PICES-2022

Book of Abstracts

PICES-2022, Busan, Korea

Prepared by PICES Secretariat

List of Sessions and Workshops

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Keynote

Better engagement of PICES science for the UN Decade of Ocean Science: A Korean Perspective

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The United Nations has urged cooperation among global communities to solve threats to the ocean by proclaiming the UN Decade of Ocean Science (UNDOS) for Sustainable Development and has identified 10 priority challenges for the success of UNDOS. The Republic of Korea is aiming to align its efforts with the seven Ocean Decade Outcomes. Here we will share the Republic of Korea's commitment to the ocean, and gaps that need to be filled in order to tackle crucial ocean issues including fisheries and ocean pollution. With regard to domestic and international issues, we note several priorities for Korea, including Ocean health, Multi-hazard warning systems, Sustainable production as well as Youth. Several of Korea's actions regarding multihazard warning systems and engagement of stakeholders for fisheries management may serve as examples for other PICES member nations, and PICES itself, as a framework to address Ocean Decade outcomes.

S1: Science Board Symposium
Sustainability of Marine Ecosystems through global knowledge networks during the UN Decade of Ocean Science

(S1 Oral 15813)

The intersection of UN Ocean Decade and PICES FUTURE in the North Pacific

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PICES FUTURE, as the core program of PICES at Phase III, has lots of intersection with the UN Decade of Ocean Science for Sustainable Development (2021-2030, refer as UN Ocean Decade). For aligning with the UN Ocean Decade, I suggest that FUTURE pays more attention on the following three aspects: Firstly, to expand from the long-lasting scientific community to different stakeholders through providing easy-understanding scientific knowledge by PICES FUTURE to policy makers and the public; Secondly, PICES FUTURE should provide operational services and products including ocean and climate prediction products, prediction of extreme conditions such as marine heat waves, early warning system of marine ecosystem of the North Pacific etc.; Thirdly, PICES can finally organize science-based transformational actions to prevent marine ecosystem disasters such as jellyfish blooms, and protect the fishery sustainable development. Taking the ocean and climate prediction as an example, I will analyze the scientific challenges faced for accurate prediction, introduce the scientific breakthroughs, and suggest potential predict products which could be shared within PICES community. This can serve as an example on the intersection of UN Ocean Decade and PICES FUTURE.

(S1 Oral 15811)

Increasing Capacity and Incentives for Data Sharing within the UN Decade, and Strategies to Incorporate PICES Research and Data into Broader International Platforms

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Data and information will be key enablers of the United Nations Decade of Ocean Science for Sustainable Development. Digitizing, preserving, managing, and exchanging a significantly increased volume and range of ocean-related data, information and knowledge will be cornerstones of the success of the Decade. To coordinate the collaboration between the vast number of partners that will contribute data to, as well as use data and products from the "digital ecosystem", an "Ocean Decade Data Coordination Platform" has been established. The UN body responsible for coordinating the UN Decade of Ocean Science for Sustainable Development (2021-2030, 'the Ocean Decade), the "Data Coordination Group" (DCG) brings together 25 experts from 12 countries. These experts represent various industries, fields and stakeholder groups who will work to reinforce and focus efforts to significantly enhance ocean data and information over the course of the Decade. Additionally, increasing and strengthening public-private partnerships and finding innovative ways to inspire the sharing of knowledge and data will help to move us towards our goals for a sustainable future. Additionally, working to increase sharing of PICES data and information through collaboration of research from working groups, study groups, and summer schools to the broader international community will help to both increase the reach of PICES-specific research and aid in the goals of the UN Decade of Ocean Science.

(S1 Oral 15733)

Identifying the Ocean Decade challenges: A common framework for Small Island Developing States

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Small Island Developing States (SIDS) share the vulnerability to stressors, such as resource scarcity and susceptibility to climate change, as well as the dependence on the Ocean and its resources. Therefore, it is extremely important to generate data and produce science with common frameworks pertinent to this group. The United Nations Ocean Decade (2021-2030), under the motto "The Science We Need for the Ocean We Want", highlights the importance of ocean sciences for the sustainable development of ocean-dependent communities, and calls for greater integration of stakeholders in the most different stages of research and resource management: from research design to implementation. In order to identify the various socio-ecological dynamics and the main Ocean Decade Challenges for SIDS, this study used the archipelago of Cabo Verde as a model. We conducted 27 semi-structured interviews with various local stakeholders: from tourism operators, environmentalists, researchers to government officials. Analyzing stakeholders' perceptions (The Ocean we want), the results establish a method for determining the most urgent scientific priorities and for designing the respective action plans (The Science We Need). We also discuss the identified socio-ecological dynamics and the similarities with different Pacific island states. Thus, this study expects to contribute for the Ocean Decade Objectives implementation in SIDS and to promote the exchange of knowledge and data between the different global regions.

(S1 Oral 15810)

Co-Designing Climate Solutions under the U.N. Ocean Decade

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The launch of the U.N. Ocean Decade provides a unique opportunity to bring together multi-sector actors across the world to co-design and deploy ocean-based solutions to the growing climate and human-ocean crisis. The Ocean Visions, a non-profit organization that aims to catalyze solutions for ocean health, together with other international organizations, has established a new decade collaborative center on ocean-climate solutions and a programme to activate a Global Ecosystem for Ocean Solutions (GEOS). These initiatives aims at taking action on a series of roadmaps that clearly articulate the innovation and research gaps that need to be overcome in order to implement scalable solutions to the climate crisis. The roadmaps target different areas spanning from ocean carbon dioxide removal to coastal solutions for climate resilience, and more. This talk will provide an overview of the co-design process of the roadmaps with some concrete example, and show how these roadmaps are activating an ecosystem of innovators and funders to advance climate solutions under the U.N. ocean decade.

(S1 Oral 15771)

Shall We Repeat Plastics Research

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Most of the global drifting plastics accumulations spots are located within oligotrophic zones of the World Ocean, including Pacific. Main scientific question here is how ocean ecosystems are meet, consume and export an anthropogenic allochthonous plastics first order ten of millions tons load annually in their biotops with following transfer to final destination - shores and(or) bottom. During 1984-1988 NOAA team (Day et al.,1990) succeeded very first results for the plastics concentrations distribution on the surface waters for the most part of the Northern Pacific, Japan Sea (East Sea) including. Surveys were conducted in the open waters by neuston nets, not covered Canada, Japan, South Korea, US and former USSR EEZ-es, outside a region of the Great Pacific Garbage Patch, discovered later, and not paid much attention to a riverine plastics ocean input of the main freshwaters flows from both continents and islands of Northern Pacific. Described results for the plastics basin-scale assessment in the PICES area were obtained around 40 years ago can became comparative. If consider plastics as a treat or, at least, as an anthropogenic challenge to the marine ecosystems of Northern Pacific, and basin here as a possible accumulation/redistribution reservoir for the micro-, macroplastics (M&M), perhaps, the 1984-1988 study should be repeated, aiming to compare assessment of the M&M concentrations North Pacific area between ~40 years ago and recently. It's right time to collect M&M and their detailed analysis at a new technologies and scientific level with interdisciplinary PICES approach. Obviously, joint multi flags R/Vs expedition(s) with same trawling gears, remote sensing and other sampling and shore analytical equipment are needed. The aim is to obtain current status of the M&M concentrations in the PICES area, EEZes including. Awaiting results - determination and comparing difference with M&M concentrations and their quality. They would clarify the plastics presence in the oligotrophic, transient and trophic belts of the North Pacific. Perhaps, proposed efforts would be implemented by PICES members as mutual scientific project. Actual idea based on the Gulf of Alaska and vicinities international NPAFC/IYS 2019-2022 winter salmonids surveys (Canada, Japan, South Korea, Russia, US) complimentary plastics materials which are shown no gaining M&M concentrations since middle 1980-ies in that part of Pacific SubArctic and transient waters. Presumably, M&M here are overturned with more high rates due to flows redistribution, phyto seasonal blooms and nekton powerful impact eliminating plastics from local ecosystems. Because PICES has a working group number 42 for microplastics research, the initial organizing steps are already done. PICES SB can to consider neediness and scientific value of proposed M&M new assessment for the Northern Pacific after deep smart re-thinking, discussions, conclusions and decisions.

(S1 Oral 15812)

SmartNet: The ICES-PICES Joint Program of the UN Decade of Ocean Science for Sustainable Development

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In June 2021, the Intergovernmental Oceanographic Commission endorsed SmartNet ('Sustainability of Marine Ecosystems through Global Knowledge Networks') as a Program of the UN Decade of Ocean Science for Sustainable Development (UNDOS; 2021-2030). SmartNet is a joint Program of ICES and PICES which aims to establish a global knowledge network for ocean science by strengthening and expanding the collaboration of ICES/PICES and partner organizations. SmartNet will support and leverage ICES/PICES member countries' activities, emphasizing areas of mutual interest including climate change, fisheries and ecosystem-based management, social, ecological and environmental dynamics of marine systems, coastal communities and human dimensions, and communication and capacity development. It also incorporates strategies to facilitate UNDOS cross-cutting inclusivity themes relating to gender equality, early career engagement, and involvement of indigenous communities and developing nations in the planning and implementation of joint activities. We will update the PICES community on the first year of SmartNet activities and introduce ideas for new actions and partnerships to accelerate PICES contributions to UNDOS.

(S1 Oral 15620)

Possible abiotic causes of catastrophic ecosystem event in Avachinskiy Bay of Kamchatka in 2020

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An unexpected and unprecedented event of mass mortality of marine biota had happened in coastal waters of Avachinskiy Bay of Kamchatka Peninsula in September of 2020. It was faced with a high attention of both local and federal governments. Russian Academy of Sciences proposed a special program of comprehensive multidisciplinary research focused not only on mechanism of this particular event but also on other potential ecosystem risks in the water off Kamchatka. Many filed investigations of 2020-2021 was carried out there just after the event by various organizations including governmental structures, academic research institutes, universities and volunteers. This resulted in general consensus that the mortality was caused by harmful algae bloom. However a mechanism of this bloom was still not clear. Among possible reasons one may expect large scale changes in the western subarctic Pacific such as observed fast warming of surface waters and possible eutrophication. Another regional reason may be associated with mesoscale water dynamics, in particular with strong anticyclonic eddies that are formed in the bays of Kamchatka and may uplift low oxygen and high nutrients water onto the shelf. Another local reason is associated with impacts of rivers and ground water discharge on biogeochemical processes in Avachinskiy Bay. To continue our study of possible abiotic reasons of the HAB bloom we organized a special cruise on r/v Professor Gagarinskiy in June-July 2022. Results of this cruise together with our previous observations off Kamchatka are discussed in this paper.

(S1 Oral 15671)

Mapping widespread hypoxia off the Pacific Northwest during the 2021 summer upwelling season: A necessary ingredient to informing sustainable use of the ocean

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The 2021 summer upwelling season off the Pacific Northwest started unusually early and was long-lasting, leading to the early onset and widespread distribution of near-bottom, low-oxygen waters. The summer upwelling season, defined as lasting between the spring (March 22) and fall transitions (September 16), was characterized by the second-most amount of southward, cumulative upwelling wind stress – an indicator of offshore surface Ekman transport compensated by the onshore flow and upwelling of deep water onto the continental shelf – in the last 37 years. During summer 2021, an unprecedented number of ship- and underwater glider-based measurements of near-bottom (within 10 m of the bottom) dissolved oxygen were made over the Pacific Northwest continental shelf and slope from a variety of programs. These include ship surveys conducted by the U. S. National Oceanic and Atmospheric Administration (Northern California Current; Pre-Recruit; Juvenile Salmon and Ocean Ecosystem Survey; Hake; Groundfish; and West Coast Ocean Acidification) and the Oregon Department of Fish and Wildlife, and underwater glider measurements made by Oregon State University and the Ocean Observatories Initiative. We use this set of observations to map near-bottom oxygen along nearly 900 km of the Pacific Northwest coast from 41-49°N. Hypoxia, dissolved oxygen less than 1.4 ml/l (64 micromoles/kg), was observed over nearly 70% of the continental shelf inshore of the 200-m. We describe robust spatial patterns in near-bottom hypoxic and normoxic waters relative to the continental shelf width and other prominent features of the region like the Columbia River plume, Heceta Bank, and Cape Blanco.

(S1 Oral 15752)

Lifting the voices of Indigenous students to empower the next generation of ocean leaders

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The Salish Sea Research Center (SSRC) at Northwest Indian College (NWIC) increases the presence and influence of Native American leadership in ocean sciences. In an educational setting, broadening diversity and participation in STEM is critical, but scientists and universities have not always been successful at this task, notably in oceanography. Tribal communities are among the most vulnerable to changing ocean climates. The UN decade of Ocean Science specifically tasks working with Indigenous communities and partners, as well as empowering the next generation of ocean leaders through building more equitable access to and capacity for marine science. At the SSRC we work with Indigenous partners to advance the research goals, needs, and interests regarding food sovereignty and healthy water issues. We collaborate at project conception, before engaging in any research, and we continue this practice with our summer undergraduate research program (URE). Our students are interested in working within Indigenous communities, and by the time they participate in an URE, they are well-equipped to weave science, policy, management, and traditional ecological knowledge (TEK) into their projects. Our partners are Lummi Natural Resources researchers, federal researchers, scholars in management, science, and policy, as well as cultural knowledge holders within Indigenous communities. We emphasize the importance of inclusive and equitable narratives and create pathways for students to continue into graduate school or professional degrees in marine sciences. After the URE, tribal students, at this point well-versed in scientific research, can provide a key voice to effectively communicate scientific findings to their communities.

S2: FUTURE/HD/MEQ Topic Session
Marine Ecosystem Services – Connecting Science to Decision Making

(S2 Invited 15198)

Integrating human wellbeing indicators in Puget Sound ecosystem restoration

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The Puget Sound of Washington State has the largest water volume of any estuary in the U.S., with over 2,500 miles of shoreline. The region is home to almost five million people, including 21 federally-recognized Tribes. In 2007, Washington State Legislature created the Puget Sound Partnership as a state agency to coordinate the recovery of the Puget Sound from its many threats associated with human development, and now global climate change. The agency was given six goals: support a healthy human population, sustain a vibrant quality of life, and protect and restore species, habitats, water quality and water quantity. All goals are monitored through indicators and used to drive regional planning for ecosystem recovery. This presentation will describe ten years of collaborative work between the state agency, university researchers, and local partners in identifying, adopting, measuring, reporting, and planning based on indicators for the first two goals (healthy human population and quality of life). These indicators measure the constructs of Air Quality, Drinking Water, Local Foods, Outdoor Activity, Cultural Wellbeing, Economic Vitality, Good Governance, Sense of Place, and Sound Stewardship.

(S2 Invited 15798)

Implementing the marine ecosystem service concept

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The concept of ecosystem services (ES) has gained traction as a means of linking societal benefits to the underlying ecology and functioning of ecosystems. ES is now frequently included in decision-making and legislation and is central on the international stage (e.g., Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES). ES research and implementation is more advanced on land than in the sea, with real world applications of ES theory hindered in marine systems by inadequate knowledge of the distribution of communities and habitats and the ecosystem functions that they provide. The scarcity of spatial data in addition to high connectivity, scale, and context-specificity present major challenges for the use of ES information in marine management and policy. This talk will cover recent progress in implementing the marine ES concept; demonstrating that simple methods can be useful when underpinned by ecological understanding, for example, by mapping ecosystem service potential using a series of principles based on current knowledge and links to biophysical parameters. This has evolved towards mechanistic modelling that incorporates multi-functionality of shellfish and highlights their importance for services including food provision, water quality regulation, nitrogen removal and sediment stabilisation in shallow coastal systems. Key considerations for management will be illustrated, including the identification of multiple ES, service 'hotspots', and the importance of environmental context. The approaches covered in this talk can be highly effective for communicating the importance and value of healthy coastal systems, which is the first step in effecting real change.

(S2 Oral 15584)

Toward the inter-regional cooperation for high seas resource conservation: Implications from the Asia-Pacific region

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Enhanced conservation measures related to fishing vessels in the North Pacific is key for sustainable fisheries and resource conservation in the entire Asia-Pacific. Here, we studied relevant measures implemented by three regional fisheries management organizations (RFMOs), namely the Western and Central Pacific Fisheries Commission (WCPFC), the Indian Ocean Tuna Commission (IOTC), and the North Pacific Fisheries Commission (NPFC). We focused on two measures: the vessel monitoring system (VMS) and the IUU (illegal, unreported, and unregulated) vessel list. We also analyzed patterns of vessels registered in these RFMOs to obtain in-depth implications for the relevant measures. Through our studies, we identified several challenges. They include data gaps of VMS (disparity in the number of vessels reported to member states and the secretary) in WCPFC, a stalemate in defining a scope of entities to be listed (i.e., vessel vs. vessel skipper or owner) in IOTC, and difficulties identifying IUU vessels due to vessels falsifying their names in NPFC. These challenges can be common in each other's RFMOs, but there was little evidence of cooperation among them in pursuit of solving the challenges. We also revealed that there are hundreds of vessels registered in more than one RFMO. Our findings indicate the need for enhanced collaborative work among RFMOs in a form of, for example, a formal communication platform where lessons, good practices, knowhow, and technologies are shared among RFMOs. Such a platform can be especially useful for NPFC, the youngest RFMO, to promote the effective measures on vessels in the North Pacific.

(S2 Oral 15647)

Floating marine debris in Shiretoko, Japan: Relationship between debris density, type and local human activities

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Floating marine debris (FMD) is known to cause several problems including entanglement, ingestion and transport of pollutants for marine species, and is considered one of the most severe marine environmental problem. Many factors may affect the distribution of FMD, both environmental factors and human activities. In our study, we focused on local human activities as a main factor. The study area was Abashiri and Rausu located in the Shiretoko area which is registered as a World Natural Heritage Site. In this region, the distribution of FMD has not been studied. To provide the first estimate of the abundance of FMD, sighting surveys were conducted on 13, 14 June, and 2, 5, July at Abashiri, and on 10, 12 July at Rausu from sighting boat; the Chipashiri (4.9 t), and Hamanasu (19 t) respectively. During the survey, GPS position, size, and type of debris were recorded. The estimated FMD densities for the two areas were 356.4/ km^2 and 79.8/ km^2, and much higher in Abashiri than in Rausu. For the composition of FMD, the percentage of debris related to fishing gears is much higher in Rausu than Abashiri. Regarding to the local human activities, population and annual number of tourist are much higher in Abashiri, and the number of fishing boat and fisherman are larger in Rausu. These social factors can be one of the reason FMD density and type difference were observed between two regions. Although marine pollution is a global-scale issue, our study suggests the need for local community-based management to solve the problem.

(S2 Oral 15651)

Evaluation of ecosystem services provided by Pacific oyster, *Crassostrea gigas,* farms in Hansan bay, South Korea

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South Korea is the secondary highest producer of cultured Pacific oyster, *Crassostrea gigas*, in the world, but the ecosystem services provided by oyster farms have not yet been evaluated. We quantified the potential values of ecosystem services of the oyster farms in Hansan bay, South Korea, by applying the Gangnery's growth model. The provisional service in production ranged from ca. 23.8 to 811.8 ton. Regulation service in nitrogen removal amount, calculated as the difference of accumulated nitrogen amount in tissue of oyster during the rearing period, ranged from ca. 0.7 to 70.5 ton. To estimate the monetary values of two services, we surveyed the prices of oyster and the costs for nitrogen removal. The estimated economic values of the two services in Hansan bay ranged from ca. 81,504,720 to 6,687,401,160 South Korean won. We plan to improve the Gangnery' growth model to evaluate the services of all Pacific oyster farms in South Korea. We hope that our study will help policymakers gage the potential value of a marine space to make decisions in coastal and marine development.

(S2 Oral 15764)

Climate attribution time series to support decision making by fisheries stakeholders

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Effective climate adaptation by fisheries stakeholders may be hindered by barriers of human perception and cognition. Examples of these cognitive barriers include the tendency to use historical experience to estimate future risk, a reluctance to attribute change, and the complexity of scientific advice. Considering these cognitive barriers is important for producing science that is usable for decision making. One recent development that could aid decision making is Extreme Event Attribution (EEA), which quantifies the human-induced risk for individual weather events. In this study, we build on EEA by constructing attribution time series for annual sea surface temperature (SST) values for the North Pacific basin and five northeast Pacific ecosystems during 1950-2021. Our time series are based on Bayesian estimates of the Fraction of Attributable Risk (FAR) derived from 23 CMIP6 climate models. These time series indicate that North Pacific climate has departed from the envelope of preindustrial variability and has reached temperatures that can only be explained through human-induced warming at both basin and regional scales (FAR > 0.99). Using a Bering Sea crab fishery and a Gulf of Alaska salmon fishery as examples, we use FAR values as covariates in simple models to illustrate the observed degradation in ecosystem services during novel anthropogenic climate conditions. We also use SST probability distributions for historical, current, and next-decade climates to illustrate the expected trend in extreme temperatures associated with the loss of ecosystem services. This approach provides an intuitive, empirically robust framework for supporting forward-looking decision making by stakeholders.

(S2 Oral 15786)

Blue carbon in South Korea: Knowledge gaps, critical issues, and novel approaches

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The international community defines ‘blue carbon’ as organic carbon captured by vegetated coastal ecosystems and stored in the sedimentary layer for a geological time scale. The concept of blue carbon began to materialize in 2009, but research on the blue carbon ecosystem started in the 1960s by Eugene Odum, centered in the United States. Considering that the research on the blue carbon ecosystem in Korea started in 2017 through the first national blue carbon research project, understanding the current status of carbon absorption in the Korean blue carbon ecosystem and its role and mechanism in the global carbon cycle should be prioritized. Also, it is necessary to increase the total carbon absorption through salt marshes (vegetated tidal flats) & seagrass restoration projects and the designation of protected coastal areas.

For non-vegetated tidal flats to be recognized as carbon reduction sources, it is required to prove that the carbon accumulated in the ecosystem is not easily reduced in the air and is stored for a long time in the form of refractory carbon. In addition, it is necessary to prepare policy measures from a long-term perspective, and creating sufficient accommodation space through land acquisitions is essential for coastal wetlands to migrate inland in response to climate change.

S3: POC/TCODE/FUTURE Topic Session
Realizing scalable artificial intelligence in marine science

(S3 Oral 15539)

Artificial neural network for ocean surface current prediction around the Korean peninsula using transfer learning

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Prediction of ocean surface current is essential for various marine activities, such as disaster monitoring, fishing industries, search and rescue operations, etc. Continuous improvements of numerical models make it possible to predict a more realistic ocean with the help of data-assimilation and fine spatial resolution. On the other hand, the well-developed ocean model requires high computational power and time, making it hard to be utilized for practical purposes sometimes. To compensate the high computational costs, there is a need to develop novel approaches with efficient computational costs, combined with the numerical model outputs. In that way, artificial neural networks could be one of the solutions because they need low computational power since it utilizes pre-trained networks. Here, we present a current prediction framework applicable to the seas around the Korean peninsula using three-dimensional convolutional neural networks (3D-CNN) with the transfer learning. The network is based on the 3D-Unet structure and modified to predict ocean currents using oceanic and atmospheric variables. The transfer learning is applied from the reanalysis model outputs to the prediction model outputs, to train more realistic data and increase prediction performance. It is optimized to minimize the error of the next day's ocean current field, and its recursively predicting structure allows more days to be predicted. The network's performance is evaluated by changing input days and variables to find the optimal surface-current-prediction artificial neural network model, which demonstrates its strong potential for practical uses near future.

(S3 Oral 15541)

Impacts of seasonal and interannual variabilities of sea surface temperature on its short-term deep-learning prediction model around the southern coast of Korea

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Sea Surface Temperature (SST), one of the ocean features, has a significant impact on climate, marine ecosystem and human activities. Therefore, SST prediction has been always an important issue. Recently, deep learning has drawn much attentions, since it can predict SST by training past SST patterns. Compared to the numerical simulations, deep learning model is highly efficient, since it can estimate nonlinear relationships between input data and output data. With the recent development of Graphics Processing Unit (GPU) in computer, large amounts of data can be calculated repeatedly and rapidly. In this study, short-term SST will be predicted through a convolutional neural network (CNN)-based U-Net method that can handle spatiotemporal data concurrently and overcome the drawbacks of previously existing deep learning-based models. The SST prediction performance depends on the seasonal and interannual SST variabilities around the southern coast of Korea. The predicted SST has a wide range of variance during spring and summer, while it has small range of variance during fall and winter. A wide range of variance also has a significant correlation with the change of the Pacific Decadal Oscillation (PDO) index. These results are found to be affected by the intensity of the seasonal and PDO-related interannual SST fronts and their intensity variations along the southern Korean seas. This study implies that the SST prediction performance using the deep learning model can be significantly affected by seasonal and interannual variabilities in SST.

(S3 Oral 15627)

Reconstruction of Long-Term Gaps of Sea Level Using Neural Network Operator

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Sporadic misses in coastal sea level observations occur frequently, which hinders understanding of ocean physics in coastal areas. In other words, general-purpose time-series analysis and prediction methods are vulnerable to missing data. For this reason, scientists have been working hard to fill this gap, but the existing reconstruction techniques have the disadvantage of producing low-accuracy values for long-term missing values. The latest technique, artificial neural networks, is also being used to reconstruct missing data, but this method has a chronic problem that the shape of the target is fixed. To overcome this obstacle, we designed a model that predicts the sea level after a unit time (one-step prediction operator) by utilizing an artificial neural network to create multivariate and nonlinear regression equations. The recursivity of this model makes it possible to reconstruct missing data even longer than 72 hours successfully, which was almost impossible by using traditional gap-filling methods. A data assimilation technique is also applied to merge seamlessly the model-predicted sea level with observations.

(S3 Oral 15547)

Bayesian inference for extracting information from abundance and catch at age time series

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We present an approach for constructing stochastic models of fish population dynamics and performing the basic Bayesian inference tasks such as filtering, prediction and smoothing. First, a deterministic model of the time series is designed by optimization of parameters of the cohort and catching equations that represent the time series the best way according to some criterion. Then, a hidden Markov model is formed with logarithms of abundances as states, logarithms of catches as observations, and distributions of residuals obtained by subtracting corresponding values from the stage-one model and the data. The transition part of the model describes the probability distribution (density) of state at age *a* given state at age *a-1*. The observation part describes density of each observation at age *a* given a state at age *a*. For all basic inference tasks, the recursive equations for marginal densities have no analytical solutions (except linear Gaussian models). We use Monte Carlo (particle) method to generate random populations distributed accordingly. To smooth their densities, kernel density estimation is applied. We updated the Fishmetica package in Julia language with functions implementing the inference algorithms. For numeric simulation, we use one of the three test data sets that used VNIRO expert groups to evaluate catch-age structured models. We calculate predictions and, for all derived densities, such statistical characteristics as means and standard deviations, medians, and MADs that allow, e. g., to evaluate the mismatch between given data and constructed models.

(S3 Oral 15543)

AIS data-driven automatic machine learning model for predicting suitable fishing vessel operating areas in Northwest Pacific

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The Northwest Pacific Ocean is rich in fishery resources and it is one of the most important fishing grounds in the world. Automatic identification system (AIS) has the advantages of large amounts of data and a wide space-time range. It plays an important role in mastering the dynamic management of fishery resources by fishing vessels. With the development of artificial intelligence technology, machine learning models are widely used in the field of fishery prediction. The automatic machine learning model can further improve the prediction accuracy of the model, but it has not been applied in the study of Fishery Ecology. Therefore, the purpose of this study is to explore the best processing method of AIS data of fishing vessels in the Northwest Pacific based on the automatic machine learning model; The prediction model of the suitable operation area for fishing vessels with main operation modes in the Northwest Pacific is constructed, and the temporal and spatial distribution changes of the suitable operation area for fishing vessels with main operation modes in the Northwest Pacific are analyzed; To explore the impact mechanism of environmental factors and climate change on the high-value production areas of fishing vessels in the Northwest Pacific.

(S3 Oral 15739)

The Problem of Learning to Make Statistical Decisions for Small Samples for Remote Monitoring Marine Ecosystems

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Application of means of remote monitoring in many cases is connected with acceptance of the statistical decision on presence on a surveyed part of studied space of this or that phenomenon. One of features of conditions of gathering of the information for such decision is the impossibility of reception statistical samples great volumes.

Therefore working out and research of optimum algorithms of distinction of the casual signals characterized by samples of the limited volume, in the conditions of parametrical aprioristic indefinite are necessary.

The article considers the “Spotting” model as an informative parameter of the background characteristics of the studied space according to remote sensing data. The most obvious way to identify spots is the threshold setting method. In this case, the area of the spot includes that part of the space in which the indicator of the medium for this channel exceeds (l+- characteristic) or does not exceed (l-- characteristic) the threshold value. The work is carried out modular structure of the statistical modeling system of spotting The structure of the software is proposed.

The analysis of empirical histograms for ‘’spottiness’’ shows, that in most cases (l+, l-) - characteristics will be coordinated with exponential distribution, and amplitude characteristics will be coordinated with normal distribution. Therefore for detection and classification of the phenomena on a surface of ocean it is necessary to apply optimal algorithms for the Computer training to taking statistical decisions for the aforesaid distributions

In the present work the generalized adaptive algorithm of training to acceptance of statistical decisions for exponential classes of distributions is developed at aprioristic parametrical uncertainty of conditions small samples. Numerical examples are shown. Efficiency of the developed optimum procedure for small samples is shown.

(S3 Oral 15785)

Using Machine Learning to evaluate ecosystem connectivity and biodiversity in marine ecosystems

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Even optimistic climate scenarios predict catastrophic consequences for marine ecosystems by the end of the century. Understanding how connectivity, biodiversity and resilience are shaped by climate variability would improve chances to establish sustainable management practices. In this regard, ecoregionalization and connectivity are pivotal to designating effective marine protected areas. Here, we show how machine learning algorithms and physical intuition can be applied to sea surface temperature anomaly data to extract ecoregions and assess connectivity and bleaching recovery potential in the Coral Triangle and surrounding oceans. Furthermore, we quantify the impacts of the El Niño Southern Oscillation on biodiversity and resilience, finding that resilience is higher for reefs north of the Equator and that the extraordinary biodiversity of the Coral Triangle is dynamic in time and space, and benefits from ENSO. The large-scale exchange of genetic material is enhanced between the Indian Ocean and the Coral Triangle during La Niña years, and between the Coral Triangle and the central Pacific in neutral conditions. Through machine learning the outstanding biodiversity of the Coral Triangle, its evolution and the increase of species richness are contextualized through geological times.

(S3 Oral 15612)

Machine learning approaches for processing large datasets from the Prawler and Oculus glider autonomous platforms.

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Autonomous and novel sensing technologies provide unprecedented amounts of water-column data with high lateral and vertical spatial resolution which can be transmitted *via* satellite communications. This talk will discuss challenges associated with processing these data (e.g. salinity, temperature, oxygen, and fluorescence) from the Prawler and Oculus glider. It will also outline our approach to developing solutions for scaling both near-real-time and delayed-mode QC and anomaly detection to streamline a significantly increased data flow. The Oculus glider is designed to sample in highly stratified, shallow waters and the Prawler enables continuous vertical CTD profiling using wave energy from a surface mooring. Each observing platform can collect thousands of profiles from a single deployment. There are random and systematic, sensor-specific errors in the data collected. Presently machine learning tools (e.g. random forests and neural networks) are being applied to random error and outlier detection and for gap-filling. Systematic errors seen across many profiles are due to sensor hysteresis and mis-alignment in the presence of exceptionally strong vertical stratification typical of the subarctic and arctic shelf environment. This particularly impacts derived variables that are highly dependent on temperature such as O_2 concentration and salinity. Such systematic errors require tailored approaches which are currently under development. The ability to rapidly QC and interpret the nuances from these substantial datasets will offer a paradigm shift in our subsurface data collection and processing as research-quality high-resolution data could become available in near-real time.

S4: BIO Topic Session
Application and best practice of imaging technologies for plankton and ecosystem monitoring

(S4 Invited 15693)

Advances in imaging technology and image analysis – applications in coastal systems

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In recent years, *in situ* imaging technology has evolved with considerable rapidity and can convey significant and novel insights into physical-biological patterns and processes. Optical methods, along with concurrent environmental sensors, can complement plankton net and acoustic sampling approaches. Combined with automated image analysis, such technologies have the potential to increase sampling efficiency thereby enabling either lower cost approaches, or expanded sampling leading to greater spatio-temporal resolution. Machine learning can reach broadly across these applications, as evidenced by its rapid rise across various disciplines and industries. The availability of machine learning allows for unique pattern/relationship seeking in model outputs, as well as for the rapid resolution of complex instrument outputs such as those from imaging systems or other observational sensors. Here we provide a brief review of the current state of imaging technology available to biological oceanographers, and some of the critical trade-offs. Included in the discussion is a view on the status of image processing, which has been a major constraint to extensive use of imaging technology. Recent work with the ***I**n **S**itu* Ichthyoplankton Imaging System (ISIIS), and its associated automated image processing pipeline, is presented as an example of where progress has been made with imaging systems. Examples are given of the application of ISIIS from projects conducted within the California Current Ecosystem ranging from detailed perspectives of thin layer dynamics in Monterey Bay, California, to riverine influence on cross shelf plankton community distributions to utilizing near-real time analyses to drive adaptive sampling within hypoxic areas off the Oregon coast.

(S4 Oral 15212)

The Prince William Sound Plankton Camera: a profiling *in situ* observatory of plankton and particulates.

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A novel plankton imager was developed and deployed aboard a profiling mooring in Prince William Sound in 2016 to 2022. The imager consists of a 12-MP camera and a 0.137x telecentric lens, along with darkfield illumination produced by an in-line ring/condenser lens system. The profiler travels from ~60 m to the surface twice daily from March to November, producing a high resolution record of the biogeochemistry of the surface ocean during the growing season. Almost $4x10^6$ images of individual plankters and particulates have been collected since 2016. A subset of ~$2x10^4$ images was manually identified into 43 unique classes, and a hybrid convolutional neural network classifier was developed and trained to identify the images. Classification accuracy varied among the different classes, and applying thresholds to the output of the neural network (interpretable as probabilities or classifier confidence), improved classification accuracy in non-ambiguous groups to between 80% and 100%. Automatically identified images from the camera were compared to manual counts of plankton taxa by an expert taxonomist on 53 concurrent vertical plankton net tows. There was high variability between the two methods (~1-2 orders of magnitude), with taxa with fine mechanoreception and strong swimming abilities (e.g. copepods) underrepresented in the images, and fragile taxa underrepresented in the net samples. With caveats, *in situ* imagery allows the study of plankton dynamics at much finer spatial and temporal scales than traditional

(S4 Oral 15606)

An automatic deep learning based measurement of plankton size

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Plankton are an essential component of marine ecosystem. Their size structures are often indicative of their demographic structure, species composition and ecosystem status. Recent developments in deep learning systems provide new tools to measure plankton size fast and rapidly. A key point detector was trained using a deep residual network, ResNet50. Using this key point detector we were able to obtain plankton size measurement with high efficiency and precision. In this procedure, the last fully connected layer was replaced by with a convolutional layer, and a heat map was generated. Then plankton size was measured from the coordinates of key points determined by the predicted maximum point in the heat map. We tested the procedure on a large number of in-situ pictures of plankton from PlanktonScope and measure body length for 4 target groups (copepod, appendicularia, chaetognath and shrimp). With each group 3000 individuals were selected and measured by the automated procedure and manually in ImageJ. Results show that measurements by the automated procedure were very consistent with manually measurements in ImageJ with ~2.34% difference. The new procedure can measure 45 individual per second. This study provides useful information on how to structure and parameterize network to achieve good performance. The new approach is robust and performed well on images collected under complex imaging conditions.

(S4 Oral 15247)

A novel end-to-end deep learning system for marine biological and environmental images

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Marine underwater imaging facilitates non-destructive sampling of species at frequencies, durations, and accuracies that are unattainable by conventional sampling methods. These systems necessitate complex automated processes to identify organisms efficiently, however, current frameworks struggle to disentangle ecological foreground components from their dispensable background content. Current underwater image processing relies on common architecture: namely image binarization for segmenting potential targets, prior to information extraction and classification by deep learning models. While intuitive, this infrastructure underperforms as it has difficulty in handling: high concentrations of biotic and abiotic particles, rapid changes in dominant taxa, and target sizes. To overcome these issues, a new system is presented that begins with a scene classifier to capture large within-image variation, such as disparities in particle concentration and dominant taxa. Following scene classification, scene-specific regional convolutional neural network (Mask R-CNN) models were trained to separate target objects into different taxonomic groups. The procedure allows information to be extracted from different image types, while minimizing potential bias for commonly occurring features. Using in situ coastal PlanktonScope images, we compared the scene-specific models to the Mask R-CNN model including all scene categories without scene classification, defined as the full model, and found that the scene-specific approach outperformed the full model with >20% accuracy in noisy images. We further tested the framework on images from a benthic video camera and an imaging sonar system with high accuracy. The end-to-end is neither instrument nor ecosystem-specific and could facilitate deployment throughout the marine biome.

(S4 Oral 15660)

A new portable tow-yo imaging system for marine snow and plankton using image recognition and tracking technique

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In-situ measurements of marine snow and aggregates have been scarce due to their fragile nature. Recently the study of marine aggregate and other microorganism distributions is becoming more dependent on image recognition techniques and neural networks. Numerous camera systems exist; some have add-in environmental sensors and are part of a larger structured research equipment. However, these camera systems tend to be very large, heavy, and expensive. Imaging technologies have been advancing rapidly that enabled us to make commercially more widely used cameras very portable. Thus, our strategy is to use these recent high specification cameras underwater. We have developed a new portable underwater camera system called SUNADAYODACAM, that consists of a SUNA nitrate sensor (SBE), YODA-profiler (JFE-Advantech), and a portable video camcorder. In this study, data gathering and testing of the SUNADAYODACAM have been conducted during three research cruises in March, June, and July 2021 in the Kuroshio-Oyashio mixed water region, in the Tateyama Bay and in the Tokara Strait for depths ranging from 0-200 m. The results indicate that our methods can produce vertical profiles of suspended particles. To fully optimize the method, the sinking speed of the camera system should be adjusted. By selecting the best focused image for every particle tracked, the particle counts in Tateyama Bay are found to be consistent with the sensor detected turbidity data. This portable camera system can be applicable to numerous systems and, when ready, distinguishes the recorded particle images and sorts them into several taxa.

Keywords deep learning , key point detection , plankton , body length

(S4 Oral 15665)

A dual mode imaging method for phytoplankton: a combination of shadowgraph imaging and fluorescence imaging

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Plankton are an important component of marine ecosystem and accurate monitoring of plankton can provide a reliable assessment of marine ecosystem status. Image-based plankton observing method provide not only plankton morphological features , but also density and length measurements in a non-invasive manner. With recent development of imaging systems and deep learning, high-resolution images acquired at high frequencies allow real-time monitoring of plankton. PlanktonScope is a shadowgraph imaging platform and capable of capturing small plankton of 50 μm to 250 μm, but it could not capture phytoplankton (5 μm to 50 μm). We propose a dual mode approach to image phytoplankton, which combines a telecentric shadowgraph imaging system and fluorescence imaging. Shadowgraph imaging provides clear morphological features and high-contrast edges, while chlorophyll fluorescence imaging complements the classification information of targets with insufficient morphological information, distinguishing between phytoplankton and abiotic particulate matter. To overcome the motion blur issue occur in fluorescent imaging due to the need of a relatively long period to collected fluorescence information b, a lightweight network is used to determine whether to preprocess, and then the fused image is passed through a Mask RCNN model for instance segmentation and recognition. The system was tested on three red tide species of algae and results showed that the dual mode imaging method can image and identify phytoplankton effectively.

Keywords: Plankton Microscopic imaging Chlorophyll fluorescence imaging Deep Learning

(S4 Oral 15725)

Increase depth of field for underwater microscopic imager

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Underwater microscopic imager can effectively characterize the visual characteristics of plankton and provide unprecedent information on their fine scale spatial and temporal dynamics. However, plankton are almost ubiquitous in water column and they often occur outside of the depth of field of the underwater microscopic imager. Therefore, depth of field affects the detection of plankton and the representative sampling of the imaging system. To solve this problem, we developed an underwater microscopic imaging system with extended depth of field based on selected deep learning models. To extend the depth of field of microscopic imaging system, an optical component, phase mask was added as a raised structure to change the optical path difference of the light waves. We designed the shape of the raised structure of the phase mask to precisely modulate the phase distribution of the light waves, so that the point spread function can achieve good consistency in an extended depth along the light path, such that the system can obtain complete optical information within the extended depth of field range. Additionally, the neural network models for the shape of the phase mask and the back-end image restoration are jointly optimized. With this approach, we extended the depth of field of the 4x microscopic imaging system more than 5 times. Simulation experiments on plankton targets with the imaging system showed that the extended depth of field microscope can effectively capture the structural characteristics of organisms at different depths, thus improving the efficiency of plankton monitoring system.

Keywords: Plankton, Microscopic imaging, extended Depth of field, deep learning

(S4 Oral 15699)

Copepoda in Yellow Sea coastal areas: influence factors for the distribution of density and size structure

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Copepods are the most abundant multicellular secondary consumers and are important prey for juvenile and larval fish. In the present study, we examined copepod abundance and size structure in the coastal areas of the Yellow Sea, an essential spawning and feeding ground for many economically important fishes. In June to August 2021, three plankton surveys were conducted using a shadowgraph plankton imaging system, PlanktonScope, and a RBR sonde for environmental factors. Copepod density distribution and size structure were quantified from PlanktonScope images using automated recognition and enumeration system. General additive models (GAMs) were constructed to examine the impacts of different environmental factors and other planktonic groups on copepod density and size structure. Result showed that both density and mean size of copepod increased as offshore distance increased. Temperature had negative impacts on copepod density and mean size between 21°C and 24.5°C, mostly occurred nearshore. Chlorophyll had positive impacts on copepoda density but negative impacts on mean size when < 2 mg·m^{-3} suggesting that low concentration of chlorophyll might be a limiting factor for copepod density. Low chlorophyll concentration mostly occurred offshore. Nearshore high turbidity waters had negative impact on copepod density, but small positive impact on mean size. Other planktonic groups showed no impacts on copepod density and size except *Appendicularia* and *Noctiluca* had nonlinear impacts on copepod density. We concluded that the distribution pattern of copepod density and size are mostly controlled by environmental factors in the study area, which might be affected by circulation in the Yellow Sea.

(S4 Oral 15692)

Planktonic trophodynamics in the Northern California Current - multiyear in-situ observations derived from underwater imaging

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The Northern California Current (NCC) off Oregon and California is a dynamic Eastern Boundary Upwelling System that sustains valuable fisheries. On the Oregon coast, upwelling is intermittent in summer, and winter is dominated by downwelling, while waters off northern California are characterized by continuous upwelling in summer and intermittent upwelling in winter. To study the effects of the different upwelling regimes on mesozoo-, and ichthyoplankton trophodynamics, the ***In Situ*** Ichthyoplankton Imaging System (ISIIS) was repeatedly towed along the Newport Hydrographic Line (NH-Line) off the central Oregon coast, as well as the Trinidad Head Line (TR-Line) off the northern California coast, in winter and summer 2018 and 2019. A Convolutional Neural Network was used to classify over 750 million images into 66 taxonomic groups ranging from protists to copepods, ichthyoplankton, and gelatinous organisms. Utilizing the fine-scale plankton distributions (1m vertical) and environmental data (e.g., chl *a,* temperature) derived from ISIIS, we used spatially explicit correlation analysis to examine variance in the spatial distributions of taxa over time and relative to prevailing environmental conditions. Analysis of the co-occurrences of different taxa across seasons and years revealed several planktonic assemblages with consistent patterns of co-occurrence, while also highlighting substantial trophodynamic differences between the two regions. These patterns point to potential mechanisms underlying the distribution of plankton in the coastal ocean.

(S4 Oral 15188)

Differential response of coastal plankton to tidal and diurnal variations

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Plankton are important components of marine ecosystems, and they show rapid response to environmental changes. Although plankton are often driven by physical processes, plankton species often respond differently to environmental changes. In the present study, we examine the impacts of tides and diurnal variations on coastal plankton using high-frequency monitoring of large phytoplankton (*Phaeocystis globosa* and *Noctiluca scintillans*) and zooplankton (jellyfish and shrimp). Data were collected using PlanktonScope, a shadow-graphic imaging off south China coast for more than one month. The *in-situ* imaging system yielded high resolution of plankton with different body lengths (40 μm-5 cm) at fine spatial and temporal scales. Results showed that the biomass changes of large phytoplankton *P. globosa* over a 24-hour period were most affected by tides, and the occurrence of peak density and spatial distribution were affected by tides. The small phytoplankton *N. scintillans* were less affected by tides. Zooplankton were less affected by tides. The hourly mean density of shrimps, relatively strong swimmers, showed diurnal variation, while weak swimmers like jellyfish showed consistency in spatial distribution. The study characterized the differential response of plankton species to tides and diurnal variations and improve our understanding of the interactions of nearshore physical process and plankton species.
methods.

(S4 Oral 15583)

Zooplankton community and size structure from surface to deep-sea for the various neighboring waters of Japan: Analysis by ZooScan

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The imaging device ZooScan is used for the net-collected zooplankton samples. The application of ZooScan is made mostly for the regional or seasonal changes in the zooplankton community, and a scarce attempt was made for vertical changes especially down to deep-sea. In this study, we made ZooScan analysis on zooplankton samples collected by vertically stratified zooplankton samples collected by VMPS down to 3000 m at seven stations of the various neighboring waters of Japan covering: the Okhotsk Sea, Japan Sea, East China Sea, and subarctic, transitional, and subtropical North Pacific. Throughout the region, both abundance and biovolume decreased with increasing depths. ANCOVA analysis revealed that the affecting factors on the vertical changes varied with the unit. Thus, depth and region were the prime important factors for determining abundance and biovolume, respectively. Cluster analysis based on abundance separated the zooplankton community into 8 groups. The occurrence of each group varied regionally and 3-5 groups occurred vertically stratified for each station. Common for all the stations, Normalized Biomass Size Spectra (NBSS) and size diversity showed great vertical changes around 150-500 m depths. For the shallower depths, the NBSS slope was steep, the intercept was high, and size diversity was low. For the deeper depths, opposite changes were the cases of each parameter. The generalized additive models revealed that various environmental parameters (depth, temperature, and salinity) had a significant effect on NBSS and size diversity. This study indicates that the imaging method may useful even for the analysis of the deep-sea zooplankton community.

(S4 Oral 15703)

Influence of freshwater on zooplankton distribution in Laizhou Bay

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Understanding what control the spatial distribution of marine organisms is at the core of marine ecology. Zooplankton provide insights on the function and structure of the local ecosystem. Laizhou Bay, located in the Bohai Sea, is an important area for marine aquaculture. To investigate zooplankton spatial distribution, zooplankton and environmental conditions were surveyed in August, 2021 using a shadowgraph imaging system, PlanktonScope and a fast respond RBR sonde for temperature, salinity, depth, chlorophyll, oxygen and pH. Zooplankton images were processed using an automated deep-learning based identification and enumeration system. In the present study, we focused on seven common plankton groups: copepods, jellyfish, larval echinoderms, Chaetognath, Appendicularia, shrimp and scylla. Cluster analysis was performed to identify environmental patterns in the study region and results suggest two distinct groups, including stations affected by high salinity water from the adjacent Yellow Sea and stations affected by freshwater. Non-metric multi-dimensional scaling analysis (NMDS) further supported the distinct distribution of zooplankton between the two groups with respect to the freshwater impacts. The abundance of zooplankton at stations affected by freshwater were much higher than stations affected by high salinity water and zooplankton were most abundant at 3-5meter depth. Temperature, chlorophyll, pH increased whereas salinity, dissolved oxygen and turbidity decreased from riverine stations to marine stations. All of the environmental variables were found to be significantly related ($p<0.05$) to the abundance. We concluded that the local freshwater input and current from the adjacent Yellow Sea are the main factors controlling zooplankton distribution in Laizhou Bay.

(S4 Oral 15688)

Automation of rapid zooplankton assessment for use in ecosystem based fisheries management

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Expertise is required to identify zooplankton accurately and this takes considerable processing time. The result is a delivery delay in valuable information used to assess ecosystem condition in Alaska waters and inform fisheries managers. Staff at the Alaska Fisheries Science Center developed a ship-board, Rapid Zooplankton Assessment (RZA) to provide coarse zooplankton community information in order to fill the gap between collection and data return. The RZA takes place at sea, where zooplankton are enumerated under a microscope and identified into broad taxonomic categories. Counts are incorporated into annual Ecosystem Status Reports, providing indicators of the larval fish prey field and are appended to long-term time-series to assess trends. Here we present preliminary results of an automated zooplankton identification algorithm designed to replicate the at sea RZA. A highly-annotated data set of plankton images was generated by staff at the Polish Plankton Sorting and Identification Center and used to train a two-step algorithm for image detection and classification. We used a trained scene-specific Mask Region-Based Convolutional Neural Network (Mask R-CNN), a combination of a region proposal network (RPN) and a residual neural network (ResNet50) separate target objects into different taxonomic groups used in the RZA. This allowed zooplankton subsamples of known volume to be analyzed for detection, classification, and enumeration. We compare zooplankton abundance estimates calculated by expert sorters, at sea sorters, and the algorithm. Results indicate that the algorithm shows similar accuracy for broad taxonomic categories. We plan on exploring the algorithm to add greater taxonomic resolution and provide more detailed information to be used in ecosystem based fisheries management.

S5: FIS Topic Session
Environmental variability and small pelagic fishes in the North Pacific: exploring mechanistic and pragmatic methods for integrating ecosystem considerations into assessment and management

(S5 Invited 15814)

Options for including environmental variability into management of California Current fish species

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Pelagic and midwater fish in the California Current are buffeted by variability in oceanography and species interactions. Major fish stocks such as sardine (*Sardinops sagax*) and Pacific hake (*Merluccius productus*) fluctuate following regime-like patterns, or exhibit episodic recruitment. Two recent examples from the California Current illustrate how we might design harvest rules and stock assessments to account for these changes in ecological conditions. In the first example, we test how climate-driven changes in sardine growth can be incorporated into stock assessments. In the second example, we evaluate harvest rules for hake that respond to prey availability, adjusting fishing rates for hake when prey (and therefore hake) productivity changes. Both of these examples illustrate the use of ecosystem modeling as a 'test bed' to screen management procedures. Specifically, they utilize a California Current Atlantis model as a full ecosystem operating model, for use in Management Strategy Evaluation and harvest control rule testing. Finally, as a third example I highlight a different approach that benefits from new advances in seasonal ocean forecasts. These oceanographic predictions have been linked to six to nine month seasonal forecasts of species distributions in the California Current. The resulting spatial distributions can directly link to fishery management decisions beyond the setting of annual quotas.

(S5 Oral 15549)

Explaining variability in the Pacific saury fishery with the help of Lagrangian characteristics in the western North Pacific

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A new model for estimation of daily probability for the Pacific saury (*Cololabis saira*) encounter was proposed. The model performance was tested for the period of 2004–2018 (August–November) using the data from the Russian vessel monitoring system. The positive effects on the encounter probability of saury were found for speed of passive particles, imitating water parcels, and its gradient, and for the gradient of the finite-time Lyapunov exponent (FTLE), while the effect of particle path length was negative. That means that saury preferred places close to the boundaries of the oceanographic features, where Lagrangian fronts are situated, but not inside the features themselves, because FTLE is small in regular flows and large at Lagrangian fronts. The model did not include information about years and volume of saury catches, but its monthly mean of catch probability in September had the highest correlation with Russian annual catches outside the national waters between Russia and Japan ($r = 0.76$, $p = 0.001$) and total annual catches there ($r = 0.73$, $p = 0.002$). Timeseries analysis of principle components (PC) from daily predictions of saury catch probabilities has also shown that the third PC correlated highly with the annual biomass of saury ($r \geq 0.8$, $p < 0.05$). We suppose that the saury biomass decline was related to the change in spatial distribution of Lagrangian fronts.

(S5 Oral 15555)

Assessment of multiscale nutrient supply processes on biological productivity in the Tokara Strait along the Kuroshio

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Previous studies reported that the Kuroshio Current carries a large amount of nutrients in dark subsurface layers, as a nutrient stream. Supplying these subsurface nutrients upward can be the supporting mechanism for its high biodiversity. Since the Kuroshio frequently flows over rough topography, strong turbulence generated over topographic features could be the key process to support the high productivity. However, these physical-biological observations are still scarce along the Kuroshio. In this study, intensive surveys were conducted in the Tokara Strait using state-of-the-art twin tow-yo profiling systems, one for turbulence (Underway-VMP), and another for biogeochemical parameters (SUNADAYODACAM) on the T.S. Kagoshima-Maru in June and November 2021. The results show that nitrate diffusive flux occurs in the subsurface layers during the stratified season (June), affecting the subsurface chlorophyll-*a*. Also, camera images taken by SUNADAYODACAM imply that chlorophyll-*a* distributions could be affected by zooplankton grazing. Meanwhile, during the fall-winter season (November), subsurface mixing above the seamounts can bring nitrate upward into a deeper surface mixed layer (~100 m). More importantly, we directory observed, for the first time, submesoscale nitrate upwelling structures associated with a submesoscale mixed layer cyclonic eddy, similar to the high-resolution coupled with a N_2PZD_2 ecosystem simulations. These simulations are used to determine the effects of the Kuroshio path modulations and submesoscale features on the nutrient supply and lower trophic levels. The results of this study can improve our understanding of the Kuroshio role and its temporal variabilities in the nutrient injections, enhancement of the productivity, and possibly fish abundance.

(S5 Oral 15564)

Effects of the Kuroshio nutrient stream intrusion into the north of Yaku Island and Osumi Strait south of Kyushu

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Although the Kuroshio Current is known to be nutrient poor in the surface layers, several previous studies have reported that a large amount of nutrients are transported in its subsurface layers as a nutrient stream. Recent high-resolution observations of turbulence and nutrients in the Tokara Strait, south of Kyushu, revealed that when the Kuroshio flows over steep seamounts, intense turbulence can be generated and persists over 100-200 km downstream, injecting nutrients into the euphotic zone. On the other hand, the Kuroshio or warm core eddies frequently intrude into the region north of the Yaku Island, forming a branch current through the Osumi Strait, which merges back into the Kuroshio after passing the Tanegashima Island. The shallow topography north of Yaku Island, as well as the shoaling southward slopes along the northern coast of Yaku Island and Tanegashima Island, can therefore form flow conditions favorable to generate negative potential vorticity. In this study, we show how the Osumi branch current frequently occurs using reanalysis data (GLORYS12V1 from Copernicus Marine Service). Also, a high-resolution numerical simulation will be conducted to consider the effects of the Osumi branch current on the nitrate supply and lower trophic level responses. Finally, we will discuss the implications on the modulations of the pelagic fish abundance.

(S5 Oral 15652)

Recruitment variability of chub mackerel (*Scomber japonicus*) with respect to varying water temperatures

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The recruitment of fish varies greatly by subtle changes in the growth and survival during the early life stages, caused by oceanographic and biotic variabilities. We evaluate the effects of water temperature on growth and mortality to project the recruitment of chub mackerel with varying water temperatures. The daily body size was determined by the temperature-dependent Gompertz-Laird and the temperature-independent von Bertalanffy growth equation. We estimated the size-dependent mortality for the entire life stages from egg to adult by using a Leslie matrix model based on their fecundity, assuming the steady-state and the bigger-is-better hypothesis. Our daily simulations showed that the growth rate increases, the mortality decreases, and the recruitment level increases as the ambient water temperature during the larval stages increases from 15℃ to 21℃. We projected that the warming ocean will enhance the recruitment of chub mackerel, and in the case of Tsushima stock, shift the spawning ground northwards, increasing the production of exploitable chub mackerel in the Korea Strait and the Yellow Sea. We expect our approach will be applied in developing bio-physical coupling models for evaluating and projecting the influences of climate change and warming ocean on fish stocks.

(S5 Oral 15655)

Effect of climate change on the Korea chub mackerel stock in stock assessment via an age-structured model

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Ocean conditions, linked to climate, are well known to determine fish vitality. Water temperatures especially affect the body growth and maturation of fish. For example, the temperature size rule (TSR) dictates the effect of temperatures on body growth and maturation of ectotherm organisms, where they mature at smaller body sizes under warmer temperatures, although TSR would be difficult to detect in the wild because growth and maturation are also affected by other factors such as food (prey) nutrition. Given length-at-age key information for the Korea chub mackerel stock in about 2000 and about 2020, we aimed to evaluate the effects of ocean conditions on fish stock assessment, reflecting different climate indices via those two information sets whose had been separately collected in two decades apart (i.e., two scenarios). We simulated all data except the actual age composition data under the respective scenario, and then fed those data to a stochastic age-structured assessment model. We are comparing the assessment results from the two scenarios in yield-per-recruit (YPR), and spawning potential ratios (SPR) because YPR and SPR are functions of body growth and maturation, which are climate change indices. We will present the results in the PICES conference.

(S5 Oral 15678)

Evaluation of model specification and parameter identifiability in state-space stock assessment models with an application to the Korea chub mackerel (*Scomber japonicus*) stock

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In the state-space framework, temporal variation in demographic processes due to environmental changes as well as fishery-dependent processes, such as selectivity and catchability, can be modelled by treating relevant quantities as random effects. This flexible framework makes state-space models (SSMs) powerful tools for modelling stocks where fishery-dependent data are the only source of information for stock assessment. However, such modelling flexibility can often entail two major structural problems: model mis-specification and structural non-identifiability of parameters. Mis-specified models predict spurious patterns in management quantities of interest, such as spawning stock biomass and fishing mortality rates. One approach to resolve such a modelling issue is to allow more parameters to be time-varying to account for unexplained temporal variability, but this treatment can render a model overparameterised, thus making some parameters structurally non-identifiable. Apart from overparameterisation, previous studies also showed that parameter identifiability issues in SSMs are associated with inseparability between process and observation error variances. Structurally problematic models can provide misleading assessment results which consequently lead to poor management decisions. Therefore, the main purpose of this study was to investigate how those possible structural issues in SSMs can be examined and resolved. For a case study, we applied a state-space length-based age-structured model to the Korea chub mackerel (*Scomber japonicus*) stock and demonstrated how the issues specified above can be diagnosed and addressed. We also present our assessment results for the mackerel stock, where we incorporated time-varying fishery-dependent process, to evaluate the current TAC management.

(S5 Oral 15731)

Responses to Phytoplankton Size and Community Composition by Calanus and Pseudocalanus During Late Summer in the Southeast Bering Sea: potential implications for age-0 pollock recruitment

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Variation in environmental conditions like temperature, salinity, and nutrients greatly influence plankton community dynamics, which constitute critical habitat features for age-0 pollock and cod that feed at lower trophic levels. Changes in phytoplankton communities represent a source of variation in the feeding environment for these lower trophic level consumers because the biochemical make-up, and thus nutritional value of phytoplankton varies with taxonomic composition and growth conditions. Environmental effects on phytoplankton communities may thus exert bottom-up effects on marine ecosystems and may ultimately affect recruitment of age-0 pollock to age-1. We examine how phytoplankton may serve as indicators that link ecosystem variability in the Bering Sea to changes in growth, survival, and recruitment of young pollock. Here we analyze key prey items for age-0 pollock and their associative responses to phytoplankton size and community composition in the context of warm and cold regimes in the southeastern Bering Sea. Our eventual goal is to identify potential indicator species (or communities) of phytoplankton and their nutritional qualities (via fatty acids) that help reveal mechanistic processes leading to either successful or unsuccessful age-0 pollock recruitment.

(S5 Oral 15682)

Calibration of Multiple Fishing Vessels by Using Secondary Reflection from Sea Bottom

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Currently, acoustic methods, which enable investigate fish stocks in a wide area and a short period of time, are often used to fisheries resources survey. Among these, the echo sounders, which are installed on most small fishing vessels, enables the acquisition of a large amount of data each time a fishing trip is made, and therefore, the basic information necessary for stock assessment can be collected over a wide area and at a high frequency. To make echo sounders quantitative, calibration using a calibration sphere needs to be performed periodically. However, this method is labor-intensive and time-consuming, making it difficult to perform it frequently and simultaneously for multiple vessels. Therefore, we devised a simple calibration method using the reflection of the sea bottom. This method involves targeting a calibrated echo sounder, and to create reflection map obtaining echoes from the sea bottom that are as flat and homogeneous as possible. Then the different vessels in the same area pass over the map and get the sea bottom echoes, and they will be calibrated by comparing the measured reflection intensity with that of the map.

(S5 Invited 15649)

Evaluating the spatiotemporal dynamics of Pacific saury in the Northwestern Pacific Ocean by using a geostatistical modelling approach

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Pacific saury (*Cololabis saira*) is an ecologically important fish in the Northwestern Pacific Ocean (NPO). Some evidence indicates that its distribution is affected by the environmental variability, but the relative importance of environmental effects versus those of other unmodelled spatiotemporal processes has not been investigated. Fisheries data from members of the North Pacific Fisheries Commission, were analyzed using a geostatistical modelling approach to examine interannual variation in the spatiotemporal distribution of Pacific saury in the NPO during the fishing season (May - December) from 2001 - 2017. The objectives were to investigate the extent to which this can be attributed to changes in the local (e.g., sea surface temperatures), regional environmental variables (e.g., Southern Oscillation Index), and the unmodelled spatiotemporal variables (e.g., species interaction). We found that the centroid of gravity of Pacific saury had an apparent eastward shifting after 2013, and a further shift with a lower relative abundance in 2017. We also found that neither a single local or regional environmental variable nor any combination of them could explain the distributional shift of Pacific saury. Instead, the change in spatial distribution is mostly attributed to the “unmodelled” spatiotemporal variables. We emphasize that developing a quantitative understanding of the underlying mechanisms is a critical area for future work. We caution that before projecting the Pacific saury distribution resulting from climate change or other environmental phenomena, analysts should first determine whether the hypothesized driving variables account for a meaningful proportion of variability in the historical distribution data.

(S5 Oral 15616)

Evaluation of modeling methods for assessing and comparing the abundance of two size classes of eulachon in British Columbia

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Eulachon (*Thaleichthys pacificus*) are an important small pelagic fish species in nearshore marine ecosystems in the northeastern Pacific Ocean. The species is anadromous spending up to 2-4 years of its life cycle in nearshore marine waters before returning to freshwater river systems to spawn. Eulachon are culturally important to many First Nations in British Columbia, as well as being caught in commercial, recreational and subsistence fisheries. The species is also being considered for listing as under the Species at Risk Act due to low abundance. Off the west coast of Vancouver Island, eulachon are captured as bycatch in both a shrimp trawl fishery and in a small mesh bottom trawl survey conducted each year since 1975. The small mesh bottom trawl survey data present an opportunity to estimate an annual index of abundance for two size classes of eulachon captured in the survey. Survey methodology and coverage has changed throughout the years requiring non-standard methods to estimate abundance. Here we compare indices of abundance from four methods, a design-based stratified random survey technique, kriging methods, and two spatio-temporal modeling approaches. In addition, the trends in the annual index of abundance are explored with regards to fishing mortality, climate indices and a suite of oceanographic variables known to influence the abundance of small pelagic fishes. Studies like these can both generate better and more useful estimates of abundance than previously available and generate insights into the environmental drivers of small pelagic fish abundance.

(S5 Oral 15769)

Future changes in the distributions of chub mackerel (*Scomber japonicus*) in the seas around Korea using a Maximum Entropy Model based on CMIP6: Importance of seasonal variation

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Chub mackerel (*Scomber japonicus*, hereafter mackerel) –a commercially important small pelagic fish in Korea– is highly sensitive to climate change, expanding its spatial distribution due to environmental changes in the recent decades. The spatial distribution of mackerel shows a distinct seasonal variation, suggesting that future changes also appear seasonal variation. However, few studies have directed toward the seasonal variation in the future changes in the mackerel distribution. In this study, we tried to examine a seasonal difference in future changes in mackerel distribution around Korean waters in the 2050s by using a Maximum Entropy Model (MaxEnt) based on CMIP6 under the three climate change scenarios (SSP1-2.6, SSP2-4.5, and SSP5-8.5). The MaxEnt in each season was constructed by the mackerel presence points with five environmental variables (i.e. temperature, salinity, current speed at 10m depth, mixed layer depth, and chlorophyll-a concentration) for 16 years (2000-2015). The model-estimated presence probabilities of the mackerel in Korean waters reveal a marked seasonal variation in the future mackerel distribution; the probabilities show an increase in spring (6.0~6.4%), summer (10.0~11.3%), and fall (3.9~4.8%), but a decrease in winter (5.5~6.5%). Regionally, the South Sea –the major spawning ground– shows a substantial decrease in all seasons except fall. Our findings suggest that the future seasonal changes in the mackerel presence probability should be considered for the effective planning of future management strategies, particularly for environmentally susceptible species such as mackerel.

(S5 Oral 15631)

Shifting distribution and abundance of sand lance in the Arctic in response to the physical environment

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Sand lance (*Ammodytes spp.)* are small planktivorous fishes that play an integral role in the pelagic ecosystems and foodwebs of the Northern Hemisphere. Arctic sand lance (*Ammodytes hexapterus*) is prevalent in the North Pacific in the Sea of Okhotsk, northern Bering Sea, Chukchi Sea, and Beaufort Sea. Recent surveys have noted increased prevalence in response to a warming Arctic. We use surveys conducted throughout the Chukchi Sea 2012-2019 and apply logistic regression and generalized additive models to evaluate distribution and abundance in response to shifting conditions in the Arctic. Arctic sand lance presence appears to be strongly influenced by surface water mass. Relative abundance was positively associated with high surface temperature and low surface salinity. Spatial distributions varied considerably across years. Evidence is mounting that the distributions of many boreal forage species are expanding on the margins of the Arctic. Our results provide insight to how to apply integrated survey data to better monitor ocean conditions that influence population status in small pelagic fishes and predict responses (e.g., abundance and distribution) to environmental variability and future changes in marine conditions.

S6: MEQ/FUTURE Topic Session
Using eDNA to assess and manage Non-indigenous species in the North Pacific

(S6 Invited 15792)

ANEMONE: an eDNA-based biodiversity monitoring network

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All Nippon eDNA Monitoring Network, or ANEMONE, is a nationwide biodiversity monitoring network based on eDNA metabarcoding in Japan. Since the first eDNA monitoring was initiated in 2015 at Maizuru Bay, Kyoto, by academic scientists, 4,298 surveys have been conducted at 861 site to identify 885 fish taxonomical groups in total. The current objective of this network is to monitor the fish biodiversity in aquatic ecosystems, including coastal and pelagic ocean, rivers, and lakes. 77 fixed monitoring stations, supported by research sites of universities, national research institutes and local governments, are currently in operation and their survey frequencies vary from weekly to seasonal. From 2020 hundreds of local citizens also started contributing to the eDNA-based survey and the number of citizen partners are increasing year by year. The procedure for eDNA metabarcoding, including water collection, filtration, DNA extraction and molecular analysis using MiFish primers and sequencing, is conducted under the common methodology that follows the standardized protocol provided by The eDNA Society (https://ednasociety.org/en/manuals/). The sequence data are translated into taxonomic occurrence by Claident, a high-throughput analysis pipeline for metabarcoding data, and made available to the public in a dedicated database, ANEMONE DB (https://db.anemone.bio), maintained at Tohoku University. A consortium of academia, government and private sectors was established on June 1, 2022 to study how the eDNA monitoring data can be used to provide solutions to a wide range of nature-related social issues.

(S6 Oral 15711)

Attempts to predict occurrences of plankton species by AI technologies in Mombetsu, Hokkaido, Japan

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To study the relationship between the change in biodiversity and long-term changes in environmental parameters, weekly monitoring has been carried out at one location off the coast of Mombetsu city from Apr 2012 to Mar 2020 (n = 445). We performed metabarcoding analyses using universal primers for eukaryotes targeting 18S and 28S ribosomal RNA (two primer sets) to detect as many taxa as possible. We identified 2,983 species, i.e., 909, 684, 296, 250, 188, 186, and 470 species in Fungi, Metazoa, Bacillariophyceae, Dinophyceae, Ciliophora, Archaeplastida, and other eukaryotes, respectively. In this study, we introduced AI technologies to predict occurrences of plankton species with seven environmental parameters (water temperature, salinity, NO_2, NO_3, PO_4, SiO_2, Chl *a*). Long short-term memory (LSTM), an artificial recurrent neural network (RNN) architecture used in deep learning, was adopted in this study. LSTM networks are well-suited to classifying, processing, and making predictions based on time series data since there can be lags of unknown duration between important events in time series. For the first six years, all data (n = 335) were used for the training AI (LSTM), and the abundances of each species were reproduced. The appearances of each species in the remaining data set (n = 110) were then tried to predict using only the environmental data sets. As a result of the prediction, 187 from 934 species (20%) based on 18S

and 80 from 562 species (14%) in 28S seemed to be predictable. Moreover, we introduced an AI model of the timeseries_forecaster in Autokeras, which can try 20 different patterns with six options with LSTM and GRU models. We compared the prediction accuracy between the previous LSTM and Autokeras and confirmed the prediction accuracy was improved in ca. 70% of the species in 18S and 28S in Autokeras. We will demonstrate the result of the prediction at the conference in detail.

(S6 Oral 15701)

Effects of antifoulants on the formation of marine biofouling communities monitored in Jangmok using environmental DNA metabarcoding approach

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Biofouling is the colonization of various aquatic organisms (e.g., bacteria, algae, barnacles, mussels, etc.) on the submerged surface of ship hulls and artificial surfaces of mariculture equipment and floating platforms, causing major economic loss and environmental impacts. However, most studies have focused on bacteria. Here, we evaluated the usefulness of eDNA metabarcoding platform for monitoring of biofouling animals. To monitor seasonal variation of biofouling animals, animal attachment on the four plates equipped at the cage aquaculture of Jangmok. Metabarcoding approach targeting the cytochrome c oxidase subunit 1 (COI) gene was employed to investigate invertebrate and specific Urochordata communities on the plate or seawater for comparison. We identified experimentally that eDNA analyses increased detection of species by more than 90% compared to conventional PCR method. Especially, we obtained all of the Phylum level that detected from PCR. The eDNA approach was very useful to identify undetectable animals when we directly compare the samples with conventional PCR method. Relatively high percentage of unclassified taxa are remained to be resolved with further study phylum-specific primer sets. Taken together, these results can contribute to understand seasonal blooming of biofouling animals and suggest usefulness of eDNA metabarcoding approach.

(S6 Oral 15726)

Assess Non-indigenous species in East China sea using traditional methods and eDNA

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The Non-indigenous species and related Risk assessment in the East China Sea was analyzed based on the data of ballast water and field by traditional methods and eDNA. There is a apparent bias between the data by traditional methods and eDNA. Recently, changes in the biogeography of harmful dinoflagellates and diatoms have been detected along the coast. Strong northward shifts in the spatial distribution of *Phaeocystis globosa* and *Karenia mikimotoi* blooms have been documented. Some new species formed bloom in different part of China which never been found before, species introductions including issues of anthropogenic sources (e.g. ballast water) or natural systems (e.g. species range extension) will be analyzed based on geographical distribution and long series monitoring data.

(S6 Oral 15758)

Marine invasive species biosurveillance in the northeast Pacific by eDNA metabarcoding

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Molecular biosurveillance by eDNA metabarcoding has the potential to transform how we monitor and manage aquatic invasive species (AIS); however, uptake of this technology has been hampered by the complexity of the method and lack of validated protocols. We address some of these challenges for the northeast Pacific by designing and optimizing a multi-marker metabarcoding tool specifically for this region that identifies marine AIS from environmental and community DNA. We compare results between the metabarcoding assay and traditional settlement plates whilst optimizing field sampling conditions to maximize AIS detection. Across 6 marinas, the metabarcoding assay detected 20 AIS in five phyla compared to just 8 AIS in three phyla detected from settlement plates. In three instances, the incorporation of molecular data improved the resolution of taxon identifications made from plates. In addition, metabarcoding generated evidence of potentially two new species not previously identified in the region: the giant acorn barnacle *Menesiniella aquila* and a southern hemisphere origin blue mussel (genus *Mytilus*). Total species communities detected from metabarcoding were significantly different between seawater and zooplankton samples, with 25% of species detected by only one type, indicating that both sample types are necessary to maximize AIS detection. Importantly, overall species richness and beta diversity measured by metabarcoding decreased over time for some phyla, indicating that spring is the optimal sampling time to maximize AIS detection. Optimizing this metabarocoding assay for the regional AIS assemblage and local sampling parameters are important steps towards enabling the use of molecular surveys in monitoring programs on our coast. We suggest molecular surveys are appropriate for broad geographical scale screening of AIS, and traditional methods are well-suited to secondary follow-up of potential new species incursions.

(S6 Oral 15738)

Metazoan diversity and seasonality through eDNA approaches: Surveillance of non-indigenous species in Jinhae Bay

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Environmental DNA (eDNA) metabarcoding is a novel technology for species identification using genetic information in the environment, allowing to generate robust species information. Here we conducted eDNA metabarcoding to survey metazoan diversity from an eight month time-series (from May to December in 2021) of seawater samples from Jinhae Bay, South Korea. Metazoan community in Jinhae Bay was mainly composed by six major phyla and showed seasonal changes in the composition of communities in association with environmental properties. In addition, the presence of Japanese sea nettle jellyfish *Chrysaora pacifica*, a harmful species to human, was identified which is native to northwest Pacific Ocean, including coast of Japan. We also conducted TaqMan real-time PCR on those eDNA samples to apply for early detection of *C. pacifica* outbreak in coast of Korea. The results were highly correlated with the distribution of *C. pacifica* through eDNA metabarcoding but had higher sensitivity, implying that TaqMan real-time PCR would be more efficient eDNA application for early detection of non-indigenous species. Our study highlights that eDNA applications would be reliable and sensitive alternative for traditional biomonitoring tools.

(S6 Oral 15794)

Detection and quantification of four main harmful algal species in the East China Sea (Yangtze river estuary) via quantitative real-time PCR

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Over the past few decades, the frequency of harmful algal blooms (HABs) in the East China Sea (ECS) has increased notably. The Yangtze River estuary (YRE) is the most notable sea area for HABs in China because of its complex physical conditions and the changes driven by human activities and climate change. *Karenia mikimotoi*, *Margalefidinium polykrikoides*, *Prorocentrum donghaiense* and *Heterosigma akashiwo* are the main harmful algal species in East Asian Sea (EAS). *K. mikimotoi*, *P. donghaiense* and *H. akashiwo* have caused severe HABs in the ECS. *M. polykrikoides* also was found in the ECS in recent years. Rapid detection of target species is a prerequisite for the timely monitoring and early warning of HABs. The four harmful algal species were detected and quantified via qPCR in this study. The results showed that the most cell concentration of *K. mikimotoi*, *M. polykrikoides* (East Asian Ribotype, EAR), *P. donghaiense* and *H. akashiwo* were 1.6×10^5, 1.3×10^5, 1.6×10^5 and 1.2×10^7 cells·L^{-1}, respectively. HABs dominated by *H. akashiwo* (1.2×10^7 cells·L^{-1}) and *P. donghaiense* (1.6×10^5 cells·L^{-1}) occurred at station S27 on July 22, 2020. Turbidity, pH and salinity influenced the distribution of *K. mikimotoi*, *M. polykrikoides* (EAR) and *P. donghaiense* in the study sea. Temperature influenced the distribution of *H akashiwo* in the study sea. The results reveal a distributive pattern of the four harmful algal species in the ECS (YRE). It is helpful to predict the future diffusion trend of the four harmful algal species in the ECS (YRE) and provides a practical case for the future construction of monitoring and warning systems for the four harmful algal species and HABs.

(S6 Oral 15656)

An eDNA-based approach to investigate species diversity and exotic species in fish

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Environmental DNA (eDNA), which has been used in many recent studies, refers to genetic material in skin tissues, mucus, secretions, excrement, etc., leaked into seawater from aquatic organisms. The studies of fish eDNA have been conducted in various environments, including ponds, lakes, streams, and rivers to detect exotic, endangered, and rare species, as well as to investigate fish species diversity through metabarcoding analysis. This talk will introduce the research regarding the estimation of fish species diversity in the sea surrounding Busan and Ulsan in Korea using underwater visual census (UVC) and eDNA analysis methods, both of which are non-destructive methods that can efficiently identify fish stocks even in complex coastal habitats. The applicability of eDNA analysis for the characterization and monitoring of fish stocks by comparing the UVC method and eDNA analysis will also be discussed. Furthermore, other studies using eDNA analysis to investigate fish species diversity and exotic species in the ocean will be introduced.

(S6 Oral 15667)

Assessing winter Gulf of Alaska biodiversity and non-indigenous species using eDNA surveys

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International Year of the Salmon (IYS) research expeditions exploring winter salmon ecology in the North Pacific included an eDNA research component. Over 100 eDNA samples in total were collected in February and March of 2019 and 2020 in the Gulf of Alaska (~650,000 km^2). We applied metabarcoding (16S and COI rDNA amplicons) on these samples and compared select species eDNA results with associated epipelagic trawls results (abundance and distribution). Here we present a summary of these comparisons, a biodiversity assessment and discuss non-indigenous species detection. This work presents the first winter Gulf of Alaska eDNA baseline.

(S6 Oral 15730)

eDNA metabarcoding reveals high microalgae diversity in the East China Sea near Jeju Island and marine environments of Korea

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Metabarcoding is quite effective for the simultaneous identification of many microorganisms within the environmental DNA (eDNA). Here we applied this method to identify species diversity of microalgae (or phytoplankton) in eDNAs of water samples collected from the East China Sea (ECS) near Jeju Island, Korea. We analyzed eight samples collected from the surface and at 30 m- and/or 50-m depths from two neritic and oceanic stations each from April 24–30. Comparisons of 15,498 pyrosequencing reads identified 172 molecular operational taxonomic units (mOUT) of phytoplankton, excluding cyanobacteria, from the four surface stations. These were represented by dinoflagellates (29%), stramenopiles (31%), and chlorophytes (>39%), with minor contributions from cryptophytes, haptophytes, and Telonemia. Our mOUTs retrieved at 30- and 50-m depths were very similar to the surface samples. However, mOUT diversity and community structure varied considerably with the stations. Dominant mOUTs included *Karlodinium veneficum*, *Ostreococcus tauri*, *Skeletonema marinoi*, and *Thalassiosira curviseriata*, and many of the detected mOUTs include new records for the present study area. In addition, we applied this method to other eDNA prepared from Korean waters and ship hull habitats. Overall, our eDNA metabarcoding revealed high diversity of microalgae when compared to microscopic taxon profiling and can be considered as a versatile monitoring tool for environmental diversity studies.

S7: BIO/FIS/POC/FUTURE/HD Topic Session
Forecasting and projecting climate variability and change on northern hemisphere marine ecosystems using coupled next generation biophysical model

(S7 Oral 15707)

ENSO prediction modulated by interactive phytoplankton feedback

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Despite recent improvements in El Niño/Southern oscillation (ENSO) simulations, predictions of El Niño's magnitude after its peak remain limited due to fast decreasing sea surface temperature (SST) in many climate models. This study shows that bio-optical phytoplankton feedback can improve highly underestimated Niño3.4 index during decaying El Niño through our twin experiments using an ESM-based climate prediction system; one experiment (BGC-on) with bio-optical feedback, while the other (BGC-off) conducts prediction without this feedback. Predicted Niño3.4 index reflecting bio-optical feedback shows that increased skill score when compared to BGC-off. Mean bias and root-mean-square-error (RMSE) in BGC-on experiment are reduced by 0.1-0.3°C and 0.1-0.2°C, respectively. When model drift derived from full-field assimilation for initialization is removed, mean biases of predicted SST anomalies in Niño3.4 region are reduced by 55% from 07- to 14-month lead in January-initialized experiment. Further analysis shows that accumulated positive anomalies of shortwave heating in upper ocean (0 - 30m) are induced by anomalous positive chlorophyll with bio-optical feedback, raising SST by 0.1°C after 3-month lead from chlorophyll peak. This result implies that improved skill scores of predicted Niño3.4 index are contributed by direct impacts related to biological phytoplankton feedback in the tropical Pacific by 30%, and the rest come from indirect impacts.

(S7 Oral 15537)

Attribution and predictability of climate-driven variability in global ocean color

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For over two decades, satellite ocean color missions have revealed spatio-temporal variations in marine chlorophyll. Seasonal cycle and interannual changes of physical environment drives the nutrient and chlorophyll variations. In order to identify contributions of seasonal and interannual components on chlorophyll, the present study investigates total chlorophyll variance (TCV) of 24-year records (September 1997 to December 2021) across satellite generations. First-order contributions of the seasonal cycle in the mid-laitude (25°-35°) ocean in the Northern and Southern Hemispheres explain 59.5% and 69.9% of TCV, respectively. In contrast, the contributions of seasonal cycle only explain 30.9% in the tropical oceans (20ºN-20ºS). Multiple linear regression model is trained to reconstruct chlorophyll anomalies by instantaneous and lagged effects of oceanic memories of eight climate indicies based on sea surface temperature anomaly. Both seasonal cycle and climate-driven variability (26.3%) explain 57.2% on TCV in the tropical oceans. Lagged climate effects generally boost the anomaly correlation coefficients between the observed and reconstructed chlorophyll timeseries from 0.64 to 0.72 in the Indian Ocean, 0.74 to 0.82 in off equatorial Northern Pacific, and 0.58 to 0.71 in the off equatorial Southern Pacific. Such lagged climate effects provide a source of chlorophyll predictability in some ocean regions, yielding one season ahead: r=0.63 in the overall tropical ocean, r=0.67 in the tropical Pacific, and r=0.60 in the Indian Ocean. The attribution of chlorophyll variability indicates promising avenues for better prediction of marine ecosystems into the earth system models by incorporating lagged climate effects.

(S7 Oral 15729)

Sources of uncertainty in global projections of oceanic fish biomass under climate change

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Ensemble projections with global Marine Ecosystem Models (MEM) driven by Earth System Model (ESM) output suggest that climate change will drive a global decline in fish biomass, with consequences for marine ecosystems and food security. However, in contrast with climate change projections, uncertainties in MEM projections remain large and poorly explored. Here, we use a spatially resolved MEM of global fisheries calibrated against observations, the BiOeconomic mArine Trophic Size-spectrum (BOATS), to characterize sources of uncertainty in fish biomass projections, applying an established framework. To this end, we drive BOATS with temperature and primary production output from a suite of IPCC AR6 climate change simulations to year 2100, under a variety of shared socioeconomic pathways and ESM formulations, including large ensembles. We use BOATS output to parse the importance of internal climate variability, scenario uncertainty, and model uncertainty for future fish biomass. We further decompose model uncertainty into contributions from Earth System Model formulation, MEM formulation, and parameter uncertainty. Our results show a limited role for internal climate variability, and highlight the large importance of model structure and parameterization over scenario uncertainty. We suggest that, to reduce uncertainty in global fish biomass projections, increased effort should go into better constraining MEMs and their response to warming temperatures and changing oceanic primary production.

(S7 Oral 15763)

Ecosystem impacts of marine heat waves in the Northeast Pacific

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Prior work has shown that marine heatwaves (MHWs), including the well-studied “warm blob” from 2014-2015, are associated with widespread surface nutrient declines in the Alaska Gyre (AG) and the North Pacific Transition Zone (NPTZ) with a strong reduction in chlorophyll confined to the NPTZ only. Nine such MHWs have occurred in the Northeast Pacific since 1958 and the frequency and intensity of such events are expected to increase in the future. In this study we use a coupled global ocean-biogeochemical model (MOM6-COBALT) with Argo float and ship-based observations to investigate how these MHWs influence marine productivity of these two regions. We find that in both regions, chlorophyll, phytoplankton, and zooplankton production respond modestly to MHWs (within 1 standard deviation of interannual variability), with the stronger response in the NPTZ. This regional difference is driven by the varied response by large (>10 μm) and small (<10 μm) phytoplankton to seasonal nutrient limitation anomalies. Reduced nutrient supply strongly influences large phytoplankton in the NPTZ but has a limited impact on the iron-limited large phytoplankton population in the AG. In contrast, there is a springtime increase in small phytoplankton production in both regions due to shallower mixed layers and weaker light limitation. Though modest, these primary production anomalies shift the phytoplankton assemblage in favor of the smaller size-class, resulting in a decrease in the large-to-small phytoplankton ratio that exceeds the interannual variability of each region. This shift is propagated through the food web, reducing secondary and export production, especially in the NPTZ.

(S7 Oral 15732)

Future projections of fish biomass to 2300: uncertainty over global and regional scales

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Recently increasing attention has been devoted to long-term responses of ecosystems to sustained anthropogenic perturbations to the climate system beyond 2100. For models that consider fish and fish biomass sensitivity to climate change, however, most work to date including model intercomparisons have thus far only considered changes to 2100. Here we consider projections to 2300 using the BiOeconomic mArine Trophic Size-spectrum (BOATS) model driven with output from five CMIP6 Earth system models (ESMs) that have been extended under an ssp585 emissions pathway. The ESMs includes CESM2-WACCM, IPSL-CM6A, MIROC-ES2L, ACCESS-ESM1.5, and UKESM1. Although these models do exhibit diversity in their degree of warming by 2300, their disagreements with projected primary production are much more pronounced, even disagreeing in sign. In considering changes in fish biomass, our presentation will include not only global- and basin-scale analyses, but also analyses at the biome-scale and for the highly productive Large Marine Ecosystem domains that are more coastally confined. We will also complement the analyses of projections with ssp585 forcing with analyses of projections to 2300 with ssp126 forcing.

(S7 Oral 15750)

Mechanistic modeling of dynamics and blooms of jellyfish in light of climate change in the northern Gulf of Mexico

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The complex life history (i.e., pelagic and benthic phases) in combination with dynamic ocean conditions often leads to challenges for mechanistically understanding the large spatio-temporal variations in jellyfish dynamics. While extensive studies have outlined the external drivers associated with bloom-forming, the intrinsic mechanisms underlying jellyfish blooms remain elusive. Modeling provides a useful tool for the study of jellyfish population dynamics. Up to now, very few modeling studies have considered the whole pelagic-benthic life cycle with fine-scaled dynamic ocean conditions and the stage-structured features of jellyfish populations. In this talk we will introduce a mechanistic population model with a fully coupled pelagic-benthic life cycle of jellyfish (*Aurelia* sp.) and fine-scaled (0.5° × 0.5°) dynamic ocean conditions in the northern Gulf of Mexico, then display the application and performance of the model to examine spatio-temporal dynamics of the species, and further discuss the mismatched bloom timing defined as abundance or biomass and its potential implications to ocean ecosystems and fisheries. This study contributes to the improved understanding of jellyfish blooms with predictions of the status, trend, and hotspots of jellyfish population dynamics in a changing environment.

(S7 Oral 15806)

The collapse of eastern Bering Sea snow crab

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Eastern Bering Sea snow crab abundance collapsed to historical lows in 2021. Over 10 billion crab disappeared from the survey during this time. Two questions now dominate conversation around snow crab in management: "What happened?" and "What do we do now?" I will describe efforts to answer these questions including the construction of population dynamics models that estimate time-varying natural mortality, simulation studies to understand the estimability of variation in mortality, and attribution studies to identify potential drivers of the collapse. We link this collapse to a marine heatwave that occurred in the Bering Sea during 2018 and 2019. Calculated caloric requirements and observed body condition suggests that starvation may have played a role in the collapse. I will also describe the difficult decisions required to implement rebuilding plans and outline counter-intuitive consequences of climate-adaptation in management targets. A fisheries disaster was declared when allowable catches in the fisheries were slashed by 90% in 2021 and short-term prospects for snow crab in the Bering Sea are uncertain. The collapse of snow crab foreshadows climate-related fisheries management problems that will be more frequently faced around the globe.

S8: BIO Topic Session
Recognizing the importance of zooplankton to fisheries research

(S8 Invited 15691)

Linking zooplankton to fish: integrated ecosystem monitoring can inform ecosystem approaches to fisheries management

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Globally, nations have been moving towards implementing Ecosystem Approaches to Fisheries Management (EAFMs) or Ecosystem Approaches to Fisheries (EAF) to address policy requirements for sustainably managed fisheries. This mandates that environmental and biological conditions of marine ecosystems are considered when assessing fish stock status. Bottom-up, or prey driven mechanisms, are hypothesized to be important for fish survival and recruitment. For example, critical period, stability, and match-mismatch hypotheses link the oceanographic and prey environment to the successful feeding by and survival of larval fish. The scientific literature includes many studies that examine the influence of zooplankton on fish outcomes; however, there are still large gaps in knowledge. For example, the diets of many fish species are often not described, which is key to understanding how bottom-up processes, such as zooplankton availability, affect fish. Although not always practical, adding sample collections, such as fish diet analyses and zooplankton sampling, to existing fish surveys is a first step towards filling knowledge gaps. Challenges to address include temporal and spatial scales of both the sampling and life histories of ecosystem components. A more integrative approach to monitoring will contribute to both our understanding and ability to forecast how marine ecosystems respond to climate change and to the application of EAFMs. This is also directly applicable to the goal of PICES's integrative science program (FUTURE) and to the Ocean-Decades' challenge to have an improved understanding of the effects of multiple stressors on ocean ecosystems and solutions to monitor ecosystems under changing environmental and climate conditions.

(S8 Oral 15705)

Linking zooplankton to fisheries stock assessment and management in changing ecosystems: challenges and opportunities

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While the importance of zooplankton in regulating fisheries population dynamics has been well recognized, limited studies have been done to link the dynamics of zooplankton and fish populations in fisheries stock assessment and management. Such a linkage can yield information critical to develop ecosystem-based fisheries assessment and management. However, there remains a large knowledge gap regarding how variations in zooplankton may influence the dynamics and production of fish populations, in particular recruitment dynamics and spatial/temporal distributions of fish populations. In this talk we will review the approaches coupling zooplankton dynamics and fisheries populations, discuss conceptual and analytical bottlenecks as well as possible solutions to explicitly consider zooplankton dynamics in fisheries stock assessment and management in the light of climate change.

(S8 Oral 15602)

The food source of anguilliform leptocephali in the Satsunan area, southern Japan

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Information on the feeding ecology of leptocephali is essential for the aquaculture of anguilliform fishes including Japanese eel *Anguilla japonica*. Previous studies have shown some evidence that leptocephali feed on marine snow, but the food source is controversial. In this study, we gained insights into the amorphous materials that occupy majority of their gut contents by multiple approaches: electron microscopic examination, DNA metabarcoding analysis for gut contents, and stable isotope analysis. Samples were collected by an Ocean Research Institute net (diameter: 160cm; mesh size: 335μm) from the Kuroshio Current and the adjacent waters from 2020 to 2021. A total of 43 leptocephali (*Gnathophis* spp., *Gymnothorax minor*, *Dysomma* spp., *Muraenesox* spp., *Saurenchelys* spp., *Heteroconger* spp., Congrinae spp., Ophichthinae spp., Nettastomatidae spp.) were used for these analyses. DNA metabarcoding analysis detected a high percentage of copepods (1.7-97%) and krills (9-92%), also contained various taxonomic groups in the gut contents. Stable isotope analysis showed that fecal pellets of calanoid copepods would be a main source of nutrition. By electron microscopic observations, particles that would have originated from fecal pellets of zooplankton were confirmed in guts of all leptocephali with amorphous content (n=19). Our data strongly suggest that leptocephali would selectively feed on the fecal pellets of zooplankton such as copepods in marine snow.

(S8 Oral 15623)

Spatiotemporal trophic dynamics of four zooplankton taxa in the East/ Japan Sea revealed by stable isotopes and fatty acid composition

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Recent changing climate is expected to affect the seasonal variation of community structure of zooplankton, as an intermediary in the aquatic food web, but its related case studies are still insufficient in marginal sea environment, western North Pacific. The four zooplankton taxa (Euchaetidae, Chaetognatha, Euphausiid, and Amphipod) were collected from August 2020 to August 2021 in the coastal and pelagic study sites of the East /Japan Sea to investigate their seasonal trophic dynamics.

In August and October 2020, the total chlorophyll-a concentration decreased while the pico-size phytoplankton proportion increased. The carbon ($\delta^{13}C$) and nitrogen stable isotope ratios ($\delta^{15}N$) in zooplankton were enriched during the productive season (February and May 2021), compared with August and October 2020. The difference in $\delta^{15}N$ among taxa showed a significant hierarchy in trophic positions of zooplankton groups, from amphipod (5.3‰) to chaetognatha (8.7‰). The total fatty acid concentration also showed seasonal variability and was the highest in February 2021. The phytoplankton markers in fatty acid, the proportion of eicosapentaenoic acid (EPA, C20:5n-3, diatoms), and docosahexaenoic acid (DHA, C22:6n-3, dinoflagellates) increased during the productive season. The ratio of DHA/EPA, which is an indicator of carnivory or nutritional quality, increased in all zooplankton taxa during the productive season and showed higher than 1 in euchaetidae and chaetognatha groups. The present study suggests trophic dynamics of four zooplankton taxa should be clarified by dual isotope and fatty acids biomarkers, revealing significant spatiotemporal variation in the East / Japan Sea.

(S8 Oral 15760)

Evidence of the importance of zooplankton to salmon success in the southern Salish Sea, USA

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Globally, numerous studies have established the importance of zooplankton to growth and survival of economically important fish populations, but the relationships are generally complex, non-linear, and difficult to resolve in the field where a mix of bottom-up and top-down processes occur. This is particularly true where long zooplankton or fish time series are lacking. In the U.S. waters of the Salish Sea, populations of several salmon species have been in decline since the 1980s. The mechanisms underlying the declines are unknown, and stocks have not recovered despite billions of dollars invested in hatcheries and other mitigation strategies. In 2013, the U.S.-Canada Salish Sea Marine Survival Project was initiated to explore controls on juvenile salmon growth and survival. One of the project's primary hypotheses for the long-term declines is that prey quantity or quality has declined, resulting in poor growth during critical life phases. Historical zooplankton data are very rare in the region, so a direct test of the hypothesis is challenging, but data collected through systematic zooplankton monitoring that began in 2014 throughout the southern Salish Sea, and since 2003 at a single station in the Strait of Juan de Fuca, enable some preliminary tests. In this presentation, I will outline the evidence that led to the hypothesis that zooplankton are key to salmon survival in the region, the limited evidence available that zooplankton have changed since the 1980s, and more recent relationships between zooplankton and salmon success that have been developed as a result of zooplankton monitoring and other data.

(S8 Oral 15544)

Spatiotemporal variability of micronekton at two fronts in the central North Pacific

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The North Pacific Subtropical Frontal Zone (STFZ) seasonally aggregates economically important fish and protected species, hypothesized in results of enhanced prey biomass due to convergence at the Subtropical Front (STF) and a sharp northwards increase in primary productivity, the Transition Zone Chlorophyll Front (TZCF), both prominent in the STFZ. Given existing data gaps, characteristics of micronekton, which are forage for top predators, were investigated using multi-frequency active acoustics and the effects of STF and TZCF accessed from a combination of *in situ* and satellite environmental data. Results of this study show a significant increase in micronekton biomass across the STF with differing taxonomic composition from its south to its north. The Pacific Decadal Oscillation as well as mesoscale events and subsurface processes were indicated to play important roles in affecting micronekton distribution and/or biomass. The large-scale 2014-2017 extreme warming event positively corresponded with micronekton biomass and changes in its composition in the region, findings that agree with expectations. Results of this work highlight the importance of our need to further our understanding of the role of large-scale variability, extreme events, and subsurface processes of micronekton in the region's ecosystem to improve management of our living marine resources.

Keywords: North Pacific Subtropical Frontal Zone (STFZ); Subtropical Front (STF); Transition Zone Chlorophyll Front (TZCF); micronekton; acoustic scattering layers; environmental forcing

(S8 Oral 15715)

Unexpected mass-occurrence of walleye pollock *Gadus chalcogrammus* in the epi-pelagic layer at the edge of the ocean basin: the benefit from copepod bloom

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Substantial amounts of walleye pollock were caught by a surface trawling net covering the 0-30 m depth layer during May 2022, at the sites 35 and 140 km south off the southern coast of the Hokkaido Island, with 1815 m and 5503 m bottom depths, respectively (hereafter referred to as slope and basin sites, respectively). Whereas the body lengths of fish from the two sites were comparable (395 ± 22 and 392 ± 20 mm SL, respectively; mean ± S.D.), body conditions (Fulton's *K*) differed considerably, with fish from the basin site being stouter (7.32 ± 0.71 and 7.85 ± 0.78, respectively; $p<0.001$, *t*-test). The stomach contents of the fish from both sites almost comprised mesozooplankton (99.6% and 93.2%, respectively) but showed the difference between the sites. While copepods and euphausiids shared similar proportions at the slope site, copepods (mainly *Neocalanus plumchrus/flemingeri* and *Eucalanus bungii*) were exclusively important at the basin site. Because the basin site showed a more advanced state of blooming than the slope site, it was suggested that walleye pollock in the Oyashio region migrate south in spring to utilize the copepod blooming in the epipelagic layer of the basin edge in recovering their body condition after overwintering.

(S8 Oral 15551)

How to adapt larval growth of widely appearing fish to food availability in the Kuroshio?

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It has been long thought to be poor food availability for fish larvae in the Kuroshio due to the low standing stocks of zooplankton under the oligotrophic conditions. Despite of a potential risk or disadvantage for larval survival and growth, Kuroshio and its neighboring waters are nursery grounds for crucial life stages of various fishes including fishery target species. Recent findings pointed out that prey availability in the Kuroshio is comparable to those in the coastal sites since plankton standing stocks and productivity were stimulated with various nutrients supplies. Here, we report how to adapt larval growth of beaked sandfish to food availability in the Kuroshio based on measurements of biochemical and conventional approaches. While they demonstrated wide appearance, we found developed larvae represented by higher protein contents, larger body length and later ages in the Kuroshio waters. No significant difference was found for their individual aminoacyl tRNA synthetases activities and width of daily otolith increments between the Kuroshio and the coastal waters where plankton standing stocks were different. These findings support that larval growth of beaked sandfish is comparable between the Kuroshio and coastal waters. We suggest that younger larvae grow in the coastal waters and developed larvae are advected to the Kuroshio and survive even under poor prey availability.

(S8 Oral 15550)

Metabarcoding analysis on prey of fish larvae appearing in the Kuroshio and its neighboring waters

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Kuroshio and its neighboring waters are known to be feeding grounds for early life stages of various fishes, despite of a potential risk or disadvantage for their survival and growth under the poor food availability. For understanding these inconsistencies, however, there is limited information on trophic pathways to fish larvae in the complicated food web. Here, we explore trophic sources and linkages of fish larvae appearing in the Kuroshio and its neighboring waters based on metabarcoding analysis of gut content DNA for 15 taxonomic groups. We obtained 1088526 reads of prey organisms, composed 19.5% of total sequence reads from gut content. Major prey items were copepods, protozoans, hydrozoans and ostracods. Copepods were the most predominant prey for other fishes but their contributions were variable among mesopelagic fishes. Copepods were the most frequently appeared prey taxa, and protozoans, appendicularians and other gelatinous zooplankton was the next. Non-metric multi-dimensional scaling on their prey compositions classified the three groups which were significantly different for major prey items. Major prey was represented by protozoans and hydrozoans, copepods and ostracods, and strong dependance on copepods, indicating niche segregation on food resources by supplementary items to preferable prey. These findings suggest that not only copepods but also the supplementary prey were important hubs of trophodynamics to fish in the Kuroshio ecosystem.

(S8 Oral 15690)

Seasonal influence of intrusion from the Kuroshio Current on microplankton biomass and community structure in the northern Satsunan area, western Japan

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Seasonal variations in hydrographic conditions, nutrients, and microplankton abundance and biomass were investigated inside and outside Kagoshima Bay in the northern Satsunan area where is a nursery ground for the migrating fish. During the mixing season highly saline water (>34.5) originating from a branch of the Kuroshio Current intruded from the surface layer into the bay causing extrusion of coastal bottom water. This intrusion generated vertical mixing between surface water and nutrient-rich bottom water. Consequently, chlorophyll *a* concentrations increased around the bay mouth. During the stratified season the coastal surface water was extruded due to intrusion of saline water from the bottom layer. High chlorophyll *a* concentrations were also observed in the surface layer in July during the rainy season. Such differences in hydrographic conditions between mixing and stratified seasons were due to vertical distribution of highly saline water from outside the bay, which seasonally migrated between surface and subsurface layers. Microplankton community structure differed between mixing and stratified seasons. The mixing and stratified seasons were characterized by high diatom abundance and low microplankton abundance, respectively. Microzooplankton abundance was related to the abundance of prey organisms, such as diatoms, thecate dinoflagellates and cryptophyte-like flagellates, rather than hydrographic conditions. Thus, saline water intrusion from a branch of the Kuroshio Current likely governs hydrographic conditions in Kagoshima Bay and consequently affects temporal variations in abundance and taxonomic composition of phytoplankton and microzooplankton communities.

(S8 Oral 15722)

Temporal changes of micoplankton community after the inflow of the Kuroshio branch current in the Northern Satsunan region, southern Japan during mixing period

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The inflow of the Kuroshio current into coastal areas is known to stimulate biological production, however; there are no detailed reports on its temporal changes. In the Kagoshima Bay, Japan, the date of inflow of the Kuroshio branch current can be identified a posteriori based on water temperature data. Therefore, by compiling the results of multiple observations, it is possible to track temporal change of biological productivity related to the inflow of the Kuroshio branch current. It has hypothesized that phytoplankton blooms occur in this area due to upwelling of the bottom water at the bay mouth during the inflow of the Kuroshio branch current. From this hypothesis, it is expected that microplankton will increase with the number of days elapsed from the inflow of the Kuroshio branch current. In this study, we compiled the results of ship observations conducted in the Kagoshima Bay from 2016 to 2019 to examine changes in water quality (temperature, salinity, nutrients), microphytoplankton and microzooplankton versus days elapsed the Kuroshio branch current inflow. In this study, significant relationships were obtained for microplankton in terms of both biomass and cell abundance, with specific growth rates could be calculated ranging from 0.060 to 0.079 d^{-1}, comparable to the growth rate of Chl-a. Over time, phytoplankton, mainly athecate dinoflagellates, and microzooplankton, mainly naked ciliates, proliferated and might be quickly preyed upon by mesozooplankton. Such events occur once every two weeks in most years, suggesting that frequent phytoplankton blooms support high biomass of mesozooplankton and larval fish.

(S8 Oral 15685)

Molecular identification of the zooplanktonic diet of *Sardina pilchardus* larvae in the SW Mediterranean Sea

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Zooplankton are the main prey for small pelagic fishes. The most common small pelagic fish species in the Alboran Sea (SW Mediterranean Sea) is the European sardine (*Sardina pilchardus*). Despite its commercial importance in the region, little is known about its larval trophodynamics and the role that zooplankton play in their recruitment success. Microscopic characterization of the larval gut contents is challenging as they prey mostly on partly digested microplanktonic organisms. Several molecular tools have been developed that may overcome this caveat. The gut content of sardine larvae (6 - 21 mm standard length) collected over a diel cycle in the Northern Alboran Sea was analyzed by mitochondrial COI metabarcoding, and compared with the field zooplankton community composition. Diel variability was observed in zooplankton relative abundances, both in the larval gut contents and in the field. Sardine larvae preys included several copepod nauplii, but also DNA of cladocera, euphausiid, gastropod and hydrozoa was detected, suggesting an opportunistic foraging behavior, instead of a selective diet.

(S8 Oral 15613)

Model-based zooplankton productivity and trophic transfer efficiency in the Strait of Georgia, Canada

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Biogeochemical models can provide productivity estimates at unprecedented spatiotemporal scales. Here, we use the SalishSeaCast model to examine productivity (primary and secondary) and trophic transfer efficiency (TTE) over a 14-year period (2007-2020) in the Strait of Georgia, Canada. Previous studies in the region have linked zooplankton biomass to large-scale climate indices. As such, we compared our results between positive (cold-phase) and negative (warm-phase) North Pacific Gyre Oscillation (NPGO) years. Primary productivity was calculated as the sum of diatom, flagellate, and ciliate productivity. Micro- and mesozooplankton productivity were calculated by multiplying the sum of grazing by growth efficiency. Results showed that primary productivity was diatom- and flagellate-driven during the spring (Mar-May) and summer (Jun-Aug) months, respectively. Microzooplankton productivity peaked in July, and was slightly higher during cold-phase (0.7 g C m^{-2} d^{-1}) compared to warm-phase (0.6 g C m^{-2} d^{-1}) years. TTE between primary producers and microzooplankton ranged from 28.0 to 60% in both cold and warm-phase years. Mesozooplankton productivity was slightly higher during warm-phase years (maximum of 0.8 g C m^{-2} d^{-1} in August) resulting in higher TTE (84%) compared to cold-phase years (TTE of 71%), which was largely driven by increased grazing on flagellates during the summer of warm years. Results will be compared to output from Atlantis, another model being implemented in the region, which extends to higher trophic levels. These findings will help us to better understand how future warming scenarios may impact zooplankton productivity, and the potential implications for energy transfer to higher trophic levels.

S9: BIO/MEQ Topic Session
The effects of ocean acidification and climate change stressors on the ecophysiology and toxicity of harmful algal species

(S9 Invited 15614)

Acclimation of various US *Dinophysis* isolates to changing light intensity: effects on growth, photosynthetic efficiency and toxin production

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Effects of light intensity on growth, photosynthetic efficiency (Fv/Fm), and toxin production (Diarrhetic shellfish toxins; DST, and PTXs) by multiple isolates of four *Dinophysis* species were investigated in this study: *D. acuminata* (DANY1, DAVA01, DAGM01, NWFSC 806), *D. ovum* (DOSS 2206), *D. fortii* (NWFSC 804), *D. caudata* (DCSS 3191). Cultures were isolated from different coastal regions in the US and acclimated for 6 months under three light intensities, 10, 100 and 400 µmol photons m^{-2} s^{-1}. Our findings showed that exposure to high light intensities 100 and 400 led to relatively lower photosynthetic activity, but elevated growth rates (2 to 3 times increase) and DST production rates in *D. acuminata* and *D. ovum* (2 to 10 times increase). High light, conversely, lowered growth rates for *D. fortii* and *D. caudata* strains (2 to 3 times decrease) as well as toxin production rates for *D. fortii* (2 to 15 times decrease) indicating a preference for lower light intensities for these species. There were exceptions: light intensity had no effect on PTX2 production in one of the *D. acuminata* strain, and an isolate of *D. caudata* produced more PTX13 at the highest light treatment when growth was photo-inhibited. The variation in growth and toxin production rates highlighted in this study could be explained by the inter and intra- specific variability, the geographical origin of the isolates, and the possible implication of other key processes (physiological, molecular, or genetic) involved in the response to changing the light intensity between *Dinophysis* isolates in their environment.

(S9 Oral 15592)

Effect of marine heatwaves on the bloom of harmful dinoflagellate *Cochlodinium polykrikoides* in Korean coastal waters: Field and laboratory approaches

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In 2018, the bloom of harmful dinoflagellate *Cochlodinium polykrikoides* occurred under abnormally high water temperature (WT) conditions caused by marine heatwaves (MHWs) in Korean coastal water (KCW). To understand the impact of MHWs on *C. polykrikoides* bloom in 2018, we conducted field surveys (the horizontal and vertical investigation) and laboratory experiments (the physiological and genetic differences between the two strains, including the strain in 2018). In laboratory experiments, although there were no genetic differences in the LSU rDNA, both strains showed a significant different growth response to high WTs; above 28°C, only CP2018 was able to grow, suggesting that CP2018 had potential growth capacity at high WTs. However, the growth rate of CP2018 was relatively lowered at 30°C. The negative correlation between the average WT and duration of *C. polykrikoides* bloom in previous 17 years ($R2 = 0.52$, $p < 0.01$) and a short duration in 2018 supports that high WT is not favorable for *C. polykrikoides* in KCW. In addition, most of the *C. polykrikoides* population was at a depth of 3–6 m during the day, where the WT was significantly lower ($p < 0.01$; Chi square = 57.98; Kruskal–Wallis test) than in the surface layer (0 m), suggesting the usage of DVM to avoid high temperature stress. Thus, our

findings indicated that in relation to MHWs, early stratification condition plays a critical role in developing *C. polykrikoides* blooms, but maintaining bloom are negatively affected under high WT conditions, as two sides of the same coin.

(S9 Oral 15664)

Correlations between ocean temperature and the concentrations of harmful algal biotoxins measured in British Columbia coastal waters

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Harmful algal blooms (HABs) and associated biotoxins have a negative impact on marine life and can result in significant losses to the aquaculture industry. Variations in the timing, extent, duration, and impact of toxic HABs have been linked to changing environmental conditions, including extreme events such as the 2014-2016 North Pacific marine heatwave. Since 2020 scientists at Fisheries and Ocean Canada have been partnering with the aquaculture industry and citizen scientists to collect biotoxin samples, phytoplankton, and environmental data in the coastal waters of British Columbia. Seawater collected at or near the surface at various locations is filtered and the water and filter samples analyzed for multiple biotoxins including those associated with amnesic, paralytic and diarrhetic shellfish poisoning. Comparisons with taxonomic and environmental data have revealed significant correlations between water temperature and the measured concentrations of certain biotoxins, reflecting seasonal changes in these variables and the abundance of harmful algae. Dinophysitoxin-1 and pectenotoxin-2 were found in most samples and were linearly correlated with water temperature at site IS-2 in the Strait of Georgia, where concentrations of these toxins and *Dinophysis* were greater in 2020 than in 2021. Similar results were obtained at a salmon farm on the West Coast of Vancouver Island for domoic acid and for saxitoxin C1, which was detected in filter samples when *Alexandrium* was present and showed different correlations with temperature before and after the spring bloom. These findings illustrate the potential linkages between climate change stressors such as ocean warming and the toxicity of HABs.

(S9 Oral 15666)

Linkages among harmful algae, marine biotoxins in shellfish, and oceanographic conditions in the Strait of Georgia, Canada.

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The coastal waters of British Columbia, Canada make up one of the most biologically productive ecosystems in the world, supporting large commercial and recreational fisheries and aquaculture industries. The shellfish industry is an important contributor to the BC aquaculture economy with many shellfish growers located within the Strait of Georgia (SoG). Harmful algae produce marine biotoxins that accumulate in shellfish flesh resulting in numerous shellfish closures in the SoG every year. Since 2015, a high resolution (~55 stations sampled bi-monthly) SoG monitoring program has been led by the Pacific Salmon Foundation. Physical parameters (temperature, salinity, depth, dissolved oxygen, turbidity, chlorophyll) and harmful algae (e.g. *Alexandrium* spp., *Dinophysis* spp., *Pseudo-nitzschia* spp.) are measured and enumerated at all of these stations, while nutrients (nitrates, silicates, and phosphates) are measured at ~30. Analysis of harmful algae dynamics revealed statistically significant links to several environmental drivers. Based on the current data-series, annual *Alexandrium* abundance appeared to be linked to the ENSO cycle. Years with high abundances of *Alexandrium* and *Dinophysis* had higher toxin concentrations (causing Paralytic and Diarrhetic Shellfish Poisonings respectively) detected in shellfish flesh (data from the Canadian Food Inspection Agency). Combining these field-based results of harmful algae and oceanographic monitoring with the prevalence of toxins in both the water column and in shellfish flesh would lead to a better understanding of climate related changes in harmful algae ecology and its impacts on marine ecosystems.

(S9 Oral 15643)

Using the Continuous Plankton Recorder to detect and monitor the spread of Harmful Algal Blooms from the Pacific into the Arctic Ocean

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Warming seas introduce an increased risk of non-native and/or harmful microbes entering the arctic environment, such as food-borne micro-organisms that negatively impact human health directly or indirectly through access to marine food resources. In recent years the Arctic Ocean has seen significant warming trends and changes in circulation, which have been shown to accommodate potentially harmful toxic phytoplankton species and bacteria. Trans-Arctic migrations are likely to become more common as warming continues and could have large impacts on the ecosystem and biodiversity. The northern boundary of the Pacific Ocean is likely to move pole-ward under climate change; this may cause adjacent areas of the Arctic Ocean to become more Pacific-like. By providing the coverage of both the North Pacific and now the boundary conditions between the Arctic, the CPR is ideally suited to tracking these changes. Such gradients of change need to be monitored over a large geographical area and using consistent time-series, to understand the implications within the marine ecosystem, and any possible impacts on marine resources. Following the successful completion of 4 annual summer voyages towing a CPR from western and eastern Canada into the Arctic Ocean, we will present some of the initial preliminary analyses and findings on potentially harmful marine microbes and the plankton community dynamics in the area.

(S9 Oral 15801)

Climate Change and the Growth and Toxicity of *Pseudo-nitzschia multiseries* from the California Current Upwelling System: Effects of Ocean Acidification and Temperature

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The effects of two critically important alterations of the California Current eastern boundary upwelling system (EBUS) - increased temperature and elevated CO_2 levels, were examined as a function of nutrient sufficiency in controlled laboratory studies of *Pseudo-nitzschia multiseries*. Our results demonstrate the adaptive capability of this diatom to grow and produce domoic acid (DA), as a function of these factors during both their nutrient-replete, exponential growth phase where cellular DA concentrations were very low, and their silicate-depleted, stationary growth phase where cellular DA levels were much greater. Non-axenic strains of *P. multiseries* were exposed to three temperatures (13, 19 and 25 °C), and three pH levels (8.10, 7.95 and 7.80) regulated by direct injection of compressed CO_2/air into culture flasks. Specific growth rates increased 2 fold from 13 to 19 °C, but the greatest DA levels (both particulate and dissolved DA) were consistently found at the highest temperature studied (25 °C) during both growth phases. The exponential growth rate of nutrient-replete cultures did not vary significantly with declining pH until pH 7.80 was reached when growth decreased by 20%. Stationary cells increased DA production relative to exponentially growing cells, but particulate DA concentrations normalized to cell abundance were not greater at either of the lower pH treatments relative to the control pH level of 8.10. These laboratory results demonstrate the capability of *P. multiseries* to rapidly increase its growth potential and become increasingly toxic in warmer waters, especially when limited by silicate, but neither cellular growth rate nor the DA production rate were significantly impacted by the decreased pH levels employed in our study. Based on these preliminary results it appears that the risk of toxic events in California coastal waters due to ocean acidification is less concerning than the impacts of increased seawater temperature from greenhouse warming.

BIO-P

(BIO-P Oral 15575)

Fiddlers on the tidal flat: fiddler crabs change their tunes depending on the contexts

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Males of the fiddler crab *Austruca lactea* is known to use drumming behavior in the burrow as a vibrational communication for courtship. However, we identified that male *A. lactea* also drum outside the burrow as a agonistic behavior. To determine if there are differences in the vibroacoustic characteristics depending on the context, we compared 5 indexes (the number of pulses in a train, pulse rate, train duration, pulse duration, and dominant frequency) between courtship and agonistic contexts. During courtship drumming, the train duration was longer and there were more pulses per train than during threat drumming ($P < 0.0001$). However, agonistic drumming had higher pulse rate ($P < 0.0001$), emitting more intensive signals than courtship drumming. Dominant frequency and pulse duration were not significantly different between the contexts ($P = 0.095$, 0.236). The result suggests that they could alter their vibrational signals depending on their purpose.

(BIO-P Oral 15598)

Don’t tread on my tidal flats: assessment of human trampling effects on the endangered fiddler crab for coastal management

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Under human visitation, the habitats of the endangered fiddler crab *Austruca lactea* have been exposed to trampling. To assess how the short-term behavioral responses of individual fiddler crabs to human trampling resulted in the relatively long-term changes of populations in cumulative trampling, we conducted two types of field experiments for three semilunar tidal cycles during the reproductive period. First, we compared the behaviors of a pair of crabs, one of whose burrow openings had undergone a single trampling event. Trampling delayed the initiation of surface activity, reduced travel distance, and altered their behavioral priorities from courting or feeding into vigilance and burrow repairment. Second, we exerted trampling constantly on subsets of the crab population for two trampling periods (28 and 14 days) and monitored whether restoration in their collective behaviors happened during additional 14 days. Under daily trampling events, the degree of total surface activities and male courtship indicators decreased, and those rhythms collapsed. After the cessation of trampling, only courtship indicators recovered at the longer trampled treatment. Overall, individuals’ surface behaviors negatively responded to a single trampling event, and it could result in adverse population activity changes under continuous trampling. Our study implies continuous coastal visitation without any regulation might aggravate the decrease in the population of *A. lactea*. Furthermore, we suggest that scientific research on indicator species’ behavioral ecology could help set up a practical management and conservation plan, which is essential for biodiversity and functions of the tidal flat ecosystem under direct human impacts.

(BIO-P Oral 15724)

Characterization of the organic matter of biodeposits derived from marine aquaculture bivalves: a meta-analysis approach

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Bivalve aquaculture is one of the world's most important food sources for humans. However, an increase in biodeposits along with the expansion of aquaculture has led to the deterioration of the seabed. To date, there has been no consensus on the organic content and elemental ratio regarding the quality of a biodeposit. Therefore, in this study, we compiled data on the elemental content and ratio of biodeposits for the first time. We determined (1) the relationship between the carbon (C) contents of biodeposits and food conditions, and (2) the representative value of the stoichiometric ratio of biodeposits with reference to Redfield ratio, (3) a comparison between the taxonomic groups, such as Venerida, Pectinida, Ostreida and Mytilida of carbon/nitrogen ratio (C/N). Nonlinear regression was performed for total particulate matter (TPM), chlorophyll a (Chl-a), and particulate organic carbon (POC) concentration, which are food concentration indicators. In addition, linear regression was performed to determine the C (%) of TPM, which is related to food quality. The C content of biodeposits was reduced to approximately 14% of the C (%) of TPM due to linear regression between C content of biodeposit and TPM. Biodeposit stoichiometry was estimated to be C:N:P = 141 (112–173): 13.2 (10.5–15.8): 1, which significantly differed from Redfield ratio. There was also a significant difference observed in the C/N between taxonomic groups, indicating that Pectinida is higher than Ostreida and Mytilida.

(BIO-P Oral 15632)

Multiple genetic sources for the golden tide *Sargassum* patches in northwestern Pacific: temporal variation in their genetic makeup

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Macroalgal blooms, or seaweed tides often have devastating effects on coastal ecosystems and local economy. Golden tide caused by genus *Sargassum*, brown macroalgae, usually occurs from winter to spring or summer. In northwestern Pacific, floating *Sargassum horneri* biomass in the East China Sea (ECS) and the Yellow Sea forms enormous patches and then inflows into the southern coasts of Korea under oceanic current. So far, the Zhoushan Islands in Eastern China were primarily assumed to be the golden tide's geographic origins based on our previous study, but there still needs to be verified. In the present study, using a combination of novel mitochondrial (mt) DNA and microsatellite markers we investigated the genetic makeup of the golden tide patches in northwestern Pacific, with reference to the 22 haplotypes database previously identified from the Chinese coast. The two genetic lineages existed in the ECS but individuals of a particular lineage dominated in the introduced populations to the Korean coast, although relative proportions of those fluctuated by the sampling periods. These results suggest that the floating populations may have originated from two different genetic sources and their genetic origins may change over time. The introduced populations in 2022 had mtDNA haplotypes that only found in northern China (e.g. Shandong province), suggesting that these regions are highly likely to be their another origin. This study provides genetic evidence for the multiple origins of golden tides inflowing into the Korean coast, which highlights the spatio-temporal dynamics of formation and development of the golden tides.

(BIO-P Oral 15618)

Mating systems and sexual patterns of red-belted anthias *Pseudanthias rubrizonatusis* in different-sized groups in Kagoshima, Japan

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Pseudanthias rubrizonatusis has been considered polygyny and monandric protogyny. In this study, we investigated mating systems and sexual patterns of this species in different-sized groups in Kagoshima Bay, Japan. The effect of group size on the mating system was studied using SCUBA, and the sexual pattern was studied using histological observations of the gonads. Spawning activities were observed from May to October. The number of individuals and sex ratio of each group were recorded. Results showed variation in mating systems based on group size. In the small groups with 50-100 individuals (sex ratio of female:male = 4:1), the mating system was harem polygyny. In the large group with 6,700-10,500 individuals, the dominant males (n ≈ 1,200) established territories near the female aggregation (7:1), and the mating system was male-territory-visiting polygamy. The subordinate males (n ≈ 800) established territories at the deeper site from the aggregation of the dominant male and females. When the females accidentally moved to the site, these males courted and spawned. All juveniles underwent bisexuality, with the ovarian lumen visible after the undifferentiated phase. In the small groups, the juveniles differentiated into females, then changed to secondary males. However, in the large group, an individual undergoing sexual differentiation into primary males was also observed. In addition, three small males, considered primary males, were collected. Therefore, in large groups, this species can be diandric protogyny. Thus, group size would affect the mating system and sexual pattern of this species.

(BIO-P Oral 15580)

Changes in pinniped prey consumption along the west coast of North America following protection from hunting and culling

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Most seal and sea lion populations have grown considerably in North America following their protection in the early 1970s. This in turn has increased concerns about fisheries competition— and has led to renewed calls to resume culling. However, relatively little is known about how much prey pinnipeds consume, and whether they have consumed significantly more prey over time. Using new models of energy requirements paired with local abundance and diet data from the 1970s and the 2010s, we calculated consumption requirements in five eco-regions between California and Alaska for 7 species of pinnipeds (California and Steller sea lions; Guadalupe and northern fur seals; harbour and northern elephant seals; and Pacific walrus). We found overall consumption in the North Pacific only increased by 25% since the 1970s for all regions combined due to rising pinniped numbers in the California Current ecosystem and Southeast Alaska. However, sharp declines occurred in pinniped numbers in the Gulf of Alaska and Bering Sea, which paralleled similar drops in the mean energy densities of their diets. Further south, diet quality also declined for northern elephant seals (which migrate to Alaska), but increased for most other species. All told, our findings suggest that the assumed exponential increase in pinniped consumption along the west coast of North America associated with population recovery from over-exploitation is an over-simplification. A more regional perspective is needed to support fisheries management and describe historical changes in marine mammal consumption.

(BIO-P Oral 15619)

Nitrogen isotope baseline isoscape using amino acid nitrogen isotope of copepod *Calanus*

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Understanding the nitrogen isotope baseline in the marine environment is important to describe a geographical variation of nitrogen sources. However, it is difficult to estimate the nitrogen isotope baseline because the inorganic nitrogen is depleted easily in the pelagic surface mixed layer via the biogeochemical nitrogen cycle in marine environment. This talk introduces how the nitrogen baseline ($\delta^{15}N_{Baseline}$) can be estimated using the nitrogen isotope ratio ($\delta^{15}N$) of amino acids and bulk tissue of the zooplankton. The copepod *Calanus* is a representative filter-feeder and would be a proper zooplankton for tracking nitrogen sources based on its widespread distribution. We used *Calanus* spp. collected from a wide range of latitudes showing different concentrations of inorganic nitrogen.

In the tropical Western Pacific, including oligotrophic Kuroshio Current, the $\delta^{15}N_{Baseline}$ values were less than 0‰, due to the dominant nitrogen fixation. In contrast, the Kuroshio Extension area displayed an increase of the $\delta^{15}N_{Baseline}$ values up to 3.8‰, likely due to the assimilation of nitrate derived from eutrophic Oyashio Current. Moreover, the $\delta^{15}N_{Baseline}$ values were gradually enriched (up to ~7.1‰) in the Bering Sea as a function of nitrate concentration through the nutrient assimilation of phytoplankton during a northward flow of the eutrophic surface seawater. The Arctic Ocean showed an unclear correlation between the nitrate inventory and the $\delta^{15}N_{Baseline}$ values due to the various factors in supplying inorganic nitrogen. The $\delta^{15}N_{Baseline}$ isoscape of copepod *Calanus* successfully reflects the geographical variation of bioavailable dissolved nitrogen source, especially in the nutrient-poor locations.

(BIO-P Oral 15753)

Prey consumption by marine mammal in the North Pacific Ocean

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Significant changes have occurred in the numbers of marine mammals inhabiting the North Pacific Ocean since PICES last assessed prey consumption during the 1990s (Hunt et al 2000). However, the extent to which consumption has changed is unknown. We used population censuses, estimates of mean body sizes, and data on dietary composition and energy density to determine the amounts of prey consumed by 52 species of marine mammals since 2010. Data were compiled for 14 geographic regions that span the North Pacific Ocean; and daily consumption was calculated by season (summer and winter) using new simple scalar models that predict consumed biomass and energy requirements as a function of body size and cost of living for each species of marine mammal. Our findings reveal significant regional changes in consumption since the 1990s that can be used to gauge the impacts of marine mammals on fisheries and ecosystems, as well as assess the nutritional and conservation needs of marine mammals.

(BIO-P Oral 15686)

Potential shift in mesozooplankton community structure in response to climate-driven changes during summer in the Ulleung basin

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The sea surface temperature exhibited increasing trend over the last decade during the summertime in the Ulleung basin. The community of mesozooplankton may be used as indicator of climate change due to their rapid response to changing environment. This study aims to characterize mesozooplankton community composition in relation to the climate-driven physical features in the Ulleung basin of the East Sea/Japan Sea during the summer of 2009-2020. The SST ranged 19.3-28.0°C (mean: 25.1°C) and risen by 0.7°C in 2020 compared to 2009. SST anomalies had two negative (2009–2011 and 2014) and two positive (2012–2013 and 2015-2020) phases. The surface chlorophyll-*a* (chl-*a*) concentrations showed slightly increasing trend and highly positive anomaly in 2020. The average abundance of mesozooplankton ranged 2,906–40,558 inds.m^{-3} (mean: 10,129 inds.m^{-3}) and showed slightly increasing long-term trend (r^2=0.31, p<0.1). The cluster analysis was carried out to identify the mesozooplankton community that contributed to the changes in long-term community structure. The community that contributed to the increasing trend were distinctive, in which *Noctiluca scintillans* contributed to the increasing trend in 2009, 2012–2015 and 2017, and immature copepods contributed to higher abundance during 2010–2011 and 2018, and abundance of *Pyrocystis noctiluca* contributed to rapid increase of mesozooplankton abundance in 2020. Our results suggest that gradually increasing abundance of *N. scintillans* and *P. noctiluca* are probably related to the increasing trends of SST and chl-*a* concentrations, and that there may be shifts in the community structure in the future.

(BIO-P Oral 15761)

Diversity and Biogeography of Dinoflagellates in the Kuroshio Region

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Various studies in dinoflagellates have been conducted over the world, especially in coastal regions due to the environmental, economical and human health impacts of the harmful dinoflagellate blooms. In the oceanic region, dinoflagellates are also widely distributed and play a key role in food-web dynamics. However, biogeography of oceanic dinoflagellates and their roles in food-web dynamics are not well understood because of the high diversity, small size (<20 mm), and the complex physiology including nutritional strategy. We examined biogeography of dinoflagellates by means of 18S rRNA metabarcoding in the Kuroshio region from the East China Sea to off Honshu, Japan, including a separated cold-core ring from large meander of the Kuroshio. A total of 2207 dinoflagellate ASVs (excluding symbiotic and parasitic members) were obtained. Shannon and Simpsons indices illustrated a high genetic diversity across stations, both decreasing in depth. At stations impacted by coastal water and in the cold-core, the diversity was low compared to the one in the Kuroshio water. The species distribution was explained by their nutritional strategies: the distribution of phototrophic dinoflagellates positively correlated to water temperature and negatively to the sampling depth, and heterotrophic species were associated with greater prey abundance indicated by high Chl a concentration. It is worth to note that some HAB species distribute widely in the Kuroshio region, indicating the transportation by the Kuroshio.

(BIO-P Oral 15735)

Role of sea ice retreat in formation of spring phytoplankton bloom in the Bering Sea

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Most part of the annual primary production in the Arctic and Subarctic oceanic environments is formed during the spring phytoplankton bloom. The Oscillating control hypothesis (OCH), proposed for the south-eastern Bering Sea shelf, states that earlier than usual (April) spring phytoplankton bloom occurs in years with later ice retreat; those conditions are more favorable, than later bloom, for the overwintering copepods which are important food source for the immature walleye pollock. According to OCH, lack of sea ice in winter or earlier ice retreat lead to later bloom (May-June) due to episodic wind mixing which disturbs formation of seasonal pycnocline. This study aims to verify the connection between timing of sea ice retreat and the spring bloom for the wider part of the Bering Sea shelf based on satellite information. Several main regions are examined, including north-western, northern and south-eastern parts of the shelf. The results allow to conclude that early phytoplankton bloom (April-May) may occur along the south-eastern Bering Sea shelf even in years with relatively early sea ice retreat (e.g. February-March) or lack of ice during winter. Such conditions were in 2001–2003, 2005, and 2014. On the other hand, in the north-western Bering Sea, relatively early blooms occurred only in years with late ice retreat. In the northern region the spring bloom followed the ice retreat, except for 2018 when ice was absent in the examined area. Those findings help to forecast better timing of the spring phytoplankton bloom in the north-western and northern Bering Sea.

FIS-P

(FIS-P Oral 15578)

Climate-driven changes in size-dependent overwintering success in age-0 Pacific cod (*Gadus macrocephalus*)

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Ocean warming is reshaping the demographics of juvenile fish in ways that will likely alter their survival and recruitment to the adult population. This is particularly important in cold-ocean seasonal environments where fish must accumulate sufficient size and energy in fall to survive winters of low productivity. In this study, we tracked the growth, condition and survival of age-0 Pacific cod held in the laboratory under varying fall and winter food-temperature scenarios. During the fall experimental phase, individually tagged and measured fish were held for 6 weeks across a series of replicate tanks maintained at two temperatures (7.0 or 10.0°C) and two food rations (~1% or 3% body weight d^{-1}). Fish were measured and subsampled for lipids after which remaining fish were redistributed into a series of new tanks to track survival and lipid loss in the absence of food across four winter temperatures (1.0, 2.5, 4.0, 6.0°C). As expected, both cooler winters and larger body size provided a winter survival advantage for juvenile cod. However, winter mortality was also elevated in fish that experienced slow growth during the fall. Both fish growth and lipid density varied within the fall phase of the experiment but was significantly lower overall under warm, low food conditions. Collectively, these results highlight how teleconnections of warm falls and winters can magnify overwintering mortality for age-0 juvenile cod and potentially lead to new population bottlenecks in regions experiencing high rates of warming.

(FIS-P Oral 15601)

Age, growth and reproductive biology of areolate grouper *Epinephelus areolatus*, southern Japan

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The demographic analysis of areolate grouper *Epinephelus areolatus*, one of the most important groupers in commercial and ecological perspectives in Kagoshima Bay, southern Japan, was conducted in this study. Specimens were obtained from October 2018 to July 2021 through mainly hook-and-line, supplementally market purchase and scuba diving. For aging analysis, sagittal otoliths were removed and processed into transverse sections (n = 141). Gonads were removed, measured for wet weight, and processed into sectioned for histological analysis (n = 250). Monthly frequency of opaque edges of transverse sections of otolith was calculated. Each gonad was assigned to one of 12 categories and determined sex histologically. Edge analysis indicated a clear pattern of annulus formation of the opaque zones on the transverse section of otolith. A von Bertalanffy growth function was fitted to total length (TL) at the assumed age to estimate each growth parameter. The asymptotic TL, the growth coefficient, and the theoretical age at TL = 0 were estimated to be 464 mm, 0.300, and -0.750, respectively. The maximum age was 19 years. The TL and age frequencies differed between sexes, with males were being larger and older than females or transitional individuals. The spawning season was estimated to be between July and October. The histological observation for gonadal development intensely indicated the possibility that all individuals have bisexual gonads before sexual differentiation to females. The present results suggested that primary male would possibly exist in the population and *E. areolatus* would be a diandric protogynous hermaphrodite.

(FIS-P Oral 15648)

Thermal effects on early life stages of Gulf of Alaska Pacific Cod: shifts in reproductive phenology, size, and growth

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A dramatic reduction in the abundance of adult Pacific Cod in the Gulf of Alaska occurred after marine heatwaves (MHWs) in 2014-2016 and 2019. To better understand the effects of MHWs on Pacific Cod, we estimated hatch dates and reconstructed size and growth for pelagic larvae collected in May and nearshore juveniles collected in July and August. Mean hatch dates for larvae (11 Apr–19 May) were later than for juveniles in July (07 Mar–17 Apr) and August (22 Feb–06 May). However, the shift to earlier hatch dates during MHWs (2015–2019) compared to cooler years (2006–2014) was similar across life stages: 18–22 days earlier for larvae and juveniles. We determined that differences in water temperature during incubation could account for ~15% of the shift in hatch dates for larvae and 33% for juveniles. Therefore, other factors, such as changes in spawn timing or selective mortality, also contributed to these observed shifts. The effect of MHWs on size and growth varied with age but, overall, the effect of MHWs on size-at-age reversed across life stages. For larvae, size-at-age was 10% greater before MHWs whereas, for juveniles, size-at-age was greater during and after MHWs. In July, mean size-at-age was 6% greater during MHWs and that difference increased to 25% by August. This reversal in the effect of MHWs between larvae and juveniles likely reflects selection on hatch date and early growth. Understanding how early stages respond to warming will be integral for predicting population-level responses to climate variation.

(FIS-P Oral 15756)

WANTED: Searching for Longfin Smelt in the Nooksack River and Bellingham Bay

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Longfin Smelt (*Spirinchus thaleichthys;* LFS) is a small forage fish that are present from San Francisco Bay, California, USA to Prince William Sound, Alaska. The well-studied population from San Francisco Bay area are considered threatened under the California Endangered Species Act due to population decline, which is a concern to the people who rely on this fish for subsistence and cultural needs. Lummi people and Pacific Northwest elders similarly describe a decline of LFS on the Nooksack River near Bellingham, WA where there is a relatively large annual spawning run of this anadromous fish. However, the life cycle of LFS is poorly characterized. This study uses a novel high-sensitivity species-specific TaqMan quantitative PCR (qPCR) assay to detect environmental DNA (eDNA) of LFS in marine and freshwater. eDNA is released by organisms in their environment, which can be used for the detection of species by collecting less-invasive water samples. This study investigates the spawning habitat and lifecycle of LFS in Bellingham Bay, WA, USA. Using this assay, we analyzed four years of data and to detect LFS at six successive sites 0-6 miles upriver from Bellingham Bay in the Nooksack River. Additionally, a preliminary survey of Bellingham Bay detects LFS for many months following spawning. This fishery is co-managed by tribal (Lummi Natural Resources) and State (Washington Department of Fish and Wildlife) entities and additional information regarding LFS spawning, rearing, and migration dynamics could inform management practices of this culturally important population.

(FIS-P Oral 15728)

Gastric evacuation rate and maintenance ration of pointhead flounder: Why do they feed at pelagic?

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Pointhead flounder (PF; *Cleisthenes pinetorum*) is a flatfish that has been increasing in both catch and abundance around Hokkaido, Japan since the 2010s. Exceptionally among the flatfishes, PF is an active swimmer feeding in the pelagic layer. In particular, their predation on juvenile walleye pollock (*Gadus chalcogrammus*) has attracted a lot of attention. To clarify the feeding ecology of PF, we measured the gastric evacuation rate and maintenance ration at 4 ºC, 9 ºC, and 14 ºC. The Q_{10} values of gastric evacuation rate and maintenance ration were 6.55 and 1.95, respectively, indicating that the effect of temperature was far greater on gastric evacuation rate. Thus, the difference between gastric evacuation rate and maintenance ration was 30.7 cal g^{-1} day^{-1} at 14 ºC, whereas at 4 ºC it was only 2.8 cal g^{-1} day^{-1}. The water temperature remains up to 4 ºC in Funka Bay, Hokkaido, Japan, where PF were sampled, during the winter through early summer. Therefore, their gastric evacuation rate will be a bottleneck and the feeding rate will be dramatically reduced, and their growth rate would be considerably limited if they stayed in the bottom layer. The unique feeding behavior of this species, feeding at pelagic, may be a compensation for such physiological characteristics.

(FIS-P Oral 15646)

Emergence of thiamine deficiency in salmon in the California Current

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Since first observed in Baltic Sea salmon in the 1970s, thiamine deficiency complex (TDC) has been reported in diverse aquatic ecosystems around the world. Animals require thiamine in their diet, and deficiencies result in potentially lethal neurological problems. In salmon, acute TDC causes behavioral abnormalities and mortality in fry shortly after hatching. Such mortality was first observed in California salmon hatcheries in 2020. We subsequently initiated a research program to understand the causes and consequences of, and possible mitigate strategies for, TDC in California salmon. Data collected to date suggest that TDC is caused by salmon diets rich in Northern Anchovy; anchovy produce an enzyme that destroys thiamine in predators that consume them. Anchovy are at historically high abundance levels in the central California Current where the affected salmon populations forage. The degree to which different salmon populations suffer TDC varies by species, run timing, and river of origin. The reasons for this are not entirely clear, but may be partly related to differences in diet shortly before return to freshwater. In the most severely-afflicted populations, a large majority of maturing salmon have such low thiamine levels that high fry mortality is expected (>50% mortality). We found a variety of treatments to be effective in alleviating TDC in hatchery and certain field settings, but there is no way to treat most naturally-spawning populations. TDC is ongoing and expanding northward with the anchovy boom, and is a new threat to already-beleaguered salmon populations in the California Current.

(FIS-P Oral 15720)

Association between Far East pink salmon catches and variations of heat content in the upper 100 m of the North Pacific during the wintering seasons, 1978-2021

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Thermal conditions in the ocean are of crucial importance for survival of pink salmon during wintering and their subsequent catches. We analyzed the correlations between catch time series of 5 main Far East pink salmon stocks and heat content in the 0-100 m layer of the North Pacific north of 40ºN for winter months in odd and even years for 1978-2021. Heat content was calculated, using EN4 dataset v. 4.2.1 from Met Office Hadley Centre, and catch statistics for pink salmon stocks is available from NPAFC. It can be supposed that areas with the maximal (by absolute values) correlation coefficients coincide with wintering areas or are located closely to them. In this case, for odd-year generations of East Kamchatka (EK) and even-year generations of West Kamchatka (WK) pink salmon the wintering areas are located within the western subarctic gyre (WSG); for odd generations of WK pink salmon, in the eastern part of the gyre, and for even-year generations of EK pink salmon, mainly in the southern Bering Sea. East Sakhalin pink salmon born in even and odd years winter mainly in the southern Sea of Okhotsk and southern WSG, respectively; for even- and odd-year generations of South Kuril pink salmon wintering areas lie correspondingly to the east of the Central Kurils and east of the South Kuril Islands. The analysis of interannual and decadal variations of heat content in the defined wintering areas allowed us to explain sharp changes in Far East pink salmon stocks and their catches during the last 40 years.

(FIS-P Oral 15600)

Application of multiple satellite datasets to sustainable use of salmon resource under changing climate

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Chum salmon is one of the important fishery resources in the North Pacific. Recently, under a changing climate, the return of chum salmon in Hokkaido tend to decrease. In particular, more precise juvenile release operation is required to adapt for warming sea temperature during its sea entry. It is necessary for this precise operation to predict coastal marine environment during the release period and monitor short-term changes in coastal residency. Here, we developed a supporting information system for the optimization of salmon release operations in the Okhotsk coast. This system was designed as a web-based visualization consisting of two site-based services, for monitoring marine environment (marine site) and supporting salmon release operation (release site). The coastal residence period for chum salmon is a critical phase in the early stage of its life history. However, recent rise in water temperature and marine heat wave in the Bering Sea and the Gulf of Alaska posed serious concerns on the survival of migrating salmon during its second and third year. Thus, becoming increasingly important for the sustainable harvest of salmon under a rapidly changing climate. We utilized multiple satellite datasets and re-analysis data from numerical forecast model to monitor the feeding and wintering environments of chum salmon at sea. This project is supported from 2022-2024 by the Japan Aerospace Exploration Agency (JAXA) / Earth Observation Research Center (EORC) under its third Research Announcement on the Earth Observations (EORA3) for promoting research, utilization, and social implementation of data from JAXA Earth observation satellites.

(FIS-P Oral 15565)

Exploration of the variation in the northwest Pacific fishing ground using improved ocean color Chlorophyll-a data

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Chlorophyll-a (Chl-a) is an important marine indicator, and the improvement in Chl-a concentration retrieval for ocean color remote sensing is always a major challenge. This study focuses on the northwest Pacific fishing ground (NPFG) to evaluate and improve the Chl-a products of three mainstream remote sensing satellites, Himawari-8, MODIS-Aqua and VIIRS-SNPP. We analyzed in situ data and found that an in situ Chl-a concentration of 0.3 mg m^{-3} could be used as a threshold to distinguish the systematic deviation of remote sensing Chl-a data in NPFG. Based on this threshold, we optimized the Chl-a algorithms of the three satellites by data grouping, and integrated multisource satellite Chl-a data by weighted averaging to acquire high-coverage merged data. The merged data were thoroughly verified by Argo Chl-a data. The Chl-a front of merged Chl-a data could be represented accurately and completely and had a good correlation with the distribution of NPFG. The most important marine factors for Chl-a are nutrients and temperature, which are affected by mesoscale eddies and variations in the Kuroshio extension. The variation trend of merged Chl-a data is consistent with mesoscale eddies and Kuroshio extension and has more sensitive responses to the marine climatic conditions of ENSO.

(FIS-P Oral 15783)

Pacific water propagation in the Sea of Okhotsk and walleye pollock fishery

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The water of Pacific origin enters the Sea of Okhotsk mostly through the northern straits of the Kuril Islands archipelago and spreads along the western coast of Kamchatka peninsula as the West Kamchatka current. This current is stronger in winter than in summer. This water is generally warmer in winter and spring comparing to the surrounding Okhotsk sea water. It is also richer in nutrients due to the enhanced vertical tidal mixing within the straits and thus highly productive. The same area along the western Kamchatka supports commercially important fisheries which are mostly based on the large stock of walleye pollock, and the major part of pollock catches there occurs in January-March during the early part of pollock spawning period. This study investigates the coincidence of pollock fishery to the Pacific water propagation. The water parcels were tracked in the area west of Kamchatka with Lagrangian approach based on satellite altimetry data. The tracking of virtual particles was carried out for every day from 1998 to 2021. The areas of pollock fishery are determined using combination of two regional fishery data bases. The coincidence of trawling activity to the origin of water is investigated with generalized additive model. The results show pollock fishery to occur significantly more often in the water of Pacific origin with short ‘life’ history within the Sea of Okhotsk (less than 3 months) entering the sea north of 48°N comparing to other water parcels including Pacific water with longer history or of more southern origin.

(FIS-P Oral 15653)

A comparison study for behavior of Japanese and Chinese neon flying squid vessel in the North Pacific using Automatic Identification System

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The neon flying squid (*ommastrephes bartramii*) is one of important fishery resources, which distributes widely over subtropical and subarctic North Pacific. As the major tools for identifying its fishing ground, logbook recording daily catch and night light image from satellite observation have been used. Recently, Automatic Identification System (AIS), autonomous tracking system for tracking location of the vessels around the globe, has attracted growing attention to fishery research community as a new tool for studying fishing ground. With this data, we can seamlessly track location of the vessels from any country under any weather condition for both day and nighttime. In this study, we aim to identify fishing ground of neon flying squid from behavior of fishing vessels with focusing on Japan and China, as the two major countries for the catch of neon flying squid. We obtained AIS data for both Japanese and Chinese vessels in May – August for 2015 – 2019. Fishing grounds were defined as the region where vessel speed is less than 2 knots. Our analysis showed that both the Japanese and Chinese fishing vessels were in operation at the fishing grounds at 40°E east of 180°E in May and June. Afterward, both the Japanese and Chinese fishing vessels moved to 42°N or farther north, although the latter or which moved to another fishing grounds west of 160°E. AIS data were shown as an effective tool for understanding fishing grounds of neon flying squid.

HD-MEQ-P

(HD-MEQ-P Oral 15723)

Economic valuation of fisheries monitoring programs: A case of the international fisheries observer program of Korea

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Illegal, Unreported, Unregulated fishing (IUU) is illegal fishing that harms the sustainability of fisheries and the marine environment. The international society is trying to prevent IUU by monitoring international fisheries activities. Many fishery monitoring methods are being utilized, and one of the traditional methods is the international fisheries observer program. In the case of Korea, it has a history of being designated as the IUU fishing country in 2013. Since the country has been trying to eradicate IUU, the Korean government actively promoted the installation of Vessel Monitoring Systems (VMS), the operation of the Fisheries Monitoring Center (FMC), and supporting the operation of the international fisheries observer program. These efforts aim to secure the sustainability of international fisheries by strengthening the international fisheries monitoring system. The present study estimated the economic value of the fisheries monitoring program using Korea's international fisheries observer program as an example. A Contingent Valuation Model (CVM) was utilized, including socio-economic and proxy variables measuring survey participants' seafood purchasing behavior. In 2022, we conducted an online survey with 16,924 participants, acquiring 1,000 usable responses; The final response rate was 5.9%. According to the survey results, 74.2% of the households were willing to pay to support the international fisheries observer program. The average willingness to pay (WTP) was estimated at USD 9.83 per household; the aggregated WTP in 2022 was calculated at USD 204,361,154; a five-year net present value of the aggregate value of the program was estimated at USD 953,508,868.

(HD-MEQ-P Oral 15658)

Comparative and historical study of international guideline and policy documents of Japan relevant to gender equality in fisheries

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The importance of the promotion of gender equality is being recognized for achieving sustainable and equitable fisheries. In the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (the SSF Guideline, FAO 2015), gender equality and equity are stated as one of the 13 guiding principles. Also in Japan, Fisheries Basic Act and Basic Plan for Fisheries emphasize the importance of promotion of women's participation in fisheries. This study aims to provide insights to promote gender equality in Japanese fisheries policies. Firstly, we compared the gender aspects of the SSF Guideline and Fisheries Basic Plan for Fisheries of Japan. Secondly, we observed a historical change of the gender aspects of the Basic Plan of Japan. As a result, the Basic Plan focus more on women's empowerment in decision-making and economic activities such as processing and marketing, whereas SSF Guideline adopted a wide range of approach for gender mainstreaming such as collection of gender-disaggregated data in official statistics and development of gender-sensitive intervention or indicators. Besides, while the first Basic Plan in 2002 stated that women's role should be assessed fairly "with clarifying the gendered division of labor", the latest Basic Plan in 2022 states the needs of capacity building in fisheries "regardless of their gender". In order to promote this new policy toward liberation from stereotypical gender roles and promote gender equality in fisheries, a critical shift from the narrowed concept focusing on women and adaptation of wider range of approach of gender mainstreaming will be needed in Japanese fisheries policies.

(HD-MEQ-P Oral 15568)

Importance of terrestrial input on marine microplastics as traces recorded in sediments from rivers through estuaries to open seas

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Growing scientific evidence on wide-ranging impacts on all aspects of life on Earth leads to calls for immediate attention and legally binding measures to end plastic pollution in near future. Global assessments indicate that only <1% of the known marine plastic budget accumulates in the ocean surface and the remainder is likely in the deep sea. Sediments are generally considered to be temporary (freshwater system) or permanent (marine system) sinks for microplastics, BUT most studies have so far focused on the transport via water-flow and the accumulation in water columns. This talk will address how microplastics in the sediments change from the terrestrial rivers through estuaries to the open oceans. To this end, we collected surface top 2-cm sediments (n=20 for river sediments; n=35 for marine sediments) from the estuaries of five major rivers of Korean peninsula in the dry (January or February) and wet (July or August) seasons. We also collected additional surface sediments from the off-sea linked with the Han River estuary (n=10) and from the marginal seas of the Northwest Pacific (the South Sea/the East China Sea; n=9). Not only the abundance of microplastics (N per kilogram of sediment) but also the diversity of polymers decreased with the distance from inland, indicating the importance of terrestrial input to the marine microplastics.

(HD-MEQ-P Oral 15567)

Ciguatera Research Strategic Planning to build local warning networks for the detection and human dimension of ciguatera fish poisoning in Indonesia

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It is well known that Ciguatera Fish Poisoning (CFP) has become a global problem in several parts of the world, both in the tropics and sub-tropics. Indonesia, as the largest archipelagic country in the world with an area of 39,583 km^2 consisting of coral reefs (about 45.7% of the total 86,503 km^2 of reefs in the Coral Triangle area), and a biodiversity reaching 590 species of rock coral and reef fish, should be prepared for this problem. Coral reefs, if not properly maintained, could be the location for the development of microbenthic algae that can cause CFP. The federal government has identified that more than 30% of the total area of coral reefs in Indonesia, or 18,000 km^2, has been seriously damaged. Apart from being caused by over-exploitation of natural resources, this condition has also been exacerbated by the impact of climate change. It is time for Indonesia to make efforts to prevent further damage to coral reef ecosystems, so that the potential danger of developing CFP in Indonesia can be identified and controlled as early as possible. If not, then CFP will be a threat that can disrupt not only the health of the marine environment and aquatic organisms that are part of the food chain of CFP transmission, but will also endanger the health of humans who consume fish obtained from coral reef ecosystems. To mitigate the threat of CFP in Indonesian coastal waters, the strategy is to conduct integrated research and monitoring, as well as capacity building of Indonesian local communities on Ciguatera in the Gili Matra Tourism Area, Lombok, West Nusa Tenggara (NTB) through collaboration between PICES (North Pacific Marine Science Organization) and various Indonesian research institutions and universities (*e.g.*, ITI - Institut Teknologi Indonesia, BRIN - National Research and Innovation Agency, UI - University of Indonesia, and UNRAM - University Mataram), also supported by the Provincial Government of West Nusa Tenggara (NTB). The base for this collaboration is the PICES project on “Building Local Warning Networks for the Detection and Human Dimension of Ciguatera Fish

Poisoning in Indonesian Communities" funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan. These activities are in line with the 2030 Sustainable Development Goals of the UN: Establish Good Health and Well-Being (No. 3), Climate Change (No. 13), and Improvements to Underwater Life (No. 14).

(HD-MEQ-P Oral 15569)

Potential threats of harmful algal blooms and ciguatera fish poisoning in the marine tourism park of Gili Matra islands, Indonesia

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Anthropogenic activities have been causing environmental quality degradation and damage to the seagrass beds, and coral reefs ecosystem of the Gili Matra, West Nusa Tenggara. Such conditions could trigger the occurrence of toxic harmful algal blooms (HABs), which cause diseases such as ciguatera fish poisoning (CFP). Although CFP cases have not been reported in Indonesia, toxic benthic dinoflagellate species have been reported and studied in several areas in the country, including in Gili Matra and Lombok. Therefore, we aimed to identify and assess the potential threat of toxic benthic HABs, which could also cause CFP. Several potentially harmful benthic dinoflagellates, such as *Ostreopsis ovata, Ostreopsis lenticularis*, *Prorocentrum lima, Prorocentrum emarginatum,* and *Prorocentrum concavum,* were identified from macroalgal and seagrass beds of the three Gili Matra islands (Gili Trawangan, Gili Meno, and Gili Air), with density up to 500 cells.m^{-2}. Planktonic cells of potential HABs species, such as *Tripos fusus*, *Tripos furca*, *Pseudo-nitzschia* spp., *Dinophysis caudata*, *Chattonela* spp., *Alexandrium* spp., and *Trichodesmium erythraeum*, were also found in the water surrounding the Gili Matra islands. Aside from *T. erythraeum* and *Pseudo-nitzschia* spp., the other potentially harmful species were found in very low density (<10 cells.l^{-1}). So far, the potential threat of benthic HABs and CFP in Gili Matra are low. Even so, a potential economic loss of between 1.5 billion to over 4 billion rupiahs (approx. 100,000 to 300,000 USD) could occur if there were HAB or CFP cases that resulted in the closure of fishing and ecotourism activities on the island.

POC-P

(POC-P Oral 15768)

Characteristics and mechanisms of marine heatwaves in the East Asian Marginal Seas: regional and seasonal differences

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Marine heatwaves (MHWs) are spatially extended and temporally prolonged warm water temperature that poses a serious threat to marine ecosystems. Previous studies on MHWs in the East Asian Marginal Seas (EAMS) (East, Yellow, and East China Seas) have hardly considered a seasonal variation. However, the ocean dynamics and atmospheric forcing have strong seasonality, their seasonal variation may affect MHW occurrence. In this study, we examined the characteristics and mechanisms of MHWs in the EAMS, with a focus on seasonal changes and regional differences using Optimum Interpolation Sea Surface Temperature data for 37 years (1982–2018). MHWs during the summer tend to be more intense and more frequent than in other seasons. For regional differences, long-term mean MHWs appear to be longer (27.5 days/year) and stronger (2.1 °C) in the East Sea than in the Yellow and East China Seas. Summer MHWs over the EAMS are driven mainly by increased surface shortwave radiation associated with the reduction of the total cloud cover and latent cooling resulting from the weakened wind speed over the western flank of developing subtropical highs. Winter MHWs in the East Sea can be explained primarily by ocean dynamics related to the northward shift of the subpolar front, providing conditions for intensified warm water in the region. Our findings suggest that the MHW mechanisms vary across seasons and regions, which leads to regional and seasonal differences in the MHW characteristics.

(POC-P Oral 15770)

Why are the marine heatwaves long-lasting in the East Korea Bay in the East Sea?

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Marine heatwave (MHW) – prolonged extremely high ocean temperature – become more intense, more frequent, and longer in the recent decades. The East Korea Bay (EKB), located in the mid-western East Sea, are known as the largest spawning ground for walleye pollock in the East Sea and undergoes various dynamic changes including cyclonic and anticyclonic eddies, the East Korea Warm Current, and the subpolar front. The EKB has the longest MHWs in the East Sea. In this study, we examine the possible physical processes that contribute to the longest MHWs in the EKB using the OISST from the NOAA for 37 years (1982-2018). The duration (16.8±24.0 days/event) of MHWs in the EKB is approximately 32% longer and the intensity is 17% stronger than in the East Sea. The long-lasting MHWs in the EKB are mainly associated horizontal advection of eddy. Especially, the longest MHWs in the EKB coincide with the strongest eddies. In addition, the MHWs in the EKB remain the longest in the East Sea after removing the global warming trend, implying EKB MHWs can be explained largely by SST variability. Our study suggests that the prolonged MHWs in the EKB associated with ocean dynamics can impacts on marine ecosystem in the EKB which requires further analysis.

(POC-P Oral 15599)

Tracking the pumice rafts from the recent eruption of the submarine volcano Fukutoku-Okanoba, Japan: a perspective from Satellites and Lagrangian Particles tracking

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On 13 August 2021, the Fukutoku-Okanoba submarine volcano in the North Pacific Ocean erupted, and satellites detected many pumice rafts that drifted westward to reach southern Japan in two months. To cope with potential danger due to the pumice rafts, it is crucial to predict their trajectories. Using a Lagrangian particle tracking model incorporating ocean currents and winds that are the major factors governing the movement of floating objects, the trajectories of the rafts were investigated. The model results showed strong sensitivity to the windage coefficient of pumice rafts, which is uncertain and could cause large errors. By comparing the model results with satellite data using a skill score, the distance between a simulated particle and the closest observed raft divided by the travel distance of the particle, an optimal windage coefficient ranging between 2 to 3 % was estimated. Different ocean models needed slightly different (less than 0.5 %) optimal windage coefficients but produced similar main pathways. The pumice rafts likely moved from Fukutoku-Okanoba, toward the Ryukyu Islands for approximately three months before being pushed toward Taiwan by the intensified wind. The techniques presented here may become helpful in managing coastal hazards due to diverse marine debris.

(POC-P Oral 15702)

Fate of river-derived microplastics from the South China Sea

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A numerical Lagrangian particle tracking experiments were conducted to evaluate the regional oceanic transport and dispersal of MPs in the South China Sea (SCS) derived from three major rivers, Pearl (China), Mekong (Vietnam), and Pasig (the Philippines), which are known to discharge large amounts of plastic waste into the SCS. As previous field surveys have suggested that MP spreads from the surface down to the deeper ocean, we considered several different particle densities, viz., positively and neutrally buoyant MPs. Transport patterns of these MPs from the three rivers clearly showed the intra-annual variability associated with seasonally varying circulations driven by the Asian monsoons in the SCS. Many MPs floating during the prevailing southwest monsoon are transported to the northwest Pacific Ocean and the East China Sea through the Luzon Strait and the Taiwan Strait to form MP hotspots. Non-buoyant MPs are broadly transported from the surface layer to depths of approximately 100 m or deeper, where in situ observations are rare. In addition, the buoyant MPs drifting on the continental shelf originating from southern China tend to be pushed toward the shore and beached by northward wind-induced currents more pronouncedly than the non-buoyant MPs. Therefore, the river-derived MPs to the SCS were found to serve as sources to adjacent basins and oceans, to be distributed not only in the upper layer but also in the abyssal ocean (non-buoyant MPs), and to be transported to the shores (buoyant MPs).

(POC-P Oral 15557)

Interannual variability of barotropic sea level difference across the Korea/Tsushima Strait and its relationship to upper-ocean currents variability in the western North Pacific

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Barotropic sea level difference (SLD) across the Korea/Tsushima Strait (KTS) is considered as an index of the volume transport through the KTS, which is an inflow into the East/Japan Sea. The interannual variability of the barotropic SLD across the KTS and its relationship to upper-ocean (< 300 m) currents variability in the western North Pacific was investigated for 1985–2017. An increase of the barotropic SLD (the inflow through the KTS) is associated with a positive sea surface height (SSH) anomaly along the coastline of Kyushu, an on-shore Ekman transport in the northern East China Sea (ECS), and a weakening of the Kuroshio through the Tokara Strait. In the wider domain of the western North Pacific, the increase of the KTS inflow is related to a weakening of the Kuroshio in the ECS and a southward shift of the North Equatorial Current (NEC) bifurcation latitude. Overall upper-ocean cooling in the North Pacific Subtropical Gyre during an increase of the KTS inflow presents a La Niña-like ocean environmental condition. Further analysis suggests that the interannual variability of the KTS inflow is linked with both the El Niño-Southern Oscillation (ENSO)-related and the ENSO-irrelevant modes of the upper-ocean current variability in the western North Pacific. While the ENSO-related mode alters the strength of the Kuroshio, the ENSO-irrelevant mode corresponds to the shift of the Kuroshio axis. The ENSO-irrelevant mode is suggested to be modulated by interannual variability of the eddy kinetic energy, which is induced by baroclinic instability between the NEC and the Subtropical Countercurrent.

(POC-P Oral 15553)

Stronger decadal variability of the Kuroshio Extension under simulated future climate change

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Understanding the behavior of western boundary current systems is crucial for predictions of biogeochemical cycles, fisheries, and basin-scale climate modes over the midlatitude oceans. Studies indicate that anthropogenic climate change induces structural changes in the Kuroshio Extension (KE) system, including a northward migration of its oceanic jet. However, changes in the KE temporal variability remain unclear. Using large ensembles of a global coupled climate model, we show that in response to increasing greenhouse gases, the time scale of KE sea surface height (SSH) shifts from interannual scales toward decadal and longer scales. We attribute this increased low-frequency KE variability to enhanced midlatitude oceanic Rossby wave activity induced by regional and remote atmospheric forcing, due to a poleward shift of midlatitude surface westerly with climatology and an increase in the tropical precipitation activity, which lead to stronger atmospheric teleconnections from El Niño to the midlatitude Pacific and the KE region. Greenhouse warming leads to both a positive (elongated) KE state that restricts ocean perturbations (e.g., eddy activity) and stronger wind-driven KE fluctuations, which enhances the contributions of decadal KE modulations relative to short-time scale intrinsic oceanic KE variations. Our spectral analyses suggest that anthropogenic forcing may alter the future predictability of the KE system.

(POC-P Oral 15716)

Destination of New Guinea Coastal Undercurrent in the western tropical Pacific: variability and linkages

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The New Guinea Coastal Undercurrent (NGCUC) is considered a bottleneck in the Equatorial Pacific, carrying upper-to-intermediate waters from the south to the northwestern Pacific. However, how the NGCUC links to the circulation in the northwestern Pacific and what mechanisms control their variability were insufficiently studied. This work explores the spatiotemporal changes in the destinations of the NGCUC and the physical processes linked with the downstream NGCUC using ocean reanalysis for 22 years (1994 – 2015). Lagrangian particle tracking analysis, suggests eight major destinations of NGCUC: the Equatorial Undercurrent (35.26%), the North Equatorial Countercurrent (12.3%), the North (13.33%) and South (8.85%) Subsurface Countercurrents, the Equatorial Deep Jet (11.49%), the Mindanao Undercurrent (13.24%), and the Indonesia (3.47%) and Halmahera (0.86%) Throughflows. In addition, the present study suggests some minor and transient destinations of NGCUC. The NGCUC waters are distributed mainly to the east (81.65%) and their dissemination varies markedly with depth. Seasonal change in the NGCUC's strength is accompanied by the seasonal change in the distribution of its water mass. Furthermore, spatial change of the NGCUC waters' dissemination is investigated interannually, which is generally phased locking to the El Niño Southern Oscillation. These changes in the NGCUC waters' distribution potentially transform the local and regional water mass characteristics around the northwest Pacific. The mechanisms of their spatiotemporal variation are discussed, as well as the important roles of eddies in trapping and redistributing the NGCUC waters.

(POC-P Oral 15542)

Seasonal variability of deep western boundary current in the Philippine Basin from observation and numerical simulation

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Deep western boundary current (DWBC) in the tropical Pacific can transport lower circumpolar deep water (LCDW) and can contribute to control the global climate. Despite of its crucial role, DWBC in the Philippine Basin is not known well due to deficiency of observations. The measurement of near-bottom current, which was carried out near the Philippine Trench for 2 years, discovered the DWBC flowing southeastward along the western side of the trench with a mean speed of about 4 cm/s. The observed DWBC revealed seasonality which becomes stronger in winter and vice versa in summer. Comparisons with data-assimilated numerical simulation outputs (GLORYS12V1) show that the reproduced DWBC agrees well with the observation with a correlation coefficient of ~0.78. Further analyses of model outputs reveal a significant coherence (> 0.9) in the seasonal period between North Equatorial Current bifurcation latitude (NECBL) and along-slope velocity of DWBC. Seasonal variability of upper pycnocline depth accompanied by the seasonal variability of NECBL becomes deeper (shallower) in summer (winter). These changes in the upper ocean induce the seasonal change of deep anticyclonic eddy trapped by bottom topography through the potential vorticity conservation. In summer, the deep anticyclonic eddy is intensified and the adjacent DWBC flows northward due to the block by the western side of deep eddy. In winter, the DWBC was able to flow southward due to weakening of the anticyclonic eddy. Our results demonstrate that the seasonally-varying upper-ocean physical processes can generate a seasonal variability of abyssal circulation in the western tropical Pacific Ocean.

(POC-P Oral 15626)

Seasonal Variation of the Surface Kuroshio Intrusion into the South China Sea Evidenced by Satellite Geostrophic Streamlines

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The long-term satellite altimeter and reanalysis data show that large seasonal variations of the Kuroshio intrusion into the South China Sea are associated with geostrophic transport through the Luzon Strait, but not with the current intensity, width, and axis position east of Luzon Island. To address this issue, we examine the seasonal variability of surface intrusion patterns by a new streamline-based method. The along-streamline analysis reveals that the seasonality of geostrophic intrusion is only attributed to the cyclonic shear part of the flow, while the anticyclonic shear part always leaps across the Luzon Strait. A possible physical mechanism is proposed to accommodate these seasonal characteristics based globally on the vorticity (torque work) balance between the basinwide negative wind stress curl and the positive vorticity fluxes induced by the lateral wall, as well as locally on loss of balance between the torques of frictional stresses and normal stresses owing to the boundary gap. Through modifying the nearshore sea surface level, the northeasterly (southeasterly) monsoon increases (decreases) the positive vorticity fluxes in response to global vorticity balance, and simultaneously amplifies (alleviates) the local imbalance by enhancing (reducing) the positive frictional stress torque within the cyclonic shear layer. Therefore, in winter when the positive torque is large enough, the Kuroshio splits and the intrusion occurs, while in summer the stress torque is so weak that the entire current keeps flowing north.

(POC-P Oral 15748)

Identification of a Seasonal Subsurface Oxygen Minimum in Rivers Inlet, British Columbia, Canada

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A subsurface oxygen minimum layer (OML) in intermediate water is identified and characterized in Rivers Inlet, a fjord on British Columbia's central coast, using data from 1998 to 2018. The OML was observed in most years from May to September and was most persistent at the middle and head of the fjord. The Rivers Inlet OML develops in three stages: (i) in early spring, the cessation of winter storms from downwelling-favourable winds stops the ventilation of the water column; (ii) throughout spring and summer, the remineralization of organic matter, likely primarily phytoplankton, consumes oxygen in the intermediate waters; (iii) in late spring, deep-water renewal by oxygenated offshore water forms the base of the OML inside the inlet. The strength and persistence of the OML vary interannually, mainly due to variability in hemispheric-scale winds and primary production. In some years, the OML was hypoxic, which could influence the local marine ecosystem. Changes to downwelling, upwelling, or primary production in Rivers Inlet could affect the OML in the future.

(POC-P Oral 15563)

Seasonal and interannual variations in major shelf-scale currents off the west coast of Canada

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Ocean currents off the west coast of Canada may affect water properties such as temperature, salinity, nutrients and dissolved oxygen, as well as distribution of planktons, fish eggs and larvae. A 1/36^{o} ocean circulation model has been used to study seasonal and interannual circulation and transport variability off the west coast of Canada.

The model is forced by the European Centre for Median-range Weather Forecasting Reanalysis Version 5 atmospheric field, major ocean tides and river runoffs. The simulation was carried out for the period from 1993 to 2021. The model results are evaluated for sea level, temperature, salinity and currents, showing good qualitative and approximate quantitative agreement with observations. The model results show that the Vancouver Island Coastal Current is poleward year round strongest in December and weakest in May. The upper-layer shelf-edge current is poleward in winter and equatorward in summer, while the subsurface poleward California Undercurrent intensifies from late spring to fall and diminishes in following winter. There are substantial interannual variations in these currents, related to longshore winds, open boundary inflows, the El Niño Southern Oscillation, and the Pacific Decadal Oscillation.

(POC-P Oral 15630)

Bi-directional energy cascades in the Pacific Ocean from Equator to Subarctic Gyre

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This study investigates how nonlinear interactions in the turbulent upper ocean transport kinetic energy (KE) across different spatial scales. This investigation is important because the energy input that drives the ocean circulation has scales at tens of thousands kilometers, whereas the oceanic mixing and dissipation take place below the centimeter scales. How oceanic KE is transported from one scale to another is neither fully understood nor adequately observed, and this is particularly true in the oceanic meso-submesoscales in the 1~300 km range. By using repeat ship-board Acoustic Doppler Current Profiler (ADCP) surveys from 2004 to 2020 in the western Pacific Ocean, we examined the cross-scale KE transfers in dynamically-different regimes of tropics, subtropics and high latitudes. We found that the KE can transfer both up-scales and down-scales due to the co-existence of balanced geostrophic motions and unbalanced wave motions. The length scale that separates the bi-directional KE transfers is geographically-dependent. It is controlled by the relative strengths of co-existing balanced and unbalanced motions, as well as by how the unbalanced wave motions are dynamically generated.

(POC-P Oral 15596)

Barotropic Rossby waves induced by tropical instability waves in the Northeastern Pacific Ocean from observation and simulation

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Tropical instability waves (TIWs), which are located at the boundary between the Pacific warm pool and the cold tongue in the equatorial eastern Pacific, propagate westward with 25–40-day periods with seasonal and inter-annual variations. TIWs are stronger during July–December and La Niña periods, when cold tongue is fully developed. It is known that they can transfer their energy northward by transmitting their energy to barotropic Rossby waves (BTRWs). To verify the northward propagation of BTRWs, we used long-term near-bottom current data at 10.5°N and 131.3°W collected during 2004–2013, satellite-measured sea surface height (SSH), and velocity results from data-assimilated ocean model, called GLORYS12V1. The in-situ near-bottom current measurements revealed a spectral peak at 25–40 days, where significant coherences were found with satellite-measured SSH in a wide region of eastern Pacific with maxima approximately 5°N. Simulated deep currents from GLORYS12V1 concur with the observed near-bottom currents, and both currents exhibit seasonal and inter-annual variations, consistent with the typical characteristics of TIW. Further analyses using 25–40-day bandpass-filtered barotropic velocity data from the model revealed that they reasonably satisfied the theoretical dispersion relation of TIW-induced BTRW ($BTRW_{TIW}$). In addition, the filtered simulated barotropic velocity results exhibit the inter-annual variations which are related to El Niño-southern oscillation (ENSO). We reconfirmed $BTRW_{TIW}$ propagating northward above 10°N in the northeastern Pacific by in-situ observations firstly with a maximum velocity of approximately 3 cm/s.

(POC-P Oral 15540)

Peripheral upwelling induced by the merging of low-density water into a warm eddy and its effects on the biological and physical environment

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When low density water (LDW) merges with a warm eddy, it generates a geostrophic flow in the opposite direction of the clockwise rotating eddy, which decelerates the peripheral current of eddy. The geostrophic flow that merges into the eddy weakens along the eddy as LDW gradually mixes horizontally with the surrounding water, resulting in an accelerated current around the warm eddy. The entrained LDW moves spirally toward the center of the eddy due to the asymmetry of jet created by LDW: the negative vorticity in the core side of the jet is greater than in the outer side of the jet. The quasi-geostrophy of the accelerated surface flow induces upwelling of subsurface water along the LDW. Upwelling along the periphery of the eddy makes a core convergent eddy, resulting long-lasting, entrapped, isolated eddy.

Almost every spring, in the southwestern East/Japan Sea, the warm current from the Korea Strait merges and encircles the clockwise-rotating warm eddy cooled during the winter and it forms a ring-shaped region of high Chlorophyll *a* concentration around the eddy. Observation of nutrient confirms upwelling formed along the warm water encircling the eddy. In the subtropical northwestern Pacific, the low-salinity water from the Intertropical Convergence Zone (ITCZ) merges and encircles the warm eddy and forms a core convergent eddies. These eddies have been found to last very long, trapping water with high ocean heat content, and could play an critical role in typhoon intensification.

W1: BIO Topic Workshop
Distributions of pelagic, demersal, and benthic species associated with seamounts in the North Pacific Ocean and factors influencing their distributions

(W1 Oral 15808)

Oceanographic influences on biological production and energy transfer in seamount ecosystems

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Oceanographic factors that contribute to biological productivity and energy transfer in seamount ecosystems span a wide range of spatiotemporal scales. At very large scales, regional oceanography determines the overall amount of primary and secondary production in the waters overlying seamounts. At mesoscales, current-topography interactions give rise to oceanographic phenomena that include enhanced turbulence, localized upwelling, seamount-trapped waves, and Taylor cones – all of which may potentially enhance energy transfer in seamount foodwebs. At sub-metre scales, localized current acceleration can affect the flux of food available to (and even the spatial orientation of) filter-feeding organisms in the seamount benthos. Variability in summit depth also plays a key role in determining the extent to which individual seamount ecosystems may benefit from such "oceanographic energy subsidies". However, our understanding of even this most basic aspect of seamount ecology remains incomplete. For example, it is widely accepted that seamounts penetrating the upper layers of the ocean can receive daily energy subsidies in the form of diel vertically migrating zooplankton and micronekton. However, as yet unexplored is the potential for the advection of layers of lipid-rich overwintering copepods to represent a significant energy subsidy to even deep seamounts (e.g. summits deeper than 800m) in mid- to high-latitude regions such as the NE Pacific, where such species tend to dominate zooplankton communities. In this talk we will first review what is known about biophysical coupling in seamount ecosystems and then offer some suggestions for investigating those aspects that remain poorly understand.

(W1 Oral 15531)

Investigating seamount effects on zooplankton in the Northeast Pacific

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Seamounts often support large aggregations of marine species and can produce significant effects on local oceanography including upwelling, enhanced turbulent mixing, and in rare instances the formation of Taylor cones. In some cases, these features have been shown to result in significant "seamount effects" on the zooplankton community which may propagate downstream. To protect these special environments Fisheries and Oceans Canada (DFO) has identified a region off Canada's west coast as an area of interest (AOI) for the creation of a future marine protected area. The AOI contains at least 39 seamounts ranging in summit depths from 285m to 2500m. Several oceanographic surveys have been undertaken within the AOI to better understand these seamount ecosystems. Using size-fractionated zooplankton/micronekton biomass, taxonomic, and oceanographic data from 12 seamounts, we aim to determine whether there are detectable seamount effects on the mesozooplankton community within the AOI, and whether seamount physiography (e.g., summit depth, orientation with respect to currents, overall elevation) determine the magnitude of the effects. Data collected from Union, Dellwood, and Explorer seamounts during the 2017 and 2019 surveys suggest that each seamount has a similar but distinct areal distribution of zooplankton biomass. We are also exploring spatial patterns of similarity among assemblages and their relatedness to oceanographic conditions and proximity to seamounts. In this presentation, zooplankton biomass distribution and community assemblage are explored in the context of local oceanographic processes and possible causes of observed seamount effects will be discussed.

(W1 Oral 15545)

Seamount effects on micronekton at a subtropical central Pacific seamount

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Seamounts are globally ubiquitous features with potential for increased biodiversity and biomass, including those of economically important fish. Although their ecological and economical importance is well known, the mechanisms for supporting seamount-associated communities are not well understood. In this study, the effects of an intermediate seamount (Cross Seamount) on the micronekton communities, forage for economically important bigeye tuna, are investigated. Relative biomass and composition estimates were calculated from multi-frequency active acoustic data from surveys over 3 years. Mean micronekton biomass was significantly higher than in the ambient environment and its composition differed over the flanks and plateau of Cross Seamount. The effects of the seamount extended ~3.5 km away from the plateau's edge, possibly further below 400 m depth at the flanks. Micronekton occupied the water column from the surface to the 400 m deep plateau with dense aggregations immediately over the bottom at night. During the day, these micronekton migrated both horizontally and downward, occupying depths of 500-700 m, preferably along the upstream flank of the seamount. Descending micronekton from near-surface waters appeared to be temporarily blocked by the topography before swimming below the plateau at the flanks. Mechanisms supporting the increase in micronekton biomass are uncertain, although hydrographic data support topographic trapping of zooplankton and the existence of transient or semi-permanent Taylor caps.

Key words: micronekton, acoustic scattering layers, active acoustics, seamounts, topographic blockage, Taylor cap

(W1 Oral 15775)

Can Gulf of Alaska seamounts be a spawning ground for sablefish recruiting to inshore nursery habitats?

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Adult sablefish have been found over the chain of seamounts far offshore in the Gulf of Alaska. Many of the females that were observed had recently spawned or were ready to spawn but, to date, there are no observations of young sablefish over the seamounts. Due to their depth and remoteness, there are no suitable shallow sablefish nursery areas in the vicinity of the seamounts, thus, individuals hatching from eggs spawned over seamounts would need to be transported hundreds of miles to suitable areas inshore if they are to successfully recruit to the fishery. Using an individual-based model of sablefish, we demonstrate that if sablefish were spawned over any of the seamounts in the Gulf of Alaska seamount province there is a reasonable likelihood that at least some individuals will be successfully transported to shallow inshore nursery areas in the coastal Gulf of Alaska. As our simulated individuals only exhibit vertical movement behavior this on-shore transport results from the prevailing currents to which they were subjected and not due to any geographic or environmental homing traits. Our analysis indicates that the strength of the on-shelf velocity is not the primary factor in determining the likelihood of transport to nursery areas. Our path analysis illustrates that there are markedly different pathways taken by successful individuals year on year. Our findings suggest that it may be necessary to expand what is considered suitable habitat for young sablefish.

(W1 Oral 15727)

Biology and fisheries of North Pacific armorhead and splendid alfonsino in the SE-NHR area (Review)

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North Pacific armorhead and splendid alfonsino are the most important targets for bottom fisheries in the Southern Emperor and Northern Hawaiian Ridge (SE-NHR) area. We review original scientific literature and summarize current knowledge of biology and fisheries for the two species.

The bottom fisheries of armorhead in the SE-NHR area were first explored by the trawl fleet of the Soviet Union in 1967. The larvae are found in the surface waters over and adjacent to the SE-NHR area whereas juveniles and subadults live in the epipelagic layer of the subarctic water mass of the central and eastern North Pacific. Subadults settle to seamounts, where they mature and spawn in winter. After settlement, they cease growth and gradually lose body weight. Armorhead on seamounts are largely dependent on plankton and deep scattering layer organisms as prey resources rather than preying on locally produced benthic food.

The fisheries of alfonsino began in the late 1970s as an alternative fishery when armorhead showed poor catch. The genetic differentiation for alfonsino has not been detected among the North Pacific populations. The spawning season in the SE-NHR area is likely to be summer. Alfonsino shows ontogenetic shift from planktivorous to micronektivorous diets in the SE-NHR area.

Given their commercial importance and concerns on stock status, preparatory work for stock assessments for these species in the SE-NHR area is ongoing to guide a sustainable harvest. We discuss challenges in conducting the stock assessments, including unique life history and the insufficient biological information.

(W1 Oral 15639)

Species Distribution Modeling to Identify and Protect Vulnerable Marine Ecosystems: Case Studies from the South Pacific Ocean

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Deep-water corals and sponges are critical foundation species found in every ocean basin. The complex, three-dimensional habitat structures they produce support thousands of associated species including other invertebrates and commercially important fish. Slow growth rates, extreme longevity, and low reproductive rates make these taxa extremely sensitive to anthropogenic disturbance, and the full recovery of damaged communities may take many decades, centuries, or even longer. Considering the extreme logistical difficulties and costs associated with restoration efforts in these remote habitats, improved conservation and management measures are urgently needed to protect these fragile ecosystems before long-term damage occurs. The United Nations has called upon nation states to identify and protect particularly Vulnerable Marine Ecosystems (VMEs); however, a paucity of observational data in deep-water environments has historically hindered the identification of VMEs over large swaths of unexplored benthic habitats. Species distribution models (SDMs) couple the known distribution of key taxa with relevant environmental parameters to predict niche and distribution in unsurveyed regions, and are increasingly being used to identify VMEs, advocate for improved protection, design and implement spatial management plans, guide research and exploration, and assess present and future anthropogenic impacts. Here, I present results from a series of SDM case studies in the South Pacific Ocean with a focus on how models can help guide conservation and management efforts.

(W1 Oral 15615)

Using species distribution modeling to predict deep-sea coral and sponge communities, hotspots, diversity and indicators

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Species distribution models (SDM) have been widely used to predict the distribution and abundance of fish and invertebrates on the continental shelf and slope in many regions of the worlds oceans. In particular these models are useful in the deep-sea where data are less common and potentially of differing quality. In this talk we will highlight a recent ICES workshop (and related working groups) that provided recommendations for applying SDM to inform management of deep-sea invertebrates. The ICES workshop included some guidance on choosing models and data, as well as some guidelines on presenting complete results including maps, response curves and uncertainties. Some applications of SDM to predict single species, diversity, and areas of high abundance for corals and sponges in Alaska will be used as examples. Some recent work on multivariate modeling to both derive and predict the distribution of indicator taxa in Alaska will also be shown. Finally, some examples of the potential pitfalls of where data is spatially biased, of lesser quantity and quality, or derived from different sources will be explored. For seamount ecosystems where data is sometimes very sparse, care will be needed in applying SDMs in order to generate robust predictions and guide future data collection and management opportunities.

(W1 Oral 15677)

Composition of cold-water corals and other deep-sea benthos in the Emperor Seamounts

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We analyzed benthic samples collected from a research vessel during scientific surveys and by scientific observers onboard commercial fishing vessels from 2009 to 2019, to examine the faunal composition of cold-water corals and other benthos in the Emperor Seamounts area. Cold-water corals were classified and listed at the family, genus, and species levels in as much detail as possible. To confirm the importance of cold-water corals, we compared the frequency and wet weight composition of all benthic taxa, and the depth distribution of cold-water corals by taxonomic group. Gorgonians occurred at highest frequency and wet weight compositions, and were distributed over the widest depth range, confirming that they are the major components of the benthic community in this area. Scleractinia had a similar frequency of occurrence, but their depth distribution was limited to a shallower range than gorgonians. Among other benthos, Crustacea and Echinoidea occurred more frequently, and the wet weight of Echinoidea, Ophiuroidea, and Porifera was higher. Many of gorgonians or colonial Scleractinia were attached or inhabited by other benthic animals such as Zoantharia, Anomura and Ophiuroidea. The composition of benthic fauna in the Emperor Seamounts area indicate that gorgonians and colonial Scleractinia are important components of the VME in terms of their ability to provide habitat structure.

(W1 Oral 15581)

Using predictive habitat models and visual surveys to identify vulnerable marine ecosystems (VMEs) on seamounts in the North Pacific Fisheries Commission's Convention Area

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The United Nations General Assembly called upon States to manage fisheries sustainably and protect vulnerable marine ecosystems (VMEs) from destructive fishing practices when they adopted Resolution 61/105 in 2006. The North Pacific Fisheries Commission (NPFC) identified four taxa of corals as indicators of potential VMEs. The NPFC has yet to use these taxa to develop quantitative methods to identify VMEs, but it does support the use of the best available data to identify them. Such data could include commercial and research catches, model predictions, and visual surveys to collect video and/or photographic images. To date no VMEs have been identified in the northeast part of the NPFC Convention Area in part due to the sparse information available, including limited visual data and coarse resolution predictions of the suitable habitat for VME indicator taxa. We propose a quantitative method for VME identification that maximizes the value of existing data, integrating both visual data and model predictions in a manner that aligns with the precautionary approach, the Convention, and the research plan of the NPFC's Scientific Committee. We use data from Cobb Seamount to illustrate our proposed methodology. This preliminary application of our approach identified areas that are likely to be VMEs at depths ranging from the summit of Cobb Seamount to 1600 m. Our primary goal is to propose and receive feedback on this approach before applying it to identify VMEs in the northeast part of the NPFC's Convention Area.

W2: FIS/HD/SB Topic Workshop
Integrated Ecosystem Assessment (IEA) to understand the present and future of the Central Arctic Ocean (CAO) and Northern Bering and Chukchi Seas (NBS-CS)

(W2 Invited 15520)

Activities of the ICES-PICES-PAME working group on Integrated Ecosystem Assessment for the Central Arctic Ocean (WGICA)

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WGICA aims to provide a holistic analysis of the present and future status of the Central Arctic Ocean (CAO) ecosystem and human activities therein.

Climate change reduces sea ice, increases light penetration, causes regionally variable trends in stratification and mixing of the water column, increases inflow in both the Atlantic and Pacific sectors, and enlarges heating of waters at the surface and extending deeper. These changes in turn affect primary production and cascade through the foodweb to ice-associated fauna, zooplankton, fish, benthos, seabirds, and marine mammals. They may be exacerbated by increasing human activities in and around the CAO, including increasing pollution from ship traffic and from the transport of contaminants to the ecoregion by rivers and ocean currents.

During this past year, WGICA has studied and described human activities in and around the CAO and resulting pressures. In the next three years, WGICA planned to identify ecological, economic, social, and institutional research questions, to enable further stakeholder involvement, and to identify integrated assessment methods that can help evaluate ecosystem conditions and changes.

In this presentation we present the main results from the ongoing reporting of the main human activities (global sources, shipping, military and tourism), pressures (contaminants, garbage, noise, etc) and the work on describing the vulnerability of the ecosystem. We will present the plans on how to use this information into a method for Integrated Ecosystem Assessment as used in ICES.

(W2 Oral 15734)

About remote monitoring of water surface and ice cover of the Arctic

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The current stage in the development of experimental radiophysical and optical methods for studying the environment is characterized by the transition from passive collection of information on the object under study to the formulation of purposeful experiments. Of paramount importance in the implementation of such experiments are the organizations of mass gathering of information about the system under study, the speed of its processing and the reliable interpretation of the observational data.

Of particular relevance in recent years have acquired remote technologies that allow obtaining operational information about water bodies and characterized by high productivity. The procedure for the synthesis of an automated data processing system for multichannel measurements includes the creation of a complex of hardware, algorithmic, model and software tools for collecting and analyzing information, taking into account the levels of its reliability and completeness.

In this paper briefly describes the physical foundations of water and ice characteristics according to microwave data. A review of the work is presented where, based on model calculations and experimental measurements, the emissivity of the ice cover in the microwave range is described, the questions of the development of models for sea ice with strong and moderate absorption and porous structures, the features of the radiation indices of young ice, ice with low salinity and pack ice.

Specific examples of the classification of phenomena on the water surface and ice cover are given. The program modules included in the system were used to process data from radiophysical experiments with the Kosmos-1500 satellite for the Arctic regions. The statistical characteristics of the "spottennes" of the radio brightness temperatures, obtained for the most informative thresholds, are analyzed. It is asserted that these characteristics can be used in the detection of abnormal phenomena on the water surface and ice cover.

(W2 Oral 15779)

Passive acoustic monitoring in the Arctic Ocean for Integrated Ecosystem Assessment

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Passive acoustic monitoring (PAM) is an environment-friendly method to observe the underwater environment, which is more useful in polar oceans where long-term monitoring is limited mostly due to the sea ice cover and low temperatures. Studies based on passive acoustics combined with monitoring of marine life, weather, natural disaster, and anthropogenic effects will be most useful and are now beginning. It should be possible to provide much needed observation data for the Integrated Ecosystem Assessment (IEA) using a few moored passive acoustic recorders. We collected underwater acoustic data using an autonomous passive acoustic recorder in the East Siberian Sea from August 2017 to August 2018. The correlations between temporal variability of sound pressure levels and marine environmental data such as sea ice concentration, extent, drifting speed, wind speed, and ocean current were estimated; then, significant sound sources affecting variability were classified in terms of geophony, biophony, and anthrophony. The sea-ice concentration at the mooring site varied significantly during September, and the spectrum levels in September and October were relatively high during the days when sea ice concentrations were low. The sound pressure level of September was 15 dB higher than that of the annual average as the seismic airgun sounds were clearly detected simultaneously. Marine mammal vocalizations from bearded seals, walrus, beluga, and similar sounds like bowhead whales were also recorded. Our results demonstrate the relationship between sound pressure level and sea ice concentration, and imply that the underwater sound levels could increase with the melting sea-ice in the future.

(W2 Oral 15780)

Vertical behavior of key copepod species subsequent to the midnight sun period in the East Siberian continental margin, Arctic Ocean

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Calanus glacialis, *Calanus hyperboreus*, and *Metridia longa* are key copepod species accounting for 50 – 90% of the zooplankton biomass in the Arctic Ocean. Changes in their vertical distribution impact the biological carbon pump and the distribution of predators. Their vertical distribution, however, remains poorly understood due to the difficulties of access and sampling. This study presents the vertical distribution of the key copepod species subsequent to the midnight sun period in the Arctic Ocean. Acoustic, oceanographic, and biological data were collected in the East Siberian continental margin from August 27 to 30, 2020. Both *Calanus* species did not perform diel vertical migration (DVM), while *M. longa* exhibited a normal DVM. *C. glacialis* was found at depths above 20 m in warm water (mean temperature of -0.6°C), where the highest density gradient was observed. *C. hyperboreus* inhabited depths between 30 and 55 m in cold water (mean temperature of -1.3°C), where a high proportion of large phytoplankton (> 20μm) appeared. *M. longa* was distributed at depths between 25 and 55 m at night and depths 100 and 135 m in the daytime. The strong water column stratification limited the migration range of *M. longa*. Our results suggest that solar radiation variations are a potential trigger of DVM in copepods, and water column stratification, temperature, and food availability affect the extent of vertical distribution in copepods. These findings could provide insight into monitoring and assessing the variation of the zooplankton distributions in the rapidly changing Arctic marine environment.

(W2 Oral 15641)

Arctic marine biodiversity and species co-occurrence under recent climate

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The Arctic region is experiencing drastic climatic changes bringing about potential ecological surprises. Here, we explored marine biodiversity and potential species co-occurrences across eight Arctic marine areas from 2000-2019. We compiled occurrence data for 69 marine taxa, and environmental factors to predict taxon-specific spatial distributions. Using multi-ensemble model outputs, we examined spatio-temporal biodiversity and species co-occurrence patterns over time and between contrasting periods of summer sea ice conditions. Overall, we captured increasing trends in species richness over time, except in the Arctic basin. However, declines in the species richness and frequency of species co-occurrence between high and low sea ice periods were observed in the Davis-Baffin Bay and Hudson Complex, with the latter registering lower number of taxa than the former. Contrarily, continental slopes and adjacent regions of Pacific Arctic and Beaufort Sea, along with the Atlantic Arctic and Kara-Laptev Sea showed increases in species richness and species pair-wise co-occurrences. These emerged in response to modeled northward habitat range expansions, especially for wide-ranging apex predators, under low summer sea ice conditions. Our results show disproportionate regional impacts of warming and sea ice loss in the Arctic and provide relevant insights on potential region-wise vulnerability to recent climate changes.

(W2 Oral 15784)

Inter-annual changes of the mesozooplankton community structure in the Central Arctic Ocean (CAO) and Northern Bering and Chukchi Seas (NBS-CS) during summers of 2016-2020

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The Arctic Ocean is undergoing rapid environmental changes including the Central Arctic Ocean (CAO) and its Pacific gateway, Northern Bering and Chukchi Seas (NBS-CS). Mesozooplankton play a crucial role as primary or secondary consumers in Arctic ecosystems and can serve as sensitive indicators of environmental changes. Mesozooplankton samples were collected at 151 stations in the CAO and NBS-CS each August from 2016 to 2020. The mesozooplankton abundance of the study area ranged from 9 to 6,172 ind. m^{-3}, and the predominant components were copepods at 7–3,866 ind. m^{-3}, of which *Pseudocalanus* spp. and *Calanus glacialis* were the most abundant. In the NBS-CS, small copepods and meroplankton, such as *Pseudocalanus* spp., Cirripedia larvae, Echinodermata larvae, and *Centropages abdominalis* were the predominant taxa. In the CAO, *C. glacialis*, *Pseudocalanus* spp., *Metridia longa*, *Oithona similis*, *Parasagitta elegans*, and *Calanus hyperboreus* were abundant. The distributions and structures of mesozooplankton communities indicated variability over large spatial scales in the CAO and NBS-CS waters due to a combination of multiple factors, such as water temperature, salinity, and sea ice coverage; however, geographical effects cannot be underestimated even during alterations in the physical properties. Our results suggest that these variable patterns of mesozooplankton communities fluctuate latitudinally from south to north as warming progresses on a regional and bathymetric scale, and can be used to infer the future status of mesozooplankton communities in the study area.

(W2 Invited 15759)

Recent ecosystem research in the Chukchi and north Bering seas

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We present an overview of recent ecosystem research in the north Bering and eastern Chukchi seas. Ecosystem level projects include Arctic Integrated Ecosystem Studies (IES) phase 1 (2012 and 2013) and 2 (2017, 2019) in August-September, and Arctic Shelf Growth Advection Respiration and Deposition (ASGARD, 2017 and 2018) in June. These projects were joint efforts among US government and academic scientists to understand the relationships among physics, lower and upper trophic levels including humans in the context of ongoing climate change on the north Bering and eastern Chukchi shelves. Data include mooring and CTD profiles of temperature, salinity, light, oxygen; water samples of nutrients, chlorophyll, phytoplankton community composition and productivity, environmental DNA, and lipid and fatty acid concentrations across trophic levels; zooplankton and ichthyoplankton abundance from Bongo nets; pelagic fish from surface and midwater trawls and acoustics; multicore deployments to examine macro and meiofauna; counts of seabirds and marine mammals. In addition, PICES working group 44 is designing an integrated ecosystem assessment encompassing data from both the western and eastern shelf regions. Lastly, a recently NPRB-funded synthesis proposal to evaluate pelagic–benthic coupling will use data from these projects and other surveys (e.g., DBO) to model and predict the impact of a warming climate on pelagic and benthic ecosystems including trophic interactions and energy flow between these systems.

(W2 Oral 15781)

Spatio-temporal variability of ice retreat in the Pacific Arctic

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Sea ice cover reflects most of the incoming solar radiation, blocks wind mixing and acts as thermal isolation layer. Therefore it largely influences heat fluxes at the sea-atmosphere interface and limits the phytoplankton vegetation. On the other hand, sea ice retreat often triggers spring phytoplankton bloom in the polar and subpolar environments. This study investigates the spatiotemporal variability of the date of ice retreat (DOR) in the Bering Sea, the Chukchi Sea and the adjacent Arctic regions. The analysis is based on NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 3. This dataset has 25×25 km spatial and daily temporal resolution; the data for interval from 1979 to 2018 is used. The DOR is determined using 0.15 threshold of sea ice concentration. The data cells are grouped with DBSCAN method. Spearman correlation coefficient of DOR time-series is applied as similarity measure. Five main regions of synchronous interannual changes of DOR are determined. The temporal variability of DOR in every region is discussed. The differences in sea ice retreat between regions are mostly associated to the wind forcing in the Bering Sea and variability of heat transport through the Bering Strait in the Chukchi Sea.

(W2 Oral 15782)

Distribution of water masses in the Chukchi Sea in August 2019 and their chemical characteristics

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Water masses form biotopes in marine environments, and their spatial-temporal variability is a key to understanding of trends in ecosystems. Their distribution and variability in the western part of the Chukchi Sea is still purely studied. This study describes distribution and characteristics of water masses based on CTD and chemical data (dissolved oxygen and dissolved inorganic nutrients) from R/V Professor Levanidov cruise from August 2019 (55 stations). Vertical and lateral structure of water column is described. Spatial distribution of six major water masses is analyzed; Alaska + Anadyr Coastal Water, Siberian Coastal Water, Melt Water, Bering Summer Water, Remnant Winter Water, and modified Atlantic Water; ACW, SCW, MW, BSW, RWW, and AW, respectively. SCW and MW had similar physical properties and chemical composition at some locations. Model data on geostrophic and Ekman surface currents from Copernicus Marine Services (product ID: MULTIOBS_GLO_PHY_REP_015_004) is used to track the origin of surface water masses. Unusually warm conditions are observed for MW and SCW (temperature of up to 4.5 and 8 °C, respectively). ACW was saltier than previously reported (up to 32.9 psu) and also unusually warm (up to 9.4 °C). Part of the AW was observed at unusually shallow depths (120 m) and had chemical characteristics which were not reported for AW before (low dissolved oxygen, high dissolved silica, and low negative N*). Observations allow to conclude on continuation of warming in the surface layer of the Chukchi Sea, and expand existing knowledge on possible variability of the water masses in the region.

(W2 Oral 15790)

The development of Japan‘s Arctic Policy and the citizens’ awareness

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Japan’s Arctic policy has mainly formed based on three pillars of science, diplomacy and business during the 1990s. When the second basic plan for Ocean Policy was decided, it became part of the cabinet matter and affiliated with the Japan’s Basic Act for Ocean Policy in 2013. The second plan also brought a strategic rationale among the three pillars. When the Cabinet adopted Arctic Policy in 2015, it further authorized and structured each pillar. With the decision of the third basic plan for Ocean Policy in May 2018, Arctic Policy strengthened its policy profile.

In accordance with these developments in the government policy, it is also observed that there are certain changes in the Japanese awareness on and their attitude toward the Arctic issues and topics related to it. This paper shows how Japan’s Arctic policy has developed as a governmental policy and present a result from the recent survey on the Japanese consciousness regarding Arctic issues. It also discusses the co-relations between the policy development and the public awareness in Japan.

W4: FUTURE Topic Workshop
Establishing a North Pacific ECOP node of the global ECOP program to increase inter-regional early career engagement and partnerships during the Ocean Decade

(W4 Invited 15795)

Opportunities within the ECOP Programme to increase inter-regional early career engagement and partnerships for the North Pacific region

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The Ocean Decade Programme for Early Career Ocean Professionals (ECOP Programme) serves as the backbone organization for global ECOP engagement throughout the Ocean Decade, helping to (a) guide the vision and strategy for ECOP engagement, (b) support the alignment of activities within topic areas, (c) establish shared principles and measurement practices to evaluate progress, (d) cultivate community engagement and ownership, and (e) advance policy, and (f) mobilize resources.

The ECOP Programme mission is to incorporate new ways of thinking into global ocean sustainability and stewardship challenges through diverse engagement. The ECOP Programme will achieve this by empowering ECOPs with meaningful networking and professional development opportunities to engage with each other and with local to global institutions through the framework of the Ocean Decade. The vision of the ECOP Programme is to elevate and strengthen the diverse perspectives of new generations of ocean professionals in a collective voice, ensuring that knowledge is transferred between experienced and early career ocean professionals, to promote ocean sustainability for "The Ocean We Want".

For the purpose of the ECOP Programme, an ECOP is a person that self-identifies as being early in their career (10 years or less of professional experience) within any field related to the ocean. The term "professional" is used in order to be inclusive of professionals from many different sectors of society.

The authors shall discuss concrete steps for the development of the North Pacific ECOP node and its advantages.

(W4 Oral 15757)

Understanding the needs and priorities of Early Career Ocean Professionals in Asia

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The regional node of the ECOP Programme in Asia aims to connect existing networks of multi-disciplinary ECOPs across Asia, and exchange knowledge related to the UN Ocean Decade. Our regional engagement strategy has been revolving around three key pillars: (1) Taking stock of the ECOP landscape; (2) Establishing a network of networks through cross-pollination; and (3) Leveraging opportunities for ECOPs. Over the past year, ECOP Asia has disseminated 2 regional surveys, reaching more than 150 ECOPs based or working in Asia, to gather key demographic statistics but to also enhance our understanding of the barriers they face and the resources they need to thrive and grow in their careers. Results revealed that the 3 major challenges for ECOPs in Asia relate to a lack of funding (52%), career opportunities (50%) and community/network cohesion (45%). Diving deeper into the funding question, scholarships, in-person conference travel support and internships were considered as the most important targets. Mentorship and engagement at the science-policy interface stood out as key priorities for ECOPs in Asia. When stratified per country, the surveys unveiled national and cultural nuances, such as the significance of language barriers and gender inequality in Japan and South Korea. The ECOP Programme strives to enhance the understanding of national contexts, to better inform and tailor future training and capacity development opportunities, outreach initiatives and inclusive engagement strategies. Our goal is to develop and sustain a vibrant, engaged and inclusive regional ECOP community in Asia, listening to and learning from a diversity of voices.

W5: FIS Topic Workshop
Integrating biological research, fisheries science and management of broadly distributed flatfish species across the North Pacific Ocean in the face of climate and environmental variability

(W5 Invited 15629)

Improving petrale sole (*Eopsetta jordani*) fishery management advice through a mechanistic understanding of oceanographic drivers of recruitment and biophysical connectivity

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Scientists and managers are often looking in the rear view mirror with respect to determining year class strength because reliable recruitment estimates often require several years of survey and fishery data. This crux of fishery management is further complicated due to the use of average recruitment assumptions in forecasts that serve as the basis for decision-making, with greater impacts for species that begin to occur in the data at older ages, resulting in a larger lag between the establishment of year class strength, data collection, and robust management advice. This presentation explores recent advances in understanding the oceanographic mechanisms that drive patterns of petrale sole (*Eopsetta jordani*) recruitment in the California Current, and how this understanding can improve management advice from fishery stock assessment model forecasts. First, a suite of life-stage and spatio-temporally specific mechanistic hypotheses and regional ocean model (ROMS) outputs provide the basis for an evaluation of oceanographic drivers of recruitment success that influence survival at each life stage. Then, an individual-based model (IBM) coupled with a ROMS hydrodynamic model provides an exploration of connectivity between spawning areas inferred from fishery data and potential settlement areas. Finally, stock assessment and management forecasts that use ROMS based recruitment indices provide an evaluation of this mechanistic understanding to improve recruitment estimation, and thus advice to fishery managers.

(W5 Invited 15638)

Groundfish biodiversity change in northeastern Pacific waters under projected warming and deoxygenation

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In the coming decades, warming and deoxygenation of marine waters are anticipated to result in shifts in the distribution and abundance of fishes, with consequences for the diversity and composition of fish communities. Most projections to date have focused on temperature, but have not accounted for the confounding influence of oxygen and depth and are limited by the spatial resolution of the global climate models. Here, we combine fisheries independent trawl survey data spanning the west coast of the USA and Canada with a high resolution regional climate model to make projections of how 40 groundfish species will be impacted by changes in temperature and oxygen in British Columbia and Washington. In this region, species that are projected to decrease in occurrence are roughly balanced by those that are projected to increase, resulting in considerable compositional turnover. Many, but not all, species are projected to shift to deeper depths as conditions warm, but low oxygen will limit how deep they can go. Thus biodiversity will likely decrease in the shallowest waters (< 100 m) where warming will be greatest, increase at mid depths (100—600 m) as shallow species shift deeper, and remain stable or decrease at depths where oxygen is limited (> 600 m). These results highlight the critical importance of accounting for the joint role of temperature, oxygen, and depth when projecting the impacts of climate change on marine biodiversity.

(W5 Invited 15696)

Importance of monitoring biological characteristics of flatfishes

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In this talk I will introduce a few examples on variations in the biological characteristics including feeding habits, somatic condition, or reproductive traits in coastal flatfishes in Japan. These variations are thought to be caused by interactions of several factors, such as climate change, habitat deterioration, and food limitation. Japanese flounder *Paralichthys olivaceus* is a widely distributed and the commercially most important species in Japan. Landings has been highest in the Pacific coast of northern Japan, where *P. olivaceus* mainly consume the anchovy and the sandlance. However, these main prey fishes has drastically decreased in the last decade. Impacts of the collapse of the prey population on the biological production of *P. olivaceus* are concerned. Similarly, food limitation has become a serious concern in other coastal species including stone flounder *Platichthys bicoloratus* and marbled flounder *Pseudopleuronectes yokohamae*, because reductions in their somatic condition and associating reproductive outputs have been observed. Another example is the coastal flatfishes in the Seto Inland Sea, western Japan. Their stock levels have been low in recent years. This is probably due to the water temperature rise, although it is mysterious that juveniles are constantly abundant in estuaries. However, it is difficult to assess the changes in biological characteristics of both adults and juveniles because of the lack of baseline information. It is important to monitor not only the stock levels but the biological characteristics for constructing the fisheries management measures.

(W5 Oral 15672)

Improved understanding of seasonal reproductive development in female Pacific halibut (*Hippoglossus stenolepis*) guiding accurate revision of maturity estimates

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The Pacific halibut (*Hippoglossus stenolepis*) is a migratory demersal flatfish species that occupies a top trophic role in the North Pacific Ocean and Bering Sea ecosystems, where it also supports various important fisheries. In order to fill existing knowledge gaps related to the reproductive biology of female Pacific halibut, and due to the influence of reproductive metrics on stock assessment and the delineation of management reference points, research efforts have been devoted to characterize female maturity in this species. The main objective of the present study was to conduct a comprehensive histological assessment of the temporal progression of female ovarian developmental stages, reproductive phases, in relation to biological indicators of Pacific halibut reproductive development, throughout an entire reproductive cycle. Oocyte size distribution analyses from females at different developmental stages showed that Pacific halibut oocyte development is group-synchronous and that fecundity in this species is determinate. In addition, ovarian histological examination showed that female Pacific halibut follow an annual reproductive cycle involving a clear progression of female developmental stages towards spawning within a single year. These results provide foundational information for upcoming studies aimed at updating maturity ogives by histological assessment and at estimating fecundity in Pacific halibut.

(W5 Oral 15640)

Understanding Pacific Halibut Spatial Dynamics in the Northern Bering Sea

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In recent years, the fish assemblage has been changing in the Northern Bering Sea (NBS), where rising water temperature has correlated with increases in abundance of sub-arctic fish species. One such species is the Pacific halibut (*Hippoglossus stenolepis*), a commercially important flatfish that is a potentially valuable resource in the NBS. To optimize harvest opportunities of this increasingly available fish, informed management is important, which in part requires understanding halibut movements and spatial dynamics in the region. Currently, this information is scarce, and as such, the current management paradigm makes a number of assumptions generalizing Pacific halibut movements within NBS management areas. To obtain spatial dynamic information for Pacific halibut in this region to better inform management decisions, pop-up satellite telemetry tags were attached to large, mature female Pacific halibut in two locations in the NBS. Data recovered from these tags was used to assess movement and habitat occupancy within the region. Preliminary findings indicate that tagged individuals remained within the NBS and Central Bering Sea, with Pacific halibut crossing multiple management boundaries, including the Russian maritime border. During the winter spawning season, Pacific halibut made long migrations to the shelf edge, ranging as far south as the Pribilof Islands. Additionally, some individuals returned to their tagging location the following year, an indication of inter-annual site fidelity to summer foraging areas. These findings are important to both local stakeholders and managers when making management decisions about this increasingly available resource.

(W5 Oral 15695)

Evaluating stress profiles and mortality rates of discarded Pacific halibut from the charter recreational fishery

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Charter (guided) recreational Pacific halibut fisheries in the central Gulf of Alaska have high catch volumes (combined annual catch of approximately 4-6 million lbs.) and high discard rates (estimated 30 – 42%). Current assumed discard mortality rates (DMRs) are based in part on studies of mortality rates in the commercial longline fishery due to a lack of data from the recreational fishery. We recently conducted a test fishing study on chartered recreational vessels in the Gulf of Alaska using common recreational gear and capture practices to investigate (1) relationships among hook release injuries, physiological condition, and stress levels of captured fish, and (2) release survival estimates with the use of two types of tags. Physiological parameters collected included condition status at capture (round weight, fat reserves) and post-handling stress levels (blood stress indicators). Short-term assessment of post-release mortality was investigated with the use of electronic survivorship Pop-up Archival Transmitting (sPAT) tags (not dependent on recaptures), while long-term survival will be examined with the use of wire tags (dependent on recaptures). Initial results and short-term post release mortality estimates will be presented. Results of this study will be used to further refine the estimation of DMRs applied to the Pacific halibut charter sector fishery.

(W5 Oral 15668)

Generation of genomic resources for the Pacific halibut (*Hippoglossus stenolepis*) to assist in population biology studies informing fisheries management

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The Pacific halibut (*Hippoglossus stenolepis*) is a flatfish species distributed throughout the North Pacific Ocean and its fishery is one of the most important commercial fisheries in the region. It is well recognized that genomic data is becoming increasingly relevant in informing management and policy decisions for a number of commercial fish species. For this purpose, the International Pacific halibut Commission (IPHC), an intergovernmental organization established by a Convention between Canada and the United States of America that conducts research on and manages Pacific halibut within Convention waters, has conducted work towards the development of genomic resources for the species. We recently generated a chromosome-scale assembly of the Pacific halibut genome by a combination of short and long read sequencing followed by Hi-C sequencing. The assembled Pacific halibut genome (https://www.ncbi.nlm.nih.gov/assembly/GCF_022539355.2/) has a size of 602 Mb including 24 chromosome-length scaffolds that represent 99.8% of the complete genome assembly, with a N_{50} value of 27.3 Mb. In addition, genome annotation by NCBI (NCBI Hippoglossus stenolepis Annotation Release 101) yielded 27,944 genes. The generated genomic tools for Pacific halibut will be instrumental for generating management-relevant information on population structure, connectivity, adaptation and response to environmental conditions, fisheries effects, among others.

W7: BIO Topic Workshop
Anthropogenic stressors, mechanisms and potential impacts on Marine Birds, Mammals, and Sea Turtles

(W7 Invited 15562)

What evidence exists on the effects of anthropogenic habitats on Saunders's gulls breeding in South Korea?

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Some seabirds commonly use artificially reclaimed lands, which are frequently located next to mainland environments, for colonially breeding. Nest predation risk caused by birds or mammals from the mainland has negative impacts on fitness-related costs and distribution of colonial seabirds. Potential factors, specifically those related to nest predation and nest environment appeared to be linked with breeding performance and colony movements of the Saunders's gull (*Saundersilarus saundersi*), a vulnerable species, on a large reclaimed area in Incheon in Republic of Korea. This reclaimed area has experienced rapid changes in communities of nest predators from the mainland and vegetation ranging from halophytes to terrestrial plants after reclamation. High nest predation in a previous year induced colony movements in a consecutive year while the breeding colony exhibited a gradual reduction in clutch size. Such movement after high nest predation seemed to be irreversible due to ongoing habitat degradation caused by construction and vegetation alteration. Additionally, colonially breeding parents and nidifugous chicks might respond to such prey-predator interactions during the breeding season. This study highlights that high nest predation may exert strong pressure on breeding colonies of Saunders's gulls. Anthropogenic impacts from the reclamation of mudflats presumably act as an ecological trap, leading to repeated breeding dispersal of breeding colonies for this vulnerable seabird in a reclaimed land.

(W7 Oral 15791)

New insights into microplastic ingested by the walleye pollock from the Bering Sea

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Microplastic is a globally concerned pollution problem with unknown impacts on our ecosystem. There is a large knowledge gap regarding the impact of microplastics on fish. We analyzed the occurrence of microplastic ingestion by Walleye walleye pollock, *Gadus chalcogrammus*, with varying ages from the Bering Sea. We observed an exponential increase in microplastic ingestion by pollocks from 2+ to 12+ age(W7 Oral 15791) groups, with overall abundance ranging from 0 to 14 item/individual, providing evidence for age-related accumulation. There is a positive linear relationship between fish age and microplastic size distribution, but not the shape or color. Rayon, polyethylene, and polyethylene terephthalate are dominant polymer types. The number of polymer types have a tendency to increase with increasing age. Our work provides insights into the risks of microplastic ingestion on fish populations. Our results also show that as a potential sink of microplastics, the Arctic Ocean needs further attention.

(W7 Oral 15258)

Geographical difference of marcury pollution across seas in the western tropical-subtropical Pacific shown by a pelagic seabird

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Individuals of a species of pelagic seabirds spend non-breeding period in the separate areas so can be an indicator of regional variation of marine pollution. Streaked Shearwaters *Calonectris leucomelas* breed in Japan but spend non-breeding period in 3-4 seas in the subtropical NW Pacific. We put geolocators on 140 birds breeding at Awashima Japan in 2019 and 2020 and recovered 105 in the following years. We mapped non-breeding areas of individuals and related these with the mercury (Hg) in their tai-feathers that replaced during non-breeding. We also measured the corticosterone and scars of the tail-feathers as indices of stress level during the non-breeding period. Individuals spend non-breeding period either in the South China Sea (SCS), the Arafura Sea (AFS) or the Pacific Ocean north of New Guinea (NNG). Contents of total mercury in the tail-feathers were higher in SCS birds than others. Both of bulk $\delta^{15}N$ and compound specific $\delta^{15}N$ (baseline) of tail-feathers was higher in SCS birds than AFS birds, indicating that the trophic level was similar between birds in SCS, AFS, and NNG. Indices of the stress level did not differ between birds spending non-breeding period in these seas. These demonstrate the usefulness of a pelagic seabird species as indicator of regional variation of pollution and its impact across oceans.

(W7 Oral 15595)

"SEAturtle" PICES special research project (2019-2023): What we learned on sea turtles of Jeju Island for the last 4 years and what we should do in future

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PICES special research project "SEAturtle" launched in 2019 to understand the ecology of sea turtles around Jeju Island in relation to environmental stressors. Though COVID 19 had interrupted the project, we had quite a successful outcome over the last 4 years. Until now (June 15, 2022), a total of 12 iridium transmitters were deployed on sea turtles bycaught or rescued in Jeju Island (10 on green sea turtles and 2 on loggerhead sea turtles). Among them, we received the signals successfully from 11 sea turtles. We found that quite a proportion of green sea turtles (N = 4 out of 9, approx. 40%) overwintered in Jeju Island even in the cold sea where the temperature dropped to 15 °C. The diving duration increased to 6 hrs and 50 min with decreasing temperature. Most of migrating green sea turtles (N = 3) traveled toward southern Japan which suggests a strong link to the population in Japan. However, our population genetics result on green sea turtles stranded suggests that a subunit of Jeju population also have an affinity to southern China. On the other hand, one of our loggerhead sea turtles moved westward but the other moved southward from Jeju Island, suggesting that they may also have connectivity to Japan and China. We also have actively worked on the threat of plastics on Jeju populations and found that derelict recreational fishing gears might cause more serious problems than commercial derelict fishing gears. To conserve the population of sea turtles in Jeju Island, we need further extensive research such as stable isotope analysis to infer the origin and should keep up international cooperation.

(W7 Oral 15712)

Effect of anthropogenic noise on the whistle production of Indo-Pacific Bottlenose dolphins (*Tursiops aduncus*) in Jeju Island, Republic of Korea

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Dolphin vocalization mediates complex social behavior and navigation while obtaining environmental information. Additionally, recent studies have shown the effects of both natural and anthropogenic ambient noise on the whistle production of dolphins. In Alinement to increased anthropogenic activities such as inshore wind power plant development and dolphin tours on the coast of Jeju Island, the study of acoustic signals in a Indo-Pacific Bottlenose dolphin (*Tursiops aduncus*) population and understanding the effect of anthropogenic noise is crucial in the marine animal conservation. The whistle characteristic of the T. aduncus population in Jeju Island was measured to understand the Jeju population. Whistles occurred in the frequency range of 0.011-23.34 kHz (mean 6.75-11.7 kHz) with durations of 0.32 – 1.86 s to further investigate the changes in whistle production. In addition, the effect of concurrent natural and anthropogenic ambient noise was examined on the whistle production (the broadband signal (20 Hz–24 kHz) and one-third-octave band levels centered on frequencies from 20 Hz to 22.4 kHz). The linear regression analysis indicated that the minimum frequency had a significant positive relationship with the ambient noise at the time of the whistles. Also, increased anthropogenic noise mainly caused by dolphin-watching vessels below the dolphin's call bandwidth resulted in shifting up of the produced whistles on the minimum frequency and reduced whistle repetition. The noise-induced change in dolphin acoustic behavior may reduce the overall effectiveness of communication and may result in group separation and significant loss of energy in efforts for group cohesion.

(W7 Oral 15713)

The behavioral effects of tour boats on Indo-Pacific bottlenose dolphins in Jeju Island, Republic of Korea

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In Jeju Island, the Republic of Korea, boat-based dolphin-watching tourism for Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) was introduced in the mid-2010s. The encounter rates of boats and dolphins reach up to 80 % in a specific area, and the number of dolphin-watching companies is constantly increasing. This study looked into the effects of boat-dolphin encounters in the Deajeong area from March 2019 to August 2020. We observed the behavioral changes and activity budget of dolphins, dolphins' use of the coastal regions, and the shift in the group composition according to the presence or absence of tour boats. The activity budgets for foraging decreased, and traveling and socializing increased to the tour boat presence. Markov chain analysis revealed that dolphins were less likely to stay foraging in the presence of tour boats and were more likely to begin traveling. Although the distance from the shore used by dolphins did not significantly change, the tour boat's movement trapped the dolphins between the coast and the boat itself. The group cohesion was also found to be significantly disturbed. The tour boat presence increased dolphins' tendency to act individually, dispersing the group or not forming a cohesive group by scattering over the area. These behavioral responses likely have energetic costs for individuals, resulting in population-level impacts. Dolphin-watching regulations beyond a by-law, including specifics such as a fine for negligence, are urgently needed to minimize potential long-term impacts on this small and distinct population.

(W7 Invited 15676)

Microplastic pollution in Monterey Bay: from water to whales

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Monterey Bay National Marine Sanctuary (MBNMS) is a 15,000 km2 region off the central California coast home to vibrant fisheries and ecotourism. It is also a global hotspot for charismatic predators including whales, sharks, turtles, and seabirds. Recent research has found microplastics in the sanctuary's epi- and mesopelagic waters, as well as in several components of the marine food web. Nevertheless, the research has been patchwork and monitoring plans are lacking. Piecemeal research with unharmonized methods makes it challenging to assess temporal changes or detect ecosystem effects of this debris. In this presentation, I will review the research being done on microplastics in MBNMS and discuss ideas for trends and effects monitoring to track this emerging stressor.

(W7 Oral 15774)

Litter and microplastics monitoring in the Arctic under the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP) and links with PICES

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Litter and Microplastics have been identified as a priority for collaborative action under several Arctic Council Chairmanships, past and present. In response to this several of the Arctic Council's working groups have undertaken litter and microplastic reviews of knowledge and assessments to better coordinate future efforts. More specifically, the Arctic Council's Artic Monitoring and Assessment Programme (AMAP) has formed the Litter and Micropalstics Expert Group (LMEG) to develop guidance and recommendations for monitoring efforts. In the spring of 2021, AMAP released the Litter and Microplastics Monitoring Plan that aims to provide recommendations that will lead to a coordinated Pan-Arctic monitoring program that will collect information for future assessments. In the summer of 2021, AMAP also released the Litter and Microplastics Monitoring Guidelines, a technical document that reviews litter and microplastics protocols and research techniques. Given that the AMAP and the PICES regions overlap in the North Pacific, it is critical that monitoring efforts are aligned and coordinated in order to better understand large scale, ocean basin wide patterns across the north Pacific. Additionally, efforts need to be coordinated with global monitoring efforts so that any data from the North Pacific can contribute to global monitoring efforts.

(W7 Oral 15597)

The designated shipping avoidance area around St. Lawrence Island, northern Bering Sea, is not sufficient to protect foraging habitat of the island's breeding seabird community

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One direct consequence of Arctic warming is the expansion of navigable portions of the Arctic Ocean. As a result, vessel traffic and the accompanying threats of spills, strikes and disturbance is intensifying throughout the Arctic. In the Bering Sea, these threats to the environment, wildlife and to the people who rely on marine resources for food and cultural continuity, are acute. We examined the spatial relevance of an Area To Be Avoided (ATBA), a shipping-risk mitigation measure, established around St. Lawrence Island with respect to seabirds, as sentinel species, habitat use. We studied four seabird species (common murre Uria aalge, thick-billed murre U. lomvia, crested auklet Aethia cristatella, black-legged kittiwake Rissa tridactyla) breeding at St. Lawrence Island in the northern Bering Sea. GPS tracking data from 47 at-sea foraging trips showed that both murre species and

crested auklets distributed outside the ATBA, during at least one stage of the breeding season. Habitat modelling further showed that the birds' most suitable marine habitats were associated with seasonal surface chlorophyll blooms, and largely extended beyond the ATBA on the shelf north of the island. Data on the murres' diet and diving behavior emphasized the importance of the shelf as a foraging habitat for these birds. We suggest that extending the ATBA to the north by only 35 km, would include areas of maximal habitat suitability. This extension would better protect seabirds, their foraging habitats and the cultural continuity of St. Lawrence Islanders, against growing threats stemming from Arctic warming.

(W7 Oral 15591)

Unraveling the migratory mysteries of North Pacific loggerheads using experimental oceanography

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North Pacific loggerhead turtles, *Caretta caretta*, undergo one of the greatest of all animal migrations, entering the sea as hatchlings from nesting beaches in Japan and appearing years later along foraging grounds off Baja California, Mexico. Yet the mechanisms that connect these distant habitats have remained poorly understood. Our research group analyzed 15 years of data from satellite-tagged juvenile loggerheads released in the Western and Central North Pacific (CNP). An outcome of this work was the Thermal Corridor Hypothesis (TCH) which we will test starting in 2023 by deploying cohorts of satellite-tagged loggerheads in the Eastern North Pacific across four years of variable environment conditions. The juvenile turtles for this experiment will be reared by the Port of Nagoya Public Aquarium (PNPA). The TCH proposes a mechanism for habitat connectivity that results in intermittent pulses of loggerheads shifting from the CNP high seas to waters near Baja. Our team conceived the TCH after combining remotely sensed oceanography data and satellite tracks of six juvenile loggerheads that formed part of a 15-year dataset of 231 PNPA turtles tracked from 1997-2013. Rather than remaining in the CNP, these six continued eastward through a biogeographic barrier that typically prevents marine organisms from passing. In combination with stable isotope analyses, evidence showed higher recruitment of loggerheads to Baja is likely a function of exceptionally warm oceanographic conditions. Our forthcoming experiment will promote a better understanding of endangered loggerheads and their habitats confronted by climate change.

(W7 Oral 15579)

Using bioenergetics to assess impacts of prey loss due to climate change on Pacific Coast Feeding Group grey whales

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Climate change and marine heatwaves threaten many coastal ecosystems—and may explain the recent poor body conditions of grey whales belonging to the Pacific Coast Feeding Group (PCFG) population. The PCFG grey whales are a small (~230 individuals) endangered population that cut short their northbound migration from Mexico to feed in the coastal waters of the Pacific northwest during the summer rather than migrating to the Arctic foraging grounds used by the majority of the Eastern North Pacific (ENP) population (~20,000 individuals). One means to gain insight into the potential impacts that climate change may have on marine mammal populations is to pair bioenergetics models with climate models. We have begun parameterizing a novel bioenergetics model with field energetics data from foraging grey whales to calculate energy requirements for the PCFG population. Subsequently pairing this model with climate change projections of benthic productivity will allow us to assess how changes in the quantity and quality of prey affects the ability of the population to meet their energy needs in the future. Comparing consumption estimates for the PCFG to existing estimates for the ENP population will further contribute to understanding how climate change will affect the energetic tradeoffs between the Pacific northwest and Arctic foraging grounds. Combining energy needs with projections of prey availability is a promising means to predict the impacts of climate change and other anthropogenic stressors on marine mammals.

(W7 Oral 15754)

Impacts of anthropogenic stressors on killer whales. How much is too much?

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Southern resident killer whales are specialized fish-eaters that are listed as endangered in Canada and the United States. Increased human use of the coastal waterways for fishing, shipping, transportation, and recreation—as well as the continued flow of contaminants into the ocean and food webs—are all considered threats. Hypothesized reasons for the low numbers of southern resident killer whales include prey shortages (possibly caused by fishing), habitat degradation and loss of feeding opportunities (due to underwater noise and vessel traffic), and compromised health (caused by bioaccumulation of pollutants) that may reduce pregnancy and survival rates. However, none of the data collected to date have been able to link these hypothesized stressors to population size—and no direct mechanistic links have been demonstrated between these stressors and killer whale vital rates. Nor is it known to what extent killer whales and other marine mammals can compensate and adapt to changes before reaching critical thresholds. Such shortcomings have led many to question whether the endangered status of southern resident killer whales can ultimately be linked to a proximate cause—or whether their status reflects the cumulative effects of multiple stressors and is therefore untestable. One way to resolve this may be to use the available data to develop simple conceptual models that asses the likelihood of different anthropogenic stressors having actual impacts on killer whales and other mammals—and thus a quantifiable means to ultimately determine "how much is too much anthropogenic stress?"

(W7 Oral 15749)

Modelling the long-term impact of oil spills on mammals and seabirds using Salish Sea Atlantis

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A wide variety of marine mammals and seabirds are directly dependent on the marine habitat and ecosystem of the Salish Sea. However, an increasing number of these groups have been listed as species of concern by Canadian and US regulators, mainly due to a combination of population growth, habitat modification, and climate change. Additionally, the Salish Sea is a major transportation route for oil including local delivery and shipments from and to oil refineries. Oil spills have been shown to have large impacts on seabirds and marine mammals due to the combination of toxic impacts of oil exposure, fouling, physical disturbances, behavioural changes and in-direct effects through the food web. These effects include bioaccumulation and lack of prey or increases in predators due to impacts on those species. A whole-ecosystem Atlantis model has been developed for the Salish Sea that allows us to explore the direct and indirect effects of contaminants on the ecosystem. We used Atlantis, forced with time-series fields of water currents, temperature and salinity from the SalishSeaCast NEMO Model, and oil spill trajectories using the Ocean Parcels toolkit, to examine the impact of oil spill scenarios on Salish Sea ecosystem. For this workshop, we explore the potential long-term impacts of point source hydrocarbon contamination on seabirds and mammals represented in the Salish Sea Atlantis model, including resident and transient orcas, harbour seals, and humpback whales.

(W7 Oral 15704)

Exposure risk for alcids from marine vessel associated oil pollution in Western Canada.

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Oiling risk from increased vessel traffic and port developments has been identified as an increasing threat for marine birds in Western Canada. We focus on the Family Alcidae as they are particularly vulnerable to oiling because of the diving foraging mode and tendency to form large groups on the ocean. We compile available historic (1990 onwards) and current at-sea data from point counts and vessel-based strip transects for Marbled Murrelet, Rhinoceros Auklet, Common Murre, Pigeon Guillemot, Ancient Murrelet as well as Tufted Puffin and Cassin's Auklet during Spring-Summer (April-September). Within the Western Canadian marine Exclusive Economic Zone (EEZ) we quantify the risks to birds from ship source oil pollution and pollution associated with coastal marinas, terminals and ports. We examine the degree of interaction between the alcids and risk from oil exposure using a hexagonal geospatial grid system for the entire BC coast. Bird densities and risk of oiling are represented together for each hexagon, supporting co-occurrence analyses to identify subregions of potential conflict on larger scales. Marbled Murrelet are widely distributed at low densities. They are birds of fjordland and are more vulnerable oil in coastal inlets than other alcids. Common Murre and Rhinoceros Auklet are among the most vulnerable in coastal regions of the EEZ. Rhinoceros Auklet, Tufted Puffin, Ancient Murrelet and Cassin's Auklet distributions are most vulnerable near breeding colonies. Pigeon Guillemot are widely distributed at low densities close to shore.

W8: HD/FUTURE Topic Workshop
Science Communication Training Workshop 2022: How to Create Memorable PICES Science Stories

(W8 Invited 15645)

Science Communication Training Workshop 2022: Learn how to Share our PICES Science with the World in an engaging way

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Ocean scientists, including PICES members, usually do amazing science, and often feel that their results speak for themselves. But many scientists are eager to learn new ways to communicate their work in a way that is more compelling and interesting for all audiences. Therefore, this workshop is the first in a series organized by the Science Communications Advisory Panel (**AP-SciCom**). Participants will become familiar with the proven ABT (And, But, Therefore) method of communicating science, and develop skills needed to broaden the social impact of our science. This first session of a series of workshops will provide participants with: 1) a general introduction highlighting important communication skills for ocean scientists, 2) tools for communicating the written word through the ABT method, and 3) an opportunity to develop written content or ideas for video content for the PICES website. During the first part of the workshop (day 1), participants will learn theories and concrete techniques, and during the second part (*optional* day 2, morning), will be given an opportunity to practice the ABT method: to create, share the communication outputs and receive a critique of their work. Stories will be shared with the broader community through various online channels such as PICES Twitter and website as tangible outputs of this workshop.

W10: SB/TCODE/MONITOR/FUTURE Topic Workshop
Openly Discoverable, Accessible, and Reusable Data and Information in the U.N. Decade

(W10 Invited 15745)

Data Coordination Across Government, Private Industry, and Non-Profit Entities: increasing access through the U.N. decade

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Data and information will be key enablers of the United Nations Decade of Ocean Science for Sustainable Development. Digitizing, preserving, managing, and exchanging a significantly increased volume and range of ocean-related data, information and knowledge will be cornerstones of the success of the Decade. To coordinate the collaboration between the vast number of partners that will contribute data to, as well as use data and products from the "digital ecosystem", an "Ocean Decade Data Coordination Platform" has been established. The UN body responsible for coordinating the UN Decade of Ocean Science for Sustainable Development (2021-2030, 'the Ocean Decade), the "Data Coordination Group" (DCG) brings together 25 experts from 12 countries. These experts represent various industries, fields and stakeholder groups who will work to reinforce and focus efforts to significantly enhance ocean data and information over the course of the Decade. Additionally, increasing and strengthening public-private partnerships and finding innovative ways to inspire the sharing of knowledge and data will help to move us towards our goals for a sustainable future.

(W10 Invited 15773)

China's practice on marine big data management and sharing

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Ocean data resources play a crucial role in understanding and utilizing the oceans, providing important support to ocean resources exploration, ocean economic development, ocean ecological and environmental protection and international ocean governance. With the rapid development of ocean observation technology and information technology, the ocean has also ushered in the era of big data, how to apply big data thinking to multi-source heterogeneous data resources management, to reveal the temporal-spatial historical law of the ocean, predict the future change of the ocean, promote researches on the physical mechanism of the ocean, and provide high quality information service and decision making support to ocean related works, has become the main trend of marine big data management and application development. This talk will briefly introduce our understanding of big data and marine big data, then take the marine data life cycle as the chain, combining the actual application cases, to introduce China's practices on marine big data acquisition, management and application.

(W10 Invited 15566)

Lessons learned from TCODE metadata federation activities

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PICES does not manage substantial funds and only coordinates national efforts in the area concerned. Marine science is an observational science. Collected and modeled data are essential components for the development of knowledge there. Thus one of the PICES objectives is to promote the collection and sharing of data. PICES community is dealing with "small science" and recently with "besides science" data. PICES has no own data management infrastructure, and expert groups are responsible for providing access to generated data using open data sharing tools, facilities, and standards. Since its establishment, TCODE focuses on implementing national data holdings inventories and metadata exchange. TCODE made available a catalog service for publishing and maintaining metadata descriptions of data, information, and services. Metadata may include links to data sets, related information, and services. Searchable metadata catalogs allow directly assessing characteristics of a resource and preliminary evaluation of its suitability. Initially, the PICES metadata federation project was funded. During that period, a TCODE team accumulated more than 4000 metadata records from all six PICES countries. Then when the service was aimed exclusively at supporting self-sustaining metadata sharing, it gradually became just storage for these sometimes outdated records. Everybody understands the importance of open data access for integrative projects. However, for most PICES members, the data sharing remains a "burdensome, time-consuming, unrewarded" part of their professional activities. Using the U.N. Decade as a cause, TCODE should grab the attention of GC and SB to the issue, analyze its own experience, status quo in participating countries, and numerous recommendations of international organizations for improvements in open data access. Also, it could collect feedback on the data-sharing issues through surveying, update existing data policy, make researchers aware of available tools for publishing and searching data, and monitor progress.

(W10 Invited 15751)

Mobilizing international salmon data from open ocean to open access

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Rapid access to salmon ecosystem data remains a critical barrier to advancing the state of knowledge and implementing effective management. Data mobilization – the process of making data available for appropriate re-use – is essential to support interdisciplinary studies and inform long-term management scenarios. Improving data mobilization efforts can facilitate data sharing, longevity, citation, synthesis, meta-analyses, and management-decision support tools. The International Year of the Salmon High Seas Expeditions in 2019, 2020, and 2022 set out to investigate factors impacting salmon early marine survival. This international collaboration represented a significant challenge and opportunity for data mobilization efforts due to the scale, volume, and diversity of data and stakeholders. The Hakai Institute partnered with the North Pacific Anadromous Fish Commission to develop a strategy to mobilize the data collected. Given the international nature of the project, a natural alignment to the United Nation's Global Ocean Observing System was realized. Under this framework, metadata records were published to a web accessible data catalogue developed using federated architecture. Technical and sociocultural barriers to data mobilization were addressed by implementing data sharing policies and a standard data template in an effort to improve data accessibility, interoperability and citation practices. By adopting and implementing existing community and international standards, the goal was ensuring that the data adheres to the FAIR Data Principles, allowing integration across data disciplines and geographic zones, both on a project and global level. Sociocultural solutions and technical infrastructure developed lay the foundation for local and international salmon data exchange into the future.

(W10 Invited 15807)

Oceanographic data and information sharing towards goals and outcomes of the UN Decade of Ocean Science

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Effective sharing of oceanographic data and information is with no doubt essential for the successful implementation of the UN Decade of Ocean Science for Sustainable Development (2021-2030) (The UN Decade). It directly contributes to one of the societal outcomes of the UN Decade, 'Transparent and accessible ocean', through establishing a further improved data and information sharing under close collaboration among international organizations including PICES, programmes and projects. International Oceanographic Data and Information Exchange (IODE), a project of the longest history of The Intergovernmental Oceanographic Commission (IOC), has been developing the Oceanographic data and Information System (ODIS) (**https://odis.org/**) over the last couple of years to well meet requirements of data and information sharing in the implementation of the UN Decade, in particular to improve accessibility and interoperability. IODE has also promoting a technical project 'Ocean InfoHub (OIH)' (**https://oceaninfohub.org/**) to enable a wide variety of users and partners in the implementation of the UN Decade to discover ocean-related data, data products, data services, information services and products based on the initiatives of ODIS. As PICES is one of the key organizations in promoting marine sciences, particularly those in the North Pacific, it is required to further enhance cooperation between PICES and IOC/IODE in developing improved data and information sharing system(s) towards the common goals of the UN Decade.

POSTERS

S1: Science Board Symposium
Sustainability of Marine Ecosystems through global knowledge networks during the UN Decade of Ocean Science

(S1 Poster 15523)

The Alaska Ocean Observing System: Critical Research Infrastructure for a Rapidly Changing Arctic

Sheyna Wisdom, Carol Janzen, Molly McCammon, Jill **Prewitt**, Darcy Dugan, Thomas Farrugia and Holly Kent

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The Alaska Ocean Observing System (AOOS), part of NOAA's Integrated Ocean Observing System (IOOS), serves stakeholders in Alaska with ocean and coastal observations, network facilitation, data access and management, and information products. AOOS actively works to fill information gaps in an environment that is often challenging due to harsh weather and lack of infrastructure by working with Federal, state, industry, tribal and non-profit partners to demonstrate technologies and applications that meet observing needs. Innovative platform solutions deliver real-time surface currents, sea ice, water level and weather data in remote areas. These observing platform solutions not only respond to Alaska's needs, but have applications across the greater Arctic and in other remote regions. AOOS has also played a vital role in supporting the Alaska Ocean Acidification Network and Alaska Harmful Algal Bloom Network to engage with scientists and stakeholders to expand the understanding of ocean acidification and harmful algal blooms in Alaska. These successful networks will serve as a model for future networks such as a newly-forming Alaska Ecosystem Network. In addition to making significant investments in observations and networks, AOOS is dedicated to making data available through its publicly-accessible Ocean Data Explorer Portal and topic-specific tools and dashboards. These allow users access to a multitude of data resources and mapping tools that can display data as combined geospatial data layers and both historical and real-time sensor data streams. Ongoing investments will be needed to keep standing systems operational and to continue innovative technology trials in order to expand observing capacity.

(S1 Poster 15608)

Consistent seabird migration route across years and populations reveals key areas for marine conservation in the North-western Pacific

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Marine predators can highlight, through their at-sea distribution, areas with particularly intense ecological interactions in marine ecosystems, such as the production or aggregation of forage species. Predators can thus be used as a bio-indicator of such ecologically- or biologically-significant areas to inform conservation planning. However, it is required to examine repeatability in these habitats' use by the predators, both among years and populations, to assess whether these areas are regionally important indeed in terms of ecosystem functioning. In this study, we used light-based geolocation loggers to track rhinoceros auklets (*Cerorhinca monocerata*) during their annual migration, from three populations in northern Japan (Sea of Japan and western Pacific sides) across one to seven years. 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, spatial overlap analyses across years and colonies showed that the three populations had similar at-sea distribution core areas. Finally, predicted levels of 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 two highlighted areas are important because they are consistently used by the auklets, across years and populations. Considering the globally significant bird numbers in this region and the threats to these birds there, we provide the scientific basis to flag these areas as regionally important for the conservation of marine ecosystems in the North-western Pacific.

(S1 Poster 15663)

How fisheries/marine science looks like in the past, present and future: from an ECOP's perspective in 2022

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This talk describes the interface of science, policy and public interest around ocean sustainability using a case study of Japan. Three kinds of data will be shown: 1) scientific performance of Japan Fisheries Research and Education Agency (JFRA), a national fisheries research organization in the country, 2) policy papers published by Ministry of Fisheries, and 3) public interest around fisheries through public inquiry log accumulated at JFRA. Combining the content analysis of peer-reviewed papers (N=2110), corresponding analysis of key words representing the fisheries policy priorities over the last three decades (1989-2018) and content analysis on public inquiry log (N=7572), it was indicated that JFRA's science was originally a part of fisheries policy, and both science and policy were inherently based on the fisheries practices in the real world, however, recent 15 years' performance of JFRA has heavily focused on bio-physical dimensions of fisheries science. Analysis of policy papers indicated that Japanese fisheries policy priority has shifted from relatively simple keywords focusing on primary fisheries production to more complex, multidimensional fisheries systems over the last three decades. Analysis on public interest indicated that public fisheries/ocean literacy seems limited, strongly caring about resource availability but without enough attention on marine ecology, stock status, fishery sector participants and fishing communities in spite of the inherently close relationship among fisheries science, policy and resource users since long ago. Based on the results, this talk suggests some of the future functions that national fisheries/marine research should consider to gain, such as 'reconnector' between direct fisheries stakeholders and wider indirect stakeholders (general public) for the ocean sustainability. The discussion will be also enriched by the experience as an ECOP engaged in various initiatives in/outside of PICES.

(S1 Poster 15737)

Development of the maximum specific rate of photosynthesis algorithm: a case study for the Atlantic Ocean

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In this study we considered the seasonal and spatial variability of the maximum specific rate of photosynthesis (assimilation number, P^B_m), which describes the photosynthetic abilities of marine phytoplankton. Based on ship (*in situ*) data from the global database of the photosynthetic curve parameters (PANGAEA), the dependence of P^B_m on Sea Surface Temperature (SST) and chlorophyll-a concentration (Chl-a) in the surface layer (0-30 meters) for the period from 2002 to 2013 was analyzed. The strongest relationship between P^B_m and SST (r=0.82, p-level<0.01) was observed in winter (December), while in spring and summer (March-August) the relationship was moderate (r=0.30, p-level<0.01), and there was no correlation between the parameters in fall. The relationship between P^B_m and Chl-a was strong only near the Grand Banks of Newfoundland (r=-0.61, p-level<0.01). We revealed a connection between P^B_m values with the growing season of marine phytoplankton and compared regional features and the range of P^B_m variability: during spring bloom P^B_m values varied in a wide range, decreased over the summer and reached their minimum in fall, the maximum values were observed in winter. In addition, well-known algorithms of P^B_m as a function of seawater temperature have been reviewed and validated: they showed a significant correlation with *in situ* data (r=0.44-0.81 at p<0.01). Moreover, due to the necessary to take into account the seasonal and regional variability of P^B_m the new empirical algorithms were developed. These new algorithms showed a better performance compared to the other algorithms.

S3: POC/TCODE/FUTURE Topic Session
Realizing scalable artificial intelligence in marine science

(S3 Poster 15654)

Analysis of water quality fluctuations in Estuary using a Random forest

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Lake Shinji, a semi-closed brackish lake located on Shimane Prefecture in Japan, is registered under the Ramsar Convention in 2005, and are attracting attention for their rich natural environment such as biodiversity. And Lake Shinji is the largest producer of the *Corbicula japonica* in Japan. Recently, in the center of Lake Shinji hypoxic water masses have occurred frequently in the bottom layer, and it has been damage to production of the *Corbicula japonica*. In this study, we performed statistical analysis using long-term water quality data collected in the Lake Shinji. It is known that dissolved oxygen in the bottom layer is affected by the bottom layer salinity and water temperature. Furthermore, based on a random forest model constructed for fluctuation in the bottom layer salinity and water temperature, it was confirmed that the bottom layer temperature is mainly tied to local air temperature. And the bottom layer of salinity is strongly affected by the inflow rate of the Hii River in the interval from 7 days to 4 days prior to bottom water measurement.

(S3 Poster 15717)

Seasonal to multiannual marine ecosystem prediction: Deep learning approaches

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Phytoplankton serve as the foundation of marine ecosystems and their services. They play a vital role in regulating the biological carbon pump efficiency and thus potentially have substantial impacts on future climate changes. Anticipating nonlinear dynamics of phytoplankton, however, has been a problem to be tackled. We used a deep-learning model based on convolutional neural network to predict phytoplankton biomass in coastal Large Marine Ecosystems (LMEs). The model was trained with Coupled Model Intercomparison Project phase 6 (CMIP6) multi-model data sets and the chlorophyll prediction skill of the model was evaluated by comparing with satellite ocean color data. We examine several critical components of deep-learning model and suggest practical aspects to construct deep learning architecture such as a various set of hyper-parameters, validation with quasi-reanalysis data and layer-wise designs. The model can skillfully predict seasonal to multi-annual variations of chlorophyll in selected LMEs. Explainable Artificial Intelligence (XAI) methods suggest the deep-learning model captured valid precursors and key features to predict chlorophyll fluctuations in targeted regions. Overall, this study demonstrates that data-driven deep-learning approach can be a complementary tool to dynamic biogeochemical forecast models with anticipated applications informing marine resource management relevant to phytoplankton food web.

S5: FIS Topic Session
Environmental variability and small pelagic fishes in the North Pacific: exploring mechanistic and pragmatic methods for integrating ecosystem considerations into assessment *and management*

(S5 Poster 15572)

Effects of spring-neap tides on the sea surface chlorophyll-a in relation to the Kuroshio path modulation during 2006-2021

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Tides are one of the most important hydrodynamic processes and have been proved their substantial effect not only on the sea surface but also in the ocean interior. A previous study using satellite data has suggested that the spring-neap tide results in variations of primary production with a fortnightly period in different areas, suggesting that the tidal mixing induced nutrient supply stimulate the phytoplankton increase. However, it remains unclear the fortnight Chlorophyll-a (Chl-a) modulations can also be seen in the south coast of Japan, where the Kuroshio nutrient stream transports vital nutrients for phytoplankton in the dark subsurface layers. Tidally driven mixing could be a critical process to inject these nutrients to sunlit layers. We analyze the relationship between the spring-neap tides on Chl-a variations during 2006-2021, including the latest Kuroshio large meander (KLM) since September 2017 to present. Furthermore, the duration of the 2017 KLM was the second longest after the KLM in 1975-1980. The satellite data was obtained from Copernicus Marine Service and TPXO9 Global Tidal Model is used to investigate the tides in wide regions along south coast of Japan. The objective of this study is to elucidate the fortnight tidal effects on Chl-a and their spatiotemporal variations associated with the Kuroshio path modulations.

(S5 Poster 15740)

Assessment for effect of climate regime shifts and extreme events on the spatial distribution of sardine, mackerels and saury in the Northwestern Pacific

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The effect of climate regime shifts and extreme events on the spatial distribution of sardine (*Sardinops melanostictus*), mackerels (*Scomber japonicus and Scomber australasicus*) and saury (*Cololabis saira*) in the Northwestern Pacific was analyzed. The materials of TINRO complex pelagic surveys in 2004-2021 from the "Marine Biology" and "Oceanography" databases, fisheries information and gridded SST, water temperature on 50 and 100 m and currents from the NEAR-GOOS project were used. Significant changes in the spatial distribution of these species in the Northwestern Pacific have occurred from 2013 to 2014. Since 2014, mackerel and sardine have been observed en masse in the waters available for Russian fishery, and since 2015 the main concentrations of saury have shifted eastward and northward. To the east of the Kuril Islands, the maximum mackerel biomass (4.74 million tons) was recorded in July-August 2015. The penetration of sardine and mackerels into the northern regions is associated with increase in their abundance, which is formed in the reproduction zone. Furthermore, changes in the water dynamics contributed to this redistribution: more northerly propagation of subtropical origin waters (Kuroshio branches and Isoguchi Jet) and weakening of the Oyashio current and its branches. Local events can also generate extreme anomalies affecting the migration routes and possibly changes in the abundance of short-cycle fish species such as saury. So, in 2015-2016 large and extremaly hot anticyclonic eddy located at the east off Hokkaido Island caused the shift in the autumn southern migrations of saury to the open waters.

S6: MEQ/FUTURE Topic Session
Using eDNA to assess and manage Non-indigenous species in the North Pacific

(S6 Poster 15788)

Invasion Success of *Ascidiella aspersa* (Chordata: Tunicata): A Population Genetic Approach predicts the Genetic Diversity of Populations Introduced in Korea

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Ascidiella aspersa (Müller, 1776) was first reported in the northeastern Atlantic and has recently become an invasive species in coastal waters worldwide. *A. aspersa* was found as an alien species at Tongyoung port in southern Korea in October 2010. Since then, this species rapidly spread out the many harbors in south-western and eastern coastlines and became more abundant than the native species on artificial structures of harbors in Korea, constituting a successful invasion. We explored its global population genetic structure using 153 COI sequences, including 82 Korean populations, obtained from genetic studies. We observed that 20 haplotypes diversity in the Korean population and confirmed that there are small but regional genetic differences between the Korean population. This study could help in understanding the genetic structure and invasive potential of alien populations, thus providing important insights into their managements.

(S6 Poster 15789)

Variation in genetics, morphology, and recruitment in the invasive barnacle *Amphibalanus eburneus* (Gould, 1841) in Korea

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The ivory barnacle *Amphibalanus eburneus* of the family Balanidae is a marine crustacean, which presents near-cosmopolitan distribution due to extensive introduction and exhibits a wide spectrum of phenotypic variation. Here, we investigated the genetic and morphological variation in *A. eburneus*, which has successfully settled in the Korean Peninsula since the late 1980s, to elucidate the processes of adaptive evolution through invasion. We amplified the mitochondrial genetic marker mtCOI and generated a haplotype network to visualize the population structure. We selected four populations representing all surrounding Korean waters and applied two-dimensional landmark-based geometric morphometrics to the scutum and tergum. Further, we estimated the density and plate occupancy of collected individuals to determine the difference in their habitat conditions among localities. We detected 35 haplotypes in four populations belonging to three distinct clades based on the moderate intraspecific pairwise distance (3.5%). The haplotypes in these clades did not distribute locality-specific. We detected interpopulation variation in the shape and morphospace structures, and one population could be separated from the rest based on its distinct morphotype of the tergum. This morphologically distinct population was also differentiated by displaying the lowest mean recruitment density and the level of plate occupancy. Our results indicate that there is no relationship between the level of the variation at the mtCOI gene and the level of variation in the operculum morphology.

S7: BIO/FIS/POC/FUTURE/HD Topic Session
Forecasting and projecting climate variability and change on northern hemisphere marine ecosystems using coupled next generation biophysical model

(S7 Poster 15538)

Oceanic and Atmospheric Drivers of Post-El-Niño Chlorophyll Rebound in the Equatorial Pacific

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The El Niño-Southern Oscillation (ENSO) strongly influences phytoplankton in the tropical Pacific, with El Niño conditions suppressing productivity in the equatorial Pacific (EP) and placing nutritional stresses on marine ecosystems. The Geophysical Fluid Dynamics Laboratory's (GFDL) Earth System Model version 4.1 (ESM4.1) captures observed ENSO-chlorophyll patterns (r = 0.57) much better than GFDL's previous ESM2M (r = 0.23). Most notably, the observed post-El Niño "chlorophyll rebound" is substantially improved in ESM4.1 (r = 0.52). We find that an anomalous increase in iron propagation from western Pacific (WP) subsurface to the cold tongue via the equatorial undercurrent (EUC) and subsequent post-El Niño surfacing, unresolved in ESM2M, is the primary driver of chlorophyll rebound. We also find that this chlorophyll rebound is augmented by high post-El Niño dust-iron deposition anomalies in the eastern EP. This post-El Niño chlorophyll rebound provides a previously unrecognized source of marine ecosystem resilience independent from the La Niña that sometimes follows.

(S7 Poster 15548)

Arctic sea ice concentration retrieval based on FY3 series MWRI sensors

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Sea ice as an important part of the global climate system, not only affects the atmosphere and ocean circulation, is also the important indicator of climate change. Sea ice concentration is one of the most important geophysical parameters to describe polar sea ice. In this study, the brightness temperature data of Microwave Imager carried by FY3 series satellites are used to retrieve the Arctic sea ice concentration. The characteristic value of daily reference brightness temperature is dynamically determined by linear regression and threshold method. The influence of weather and land pollution on the calculation of sea ice concentration is eliminated by using weather filter and land pollution correction method. The trend of sea ice extent and sea ice area calculated from 2019 to 2020 has a strong correlation with the sea ice concentration products released by NSIDC. The difference of sea ice concentration is less than 3% in winter and less than 8% in summer. The verification with SAR data shows that the retrieval result of Bootstrap algorithm is better than that of NASA Team algorithm. The accuracy is improved by about 1% in winter and about 4% in summer. This research has laid a foundation for the business release of sea ice intensive products of China's autonomous satellites.

Key words: Polar remote sensing, Microwave radiometer, MWRI sensor, Sea ice concentration, Arctic, Bootstrap algorithm

(S7 Poster 15669)

The role of stratification variability on biogeochemical properties across British Columbia's Queen Charlotte Sound shelf system

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Queen Charlotte Sound (QCS) is a broad shelf region on Canada's west coast that is highly biologically productive and hosts several Marine Protected Areas. However, ecosystems in QCS are becoming increasingly susceptible to climate change stressors such as marine heatwaves, ocean acidification, and deoxygenation. In this system, stratification plays an important role in setting the physical and chemical environment, thus impacting how climate affects the region, including its biogeochemical cycles and ecosystems. Here, a full year of sustained underwater glider observations in QCS are used to investigate how variability in stratification and cross-shelf exchange between the coast and open ocean influence the physical and biogeochemical properties in QCS. Specifically, we investigate how varying temperature and salinity contributions to density stratification set up distinct stratification regimes whose presence and spatial extent vary seasonally across the shelf. The seasonal stratification variability and the dominant drivers of these stratification regimes such as freshwater inputs, estuarine circulation, seasonally-varying atmospheric forcing, topographic steering through multiple troughs, and unique mixing regimes will be presented and discussed. Further, the influence of the varied stratification regimes on the spatial patterns of dissolved oxygen, chlorophyll and CDOM across the shelf will be characterized. The criteria used in this study to characterise the various dynamical regimes from coast-to-open ocean can be applied to other shelf systems. Lastly, we will discuss what these findings inform us about stratification in QCS in the context of climate change with increased riverine inputs, melting glaciers, increased precipitation and warmer waters.

(S7 Poster 15673)

Seasonal and interannual variability of the longwave radiation flux in the northwestern Pacific Ocean according to ERA5 reanalysis data

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The monthly average longwave radiation flux (LWRF) values (1998 – 2021) in the northwestern part of the Pacific Ocean (NWPO) and the Far Eastern seas are considered. It was revealed that the long-wave radiation flux, which expresses ocean heat loss, reaches the highest values in winter and autumn in the Sea of Japan, in the western part of the Sea of Okhotsk and the part of the NWPO adjacent to the eastern coast of Honshu Island. A narrow strip along the entire continental coast stands out especially in the autumn period; obviously, this effect is due to the northwestern offshore winds influence (winter monsoon). In winter, in areas north of latitude 48°, this phenomenon is less pronounced, probably due to the ice cover influence. LWRF minimum absolute values are observed in July, sometimes in August. LWRF spatiotemporal variability is well described by the first EOF mode, which spatial function values increase in absolute value from east to west. The variations of its time function are dominated by the annual variation with an amplitude of 0.4 W/m^2, the interannual variations are expressed in its low-frequency modulation. In winter maxima variations, the role of the three-year component, which manifests itself in the eastern part of the Sea of Okhotsk, is most significant. In summer minima fluctuations, the most interesting is the 11-year cycle, which influence zone is concentrated on the northern shelf of the Sea of Okhotsk and coincides with the manifestation area of the short-wave radiation flux similar component.

(S7 Poster 15683)

IPCC AR6 simulates the impact of climate change under different scenarios on the marine environment and cephalopods in the southern Eastern China Sea

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Cephalopods are high value in commercial fishery industries in Taiwan. Climate change events has substantial impacts on the catch and habitat of these species. However, in studies on cephalopods, such information remains poorly utilized, and its effects on cephalopod communities in the southern Eastern China Sea has not been well documented. In this study, we examined the habitat and spatial distribution of five commercial cephalopods using logbooks and voyage data from the commercial fishery vessels (2014–2019). Then, the time series trend of environmental variables under the latest global Shared Socioeconomic Pathways (SSPs; 1-19, 1-2.6, and 5-8.5) was examined. The results showed that mitre squid was mainly caught using light fishing (68%), whereas trawling was the main fishing method (38-84%) for the bigfin reef squid, pharaoh cuttlefish, golden cuttlefish, and octopus. Pharaoh cuttlefish and bigfin reef squid were mostly distributed in the northwestern Taiwan Strait (TS), whereas golden cuttlefish were distributed in the southwestern TS. While the mitre squid and octopus were mostly distributed in the coastal TS. The sea surface temperature (SST) in SSP1-2.6 and SSP5-8.5 were found to have significant changes compared with 2015-2020 and 2065-2070 in the study area. Furthermore, in the fishing grounds of Cephalopods, the average SST were changed from 23.5 to 25.0°C in the northwestern and 25.5 to 26.7°C southwestern TS, respectively. Future projections of commercial cephalopod distributions will be were predict by using different environmental factors with spatil distribution models under SSPs scenarios.

(S7 Poster 15700)

Predictability of Metabolic index in an Earth System model

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Climate change has caused shifts in the abundance, geographic distribution, and phenology of marine species. Spatial shifts of species due to global warming will cause high local-extinction rate and decrease fisheries catch and species richness at tropical latitudes. Predicting the migration of marine life to climate change is important not only ecologically but also economically in the management of marine living resources. However, understanding how the habitable area of species will change still remains a challenge. Using an Earth system prediction system, this study examines the predictability of the metabolic index that represents metabolically viable habitats. The metabolic index, defined with dissolved oxygen and temperature, generally has a higher predictability compared to temperature, particularly over the tropics. The high predictability of metabolic index is associated with the longer persistency of oxygen compared to temperature. The relative contribution of temperature and oxygen to the variability of metabolic index differs by region. In the western equatorial region, variability of metabolic index is more affected by temperature variability, whereas in the eastern equator, by oxygen variability.

(S7 Poster 15706)

Environmental impacts on fish catch in the Arctic/Subarctic EEZ assessed with reconstructed ocean biogeochemistry

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Ocean temperature in the Arctic region has risen three times than the global mean temperature. Sea ice has decreased, freshwater has flowed, and ocean acidification has progressed in the Arctic region. As a result, it is feared that the structure of the marine ecological food chain would change rapidly and biodiversity would decline. By using the data assimilative Earth system model outputs, this study investigated historical fluctuations in fishery resources in exclusive economic zone (EEZ) and their relationship with environmental drivers during the period 1970-2017. Bottom-up drivers, such as temperature, dissolved oxygen, and mesozooplankton production are used to evaluate the potential impact of bottom-up drivers on fish catch. A series of statistical analysis in the metabolic and thermodynamic aspects show that the variation in bottom-up drivers in the EEZ regions are associated with well-known climate variability patterns. These findings could be used for reliable projections of fish catch changes and provide a basis for the sustainable management of fisheries resources in the Arctic/Subarctic regions.

S8: BIO Topic Session
Recognizing the importance of zooplankton to fish*eries research*

(S8 Poster 15561)

Copepod community determined with metabarcoding analysis represents advection of with coastal waters to the Kuroshio

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Kuroshio and its neighboring waters have been known as nursery grounds for early life stages of various forage fishes, despite of a poor food availability under the oligotrophic conditions. Recent findings suggest that biological productivity in the Kuroshio is supported by zooplankton standing stocks advected with coastal waters. However, identification of coastal zooplankton is ambitious due to diminished changes of community structure under the variable ocean conditions. Here, we compare copepod community structures determined with metabarcoding analysis on water (eDNA) and net samples (zDNA) across the Kuroshio to identify copepods advected with coastal waters. We identified copepod community including 4 orders and 19 families from eDNA and 5 orders and 24 families from zDNA in the Kuroshio and its neighboring waters. Since copepods were the most predominant among sequence reads of zDNA different from those of eDNA, zDNA was likely representative for zooplankton community in the water column. Non-metric multi-dimensional scaling on copepod community determined with zDNA classified the three groups specific to the Kuroshio, coastal waters and their mixtures. Similarity of percentages demonstrated that representative copepods were large copepods like Eucalanidae, Metridinidae and Calanidae for the Kuroshio, and small copepods like Paracalanidae, Oithonidae and Calocalanidae for the coastal waters. These findings suggest that zDNA classify copepod community specific to the Kuroshio and coastal waters and thus identify copepods advected with the coastal waters.

(S8 Poster 15603)

Distribution and feeding habits of skinnycheek lanternfish *Benthosema pterotum* larvae and juveniles in Kagoshima Bay, southern Japan

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The skinnycheek lanternfish *Benthosema pterotum*, which belongs to the order myctophiformes, is a dominant species in Kagoshima Bay, southern Japan. This study aims to examine distribution and feeding habits of their larvae and juveniles in Kagoshima Bay and the adjacent area, southern Japan. Larvae and juveniles were collected in 2015 and 2021 by an ORI and LC nets, respectively. In the laboratory, the body length was measured. The prey composition was analyzed by microscopic and DNA metabarcoding analyses for their gut contents, and the nutrition sources and trophic level were estimated by stable isotope analysis. Larvae were mainly distributed inside Kagoshima Bay during summer. The highest abundance was 182 individuals per $10m^3$. Based on microscopic identifications, feeding rates of larvae and juveniles were 24% and 50%, respectively. A significant positive correlation was observed between larval body length and prey size (body width) ($P < 0.05$). Larvae and juveniles fed mainly on various life stages of copepods including nauplii. Metabarcoding analysis on gut content DNA detected a high percentage of calanoid copepods for larvae (29%) and juveniles (26%), and bivalves (26%) and appendicularians (19%) increased their importance for juveniles. Stable isotope analysis suggested that small and large-sized calanoid copepods would be main nutrition sources for larvae and juveniles, respectively, and there would be a clear difference in trophic level between larvae and juveniles. The present data shows that calanoid copepods are consistently important as prey throughout larval and juvenile stages although the diet composition and trophic level differ during the ontogeny.

(S8 Poster 15604)

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

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The northern Satsunan area, southern Japan is used as an important spawning and nursery ground for chub mackerel *Scomber japonicus*. We estimated growth and food requirement of *S. japonicus* larvae in the study area. Larvae were collected at 15 stations in the mouth of Kagoshima Bay and adjacent area using the ORI net for growth analysis in 2018 and 2019, and for estimation of food requirement in 2021. For growth analysis, *S. japonicus* larvae were identified by PCR-RFLP method. The effects of temperature and prey density on the recent growth rate (RGR) were analyzed using a generalized linear mixed model, which showed that only temperature positively affected the RGR of larvae. Food requirement was estimated for *Scomber* spp. larvae (*S. japonicus* and *Scomber australasicus*). The weight-specific growth coefficient (Gw) was 0.14 d^{-1}. Based on the reported relationship between Gw and ingestion rate of the larval fishes, the daily ration was calculated to be 0.52% of body dry weight d^{-1}. Mean and 95% confidence interval of food requirements was 0.05 ± 0.01 mg C m^{-2} d^{-1}. Predatory impact of *Scomber* spp. larvae on the production rate of mesozooplankton was estimated to be approximately 0.16–0.21%.

(S8 Poster 15607)

Protein synthetases activity of fish larvae appearing in the Kuroshio and its neighboring waters

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It has been thought that food availability for fish larvae was poor in the Kuroshio due to the low standing stocks of plankton in the oligotrophic conditions under the thermal stratification throughout the year. Despite of a potential risk or disadvantage for larval survival and growth, Kuroshio and its neighboring waters are nursery grounds for early life stages of various fishes. Here, we compared protein synthetases activities of fish larvae among 15 taxonomic groups appearing the Kuroshio and its neighboring waters based on protein synthetases activity and protein contents. Protein-specific ($_{sp}$AARS) and individual-based aminoacyl tRNA synthetases activities ($_{i}$AARS) and protein contents (PRO) of fish larvae were variable among the taxonomic groups and not classified between mesopelagic groups and the others. Significantly negative correlation was found for $_{sp}$AARS to PRO among all taxonomic groups. The correlation showed no significant difference between the Kuroshio and its neighboring coastal waters, indicating that growth activities to their body mass were comparable in the Kuroshio and its neighboring waters. Based on non-metric multi-dimensional scaling on their $_{sp}$AARS, $_{i}$AARS and PRO, two different groups were classified for fish larvae represented by high $_{i}$AARS under low $_{sp}$AARS to high PRO and low $_{i}$AARS under high $_{sp}$AARS to low PRO, meaning the different life strategies for larval growth. The present findings suggest that these biochemical indices are useful for evaluating growth activity of fish larvae among various taxonomic groups and food availability is enough for supporting their larval growth in the Kuroshio and its neighboring waters.

(S8 Poster 15766)

A field-based intercomparison of biochemical methods for measuring zooplankton secondary production off the coast of Vancouver Island

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Despite their role as key intermediaries in the transfer of energy from marine primary producers and higher trophic levels, surprisingly little is known about the rate at which zooplankton production ("secondary production") occurs in the field. Recent advances in the development of biochemical measures of secondary production rates include the chitobiase method, which provides in situ production rate estimates of crustacean zooplankton. The chitobiase method has been used along the west coast of Vancouver Island to characterize how zooplankton productivity varies with oceanographic conditions including recent marine heatwaves. However, chitobiase-based measurements are limited to crustacean zooplankton (e.g. copepods, krill) and cannot account for the contribution of non-crustacean zooplankton to total community production. Here we explore the efficacy of another biochemical technique which measures the activity of aminoacyl-tRNA synthetase (AARS) enzymes. The AARS method is a proxy measure that is not limited to crustacean zooplankton; however, its efficacy for mixed zooplankton assemblages is not well understood. Pairing these two methods in a field setting presents the opportunity to test both the accuracy of the AARS method and to measure the production rates of the non-crustacean zooplankton community. Preliminary depth profiles of particle distribution obtained using an Underwater Vision Profiler (UVP) from Ocean Networks Canada (ONC) will also be included to validate the distribution of large particles and zooplankton in the water column. Here we present preliminary results of the first field comparison of these biochemical estimates of zooplankton production rates and compare the relative contributions of crustacean and non-crustaceans to zooplankton production.

S9: BIO/MEQ Topic Session
The effects of ocean acidification and climate change stressors on the ecophysiology and toxicity of harmful algal species

(S9 Poster 15213)

Coastal HABs driven by kleptoplastidy and bi-species interaction along the *Teleaulax-Msodinium-Dinophysis* prey chain

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For the last thirty years South Sea of Korea has long been noted for the annually recurrent HABs by dinoflagellates (*Cochlodinium* and *Akashiwo*) and Raphidophyceae (*Heterosigma*) along with the getting-more-frequent blooms by the mixotrophic and kleptoplastidic ciliate, *Mesodinium rubrum*, since 2010. Recently, the ciliate blooms became the 4th most frequent HAB from the 11th one during 1990-2009. Without the plastid-donor species (mostly TPG-clade cryptomonads including *Teleaulax amphioxeia*) *M. rubrum* is not able to grow and form massive blooms. In turn, another HAB dinoflagellates in the genus *Dinophysis* which can cause DSP at low abundance (<10 cells ml^{-1}) need the obligate second-hand cryptomond's plastids from *M. rubrum*. Thus, spatio-temporally well-matched unique bi-species and tri-species interactions in the sea might be the key biological factor for the bloom formation by the mixotrophic ciliate *M. rubrum*, and the DSP dinoflagellates *Dinophysis* species. Among the original plastid-donors, *Teleaulax* species or TPG-clade cryptomonad species, intra- and inter-specific differences of the kleptoplastid functionality for *M. rubrum* and *Dinophysis* species needs to be further explored. Lastly, systematically tracking the spatial fates of the key species in the prey chain at reasonable time intervals could be crucial for the data-driven and sound prediction for the two HABs.

BIO-P

(BIO-P Poster 15529)

Helminths in the schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913) off the northern Kuril Islands

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Continental slope areas in the Pacific Ocean off the northern Kuril Islands is a traditional region for commercial trawl harvest for the schoolmaster gonate squid since the 1980s. Data on the squid parasites were collected on commercial vessel during September, 2021. A total of 103 individuals were collected from 18 trawl hauls. Freshly caught squids with dorsal mantle length 18-29 sm were analyzed. All helminths were located in digestive organs: stomach, pancreas, liver and intestines. Parasites were found in all squid individuals. Larvae from nine species of helminthes, which belong to 2 phyla, 2 classes, 4 orders, 4 families and 6 genera were observed.

The squid individuals were most heavily infected with a tapeworm *Phyllobotrium* sp., with extensiveness of invasion (EI) of 99.03%. This tapeworm was also the most numerous parasite, with the amplitude of invasion (AI) of 2–115 specimens per one squid individual, and the index of abundance (IA) of 33.75 specimens. Another tapeworm, *Nybelinia surmenicola*, was the second in occurrence helminth in *B. magister*, with EI 98.06%, AI of 1–15 specimens, and IA of 4.9 specimens. Two other species of tapeworms were less numerous, and with lower values of invasion parameters: *Pelichnibothrium* sp. EI of 0.97%, AI 1 specimens, and IA of 0.01 specimens, and *Tentacularia* sp. with EI of 3.88%, AI of 1-2 specimens, and IA of 0.05 specimens.

We have also found 2 species of anisakid nematodes, which total EI was 25.24%: *Anisakis simplex* (EI 19.42%; AI 1-6 specimens; and IA 0.32 specimens), and *A. typica* (EI 7.77%; AI 1-2 specimens; and IA 0.09 specimens.).

(BIO-P Poster 15586)

Attached bacterial community dynamics with changes in core phytoplankton species based on the phycosphere concept

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Variations in the attached bacterial communities according to changes in core phytoplankton species were analyzed in samples collected from the southern coastal waters of the Jangmok Bay, South Korea, from November 2016 to June 2017 (total investigation periods: 210 days). Samples were examined under microscopes (light microscope and Scanning electron microscope) and analyzed using metagenomic amplicon sequencing (16S rDNA V3-4 regions) methods. Seven core phytoplankton species were focused on during the investigation period. When the Dinophyceae *Akashiwo sanguinea* bloomed, *Rickettsia rhipicephali* (Alphaproteobacteria) was dominant and showed a significant correlation with *A. sanguinea* ($r = 0.92$, $p < 0.001$). An increase in *Cryptomonas* sp. (nanosized Cryptophyceae) was associated with '*Candidatus Limnoluna rubra*' (Actinomycetia) ($r = 0.50$, $p < 0.05$). When the Bacillariophyceae *Skeletonema marinoi-dohrnii* complex and *Pseudo-nitzschia delicatissima* were dominant, large populations of *Gilvibacter sediminis* (Flavobacteriia) and *Lewinella nigricans* (Saprospiria) were observed, but there was no significant correlation between the dominant phytoplankton and bacteria. Moreover, when the three diatom species, *Chaetoceros curvisetus, Leptocylindrus danicus*, and *Thalassiosira tenera*, were found together, the attached bacteria *Planktomarina temperata* (Alphaproteobacteria), *Crocinitomix catalasitica*, and *Lishizhenia caseinilytica* (Flavobacteriia) showed a high relative abundance. In particular, *L. danicus* showed a strong correlation with *C. catalasitica* ($r = 0.92$, $p < 0.001$). Therefore, we speculate that the advantages of attached bacteria living in the phycosphere are protection from outer environments and the opportunity to utilize the extracellular polysaccharide secreted by phytoplankton as an energy source. Thus, attached bacteria may contribute to the biochemical cycling between seawater and phytoplankton, and have a competitive relationship with phytoplankton for nutrients from seawater.

(BIO-P Poster 15587)

Spatial, vertical, size, and taxonomic variations in stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) of zooplankton and other pelagic organisms in the western North Pacific

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Stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) of zooplankton are useful keys for evaluating trophic levels of the organisms in marine ecosystems. While their importance, information on their spatial, vertical, size, and taxonomic variations are scarce. In this study, we evaluated regional, vertical, and size variations in stable isotopes of zooplankton at eleven stations in the western North Pacific. As regional differences, the highly significant regressions (p<0.0001) were observed for both the subarctic and transitional regions. However, the regressions were greatly varied with the region (p<0.0001, ANCOVA). For vertical changes in the stable isotopes, vertical observations from the sea surface down to 3000 m at five stations (29°, 31°, 33°, 37°, 41°N) showed that there were no significant changes in $\delta^{13}C$ throughout the stations. However, in $\delta^{15}N$, significant regressions which increased with increasing depths were observed only for the subtropical stations (29°, 31°, 33°N). Concerning size differences, size-fractionated zooplankton measurements on epipelagic zooplankton (0-200 m) along the latitudinal transect (29°-42°40'N) were made. Through this analysis, $\delta^{13}C$ was not varied with neither size nor latitude. On the other hand, $\delta^{15}N$ showed the clear size and latitudinal patterns. Thus, $\delta^{15}N$ values were increased with increasing zooplankton sizes (112 μm < 407 μm < 925 μm), and significant regressions increased with increasing latitudes were present for all three size classes (p<0.001). Subsequent ANCOVA revealed that the regressions were not varied with sizes. These regional, vertical, and size variations in stable isotopes may be induced by the taxonomic accounts.

(BIO-P Poster 15687)

Macrozoobenthos of river estuaries of Sakhalin Island

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All river estuaries of Sakhalin are divided into two types: 1) "whole" estuaries (southern part) and 2) estuaries of the northern part.

Estuaries of southern part are characterized by a complete set of estuarine elements in terms of water salinity: upper (oligohaline); middle (mesohaline); lower (polyhaline) estuary. The boundaries of zones are α-horohaline (5–7 psu) and β-horohaline (22–26 psu). The mesohaline zone is indistinct. The water column here is two-layered: the polyhaline lower layer and narrow mesohaline upper layer. In the polyhaline zone observed specific estuarine species (amphipoda *Haustorioides*, *Kamaka derzhavini*) and marine coastal species (polychaeta *Eteone flava*, *Nephtys neopolybranchia*, amphipoda *Allorchestes malleola*, *Cryptodius kelleri*, *Eogammarus possjeticus*, *Wecomedon minusculus*, and isopoda *Ianiropsis derjugini*). Typical representatives of the brackish-water fauna in the mesohaline part are the polychaetes *Hediste japonica*, amphipoda *Dogielinotus moskvitini*, *Jesogammarus annandalei*. The indicators of the oligohaline part are the Chironomidae *Monodiamesa bathyphila*, amphipoda *Eogammarus kygi*, and mysids *Neomysis awatschensis*. Bivalvia *Corbicula japonica* and shrimp *Palaemonetes sinensis* are common in the oligohaline part of relatively large rivers. An increasing of the biomass and daily production was noted in the upper part of the lower estuary and upper estuary zones, both.

The rivers of the northern part flow into lagoons, which play the role of the mesohaline and polyhaline parts. Estuaries are represented only by oligohaline zone. The basis of species composition here is formed by Diptera (Chironomidae), Oligochaeta. Cumacea are common here. Gastropoda, mainly *Cincinna tymiensis*, dominate in biomass.

(BIO-P Poster 15736)

Ecological characteristics of Zooplankton community in the Shengsi Sea Area of the East China Sea

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This article discusses the Ecological characteristics of Zooplankton community in the Shengsi Sea Area of the East China Sea. The ecological characteristics of Zooplankton and their adaptability to the environment were also considered. Oceanographic investigation was carried out in the Shengsi Sea Area of the East China Sea (30 ˚ 30 ‘ ~31 ˚ N and 121 ˚ 30 ‘ ~122 ˚ 42 ‘ E) in four seasons from 2016 to 2017. It was found that the total abundance showed obviously seasonal variations. It peaked in summer with a mean value of 475.88mg/m^3, followed by spring (116.13mg/m^3). The lowest value occurred in winter (15.94mg/m^3) and the mean biomass of Zooplankton was 168.62 mg/m^3. The seasonal variation of zooplankton abundance in Shengsi sea area is also obvious. It peaked in summer with a mean value of 94.93 ind./m^3, followed by spring (75.37 ind./m^3). The lowest abundance occurred in winter (15.63 ind./m^3).The mean density of Zooplankton was 55.30 ind./m^3. For the horizontal distribution, abundance in spring and winter was higher in the near shore than in the off shore, and other seasons were higher in offshore than in nearshore areas. The redundancy analysis results show the diverse correlation between the dominant species abundance and the environment factors of the four seasons.

(BIO-P Poster 15743)

Coastal reservoir utilization and estuarine restoration in Korea: recent cases and lessons

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Extreme events such as extreme drought and flooding due to climate change are increasing worldwide. These changes in land water resources and environments are closely linked to the coastal environment and have various effects on shaping the coastal environment and ecosystem. In Korea, water security and water resources management are important due to the characteristics of annual precipitation pattern with heavy rainfall in the summer. The estuarine delta developments have been performed with diverse cases since due to its high population density and many mountainous areas. Until now, a lot of efforts have been made to build and use coastal reservoirs through the construction of seawalls in the estuary area. Recently, however, with the increased awareness of the natural environment and the development of various engineering technologies, various efforts have been made to restore and use estuaries to promote land and ocean connectivity. The present presentation introduces various cases and characteristics such as Sihwa Coastal Reservoir with the world’s largest tidal power plant, Nakdong River Estuary disconnected by estuary dike for nearly 40 years, and several local marine ecosystem restoration cases. Through these cases, I would like to review the major status on implementation of coastal reservoirs and environmental restoration, and share related achievements and lessons for further consideration.

(BIO-P Poster 15755)

Counting calories: Energy density and lipid content of zooplankton in the Northeast Pacific

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Zooplankton are a major food source for many small pelagic fish species and marine mammals, representing a key link between primary producers and larger consumers in the open ocean. For this reason, quantifying energy proxies such as zooplankton lipid content can aid in the understanding of local food web processes. Oceanographic surveys have been undertaken in 2017, 2019, and 2021 within a DFO Area of Interest (AOI) for a future marine protected area off Canada's west coast. During these surveys zooplankton/micronekton net samples were collected to study zooplankton as a food source in this region. More specifically, frozen samples are being used to characterize variation of lipid content with size class across a broad set of oceanographic conditions. Here we use size-fractioned ash-free dry weight and gravimetrically measured total lipid to estimate energy density of zooplankton. Analysis of 2017 and 2019 samples indicates that the smallest size fraction of zooplankton (0.25mm - 1mm) is the most lipid dense (%DW) while energy density (joules/gram) does not differ as significantly between size fractions. The 2021 samples will be compared to depth profiles of particles obtained using an Underwater Vision Profiler (UVP) from Oceans Networks Canada (ONC) to estimate the vertical distribution of these energy proxies in the water column. We are also investigating how the relationship between total lipids and energy density varies between each size fraction. Taxonomic composition and local oceanographic conditions will also be used to help explain variability of energy density and lipid content across the region.

FIS-P

(FIS-P Poster 15556)

Biomass of commercial bottom ichthyofauna in the northwestern part of the Japan/East Sea

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In 2009-2020, according to surveys, the total biomass of fish in the Primorye subzone varied from 222.2 to 599.2 thousand tons, averaging 396.1 thousand tons; and their total number – from 1.7 to 10.0 billion specimens), with an average value of 4.0 billion specimens). Of the estimated fish stocks () in the Russian zone of the Japan/East Sea, the Primorye subzone accounts for an average of 62.4% in biomass and 68.2% in abundance. The total specific biomass of fish in the Primorye subzone remained approximately at the same level throughout almost the entire research period, in most cases varying from 4.5 to 5.8 t/km^2. Peter the Great Bay and northern Primorye did not differ significantly in terms of the biomass of all fish per unit of area (6.5-7.9 t/km^2). And in the Khabarovsk part of the subzone, in 95% of cases, according to the Student's criterion, the total specific biomass of fish was significantly lower and, according to the long-term average data, amounted to 4.2 t/km^2.

During the research, a decrease in the resources of flounders and Saffron was noted. At first, the biomass of sculpins increased slightly (until 2016), and then also decreased. Greenling resources fluctuated significantly over the years without showing clear trends. And the biomass of Pacific cod, in general, has increased significantly, due to an increase in the number of Pacific cod of the Tatar Strait.

HD-MEQ-P

(HD-MEQ-P Poster 15662)

Fisheries in the time of pandemic: toward the sustainable future of seafood system

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Like many other countries, the economy and society of Japan have been deeply affected by the Covid-19 outbreak, and the fishery sector is no exception. This talk demonstrates how the pandemic has impacted the sector, using a case study of Japan during 2020 and 2022. The first work, which was carried out in 2020 right after the first call of State of Emergency in the country, revealed the higher resilience among small-scale coastal fisheries than among large scale corporate fisheries businesses, which could be explained by the more diverse and flexible nature of small-scale fishing activities in Japan. Bonding social capital was also utilized for mutual help, most significantly among small-scale fishery sector than in other sub-sectors. This customary nature of Japanese fisheries, at the same time, seemed to be a barrier for the transformation of the industry, especially through the structural challenge embedded in the complex seafood value chain. The second work, which has been carried out since 2022, aims to visualize and evaluate this structural challenge of seafood value chain, applying a social network analysis. The preliminary results will be shown at the conference to trigger the discussion among North Pacific countries toward sustainable future of seafood system in the region.

Keywords: Covid-19; small-scale fisheries; social network analysis; building better back

POC-P

(POC-P Poster 15594)

The causes of the sea level rise in the East Asian marginal seas since 1993

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The East China Sea (ECS), Yellow Sea (YS), East/Japan Sea (EJS), and South China Sea (SCS) are major marginal seas of the western North Pacific. Owing to notable impacts on the coastal lowlands with high-density population, regional sea-level rise in the marginal seas has been received considerable attention. Globally, the mean sea-level has risen ~20cm over the past century and has been rising by ~3mm/yr since the altimeters were launched in 1993. The global mean sea-level (GMSL) rise is attributed to the effects of thermal expansion and barystatic input from glaciers, ice sheets, and land water storage. However, regional sea-level usually differs from the GMSL rise due to additional processes including sterodynamic component due to oceanic processes and gravitational, rotational and deformational effects accompanying global barystatic sea-level changes. Understanding the processes and regional sea-level rise in the future is of high importance for coastal strategies. In this study, we investigate the causes of the sea-level rise in the East Asian marginal seas (EAMS) and quantify the role of each component over the past three decades. Based on regional sea-level budget analysis, our results show different dynamics of regional sea-level rise in each marginal sea. On the shallow shelves of the YS and ECS, the sea-level trend is determined by barystatic changes due mainly to loss of land ice and ocean mass redistribution driven by sterodynamic changes. In contrast, in addition to land ice loss, local steric changes explain most of change in sterodynamic components in deep SCS and EJS.

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(POC-P Poster 15621)

Characteristics and types of evolution of marine heatwaves in the East Sea (Japan Sea)

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Marine heatwaves (MHWs) are extreme warm water events (above the 90th percentile threshold) in the ocean which has numerous impacts on the marine ecosystem and human society. The East Sea (Japan Sea) is the mid-latitudinal marginal sea where the most rapid upper ocean warming has been detected. In spite of presumably increasing frequency and intensity of MHWs in the East Sea, detailed characteristics and evolution of MHWs in this sea, particularly subsurface evolution of MHWs, is still not well explored. The reliability of reanalysis data is first verified by comparing the MHWs identified from reanalysis data with those from a long-term (from 2000 to 2014) time-series observation near the east coast of Korea. Then, using the reanalysis data in the whole East Sea, we found an increased frequency of MHWs annually and in summer (JJA; June-July-August) from 1982 to 2019, yielding the maximum increase rate of summer MHWs frequencies of 0.45 events per decade. Six sub-regions within the East Sea (three in the western part and the other three in the eastern part) were selected to examine three primary types of MHW evolutions, i.e., 1) surface evolution, 2) surface to subsurface evolution, and 3) subsurface to surface evolution. In this presentation, we will discuss possible explanations for these types of MHW evolution in the selected sub-regions. This study provides a better understanding of the detailed MHW characteristics in the most rapidly warming region among the world seas.

(POC-P Poster 15622)

Modulation of Kuroshio intensity in the East China Sea on interannual time scales

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Understanding the changes of the Kuroshio intensity in the East China Sea (ECS) can provide important information on regional environment and ecosystem. In this study, we investigated the Kuroshio intensity in the ECS and its modulation on an interannual timescale. Previous studies have suggested that eddy activities of subtropical counter current (STCC) are the major factor that modulate the interannual Kuroshio intensity in the ECS. However, according to the extended record of altimetry-based datasets suggested that a well-known strong positive correlation between the interannual Kuroshio intensity in the ECS and eddy kinetic energy along the STCC diminished after the early 2000s. Our observational analyses showed that the Kuroshio intensity in the ECS can be modulated by the combined effect of westward-migrating mesoscale eddies and westward-propagating oceanic planetary waves from the east. Until the early 2000s, the interannual variability of Kuroshio was mainly affected by eddy migration from the STCC region, associated with oceanic instability driven by large-scale wind patterns over the western North Pacific. Since then, oceanic planetary waves propagating westward across the Pacific basin have largely modulated the interannual variability of the ECS and Kuroshio intensity by superimposing the sea level anomalies related to mesoscale eddies that propagated towards the east of Taiwan.

(POC-P Poster 15636)

Observations on enhanced mixing over the steep continental slopes in the southwestern East Sea (Japan Sea)

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Diapycnal mixing in a stratified ocean plays a pivotal role in modifying the physical properties of seawater, redistributing nutrients and chemical materials, and influencing regional ocean circulation and ecosystem. However, the detailed mechanisms underlying enhanced and depressed turbulent mixing in the southwestern East Sea (SWES) consisting of steep slopes and shallow banks, have not been well documented primarily due to a lack of observations. In this study, we examined turbulent mixing properties from Conductivity-Temperature-Depth (CTD), Acoustic Current Doppler Profiler (ADCP), and vertical microstructure profiler (VMP) data collected in December 2021. An anti-cyclonic circulation around the bank controlled by bottom topography was observed from the ADCP measurements, which is consistent with geostrophic flow derived from the CTD measurements, yielding a strong vertical shear of currents between 80 and 100 m depth, near the bottom. The water column stability was quantified with Richardson number (Ri) squared as a ratio between buoyancy frequency squared (N^2) and velocity shear squared (S^2). Resulting in unstable conditions near the surface and bottom boundaries and intermittently near the pycnocline, e.g., at depth of 80 m on the bank or 70-80 m on the slope where S^2 well exceeds N^2, yielding Ri less than 0.25. Consistently, enhanced turbulent kinetic energy dissipation rate of an order of 10^{-4} W kg^{-1} and the eddy diffusivity of ~10^{-2} m^2 s^{-1} derived from the VMP measurements were observed in the region. This study provides observational evidence on enhanced and depressed turbulent mixing over the steep slopes in the SWES.

(POC-P Poster 15642)

Spatial Patterns of Long-term (1995-2021) Changing Surface and Subsurface Temperature and Salinity around the Korean Peninsula

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Physical seawater properties (temperature and salinity) in the seas around Korean Peninsula (KP) vary over multiple spatial and temporal scales due to many reasons, and better understanding the spatial patterns of their temporal variations helps better adapting to changing climate and ecosystems. In this study, Cyclostationary Empirical Orthogonal Function analysis with a nested period of 1 year was applied to the long-term (27 years from 1995 to 2021) in-situ temperature and salinity data collected at the upper 500 m in the seas around the KP after removing seasonal climatology. Here, the target variable is 500 m temperature so that the first mode PCT (Principal Component Time Series) explains most portion (72%) of total variance. The first mode cyclostationary loading vectors (CSLVs) generally show long-term warming patterns regardless of season and depth, freshening patterns at the upper 50 m, and salinification patterns below 250 m depth. Off the east coast of KP, the warming and salinification rates are clear (+0.12℃ per year and +0.0036 psu per year) at depths around 150 m. Off the western and southern coasts of KP, long-term temperature changing (warming) rates of +0.016 and +0.015℃ per year, respectively, are detected while long-term salinity changing (freshening) rates of -0.0054 and -0.0033 per year, respectively, are significant. This study reveals spatially coherent long-term warming and salinification/freshening in the seas around the KP.

(POC-P Poster 15714)

Evaluation of Thermocline Depth Bias in the Seychelles-Chagos Thermocline Ridge (SCTR) simulated by the CMIP6 models

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The Seychelles-Chagos Thermocline Ridge (SCTR) refers to an open ocean upwelling region in the southwestern Indian Ocean (5°S–10°S, 50°E–80°E), a result of the negative wind stress curl between the southeasterly trade wind and equatorial westerlies. Considering the increasing need to understand the sea-air interaction that shapes the variability of the Indian Ocean, the simulation of SCTR is evaluated using outputs from the Coupled Model Intercomparison Project Phase Sixth (CMIP6) and Phase Fifth (CMIP5) models. Compared with observations, by calculating the 20°C isotherm depth (D20), 23 of 27 CMIP6 models tend to simulate considerably deeper thermocline depth – a common bias in CMIP5 models. The thermocline dome, the shallowest D20 in the 5°S–10°S band, is also located in the eastern part of the Indian Ocean in most of the CMIP6 and CMIP5 models, whereas the dome from observation is located at the western part around 60°E. These biases are found to be associated with the easterly wind bias in the equator, which generates markedly weak Ekman pumping velocity. The models with deeper thermocline depth bias showed a relatively warmer sea surface temperature, probably owing to a weaker thermocline feedback mechanism. Quantitative analysis showed that the CMIP6 models simulate better the thermocline depth and dome, compared to the CMIP5 models. This study highlights the problems with the CMIP6 models for reproducing the SCTR region in the Indian Ocean and might assist the improvement of climate models in the future.

GENERAL POSTER SESSION

(GP Poster 15527)

Studies on the use of locally (Coxs Bazar and Saint Martin) available alternative renewable seaweeds wastes as compost organic fertilizer resources

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Marine algae (Seaweeds) species are often regarded as an underutilized bio-resource seaweed 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 agricultural northern compost organic fertilizer raw materials system.

Key Words : Seaweed, Plant Growth, Organic Material, northern fertilizer, Sustainable.

(GP Poster 15228)

Morphology and Abundance of Crabs (Decapoda) In Opi Aji Lake, Enugu State, Nigeria

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The morphology, distribution and abundance of fresh water crabs in all the continents including, Africa, Nigeria throughout the tropical regions is very paramount and forms the basis of stock assessment. The morphology and abundance of Crabs in Opi-Aji Lake, Enugu State, Nigeria were studied. Total number of 14 crabs (males) was collected from three randomly selected stations from July- September, 2018, during the peak of rainy season and flooding. All the crabs obtained were mainly *Callinectes amnicola* (Portunidae). Some of the morphological characteristics observed were; carapace length (CL) which ranged from 1.2-2 cm, dactylus length (2.5-3.7 cm), DL, polex length (1.9-2.7 cm), coxa length, CXL (0.5-1.2 cm), the chelipeds are strong and unequal, frontal margin length, FML (1.2-1.9 cm), orbit length, OL (0.7-1.1 cm), carpus length (1.1-1.8cm). At each station some physico-chemical determinations (surface water temperature, pH, dissolved oxygen, wind directions, turbidity, alkalinity and Total hardness) were carried out. From the three stations (A-C), selected for the crab sampling, station B (Lat. N 6° 51' 51'', Long. E7° 23' 14'') has the highest percentage of crab abundance (52.19%) followed by station A (Lat. 6° 42' 8.298"N, Long. 7° 32' 52.536") with 45.65% abundance, and station C (Lat. 6° 42' 9.9" N, Long. 7° 32' 53.076" E) with zero occurrence/or abundance of *Callinectes amnicola*. The DO values had a progressive increase in all the stations every month (July- September) while the observed changes are significantly different ($P<0.05$). The maximum pH values in the month of August (6.35±0.12) did not differ significantly ($P>0.05$) from the pH values between July and September. The optimum temperature 24.40±0.64°C in Opi-Aji Lake was observed in the month of July. However, the free CO_2 was significant in the month of July and August, while in the month of September, no significant change ($P>0.05$) was observed in the alkalinity level. Regression analysis revealed the relationship between dissolved oxygen and crab abundance and explained 39.79 % of the variation in crab abundance. Dissolved oxygen showed significant negative correlations with crab across the study months ($r = -0.787$, $p < 0.05$) while the *Callinectes amnicola* which are most abundant in the Opi Aji Lake in the month of July appeared to diminish thereafter. This is an indication that Opi Aji Lake is an important ecological zone for benthos macroinvertebrates conservation.

Key words: morphology, distribution, *Callinectes amnicola*

(GP Poster 15628)

Higher thermal extremes and relationship of northern Indian Ocean's Sea surface temperature and atmospheric temperature over land in Pakistan

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The objective of this study is to analyze the impact of higher thermal extremes in northern Indian Ocean's (IO) sea surface temperature (SST) and atmospheric temperature over land (ATL) in Pakistan. It also analyzes the relationship between Nino4 Index with northern IO's SST and ATL in Pakistan. The seasonal and monthly thermal extremes for the Pakistan and northern IO region have been analyzed for the period of 1979-2015. The higher thermal extremes were analyzed for 5, 7, and 10 days stretch for monthly analysis (i.e., March-August) and for seasonal analysis (i.e., spring (March-May) and summer (June-August)). Data of Era-interim at 0.75 degrees spatial resolution was used in this study. SST shows higher thermal extreme events over different stretch of days as compared to ATL. Higher thermal extreme events were observed in northern IO's SST in the years of El Niño events. ATL has significantly prompted to SST when observed on seasonal basis however, insignificant relationship was found on monthly basis. Tmax and Tsfc (surface temperature) shows significant relationship with Nino4 Index for sea and land.

(GP Poster 15674)

Size–age composition and some characteristics of the population biology of *Ruditapes philippinarum* (Adams et Reeve, 1848) in the Salmon Bay (Aniva Bay, Okhotsk Sea)

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This study is based on the results of scientific trip, carried out in May 2021 and 2022 in the eastern part of Salmon Bay (Aniva Bay, Okhotsk Sea). The collection of material for *R. philippinarum* was carried out at depths from 0 to 0.2 m by hand. In 2022, as in the previous year, species distribution area did not change and was 0.26 km^2. The size-weight composition of the settlement over the period under consideration was practically similar. The average clam shell length was 41.3 mm in 2021 and 41.4 mm in 2022, the average weight was 21.5 and 18.5 g respectively. The maximum age in both years did not exceed 7+ years. In the main, mature individuals prevailed in aged 3+–4+ years. Comparison of two consecutive years revealed significant changes in this clam stock value. In 2021 the commercial aggregations of *R. philippinarum* was 100% of the total stock, in 2022 – 99.2%. If in 2021 the current value of its commercial biomass was determined at 117.0 t, then in 2022 – 43.4 t. The decrease in relative biomass by 2.7 times in 2022 compared to 2021 could be affected by positive sea surface temperature anomalies, especially in July 2021, when the average monthly temperature (according to satellite data) reached 20.9°C (at normal 14°C). And in shallow water, warming could be even higher. During the year the specific density of *R. philippinarum* in the settlement decreased by 2.3 times. In 2022 the specific density did not exceed 38 ind./m^2.

(POC-P Poster 15767)

Assessment of future changes in the sea surface temperature in the Northwest Pacific projected by CMIP6 models

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Coupled Model Intercomparison Project Phase 6 (CMIP6) models project more rapid warming compared with CMIP5. However, CMIP6 models still have considerable inter-model differences for future sea surface temperature (SST) projection. In this study, we examine SST biases in the Northwest Pacific (NwP) simulated by 27 CMIP6 models and evaluate future changes in the SST under both the lower emission scenario (SSP1-2.6) and higher emission scenario (SSP5-8.5) projected by the selected seven CMIP 6 models based on their performance. The selected seven models were ACCESS-ESM1-5, CanESM5, EC-Earth3, KACE-1-0-G, MPI-ESM1-2-HR, MRI-ESM2-0, and UKESM1-0-LL. The SST in the NwP is projected to increase by approximately 1.8°C for SSP1-2.6 and 4.5°C for SSP5-8.5. Noticeably, the projected SST changes are greater in summer (August) than in winter (February) under SSP5-8.5. The stronger surface warming in summer are primarily attributed to thinning of the summer shallow mixed layer. The inter-model difference in the future SST changes is considerably large in the mixed water region (interfrontal zone) between Kuroshio and Oyashio, suggesting less reliability in future projection in the region.

(POC-P Poster 15776)

Submesoscale mapping of kinematic and physical ocean properties obtained from unmanned surface vehicles and Lagrangian surface drifters

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We evaluate the performance of mapping the kinematic properties, including spatially averaged surface currents and deformation rates of surface currents, as well as physical properties (e.g., temperature and salinity) obtained from unmanned surface vehicles and Lagrangian drifters into the Eulerian grid. Since the submesoscale processes are described with O(1) km spatial scale and less than O(1) hour time scale, the mapping methods should maintain nearly identical near-inertial motions, which are ubiquitous oceanic processes, and turbulent characteristics of the physical properties prior and after the mapping, which will be used as the indicators to evaluate the consistency and performance of the mapping. We formulate the optimal interpolation for gridding in terms of the size of the Eulerian grid.

(GP Poster 15684)

Indicators of pelagic forage community shifts related with the abundance of economic tunas in the Indian Ocean

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Species abundance and population dynamics variations would not only show the synchronously fluctuations, also occur complex ecological process (e.g., asynchronous phenomenon) through the fishing exploitation and climate changing. Therefore, in this study, the standardized catch per unit effort (CPUE) were calculated for yellowfin tuna (YFT) and bigeye tuna (BET) from longline fisheries data of Indian Ocean Tuna Commission. The pelagic forage community data collected from the Sea Around Us Project website to further used to compare the CPUE trends and estimated primarily preys' variations between YFT and BET. For the spatial distribution, the high CPUE overlapping areas (>80% grids) for YFT and BET were in the western Indian Ocean (area A1), and the high CPUE of YFT with lower overlapping areas were occurred in the Arabain Seas (area B1). The wavelet cross-correlation analysis showed that the YFT and BET had a 4–8 year positive correlation periodicity from 1980 to 2000. Furthermore, the relationship between pelagic forage community and tunas revealed high negative correlation with cephalopods (YFT: r=-0.7227 and BET: r=-0.7315) and crustaceans (YFT: r=-0.6709 and BET: r=0.5995) in area A1. The area B1 also recorded high negative correlation between YFT with cephalopods (r=-0658) and crustaceans (r=-0.8313). This study revealed the YFT and BET had positive correlation periodicity but showed the negative correlation with pelagic forage community. Thus, we suggested that the impact of fishing exploitation on top predators may changes species density of fish populations and conditioned through top-down control processes in the Area A1 and B1.

(GP Poster 15689)

Spatial and temporal variability of chlorophyll-a and its relation to physical and biological parameters: a case study for the European Arctic Corridor

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In this study we analyzed spatial and temporal variability of chlorophyll-a (Chl-a) concentration as an indicator of ocean productivity in the European Arctic Corridor (the Barents, Norwegian and Greenland Seas), and its dependence on the environmental parameters: euphotic layer depth (Z_{eu}), Photosynthetically Active Radiation (PAR), Sea Surface Temperature (SST), Mixed Layer Depth (MLD) and Sea Surface Salinity (SSS). We used monthly 4x4 km remote sensing data for 2010-2019 years from: Ocean Colour Climate Change Initiative (OC CCI) database (Chl-a and Z_{eu}), NASA's Ocean Biology Processing Group's MODIS images (PAR), MUR SST database (SST), ESA's SMOS images (SSS), while MLD was calculated from *in situ* EN4 Hadley Center and ARMOR data. Using the Random Forest Machine Learning algorithm in the Classifier modification we created models describing the relationship between Chl-a and environmental parameters, and retrieving the position of high-productivity waters (Chl-a > 1 mg m^{-3}) on the basis of these relationships. The results suggested that Ch-a variability is mostly determined by light availability (PAR and Z_{eu}) and intrusions of dynamically active warm, saline Atlantic waters and low-salinity river output and melting ice (SST and SSS as indicators).

According to validation, all the models showed a good performance (f1-score = 74-95%) and slightly underestimated actual Chl-a values and positions of high-productivity waters.

(GP Poster 15721)

Biokinetics of fluorophore-conjugated polystyrene microplastics in marine mussels

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Biokinetic information on microplastics in bivalves is required to reduce the human exposure, but little is known about the time-course and size effect on tissue absorption and clearance. The biokinetics of fluorophore-labeled polystyrene microbeads with diameters 10 μm (PL10) and 90 μm (PL90) in *Mytilus galloprovincialis* marine mussels was investigated in the present study. It was found that both PL10 and PL90 showed a biphasic tissue distribution pattern in digestive and non-digestive tissues, highlighting the significant tissue distribution starting from 48 h post-treatment. The differential size effect on tissue distribution was observed only in the gills, which suggests that PL10 accumulates more than PL90. The depuration kinetics show that particles of both sizes can be cleared in any tissue, but non-digestive tissue requires a longer duration for depuration than digestive tissue. The differential size effect on depuration was observed for both digestive and non-digestive tissues, suggesting that PL10 needed a longer duration for depuration than PL90. More than seven days were needed for depuration of microplastics in mussels, which is an exceptionally longer period compared to conventional depuration of bivalves. The most significant improvement of this study is providing the biokinetics of two different-sized microplastics in mussels and the differential time for purging microplastics from mussels.

(GP Poster 15605)

Assessment of attached phytoplankton to polypropylene according to season and nutrient conditions

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The most ubiquitous marine debris is plastic and is associated with negative ecological impacts. To determine the attachment dynamics of phytoplankton to plastic such as polypropylene, we set up mesocosm experiments during the spring (avg. water temperature = 19.6℃, avg. salinity = 33.3 psu), summer (avg. water temperature = 28.6℃, avg. salinity = 29.5 psu), and autumn (avg. water temperature = 17.8℃, avg. salinity = 32.4 psu) in Jangmok Bay, Geoje. The mesocosm experiments were conducted for 15 days each season with three nutrient treatments (control, low, high). In all seasons, the amount of phytoplankton was greatest in the high nutrient treatment and the lowest in the control treatment. The high nutrient treatments had approximately 10 times more phytoplankton attached to polypropylene compared to the control. Phytoplankton abundances in the ambient water grew until the 8th day in spring, 5th day in summer, and 4th day in autumn, then sharply decreased due to nutrient depletion. However, phytoplankton continued to accumulate on polypropylene over time. In spring, the maximum phytoplankton biomass attached was observed on the 6th day which was earlier than the maximum phytoplankton biomass in the ambient water. Seasonally, the attached phytoplankton was highest in autumn and lowest in summer. Understanding how seasonality and nutrient concentrations influence the attachment dynamics of phytoplankton can elucidate how plastic debris will continue to impact marine ecosystems.

(GP Poster 15610)

Interaction of Marine Nucleocytoplasmic Large DNA Viruses with Eukaryotic Plankton Communities in the Sub-Arctic Kongsfjorden: A Metagenomic Analysis of Marine Microbial Ecosystems

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Nucleocytoplasmic large DNA viruses (NCLDVs) infect various marine eukaryotes. Characterizing the ecological relationships between NCLDVs and eukaryotes is critical for understanding marine ecosystems. However, little is known about NCLDV diversity and their relationships with eukaryotic hosts in marine environments. To elucidate the interplay between NCLDVs and the eukaryotic plankton community (EPC) in the sub-Arctic area, we used metagenomics to investigate NCLDVs and the EPC at the Krossfjorden ecosystem of Svalbard (Norway) in April and June 2018. In April, *Gyrodinium* sp. (Dinophyceae) was the most prevalent eukaryotic taxon in the EPC. However, in June, the pre-dominant taxon was *Aureococcus anophagefferens* (Ochrophyta). *Mimiviridae* and *Phycodnaviridae* NCLDVs appeared in higher proportions increasing the Ochrophyta, Chlorophyta, and Dinophyceae groups. In addition, the non-metric multidimensional scaling analysis showed no difference in vertical zones, but revealed evident differences between April and June for each NCLDV and EPC compositions. Thus, differences in NCLDVs may be caused by changes in EPC compositions according to environmental changes, such as the water temperature and light intensity increases.

(GP Poster 15625)

Assessment of regional progress towards the sustainable development goal 14 in the east sea based on the voluntary national reviews of participating countries

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This study aims to assess the regional progress towards the Sustainable Development Goal (SDG) 14 in the East Sea based on the Voluntary National Reviews (VNRs) by which participating countries' policies and status are recognizable. The East Sea is shared among Democratic People's Republic of Korea (DPRK), Japan, Republic of Korea, and Russia. All of these four countries had submitted its VNR since 2016. Except Japan (2017, 2021), rest of them were published once; ROK's VNR in 2017, Russia's VNR in 2020, and DPRK's VNR in 2021. Japan's VNR (2016) and ROK's VNR (2017) are relatively brief (about 50 pages) while Russia's VNR (2020) and Japan's second VNR (2021) are comparatively long (more than 200 pages), comprehensive, and updated in case of Japan. DPRK's VNR (2021) is recently published but still brief (about 50 pages). As ROK's VNR is outdated, it is complemented by the third national master plan for Sustainable Development of ROK (2021~2040), which is the reflection of its strategies for the progress of SDGs. This study examines acceptance and reflection of ten targets and/or eleven indicators of the SDG 14 in the four countries. Interestingly, Target 14.6 related to fisheries subsidies is excluded in most countries. DPRK and ROK do not accept the Target 14.6 in their own SDGs systems, while Russia and Japan do not proclaim their own SDGs target and indicator systems. Therefore, this study argues that there is a critical issue need to be addressed for the regional progress towards the SDG 14 in the East Sea.

(GP Poster 15650)

The structure and dynamics of phytoplankton in coastal waters of Russky Island (Peter the Great Bay, Sea of Japan)

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A detailed characterization of phytoplankton is especially necessary for waters having the status of specially protected areas, mariculture development areas, and spawning grounds sites such as Paris Bay and Zhitkov Bay. From December 2018 to January 2020 (water t = -1,8–25°C, S = 19–36‰) revealed 181 taxa of microalgae belonging to 7 classes. *Cyclotella atomus* var. *gracilis* (t = 22°C, S = 19‰) was for the first time identified in marine waters. *Thalassiosira lundiana* (t = 18–19°C, S = 28–31‰) is the first record for the northwestern Sea of Japan. *Minidiscus comicus* (t = 18°C, S = 31‰) occurred as the dominant species of phytoplankton in the seas of Russia for the first time. The seasonal dynamics of microalgae density in researched bays was characterized by five peaks. A winter peak in January 2020 was characterized by the predominance in plankton *Thalassiosira nordenskioeldii* (Paris Bay – 1,6x10^6 cells/L, Zhitkov Bay – 1,0x10^6 cells/L). In March 2019, *Heterosigma akashiwo* (Zhitkov Bay, 1,4x10^6 cells/L) was dominated, in July – *Skeletonema dohrnii* (Paris Bay, 4,6x10^6 cells/L). In September bloomed *Cyclotella* spp. (Paris Bay, 4,4x10^6 cells/L), *Skeletonema japonicum* и *T. lundiana* (Zhitkov Bay, 1,4x10^6 cells/L). In October, both bays were dominated by *S. japonicum*.

This study was carried out at the Center for Collective Use “Primorsky Oceanarium” of the NSCMB FEB RAS.

(GP Poster 15719)

Upward expansion of subtropical echinoderms in South Korea

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The East Sea of South Korea has shown remarkable environmental changes in present, and it is rapider than a mean of all other regions in the world. So, numerous sub- or tropical marine species have been reported from Ulleung Island (37°30’N) in the East Sea during last two decades. In this study, two subtropical echinoderms, *Nacospatangus altus* (A. Agassiz, 1864) and *Andrometra psyche* (A.H. Clark, 1908), were collected from the depth of 15-27m in Ulleung Island. These two species are rarely founded in southern Jeju Island (33°13’N), and among them, *N. altus* is designated as endangered species II in Korea. Thus, the distribution range of *N. altus* and *A. psyche* was expanded to a higher latitude region and we postulated it to be influenced by a branch of the Kuroshio warm current which is stronger than before.

(GP Poster 15228)

Potential trends in the Bering Sea pollock recruitment, abundance and spatial distribution in 2022-2032

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Recent research demonstrated that annual changes in the Bering Sea physical oceanographic conditions and zooplankton species composition and productivity were associated with the greater differences in the Bering Sea pollock seasonal distribution, reproduction, abundance of year classes and total population biomass. According to the general trend of changing environmental processes in 2022-2024, the Bering Sea ecosystem status indicates that pollock biomass will remain stable at the average level (7.0-7.5 mln t).

It is expected that northward pollock feeding migration during postspawning period will be slower, and that the scale of distribution of older pollock into northern Bering Sea in summer will be slower and the start of active southeastern migration will pick up in early autumn.

Increased pollock biomass up to 8.0-8.5 mln t is expected in 2025-2029 because of relatively high abundance of large zooplankton (euphasiids and large copepods) and higher survival of the pollock juveniles in overwinter period due to feeding on the high lipid food, which will bring higher pollock year classes abundance.

Decreased pollock biomass down to 7.0-7.5 mln t is expected in 2030-2032 due to the increasing sea water temperature and, therefore, decrease in large zooplankton abundance and pollock year classes abundance by the end of 2030s.

(GP Poster 15588)

Species diversity of epiplastic diatoms at the drifting Chinese plastic debris in Korean coastal waters

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Marine plastic debris (MPD) provides new habitats for the fouling diatoms, they can be transported along with these durable substrates. In January 2021, a large number of marine debris originated from China were drifted along the *Sargassum* golden tide at the beach of Jaeun Island of South Korea. In order to know what kinds of diatoms can be occurred in plastic surface, we investigate the species diversity of diatoms attached to the surface of MPD. We collected 20 MPD that consist of polyethylene terephthalate bottles, polystyrene buoy and fragment and other types of plastic debris. Total 143 diatom species were observed, among these, *Tabularia investiens* and *Grammatophora marina* were found all debris. Both species frequently occurred in the marine environment where they can attach to the coast regardless of the substrate, and there was no MPD substrate specificity. In some MPD materials, the freshwater diatom species such as *Planothidium lanceolatum*, *Caloneis* sp., *Hantzschia* spp. and *Surirella minuta* were observed, and it indicates that the diatoms can be used as an indicator to trace the origin where MPD were threw away.

(GP Poster 15593)

Summer distributional characteristics of phytoplankton related with multiple environmental variables in the Korean coastal waters in 2019

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Multiple environmental variables related to ocean currents, freshwater run-off, and upwelling in a coastal area have complex effects on the phytoplankton community. To estimate the influence of environmental variables on the phytoplankton community structure during the summer of 2019, we investigated the various abiotic and biotic factors in Korean coastal waters (KCWs), separated into five different zones. Summer environmental factors in KCWs were strongly influenced by Changjiang Diluted Water (CDW) in St. SO 1 and 2, upwelling in St. SI 2-4, and Nakdong River discharge in St. SI 12. In particular, low-salinity water masses (*t*-test: $t = 6.434$, $p < 0.05$ for nearby locations) of CDW have gradually expanded to southwestern KCWs from June to July. In addition, there were high nutrients and low salinity following freshwater runoff from the Nakdong River in southeastern KCW, which led to the dominance of *Cryptomonas* spp.. On the other hand, upwelling area in southwestern KCW were dominated by diatoms *Skeletonema costatum*-like species, which is characterized with high phosphate concentrations (*t*-test: $t = -3.807$, $p < 0.05$) and low temperature (*t*-test: $t = -5.31$, $p < 0.05$) compared to nearby locations. Low nutrient concentrations were maintained in the East Sea and Yellow Sea, which were characterized by low chlorophyll *a* and dominated by unidentified small flagellates. Therefore, our results indicated that hydro-oceanographic events such as upwelling and freshwater run-off provide nutrients to the euphotic layers of coastal environment and play crucial roles in determining the phytoplankton community structure during summer in the KCWs.

(GP Poster 15634)

Microplastic ingestion by mesopelagic fish and acoustic quantitative estimate in the Pacific side of Hokkaido Island, Japan

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Mesopelagic fishes have vast amounts of biomass in the ocean and play an important role in vertical nutrient flux, through diel vertical migration. It is concerned that large-scale feeding in the surface layer and fast descent into the mesopelagic layer accelerates the sedimentation of microplastics ingested by mesopelagic fishes. An acoustic and midwater trawl survey with 37 transect lines was conducted in June-July 2019, in the Pacific area of Hokkaido to estimate the microplastic ingestion by mesopelagic fishes quantitatively. In the study area, Myctophidae was the predominant group which occupied 83% of all mesopelagic fishes. The eastern part of the survey area, affected by the Tsugaru Warm Current, was dominated by *Notoscoplus japonicus* (average length, 125 mm) and *Stenobrachius leucopsarus* (77 mm). The western part, affected by coastal cold water, was dominated by *Lampanyctus jordani* (116 mm). A total of 81 plastic particles (0.4 – 1.5 mm) were detected in 48 fishes by microscopic observation of the digestive canal of 594 fishes. The content rate of plastic particles varied among species (e.g. 10% in *N. japonicus* and 3% in *S. leucopsarus*). In addition, the content rate varied among regions even in the same species. Results suggested that the extent of the plastic ingestion was affected by the fish species and size, vertical migration pattern, and dominant current of the habitat. Acoustic estimate indicated that the total biomass of mesopelagic fishes in the survey area (4,078 km^2) was about 0.3 million tonnes, and 2.8 billion microplastic particles were ingested by them.

(GP Poster 15635)

The characteristics of spatial distribution of Mesopelagic fishes by acoustic survey off eastern Hokkaido Island, Japan

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Mesopelagic fishes are the key component in the acoustic scattering layer and play a significant role in the marine ecosystem in the eastern part of Hokkaido which is one of the important fishing grounds in Japan. A day/night acoustic and trawl survey were conducted along 35 transect lines extending from the shelf-slope to the open ocean at a depth of about 1300 m in July 2021 to investigate the relationship between environmental and geomorphological factors and the species composition, spatial distribution, and vertical migration patterns of mesopelagic fishes. The survey area was divided into cold water areas derived from the coastal Oyashio current and other warm water areas from the Tsugaru warm current. The composition of fish species differed among the areas, with *Notoscopelus japonicusand* and *Stenobrachius leucopsarus* dominating in the inshore areas of the study area, while *Lampanyctus jordani* dominated in the offshore areas. In some areas around Cape Erimo, *Diaphus theta* was dominant. In both areas, differences in fish density and vertical distribution between the shelf-slope area and other open ocean areas were observed, suggesting that the geographical factor such as slope gradient and water depth affects the quantitative distribution and vertical migration patterns in the mesopelagic fish community.

(GP Poster 15657)

Stratification in the northern Bering Sea in early summer of 2017 and 2018

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We investigated spatial and interannual variation in the physical environment in the northern Bering Sea focusing on stratification, which is one factor affecting biological production in Arctic/subarctic regions. In particular, we analyzed in situ data obtained onboard the training ship Oshoro Maru in early summer in 2017 and 2018. We found that stratification in the areas just north of St. Lawrence Island (around 64.5°N and west of 168.5°W) and south/southwest of St. Lawrence Island was significantly weaker in 2018 than in 2017. These results are consistent with the extremely low sea-ice extent present in the winter of 2017/2018, which would have resulted in less freshwater being supplied to the surface layers and a warmer and less saline bottom water. Conversely, stratification was as strong in 2018 as in 2017 in the area close to the Alaska mainland, including the Bering Strait area, suggesting that the Alaskan Coastal Water dominates stratification in this area in early summer. Moreover, we found that the weakly stratified water column in the Bering Strait area stratified quickly shortly after the occurrence of strong northerly winds, likely because of the Ekman transport of warm and low-salinity Alaskan Coastal Water from the east.

(GP Poster 15659)

An acoustic glider observation for monitoring physical and biological environment in the upper ocean

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Autonomous platforms have been widely used for monitoring ocean environment from basin scale to (sub-) mesoscale and microscale. Underwater gliders can install various scientific sensors that measure physical as well as biogeochemical parameters in the ocean and have become an important tool for ocean monitoring. Since the ocean environment off the east coast of Japan influences the formation of fishing ground of commercially important pelagic fish such as chub mackerel, we have continued glider observations in spring till summer to monitor the physical oceanographic conditions at this site in recent years. From 2020, an acoustic glider (Sea Explorer, Alseamar), which installs a CTD (LEGATO, RBR), optical sensors (OCR504 by Sea-Bird Scientific and ECO Puck FLBBCD by Wetlabs) and an echo-sounder (IMAGENEX 853), has been added to the glider monitoring to grasp the distribution of planktons along with the water mass distribution at this site. The echo-sounder successfully detects notable signal of diurnal vertical migration probably associated with the zooplankton, and the depth of migration follows the limit of light detection by the optical sensor. The observations also reveal different ocean conditions between 2021 and 2022, which seems to affect the plankton distribution and abundance. We anticipate that the accumulation of observational data and integration of multiple frequencies to the glider’s echo-sounder would reveal long-term variation of physical and biological environment at this site and deepen our understanding of the linkage between the distribution and dynamics of planktons and physical environment.

(GP Poster 15661)

Developing High-Resolution Tow-Yo measurements

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For achieving high-resolution oceanographic surveys, we have been developing tow-yo measurement techniques. The UTA (Undulating Towed sensor Array) system consists of an array of sensors (5+ CTDs) attached on the towing cable, and a depressor wing at the end of the cable. By repeating paying out and pulling in the towing cable by using an observation winch while the vessel is navigating, the system can observe the vertical transect of the targeted depth range of the ocean interior. The bio-UCTD probe is an originally developed bio-geochemical probe for the Underway-CTD system (Rudnick and Klinke 2007). In addition to the normal usage in the same manner as the original Underway-CTD probe, the weight of the probe can be adjusted for a continuous tow-yo measurement without loading a line on the probe tail. In the presentation, we will demonstrate our recent observational results by the developed systems.

(GP Poster 15670)

Characterization of the sex-determining genomic region in the Pacific halibut (*Hippoglossus stenolepis*) and identification of a putative gene responsible for sex determination

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The Pacific halibut (*Hippoglossus stenolepis*) is a key species in the North Pacific Ocean and Bering Sea ecosystems, where it also supports important fisheries. Past research to identify genetic markers diagnostic of sex in Pacific halibut for their application in fisheries management identified several sex-linked loci that, in the absence of a Pacific halibut genome, led to the suggestion that genetic sex in Pacific halibut is likely under the control of loci present on a single chromosome. With the recent chromosome-level assembly of the Pacific halibut genome (**https://www.ncbi.nlm.nih.gov/assembly/GCF_022539355.2/**), we have conducted genome-wide association analyses between female and male Pacific halibut to further characterize the sex-determining region in this species. These studies have resulted in the identification of a defined sex-linked region in females in Chromosome 9 that likely corresponds to the sex-determining region in Pacific halibut. Furthermore, within this region we have identified a potential candidate for the master sex-determining gene in Pacific halibut. These results suggest that, as observed in other teleost groups, the mechanisms responsible for sex determination among Pleuronectiform species have not been well conserved during evolution.

(GP Poster 15679)

Persistent continental shelf carbon sink at the Ieodo Ocean Research Station in the Northern East China Sea

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Hourly (2017–2021) to seasonal (2015–2021) inorganic C data were collected at the Ieodo Ocean Research Station (32.07°N and 125.10°E) in the northern East China Sea (ECS), located under the influence of the nutrient-rich Changjiang diluted water. An increase in phytoplankton biomass from April to mid-August (the warming period) equalized much of the temperature-driven increase in the surface pCO_2 and thus made the northern ECS a moderate sink of atmospheric CO_2. From November to March (the cooling period), both a large pCO_2 reduction driven by a temperature reduction and a high air–sea CO_2 exchange rate because of high windspeeds transformed the basin into a substantial CO_2 sink, yielding an annual net C uptake of 61.7 g C m^{-2} yr^{-1}. The effects of biological production and temperature reduction on seawater pCO_2 (and, thus, the net air–sea CO_2 flux) were decoupled each season and acted in concert to increase the net annual CO_2 sink by the region. The present study provided the observational and mechanistic lines of evidence for confirming "continental shelf C pump" theorized by Tsunogai et al. (1999)—a mechanism in the shallow waters of the continental shelves accumulating a significant amount of C (via reinforced cooling and promoted biological C uptake) to be transported from surface waters of the basin to the interior of the adjacent deep ocean. In the future, increasing input of anthropogenic nutrients into the northern ECS is likely to make the region further the stronger CO_2 sink.

(GP Poster 15708)

Salinity regime of the northwestern Bering Sea shelf

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The present study has examined the long-term variability of water mass properties and its relation to sea ice production (SIP) in the northwestern Bering Sea shelf using hydrographic and satellite data, and output from atmospheric reanalysis. As per our analysis of hydrographic data in the summer seasons, significant variability in bottom water temperature and salinity was noted. The temperature in 2018 showed particularly remarkable warming of the whole water column throughout the Gulf of Anadyr (GOA) and cold pool (CP) region. These oceanic parameters exhibited correlations with SIP in the Anadyr polynya, which is identified as one of the most active polynyas in the Northern Hemisphere. Specifically, there were more saline and colder water during high-SIP years, suggesting the influence of dense shelf water (DSW) that is formed during freezing processes; however, in low SIP years, bottom salinity has been observed to behave inversely, resulting in more saline water with lower SIP. We suggest that the influence of warm and saline water, originating from the Pacific, transported by ocean currents intensified by wintertime southerly winds in low-SIP years. The properties of bottom water in the semi-closed GOA are influenced by intrusion of the Pacific-originated water and DSW.

(GP Poster 15710)

Japanese Consumers' Demand for Traceability Information -Tokyo Bay Fish Passport as a case study-.

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Proper resource managements of fisheries is necessary due to the growing pressure on the fishing control globally. One possible solution is to offer technology that trace information from catch to consumption. To make the fish traceability information as new business opportunity, expected benefits analysis is required. Some studies analyzed the economic value of the fishery certification, however, the similar study on traceability is limited. To fill the gap, this study identifies how much Japanese average consumer's willingness-to-pay (WTP) for the fish traceability information of the *Lateolabrax japonicas* with "Tokyo Bay Fish Passport" developed by Ocean To Table Council as a case study. Information shared on the passport enables consumers to access to the fish traceability information; such as geographic and time series information on catch, profile of the fisherman and the middleman, and information of the store and products using block chain and IoT. To identify the consumer's WTP for the information, the study applies the conjoint analysis, methodology for product development which enables to identify how each product element influences the total evaluation of the products with one thousand general consumers via the online survey. We found that general consumers are willing to pay for the fishery traceability information additionally with statistically significance: approximately 30 JPY for *Lateolabrax japonicas* which values 200 to 300 JPY. In addition, past experience of the purchasing increased the WTP with statistically significance.

(GP Poster 15718)

Recruitment and settlement patterns of two invasive ascidians in South Korea

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The coverage of the two invasive ascidians such as *Didemnum vexillum* Kott, 2002 and *Symplegma reptans* (Oka, 1927) were recorded every three months from April 2017 to April 2018. Recruitment and settlement of two invasive ascidians were observed to correlate with environmental parameters (water temperature and salinity) over the one-year investigation. These two invasive species were recruited during the first three to six months of plate immersion (July to October, 2018). According to the results, the recruitment of these two invasive ascidians has expanded throughout three coastal regions in South Korea (Yellow Sea, Korean strait and East Sea). Over a twelve-month period, *D. vexillum* settled predominantly in the Yellow Sea and East Sea, with average cover maxima of 29.6% in Mokpo and 20.1% in Yangpo. *D. vexillum* and *S. reptans* species survived at low water temperatures during the winter season, although *S. reptans* settled with less coverage than *D. vexillum* (*D. vexillum*: 22.2%; *S. reptans*: 2.0%). Furthermore, *S. reptans* was unable to deal with the particular environmental characteristics of the settlement locations until the twelve-month period. The intensity of recruitment varied throughout the immersion period, but in Mokpo, it demonstrated a rising trend of *D. vexillum* that peaked within the specified time. These invasive species posed a significant threat to invertebrate communities, particularly indigenous species, and their individual abilities to outgrow earlier settlers and survive in cold conditions appear to be becoming increasingly important in monitoring and management research.

W1: BIO Topic Workshop
Distributions of pelagic, demersal, and benthic species associated with seamounts in the North Pacific Ocean and factors influencing their distributions

(W1 Poster 15533)

Identification of functional genes in deep-sea corals from seamounts in West Pacific by *de novo* RNA sequencing

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This is a study about investigation the biodiversity of the deep-sea seamount in the West Pacific and discovering the marine biological genetic resources. Coral samples were obtained using Remotely-operated vehicle (ROV) which was one of the collection equipment of Isabu Research Vessel in Korea Institute of Ocean Science and Technology. To classify the coral species, DNA sequences of CO1 was used together with morphological classification method. RNA was extracted by following the method optimized for the soft coral and *de novo* RNA sequencing (RNA-seq) was carried out to explore the functional genes in three deep-sea coral species, *Chrysogorgia* sp., *Paragorgia* sp. and *Narella* sp.. Approximately 134,425 unigenes from *Chrysogorgia* sp., 111,228 unigenes from *Paragorgia* sp. and 137,111 unigenes from *Narella* sp. were identified and those unigenes were classified their functions using NCBI Nucleotide, Pfam, Gene ontology (GO), EggNOG, and UniProt databases. This study focused on the identification of functional genes in deep sea corals and this genetic information will be used for the various analyses of secure genetic sources of target species and understand their environmental characteristics.

(W1 Poster 15709)

Distribution of giant grenadier (*Albatrossia pectoralis*) at different stages of ontogenesis in the Bering Sea

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Currently, despite the increasing interest of fishermen in such deep-sea species as the giant grenadier (*Albatrossia pectoralis*) and the development of fishing technical facilities, this species remains underinvestigated. Available publication provide hypothesis about habitats of juveniles and areas and time of spawning only. Large depth of the species habitat as well as rough bottom, which does not allow to use bottom trawls in most areas, make the giant grenadier investigation even more difficult. Data from TINRO-VNIRO deep-sea research during 1963-2020 were used to study the distribution of giant grenadier at different ontogenetic stages in the Bering Sea. In total, 484,956 trawl stations were analyzed, 264,567 of which were executed using bottom trawl and 220,389 midwater trawl. Giant grenadier were present in 280,65 trawl catches. Qualitative and quantitative analyses of catches included measurements of fish length and weight, sex and maturity stage of gonads. The obtained data on catches were converted into standard values for comparison (individuals per km^2). In the Bering Sea juveniles of giant grenadier (up to 30 cm in length) were registered in trawl catches throughout the surveyed area, unlike mature males and females. It was discovered that juveniles live in the mesopelagic zone in deep-sea areas. After reaching the size of more than 30 cm in length the giant grenadier start bottom life. Mature individuals lead bottom life, living on the continental slope in the depth range from 250 to 2300 m. Spawning continues over several months with a peak in September. The obtained results will be used for stock assessment and fishing management of the giant grenadier in the Bering Sea.

(W1 Poster 15772)

Features of spatial distribution of dominant groundfish species on the Koko Seamount (Emperor Seamounts) in 2019

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Russian fisheries research on the Emperor Seamounts began in the 1960s, but their ichthyofauna has not yet been fully studied. Until 2019, the last Russian studies on Koko Seamount were conducted in 2010. In April 2019, six bottom trawl hauls were carried out at the R/V "Professor Kaganovsky" on Koko Seamount. The dominant species in the catches was pencil cardinal *Epigonus denticulatus* with maximum concentrations observed near the slopes and reduced catches in the central part of plateau. Japanese codling *Physiculus japonicus*, the second most abundant species, was found mainly in the southwestern part of plateau, where its maximum concentrations were observed near the eastern and western slopes of the plateau. This species has become very abundant in this area recently. The slender armorhead *Pseudopentaceros wheeleri*, which previously dominated the Emperor Seamounts, was recorded in 2019 in only three catches, which indicates its extremely low abundance and ongoing depletion of stocks. Alfonsino *Beryx decadactylus* on the Koko Seamount was recorded in just single catch. The main catches of *Helicolenus avius* were observed along the slopes of the seamount.

Since the 1960s to the present, significant changes in the structure of fish communities have been observed on Koko Seamount. In the 2000s, pencil cardinal began to dominate here, which in the 1960s-1970s was found only once in this area, while slender armorhead, alfonsinos, and *H. avius* dominated in catches. In general, the northward extension of the ranges of some fish species was noted, which is probably due to climatic changes.

W2: FIS/HD/SB Topic Workshop
Integrated Ecosystem Assessment (IEA) to understand the present and future of the Central Arctic Ocean (CAO) and Northern Bering and Chukchi Seas (NBS-CS)

(W2 Poster 15559)

Acoustic research of spatial distribution and abundance of arctic cod in the southwestern part of the Chukchi Sea in 2003–2020

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The features of spatial distribution and abundance of arctic cod (*Boreogadus saida)* were analyzed using the data sets from the acoustic-trawl surveys conducted by TINRO in southwestern part of the Chukchi Sea in August–September 2003-2020. The highest rates of arctic cod abundance in the form of nautical area backscattering coefficient s_A (m^2/n.mi^2), fish density by number (ths.pcs./n.mi^2) and biomass (tones/n.mi^2), were recorded in August 2003. In 2007-2008, acoustic estimates of fish significantly decreased and in 2010 were the lowest for the entire series of observations. In 2014, the abundance of arctic cod in the surveyed polygon noticeably increased due to the high proportion of juveniles in the aggregations. However, in 2015 arctic cod density again decreased and in 2018-2020 continued to decline, reaching the minimum values in 2020. At the same time, the influence on arctic cod distribution of warm Bering Sea current and the growth of walleye pollock quantity in this region became particularly noticeable. The two–layer vertical structure of aggregations in the near–surface and near–bottom layers is typically. To the east of 174°W, aggregations are usually formed by larger individuals in the near-bottom layer. In the western sector, they have a two-layer structure with a predominance of juveniles in the upper layer. The dependence of arctic cod vertical movements on daytime was not expressed. At night the structure of aggregations was usually more sparse. However, aggregations were also in the form of dense schools, both in the daytime and at night.

W3: SB/POC/FUTURE/MONITOR Topic Workshop
SmartNet: Promoting PICES and ICES Leadership in the UN Decade of Ocean Science for Sustainable Development

(W3 Poster 15680)

How do young adult fishers feel and adapt ocean climate changes in Japan?

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Introduction

Recently, changes in the distribution of fish species and sea temperature of coastal water have been observed in around sea areas of Japan. This study aims to clarify realities and adaptation measures that fishers are taking in response to the recent natural disasters and environmental changes through workshops with coastal fishers.

Methods

In June 2019, a workshop was held for 61 fishers and Fisheries Cooperative Associations' staffs from various regions of Japan under the title "The Role of Youth Adult Fishers in Climate Change Adaptation." Information on natural disasters and environmental changes in coastal waters was collected using by the workshop on transdisciplinary approach. And then group-work was conducted to discuss the reality of climate change facing the community and adaptation measures.

Results and Discussion

Fishers felt that they were facing natural disasters caused by typhoons and floods in western Japan and earthquakes and tsunamis in eastern Japan. And some fishers were practicing activities such as cleaning up marine debris from natural disasters and establishing emergency communication flows and assistance systems for elders. Fishers also felt nationwide, changes in the distribution of fish species and sea temperature in coastal water. Therefore, some fishers were taking measures such as improving fishing gears, conserving and restoring for fishing grounds and capacity building for youth fishers. The results of this study identified that fishers have adapted to ocean climate changes around Japan. In addition, the results indicated that workshop on transdisciplinary approach contribute the discussions of realistic adaptation measures through the information sharing and mutual learning among stakeholders.

W7: BIO Topic Workshop
Anthropogenic stressors, mechanisms and potential impacts on Marine Birds, Mammals, and Sea Tu*rtles*

(W7 Poster 15259)

Plastics in the stomach of two species of albatrosses in the western North Pacific

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We examined stomach contents of 96 Laysan *Phoebastria immutabilis* and 25 Black-footed Albatrosses *P. nigripes* caught incidentally in the western North Pacific during 2014 — 2018. Proportion of individuals that had plastics in their stomach was higher in Laysan (91 %) than Black-footed (48 %) as reported in the central North Pacific and the mean mass and size of each piece of fragment or pellets were greater for Laysan (0.073 g, 8.25 mm) than Black-footed (0.031 g, 5.86 mm). This species difference in the plastic loads could not be explained by the overall species range and diet. The plastic load of these two albatross species in the northern North Pacific is greater than that in the albatrosses caught incidentally or stranded ashore in the western South Pacific, so is a matter of concern.

(W7 Poster 15675)

A high-quality chromosome-level genome of the Omura's whale (*Balaenoptera omurai*)

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The Omura's whale (*Balaenoptera omurai*) is a newly discovered living baleen whale since 21st century, occurring in tropical and warm-temperature regions. This species tend to inhabit in coastal zones. Its apparent genetic diversity is low and its evolutionary history is initially constructed based on mtDNA. Advancement in long reads sequencing allows for construction of high quality genome for studies of ecological and evolutionary processes in Balaenopteridae. Here, we report the first high-quality chromosome-level Omura's whale genome. The generated genome assembly (2.92 Gb) has a contig N50 of 40.11 Mb and a scaffold N50 of 129.16 Mb. Approximately 96.16% contigs of *B. omurai* genome were anchored onto 22 chromosomes. Collinearity analysis revealed *B. omurai*'s higher synteny conservation with *B. musculus* than *B. brydei*. The repeat sequences accounts for 46.37% of the genome assembly, and a total of 20,464 (99.10%) genes were functionally annotated. Phylogenetic analysis indicated that *B. omurai* was close to *B. brydei*, and then clustered with *B. musculus*. Gene families related to gap junction and phagosome were contracted and those associated with renin-angiotensin system and notch signaling pathway were expanded. In addition, gene families related to amino sugar and nucleotide sugar metabolism and biotin metabolism were under positive selection. Overall, the high-quality genome assembly and annotation represent significance to the genomic resources available for the study of evolution, phylogeny and conservation of rorqual baleen whales.