these patterns. For example, stock assessments often assume that body weight-at-age (i.e. size) is constant across the stocks' range, and may thereby miss important spatio-temporal patterns. This is becoming increasingly relevant given climate-driven distributional shifts, because samples for estimating size-at-age can be spatially unbalanced and lead to biases when extrapolating into unsampled areas. Here, we jointly analysed data on the local abundance and size of walleye pollock (*Gadus chalcogrammus*) in the Bering Sea, to demonstrate a tractable first step in expanding spatially unbalanced size-at-age samples, while incorporating fine-scale spatial and temporal variation for inclusion in stock assessments. The data come from NOAA's bottom trawl survey data and were evaluated using a multivariate spatio-temporal statistical model. We found extensive variation in size-at-age at fine spatial scales, though specific patterns differed between age classes. In addition to persistent spatial patterns, we also documented year-to-year differences in the spatial patterning of size-at-age. Intra-annual variation in the population-level size-at-age (used to generate the size-at-age matrix in the stock assessment) was largely driven by localized changes in fish size, while shifts in species distribution had a smaller effect. The spatio-temporal size-at-age matrix led to marginal improvement in the stock assessment fit to the survey biomass index. Results from our case study suggest that accounting for spatially unbalanced sampling improved stock assessment consistency. Additionally, it improved our understanding on the dynamics of how local and population-level demographic processes interact. As climate change affects fish distribution and growth, integrating spatiotemporally explicit size-at-age processes with anticipated environmental conditions may improve stock-assessment forecasts used to set annual harvest limits.

**(S11 17768 Oral)** (ECOP)

## Impacts of Hypoxia and Warming on Petrale Sole (*Eopsetta jordani*) Growth: Introspection of a 24-Year Time Series

Savannah **Clax**[1], Jessica A. Miller[1], Jenny Waddell[2]

[1]Oregon State University, Coastal Oregon Marine Experiment Station, Department of Fisheries, Wildlife, and Conservation Sciences, 2030 SE Marine Science Drive, Newport, Oregon 97365, USA email: claxs@oregonstate.edu

[2]Olympic Coast National Marine Sanctuary Headquarters, 115 E Railroad Ave, Ste 301Port Angeles, WA 98362, USA

The interactions among multiple stressors such as warmer temperatures and lower dissolved oxygen and their potential synergistic or antagonistic effects present significant challenges for effective fisheries management strategies. Flatfish, such as the Petrale Sole, are particularly vulnerable to increasing hypoxia and temperature stress. Understanding the impact of the changing environment on fish growth, recruitment, and maturity is essential for accurate stock assessments and sustainable fisheries management. Otolith analysis offers insights into growth rates and possible effects the environment may have on growth. Furthermore, otolith manganese to calcium (Mn:Ca) can serve as a proxy for hypoxia exposure over a fish's lifetime. Over 200 archived otoliths that were aged, sexed, and measured by the Washington Department of Fish and Wildlife spanning from 1998 to 2022 were used to analyze Mn:Ca ratios alongside growth. As age and length data are available, hypoxia trends can be established with the physiological changes to fill in gaps that otolith data may not provide. To complement this 24-year time series, data on temperature and dissolved oxygen from the Olympic Coast National Marine Sanctuary and the Northwest Association of Networked Ocean Observing Systems will be used to compare with Mn:Ca values and growth estimates. This will be done to ground the growth findings with what's being seen in the water column. The integration of these data sources will enable a comprehensive examination of hypoxia and warming on Petrale Sole growth responses, allowing for this oceanographic data to be connected to higher trophic levels for the first time.

**(S11 17774 Oral)** (ECOP)

## Climate, fishing, and size structure in an ever-changing marine food web

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

[1]Coastal Oregon Marine Experiment Station, Oregon State University, Newport, OR, USA

email: cheryl.barnes@oregonstate.edu

[2]Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, WA, USA

[3]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, USA

With surmounting evidence of climate-driven shifts in community composition, there is a pressing need to consider ecological contexts for fisheries management. It is difficult, however, to quantify the mechanistic underpinnings of ecosystem structure and function, especially in the marine realm. Multispecies size spectrum models (MSSMs) integrate ecological theory and a broad range of data (e.g., biomass estimates, life history parameters, fishery selectivity) to explore controls on marine food webs. Specifically, MSSMs relate individual body mass to population- and community-level processes to approximate ecosystem steady states and simulate changes through time. We constructed a MSSM for the Gulf of Alaska, a highly productive ecosystem that has undergone multiple instances of community reorganization. We focused this work on the demersal fish assemblage, which includes economically and ecologically important species such as arrowtooth flounder (Atheresthes stomias), Pacific cod (Gadus macrocephalus), Pacific halibut (Hippoglossus stenolepis), Pacific Ocean perch (Sebastes alutus), sablefish (Anoplopoma fimbria), and walleye pollock (Gadus chalcogrammus). The MSSM was calibrated using information from stock assessments, standardized surveys, and the available scientific literature to quantify nonlinear and nonlocal effects on size-based metrics such as biomass density, trophic level, and predation mortality. We then simulated these metrics under future climate and fishing scenarios. Here, we highlight how MSSMs can be used to understand population- and community-level responses to perturbation in high latitude systems. This project is part of NOAA's Gulf of Alaska Climate Integrated Modeling (GOACLIM) project – a transdisciplinary working group tasked with identifying factors that may impact ecosystem productivity under future climate change.

**(S11 17841Oral)**

**Environmental impact on growth in Barents Sea capelin, cod and haddock**

Edda **Johannesen**, Johanna Fall and Georg Skaret

Institute of Marine Research, Bergen, Norway. E-mail: eddaj@hi.no

The Arctic is warming three times as fast as the global average. Barents Sea is one of the shelf seas bordering the Central Arctic Ocean, here the ocean temperature has increased since the 1990's, with reduced ice cover and record high temperatures, peaking in 2016. The Barents Sea is also an important area for commercial fishing, with capelin (*Mallotus villosus*), cod (*Gadus morhu*a) and haddock (*Melanogrammus aeglefinus*) being the most important commercial stocks. These stocks interact but differ in life-history and diet: cod and haddock are iteroparous, whereas capelin is semelparous, cod is primarily piscivorous, capelin planktivorous, and haddock benthivorous. Several studies evaluating the impact of warming on these stocks, state that cod and haddock (boreal species) will do well under warming, whereas the impact on capelin (arcto-boreal species) is more uncertain or negative. The studies have been primary focused on optimal temperatures for growth and reproduction. However, density dependent growth is prevalent for all three species, with typically slower growth of stronger cohorts. Furthermore, warming is affecting reproduction which in turn impacts population density. Here we analyze the relative impact of temperature and density on growth on spatially resolved survey data. We investigate at which life stage the growth trajectory of a cohort is determined and which factors limit or enhance growth and maturation to assess the consequences of continued warming of the Barent Sea ecosystem.

**(S11 17843 Oral)**

**Temperature-dependence assumptions regarding fish growth drive projected responses of diverse size-based food webs to warming**

Jonathan. C. P. **Reum**[1], Phoebe Woodworth-Jefcoats[2], Camilia. Novaglio[3,4], R. Forestier[3], Asta Audzijonyte[3,4], Anna Gårdmark[5], Max Lindmark[5] and Julia. L. Blanchard[3,4]

[1]NOAA Alaska Fisheries Science Center, Seattle, WA, USA. E-mail: jonathan.reum@noaa.gov

[2]NOAA Pacific Island Fisheries Science Center, Honolulu, HI, USA

[3]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS, Australia

[4]Centre for Marine Socioecology, University of Tasmania, Hobart, TAS, Australia

[5]Department of Aquatic Resources, Swedish University of Agricultural Sciences, Uppsala, Sweden

Marine food webs are strongly size structured and therefore sensitive to biological processes that govern individual body growth dynamics. However, the temperature dependence of biological processes are uncertain and may have implications for uncertainty in climate-forced projections of fish communities. We systematically evaluated a range of different assumptions about temperature-dependence on rates, including size-dependent effects, that control body growth (food intake, metabolism) and non-predation mortality in fishes using species-resolved size spectrum food web models that link individual-level physiological processes to population and community dynamics. We simulated the physiological effect of warming in a range of size-structured food web models calibrated to different marine ecosystems and in simplified trait-based models. Higher food intake in warmed conditions increased total fish biomass, catches, and mean body weight, but these effects were offset by the negative effects of warming on metabolism and mortality, which combined resulted in lower total biomasses and catches for most food webs. These effects were enhanced when warming increased metabolic rates more than food intake, and the outcomes were also sensitive to size dependency of temperature responses. Importantly, these general patterns were not uniform across all food webs—individual functional groups and fish species within food webs responded to warming in different ways depending on their position in the food web and its structure. Hence, caution is warranted when generalizing food web or species outcomes to warming because they are mediated by community interactions. Uncertainty related to temperature dependence and ecological interactions will impact food web projections and should be represented in climate change projections.

**(S011 17884 Oral)** (ECOP)

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

Jennifer **Bigman[1]**, Lewis Barnett[2], Kelly Kearney[2], Darren Pilcher[3,4], Wei Cheng[4], Al Hermann[3,4], Krista Oke[5,6], and Lauren Rogers[2]

[1]NOAA Office of Science and Technology, Seattle, WA, USA.E-mail: jennifer.bigman@noaa.gov

[2]NOAA Alaska Fisheries Science Center, Seattle, WA, USA

[3]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA

[4]NOAA Pacific Marine Environmental Laboratory, Seattle, WA

[5]NOAA Pacific Marine Environmental Laboratory, Juneau, AK

[6]Fisheries, Aquatic Science, and Technology Laboratory, Alaska Pacific University, Anchorage, AK

The temperature size rule, or the inverse relationship between temperature and ectothermic body size, is reflected across scales from laboratory treatments where individuals reared in warmer waters grow faster to a smaller maximum size, and the macroecological pattern of smaller, faster-growing individuals (and species) in warmer waters. Despite being widespread, the interplay among size, growth, and temperature that gives rise to such patterns is not well understood. In particular, the effects of temperature on size and growth are likely 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. Here, we bridge macroecological theory with fisheries science to understand the interaction of size and growth with temperature and whether this relationship can predict fisheries productivity in a changing climate. We also examine whether oxygen - a proposed mechanism behind the temperature-size rule, better explains patterns of weight-at-age across species. First, we ask whether the weight-at-age of four Alaskan groundfish species in the eastern Bering Sea has changed over the last few decades and, second, whether these changes can be explained by temperature or oxygen. Third, we assess the forecast skill of relationships between weight-at-age and temperature or oxygen to understand the utility of using simple population-climate relationships for predicting future change. We find that weight-at-age of all four species was highly variable in the past and has changed over time. For most age classes, weight for Pacific cod, Yellowfin sole, and Arrowtooth flounder has increased since the early 2000s (mid 2010s for Yellowfin sole). Weight for Walleye pollock for most ages has been relatively stable over time, with some short-term variation. Temperature was more important in explaining patterns of weight-at-age for Pacific cod, Walleye pollock, and Yellowfin sole, but oxygen had more support for Arrowtooth flounder. The direction of these relationships varied by age class - younger ages had mostly positive relationships with temperature (oxygen for Arrowtooth flounder), and older ages generally had negative relationships, with the directional switch occurring around the age-at-maturity. These findings provide support for the

temperature- size rule in natural populations and highlight that changes in size and growth with temperature and oxygen do vary across ontogeny. We also present whether these simple climate-population relationships can reliably forecast size-at-age over time.

**(S11 17917 Oral)**

**A new approach to integrate multiple environmental covariates into state-space stock assessments.**

Juliette **Champagnat**[1], James Thorson[2], Cole Monnahan[2], Kalei Shotwell[3], Jane Sullivan[3] and Andre Punt[1]

[1]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, USA. Email: jchampag@uw.edu

[2]Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA 98115, USA

[3]Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Juneau, AK 99801, USA

Rapid changes in many marine ecosystems highlight the importance of integrating environmental drivers in stock assessment models which support management decisions. One common approach has been to link environmental covariates explicitly to population processes such as recruitment, natural mortality or growth. However, this approach fails to consider the multiple interactions among covariates driving population processes. Here we present dynamic structural equation models (DSEM) as a new integrated framework to estimate simultaneous and lagged interactions among covariates and population processes (hereafter called causal maps) within a state-space age-structured assessment model. Causal maps specify causal relationships based on process research and expert knowledge, thus in turn integrating much more information than a simple covariate time series. They can handle missing observations, be projected using statistical time-series models, and revert to qualitative network models when data are absent. This novel application of DSEM integrated within the population models provides a straightforward and standardized way to build and compare models of increasing complexity, from simple non-stationary processes to multiple interacting environmental covariates affecting various population processes. The estimated relationships with environmental variables are accounted for when projecting into the future, thus enabling climate-linked management advice. We applied this framework to Alaskan groundfish stocks and identified significant environmental drivers of recruitment and growth of groundfish stocks, giving important insight into the productivity of the stocks.

**(S11 17918 Oral)** (ECOP)

**Dynamics of growth autocorrelation in Japanese anchovy larvae: Influence of sea temperature and feeding conditions**

Shota **Tanaka**[1], Shizuna Togoshi[1], Naotaka Yasue[2], Masahiro Nakamura[3], Corinne M. Burns[4], Dominique Robert[4] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: shotana0326@gmail.com

[2]Wakayama Prefectural Fisheries Experimental Station, Wakayama, Japan.

[3]Fisheries Technology Institute, Miyazu Field Station, Japan Fisheries Research and Education Agency, Miyazu, Japan.

[4]Institut des Sciences de la Mer, Université du Québec à Rimouski, Rimouski, QC, Canada.

To understand the effects of increasing temperature on fish body size, it is important to elucidate the relationship linking growth to temperature. Our recent study showed that growth autocorrelation during the larval stage of three clupeoid species, Japanese anchovy *Engraulis japonicus*, Japanese sardine *Sardinops melanostictus*, and Pacific round herring *Etrumeus micropus* was relatively high compared to other species studied to date. This indicated that early growth rates determined later growth rates for these clupeoid species. However, the level of growth autocorrelation is known to vary spatially (among ecosystems) and temporally (among cohorts) for some species. Here, we examined the dynamics of growth autocorrelation in Japanese anchovy larvae in relations to sea temperature and feeding conditions. The larvae were collected by a commercial trawl in the Kii Channel, Japan, from April 2021 to April 2022. Growth autocorrelation was represented as the correlation coefficient between widths of the otolith daily increments formed directly before capture and 5 days before capture, for larvae 30–40 days old (11 samples and 1,833 individuals). The autocorrelation values were positively related to sea temperature and the proportion of feeding individuals at the sample level. A possible mechanism behind growth autocorrelation is a retroactive loop between growth performance and feeding success. Hence, variability in temperature and feeding conditions would influence the growth–feeding relationship, causing variation of growth autocorrelation values. We also present preliminary results of the growth–feeding relationship in anchovy larvae, based on larval gut content analysis.

**(S11 17927 Oral)**

**Analysis of California Current groundfish growth using a state-space autoregressive length-at-age (sarla) model.**

Christine C. **Stawitz**, Sean Anderson, Melissa A. Haltuch, Paul D. Spencer, Timothy J. Miller, Timothy E. Essington and Alan Baudron

National Marine Fisheries Service, Office of Science and Technology, Seattle, WA 98115, USA email: christine.stawitz@noaa.gov

Many factors cause fish growth to vary over time, with factors affecting different segments of the population. For example, genetic factors affect the growth of individuals and close kin, the history of environment and food availability can affect growth in individuals and cohort groups, and environmental changes, such as changing temperature or salinity, can affect entire populations at a given time interval. Ideally we could track the changes in growth rates by repeated measurements of a single fish, but the most commonly available data are from fish caught in subsequent years in fishery-independent and -dependent samples. To quantify the effects of changes in the environment on growth, we need a method that can estimate environmentally-induced growth change across fish temporally while accounting for the effects of individual and sampling variability. We first introduced a state-space model to estimate annual, initial size, and cohort variability in mean length-at-age data in Stawitz et al. (2015). This state-space model for fish length-at-age was modified to improve sampling performance and allow simultaneous estimation of different types of variation in the Stan language and packaged in the R package sarla to allow for wider use. We also compared the model performance against alternative methods developed in Miller et al (2018) and Baudron et al (2014) on a dataset of California Current groundfish growth to explore the relative ability of these three models to detect growth change. Furthermore, fitting these alternative models to the same dataset allows us to determine if the modeling approach used influences the conclusion of whether or not environmental conditions affect fish growth.

**(S11 17928 Oral)**
(ECOP)

**Spatial distribution of Pacific Cod in the Gulf of Alaska across life history stages to identify stock structure**

Claire **Rosemond**[1], Lorenzo Ciannelli[1], Lauren Rogers[2], Pete Hulson[2], Kally Spalinger[3], Albert Hermann[4], and Ingrid Spies[2]

[1]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA. E-mail: claire.rosemond@oregonstate.edu

[2]National Oceanic and Atmospheric Administration, Alaska Fisheries Science Center, Seattle, WA, USA

[3]Alaska Department of Fish and Game, Commercial Fisheries, Westward Region, Kodiak, AK, USA

[4]National Oceanic and Atmospheric Administration, Pacific Marine Environmental Lab, Seattle, WA, USA

The spatial structure of populations influences the way they are surveyed, assessed, and managed. Currently, Pacific Cod in the Gulf of Alaska (GOA) is assessed as a single stock, but recent genetic, tagging, and oceanographic studies challenge this assumption. Our study focuses on size-specific spatial distribution of Pacific Cod in the GOA to understand habitat use and population structure to inform possible multi-stock configurations for assessment and management. Pacific Cod shift habitats throughout their ontogeny and there may be separate populations that express differential habitat preferences at each life history stage. We created a dataset combined of four existing long-term survey datasets including catch and length data spanning the last 35 years and paired these data with georeferenced environmental data. Using generalized additive models, we explored the influence of habitat characteristics and oceanographic conditions on the spatio-temporal distribution of multiple size classes of Pacific Cod, including juveniles and adults. We found that the abundance and spatial distribution of each size class varied over time and was influenced by oceanographic conditions. In addition, abundance of each size class was influenced by habitat characteristics, such as depth. The results of this study will help identify potential population boundaries and which populations are more subject to fluctuations based on changes in habitat characteristics or environmental conditions.

**(S11 17930 Oral)**
(ECOP)

**Ecological and ontogenetic responses of groundfish species to climate-induced changes in the Northern California Current Ecosystem**

Sajna **Hussain**[1], Lorenzo Ciannelli[2], Mary Hunsicker[3], Owen Liu[4], Jameal Samhouri[4] and Eric Ward[4]

[1]Oregon State University, Corvallis, OR, USA. E-mail- sajna.hussain@oregonstate.edu

[2]Oregon State University, Corvallis, OR, USA

[3]NOAA Fisheries, Northwest Fisheries Science Center, Newport, OR, USA

[4]NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA, USA

Climate change has unprecedented effects on the marine ecosystem through changes in water temperature, oxygen, salinity, pH and other biogeochemical properties of the ocean. Fish species respond to these changes through physiological and distributional shifts across life stages, exhibiting spatial connectivity in diverse marine habitats. Our research explores the effects of climate-induced habitat changes on the distribution and spatial overlap of different life history stages of selected groundfish species in the Northern California Current (NCC) from an ontogenetic and ecological perspective. Representative species include dover sole (*Solea solea*), sablefish (*Anoplopoma fimbria*), petrale sole (*Eopsetta jordani*), long spine thorny head (*Sebastolobus altivelis)* and short spine thorny head (*Sebastolobus alascanus*). Using groundfish survey data (2000-2022), size/stage-specific species distribution models were developed with Boosted Regression Tree and sdmTMB. Models used local abundance at size/stage as response variables and geographic (latitude, longitude, depth) and environmental (temperature) data as predictors. Results indicate specific distributional patterns for life history stages varying with depth and temperature. Historical analysis of ecological indices reveals significant shifts in the area and biomass overlap in response to varying temperatures in the region. This research enhances understanding of climate change impacts on groundfish populations, specifically ontogenetic connectivity across life stages, potentially informing ecosystem-based fisheries management in the context of ongoing changes in the NCC Ecosystem region.

**(S11 17966 Oral)**
(ECOP)

**Incorporation of the effect of climate change into management strategy evaluation: illustration with chub mackerel (*Scomber japonicus*) in Korean waters**

Soyeon **Nam**[1], Jinwoo Gim[2], Sukyung Kang[2] and Saang-Yoon Hyun[1]

[1]Department of Marine Biology, Pukyong National University, Busan 48516, Republic of Korea. E-mail: shyunuw@gmail.com

[2]Fisheries Resources Management Division, National Institute of Fisheries Science, Busan 46083, Republic of Korea

Global warming is known to have many physiological and ecological effects on marine organisms. Among the effects of global warming, the Temperature Size Rule (TSR), which represents the effect of rising water temperatures on organisms, is a phenomenon that changes the growth and development rates and decreases in size at maturity. It will affect fisheries management such as the natural mortality, the number of recruits, spawners and eggs, resilience, yield per recruit (YPR) and the maximum sustainable yield (MSY). Baudron et al. (2014) has shown that increasing water temperatures lead to a decrease in both maximum length ($L\infty L\infty$) and YPR in several fish species. If a species affected by TSR is the target of a stock assessment, a new model needs to be developed to reflect climate change. We have developed a length-based model that incorporates the effect of the TSR. We want to use the new model for a framework of management strategy evaluation (MSE) whose purpose is to adjust fishery management decisions in response to the effect of climate change. We will illustrate our model and MSE frame, using data on chub mackerel (*Scomber japonicus*) in Korean waters.

**(S11 17998 Oral)** (ECOP)

**Body condition as a shared response to environmental conditions in a demersal fish assemblage**

Philina A. **English**, Sean C. Anderson, and Robyn E. Forrest

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

Available energy reserves are known to affect both survival and reproductive potential of organisms. Measures of weight-at-length are considered reliable indicators of the energy reserves or 'condition' for fish, which in turn are related to fecundity through timing, quality, and quantity of gamete production. We investigated how environmental changes in Canadian Pacific waters are influencing body condition for 27 fish species captured on bottom trawl surveys. Because condition of mature males, mature females, and immatures have different implications for population dynamics, measurement issues, and ecological drivers, we separated individual fish and overall catches into these components. We estimated spatiotemporal biomass distributions, calculated relative body condition deviations, modelled spatiotemporal change in these deviations, and generated a density-weighted annual index of condition for each component of the population. We then applied Bayesian Dynamic Factor Analysis to identify common trends across species and tested for correlations between these trends and environmental conditions. The Pacific Decadal Oscillation was related to common trends for all sex and maturity categories, but whether this relationship was negative or positive differed between species. Primary production was related to body condition in mature males and immatures, whereas temperature appeared most influential for mature females. Our approach propagates uncertainty between levels of analysis and provides an ecosystem perspective, or shared responses across an assemblage of species, while also providing species-specific inference. Robust estimates of relationships between condition, and hence energy reserves, and environmental variables can inform an ecosystem approach to fisheries management including through short-term forecasts of weight-at-age or recruitment.

**(S11 18052 Oral)**

## Fish weight reduction in response to intra- and interspecies competition under climate change

Zhen Lin[1,2] and Shin-ichi **Ito**[1]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan. E-mail: goito@aori.u-tokyo.ac.jp

[2]Graduate School of Agriculture and Life Sciences, University of Tokyo, Tokyo, Japan

As described by the temperature–size rule paradigm, fish living in warmer temperatures grow faster but have a smaller mature body size. However, the changes in the body size of fish communities in the western North Pacific, which is one of the most active fishing grounds, remain unclear. This study aimed to investigate body weight changes of fish assemblages in the western North Pacific and whether fish sizes were potentially driven by the temperature–size rule, bottom-up effects and intra- and interspecies competition at a community scale. We evaluated the fish weight data of 6 stocks of 4 species from 1978 to 2018 and 17 stocks of 13 species from 1995/1997 to 2018. Weight reduction in the fish assemblage was observed in the 1980s and was associated with the biomass peak of the Japanese sardine, indicating the effect of intra- and interspecies competition. Another weight reduction was observed in the 2010s, which was associated with a moderate increase in the biomass of the Japanese sardine and chub mackerel. Our analyses indicate that stronger stratifications in the surface layers during the 2010s potentially reduced the nutrient supply from the subsurface to the surface layers. This limitation in food availability forced intra- and interspecies competition under a moderate increase in fish biomass. Our findings underscore the critical significance of integrating the impacts of species competition and climate change on fish sizes to improve fishery management at a community level. This research was published in Fish and Fisheries (https://doi.org/10.1111/faf.12818).

**(S11 18060 Oral)** (ECOP)

**Strong density-dependent decline of condition factor of Japanese sardine (Sardinops melanostictus) linked to enhanced top-down effect on Neocalanus plumchrus under summer warming conditions off eastern Hokkaido, Japan**

Daichi **Arima**[1], Hiroshi Shimada[2], Hiroki Ubukata[2], and Hiroshi Yamaguchi[1]

[1]Hokkaido Research Organization, Central Fisheries Research Institute, Yoichi, Japan. E-mail: arima-daichi@hro.or.jp

[2]Hokkaido Research Organization, Kushiro Fisheries Research Institute, Kushiro, Japan

Inter-annual variations in the mesozooplankton biomass, large grazing copepods and condition factor of Japanese sardine (Sardinops melanostictus) were investigated off eastern Hokkaido, Japan. The mesozooplankton biomass in August was lower in the 2010s than the early 2000s. On the other hand, the abundance and biomass of large grazing copepods, especially Neocalanus plumchrus, showed significant declines after 2015 in August and after 2018 in June. The condition factor of large sardines (≥ 19 cm) declined from 2017 to 2019, indicating a stronger density-dependent effect than in the 1980s. These findings suggest that the condition factor of large sardines was more likely limited by the June population levels of N. plumchrus than the mesozooplankton biomass. Considering the ecological characteristics of N. plumchrus and large sardines, the simultaneous decrease in the population of N. plumchrus and the condition factor of large sardines suggested that a top-down effect on N. plumchrus by predation of the sardine became stronger after 2018. The top-down effect and the strong density-dependent condition factor decrease, despite the lower sardine stock than the population size in the 1980s, could be attributed to a mismatch between the earlier expansion of migration of large sardines driven by higher temperatures and the growth pattern of N. plumchrus, leading to consumption of less nutrition. These results indicate that temperature increases related to oceanographic change during spring to summer both shorten the duration of the period of high phytoplankton productivity, and also enhance the top-down effect through the earlier expansion of migration of large sardines.

**(S11 18069 Oral)** (ECOP)

**Deep learning techniques for evaluating the ecological impacts on the spatio-temporal varitions of tuna in the eastern Pacific Ocean**

Peng **Lian**[1,2] and Le Gao[3,4]

[1]Chinese Academy of Fishery Sciences, Beijing, China. E-mail: lianpeng@cafs.cn

[2]Experimental Station for Remote Sensing Scientific Observation of Fisheries, Ministry of Agriculture and Rural Affairs, Beijing, China

[3]Key Laboratory of Ocean Observation and Forecasting, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China.

[4]Key Laboratory of Ocean Circulation and Waves, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China.

Tuna is an important migratory species that forages deeply, and El Niño events highly influence its distribution in the eastern Pacific Ocean. While sea surface temperature is widely recognized as the main factor affecting bigeye tuna (BET) and yellowfin tuna (YFT) distribution during El Niño events, the roles of different types of El Niño and subsurface oceanic signals, such as ocean heat content and mixed layer depth, remain unclear. We conducted A spatial-temporal analysis to investigate the relationship among BET and YFT distribution, El Niño events, and the underlying oceanic signals to address this knowledge gap. We used monthly purse seine fisheries data of BET in the eastern Tropical Pacific Ocean (ETPO) from 1994 to 2020 and extracted the Central-Pacific El Niño (CPEN) indices based on Niño 3 and Niño 4 indexes. Furthermore, we employed Explainable Artificial Intelligence (XAI) models to identify the main patterns and feature importance of the six environmental variables and used information flow analysis to determine the causality between the selected factors and BET and YFT distribution. Finally, we analyzed Argo datasets to calculate the vertical, horizontal, and zonal mean temperature differences during CPEN and normal years to clarify the oceanic thermodynamic structure differences between the two types of years. Our findings reveal that tuna distribution during the CPEN years is mainly driven by advection feedback of subsurface warmer thermal signals and vertically warmer habitats in the CPEN domain area, especially in high-yield fishing areas. The high frequency of CPEN events will likely lead to the westward shift of fisheries centers.

**(S11 17815 Poster)** S11-P1

**Rapid melting of ice leads to the surge of primary productivity and its impact on the redistribution of fishery resources in the Arctic and surrounding areas**

Changan **Xu** and Zongyong Gao

Third Institute of Oceanography, Ministry of Natural Resources, P.R. China.E-mail: xuchangan@tio.org.cn

The rise in greenhouse gas concentrations is driving widespread and rapid changes in the highly sensitive Arctic climate, environment, and ecosystem. Among them, the continuous melting of Arctic sea ice has led to an increase in primary productivity there, while the latter has led to the migration of low latitude fish outside the polar region to higher latitudes, changes in the distribution of fishery resources, and the emergence of new fishing grounds. This study is based on the investigation results of multiple voyages on the primary productivity of the Arctic, examining the impact of Arctic ice melting on the plankton community and the marine food web it forms in the Arctic sea area. It also investigates the impact of changes in the food chain on the distribution and quantity of various invertebrates, fish, and marine mammals, in order to explain the phenomenon of swimming animals migrating northward and the continuous emergence of new fishing grounds. At the same time, it explores effective ways to manage the high seas fishery resources in the core area of the Arctic Ocean.

**(S11 17848 Oral)** (ECOP)

**Seasonal differences of Pacific herring larval and embryo metrics are small and proteomic analysis holds promise for uncovering subtle changes in physiology and environmental resilience**

Ariel **Shiley**, Brooke Love, Emmanuel Keene, Lilia Vivaldo, Nic Benmam and Sabina Guzek

Western Washington University, Environmental Science, USA email: shileya@wwu.edu

Of the 21 recognized spawning populations of Pacific herring in the Salish Sea, spawning biomass estimates are variable from year to year. The decline of the late spawning Cherry Point population is notable and motivated this investigation of seasonal differences in larval morphology and lipid provisioning of embryos and larvae. We included proteomic analysis because these molecular methods can identify mechanisms of observed differences and uncover additional subtle changes in physiological state. Embryos were collected by the Washington Department of Fish and Wildlife and cultured at in-situ temperature conditions to obtain samples of early and late development embryos and post-hatch larvae. We compared cohorts from the Semiahmoo Bay population collected in February, March, and April of 2023. No spawn was detected in either target late spawning population (Elliot Bay, Cherry Point). While significant temperature differences were expected across the seasonal gradient, a lack of late spawning resulted in a small temperature range between 7 and 8° C. Cohorts through the spawning season were similar in most measures, including lipid provisioning and yolk sac size at hatch. Length at hatch increased slightly across the spawning season, and deformity rates were lowest in the March cohort, with relatively higher rates of deformity in the early and late cohorts. Proteins present in early-stage embryos between February and April of 2023 were broadly similar with only 17 proteins of over 2000 that were identified showing significant seasonal differences, supporting the general similarity between cohorts seen in other measures. The proteins that had seasonal differences in abundance were primarily associated with genetic information processing, cell growth and metabolism. We also identified large differences in the suites of proteins in early versus later stage embryos including numerous heat shock and chaperoning proteins as well as those associated with cytoskeletal systems. Development of these methods and ongoing analysis of these data should help guide hypothesis testing regarding the resilience of embryos to environmental conditions as they develop.

**(S11 17902 Poster)** S11-P3 (ECOP)

## Delayed impacts of ENSO on fish size classes in the tropical Pacific

Hyung-Gyu **Lim**[1] and Colleen M. Petrik[2]

[1]Korea Institute of Ocean Science and Technology, South Korea. E-mail: hglim@kiost.ac.kr

[2]Scripps Institution of Oceanography at University of California San Diego, United States

The El Niño–Southern Oscillation (ENSO) event influences the bottom-up drivers of marine ecosystem by changing thermocline depth and nutrient supply. However, timescales from ENSO to higher trophic level responses has been understudied. We analyzed ENSO related fish biomass anomalies simulated by a spatially explicit, mechanistic model of three fish functional types of fishes: forage, large pelagic, and demersal fishes called the FishErIes Size and functional TYpe model (FEISTY), forced by bottom-up drivers simulated by the Community Earth System Model version 1 (CESM1) based an ocean–sea ice simulation forced by an atmospheric reanalysis (FOSI reconstruction). We found that El Niño event decreases the small fish biomass in the NINO3.4 region, maximized at 2-month later while all bottom-up drivers of fish such as pelagic temperature, bottom temperature, particulate organic carbon flux in the seafloor, pelagic mesozooplankton biomass, and mortality rate are decreased, simultaneously. For the large pelagics and demersals biomass, ENSO responses are extended in prolong year, maximized at 8-month and at 18-month, respectively. These results imply that effective generation time or turnover rate of different size classes of fish could impact variabilities of fish functional types biomass.

**(S11 17989 Poster)** S11-P4

**Declines in body size of Fraser River sockeye salmon and impacts on age-at-maturity, fecundity, and run timing**

Dejan **Brkic**, Eric Taylor, Angela Phung, Stephen Latham

Pacific Salmon Commission, Vancouver, Canada. e-mail: brkic@psc.org

Body size of salmon is of great importance from an ecological and economic perspective. Declines in size have been reported for Chinook, chum, pink and sockeye salmon in the eastern North Pacific Ocean and have been linked to climate change and increased competition. We explored the consequences of decreasing body size in Fraser River sockeye. Fisheries in the Fraser River and nearby marine areas provided data on length, weight, age composition, and run timing. Length, age, and fecundity data from sockeye sampled from Fraser River spawning grounds were also compiled. Average weights and lengths of Fraser River sockeye salmon decreased in the past 20 years, with more drastic decreases in older sockeye (ocean age 3). The average age of sockeye increased across all major stock groups, partly due to a drastic decrease in returns of jacks (ocean age 1), possibly relating to a decreasing growth rate. This has evolutionary implications as diverse age structure may increase resilience in the face of environmental change. Fecundity decreased with body size, which coincided with decreased production of recruits per spawner. Decreases body size also coincided with later return timing, with ecological implications including bycatch and other management concerns in mixed-species fisheries. The relevant data are available online through an R Shiny application to stimulate broader, improved research on this issue and on appropriate management responses.

**(S11 18043 Poster)** S11-P5 (ECOP)

**Alterations of pelagic food web structure in the marginal seas of western North Pacific under changing climate**

Eun-Ji **Won**[1], Ji-Eun Kim[1], Hee Young Yun[1], Ha-Eun Cho[1], Seok-Hyeon Youn[2], Sae-Yun Kwon[3] and Kyung-Hoon Shin[1]

[1]Hanyang University, Ansan, Republic of Korea. E-mail: ejwon@hanyang.ac.kr

[2]National Institute of Fisheries Science, Busan, Republic of Korea

[3]Pohang University of Science and Technology, Pohang, Republic of Korea

Many studies have already noted changes in basal food webs (e.g., planktonic food webs) due to changing climate. Changes in the basal food web can affect the complexity of the entire food web, including the plasticity of the trophic positions of marine organisms.

In this study, we discovered changes in the structure of the food web in the marginal seas of the North Pacific. The trophic positions of zooplankton was investigated using stable isotope analyses of carbon (C) and nitrogen (N) in bulk tissue and individual amino acids in zooplankton collected from four regions (West Sea, ECS, South Sea, and East Sea). In the results, only the Calanus sp. in the East Sea during the winter season had a higher trophic position compared to others, and, the pico-plankton occupied very high predominance in the East Sea during that season suggesting the longer food chain from the basal diet to meso-zooplankton according to the increased contribution rate of small size (pico and nano) plankton biomass compared to other seasons. Additionally, the trophic position of mackerel (Scomber japonicus), as a pelagic fish species was higher in the East than the South Sea in winter. It demonstrates significant trophic linkage between the shift in dominant phytoplankton size and pelagic food web structure in the East Sea due to recent changing climate and the following increased seawater temperature in the western North Pacific.

**(S11 18094 Poster)** S11-P7

**Impacts on fecundity and fisheries of declining body size in Fraser River pink salmon**

Stephen **Latham**, Dejan Brkic and Angela Phung

Pacific Salmon Commission, Vancouver, Canada. E-mail: Latham@psc.org

Reduced size-at-age in mature Pacific salmon has been reported for multiple stocks across species. Growth and body size are important parameters in many ecological processes underlying fisheries management models and frameworks. We explored the consequences of decreasing body size in Fraser River pink salmon (*Oncorhynchus gorbuscha*) for productivity and run timing. A multi-decadal data set was compiled including annual estimates of adult body size, run size, return timing, spawning escapement, fecundity, and fry outmigration. Average body size of Fraser River pink salmon decreased approximately 30% over the 1961-2023 time series, with most of that decline occurring between the 1970s and 1990s. Fecundity declined as a result, and this was correlated with a sharp decline of fry production per spawner over this period. The management system for Fraser River pink salmon establishes spawning escapement targets and allowable catches in terms of numbers of fish (rather than biomass, for example); it may be beneficial to account for annual variability in body size when setting these targets to better achieve egg deposition and economic objectives. The effect of body size on migration timing was less clear than its effect on fecundity, with Fraser pink salmon initially returning later as body size decreased, as expected, but then reverting in recent years despite no recovery in body size. The change in timing over the last decade has increased temporal overlap with sockeye stocks of concern and further limited the pink salmon biomass harvested in this fishery.

# S12: MEQ Topic Session

**The Changes in Distribution of Harmful Algal Blooms (HABs) in the North Pacific Region**

**Convenors:**
Mark L. Wells (USA) *corresponding*
William Cochlan (Canada)
Natsuko Nakayama (Japan)
Yoichi Miyake (Japan)

Higher latitude regions are experiencing the fastest rates of climate change, impacting marine biodiversity and plankton diversity, but significant changes are also occurring across mid-latitude coastal zones. These changes in physical and chemical conditions are affecting the biodiversity of plankton communities, creating new ecological spaces, resulting in local appearances of new HAB species and the blooming of endemic HAB species that previously had not been problematic. For example, recent observations show the appearance of paralytic shellfish toxin-containing plankton far north of the Arctic Circle. This condition would not have been possible with the very short planktonic growing season only two decades earlier. Indeed, northward-moving Pacific warm waters are shown to now carry Alexandrium blooms as far north as the Chukchi Sea. Similarly, Gambierdiscus species, the causative agents for ciguatera fish poisoning, historically found in tropical regions, have now been isolated in Japanese coastal regions. The importance of latitudinal shifts in biodiversity related to future HABs is highlighted in published proceedings from at least two international meetings co-sponsored by PICES. Yet, information on these changes in PICES nations must be more present. This session invites PICES and non-PICES experts from several countries to present their findings on how HAB species' distribution, prevalence, and emergence have changed over the last decades in the North Pacific region and elsewhere. Time will be set aside to discuss these changes and the steps needed to understand their mechanistic drivers better. Combined, these presentations will provide an overview of how changing ocean conditions have altered contemporary HAB events, provide insights into the trajectory of HAB risks, and consider if the HAB events are transitory or represent stable trophic shifts as climate change accelerates.

**(S12 17742 Oral)**

**Physical drivers of *Noctiluca scintillans* (Dinophyceae) blooms outbreak in the northern Taiwan Strait: A numerical study**

Zhonghao Lin[1], Peng Zhan[2], Jianping Li[3], Jun Sasaki[4], Chun Chen[5], Shuangyan Zou[6], Xiaotong Yang[1] and Haifeng **Gu**[7]

[1]School of Marine Sciences, Nanjing University of Information Science and Technology, Nanjing, 210044, China

[2]Department of Ocean Science and Engineering, Southern University of Science and Technology, Shenzhen, 518055, China

[3]Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, 1068 Xueyuan Avenue, Shenzhen, 518055, China

[4]Department of Socio-Cultural Environmental Studies, Graduate School of Frontier Sciences, The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba, 277-8563, Japan

[5]Island Research Center, Ministry of Natural Resources, Pingtan, 350400, China

[6]Agricultural and rural development service center of Pingtan comprehensive experimental area, Fuzhou，350004, China

[7]Third Institute of Oceanography, Ministry of Natural Resources, Xiamen, 361005, China. E-mail: guhaifeng@tio.org.cn

The red *Noctiluca scintillans* (*RNS*) blooms break out near Pingtan Island in the northern Taiwan Strait from April to June regularly. It is essential to gain insight into their formation mechanism to accurately predict and provide early warnings for these blooms. Previous studies and observations showed that *RNS* blooms are the most likely to occur during shifting and weak winds. To explore this phenomenon further, we employed a high-resolution coastal model to investigate the hydrodynamics influencing *RNS* blooms around Pingtan Island from April to June 2022. The model results revealed that seawater exhibited weak circulation but strong stratification during *RNS* blooms. Residence time during both bloom and non-bloom periods were examined through numerical experiments by releasing passive neutrally-buoyant particles in three bays of Pingtan Island. The results showed a significantly longer fast-flushing phase during *RNS* blooms, indicating reduced flushing and self-purification within the bays. This hydrodynamic environment provided a favorable basis for *RNS* blooms breakout near Pingtan Island. The shifts and weakening of the northeast wind contributed substantially to weakening the flow field around Pingtan Island, and played a crucial role in creating the hydrodynamics conducive to *RNS* blooms. Our study offers fresh insights into the mechanisms underpinning *RNS* blooms formation near Pingtan Island, providing a vital framework for forecasting *RNS* blooms in this region.

**(S12 17807 Oral)**

**A study on the diversity of sand-dwelling dinoflagellates at Pyoseon Beach on Jeju Island, Korea from spring to winter 2023**

Su-Min **Kang**, Joon-Baek Lee and Jin Ho Kim

Department of Earth and Marine Sciences, Jeju National University, Jeju, Republic of Korea. E-mail: kimj@jejunu.ac.kr

Benthic dinoflagellates are important primary producers in benthic ecosystems, with some species possessing toxicity that can lead to harmful algal blooms. Basic investigations remain largely understudied, and their diversity remains poorly understood. In this study, environmental factors were measured monthly from January to November 2023 at the intertidal zone of Pyoseon Beach in Jeju Island, South Korea, and the community distribution and species diversity of benthic dinoflagellates were investigated. During the study period, the sea temperature and salinity ranged from 15.2 to 29.4 °C and 31.2 to 34.1 psu, respectively. The sediment temperatures in the upper, middle, and lower intertidal zones ranged from 12.4 to 32.5 °C, 12.5 to 31.6 °C, and 13.2 to 29.5 °C, respectively. The moisture content varied from 20.9% to 100.8%. The monthly average abundance of total benthic microalgae ranged from 34 to 178 cells/$cm^3$. Shannon's species diversity index ranged from 0.58 to 2.21. During the survey period, 24 genera 68 species of benthic dinoflagellates were identified, including four potentially toxic species, 14 unrecorded species, and 17 unidentified benthic dinoflagellates. According to the redundancy analysis, the abundance of benthic dinoflagellates showed a positive correlation with sediment moisture content and a negative correlation with both the abundance of diatom and temperature fluctuation of sediment after low tide. Through this study, fundamental information on the community dynamics of benthic dinoflagellates in response to seasonal marine environmental changes has been obtained. This will contribute to further research on the impact and changes in benthic ecosystems due to climate change.

**(S12 17818 Oral)**

**Harmful algae dynamics in the Strait of Georgia, Canada.**

Svetlana **Esenkulova** and Isobel Pearsall

Pacific Salmon Foundation, Vancouver, BC, Canada. E-mail: sesenkulova@psf.ca

Based on the monitoring program supported by the Pacific Salmon Foundation, we present ten years of high-resolution data (~55 stations sampled ~18 times a year) on oceanographic conditions and harmful algae prevalence and concentrations in the Strait of Georgia, Canada. Routinely enumerated harmful algae taxa include Alexandrium spp., Chaetoceros convolutus/concavicorne, Dictyocha spp., Dinophysis spp., Heterosigma akashiwo, Noctiluca scintillans, Pseudo-nitzschia spp., and Rhizosolenia setigera. The prevalence of some taxa appeared to be linked to climate patterns (i.e. ENSO, NPGO), while others are driven by local factors. Unusual observations included atypical phytoplankton dynamics during the 2015 (super El Niño), a rare coccolithophore bloom in late summer of 2016 (uncommon here due to generally lower pH conditions), the first confirmed human infection caused by Shewanella algae/bacteria (typically found in tropical waters) in 2021, and a high abundance of Proroceratium reticulatum in 2022. These findings highlight significant changes in harmful algae distribution and prevalence over the past decade, emphasizing the need to understand the mechanistic drivers behind these changes as climate change accelerates. Understanding these shifts is crucial for assessing impacts on trophic level transfer, human health, and the food supply for salmon.

**(S12 17862 Oral)**

**Multi-decadal trends in blooms of harmful algae Chattonella spp. in Japan**

Yoichi **Miyake**[1,2] and Goh Onitsuka[2]

[1]Japan Fisheries Research and Education Agency (Headquarters), Yokohama, Kanagawa, Japan. E-mail: miyake_yoichi28@fra.go.jp

[2]Japan Fisheries Research and Education Agency (Fisheries Technology Institute), Hatsukaichi, Hiroshima, Japan.

The harmful raphidophyte Chattonella spp. frequently kill cultured fishes in Japan. For identifying multi-decadal trends in their blooms, we analyzed 30-year data (1991–2020) from the annual reports published by the Fisheries Agency of Japan. We used three spatial scales; the largest was western Japan, the medium was “Seto Inland Sea” and “Kyushu waters,” and the smallest was water divisions (e.g., bays). For each spatial scale and year, we organized the numbers of blooms, damage cases, and water divisions with blooms, amount of damage, maximum cell density, period, and onset dates of the first and last blooms. Since the definition of bloom may vary among the data reporting prefectures, we also created and used a filtered dataset based on the maximum cell density. We performed the (modified) Mann-Kendall test for the trend analyses. For both non-filtered and filtered datasets, the number and period of bloom and number of water divisions with blooms showed significant increasing trends in western Japan. In the same spatial scale and both datasets, the results indicated the later occurrence of the last bloom of the year. In contrast, the timing of the first bloom (both datasets) showed significant decreasing trend, indicating earlier occurrence of the first bloom in the regional scale, Seto Inland Sea. This sea also showed a significant increasing trend in the number of water divisions with blooms (both datasets). In the water division scales, increasing trends were found for multiple data categories. These trends indicate changing phenology and spatial expansion of Chattonella spp.

**(S12 17873 Oral)**

**Observational evidence for arrival and evolution of Karenia spp. in the Pacific waters off southeast Hokkaido, Japan in 2021**

Yukiko Taniuchi[1], Hiroshi Kuroda[1], Akira Kuwata[2], Tsuyoshi Watanabe[1], Takuya Ohshini[1], Hiromi Kasai[1], Tomonori Azumaya[1], and Takuya **Nakanowatari**[1]

[1]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Kushiro, Japan. Email: nakanowatari_takuya71@fra.go.jp

[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Shiogama, Japan.

In September 2021, unprecedented large-scale harmful algal blooms (HABs), primarily composed of Karenia spp., occurred in the southeastern coastal area of Hokkaido (Japan), and had drastic impacts on both the coastal ecosystem and the local fishery industry. In this study, we examined the arrival time and inferred the origin of Karenia spp. in terms of water mass properties by analyzing the in situ monitoring data over the past several years. Microscope analysis to estimate phytoplankton abundances revealed that Karenia spp. emerges in the offshore region of southeastern coastal area of Hokkaido in May, and the substantial amount distributes in early July, and then the HABs occurred in October. In July, Karenia spp. was detected primarily in surface layer of Oyashio water mass, and that the largest concentrations of cells tended to be around 15°C ocean temperature. We also found that the abundances of major diatom tax was quite low level on July 2021 just before the intensive and extensive marine heatwaves occurred and the decline was maintained in the continental shelf area which is the hotspot of the HABs 2021. These results suggest that a hypothesis that major diatom taxa that are dominant in normal years were declined by the marine heatwaves in 2021 which results in the outbreak of HABs must be modified.

**(S12 17874 Oral)** (ECOP)

## Water temperature changes blooming pattern and saxitoxins (STXs) synthesis in toxic dinoflagellates Alexandrium catenella and A. pacificum

Han-Sol **Kim**[1,2], Quynh Thi Nhu Bui[1], and Jang-Seu Ki[1]

[1]Sangmyung University, Seoul, Republic of Korea. E-mail: biohansol0109@gmail.com

[2]The Institute of Life Sciences of Sangmyung University, Seoul, Republic of Korea

The marine dinoflagellate Alexandrium occurs in oceans around the world, and some can form harmful algal blooms and produce toxic substances. Particularly, A. catenella and A. pacificum can produce saxitoxins (STXs), contaminating seafoods and causing human illness by their consumption. Both toxic Alexandrium are known to be sensitive to oceanographic conditions, with each species and strain having its own optimal temperature for blooming and STXs production. However, the molecular biological understanding of response to temperature changes remains unclear. Here, we determined several genes involved in STXs biosynthesis (sxt) in the toxic Alexandrium. Then, we evaluated physiological (cell growth), biochemical (STXs content), and molecular (sxt gene expression) changes in cells exposed to cold and thermal stressors. Principal component analysis (PCA) demonstrated a high correlation between STXs synthesis and sxt expression under cold stress and low-temperature status. In breif, rapid fluctuations in water temperature, especially cold stress, were found to be responsible for the increase in STXs production in toxic Alexandrium. These explain the paralytic shellfish poisoning (PSP) incidents in the North Pacific in spring in molecular biological aspects.

**(S12 17895 Oral)** (ECOP)

**The *in-situ* release of algal bloom populations and the role of prokaryotic communities in their establishment and growth**

Xiao **Ma**

Key Laboratory of Tropical Marine Bio-Resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China E-mail: maxiao@scsio.ac.cn

Harmful algal blooms (HABs) may quickly travel and inoculate new water bodies via currents and runoff in estuaries. The role of in-situ prokaryotic communities in the re-establishment and growth of inoculated algal blooms remains unknown. A novel on-board incubation experiment was employed to simulate the sudden surge of algal blooms to new estuarine waters and reveal possible outcomes. A dinoflagellate (*Amphidinium carterae*) and a diatom species (*Thalassiosira weissflogii*) which had bloomed in the Pearl River Estuary (PRE) area were cultured to bloom densities and reintroduced back into PRE natural seawaters. The diatom showed better adaptation ability to the new environment and increased significantly after the incubation. Simultaneously, particle-attached (PA) prokaryotic community structure was strongly influenced by adding of the diatom, with opportunistic prokaryotes significantly enhanced in the diatom treatment. Whereas the dinoflagellate population did not increase following incubation, and their PA prokaryotic community showed no significant differences relative to the control. Metagenomic analyses demonstrated that a variety of labile carbohydrates and nitrogen sources were actively transported into the cell and quickly utilized by opportunistic PA prokaryotes, such as the Planctomycetaceae, Rhodobacteraceae and Cryomorphaceae. Examination of the genome of Planctomycetaceae Bin P01 suggests that the Planctomycetaceae and T. weissflogii are likely associated in a mutualistic relationship, with the diatom providing organic matter for Planctomycetaceae and the bacteria supplying vitamins, detoxifying nitriles, and hydrogen peroxides in exchange. The proposed symbiosis facilitates the growth of the diatom and PA bacteria, thus improving the chances of successful inoculation and establishment of an algal bloom.

**(S12 17922 Oral)** (ECOP)

## Competitive interaction between the dinoflagellates Karenia selliformis and Karenia mikimotoi co-occurred in Autumn of 2021 off the Pacific coast of Hokkaido, Japan

Ryoko **Yano**[1], Saho Kitatsuji[1], Yuki Takai[2], Yohei Shimasaki[2], Yasuhiro Yamasaki[3] and Tomoyuki Shikata[1]

[1]Fisheries Technology Institute, Japan Fisheries Research and Education Agency, Goto, Japan. E-mail: yano_ryoko14@fra.go.jp

[2]Kyushu University, Fukuoka, Japan

[3]National Fisheries University, Japan Fisheries Research and Education Agency, Shimonoseki, Japan

To understand the developmental mechanism behind a Karenia red-tide that occurred in Autumn of 2021 off the Pacific coast of Hokkaido, Japan, the growth interaction between two co-occurring Karenia species was investigated using bi-algal cultures. At the beginning of the outbreak, several Karenia species, including K. mikimotoi and K. selliformis, coexisted at low cell densities, but K. selliformis subsequently became solely dominant, suggesting that competitive interactions within the genus Karenia contributed to the red-tide dynamics. Bi-algal cultures with several combinations of initial cell densities (0, 200 and 2000 cells mL-1) of K. selliformis and K. mikimotoi showed that K. selliformis significantly inhibited the growth of K. mikimotoi, regardless of the ichthyotoxicity of K. mikimotoi. This finding was based on results obtained from two culture strains of K. mikimotoi with different ichthyotoxicity. The maximum cell densities of K. mikimotoi during the culture period decreased to less than 22% in co-culture with K. selliformis compared to the monoculture, even when K. mikimotoi (2000 cells mL-1) was exposed to lower cell densities of K. selliformis (200 cells mL-1). A growth simulation of both species in the bi-algal cultures using the Lotka–Volterra competition equation to quantify the interaction showed that the competitive effect of K. selliformis on K. mikimotoi was more than twice the inhibitory effect of K. mikimotoi on K. selliformis. These results suggest that the growth inhibition of K. mikimotoi by K. selliformis was an important factor in the monospecific bloom of K. selliformis in Hokkaido in 2021.

**(S12 18096 Oral)** (ECOP)

**Using autonomously collected eDNA to assess phytoplankton community composition and the presence of harmful algal species**

Max **Taylor**, Nicolaus Adams and Stephanie Moore

Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, WA, USA. E-mail: margaret.taylor@noaa.gov

The Olympic Coast National Marine Sanctuary on the U.S. West Coast is home to a number of economically and culturally important species that are sometimes affected by harmful blooms of diatoms in the genus Pseudo-nitzschia. Some species of Pseudo-nitzschia, most notably P. australis, produce the neurotoxin domoic acid which can accumulate in filter-feeding fish and shellfish, shutting down fisheries and causing illness or even death in humans and marine birds and mammals. This study uses environmental DNA (eDNA) collected by an advanced autonomous sampler called the Environmental Sample Processor to assess phytoplankton community composition, including the presence of Pseudo-nitzschia. DNA metabarcoding analysis using the 18S rRNA V9 region was performed on 37 samples collected and archived by the ESP during two deployments in summer/fall 2021 and spring 2022. The eDNA reads were classified using the PR2 reference database to identify phytoplankton community composition at the genus level. The phytoplankton community composition differed significantly between the two deployments, with higher relative abundances of Pseudo-nitzschia in the summer/fall, consistent with higher levels of domoic acid. Five Pseudo-nitzschia species were observed: australis (71% confidence), seriata (90%), delicatissima (78%), heimii (96%), and fraudulenta (72%). The ciliate genera Mesodinium and Eutintinnus, the dinoflagellate family Thoracosphaeraceae and the diatom genera Corethron and Thalassiosira were the most closely correlated with Pseudo-nitzschia, occupying a similar ecological niche. Further monitoring of Pseudo-nitzschia, domoic acid and phytoplankton communities will help us determine what allows Pseudo-nitzschia to outcompete these genera and form harmful algal blooms.

**(S12 17752 Poster)** S12-P1

## Physicochemical impact of green algae bloom in coastal area of Jeju, Korea

Taehee **Lee**, Kihwan Lee and Young Baek Son

Tropical & Subtropical Research Center, Korea Institute of Ocean Science & Technology, Jeju, Republic of Korea. E-mail: thlee@kiost.ac.kr

The coastal areas of Jeju island is rapidly change marine environment by affected global climate change and sub-tropicalization is in progress. Increased pollutant inputs are contributing to coastal pollution, leading to coastal eutrophication and green algae blooms. In the coast of Jeju island, green tides of *Ulva sp*. have occurred annually since the early 2000s. It has an impact on the coastal ecosystem, disrupting and severely damaging coastal fisheries and tourism industries. Along the coast of Jeju, large amounts of effluent from land-based aquaculture farms (LAFE) input the coastal waters, and submarine groundwater discharge (SGD) input the coast, acting as a source of nutrients. Both LAFE and SGD have high concentrations of nitrate. However, concentrations of ammonia and phosphate are high in LAFE, but relatively low in SGD. Therefore, although *Ulva sps*. grows in most parts of Jeju's coast, most of the green algae blooms are thought to occur around fish farms. Green algae blooms tend to occur in areas of stagnant water flow, such as bays with narrow inlets. Bangdu Bay in Jeju is a bay with a very narrow mouth, and the flow of water in the bay is very slow, and water does not drain well into the open sea. LAFE and SGD also have an impact on the bay. Consequently, green algae blooms occur in the bay throughout the year, resulting in serious localised environmental problems.

**(S12 17772 Poster)** S12-P2

## Co-occurrence patterns and temporal changes of dinoflagellate communities in a semi-enclosed bay: Intensive monitoring of predominant key species

Yu Jin Kim[1,2], Hyun-Jung Kim[1,3], Kang Eun Kim[1,2], JunSu Kang[4] and Seung Won **Jung**[1,2]

[1]Library of Marine Samples, Korea Institute of Ocean Science & Technology, Geoje, Republic of Korea. E-mail: diatomas@kiost.ac.kr

[2]Department of Ocean Science, University of Science and Technology, Daejeon, Republic of Korea.

[3]Department of Oceanography and Marine Research Institute, Pusan National University, Busan, Republic of Korea.

[4]Ballast Water Research Center, Korea Institute of Ocean Science & Technology, Geoje, Korea

To understand the dynamics of dinoflagellates on the southern coast of South Korea, the total Phytoplankton transition was analyzed through 18s rDNA Metabarcoding analysis at 3 days of intensive (260-time series monitoring) from November 2018 to June 2020. In a total of 16,224 ASVs (amplicon sequencing variables), 38% of dinoflagellate taxa appeared in total relative abundance. The dinoflagellates community was classified into 21 groups using Bray-Curtis dissimilarity, but their groups showed no significant differences ($p>0.05$). In common, the appearance of dinoflagellate taxa (with a mean relative abundance >1% in all samples) was selected as the 11 dominant taxa. The predominant taxa were Heterocapsa rotundata (ASV#002, dominance of most investigated times), Euduboscquella sp. (Feb.-Mar.), Dissodinium pseudolunula (Feb.-Mar.), Sinophysis sp. (Feb.-Mar.), Spiniferites ramosus (Mar.), Gymnodinium sp. (May-Jun.), Amoebophyra sp. (Jun.-Jul.), Karlodinium veneficum (Aug.-Sep.), Protodinium simplex (Oct.), Akashiwo sanguinea (Oct.-Nov.), Katodinium glaucum (Nov.). In CCA and Multiple regression analyses, each species in common dinoflagellate taxa had different impacts from competition, predation, parasitism, and environmental factors. In particular, Heterocapsa rotundata and Gymnodinium sp. were significantly strongly affected by predators and competitors ($R2=0.999$, $p<0.001$). However, Akashiwo sanguinea was strongly affected by environmental factors ($R2=0.349$, $p<0.001$). Thus, when dinoflagellates did not bloom, biological factors also had strong influences, but when red tide did occur, environmental factors had a main influence over other biological influences.

**(S12 17780 Poster)** S12-P3

**First description of occurrence and distributions of the epibenthic dinoflagellate *Coolia palmyrensis* from Jeju coastal waters in Korea**

Jun-Ho **Hyung**[1], Jaeyeon Park[1], Seung Joo Moon[1], Hangy Lee[1], Suk Yeon Lee[2] and Yeong Du Yoo[2]

[1]Advanced Institute of Convergence Technology, Suwon, Korea. E-mail: bada0@snu.ac.kr

[2]Kunsan National University, Kunsan, Jeollabuk-do, Korea.

The epiphytic benthic microalgae are recognized for their cosmopolitan distribution spanning tropical and temperate regions, and the toxic molecules they produce pose a potential threat to public health during harmful algal blooms (HABs). However, the distribution patterns of benthic dinoflagellates, including *Coolia* spp., are undergoing changes as a reaction to climate change. In this study, we first found the species *C. palmyrensis*, known to inhabit tropical regions, in Seogwipo on Jeju Island, Korea, located in a temperate region at 33° latitude. We identified both the morphology and molecular lineage of the strains after establishing a clonal culture. For the phylogenetic analysis of Coolia based on the ITS regions and D1-D3 LSU rDNA sequences, the isolates were grouped in the phylogenetic clade of C. palmyrensis, with high statistical support values.

From 2021 to 2023, using a species-specific quantitative PCR assay, the presence of *C. palmyrensis* was predominantly observed during autumn in Jeju coastal waters, with a maximum cell density of 242 cells per g wet weight on macroalgae detected in Seogwipo in 2021. We confirmed the settling of this species established benthic phytoplankton communities in Jeju coastal waters, as overwintering populations were observed in 2023. Moreover, the species was detected in Pohang and Ulsan in east coast of Korea, with maximum abundances of 13 and 8 cells/g wet weight on the macroalgae, respectively. We confirmed it could be the evidence of habitat shifts of benthic dinoflagellates driven by global warming, as the species adapt to survive within their thermal tolerance ranges.

**(S12 17791 Poster)** S12-P4

**The isolation of toxic compounds from the marine dinoflagellate Prorocentrum lima and the variation of the compound amounts over time as the culture grows**

Sangbum Lee, Yeong Kwang Ji, Yeong Du Yoo and Jung-Rae **Rho**

Kunsan National University, Gunsan, South Korea. E-mail: jrrho@kunsan.ac.kr

Benthic marine dinoflagellates, known as a species of Harmful Algal Blooms (HAB), pose a significant threat to marine ecosystems and have been extensively studied. Recently, we focused on Prorocentrum lima, a benthic marine dinoflagellate isolated from Korean seawater. By cultivating these organisms on a mass scale, we were able to extract metabolites and analyze their chemical compositions. Using organic solvents, we carefully extracted the dinoflagellate and separated the fractions based on polarity to eliminate salts and fatty acids. Employing bioassay-guided fractionation techniques, we utilized chromatography to isolate cytotoxic compounds. The purified substances were identified using HR-qTOF instrument and their detailed chemical structures were elucidated through NMR experiments. Our findings revealed the isolation of six derivatives of OA or DTX-1, alongside a polyhydroxy compound known as limaol, from P. lima. Moreover, we successfully separated and characterized two analogues of prorocentrolide (prorocentrolide C and 4-hydroxy prorocentrolide). Moreover, our investigation into the variation of toxic compound content over the growth period of P. lima provided critical insights into the dynamics of toxin production. By correlating the growth phases with toxin levels, we identified specific periods during which the concentration of toxic compounds peaks. This information is invaluable for both ecological studies and practical applications, such as the harvesting of these organisms for toxin extraction.

**(S12 17875 Poster)** S12-P5 (ECOP)

**Unveiling saxitoxins (STXs) synthesis potential of dinoflagellate Alexandrium through STXs synthesis genes (sxt) analysis**

Han-Sol **Kim**[1,2], Quynh Thi Nhu Bui[1], Jeongmin Shin[1], Taehee Kim1, and Jang-Seu Ki[1]

[1]Sangmyung University, Seoul, Republic of Korea. E-mail: biohansol0109@gmail.com

[2]The Institute of Life Sciences of Sangmyung University, Seoul, Republic of Korea.

The marine dinoflagellate genus Alexandrium is unicellular and planktonic organisms, which are widely distributed in oceans around the world, and some can produce saxitoxins (STXs). The three species of A. catenella, A. pacificum, and A. affine proliferate between spring and fall under different temperature conditions along the coast of Korea. It is well known that A. catenella and A. pacificum can produce STXs, whereas it is controversial in A. affine. Here, de novo transcriptomes of three species were analyzed, and a large number of STXs synthesis genes (sxt) were identified to determine their STXs production potential. The core sxt genes were conserved in their sequence and structure; however, expressional levels of sxtA, sxtG and sxtI in A. affine were significantly lower than the other species. These represent that the inhibition of the sxt genes and/or their low copy number may negatively affect STXs synthesis capacity in the Alexandrium species In this regard, A. catenella and A. pacificum produced 86.4 and 64.0 STXs eq fmol/cell under optimal growth conditions (16°C), whereas less than 0.8 STXs eq fmol/cell were detected in A. affine. These suggest that A. affine can produce STXs, although it is unlikely to cause shellfish poisoning incidents.

**(S12 17891 Poster)** S12-P6

**Drifting seaweed may be an ideal carrier for the transport pathway of harmful algae**

Chunjiang **Guan**, Yanlong Chen, Lu Yang and Jingfang Zhang

National Marine Environmental Monitoring Center, Ministry of Ecology and Environment, 42 Linghe St., Dalian City 116023, PR China E-mail: cjguan@189.cn

From 2015 to 2020, satellite remote sensing methods were used to monitor the distribution area and drift path of drifting seaweed. The measurement frequency is once every 3 days. As of mid August 2020, monitoring results showed that the distribution area of planktonic seaweed (*Sargasum horneri*) in Liaodong Bay in 2020 was the largest in six years since 2015. On June 28, 2020, the maximum distribution area of *Sargasum horneri* in Liaodong Bay was detected to be 640 square kilometers; On July 7, 2020, a drift source was detected from the northern Yellow Sea, with a transmission distance of approximately 300km from the starting point of the Yellow Sea to the discovery point in the Liaodong Bay of the Bohai Sea. On August 8, 2020， an investigation in Liaodong Bay found that there were still Sargassum drifting, and each drifting seaweed group was entangled with artificial floating bodies such as foaming foam. Perhaps the buoyancy of seaweed itself is not sufficient for long-distance drifting. With the help of external floating debris, it can maintain long-term growth and drift. Many young fish can be seen under the sargassum community. Drifting seaweed and its carried fish eggs or juveniles, as well as phytoplankton, drift and spread over long distances in the ocean. Wherever they go, they are all non native species (NIS) and may be an ideal carrier for studying harmful algal transport pathways.

**(S12 18100 Poster)** S12-P7

**Northward expansion and large-scale outbreaks of harmful algae along the coasts of Japan reported since the 21st century**

Setsuko **Sakamoto**

Fisheries Research and Education Agency, Hatsukaichi, Hiroshima, Japan. E-mail: sakamoto_setsuko59@fra.go.jp

Harmful red tide algae have frequently occurred along the coasts of Kyushu and the Seto Inland Sea, Japan, causing great damage to the fisheries industry. On the other hand, the Pacific coasts of Hokkaido and the Tohoku region have long been affected by toxic algae that accumulated PSP and DSP in bivalve mollusks, but no reports had been made of harmful red tide algae such as *Chattonella*, and *Karenia* species were reported. In recent years, it's distribution and occurrence scale of harmful algae have changed in Japan. In this study, the changes in the distribution and occurrence of harmful algae along the coasts of Japan since 2001 were summarized. First of all, the northern limit of the distribution of some harmful algae has been changing. For example, the appearance of *Chattonella* spp., *Karenia mikimotoi* and *Margalefidinium polykrikoides* was reported for the first time along the western Hokkaido. Subsequent investigations have confirmed that *K. mikimotoi* is widely distributed along the coast of Hokkaido. In addition, *K. mikimotoi* red tide were repeatedly reported in Hakodate Bay in southern part of Hokkaido. Secondly, a large-scale red tide caused by new species *Karenia selliformis* occurred. This was the first report of the species along the Japanese coast. Changes in the occurrence scale of toxic *Alexandrium* spp. also reported. Along the coasts of Hokkaido and the Tohoku region, they usually occur at densities of > 1 cell/mL without coloration, but in recent years, large-scale outbreaks that coloration of the sea surface have been reported.

# S13: BIO Topic Session

**Rapid plankton assessment for ecosystem assessment**

**Convenors:**
Hongsheng Bi (USA), *corresponding*
David Kimmel (USA), *corresponding*
Satoshi Kitajima (Japan)

**Invited Speaker:**
Sophie Pitois
(Cefas, UK)

The objective of this session is to explore the importance of rapid plankton assessment in comprehending and managing the ocean carbon cycle, highlighting the crucial role of plankton in ecosystem management. We will concentrate on underwater imaging techniques and leverage deep learning technologies for efficient plankton assessment and subsequent application of this information to address ecosystem management in the face of a changing climate. This session aims to unite experts in underwater imaging and deep learning systems, focusing on the applications of these techniques to facilitate rapid plankton assessment. Our aspiration is that this session will drive progress in plankton assessment methodologies, allowing us to develop a framework that integrates real-time or near real time plankton data with information from other sensors. This integration will be instrumental in examining and forecasting ecosystem status.

**(S13 17750 Invited)**

**Are plankton nets a thing of the past? How we can use AI for rapid plankton and ecosystem assessments**

Sophie G. **Pitois**

Center for Environment, Fisheries and Aquaculture Science (Cefas), Lowestoft, UK. E-mail: Sophie.pitois@cefas.gov.uk

Zooplankton information has been collected for over 100 years, traditionally using sampling with a net and subsequent microscope analysis to count and identify species. This is a resources intensive process. The last 20 years have seen an exponential development of AI tools as well as the increase in the number of automated imaging instruments.

At Cefas (UK) we have been involved in the development of the Plankton Imager (Pi-10): a high-speed line-scan camera that images all particles continuously in a through-flow sampling system and combines automated sampling and image analysis. When connected to the water supply of a research vessel, the Pi-10 can thus image zooplankton continuously as the ship is underway, capturing 100s of images per second; Too many for a human to classify, too many to transmit using satellite network. Yet, the high frequency nature of the instrument means it can provide a description of the zooplankton at unprecedented spatial resolutions.

To address those challenges, we deployed quick and robust classifier on an edge-AI solution for real time visualization of plankton metrics. We show some applications of using high resolution plankton data with a low taxonomic resolution and we discuss how further development in data analytics tools could open the door to a new era of pelagic research and understanding of the role of plankton within the ecosystem, ultimately likely to make plankton nets a thing of the past.

**(S13 17793 Oral)**

**Typhoon-Induced variations in zooplankton populations on the central Guangdong coasts: real time data from the PlanktonScope Imaging System**

Jialin Zhang[1], Hongsheng **Bi**[2,], Jian Zhao[2], Huiliu[3], Zhonghua Cai[1]

[1]Tsinghua Shenzhen International Graduate School, Guangdong, China

[2]University of Maryland Center for Environmental Science, Solomons, Maryland, United States. Email: hbi@umces.edu

[3]Texas A & M University at Galveston, Galveston, Texas, United States

Under climate change, the frequency and intensity of typhoon events along the South China coast are expected to increase significantly. However, the impacts of these typhoons on coastal pelagic ecosystems remain underexplored, as most studies are conducted post-typhoon and proximally to the affected areas. This study utilizes high-frequency in situ plankton imagery data collected by the PlanktonScope along the Central Guangdong coast in Yangjiang to examine the impact of seven typhoon events on local plankton populations. Our results indicate that while nearly all typhoon events adversely affect pelagic organisms during the events, the extent and duration of these impacts vary depending on the typhoons' landfall locations relative to the direction of local currents. The predominant coastal current, which flows from east to west along the coast, is influenced during the summer by low-salinity water from the Pearl River, affecting the study area. Typhoons making landfall on the eastern side typically have more prolonged impacts compared to those landing on the western side. Conversely, typhoons originating from the south have shorter-lived effects due to rapid water replacement. This study highlights the significant influence of episodic events on pelagic ecosystems and provides insights into the long-term effects of climate change on local marine environments.

**(S13 18074 Oral)** (ECOP)

**Plume Dynamics and Species Interactions in the Northern California Current**

Kylie **Cherneskie**[1], Dong Liang[1], Katie Lankowicz[2], Hongsheng Bi[1], Brian Wells[3], and Richard Brodeur[45]

[1]University of Maryland Center for Environmental Science, Solomon's Island, MD, USA.

E-mail: kcherneskie@umces.edu

[2]Gulf of Maine Research Institute, Portland, ME, USA

[3]NOAA Fisheries, Southwest Fisheries Science Center, Fisheries Ecology Division Santa Cruz, CA, USA

[4] NOAA Fisheries, Northwest Fisheries Science Center, Newport, OR, USA.

[5]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Newport, OR, USA

This study investigated the influence of plume dynamics on species distributions and predator-prey interactions within the Northern California Current System. Samples were collected near the Columbia River plume off the coasts of Washington and Oregon using the PlanktonScope optical imaging system. The imaging system was fitted with a CTD sensor and deployed in transects to simultaneously examine fine-scale spatial distribution patterns for multiple zooplankton species and environmental variables such as temperature, depth, and salinity. Using spatial cluster analysis, we examined and quantified fine-scale planktonic distribution in relation to environmental gradients driven by plume dynamics. We further explored the emergence of zooplankton spatial patterns relative to CTD-measured environmental variables, remotely sensed chlorophyll-a concentration, and ocean currents using generalized additive models (GAMs). GAMs relating the distribution of zooplankton to chlorophyll-a concentration illustrate how changes in primary productivity, indicated by chlorophyll-a, can influence the distribution and interactions of higher trophic levels. By integrating spatial cluster analyses of single species, GAM analysis of multispecies interactions, and the theoretical uncertainty due to low sampling volumes of the in-situ image tools, our study examines the potential impacts of spatial patterns and processes on multispecies interactions. Our research contributes to advancing our understanding of marine ecosystems and underscores the importance of interdisciplinary approaches in addressing complex ecological questions.

**(S13 18103 Oral)**

**Rapid assessment of keystone species through in situ imaging along the Seward Line, Northern Gulf of Alaska**

Russell R. **Hopcroft**, Hannah E. Kepner and Thomas B. Kelly

University of Alaska Fairbanks, Fairbanks, USA E-mail: rrhopcroft@alaska.edu

The Seward Line in the North Gulf of Alaska began as part of the US GLOBEC program in the fall of 1997 and has continued uninterrupted during May and September annually. Recently, we have added an in situ imaging system, the ISIIS-DPI, that is tow-yowed along the length of the transect. Like most imaging systems, image classification is more accurate for particles of larger size that adequately resolve feature attributes. With a pixel size of ~50 µm, our keystone spring-time genera, Neocalanus and Eucalanus, are well-resolved and predicted with high accuracy. Here we compare predicted abundances of these large-bodied keystone copepods in situ to those obtained with traditional plankton nets. We will also explore overall patterns in the spatial variability estimated by nets, with those from the ISIIS-DPI. With training sets now well-developed for the Northern Gulf of Alaska, the system is now poised to make such estimates at sea in near real time.

**(S13 18118 Oral)**

**Rapidly analyzing in-situ plankton images by using metadata to enhance unsupervised clustering**

Jeffrey S. **Ellen**[1] and Jared W. Wilson[2]

[1]Scripps Institution of Oceanography, San Diego, CA, USA. E-mail: jellen@ucsd.edu

[2]Princeton University, Princeton, NJ, USA

In this talk we describe the machine learning technique of unsupervised clustering, which requires less training data and computation time than other, supervised deep-learning methods, thereby lending itself to rapid analysis. Unsupervised clustering of underwater biological images, such as plankton or fish, is applied by a researcher to accomplish goals such as locating new or rare species or building a training set for a supervised deep learning algorithm. As a baseline, we start by applying unsupervised clustering to in-situ planktonic images, as has been done in other published works. We then compare those results to our novel approach of augmentation of the pixel-based clustering with contextual metadata, resulting in a more holistic analysis of the images. We describe the complete procedure in detail suitable for adaption to existing machine learning pipelines. Specifically, we use t-SNE projection, which creates a feature space embedding of our input plankton images. We use a smaller, well-proven open source deep learning model (ResNet in PyTorch) to extract the features from the images.

This talk is relevant to most analysis of underwater imaging techniques, including fish, for two reasons. First, the technique does not use plankton-specific metdata. Second, the technique works on smaller datasets as well as larger datasets. Between smaller datasets and ease of coding, this technique should be accessible to a wide audience.

**(S13 17973 Poster)** S13-P1 (ECOP)

# Regional and vertical changes in body sizes of two copepod taxa: their effects on size spectra of the whole zooplankton community of 0–3000 m at five stations in the western North Pacific

Dongwoo Kim[1], Shintaro **Yoshida**[1], Sota Komeda[2], Kohei Matsuno[1] and Atsushi Yamaguchi[1]

[1]Hokkaido University, Hakodate, Japan. E-mail: lionelshinta10@eis.hokudai.ac.jp

[2]Marine Ecology Research Institute, Onjyuku, Chiba, Japan

In marine ecosystems, the most dominant taxa in the marine zooplankton community are copepods. However, little information is available on the effects of copepod body sizes on the whole zooplankton size spectra in the field. In this study, we collected vertically stratified zooplankton samples down to 3000 m depths at five stations in the western North Pacific during autumn. Size and taxonomic data were obtained from ZooScan imaging analysis. For indices of zooplankton sizes, we calculated the normalized biovolume size spectra (NBSS) and size diversity. The dominant taxa in zooplankton abundance for whole samples were the two copepod taxa: order Calanoida and suborder Ergasilida (=Poecilostomatoida). The mean ESD of Calanoida was larger than Ergasilida through the stations and depths. Regional and vertical changes in ESD were present for Calanoida, characterized by the large sizes at subarctic regions and deep layers. Concerning Ergasilida, while slight vertical changes were present, no regional changes were detected. The whole zooplankton NBSS and size diversity showed vertical changes characterized by lower intercept and flatter slope of NBSS and larger size diversity with increasing depth. For the effects on zooplankton NBSS and size diversity, the ESD of Calanoida had high correlations ($p<0.001$). The moderate NBSS slope and large size diversity of the whole zooplankton size spectra were caused by the large ESD of Calanoida. Thus, this study demonstrated that the body size of Calanoida governed the regional and vertical changes in the zooplankton size spectra.

# BIO Contributed Paper Session - POSTERS ONLY

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

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 17751 E-Poster)** BIO-P-P1 (ECOP)

**PHYTOPLANKTON COMPOSITION AND DYNAMICS IN THE OCEAN OFF THE COAST**

Raimot Titilade **Akanmu**[1], Aderonke Omolara Lawal-Are[2] and Ikenna Charles Onyema[2]

[1]Centre for Environmental Studies and Sustainable Development, Lagos State University, Ojo E-mail: titipopoola@gmail.com

[2]Department of Marine Sciences, University of Lagos, Akoka Lagos

The dearth of information on the phytoplankton in a region where oceanic properties are exchanged, mixed, and redistributed between different ocean basins led to the investigation of phytoplankton composition in the Ocean off the coast between May 2015 and April 2017. Ten sampling stations were established 15 km away from the shore along the shoreline to cover the entire length off the coast area in the Ocean. Phytoplankton samples were collected monthly at each sampling station for twenty-four months, using 55 µm mesh size standard plankton net towed horizontally to a motorized boat for 5 minutes at <4 Km/h. The plankton samples were preserved by the addition of 4 % unbuffered formalin. The drop count microscopic analysis method was used to study the phytoplankton species. There was no significant difference ($p > 0.05$) in the phytoplankton species recorded across the wet and dry seasons as well as sampling stations of the study despite the seasonal variability of 6.46%. This could be a result of steady sea conditions in the area. A total of eighty-six phytoplankton species (dominated by diatoms) from three algal classes namely Bacillariophyceae (62 species), Cyanophyceae (10 species) and Dinophyceae (14 species) were observed. Notable species were *Chaetoceros, Coscinodiscus, Melosira, Odontella, Thalassiosira, Bacillaria*, *Fragillaria, Nitzschia, Thalassionema*. *Oscillatoria*, *Trichodesmium Noctiluca, Ceratium, Peridinium* and *Protoperidinium* across wet and dry seasons of the study. The increased temperature could have led to the occurrence of *Trichodesmium thiebautii* throughout the sampling periods as compared to previous studies.

**(BIO-P 17732)** BIO-P-P2

**Genetic Connectivity of Seamounts in the West Pacific region for management of benthic ecosystem**

Seonock **Woo**, Nayoung Lee and Yejin Jo

Korea Institute of Ocean Science and Technology, Busan 49111, Republic of Korea, e-mail: cwoo@kiost.ac.kr

Patterns of genetic connectivity are increasingly considered in the design of marine protected areas (MPAs) in both shallow and deep water. Currently, patterns of genetic connectivity among deep-sea populations throughout West Pacific seamounts are not well understood. Using the mitochondrial *Cytochrome Oxidase I* and *16S rRNA* genes as genetic markers, this study aimed to elucidate patterns of genetic connectivity among populations of two benthic invertebrates with contrasting life history strategies. Populations of the cnidaria, *Bathypathes brook* and the crinoidea, *Thalassometra glacilis* were sampled from continental slope, seamount, and offshore rise habitats on the KC-7, KC-8, KC-9 and OSM-x. For the coral, significant population structure was detected among distinct populations on the KC-7, KC-8. Significant genetic differences existed between KC-7 and OSM-X. In contrast, no significant population structure was detected across the study area for the crinoid. Patterns of genetic connectivity in *Thalassometra glacilis* are likely influenced by a number of factors including current regimes that operate on varying spatial and temporal scales to produce potential barriers to dispersal. The results of this study are discussed in the context of existing conservation areas that are intended to manage deep-sea benthic communities in the West Pacific region.

**(BIO-P 17755)** BIO-P-P3

**Growth, mortality, and predatory impact on mesozooplankton of Scomber spp. larvae in the northern Satsunan area, southern Japan**

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

[1]Kagoshima University, Kagoshima, Japan. E-mail: kume@fish.kagoshima-u.ac.jp

[2]Kyushu Environmental Evaluation Association, Fukuoka, Japan

[3]ECOH Corporation, Naha, Japan

[4]Prefectural University of Kumamoto, Kumamoto, Japan

The northern Satsunan area, southern Japan is an important spawning and nursery ground for chub mackerel Scomber japonicus and spotted mackerel S. australasicus in Japan. This study examined the effects of water temperature and prey density on the growth, mortality, and predatory impact of Scomber spp. larvae (S. japonicus and S. australasicus) in the northern Satsunan area. In the study area, S. japonicus larvae were dominant in 2021 (89.7%) and 2022 (96.8%) compared with S. australasicus larvae, when their population level was high around Japanese waters. The recent growth (measured as the average width of the last three otolith increments) of Scomber japonicus larvae positively correlated with water temperature but not with prey density, indicating that prey abundance was enough for larvae and water temperature was a controlling factor for their growth rate in the study area. The instantaneous daily mortality rate of Scomber spp. larvae was estimated as 0.322 in 2021 and 0.252 in 2022 (equivalent to 27.5% mortality $d^{-1}$ in 2021 and 22.3% in 2022). The food requirement of Scomber spp. larvae and production of mesozooplankton were estimated to be 0.00427 ± 0.00334 and 6.37 ± 3.04 (mg DW $m^{-3}$ $d^{-1}$), respectively. Predatory impact on mesozooplankton by Scomber spp. larvae was not significant (0.0869 ± 0.0796%). The present study strongly suggests that all plankton feeders do not exert any significant top-down control as to suppress mesozooplankton biomass in the northern Satsunan area, where provides favorable food environment for S. japonicus and S. australasicus larvae.

**(BIO-P 17757)** BIO-P-P4 (ECOP)

**Unveiling the million-dollar loss in commercially cultivated red macroalga *Pyropia haitanensis* farms: The hidden impact of microalgal stress**

Vishal **Patil**[1,2], Lin Sun[2], Vitthal Mohite[3], Junrong Liang[1], Dazhi Wang[1,2], Yahui Gao[1,2*] and Changping Chen[1]

[1]Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystem, College of Environment and Ecology/ School of Life Sciences, Xiamen University, Xiang'an Campus, Xiamen, Fujian, China 361102 email: smilevishu9@yahoo.com

[2]State Key Laboratory of Marine Environmental Sciences, Xiamen University, Xiang'an Campus, Xiamen, Fujian, China 361102

[3]Department of Zoology, Thakur College of Science and Commerce, Kandivali (E), Mumbai, India 400101

This study delves into how two ecotypes of diatom affect the *Pyropia haitanensis*, a valuable and commercial red macroalga. To understand the reason behind multibillion loss of macroalgal aquaculture production, we co-cultivated *P. haitanensis* with an axenic planktonic diatom *Skeletonema costatum* and benthic diatom *Navicula climacospheniae*. The results showed that benthic diatom significantly hindered *P. haitanensis* growth, while planktonic ones had no major impact. The macroalga restrained planktonic diatom growth but did not affect benthic diatom. Photosynthetic pigments of macroalga, except chlorophyll, were higher, indicating stress when exposed to diatoms. Microscopic images revealed dense benthic diatom attachment, potentially stressing thalli due to limited light and EPS secretion. Total carbohydrate slightly decreased in both diatom treatments, while total protein significantly decreased with increasing benthic diatom densities. In summary, benthic diatom notably influenced *P. haitanensis* growth, pigments, and total protein levels. This study sheds light on the interaction between microalgal ecotypes and commercial macroalga *P. haitanensis*, which is crucial for its economic significance.

**(BIO-P 17760)** BIO-P-P5 (ECOP)

**Modeling the transport and connectivity of the parasite *Toxoplasma gondii* to improve marine mammal conservation**

Jennifer A.T.K. **Wong-Ala**[1], Johanna L.K. Wren[2], Stacie J. Robinson[3,4], Michelle Barbieri[3], Ryan R. Rykaczewski[2], Donald R. Kobayashi[2] and Lorenzo Ciannelli[1]

[1]College of Ocean, Earth, and Atmospheric Sciences Oregon State University, Corvallis, Oregon, USA. E-mail: wongalaj@oregonstate.edu

[2]Pacific Islands Fisheries Science Center Ecosystem Sciences Division/Pelagic Research Program, Honolulu, Hawai‘i

[3]Pacific Islands Fisheries Science Center Protected Species Division/Hawaiian Monk Seal Research Program, Honolulu, Hawai‘i

[4]USDAWS National Wildlife Research Center, Fort Collins, Colorado, USA

*Toxoplasma gondii* causes the parasitic infection toxoplasmosis which is found in warm-blooded animals. *T. gondii* oocysts are shed by cats, contaminating both the land and sea. Oocysts can persist in saltwater for years, pose a threat to marine animals such as the Hawaiian monk seal, and little is known about their fate in marine habitats. Our study focused on characterizing the connectivity and transport of *T. gondii* in waters surrounding the main Hawaiian Islands (MHI), investigating how ocean conditions affect oocyst distribution. We examined transport using a particle tracking model and Regional Ocean Modeling System (ROMS) for 2018–2021. We compared two ROMS setups: unnested (MHI ROMS) and nested (MHI ROMS, O‘ahu South shore (OSS) ROMS), to investigate the influence of finer ocean model resolution on oocyst transport in areas frequented by monk seals. A constant and variable number of particles were used to determine initial particle density. Our results show consistent retention for all islands and limited connectivity between northern and southern islands. Comparisons between ROMS setups show more connections between islands and greater retention in unnested simulations than nested simulations due to the higher resolution of currents in the OSS region. Initial particle density influences connectivity and transport at an order of magnitude less than the ROMS setup. Our work demonstrates the application of particle tracking models in understanding oocyst distribution. This model can aid current and future conservation practices to protect the Hawaiian monk seal and other marine mammals from areas with high oocyst exposure.

**(BIO-P 17764)** BIO-P-P6

**Cool ocean temperatures fail to buffer the negative impacts of heat exposure during low tide on the keystone predator *Pisaster ochraceus* (Ochre sea star)**

Lydia N. **Walton**[1], Viola R. Watts[1], Jasmin M. Schuster[1,2] and Amanda E. Bates[1]

[1]University of Victoria, Victoria, British Columbia, Canada. E-mail: lydiawalton14@gmail.com

[2]Hakai Institute, Calvert Island, British Columbia, Canada

Air temperatures are warming at faster rates than ocean temperatures, which may create reprieves from thermal stress by providing cool underwater refugia during extreme heat events. Many intertidal organisms rely on thermal refugia during aerial exposures at low tide, including the keystone predator *Pisaster ochraceus* which supports biodiversity in rocky shore ecosystems from Alaska to Baja California. Here we tested the feeding response and mortality rate of juvenile *Pisaster* under experimentally manipulated air (~20°C, 25°C, 30°C) and water (~15°C, 20°C) temperatures representing early summer, late summer, and heatwave conditions in Barkley Sound (British Columbia, Canada). We further made observations of air temperatures, sea surface temperatures, and *Pisaster* moribundity at our study location to support interpretation of our results. We predicted feeding would increase with late summer temperatures, but decrease during heatwave conditions as animals surpass their thermal optimum. We also predicted that mortality rates would be highest in temperatures above the thermal optimum of juvenile *Pisaster* (~30°C air). We observed the greatest mortality and lowest feeding in animals exposed to cool ocean temperatures (~15°C) and high aerial temperatures typical of extreme heat events (~30°C). Feeding rates increased with heat stress duration, indicating animals may be compensating for elevated metabolism. The highest levels of experimental and field moribundity were observed in August, suggesting *Pisaster* may have accumulated physiological stress damage following elevated air and ocean temperatures throughout the summer. Our research implicates shifts in community dynamics due to the loss of this keystone predator as air temperatures warm.

**(BIO-P 17779)** BIO-P-P7

**Comparison of microzooplankton grazing rate and phytoplankton growth rate in two different sites in Korean coastal waters**

Jaeyeon **Park**, Seung Joo Moon, Jun-Ho Hyung, Hangy Lee and Eun Young Yoon

Advanced Institute of Convergence Technology, Suwon, Korea. E-mail: bada0@snu.ac.kr

The NPZ model, like other marine ecosystem models, serves as a fundamental tool for understanding primary ecosystems. Within the NPZ model, biological factors such as grazing and growth rates are typically treated as constants due to the challenge of assigning varying values across different regional seas. However, relying on these constants can lead to increased uncertainty when applied to ecosystems in regional seas experiencing rapid changes due to global warming. To address this, we conducted dilution grazing experiments in two distinct sea areas to obtain actual measured values for parameters such as grazing and growth rates. By comparing these values between sea areas, we aim to improve the accuracy of future marine ecological models.

We conducted dilution grazing experiments in two distinct locations: Jinhae Bay, known for its relatively stable primary ecosystem, and the western coast of Jeju, which is significantly impacted by rising water temperatures. In each area, experiments were conducted during May and September to measure grazing and growth within the primary ecosystem. The results revealed notable differences between the two areas. Despite similar water temperatures and salinity levels, significant variations were observed in phytoplankton biomass, growth rates, mortality rates, and zooplankton feeding rates. Furthermore, the community composition of the primary ecosystems in these areas showed significant distinctions.

These findings are expected to provide a valuable foundation for further research aimed at enhancing the predictive capabilities of marine ecological models through the incorporation of actual data.

**(BIO-P 17783)** BIO-P-P8 (ECOP)

**Comparison of trophic sources and pathways of mesozooplankton and ichthyoplankton in the Kuroshio and its neighboring waters**

Ayane **Taniguchi**[1], Toru Kobari[2], Gen Kume[2], Mutsuo Ichinomiya[3], Tomohiro Komorita[2] and Junya Hirai[4]

[1]Graduate School of Agriculture, Forest and Fisheries, Kagoshima University, Kagoshima, Japan. Email: k5576935@kadai.jp

[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan

[3]Faculty of Environmental and Symbiotic Sciences, Prefectural University of Kumamoto, Kumamoto, Japan

[4]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan

Commercially important fishes spend their vulnerable early life stages in the Kuroshio and its neighboring waters resulting in their high fishery production, even in the vicinity of poor prey availability under the oligotrophic conditions. Nevertheless, there is little information on how ichthyoplankton are supported by trophodynamics in the complicated food webs. Here, we explore trophic sources and pathways toward ichthyoplankton in the Kuroshio and its neighboring waters based on metabarcoding analysis of gut content DNA for major taxonomic groups of mesozooplankton and ichthyoplankton. Calanoids were the most predominant and frequently appearing prey and gelatinous prey was the secondary for most of mesozooplankton and ichthyoplankton groups. Trophic networks based on their gut content DNA demonstrated that calanoids were the most important node with multiple linkages among their prey and predators and gelatinous mesozooplankton were the secondary node. Non-metric multi-dimensional scaling on their prey compositions classified the two different groups between the Kuroshio and its neighboring waters due to the dependance on calanoids. These findings suggest that calanoids were important hubs of trophic pathways toward ichthyoplankton and gelatinous mesozooplankton groups strengthen trophic relationships with multiple components. Contrary to the general thought, our metabarcoding analysis explores that trophodynamics toward ichthyoplankton are not strongly dependent on the grazing food chain but supported by multiple trophic pathways in the Kuroshio and its neighboring waters.

**(BIO-P 17787)** BIO-P-P9 (ECOP)

## Fatty acid composition of zooplankton composition in the Kuroshio and neighboring waters

Nao **Kominato**[1], Reo Ishimaru[1], Masafumi Kodama[2], Gen Kume[2] and Toru Kobari[2]

[1]Graduate School of Agriculture, Forest and Fisheries, Kagoshima University, Kagoshima, Japan. E-mail: k0660779@kadai.jp

[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan

The Kuroshio and its neighboring waters have been known as nursery grounds for early life stages of migratory fishes, despite of a poor food availability under the oligotrophic conditions. Recent findings suggest that zooplankton standing stocks are not always low and provide good prey availability for these larval fishes. However, there is limited information on nutritional evaluation of zooplankton community as the larval prey. Here, we investigated spatial and temporal variations in fatty acids contents of zooplankton community from the transect lines across the Kuroshio for evaluating nutritional conditions in the Kuroshio and its neighboring waters. We detected 5 saturated (SFA), 4 mono-unsaturated (MUFA) and 12 poly-unsaturated fatty acids (PUFA) from zooplankton community. Multivariate analysis demonstrated that fatty acids contents to zooplankton dry mass were changed between the regions and the seasons. SFA increased during summer and determined the temporal change. Major PUFA contents represented by arachidonic (ARA), eicosapentaenoic (EPA) and docosahexaenoic acids (DHA) were increased in the Kuroshio. These major PUFA contents exhibited significantly positive correlations to genetic abundance of Eucalanidae copepods and molluscans determined with metabarcoding analysis. These contents were also positively correlated with the representative fatty acid contents of diatoms, dinoflagellates, and haptophytes. These findings suggest that major PUFA contents of zooplankton community in the Kuroshio are equivalent to those in the Inshore of the Kuroshio due to the specific taxonomic groups and their feeding on major phytoplankton groups.

**(BIO-P 17790)** BIO-P-P10 (ECOP)

**Impacts of advected coastal community on zooplankton standing stocks, productivity and taxonomic composition in the Kuroshio**

Masahiro **Kodama**[1], Gen Kume[2], Masafumi Kodama[2], Hirohiko Nakamura[2], Ayako Nishina[2], and Toru Kobari[2]

[1]Graduate School of Agriculture, Forest and Fisheries, Kagoshima University, 4-50-20 Shimoarata, Kagoshima 890-0056, Japan. Email: k0848173@kadai.jp

[2]Faculty of Fisheries, Kagoshima University, 4-50-20 Shimoarata, Kagoshima 890-0056, Japan.

Kuroshio and its neighboring waters have been known as nursery grounds for early life stages of various forage fishes, despite of a poor prey availability under the oligotrophic conditions. Numerical experiments suggest that biological standing stocks and productivity in the Kuroshio is supplemented by zooplankton community advected with coastal waters. However, there is less information on the impacts of advected coastal community from oceanographic observations. Here, we investigated geographical variations in zooplankton standing stocks, productivity and taxonomic composition across the Kuroshio to evaluate the impacts of advected coastal community. The mixed ratios of the coastal waters estimated from salinity in the sampling layer were high at the stations near the southern Kyushu, while such spatial patterns were unclear at those in the northern East China Sea. Zooplankton abundance, biomass and individual body mass were increased with the mixed ratio of the coastal waters, indicating high standing stocks composed by larger animals in the coastal waters. Multivariate analysis on copepod taxonomic compositions identified the three groups, which were more pronounced for the seasonal appearance of Eucalanidae than the spatial patterns represented by pelagic copepod families (i.e., Mertridinidae, Clausocalanidae and Calocalanoidae). However, the relative contribution of major copepod families (Calanidae and Paracalanidae) to the pelagic copepod families was high under the high mixing ratios. These findings suggest that advections of the coastal waters increase zooplankton standing stocks in the Kuroshio and its neighboring waters due to the major copepod families.

**(BIO-P 17800)** BIO-P-P11 (ECOP)

**Modelling visitor nitrogen waste in coral reef habitats and implications for the future of sanitation management**

Mitra L. **Nikoo**[1] and Amanda E. Bates[1]

[1]University of Victoria, Victoria, Canada. Email: mnikoo@uvic.ca

Tropical coasts are a popular holiday destination for their coral reefs. Many countries want to expand their tourism sector to capitalize on these natural spaces. However, sanitation management is often neglected in development plans and visitors are often unaware of issues, unless confronted by an ugly reality. Extra nutrients from ocean-bound sewage, such as nitrogen, can fuel algal blooms and damage corals. This degrades the very environments that communities are trying to entice tourists to visit. Few studies have investigated tourism sewage outflow near these nutrient-sensitive habitats, and many only after problems with reef health became apparent. The COVID-19 pandemic provided a unique opportunity to examine on a global scale how much sewage nitrogen was prevented from entering coral reefs due to international travel restrictions and what effect this may have had on coastal algae. We used large-scale global datasets on food availability, tourism, population, and sanitation access to model the nitrogen waste from international visitors and how COVID-19 affected this output in marine biodiversity hotspots. We also examined whether the change in visitor nitrogen output was enough to prompt a detectable response from marine algae using remote sensing data, and the role sanitation treatment systems can play in reducing nitrogen output as tropical coastal communities draw visitors back to their coasts. Regions of high tourist activity and human density are at greater risk for eutrophication and coral disease on surrounding reefs. Results from this study may inform how to manage tourism wastewater impacts and improve management strategies.

**(BIO-P 17820)** BIO-P-P13

**Feeding by the marine chlorophytes on the unicellular cyanobacterium Synechococcus**

Suk Yeon Lee, Eun Sook Hwang, Chul Ho Kim, Jung Rae Rho and Yeong Du **Yoo**

Department of Oceanography, Kunsan National University, Kunsan 54150, Republic of Korea.
E-mail: ydyoo77@kunsan.ac.kr

Green microalgae are cosmopolitan species of phytoplankton and primary producers in marine environments. They often form harmful algal blooms in the coastal water of many countries. Thus, it’s very important to understand the bloom dynamics of chlorophytes. Some chlorophyte species are known to be mixotrophic organisms. The common marine chlorophytes Pyramimonas propulsa and Tetraselmis convolutae have not been investigated the nutrition modes. We explored the grazing by these species on the cyanobacterium Synechococcus. To test whether each species is able to ingest Synechococcus, we carefully observed the protoplasm of these species using epifluorescence microscope. We also measured the ingestion and clearance rates of P. propulsa and T. convolutae on Synechococcus as a function of prey concentration. Both P. propulsa and T. convolutae were able to feed on Synechococcus cells. The ingestion rates of P. propulsa on Synechococcus sp. increased rapidly with increasing mean prey concentration at the prey concentrations < 1.2 × 106 cells ml-1, but became saturated at higher prey concentrations. The ingestion rates of T. convolutae on Synechococcus increased rapidly with increasing mean prey concentration at the prey concentrations < 3.6 × 106 cells ml-1, but became slowly increased at higher prey concentrations. The maximum ingestion rates of were 0.40 and 0.49 cells predator-1 h-1. Thus, P. propulsa and T. convolutae could be effective grazers of cyanobacteria and would be valuable mixotrophic ability in marine ecosystems.

**(BIO-P 17840)** BIO-P-P14 (ECOP)

**Ecological interruption on food web dynamics by eutrophic water discharge from the world's longest dike at Saemangeum, Yellow Sea**

Inog **Lee**[1], Hosang Kim[1], Inha Kwon[1], Bong-Oh Kwon[2], Jae-Sung Kim[3], Junghyun Lee[4], Junsung Noh[5] and Jong Seong Khim[1]

[1]School of Earth and Environmental Sciences & Research Institute of Oceanography, Seoul National University, Republic of Korea. E-mail: leeinog@snu.ac.kr

[2] Department of Marine Biotechnology, Kunsan National University, Kunsan, Republic of Korea

[3] Water and Eco-Bio Corporation, Jungboo Building, Kunsan, Republic of Korea

[4] Department of Environmental Education, Kongju National University, Gongju, Republic of Korea

[5] Department of Environment & Energy, Sejong University, Seoul 05006, Republic of Korea

The man-made sea dike has disrupted the natural link between riverine and marine ecosystems and caused eutrophication within the aquatic ecosystem. The eutrophic water discharge has also raised concerns. As a representative tidal flat with the longest dike in the world, Saemangeum has experienced the problem of eutrophication. To elucidate the discharge water effects on the food web dynamics, a four-year round sampling was conducted in/outside of the Saemangeum sea dike. Stable isotope analysis was applied to benthos (a total of 54 species) and their potential diets. Water discharge tripled in period II (2021−2022) compared to the period I (2019−2020). However, there were no significant impact changes in food web structure between the two periods due to improved lake water quality in period II. A positive correlation of nutrient concentration between the inner and outer areas of the dike revealed a direct effect of the water discharge on the outer tidal flat. The water discharge altered the spatial environmental conditions and the food web structure of the outer tidal flat. High TN concentrations stimulated the biomass of microphytobenthos (MPB) near the water gates, which in turn increased MPB consumption by benthos, demonstrating the in/direct impacts of water discharge on the food web. Furthermore, filter feeders exhibited a more sensitive response to spatial organic matter distribution compared to deposit feeders in diet utilization. Overall, our novel findings on food web dynamics in a tidal flat with artificial structures emphasize the necessity of continuous monitoring to ensure the sustainability of coastal ecosystems.

(BIO-P17852 Poster) BIO-P-P15

# K-Blue Carbon Project: Estimating blue carbon sequestration potential of *Magallana gigas* in Korean aquaculture farms

Hyeong-Gi **Kim**[1], Du-young Jung[2], Bong-Oh Kwon[3], Tae-Lim Kim[2], Seohee Lim[2], Julie A. Kopplin[2], and Jong Seong Khim[4]

[1]Department of Marine Environmental Sciences, Chungnam National University, Daejeon 34134, Republic of Korea e-mail: h-g.kim@cnu.ac.kr

[2]Department of Earth, Environmental & Space Sciences, Chungnam National University, Daejeon 34134, Republic of Korea

[3]Department of Marine Biology, Kunsan National University, Kunsan, 54150, Republic of Korea

[4]School of Earth and Environmental Science & Research Institute of Oceanography, Seoul National University, Seoul, 08826, Republic of Korea

Bivalves absorb bicarbonate ($HCO_3^-$) from seawater to form their shells ($CaCO_3$), and as filter feeders, they can rapidly sequestrate organic carbon from seawater into sediments, thereby contributing to long-term carbon sequestration. This study aims to investigate the carbon storage potential of *Magallana gigas* cultured in Korea. Oyster samples were monthly collected at four aquaculture farms on the southern coast of Korea from April 2022 to March 2024 to analyze their growth rate, the proportion of organic carbon in the body and inorganic carbon at the shell. Sediment core samples were also collected to investigate the amount of organic and inorganic carbon in the sediment of aquaculture farm. Oysters contained 11.5 ± 0.07% inorganic carbon through the shell and 39 ± 2% organic carbon through the tissue, with no changes in carbon content observed with growth It was found that Korean oyster farms store 8.1 MgC ha-1 yr-1 of carbon through their shells and 12.1 MgC ha-1 yr-1 of carbon through their tissues. The bivalve aquaculture area on the southern coast of Korea were estimated to store about 11.23 MgC ha-1 of organic carbon and 11.81 MgC ha-1 of inorganic carbon, which is a high amount compared to the tidal zone in other countries. These results demonstrate that oyster farming can play a significant role in long-term carbon storage.

(BIO-P 17906) BIO-P-P16

**Bloom formation of colony-forming harmful diatom Thalassiosira diporocyclus in the Kagoshima Bay and its significance as prey for some copepods**

Mutsuo **Ichinomiya**[1], Tomohiro Komorita[1], Gen Kume[2] and Toru Kobari[2]

[1]Prefectural University of Kumamoto, Kumamoto, Japan. E-mail: ichinomiya@pukumamoto.ac.jp

[2]Kagoshima University, Kagoshima, Japan

The colony-forming diatom species, Thalassiosira diporocyclus, which forms large colonies up to several millimeters, often makes condense blooms in the coastal areas of Japan along with the Kuroshio Current. This species is recognized as a harmful alga since its gelatinous colonies become entangled in fishing nets, making trawling difficult. However, little is known about factor of bloom formation and their significance as food items for mesozooplankton. We investigated the abundance of T. diporocyclus in spring in Kagoshima Bay and conducted feeding experiments of the dominant copepods on T. diporocyclus. T. diporocyclus was dominant among the diatom community at the bay mouth where upwelling events occurred due to intrusion of the warm water mass originated from the Kuroshio Current. This suggests T. diporocyclus makes bloom due to the nutrient supply accompanying upwelling in the front between the coastal areas and the Kuroshio Current. Colony size was 1.7±1.0 mm in average, reaching a maximum of 10.1 mm. At the feeding experiment, the ingestion rates of Calanus sinicus, Eucalanus spp. and Oncaea spp. on the colonies were quite low, but they actively ingested on the single cells. The single cells of T. diporocyclus after disintegration of the colonies would be important food items for the dominant copepods, while their colonies are not utilized.

**(BIO-P 17929)** BIO-P-P-17

**Long-term trend of Baird's beaked abundance in the Pacific coast off Japan**

Hiroko **Sasaki** and Yu Kanaji

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

Baird's beaked whales *Berardius bairdii* have long been taken by coastal whalers since early 17$^{th}$ century. Among three putative stocks around the Japanese coast, Pacific coast (PC) stock inhabiting the waters off Sanriku and southern Hokkaido has been a main target by the coastal whaling. Warm Kuroshio and cold Oyashio converge in these waters, which makes highly productive fishing grounds. On the other hand, these areas have often experienced extremely high-water temperatures in recent years, which affected both biomass and distributions of several species. Given long whaling history and recent environmental changes, the population status of PC stock of Baird's beaked whales and sustainability of coastal whaling have been concerned. The first quantitative assessment of PC stock abundance was made in early 1990s; that was 4,200 whales (Confident Intervals, CI = 2,718–6,549). Our research group has conducted long-term dedicated sighting survey (JAFRACSS-BB) and published those abundances to be 1,524 in 2008 (885-2,626) to 3,596 (1,966-6,576) in 2017. This presentation reports updated abundance estimates for 2021–2023 based on the data collected by JAFRACSS-BB program. Similar to the previous analyses, abundance was estimated according to standard line-transect approach. As a result, we obtained the following abundance estimates for the PO stock of Baird's beaked whales: 2,005 (1,090–3,688) in 2021, 3,692 (1,984–6,868) in 2022, and 1,611 (856–3,031) in 2023. When a simple exponential model was fit to the past and recent abundance time-series, we found that the stock tended to decrease over the past few decades.

**(BIO-P 17951)** BIO-P-P-18

**Estimating species- and population-specific life history parameters of two small cetacean species, particularly important for population dynamics modeling**

Hikari **Maeda** and Yu Kanaji

Japan Fisheries Research and Education Agency (FRA), Yokohama, Japan. E-mail: maeda_hikari39@fra.go.jp

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. In addition, some important parameters, such as reproductive senescence observed in female short-finned pilot whales, were not explicitly modelled. Incorporating these species- and population-specific biological characteristics would provide more realistic modeling on their population dynamics. Here, we analyzed the relationship between age and maturity status and estimated age at sexual maturity by sex and survival rate for common bottlenose dolphins and short-finned pilot whales in Bayesian framework using latest biological information. We will discuss how the biological characteristics can be integrated into the population dynamics models and can improve future direction in management and conservation of small cetacean species

**(BIO-P 17969)** BIO-P-P-19 (ECOP)

**Global boiling and adaptive green-living shoreline project with blue carbon, South Korea**

Junsung **Noh**[1], In Ok Lee[2] and Moo Joon Lee[3]

[1]Department of Environment & Energy, Sejong University, Seoul 05006, Republic of Korea. *E-mail: junsungsea@sejong.ac.kr

[2]School of Earth and Environmental Sciences & Research Institute of Oceanography, Seoul National University, Seoul 08826, Republic of Korea *E-mail: leeinog123@gmail.com

[3]Department of Marine Biotechnology, Anyang University, Incheon 23038, Republic of Korea *E-mail: mjoon@anynag.ac.kr

The Korean government has recognized the significance of "Blue Carbon (BC)" as a promising solution for reducing carbon in marine environments with a 2050 Net-zero future in mind. To this end, Korean marine scientists have proposed a new initiative called the "Coastal New Deal (CND)," which benchmarks the BC concept and incorporates the US Living Shorelines project. This initiative aims to explore sustainable shoreline management techniques, including enhancing marine biodiversity, mitigating coastal erosion, and buffering against sea-level rise, all tailored to the Korean coastal regime. The CND initiative incorporates three primary strategies. First, the "Green Living" approach involves planting salt-tolerant plants and seagrasses to enhance carbon sequestration. Second, the "Blue Living" strategy emphasizes the creation of oyster reefs and similar structures to combat coastal erosion. Finally, the "Soft Living" method focuses on modifying hard coastal infrastructure to better adapt to rising sea levels. As part of the Green Living approach, we have designed an experimental mesocosm system to simulate the increase in surface seawater temperature in salt marshes and evaluate potential changes in carbon storage within tidal flat sediments. The purpose of this study is to understand the altered carbon sequestration rates in future blue carbon ecosystems and to find adaptive techniques suited to warming future coastal environments. The ultimate goal is to promote sustainable salt marsh management and contribute to the achievement of Net-zero 2050.

**(BIO-P 17971)** BIO-P-P20

**Life cycle analysis of the dominant planktonic copepod *Metridia okhotensis* based on samples collected by deep-ocean water pumping at Rausu in the southern Okhotsk Sea**

Atsushi **Yamaguchi**[1], Kazuki Maeda[1], Daichi Arima[2], Takahiro Nobetsu[3], and Hideki Yamaishi[4]

[1]Hokkaido University, Hakodate, Japan. E-mail: a-yama@fish.hokudai.ac.jp

[2]Hokkaido Research Organization, Yoichi, Hokkaido, Japan

[3]Shiretoko Nature Foundation, Rausu, Hokkaido, Japan

[4]Rausu Town, Rausu, Hokkaido, Japan

The calanoid copepod *Metridia okhotensis* is the predominant species of zooplankton community in the southern Okhotsk Sea. However, limited information is available on the life cycle of *M. okhotensis* in the southern Okhotsk Sea. Rausu Town on the southern Okhotsk Sea collects deep-ocean water by pumping from a depth of 356 m at 2.78 km from Rausu fishing port. This study analyzed time-series zooplankton samples collected by the deep-ocean water pumping in Rausu, and evaluated the life cycle patterns of the dominant copepod *M. okhotensis*. 515 zooplankton samples were collected from September 2007–September 2009 and September 2022–September 2023. There were clear seasonal changes in population structure, sex ratio, and C6F gonad maturation of *M. okhotensis*. Adults (C6) were the most abundant in population structure from January to April. For the sex ratio, females and males were nearly equal in C5 throughout the year. While in C6, females predominated from June to November, males rapidly increased their compositions in December, and males outnumbered females from December to April. The gonad maturation of C6F also showed clear seasonality. The majority of C6F had immature gonads from July to November. Gonad maturation began rapidly after December, and the spawning individuals were abundant from February to May, with a peak in late April. Through this study, the life cycles of *M. okhotensis* were summarized as follows: *M. okhotensis* may have a resting phase at C6F with immature gonads and C5M during the warm-water period: July to November.

**(BIO-P 18004)** BIO-P-P21

**Springtime upwelling conditions drive thiamin-associated microbiomes in the California Current Ecosystem (CCE)**

Kelly C. **Shannon**[1], Gillian St. John[1], Robin Gould[1], Christopher Hartzell[1], Hailey Matthews[1], Elizabeth J. Brennan[1], Luis M. Bolaños[2], Steven T. Lindley[3], John C. Field[3], Nate Mantua[3], Rachel Johnson[3,4], Carson Jeffres[4], Frederick S. Colwell[1], and Christopher P. Suffridge[1]

[1]Oregon State University, OR, USA. E-mail: shannonk@oregonstate.edu

[2]University of Exeter, United Kingdom

[3]NOAA Fisheries, Santa Cruz, CA. USA.

[4]University of California, Davis, CA, USA.

Seasonal upwelling makes the California Current Ecosystem (CCE) one of the most biologically productive ecosystems on Earth. Few studies have measured dissolved concentrations of thiamin (vitamin B1; B1), an essential metabolic coenzyme that structures marine microbial communities. To connect thiamin availability with microbial communities in the CCE, we measured both concentrations of dissolved thiamin and its biochemically related moieties (thiamin-related compounds; TRCs) and 16S rRNA genebased microbial communities during the spring upwelling. Our data revealed significant correlations between TRC concentrations and relative abundances of bacteria, archaea, and eukaryotic algae in depths spanning the mixed layer. During our sampling dates, periods of strong upwelling were associated with lower concentrations of thiamin precursors and breakdown products, while weaker upwelling periods saw relatively high TRC concentrations. These findings suggest that upwelling-driven microbial community changes alter the dissolved pool of TRCs. TRC-associated microbial genera varied in relative abundances based on the chemical and oceanographic characteristics of individual sample stations, independent of sampling latitude. Diatoms, Proteobacteria, Bacteroidota, Verrucomicrobiota, Crenarchaeota, and other taxa of high relative abundances influenced concentrations of thiazole moieties to a larger degree than other TRCs, implicating these compounds as important metabolic currencies to CCE microbial communities. Our data show that upwelling conditions and site-specific chemical and oceanographic factors influence thiamin-related microbiomes. Eastern boundary current ecosystems are disproportionately impacted by climate change, resulting in altered food web diversity and making the study of fine-scale controls on biological productivity in these systems essential.

**(BIO-P 18026)** BIO-P-P22 (ECOP)

**Importance of mixotrophic oligotrich ciliates in the subarctic and subtropical western North Pacific**

Chiho **Funaki**, Taketoshi Kodama, Mitsunori Iwataki and Kazutaka Takahashi

Graduate School of Agricultural and Life Sciences, The University of Tokyo, Bunkyo, Tokyo, Japan. E-mail: chiho-funaki@g.ecc.u-tokyo.ac.jp

Mixotrophic plankton, which combine the uptake of inorganic resources and the ingestion of living prey, are ubiquitous in marine ecosystems, but their spatiotemporal variations are less investigated, and thus its integrated impact on global biogeochemical cycles and biological production remains unknown. In this study, we focused on the oligotrich ciliates, which are major components of microplankton and often known to be important non-constitutive mixotrophs, in particular for their abundance, biomass, and growth rates in the western North Pacific. Field samplings were conducted at the subarctic HNLC region and subtropical oligotrophic region in July 2023 to investigate the vertical distribution and contribution of mixotrophic cells in the surface waters. Mean integrated cell abundances of oligotrich ciliate were $121 \times 10^6$ cells $m^{-2}$ (0–60 m) in the subarctic and $28 \times 10^6$ cells $m^{-2}$ (0–100 m) in the subtropical regions. Mean contributions of mixotrophic cells to total oligotrich ciliate were 80% and 84% for subarctic and subtropical regions, respectively. The growth rates of oligotrich ciliate were faster than diatom and dinoflagellate regardless of the sampling stations: 0.3–1.8 $day^{-1}$ and 0.32–1.4 $day^{-1}$ in the subarctic and subtropical regions, respectively. The results indicate that almost oligotrich ciliates in the western North Pacific during summer show mixotrophy, which is possibly key to sustaining its high growth rates. Since oligotrich ciliate is the main prey of copepods both in subarctic and subtropical regions, the high contribution of mixotrophy may be essential to maintaining the grazing food chain in the western North Pacific during summer.

**(BIO-P 18034)** BIO-P-P23 (ECOP)

**Local-scale recovery of the red-listed sunflower sea star (*Pycnopodia helianthoides*) is associated with kelp in Barkley Sound, BC**

Valesca **de Groot**, Jasmin M. Schuster, Mara Bohm, Tomas Bird and Amanda E. Bates

University of Victoria, 3800 Finnerty Rd, Victoria, BCV8 P5C2, Canada. E-mail: vdegroot@uvic.ca

Mass mortality events may become more frequent or severe due to climate change and have cascading effects when impacting keystone predators. For instance, the population collapse of the Pacific Northeast sunflower sea star (*Pycnopodia helianthoides*; 2013-2015) reduced their population by 90%. *Pycnopodia* is a top predator and promotes healthy kelp forests by keeping the densities of barren forming urchins in check, thus playing a role in supporting kelp ecosystems. Kelp forests are important fish nursery sites, but their impact on *Pycnopodia* recovery remains understudied. Here, we ask whether kelp habitats are associated with *Pycnopodia* recovery. We predicted higher abundance of *Pycnopodia* at sites with kelp, associated with more successful juvenile retention. We recorded *Pycnopodia* abundance and size data over 4 years (2021-2024) on shallow rocky reefs (4-10m depth) in Barkley Sound (British Columbia, Canada). In 2021 and 2022, *Pycnopodia* were present at only 3 and 4 sites (n=13 sites), respectively, and did not reach adult sizes (<20cm). In 2023, occupancy doubled, and density increased by ~400%, with 84% of *Pycnopodia* occurring at sites where kelp was present. Adult *Pycnopodia* were only recorded in 2023 (n=4 individuals). While occupancy dropped by nearly half in 2024, sites with kelp hosted 77% of the *Pycnopodia* observed, suggesting that kelp may be a preferred habitat with selection occurring at larval/post-settlement stages. Our findings imply that kelp forest restoration efforts may also support *Pycnopodia* recovery, reintroducing crucial predation pressures on urchins to further re-establish kelp forests and the ecosystem functions they provide.

**(BIO-P 18038)** BIO-P-P24

**Response mechanism of meiofaunal communities to multi-type of artificial reef habitats from the perspective of high-throughput sequencing technology**

Zhaoyang **Jiang**, Zhenlin **Liang**, Minpeng Song, Jiahao Wang, Yuxin Wang, Renge Hu, Lu Wang and Zhansheng Guo

Shandong University, Weihai, China. E-mail: jiangzy@sdu.edu.cn

Multiple types of artificial reefs have been widely deployed in the coast of northern Yellow Sea, which can enhance fishery resources, restore coastal habitats and improve the marine environment. Meiofauna plays important ecological roles in marine ecosystem, but the response mechanism of meiofaunal community to different types of artificial reef is still poorly understood. In this study, we characterized the meiofaunal communities of concrete artificial reef habitat (CAR), rocky artificial reef habitat (RAR), ship artificial reef habitat (SAR) and adjacent natural habitat (NH) using 18S rRNA gene high-throughput sequencing technology, and explored the relationship of community-environment. The results showed that the diversity and community structure of meiofauna differed significantly on both spatial and temporal scales. Spatial differences were mainly contributed to the flow field effects and biological effects generated by artificial habitats, while temporal differences were driven by temperature (T) and dissolved oxygen (DO). The dominant taxa of meiofauna included arthropods, annelids, platyhelminths and nematodes. Platyhelminths were mainly positively influenced by artificial habitats but annelids were the opposite. Co-occurrence network analysis revealed that NH was more sensitive to environmental change than artificial habitat, while the performance of CAR and SAR were more stable. These results indicated that meiofauna can respond accordingly to different types of artificial habitats, and could be superimposed over the normal seasonal effects. The current study could provide fundamental data for understanding the response mechanism of meiofaunal community to different types of artificial habitats and a reference for assessments of the impact of artificial reefs on the marine environment.

**(BIO-P 18049)** BIO-P-P25 (ECOP)

**Importance of Accurately Identifying Trophic Position in Pollution Assessment Studies**

Eun-Ji **Won**[1], Dokyun Kim[1,2], Ha-Eun Cho[1], Jangho Lee[3], Sae-Yun Kwon[4] and Kyung-Hoon Shin[1]

[1]Hanyang University, Ansan, Republic of Korea. E-mail: ejwon@hanyang.ac.kr

[2]Korea Institute of Ocean Science and Technology, Busan, Republic of Korea

[3]National Institute of Environmental Research, Incheon, Republic of Korea

[4]Pohang University of Science and Technology, Pohang, Republic of Korea

This study presents an integrated approach for evaluating the trophic position (TP) and mercury concentration ([Hg]) in black-tailed gull (Larus crassirostris) eggs collected from Korean islands. Using compound-specific isotope analysis (CSIA) and quantitative fatty acid signature analysis (QFASA), we estimated the TP of seabirds across various ecosystems. The application of multiple mixing trophic discrimination factors (TDF) and mixing β enabled accurate TP calculation. The TP of black-tailed gull eggs was estimated to be 3.3–4.0, reflecting spatial differences in diet origin. Additionally, mercury concentrations in the eggs were adjusted according to TP, allowing for regional comparisons. After TP adjustment, the total [Hg] in all egg samples was standardized to levels exceeding EU criteria. This integrated approach demonstrates the utility of black-tailed gull eggs for marine pollution monitoring and environmental reconstruction, providing valuable insights into the relationship between avian ecology and environmental contamination.

(BIO-P 18077) BIO-P-P26 (ECOP)

**K-Blue Carbon Project: Estimating blue carbon sequestration potential based on shell growth of *Argopecten irradians* in Korean aquaculture farm**

Tae-Lim **Kim**[1], Hyeong-Gi Kim[1, 2, *], Du-young Jung[1], Bong-Oh Kwon[3], Seohee Lim[1], Julie A. Kopplin[1] and Jong Seong Khim[4]

[1]Department of Earth, Environmental & Space Sciences, Chungnam National University, Daejeon 34134, Republic of Korea e-mail: h-g.kim@cnu.ac.kr

[2]Department of Marine Environmental Sciences, Chungnam National University, Daejeon 34134, Republic of Korea

[3]Department of Marine Biology, Kunsan National University, Kunsan, 54150, Republic of Korea

[4]School of Earth and Environmental Science & Research Institute of Oceanography, Seoul National University, Seoul, 08826, Republic of Korea

This study investigates the carbon sequestration capabilities of *Argopecten irradians*, a species accounting for 18.3% of domestic bivalve aquaculture production, which witnessed a significant increase in yield in 2024. Bivalves capture carbon dissolved in seawater, transforming bicarbonate into calcium carbonate for shell formation and sequestering organic carbon through metabolic activities. From August 2023 to April 2024, monthly samples from a south coast aquaculture farm were analyzed to determine growth rates and inorganic carbon content within the shells. Preliminary findings from August to October 2023 indicated an inorganic carbon presence of 11.84 ± 0.08% in the shells, with no significant changes correlating to growth (Pseudo-F = 3.08, df = 2, p-value = 0.07). The results suggest that Korean scallop farms have the potential to store approximately 1.61 MgC ha-1 yr-1 in shell carbon, highlighting the role of domestic aquaculture in long-term carbon sequestration.

**(BIO-P 18083)** BIO-P-P27 (ECOP)

**The intra- and inter-specific overlaps of foraging sites and diet in sympatric seabirds breed on the colonies in the Tsugaru strait, Japan**

Hikari **Ozawa**, Teru Kanaida, Shunsuke Nibe, Tatsuki Kojima and Motohiro Ito

Tokyo University, Asaka, Japan. E-mail: hikari.ozawa0303@gmail.com

Sympatric seabirds might face intra- and inter-specific competitions especially during the central place foraging. It is important to understand their ecological niche partitioning / sharing among coexisting multi-species and among same species breed on adjacent colonies. In this study, we compared foraging site selection by GPS-logger data and prey selection by bill-loads or regurgitation analysis in two sympatric seabirds, Rhinoceros auklet *Cerorhinca monocerata* (diving foragers) and Black-tailed gull *Larus crassirostris* (surface foragers), breed on the three adjacent colonies (Matsumae-Kojima, Tai and Benten), in the Tsugaru Strait. We found that all species from all adjacent colonies, except the gulls from Tai Island, overlapped at the Cape Esan (overlap index: UDOI = 0.31-0.51), and segregated foraging sites with all adjacent conspecifics at around their colonies (UDOI = 0-0.08), as well. The foraging sites of the sympatric breeding auklets and gulls often overlapped at near their colonies (UDOI=0.31-0.51). Anchovies were the main diet both in the auklets and gulls, but more dominant in the auklets (Wet Weight % > 57.3-100%) than in the gulls (Wet Weight % > 42.9-50.4%), and the gulls use the more wide-ranging food sources including invertebrates and mesopelagic micronectons. Although foraging site and diet often overlapped among intra- and inter-specifics, all species had some differentiated features, may mitigate competitions. Furthermore, both species in this region specifically used the Cape Esan, located on the Pacific side of the Tsugaru Strait. This area may have formed a biological hotspot that provide large benefits for seabirds beyond the intra- and interspecific competitions.

**(BIO-P 18098)** BIO-P-P29

## Synchronized birthdates and lay dates: ocean-climate modulated phenology of rockfish and seabirds within the California Current Ecosystem

John C. **Field**[1,2] ,Tanya L. Rogers[1,2],Jarrod A. Santora[1,2], Jaime Jahnke[3], Pete Warzybok[3], Mike Johns[3] Steven J. Bograd[2,4] and Isaac D. Schroeder[2,4]

[1] Fisheries Ecology Division, Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz, CA, USA email: John.Field@noaa.gov

[2] Institute of Marine Sciences, University of California, Santa Cruz, CA 95064, United States

[3] Point Blue Conservation Science, Petaluma, CA 94952, USA

[4] Ecosystem Science Division, Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz, CA, USA

We explore how regional variability in oceanographic conditions affects the phenology of recruitment success in pelagic juvenile rockfishes and how that relates to the phenology of reproductive effort in seabirds on the Farallon Islands that forage on rockfish within the California Current Ecosystem. Mean parturition (birthdates) for several species of live-bearing, winter spawning rockfishes (*Sebastes spp.*) were estimated from a time series of pelagic young-of-the-year (YOY) abundance from a midwater trawl survey since 1983. Seabird egg lay date data for several species (including Common Murre and Cassin's Auklet) have been monitored since 1972 (along with population abundance and productivity data). Through a previously established ecosystem oceanographic framework, climate and oceanographic observations were compiled from late winter through spring, and path models were developed to link climate indices to biological time series (rockfish parturition dates, rockfish abundance, seabird egg lay dates) to test hypotheses pertaining to the drivers of rockfish and seabird phenology. Our results suggest that neither rockfish nor seabirds show temporal trends in reproductive phenology, that rockfish and seabird phenology are positively correlated (early rockfish parturition dates are associated with earlier egg lay dates), that rockfish phenology is best explained by source water composition, and that seabird phenology is best explained by both rockfish phenology and ocean temperatures. The results are consistent with previous analyses that emphasize the close relationship between YOY rockfishes and breeding seabird dynamics and productivity in this ecosystem.

**(BIO-P 18109)** BIO-P-P30

**Microbial food web dynamics in the North Bering and Chukchi Seas assessed using linear inverse modeling**

Jens M. **Nielsen**[1], Thomas B. Kelly[1], Silvana Gonzalez[1], Michael W. Lomas[1], Lisa B. Eisner[1], Calvin Mordy[1], Andrew McDonnell[1], Stephanie O'Daly[1], Russ Hopcroft[1], Dean Stockwell[1], Seth Danielson[1], Laurie Juranek[1], Haley Cynar[1], Jeff Krause[1], David Kimmel[1], Adam Spear[1], Astrid Schnetzer[1], Miranda Hart[1], Remi Pages[1], Claudine Hauri[1], Tyler Hennon[1] and Laura Whitmore[1]

[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington email: jens.nielsen@noaa.gov

Resolving carbon flows in marine planktonic foodwebs is a fundamental step for understanding the energy available for higher trophic level consumers and overall food web processes, production and function. Inverse food web modeling is a convenient data driven modeling approach for estimating carbon fluxes in marine food webs. Using empirical biomass and rate measurements, inverse food web modeling allows reconstruction of trophic flows and quantification of biological rates that are commonly challenging to measure. Here we use in-situ phytoplankton, microzooplankton, zooplankton, sedimentation and primary production data collected from 3 ecosystem surveys in the Chukchi and Northern Bering seas, June (spring) 2017 and 2018, and August-September (summer) 2017 and 2019. We assess, 1) partitioning of energy, in terms of carbon, between the pelagic food web and deposition to the benthos, 2) how does transfer and major pathways vary between seasons (June vs August/September), and 3) how does food web carbon pathways vary between nutrient replete and deplete areas. Initial simulations indicate seasonal differences in major carbon pathways. Higher carbon fluxes appeared to be available for benthic consumers in spring (in areas of high primary production) compared to late summer. Our initial analyses also revealed the importance of carbon uptake and transfer in microzooplankton and bacterial compartments, organisms and processes that are often underestimated on many ecosystem models. Overall, our results indicate variable carbon transfer efficiencies among seasons and areas of nutrient replete and deplete conditions, something that should be considered when evaluating larger food web processes.

**(BIO-P 18110)** BIO-P-P31 (ECOP)

**Blood stable isotope ratio of adults of a diving piscivore seabird shows variation in trophic niche across years and colonies**

Tatsuki **Kojima**[1], Hikari Ozawa[1], Jumpei Okado[2], Yutaka Watanuki[3], Kotaro Shirai[4], Yasuaki Niizuma[5], Tomohiro Kuwae[6], Kenta Watanabe[6], Kazuya Matsumoto[7], and Motohiro Ito[1]

[1] Toyo University, Asaka, Japan. E-mail: ito@toyo.jp

[2] Nagoya University, Nagoya, Japan

[3] Hokkaido University, Hakodate, Japan

[4] The University of Tokyo, Kashiwa, Japan

[5] Meijo University, Nagoya, Japan

[6] Port and Airport Research Institute, Yokosuka, Japan

[7] Tsukuba University, Tsukuba, Japan

Rhinoceros Auklets *Cerorhinca monocerata*, a diving piscivore seabird, switch prey species in the bill-loads brought back to colonies for their chicks in responding to the recent decadal climate change in the western North Pacific. The adults are expected to feed on prey species that is different from those for chicks as they capture and digest their food at the sea. But quantitative evaluation of the diets of adults was technically challenging. To evaluate the spatio-temporal variability of trophic niche size of adults as well as prey for chicks, we sampled blood of the auklets as well as bill-loads for chicks at five breeding colonies in the northern Japan (Teuri, Matsumae Kojima, Tai, Benten, and Daikoku) in 2004, 2005 and the intermittent years from 2015 to 2023. Using the stable isotope ratio ($\delta^{13}C$ and $\delta^{15}N$) of the blood plasma, we estimated the trophic niche size (SEAc; SIBER in R) of adults. Anchovy was the primary prey in the bill-loads across colonies in 2004-2005 and 2021-2023, but cold-water living fishes, including juvenile greenling and salmon were dominant in 2015-2019. The trophic niche size of the adults varied between years and colonies and was negatively affected by the proportion of anchovy in chick's diet ($r^2$=0.37, $p<0.05$). This indicates that variability of the adult's diet shows a similar trend with that for chicks. The stable isotope ratio of adult blood, however, varied between colonies and years even when anchovy was dominant prey for chicks; indicating spatio-temporally variability in the lower tropic components.

**(BIO-P 18113)** BIO-P-P32 (ECOP)

**Hidden underlying mechanisms for changes in mesozooplankton communities: Transport and eddy driven changes**

Minju **Kim**[1,2], Wonkeun Choi[2,3], Chan Joo Jang[2,3,4] and Jung-HoonKang[1,2]

[1]Ecological Risk Research Department, Korea Institute of Ocean Science and Technology, Geoje 53201, Republic of Korea. E-mail: minjukim@kiost.ac.kr

[2]Department of Ocean Science, University of Science and Technology, Daejeon 34113, Republic of Korea

[3]Ocean Circulation and Climate Research Department, Korea Institute of Ocean Science and Technology, Busan 49111, Republic of Korea

[4]Ocean Science and Technology School, Korea Maritime and Ocean University, Busan 49112, Republic of Korea

Mesozooplankton communities have been used extensively as reliable climate change indicators, mainly because of their rapid growth and sensitivity to environmental changes. This study explored the modifications in the taxonomic composition of the mesozooplankton community and the associated physical changes of transport-driven, eddy-driven, and marine heatwaves in the summers of the last 14 years (2009–2022) within the mixed layer of the Ulleung Basin in the East Sea/Japan Sea, where surface waters have rapidly warmed in recent decades. A slight increase was observed in the abundance of mesozooplankton from 2009 (3709 inds.$m^{-3}$) to 2022 (4231 inds.$m^{-3}$), with two notable peaks in 2015 (11,377 inds.$m^{-3}$) and 2020 (11,184 inds.$m^{-3}$), which was mainly attributed to the prevalence of *Noctiluca scintillans*. The first peak in 2015 showed thaliaceans to be the next dominant taxa, in which the southward direction of meandering in East Korea Warm Current (EKWC), presence of the Ulleung warm eddy, lower volume of the Western Channel (V-west) of the Korea Strait, and marine heatwaves (MHWs) did not occur. In contrast to the first peak, the second peak in 2020 showed *Pyrocystis pseudonoctiluca* to be the next dominant species, which may have been transported and advected by the strong V-west and eastward direction of the EKWC and the occurrence of MHWs that allowed the persistence of the subtropical species *P. pseudonoctiluca*. Overall, the significant increases in the second dominant mesozooplankton taxa appeared to be affected by physical changes, including transport or eddy-driven changes, along with the occurrence of strong V-west, the direction of the EKWC, and the occurrence of MHWs, which may synergistically influence the increase in the second dominant taxa during summer. This study highlights the complex interplay between notable variations in mesozooplankton communities and environmental factors, highlighting the potential consequences of different physical changes (transport-driven and eddy-driven) in this regional ocean.

**(BIO-P 18116)** BIO-P-P33 (ECOP)

**Seasonal resilience of fish biogeography in the temperate estuary under climate change**

Cui **Liang**[1,2], Zhaopeng Zhang[1,2], Yuanchao Wang[1,2],Lei Zheng[1,2] and Weiwei Xian[1,2,3]

[1]Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China. E-mail: wwxian@qdio.ac.cn

[2]Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

[3]Center for Ocean Mega-Science, Chinese Academy of Sciences, Qingdao, China

The complexity of how seasonal environmental fluctuations affect fish populations and functional assemblages in biogeography under climate change remain to be elucidated. Collected monitoring data on fish resources in the temperature estuary provide an opportunity to assess the effects of seasonal environmental fluctuations on populations and functional assemblages under climate change. We first developed a framework for predicting habitat suitability under different climate change scenarios (SSP1-2.6 and SSP5-8.5) for 12 fish populations in the Yangtze estuary by examining the seasonal environmental affinities of temperate estuarine fishes. We then summarized the multidimensional habitat suitability responses (HSRs) of populations and functional assemblages and discussed the possible driver underlying these changes. The results suggest that the acidity of the Yangtze estuary may decrease in the future, threatening the availability of habitat for many fish species and that this threat may increase as the climate warms. Prospective climate change may influence the HSRs of fish populations in terms of redistribution, area change, and centroid migration of suitable habitats, while similarities in the affinity of populations for environmental variables may only distinguish their spring response patterns. From the perspective of suitable habitat area, both fish (5 populations) and functional assemblages (11 assemblages) may show resilient adaptations or non-adaptations to climate change as seasons change. Predictions also indicate that suitable habitat centroids for most fish and functional assemblages tend to move northeast in the spring and southeast in the autumn. Efforts to address climate risks and protect resources should take this seasonal forecast information into account.

**(BIO-P 18124)** BIO-P-P34 (ECOP)

**Seabird mechanisms of response to changing ocean stratification**

Helen **Killeen**, William J. Sydeman, Sarah Ann Thompson, Trond Kristiansen, Brian Hoover, Gammon Koval, and Marisol García-Reyes

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

Increasing thermal (and density) stratification limits ocean mixing, and can affect nutrient availability and lower trophic level productivity. Thermal stratification may thereby impact predator trophic dynamics and reproductive performance by affecting prey abundance or the accessibility of prey in the epipelagic zone. These mechanisms are particularly threatening for marine predators, such as seabirds, whose foraging range is vertically constrained to the surface layer of the ocean. Ocean stratification has increased globally by 5.3% since the 1960s, corresponding to decades of decline in productivity of many seabird species. Stratification is expected to continue to increase over the next 50 years, making it critical to understand stratification effects on secondary and tertiary (seabird) productivity. In this study, we test the hypothesis that stratification impacts seabird productivity through food availability in the North Pacific and other regions of the world. Specifically, we use structural equation modeling to assess linkages between stratification (ocean reanalysis model [GLORYS]-derived potential energy anomaly), primary production (GLORYS-derived chl-a concentration), prey availability and seabird breeding productivity (concurrent, co-located time series). We use standardized coefficients to estimate variation in the weight of linkages between variables and assess the direct effect of stratification on seabirds compared to the step-by-step indirect effect of stratification on seabirds (i.e., through its influence on chl-a, the influence of chl-a on prey, and the influence of prey on seabirds). This study characterizes geographically diverse pathways through which stratification impacts a taxonomically diverse group of marine predators, improving our understanding of the ecological implications of climate change.

**(BIO-P 18140)** BIO-P-P35

**Threat of microplastic ingestion and chemical accumulation to cetaceans in the Republic of Korea**

Taewon **Kim**[1,2], Byeongyong Park[1,2], Seungho Kim[1,2], Soobin Joo[1,2] and Kyungsik Jo[1,2]

[1]Program in Biomedical Science and Engineering, Inha University, 100 Inha-ro, Michuhol-gu, Incheon 22212, Republic of Korea. E-mail: ktwon@inha.ac.kr

[2]Department of Ocean Sciences, Inha University, 100 Inha-ro, Michuhol-gu, Incheon 22212, Republic of Korea

Plastic, even though incredibly useful, is a hazardous pollutant that poses risks to the environment and wildlife. Cetaceans, in particular, may face extreme exposure to microplastics, yet the extent and how they ingest these microplastics remain poorly understood. In this study, we investigated the correlation between microplastic intake from different sources and the accumulation of chemicals through necropsies of stranded cetaceans in Korea. Firstly, we analyzed the ingestion of MPs in the digestive tract of five species (fin and sei whale, Indo-Pacific bottlenose and common dolphin, finless porpoise). Secondly, we compared the intake of MPs in the digestive tract and respiratory system of finless porpoises. Thirdly, we analyzed the ingested MPs and the concentration of Bisphenol A in the fat of finless porpoises. In all samples, MPs were detected with a mean abundance of 3.42±3.2 items/g and were predominantly transparent-white, fragment-shaped polypropylene smaller than 200 μm. The biological characteristics of the finless porpoises didn't show a correlation with the number of ingested microplastics. Finless porpoises had microplastics in their lungs, matching the properties of those ingested. Moreover, finless porpoises with higher microplastic counts in their bodies exhibited elevated concentrations of Bisphenol A in their fat. There is limited knowledge regarding the direct effects of microplastics. However, given the observed positive correlation between plastic ingestion and Bisphenol A accumulation, it is anticipated that plastic ingestion is linked to chemical accumulation. Our findings suggest that for species struggling to recover from human-induced pressures, understanding the threat posed by microplastics is crucial.

**(BIO-P 18151)** BIO-P-P36 (ECOP)

## Testing the validity of environmental DNA analyses on the benthic fauna of pelagic seamounts

Satoi **Arai**[1], Motoomi Yamaguchi[1], Kota Sawada[1], Yumiko Osawa[1], Mai Miyamoto[2], Christopher Gardner Ayer[1] and Bungo Nishizawa[1]

[1]Japan Fisheries Research and Education Agency, Yokohama, Japan
E-mail: arai_satoi36@fra.go.jp

[2]Japan NUS CO., LTD., Tokyo, Japan

Environmental DNA (eDNA) can non-invasively detect organisms inhabiting environments where direct sampling or observation is difficult, such as the deep-sea floor. For elucidating the effectiveness of eDNA in studying the distribution of deep-sea benthic animals on oceanic seamounts, we conducted eDNA samplings in 2022 and 2023 along the Emperor Seamounts chain, which is a prominent fishing ground in the high seas of the central North Pacific. To test the effectiveness of eDNA-based faunal research for different environments and fauna on the deep-sea floor, the first 2022 samplings were conducted on three relatively shallow southern seamounts, and in 2023, the sampling area was expanded to more northern and deeper seamounts, resulting in seven seamounts in total. We primarily focused on fishes, because of the existence of established protocols and rich reference data, and the commercial importance of some species. In addition, we expanded our focus to include cold-water corals (octocorals), which are important but sometimes vulnerable organisms in seamount ecosystems. The eDNA analyses results were compared with the data from direct visual surveys of the seafloors in corresponding sites, and with species records from our previous fishery surveys and literatures. In this poster, we will report our findings and demonstrate the potential usefulness of eDNA surveys in the study of biodiversity among fishes and octocorals in challenging environmental conditions, such as the deep-sea , while illustrating some caveats.

# FIS Contributed Paper Session - POSTERS ONLY

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

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 17748)** FIS-P-P1

**Status and interannual variability of the Bering Sea and Chukchi Sea pollock stocks**

Mikhail A. **Stepanenko** and Elena V. Gritsay

Pacific branch of VNIRO («TINRO»), 4 Shevchenko Alley, Vladivostok, 690091, Russia

e-mail: mikhail.stepanenko@tinro.vniro.ru

A comparative analysis of long-term survey data indicates that pollock resources in the Bering Sea in 2020-2023 are at a level close to average. In recent years, most generations of pollock (2006, 2009-2011, 2013-2014, 2017, 2019-2020) had average abundance, some (2008, 2012, 2018) had high abundance. As a rule, generations of high abundance pollock appear during periods of shifting thermal conditions in the Bering Sea towards cooling. The appearance of numerous generations of pollock during periods of shifting water temperatures, when the abundance of large fraction zooplankton is relatively significant, has been noted in all observations in recent years. These data confirm the assumption that there is a connection between the abundance of zooplankton and the survival rate of generations of pollock in the first year of life in winter. The resources of the West Bering Sea population of pollock, distributed in Karaginsky and Olyutorsky bays, are currently still at a level below average, at the same time, in recent years there has been a tendency to increase them. A significant distribution of pollock from the Bering Sea to the Chukchi Sea through the Bering Strait was noted in 2018-2023. In 2020, the biomass of pollock in the Chukchi Sea, according to bottom trawl survey data, was estimated at 153.4 thousand tons. The majority of pollock biomass (95.9%) in the Chukchi Sea is made up of older pollock (length more than 50 cm, age 8 years and older). Small numbers of yearlings were carried into the Chukchi Sea by prevailing currents. The scale of pollock distribution into the Chukchi Sea in 2018-2023 is significantly greater compared to 2003 and 2014 according to survey data.

**(FIS-P 17796)** FIS-P-P2

**Biological and reproductive parameters of yellow striped butterfish Labracoglossa argentiventris around the Izu Islands: a step toward application of egg production method**

Junichi **Iijima**[1,2] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Science, The University of Tokyo, Tokyo, Japan. E-mail: Junichi_Iijima@member.metro.tokyo.jp

[2]Oshima Branch Office, Islands Area Research and Development Center for Agriculture, Forestry and Fisheries, Tokyo, Japan

Yellow striped butterfish Labracoglossa argentiventris is an important fishery species in the Izu Islands, Japan. To manage the stock, a virtual population analysis (VPA) has been applied to fisheries data for their stock assessment. However, the number of fishermen is decreasing and thus, the data required for a VPA has become insufficient. Accordingly, we need to adopt a fishery-independent stock assessment method. As a step toward application of egg production method, we conducted five processes to collect basic biological and reproductive parameters of yellow striped butterfish around the Izu Islands: 1) spawning seasons, 2) egg identification method, 3) pattern of oocyte maturation and spawning, 4) batch fecundity, and 5) spawning ground. First, we examined the monthly changes in gonadosomatic index (GSI). The GSI increased in November to December. Second, we conducted DNA barcoding to identify the eggs. The eggs were characterized by spherical shape with a diameter range of 0.91–1.10 mm and an oil globule of 0.21–0.25 mm. Third, we measured the egg diameter in ovary. A bimodal pattern in the histogram indicated the group-synchronous oocyte development type in this species. Fourth, we counted the number of the most developed eggs (diameter range: 0.4–0.7 mm) in the ovary. The mean number of developed eggs was 55,000. Lastly, a major spawning ground was identified based on the egg distribution. We intend to make a model case of an egg production method for a regional fisheries resource by collecting more detailed parameters in the near future.

**(FIS-P 17812)** FIS-P-P3 (ECOP)

## Distribution and growth rate of flathead grey mullet and longspine snipefish larvae and juveniles in the Kuroshio Current region in winter

Taro **Taniguchi**[1], Shigetaka Usui[1], Shijie Ma[1], Kazunari Higashiguchi[1.2], Mikio Watai[2], Junji Kinoshita[2], Chiyuki Sassa[2], Hiroshi Kuroda[2], Takeshi Okunishi[2], Tohya Yasuda[2] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: taniguchi-taro464@g.ecc.u-tokyo.ac.jp

[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama/ Nagasaki/ Kushiro/Shiogama, Japan

The Kuroshio Current region forms nursery and feeding grounds for small pelagic fish such as Pacific saury Cololabis saira in winter. Recently, we found that flathead grey mullet Mugil cephalus and longspine snipefish Macroramphosus scolopax larvae and juveniles are also predominant in the pelagic zones in the Kuroshio Current system in winter. Therefore, they may play an important role in the pelagic ecosystem. In the present study, we examined the distribution and growth rate of mullet and snipefish larvae and juveniles in relation to environmental factors in the Kuroshio Current system in winter. The mullet and snipefish larvae and juveniles were extracted from a part of the samples collected by a neuston net in the egg surveys off the Pacific coast of Japan during the last decade. Recent growth rate was estimated through otolith microstructure analysis. The distribution pattern and recent growth rate were related to sea surface temperature (SST), salinity (SSS), and chlorophyll-a concentration. Both mullet and snipefish larvae and juveniles were densely distributed around the Kuroshio axis and on the offshore side of the Kuroshio axis, with a considerable overlap with Pacific saury larvae and juveniles. The growth rate of mullet responded to SST and SSS with an optimal SST at 22°C; the growth rate of snipefish responded to SST with an optimal SST at 21°C. Hence, there is a possibility that mullet and snipefish are potential competitors with saury during the early life stages. Further studies on trophodynamics will be needed to test this idea.

**(FIS-P 17828)** FIS-P-P4

## Growth and diet of juvenile yellowtail (*Seriola quinqueradiata*) in the Satsunan area, southern Japan

Shin-nosuke **Goto**[1], Toru Kobari[2], Masafumi Kodama[2], Hayato Nakatani[2], Shuhei Tsuda[2], Akimasa Habano[2], Fumihiro Makino[2], Takafumi Azuma[2] and Gen Kume[2]

[1]Graduate School of Agriculture, Forest and Fisheries Kagoshima University, Kagoshima, Japan. Email: akgoto@icloud.com

[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan.

In this study, we investigated the growth and diet of juvenile yellowtail associated with floating seaweeds in the Satsunan area, southern Japan. We collected juveniles associated with floating seaweeds in February and March in 2022, February in 2023 and February and March in 2024. The floating seaweeds were visually found on research vessels and caught by nets. Specimens were stored at -20°C onboard. After measuring fork length (FL) and body weight of specimens in the laboratory, they were dissected to collect sagittal otoliths, which were embedded on a glass slide with epoxy resin. The otoliths were polished on the surface and the total number of otolith increments was counted using the RATOC otolith measurement system (ARP/W+RI, RATOC System Engineering Co.). Their stomach contents were extracted using a fine needle and were identified morphologically under a stereomicroscope. The relationships between ages in days (D) and FL were expressed as $FL=15.53e^{0.029D}$ in 2022 ($r^2 = 0.71$, n = 69), $FL=13.89e^{0.036D}$ in 2023 ($r^2 = 0.58$, n = 7) and $FL=6.34e^{0.053D}$ in 2024 ($r^2 = 0.93$, n = 16). Stomach contents were found in all specimens (n=23). The diet composition clearly differed during their ontogeny. Fish eggs, calanoid copepods, and fish juveniles were the main preys for juveniles of 10-20 mm FL, 20-40 mm FL and larger than 40 mm FL, respectively.

**(FIS-P 17829)** FIS-P-P5

**Feeding habits of Japanese glass-eels, *Anguilla japonica*, in the Sendai River, southern Japan**

Hiroki **Takahira**[1], Toru Kobari[2], Masafumi Kodama[2], Kazuhiko Anraku[2], Tomonari Kotani[2] and Gen Kume[2]

[1]Graduate School of Agriculture, Forest and Fisheries, Kagoshima University, Kagoshima, Japan. Email: hiroki1004@icloud.com

[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan

In this study, we investigated the feeding habits of glass-eels, *Anguilla japonica*, in the lower reach of the Sendai River, southern Japan. We collected glass-eels for 2 hours after sunset on day of spring tide at the two stations from January in 2022 to June in 2024. A total of 101 glass-eels were collected and stored at -60°C. After glass-eels were categorized into each developmental stage ($V_{B1}$, $V_{B2}$, $VI_{A0}$ - $VI_{A4}$, $VI_B$), total length and body weight were measured. Morphological and DNA metabarcoding analyses of the gut contents and stable carbon and nitrogen isotope analyses were performed to elucidate their diet. Under the stereomicroscope, gut contents, including aquatic insects, were observed in 5 of 87 glass-eels ($VI_{A2}$–$VI_{A4}$) and 8 of 14 elvers ($VI_B$). Under the scanning electron microscope, small particles were observed in 5 of 16 glass-eels ($V_{B1}$–$VI_{A4}$). Various eukaryotes were detected via DNA metabarcoding. However, the number of sequence reads from gut contents was low and their compositions are similar to those of body surfaces. The values of the stable carbon and nitrogen isotope clearly differed between glass-eels (n = 43) and elvers (n = 11). We concluded that glass-eels do not practice actively feeding activities in the lower reach of the river until they reach to elver stage.

**(FIS-P 17899)** FIS-P-P6

**Modeling the impacts of ocean conditions to Japanese chum salmon abundance**

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

[1]Arctic Research Center, Hokkaido University, Sapporo, Japan. E-mail: ssaitoh@arc.hokudai.ac.jp

[2]NPO Digital Hokkaido Community, Sapporo, Japan

[3]Kitami Salmon Enhancement Program association, Abashiri, Japan

[4]Green & Life Innovation, Inc., Hakodate, Japan

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 oceanographic conditions during its seaward migration from 1998 to 2019 and related these changes to the annual total catch data of Chum salmon in Japan from 2001 to 2022. We computed the mean zooplankton biomass during its feeding migration (June-November) in the Okhotsk and Bering seas and total area within its optimal coastal (May-July; Okhotsk Sea, 5°-8°C) and wintering (December-May; 5°-7.5°C) temperatures for each brood year (1998-2019) in the western subarctic gyre (WSAG) and Gulf of Alaska. Using these data, we then developed generalized additive models to capture the relative importance of environmental conditions before its average return migration at age-3. The full model captured 91.3% of the overall variance in the Chum salmon catch in the last 22 years and underpinned the importance of optimal wintering area in the WSAG and feeding conditions in the Okhotsk and Bering seas to the abundance fluctuations from 2001-2022. Thus, our results shed light on potential impacts of changes in ocean environment on Chum salmon abundance and its subsequent availability to fisheries.

**(FIS-P 17919)** FIS-P-P8 (ECOP)

**Development of individual identification of the Japanese sea cucumber Apostichopus japonicus based on deep metric learning**

Hiroya **Kito** and Hirokazu Matsuda

Mie University, Tsu, Japan. E-mail: 523d301@m.mie-u.ac.jp

The Japanese sea cucumber Apostichopus japonicus is widely distributed in the coast of East Asia and highly valued as traditional seafood in Japan and China. Nevertheless, the fundamental biological knowledge, such as growth and migration, for stock management is limited. This is caused by the difficulty of individual identification due to the inability to tag on the body wall mainly comprised of connective tissue. In this study, we developed an individual identification model of image analyses for this species. The dorsal surface of this species exhibits distinctive patterns, and we extracted these features from photographs using a deep metric learning model. The model was developed based on ConvNeXt, a modern CNN architecture, and using ArcFace as the loss function for identification of known and unknown individuals by cosine similarity. In this study, images of ten sea cucumbers (red type) were captured on a variety of underwater backgrounds; they continuously extended and contracted their bodies during the image shoot. Five sea cucumbers were used for the training dataset, with 120 images for each individual, divided into two groups for training and validation against known individuals. The remaining five individuals were used for validation against unknown individuals. The results showed that the images of all trained individuals showed the predominant cosine similarity to the correct individuals, respectively. For unknown individuals, the cosine similarity was extremely low. These suggest the model has the potential to identify individuals of the sea cucumber based on the appearance images.

**(FIS-P 17921)** FIS-P-P9 (ECOP)

## Long-term changes in fish assemblage structure in the Yellow Sea from 1968 to 2019 in relation to climate change

Seonggil **Go**[1], Sunkyu Park[2], Sun Kyeong Choi[1], Sukgeun Jung[2] and Young Baek Son[1]

[1]Korea Institute of Ocean Science & Technology (KIOST) Jeju Research Institute, Jeju, Korea. E-mail: seonggil117@gmail.com

[2]Department of Marine Life Science, Jeju National University, Jeju, Korea

The Korean waters, including the Yellow Sea (YS), are one of the most rapidly warming regions in the world's oceans over the past 30 years, and the marine environmental changes have an impact on the distribution of fisheries species. In this study, we evaluated the changes in fish assemblage, and their relationships with oceanographic environments in the YS. For this purpose, we collected commercial fisheries data in the YS from the Sea Around Us and depth-specific oceanographic data from the Korea Oceanographic Data Center. Using these data, we conducted a canonical correspondence analysis (CCA) to analyze the species composition in terms of biomass ratio of fish species from 1968 to 2019 and their relationships with the environmental changes. To detect shifts in the time-series of the two-dimensions from CCA and oceanographic conditions, we applied a sequential t-test of regime shift (STARS). The CCA revealed major shifts in fish assemblage structure between 1988 and 1991, with this change being associated with water temperature at 0, 10, and 50-m depth and salinity at all depths. This shift in fish assemblage structure seemed to be related to the late 1980s climate regime shift in the North Pacific. Further multidisciplinary researches are necessary to identify the oceanographic and biological processes influence climate-driven physical changes to fish recruitment and habitat variations.

**(FIS-P 17926)** FIS-P-P10 (ECOP)

**Establishing baselines, risks, and mechanisms of thiamine deficiency in British Columbia Chinook salmon**

Anna K. **McLaskey**[1], Jacob E. Lerner[1] and Brian P.V. Hunt[1,2]

[1]University of British Columbia, Vancouver, BC, Canada. Email: a.mclaskey@oceans.ubc.ca

[2]Hakai Institute, Campbell River, BC, Canada

Thiamine (vitamin B1) is an essential nutrient produced at the food web base and transferred to higher trophic levels. Without sufficient thiamine, animals experience metabolic shifts, neurological disorders, immunosuppression, and ultimately death, in a phenomenon called thiamine deficiency complex (TDC). First identified in the northeast Pacific in Yukon River Chinook in 2014, TDC was subsequently detected in California Chinook and steelhead in 2020, where it has continued, requiring adaptive management in hatcheries. Despite evidence of TDC to the north and south of British Columbia (BC), Canada, few thiamine measurements existed from its many diverse and in some cases endangered Chinook populations. To fill this data gap, we sampled egg thiamine from eight Chinook populations across BC in 2023 and compared concentrations to experimentally derived requirements for fry survival. All populations contained individuals with egg thiamine levels that cause TDC symptoms in fry (< 7.7 nmol $g^{-1}$), but the proportion of affected individuals and mean thiamine levels varied among populations. We begin to address several hypothesized drivers of TDC including migration distance, marine foraging area, and consumption of prey species like northern anchovy, which contain the thiamine-degrading enzyme thiaminase. Populations with highest egg thiamine levels had the shortest freshwater migration distances and are expected to have similar marine distributions with greatest exposure to anchovy. It is likely that TDC is already affecting BC Chinook and these data provide first insights into which Chinook populations may be most at risk of TDC, laying a baseline to further understand its drivers.

**(FIS-P 17938)** FIS-P-P11 (ECOP)

**Relationship between mesoscale eddies and habitat distribution of a pelagic squid in the Northwest Pacific Ocean**

Wei **Yu**[1], Yuchen Zhang[1] and Xinjun Chen[1]

[1]Shanghai Ocean University, Shanghai, China. E-mail: wyu@shou.ed.cn

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.

(FIS-P 17967) FIS-P-P12

**Comparing large-scale environmental indices used as covariates in Pacific salmon models**

Gottfried **Pestal** and Tatiana Tunon

SOLV Consulting Ltd., Vancouver, Canada. E-mail: gpestal@solv.ca

Population models for Pacific salmon (Oncorhynchus spp.) increasingly consider environmental covariates to improve forecasts or develop estimates of management reference points that respond to changing conditions. Indices of large-scale ocean conditions used for Pacific salmon models include Pacific Decadal Oscillation (PDO), Multivariate El Niño / Southern Oscillation Index (MEI), Oceanographic Niño Index (ONI), North Pacific Gyre Oscillation (NPGO), and North Pacific Index (NPI). Pacific salmon models generally use similar environmental covariates based on these indices, but with potentially significant differences in source data and how they are treated. For example, PDO covariates have used either the OI SST version 2 or ERSST version 5 of the PDO and calculated either the mean monthly anomaly for Nov-Mar or the sum of monthly anomalies over Dec-Feb for the winter preceding ocean entry of juveniles. In addition, some of the indices are highly correlated at different lag-times, even in terms of detrended anomalies, increasing the potential for spurious relationships in Pacific salmon models. Using the open-source Pacific Salmon Environmental Covariates (PSEC) data set, available online at github.com/SOLV-Code/Open-Source-Env-Cov-PacSalmon, we summarize and compare alternative versions of covariates for large-scale ocean conditions used in select publications focused on Pacific salmon from Washington state, British Columbia, and Alaska.

**(FIS-P 17993)** FIS-P-P13 (ECOP)

**Investigating habitat use and trophic overlap among North Pacific predators and their implications for Pacific salmon**

Genyffer C. **Troina**[1], Philip Riekenberg[2], Marcel T.J. van der Meer[2], Evgeny Pakhomov[1,3,4] and Brian P.V. Hunt[1,3,4]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: g.troina@oceans.ubc.ca

[2]NIOZ Royal Netherlands Institute for Sea Research, Texel, The Netherlands.

[3]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada

[4] Hakai Institute, Heriot Bay, BC, Canada

Inter-specific competition for food may have significant impacts on the distribution and abundances of marine species. A first step to determine whether co-occurring species compete for food is to define their preferred habitats and dietary overlap. The eastern North Pacific (ENP) high seas pelagic food web comprises diverse mid-trophic level predators with high potential for resource overlap with implications for the productivity of Pacific salmon species that use the ENP for maturation. In this study we investigated potential competitive interactions among pelagic predators using bulk-tissue stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) and compound-specific nitrogen isotopes in individual amino acids (CSIA-N-AA). Our analyses have shown that $\delta^{15}N$ values of source AAs, representing the $\delta^{15}N$ at the base of the food web, followed west-east/north-south gradients in the ENP that aligns with underlying spatial differences in the nitrogen sources supporting these food webs. This allows us to identify species-specific preferred feeding areas, as source AA-$\delta^{15}N$ values in spatially separated consumers reflect habitat fidelity to spatially different nitrogen sources. In addition, $\delta^{15}N$-AA values provided evidence for potential overlap in trophic positions of myctophids, cephalopods, and Pacific salmon. Our findings support overlap in resource use among these predators, with potential implications for foraging salmonids, and can be used to inform models to investigate the impacts of competition when resources are limited and / or consumer abundance changes.

**(FIS-P 18005)** FIS-P-P14 (ECOP)

**Early life history of juvenile sablefish using eye lens stable isotopes and trophic discrimination factors: An experimental lab study**

Mariela **Brooks**, Matthew Rogers, Fletcher Sewall, Jacek Maselko, and Wil Licht

NOAA NMFS Alaska Fisheries Science Center, Auke Bay Laboratories, Juneau AK, USA

Email: mariela.brooks@noaa.gov

Sablefish (Anoplopoma fimbria) are a commercially important species in Alaska, however environmental effects on early life history and eventual recruitment are not fully understood. Trophic life history and habitat utilization by juvenile sablefish may play an important role in growth and survival. Eye lens layers, a sequentially grown and long-lived tissue, are a unique sample type that can provide information about habitat and trophic life history shifts as recorded in stable isotope values ($\delta 15N$ and $\delta 13C$). We conducted a wet lab feeding experiment at the Auke Bay Laboratories in Juneau, Alaska for ~6 months (Oct 2022 - April 2023) on live juvenile sablefish (n=42, ~age 1) collected in Saint John Baptist Bay, Southeast Alaska. We measured stable isotopes of each eye lens layer for a subset of individuals (n=17) to evaluate changes and patterns in juvenile sablefish early life history. Individual eye lenses were dissected, obtaining between 12 to 24 eye lens layers each. Initial results show variability in eye lens isotopes with comparable shifts in both $\delta 15N$ and $\delta 13C$ at similar eye lens diameters, suggesting potentially coherent diet or habitat shifts for individuals prior to collection. In this study we also assess the feasibility of estimating experimentally determined trophic discrimination factors (TDF) in juvenile sablefish. We present preliminary data as well as discussion around TDF estimates in muscle and eye lens tissues. Combining experimentally determined TDF with eye lens layer isotopes may provide additional valuable information about trophic life history patterns and ontogenetic shifts in diet or habitat use.

**(FIS-P 18035)** FIS-P-P15 (ECOP)

**A study design analyzing the contribution of Pacific lamprey (*Entosphenus tridentatus)* to levels of thiamine in Battle Creek, Central Valley, California**

Sebastian **Vassas**, RJ Bottaro, and Patricia Bratcher

U.S. Fish and Wildlife Service, Red Bluff, CA, USA. E-mail: Sebastian_vasasas@usfws.gov

Thiamine is an essential, water-soluble vitamin that plays a vital role in the developmental processes of juvenile fish of all species (Harder, A.M., *et al*., 2018). A Thiamine Deficiency Complex (TDC) has been documented in anadromous salmonids due to a dietary increase of a thiamine-breaking-down enzyme: thiaminase (Harder, A.M., *et al*., 2018). Studies have demonstrated that Japanese Lamprey (Enthosphenus, japonicus) thiamine levels greatly exceeds that of other fishes (Higashi, H., *et al*., 1958,). It is believed Pacific Lamprey (*Entosphenus tridentatus*) have similar ecological and biological characteristics, including high levels of thiamine, and upon returning to a watershed will contribute these marine-derived nutrients back into the environment after spawning, making it available for other species, especially Chinook Salmon (*Oncorhynchus, tshawytscha*).

A viable population of Pacific Lamprey is present, with known limits to anadromy, in Battle Creek, located in the upper Sacramento River basin. The goal of our study is to provide a thorough protocol for applying eDNA testing for the presence of thiamine and Pacific lamprey, and further confirming the vitamin contents of these adult Pacific lamprey. By using adult video counts we will compare the abundance of overall lamprey in Battle Creek, and collect tissue samples of adult lamprey. eDNA testing can confirm the limits to (lamprey) anadromy to refine areas to assess thiamine in the watershed. These sites will then be used to collect water samples to test thiamine levels in the environment. Results could lead to implications for mitigating TDC in salmonid populations within Pacific waters.

**(FIS-P 18041)** FIS-P-P16 (ECOP)

## Spawning responses of Peruvian anchovy and Pacific sardine to environmental variability in the northern Humboldt Current system

Mingkun **Li**[1], Patricia Ayón[2] and Akinori Takasuka[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: li-mingkun1025@g.ecc.u-tokyo.ac.jp

[2]Instituto del Mar del Perú (IMARPE), Callao, Perú

Spawning responses to environmental factors are crucial for understanding mechanisms behind dramatic population dynamics of small pelagic fish under climate variability. This is particularly relevant for Peruvian anchovy (*Engraulis ringens*) and Pacific sardine (*Sardinops sagax*), which exhibit out-of-phase population oscillations in the northern Humboldt Current system at a multidecadal scale. We reanalyzed a long-term dataset of egg surveys in the northern Humboldt Current system off Peru, using non-parametric smooth regression methods, to explore the spawning responses of these two species to variability of geographic, physical, and biological factors over time. Generalized additive models (GAMs) were applied to the data of egg presence/absence and egg density given presence in relation to these environmental factors. As a result, sea surface temperature (SST) had a crucial impact on the occurrence and density of eggs for both anchovy and sardine. In addition, sea depth, chlorophyll-*a* concentration (CHL), plankton density (PL), and other environmental factors also significantly affected the spatio–temporal variability of distribution of their eggs to varying degrees. These responses characterized the spawning habits and their dynamics of the two species. In conclusion, the distribution patterns of anchovy and sardine eggs (and thus spawning) responded differently to environmental variability. The biological information presented here would be essential as a step toward constructing predicting models for spawning habitats under climate variability.

**(FIS-P 18045)** FIS-P-P17

**Comprehensive evaluation of tropical reef fishes and habitats using geographic information system and length-based evaluation approach in data-poor situation in Mauritius**

Naoki **Tojo**[1], Vinesh Emrith[1], and Nadeem Nazurally[2]

[1]Fisheries Sciences, Hokkaido University, Hakodate, Japan. E-mail: n.tojo.raven@fish.hokudai.ac.jp

[2]Dept. of Agricultural and Food Science, Faculty of Agriculture, University of Mauritius.

For sustainable fisheries, it is necessary to conduct investigations from multiple perspectives, such as resources, fishings, and habitat ecosystems. On the other hand, comprehensive investigation with them requires significant resources and efforts. Practical empirical information, such as local ecological knowledges (LEK), may be convenience, and reliable scientific surveys should be applied with them but with low cost. In Mauritius, a variety of management efforts based on "blue economy" concept has been implemented with limited resources, but comprehensive investigations and developing measures with integrative information has been challenged in the reality in island country. In this study, size information of key species from both ecological and economic importance, such as Naso unicornis and Epinephelus merra, and their habitat and information of associated other key species are collected by field surveys then analyzed with local fishers in the workshops. Habitat information corrected with LEK were organized as a spatial database using geographic information system (GIS), and parameters of the size-based models were collected by focus group discussions and field experiments with fishers. Models including with combinations of obtained parameters were used for estimations of spawning potentials. Habitat quality indices were spatially and geo-statistically compared to the present marine protection efforts including fishing reserves. Application of LEK improved our analyses. Present degradation of coral bed and potential fishing mortality could result in collapse of local fisheries and livelihood of coastal fishing communities. Improvement of zoning designs and proper measures with information collection by participation of local fishers are necessary for Mauritian coastal sustainability.

**(FIS-P 18058)** FIS-P-P18 (ECOP)

**A tropical sardine in a temperate environment: understanding the biology of *Sardinella lemuru* in the northern waters of Japan**

Alexanra **Bagarinao-Regalado**[1,2] and Shin-ichi Ito[2]

[1]Department of Aquatic Bioscience, Graduate School of Agriculture and Life Sciences, The University of Tokyo Email: regaladoab@aori.u-tokyo.ac.jp

[2]Atmosphere and Ocean Research Institute, The University of Tokyo

The Bali sardinella, *Sardinella lemuru,* is one of the most abundant sardine species in the tropical western Pacific. In the recent years however, it has been observed in the temperate waters of northern Japan, which is outside its reported distribution range. To understand this event, information on the biology of this species caught in the area should be investigated. This study explored the possible distribution range of *S. lemuru* here in Japan and provides initial estimates of age, growth, and reproductive characteristics. Environmental DNA analysis of water samples collected in the 2022 research cruise detected their possible presence in the relatively deeper waters (50-100 m) of northern Japan (Tohoku region) with May having higher read abundances than August. Fish specimens were collected from both southern and northern areas of Japan in July 2023 and April – June 2024 with size ranging from 15.8 to 23.2 cm SL. For individuals with size range of 16.4 – 22.4 cm SL (standard length), the estimated age range based on daily otolith increments is 371 – 435 d. Wide increment widths were observed at day 40 - 80, suggesting faster growth during this period. Hatch months of specimens caught in July 2023 were estimated to be from May-July 2022, indicating possible spawning months. The 2024 specimens show that April caught individuals are still immature or developing with an average gonadosomatic index (GSI) of 1.1. By May & June, individuals start to mature or spawn with an average GSI of 3.7 and 5.4, respectively. This suggests that *S. lemuru* could possibly complete its life cycle here in the temperate waters of Japan.

**(FIS-P 18078)** FIS-P-P19 (ECOP)

**Projected Decline in Commercially Important Fish Catches in the Arctic and Subarctic Assessed Using a Reconstructed Ocean Biogeochemical Model**

Eun-Young **Kim**[1] and Jong-Yeon Park[1,2], Hyung-Gyu Lim[3]

[1]Department of Environment and Energy, Jeonbuk National University

[2]Department of Earth and Environmental Sciences, Jeonbuk National University, Jeonju, Republic of Korea. E-mail: jongyeon.park@jbnu.ac.kr

[3]Korea Institute of Ocean Science and Technology, Busan, Republic of Korea

Fish use oxygen to produce the energy necessary for their life activities. As climate change causes temperatures to rise, the oxygen demand for fish increases, while the solubility of oxygen in seawater decreases. Consequently, fish may migrate to more hospitable surroundings or face higher rates of mortality. Fish species that are sensitive to changes in water temperature can be found in the Arctic region, which is experiencing temperature increases more than four times faster than other regions. Although previous studies have investigated the connection between water temperature and fish catch, research on the impact of oxygen on fish catch has been limited due to a lack of oxygen data. In this study, we calculated the metabolic index using reanalysis data on oxygen and water temperature obtained from the GFDL-ESM2 (Geophysical Fluid Dynamics Laboratory Earth System Model) for the Arctic/Sub-Arctic EEZ region from 1970 to 2017. We found that large demersal fish species' catches exhibited a strong correlation with the metabolic index. Through permutation importance analysis, it was evident that the number of regions where dissolved oxygen played a more critical role than temperature was higher. By examining predictability by lead time, we observed that fish catches in subsurface regions with higher dissolved oxygen importance showed longer lead times. This could be attributed to the longer memory of biogeochemical variables. Projecting future fish catches under various Shared Socioeconomic Pathways (SSP) scenarios up to 2100, we observed a continuous decline in catches across all scenarios. Consequently, it is desirable to incorporate the physiological characteristics of fish into sustainable fisheries resource management.

**(FIS-P 18085)** FIS-P-P20 (ECOP)

**Dungeness crab larval recruitment patterns in the Salish Sea and linkages to the coastal ocean**

Heather **Gordon** and Evgeny Pakhomov

University of British Columbia, Vancouver, BC, Canada. Email: hgordon@eoas.ubc.ca

Population connectivity for many benthic marine species occurs primarily via dispersal of pelagic larvae. Understanding the biophysical processes that influence larval dispersal can inform our knowledge of the degree to which populations self-recruit or receive subsidy recruits from other populations, with implications for population regulation and maintenance. The Dungeness crab (*Metacarcinus magister*), a commercially important decapod crustacean widely distributed in coastal and estuarine waters of the Northeast Pacific, has pelagic larvae that progress through six developmental stages over several months in the plankton before settling as juveniles in nearshore benthic habitats. Our understanding of the dispersal and recruitment patterns of larval Dungeness crab comes from research conducted primarily in coastal waters of the California Current Ecosystem; far less research has been conducted in semi-enclosed basins and fjords. Dungeness crab have significant ecological, cultural, and commercial value in the Salish Sea, a semi-enclosed estuarine system spanning the US-Canada border. Our study aims to investigate the mechanisms underlying variability in larval recruitment to the nearshore and the transport of larvae from the coastal ocean into the Salish Sea using near-daily time series larval recruitment data collected by the Pacific Northwest Crab Research Group. This research will further our understanding of the environmental drivers of Dungeness crab larval dynamics in the Salish Sea with the goal of contributing to more effective management of this recruitment-limited species in the inland waters of Washington state.

**(FIS-P 18092)** FIS-P-P21

**2010: A breakpoint for salmon productivity in the Northern California Current?**

Brian **Beckman**[1], Meredith Journey[2], Cheryl Morgan[3] and Brian Burke[1]

[1]Oregon State University, Newport, OR, USA. E-mail: Brian.Beckman@NOAA.gov

[2]University of Wyoming, Laramie WY, USA,

[3] National Marine Fisheries Service, Seattle, WA, USA.

Two measures of coho salmon productivity changed in the Northern California Current (NCC) in 2010, based on 20+ year time series. 1) Early summer growth for juvenile coho salmon has been assessed in the Northern California Current since 2000. 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. 2) An additional line of data suggests 2010 represents a breakpoint with regard to salmon productivity. Jacks are male coho salmon that return from marine rearing after ~ 6 months of marine rearing, in contrast to full size adults that generally spend 18 months in the ocean. Jack returns in some systems are well correlated with the subsequent return of adults a year later, this "sibling relationship" can be used to forecast adult returns. The jack to adult relationship shifted in 2010, based on the same time series (2000 – 2023) with a significant decrease in the number of adults returning per jack. Or, put another way, the slope of the jack to adult relationships changed in 2010. Both of these indicators suggest that there was some ecosystem shift in the NCC in 2010.

**(FIS-P 18115)** FIS-P-P22

**Does the Zhenbei seamount in the South China Sea harbor distinctive biodiversity? A primary study based on eDNA metabarcoding**

Hui **Zhang**[1] Xiaofei Chen[1,2] and Hui Jia[1,3]

[1]CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, China. E-mail: zhanghui@qdio.ac.cn

[2]College of Life Sciences, Qingdao Agricultural University, Qingdao, 266109, China

[3]School of Oceanography, Ningbo University, Ningbo, 315211, China

The seamounts may play a role in shaping the biodiversity of the surrounding continental coastal waters. However, the diversity, composition, and distribution of eukaryotic species in the seamount regions of Zhenbei remain largely unexplored. In this study, we utilized eDNA metabarcoding to analyze the biodiversity of four communities in Zhenbei seamount and investigated their biogeographical distribution and its relationship with environmental factors. We identified single-celled organisms (phytoplankton with 158 species) to multicellular organisms (invertebrate metazoans with 163 species and fish with 82 species). However, compared to other communities, the fish community structure was more stable. The topography and hydrological environment around the seamount influence the connectivity of phytoplankton and invertebrates in both horizontal and vertical directions. In comparison to deep-sea basins and cold spring habitats, invertebrate and fish communities in the Zhenbei seamount exhibited higher taxonomic unit richness, while the phytoplankton community showed equivalent or lower taxonomic unit richness. Despite the differences in species richness at the Zhenbei seamount, the combined species displayed unique dominant species and communities within the seamount. Furthermore, temperature was identified as a fundamental factor influencing the community structure of phytoplankton and invertebrates. Our research has highlighted the impact of the Zhenbei seamount on the composition and diversity of assemblage communities, contributing to a deeper understanding of seamount ecosystem structure and promoting biodiversity conservation.

**(FIS-P 18125)** FIS-P-P23

## Collaborating with longline fishers to improve the post-release survival of mobula rays

Jennifer **Stahl**[1], Melanie Hutchinson[2], Chelsey Young[3], Joshua Tucker[1,4], Forest O'Neil[5], and Emily Crigler[1]

[1]Pacific Islands Fisheries Science Center, National Marine Fisheries Service, 1845 Wasp Boulevard, Honolulu, HI, 96818 Email: jennifer.stahl@noaa.gov

[2] Inter-American Tropical Tuna Commission

[3] Pacific Islands Regional Office, National Marine Fisheries Service,

[4] Cooperative Institute for Marine and Atmospheric Research

[5] IBSS Corp

Developing conservation strategies for the threatened giant manta ray (*Mobula birostris*) and other mobulid rays (devil and reef manta rays) captured in U.S. longline fisheries is hindered by a lack of data on species specific catch, fisher handling and release practices, and survival rates post-interaction.

To better understand the catch dynamics for mobulid species interacting with the Hawaiʻi-based tuna longline fishery, a multi-pronged approach was used to generate species specific catch data, record handling and release practices, and to quantitatively assess post-release survival rates through a satellite tagging telemetry program. A species identification guide was developed to facilitate accurate identification by fishers, observers, and researchers, and genetic samples were collected on observed trips by the Pacific Islands Region Observer Program. Electronic monitoring (EM) video, collected from volunteer vessels as part of research conducted by the Pacific Islands Fisheries Science Center, was also evaluated for potential identification on trips with mobulid interactions.

To quantify the post-release survival of mobula rays interacting with the Hawaiʻi longline fisheries, fishers were trained to tag incidentally caught mobulid rays with satellite tags and to collect video and data on the interaction. This project is still in progress; at present, six mobula rays of five different species have been tagged with five animals surviving to at least 60 days after the interaction.

This unique project demonstrates the benefits of collaborations across fishery stakeholder groups to fill data gaps and address bycatch issues from different perspectives.

**(FIS-P 18147)** FIS-P-P24

# Impact of warming on the distribution pattern of the sardine *Sardinops melanosticta* (Temminck et Schlegel, 1846) in the northwestern Pacific Ocean

Dmitriy **Antonenko**, Yuriy Novikov, and Evgeniy Basyuk

Pacific branch of "VNIRO" ("TINRO"), Vladivostok, Russia. dmantonenko@yandex.ru

The trend of sardine stocks increasing after 2010 has determined significant spatiotemporal expansion of this fish range during the feeding period. It is reflected in significantly earlier feeding migrations to the north and east and also later migrations to wintering grounds. According to expeditionary studies, the stock level of the Pacific sardine population has not yet reached the high level of the 1980s. However, sardine distribution during the period of maximum warming of surface waters in summer and autumn to the north and east exceeds such indicators of the second half of the last century. Expansion is also facilitated by changes in the oceanographic regime of the Kuril waters. Starting from 2018, the development of oceanographic conditions in the Kuril waters occurs according to the "warm years" type; a distinctive feature of such years is the unusually high rates of spring warming and low rates of autumn cooling. From 2021 to 2023, the oceanographic regime of the region can be characterized as "abnormally warm"; a characteristic feature of such years is the predominance of maximum positive anomalies during the year. Thus, significant warming in recent years in the northwestern Pacific Ocean has contributed to an increase in the length and duration of sardine migrations during the feeding period. A comparison of average summer SST in the 1980s and in recent years shows that SST values are currently 2-4°C higher. Rising average ocean surface temperatures off the Japanese and Kuril Islands encourages sardine schools to migrate north and east to the shores of Kamchatka, the Aleutian and Commander Islands, and the southern Bering Sea.

# HD Contributed Paper Session - POSTERS ONLY

**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 17745)** HD-P-P1

**Spatial and Temporal Differentiation of the Coordination and Interaction among the Three Fishery Industries in China from the Value Chain Perspective**

Meng **Su**, Jintian Gao, and Kai Cheng

Ocean University of China, School of Economics, China, PR email: sumengouc@qq.com

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.

(HD-P 17759) HD-P-P2

**Marine ecological damage compensation: Monetary compensation or ecological restoration?**

Jingzhu **Shan** and Jingmei Li

Ocean University of Chian, Qingdao, China. Email: oucshanjingzhu@126.com

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 monetary compensation achieves the effective allocation of ecological, economic, and social benefits among different stakeholders through the internalization of externalities, is more in line with the public's value judgment and more widely applicable. However, there are also controversies regarding compensation contents and evaluation methods. Marine ecological restoration aims to ensure that the baseline level of marine ecological service functions remains unchanged, fully reflecting the essential requirements of ecological compensation. While it also has problems, including difficulties in implementing restoration and verifying the effectiveness of compensation. 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.

**(HD-P 17789)** HD-P-P3

**Socioeconomic implications due to climate change in the Pacific Islands fisheries**

Hing Ling **Chan**

Pacific Islands Fisheries Science Center, NOAA Fisheries, Honolulu, HI, USA. Email: hingling.chan@noaa.gov

The NOAA Climate, Ecosystems, and Fisheries (CEFI) aims to prepare and respond to the climate change impacts on marine ecosystems and fisheries. It will build operational modeling and decision support systems needed to provide decision-makers with actionable information to reduce impacts and increase resilience of the nation's valuable marine resources and resource-dependent communities in a changing climate. For the Pacific Islands region, we plan to create end-to-end, operational modeling that includes physical and oceanographic forecasts that will link with species distribution and ecosystem modeling. Output from the physical and oceanographic forecast and species distribution and ecosystem modeling will link with various socio-economic modeling for the Pacific Islands fisheries. This socio-economic modeling will support fisheries management and seafood sector in their planning for future climate change by providing a better understanding of the economic consequences of climate change and shifting fish availability and distribution, such as vessels' location choices, operational costs, and seafood market dynamics. For example, if sea surface temperature is higher and deteriorates fish quality causing fish prices to drop, this may drive fishers to go further from Honolulu port to look for better quality of fish in cooler water. This would increase fishing trip costs and lower profits. Fishers have to balance the potential higher fish prices with higher trip costs. The socioeconomic models will take into account the changes in environmental factors, fish distribution and abundance due to climate change and estimate the economic implications.

**(HD-P 17797)** HD-P-P4 (ECOP)

**The impact of communication as a tool for the sustainable resource use**

Takato **Ishikawa**, Shintaro Arakane and Naoki Tojo

Hokkaido University, Hakodate, Japan. E-mail: ishikawa.takato.u6@elms.hokudai.ac.jp

The Sustainable Development Goals (SDGs), consisting of the 17 goals which should be achieved by 2030, are targets for realizing a sustainable world. The research and activities are actively conducted around the world to achieve these goals. One of these goals is '14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development'. To utilize marine resources sustainably, one issue that must be resolved is “The Tragedy of the Commons”, proposed by Hardin in 1968. This refers to a situation which describes the depletion of a shared resource due to excessive fishing by many parties. Several conditions for functioning autonomous management of common lands have been described in previous studies. In these conditions, it is assumed that communication between individuals is active and the connections continue to be maintained. However, studies investigating the effect of communication on “The Tragedy of the Commons” are scarce. Therefore, we conducted a game experiment with groups of 4 to 5 individuals assuming fishing communities. Players are required to utilize resources sustainably and maximally. We tested whether communication could be a solution to “The Tragedy of the Commons” by using data from this experiment. In the process, it also tested whether income was stable at a high level in order to examine economic sustainability. The study may highlight the importance of communication in fishing communities. On the other hand, it may suggest limitations of communication.

**(HD-P 17861)** HD-P-P5 (ECOP)

**Synergies between Gender Equality and Sustainability in Coastal Fisheries Resource Use: Case Studies in Japan**

Hana **Matsubara** and Mitsutaku Makino

University of Tokyo, Tokyo, Japan. E-mail: hmatsubara@g.ecc.u-tokyo.ac.jp

Despite international agreements to promote gender mainstreaming, efforts in the fisheries sector often lag behind. One reason is the differing motivations among stakeholders: the development sector prioritizes gender equality as a human rights issue, while the fisheries sector focuses on sustainability in marine resource utilization through gender equality promotion. Bridging this gap requires identifying factors that create synergies between gender equality and sustainable resource use.

This presentation examines examples of such synergies through three case studies from different stages of the fisheries value chain in Japan: (1) production through husband-wife boat operations in Chiba, (2) processing with Akamoku (*Sargassum horneri (Turner) C. Agardh*) resource in Fukuoka, and (3) marketing via the Fisheries Cooperative Association-operated "Mothers' Restaurant" in Ibaraki. Semi-structured interviews were conducted in each region, and the results were qualitatively analyzed using three-step coding. The findings indicate synergistic effects in all cases, including contributions to economic sustainability through value-added fishery resources, ecological sustainability through adaptive resource management based on women's input, and social sustainability by addressing the decline in fishery successors through women's involvement. These multifaceted benefits also suggest contributions to other SDGs, including SDG 11 and SDG 13. This study provides insights for promoting a Nexus approach, which aims to achieve multiple SDGs synergistically by leveraging the interplay between gender equality and sustainable resource use in the fisheries sector.

**(HD-P 17978)** HD-P-P6 (ECOP)

**Pathway study on how Marine Spatial Planning can contribute to ocean carbon negative emissions**

Yuting **Hou** and Dahai Liu

First Institute of Oceanography (FIO), Ministry of Natural Resources (MNR), China. Email: houyuting@fio.org.cn

The ocean is the largest carbon reservoir in the earth's surface system and one of the most important regulators of climate change. As a method to guide human beings on how, when and where to utilize the oceans, Marine Spatial Planning (MSP) can play a crucial role in guiding ocean carbon sinks to play a role in carbon emission reduction. This study analyzes the correlation between MSP and ocean carbon sinks by summarizing the development of global MSP policies and the statistics of the global carbon peak and neutral targets, and points out the key issues for MSP to play a guiding role on ocean carbon sinks. On this basis, a global pathway for MSP to promote ocean carbon sinks is proposed. Specifically, it includes theoretical and methodological research on ocean and coastal zone carbon sink patterns, key influencing factors, the delineation of natural and artificial carbon sink functional zones, and ocean and coastal zone carbon sink planning that combines decision and policy making. Milestones such as the proposal of the MSP Global 2060 initiative under the UN Ocean Decade's Global ONCE (Ocean Negative Carbon Emissions) Program, as well as the construction of platforms such as a database for climate change and MSP linkages, a data-driven decision-making support system, and an innovative cross-sectoral partnership strategy. The pathway study will be of great significance in enhancing the role of MSP in global carbon emission reduction and in promoting ocean carbon sinks to better play their role in climate change regulation.

**(HD-P 18017)** HD-P-P7

**The Arabian Gulf and Climate Change: On the imperative of regenerative ecology and partnerships building**

Saif M. **AlGhais**

Environment Protection and Development Authority, Government of Ras AlKhaimah,

United Arab Emirates. Email: alghais@emirates.net.ae

This paper/presentation explores the challenges posed by a changing climate and rising seas in the Arabian Gulf region, focusing on the need for regenerative environments and community partnerships. As the Gulf faces increased vulnerabilities, this study investigates sustainable strategies and innovative solutions to adapt and thrive in the face of environmental changes. Critical drivers of environmental change compounding the impacts of climate change include oil spills, industrial waste discharges, marine debris and coastal habitat disturbance due to development projects. It delves into the imperative of the integration of regenerative practices, emphasizing ecological restoration, resilient infrastructure, and community engagement as essential components for building a sustainable and adaptive future in the Arabian Gulf.

The Arabian Gulf is experiencing noticeable changes in its climate, characterized by rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events. These shifts pose significant challenges, impacting ecosystems, water resources, and human activities in the region. As temperatures rise, the Gulf faces heightened risks of heatwaves, desertification, and sea-level rise, further exacerbating existing environmental pressures. Adaptation strategies and sustainable practices are crucial to mitigate the adverse effects of this changing climate and promote resilience in the Arabian Gulf.

**(HD-P 18044)** HD-P-P8

**Value chain analysis of low-priced small pelagic fisheries on the Western coast of Sri Lanka amid data and information scarcity**

Naoki **Tojo**[1], Don Wasalathanthri[2], Lasami Upsala De Silva[2] and Waradana Nilantha De Silva[3]

[1]Fisheries Sciences, Hokkaido University, Hakodate, Japan email: n.tojo.raven@fish.hokudai.ac.jp

[2]National Aquatic Resources Research and Development Agency, Crow Island, Colombo 15, Sri Lanka

[2]Fisheries Sciences, Hokkaido University, Hakodate, Japan email: n.tojo.raven@fish.hokudai.ac.jp

[3]Faculty of Agriculture, University of Ruhuna, Matara, Sri Lanka

Sardinella spp. (*Sardinella gibbosa*, *Sardinella albella* and *Sardinella longiceps*) and Hilsa shad (*Hilsa kelee*) are abundant and economically significant fishing target for small scale fishers in Western coast of Sri Lanka as these species are abundant in their year-round catches with intra-annual fluctuations. Despite their significance, catches of those fishes are seasonally and inter-annually variable. Besides, prices of them are lower most likely due to less consumer preference. These challenges associating to economy with specific small pelagic fishes brought limitations in economic activities of household of local fishers, depending upon those species. Improving fishers' livelihoods requires sufficient amount of information in their economic activities including fishing activities. However, statistics of small scale fishers are often unavailable due to difficulties in field surveys. In this study, we apply value chain analysis for small scale fisheries targeting Sardinella spp. and Hilsa. Then we examine the profitability and economic efficiency of each activity in these fisheries under ecological and economic uncertainties. The data will be collected in semi-structured questionnaire surveys in selected fishing communities and in focus group discussions with the respective fishing groups. Bayesian approach with Markov chain Monte Carlo simulation has been applied to model value chain of fishers' economic activities in the given data-limited situation in the field, and significant variables and parameters are evaluated using sensitivity analysis. We expect our study can provide insights to improve fishers' households with target fishes in dynamic ecosystems under condition of data limited situation in the Western coast of Sri Lanka.

**(HD-P 18057)** HD-P-P9 (ECOP)

**A bioeconomic analysis on the effectiveness of TAC in South Korea**

Min-Je **Choi**, Young Il Seo, Sang Chul Yoon, and Heejoong Kang

Coastal Water Fisheries Resources Research Division, National Institute of Fisheries Science, Busan, Rep. of Korea. E-mail: cmj543@korea.kr

The purpose of the Total Allowable Catch (TAC) system is to protect fishery resources and ensure their sustainable use. In Korea, TAC was first introduced in 1999, and as of 2024, it covers 15 species and 17 fishing methods. In addition, Korea is currently piloting TACs for anchovies and plans to expand TACs to all coastal fisheries. Against this backdrop, this study aims to assess the effects of TAC on catch increases and the resulting economic impacts using bioeconomic analysis. For this analysis, bioeconomic analyses were conducted for chub mackerel, jack mackerel, pen shell, and swimming crab, which were subject to TACs relatively early in their history. Specifically, TACs were implemented in 1999 for chub mackerel and jack mackerel, 2001 for pen shell, and 2003 for swimming crab. The CMSY model was conducted for stock assessment and compared the actual catch with the expected catch in the absence of TACs. Additionally, we analyzed the relationship between production volume and producer prices for each species to assess bioeconomic effects. The results of the analyses showed that the implementation of TACs increased the catch of jack mackerel, pen shell, and swimming crab, and resulted in economic benefits. In contrast, chub mackerel did not show increases in catch or economic benefits. However, further analysis indicated that chub mackerel resources have steadily increased since TAC implementation, demonstrating effectiveness in resource conservation. Therefore, from a long-term perspective, it is expected that TAC will lead to increased catches and economic benefits.

**(HD-P 18071)** HD-P-P10

**Towards a Transformative Ocean Science for climate change adaptation using FishGIS**

Mitsutaku **Makino**

The University of Tokyo, Atmosphere and Ocean Research Institute (AORI), Japan email: mmakino@aori.u-tokyo.ac.jp

In the past PICES-MAFF Projects, we have co-designed and co-created a FishGIS system where local people, including small-scale fishers, can monitor changes in coastal ecosystems using their own mobile phone and share information with wide rage of stakeholders. Recently, climate change is apparent, and more and more abnormal phenomena are occurring in coastal areas. Local fishers observe those phenomena via daily operations, but their information is scattered and the overall picture is unclear. To adapt to climate changes, it is important for local fishers to properly understand the natural scientific mechanisms behind them. Therefore, using FishGIS, we develop a national-scale information collection system for abnormal phenomena by Japanese coastal fishermen. In addition, we will create a system in which academia such as universities and research agencies will collectively prepare natural scientific knowledge on the occurrence mechanism of such abnormal phenomena and share it with the entire society, including local people. Through the above collaboration among local fishers, academia and society, we will improve Japanese national literacy to climate change and socially support climate adaptation in coastal areas.

**(HD-P 18127)** HD-P-P11 (ECOP)

**Information, Altruism, and the Value of Traceability in Seafood**

Mina **Fukagawa**, Nobuyuki Yagi and Yutaro Sakai

University of Tokyo, Tokyo, Japan. E-mail: mina-fukagawa@g.ecc.u-tokyo.ac.jp

Illegal fishing activities pose a significant threat to the global sustainability of seafood. Effective traceability systems are essential to ensure the safety, legality and sustainability of seafood, yet their implementation remains slow worldwide. One way to improve this situation could be intervention from the demand side to add value to traceable seafood by providing information to consumers. Given the multidimensional functions of seafood traceability, however, it is not clear which functions should be emphasized, and the answer may depend on each consumer's preferences.

This study conducts choice experiments to quantify the consumers' marginal willingness to pay (MWTP) for traceability in Japan, a major seafood consumer in the world. Participants were randomly divided into four groups and given information highlighting different functions of traceability: food safety, resource conservation, prevention of human rights violations, and prevention of mislabeling of place of origin. To examine the relationship between consumer preferences and the effects of information, we measured the participants' altruism by using the dictator game.

We found that, on average, the group given information emphasizing prevention of human rights violations showed the greatest MWTP for traceability. However, the least altruistic participants exhibited the highest MWTP in response to the prevention of mislabeling of place of origin. In addition, we demonstrated that information provision transforms the relationship between quality and traceability from a substitutive to a complementary relationship. Overall, the study suggests it is possible to gain consumer support for traceability systems by emphasizing social and ethical aspects and providing information to appropriate audiences (250).

**(HD-P 18131)** HD-P-P12

**Exploring potential strategy for highly exploited multispecies fisheries management**

Peng **Sun**, Runlong Sun, Guankui Liu, Yongjun Tian and Yanli Tang

College of Fisheries, Ocean University of China, Qingdao, China. E-mail: sunpeng@ouc.edu.cn

Balanced harvest (BH) proposes moderate fishing mortality rates across all species or sizes in proportion to productivity, serving as a possible strategy for ecosystem-based fisheries management. Fishing patterns in some developing countries (e.g. China, the largest producer of seafood) closely resemble BH, where catches have been highly diversified by unselective gears due to market demand for almost all species. In this study, we employed an OSMOSE ecosystem model developed for the Yellow Sea in China to investigate the potential occurrences and advantages of BH in this region with highly exploited multispecies fisheries. Simulations were carried out under four types of fishing scenarios, where various levels of fishing mortality rates for all species or specific functional groups were implemented. Results indicated that the occurrences of BH depended on fishing pressure and targeted functional groups, and that size-level BH was significantly correlated with biomass and yield for most species. In particular, varying fishing pressure for certain functional groups resulted in BH, which produced a high yield for specific species and ensured their biomass sustainability. We concluded that the benefits of BH could be potentially achieved by adjusting fishing pressure for certain functional groups based on the existing fishing pattern in over-exploited ecosystems.

# MEQ Contributed Paper Session - POSTERS ONLY

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

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 17935)** MEQ-P-P1

**Bio-monitoring system for early detection of toxic dinoflagellate Alexandrium pacificum using the shell valve movements of bivalve**

Seok Jin **Oh**, Soo Yong Jeong and Chang Geun Choi

Pukyong National University, Busan, Korea. E-mail: sjoh1972@pknu.ac.kr

Consuming poisoned shellfish can lead to severe health problems and even death. Alexandrium species cause paralytic shellfish poisoning (PSP) in Korea, and PSP is detected more in a wider area. Aquaculture in the coastal areas of Korea, dominated by seaweed and shellfish, accounts for over 60% of Korea's fishery production. We examined changes in the shell valve movements (SVMs) of Mytilus edulis and Crassostrea gigas using a Hall element sensor to investigate the early detection of the toxic dinoflagellate Alexandrium pacificum. No increase or decrease was observed in SVMs caused by the non-toxic algae Isochrysis galbana in both M. edulis and C. gigas. However, when M. edulis and C. gigas were exposed to A. pacificum, which causes paralytic shellfish poisoning, the average SVMs for 12 hours before and after exposure increased from 1.25 times/hr to 2.13 times/hr and 2.23 times/hr to 8.91 times/hr, respectively. After exposure to A. pacificum, the SVMs of M. edulis increased rapidly within 1 hour and then decreased gradually. However, C. gigas showed high SVMs until 4 hours after exposure. SVMs of C. gigas appeared to be more sensitive to toxic dinoflagellate than those of M. edulis. Therefore, these results are expected to be used as basic data for the establishment of a biological monitoring system for early detection of the toxic dinoflagellate A. pacificum.

**(MEQ-P 17956)** MEQ-P-P2 (ECOP)

**Contrasting seasonal behavior of dissolved rare earth elements and anthropogenic gadolinium in the estuary dam system, Korea**

Jumi **Kim**[1], Ijin Lim[1], Jiwoo Kim[1], Hunsub Sim[1], Taejin Kim[1], Hojong Seo[2] and Guebuem Kim[2]

[1]Pukyong National University, Busan, Republic of Korea. E-mail: jumi782@gmail.com

[2]Seoul National University, Seoul, Republic of Korea

Estuaries are the places where the river water meets seawater and complex biogeochemical reactors that modify the fluxes and chemical compositions of water. Estuary dams, while not as common as other alterations, have been constructed to manage the water supply and saltwater intrusion for industrial, agricultural, and domestic purposes. Rare earth elements (REEs), which are composed of 15 elements of the lanthanum group, have been utilized as excellent tracers in estuaries because of their fractionations. Among the REEs, gadolinium (Gd) is used as a paramagnetic contrast-enhancing agent for magnetic resonance imaging (MRI). Therefore, positive Gd anomalies have been utilized to evaluate anthropogenic influences in estuarine environments. Although various studies have studied dissolved REEs and Gd anomalies in estuarine environments, no study to our knowledge has discussed the geochemical behaviors of dissolved REEs in the estuary dam system. In this study, therefore, seasonal variations of dissolved REEs in the Nakdong River Estuary, Busan, Korea, where the estuary dam is present, were investigated to assess how estuary dam affects the distributions and fractionations of dissolved REEs. Furthermore, using Gd anomalies, seasonal behaviors of anthropogenic Gd (Gdanth) could be evaluated quantitatively. Our study suggests that estuary dam system has large influences on distributions and chemical behaviors of dissolved REEs depending on the elements and seasons.

**(MEQ-P 17958)** MEQ-P-P3 (ECOP)

**Contribution of an estuarine dam to controlling the temporal variability of biological productivity in the Yeongsan River Estuary, South Korea**

Yujeong **Lee**[1], Hyung-Mi Cho[1], Yong-Woo Lee[2] and Tae-Hoon Kim[3]

[1]Inha University, Incheon, South Korea. E-mail: stellalee518@naver.com

[2]Korea Marine Environment Management, Busan, South Korea

[3]Chonnam National University, Gwangju, South Korea

The Yeongsan River, one of the four major rivers in South Korea, has experienced significant ecological changes since the construction of the estuarine dam in 1981. To examine the factors determining the water quality and biological productivity in the Yeongsan River, we analyzed time-series data obtained from the National Marine Environmental Measuring Network Program (www.meis.go.kr) over the last five years (2016-2020). We analyzed salinity, water temperature, dissolved oxygen, pH, dissolved inorganic nitrogen ($NH_4^+$+$NO_3^-$), phosphorus ($PO_4^{3-}$), silicon ($SiO_2$), chlorophyll-a, turbidity, precipitation, and freshwater discharge. We conducted a comparative analysis of data from 2016 and 2020 to analyze the key factors influencing biological productivity. In 2016, following a freshwater discharge event, a rapid increase in chlorophyll-a concentration was observed, accompanied by abundant nutrients, salinity exceeding 25, and water temperatures above 20 ℃. However, in 2020, despite significant freshwater discharge and associated nutrient supply, a noticeable peak in the chlorophyll-a concentration was not observed. This could be because increased turbidity due to seven times more freshwater discharge compared to 2016 may have hindered biological productivity. Furthermore, changes in N:P:Si ratios indicate that the dominant species of phytoplankton may change seasonally. An increasing N:Si ratio indicates that winter-spring diatom growth may have become DSi-limited in this area. Subsequently, it gradually transformed into a DIN-limited environment during the spring-summer period. This study highlights that the factors influencing biological productivity in dam-constructed estuarine areas are strongly related to the extent of freshwater discharge and are attributable to the complex environmental changes that occur after such discharges.

**(MEQ-P 18154 Poster)** MEQ-P-P4 (ECOP)

**Nature-based Solutions for Ocean Resilience and Sustainability**

Pengbin **Wang**[1,2], Dorsa Sheikholeslami[1], Naomie Kayitesi[1,3], Mikhael De Souza[1], Charles Karangwa[1]

[1] Nature-based Solution Management Hub, International Union for Conservation of Nature, Gland 1196, Switzerland.

[2] Key Laboratory of Marine Ecosystem Dynamics at the Second Institute of Oceanography of the Ministry of Natural Resources of the People's Republic of China (MNR), China.

[3] Institute of Earth Surface Dynamics, University of Lausanne, Switzerland.
E-mail: pengbin.wang@iucn.org

Oceans are facing unprecedented challenges due to anthropogenic activities, climate change, and environmental degradation, which threaten vital marine ecosystems. Nature-based Solutions (NbS) offer a promising approach to enhance ocean resilience and sustainability by leveraging natural processes. These solutions include the restoration of coastal habitats like mangroves, coral reefs, and seagrasses, which act as natural buffers against storm surges, prevent coastal erosion, and sequester carbon, thereby mitigating climate change. NbS also promote sustainable fisheries and the creation of marine protected areas, conserving biodiversity and enhancing the livelihoods of coastal communities. By focusing on ecosystem restoration and conservation, NbS contribute to climate adaptation, disaster risk reduction, increasing biodiversity, and economic benefits such as food security and eco-tourism. In addition to these benefits, the cost-effectiveness of NbS compared to traditional grey infrastructure showcase how NbS can deliver long-term economic and environmental gains. Numerous examples of NbS in marine environments illustrate how integrating nature-based approaches into policy and management frameworks can deliver ecological, social, and economic benefits. The importance of cross-sectoral collaboration and community engagement will be highlighted, along with the need to scale up NbS to secure a sustainable future for oceans. By implementing NbS, a more balanced relationship between nature and human activities can be fostered, ensuring the long-term health of our oceans and the well-being of the communities that rely on them.

# POC Contributed Paper Session - POSTERS only

**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 18106)** POC-P-P1

**Emulation of MOM6-based downscaling results in the Northeast Pacific using Machine Learning methods**

Albert J. **Hermann**[1,2], Wei Cheng[2], Vivek Seelanki[1,2], and Phyllis J. Stabeno[2]

[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle, WA, USA. E-mail: albert.j.hermann@noaa.gov

[2]Pacific Marine Environmental Laboratory, Seattle, WA, USA. E-mail: wei.cheng@noaa.gov

As part of the new Climate and Ecosystems and Fisheries Initiative (CEFI), we have been comparing results from a dynamical downscaling regional model, based on the Modular Ocean Model version 6 (MOM6), with hydrographic and current meter data from the Bering Sea and surrounding waters. Ultimately under CEFI this regional model is to be used for hindcasts, seasonal to multiyear forecasts, and multidecadal projections of conditions in the Northeast Pacific. Early results have shown an impressive correspondence between the new model and observations in the Bering Sea, including metrics which are central to the management of fisheries. Here we present preliminary results from an application of Machine Learning methods, used to create a compact emulator of the full MOM6-based dynamical model. The method is based on dimensional reduction via 3D EOFs, followed by an application of a Recurrent Neural Network method (specifically, the Long Short-Term Memory technique). We explore whether the emulator can capture major features of the Bering Sea such as the summertime "cold pool". By virtue of its computational efficiency, a validated emulator of this type could be used to: 1) expand dynamically-produced ensembles of regional forecasts and projections of conditions in the Bering Sea; 2) expand our sensitivity analyses of the regional downscaling model.

**(POC-P 17778)** POC-P-P2

**Submesoscale Seasonal Dynamics of Phytoplankton Production in Eastern Boundary Upwelling Systems and Their Susceptibility to ENSO Events and Climate Change**

Diego Andre **Otero Huaman** and Takeyoshi Nagai

Tokyo University of Marine Science and Technology, Tokyo, Japan. E-mail: otero.diego.andre@gmail.com

Eastern Boundary Upwelling Systems (EBUSs) are the most productive marine ecosystems in the world, generating 20% of the global fish catch from 1% of the ocean area. High productivity is supported by the large upward nutrient transport caused by coastal upwelling from the deep layers to the illuminated surface layers, which phytoplankton utilize for growth. Generally, it is understood that coastal upwellings cause an increase in primary production due to the availability of nutrients. In contrast, a recent study pointed out that the seasonal upwelling favorable wind time affects phytoplankton upwelled nutrient consumption efficiency. However, the effects of submesoscale processes (eddies and filaments), which could regulate the nutrients fate, are overlooked. Since these submesoscale flows also exhibit seasonal changes, it is important to understand its role on the fate of upwelled nutrients. Then, we can predict the possible variations caused by ENSO events and climate change. For this purpose, using a high-resolution model: CROCO coupled with a biogeochemical model: BioEBUS, we simulated the Chilean EBUS and an Imitated Peruvian Upwelling, taken as references for other EBUSs, to investigate the effects of upwelling wind timing. We found that mesoscale and submesoscale flows send upwelled nutrients back to lower layers, preventing phytoplankton from utilizing them. More importantly, this effect is more intense when EBUSs experience upwelling favorable winds during winter. To investigate the effects of ENSO and the prospective stratification increase due to global warming on these meso and submesoscale nutrient transports, we use reanalysis records from CMEMS COPERNICUS, from 1993 onwards.

**(POC-P 17808)** POC-P-P3

**Impact of anticyclonic eddy on fish distribution in Kuroshio-Oyashio transition area**

Ryo Dobashi[1], Hiromichi **Ueno**[2], Riku Kato[2], Naizheng Yan[2], Tohru Mukai[2], Hiroki Yasuma[2], Daiki Nomura[2], Sachihiko Itoh[3] and Akihide Kasai[2]

[1]University of Hawai'i at Mānoa, Hawaii, USA

[2]Hokkaido University, Hakodate, Japan. E-mail: ueno@fish.hokudai.ac.jp

[3]The University of Tokyo, Kashiwa, Japan

Kuroshio-Oyashio transition area has water originating from subtropical and subarctic areas and forms productive ecosystems. Mesoscale eddies play important roles in these ecosystems, such as by transporting heat and organisms. Micronektonic mesopelagic fishes play crucial roles in biogeochemical cycles; however, further research is needed to understand the physical, chemical, and biological effects of mesoscale eddies on these fishes. Ship observation was conducted using Underway CTD and quantitative echo sounder in June 2019 to examine the impact of a mesoscale eddy on fish distribution in this area. The observed anticyclonic eddy originated from Kuroshio extension and had warm and saline water inside it. Acoustic volume backscattering strength (SV) at 38 kHz showed peaks along the density isolines around 75 dbar and 400 dbar, and the comparison of the SV at 120 kHz and 38 kHz suggested that the peaks of the SV were associated with fishes. The distribution of fishes inside the eddy became 13–19 dbar and 27–37 dbar deeper than outside of the eddy in surface and intermediate depth. Mean SV in intermediate depth were higher inside eddy compared to that outside eddy, suggesting the presence of denser fish within the eddy.

**(POC-P 17838)** POC-P-P4

**Introduction to Quality Management of Observation Data from the Ieodo Ocean Research Station (Ieodo-ORS) and Its Registration in International Observation Networks**

Kwang-Young **Jeong**[1], Gwang Ho Seo[1], Hyun-Sik Ham[1], Jinyong Jeong[2], Yongchim Min[2], Hee Yoon Park[1], Seok Jae Kwon[1] and Hyun-Ju Oh[1]

[1]Korea Hydrographic and Oceanographic Agency (KHOA), Busan, Republic of Korea. E-mail: kwangyoung@korea.kr

[2]Korea Institute of Ocean Science and Technology (KIOST), Busan, Republic of Korea

The Ieodo Ocean Research Station (I-ORS) is a remote offshore structure located southwest of Jeju Island, Republic of Korea. Since its completion in 2003, it has been monitoring 15 ocean and atmospheric parameters for about 20 years. Among these, Key observational parameters such as water temperature, salinity, air temperature, wind, humidity, and pressure, measured at 10-minute intervals, are meticulously managed for quality. The observational data are quality-controlled by evaluating their validity and detecting errors using scientific methodologies based on established standards. The primary quality control measures include automatic QC to assign the initial flag using physical limit (range) checks, variability (standard deviation) checks, spike detection, and constant value checks, flowing the OOI protocols. Subsequently, to determine errors in the observation values, manual inspections are conducted by reviewing the oceanographic conditions at the time and examining maintenance reports of facilities and equipment, with flags adjusted accordingly. These quality-controlled data are registered on international platforms such as OceanSITES, SEANOE, and EMODnet along with metadata. These datasets are accessible for download and research use by the global scientific community through international observation networks.

**(POC-P 17839)** POC-P-P5

**Coastal disaster risk assessment based on climate change scenarios along the Korea coasts**

Gwang Ho **Seo**[1], Kwang-Young Jeong[1], Hwa Young Lee[1], Hyun Ju Oh[1], Myung Won Kim[2] and Tae Soon Kang[2]

[1]Korea Hydrographic and Oceanographic Agency (KHOA), Busan, Republic of Korea. E-mail: seogh777@korea.kr

[2]Geo System Research Corporation, Gyeonggi, Republic of Korea.

The coastal areas of Korea are experiencing an increase in the frequency and intensity of natural disasters due to the acceleration of climate change. This has resulted in a loss of life and damage to property. There is a growing demand for scientific disaster information to prepare for increased coastal inundation and erosion due to sea level rise and typhoon intensity under climate change. However, current coastal disaster assessments rely primarily on past climate data.

In this study, we developed a coastal disaster risk assessment system that considers future climate change conditions. The Korea Meteorological Administration's climate change scenario (SSP 5-8.5) was selected based on data resolution, applicability, and ease of data collection.

The data required for the exposure and vulnerability indexes were obtained from authorized organizations, including the National Institute of Fisheries Science and the National Geographic Information Institute. The output data from the East Asia climate change scenario was utilized as input for the numerical model, which calculated the wave and tsunami components of the hazard index. For wind and rainfall, we used output data from the Korea Meteorological Administration's Korea (1 km) climate change scenario.

The assessment employed formulas based on the IPCC AR5 assessment framework to calculate the results for each scenario. The findings of this study are anticipated to provide information on coastal hazards in the context of future climate change, with the objective of establishing coastal hazard reduction measures.

**(POC-P 17881)** POC-P-P6

**The Kuroshio intrusion into the East China Sea revealed by a new mixed layer water mass analysis**

Yisen **Zhong** and Shuangzhao Li

School of Oceanography, Shanghai Jiao Tong University email: yisen.zhong@sjtu.edu.cn

Though the Kuroshio intrusion (KI) into the East China Sea (ECS) is relatively weaker during summer, it is of great importance to the ECS shelf ecosystem in this biologically-active season. The interannual variability of the summer intrusion is less explored as the long-term observations of the oceanic current are insufficient to draw a complete and unbiased conclusion. Using 3-year in situ measurements, we develop and validate a new tracer-based mixed-layer optimal multi-parameter (MLOMP) water mass analysis, which can well capture the intrusion pattern and year-to-year variation. The result exhibits a two-layer intrusion with decoupled interannual variations. The surface intrusion is controlled by the interaction between the Kuroshio and steep topography. During the year with abnormally weak upstream transport, the Kuroshio surface water may notably enter the ECS shelf and can reach farther north, as opposed to the very weak summer intrusion revealed by previous seasonal studies. The intrusion of Kuroshio subsurface water is characterized by a northward nearshore branch current, which is regulated by the offshore Ekman transport and shoreward pressure gradient at the interannual scale. The new MLOMP is also applied to the satellite temperature and salinity to examine the surface intrusion. The results still depict a reasonable spatial distribution and year-to-year variability of the intrusion, implying potentially a more practical use for longer-term intrusion analysis.

**(POC-P 17888)** POC-P-P8

**Linking northeastern North Pacific oxygen changes to upstream surface outcrop variations**

Sabine **Mecking** and Kyla Drushka

Applied Physics Laboratory, University of Washington, Seattle, WA, USA. Email: mecking@uw.edu

This study focuses on the North Pacific thermocline, where some of the world's oceans' largest oxygen variations have been observed. These variations, described as bi-decadal cycles on top of a small declining trend, are strongest on subsurface isopycnals that outcrop into the mixed layer of the northwestern North Pacific in late winter. In this study, surface density time series are reconstructed in this area using observational data only and focusing on the time period from 1982, the first full year of the satellite sea surface temperature record, to 2020. It is found that changes in the annual maximum outcrop area of the densest isopycnals outcropping in the northwestern North Pacific are correlated with interannual oxygen variability observed at Ocean Station P (OSP) downstream at about a 10-year lag. The hypothesis is that ocean ventilation and uptake of oxygen is greatly reduced when the outcrop areas are small and that this signal travels within the North Pacific Current to OSP, with 10 years being at the higher end of transit times reported in other studies. It is also found that sea surface salinity (SSS) dominates over sea surface temperature (SST) in driving interannual fluctuations in annual maximum surface density in the northwestern North Pacific, highlighting the role that salinity may play in altering ocean ventilation. In contrast, SSS and SST contribute about equally to the long-term declining surface density trends that are superimposed on the interannual cycles.

**(POC-P 17896)** POC-P-P9

**Sources and sinks of N2O in the subtropical Jiulong River Estuary, Southeast China**

Yang **Luo**, Yuhong Li, Jian Liu, Wangwang Ye, Jiexia Zhan, and Liyang Zhan

Third Institute of Oceanography (TIO), Ministry of Natural Resources (MNR), Xiamen, China.
E-mail: luoyang@tio.org.cn

Nitrous oxide (N2O) is one of the most important greenhouse gases and contributes to the depletion of ozone in the stratosphere. Estuaries are areas of intensive biological production and associated N2O emissions through both denitrification and nitrification processes. The spatial and temporal variations of N2O in the Jiulong River Estuary, a subtropical estuary, were explored to evaluate sources and sinks of N2O in this area. The estuary was found to be a strong source of N2O, its saturation in the surface water ranged from 113 to 2926% relative to the ambient atmospheric concentrations, showing great temporal and spatial variations and was influenced by multiple factors such as the concentration of dissolved inorganic nitrogen (DIN, i.e., NO- 3,NH+ 4, and NO- 2), salinity and dissolved oxygen. N2O concentrations were at a high level in upper estuary but reduced to the lower parts of the estuary. Groundwater input could be another contributor to N2O in the estuary. Almost all N2O within the estuary was released into the atmosphere rather than being transported to the bay. The N2O flux in the estuary (mean 597 mmol/m2/d) was at the higher end of the range observed in estuaries worldwide due to the very high DIN loads in the Jiulong River Estuary. Our data indicate that the N2O saturation in the estuary continues to increase, although the DIN inputs began to decline in 2011, which might be relate to the improved environmental conditions with increased oxygen concentrations. N2O production pathways have changed from predominantly denitrification in the past toward significant production from nitrification in the present. Further investigation is needed to better understand the behavior of N2O in the Jiulong River Estuary.

**(POC-P 17963)** POC-P-P10 (ECOP)

**Long-term transport of Fukushima originated-137Cs based on a Lagrangian particle tracking model**

Haejin **Kim**, Kyeong Ok Kim and Seongbong Seo

Korea Institute of Ocean Science & Technology, Busan, Rep. of Korea.

E-mail: hjkim127@kiost.ac.kr

The accident at the Fukushima Dai-ichi Nuclear Power Plant (FDNPP), caused by the great earthquake in March 2011, released a huge amount of radioactive material into the atmosphere and ocean. Measurements showed that the cesium (137Cs) from Fukushima reached the Canadian coast after 2 years and showed a maximum concentration 4 years after the accident.

This study examined the long-term transport of cesium considering both atmospheric deposition and direct ocean discharge, using a Lagrangian particle tracking model. The three-dimensional horizontal and vertical flow fields of the ocean circulation model (Modular Ocean Model version 5: MOM5) operated by the Korea Institute of Ocean Science and Technology (KIOST) were used to represent the transport of radioactive materials more realistically.

The numerical simulation reproduced the temporal variations and vertical structures quite similarly compared to the observations over the Northeast Pacific. The importance of vertical velocities for long-term dispersion and vertical structures is discussed as well.

**(POC-P 17965)** POC-P-P11 (ECOP)

**Frontogenesis elevates the maximum chlorophyll a concentration at the subsurface near the Kuroshio during well-stratified seasons**

Daiki **Ito**[1], Taketoshi Kodama[1,2], Yugo Shimizu[1], Takashi Setou[1], Kiyotaka Hidaka[1], Daisuke Ambe[1] and Sayaka Sogawa[1]

[1]Japan Fisheries Research and Education Agency, Yokohama, Japan. E-mail: ito_daiki41@fra.go.jp

[2]Now at The University of Tokyo, Tokyo, Japan

During well-stratified seasons, the increase in subsurface primary productivity associated with nutrient transport from the lower to the euphotic zone is important for biological production in the Kuroshio region. Frontogenesis is the development of oceanic fronts associated with background deformation flow, which are accompanied by large vertical velocity and thus promote nutrient supply to the surface layer, contributing to increased primary productivity. In this study, an intensive summer survey was conducted near the Kuroshio to examine the conditions under which subsurface chlorophyll a maximum (CHLSCM) increased due to the mesoscale front and frontogenesis. The process of submesoscale current was diagnosed using a high-resolution ocean reanalysis data set. In addition, repeat seasonal surveys across the Kuroshio and sea surface height data were analyzed to evaluate increases in CHLSCM associated with the mesoscale variation of the front both at the surface and in the interior. Frontogenesis supplied nutrients and increased CHLSCM; that is, chlorophyll a concentration was positively correlated with the strength of fronts and frontogenesis. Moreover, CHLSCM was estimated using satellite-derived geostrophic velocity.

**(POC-P 17975)** POC-P-P12

**Summertime hypoxic water in the bottom of Funka Bay, Japan**

Hiroto **Abe**, Chihiro Miki, Hiroji Onishi, Atsushi Ooki and Tetsuya Takatsu

Hokkaido University, Hakodate, Hokkaido, Japan. Email: abe@fish.hokudai.ac.jp

Hypoxic water (< 2 mL of $O_2$ per L), which can cause mass mortality of demersal fishes, crustaceans and mollusks, is reported to occur in the enclosed coastal area around the world. Funka Bay, a semi-enclosed and cone-shaped bay with a maximum depth of 107 m, located in the southern part of Hokkaido, Japan, also suffers summertime bottom hypoxic water, which is resolved by intrusion of Kuroshio-origin water in summer-to-autumn season and wintertime convection by buoyancy loss through surface water cooling. Our long-term monitoring since 2012 reveals that the occurrence of severe hypoxic water in August and September 2023 with dissolved oxygen value below 1 mL per L in minimum and continuation of hypoxic state more than 2 months. This indicates a relatively long period of severe hypoxic water, which has not been observed in this bay for the past 10 years. In this presentation, we would like to introduce our activity for monitoring water mass property in the Funka Bay based on mooring and hydrographic observation, and recent change of ocean environment in the bay.

**(POC-P 17976)** POC-P-P13 (ECOP)

**Predictability and prediction skill of summertime East/Japan Sea surface temperature events**

Youngji **Joh**[1], SeonJu Lee[2,3], Young-Gyu Park[2], Thomas L. Delworth[4], Gyun-do Pak[2],

Liwei Jia[4], William F. Cooke[4], Colleen McHugh[5], Young-Ho Kim[6] and Hyung-Gyu Lim[2]

[1]Atmospheric and Oceanic Sciences, Princeton University, Princeton, NJ, USA. E-mail: Youngji.joh@noaa.gov

[2] Korea Institute of Ocean Science and Technology, Busan, South Korea

[3] Cooperative Institute for Satellite Earth System Studies (CISESS)/Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, College Park, Maryland, USA

[4] Geophysical Fluid Dynamics Laboratory, NOAA/OAR, Princeton, NJ, USA

[5] Science Applications International Corporation, Reston VA, USA

[6] Department of Oceanography, Pukyong National University, Busan, Republic of Korea

The East/Japan Sea (EJS), a marginal sea of the Northwestern Pacific, is one of the ocean regions showing the most rapid warming and greatest increases in ocean heatwaves over the last several decades. Predictability and skillful prediction of the summer season EJS variability are pivotal given that the increasing severity of ocean temperature events profoundly impacts fisheries and reinforces climate conditions (e.g., East Asian rainy season), affecting the adjacent high-population density areas over East Asia. We use observations and the Geophysical Fluid Dynamics Laboratory (GFDL) Seamless System for Prediction and Earth System Research (SPEAR) seasonal forecast system to investigate the summertime EJS Sea Surface Temperature (SST) predictability and prediction skill. The observations and forecast system both support that the summer season EJS SST can be closely linked to the previous winter basin-scale air-sea coupling and predictable 8-9 months in advance. We suggest that slowly evolving oceanic anomalies (e.g., Ekman transport) coupled with the mid-latitude atmosphere can yield significant long-lead predictability of summer EJS SST events. The GFDL SPEAR seasonal prediction system demonstrates skillful forecast of EJS SST events from summer to late fall, with added skill for long-lead forecasts initialized in winter. We discuss potential linkages between the seasonal EJS SST and large-scale climate variability and further potential improvements and limitations of seasonal EJS SST prediction.

**(POC-P 18003)** POC-P-P14

**MOM6-NEP simulated connectivity pathways between the Northeast Pacific LMEs: from the Gulf of Alaska to the Chukchi Sea**

Wei **Cheng**[1], Albert J. Hermann[1,2], Vivek Seelanki[1,2] and Phyllis Stabeno[1]

[1]Pacific Marine Environmental Laboratory, Seattle, WA, USA. E-mail: wei.cheng@noaa.gov

[2] University of Washington, Seattle, WA, USA.

Transporting water parcels from one location to another is crucial for establishing water mass and biogeochemical (BGC) properties, as well as for fisheries processes such as larvae survival, which depends on their ability to move from spawning locations to suitable settlements. In the high latitudes of the Northeast Pacific, connectivity among the different Large Marine Ecosystems -- the Gulf of Alaska, Bering Sea, and Chukchi Sea -- is limited by geographical features such as the passes along the Aleutian Island chain and the narrow and shallow Bering Strait. Due to their fine spatial scales, modeling transport through these passages in regional ocean hydrodynamical models is often challenging.

Recent advances in MOM6-NEP include the incorporation of an Arbitrary Lagrangian-Eularian vertical coordinate, shaved cells that eliminate the need of bathymetric smoothing, and improved physics parameterizations (surface mixed layer and interior ocean mixing schemes). These advances prompted us to revisit key transport metrics between these three LMEs. We focus on transport where validating observational data are available; this includes time series of volume transports through Unimak and Amukta Passes, and Bering Strait.

Preliminary results from hindcast simulations of MOM6-NEP, forced by atmospheric and oceanic reanalysis products, show that modeled volume transports through these passages closely correspond with observations. We will also conduct sensitivity tests to further identify the physical processes contributing to the mean state and interannual variability of the modeled transports.

**(POC-P 18021)** POC-P-P15 (ECOP)

**Factors affecting the local variability of the Kuroshio: The Changjiang diluted water effect**

Eun-Seo **Jeong** and Jae-Hyoung Park

Department of Oceanography, Pukyong National University, 45 Yongso-ro, Nam-gu, Busan 48513, Republic of Korea. E-mail: eunseojeong6@gmail.com

The Changjiang diluted water (CDW) influences not only the marine ecosystem but also the circulations in the East China Sea (ECS) during summer. While it has long been known that the Kuroshio current, flowing along the edge of the ECS, primarily determines oceanic environment, the quantitative impacts of the CDW on the Kuroshio current have not been identified. We have conducted investigations of the characteristics of the Kuroshio and the spatial distribution of the CDW by using the absolute dynamic topography from the Copernicus Climate Change Service (C3S) and satellite-based salinity data from the Soil Moisture Active Passive (SMAP) mission. We also used ship-based hydrographic data in PN section provided by Japan Meteorological Agency (JMA) to quantify the variations of the pressure gradient by low-salinity water masses in the cross-stream direction. As a result, we found that the CDW widely spread over the ECS and expanded to the Kuroshio region in July. Two types of along stream component of geostrophic velocities (Vg) were compared for magnitude to quantify the effect of the CDW on Kuroshio. One type was estimated based on the observed salinity, while the other based on fixed salinity. The results showed that the Vg with observed salinity decreased by 2 cm s-1 compared to the Vg with fixed salinity. That is to say, approximately 1% of the total Kuroshio velocity was influenced by the CDW has a minor effect on the variability of the Kuroshio. We will address an interaction of the Kuroshio with regional drivers such as eddy and local atmospheric forcing in the future research.

**(POC-P 18027)** POC-P-P16 (ECOP)

**Pairwise surface drifter separation by eddies in the Western Pacific, Kuroshio Extension, and Bering Sea**

Seongbong **Seo**[1], Jun Myoung Choi[2], Dong Guk Kim[1], Kyeong Ok Kim[1] and Young-Gyu Park[1]

[1]Korea Institute of Ocean Science and Technology, Busan, Republic of Korea. E-mail: sbseo@kiost.ac.kr

[2]Pukyong National University, Busan, Republic of Korea.

Using surface drifters, we investigated the horizontal dispersion and diffusivity due to mesoscale eddies in the western Pacific, the Kuroshio Extension, and the Bering Sea. In each region 23, 20, and 10 drifters were deployed, and from those drifters 22, 20 and 5 pairs were produced. The drifters were tracked for up to 2 years, and the separations of the pairs were characterized by the Finite-Scale Lyapunov Exponent (FSLE) and the horizontal eddy diffusivity was estimated. The FSLE revealed that the Kuroshio Extension region exhibits a ballistic, whereas the western Pacific and the Bering Sea exhibit Richardson behavior at scales below 10 km. The horizontal diffusivity was estimated to be $O(10^2)$ and $O(10^3)$ $m^2s^{-1}$ at separation length scales of 10 and 100 km, respectively. The Kuroshio Extension, where eddies are greater and stronger, exhibited the highest dispersion and diffusivity, while the Bering Sea, where eddies are smaller and weaker showed the lowest.

**(POC-P 18048)** POC-P-P 17

**Meso, submeso and microscale structures in and around a cyclonic eddy**

Sachihiko **Itoh**[1], Eisuke Tsutsumi[2], Ryuichiro Inoue[3], Takeyoshi Nagai[4], Yusuke Sasaki[1], Anne Takahashi[1], Shin-ichi Ito1 and Ichiro Yasuda[1]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan email: itohsach@aori.u-tokyo.ac.jp

[2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan

[3]Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan

[4]Tokyo University of Marine Science and Technology, Tokyo, Japan

Observations were conducted across a mesoscale cyclonic eddy in the north of the Kuroshio Extension using a towed-CTD and a vertical microstructure profiler. The target cyclonic eddy was generated through the interaction of the Kuroshio Extension and the Oyashio Currents. A mesoscale dome-shaped pycnocline structure with a cold and fresh core water was clearly detected by underway CTD observations, while the width of a front of the eddy was specified at a submesoscale range, and a number of submesoscale patches characterized by temperature and salinity anomalies are found within the eddy. Vertical microstructure measurements revealed the enhancement of turbulence around fronts, from $\varepsilon \sim 10^{-9}$ W kg$^{-1}$ to $\varepsilon \sim 2–6 \times 10^{-9}$ W kg$^{-1}$. Since the concurrent drifter observations did not indicate signals of near inertial wave propagations, the enhancement was likely caused by local processes. Based on the analysis of surface strain field and ray-tracing experiments over the observed frontal structure, we suggest that enhancement of the mixing around the front was caused by the trap of internal waves locally generated in the area associated with the frontogenesis.

**(POC-P 18056 Poster)** POC-P-P18 (ECOP)

**Seasonally contrasting wind-driven submesoscale dynamics contributes to chlorophyll-a patchiness in the Northern Gulf of Alaska**

Isaac **Reister**, Seth Danielson, Tyler Hennon, Thilo Klenz and Ana Aguilar-Islas

University of Alaska, Fairbanks, Alaska. E-mail: isaac.reister@gmail.com

Horizontal density fronts and instabilities can be sites of accumulated biomass and high biological activity and contribute to biological patchiness on some continental shelves. These submesoscale O(100 km) dynamics evolve on timescales similar to phytoplankton growth cycles and within the context of the broader, shelf-wide seasonal and interannual thermohaline patterns. We document the interplay of multiple short-term and long-term environmental drivers in the Northern Gulf of Alaska (NGA) and hypothesize that weak fronts offshore of a prominent coastal current exhibit seasonal dependences that contribute to this shelf's biological patchiness. In this study an in situ towed-undulating Conductivity-Temperature-Depth (CTD) and bio-optics measurement package captured spring, summer, and fall high-resolution (250 x 1 m) data over the upper 50 meters across an ~250 km NGA transect (the Seward Line), which extends from the coast to beyond the shelf break. The interaction between submesoscale dynamics and wind is explored with shipboard wind data and reanalysis data. A 27 year-long record of CTD casts along the Seward Line as well as transect data of nutrients and light provide interannual and seasonal context. We find that while the Seward Line density is primarily salinity-controlled, the upper 50 m across most of the shelf and slope are temperature-controlled during parts of the year. Wind stress, euphotic zone depth, and surface nitrate concentrations change seasonally and with distance from the coast, and coincide with changes in chlorophyll-a concentrations. Ekman buoyancy flux and symmetric instabilities at the submesoscale change seasonally and may modify chlorophyll-a levels.

**(POC-P 18072)** POC-P-P19

## Intrusion of Coastal Oyashio water to southwest Hokkaido Island, Japan, occasionally disturbed by Kuroshio-originating warm core ring

Hiroto **Abe**[1], Yuta Yahiro[1], Takuya Hasegawa[1, 2], Toru Hirawake[1,3], Hiroji Onishi[1], Atsushi Ooki[1], Tetsuya Takatsu[1], Ken'ichi Sasaki[4], Masahide Wakita[4], Hitoshi Kaneko[4], Shuichi Watanabe[4], Takahiro Tanaka[5], Takeshi Okunishi[5], Shintaro Ohno[1] and Satoru Hashizume[1]

[1]Hokkaido University, Hakodate/Sapporo, Hokkaido, Japan. Email: abe@fish.hokudai.ac.jp

[2]Tohoku University, Sendai, Miyagi, Japan

[3]National Institute of Polar Research, Tachikawa, Tokyo, Japan

[4]Japan Agency for Marine–Earth Science and Technology (JAMSTEC), Mutsu, Aomori, Japan

[5]Japan Fisheries Research and Education Agency, Shiogama, Miyagi, Japan

Water mass property in the southwest of Hokkaido Island, Japan, in the winter-to-spring season has been examined using 9 years' hydrographic data and satellite data as well as ocean reanalysis data for 2010–2018. Hydrographic and moored observations indicate a regime shift in the 2010s; a cold period in 2010–2014 and a warm period in 2016–2018. The regions are known to be influenced by intrusion of Coastal Oyashio water (COW), which is cold fresh water originated from the Okhotsk Sea. Satellite-based sea surface temperature and altimeter data reveal that Coastal Oyashio flowing westward along the southern coast of Hokkaido Island to Funka Bay in the cold period and further to Tsugaru Strait in 2014. The western limit of COW does not reach Funka Bay in 2016–2018. During warm period, a warm core ring (WCR) originating from the Kuroshio Extension, approaches the southern coast of Hokkaido Island. Our analysis of high-resolution ocean reanalysis data indicates that the WCR disturbs inflow of the COW and/or provides warm saline water to the COW. Our finding suggests that in the winter-to-spring season, the ocean environment of southwest of Hokkaido Island can be controlled by the Kuroshio-originating WCR that disturbs intrusion of the COW.

**(POC-P 18122)** POC-P-P20 (ECOP)

**Variability in the Alaskan Stream and the Subarctic Gyre in the NE Pacific**

Emily P. **Lemagie**, Hristina Hristova and Phyllis Stabeno

[1]NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA. Email: emily.lemagie@noaa.gov

The Alaskan Stream is a narrow (~50 km) western boundary current that transports 10–30 $x10^6$ $m^3$ $s^{-1}$ of water southwestward along the Aleutian Islands archipelago. Transport of Alaskan Stream water through the Aleutian passes is an important source of mass, heat, and nutrients from the North Pacific into the Bering Sea. The strength of the Alaskan Stream determines the magnitude of heat and salt flux into the Bering Sea. Increased heat transport warms the Bering Sea and can play a role in delaying the advance of sea ice on the eastern Bering Sea shelf. We examine over 30 years of transport estimates for the region. based on combination of satellite sea surface height measurements, geostrophic currents from Argo profiling floats temperature and salinity and mooring observations. While estimates of the subarctic gyre strength indicate a positive trend over the last 30 years, there has been a decreasing trend in estimates of the Alaskan Stream transport near 170$^o$W over the last decade. The implication of this decrease on the marine ecosystem of the Aleutian Passes is unknown. Local wind forcing can be an important driver of variability in transport around the Gulf of Alaska. Here we analyze the circulation in the subarctic gyre around the Gulf of Alaska from 1993-2023 relative to wind patterns, seasonal variability, and eddies.

**(POC-P 18133)** POC-P-P21

**Observed multi-decadal increase in the surface ocean's thermal inertia**

Hajoon **Song**[1], Chaehyeong Lee[1], Yeonju Choi[1], Ajin Cho[1] and John Marshall[2]

[1]Department of Atmospheric Sciences, Yonsei University, Seoul, Republic of Korea.

E-mail: hajsong@yonsei.ac.kr

[2]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA USA

The ocean surface layer plays a pivotal role in Earth's climate by absorbing excess atmospheric heat, thereby regulating global temperatures. Here we document a notable increase in the persistence of sea surface temperature across the global ocean over the past four decades. This increase is also analyzed in the frequency space, which shows statistically significant decrease in high-frequency variance (shorter than a month), but a slight increase in low-frequency during this period. The application of a simple stochastic model shows that this prolonged memory is due to three key factors: a deepening of the surface mixed layer, a weakening of the oceanic forcing, and a decrease in the damping rates. The first two factors contribute to the reduced high-frequency variance, resulting in a slower decay of temperature anomalies in recent years.

The last factor increases the low-frequency variance, allowing the slowly varying SST signal to contribute to the increase in temperature persistence. Our findings have great relevance to the observed increase in the duration of marine heatwaves and associated heightened thermal threats to marine organisms. Our study also suggests that the ocean's ability to sequester heat is weakening, a trend that may accelerate through the 21st century.

**(POC-P 18148)** POC-P-P22

**Dissolved oxygen depletion in the intermediate layer in the Kuril region of the northwestern Pacific Ocean**

A.S. **Kurnosova** and E.Yu. Malygin

Pacific branch of “VNIRO” (“TINRO”), Vladivostok, Russia anna.kurnosova@tinro.vniro.ru

The content of dissolved oxygen is an important indicator of the status of the water area. In the World Ocean, the content of dissolved oxygen has decreased by 2% over the past 50 years due to the global warming. In the northwestern Pacific Ocean (NWPT), oxygen enriches the intermediate layer with waters inflowing through the southern Kuril Straits. Therefore, analysis of the dissolved oxygen content in this water area is an urgent task. Hydrochemical data obtained in the TINRO expeditions in June of 2013-2024 were considered to assess the change in the dissolved oxygen content in the intermediate layer in the Kuril region of the northwestern Pacific Ocean. A decreasing trend in the dissolved oxygen content was revealed in the section along the Kuril Ridge for the period under consideration. However, there are individual pronounced peaks in the maximum values in certain years. A decreasing trend can be traced at all considered layers from the surface to 1000 m. The clearest manifestation of the dissolved oxygen depletion is noted in the intermediate layer at the depths of 500 m and 1000 m. The calculated general rate of the oxygen depletion is -0.03 ml/l per year in the photic zone, and -0.06 ml/l per year at the depths of 500 m and 1000 m. Thus, the revealed trends of interannual variability of dissolved oxygen in the Kuril region are consistent with the general concept of “dissolved-oxygen depletion” in the North Pacific Ocean.

# W1: FUTURE/BIO/MONITOR/TCODE Topic Workshop

**North Pacific plankton time series data analyses and synthesis**

**Convenors:**
Akash Sastri (Canada), *corresponding*
Julie Keister (USA)
Kazuaki Tadokoro (Japan)
Samantha Zeman (USA)
Xuelei Zhang (China)

**Invited Speakers:**
**David Kimmel**
(NOAA Fisheries, USA)
**Hiroomi Miyamoto**
(Japan Fisheries Research and Education Agency (FRA), Japan)

Plankton monitoring is a key component of observational programs in the North Pacific. Many of these programs contribute to mature and relatively short plankton time series which provide early and rapid biological indicators of response to climate-ocean variability and extreme events (e.g. marine heatwaves) occurring with increasing frequency. A major goal of this workshop is to bring PICES-region plankton monitoring groups together and develop a common understanding of differences and similarities in sampling methods (gear, timing, coverage) and analytical methods. Discussion and presentation of non-standard but complementary sampling (biochemical, imagery, etc.,) methods and time series analyses of plankton are also important to this goal. Against this background, our objective is to begin a comparison of regional phyto- and zooplankton time series with the goal of identifying common metrics and methods useful at broader scales relevant to the North Pacific. An additional motivation for this workshop is to census the appetite for continued group discussion and regular updates on regional plankton time series.

**(W1 17762 Invited)**

**Zooplankton Community Change in the Transition and Subarctic Regions of the North Pacific Ocean from 2004 to 2023**

Hiroomi **Miyamoto**

Japan Fisheries Research and Education Agency, Kanagawa, Japan. E-mail: miyamoto_hiroomi47@fra.go.jp

The transition and subarctic regions of the western and central North Pacific Ocean are one of the highest biological production area in the global ocean. Various fish species, such as sardines, mackerels, and Pacific saury, use these regions as feeding grounds. Recently, water temperatures in these regions rapidly rise due to marine heatwaves and current meandering, potentially affecting the pelagic ecosystem. This study investigated the long-term distribution changes of zooplankton communities, especially pelagic copepods, in early summer, based on zooplankton samples collected in the transition regions from the coast to approximately 4,500 km offshore to the east (mainly area: 143°E to 165°W and 38°N to 45°N), spanning from 2004 to 2023. During the two decades, large-sized calanoid copepods, such as Neocalanus and Calanus species, have decreased. Among these species, Neocalanus plumchrus has shifted northward by approximately 3 degrees of latitude. On the other hand, small subtropical and temperate species, such as Clausocalanus and Ctenocalanus species, have increased and now occur at higher latitudes with lower temperatures. The present monitoring program demonstrated that the pelagic ecosystems in the transition region have shifted from subarctic ecosystems, which were characterized by the dominance of large copepods, to subtropical ecosystems where small species are dominant. This community change might influence the energy availability for higher trophic-level organisms

**(W1 17912 Invited)**

**Development and application of zooplankton time-series for use in ecosystem based management in Alaska**

David G. **Kimmel**

Alaska Fisheries Science Center/NOAA, Seattle, WA, USA. E-mail: david.kimmel@noaa.gov

Marine ecosystems of the north Pacific face unprecedented change and an uncertain future. Change is occurring at a rapid pace and environmental time-series are proving to be valuable investments. Zooplankton are collected across the north Pacific and used in both basic and applied research related to ecosystem monitoring. These data are used to develop time-series that provide context for how present ecosystem conditions relate to past and possible future conditions. As an introduction to the workshop, my goal will be to provide a comprehensive overview of zooplankton time-series development and application to management in Alaska, with particular emphasis on challenges and lessons learned. I will begin with the rationale for developing zooplankton time-series and the decision processes that led to where and when to sample zooplankton. Next, the relationship between zooplankton time-series and the environment in Alaska's large marine ecosystems will be explored. This led to the synthesis of zooplankton information for application to management and I will describe this process. Finally, I will end with a discussion of future directions for both basic and applied research into zooplankton variability over time, including ideas for cross-system comparisons and regional time-series development.

**(W1 17794 Oral)**

**Unveiling the impact of winter storms on the dynamics of zooplankton populations in shallow estuaries**

Hongsheng **Bi**, Jian Zhao and Wenjing Liu

University of Maryland Center for Environmental Science, Cambridge, Maryland, USA. Email: hbi@umces.edu

Plankton play a vital role in marine food webs, and monitoring their populations is crucial for understanding their dynamics and underlying processes. Since February 21, 2023, we have deployed the PlanktonScope to collect in situ, high-frequency, real-time observations of plankton at the research pier at the mouth of the Patuxent River. Our results show that during later winter and early spring, the study site was primarily influenced by riverine water, characterized by a large population of copepods, specifically Eurytemora, with high density and large size. In contrast, during summer, the monitoring site was predominantly affected by high salinity bay water. Our study suggests that the high abundance of large copepods is closely associated with winter storms, indicating that these events have a significant impact on copepod interannual variation, which in turn affects the recruitment of estuary-dependent fish. Additionally, storm events may increase the density of copepods and lead to larger interannual variations. The present study provides insights on how episodic winter storm affect local zooplankton dynamics which subsequently affect long term trend.

**(W1 17970 Oral)**

**Interannual changes of zooplankton assemblages in the western subarctic Pacific based on Continuous Plankton Recorder during 2001–2020: Analysis by GDM and future prediction**

Yutaka Fukai[1], Sanae Chiba[2], Sonia Batten[2], Yuka Sasaki[3], Kosei Sasaoka[4], Kohei Matsuno[5] and Atsushi **Yamaguchi**[5]

[1]Hokkaido Research Organization, Kushiro, Hokkaido, Japan

[2]North Pacific Marine Science Organization (PICES), British Columbia, Canada

[3]Suidosha, Kawasaki, Kanagawa, Japan

[4]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan

[5]Hokkaido University, Hakodate, Japan. E-mail: a-yama@fish.hokudai.ac.jp

The study analyzed annual changes in zooplankton assemblages in the western subarctic Pacific based on 1788 zooplankton samples collected by the Continuous Plankton Recorder (CPR) during the spring, summer, and autumn of 2001–2020. Environmental data such as sea surface temperature (SST), sea level anomaly (SLA), and chlorophyll *a* (chl. *a*) were obtained from satellite measurements. The analysis revealed increasing trends in both SST and SLA across all three seasons, with one or two regime shifts detected during the observation period. Zooplankton assemblages were categorized into seven communities. While interannual changes in zooplankton communities were minimal during spring, significant changes were observed during summer and autumn. The shifts in zooplankton communities during summer and autumn corresponded with the regime shift timing of SST. The increase in the abundance of *Neocalanus plumchrus* was identified as the cause of interannual changes in summer and autumn zooplankton, potentially influenced by the rising SST in the region. Generalized Dissimilarity Modeling (GDM) analysis indicated that the most important environmental factors affecting zooplankton assemblages were SST and SLA. The study also provided insights into the future prospects of zooplankton assemblages in this region over the next 20 years.

**(W1 17972 Oral)** (ECOP)

## Spatial changes in zooplankton communities within the western Subarctic Pacific during summers 2000–2020: Comparison between warm and cold years and with data from the eastern Subarctic Pacific

Shintaro **Yoshida**[1], Yutaka Fukai[1,5], Sanae Chiba[2], Sonia D. Batten[2], Brian A. Hoover[3], Kosei Sasaoka[4], Kohei Matsuno[1] and Atsushi Yamaguchi[1]

[1]Hokkaido University, Hakodate, Japan, E-mail: lionelshinta10@eis.hokudai.ac.jp

[2]North Pacific Marine Science Organization (PICES), British Columbia, Canada

[3]Schmid College of Science and Technology, California, United States

[4]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan.

[5]Present address: Fisheries Research Department Kushiro Fisheries Research Institute, Kushiro, Japan

Although the Continuous Plankton Recorder (CPR) survey was initiated in the western Subarctic Pacific in 2001, changes in the zooplankton community between cold and warm years and comparisons with those in the eastern Subarctic Pacific are not fully understood. In this study, we analyzed spatial and annual changes in zooplankton communities based on CPR data and evaluated the effects of environmental parameters in the western Subarctic Pacific during the summers of 2001 to 2020. An east–west comparison was also made with the eastern Subarctic Pacific for the same period. We identified three cold years and four warm years in the western Subarctic Pacific during the study period, and these varied from those in the eastern Subarctic Pacific due to the Pacific Decadal Oscillation. With respect to east-west differences in the zooplankton community, dominant species/taxa were more numerous and divergent in the east than the west, and these patterns were attributed to warm conditions in the eastern Subarctic Pacific. In the western Subarctic Pacific, zooplankton communities were classified into six groups, and the occurrence of each group varied significantly between cold and warm years. Five groups were present in cold years and high horizontal/spatial variabilities were observed, whereas one group occupied a wide area in warm years. During cold years, mesoscale eddies induced high spatial diversity in zooplankton communities. However, in warm years, zooplankton communities were characterized by the dominance of warm water species extending to high-latitude areas, which may mask the effects of mesoscale eddies.

**(W1 18007 Oral)**

**Differential response of zooplankton to warm events in the Salish Sea, Northern Gulf of Alaska, and Bering Sea**

Julie E. **Keister**[1,2], David Kimmel[1], BethElLee Herrmann[2], Amanda Winans[2]

[1]Alaska Fisheries Science Center, NOAA, Seattle, WA, USA. E-mail: Julie.Keister@noaa.gov

[2]School of Oceanography, University of Washington, Seattle, WA, USA.

We compare time series of zooplankton species abundances collected as part of monitoring programs that sample zooplankton across the eastern North Pacific from the Salish Sea to the Bering Sea. NOAA's Ecosystems & Fisheries-Oceanography Coordinated Investigations (EcoFOCI) program has been sampling for decades from the Northern Gulf of Alaska to the Northern Bering Sea. The Puget Sound Zooplankton Monitoring Program (PSZMP), established in 2014, samples the southern Salish Sea. Both were established to provide plankton data in support of fisheries science and management. Here we compare zooplankton time series collected by these programs in the Bering Sea (2005-present), Northern Gulf of Alaska (1994-present), and southern Salish Sea (2014-present) to explore similarities and differences in species responses to climate variability. These programs sample at different temporal resolutions, from bi-annually to bi-weekly, but with similar sampling protocols that enable comparison of response to large-scale environmental changes, including marine heatwaves. To compare data collected with different temporal and spatial resolution, we summarize the data into annual z-scores and explore responses to environmental change among regions. Here we will introduce these datasets and explore patterns in the zooplankton data that highlight regional differences in response to climate events and differential responses among species

**(W1 18102 Oral)**

**A quarter century of observations along the Seward Line: the good, the bad and the ugly of long time-series**

Russell R. **Hopcroft**

University of Alaska Fairbanks, Fairbanks, USA E-mail: rrhopcroft@alaska.edu

The Seward Line in the North Gulf of Alaska began as part of the US GLOBEC program in the fall of 1997. It continues as uninterrupted observations made during May and September annually. Such time-series are critical at establishing both the natural variability in the ecosystem and the impact of climatic forcing upon major ecosystem elements. For example, the Pacific Decadal Oscillation is a major driver of Seward Line zooplankton communities. Nonetheless maintaining such time series requires huge effort, and that effort can vary over time. Here we consider some of the tradeoffs in maintaining consistency of a time-series over the long haul while also trying to improve upon it. We show examples of how more nuanced patterns in time-series can be impacted by changes in taxonomic effort and taxonomic resolution, to stimulate further discussion.

**(W1 18105 Oral)**

## Seasonal and monthly scale plankton sampling along the southwestern coast of Vancouver Island, British Columbia, Canada.

Akash R. **Sastri**[1,2], Kelly Young[1], Moira Galbraith[1], and R. Ian Perry[1,3]

[1]Institute of Ocean Sciences, Sidney, BC, Canada. E-mail: Akash.Sastri@dfo-mpo.gc.ca

[2]Department of Biology, University of Victoria, Victoria, BC, Canada.

[3]Pacific Biological Station, Nanaimo, BC, Canada

The west coast of Vancouver Island (WCVI) lies in the transitional zone between the equatorward flowing California Current and the poleward flowing Alaska Current. Zooplankton composition and biomass in this area are subject to variation in the position of the transitional streamline and strong seasonality in timing and intensity of upwelling and downwelling. Fisheries and Oceans Canada (DFO) maintains several plankton monitoring programs along the BC outer coast. Here, we compare two time series situated on the continental shelf off of southwestern Vancouver Island: 1) the La Perouse plankton program; and 2) the Barkley Sound krill sampling program. The La Perouse program started in 1979 and was focused on the shelf and later expanded to also sample continental slope and offshore waters. The Barkley Sound program started in 1992/1993 with a focus on the locally productive euphausiid populations which are important to early marine phase of juvenile WCVI coho and chinook salmon. La Perouse stations have been sampled continuously on a seasonal basis, whereas Barkley Sound stations have been sampled on a monthly basis but with an eight-year gap between 2014- 2021. Here we compare each time series in the context of sampling and analytical approaches used to characterize interannual variation of biomass and seasonal timing of key groups.

# W4: MEQ Topic Workshop

**Contrasting the occurrence of toxic *Alexandrium* blooms in the eastern and western North Pacific**

**Convenors:**
Mark L. Wells (USA), *corresponding*
William Cochlan (USA)
Vera Trainer (USA)
Charles Trick (Canada)
Pengbin Wang (China)

**Invited Speaker:**
**Satoshi Nagai**
(Japan Fisheries Research and Education Agency (FRA), Japan)

There is clear evidence of contrasting occurrence and impacts of toxin-producing dinoflagellates of the genus Alexandrium between the western and eastern Pacific. All PICES nations have experienced Alexandrium blooms, and there is evidence that the seasonal window for these blooms is expanding with increasing ocean temperatures. However, there are significant differences in oceanographic conditions in the eastern and western margins of the Pacific. A better understanding of the similarities and differences in these bloom phenologies, magnitude, and character across this oceanographic framework would strengthen the foundation for forecasting how these toxic events may change in the future oceans, a key finding of PICES-funded international workshops on HABs and Climate Change. Indeed, while a recent global assessment of HABs finds little firm evidence of climate-induced changes in HABS, there are indications that regional trends may be obscured. This workshop is a continuation of our successful east-west Pacific HAB comparisons, which now will focus on Alexandrium species that historically have had massive economic and human health impacts in PICES member countries. The workshop foundation will be an extension of contemporary datasets in the PICES region back to the 1990s and earlier where available, with PICES participants pre-submitting available data on HAB species presence, maximum abundance, toxicity, optimal conditions for growth, time of year, temperature range, salinity range, water clarity, nutrients, wind, hydrologic intensification, and upwelling indices. Workshop participants will evaluate the trends and patterns in these data to develop hypotheses for development into outlook products on day 1 and develop a detailed outline for manuscript preparation on day 2, including writing assignments and submission deadlines. The manuscript will be prepared as a PICES Special Publication and/or an appropriate peer-reviewed journal.

**(W4 17792 Invited)**

**Population genetic studies of worldwide populations in the toxic dinoflagellate *Alexandrium catenella***

Satoshi **Nagai**

Japan Fisheries Research and Education Agency, Fisheries Technology Institute, 2-12-4 Fukuura, Kanazawa-Ku, Yokohama, Kanagawa 236-8648, Japan email: nagai_satoshi44@fra.go.jp

The geographic range of *Alexandiurm catenella* poisoning appears to be increasing on both regional and global scales. The molecular ecological study of genetic relationships using highly polymorphic genetic markers may reveal the dispersal mechanism of this species. In this study, MIG (multiplexed ISSR Genotyping)-seq was employed to reveal the genetic relatedness among Pacific Rim populations. Loci which were detected in >70% individuals and isolates in which >50% loci were detected were chosen for the further analysis, resulting in detecting 349 SNPs in 165 samples isolated from Atsukeshi (eastern Hokkaido), Sendai, Osaka, Hiroshima Bays (Japan), Jinhae Bay (Korea), Bering Sea, Chukchi Sea, Puget sounds (USA) and Chile. Pairwise Fst values showed significant differences among most of the pairwise samples except for between Osaka & Jinhae Bay and Osaka & Hiroshima Bay. In the principal coordination analysis, the samples from Japan and Korea, the Bering Sea, and the Chukchi Sea (7 samples) were positioned closely, but Puget sounds and Chilean samples were plotted quite far away. Also, the bar plot data by STRUCTURE suggested when K = 3, each cluster was grouped as 1) Japan and Korean except for Akkeshi Bay, 2) Akkeshi Bay and the Bering/Chukchi Sea, 3) Puget sounds and Chilean samples. These data suggested the presence of a large genetic break between the Bering Sea and Puget sounds populations and genetic connectivity between Akkeshi Bay and the Bering/Chukchi Sea populations. At the workshop, I will show the population genetic structures in other *Alexadnrium* species compared to *A. catenella*.

**(W4 17819 Oral)**

**Alexandrium in the Strait of Georgia, a semi-enclosed sea of the eastern North Pacific.**

Svetlana **Esenkulova** and Isobel Pearsall

Pacific Salmon Foundation, Vancouver, BC, Canada. E-mail: sesenkulova@psf.ca

The Strait of Georgia citizen-led oceanography monitoring program has been operated by the Pacific Salmon Foundation from 2015 to 2024. Sampling occurred at approximately 55 sites on a regular schedule, about 18 times a year. Over ten years of operation, the program has produced a dataset based on approximately 14,000 records of Alexandrium spp. presence/absence and its concentrations (cells per mL), with ~70% of the samples collected at the surface and the rest at 5, 10, and 20 meters (~10% each). Most of these sampling events also include associated data on physical parameters (temperature, salinity, depth, dissolved oxygen, turbidity, and chlorophyll), with about 15% having data on chemical parameters (nitrates, phosphates, and silicates) collected by the same monitoring program. Based on these high-resolution results, Alexandrium is one of the most commonly occurring harmful algae in the Strait. It is mostly observed from May through September. Regionally, it most frequently occurs in shallow, restricted embayments and inlets. Over ten years of monitoring, Alexandrium dynamics appear to be linked with large-scale climate patterns.

**(W4 17853 Oral)**

**Paralytic shellfish poisoning on the US Pacific Northwest coast in spring 2024**

Vera **Trainer**[1], Anthony Odell[1] and Melissa Peacock[2]

[1]Olympic Natural Resources Center, University of Washington, Forks, WA, USA email: verat@uw.edu

[2]Salish Sea Research Center, Northwest Indian College, Bellingham, WA, USA

In late May 2024, the Oregon, USA, health authority warned anyone who gathered mussels from certain beaches on the northern Oregon coast to throw them out after reports of people sickened by a shellfish-borne biotoxin. More than 30 people fell ill after eating mussels gathered on the central Oregon coast. An unknown number of people were hospitalized, but there have been no reported deaths. This advisory was expanded to include all shellfish species from growing areas in Willapa Bay, Washington and distributed to Arizona, California, Colorado, Hawai‘i, Nevada, New York, Oregon and Washington, showing the widespread impacts of this event.

The Oregon patients reported symptoms of paralytic shellfish poisoning (PSP), which can cause numbness of the mouth and lips, nausea, vomiting, diarrhea, weakness and in severe cases shortness of breath or irregular heartbeat. Phytoplankton monitoring through the Olympic Region Harmful Algal Bloom (ORHAB) partnership, has indicated that *Alexandrium* (the causative agent for PSP) numbers were elevated in WA, and sporadic phytoplankton monitoring by University or Oregon and Oregon Dept of Fish and Wildlife (ODFW) showed that these cells are also still present in OR at least until mid-June 2024.

We initiated a rapid response to one of the largest PSP events in recorded US history to provide a rapid testing method to alleviate the stress on WA and OR health departments. We will discuss the difference in phytoplankton monitoring programs in WA and OR that may have led to the PSP event and the implementation of rapid kits for PSP screening of seawater and shellfish to provide an early warning of these events.

**(W4 17923 Oral)**

**The occurrence of toxic *Alexandrium* blooms in China coastal waters**

Douding Lu, Pengbin Wang and Ruoyu Guo and Xinfeng **Dai**

Key Laboratory of Marine Ecosystem Dynamics, Second Institute of Oceanography, Ministry of Natural Resources (MNR), Hangzhou 310012, China email: xinfengdai@sio.org.cn

*Alexandrium* species have widely been detected in coastal waters of China. The distribution pattern of these species is affected by a variety of factors, such as sea temperature, nutrient levels, and current systems. *A. tamarense* complex appeared to be the most widely distributed species, Before the year 2000, there were virtually no recorded cases of *Alexandrium* bloom in China. After the year 2002, more than 10 bloom events were documented in Chinese coastal waters based on the China Marine disaster bulletin. Cyst abundance of *Alexandrium* exhibited a gradual increasing trend in the several sediment cores in the Changjiang River estuary. Some studies suggested that *Alexandrium tamarense* species complex Group IV (*A. pacificum*) formed massive blooms in the East China Sea. *A. tamarense* complex Group I blooms have been reported in Bohai Sea in 2006, which caused severe losses of abalone through PST contamination. *A. tamarense* complex Group IV strains produce mainly the N-sulfocarbamoyl toxin C1/2 (around 60–80 % of total toxins) ; *A. tamarense* complex Group I strains from Bohai Sea and Northern Yellow Sea also mainly produce C1/2 toxin, whereas that from Southern Yellow Sea produce exclusively GTX1/4 (89 %) and GTX2/3 (11 %).

**(W4 17939 Oral)**

**The distribution of *Alexandrium* cysts in the China Seas**

Xinfeng Dai, Pengbin Wang and Ruoyu Guo and Douding **Lu**

Key Laboratory of Marine Ecosystem Dynamics, Second Institute of Oceanography, Ministry of Natural Resources (MNR), Hangzhou 310012, China email: doudinglu@sio.org.cn

Toxic *Alexandrium* species are renowned for their capacity to produce paralytic shellfish toxins, leading to widespread occurrences of paralytic shellfish poisoning events globally. The China Marine disaster bulletin documents 22 *Alexandrium* blooms recorded in the China Seas, predominantly attributed to *Alexandrium tamarense* (7 occurrences) and *Alexandrium catenella* (8 occurrences). These blooms predominantly concentrated in the northern and middle Chinese coastal waters. Notably, cysts of *A. tamarense* complex, *A. minutum*, and *A. affine* are extensively distributed in Chinese coastal waters. Specifically, *A. catenella* cysts predominantly found in the Bohai Sea and Yellow Sea, while the *A. pacificum* cysts are prevalent in the East China Sea and South China Sea. Additionally, cysts of *Alexandrium leei* have been identified in Dapeng Bay and the Minjiang River Estuary. The distribution range of *Alexandrium* cysts appears to be broader than that of vegetive cells in the China Seas. Furthermore, sediment core analyses in the Changjiang River estuary reveal a gradual increase in the abundance of *Alexandrium* cysts over time.

**(W4 18036 Oral)**

**Paralytic shellfish toxin profiles from an event in Oregon, USA, in spring 2024**

Misty **Peacock**[1], Megan Schulz[1], Rosa Hunter[1], Steffan Kinley[1], Anthony Odell[2] and Vera Trainer[2]

[1]Salish Sea Research Center, Northwest Indian College, Bellingham, WA, USA email: mpeacock@nwic.edu

[2]Olympic Natural Resources Center, University of Washington, Forks, WA, USA

In late May 2024 a rapid response to one of the largest paralytic shellfish poisoning (PSP) events in recorded US history happened in Oregon, USA. A rapid response for testing was initiated after 21 people fell ill. This forced immediate closures from Oregon to northern Washington, including most growing and recreation areas, and a massive recall from eight states. A rapid response testing protocol was initiated using enzyme linked immunosorbent assay (ELISA) Beacon® PSP kits to alleviate pressure on Oregon and Washington health departments and keep humans safe from ingesting toxic shellfish.

To better understand the toxin profile of this event, filtered seawater, and shellfish samples were extracted for paralytic shellfish toxins (PSTs). These were analyzed using liquid chromatography tandem mass spectrometry (LC/MS-MS). LCMS which can provide an accurate toxin profile which can elucidate differences in shellfish PST uptake, distribution, metabolism, excretion and instances of biotransformation within the shellfish. This is an important step to understand differences in increased toxicity of the shellfish compared to the original toxin profile of the algae. The suite of toxins quantified include: saxitoxin (STX), N-Sulfocarbamoylgonyautoxin-2 & -3 (C1&2), decarbamoylgonyautoxin-2 & -3 (dcGTX2&3), decarbamoylneosaxitoxin (dcNEO), decarbamoylsaxitoxin (dcSTX), gonyautoxins-1 & -4 (GTX1&4), gonyautoxin-2&3, gonyautoxin-5 (GTX5), gonyautoxin-6 (GTX6), and neosaxitoxin (NEO). This also provides an opportunity to determine if there is cross-reactivity amongst PSTs in the ELISA kits.

The quantified toxins will be compared against the ELISA kits from Oregon, as well known algal and shellfish toxin profiles from the Eastern Pacific. We hope to gain understanding of the processes that impact shellfish toxicity and what led to the Oregon toxicity event in May 2024.

**(W4 18067 Oral)** (ECOP)

***Alexandrium* species in the coastal of China based on eDNA analysis**

Pengbin **Wang**[1,2], Junjie Zheng[1], Zihan Sun[1], Ruoyu Guo[1], Xinfeng Dai[1] and Douding Lu[1]

[1]Key Laboratory of Marine Ecosystem Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou 310012, China. E-mail: algae@sio.org.cn

[2]Ocean College, Zhejiang University, Zhoushan 316021, China

*Alexandrium* is a group of harmful algae that have bloomed globally. They can produce paralytic shellfish toxins (PSPs), which can accumulate in marine organisms such as shellfish and be transmitted through the food chain, posing a threat to humans and other animals. This study conducted eDNA to analyze samples from the coast of China. A total of eight *Alexandrium* species were detected, as *Alexandrium affine*, *A. fraterculus*, *A. leei*, *A. minutum*, *A. ostenfeldii*, *A. pacificum*, *A. pohangense* and *A. tamiyavanichii*. *A. fraterculus* and *A. pacificum* were not detected in the southern part. *Alexandrium affine* was the most widely distributed species, and has been detected along the coast of China. Including *Alexandrium affine*, *Alexandrium fraterculus*, *A. leei* and *A. tamiyavanichii* were detected both in the Bohai Sea and the Yellow Sea. *Alexandrium affine* and *A. ostenfeldii* were detected in the East China Sea. All eight species of *Alexandrium* exist in the South China Sea, especially in the Beibu Gulf. All these eight species of *Alexandrium* appear in the northern part of the Beibu Gulf, while *Alexandrium affine*, *A. fraterculus*, *A. leei*, and *A. tamiyavanichii* were found in the northernmost and southernmost parts of the Chinese coast. *Alexandrium ostenfeldii* is widely distributed in the East China Sea and southern area. *Alexandrium minutum*, *A. pacificum*, and *A. pohangense* have only been detected in the Beibu Gulf region.

# W5: FUTURE/SmartNet Topic Workshop

**Exploring international knowledge co-production: Lessons learned from international marine science organizations at the science-policy interface**

**Convenors:**
Erin Satterthwaite (USA), *corresponding*
Steven Bograd (USA)
Mitsutaku Makino (Japan)
Hanna Na (Korea)
Jörn Schmidt (Malaysia)

**Invited Speakers:**
Kentaro Ando
(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), UNESCO/IOC Sub-Commission for the Western Pacific (IOC/WESTPAC)
Kristin Kleisner
(Environmental Defense Fund (EDF), USA)

**Due to its structure, the workshop W5 does not have an open call for abstracts for oral presentations**.

The vast and complex nature of the ocean necessitates large scale coordination of science and policy across local, national, and international institutions. We propose a workshop aimed at exploring the successful models of the North Pacific Marine Science Organization (PICES), the International Council for the Exploration of the Sea (ICES) and the UN Decade of Ocean Science for Sustainable Development (UNDOS) to inspire and guide institutions, scientists, and policymakers in fostering international marine science collaboration and knowledge co-production. The proposed workshop provides a unique opportunity to explore how ICES, PICES, and other organizations/programs are working to bridge the science-policy interface, offering valuable insights for the global scientific community. Experts from partner organizations and UNDOS Programs are strongly encouraged to participate in the discussion and we invite other examples/success stories/challenges to participate. We plan to produce a publication (e.g., PICES Press article or ICES IMS 'Food For Thought' article) detailing the outcomes of the workshop. By delving into the roles of institutions, interdisciplinary approaches, and the interface between research and application, participants can gain valuable insights to apply in their own regions and foster global science collaboration.

**(W5 17845 Invited pre-recorded)**

## UN Ocean Decade Actions at IOC/WESTPAC

Kentaro **Ando**[1], Wenxi Zhu[2] and all representatives of the UN Ocean Decade Actions at IOC/WESTPAC

[1]Advanced Institute for Marine Ecosystem Change (WPI-AIMEC), JAMSTEC, Yokohama, Japan. E-mail: andouk@jamstec.go.jp

[2]IOC/WESTPAC Office and UN Decade Regional Coordination Office, Bangkok, Thailand

WESTPAC as one of regional subsidiary bodies of IOC has been developing the UN Ocean Decade Action Programme/Project via intensive discussion at the UN Ocean Decade Regional Conferences (1st in November 2021, and 2nd in April 2024). Currently, WESTPAC has four Programmes/Projects, thjat are UN-21: Accelerate Marine Spatial Planning in the Western Pacific; UN-22: Stem the Tide of Asia's Riverine Plastic Emission Into the Ocean; UN-23: Accelerating Capacity Development Transformation in the Western Pacific Regional Network of Training and Research Centers (RTRCs); UN-24: Exploring strongest ocean current in the western Pacific (CSK-2). UN-21 builds on the MSPglobal 1.0 outputs, and further promote and accelerate MSP in the region, with a view to assisting member states in achieving an ecosystem-based approach to the management of ocean resources, blue economy etc. UN-22 was built on the past achievements since 2017 in marine microplastic research, capitalizing on the well-established regional research and monitoring network, enhanced national and regional capacity for plastic research, and the ever-increasing commitment of Member State. Actions related to UN-23 has also been expanding and has committed to contributing to capacity development in the region. Up to now six RTRCs have been established with specific focuses in the region. UN-24 aims to enable ocean research communities and other relevant ocean stakeholders to co-design and co-implement integrated research on the Kuroshio and its adjacent regions, in order to improve weather and climate predictions, and inform fisheries management. These four actions are introduced together with the history of the actions in WESTPAC.

**(W5 17886 Invited)**

**Protecting the ocean twilight zone: Building from Science to Action**

Kristin M. **Kleisner[1]**, Kacky Andrews[2], Mattias Cape[1] and Chris Dorsett[2]

[1]Environmental Defense Fund, Boston, MA, USA. Email: kkleisner@edf.org

[2]Ocean Conservancy, Washington D.C., USA

The twilight or mesopelagic zone is host to a wealth of ocean biodiversity. A critical component of the ocean food web, these species are important prey species. Due to daily mass migrations, mesopelagic species transfer 2-6 gigatons of carbon per year to the deep sea, an amount equivalent to twice the emissions produced by cars worldwide annually. Recognizing the significant abundance of biomass in the twilight zone, efforts have been made over time to commercially extract these resources. While none of those past fisheries have resulted in fishing at scale, pressure is rising as current stocks of small pelagic species, critical inputs to fishmeal and fish oil production, are declining or shifting their distributions due to climate change. Given what we know about the importance of the twilight zone, it is imperative that these critical ecological and climate services are protected. A number of published papers have identified pathways for large-scale protections. They include actions within country EEZs based on existing governance frameworks, expert guidance from the UN Food and Agriculture Organization, the IPCC, and the wider scientific community, actions by regional fishery management organizations, expansion of the role of the London Protocol on regulating marine carbon dioxide reduction research; and the pending ratification of the BBNJ agreement. This talk will present the work of a group of actors spanning academia, NGOs, and government entities to leverage the existing base of science and knowledge about the ocean twilight zone in support of sound policy to protect these critical resources.

**(W5 18070 Poster)** W5-P1

## Identifying opportunities and challenges of new Anti-IUU Policy in Japan: a perspective from national stakeholders

Toya **Hirokawa** and Mitsutaku Makino

Atmosphere and Ocean Research Institute, The University of Tokyo, Tokyo, Japan email: toya.hirokawa@gmail.com

Illegal, unreported, and unregulated (IUU) fishing has been one of the major threats to global sustainability in fisheries and seafood consumption. Countries and regions have implemented several measures to tackle IUU fishing. One of them is market-related measures, which the EU and the U.S. have already implemented, utilizing catch documentation and import controls. These measures are effective in not only preventing the entry of IUU products into their markets but also encouraging third countries to stop IUU-related activities. In December 2022, Japan, the world's third largest seafood importer, implemented the "Act on Ensuring the Proper Domestic Distribution and Importation of Specified Aquatic Animals and Plants" or Anti-IUU Policy, aiming to eliminate IUU products flow in the Japanese market. Additionally, our previous studies revealed the concerns of importing companies over new practices on the Anti-IUU Policy. Now that a year and a half has already passed, the perspectives from different stakeholders on the Anti-IUU Policy's effectiveness, challenges, and potentials should be scrutinized. Therefore, this research tries to find the above factors by conducting semi-structured interviews with policymakers, the private sector, civil society, and researchers to reveal their experiences and opinions on what can be done to improve the current market-related measures in Japan. By conducting and analyzing interview results, findings will expectedly show what Japan should do to make the Anti-IUU Policy develop, and how Japan can contribute to the global movement in combating IUU fishing.

# W6: MONITOR/TCODE Topic Workshop

**Co-creating a shared framework for ocean data management: Finding common ground on terminology**

**Convenors:**
Erin Satterthwaite (USA), *corresponding*
Naomi Boon (Canada)
Jeanette Gann (USA)

**Invited Speakers:**
**Steve Diggs**
(California Digital Library (CDL), USA)
**Chunhua Han**
(National Marine Data and Information Service (NMDIS))

**Due to its structure, the workshop W6 does not have an open call for abstracts for oral presentations**.

In an era of burgeoning ocean data, this workshop will bring together ocean professionals interested in and working with ocean data across a range of experience levels (e.g., early career professionals, data managers, researchers) to establish a unified framework and shared language for effective ocean data management. With data's pivotal role across marine disciplines, cultivating a harmonized approach becomes imperative. Through interactive discussions, the workshop will collaboratively construct a common vocabulary of key ocean data concepts, and establish a comprehensive data framework – from collection to utilization. Additionally, the workshop will explore next steps, such as effective strategies to share the resulting terminology and framework and the potential development of a training. In doing so, the workshop aims to lay a foundation for improved data management practices within and across PICES, UN Ocean Decade actions, and the broader marine science community. By creating a common understanding of key data science terminology and data frameworks, the workshop seeks to enhance science collaboration, streamline processes, and elevate data utilization.

**(W6 17954 Invited)**

**Methods and practice of ocean data lifecycle management in China**

Chunhua **HAN**, Jinkun YANG and Fangfang WAN

National Marine Data and Information Service, Ministry of Natural Resources of China, Email: hanchunhua2008@126.com

This talk will introduce the status quo and practices of ocean data management in China, leading by the National Ocean Data and Information Service (NMDIS). It focuses on the important aspects of data life cycle, from data collection and transmission, data processing, quality control, data management, data integration, product R&D, data sharing services, to data circulation, trading, and value mining.

We will give detailed introduction to the "Four Horizontal and Four Vertical" ocean data governance system runs through the entire life cycle of ocean data governance established by NMDIS. The system covers eight areas including ocean data strategy, ocean data control, ocean data architecture, ocean data integration, ocean data exchange and sharing, ocean data quality management, ocean data security management and ocean data asset management.

# W7: FIS Topic Workshop

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

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

**Invited Speaker:**
**Shuyang Ma**
(Institute of Marine Research (IMR), Bergen, Norway)

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, three FIS-sponsored PICES workshops have been organized at recent 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 (featured 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 a Special Issue in the journal Fisheries Research that was edited by the convenors and that appeared in 2023. The second workshop took place at the 2022 PICES Annual Meeting (W5) and focused 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 (featured in PICES Press). This workshop will be followed by a third one at the 2023 PICES Annual Meeting (W7) with identical objectives and that has received considerable attention as shown by the full program (3 invited speakers and 10 oral communications). In order to capitalize on the gains of these three workshops, the convenors are proposing a fourth workshop during the 2024 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 17758 Invited)** (ECOP)

**How to explore climate-induced fish population dynamics? – conceptual frameworks and statistical advancements**

Shuyang **Ma** and Olav Sigurd Kjesbu

Institute of Marine Research, Bergen, Norway. Email: shuyang.ma@hi.no

Climate change has the potential to markedly influence vital parameters of fish populations, including natural mortality, body growth and recruitment, and thereby ultimately stock productivity, which is key for fishery sustainability. Based on the reality that recruitment success is a bearing component of productivity, we took advantage of today's extremely fast improvements in statistics as well as those seen in down-scaled physical and biogeochemical models to more closely investigate the causal factors behind the substantial interannual variability observed in recruitment strength. Such thinking is not original but these substantial advancements in analytic tools revealed that recruitment regime shifts and nonstationarity are widespread phenomena in harvestable stocks experiencing pronounced climate fluctuations. Consequently, it is time to move from the paradigm of linearity and stationarity to the one fully acknowledging nonlinearity and nonstationarity in biological processes. Next, we found that the Bayesian framework shows great prospects in quantifying stock productivity and the uncertainties involved, including identifying shared trends and project future patterns. Thus, this approach should now make us much better able at determining essential baselines for adaptive fishery management in the face of climate change. Using the Bayesian framework– addressing, as for the recruitment analyses, primarily the Northeast Atlantic–we present productivity hindcasts followed by productivity forecasts under different emission scenarios. We contrast these statistical results with the related climate-vulnerability assessments of experts (opinions) finding examples of revised directional effects, underlining the high complexity of processes affecting changes in stock productivity.

**(W7 17798 Oral)**

**Non-Linear Catchability and Optimal Fisheries Management Target**

Minling **Pan**

NOAA Pacific Islands Fisheries Science Center, USA email: Minling.Pan@noaa.gov

Setting a long-term optimal target is an important task for fishery management. Traditionally, economists used Gordon-Schaefer's steady model to determine maximum economic yield (MEY). However, the Gordon-Schaefer's model with fixed catchability and associated linear catch-per-unit-effort (CPUE) does not reflect the variable nature of catchability resulting from technological progress and schooling behavior, leading to a biased estimation of MEY or economic optimal biomass ($B_{MEY}$). This could be the reason that few implementations of MEY as the management target are found in real world fishery management. The objective of this study is to improve upon Gordon-Schaefer's bioeconomic model by incorporating nonlinear CPUE to reflect the spatio-temporal fishery dynamic into the model to define MEY.

This study also discusses the relationship of MEY and MSY under different fishery dynamic conditions. In general, when we consider nonlinear CPUE performance in response to biomass changes in individual fisheries, the actual MEY might be closer to or further away from MSY, compared to Gordon-Schaefer's MEY. The less sensitive CPUE is in response to changes in biomass, the lower the stock effect, and the closer the economic optimum $B_{MEY}$ is to the biological optimum $B_{MSY}$. When CPUE is constant (or increasing) with decreasing biomass, MEY is shown analytically to be the same as the biological optimal yield (MSY), implying MEY = MSY, and the related optimal biomasses are equivalent, $B_{MEY} = B_{MSY}$. On the other hand, when CPUE is sensitive to changes in biomass, the stock effect is more noticeable and MEY could be much less than MSY. Simulation analyses further illustrate that the traditional Schaefer economic optimum does not apply to all fisheries. Analyses also demonstrate that MEY could be indifferent to, closer to, or further away from MSY based on characteristics of individual fisheries.

**(W7 17878 Oral)**

**Spatial characterization of histology-based maturity estimates for female Pacific halibut in the Northeastern Pacific Ocean**

Colin L. Jones, Ray Webster, Allan C. Hicks, Ian J. Stewart, and Josep V. **Planas**

International Pacific Halibut Commission, Seattle, WA, USA. E-mail: josep.planas@iphc.int

The maturity state for female Pacific halibut (*Hippoglossus stenolepis*) has been determined using macroscopic visual criteria from fish collected on the annual IPHC fishery-independent setline survey (FISS). However, estimates of maturity-at-age for use in the annual stock assessment have not been updated in recent years due to uncertainty in the method used to assess maturity in the field and to the apparent stability in maturity-at-age despite large changes in size-at-age over the last few decades. Therefore, more accurate microscopic (i.e. histological) criteria have been recently developed to revise maturity estimates for Pacific halibut. In 2022, we initiated studies to revise maturity schedules for female Pacific halibut throughout its distribution range in the northeastern Pacific Ocean, including the U.S. West Coast, British Columbia, Gulf of Alaska, Bering Sea, and Aleutian Islands. A total of 1,023 Pacific halibut ovarian samples were collected on the FISS coastwide in 2022 and 1,111 samples in British Columbia and Gulf of Alaska in 2023 due to a reduction in geographic coverage during the 2023 FISS. Preliminary analyses of the histology-based maturity assessment data from samples collected in 2022 estimate the coastwide maturity-at-age A50 value to be 11.3 years of age, similar to previous estimates from macroscopic (field) data. Furthermore, significant spatial differences in maturity-at-age and maturity-at-size are apparent across the various sampled geographic regions. These results are the first to identify spatial differences in histology-based maturity schedules for female Pacific halibut in the northeastern Pacific Ocean and will be integrated to provide population-level maturity schedules for use in the annual Pacific halibut stock assessment.

**(W7 17897 Pre-recorded)**

## Can nearshore surveys improve management of flatfishes with coastal habitat dependencies?

Lorenzo **Ciannelli**[1], Waldo Wakefield[1,2], Jennifer Fisher[1,3], Katlyn Lockhart[4], Jason Phillips[1], Toby Auth[5], and Kym Jacobson[3]

[1]Oregon State University, Corvallis, Oregon, USA. Email: lorenzo.ciannelli@oregonstate.edu

[2]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, Oregon, USA

[3]NOAA Northwest Fisheries Science Center, Newport, Oregon, USA

[4]Oregon Department of Fish and Wildlife, Charleston, Oregon, USA

[5]Pacific States Marine Fisheries Commission, Newport, Oregon, USA

Many flatfishes spend at least part of their life-cycle in nearshore (<50-m depth), soft sediment habitats, which are not well monitored due to the challenges of operating in shallow waters. This prompts the following questions: 1) what are we missing? and 2) could the management of flatfish species and conservation of coastal habitats benefit from having a nearshore survey? In this study, we address both questions by presenting results from a beam-trawl sampling survey conducted on the central Oregon coast along the Newport Hydrographic line in 2012-18. We found that the nearshore (<55-m depth) fish assemblages were dominated by: English sole, sand sole, speckled sanddab, and butter sole. Offshore (>55-m depth) assemblages were dominated by: slender sole, petrale sole, Pacific sanddab, and larger English sole. Settlement pulses occurred mostly in late-winter (English sole) and spring (butter sole) in nearshore habitats, while they were concentrated in late-spring (Pacific sanddab) and summer (slender sole) in offshore habitats. The abundance of larval stages of slender, butter, and sand sole from ichthyoplankton surveys were significant predictors of respective newly-settled stages 1-5 months later. There were no significant correlations for Pacific sanddab and English sole, suggesting the presence of unobserved mortality from pelagic to benthic habitats. The boundary between coastal and offshore assemblages corresponded with the shallowest bathymetry sampled by the NOAA groundfish bottom-trawl survey. Consequently, the latter underestimated the abundance of nearshore species, while overestimating the size compositions of offshore species.

**(W7 17999 Oral)** (ECOP)

**How are environmental conditions influencing productivity of Petrale Sole in Canada?**

Philina A. **English**, Sean C. Anderson, Kendra R. Holt, Mackenzie D. Mazur, Nicholas C. Fisch and Robyn E. Forrest

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

Managing fisheries in the face of climate change requires understanding how the environment influences population dynamics. As a case study, we investigated correlates of recruitment and body condition of Petrale Sole in Pacific Canada. We used recruitment deviation posteriors for 1995-2018 from the 2024 stock assessment. For a similar time period, we extracted samples of average Le Cren's relative body condition factors standardized using separate spatiotemporal models for immature fish, mature males, and mature females. We then used Bayesian time-series regressions to test for correlations between body condition and recruitment in the following year, and between these biological responses and potentially relevant environmental and ecosystem indices. Our approach propagates uncertainty between levels of analysis. We found positive correlations between recruitment deviations and winter and spring sea surface temperature, and between body condition and sea floor temperature. The relationship between the index of body condition for mature individuals and recruitment in the following year was also positive. These results suggest that productivity could increase under warmer conditions. Both recruitment and mature male body condition were also positively correlated with Pacific Decadal Oscillation and euphausiid abundance. In contrast, immature body condition was negatively related to euphausiids and primary production, and positively with sea floor oxygen and the North Pacific Gyre Oscillation, implying a negative response to upwelling. Importantly, these relationships apply only to conditions represented in our timeseries. However, these relationships can still inform when it may be appropriate to consider environmental variables or non-stationary productivity in future Petrale Sole assessments.

~~**(W7 18037 Pre-Recorded)** (ECOP) **CANCELLED**~~

~~**Evaluating the impact of age data on Petrale Sole stock assessment and management under varying environmental conditions**~~

~~Mackenzie **Mazur** and Kendra Holt~~

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

~~Age composition data for Petrale Sole in British Columbia (BC) are limited over time and space, which presents uncertainty for stock assessment and thus management. Also, the impact of environmental conditions on Petrale Sole life history is not well understood, adding additional uncertainty. This study evaluates the impacts of biased age data in combination with incorrect stock assessment assumptions on Petrale Sole stock assessment and management under time-varying life histories. To do this, scenarios with time-varying life histories and stock assessment assumptions and with and without bias and gaps in age data were simulated for Petrale Sole in BC. A closed-loop simulation framework with an age-structured operating model and stock assessment model was used. Preliminary results suggest that when a change in life history was not accounted for in the stock assessment model, age data had a larger impact. This study highlights the importance of evaluating the effect of composition data on stock assessments in order for sampling effort to be applied so that is has the most impact. This framework can be used to answer other questions regarding uncertainties in stock assessment.~~

# W9: BIO Topic Workshop

**Puffin diet samples as indicators of forage nekton availability and community structure in the North Pacific**

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

**Invited Speaker:**
**Yutaka Watanuki**
(Hokkaido University, Japan)

Marine predators have been put forth as samplers of poorly known forage nekton in remote coastal ecosystems. The Aleutian Archipelago is uniquely situated between sub-tropical and sub-arctic biomes in the Northcentral Pacific, and is a "hotspot" of biodiversity for upper level consumers. Longitudinal variation in water mass characteristics, as well as large-scale current and tidal transport of waters across the archipelago promotes high levels of primary and secondary productivity, but sampling of secondary production is lacking. Climatic events, including a long-lasting marine heat wave and apparent shifts in the PDO, also suggest substantial recent changes in key forage species, with lagged effects now appearing in the populations of some trophically-dependent predators. Fortunately, several long-term (1970-present) datasets on the diets of seabirds exist for the region, but these data have yet to be fully analyzed to understand variability and trends in meso- to epipelagic food webs through space and time. In this workshop, we will examine statistical and other approaches which could be used as indicators of forage availability, data available from coastally-foraging puffins (tufted, horned, and rhinoceros) from the Aleutian marine ecosystem. Puffins return "bill loads" of freshly caught fish and squid to colonies where they may be sampled for species, mass, size, and proximate composition. Sampling using puffins offers opportunities and challenges that must be examined in order to interpret dietary datasets properly, and use them in marine ecosystem ecology and management. We anticipate a report on analytical approaches for the use of puffin diet as indicators of forage nekton will result from this workshop.

**(W9 1770 Invited)**

## Food of Rhinoceros Auklets as an indicator of regional abundance and body size of forage fish

Yutaka **Watanuki**[1], Jumpei Okado[2,3], Motohiro Ito[4] and Jean-Baptiste Thiebot[1]

[1]Hokkaido University, Hakodate, Japan. E-mail: yutakawatanuki138@gmail.com

[2]Japan Fisheries Research and Education Agency

[3]Nagoya University, Nagoya, Japan

[4]Toyo University, Saitama, Japan

Rhinoceros Auklets *Cerorhinca monocerata* (RHAU) feed on forage fishes within 200 km from their colony during the breeding season and bring back these in their bill to the chicks. We sampled their bill-loads at five breeding colonies (four in the Japan Sea and one in the Pacific Ocean) around Hokkaido, Japan, during decades. Interannual and regional differences in the mass proportion of profitable prey (anchovy *Engraulis japonicus* and sardine *Sardinops melanostictus*) reflected regional abundance index of these fish species, but those of alternative prey (0-year greenling *Pleurogrammus azonus* and 0-year salmon *Oncorhynchus* spp.) did not. In 2021-2023, RHAU fed on anchovy at most colonies, with some regional differences, but they fed on contrasted alternative prey species locally in 2014-2020 when anchovy might be less available; they fed on 0-year greenling at two northern Japan Sea colonies and 0-year salmon at the Pacific colony. Body size (fork-length) of anchovy in the diet was smaller in 2022-2023 (50–120 mm) than 1992-2013 (140-160 mm) in all studied colonies. At Teuri Island, size of 0-year sand lance *Ammodytes* spp. in the diet increased seasonally, possibly reflecting age-related fish growth, but with variable slope and intercept between years. RHAU food provides useful information on interannual and regional variation in the abundance of profitable prey and body size of forage fish. RHAU are particularly helpful bio-indicators of forage fish in the region where no long-term, ship-based fish survey is available as their food is conveniently sampled at the breeding colonies.

**(W9 178877 Invited)**

**Model-based standardization of prey abundance indices using predator diet samples**

James T. **Thorson**, Arnaud Grüss and Jonathan C. P. Reum

Alaska Fisheries Science Center, NMFS, NOAA, Resource Ecology and Fisheries Management, USA email: James.Thorson@noaa.gov

Global climate change is driving changes in ocean ecosystems, and there's growing interest in linking ocean physics to fisheries productivity via changes in secondary production and forage availability. However, survey gears are often inefficiency and expensive for sampling forage species. This recognition has led a growing interest in using predators (e.g., seabirds) as an efficient sampler for available forage.

**(W9 17850 Oral)**

**Using predator diets to inform forage fish distributions and trends**

Kayla Gunther[1], Matthew **Baker**[2] and Kerim Aydin[1]

[1]NOAA, Alaska Fisheries Science Center, Seattle, WA 98115 USA

[2]North Pacific Research Board, Anchorage, AK, USA email: Matthew.Baker@nprb.org

Forage fishes comprise an integral part of marine food webs in the North Pacific. Standardized bottom trawl surveys lack gear and protocols to quantitatively evaluate populations of small pelagic fish. Predators may serve 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. Using groundfish diets, we constructed depth and temperature habitat profiles and used center of gravity and global index of collocation to examine predator-prey overlap. Results provide insight to habitat partitioning in forage species and dynamics between predators and prey. Sandlance comprised the largest percent weight of any forage fish in both halibut and cod diets. Capelin was the most prevalent by weight in walleye pollock diets and herring in arrowtooth flounder. Sandlance distribution was concentrated nearshore (≤53 m) and had the warmest bottom temperature profile of any forage fish (2.5-3.8°C). Capelin and smelt had similar nearshore distributions. Herring were the most widespread, indicating little preference for depth, but preferred much colder waters (50% in waters <1.8°C). Interannual analyses indicated recent periods of cooling and warming had significant effects on the distribution of forage fish populations. In warm years, sandlance and smelt shifted north and offshore; herring shifted north and were more broadly distributed across the shelf. Results highlight the need to understand how 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. Parallels are made to how marine birds inform similar analyses, past analyses conducted using puffin diets, data available, and potential future opportunities to leverage data and observations related to puffins and other avian piscivores in the North Pacific and Aleutian region.

**(W9 17856 Oral)**

## Puffin diets provide annual forage fish indices to inform ecosystem-based fisheries management in Alaska

Mayumi **Arimitsu**[1], Curry Cunningham[2], Brie Drummond[3], Bridget Ferriss[4], Dan Goethal[4], Scott Hatch5, Krista Oke[4,6], John Piatt[1], Heather Renner[3], Nora Rojek[3], Kalei Shotwell[4], Wesley Strasburger[4], Lindsay Turner[2] and Shannon Whelan[5]

[1]USGS Alaska Science Center Juneau, Alaska USA Email: marimitsu@usgs.gov,

[2]University of Alaska Fairbanks Juneau Alaska USA

[3]USFWS Alaska Maritime National Wildlife Refuge Homer, Alaska USA

[4]NOAA NMFS Alaska Fisheries Science Center Juneau Alaska USA

[5]Institute for Seabird Research and Conservation Anchorage Alaska USA, 6Alaska Pacific University Fisheries, Aquatic Science, and Technology Laboratory Anchorage Alaska USA

Seabird diet data span 45 years and >3000 km in the Aleutian Islands and Gulf of Alaska. Puffins (tufted puffins, horned puffins, rhinoceros auklets) feed primarily on small pelagic schooling fish, juvenile groundfish, and mesopelagic species. Puffin diet data provide insights into biogeography, temporal trends, and the nutritional quality of forage fish, offering context for multidecadal changes in upper trophic-level biology and ecology. Herein we synthesize current efforts to use puffin diets to inform ecosystem status assessments and groundfish management decisions in Alaska. Puffin diets from long-term monitoring sites at Buldir, Aiktak, Chowiet, Suklik, Middleton, and St. Lazaria Islands provide indices of forage fish in Ecosystem Status Reports prepared annually for consideration by the North Pacific Fisheries Management Council. Additionally, age-0 sablefish, a key prey species for seabirds at Middleton which are otherwise difficult to sample, provide an annual index of growth for the sablefish Ecosystem and Socioeconomic Profile. Moreover, these data are being evaluated for their utility in providing early indicators of sablefish recruitment strength, and in studies of genetics, growth, diet, and condition. Finally, we discuss recent efforts to combine historical data datasets, which found common signals in the occurrence of key forage species within predator diets and trawl/seine catch data since the 1970’s. With consistent monitoring over time and multi-institutional coordination, puffin diets provide innovative indicators for ecosystem-based fisheries management in Alaska.

# BECI Special Workshop

**Bringing together models for fisheries management under climate change – multiple model ensembles and inference to guide decision-making**

**Convenors:**
Vivitskaia Tulloch (Canada), *corresponding*
Kathryn Berry (Canada)

**Due to its structure, the workshop does not have an open call for abstracts for oral presentations.**

The Basin-scale Events to Coastal Impacts (BECI) project is a UN Ocean Decade program led by the North Pacific Marine Science Organization (PICES) and North Pacific Anadromous Fish Commission (NPAFC), with goals of providing decision support to detect and predict ecosystem impacts and inform fisheries management under climate change.

The primary goal of this workshop is to enhance regional marine ecosystem modelling in a changing climate. We will bring together scientists with existing, proposed or work-in-progress ecosystem, biophysical and multispecies marine modelling approaches based in the North Pacific, which either already include, or have the capacity to include or couple to, climate and/or environmental drivers. We plan to focus on models that include target species of salmon, halibut, and/or small pelagic fish, but approaches with other focal components are welcome.

We will review the different approaches and assess their candidacy to contribute to a proposed North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME). The NOMEME builds upon work being developed for the Southern Ocean, facilitated by the Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP) 2.0 protocol, and aims to reduce uncertainty and build confidence in regional marine ecosystem models (MEMs) as ecosystem-based management tools in a changing climate. Marine ecosystem model (MEM) ensembles can assist policy and decision making by projecting future changes and allowing the evaluation and assessment of alternative management approaches.

The outcomes of this workshop will include a tangible protocol for bringing together multiple models in an ensemble approach at a regional scale for the eastern region of the North Pacific and provide a foundation for these ensembles to be developed for other regions. We hope that the NOMEME will also be able to contribute to the FishMIP regional model inter-comparison initiative.

We plan to hold an online pre-workshop meeting for those participants interested in joining, to build upon our candidate list of models for proposed inclusion in the NOMEME.

(BECI-18141) BECI-P1

**Challenges in the Post-Harvest Value Chain Fishing Industry in Gwagwalada, Abuja , Nigeria**

Michael **Oke**[1]

[1]Federal Capital Territory Agricultural Development Programme and Michael Adedotun Oke Foundation, Federal Capital Territory Abuja, Nigeria Email: maof2020@gmail.com

The people who live in the Gwagawalada Area Council may have benefited from the fishing industry given the various diversity, cultural backgrounds and differences, of population, high Unemployment, and potential benefits associated with the level of nutritious values that could Have being provided. As a result, there are numerous issues that are now failing to improve the fish productivity of farmers and fish merchants. Our range of research activities includes visiting various farms, studying and interviewing Some of the owners of fish cold roomers, which includes market fish vendors in Old Kutunku. We used a variety of visual representations to support our conclusions. We observed that in Gwagwalada Abuja, Nigeria, the post-harvest values of fishing encompass a variety of challenges related to transportation, preservation, inadequate cold rooms, and inadequate facility. Connectivity of highways to other farms, and processing inefficiencies, culminating in a Inadequate supply chain, disruptions, and other infrastructural deficiencies, as well as the need for the fish communities to be improved.

Additionally, we recommended more Research on the various segregated markets, oral interviews, adaptive research providing numerous insights into the needs of fish farmers, how to connect the various highways between the farms and the markets, and the introduction of basic refrigerator van delivered systems from the farm to the market and within too. Concerns vary over how to effectively transform various fish products such as fish water, fish by-product's, and unshelled fish into marketable fish goods. The fish feed manufacturing Facilities. The requirements for the procedural stages of safety and monitoring involving the smoke-free Fish, as well as the recognition of the facts regarding supply and demand in larger and commercial scale purposes of production are important to consider when investing in fish processing. Innovative methods of adding value can be achieved through good design to attract investors.

Competitive rates and investigate exporting to overseas nations Even though we are unable to identify the various specific issues impacting the fish storage systems, measuring the fish at the time of marketing. The background suggestions of the study safely support the introduction of new fish drying Procedures because, as said, some species may require extra attention to yield better Outcomes. Given this, efforts to guarantee that fish are kept in hygienic conditions as well as cold rooms tailored to commercial needs should be established. Chance to insist on using the Right strategies for profitability. Strategies are all necessary for making such a diligent effort to attract sales and income on this. These programmes aim to support the growth of the fishing sector and provide Opportunities for fishermen to earn a living. As a result, it is crucial to effectively handle the many post-harvest fish that fishermen lose.