PICES-2021 Virtual Annual Meeting

Book of Abstracts

October 18-28, 2021, Victoria, BC, Canada

Prepared by the PICES Secretariat

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Please check PICES-2021 for any changes in the schedule:
https://meetings.pices.int/Meetings/Annual/2021/PICES/PICES-2021-Schedule-Web.pdf

Presentations will be available here:
https://meetings.pices.int/publications/presentations/PICES-2021

Interactive E-Poster Session:
https://meetings.pices.int/meetings/annual/2021/pices/poster-session

Program details:
https://meetings.pices.int/meetings/annual/2021/pices/Program

Abstracts
Oral Presentations

SESSION 1

Science Board Symposium
Towards a shared vision of sustainable marine ecosystems

S1-LiveOral-1 (PaperID=15044)

Identifying changes of research focuses and potential collaborations in PICES toward the UN Decade of Ocean Science for Sustainable Development (UNDOS)

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Introduction:

PICES have contributed many international research projects, and a lot of research products have been published in PICES website since 1992. There are over 9000 abstracts in abstract books for annual meetings. Also, there are over 100 TORs for research activities such as WGs and SGs on the website. These data could be used to identify changes in research topics and similar research activities in PICES. The objective of this research was to develop a methodology to identify changes of research focuses over time and potential collaborations in PICES toward UNDOS.

Method:

Text information (abstract books and TORs), and meta-information for abstract books (e.g., published years) and TORs (e.g., name of research activities) were compiled to the database. Then, 100 nouns were selected for each abstract books and TORs from the database using by natural language processing technology. Finally, the correspondence analysis was conducted to identify changes of research focuses in abstract books over time and to evaluate similarity between TORs for research activities in PICES based on 100 nouns' distribution of frequency.

Results and Discussion:

As results of abstract books, most research focused on observations of sea at the beginning stage of PICES. Then, research focuses moved to understanding mechanism of marine ecosystems at the middle stage. Recently, "Adaptation" to changes of marine ecosystems became a key area. In addition, results of TORs for PICES activities show the potential collaboration in PICES. In this presentation, we will discuss the characteristics of research activities and potential research collaborations in PICES toward UNDOS Outcomes and Challenges.

S1-LiveOral-2 (PaperID=15067)

Phytoplankton community composition in the Gulf of Alaska determined using CHEMTAX and OLCI Sentinel 3 satellite data

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Spatio-temporal dynamics of phytoplankton community composition in the Gulf of Alaska were assessed as part of the International Year of Salmon (IYS) expedition in the Gulf of Alaska (GoA) between February to March 2019 and from March to April 2020. Phytoplankton community composition was assessed using HPLC pigment data, CHEMTAX data, microscopy data, satellite-derived phytoplankton biomass, and phytoplankton groups derived from OLCI Sentinel 3 satellite data. Surface waters samples to measure HPLC pigment and the phytoplankton cell abundance were collected from (~ 2m depth) using CTD/rosette system. In addition, an above-water radiometer was installed on the bow of the ship to measure the water-leaving radiance. Above-water reflectance measurements show a clear case-1 water with a low concentration of dissolved organic matter and suspended sediments. Sentinel 3 derived phytoplankton biomass showed very low ($\leq$ 0.5 mg/ m^3), concentration in the Alaska Gyre and increased concentration towards the shelf region ($\geq$ 1 mg/ m^3). HPLC derived TChla concentration and Sentinel 3 derived TChla concentration showed an excellent agreement ($r=0.65$, $p<0.001$). Overall, the accessory pigment/ TChla ratio indicates 19′-HF, Fucoxanthin, 19′-BF, Chl-b, Peridinin was the dominant pigments. Phytoplankton community compositions derived from the CHEMTAX analysis demonstrated haptophytes, pelagophytes, Green algae, and diatom. Similarly, the satellite-based model retrieves different phytoplankton groups showed good retrieval for the dominant phytoplankton groups such as haptophytes (R^2=0.51, MDPD=28%), pelagophytes (R^2=0.45, MDPD=27%), green algae (R^2=0.47, MDPD=23%), dominance in the iron-poor open ocean waters and diatom in the shelf region.

S1-LiveOral-3 (PaperID=15086)

The evolving efforts of PICES early career ocean professionals to foster international, intergenerational and cross-sectoral engagement in the North Pacific and beyond

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Since its inception in 2020, the Study Group on early career ocean professionals (SG-ECOP) has been actively engaged across a variety of initiatives within PICES and in cooperation with international partners, especially in the context of the UN Decade of Ocean Science for Sustainable Development (2021-2030). In this talk, we will offer an overview of the research and collaborative activities ECOPs have been pursuing over the past year, including results of online surveys and workshops we recently conducted across the PICES community. Concrete recommendations for designing an effective mentorship platform will also be provided, with the aim to encourage intergenerational and cross-country knowledge exchanges in the North Pacific while helping to retain ECOPs into the PICES structure. In addition, we will showcase the distinct leadership roles that ECOPs took on during international UN Decade-sponsored events and conferences (e.g., V.ECOP day, Ocean Visions Summit, etc.), and highlight international and nascent collaborations that PICES ECOPs are nurturing (e.g., ICES, regional and global ECOP associations). As we look to further contribute to the development, communication and promotion of PICES science and its future leading role in the UN Decade, our talk aims to emphasize how the interdisciplinary, inclusive and cross-pollinating nature of our ECOP group can help support and steer the PICES ship throughout this transformative decade for our global ocean.

S1-LiveOral-4 (PaperID=15042)

Basin-scale Events to Coastal Impacts (BECI): An ocean intelligence system for a changing world

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Changing climate and anomalous events are exposing ecosystems of the North Pacific Ocean to conditions outside past norms. While billions of dollars have been invested in management, conservation and restoration efforts for species such as Pacific salmon and saury, there continues to be insufficient investment to fully understand the impacts of climate change on the ocean. Further, we lack the institutional capacity required to study large marine ecosystems and provide timely information and advice to decision-makers. The NPAFC and PICES are convening a consortium of partners to design, test, and implement an international ocean intelligence system. This system will utilize partnerships, innovative monitoring, data mobilization and analytical methods to provide timely knowledge and advice to decision-makers about the effects of climate on ocean basin conditions and coastal socio-ecological systems. This system will inform decisions on fisheries management, fisheries compliance, food security, ecological restoration, and much more. The NPAFC and PICES submitted a concept proposal for this program known as BECI (Basin-scale Events to Coastal Impacts) to the UN Decade of Ocean Science in early 2021, with the goal of developing the intelligence system over the period of the Ocean Decade (2021–2030). In winter 2022, we expect BECI will launch with a pan-Pacific expedition involving up to five research vessels and participants from Canada, Russia, the United States, Japan, and Korea. The expedition will bring together key partners and stakeholders and allow for the testing of a range of novel technologies and tools that will form the ocean intelligence system.

SESSION 2

POC Topic Session
Global warming patterns and multiscale climate variability in the North Pacific

S2-Invited-1 (PaperID=15049)

Role of the Indo-Pacific oceanic channel dynamics in ENSO development and global climate change

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The variations of the Indonesian Throughflow (ITF) impact the western Pacific warm pool, which plays a central role in ENSO dynamics and in global climate change. The exchange of the western Pacific circulation with the Indian Ocean has been disclosed to significantly impact the regional heat and freshwater inventories. The WPOC-ITF mooring arrays have provided a large amount of direct synchronous time series measurements of the western tropical Pacific circulation and of the ITF in key straits of the Indonesian seas. In this talk, the variability of the surface and sub-thermocline circulation in the western tropical Pacific Ocean and their interactions with the Indian Ocean during the latest interannual events are analyzed based on these observations. The dynamics of the latest ENSO and the accelerated global warming will be discussed in light of these disclosed variability.

S2-LiveOral-2 (PaperID=15089)

Multidecadal oceanographic variability over the Bering Sea Inner Shelf

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The climate is warming in the Northern Pacific. In the Bering Sea historical patterns and physical drivers of oceanic variability have been extensively monitored and studied over the middle shelf in order to develop climate projections. The dynamics differ between the northern and southern regions of the middle shelf, contributing to shifts in species distributions and abundances between historical warm and cold periods. Fewer observations have been collected over the inner shelf (i.e. <50 m water depth) and long-term trends are less well understood in this ecologically important coastal region. Here, climate variability over the inner shelf of the Bering Sea is investigated using results from the 10 km resolution Bering10K Regional Ocean Model (ROMS) configuration spanning the years 1971-2020. The inner shelf has a weaker temperature gradient from north to south than over the middle shelf with a stronger correlation between the two regions and the inner shelf also has greater intraseasonal and interannual variability. These results indicate different mechanisms control the inner shelf dynamics relative to the middle shelf. The inner shelf oceanography may be more impacted by changes in atmospheric forcing and river discharge while experiencing less variability in sea-ice coverage than the middle shelf, particularly in the southern region. Many of the key species in the Bering Sea utilize the inner shelf habitat during some of their life stages so as the ecosystem is experiencing rapid transformation, increased understanding of the climate variability across the inner shelf will provide critical knowledge for building out future projections.

S2-LiveOral-3 (PaperID=15041)

Preliminary assessment of simulated tropical Pacific SST warming based on CMIP models

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Based on the outputs from CMIP5/6 models, this study presents a preliminary assessment of warming features of the simulated tropical Pacific SST during the period 1950-1999. The results indicate that different models display large discrepancies compared with the observation, especially over the eastern equatorial Pacific. The multi-model ensemble average results show a warming trend of CP El Niño-like pattern. By considering the decadal trend, this study also presents an assessment of decadal trend variability of tropical Pacific SST. The results reveal that the CMIP models show relatively weak decadal trend variability compared with observation.

S2-LiveOral-4 (PaperID=15034)

Resilience to climate variability of nutrient delivery and primary productivity in a coastal sea

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To evaluate the likelihood of tipping points in an ecosystem, one can identify the pressure points on the system, that is, key processes that are vulnerable to significant change under climate variability. On the other hand, some key processes seem remarkably resilient to climate change. Here we consider the key process of primary productivity, the base of the food chain. Our study region is the Strait of Georgia on the east side of the North Pacific Ocean. Recent sediment core studies have revealed remarkably little change in primary productivity in the last 100 years. Nutrients are supplied to this system in tidal mixing hot spots which would be consistent with the small change. Yet, spring bloom phytoplankton timing is highly variable between years and much summer productivity is episodic, correlated with strong wind events and upwelling. We will present a method, based on a coupled bio-physical model, to evaluate light versus nutrient limitation on primary productivity and to quantify the nutrients delivered by tidal mixing, versus wind-driven upwelling and mixing, versus freshwater-driven mixing and sources. Using these results, we will investigate whether the Strait of Georgia is truly resilient to climate change (as most nutrients are delivered by tides) or vulnerable to climate change (if most nutrients are delivered through wind or freshwater).

S2-LiveOral-5 (PaperID=15016)

Application of remote sensing to study the correlation of climate variability with air-sea CO_2 exchange to develop Sea-Level Variability Forecasting Models (SLVFM) over tropical oceanic regions

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The seminal scientific research is needed to develop Sea-Level Variability Forecasting Models (SLVFM) Over Tropical Oceanic Regions, to understand the major Atmospheric challenges due to extreme weather events caused due to mesoscale convective systems, Global Carbon Cycle, Ocean Salinity, and Marine Pollution resulting due to the toxin, toxin gases over the Oceanic and sub-surface Oceanic regions.

The Ocean Circulations, Ocean-Atmospheric (OA) interactions, and the inorganic contaminants get affected by the Ocean Salinity. Researchers found that the Sea-level rise was due to rising levels of Carbon Dioxide and other Green House Gases (GHG), as opposed to other types of forces. Hence, it's imperative to analyze Satellite imageries (IR & VR) over the Tropical Oceanic regions comprising Transitional areas (TAs) & (WBCs).

Transitional Areas (TAs) are the potential oceanic regions of early detection of Climate variability. Transitional areas (TAs) are areas of strong gradients in the physical environment that challenge biological communities, exposed to their physiological limits. These areas are associated with Sea-level Variability Mechanism, Sub-Mesoscale Dynamics over the Oceanic areas impacting the Climate change more dramatically and sooner over the (TAs) than of homogeneous areas.

Western Boundary Current (WBC) are the Pacific oceanic regions of mid- latitudes in Northern Hemisphere (NH). There is a complex interaction of Oceanic-Atmospheric dynamics and thermodynamics affecting the regional air–sea exchange processes and their larger-scale interactions. WBC are hubs for the subduction of anthropogenic carbon-laden waters into the ocean interior during mode water formation. WBC are Ocean Carbon Hot

Spots regions identified by the largest magnitude air-to-sea carbon dioxide (CO2) fluxes in the oceanic regions incorporated with large spring blooms and high eddy activity.

Therefore, the present investigation aims to understand air-sea exchange during extreme atmospheric forcing to correlate Air-Sea CO2 exchange with Climate Variability for estimating energy and material (Carbon, Nitrogen) exchange between the upper and deep ocean as well.

The correlation of climate variability with sea level variability mechanism, sub-mesoscale dynamics would be computed through the study of multi-scale ocean-atmosphere coupled processes e. g. Sea-level rise, rise of GHG-level and its control by chemical processes, e.g. Carbon-Absorption-Sinks (CAS), GHG- Detoxifiers to check the rising levels of Carbon Dioxide and in order to develop the Sea-Level Variability Forecasting Models (SLVFM) over tropical oceanic regions.

S2-RecordedOral-6 (PaperID=15140)

Predictability and Empirical Dynamics of Fish Indicators in the North Pacific

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It is now well known that large-scale modes of sea surface height (SSH) and sea surface temperature (SST) variability in the North Pacific such as the Pacific Decadal Oscillation and the North Pacific Gyre Oscillation exert a strong influence on marine ecosystems and fish species. In the central and western North Pacific along the Kuroshio-Oyashio Extension (KOE), the expression of these modes in SSH and SST is linked to the propagation of long oceanic Rossy waves, which extend the predictability of the climate system to ~3 years. Using a multivariate physical-biological linear inverse model (LIM) we explore the extent to which the physical predictability leads to multi-year prediction of dominant fishery indicators inferred from three fish dataset (e.g. FAO, LME, RAM). We find that on average the LIM leads to a dynamical forecast skill of the fish indicators up to 8-10 years, which is larger than the persistence skill ~7 years. Two different physical situations are considered in the LIM, an uncoupled system where tropics and extratropics are fully indipendent and a coupled system where the interaction between the two regions is considered. Although more studies are required to confirm the link between the tropical-extratropical interaction and the forecasting skill of the LIM ,the higher forecasting skills revealed in the coupled LIM suggests that the coupling dynamics between the tropical and North Pacific play a key role in the dynamics and predictability of fish stocks in the North Pacific.

S2-RecordedOral-7 (PaperID=15154)

Climate-induced fluctuations in primary production required in summertime upwelling ecosystems around the Taiwan Bank

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Climate-induced fluctuations in marine fish populations have been demonstrated in the Taiwan Strait region. Through predation and competition, interspecific relationships in the ecosystem are affected layer by layer. Taiwan Bank (TB) is located in the southern Taiwan Strait, where the marine environment is influenced by South China Sea Warm Current and Kuroshio Branch Current during summer. The uplifted continental slope and bottom currents bring upwelling areas and create an important fishing ground. Using trophic dynamic theory, fishery resources can be converted into primary production required (PPR) by primary production, which indicates the environmental tolerance of marine ecosystems. This study calculated the PPR, sea surface temperature (SST), upwelling size, and net primary production (NPP) to analyze fishery resource structure and the spatial distribution of PPR in upwelling, non-upwelling, and thermal front (frontal) areas of the TB in summer. The *Scombridae*, *Carangidae* families and *Trachurus japonicus* dominated the main pelagic species, the benthic species were dominated by *Mene maculata* and members of the *Loliginidae* family. NPP was the main factor affecting the PPR of benthic species in all three habitats. Pelagic species were affected by high NPP, as well as low SST and negative values of the multivariate El Niño–Southern Oscillation (ENSO) index in upwelling habitats (16.9%) and non-upwelling habitats (11.5%) by Generalized additive models. Overall, pelagic species resources are susceptible to climate change, whereas benthic species are mostly insensitive to climatic factors and are more affected by NPP.

SESSION 5

BIO/POC Topic Session
Atmospheric nutrient deposition and microbial community responses, and predictions for the future in the North Pacific Ocean

S5-LiveOral-1 (PaperID=15126)

Impact assessment of deposition of atmospheric nitrogen compounds to the surface chlorophyll-a concentration over Northwestern Pacific Ocean

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To investigate the sensitivity of ocean phytoplankton (chlorophyll-a concentration) to deposition of atmospheric inorganic nitrogen compounds over Northwestern Pacific Ocean (NWPO), we conducted simulations using a lower trophic-marine ecosystem model (COCO-NEMURO) combined with an atmospheric regional chemical transport model (WRF-CMAQ). The monthly mean values for the wet and dry deposition of nitrogen compounds, including gases (HNO_3 and NH_3) and aerosol particles (NO_3^- and NH_4^+), were determined using the WRF-CMAQ for the NWPO from 2009 to 2016. These values were input into the NEMURO as an additional nitrogen source at the surface layer. Our results showed that supply of atmospheric inorganic nitrogen compounds enhanced the annual average of surface chlorophyll-a mass concentration, especially in the subtropical region. This is because aerosol deposition has enhanced the supply of essential nutrients which typically limit production under natural conditions near the ocean surface. These results indicate that the deposition of atmospheric inorganic nitrogen compounds to the NWPO could have a high nutrient impact on the marine ecosystem.

S5-RecordedOral-2 (PaperID=15070)

The distribution and diversity of antibiotic resistance genes in aerosols between a coastal site and marine sites

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In this study, total suspended particle (TSP) samples were collected to investigate the spatial and spatiotemporal distributions of airborne antibiotic resistance genes (ARGs) in the coastal areas of northern China and over the Yellow Sea and Bohai Sea and determine the relationships with meteorological factors, air pollutants and chemical species in the TSP. Forty sets of 24-hr TSP samples were collected from December 2019-June 2020 from the coastal atmosphere, while 13 sets of 20-hr samples were collected from May–June 2020 over the seas. The observations showed that both the abundance and diversity of airborne ARGs in the coastal area increased from nonpolluted to polluted air quality levels. In marine TSP samples, the abundances of airborne ARGs were always higher than those measured at the nonpolluted air quality level but substantially lower than those in polluted weather in coastal areas. Our results demonstrated that *tetW*, *strB*, and *sul3* in the marine TSP were derived mainly from long-range continental transport, while other ARGs may come mainly from sea-spray organic aerosols, making marine aerosols a potential repository of ARGs. Sea-derived airborne *bla-NDM1*, *bla-CMY2*, *sul2* and *tetA* may also be transported to the coastal atmosphere, especially on nonpolluted days with clean onshore winds. The impact of airborne ARGs on the treatment of human respiratory diseases should not be ignored. Collectively, this study first demonstrates the dual role of marine areas, i.e., as receivers and emitters of ARGs.

S5-RecordedOral-3 (PaperID=15072)

The response of phytoplankton in the oligotrophic and eutrophic waters of the Yellow Sea to the addition of haze in spring

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In this study, we collected seawater from the Yellow Sea to conduct a series of onboard incubation experiments in the spring of 2019 to explore the changes of phytoplankton community under haze addition in different nutritional environment. At oligotrophic site with N limitation, the addition of haze promotes the increase of the total Chl-a concentration. The contribution of microsized (20-200 μm) phytoplankton to the total Chl-a is positively correlated with the concentration of NO_3^-+NO_2^- (r = 0.94), indicating that the nitrogen(N) brought by haze particle shift the size structure of phytoplankton to large size. At eutrophic site without nutrient limitation, the addition of haze has little effect on the total Chl-a concentration, but also shift the size structure of phytoplankton to large size. The haze particle with the characteristics of high N:P gradually depleted PO_4^{3-} in seawater during the incubation. And the alkaline phosphatase activity (APA) in haze treatments was significantly higher than that of the control, indicating the haze addition promotes the utilization of dissolved organic phosphorus (DOP) by phytoplankton. The contribution of microsized phytoplankton to the total Chl-a is positively correlated with APA (r = 0.65), indicating that microsized phytoplankton has an important contribution to the increase of APA in seawater, which explain the haze addition in eutrophic seawater causes the phytoplankton shift to large size. In summary, this study reveals the different mechanisms of haze addition on the transfer of phytoplankton size structure in oligotrophic and eutrophic waters.

S5-LiveOral-4 (PaperID=15153)

Estimation of the contribution of combustion Fe in marine aerosols over the North Pacific using Fe stable isotope ratios

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Iron (Fe) is one of the limiting factors on phytoplankton growth in oceanic regions (Martin and Fitzwater, 1988). Atmospheric aerosol, including natural and combustion origins, is considered an important Fe source. However, the relative contribution of combustion and natural Fe remains unclear, especially in the open ocean. Based on the previous results that the Fe stable isotope ratio (δ^{56}Fe) of combustion Fe is approximately 4‰ lower than that of natural Fe (Kurisu et al., 2016; 2019), we analyzed δ^{56}Fe of size-fractionated aerosols collected over the North Pacific to distinguish different aerosol sources. The δ^{56}Fe as low as −3‰ was detected in fine particles collected near the coast of Japan or North America due to the presence of combustion Fe. Furthermore, the soluble fraction of the fine particles yielded δ^{56}Fe lower than the total, suggesting the important contribution of combustion Fe as a soluble Fe source. On the other hand, the δ^{56}Fe was close to the crustal average in the open ocean, indicating the predominance of natural Fe. The contribution of combustion Fe estimated by a mass balance equation was up to 21%. The estimated contributions were consistent with those estimated by an atmospheric chemical transport model for fine particles, whereas the model estimated a larger fraction of combustion Fe in coarse particles, presumably due to the different characteristics of combustion Fe included in the model and the δ^{56}Fe-based estimations, suggesting the importance of size-fractionated observational data to scale the combustion Fe emission by the model.

S5-RecordedOral-5 (PaperID=15100)

The concentrations and depositions of atmospheric particles nutrient into the China adjacent seas

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Atmospheric deposition is an important source of silicon (Si) in the seawater which impact on geochemical cycles and marine productivity. In this study, an adaptor to generate anthropogenic and shipping Si emission inventories for China was developed by combing the source-specific mass fractions of Si in $PM_{2.5}$ and $PM_{2.5}$ emissions from multi-resolution emission inventory for China (MEIC) and shipping emission inventory model (SEIM). $PM_{2.5}$ samples were collected and analyzed in Qingdao for four seasons (14 days) in 2019. The concentrations and dry depositions fluxes of Si in Qingdao and China marginal seas were simulated for four seasons 2019 by WRF-CMAQ model based on the bulit emission inventories. There were good correlations between simulated and observations Si concentrations. The seasonal variation of Si concentration is 8.95×10^2 ng m^{-3}(winter)>5.05×10^2 ng m^{-3} (spring)>4.97×10^2 ng m^{-3} (autumn)>4.80×10^2 ng m^{-3} (summer) in the Bohai sea and 8.91×10^2 ng m^{-3} (winter)>7.02×10^2 ng m^{-3} (autumn)>6.08×10^2 ng m^{-3} (spring)>5.15×10^2 ng m^{-3} (summer) in the Yellow Sea. The seasonal variation of Si dry depositions fluxes is 27.9 μg m^{-2} d^{-1} (spring) >27.4 μg m^{-2} d^{-1} (autumn) >23.6 μg m^{-2} d^{-1} (winter)>13.7μg m^{-2} d^{-1} (summer) in the Bohai Sea and 31.1 μg m^{-2} d^{-1} (winter)>19.1 μg m^{-2} d^{-1} (spring)> 18.2 μg m^{-2} d^{-1} (autumn)> 9.5μg m^{-2} d^{-1} (summer) in the Yellow Sea.

S5-LiveOral-6 (PaperID=15144)

Dry nitrogen deposition to the eastern Indian Ocean during boreal autumn and its impact on the primary production

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Anthropogenic nitrogen emissions to the atmosphere have increased significantly in South Asia due to the economic growth, and the deposition of nitrogen compounds to the Indian Ocean may impact on the marine primary production and the carbon cycle. To evaluate the ocean fertilization effect of atmospheric nitrogen deposition to the eastern Indian Ocean, atmospheric samples were collected along the 88 degrees east transect during the R/V Hakuho Maru cruise in boreal autumn 2018, the beginning of the Indian winter monsoon season. Backward trajectory analysis suggested that the Bay of Bengal was strongly influenced by anthropogenic pollutants from the Indian subcontinent, whereas the southeastern Indian Ocean was under the influence of pristine marine airmasses. The concentrations of nitrogen compounds in the gas, aerosol and rainwater samples showed a clear north-to-south gradient. By using deposition velocities derived in WRF-CMAQ model, the mean dry deposition flux of nitrogen was estimated to be 0.24 mgN m^{-2} d^{-1} and 0.02 mgN m^{-2} d^{-1}, respectively, in the Bay of Bengal and the southeastern Indian Ocean. If the receiving waters are nitrogen limited and all the nitrogen form the atmosphere is used by the phytoplankton, the carbon uptake would be 1.9 mgC m^{-2} d^{-1} and this value was found to be 19% to the primary production at the surface 1 m of the Bay of Bengal. It was indicated that nitrogen from the atmosphere was an important factor supporting the primary production of the surface layer in the Bay of Bengal in the Indian winter monsoon season.

SESSION 6

S-CC Topic Session
Connecting knowledge of ocean deoxygenation in coastal and offshore regions of the North Pacific

S6-LiveOral-1 (PaperID=15103)

Isopycnal shoaling causes interannual variability in oxygen on isopycnals in the subarctic Northeast Pacific

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Over sixty years of observations from Ocean Station Papa (OSP) in the northeast Pacific indicate the region is losing dissolved oxygen (O_2) faster than the average global rate. The greatest trends of O_2 loss occur on isopycnals in the upper water column (σ_σ = 26.1–26.8 kg m^{-3}) but have considerable uncertainty due to natural variability. Eight Argo profiling floats equipped with oxygen optode sensors were used to assess the 2008–2016 interannual variability of subsurface O_2 near OSP. The optodes have a slow response time that leads to a time-lag in the O_2 observations in the oxycline. We developed a method to correct the optode profiles using high frequency CTD data and used reference profiles from OSP to calibrate the O_2 observations. The time-lag correction markedly improves subsurface bias. Isopycnal properties were analyzed for two rapid O_2 loss events to determine the driving mechanism. We concluded that the O_2 loss during the events was caused by episodic shoaling of the isopycnals, due to the higher concentrations of organic matter and greater respiration rates at shallower depths. Reduced net community production during the "Blob" marine heatwave may have reduced the impact of the second shoaling event examined. Studying the natural variability of O_2 in these layers can provide context for the uncertainty in the long-term trends, as well as provide insight towards the future potential for extreme oxygen minima from the combined impacts of the long-term trend and natural variability.

S6-LiveOral-2 (PaperID=15130)

Drivers of oxygen trends and variability in the Northeast Pacific

Ana C. **Franco**[1], Debby Ianson[1,2], Tetjana Ross[2], Roberta C. Hamme[3], Adam H. Monahan[3], James R. Christian[2], Marty Davelaar[2], William K. Johnson[2], Lisa A. Miller[2], Marie Robert[2], and Philippe D. Tortell[1,4]

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Dissolved oxygen in the Northeast Pacific is decreasing rapidly relative to other ocean basins. In this study, we make use of extensive timeseries data collected under the Line P program in the eastern North Pacific to estimate long-term (30-year) trends and shorter-term variability in oxygen concentrations and apparent oxygen utilization (AOU). Focusing our analysis on the core of the North Pacific Intermediate water (isopycnals 26.7 and 26.8), we find a statistically significant increase in AOU in coastal and offshore waters of the Line P sampling transect at. At the 26.7 isopycnal, these AOU trends are more pronounced in coastal waters (0.7 μmol kg^{-1} yr^{-1}, 70 km from the coast) relative to oceanic waters (0.2 μmol kg^{-1} yr^{-1}). On top of the long-term trend, AOU and dissolved inorganic carbon exhibit bi-decadal variability at the offshore end of our sampling transect. We trace these oscillations to alternating periods of strong and weak ventilation in the Northwest Pacific, and the resulting changes in anthropogenic carbon uptake and carbon remineralization. We discuss possible mechanisms driving the spatial and temporal patterns of AOU in our study region, and examine the potential impact of increasing AOU on the inorganic carbon cycle.

S6-LiveOral-3 (PaperID=15164)

Variability in oxygen within the coastal region of Queen Charlotte Sound: Seasonal patterns, spatial trends, and implications for the marine carbonate system

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Queen Charlotte Sound (QCS) is a highly productive region of the British Columbia central coast that is bounded by Haida Gwaii to the north, Vancouver Island to the south, and is exposed to the Pacific Ocean to the west. The sound features several marine canyons that extend over 130 km into the continental shelf from the shelf-slope and facilitate the exchange of shelf waters with deeper offshore waters that are typically oxygen-depleted and lower pH. Here, we use data from a variety of observing efforts, which include moorings deployed near the shelf-break and near-shore from 2016-present, ocean glider transects capturing a full annual cycle of coast-to-open ocean properties, and shipboard CTD casts that survey the region from 2013-present, to characterize variability in temperature, salinity, and oxygen within QCS on timescales of hours to years. We further estimate variability in carbonate system parameters (pH and aragonite saturation state) via the use of empirical models (a regional multiple linear regression model) applied to measured properties. Our analysis reveals significant variability in physical and carbonate systems parameters on a wide range of timescales. Notably, we document significant episodic variations in winter, a season hitherto sampled sparsely in this region. In this talk, we discuss key findings that are especially relevant to oxygen variability within QCS. Specifically, we highlight and discuss the drivers of oxygen variability, spatial differences in oxygen trends, and the relationship between oxygen concentration and carbonate system parameters.

S6-LiveOral-4 (PaperID=15055)

Identification of a seasonal subsurface oxygen minimum in Rivers Inlet, British Columbia

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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 the 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 May / early June, 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 vari ability 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.

S6-LiveOral-5 (PaperID=15062)

Continuous monitoring and future projection of ocean warming, acidification, and deoxygenation on the subarctic coast of Hokkaido, Japan

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As the ocean absorbs excessive anthropogenic CO_2 and ocean acidification proceeds, it is thought to be harder for marine calcifying organisms, such as shellfish, to form their skeletons and shells made of calcium carbonate. Recent studies have suggested that various marine organisms, both calcifiers and non-calcifiers, will be affected adversely by ocean warming and deoxygenation. However, regardless of their effects on calcifiers, the spatiotemporal variability of parameters affecting ocean acidification and deoxygenation has not been elucidated in the subarctic coasts of Japan. This study conducted the first continuous monitoring and future projection of physical and biogeochemical parameters of the subarctic coast of Hokkaido, Japan. Our results show that the seasonal change in biogeochemical parameters, with higher pH and dissolved oxygen (DO) concentration in winter than in summer, was primarily regulated by water temperature. The daily fluctuations, which were higher in the daytime than at night, were mainly affected by daytime photosynthesis by primary producers and respiration by marine organisms at night. Our projected results suggest that, without ambitious commitment to reducing CO_2 and other greenhouse gas emissions, such as by following the Paris Agreement, the impact of ocean warming and acidification on calcifiers along subarctic coasts will become serious, exceeding the critical level of high temperature for three months in summer and being close to the critical level of low saturation state of calcium carbonate for two months in mid-winter, respectively, by the end of this century. The impact of deoxygenation might often be prominent assuming that the daily fluctuation in DO concentration in the future is similar to that at present. The results also suggest the importance of adaptation strategies by local coastal industries, especially fisheries, such as modifying aquaculture styles.

S6-LiveOral-6 (PaperID=15159)

Impact of natural and anthropogenic deoxygenation on the habitat distribution of Pacific Halibut

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Future ocean warming and deoxygenation will modify the habitat of many aerobic organisms. Groundfish habitat is particularly sensitive to deoxygenation, as low oxygen concentrations occur naturally in continental shelf bottom waters. Here we examine the potential impacts of deoxygenation and ocean warming on the habitat distribution of Pacific halibut, one of the most important commercial groundfish fisheries in North America. We combine fisheries-independent halibut survey data (1998 – 2020) with oceanographic measurements and output from a regional ocean circulation model to investigate current and future (year 2100) influences of deoxygenation and warming on optimal halibut habitat. We use the observations and model output to derive a metabolic index as an indicator of halibut-specific suitable habitat. Our results show high halibut abundance in regions where the metabolic index is greatest, while also demonstrating interannual variations in halibut abundance that are coherent with the Pacific Decadal Oscillation. Working with model projections, we estimate future changes in suitable halibut habitat by the end of the century under a high CO_2 emissions scenario. These projections indicate that suitable halibut habitat may largely disappear off the coast of Washington state, and decrease by about two-fold (from 80% to 40% of the continental shelf bottom waters) along coastal British Columbia and Alaska. Such habitat changes may drive a strong northward shift in halibut abundance, with significant implications for commercial fisheries.

S6-LiveOral-7 (PaperID=15143)

Interactive effects of ocean deoxygenation and acidification on demersal fish in early life stages

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Acidification and deoxygenation are major threats to ocean environments. Despite the possibilities of their co-occurrence, not much is known about the effects of their interaction on marine organisms. In this study, we investigated multiple effects of high pCO_2 and low dissolved oxygen (DO) on the early life stages (embryonic and larval stages) of the demersal fish *Sillago japonica*. To test the effects of interaction between acidification and deoxygenation, we set 25 experimental treatments in five levels of pCO_2 between 400–1,500 μatm and DO between 50–230 μmol/kg. We then investigated the hatching rate of the eggs and survivability of the larvae after 24 h at 25°C. We found that low DO values significantly affected both embryos and larvae, as compared with pCO_2. Although the hatching rate and survivability were more than 90% in ≥150 μmol/kg DO, the values decreased in lower DO. In fact, all embryos and larvae died under <50 μmol/kg DO. For each pCO_2 condition, we calculated the 50% lethal concentration (LC_{50}) of DO for both embryos and larvae, and found that LC_{50} of DO was lower at 1,000–1,250 μatm pCO_2 and higher at 400 and 1,500 μatm pCO_2. These results indicate that high pCO_2 and low DO have interactive effects on this species, at least in its early life stages, and that embryos and larvae of *S. japonica* may have physiological tolerance to lower DO under certain pCO_2 level.

S6-LiveOral-8 (PaperID=15135)

Evaluation of the effects of ocean acidification and deoxygenation on eggs of Japanese whiting, Sillago japonica: An approach based on comprehensive gene expression analysis

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We evaluated the effects of (1) high pCO_2 (2) low O_2, and (3) the combined stress conditions on eggs of Japanese whiting, *Sillago japonica*. The seawater with pCO_2 (about 1500 µatm) and dissolved oxygen saturation (about 20%) was prepared by aerating with a gas mixture, and the sample eggs were exposed in this seawater for two hours. After RNA extraction from the eggs, RNA-seq was performed. Then the transcriptome sequence was assembled and mapped to quantify and visualize the expression levels. The results of the comprehensive gene expression analysis showed that the gene expression pattern in the high pCO_2 condition was relatively similar to that of the control. On the other hand, under the low O_2 and the combined stress conditions, a large number of gene expressions were found to be variable. In particular, there was a remarkable change in gene expressions under the combined stress condition. These results indicate that anoxic condition with a saturation level of 20% have a more pronounced effect on fish eggs than acidification. In this presentation, we will review the demersal fish egg response to ocean acidification and anoxia at the molecular level, based on those functional genes that showed variation in this study as well as findings from previous studies.

SESSION 7

FUTURE/POC Topic Session
Predictions of extreme events in the North Pacific and their incorporation into management strategies

S7-LiveOral-1 (PaperID=15054)

Recent advances in measuring and predicting the occurrence and impacts of harmful algal biotoxins in British Columbia coastal waters

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The frequency and magnitude of marine harmful algal blooms (HABs) appear to be increasing worldwide, influenced by factors such as eutrophication and climate change. Algal biotoxins and physical damage caused by HABs have a negative impact on marine life including fish, mammals and seabirds 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. Scientists at Fisheries and Ocean Canada are partnering with the aquaculture industry and citizen scientists to collect biotoxin samples, taxonomic and environmental data in British Columbia (BC) coastal waters. The goal of this research is to identify the biotoxins responsible for impacting wild and farmed species, and the environmental conditions and mechanisms that give rise to these impacts. To enable this research, new methodology has been developed to quantify multiple biotoxins in seawater and phytoplankton, including toxins associated with amnesic, paralytic and diarrhetic shellfish poisoning in humans. The method is being used to generate spatial and temporal profiles of harmful algal biotoxins in BC coastal waters, including aquaculture facilities and critical habitat for marine mammals and their prey (e.g. salmon). Initial results suggest that biotoxin concentrations may be related to water temperature as well as the presence of associated harmful algae. Such information can be used to help predict and manage the impacts of toxic algal blooms on marine fisheries and ecosystems in the North Pacific.

S7-LiveOral-2 (PaperID=15133)

The next decade of ocean acidification research in the Bering Sea: What we've learned and what's coming next

Jessica N. **Cross**[1], Darren Pilcher[2,1], Hongjie Wang[2,1], Elizabeth Siddon[3], Natalie Monacci[4], W. Christopher Long[5], and Esther Kennedy[6]

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Over the last decade, ocean acidification (OA) has emerged as one of the most prominent issues in Alaskan marine research, and a possible threat to culturally and commercially important marine resources. Multiple communities around the state are now engaged in their own OA studies and monitoring, and are asking a common question: what risks does my region face? These are especially salient questions for Alaskans, given that the intensity, duration and extent of OA events have been greater than other ocean basins. Given the pace of the observed changes due to OA around Alaska, the area is commonly referred to as a bellwether and the proverbial "canary in the coal mine" for the rest of the global ocean. Here, we will take a look back at the last ten years of OA research in the Bering Sea, and highlight new, cutting-edge synthesis and biogeochemical modeling, forecasting, and projection efforts that have dramatically increased our capacity to understand Alaskan OA from a large-scale perspective just in the past year. For example, we have scaled point observations to the entire Bering Sea shelf to show that corrosive conditions have covered almost 60% of critical habitat areas in the last ten years. Our goal is to continue refining our capacity to identify new risks and emerging resilience of Alaskan ecosystems, and guide sound, evidence-based decisions that support sustainable marine resources in the future, including the evaluation of marine carbon dioxide removal techniques.

S7-LiveOral-3 (PaperID=15134)

Tropical influence on the development of Northeast Pacific marine heatwaves

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Starting in Winter 2013/14, the Northeast Pacific experienced extremely warm sea surface temperatures (SSTs) that began in the center of the Gulf of Alaska and subsequently extended along the U.S. West Coast, where they persisted into 2016 with evolving intensity and spatial pattern. Building on previous research showing that intense Northeast Pacific warming events undergo similar evolutions, in this study we explore large-scale deterministic influences on Northeast Pacific MHW development, and the degree of predictability of these events. A Linear Inverse Model (LIM), constructed from both SST and sea surface height (SSH) monthly anomalies, is used to determine the optimal precursors of Northeast Pacific MHWs at different lead times. Our analysis identifies initial precursors anomalies characterized by weak SST anomalies in the Northeast Pacific, subtropical anomalies reminiscent of the Pacific Meridional Mode, as well as warm conditions in the central equatorial Pacific, and by SSH anomalies that achieve their largest values in the tropical Pacific and are consistent with off-equatorial Rossby wave dynamics. These optimal initial conditions develop into Northeast Pacific MHWs after two-to-three seasons, in conjunction with the development of Central Pacific (CP) El Niño conditions in the tropical Pacific. Diagnosis of the key ENSO eigenmodes determined from the LIM dynamical operator, which represent different aspects of evolving ENSO diversity, is used to examine their respective roles in the subsequent growth of the MHW. This analysis demonstrates a key role for ocean dynamics and especially for tropical CP El Niño conditions, in sustaining that growth.

S7-RecordedOral-4 (PaperID=15017)

Co-occurrence of California drought and northeast Pacific marine heatwaves under climate change

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From 2013–2016, an exceptional California drought co-occurred with extreme northeast Pacific marine heatwaves, leading to significant social-economical-ecological impacts. The evolution of this event led us to examine California drought co-occurring with marine heatwaves in the California Current and in the Gulf of Alaska, as well as other relevant sequential events. To separate effects of long-term trends from year-to-year changes, we examine the changes with and without trends respectively. Here, we show that under global warming, the co-occurrences of extreme warm northeast Pacific ocean and dry California conditions will become dramatically more frequent by the end of the 21st century. This increasing frequency of co-occurrence is strongly driven by anthropogenic warming and drying trends. If these trends are removed, the co-occurrence between Gulf of Alaska marine heatwaves and California drought will increase relative to cases with no warming, but the co-occurrence of California Current marine heatwaves and California drought remains unchanged. We also found stronger links between the marine heatwaves in the Gulf of Alaska and subsequent marine heatwaves in the California Current, and reduced frequency of persistent California droughts. Understanding changes not just in extremes but in their co-occurrence is critical to projecting the future impacts of multiple ecosystem stressors.

S7-RecordedOral-5 (PaperID=15139)

Detecting and identifying saxitoxin-producing algae in the Salish Sea

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The Salish Sea, a network of waterways along the coast of British Columbia, Canada and the state of Washington, United States is home to the Coast Salish People. Residents, including the Lummi People, rely on shellfish for subsistence harvesting. The goal of our project is to detect harmful algae blooms in the ecosystems along the coast of the Lummi Nation. The Salish Sea Research Center currently monitors harmful algae with microscopy, but we are exploring the feasibility of incorporating a commercially produced quantitative polymerase chain reaction (qPCR) assay. Preliminary results have enabled us to detect the gene responsible for producing saxitoxin (*SxtA4*), one of the Paralytic Shellfish Toxins that can cause harm to humans if ingested. Plans to develop a new qPCR assay to identify *SxtA4* produced by *Alexandrium catenalla,* a species of concern in our study area, will be presented. The inclusion of qPCR methods will rapidly and accurately detect genes known to threaten food sovereignty and human safety in the Salish Sea.

S7-RecordedOral-6 (PaperID=15160)

Extreme events in the thermal state of the Far-Eastern Seas and adjacent waters of the Northwestern Pacific

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In this study extreme events in the thermal state of the Far-Eastern Seas and adjacent waters of the Northwestern Pacific were analyzed using regional datasets based on historical observations. In the Far-Eastern Seas, the frequency of extreme situations has increased in the last 20 years. Extremely warm and cold winters were characterized by strong atmospheric anomalies with the change in the trajectory of cyclones. Since the middle of 1980s the well-known contrast in the oscillation phases of ice coverage in the Okhotsk and Bering Seas have been disrupted. However, in some "extreme" years the ice cover anomalies of the Okhotsk Sea were in opposite phase with the Bering Sea. The formation of strong winter atmospheric anomalies over the Far-Eastern region causes the fast response in large ice cover anomalies. During the warm period, the position and intensity of the summer centers of atmospheric action, especially the ridge of the Pacific anticyclone (for example, its impact on the Japan Sea in the summer of 2021), affect the formation of extreme SST anomalies in the region. Local events can also generate extreme anomalies affecting the spatial distribution, migration routes, and possibly changes in the abundance of short-cycle fish species such as Pacific saury. For example, large anticyclonic eddy with extreme temperature anomalies located east off Hokkaido Island in 2015-2016 caused a shift in the autumn southern migrations of saury from coastal areas to the open waters. Subsequently, the abundance of saury decreased significantly in the areas of traditional fishing.

SESSION 8

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

S8-RecordedOral-1 (PaperID=15060)

Evaluating species as bioindicators for plastic pollution in North Pacific food webs

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Synthetic marine debris has become a ubiquitous component of the Anthropocene ocean. Plastic ingestion by marine wildlife was first reported half a century ago and since that time, roughly one thousand species have been reported to consume this debris. This study focuses on plastic ingestion by marine organisms in the North Pacific Ocean. We assess the scope of the problem and identify key bioindicator species to develop a monitoring program for plastic debris in North Pacific food webs. Using data from 1969-2020, our meta-analysis confirmed that foods webs in the North Pacific are among the most polluted globally; roughly half of all fish and seabirds surveyed in the region had consumed plastic, and more than three-quarters of sea turtles and bivalves. While there is not enough standardized data to assess if the problem is worsening, standardization and reporting of methods are improving over time. Using a rubric-evaluation approach, we evaluated 335 species for their potential to serve as bioindicators of plastic pollution in North Pacific food webs. Linking our results and suggested bioindicator species to other monitoring programs worldwide will be paramount to track humanity's progress on mitigating plastic pollution in the marine environment.

S8-RecordedOral-2 (PaperID=15111)

Assessing impacts of plastic accumulation in Laysan Albatross (*Phoebastria immutabilis*) chick growth and body condition

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Laysan albatross (*Phoebastria immutabilis*) are characterized by a high frequency of occurrence and loads of ingested marine plastic debris. While there is correlational evidence of delayed growth and depressed body condition in albatross chicks with larger ingested plastic loads, very little is known about how this material accumulates in their two stomach chambers (proventriculus, gizzard). We measured the growth and body condition of 130 chicks from French Frigate Shoals and necropsied 44 salvaged chicks. We used these specimens to: (1) document the accumulation of ingested plastic through their development (February – July); and (2) investigate impacts of plastic ingestion on their growth and body condition. First, we documented distinct trends of ingested plastic mass in the two stomach chambers. While gizzard plastic increased through chick development, proventriculus plastic increased initially and declined once chicks started casting boluses. Thus, the combined mass of ingested plastic levelled off during the chick-rearing period (19-90 days), but the proportion of plastic in the gizzard peaked during the bolus-casting period (>90 days). Second, we related four chick growth metrics to body condition and ingested plastic mass using PCA. PC1 was positively correlated with gizzard plastic mass and PC2 was positively correlated with proventriculus plastic mass and body condition. These results do not suggest that higher plastic loads cause slower chick growth or depressed body condition. However, because fledging success was significantly lower in the study year (2011), compared to the 2006-2011 baseline, the plastic signal may have been swamped by other factors, including food-provisioning and dehydration.

S8-RecordedOral-3 (PaperID=15066)

Field measurements reveal the risk of microplastic ingestion by filter-feeding megafauna

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Microplastics including microfibers are ingested by nearly 1000 species across the global ocean. When consumed, microplastic can damage the endocrine and digestive systems, compromise nutrition and energy gains, and even result in death. We use high-resolution field measurements from feeding blue, fin, and humpback whales, combined with depth-integrated microplastic data in the California Current Ecosystem, to quantify plastic ingestion by these marine top predators. Projected daily ingestion varied by two orders of magnitude driven by differences in prey type; a krill-obligate blue whale may ingest 1.09×10^7 particles d^{-1} (48.3 kg d^{-1}) whereas a fish-feeding humpback may ingest 1.96×10^5 particles d^{-1} (0.87 kg d^{-1}). Quantifying the plastic consumed by baleen whales is a necessary step towards understanding the role of plastics in inhibiting the recovery of these global giants. As the use of plastic increases unabated and the disposal of microplastic remains ineffective, plastic debris will continue to threaten the health of the global ocean and hinder the recovery of vulnerable populations.

S8-RecordedOral-4 (PaperID=15048)

Occurrence and risk assessment of microplastics in various shellfish from the two major coastal cities of China

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Microplastics in shellfish have caused widespread concern due to their potential health risk to humans. This study investigated and compared the contamination levels and potential human health risks of microplastics in the digestive system of commercial shellfish from Qingdao and Xiamen, China. Microplastics were found in 70% – 100% of shellfish samples from Qingdao and 70% – 90% of shellfish samples from Xiamen, with abundances ranging from 1.2 to 4.1 items/individual (or 0.8 – 4.4 items/g, wet weight of digestive system) in shellfish from Qingdao and 1.3 – 6.0 items/individual (or 2.1 – 4.0 items/g) in shellfish from Xiamen. The microplastics were in various shapes and polymer types, of which fibrous rayon accounted for the majority. Microplastics <500 μm were the dominant size range, in which the size range of 100 – 200 μm was the most abundant one. Features of microplastics in the water-dwelling shellfish differed from those of the sediment-dwelling shellfish, and the microplastic features in the shellfish were closely related to the sampling region and biometric parameters. Risk assessment results revealed that the potential human health risk posed by microplastics ingested by commercial shellfish was higher in Qingdao than in Xiamen. Our results suggested that the pollution of microplastics in shellfish needs attention.

S8-RecordedOral-5 (PaperID=15071)

Widespread plastic ingestion in an abundant pelagic fish species, *Alepisaurus ferox*, across the subtropical North Pacific

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Anthropogenic debris, and specifically plastics, are now widespread components of global marine ecosystems. With increasing study, a diversity of marine species spanning all levels of marine food webs are reported to ingest plastic debris. However, access to long-term datasets limits our ability to better understand impacts to marine life and the broader-scale ecological and/or environmental factors that explain plastic ingestion across vast pelagic ecosystems. We examine a unique long-term diet dataset for an abundant pelagic fish species, the longnosed lancetfish (*Alepisaurus ferox*), to assess temporal and spatial trends in plastic debris ingestion across the subtropical North Pacific. In partnership with fishery observers, we co-collected diet and plastic ingestion data from ~2009-2019, spanning approximately 2,500 lancetfish specimens. We found that approximately one in every three lancetfish ingested some form of plastic debris. Large (> 1 m length) lancetfish ingested different types and sizes of plastic debris than small (< 1 m length) lancetfish. Spatial and temporal trends are also examined in relation to common prey items ingested by the lancetfish across different water column depths. Our results suggest that strategic and continuous monitoring of lancetfish diet could serve as effective large-scale marine monitoring of plastic pollution across difficult to access pelagic ecosystems.

S8-RecordedOral-6 (PaperID=15073)

Ecological risk assessment of waterborne microplastic particles in the marine environments of Korea

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Ecological risk posed by microplastics is needed to be assessed for implementing further action plan. But, there has been a mis-match in size and shape of microplastics found or monitored in the field and used in laboratory bioassay. This study assessed the ecological risk of microplastics in surface and subsurface seawaters in coastal, continental shelf, and deep-sea areas of Korea considering microplastic size and shape. The target microplastics for risk assessment were specified as only non-spherical type microplastics in the size range 20–300 μm, because this type was predominantly observed in our study areas, and adverse biological effects have previously been reported. Exposure data for non-spherical microplastics were obtained from a previous study or were measured for microplastics of sizes down to 20 μm. A predicted no-effect concentration (PNEC) of 12 particles/L was derived by employing a species sensitivity distribution approach. Then the results were compared to the in situ observed concentrations at each site. The detected microplastic concentrations did not exceed the derived PNEC, i.e., the current pollution levels of fragment and fiber microplastics in the size range 20–300 μm would not pose a significant threat to the marine ecosystem in Korea. However, predictions are that microplastic pollution will increase to 50-fold by 2100 at the current rates, and in this scenario, the microplastic concentration is expected to far exceed the derived PNEC values for marine ecosystems. It is therefore urgent to take precautionary actions to prevent a further increase in microplastic concentrations in these environments.

S8-RecordedOral-7 (PaperID=15095)

First estimates on the amount of water-borne microplastics entering the ocean from the Korean Peninsula

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Most of plastic debris found in marine environment is esimated to originate from the inland, which includes riverine input and atmospheric deposition and direct discharge from wastewater treatment plant (WWTP) located at the coastal region. So far, many studies have estimated the riverine plastic emission to the ocean based on socioeconomic data and/or hydrological data but riverine emission of microplastics (MPs) based on monitoring data is very limited. Moreover, the relative contribution of input pathways is rarely known. To estimate the annual load of water-borne MPs discharged from Korean peninsula, we investigated the time-variation of MPs discharged from both rivers and WWTPs. First, MPs in the surface and bottome water of major five Korean rivers that accounted for 90% of total riverine water discharge for dry and wet season. Secondly, the monthly variation was additionally investiaged for the Han River, the largest river in Korea, and the correction factor between the two methods was applied to estimate MP discharge from uninvestigated streams and rivers. Thirdly, three major WWTPs located around the Han River estuary were investigated four seasons and its mean emission factor was applied for total 92 WWTPs located at the coastal region of Korean peninsula. The estimated annual input of MPs to the Korean coastal region was ~80×10^{12} items/year (equivalent to 455 tons/year), with more dominant contribution of riverine input (78% in counts and 77% in mass) than direct input of WWTPs. However, their relative contribution varied with three different sea areas, depending on hydrological and demographic characteristics.

S8-RecordedOral-8 (PaperID=15021)

Prevalence of small high-density microplastics in continental shelf and deep-sea waters of East Asia

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Microplastics are widely distributed throughout aquatic environments. Information about the vertical distribution and fate of microplastics in seawater remains limited. To elucidate the vertical distribution of microplastics, three to six vertical water column layers were sampled based on the thermocline depth, from which the vertical distribution and characteristics of microplastics larger than 20 mm were investigated in continental shelf and deep-sea waters around South Korea. In addition, microplastics incorporated into marine aggregates (aggregated fraction) were investigated to determine the contribution of aggregates to vertical transport of microplastics. The abundance of microplastics was in the range of 15–9400 particles/m^3. No consistent trend was observed in the overall vertical profiles. The size, shape and polymer compositions of microplastics at each station were generally comparable throughout the water column. Unexpectedly, high-density (HD; >1.02 g/cm^3) polymers accounted for an average of 73% of total microplastics. As polymer density increased, the proportion of microplastics less than 100 mm in size increased. Due to the relatively high proportion of HD polymers in offshore waters, high-density solution should be used to extract microplastics, even from surface seawaters. The aggregated fraction accounted for 0–28.6% (average, 3.4%) of total microplastics. Marine aggregates are considered an important mechanism of transport for microplastics less dense than seawater to the deep-water column, but they showed lower proportions than expected in continental shelf and deep-sea waters around South Korea.

S8-RecordedOral-9 (PaperID=15119)

Polyolefins and the effect of biofouling on their sinking behaviours in the oceanic water column

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Floating plastic is ubiquitous at the surface of the ocean, but the transport mechanisms associated with the effect of environmental parameters including the presence of a biofilm to the polymers are very limited. Biofilm affects the plastic object's buoyancy and alters the effect of photodegradation, hence impacting the distribution and sinks of discarded plastics in the marine environment. In this study, we assess the effect of biofouling on the sinking behaviour of positively buoyant polyolefins and its degradation rate in the water column in environmentally relevant marine conditions. In order to establish whether biofouling influences the transport of plastics and enhances its removal from surface waters, we conduct a long-term monitoring experiment within a flow-through aquaculture system on Oahu, Hawaii using low density polyethylene (LDPE), high density polyethylene (HDPE), and polypropylene (PP) of three different shapes (films, rods, and cubes) and thicknesses (ranging from X to Y). Physico- chemical variables of the polymers are being measured on a weekly and monthly basis, while environmental parameters (Chl a, UVA, UVB, PAR, dissolved oxygen, seawater temperature, air temperature, pH, salinity, nitrates, and phosphates) are being monitored at high-time resolution (minutes). This study offers one of the first empirical data to incorporate into numerical models assessing the effect of biofouling on plastic sinking velocities of various shapes and sizes, and help predict more accurately the fate and sinks of positively buoyant plastics in the ocean.

S8-RecordedOral-10 (PaperID=15043)

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

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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.

S8-LiveOral-11 (PaperID=15035)

Using shellfish as potential microplastic pollution indicator

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Microplastics have raised global concern due to their potential risks to humans. Finding an appropriate bio-indicator to monitor environmental microplastic pollution level is important for assessing the impact of microplastics. We looked into the distribution patterns, the physiochemical properties, and the potential human risks of microplastics in shellfish from different countries. Statistical analysis revealed that though features of microplastics (abundance, shape, size, color, polymer type) might be different in shellfish from different areas, there is a significant qualitative and quantitative connection between microplastics in shellfish and their surrounding environments. Since shellfish consumption is a non-negligible pathway for human exposure to microplastics, shellfish can be a good bioindicators for monitoring microplastic pollution. Considering the varying living environment and conditions of different organisms and the complex nature of microplastics, we may need bioindicators coming from different background.

SESSION 9

FUTURE/POC/TCODE Topic Session
Applications of artificial intelligence to advance the understanding of North Pacific ecosystems

S9-LiveOral-1 (PaperID=15112)

Enhanced dynamical downscaling of global climate projections to regional scales using Machine Learning

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We explore the use of Machine Learning methods to assist in the downscaling of global model projections to regional ocean dynamics. Ongoing research programs use dynamical downscaling to predict conditions in the Bering Sea and other regions; this entails the application of global seasonal forecasts, and CMIP multidecadal projections, as forcings to finely resolved dynamical regional models. Such high-resolution regional models are typically more computationally expensive to run than the global models which drive them. This severely limits the ultimate size of the donwscaled regional ensemble, which in turn severely constrains the skill and uncertainty estimates of the regional forecasts, needed for their effective use in fisheries management. First, we present Principal Component based statistical methods, which summarize the dominant patterns generated by the regional model in response to dominant patterns of the coarse-scale atmospheric/oceanic forcing. This “hybrid” statistical summary is then used to estimate the regional responses that would have been obtained if a larger dynamical downscaling ensemble had been computationally affordable. Second, we explore an extension of this approach using a Nonlinear Autoregressive model with Exogenous Input (NARX) Neural Network, trained using our dimensionally reduced global model forcing and regional model response. As a sanity check, these NARX-based results are compared with those from simpler, linear regression-based methods.

S9-RecordedOral-2 (PaperID=15083)

Auto-detection of marine mammals from drone photos based on deep learning

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Aerial observation of marine mammals has been an important method that facilitated the research on these animals, while many researchers are turning to drones from conventional manned airplanes. The use of drones (Unmanned Aerial Vehicles, or UAVs) has expanded into various fields in the last decade because of the technology advances and cost reduction in both aircraft and sensors. However, visual-manual identification of target animals from large amounts of aerial photos acquired from drone surveys are time consuming and visually stressful. In order to improve efficiency, we developed an auto-detection software that is capable of identifying marine mammals visible in aerial photos using deep learning functions. The function was trained with manually identified photo sample sets and extracted features of certain species before generating an image dataset of object types and models that perform image prediction and identify objects. The software also features a size calculation function that measures the total length of identified animals based on photogrammetry principles. Case studies using this software indicated potential to replace visual-manual identification efforts, as processing time reached 2 s/photo at moderate identification rate, although detection accuracy was still lower than visual-manual identification and prone to negative factors including sun glint, inaccurate exposure, and floating objects. Further development for this software will target for higher accuracy with larger training sets and enhanced pretreatment of photos.

S9-RecordedOral-3 (PaperID=15039)

Fine-scale interannual distributions of meso-zooplankton in the Northern California Current

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The Northern California Current (NCC) off Oregon is a dynamic Eastern Boundary Upwelling System with intermittent upwelling in summer and downwelling in winter, which supports valuable fisheries. To study the effects of NCC oceanography on meso-zooplankton and ichthyoplankton, sampling along the Newport Hydrographic Line (NH-Line) off the central Oregon coast was initiated in 1961. In 2016, 2018, and 2019, the NH-Line was sampled using a towed, undulating underwater imaging system to investigate fine-scale (1-m vertical) zoo- and ichthyoplankton distributions along a 70-km section of the NH-Line, encompassing the shelf, shelf break, and slope. A sparse Convolutional Neural Network was used to automate the identification of over 150 million plankton images of 66 plankton taxa, ranging from protists to copepods, ichthyoplankton, and gelatinous organisms. Taxa distributions at 1-m vertical resolution were kriged over the transect, providing unprecedented insight into their horizontal and vertical distributions. Oceanographic conditions differed among the three years, with the 2016 transect experiencing the effect of “the Blob,” an anomalous ocean condition characterized by high ocean temperatures and an increase in the abundance of warm water taxa. Despite such physical differences among years, hierarchical clustering of plankton taxa revealed several assemblages with consistent interannual spatial patterns. Such assemblages (along with those with high variance) point to mechanisms underlying the distribution of plankton in the coastal ocean.

S9-LiveOral-4 (PaperID=15061)

Using the PICES TCODE catalog service

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The advancement of PICES science is impossible without the collection and sharing of numerous types of data. Since PICES has no adequate IT infrastructure, the essential part of the data is generated and managed by expert groups and individuals. TCODE merely maintains an inventory of the PICES data holdings entirely created by expert groups as part of their activities. Data architecture for applications of AI/ML is different from one in the traditional modeling approach, where data are intended for parametric identification and testing. AI/ML works with large volumes of data represented and stored (in, e. g., data lakes) not only in the relational (table) form. In this situation, data catalogs have to become core elements of data management. A data catalog is a searchable collection of metadata records that allows identifying the suitability of described items to potential usages. Data catalogs function in environments that provide authorization, editing, publishing, moderation, searching. As a part of the PICES metadata federation project, TCODE members have prepared a collection of metadata descriptions of different resources for every country. A service that allows running their catalogs by expert groups and individuals has been arranged too. However, the PMF catalog and the catalog service are not in demand of the PICES community. There are plenty of reasons for such a state of things that are not specific to PICES. For example, there is no adequate formal recognition of data products, mandatory sharing policies, an understandable and explicit legal basis regarding usage rights, and the like. Young career scientists who apply AI/ML can reverse the momentum if they try and adopt the catalog service as a required tool for data management of large volumes of reusable data that are usually processed.

S9-RecordedOral-5 (PaperID=15145)

Disentangling climate impacts on Sockeye Salmon population dynamics using machine learning

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Disentangling climate impacts on population dynamics when relationships are non-linear is a pervasive challenge for Pacific salmon. In this study, we developed boosted regression trees (BRT) models to examine the linkages between the population dynamics of a commercially and culturally important Sockeye stock of Chilko Lake (Fraser River, British Columbia) and freshwater and oceanic environmental drivers over the past 70 years. This non-parametric machine learning approach can easily incorporate non-linear dynamics in associating response variables with climate change and highlight important drivers without parametric assumptions, unlike the current parametric approach. The BRT models successfully captured a high degree of temporal variability in all population metrics (adult return, productivity, and age proportions in the adult return) with correlation coefficients ranging from 0.42-0.98. There are three major findings: (1) total adult return was mainly explained by spawner abundance, juvenile out-migrants, and environmental conditions in ocean phase (sea surface temperature in the Gulf of Alaska), and return phase (Fraser River discharge); (2) freshwater productivity (age-1 smolts-per-spawner) was mainly explained by freshwater-related dynamics (smolt length, smolt abundance and the artificial spawning channel), marine productivity (recruits-per-smolt) was mainly associated with marine dynamics (downwelling-favourable wind stress near the Central Coast), and total productivity (recruits-per-spawner) was influenced by both freshwater and marine processes; (3) age proportions were largely associated with environmental variables particularly sea-surface temperatures in coastal waters during juvenile outmigration year. These findings improve our knowledge of Sockeye salmon dynamics and suggest methods to incorporate environmental drivers in ecosystem-based fisheries management.

S9-RecordedOral-6 (PaperID=15099)

Projected changes in the potential habitat distribution of Japanese anchovy (*Engraulis japonica*) in Korean waters from a maximum entropy model

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Due to global warming, changes in distributions of marine organisms have been observed, particularly small pelagic fishes known as sensitive to habitat changes, such as Japanese anchovy (*Engraulis japonica*) – the most important fish commercially and ecologically. To understand future changes in the habitat distribution of the anchovy in Korean waters, we established monthly maximum entropy model (MaxEnt) – a widely-used species distribution model that requires only presence data, by using the catch points and the five environmental variables (temperature, salinity, velocity, and chlorophyll-a concentration at the surface and mixed layer depth) during 2000-2015. We then applied the MaxEnt to project the habitat distribution for next three decades under three different representative concentration pathways (RCP 2.6, RCP 4.5, and RCP 8.5), focusing on seasonal differences in the habitat changes. The MaxEnt showed that temperature and salinity are the most important environmental variables affecting the anchovy distribution in winter, spring, and summer, while chlorophyll-a concentration is the most considerable variable in autumn. The future changes in highly suitable areas increase in winter and spring, while decrease in summer and autumn: area higher than the tenth percentile training presence, as a suitability threshold projected to increase the most 264% in March and decrease the most 11% in July for RCP 8.5 in the 2050s. In summary, summer and autumn when the habitat changes less-suitable include the main spawning periods of the anchovy, so it is expected that it may cause a decrease in the anchovy biomass and catch in Korean waters in the future.

S9-LiveOral-7 (PaperID=15162)

A Linear Inverse Model Approach to Comprehensively Examine Marine Heatwaves

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Marine heatwaves (MHWs), defined as the anomalously warm ocean for an extended period (i.e., analogous to the tail of the ocean temperature probability distribution), are historically rare and extreme events. As such, an understanding built on the few historical MHWs may not be statistically significant. The Linear Inverse Model (LIM), an empirical dynamical model established on the covariance of the past and the current state variables, is capable of integrating the dynamically consistent stochastic forcings forward infinitely, hence providing a large quantity of alternative MHW events. This data augmentation tool has enabled statistically robust examination of the Northeast Pacific MHWs, one of the worldwide famous MHW hot spots, on their association with tropical/extratropical variability and climate change. Specifically, we have analyzed thousands of LIM simulated Northeast Pacific MHWs, and found that the tropics influence MHWs primarily by increasing their duration, with MHW amplitude driven more by extratropical conditions. A more sophisticated data augmentation process is to separate the climatic trend from the internal ocean variability, and subsequently generate thousands of MHWs targeting the climatic trend effect while excluding the internal ocean variability effect or vice versa. This process, which we have applied on Northeast Pacific MHWs, shows a notable mean warming of the Northeast Pacific leading to increasing occurrences of MHWs, while the variability increase is not as notable. Overall, applying the data augmentation tool of LIM on the Northeast Pacific MHWs is promising, implicating the potential of providing large data of global MHWs for training other artificial intelligence methods.

S9-LiveOral-8 (PaperID=15069)

Using Machine Learning (ML) to study the timing of renewal evens in Douglas Channel, British Columbia, Canada

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Douglas channel is a deep fjord located off the north west of British Columbia, Canada. Deep water renewal events are observed from multi-year ADCP and salinity timeseries. These renewal events are closely related to the salinity on the shelf – Hecate Strait. It is shown that both local and remote wind conditions along the shelf are correlated with the salinity variability in Hecate Strait. These salinity changes are usually associated with upwelling or downwelling favourable winds. Here we study the timing of the shelf salinity and temperature variability using the local (close to Hecate Strait) and remote (39^{o} N) upwelling indices. Machine Learning methods are used to predict the timing of the renewal from the upwelling indices and the shelf salinity and temperature timeseries. Results are compared with the observations in Douglas Channel.

WORKSHOP 1

BIO/FIS Topic Workshop
Can we link zooplankton production to fisheries recruitment?

W1-RecordedOral-1 (PaperID=15019)

Comparison of plankton community structure, standing stocks and productivity along the Kuroshio at the Tokara Strait

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Plankton standing stocks and productivity have been long thought to be low in the oligotrophic Kuroshio Despite the low food availability, major migratory fishes exhibit a risky strategy of life cycles to reproduce and recruit in the vicinity of the Kuroshio. While nutrients supplies around the Tokara Strait are suggested to be stimulated biological productivity in the oligotrophic Kuroshio, no information is available for oceanographic observations and sample analysis. Here, we compare plankton community structure, standing stocks and productivity around the Tokara Strait based on Lagrangian observations and samplings. Surface temperature and salinity were declined in the downstream of the Kuroshio at the Tokara Strait. At these stations, high chlorophyll *a* concentrations in nano- and micro-fractions were corresponded to high subsurface nutrients. While no substantial difference was found for net zooplankton abundance, community structure between the upstream and downstream Kuroshio at the Tokara Strait, protein-specific aminoacyl-tRNA synthetases activity were high throughout the stations. Their biomass and production rate were increased by contribution of medium to large fractions toward the downstream Kuroshio at the Tokara Strait. Taking into account for advected less saline waters, such increases of plankton standing stocks and productivity might be resulted from growth stimulated with coastal nutrients supply and/or accumulation of coastal plankton community.

W1-RecordedOral-2 (PaperID=15020)

Distribution, feeding habits, and growth of chub mackerel, Scomber japonicus, larvae during a high-stock period in the northern Satsunan area, southern Japan

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To evaluate the importance of the northern Satsunan area in southern Japan as a spawning and nursery ground for chub mackerel (*Scomber japonicus*), we investigated their early life history characteristics over five successive years. This area is considered the main habitat and spawning ground of the congeneric species *S. australasicus*. Using polymerase chain reaction-restriction fragment length polymorphism analysis, we first confirmed that *S. japonicus* larvae were abundant in the northern Satsunan area, potentially representing a major spawning and nursery ground in that region. The number of recorded larvae started to increase in 2016, corresponding to the population dynamics of the Pacific stock of the species, which has shown increasing trends in recent years. Morphological and DNA metabarcoding analyses of gut contents and stable isotope analysis showed that, in addition to copepods, the larvae fed substantially on appendicularians. The trophic pathway involving appendicularians might support the feeding habits of *S. japonicus*, promoting its coexistence with other dominant species. Both the instantaneous growth rate and daily specific growth rate were comparable to those in the southern East China Sea, which is the main spawning and nursery ground of the species. Our data strongly suggest that the northern Satsunan area has sufficient carrying capacity to sustain high larval population densities, even during phases with high population numbers. Our results provide insights for the fisheries management for *S. japonicus* in the Japanese Pacific coastal area, especially during high-stock periods.

W1-RecordedOral-3 (PaperID=15022)

Community structure of fish larvae associated with advections of the Kuroshio and its neighboring waters

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The Kuroshio has been long thought to be disadvantageous for food availability of fish larvae due to the low standing stocks of zooplankton even under the high thermal regime. Despite of a potential risk for survival, various fish larvae including fishery target species appear in the Kuroshio and its neighboring waters. Here, we report community structure of fish larvae associated with advections of Continental shelf waters (CW) to the Kuroshio (KR) based on multivariate analysis on their taxonomic compositions. 16 orders, 75 families and 449 groups were classified in the present study. Mesopelagic fishes more abundantly appeared in KR than in CW. Non-metric dimensional scaling plot and analysis of similarity demonstrated that taxonomic compositions were likely isolated between KR and CW (Global R=0.251, p=0.029). Based on similarity of percentages, representative groups were Gonostomatidae , Myctophidae and Notosudidae for KR correlated with high salinity and Callionymidae , Bothidae , Labridae and Bregmacerotidae for CW associated with low salinity. However, taxonomic compositions were similar at some stations in the Tokara Strait due to abundant appearance of *G. gracile* and *V. nimbaria*. We suggest that fish larvae advected with the different water mass result in their high species diversity in the Kuroshio and its neighboring waters.

W1-RecordedOral-4 (PaperID=15030)

Importance of gelatinous zooplankton on plankton food web in the Kuroshio based on metabarcoding analysis

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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, information is limited for trophic pathways to fish larvae trophodynamics. Here, we explore trophic sources and linkages of plankton community in the Kuroshio based on metabarcoding analysis of gut content DNA for mesozooplankton and fish larvae. Major prey items of mesozooplankton were dinoflagellates and calanoids for omnivores and calanoids, poecilostomatoids and amphipods for carnivores. Larvaceans and hydrozoans were the most frequently appeared prey taxa for both omnivores and carnivores. Multivariate analysis on gut content DNA demonstrated that major prey groups overlapped but contributions of gelatinous prey differed among taxonomic groups, indicating supplementary prey for niche segregation on trophic sources. Network analysis of the gut content DNA exhibited that omnivorous copepods like calanoids and poecilostomatoids, and gelatinous organisms such as larvaceans and hydrozoans, are important hubs of planktonic food web because of their multiple trophic linkages to many components. Furthermore, gelatinous forms were consumed by some fish larvae. These findings suggest that gelatinous organisms beside copepods were important hubs of trophodynamics for the Kuroshio planktonic food web.

W1-RecordedOral-5 (PaperID=15031)

How to adapt growth and productivity of fish larvae to 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 even under the high thermal regime. 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. Here, we report how to adapt larval growth and productivity of beaked sandfish to the Kuroshio based on measurements of biochemical indices. Wide appearance of the larvae was found across the coastal and Kuroshio waters. The individuals appeared in the Kuroshio exhibited lower protein-specific aminoacyl-tRNA synthetases activities ($_{sp}$AARS), higher individual protein contents ($_{i}$PRO) and higher individual aminoacyl-tRNA synthetases activities ($_{i}$AARS) than those appeared in the coastal waters. While significant correlation was negative for $_{sp}$AARS and positive for $_{i}$AARS to $_{i}$PRO, lower $_{sp}$AARS and $_{i}$AARS to $_{i}$PRO were found for the individuals appeared in the Kuroshio waters compared with those in the coastal waters. Significant correlation was also found for $_{sp}$AARS (positive), $_{i}$PRO and $_{i}$AARS (negative) to chlorophyll *a* and zooplankton biomass averaged in the water column. These findings suggest that larval growth of beaked sandfish occurs in the productive waters and individuals accumulated high protein contents can survive in the Kuroshio.

W1-RecordedOral-6 (PaperID=15037)

Model-based spatiotemporal variability in mesozooplankton productivity in the Salish Sea

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In situ mesozooplankton productivity estimates are often time-consuming and labour-intensive, yet these estimates are crucial to understanding how much energy is available to higher trophic levels in an ecosystem. Alternatively, biogeochemical models can provide productivity estimates at an unprecedented spatiotemporal scale. Here we first evaluate mesozooplankton productivity and growth rates from the SalishSeaCast model against previously collected in situ measurements of crustacean productivity in the Salish Sea. Crustaceans often comprise up to 80% of the mesozooplankton biomass, and thus the majority of the secondary production, in this region. Mesozooplankton productivity in the model is calculated by multiplying the sum of grazing by a literature-based value of growth efficiency. In situ community-level crustacean productivity measurements were made using the 'chitobiase method', which measures the rate of decay of the chitobiase enzyme released by crustaceans upon moulting. In addition, Daily P/B (production/biomass) estimates, equivalent to the mean daily growth rate of the crustacean community, were compared to model specific growth rates (d^{-1}). Mean productivity values between model and observations were similar (3.01 and 3.28 mg C m^{-3} d^{-1}, respectively), and model values consistently fell within the range of observed values. Point-by-point comparisons showed that the model more effectively captured surface (<25 m) productivity and growth rates. As a result, spatial patterns in model surface mesozooplankton productivity were subsequently examined over a 10-year time period (2010-2020) to better understand regional variability in productivity within the Salish Sea, with attention to areas that are important feeding grounds or migration routes for juvenile fishes.

W1-RecordedOral-7 (PaperID=15040)

Source of coastal waters advected to the Kuroshio using particle-tracking experiments on high-resolution coastal ocean model

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Despite the low food availability, major migratory fishes exhibit a risky strategy of life cycles to reproduce and recruit in the vicinity of the Kuroshio. While advected nutrients and plankton community in coastal waters are suggested to stimulate plankton standing stocks and productivity and then to provide good food availability for fishes in the Kuroshio, there is no information how and where coastal waters are advected to the Kuroshio. Here, we explore source of coastal waters advected to the Kuroshio using particle-tracking experiments on high-resolution coastal ocean model. Particles as tracers for coastal waters were released from the East China Sea (ECS), the southwestern Kyushu (SWK) and the southern Kyushu (SK) where were corresponded to the nursery grounds for fish larvae. Their advections to the Kuroshio exhibited the seasonal differences among the regions which were enhanced during fall in the SWK, during winter in the ECS and winter and summer in the SK. Such advections happened in the Tokara Strait and the SWK and SK were more important source areas for the coastal particles advected the Kuroshio compared with those from the ECS. These particles were transported along the front of the downstream Kuroshio. These results suggest that the coastal waters in the SWK and SK are one of important sources of nutrients and coastal community to stimulate plankton productivity in the downstream Kuroshio.

W1-RecordedOral-8 (PaperID=15077)

Evaluating pathways of environmental association with mesozooplankton and fisheries production

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The interactions between pelagic organisms and their environment are complex and difficult to describe. Bayesian belief networks (BBNs) provide a graphical means by which the probabilistic associations between ecosystem variables can be assessed and effectively communicated. We compiled data from the Line P long-term time series, optically-derived estimates of mesozooplankton production, stock specific chinook salmon recruits per spawner information as measure of fish productivity, and open-access climate data to build a suite of BBNs. We present preliminary findings evaluating the linkages between chlorophyll-a, mesozooplankton (biomass and production), and south coast chinook salmon productivity. Specifically, we demonstrate how including chlorophyll-a and mesozooplankton parameters (biomass, production) alters the probability of above and below average chinook salmon production. The BBNs demonstrated that for 9/13 stocks below/above average productivity was best predicted when mesozooplankton were included in the BBN. The other four stocks (Harrison, Lake Washington, Queets, and Quillayute) were best predicted using the chl-a BBNs. The conditions (e.g., low/high mesozooplankton biomass/production, chl-a) and environment determining the highest probability of above/below average chinook productivity varied across stocks. Thus, shifts in climate may strongly influence mesozooplankton production with notable consequences for higher trophic levels. We demonstrate the importance of testing for the influence of mesozooplankton in ecosystem and fisheries models across multiple stocks, rather than making broad inferences from a single stock group.

W1-RecordedOral-9 (PaperID=15108)

Promising perceptions of linking zooplankton production to fisheries dynamics

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Predictive understanding of ecological processes driving population dynamics remains a challenge in fisheries research. Recruitment variability is one of remarkable features of the population dynamics of marine fish and an important source of uncertainty facing fisheries managers. Zooplankton play a vital role between primary producers and higher-level consumers and are thus highly relevant to fisheries and ecosystems. Owing to their key role in the growth and survival of larval fish, change in abundance, biomass and species composition of zooplankton has implications to year-class strength and recruitment of fish stocks. However, limited attention has been paid to the role of zooplankton in sustaining fisheries production, which is largely because routine observations of secondary production remain challenging. This talk will focus on an overview of recent studies on zooplankton and fisheries across estuaries and coastal waters using observational and modelling approaches to display the potential for further understanding the role of zooplankton production in fisheries dynamics.

W1-RecordedOral-10 (PaperID=15110)

The Tortoise and the Hare: Distinct early growth strategies in a nearshore groundfish persist in the seasonally variable Northern California Current

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The Northern California Current (NCC) is a highly productive eastern boundary current system that sustains socio-economically important fisheries. One such species, cabezon (*Scorpaenichthys marmoratus*) recruits in multiple events throughout the reproductive season, a departure from the more common single-pulse recruitment strategy. The extended recruitment window coupled with seasonal variability in the NCC exposes individuals from the same year class to distinct environmental conditions (e.g., variable temperature and prey availability) during vulnerable early life stages. Therefore, we hypothesized that cabezon exhibit a "portfolio" of early life strategies that increase survival by maximizing chances of alignment with suitable environmental conditions. We quantified otolith-based early life history traits (e.g., growth rate, age-at-settlement) of new settlers across five annual recruitment seasons. Our findings revealed that at least two distinct early life strategies were consistently represented each year, encompassing significant environmental variability including an anomalous warming event associated with shifts in zooplankton community composition (2014-2016 northeast Pacific marine heat wave). Plasticity in early life may be a source of resilience for populations, which is especially important considering that phenological processes that regulate recruitment, such as the coincidence of fish early stages and zooplankton prey, are predicted to become decoupled with climate change.

W1-RecordedOral-11 (PaperID=15132)

The effect of zooplankton community composition on spatiotemporal variability of trophic transfer efficiency in the NE Pacific

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Trophic transfer efficiency (TTE) is the proportion of energy passed from one trophic level to the next. As such, TTE is a critical component shaping marine ecosystems whereby small variations in TTE can propagate upwards, potentially impacting the amount of food available for higher trophic levels. Long-assumed to be ~ 10%, TTE can be highly variable across oceanographic regimes. However, identification of the factors driving TTE variation as well as routine measurements of TTE specifically between phytoplankton and zooplankton are virtually non-existent. Here, TTE measurements are presented from the west coast of Vancouver Island and Gulf of Alaska from 2015-2018 with TTE ranging from 0.1 – 35%. Additionally, zooplankton diversity and community composition were assessed as factors driving variation of TTE. The functional and taxonomic diversity metrics functional dispersion, functional divergences, and species evenness as well as mixed layer depth were significant predictors of TTE across the study area. Zooplankton community composition was also significantly different between high TTE (27.7% average) and low TTE (3.9% average) conditions. Differences in TTE were driven by crustacean zooplankton species considered lipid-rich (boreal-shelf copepods) and lipid-poor (southern copepods), where dominance of the latter may be detrimental to ecologically and economically important fish, sea-bird and mammal species.

WORKSHOP 2

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

W2-RecordedOral-1 (PaperID=15015)

Response of abundance and distribution of a top predator squid species to short-lived eddies in the Eastern Equatorial Pacific Ocean

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Based on the fisheries data of *Dosidicus gigas* and important environmental factors including sea surface temperature (SST), vertical water temperature structure, currents and chlorophyll-a (Chl-a), the eddies characteristics in the Eastern Equatorial Pacific waters during April-June 2017 were clarified based on geometrical characteristics with the flow field. The influence mechanism of eddy on the biophysical environment as well as *D.gigas* abundance and distribution were explored. Results indicated that the eddy lifetime was relatively short with only three eddies surviving for more than two weeks. The number of eddies in each month showed the similar variability trend with the monthly average catch-per-unit-effort (CPUE) of *D.gigas*. Taking two eddies with longer lifetime (more than two weeks) as examples, it revealed that the environments around the eddies significantly changed. When the eddy generated for 8-10 days, SST and vertical temperature gradually decreased, while Chl-a significantly increased. At the same time, the habitat quality of *D.gigas* gradually increased, and the gravity center of the fishing ground was consistent with the movement of the eddy. It was speculated that the eddy-induced Ekman pumping led to the transportation of deep waters with rich nutrients into the euphotic layer, promoted the reproduction of bait organisms and yielded favorable water temperature conditions for *D.gigas*. These environmental changes was conducive to the formation of high-quality habitats, increased *D.gigas* abundance and the catch, and drove the shift of the gravity centers of fishing ground with the eddy. Our findings suggested that the eddy activities yielded significant impacts on *D.gigas* stock.

W2-RecordedOral-2 (PaperID=15052)

Oceanographic and trophodynamic underpinnings of larval anchovy success in the northern California Current

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The recent breakdown in the anchovy-sardine cold-warm water paradigm in the California Current (CC) suggests that recruitment may not be a simple reflection of large-scale physical drivers. Instead, consideration of larval fish trophodynamics together with local oceanography is likely necessary to mechanistically relate survival and recruitment to the physical environment. We examined otolith-derived metrics of northern anchovy (*Engraulis mordax*) growth in the context of high resolution oceanography and *in situ* prey and predators in the northern CC during two years of contrasting local summer conditions: upwelling relaxation (2018) and sustained moderate upwelling (2019). Overall anchovy growth rate did not differ between years but was on the high end of rates previously recorded for this species. Early larval growth was similar across space until 11 days post hatch when growth diverged such that offshore anchovy grew significantly faster than inshore anchovy in 2018, whereas the reverse occurred in 2019. Model results indicated that fastest recent growth (last 3 full days) occurred at the highest concentrations of calanoid copepod prey and a gelatinous predator. The relationship with predators may be indicative of selective mortality induced by predators on slow-growing larvae which increases the apparent average growth of the survivors. Temperature did not directly impact growth during our sampling period. Variability in anchovy growth with local oceanographic conditions and fine-scale distributions of prey and predators illustrates the importance of examining food-web dynamics when predicting the response of forage fish to ecosystem variability.

W2-RecordedOral-3 (PaperID=15113)

Impact of environmental variability on jack mackerel spawning grounds in the open sea of the Southeast Pacific Ocean

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Jack mackerel (*Trachurus murphyi*) is a species broadly distributed in the Pacific Ocean. Its main spawning grounds are located in the high seas zone off the Chilean coast. Several ichthyoplankton surveys have been conducted in this region, showing shifts in egg distribution, which have become more noticeable in the last decade. The environmental drivers underlying these changes have been little studied. However, this knowledge is critical for understanding the effects of environmental forcing on spawning grounds and trends in this fish population. This research aimed to determine the impacts of climate variability on spawning grounds. Egg occurrence data from 14 ichthyoplankton surveys (1999-2018), as well as remote sensing data, were used to model egg-environment relationships using the Maxent species distribution model. The results suggest that temperature is a relevant factor in spawning, and its interannual variability has an impact on eggs by reducing the occurrence probability due to abnormally warmer or cooler conditions. Further, changes in Jack Mackerel (JM) egg distribution reflect the species' adaptive response to climatic variability. Specifically, variability in sea surface temperature drives shifts in JM distribution, mainly latitudinal, in search of suitable spawning conditions. Other factors, including anomaly temperature, sea level and winds variability, shape unsuitable spawning habitats.

WORKSHOP 4

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

W4-RecordedOral-1 (PaperID=15057)

Characterizing phytoplankton phenology patterns in the Northeast Pacific coastal waters using the GlobColour Project

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To effectively monitor marine environmental health and any changes thereof, it is necessary to employ ecological indicators to provide objective and quantitative metrics upon which to evaluate the state of the ecosystem and their response to environmental and climatic perturbation. Phytoplankton phenology is an important ecological indicator that characterises the timing of annually occurring phytoplankton growing periods and has been typically synthesized into a set of indices encompassing the timing, duration and magnitude of bloom events. Observing changes in phytoplankton phenology requires vast spatial coverage and temporal frequencies, which is achieved through ocean colour satellite imagery. The GlobColour Project incorporates observational data from multiple ocean colour satellites by employing the Garver-Siegel-Maritorena (GSM) algorithm, a semi-analytical bio-optical model, that uses a weighted average to generate a merged chlorophyll dataset spanning 1998 to present at 4 km daily resolution along the entire British Columbia (BC) coast. We evaluate the performance of GlobColour in BC waters through a match-up analysis using data from Fisheries and Oceans Canada (DFO) in the Strait of Georgia, the shelf off the west coast of Vancouver Island, and Line P ($R^2 = 0.83$, $p = 9.5e^{-48}$, RMSE = 0.2, BIAS = 0.98, MAE = 1.5). Missing spatial data are subsequently interpolated using the Data Interpolating Empirical Orthogonal Functions (DINEOF) method, which has been shown to be effective for filling spatial gaps in remote sensing datasets. From this dataset, phytoplankton phenology dynamics along the coast are defined to reveal the spatio-temporal patterns along the BC coast over the last 20 years.

W4-RecordedOral-2 (PaperID=15059)

Assessment of the distribution of tidal flats in the Northwest Pacific region

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Tidal flat is one of important biological habitats for marine biodiversity conservation. In the Northwest Pacific region, wide tidal flat areas are distributed in China, Japan and Korea. Monitoring and study on tidal flat is implemented in each country, but there are no regional distribution maps available. Therefore, Special Monitoring & Coastal Environmental Assessment Regional Activity Centre (CEARAC) of Northwest Pacific Action Plan (NOWPAP), one of the Regional Seas Programmes of UNEP, tries to map the distribution of tidal flats in the Northwest Pacific region with a global mapping tool called Global Intertidal Change (GIC). GIC, a machine learning tool in Google Earth Engine by using satellite images, is developed by Dr. Nicholas Murray (http://dx.doi.org/10.1038/s41586-018-0805-8). National data on distribution of tidal flats were provided from member states to improve the tool to suit for the NOWPAP region. Compared with the original GIC, the improved GIC can provide higher accurate distribution maps; however, there are some limitations in detection of tidal flats. During the workshop, results of the pilot studies on mapping tidal flats and differences between created maps and real distributions of tidal flats will be reported.

W4-RecordedOral-3 (PaperID=15068)

Overview of the National Marine Ecosystem Monitoring program in Korea

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National Marine Ecosystem Monitoring program is legal survey based upon the Conservation and Management of Marine Ecosystem Act and the Wetlands Conservation. This program is conducted by Korean Marine Environment Management Corporation(KOEM) with support of the Ministry of Oceans and Fisheries(MOF). In the general investigation, Korea's ocean has been divided into two areas and general status of the marine ecosystem has been studied once every two year from 2015. This monitoring program consists of a fundamental survey (tidal flat, inshore, rocky shore, and offshore) and a hot spot survey (tidal flat, estuary/upwelling, and rocky shore) depending on various marine characteristics in Korea. The marine ecological network is to be introduced for its application as the highest management framework for the marine ecosystems in Korea. In 2020, MOF and KOEM have established five major marine ecological networks in connection with the habitats and routes of the marine organisms and base points with ecological values (marine protected areas, etc.) to represent the connectivity of the marine ecosystems based on this monitoring program. Furthermore, this presentation will introduce the major outcomes of this program, such as Marine Protected Area designation, marine ecosystem assessment, protected species conservation and so on.

W4-RecordedOral-4 (PaperID=15075)

Contributions of fisheries surveys to monitoring essential ocean, climate, and biodiversity variables: A synthesis from the U.S. West Coast

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Fisheries-related surveys that collect fisheries-independent data (hereafter referred to as "fisheries surveys") are a key pillar of sustainable fisheries management and are ubiquitous in the U.S. and other PICES member countries. From the perspective of ocean observing, fisheries surveys offer three key strengths: 1) they are sustained due to largely consistent funding support from federal and state public sector fisheries agencies, 2) they collect paired physical, biogeochemical, and biological data, and 3) they have large and frequently overlapping spatial footprints that extend from nearshore to offshore. Despite this, information about fisheries survey data can remain poorly known to the broader academic and ocean observing communities. To increase awareness, we catalog the oceanographic and ecological data collected by the nine major federal or state fisheries surveys on the U.S. West Coast and examine which essential ocean, climate, and biodiversity variables are collected by each survey. We find that along the U.S. West Coast, fisheries surveys increase the spatial coverage of ocean ecosystem monitoring by more than 75%, and surveys measure many essential ocean and biodiversity variables, including fish, zooplankton, species distributions, species abundances, community abundance, ecosystem disturbances, and ecosystem distribution, as well as standard oceanographic variables (T, S, DO). Surveys that collaborate with academic partners typically collect a wider breadth of essential variables, indicating the value of these partnerships. We recommend similar efforts be undertaken for other PICES regions to increase awareness of fisheries survey data collection and to encourage cross-survey cooperation and analysis in support of ocean observing goals.

W4-RecordedOral-5 (PaperID=15078)

Adoption and implementation of Seagrass Essential Ocean Variables (EOVs)

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Globally, regionally and locally, seagrass habitats have been prioritized as indicators of ocean health. To take stock of seagrass habitats across these scales, standardized biological and ecological Essential Ocean Variables (EOVs) are being developed to inform societal needs and governance of marine ecosystems. Supported by international ocean observing initiatives (i.e., Global Ocean Observing System, Marine Biodiversity Observation Network), the global seagrass research community (C-GRASS), is building consensus for core seagrass EOV variables and sub-variables. Concurrently, to advance adoption of seagrass EOVs at the local and regional level, the Hakai Institute is supporting data producers in British Columbia (B.C.) by linking international standards with community-based coastal science in British Columbia. We illustrate recent advances in EOV implementation and technology transfer through the case study of seagrass monitoring conducted by Indigenous coastal communities and the Provincial Government through MaPP; the Marine Plan Partnership for the North Pacific Coast. Here, remote sensing tools (drones, planes and satellites) provide information on critical EOVs for seagrass that can be ground-truthed by local communities, and augmented with core field-based EOV parameters. In partnership with MaPP and First Nations, Hakai also builds capacity for local seagrass monitoring, by facilitating information exchange on EOV standards and methodologies (i.e. drone mapping). The seagrass example shows that biological EOVs are primed for adoption across a range of scales, from local to global, and provide a framework for prioritized data collection and standardized data management necessary to address human impacts on coastal ecosystems.

W4-RecordedOral-6 (PaperID=15079)

High temporal resolution phytoplankton compositions and environment drivers in the northern Salish Sea, British Columbia, Canada

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Measures of phytoplankton dynamics are vital Essential Biodiversity Variables as phytoplankton form the base of the marine food web underpinning ecosystem structure and function. In this work, we illustrate the value of pigment-based (Chemtax) approaches for monitoring phytoplankton through the presentation of a published four-year (2015-2018) high temporal resolution (weekly) timeseries of phytoplankton composition in the northern Salish Sea, British Columbia, Canada. This approach has many advantages over traditional methods including that it is less subject to analyst bias/skill, easy to collect and cost effective and resolves pico-sized species. Through the timeseries, blooms were largely dominated by diatoms with spring diatom bloom timing and magnitude varying widely and driven by complex interactions of solar radiation, wind, stratification, and grazing. In turn, redundancy analysis showed inverse relationships between diatoms and temperature and stratification suggesting that post-spring diatom blooms were associated with surface nutrient renewal. A single non-diatom bloom in July 2016, dominated by silicoflagellates, was the timeseries maximum biomass and occurred under warm and stratified conditions, which the group was positively linked through RDA. Outside of bloom conditions, prasinophytes and cryptophytes showed persistent contributions with their highest biomass during summer. Uniquely, these groups often persisted through nutrient renewal and drawdown events typically associated with diatom blooms and suggestive of high grazing pressure. The analysis of this timeseries forms a baseline for continued monitoring and highlights the value of Chemtax for studying phytoplankton communities. Unpublished observations from post 2018 and potential of data inclusion into CIOOS and OBIS will also be discussed.

W4-RecordedOral-7 (PaperID=15093)

"Wishing I'm Fishing": OceanView — A fisherman's lifelong app

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Fueled by the seasonal upwelling of cold and nutrient-rich water, the California Current System consists of a diversity of marine species and provides significant economic, cultural, social, and aesthetic benefits that enhance the quality of life for coastal communities. However, increasing anthropogenic activities such as overfishing and coastal development affect marine ecosystems, thus long term ocean data is needed to understand changing marine ecosystems. We have been developing a participatory citizen science app, in partnership with the California Cooperative Oceanic Fisheries Investigations (CalCOFI) ecosystem observing program, to augment existing long term ocean observations off the coast of California. The app will allow recreational ocean users to upload detailed information on marine species they caught or observed, including the image of the organism, the species name, time, and location. If they don't know the species name, a suggestion will be offered by the image recognition algorithm. To incentivize users to use our app, we will also provide other functions, such as a real-world map showing Marine Protected Areas in California, a platform allowing users to discuss species they observed, etc. The data collected can be utilized to augment existing long term sampling of biological Essential Ocean Variables (EOVs) and to support future scientific research and analysis such as species distribution modeling and invasive species detection. As a citizen science app, we hope to inspire citizens to take part in and contribute to ocean observing, marine research, and to become more aware of marine conservation.

W4-RecordedOral-8 (PaperID=15098)

Sustaining Arctic Observing Networks: A Roadmap for Arctic Observing and Data Systems (SAON-ROADS)

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Arctic observing and data systems have been identified as critical infrastructures to support scientific understanding and decision-making from local to regional and global scales. Yet there are many challenges to developing, integrating and sustaining the needed systems. These challenges arise from the complexity of coordination across many organizational centers of action, sparse deployment and telecommunications infrastructure and physical conditions of polar regions that constrain technology options. Sustaining Arctic Observing Networks (SAON) was initiated to address the challenges related to coordination across a heterogeneous collection of national and organizational actors engaged in Arctic observing. Within this complex partnership setting, SAON recognizes the value of 'polycentric' governance models, which work to generate alignment around shared goals across many centers of action in non-hierarchal arrangements. Polycentric thinking has inspired SAON's vision for a coordination and planning framework for developing observing and data system requirements and implementation strategies under its Roadmap for Arctic Observing and Data Systems (SAON-ROADS). The success of the SAON-ROADS vision is highly dependent on the engagement of SAON partners in the planning process. We will present a comparative analysis of how two independent projects, both self-identified as SAON-ROADS partners, are interpreting the ROADS guidance and initiating efforts under its framework. We will also illustrate how nationally coordinated actions within the US can serve as a model for supporting the ROADS process. Both will inform the alignment, engagement and capacity building actions needed to assure ROADS' success.

W4-RecordedOral-9 (PaperID=15101)

Integrating coastal zooplankton monitoring programs into an Essential Biodiversity Variable (EBV) framework: Current status, challenges, and new developments, for Canada's west coast

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Zooplankton composition, grazing, and growth directly (and indirectly) influence material/energy transfer dynamics and food available to higher tropic levels such as young fish, seabirds, and some whales. Static zooplankton measurements such as abundance, biomass, and taxonomic composition, are informative, however, treated in isolation, these measurements offer limited information about processes critical to ecosystem function. The Essential Biodiversity Variables (EBV) framework is a biodiversity monitoring approach attempting to reconcile diversity with process-oriented metrics such as productivity. EBVs applicable to zooplankton fall into the six classes: Genetics; Populations; Communities; Species Traits; Ecosystem Function; and Ecosystem Structure. Zooplankton monitoring programs for coastal British Columbia (Line P, La Perouse, Continuous Plankton Recorder, and the Calvert Island surveys) are mature (10-40 year time series). We focus on how measured variables relevant to populations, communities, structure, and to some extent, function, can be integrated into an EBV framework. This effort is approachable since detailed taxonomy, abundance, and biomass measurements are common to each program; however, methodological differences in spatial extent, sampling frequency and depth of sampling, present challenges for a useful harmonization of data sets. Here we discuss the degree of harmonization required, data gaps, and also provide an overview of emerging molecular, biochemical, and trait-based initiatives, relevant to future integration of zooplankton EBVs for our study region.

W4-RecordedOral-10 (PaperID=15106)

Marine Biodiversity Observing in the Northern California Current: Understanding changing plankton community composition and seascape habitats

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Coastal ecosystems face multiple stressors associated with global change, including warming, reduced oxygen, reduced pH, changing productivity, and loss of sea ice, but also changes in water quality associated with upland land use, nutrient pollution, and coastal infrastructure. Stressors, their interactions, and the scales at which they affect ecosystems are modulated by different levels of biological organization— including changes across multiple types of biodiversity. Essential Biodiversity Variables (EBVs) are ecosystem agnostic, biological state variables are sensitive to change and capture critical scales and dimensions of biodiversity, including genetic composition, species populations, species traits, community composition, ecosystem functioning and ecosystem structure that serve as indicators of change. As part of a growing Marine Biodiversity Observing Network (MBON), we have integrated moored, ship-based, and satellite data that measure community composition and size distribution across multiple trophic levels to determine drivers of biodiversity, size distribution, seascape habitat distributions, and net community metabolism across dynamic pelagic habitats or seascapes. Community composition data is obtained using bio-optical approaches including multitrophic level imaging; traditional microscopy and ship-based observations, and environmental DNA. Communities are compared and scaled up using satellite plankton type algorithms and seascape habitats. EBV development has contributed to understanding species-habitat relationships, but also the impact, duration, intensity, and spatial extent of anomalous events like severe storms or marine heatwaves. EBV indicators will benefit monitoring within management units such as National Marine Sanctuaries, but also Integrated Ecosystem Assessment.

W4-RecordedOral-11 (PaperID=15117)

Linking marine ecosystem data to action within the context of climate change: Toward developing the global observing system for marine life

Erin V. **Satterthwaite**[1], Nic Bax[2,3], Gabrielle Canonico[4], Lavenia Ratnarajah[2,5], Brice Semmens[6], Ralf Goericke[6], Rasmus Swalethorp[6], Noelle Bowlin[7], Andrew Thompson[7] Natalya Gallo[8], Kevin Travis[1,9], Kathryn Beheshti[1,10], CalCOFI Committee, GOOS BioEco panel, and PEGASuS 2 working group participants

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Maintaining healthy, productive and resilient ecosystems in the face of human impacts including climate change requires globally coordinated and sustained observations of marine life. Such global coordination requires an assessment of the scope and capacity of existing monitoring programs, encouraging the use of standardized, interoperable practices for data management, and identifying gaps in spatial and ecosystem coverage. It further requires engagement with policymakers and managers to ensure monitoring activities align with management priorities and inform about socially relevant indicators. This talk will explore the current state of international biological observations in the context of the biological Essential Ocean Variables (EOVs), provide a case study exploring how one of the longest marine ecosystem observing programs, the California Cooperative Oceanic Fisheries Investigations (CalCOFI), has been working toward translating long-term observing data into policy and management actions, and provide recommendations for enhanced coordination of ocean observations internationally and within the North Pacific.

W4-RecordedOral-12 (PaperID=15163)

Mobilizing essential salmon biodiversity variables collected by the Hakai Institute Juvenile Salmon Program via the Canadian Integrated Ocean Observing System

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The Hakai Institute studies ocean sciences on the coastal margin of British Columbia, Canada with research programs spanning archaeology to oceanography, and forest ecology to salmon biology with the aim to mobilize knowledge and data in the public interest. Through our involvement with the creation and development of the Canadian Integrated Ocean Observing System—a Regional Alliance aligned with the Global Ocean Observing System connecting oceanographic institutions and data across Canada—we are contributing observations of Essential Biodiversity Variables (EBVs) through several research programs. The Hakai Institute Juvenile Salmon Program has been monitoring the migration of juvenile salmon through the northern Salish Sea since 2015 in an effort to understand the factors influencing early marine survival. We publish several Essential Biodiversity Variables, including Fish Abundance and Distribution data collected using traditional purse seine methods and more recently using environmental DNA. These data are published under the principles of FAIR (Findable, Accessible, Interoperable, Reusable) Data. Metadata records are published to the Hakai Institute Data Catalogue which are harvested by other data catalogues, including the Canadian Integrated Ocean Observing System National Catalogue. Each metadata record contains standard information describing each dataset and provides persistent links to where data can be downloaded. Data from the Hakai Institute Juvenile Salmon Program are hosted in a GitHub repository for open access and version control, while species observations and EBVs are hosted on the Ocean Biodiversity Information System to enhance interoperability and facilitate data reuse while promoting appropriate data citation.

Abstracts
Poster Presentations

SESSION 1

Science Board Symposium
Towards a shared vision of sustainable marine ecosystems

S1-E-poster-1 (PaperID = 15050)

Promoting cooperation of monitoring, control, and surveillance for IUU fishing in the Asia-Pacific

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Illegal, unreported, and unregulated (IUU) fishing is becoming a growing threat to sustainable fisheries and the economy worldwide. To solve this issue, various efforts on monitoring, control, and surveillance (MCS) have been made at the national, regional, and international levels. However, there is still a lack of measures against IUU fishing vessels at the multilateral level. Here, we assessed the situations of fisheries, and the current systems and challenges of MCS in eight Asia-Pacific countries with a focus on MCS for IUU fishing vessels at sea. Through a literature review and interviews, we confirmed that the situations of IUU fishing were linked with the status of fisheries in each country, and that each country implements various MCS measures with different emphases. However, there was a trend of enhancing or newly establishing four areas of MCS: vessel tracking, patrol, onboard observers, and port State measures, with amended or newly adopted laws. We also identified challenges of MCS such as insufficient MCS in coastal areas and fragmented cooperation among the countries. Based on our findings, we advance several recommendations including the enhancement of cooperation among stakeholders, especially fishers for co-monitoring in coastal areas and the establishment of a communication platform for Asia-Pacific countries.

S1-E-poster-2 (PaperID=15087)

Delineation of marine bioregions of British Columbia and Southeast Alaska using Sentinel-3 Chlorophyll-a data and self-organizing maps

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The delineation of marine bioregions is an essential step to identifying functional ecosystem units and assessing changes in ecosystem structure, while providing a relevant area-based management framework for fisheries ecology and ocean management strategies. Furthermore, considering rapid climate change and its predicted impact on oceans, yet limited resources for in situ observation, there is an urgent need for both alternative observation strategies and optimization of existing observation programs through establishment of representative monitoring regions. Bioregionalization using remotely sensed data presents a valuable tool to address this problem. To our knowledge, no bioregionalization at national scale has been attempted for the coastal oceans of British Columbia (BC) and Southeast Alaska (SEA), which host important habitat for several critical species. We present a two-step classification procedure, i.e., a Self-Organizing Maps (SOM) analysis followed by the affinity propagation clustering method, to define bioregions based on the seasonal climatology of high-resolution Sentinel-3 surface Chlorophyll-a data (a proxy for phytoplankton biomass), for the period 2016-2020. The two-step classification procedure identified distinct seasonal climatological cycles. Specifically, the classification recognized separation between regions located offshore from those in shelf and coastal waters. Bimodal chlorophyll-a cycles (i.e., displaying two annual peaks) were the most frequent trend across the study area and period. Interestingly, whereas in some bioregions, the spring bloom generated the highest phytoplankton concentration, in others, the fall bloom reached higher biomass peaks. Overall, the results highlighted differences in phytoplankton phenology among bioregions, probably linked to basin-scale and regional oceanographic and climate processes.

S1-E-poster-3 (PaperID=15096) CANCELLED

Jellyfish nuisances reshuffling local fishery patterns and ecological communities in the Korean peninsula

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Jellyfish profoundly leverage ecosystem structure through heavy pressure into trophic paths, thereby inducing local fishery losses. East Asian Marginal Seas (EAMSs), encompass prominent productive and commercial fishery grounds, where massive jellyfish blooms are acknowledged as major risks for local fisheries. Here, we gathered a comprehensive bioclimate dataset, including jellyfish and fish surveys, covering the Korean peninsula over the period 2010 – 2020. Using Bayesian network models, we assessed jellyfish phenology, the probability of jellyfish-driven trophic cascades and their potential for reshuffling fish communities. Our results provided a synoptic picture of mediators linking hemispheric-wide climate phenomena, such as El Niño Southern Oscillation (ENSO), Pacific Decadal Oscillation, and East Asia winter monsoon (EAWM), and regional/local environmental factors, ultimately shaping jellyfish biomass and fish communities. Sea Surface Temperature (SST) appeared as leading driver of the timing of jellyfish ($R=-0.76$, $p<0.05$). Such relationship, however, varied at the species level, with local jellyfish dynamics, e.g., *Aurelia coerulea*, driven by local temperature, while the variability of non-local species, e.g., *Nemopilema nomurai*, was ascribed to regional climate patterns. In turn, jellyfish biomass changes shaped fish production, which markedly dropped under jellyfish massive blooms, i.e., 2012 and 2013, and rose under years of low jellyfish biomass, i.e., 2017 and 2018. Our results highlight the role jellyfish bloom events have on structuring marine harvested communities, thus challenging a sustainable governance of marine resources in the region.

S1-E-poster-4 (PaperID = 15122)

Ecological characteristics of phytoplankton community in the East China Sea

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Based on the study of phytoplankton community structure and basic environmental elements in the East China Sea in recent years, combined with the changes of basic elements of marine environment in the East China Sea (water temperature, nutrient content and structure, COD and suspended solids concentration), this paper expounds the relationship between phytoplankton community structure and environmental factors in the East China Sea. The results show that the dominant species of phytoplankton in spring are mainly composed of *Coccinodiscus oculus-iridis*, *Coccinodiscus jonesianus* and *Skeletonema costatum*, and the dominant species in summer are *Skeletonema costatum*. The phytoplankton abundance in the west of the Changjiang Estuary Fishery and Zhoushan Fishery maintained a high value consistent with the historical survey data. The redundancy analysis results show that from the spring of 2015 to 2017, the environmental factors that have a great impact on phytoplankton in the investigated sea area are active phosphate, water temperature and pH; From the summer of 2015 to 2017, the environmental factors that have a great impact on phytoplankton in the investigated sea area are dissolved oxygen, chemical oxygen demand, active phosphate and inorganic nitrogen.

S1-E-poster-5 (PaperID = 15137)

Effects of climate variability on the catches and habitat suitability variations of three swimming crabs in the Taiwan Strait

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The swimming crab is a high-value species in commercial fishery industries in subtropical and tropical Asia. However, El Niño–Southern Oscillation (ENSO) events substantially impact the catch and habitat of this species. In this study, a weighted habitat suitability index (HSI) model was constructed using logbooks and voyage data from Taiwanese crab vessels (2013–2019) with the addition of environmental variables to examine the influence of ENSO events on catch rates (CRs) and HSI for *Charybdis feriatus*, *Portunus pelagicus*, and *Portunus sanguinolentus* in the Taiwan Strait (TS) during autumn (September–October; major fishing season). The CRs for *C. feriatus* and *P. pelagicus* were higher (>7.0 and >8.0 kg/h) during La Niña events, with the increase being more than 40.0% compared with normal and El Niño events in autumn. For *P. sanguinolentus*, the CRs were higher during La Niña and El Niño events (>8.0 kg/h) than in normal years. The high CRs for *C. feriatus* and *P. pelagicus* were observed in areas with high HSI in the La Niña years but were distributed more widely with a lower HSI during normal and El Niño years. The low CRs for *C. feriatus* and *P. pelagicus* during normal and El Niño years and the low CR for *P. sanguinolentus* in normal years during autumn were highly consistent with substantial shrinkage of HSI. Our findings suggest that ENSO events strongly affected the catch and habitat suitability of *C. feriatus*, *P. pelagicus*, and *P. sanguinolentus* during autumn in the TS.

S1-E-poster-6 (PaperID = 15147)

The structure of fishery resources and construction of ecosystem model in the southwestern waters of Taiwan

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The complex seabed topography and the convergence of sea currents that change with the seasons, this forms a nutrient-rich sea area with high biodiversity in southwestern waters of Taiwan. The purpose of the study tried to investigate the environmental seasonal variation affect the structures of marine ecosystem in southwestern waters of Taiwan. We collected various fishing data from 2011 to 2016, and analyze the fishery resource structure. The model constructed by Ecopath with Ecosim (EwE) showed that the main species of trophic level 2 and 3 were Auxis rochei rochei and Scomber australasicus respectively. The advantage top predators in the study areas were Istiompax indica and Thunnus albacares. The mean trophic level in EwE is 2.88, and indicated that most of the fished species belong to the middle trophic level. Through the Mixed Trophic Impact to analyze the interaction between the functional groups in this system, it can be found that fishing has a negative impact on species of higher trophic level in the ecosystem. In additional, the low-trophic-level species transfer energy to increase the biomass of high-trophic-level species and revealed bottom-up control ecosystem in the southwestern waters of Taiwan. In addition, this study is further conducted on the ecosystem of the network analysis, the system connection index is 0.349, and the total number of pathways is 2214, by comparing aforementioned indexes different regions, we can find that the ecosystem in this region is rich and closely connected.

Key word : southwestern waters of Taiwan, mass balance ecosystem model, ecosystem structure.

S1-E-poster-7 (PaperID=15148)

Explore the simultaneous characteristics of abundance and habitats of tuna species in the Pacific Ocean

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Information regarding the oceanic environment is vital for determining species distributions and habitat preferences. The Yellowfin tuna (Thunnus albacares, YFT) and Bigeye tuna (Thunnus obesus, BET) are two important commercial species for longline fisheries in the Pacific Ocean. This study collected long-term longline fishing data for YFT and BET from 1969-2018 at the Western and Central Pacific Fisheries Commission and Inter-American Tropical Tuna Commission. Besides, we extracted the satellite-based oceanographic data of sea surface temperature, sea surface height, sea surface salinity, mixed layer depth to establish habitat suitability index (HSI) and explore the tuna species interactions including the abundance and distributions under the climate change. The analysis results show that the high catch rates of YFT and BET are mainly distributed in the central western Pacific Ocean and the equatorial eastern

Pacific Ocean, respectively. Furthermore, the areas co-occurred high catch rate of YFT and BET were in the tropical area (10°N~10°S,160°E~140°W)and accounted for about 10% Pacific Ocean. The areas also revealed the high HSIs of YFT and BET, but

the variations of catch rates between two species didn't had the similar patterns. We suggested the phenomenon may led by density-dependent resource competition and competitive exclusion from the two species in the tropical area. Further study will explore the possible causes and mechanisms on the simultaneous characteristics between the climate indices, distribution and abundance of the tuna habitat.

S1-E-poster-8 (PaperID=15156)

Analyze the relationship between the fishing conditions of *Scomberomorus* species and changes in forage species around the waters of Taiwan

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The narrow-barred Spanish mackerel (*S. Commerson*), Japanese Spanish mackerel (*S. Niphonius*) and Spotted Spanish mackerel (*S. Guttatus*) are the crucial commercial species of Spanish mackerel around the waters of Taiwan (WT). The purpose of this study was to understand information on fishing ground and biomass for three commercial Spanish mackerels and the relationship between medium and low trophic levels in the Taiwan waters (TW). The changes in abundance and distribution may also affect the fishing conditions of Spanish mackerels. Therefore, we collected the logbook and voyage data recorder data from Taiwanese fishing vessels (2012 to 2019) of three Spanish mackerels (trophic level 4.3±0.67) and forage species (trophic level 1.5- 3.5) around WT. The catch rate (CRs) and spatial-temporal gravitational center of Spanish mackerels were used to investigate the relationships with the CR patterns of forage species. The results showed that the gillnets were the main fishing gear to catch Spanish mackerels in WT, with the major fishing season is from September to February. The CRs of narrow-barred Spanish mackerel showed significant positive correlations with Japanese Jack Mackerel (r=0.27) and Spotted Chub Mackerel (r-=0.46) and then negative correlation with Japanese Anchovy (r=-0.25). In the other hands, both Japanese Spanish mackerel and spotted Spanish mackerel had positive correlations with Spotted Chub Mackerel (r=0.24&0.41) and negative correlation with squid (r=- 0.38). The multivariate analysis will further use to analyze the influence of interannual climate variability on the time series of Spanish mackerels populations to explore the phenomenon of bottom-up control of the food chain.

S1-E-poster-9 (PaperID=15152)

Integrated assessment of ocean acidification risks to pelagic calcifiers in the northern high latitudes: Regional comparison of exposure, sensitivity and adaptive capacity

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Exposure to the impact of ocean acidification (OA) is increasing in high-latitudinal habitats. Pelagic calcifying snails (pteropods), a significant component of the diet of economically important fish, are found in high abundance in these regions. Pteropods have thin shells that readily dissolve at low aragonite saturation state, making them susceptible to OA. We conducted a first integrated risk assessment for pteropods in the Eastern Pacific subpolar gyre, including the Gulf of Alaska, Bering Sea, and Amundsen Gulf. We determined the risk for pteropod populations by integrating measures of OA exposure, biological sensitivity, and resilience. Exposure was based on physical-chemical hydrographic observations and regional biogeochemical model outputs, delineating seasonal and decadal changes in carbonate chemistry conditions. Biological sensitivity was based on pteropod morphometrics and shell-building processes, including shell dissolution, density and thickness. Resilience and adaptive capacity were based on species diversity and spatial connectivity, derived from the particle tracking modelling. Extensive shell dissolution was found in the central and western part of the subpolar gyre, parts of the Bering Sea, and Amundsen Gulf. Genetic analyses based on mitochondrial haplotypes identified a single species, without differentiation between the morphological forms. An integrated risk evaluation based on multiple approaches assumes a high risk for pteropod population persistence with intensification of OA in the high latitude eastern North Pacific. Such a comprehensive understanding would permit improved prediction of ecosystem change relevant to effective fisheries resource management, as well as a more robust foundation for monitoring ecosystem health and investigating OA impacts in high-latitudinal habitats.

SESSION 2

POC Topic Session
Global warming patterns and multiscale climate variability in the North Pacific

S2-E-poster-1 (PaperID=15014)

Synchronous changes in potential habitats of *Trachurus murphyi* and *Dosidicus gigas* off Chile in relation to regime shift of Pacific Decadal Oscillation

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Understanding concurrent responses of habitat pattern of pelagic fish species to climate variability is favorable for sustainable exploitation and fisheries management. In this study, the key environmental factors affecting *Dosidicus gigas* (sea surface salinity (SSS), sea surface height anomaly (SSHA) and water temperature at 400m (Temp_400m), and *Trachurus murphyi* (sea surface temperature (SST), mixed layer depth (MLD) and Temp_400m), were used in combination with the Pacific Decadal Oscillation (PDO) index to examine synchronous habitat variations off Chile based on habitat suitability index model (HSI). All environmental factors were significantly related to the PDO. A significantly negative relationship was found between the HSI of *D.gigas* and the PDO index, while a significantly positive correlation was observed in the HSI of *T.murphyi*. In the warm PDO regime, MLD was shallower, SST increased, and SSHA decreased from the northeast to the southwest off Chile. SSS and Temp_400m in northern waters off Chile were higher than those in southern waters. The suitable habitats of *D.gigas* contracted and shifted southwestward. While the area and distribution of *T.murphyi* changed little, but its habitat quality enhanced. In the cold PDO regime, SST and SSHA decreased, and MLD deepened. Variations in SSS and Temp_400m were consistent with those in the warm PDO regime. The suitable habitats of *D.gigas* enlarged and moved northeastward. Whereas the suitable habitats of *T.murphyi* slightly reduced with small change occurred with its spatial location. Our findings suggested that the PDO played important roles in the long-term concurrent habitat variations of Chilean *T.murphyi* and *D.gigas*.

S2-E-poster-2 (PaperID=15051)

Ocean acidification in the Pacific off Mexico: How to change the pH values across various regions

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This work was carried out in the Pacific off Mexico and is focused on discerning the Spatio-temporal changes of variables such as surface water temperature, total alkalinity, pH, and omega aragonite, the latter allowing us to deduce how the calcification of organisms has been affected due to the reduction of pH, which is known as ocean acidification. Low pH values were identified that led to a reduction in the omega aragonite saturation horizon, especially in the northern region of the study, which corresponds to the southern portion of the California Current System, although the data reported are not below saturation, they presented seasonal variations with lower values in spring. The central region of study, Cabo Corrientes, presented a pH range of 7.85 to 8.2, which indicated that there are seasonal changes that may be associated with the physicochemical and biological dynamics of the area. The region located to the southeast was the Gulf of Tehuantepec, where seasonal variations in pH and higher values of omega aragonite were also identified.

This research is a first approximation of the changes in the chemistry of the Pacific off Mexico in the last 28 years, which allowed us to observe that there are Spatio-temporal differences in the variables studied.

S2-E-poster-3 (PaperID=15129)

Decadal climate indices effect on the spatiotemporal distribution in Indo-Pacific yellowfin tuna population

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Recurrent observation of variations in tuna population distribution and abundance indicated strongly linked to large-scale climate indices, such as the Pacific Decadal Oscillation (PDO) index, Atlantic Multidecadal Oscillation (AMO) and North Pacific Gyre Oscillation (NPGO). The standardized CPUE of yellowfin tuna were higher value during negative- AMO phase and positive PDO phase, respectively. The abundance and habitat preference of yellowfin tuna would significantly influence by the PDO phase-changing in Indo-Pacific Ocean, and the northern and southern western tropical Pacific Ocean showed “see-saw” phenomenon. The PDO also changed the environmental parameters overall Indian Ocean, so the habitat preference of yellowfin tuna also showed the consistently through the Indian Ocean. However, the variations of habitat suitability were not corresponded with the distribution and standardized CPUE of yellowfin tuna through the Indo-Pacific Ocean in the AMO events. We further suggested the ocean warming and overexploitation of tuna species after 1980s would exactly fit to the AMO shifting phase occurred in the 1990-2000s, and leaded significant and higher correlations with longline fishery data when processing long-term time series analysis.

Keywords: Climate change, Decadal climate indices, Yellowfin tuna, Spatial distribution of habitat preference, Marine ecosystem

S2-E-poster-4 (PaperID=15141)

The fishery dynamics of narrow-barred spanish mackerel (*Scomberomorus commerson*) related to oceanographic factors in the southern East China Sea

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This study explored the relationship of the catch rates and fishery dynamics of Spanish mackerel (Scomberomorus commerson) with oceanographic factors around the waters of Taiwan using high-resolution fisheries and environmental data from 2011–2016. The results revealed that trammel nets accounted for 69.79% of the total catch and operated mostly in the Taiwan Strait. Seasonal variations were found in the distribution of higher catch rates, which occurred in the southwestern Taiwan Strait, including the waters along the southwestern coast of Taiwan and around the Penghu Islands, extending to the Taiwan Bank during autumn, and increasing in winter. To predict the spatial and temporal pattern of Spanish mackerel density and its related with oceanographic variables and spatio-temporal variables, generalized additive models (GAMs) would be used. Total explained deviance was from 48.4%, which conformed to the assumption of the Gaussian distribution. All variables examined were statistically significant predictors ($p < 0.05$). The interaction of latitude and longitude was the most important factor among spatio-temporal variables, whereas sea surface chlorophyll-a (CHL) was the most important factor among oceanographic variables. The results of projected changes in El Niño/Southern Oscillation events for S. commerson revealed that catch rates were higher and distributed further southward during La Niña events. We inferred that the distribution of S. commerson gradually concentrated toward the southwest with the northeast monsoon, which was enhanced during La Niña in winter.

S2-E-poster-5 (PaperID=15157)

The annual variations of grey mullet (*Mugil cephalus*) population in related to changed sea surface temperature and multiscale climate indices in the Northwest Pacific Ocean

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The study analyzed long-term (1970-2010) records of grey mullet (*Mugil cephalus*) fishing data to analysis different regions characteristic of landing fluctuations of grey mullet in Northwest Pacific Ocean including waters around Taiwan, Japan, and Korea. The time series trends and correlations between landing of grey mullet and sea surface temperature influences by multiscale climate indices were analysis using Empirical orthogonal function and wavelet coherence analyze. The results revealed similar long-term trends in landing data of Japan, Korea and Taiwan, and the significantly correlated to the landing data revealed a periodicity of 13-16 years across 1970 to 2010. Through EOFs found that the similar spatial distribution and time series patterns between SST and grey mullet in autumn and winter, and could further divided into four sub-zones including Yellow Sea, Southwest Japan Sea, Northeast Japan Sea, and East China Sea. Furthermore, the significantly correlations were found between Western Pacific Oscillation (WPO), Pacific Decadal Oscillation (PDO) and North Pacific Gyre Oscillation (NPGO) and had periodicity of 8-10 years with landing of grey mullet in the Japan, Korea, and Taiwan. A significant coherence between landing and NPI with a periodicity of 13-16 years were occurred in the three areas. Our results demonstrated the population and migration pattern of grey mullet were influenced by decadal (PDO and NPI) and interannual (WPO) climate indices via ocean-atmosphere interactions in the Northwest Pacific Ocean.

Keywords: Grey mullet, Climatic Indices, SST, Wavelet Analysis

S2-E-poster-6 (PaperID=15165)

Developing Synergies between the U.N. Southern Ocean Task Force and the North Pacific: A Safe Ocean

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In the framework of the United Nations Decade of Ocean Science for Sustainable Development, the Southern Ocean Community engaged in a stakeholder-oriented process to develop the Southern Ocean Action Plan to provide a framework for Southern Ocean stakeholders to formulate and develop concrete activities that support the Decade vision. The outcome is the Southern Ocean United Nations Task Force (https://link.edgepilot.com/s/35aa2d90/m7fK0hqp1Emq8TT4_2azCg?u=https://www.sodecade.org/), which includes 8 working groups on topics such as ocean safety, resiliency, sustainability, and cross-cutting themes. In the Southern Ocean, the combined effects of various forms of pollution, transport, tourism, migration, infrastructure, and the pursuit of natural resources, as well as accelerated climate change at high latitudes, are exerting increasing pressures on the environment. These climate- and human-induced changes have the potential to alter the role the polar regions play in regulating global climate and other systems, as well as impacting a host of other important ecosystem services. Since the Southern Ocean Community of stakeholders is globally unique in its operation within the Antarctic Treaty System, which is entirely based on scientific understanding and environmental protection, it is imperative to strengthen international collaborations to improve scientific and political understanding of this remote region.

Working Group 5, “A Safe Ocean,” focuses on mitigating, understanding, and adapting to extreme weather events and other hazards. In this work, we discuss how we can develop synergies and collaborations with the North Pacific and Arctic communities under the U.N. Ocean Decade, with a specific focus on ocean hazards. We explore how stakeholders from academia, government, and industry can work to create a safe environment for humans and wildlife in both of the polar regions, preserving the environment for future generations.

SESSION 3

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

S3-E-poster-1 (PaperID=15033)

Signal of near inertial waves in Peter the Great Bay, the Japan/East Sea, from ADCP data measured at the WaveScan stationary buoy

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Inertial oscillations in the southwestern Peter the Great Bay, the Japan/East Sea, were studied based on hourly velocity measurements by ADCP installed at the stationary WaveScan buoy from May through December 2016. The inertial oscillations were detected in the 0–38 m layer, gradually weakening with the depth, and strengthening during the strong wind events and sometimes without noticeable wind forcing. They were the strongest in late August through early September during the intense atmospheric cyclogenesis, with the passage of the extratropical hollow and cyclone merging with the former Lionrock typhoon; however, the inertial energy maximum occurred before the Lionrock passage. At that time, the direct cascade was detected on imescales of 2 to 80 days and of 2 hours to 1 day, showing the strong dissipation and followed by the reverse cascade. Using decomposition to complex (Hilbert) empirical orthogonal functions in the depth – time domain, the signal was revealed around the inertial timescale, alternately moving down and up with the speed $(1.3–1.9)\times10^{-2}$ cm/s. This signal can be related to near inertial waves and their reflection from the bottom; it is accompanied by either red or blue shifts of the inertial frequency. The background relative vorticity related to this shift is estimated and the flow is shown to reach the quasi-geostrophic regime in the times when the signal was strong. On average, the background relative vorticity was anticyclonic and one can expect energy trapping within eddies, which is an effective mechanism for downward energy transfer.

S3-E-poster-2 (PaperID=15053)

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 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 the 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 basin-wide 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.

S3-E-poster-3 (PaperID=15064)

Impact of submesoscale currents on the vertical transport of nutrient in the East China Sea

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The East China Sea (ECS), located on a wide shelf, holds several world-famous fishing grounds due to its high primary productivity (PP). The PP in the ECS is limited by light in winter and by nutrient in summer. This study aimed to find the potential vertical nutrient pathway in summer other than the diffusion. Ubiquitous ephemeral submesoscale currents due to mixed-layer instabilities, frontogenesis and turbulent thermal wind has been found in the ECS by high-resolution numerical models based on the Finite Volume Coastal Ocean Model (FVCOM). A biogeochemical component based on Nutrient-Phytoplankton-Zooplankton-Detritus (NPZD) model was further coupled to the physical model in this study. The model was set up with two horizontal resolutions at the ECS, ~0.5 km and ~10 km, hereafter referred to as High-Resolution Model (HRM) and Low-resolution Model (LRM), respectively. The HRM can resolve more the submesoscale currents than the LRM. Resolving more submesoscale currents results in an approximately 40% increase in primary productivity during the summer, which was closer to the observations. Via diagnostic analyses in terms of multiscale physical processes, it was found that submesoscale vertical advection became the most important vertical nutrient supply pathway, rather than the vertical mixing, from the nutrient-rich bottom water to the nutrient-depleted surface water in summer, particularly on the middle and outer shelves. This study revealed the importance of submesoscale currents in promoting primary productivity in stratified shelf seas.

S3-E-poster-4 (PaperID=15081)

Eddy kinetic energy variability of the Kuroshio Extension and its upstream-downstream connectivity

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The Kuroshio Extension (KE) system in the western North Pacific includes energetic meanders of the Kuroshio jet and full of mesoscale eddies. This study analyzed eddy kinetic energy (EKE) variability in the KE region, focusing on its upstream (142–148°E, 32.5–36.5°N) and downstream (153–164°E, 33.5–38.5°N) connectivity, using a reanalysis product "Four-dimensional variational ocean reanalysis for the western North Pacific over 30 years" obtained from Japan Agency for Marine-Earth Science and Technology. Three dominant modes were identified during 1993–2014 through the empirical orthogonal function analysis. The first and third modes present an out-of-phase relationship between the upstream and downstream. The PC time series of the first mode exhibits interannual to decadal variability, correlated to the North Pacific Gyre Oscillations with a time lag of about three years. It is also correlated with the PC time series of the third mode with a time lag of two years, which suggests the third mode precedes the first mode associated with westward propagation of baroclinic Rossby waves. The second mode, however, shows an in-phase spatial pattern between the upstream and downstream, and its PC time series exhibits strong seasonal variability with interannual modulation. It is concluded that the upstream-downstream connectivity of the EKE in the KE region is modulated by both the remotely forced out-of-phase variability on the decadal timescale and the locally forced in-phase variability on the seasonal to interannual timescales.

S3-E-poster-5 (PaperID=15109)

River-induced submesoscale processes in a southwest Pacific shelf sea and similarities to a northeast Pacific shelf sea

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This talk will address how river discharges connect terrestrial and oceanic environments, and how physics drives biology in shelf seas through submesoscale processes. Underwater glider observations, satellite data and ocean model outputs were used to understand the dynamics of river-induced submesoscale features in a New Zealand (NZ) shelf sea, Greater Cook Strait. This NZ shelf sea is located between its North and South Islands, connecting the Tasman Sea to the Pacific Ocean through the 23 km wide Cook Strait. Results on this NZ shelf system influenced by tidal straining, strong winds, coastal upwelling, coastal currents, residual tidal currents, discharge from small mountainous rivers, extreme weather (e.g. cyclones) and diurnal cooling will be presented. A process-focused experiment in this shelf sea showed that in addition to the traditional concept of upwelling-related enhanced primary production, river-induced submesoscale features in Greater Cook Strait are also important for the biology of this continental shelf. The role of various drivers (tides, river discharge variability, wind strength) were also investigated. The offshore reach of the river-induced submesoscale features is constrained by a coastal barotropic current that modulates their advection and lifetime on the shelf. Further to presenting results from this southwest Pacific shelf sea, this talk will also outline how the knowledge gained will be applied to British Columbia's Queen Charlotte Sound in the northeast Pacific. The two shelf systems have many points of comparison. Some of them include freshwater forcing from mountainous rivers, wind-driven upwelling, estuarine-like circulation, shelf exchanges with fjords and implications for MPAs.

S3-E-poster-6 (PaperID=15169)

Diurnal shelf waves in the area of South Kuril Islands from TOPEX/Poseidon satellite altimetry data

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Based on the analysis of alongtrack small-scale variations in the amplitudes and phases of diurnal tidal waves O1 and K1 (estimated from TOPEX / Poseidon satellite altimetry data), the zones of manifestation of diurnal shelf waves in the region of the South Kuril Islands were determined. It was revealed that shelf waves, existing in the form of baroclinic modes [Rabinovich, Thomson, 2001], are manifested mainly on the ocean shelf of the Iturup Island, and to a somewhat lesser extent on the shelf of Urup Island (in its northern part - only for O1 constituent). A similar statement is also true for the southern part of the study area - on the shelf of Shikotan Island, a shelf wave of a lower-frequency component O1 appears only. Diurnal shelf waves are the cause of a sharp increase in the amplitudes of diurnal waves O1 and K1 at the coastal stations of Iturup (especially in its southern part of the Island) and Urup compared to the open ocean. They also cause intense diurnal currents, which is confirmed by the data of instrumental measurements. Baroclinic shelf waves are also the cause of vertical movements, causing variations in the temperature of seawater at sufficiently great depths, which can have a significant impact on the living conditions of benthic communities.

SESSION 5

BIO/POC Topic Session
Atmospheric nutrient deposition and microbial community responses, and predictions for the future in the North Pacific Ocean

S5-E-poster-1 (PaperID=15074)

Distinct impacts of dust and haze particles on marine phytoplankton

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Depositions of natural and anthropogenic aerosols can affect marine primary productivity, but their difference remains unclear. We conducted 12 microcosm incubation experiments enriched with dust particles (DPs, a natural aerosol), haze particles (HPs, an anthropogenic aerosol), and various nutrients from 2014 to 2016 in the Northwest Pacific Ocean. DP additions supplied substantial nitrogen (N), and stimulated phytoplankton growth indicated by total Chlorophyll *a* (Chl *a*) and shifted the phytoplankton size structure towards larger cells (> 2 μm in cell size) indicated by size fractionated Chl *a*. The increase in total Chl *a* enriched with DPs was generally higher than that in N treatments, but was close to that in N + phosphorus (P) treatments. This suggests that DP fertilization tends to be a combined effect of N and P, which was likely related to the enhanced utilization of dissolved organic P. The impact of HP additions had two types: I. Net stimulation impact. HP additions (0.39-2.56 μmol N L^{-1}) and DP additions had similar stimulation mechanisms, but the effect of HP additions was weaker than that of DP additions at the same N loading. II. Net inhibition impact. When the particle loading was large enough (~12.81 μmol N L^{-1}), the inhibition impact became obvious. These results suggest that the impact of HP addition on phytoplankton is a composite result of stimulation by nutrients and inhibition by toxic matter. The different kinds of deposited matter may cause varying carbon sequestration efficiencies in the ocean by regulating phytoplankton biomass and size structure.

S5-E-poster-2 (PaperID=15084)

Impact of atmospheric deposition on the utilization of dissolved organic phosphorus by phytoplankton in the Pacific Ocean

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Atmospheric deposition can promote the utilization of dissolved organic phosphorus (DOP) through provide a lot of nitrogen nutrients which could lead to serious P limitation. However, the triggering condition for atmospheric deposition promoting DOP utilization, the DOP usage amount under the impact of atmospheric deposition, and the correlation between DOP utilization and carbon sequestration are still unknown. In this study, seven on-board microcosm experiments amended with atmospheric aerosols, nutrients and trace metal were implemented in the Pacific Ocean during the Spring and Summer cruises in 2018-2021. The results showed that, although supplied negligible DIP relative to the background levels of the sea water, atmospheric deposition could promote phytoplankton growth under P or N+P limitation, indicating the existence of other bioavailable P sources like DOP. We thus analyzed the alkaline phosphatase activities (APA) which could reflect DOP utilization, and found that APA was enhanced 6.2-227.7% after the addition of atmospheric aerosols. The DOP usage amount (▲DOP) was therefore estimated and it was shown that DOP accounted for more than 80% of P consumed by phytoplankton in the Summer of the western marginal sea of the Pacific Ocean, while much lower in the Spring of the western marginal sea of the Pacific Ocean. And 2.4-55.9% enhancement of ▲DOP was found after atmospheric aerosols amendment. However, the promotion of atmospheric deposition on DOP utilization, reflected by APA improvements, was only occurred when Chl *a*/DIP higher than 10.

S5-E-poster-3 (PaperID=15124)

Nutrient consumption by diatom in darkness below the euphotic zone during spring bloom in Funka-bay, Hokkaido, Japan

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Massive diatom spring bloom occurs in early March every year in Funka-bay, Hokkaido, Japan. We conducted shipboard observations in the bay 4 times between February (pre-bloom) and April (post-bloom) in 2019. The euphotic zone (0.5 % depth of surface PAR) was shallower than 20 m depth during the bloom. In the middle layer below the euphotic zone (20 – 50 m), nutrient concentrations (nitrate, phosphate, silicate) decreased from March 5th to March 14th. We also conducted incubation experiments using diatom, Thalassiosira nordenskioeldii, which prevails in early phase of diatom bloom in the bay. We verified that nutrient depleted diatom cells consumed nutrients in the incubation bottles in darkness. We considered that the consumed N, P, and Si between 20 and 50 m in darkness in the bay were transported to deeper layer by sedimentation of particle. It is important to estimate the nutrient consumption in darkness below euphotic zone when there are a lot of settling diatom cells during spring bloom. We will discuss the nutrient consumption in relation to primary production and respiration using the dissolved inorganic carbonate (DIC) data as well as isoprene (C_5H_8) data.

S5-E-poster-4 (PaperID=15146)

Seasonal Asian dust transport to the western subarctic Pacific based on the cathodoluminescence analysis of single quartz grains

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The western subarctic Pacific is known as the high-nutrient low-chlorophyll (HNLC) area, where the phytoplankton productivity is limited by the availability of iron in the surface mixed layer. The dust from Asian deserts is one of the major sources of iron in this region, but its depositional flux, the seasonality, and impacts on the phytoplankton productivity have not been proved yet. Here we estimated the concentration of Asian dust within the shallow seawater (10m, 20m, and 40m depths) of the station K2 (47N, 160E) at various seasons in 2003 and 2004. For this purpose, we conducted a provenance study of single quartz grains in seawater using the Scanning Electron Microscope-cathodoluminescence (SEM-CL) method (Nagashima et al., 2017). The CL spectroscopy can detect crystal-chemical features in quartz, such as impurities and native imperfections, and is useful to identify the grains from Asian deserts. The results show the high dominance and a large number of quartz grains from Asian deserts in seawater of Spring 2004, and Summer 2003 and 2004, which we calculated to equivalent the deposition flux of Asian dust for ca. 20–35 mg m^{-2} day^{-1} and ca. 10–16 mg m^{-2} day^{-1}, respectively. Those estimated values together with the bioavailable iron content within Asian dust suggest that Asian dust could be the primary source of iron in this region, especially in summer, when the supply from other sources (e.g., iron from the intermediate water (>26.8 σ_θ) via the Okhotsk Sea) seems to be minor due to the ocean stratification.

SESSION 6

S-CC Topic Session
Connecting knowledge of ocean deoxygenation in coastal and offshore regions of the North Pacific

S6-E-poster-1 (PaperID=15155)

Application of E-TRIX index for evaluation of eutrophication in the Amur Bay, as a background for its bottom layer deoxygenation

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Eutrophication of the coastal waters increases risk of hypoxia at the sea bottom, that can be observed in the Amur Bay – a shallow secondary bay near Vladivostok. It is important to monitor the situation in such cases and respond in a timely manner. At the moment, there is no a single index for quantitative assessing the degree of eutrophication. In this study, based on the data of chemical monitoring of the Amur Bay in the ice-free period of 2019, the trophic index E-TRIX is tested. This index is an integral complex indicator associated with parameters of primary production (Chl *a*) and nutrients concentration. E-TRIX values >6 are typical for areas with high concentration of nutrients and low transparency, where hypoxia is available in the bottom layer. Conversely, E-TRIX values <3 indicate low concentration of the main nutrients and high transparency, the entire water column in such areas is usually well-aerated.

In the Amur Bay, E-TRIX values calculated for the sea surface varied from 2.9 to 6.9. The minimum values were observed in early spring and late fall, when the water was not stratified that prevented phytoplankton blooming. The highest values were observed in summer in the tip of the bay, where the Suifen/Razdolnaya River flows into. Low oxygen content in the bottom layer was observed at those stations where the index values were high. There is concluded that the E-TRIX eutrophication index for the sea surface allows to reveal the areas with a threat of hypoxia in the bottom layer.

SESSION 7

FUTURE/POC Topic Session
Predictions of extreme events in the North Pacific and their incorporation into management strategies

S7-E-poster-1 (PaperID=15088)

The effects of ocean data assimilation on North Pacific marine heatwave prediction

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Marine heatwave (MHW) is prolonged, extremely warm water events over the upper ocean. It can substantially lead to ecological and socioeconomic impacts, and therefore have significantly scientific interests. The 2013-2015 North Pacific MHW was the most famous MHW with a long duration, remarkable intensity, and huge impacts, called The Blob in the scientific literature and media.So far, many studies focued on the physical drivers of the MHW, but there are few studies on improving the prediction skill of the MHW. Based on NUIST-CFS1.0 (i.e., previously SINTEX-F) that had used coupled Sea Surface Temperature (SST)-nudging initialization method, we employ the ensemble Kalman filter (EnKF) to assimilate SST, altimeter satellite gridded sea level anomalies, in situ temperature and salinity profiles to improve the MHW prediction skill. We assess the differences in the North Pacific initial fields and prediction skills at lead times of up to 24 months with and without the ocean data assimilation. The results show that the North Pacific initial conditions are improved largely with the ocean data assimilation, and the North Pacific mean prediction skills of SST and subsurface temperature with EnKF are improved at 1-24 months lead. The ocean data assimilation also improves the prediction skill of the Blob event, especially the prediction skill of regional subsurface temperature. The prediction skill of strong subsurface temperature anomalies in the North Pacific is largely improved with ocean data assimilation, which can also help predict the origin and development processes of the MHW.

SESSION 8

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

S8-E-poster-1 (PaperID=15076)

A close relationship between microplastic contamination and coastal area use pattern

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Human activity is thought to affect the abundance and contamination characteristics of microplastics (MPs) in the environment, which may in turn affect aquatic species. However, few studies have examined the impact of coastal area use pattern on characteristics of MPs in coastal regions. In this study, we investigated MP contamination of abiotic matrices (seawater and sediment) and biotic matrices (bivalves and polychaetes) in three coastal regions characterized by different types of human activity, covering urban, aquafarm, and rural areas. MP abundance was higher in sediment from the urban site than in that from the rural site, but similar to that from the aquafarm site. In the abiotic matrices, different MP polymer compositions were observed among the three sites. Diverse polymers were found in marine matrices from the urban site, implying diverse MP sources in highly populated and industrialized areas. Polystyrene was more abundant in the aquafarm site, reflecting the wide use of expanded polystyrene aquaculture buoys. Polypropylene was more abundant at the rural site, probably due to the use of polypropylene ropes and nets in fishing activity. MP accumulation profiles in marine invertebrates showed trends similar to those exhibited by abiotic matrices, reflecting coastal area use patterns. These results indicate that marine MPs are generated from both land- and marine-based sources, and that the abiotic and biotic marine matrices reflect the MP characteristics.

S8-E-poster-2 (PaperID=15080)

Microplastics and microfibers in surface waters of Monterey Bay National Marine Sanctuary, California

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Monterey Bay National Marine Sanctuary (MBNMS) is known for its biological productivity,robust fisheries, and ecotourism, but microplastic pollution is an emerging concern. Recently, high concentrations of microplastics and microfibers have been reported in the mesopelagic waters of MBNMS; however, little is known about these particles in MBNMS surface waters.

From 2017-2019, we sampled two nearshore and two offshore locations within MBNMS using a manta trawl and analyzed these samples for microplastics and microfibers. Following density separation, chemical digestion, and vacuum filtration, we found an average concentration of 1.32 ± 0.70 (SE) particles per m^3. We found the highest concentration of particles closest to shore, and the lowest concentration above the remote Davidson Seamount. Fiber-like debris was found to be more common at offshore sampling locations. We used Fourier-transformed infrared spectroscopy (FTIR) to identify a subset of particles in our sample to polymer type and found these particles to be primarily buoyant synthetic polymers. Our results provide baseline data on the extent of microplastic pollution in MBNMS surface waters and confirm that microplastic pollution can be found in waters from the surface to at least 1000m depth.

S8-E-poster-3 (PaperID=15085)

Importance of seasonal sea ice in the western Arctic Ocean to the Arctic and global microplastic budgets

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Arctic sea ice entraps microplastics (MP) from seawater and atmosphere and is recognized as sink and transport vector of MPs. However, ice-trapped fraction in the global MP budget, contribution of atmospheric input, and linkage among Arctic basins remain unclear. The number-based results (i.e., count per m^3), which depends on plastic fragmentation and measured cutoff size, do not provide solid information for budgeting the Arctic MP source and sink estimates. Here, we present the number- and mass-based data separated by size and shape geometry for MPs measured in sea ice, snow, and melt pond water in the western Arctic Ocean (WAO). This first mass budget for Arctic MPs show that 1) concentration, polymer composition, and size distribution significantly varies depending on measured size and geometry and thus a direct comparison of different datasets leads to erroneous conclusion, 2) small MP particles, though prevalent in the fraction of counts, constitute a minor fraction of total MP mass, 3) all Arctic basins are polluted at similar levels, with a much closer linkage between the Arctic Central Basin and the WAO when MP data were compared for the same size range and geometry, 4) the MP amount trapped in seasonal sea ice (41–280 kilotons) in the WAO is unexpectedly large, being comparable to the stock of MP afloat in global oceans, and 5) atmospheric deposition (i.e., snowfall) accounts for only a small fraction (<1%) of the ice-trapped MP amount. We suggest that a significant amount of plastic particles missed from the global inventory may accumulate in the WAO, which is substantially responsible for MPs found in the other Arctic basins.

S8-E-poster-4 (PaperID=15097)

Importance of point source to microplastic accumulation in Antarctic environment

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Antarctica, which is sensitive to changes in the global environment, is one of the pristine areas with relatively low levels of pollution. However, this continent surrounded by the Antarctic Circumploar Current may accumulate microplastics (MPs) discharged from its pontential point sources such as research camps. However, the effect of the point source on MP accumulation has so far been little known. The Marian Cove is located in Maxwell Bay at the King George Island and the King Sejong station at the mouth of the cove operates since 1988. We investigated MPs in various compartments around the research camp, including seawater, bed sediment, benthic organisms, and wastewaters. MP abundance in wastewater effluent was three orders of magnitude higher than in seawater, indicating that wastwater could be a strong input source. MPs distributed vertically uniformly in seawater column due to a strong mixing driven by tide and wind. In horizontal distribution, both seawater and sediment showed an increasing MPs from the mouth to the inner sites of the Marian Cove. Higher MP contents in benthic sediment than in seawater implied the sinking and accumulation of MPs in seabed. The MP amount in the Marian Cove was estimated to overwhelm historically discharged MPs from the Sejong Research station, indicating the additional input and accumulation of MPs discharged from neighboring other research camps in the Maxwell Bay. This result highlight that MPs can accumulate in geographically semi-enclosed area with a local source.

SESSION 9

FUTURE/POC/TCODE Topic Session
Applications of artificial intelligence to advance the understanding of North Pacific ecosystems

S9-E-poster-1 (PaperID=15032)

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

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Empirical orthogonal function (EOF) analysis is frequently applied to spatiotemporal data, thus making it possible to represent multiscale variability as a sequence of modes ordered by a share of the total variance accounted for by each of them. The spatial dimension is usually a longitude-latitude plane; however, it seems reasonable to analyze data varying in depth and time. POI performs an ecological monitoring off Vladivostok, in Peter the Great Bay, the Japan/East Sea, including long-term moorings where physical characteristics of marine environment are measured. To extract robust patterns from these abundant data with high temporal resolution, we suggest using of the EOF analysis in the depth – time domain and several examples are presented here. The vertical profiles of the buoyancy frequency and temperature from the *Aqualog* mooring at the continental slope near the eastern border of Peter the Great Bay were analyzed for the warm season 2015 and fluctuations in the vertical stratification were assessed and linked to the passage of dynamic structures near the mooring. Temperature anomalies moving in the vertical direction were also revealed, using the complex (Hilbert) EOFs. Coastal currents in the southwestern Peter the Great Bay were studied based on hourly data measured at the stationary WaveScan buoy from May through December 2016. Vertical velocity shear was assessed from complex EOFs of the velocity vectors. The signal around the inertial timescale, alternately moving down and up, was revealed and related to near inertial waves and their reflection from the bottom.

S9-E-poster-2 (PaperID=15065)

Unsupervised Machine Learning for ocean profile classification and outlier detection using the Pacific Ocean temperature-conductivity-depth profile data

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Fisheries and Oceans Canada has been conducting oceanographic observations and oceanographic research since early 1900. The department collects ocean observations using in-situ instruments and remote sensing technologies. However, current ocean data analysis mostly use manual classification and quality control. Ocean data are multidimensional where ocean observations are collected at different depths of the ocean. Moreover, many in-situ ocean observations suffer from spatial and temporal variability. Data-driven approaches are better suited for such type of analysis. To find (dis-)similarities between multidimensional profiles of oceanographic data of the Pacific Ocean, in-situ conductivity-temperature-depth (CTD) profiles are classified using a machine learning approach (Profile Classification Model). Two sets of experiments where conducted. The first experiment clusters a total of 3602 CTD profiles to a maximum pressure of less than 1,000 dbar and according to their temperature value only. Results have shown that the dataset of temperature profiles contains 9 groups of vertically coherent heat patterns, or classes. Each of the classes reveals unique and physically coherent heat profiles and corresponds with distinct oceanic regions, even if no spatial information was used in the model determination. In the second experiment, both temperature and salinity observations are considered. Results have shown that depending on the choice of seasons, up to 15 classes are observed, with occasional classes that correspond to sensor failures. To the best of our knowledge, this is the first attempt at clustering in-situ CTD profiles that are collected from the Pacific Ocean.

S9-E-poster-3 (PaperID=15105)

Big data processing algorithms and environmental indicators in multi –channel monitoring systems

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In this paper problems connected with the decision making when the natural or anthropogenic processes are studied and assessed basing on the big data clouds delivered by the multi-channel monitoring systems. Decision making tool is developed basing on the classical and sequential analysis procedures. It is supposed that studied process is assessed on the base of specific indicator and a set of its values is formed from different information sources.

Many problems arising in the climate-nature-society system (CNSS) for their solution need the development of decision-making procedures allowing search acceptable strategies for the sustainable development. Sustainable development indicators usually are applied for the assessment of the integral state of studied system or process. As rule, the evaluation of their dynamic characteristics is based on the disembodied data that reflect the endowments of direct and indirect correlations between the processes that act on the studied system. In common case, indicators are used as integral index of the system or process state. A set of indicators is characterized by the variety of their forms and subject orientation. Nevertheless, each indicator is function of many natural and anthropogenic parameters numerical values of which delivered episodically at the time and fragmentary in the space. Under this conditions decision making procedure is to provide the reliable conclusion about the studied system state and to give the recommendations how and what is to be made for the solution of existing problem.

Proposed in this paper multi-channel decision making system (MCDMS) can considered as expert system that automatizes decision making process in different applied areas if the indicator of the studied subject state is defined.

Keywords—algorithm, decision making, indicator, climate-nature-society system, big data, multi-channel monitoring systems

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S9-E-poster-4 (PaperID=15121)

Data Lakes for Ocean Data - How CIOOS is enabling data-science and AI research projects in the North East Pacific

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The Canadian Integrated Ocean Observing System (CIOOS) is a collaborative project between the Canadian Government (Fisheries and Oceans Canada), Universities and Non-governmental Organisations in Canada. Working with data providers, CIOOS brings together data from different sources to a common standard that adheres to the FAIR (Findable, Accessible, Interchangeable and Reusable) best practices for data and the ISO-19115 metadata standards.

One of the problems in this age of big data is the effort needed to transform observations from various sources to a consistent form that has been cleaned and curated for eventual use as a training or validation dataset in a machine learning application.

In this presentation we discuss the concept of a 'Data Lake', the essential features of such a resource and why it is a necessary step in most data-science and AI projects. We will present tools and technologies used by CIOOS to create one such open and publicly accessible resource where users can discover and download data automatically to drive their data-science and AI research projects. Using case-studies, we will demonstrate how this resource is being used to enable AI research projects in the North East Pacific.

S9-E-poster-5 (PaperID=15136)

Machine learning methods for chub mackerel fishing area forecasting in the northwestern Pacific Ocean

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Russian fishery for chub mackerel *Scomber japonicus* Houttuyn, 1782 within the EEZ was resumed in 2016. Fishing is carried out on feeding grounds, and high catch period is relatively short. Therefore it is important to minimize fleet searching time for chub mackerel fishing grounds.

The use of machine learning methods good proved their efficiency for short-term fishing support in the Russian EEZ. This made it possible to forecast fishing grounds shaping 1-3 days ahead, as well as identify areas with potentially high catches. Approximately 84% of the annual catch of chub mackerel was taken at predicted sites during highest catches in 2020.

Machine learning methods for forecasting of the fishing grounds area were used. The gradient boosting library LightGBM was used as the first step.

Fishery statistics for 2016–2020 and SST with 4–7 days delays from the date of catch as input data were used. Additional features were calculated, based on SST. The problem of perspective fishing grounds definition was reduced for a binary classification task. The dataset included SST and additional features with 1-7 days delays. The applied algorithm showed good predictive ability. AUC for the test dataset was 0.93. Validation on data from 2020 showed AUC 0.78.

Deep learning using the Torch library was applied as the second step. Daily catches were divided into 5 ranges. This made it possible to significantly improve the results. The AUC for multiclass classification when validated for 2020 data was 0.78.

S9-E-poster-6 (PaperID=15142)

About problems of the biocomplexity of marine ecosystems on the example of the Okhotsk Sea

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Biocomplexity of the marine ecosystems and synthesis of simulation model of marine ecosystems, allowing to give prognostic an estimation of a condition ecosystem depending on global andregional changes in an environment, certainly, is an actual problem. By means of this model probably to establish some laws of dynamics of a trophic pyramid of the sea, and also to understand mechanisms of regulation of community of the sea due to external influences.

Biocomplexity refers to phenomena that result from dynamic interactions between the physical, biological and social components of the *Nature/ Society System* (NSS). The investigations of the processes of interaction between the *Society* and *Biosphere* are, as a rule, targeted at understanding and estimating the consequences of such interactions. The reliability and precision of these estimations depend on criteria founded on conclusions, expertise and recommendations. At present, there is no unified methodology for selection between the set of criteria due to the absence of a common science-based approach to the ecological standardization of anthropogenic impacts on the natural environment. After all, the precision of the ecological expertise for the functioning and planning of anthropogenic systems, as well as the quality of the global geoinformation monitoring data, depend on these criteria.

This paper is oriented on the development of biocomplexity indexes basing on the remotely measured environmental characteristics. Microwave radiometry is used as effective technique to assess the sea water parameters.

As an example, the biocomplexity model of the Okhotsk Sea ecosystems is considered

Key words: marine ecosystem, geoinformation monitoring, biocomplexity, trophic pyramid , microwave radiometry

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GENERAL POSTER SESSION

GP-E-poster-1 (PaperID=15036)

Economic evaluation of MSY-based fishery policy using Input-Output Table: A case study of squid-related industries in Hakodate City, Hokkaido Prefecture, Japan

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In December 2020, the Amended Fishery Act of 2018 was enacted. A new resource management policy based on Maximum Sustainable Yield (MSY) was introduced for 8 kinds (9 species) of fisheries resources. There are some studies which evaluate the economic impact of fishery-related policy using an Input-Output table. However, there is little research assessing that of MSY-based fishery policy. To fill the gap, this study evaluates the regional economic impact of MSY-based fishery policy in the case of the Japanese common squid (*Todarodes pacificus*) and related industries in Hakodate-city, Hokkaido Prefecture. Combining the Input-Output table of Hakodate city and the stock assessment report for the Japanese common squid, this study compares the expected regional economic impact 1) of MSY-based fishing pressure (new policy) and 2) of conventional fishing pressure (2017 – 2019 average) for 10 years. They are each calculated under two scenarios of normal and low recruits of the squid. The results show that the total regional economic impact of MSY-based fishing pressure would be more than that of conventional fishing pressure; however, the economic difference of those two fishing pressures is smaller in normal recruits than in low recruits.

GP-E-poster-2 (PaperID=15045)

Influence of climatic changes of the eastern coast of Chukotka on ice coverage of the Bering Sea

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The aim of this work was to study the influence of climatic changes on the coast of the Chukchi Peninsula of Russia on the ice cover of the Bering Sea for 1961–2017. Correlation analysis was carried out between the mean monthly air temperature, the amount of atmospheric precipitation at 6 coastal meteorological stations and the ice cover from January to May.

Positive trends in ice coverage from January to March were revealed, the most significant trend was in January (the coefficient of determination R = 0.12 with a significant R = 0.06). In April and May, the trend is neutral.

The thermal regime of the coast from January to May has a close inverse relationship with the ice extent of the Bering Sea (correlation coefficient r = 0.5 - 0.6 with significant r = 0.25). In January, there is a significant decrease in air temperature (R = 0.11) against the background of a simultaneous increase in ice coverage. In the remaining months, the air temperature increases, linear trends are statistically significant (R = 0.5-0.7). However, the area of the ice cover is growing insignificantly or remains at the same level.

As for the precipitation regime, an inverse relationship was found (r = 0.25 - 0.46 with a significant r = 0.25), which indicates an increase in ice coverage against the background of a decrease in precipitation.

GP-E-poster-3 (PaperID=15046)

From theory to action: solutions for climate-ready fisheries

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Climate-induced effects on ocean temperature, ocean acidification, deoxygenation, and sea level rise are increasing in frequency and intensity. With the start of the U.N. Decade of Ocean Science for Sustainable Development, there is an opportunity to co-develop, diffuse, and implement solutions that help communities adapt to these changes. A key area for adaptation is fisheries. Fishers and fishery managers are already experiencing the impacts of a changing climate on the water and are actively preparing for different future scenarios. “Climate-ready fishery management” is proposed as a solution, but much of the discussion on how to adopt and implement it remains theoretical.

Sharing experiences from different fisheries can help identify key questions, obstacles, and good practices. This presentation brings experiences from three U.S. regions, the Pacific, North Pacific, and Mid-Atlantic, that have started taking a proactive approach to climate adaptation in fishery management. For instance, new mechanisms highlighted through work with managers and commercial fishermen in Alaska include Fishery Ecosystem Plans, climate risk and vulnerability analyses, habitat protections, and the development of original metrics, such as food web production or function targets to inform fishery management. Other approaches being tested through fishery management councils and by the National Marine Fisheries Service in East Coast and Pacific regions include stock assessments with environmental covariates, ecosystem reporting, management strategy evaluation, scenario planning, and stakeholder-driven efforts to identify management challenges and adapt to a changing ecosystem.

GP-E-poster-4 (PaperID=15056)

Horizontal scale of chlorophyll *a* variation in relation to eddy activities in the midlatitudes of global oceans

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Horizontal characteristic scale of near surface chlorophyll *a* (CHL) is essential for understanding the ubiquitous structure of biological production, and is an important factor which closely related to biodiversity, biological production, and carbon absorption of ocean. Therefore, CHL variation based on the satellite observations from 2001 to 2019 were analyzed in association with eddy activity in mid-latitude regions of the five basins including the North/South Pacific (NP/SP), the North/South Atlantic (NA/SA), and the South Indian Ocean (SI), comparing with some representative scales such as internal Rossby’s deformation radius (L_D) and Rhines scale (L_R). In the open ocean, the horizontal scale decreased with increase of the eddy kinetic energy (EKE) and generally converged to πL_D in the EKE range of >0.1 $m^2 s^{-2}$. The ratio of CHL variation in the latitudinal direction (D_z) to that in the meridional scale (D_m) also converged to one with increase of EKE except for the regions where intense mean flows such as the Kuroshio and the Gulf Stream occur, implying isotropic uniformization due to the eddies, and distortion due to the mean flows. In the regions with small EKE (especially the central subtropical and eastern parts of each basin), D_m was shown to be larger than L_D, having a similar scale with L_R, rather than L_D. In these regions, D_z larger than D_m, having a scale of 500–1000 km was found. However, sensitivity of EKE on D in these regions was tended to be higher than that in the western boundary regions.

GP-E-poster-5 (PaperID=15063)

Toxic effects of aged-High Density Polyethylene fragment on zebrafish

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Microplastic pollution has become one of the most important environment issues to be addressed. To understand environmental microplastics contamination, it is necessary to recognize how much the microplastics that are found in the environment are harmful to organisms in the ecosystem. However, many studies use commercial microplastics that can be easily purchased to evaluate toxicity in the laboratory. This might suggest that toxicity data obtained from the studies are not enough to declare microplastics as a potential stressor to environment, and to reflect real world effects of microplastic contamination.

In this study, we assessed the effect of virgin MP (106 um), physical aged MP (25 um) and photo-aged MP (25 um-UV irradiation) in adult zebrafish. Zebrafish were exposed for 7 days to 3 type of HDPEs at a concentration of 50 ppm. The results showed that after exposure, MPs accumulated in fish gills, liver and G-I. In zebrafish G-I, the smaller the size of microplastic, the higher the residual rate. MP induced oxidative stress and immune response in the liver as well as enhanced neurotoxicity in the brain. Moreover, compared to the controls, fish exposed to MP showed less distance to travel at the bottom of tank. MP also regulated the gene expression of oxidative stress (Atp1bla, Cat, SOD), immune response (TNF-a, Il-1b), neurotoxicity (Ache, Th).

GP-E-poster-6 (PaperID=15082)

Influence of environmental factors on the Bering Sea pollock reproduction, abundance and spatial distribution

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Interannual climate fluctuations have high influence on the Bering Sea plankton community structure and consequently on pollock juvenile survival, year class abundances, seasonal migrations, and post spawning spatial distribution. Large plankton crustaceans with high lipids contents increase as the climate cools. In 2019-2021 trends have appeared with water temperature cooling in the Bering Sea which have been determined as a climate-induced shift and could continue for subsequent years. These colder conditions therefore potentially have positive influence on pollock juveniles' food supply and survival in overwinter conditions and finally on year class specific abundances. This resilient strategy of pollock behavior in periods of higher trophic level due to high large plankton abundance are not very big scale and slow northward their feeding migrations from winter and spawning habits. Therefore, the Bering Sea ecosystem status prediction according to scenario of general trends environmental processes for next 4-5 years, since 2022, are relatively higher biomass of large plankton (euphausiids and large copepods), higher pollock year classes abundance, increasing pollock total biomass, not intensive and slow northward pollock feeding migration at early summer, shift of active back southeastern migration to early autumn and lower distribution older pollock in the northern Bering Sea at summer.

GP-E-poster-7 (PaperID=15090)

Variability of longshore surface current on the shelf edge and slope off the west coast of Canada

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The shelf-edge and slope current off the western coast of Canada has been monitored at a site off West Vancouver Island since 1985. However, observations at this site may not represent characteristics of the shelf-edge and slope current off the west coast of Canada. Here we use along-track satellite altimetry data to investigate characteristics of the surface geostrophic currents over the shelf edge and continental slope off the western coast of Canada over 1992 to 2020. We find that the surface current over the shelf edge and slope has some different features from the south to the north. While the surface current is poleward in winter and equatorward in summer off South Vancouver Island, it is poleward year round off the rest of the west coast of Canada. The seasonal current anomalies show longshore correlation significant at the 95% confidence level, except off North Haida Gwaii . The seasonal current anomalies are correlated with the longshore wind anomalies both off South Vancouver Island and off Oregon, except off North Haida Gwaii. The seasonal current anomalies are not correlated with either Nino3.4 index or the Pacific Decadal Oscillation index, though they often show large episodic events during strong El Nino and La Nina years. Consistent with previous findings, the present study indicates that the surface currents over the shelf edge and continental slope off the west coast of Canada are related to regional and remote longshore wind forcings, and impacted by local winds and freshwater runoffs in the northern region as well. The surface currents along the shelf edge and continental slope can affect heat and salt exchange as well as nutrient supply. They may impact transport and distribution of fish eggs and larvae.

GP-E-poster-8 (PaperID=15091)

Effects of the Kuroshio Large Meander on euphausiids in Suruga Bay, Japan

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The Kuroshio Large Meander (KLM) is a phenomenon that the Kuroshio Current takes a meandering path off the Pacific coast of Honshu Island, Japan for relatively long periods. The most recent KLM began in August 2017 and continues up to now. Suruga Bay is open to the Pacific and the surface water is affected by the Kuroshio Current. However, few attempts have been made to clarify the effect of the KLM on abundance and/or species diversity of macrozooplankton in the Bay. We conducted monthly survey from January 2015 to December 2019 to examine the effects of the KLM on the species diversity and population dynamics of euphausiids in Suruga Bay. Higher water temperatures and salinities in the upper 200 m were observed during the KLM periods, reflecting inflow of Kuroshio water in the Bay. The total euphausiid abundances were significantly lower during the KLM period than the non-KLM period ($p < 0.01$). In total 36 species of euphausiids were identified, and the species richness and evenness were significantly higher during the KLM than non-KLM ($p < 0.05$), especially during the February–July season. In this season, number of species inhabiting Kuroshio regions occurred which increased the species diversity. Community structure analysis using of Bray-Curtis similarity index revealed that euphausiids communities were mostly different between those appeared in the KLM and non-KLM periods. Our study suggests that the KLM affects on euphausiids in Suruga Bay in terms of abundances, species diversities, and community structures.

GP-E-poster-9 (PaperID=15092)

"Wishing I'm Fishing": OceanView - A fisherman's lifelong app

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Fueled by the seasonal upwelling of cold and nutrient-rich water, the California Current System consists of a diversity of marine species and provides significant economic, cultural, social, and aesthetic benefits that enhance the quality of life for coastal communities. However, increasing anthropogenic activities such as overfishing and coastal development affect marine ecosystems, thus long term ocean data is needed to understand changing marine ecosystems. We have been developing a participatory citizen science app, in partnership with the California Cooperative Oceanic Fisheries Investigations (CalCOFI) ecosystem observing program, to augment existing long term ocean observations off the coast of California. The app will allow recreational ocean users to upload detailed information on marine species they caught or observed, including the image of the organism, the species name, time, and location. If they don't know the species name, a suggestion will be offered by the image recognition algorithm. To incentivize users to use our app, we will also provide other functions, such as a real-world map showing Marine Protected Areas in California, a platform allowing users to discuss species they observed, etc. The data collected can be utilized to augment existing long term sampling of biological Essential Ocean Variables (EOVs) and to support future scientific research and analysis such as species distribution modeling and invasive species detection. As a citizen science app, we hope to inspire citizens to take part in and contribute to ocean observing, marine research, and to become more aware of marine conservation.

GP-E-poster-10 (PaperID=15094)

Application of the NEAT for global eutrophication assessment

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Human activities and their negative impacts on coastal waters are increasingly threatening the integrity of coastal ecosystems. The NOWPAP eutrophication assessment tool (NEAT) is a eutrophication preliminary screening tool used by the Special Monitoring and Coastal Environmental Assessment Centre of the Northwest Pacific Region Action Plan (NOWPAP) hosted by the Northwest Pacific Region Environmental Cooperation Center to detect symptoms of coastal eutrophication using satellite-derived chlorophyll-a (CHL) data. The NEAT applies a long-term consistent data record of CHL to identify temporal trends in CHL and associated them with eutrophication potential waters. In this presentation, we introduce the NEAT, its strengths and limitations and the recent advances in its development. Further, we also discuss the potential contribution of the NEAT as one of inexpensive global indices of coastal eutrophication. The NEAT introduces the prospect for a consistent global assessment of eutrophication trends with major implications for monitoring Sustainable Development Goals (SDGs) more specifically SDG 14: Life Below Water—conserve and sustainably use the oceans, seas and marine resources—indicator 14.1.1a "Index of coastal eutrophication".

GP-E-poster-11 (PaperID=15120)

Heavy metals in brown algae, vascular plants and soils of Bering Island (Commander Islands) in 2020

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Bering Island is part of the Commander Islands Nature and Biosphere Reserve. On Bering Is., a settlement, Nikolskoye village (Kamchatka territory, Russian Federation), is a part of the protected area as transition area. The rest of the island is ranked into the buffer and core areas. In this study, we determined the levels of Zn, Cu and Pb in different components of the coastal ecosystem: tidal brown algae, vascular plants and soils. Samples were collected in September 2020 in transition and buffer areas. In soils of the transition area, Zn content made 32.6-326.4 mg/kg (hereafter: dry weight), Cu – 9.8-42.7 mg/kg, Pb – 0.5-38.5 mg/kg. Among plants, the maximum values of Zn (117.9 mg/kg) and Cu (33.5 mg/kg) accumulation were revealed in *Artemisia vulgaris*; maximum values of Pb – in *Calamagrostis purpurea* (0.64 mg/kg). In algae, Zn and Cu accumulation capacity was lower than that in higher plants. In transition area, Zn content in algae was in the same ranges and made 12.6 mg/kg. In *Fucus distichus*, Cu concentration reached 6.0 mg/kg, and in *Alaria marginata* it varied from 0.2 to 1.3 mg/kg. The Pb content in algae significantly exceeded than that in higher plants, reaching 3.3 mg/kg in some samples. The accumulation of Zn, Cu, and Pb in all studied samples of the transition area was significantly higher than in samples from the buffer area. The settlement, Nikolskoye village, and economic activities associated with its service contribute to introduction and accumulation of heavy metals in the coastal ecosystems of the Bering Is.

WITHDRAWAL GP-E-poster-12 (PaperID=15123)

Chinook salmon behavior may mediate prey availability for North American resident killer whales

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Declines in resident killer whale (*Orcinus orca*) abundance have been attributed to reduced availability of their primary prey, namely Chinook salmon (*Oncorhynchus tshawytscha)*. Estimates of resident killer whale prey availability typically are generally based on the abundance of large regional aggregates of Chinook salmon; however, such ecologically-coarse metrics are likely an imperfect proxy for regions such as southern British Columbia. Here, two populations of resident killer whales (northern and southern) interact with dozens of stocks of Chinook salmon, with substantial variation among stocks in seasonal distribution and behavior. We attempted to improve estimates of prey availability in southern BC by better integrating information on Chinook salmon ecology, leveraging existing fisheries-dependent catch data, as well as a new, acoustic telemetry-focused field program. We identified a gradient among stocks in seasonal distributions, ranging from year-round presence to brief and dramatic increases in abundance. Data from tagged individuals indicated substantial additional variability in behavior *within* populations, as well as among years. Finally, we observed relatively high levels of mortality, particularly during the final stages of marine migrations. Together, these data improve our understanding of how distinct populations of Chinook salmon utilize nearshore marine habitats and provide insight into why specific stocks may be key prey resources of resident killer whales.

GP-E-poster-13 (PaperID=15125)

Age-size composition and some characteristics of the population biology of the Helicolenus avius on the underwater uplifts of the Emperor ridge

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This study is based on the results of scientific trip, carried out in April 2019 on central Emperor Seamounts aboard the R/V Professor Kaganovsky. Bottom trawlings were carried out on the plateau of seamounts at depths from 291 to 1030 m. *H. avius* was mainly caught on Koko Seamount.

The body size (TL) of *H. avius* varied from 85 to 340 mm (body weight 10 - 627 g). 92,4 % individuals belonged to the range of 213 - 340 mm . Females prevailed in catches (52.9%). Males were larger (TL_{avg}= 288.2 cm, M_{avg}= 448.2 g) than females (TL_{avg}= 273.1 cm, M_{avg}= 379.5 g). More than 43% individuals had gonads in a post-spawning state, and about 40.6% had gonads at stage 3 of maturity. The smallest size of the spawned individual was 214 mm.

Otoliths were sampled from 68 individuals, including 32 males and 36 females with a body length from 155 to 340 mm. Independently measured by two operators age ranged from 2 to 9 years. The average CV for the measurements was 9.16%.

We can conclude that maturation in this species occurs at the 4th year. The relatively small age of mature individuals in comparison with the age of related species of this genus from the Atlantic Ocean may indicate a relatively recent or not permanent habitation of this species in this area. It is possible, that there is a dependent population. This aspect must be carefully investigated before organizing the fishery for this species on the Emperor Seamounts.

GP-E-poster-14 (PaperID=15128)

Distribution and chemical speciation of iron on the outer edge of the Changjiang diluted water plume of the East China Sea

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We investigated the distribution of dissolved iron (DFe) and organic iron-binding ligands (L_{Fe}) in the area of contact between the Changjiang diluted water (CDW) plume and the branch of the Kuroshio Current to evaluate how the interaction of these water masses affects the iron chemistry in this region. The surface water, influenced by the CDW, contained relatively high concentrations of DFe and humic-like substances of riverine origin. However, the concentration of L_{Fe} in this water mass was not significantly different from that in the surrounding water masses. In the hypoxic water which occurred at the bottom of the shelf, the DFe concentration was high, and the concentration of humic-like substances was lower than that in the water from the upper layers. In addition to the L_{Fe} found in the oxygenated water, L_{Fe} with weaker affinities for ferric ions were also detected in this hypoxic water, and the total concentration of L_{Fe} was significantly higher than that in the other water masses. These results suggest that L_{Fe} released through biological decomposition of organic matter is more important for iron complexation in this area than humic-like substances. Therefore, it is essential to quantify diapycnal mixing with deep water on the continental shelf and shelf edge to evaluate the Kuroshio branch as a transporter of iron and L_{Fe} to the Sea of Japan.

GP-E-poster-15 (PaperID=15151)

Using animal trajectory tracking software to compare the effects of different baits on the behavior of Portunidae

Wei-Yu **Lee**[1], Kuo-Wei Lan[1], Muhamad Naimullah[1] and Lu-Chi Chen[2]

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Understanding the feeding behavior of Portunidae crabs can improve bait selection to increase the catch and reduce the bycatch in trap fishery. This study selected two important swimming crab species in the Taiwan waters, *Portunus sanguinolentus* and *Charybdis natator*, as the experimental subjects. The animal trajectory tracking system (EthoVision XT 13) was used to compare crabs' behavior with two natural bait, mackerel, and squid with different muscle compositions. This study results show that mackerel recorded a higher time percentage of *P. sanguinolentus* in the baited area than when using squid and control experiment (without bait). However, squid recorded the fastest average moving speed of *P. sanguinolentus* (1cm/s) compare to mackerel and control, 0.51 cm/s and 0.25 cm/s, respectively. However, for *C. natator*, the time percentage recorded zero percentage in the baited area when using squid and control experiments, whereas mackerel recorded 8% of time percentages in the baited area with an average moving speed 0.41cm/s. This result shows that mackerel can attract *P. sanguinolentus* and *C. natator* moving near the baits area and affecting swimming crab behavior. Differences in muscle composition between the two types of bait may have caused behavioral changes for *P. sanguinolentus* and *C. natator* in this study, where fish meat did not have a strict muscle building system, while the epidermis of squid muscle tissue consisted of vital collagen.

GP-E-poster-16 (PaperID = 15166)

Marine science communication in the UN Ocean Decade: What we have done, and what's coming next

Aoi **Sugimoto** (representative of SG-SciCom)

Japan Fisheries Research and Education Agency

Global policy and science platforms increasingly recognize the importance of engaging diverse perspectives from scientific disciplines, including conservation practitioners as well as local and indigenous communities to achieve desirable ecosystem governance, illuminated by the launch of the UN Ocean Decade of Ocean Science. This trend involves many individual scientists and scientific organizations that are upgrading their science communication activities. This presentation describes a few examples of these activities from the perspective of an early career scientist who is involved in science communication both at individual and organizational level.

At the individual level, collaborative work with artists, designers and musicians to better communicate the importance of Okinawan coral reef sustainability, clearly demonstrates multiscale governance that goes beyond the conventional science-policy interface, reaching audiences beyond academia and government organizations. At the organizational level, the activities of the PICES Study Group on Science Communications have secured a plan for communicating PICES science to a wider audience, including the next-generation of scientists, under-represented communities, and the general public. This transformation is challenging however, but is an important strategy for moving our science forward during the UN Decade. The presentation will discuss both challenges and possibilities of upgrading science communication in PICES.

WORKSHOP 2

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

W2-E-poster-1 (PaperID=15118)

Effects of environmental variability on the spatial dynamics of common squid (*Todarodes pacificus)* in Korean waters

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Changes in environmental conditions in marine ecosystems could directly or indirectly affect distribution and abundance of fishery resources. Understanding species-specific and age(size)-specific responses to environmental variability is important for managing commercially important stocks. In Korean waters, common squid (*Todarodes pacificus*) is a commercially important species. Their commercial catches have been decreased since the mid-2000s. Using historical fishery-dependent data, to examine effects of biotic and abiotic factors on the spatial dynamics of the common squid in Korean waters, we applied various machine learning approaches (i.e., maximum entropy model, support vector machine, random forest). The full model included abiotic (i.e., seawater temperature, salinity, water velocity, sea surface height, mixed layer depth) and biotic (i.e., chlorophyll-a concentration) factors. Our results showed that the range of common squid distribution was expanded to north during summer and fall. The seasonal differences of common squid spatial distribution were related with variability of seawater temperature and mixed layer depth.

W2-E-poster-2 (PaperID=15167)

Analysis of thermal conditions in the northwest Pacific Ocean rom satellite data

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The monthly average SST values (1998 – 2020) in the northwestern part of the Pacific Ocean and the Far Eastern seas are considered. It was shown that the amplitude of the first EOF mode (more than 95% of the variance) had significant positive anomalies in January – April 2020 in the southern part of the study area, where traditional feeding grounds for pink salmon are located. Possibly, the anomalous high temperatures affected the survival conditions of pink salmon and caused its weak spawning approaches to the Russian Far East coast in the summer of 2020. In spring (May – June), the magnitude of anomalies in the southern part of the study area decreased, but significant positive deviations were formed in its northern part, near the eastern (including Karaginsky Bay) and western coasts of Kamchatka. In the amplitudes of the main modes, very weak upward trends were revealed, indicating the absence of significant manifestations of global warming in the region. In the envelope curve of the lower values, an 11-year cycle was found, which is in antiphase with the solar activity index. No regular cyclic components were found in the variations of summer maxima in the amplitude of the first mode. The cyclic component with a period of 22 years made the main contribution to the oscillations of the amplitude maxima of the second mode.

W2-E-poster-3 (PaperID=15163)

Seasonal and interannual variability of shortwave radiation in the northwest Pacific Ocean from satellite data

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The monthly average shortwave radiation values (1998 – 2020) in the northwestern part of the Pacific Ocean and the Far Eastern seas are considered. The seasonal variability of this parameter clearly shows the annual harmonic with a peak in June-July and a minimum in December-January. The amplitude of the annual harmonic increases from the southeast to the northwest and the phase changes very insignificantly. The contribution of other seasonal harmonics is small. In the winter-spring period, the SWR isolines deviate from the zonal ones in the areas adjacent to the average position of the ice cover. In winter and spring, positive SWR trends dominate over the studied water area; the trend emerges in February, in the southern, central and eastern parts of the Sea of Okhotsk. In summer, the opposite picture is observed - negative trends prevail, and they are most pronounced in June, gradually decreasing towards autumn. In the autumn period (from October to December), there are practically no trends. As for the periodic fluctuations, in July, in the northern part of the Sea of Okhotsk, low-frequency components are distinguished with a period of 9 to 11 years. In the area north of Hokkaido Island, the peak falls on the 8-year harmonic. In the area of the Shantar Islands, the harmonic with a period of 7 years prevails. In the eastern part of the Sea of Okhotsk, high-frequency components prevail from 3 to 6 years.

WORKSHOP 5

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

W5-E-poster-1 (PaperID=15149)

New marine objects in the pacific salmon nutriment

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The purpose of the research is to develop additives to feed for salmon fish from waste obtained during the cutting of marine hydrobionts.

The work was carried out using methods of behavioral test reactions to pellets of artificial feed impregnated with an aqueous extract of hydrobionts. The number of experiments conducted on coho - 325, keta - 200.

The northern chilim shrimp Pandalus eous, the opilio crab R. Chionoecetes, and the kelp Saccharina bongardiana were used as water extracts. These water extracts were added to pellets (Agro Server company).

As a result of experiments, it was found that the extracts of hydrobints used have a very attractive taste for coho and chum salmon. For the coho salmon, the most effective attractive taste stimulus was granules of the extract of the northern chilim shrimp Pandalus eous and the opilio crab R. Chionoecetes in all concentrations used, which significantly increased the consumption of granules from 74.9% to 98%.

In experiments with chum salmon, additives from the opilio crab R. Chionoecetes of different concentrations were used, the palatability increased from 93.9% to 97-100%.

Thanks to the research, the attractants obtained from the waste of processing crab, shrimp fishing and algae were identified, as well as their optimal concentrations of use as feed additives.

Such use of secondary raw materials can increase the level of use of aquatic biological resources, as well as reduce the anthropogenic impact on the environment.

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