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Book of Abstracts

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Abstracts

Session 1: Toward integrated understanding of ecosystem variability in the North Pacific

October 29, 11:15 (S1-13826) Invited

What is gained (and lost) through an integrated modeling approach: Assessing climate change impacts on Bering Sea fish and fisheries

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Climate change has the potential to impact an entire marine ecosystem, from physics through fishers, and can interact with structuring processes to influence ecosystems in ways that are difficult to anticipate. At the same time, emerging resource management approaches and evolving technologies offer sustainable adaptive solutions that may attenuate or amplify climate-driven changes. Consideration of these combined pressures and potential adaptive responses can yield divergent, yet equally plausible modeled future trajectories, which invariably reflect model treatment of the relative strength of bottom-up, top-down, and density-dependent interactions. Thus modeling climate change impacts on marine ecosystems requires an integrated approach that can address the multiple compound impacts and attendant uncertainty of climate and management interactions. We demonstrate the value, and challenge, of using a multi-model integrated framework as part of the Alaska Climate Integrated Modeling (ACLIM) project. This includes projecting the biomass and distribution of groundfish and invertebrate species in the Bering Sea, Alaska (USA) under 11 future climate trajectories with low to high carbon emissions, various assumptions regarding climate-recruitment relationships and trophic interactions, as well as multiple socioeconomic, harvest, and management scenarios. We demonstrate that management performance varies under future climate conditions, and that trophic interactions can both amplify and attenuate climate impacts. Our results reinforce the importance of conducting multiple climate and management projections that can provide the contrast and breadth of scientific support needed to evaluate policy trade-offs under future climate change.

October 29, 11:45 (S1-13588) Invited

Understanding human and natural changes in North Pacific social-ecological marine systems: The FUTURE framework

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'Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems' (FUTURE) is the flagship integrative Scientific Program undertaken by the member nations and affiliates of PICES. One of the principal goals of the FUTURE Scientific Steering Committee is to develop a framework for investigating interactions across disciplinary dimensions and scales, specifically within North Pacific Social-Ecological-Environmental Systems (SEES). These interactions are complex and nonlinear, occur across a range of spatial and temporal scales, and can complicate management approaches to shared problems. Here we demonstrate the FUTURE SEES framework by looking at four case studies: (a) species alteration in the western North Pacific; (b) ecosystem impacts of an extreme heat wave in the eastern North Pacific; (c) jellyfish blooms in the western North Pacific; and (d) warming and species distributional shifts. An effective and comprehensive SEES approach is necessary to maintain resilient ecosystems within a changing climate. PICES provides the structure required to address the multi-national, inter-disciplinary issues we face in the North Pacific.

October 29, 12:15 (S1-13656)

Ecosystem variability and connectivity in the Gulf of Alaska following another major ecosystem perturbation

Robert **Suryan**[1], Stephani Zador[2], Mandy Lindeberg[1], Donna Aderhold[3], Mayumi Arimitsu[4], John Piatt[5], John Moran[1], Janice Straley[6], Heather Coletti[7], Dan Monson[5], Thomas Dean[8], Russell Hopcroft[9], Sonia Batten[10], Seth Danielson[9], Benjamin Laurel[11]

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Climate patterns in the Gulf of Alaska (GOA) vary over annual and decadal time scales. Likewise, bio-physical coupling between the GOA and other large marine ecosystems (LME) in the North Pacific can also vary over time. Within the GOA, habitat complexity can modulate local-scale as well as basin-scale drivers of ecosystem response. We explore ecosystem variability in the GOA in the context of the recent marine heatwave, a period of prolonged ocean warming in the northeast Pacific between 2013 and 2016. We demonstrate the far-reaching effects of the heatwave from offshore epibenthic to nearshore intertidal species and across multiple life stages. We further demonstrate how the magnitude of the recent marine heatwave induced broad-scale ecosystem responses throughout the GOA. Examples of responses include unusual mortality events, reproductive failures and starvation in seabirds and marine mammals, changes in predator foraging behavior, changes in prey availability and energy content, missing pre-recruit cohorts, presence of species not often found in Alaska, and wide-spread effects on typically more resilient intertidal organisms. This large-scale marine climate event offers an opportunity to understand mechanisms of variability within and among LMEs and evaluate the relative strength of local to basin-scale drivers.

October 29, 14:00 (S1-13779)

Seasonal- to centennial-scale projections of the California Current System in aid of fisheries management

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As management bodies and industries increasingly strive to incorporate environmental information into decision making regarding living marine resources, for example in ecosystem-based fishery management, there is increased demand for regional estimates of future ocean conditions. Ocean models can provide these estimates by dynamically downscaling global climate model output to resolve important fine-scale dynamics; this process is now employed regularly, though details of the downscaling process can vary considerably and have significant impacts on the predicted future ocean state. We have developed seasonal (1-12 month) forecasts and climate projections (out to 2100) of the California Current System, spanning the U.S. west coast and extending ~1000 km offshore, with the aim of supporting fisheries management. Here we present key findings from those model runs as well as sensitivities of the results to downscaling considerations including treatment of forcing from global models. Finally, we discuss the application of the regional model output for predicting future marine species distributions, and in particular which physical variables and spatiotemporal scales are expected to generate predictable species responses.

October 29, 14:20 (S1-13827) Invited

Environmental changes induced population dynamics of marine species in North Pacific waters

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The North Pacific water is the important waters for fisheries, with the extensive and in-depth development of human activities, the problems on environment and resources in inshore waters are becoming increasingly severe. The fragmentation and defunctionalization of the spawning and nursery grounds caused by the loss of wetlands, seriously destroyed the recruitment and sustainable production of inshore fishery resources. Environmental changes in coastal waters and its effects on marine fishery resources is a fundamental and advanced subject in the succession of marine ecosystem and sustainable yield of marine fisheries. In this presentation, the North Pacific waters have been taken as the case studies, the important commercial fishery species were as the target species. The research mainly focuses on two key scientific problems, including “the formation, transition process and mechanism of fishery species habitat during early developmental stage” and “driving-foundation of fishery species recruitment and their adaptive mechanism to environmental changes”.

October 29, 14:50 (S1-13752)

A new integrated method to elucidate climate variability impacts on living marine resources

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Various studies have been conducted to elucidate the climate variability impacts on living marine resources. Larval and juvenile stages are critical periods for the recruitment of living marine resources. However, limitations of observation methods for directly investigating the environments that larvae and juveniles experienced have been obstacles to our understanding. We reviewed the previous studies on climate variability impacts on living marine resources and discussed how reconstruction of environmental histories of larvae and juveniles is important for our understanding of climate variability impacts on living marine resources. We proposed a new integrated method to reconstruct environmental histories of larvae and juveniles using otolith oxygen stable isotope analyses and fish growth-migration models. Together with the growth estimated from otolith daily increments, it is possible to elucidate climate impacts on larval and juvenile growth through environmental histories of larvae and juveniles using their realistic migration routes. This study was published on “Oceanography in Japan” in 2018.

October 29, 15:10 (S1-13255)

Synchronicity of climate driven regime shifts among the East Asian Marginal sea waters and major fish species

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Climate regime shift (CRS) in 1976, 1988 and 1998 were well detected in different East Asian Marginal Seas (EAMS) ecosystems. However, synchronous pattern of these regime shifts among the ecosystems are limited. In this study, we examine the synchronicity of regime shifts among major climate patterns in north Pacific, sea water temperatures (SWT) and major fish species in north East Sea (NES), south East Sea (SES), East China Sea (ECS) and Yellow Sea (YS). Results suggest that 1976 CRS was occurred for a long duration period (1970-1979). Abrupt shifts were observed in North Pacific Index (NPI) (1975) and Pacific Decadal Oscillation (PDO) (1977). Early abrupt shift was detected in ECS (1970), YS (1972) and NES (1976) in SWT. Early positive shift was detected in walleye pollock, anchovy and hairtail; abrupt enhance of sardine and collapse of saury occurred in 1977. In 1988 CRS, most climate patterns were shifted within very short time (1987-1989). Abrupt shift was observed in Arctic Oscillation (AO) (1987), East Asian Winter Monsoon (EAWM) (1987) and Siberian High Pressure (1989). Positive shift of SWT in most of the EAMS area was detected within very short time (1985-1989). Collapse of sardine (1983) and walleye pollock (1985) occurred early; a positive shift was detected in squid (1989). All climate patterns were shifted earlier in 1998 CRS period; abrupt negative shift was detected in SWT of SES (1999). Negative shift was detected in Yellow croaker (1998), Chub mackerel (2001) and a positive shift in the Pacific cod (2001).

October 29, 15:30 (S1-13817) Invited

Multi-site, high-frequency monitoring of marine ecosystems using environmental DNA

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Environmental DNA (eDNA) is DNA molecules that organisms shed into the environment. It has been shown that an analysis of eDNA extracted from the environmental samples (e.g. soil and water) enables us (i) detecting the rare and hard-to-locate target species, (ii) determining species composition of a focal community or even (iii) quantifying their relative abundance in field. In this talk our recent study on eDNA techniques and its applications to marine fish communities will be introduced. The two major advantages of eDNA monitoring are a lower cost in monitoring effort and time and high taxonomic resolution, which allow one to conduct a species-resolved monitoring at a greater numbers of monitoring sites and/or with higher frequencies than previous methods such as trapping and seining. Such an eDNA monitoring makes available ecological “big data”, which, combined with appropriate analysis, provides more resolved and larger-scale information of ecosystems, such as temporal dynamics and spatial distributions of many-species ecological community. The eDNA monitoring will grow as the central tool and not only contribute to the applied area related to natural resource management and biodiversity conservation, but also catalyze the rapid development of ecology as a “big data science”. We would like to introduce our recent effort to enhance eDNA-related research and speed up the social implementation of eDNA monitoring, including the establishment of The eDNA Society in the Spring of 2018.

October 29, 16:20 (S1-13552)

Spatial and inter-annual variability in the primary productivity of the East China Sea and Southern Yellow Sea (1998-2012)

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East China Sea (ECS) and southern Yellow Sea (SYS) ecosystems have undergone drastic changes over the past two decades. The changes in the ecosystems are attributable to the on-going anthropogenic and natural stressors as well as the recent in-land activities such as the implementation of the world's largest dam and the gigantic water-management scheme in China. Here, we assessed the long-term spatial and temporal variability in the marine primary productivity using SeaWiFS and MODIS-aqua merged remotely sensed data from 1998-2012. We also analyzed the decadal changes in chlorophyll-a, photosynthetically active radiation, sea surface temperature, euphotic depth, as well as the Changjiang river discharge (CRD) in the study area. Our results indicate that the ECS and SYS primary productivity can be characterized by high spatial and temporal heterogeneity. For instance, despite the reduction of the CRD after the operation of the Three Gorges Dam, we observed an increase in productivity in the vicinity of the river mouth as the nutrient loading has continuously increased. We, however, also observed a decrease in the primary productivity in the offshore regions where the CRD influence was greatly reduced after the operation of the dam. In contrast to the coastal water, the slope region showed a gradual decrease in the productivity, mainly due to warming while some region did not show a clear trend as the other regions. Based on our observations, we infer that both natural and anthropogenic forcing will likely to intensify which in turn will amplify the spatial and temporal variability in the ECS and SYS productivity in the future.

October 29, 16:40 (S1-13649)

Millennial- to decadal-scale variability in the Bering Sea: Changes in the density of seabird species in response to climate fluctuations

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The long-term impacts of climate change are of immense concern. However, we know little about how future climate states will impact marine ecosystems. Here, we examine how the ecosystem of the eastern Bering Sea has responded to millennial-scale and decadal-scale fluctuations in climate. We provide a brief discussion of millennial patterns of use of marine resources, including seabirds, by early Aleut communities. We then examine more recent trends in seabird abundance; we found significant changes in the densities of seabirds between 1975 and 2014, with declines in the density of 22 of 35 species, of which 6 showed significant declines. At a decadal-scale, we report how seabird densities responded to variation in ocean-climate conditions by examining the densities of seabird species in years of early and late sea-ice-retreat. We predicted that, in years when prey resources were expected to be scarce, seabird densities would be lower. We found that in years with early sea-ice-retreat, the euphausiid *Thysanoesssa raschii* and the copepod *Calanus marshallae* were scarce and age-0 pollock (*Gadus chalcogrammus*) increased in availability in the upper water column of the middle shelf. We found substantial changes in the densities of seabird species between years with early and late sea-ice-retreat, with 29 of 35 species showing lower densities in years with early sea-ice-retreat. In addition, fine-scale analysis using stable isotopes revealed that diet became increasingly variable through time, possibly reflecting prey switching or food web disruption. We anticipate that many seabird species are likely to decline further with long-term warming.

October 29, 17:00 (S1-13777)

Diagnosing the impacts of large-scale climate variability on local ecosystems in the Salish Sea, USA

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Over the past several years, the Northeast Pacific has experienced a broad range of conditions ranging from "normal" to unprecedented warm temperature anomalies. Such extreme climate variability has clear impacts on the biology and provides the opportunity to explore the mechanisms through which large-scale climate change influences local systems through bottom-up processes. We used data from several monitoring programs in the inland regions of the Salish Sea (the Strait of Juan de Fuca and Puget Sound) to explore spatial and interannual variability in ecosystem response to environmental change over the period of 2014-2017, a period of unusually large climate anomalies for the region. We focus on changes in phytoplankton and zooplankton and their links to salmon and forage fish. Large interannual shifts in the physical environment had strong effects on plankton community structure, phenology, and biomass, with responses differing among local sub-regions due to differences in local mixing, stratification, and degree of ocean influence. The similarities and differences in response among regions are explored to better understand the physio-chemical underpinnings of the observed changes and their implications for local fisheries.

October 29, 17:20 (S1-13410)

Density dependence at the time of spawning: Disentangling density-dependent effects in the life histories of fish

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Spawning stock biomass (SSB) is directly proportional to total egg production (TEP) of fish stocks — this "SSB–TEP proportionality" paradigm has been a basic premise underlying spawner–recruitment models for fisheries management and studies on recruitment mechanisms of fish. Despite the progress in studies on maternal effects on reproduction, this paradigm has rarely been tested directly at multidecadal scales because of data limitations worldwide. Here we tested the paradigm for small pelagic fish in the most direct manner, based on a combination of two independent 38-year time series: fishery-dependent stock assessment data and fishery-independent egg survey data. This test showed that the SSB–TEP proportionality was distorted by density dependence in total egg production per spawner individual (TEPPS) or unit weight (TEPPSW) at a multidecadal scale. The TEPPS/TEPPSW exponentially declined with biomass and thus was density-dependent for Japanese sardine (*Sardinops melanostictus*), which exhibit a high level of population fluctuation. In contrast, the TEPPS/TEPPSW was sardine-density-dependent for Japanese anchovy (*Engraulis japonicus*), which exhibit a moderate level of population fluctuation being out-of-phase with sardine. Our analysis revealed intraspecific (sardine) and interspecific (anchovy) density dependence at the time of spawning, which was unaccounted for in spawner–recruitment relationships. Subsequently, we disentangled density-dependent effects on spawning and survival from egg to recruitment, to discuss how the existence of density dependence at the time of spawning can change the current understanding of density-dependent processes in the life histories of fish. We propose to develop an egg-production-based framework in studies on recruitment dynamics under climate variability.

October 29, 17:40 (S1-13508)

To initiate seasonal prediction for PICES FUTURE

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The vertical mixing induced by surface waves dominates the thermal structure of the upper ocean, which influences the atmosphere-ocean coupling system through air-sea exchanges. By including the surface wave-induced vertical mixing into the First Institute of Oceanography Earth System Model (FIO-ESM), the seasonal prediction error of sea surface temperature anomaly (SSTA) is significantly reduced at high latitudes of the North Pacific. The climate model can well predict the meridional distribution of SSTA, especially the characteristics of rapid decline during 25°N-45°N. This is a clue to improve our prediction ability of the North Pacific. As the seasonal prediction is one of key factors in FUTURE program, we propose to initiate operational prediction as soon as possible under PICES framework.

October 30, 14:00 (S1-13778)

Linking global to regional ocean forecasts: A hybrid dynamical-statistical approach

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Dynamical downscaling is a powerful technique for generating regional forecasts from coarse-scale global forecasts, yet is computationally expensive at fine spatial and temporal scales. Statistical downscaling trained on present local conditions is computationally fast, yet can be misleading as dominant spatial patterns and processes shift through time. Typically, the number of available (and demonstrably skillful) global forecasts on seasonal or multi-decadal timescales far exceeds the number that can be affordably downscaled to any region through purely dynamical methods. Here we describe a hybrid dynamical-statistical scheme, based on covariance analysis, which quickly generates a large ensemble of forecasted regional futures. The method proceeds through statistical (EOF) analysis of a small ensemble of output from both the (forcing) global models and the (dynamically downscaling) regional models; this establishes characteristic multivariate patterns of regional response to both present and future large-scale forcing. Once established, these statistical relationships are applied to a much larger ensemble of global model realizations, using the large-scale multivariate patterns as predictors of the multivariate regional response. This affordably generates a large ensemble of regional futures, helping to establish the statistics of such regional forecasts (e.g. the probability of extreme events). Ideally, this reduces the need to dynamically downscale each global realization of the future. This approach has been successfully applied to annual averages from multi-decadal biophysical projections of the Bering Sea. We consider its extension to seasonal and multi-decadal biophysical predictions of the Bering Sea, Gulf of Alaska and Pacific Northwest.

October 30, 14:20 (S1-13384)

Depletion of micronutrient trace metals in Line P surface waters during the 2014 warm water anomaly: Implications for marine ecosystems and climate change in the NE Pacific

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Iron (Fe), an essential micronutrient, has been measured along Line P since 1997, providing a unique time series of such measurements between the Fe-rich coastal waters of British Columbia and the Fe-limited waters of the Alaska gyre. After seven years of mainly cool conditions, surface waters in the NE Pacific began to warm in 2013, peaking in early 2014 in the mid-Gulf of Alaska. This feature, nicknamed the "Blob", was the warmest temperature anomaly ever observed in the region. To capture its impact on the availability of micronutrients to marine phytoplankton, we measured dissolved trace metal concentrations in seawater samples collected between 2012 and 2016 as part of the Line P program. Seasonal and inter-annual variability in dissolved Fe were the highest on record except for 1999 and 2005, during which a similar return to cooler conditions after a significant warming event also coincided with an increase in dissolved Fe. Dissolved copper (Cu) was also elevated in June 2016 following the "Blob", but both Cu and Fe were depleted in surface waters in August 2014. Other metals that showed significant depletion in surface waters during the "Blob" were nickel (Ni), cobalt (Co) and cadmium (Cd), which also act as (or can substitute for) co-factors in key enzymes. These observations are consistent with increased stratification, which inhibits the vertical mixing of nutrient-rich deep water to the surface. The potential of climate-related changes in the duration and frequency of such events to impact phytoplankton ecology and productivity will be discussed.

October 30, 14:40 (S1-13385)

Wind, circulation, and topographic effects on alongshore phytoplankton variability in the California Current

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We present results from a retrospective analysis at 3 km resolution of alongshore phytoplankton variability in the California Current System during 1988-2010. The coupled physical-biogeochemical simulation is a first of its kind as it benefits from downscaling a regional circulation reanalysis which provides improved physical ocean state estimates (i.e., regional- and basin-scale influences) in the high-resolution domain. The emerging pattern is one of local upwelling intensification in response to increased alongshore wind stress in the lee of capes, modulated by alongshore meanders in the geostrophic circulation. While stronger upwelling occurs near most major topographic features, substantial increases in phytoplankton biomass only ensue where local circulation patterns are conducive to on-shelf retention of upwelled nutrients. Locations of peak nutrient delivery and chlorophyll accumulation also exhibit interannual variability and long-term trends noticeably larger than the surrounding shelf regions. As such, our results not only provide a dynamical characterization of observed primary production patterns along the U.S. west coast, but additionally suggest that planktonic ecosystem response in the California Current System, and presumably other eastern boundary current upwelling regions, exhibit significant alongshore variability at local scales (O(100 km)).

October 30, 15:00 (S1-13731)

Warming from recent marine heat wave lingers in deep British Columbia fjord

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While satellite data indicate that the surface expression of the North Pacific marine heat wave, nicknamed "The Blob", disappeared in late 2016, Argo float and ship-based CTD data show that warm conditions persisted below the surface mixed layer through at least March 2018. We trace this anomalously warm subsurface water from the open ocean through Queen Charlotte Sound to Rivers Inlet, on British Columbia's central coast. In Rivers Inlet, deep water below the 140 m sill depth continues to be 0.3° to 0.5°C warmer than the monthly average, suggesting that impacts of the Blob have persisted in coastal waters at least 4 years after its onset. Impacts of the lingering marine heat wave on coastal ecosystems will be discussed.

October 30, 15:20 (S1-13674)

Causes and consequences of the great pyrosome bloom in the Northern California Current

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Pelagic urochordates (salps and appendicularians) are dominant components of oceanic, low productivity waters globally and have been studied with some regularity in many ecosystems. However, a smaller group of pelagic urochordates, the colonial pyrosomes, are generally restricted to oceanic tropical seas and have been far less studied. The subtropical cosmopolitan species, *Pyrosoma atlanticum*, has been known for a long time but does not favor productive coastal waters containing large phytoplankton which may clog its filtering apparatus. In the California Current, this species occurs off Southern California and is caught occasionally during warm years. With the advent of anomalously warm conditions in the Central North Pacific in 2014, *P. atlanticum* started appearing in coastal trawl surveys off Oregon and Washington, continuing to increase dramatically for the next four years and becoming the dominant component of pelagic surveys in 2017 and 2018. These massive blooms impaired commercial fisheries and washed up on beaches prompting public concerns. The occurrence of smaller individuals in the winter suggests that it may now be reproducing in mid-latidudes, further sustaining the bloom. Due to the paucity of information on this species outside its normal range, we examined horizontal and vertical distribution, habitat preferences, energy density, diets based on fatty acid and stable isotopic signatures, grazing rates, and utilization by higher trophic levels. Given that this tropical invader may be established in this productive temperate ecosystem indefinitely, understanding it ecology and potential impacts to the pelagic and benthic food webs and human utilization may fill a critical gap.

October 30, 15:40 (S1-13586)

Variable trends in pteropod abundance between the shelf and slope from two decades of observations off Newport Oregon, USA

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Waters which upwell nearshore in the northern California Current have low pH and aragonite saturation values < 1.0 which may impair the ability of the planktonic snail *Limacina helicina* to produce aragonite or may lead to shell dissolution, resulting in mortality. Here, we present data on the abundance of *L. helicina* over 20 years from two stations located on the continental shelf and slope that are exposed to upwelled waters differentially. Over the 20 year time span, the seasonal peak abundance of *L. helicina* followed a negative trend in the nearshore coastal upwelling zone where waters are corrosive. In contrast, the seasonal peak abundance increased offshore where aragonite saturation values are generally >> 1 year round. Further, the long term trend nearshore in the coastal upwelling region was variable while the long term trend offshore was inversely correlated with the North Pacific Gyre Oscillation.

October 30, 16:20 (S1-13652)

Impacts of hypoxia on diel vertical migration of zooplankton

Mei **Sato**[1], David L. Mackas[2] and John F. Dower[3]

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Low dissolved oxygen, or hypoxia, is an increasing threat for coastal ecosystems affecting the quantity and quality of habitat available to aquatic organisms. Zooplankton have been considered to have high tolerance to hypoxic conditions, but small-scale variability in their behavioural response is not well understood. We hypothesized that zooplankton would modify their diel vertical migration behaviour in relation to oxygen dynamics as a physiological response. We examined this hypothesis through assessment of the temporal variability of diel vertical migration of euphausiids associated with the seasonal change in dissolved oxygen concentrations in Saanich Inlet, Canada. Continuous, high-resolution measurements of biological and environmental properties over 10 years through the Ocean Networks Canada cabled observatory provided unique data sets to decouple co-varying factors and to examine the effect of hypoxia on animal behaviour. We examined the data collected during winter months (November – January) to minimize the variability in biological factors including euphausiid size and their food availability, while oxygen concentrations at their daytime depth varied below and above their critical oxygen saturation level (0.75 ml L^{-1}). Instead of the traditional view of ceasing diel vertical migration during winter, we observed weak but persistent migration behaviour of euphausiids. Acoustically-observed migrating biomass was 8 times higher when the bottom oxygen concentrations reached below 0.75 ml L^{-1} compared to the period with well-oxygenated bottom waters. Continuous measurements of interdisciplinary data sets in a seasonally hypoxic fjord are providing insight into the behavioural response of pelagic ecosystem under highly variable oxygen conditions.

October 30, 16:40 (S1-13451) CANCELLED

Effect of vertical structure of water column on depth dependent trends in walleye pollock (*Theragra chalcogramma*) in the Western coast of the East/Japan Sea

Hae Kun **Jung**, Joo Myun Park, and Chung Il Lee

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This study examined the vertical distribution pattern of walleye pollock inhabiting the western coast of the East/Japan Sea (WCES), and its response to change in oceanic condition. Our showed that walleye pollock mainly distributed between 200 m and 400 m where is below the thermocline. In general, the individuals of small size group mainly distributed at 100-200 m deep, whereas larger fishes (>30cm) tended to accumulate at depth below 300 m. The vertical distribution patterns of walleye pollock showed distinct interannual variations between 2016 and 2017. Because there were some differences of vertical water temperature patterns between 2016 and 2017, this study hypothesized those vertical distributions of walleye pollock might respond interannual changes in vertical structure of water column. In 2017 compared to 2016, water temperature in the upper layer (<100m) has been warmer in response of increased volume transportation of Tsushima Warm Current (TWC) and warmer atmospheric condition, while lower water temperature in the middle layer (100-200m) might be influenced by strong permeation of colder water mass derived from the norther part of the East/Japan Sea where is known as origin of the North Korea Cold Current (NKCC). In addition, the difference of water temperature between middle and bottom waters was due to dramatical decrease of water temperature in the middle layer. In conclusion, these changes of oceanic condition probably influenced seasonal and interannual patterns of the vertical distribution of walleye pollock More studies are demanded to convince our hypothesis including its ontogenetic preferences of depth and/or water temperature ranges via long period monitoring.

October 30, 17:00 (S1-13598)

Estimation of the origins of particulate organic matter in coastal waters for understanding the oceanic environmental change around Tsushima Islands

Mitsuo **Yamamoto**[1], Akira Yamaguchi[2], Dan Liu[3], Aigo Takeshige[4] and Shingo Kimura[1]

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Seaweed bed distributions in Tsushima Islands are different between the eastern and western areas. Dependence of the oceanic environmental change in the East China Sea on the seaweed bed distributions was investigated using re-analysis data and water quality investigations in northeastern and southeastern areas of Tsushima Islands in a previous study. The effect of the Changjiang diluted water was found to be increased in the southwestern area. To evaluate the reliability of the result, origins of particulate organic matter (POM) in coastal waters in the northeastern and southwestern areas were investigated in this study. Stable carbon isotope ratios ($\delta^{13}C$) of POM in seawater and river water were monitored from June 2016 to Mach 2018, together with the analyses of iron, nitrogen and phosphate concentrations. Surface and bottom seawaters at three sites and river waters at two sites were collected both in the northeastern and southwestern areas. $\delta^{13}C$ values in seawater in the southwestern area were constantly low (-24.7~ -21.7‰), meanwhile those in the northeastern areas were seasonally changed from -26.6‰ to -19.9‰. It was estimated that terrestrial waters influenced the coastal environment in the southwestern area continually whereas oceanic waters influenced the environment in the northeastern area strongly in some seasons. The mechanism of the difference in seaweed bed between two areas will be discussed in the talk focusing on hydrodynamic fluctuations using re-analysis data. The present study indicates that the origins of POM in the coastal areas of Tsushima Islands are different between the northeastern and southwestern areas.

October 30, 17:20 (S1-13387)

Corporate control and global governance of marine genetic resources

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Marine genetic resources are the subject of extensive commercial interest, with the value of the marine biotech industry rapidly expanding. But which species are attracting this focus, what entities are registering patents on them, and how have these trends changed over time? By collecting 38 million records of genetic sequences associated with patents, it has been possible to create a database of all marine species that have sequences associated with patents, and to collect information about the entities registering these patents. A total of 862 marine species and 12,998 genetic sequences were identified. A single multi-national corporation is responsible for registering 47% of the patent sequences. The geographic location of entities engaged in registering patents associated with marine species is similarly skewed, with 98% of patent sequences from marine organisms registered by entities headquartered in just 10 countries. In addition to presenting these empirical results from the newly constructed database, the talk will cover the relevance for the ongoing UN treaty negotiations on biodiversity in areas beyond national jurisdiction, where marine genetic resources and associated issues of access and benefit sharing are one of the core – and most contentious – issues.

S2: Fish production through food web dynamics in the boundary current systems

November 1, 11:00 (S2-13297) Invited

Prey stoichiometry influences growth rate and production of marine zooplankton

Pei-Chi Ho[1,2], Esther Wong[3], Fan-Sian Lin[4], Akash R. Sastri[5,6], Carmen García-Comas[7], Noboru Okuda[8], Fuh-Kwo Shiah[1,9], Gwo-Ching Gong[10], Rita S.W. Yam[11] and Chih-hao **Hsieh**[1,4]

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8 Research Institute for Humanity & Nature, Kyoto, Japan
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Manipulative laboratory studies show strong evidence that phytoplankton stoichiometry, besides phytoplankton carbon (C) biomass, affects zooplankton growth and secondary production (SP). However, support for stoichiometric effects from field data in natural systems remain scarce. Here, we used *in situ* incubation experiments to examine how zooplankton (mainly copepods) weight-specific growth rate (GR) and SP are affected by prey biomass (mainly phytoplankton), primary production (PP) and carbon:nitrogen:phosphorus (C:N:P) molar ratios of prey as well as plankton compositions in the East China Sea. We found that zooplankton GR increases in a saturating manner with prey P biomass and molar P:N ratio, and that the pattern is not as strongly tied to prey C and N biomass. This relationship indicates that prey P supply affects GR. Most importantly, SP is greater under low prey C:N and C:P ratio (i.e. stoichiometry that is closer to zooplankton). Finally, multivariate regression indicates that prey C:N ratio explains most of the variation in SP, followed by variation of plankton composition, while PP exerts a weak influence on SP. Our findings suggest that prey stoichiometry rather than production determines SP, and that consumer and prey compositions further modify SP in marine food webs.

November 1, 11:30 (S2-13287)

Trophic pathways of plankton food web to support food availability for vulnerable life stages of migratory fishes in the Kuroshio: As a key for the Kuroshio paradox

Toru **Kobari**[1], Taiga Honma[2], Takeru Kanayama[2], Fukutaro Karu[2], Wataru Makihara[1], Takahiro Kawafuchi[1], Kie Sato[1], Koji Suzuki[3], Daisuke Hasegawa[4], Naoki Yoshie[5], Hirohiko Nakamura[5] and Gen Kume[1]

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Many migratory fishes risk encountering low food availability during vulnerable life stages by reproduced and recruited around the oligotrophic Kuroshio (the Kuroshio paradox). Here we report adequate food availability for migratory fishes and trophic pathway of plankton food web in the Kuroshio of the East China Sea (ECS-Kuroshio). Whereas phytoplankton growth rates were limited under low nutrients in the Kuroshio path and the offshore site, mesozooplankton standing stocks and productivity in the Kuroshio Path were equivalent to those in the continental shelf waters. Mesozooplankton community was predominated by small copepods like calanoids, poecilostomatoids and nauplii. Dilution experiments showed that microzooplankton grazing rates were higher for nano-autotrophs than those for pico- and micro-autotrophs and their impacts on phytoplankton community composed more than half of primary production. Removal bottle experiments demonstrated that mesozooplankton filtering rates were positive for nano-autotrophs, athecate flagellates and naked ciliates, indicating major food items for mesozooplankton community. These results suggest that nano-autotrophs via ciliates to copepods (i.e., trophic linkage by copepods between microbial and grazing food webs) is a major trophic pathway in plankton food web and support food availability for vulnerable life stages of these migratory fishes in the ECS-Kuroshio.

November 1, 11:50 (S2-13296)

The importance of the north Satsunan area, southern Japan as the spawning and nursery ground for small pelagic fish

Gen **Kume**[1], Toru Kobari[1], Mutsuo Ichinomiya[2], Tomohiro Komorita[2], Junya Hirai[3], Maki Aita-Noguchi[4], Fujio Hyodo[5], Tsutomu Takeda[1], Taichi Shigemura[1], Hiroumi Kuroda[1], Shohei Yoshinaga[1], Kei Nakaya[1] and Atsushi Narumi[1]

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The north Satsunan area including Kagoshima Bay is assumed as the important spawning and nursery ground by the fishery-targeting small pelagic fish. In the present study, we clarify the seasonal occurrence patterns and feeding habits of larval fish in the subject area. The fish assemblages were consistently different between the inner and outer part of the bay throughout the year, the larval abundance and diversity generally being higher and lower in the bay, respectively. Larvae of the *Clupeiformes* and mesopelagic fish (i.e. *Sigmops gracilis* and *Myctophum asperum*) were dominant in the inner and outer part of the bay, respectively. Based on the morphological and DNA meta-barcoding analysis for gut contents and the stable-isotope analysis for larvae, we examined the larval diet of small pelagic (*Engraulis japonicus*, *Trachurus japonicus*), coastal (*Sebastiscus* spp., Triglidae spp.) and mesopelagic species (*S. gracilis*, *M. asperum*), which are dominant in the study area in winter and spring. The small pelagic and coastal species fed actively on copepods and appendicularians were also important preys for the mesopelagic species. The stable-isotope analysis suggested that interspecific competition for prey species would be occurring among five species groups except for *Triglidae spp.* The oceanic water sporadically inflows into Kagoshima Bay during the winter and spring months, causing the upwelling around the mouth of the bay. The present data implies this seasonal oceanographic phenomenon would play an important role in the spawning and nursery ground for many species including small pelagic fish being formed in the north Satsunan area.

November 1, 12:10 (S2-13567)

Feeding habits of multiple larval and juvenile fish taxa collected in the Kuroshio off Japan

Yuji **Okazaki**[1], Hiroomi Miyamoto[2], Koji Suzuki[3], Hiroaki Saito[4], Kiyotaka Hidaka[5] and Tadafumi Ichikawa[5]

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We examined the feeding habits of multiple larval and juvenile fish taxa collected in the Kuroshio off Japan. The fish taxa were classified into eight groups and six outliers in the cluster analysis. Four out of the eight groups consumed mainly calanoid (*Paracalanu*s spp. and *Clausoclanus* spp.) or poecilostomatoid copepods (*Oncaea* spp. and *Corycaeus* spp.), whereas two out of the groups preyed mainly on ostracods or appendicularians. The maximum values for frequency of occurrence (%FO) of prey items matched well with the numerically dominant prey items (%N) in each cluster group. Furthermore, prey selection by these larval and juvenile fishes was determined not only by prey size but also by the prey taxa available. Because non-metric multidimensional scaling (nMDS) result revealed that temporal and spatial variation in the diets of the dominant fish taxa was not likely to occur, prey selection may be robust and inherent in nature among these taxa of larval and juvenile fishes. Finally, based on our results and literatures, we identified the three major trophic pathways (grazing, microbial, and tunicate food chains) between the primary producers and the fish larvae or juveniles via zooplankton in the Kuroshio ecosystem. These diverse food chains and their combinations may support the high diversity and production of fishes in the Kuroshio ecosystem.

November 1, 12:30 (S2-13360)

Feeding ecology of age-1 Pacific saury during northward migration in June and July with remarks on difference of feeding habits by migration routes

Hiroomi **Miyamoto**[1], Kazuaki Tadokoro[2], Satoshi Suyama[1] and Hideaki Kidokoro[1,2]

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Pacific saury is ecologically and economically important components of pelagic ecosystems in the North Pacific Ocean. In early summer, June and July, Pacific saury is widely distributed in the transition area, and migrates northward to feed on abundant subarctic zooplankton. The feeding of early summer is regarded to be essential for growth and fatness of Pacific saury. Here, we observed the gut contents of age-1 Pacific saury collected widely from 140°E to 140°W in early summer to clarify the relation of migration routes to their feeding ecology. The fatness degree of Pacific saury was tended to high in the western area. The gut contents were found in 88% of total observed individuals (100 individuals). The prey composition was different in longitude. To the west of 160°E, Pacific saury fed on diverse taxa, such as *Neocalanus plumchrus*, euphausiid larvae, and *Calanus* spp, but *Neocalanus plumchrus* was their main prey in the area of between 160°E and 170°W. In further eastern area (170°W to 140°W), *Neocalanus cristatus* was dominated in their prey composition. The longitudinal difference in the guts contents was not consistent with the horizontal distribution of *N. plumchrus* and *N. cristatus*. On the other hand, the longitudinal difference in the guts contents were explained with spatial change in the fatness degree of Pacific saury, suggesting that the prey of Pacific saury between eastern and western routes of northward migration influenced the increasing of body size and fatness during early summer.

November 1, 14:00 (S2-13572)

Interaction equatorial rossby-kelvin waves to monitoring of fishing area and ocean primary productivity in Northern Indonesia 2012-2017

Khafid Rizki **Pratama**[1] and Richard Mahendra Putra[2]

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The interaction of rossby and kelvin waves has a significant relationship to the tropical waters of Northern Indonesia. The formation for a warm pool became one of the growth and collection indicators for *phytoplankton* blooming with the lifting mechanism of a maximum chlorophyll-a concentration near the sea surface level. This study examines the relationship of equatorial rossby-kelvin waves interaction in 2012 to 2017 to the fertility of waters in Northern Indonesia. The analysis for the contribution of rossby wave in increasing aquatic productivity based on climatological data of sea surface temperature, seasonal data of chlorophyll-a, argo float and buoy data in Northern Indonesia to near pacific waters shows an abundance to the increase of *phytoplankton* condition. Quantification of the contribution for kelvin wave interaction is indicated by increasing chlorophyll-a during the western (January-March) season in the north-central region of Indonesia. The oceanic climatology dynamics condition significantly affects the primary productivity for the tropical waters of Indonesia's tropical regions with high vertical salinity density indications thus lifting the nutrients upwards and pilling up the nutrient-depleted water. The relationship of these two wave interactions influence the distribution pattern of the fishing area, the fertility of the waters and the rate of fishing in the tropical North of Indonesia.

November 1, 14:20 (S2-13562)

Spatio-temporal distribution of planktonic copepods and planktonic stages of small pelagic fishes: Copepod community structure and species diversity in egg- and larvae-rich Kuroshio and Kuroshio Extension area

Sayaka **Sogawa**[1], Kiyotaka Hidaka[1], Yasuhiro Kamimura[1], Masanori Takahashi[2], Hiroaki Saito[3], Yuji Okazaki[4], Yugo Shimizu[1], Takashi Setou[1] and Ichikawa Tadafumi[1]

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Copepods are of great ecological importance as they comprise one of the most numerous groups of metazoan in marine ecosystem and play various roles in the food web as herbivores, omnivores/detritivores and carnivores. Prey-predator and competition relationships among copepods and ichthyoplankton have been pointed out previously, thus, the abundance and community structure of copepods directly affect the dynamics of fishery resources. However, studies on the early life stages of small pelagic fishes around the Kuroshio are mostly limited to sea surface temperature and current. We investigated community structure and species diversity of copepods, and compared with distribution patterns of eggs and larvae of small pelagic fishes (Japanese sardine and mackerels) and oceanic environment around spawning and nursery grounds of the Kuroshio to the Kuroshio Extension area. The survey was conducted in spring (April of May) during 2012 to 2014 from the Kuroshio area east of 138˚E to 147˚E, the downstream Kuroshio Extension area. Community structure analysis revealed copepod communities that appeared through all year (2 communities at 45% similarity) and communities specific to each year (3 communities at 45% similarity). One of the former communities showed lower copepod abundance and higher species diversity with high water temperature and salinity, whereas, the other showed higher copepod abundance, nutrient and chlorophyll concentration, where eggs and larvae of small pelagic fishes were also abundant.

November 1, 14:40 (S2-13308)

Comparative analysis of the early growth history of Pacific bluefin tuna *Thunnus orientalis* from different spawning grounds and nursery areas

Mikio **Watai**[1], Yuko Hiraoka[2], Taiki Ishihara[2], Izumi Yamasaki[3], Tomoko Ota[2], Seiji Ohshimo[4] and Carlos Augusto Strüssmann[5]

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This study compared the growth history of young-of-the-year (YOY) Pacific bluefin tuna (PBF; *Thunnus orientalis*) from three cohorts (born in the Nansei Islands area and grown up in the Pacific coast of Japan, born in the Nansei Islands areas and grown up in the Sea of Japan, and born and grown up in the Sea of Japan) in five year classes (2011–2015). Larval growth rates of PBF in the Sea of Japan were highly variable compared to those in the Nansei Islands areas and were not necessarily higher in the former as expected from the inherent higher primary and secondary productivity of the Sea of Japan. The uncoupling of larval growth rates on food abundance in the Sea of Japan appears to be related to the thermal instability and the proximity of winter in relation to the spawning season in this area. Unlike larvae, local-born juveniles and Nansei Islands-born YOY inhabiting the Sea of Japan had high growth rates compared to those in the Pacific in a manner that is consistent with the higher productivity in this area.

November 1, 15:00 (S2-13633)

Oceanographic conditions and the spatial distribution of saury, sardine and mackerels in the open waters of the Northwest Pacific based on the fishery-independent R/V "Hokko-maru" survey data

Elena **Ustinova**[1], Hideaki Kidokoro[2], Dmitry Antonenko[1] and Hiroomi Miyamoto[3]

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The fishery-independent surveys conducted annually in prior to major fishing season by scientific research vessels of Japan are suitable for the studies of the oceanographic conditions influence on the distribution of saury (Cololabis saira), mackerels (Scomber japonicus and Scomber australasicus) and sardine (Sardinops melanostictus) in the open waters of the Northwest Pacific because they transects the Subarctic frontal zone and waters to north and south with various nutrient properties and food availability. We analyzed the influence by the example of R/V "Hokko-maru" survey in 2017. The spatial distribution of the species corresponded to the water masses composition and proper fronts, with the exception of a single station where salps were in abundance. The species of the "Kuroshio ichthyocene", which migrate to the subarctic frontal zone and further to the north, were caught in mixed and transformed waters in June. Key dynamic structures (oceanic branches of the Kuroshio, Oyashio, Subarctic and Kuril currents, Isoguchi Jet and mesoscale eddies) and related oceanographic fronts have effect on the migration patterns. In 2017 the flow of transformed subtropical water spread farther north than usual and characterized by positive temperature and salinity anomalies in the 0-350 m layer. The relatively strong northeastward "third" Kuroshio branch (or Isoguchi Jet) was favorable for more intense northward migrations in the food-rich subarctic waters. According to the data of TINRO-Center's R/Vs, in June the large nutrient supply was found in the central region of the Western Subarctic cyclonic Gyre, and in July-August the maximum catches of mackerels and sardine were recorded here.

November 1, 15:20 (S2-13630)

Spatial-temporal variations in the distribution and abundance of loligo squids in Shandong offshore of Yellow Sea and Bohai Sea in relation to environmental factors

Bin **Wang**[1], Yongjun Tian[1, 2], Yumeng Pang[3], Caihong Fu[4], Peng Sun[1], Chi Zhang[1], Shuyang Ma[1], Rong Wan[5] and Jianchao Li[1]

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In spite of the declines in traditionally commercially-important fishery resources in China Seas under over-exploitation, cephalopods have been increasing and becoming major targets of fishing. Among cephalopods in Yellow Sea and Bohai Sea, loligo squids (*Loligo spp.,* mainly *Loligo japonica* and *Loligo beka*) are the most commercially-important species. Their landings increased gradually from several thousand tons in 1980s to its peak around thirty thousand tons in the late 2000s. Because of the short lifespan of squids, their spatial-temporal variations in the distribution and abundance associate largely with environmental factors and then affect the fluctuation in landings accordingly. In this study, we explored the spatial-temporal variations in the distribution and abundance of loligo squids based on four seasonal bottom trawl surveys during 2016-2017, and examined impacts of environmental factors using generalized additive models (GAM). Results showed that the abundance of loligo squids exhibited distinct seasonal and spatial variation patterns with the highest abundance in the fall (October) and the lowest in the spring (May). High distribution was occurred in the south of Shandong Peninsula, particularly in the Haizhou Bay which is the primary spawning ground of loligo squids in Yellow Sea. GAM analysis indicated that the distribution was affected by SST, water depth, and salinity; while the abundance increased with SST (within 5-16°C) and salinity (>31 psu) but the water depth has no significant effect. The variations in spatial-temporal distribution and abundance may relate to their spawning and overwintering migrations as well as response to seasonal environmental changes. The present research has important implications for the sustainable utilization and management of cephalopods in the over-exploited China Seas.

November 1, 15:40 (S2-13754) CANCELLED

Effects of environmental change and exploitation on marine communities around the Zhoushan archipelago: A functional traits perspective

Yongjiu **Xu**, Rijin Jiang, Qiang Hao, Wenbin Zhu, Cody Szuwalski, Shengqiang Wang, Cungen Yu

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The Zhoushan Archipelago is a traditional spawning and nursery grounds for many commercial species in Zhejiang, China. Seasonal changes in environmental conditions and fishing pressure likely influence the dynamics of the ecosystem and we performed bottom trawl surveys at 80 stations during the November of 2015 and May of 2016 to better understand these dynamics. This period of time roughly corresponds to the beginning and closure of the trawl fishing season, respectively and spans relatively large changes in environmental conditions. We identified two distinct habitats (bay and offshore) based on salinity, temperature and turbidity. Species composition within these habitats varied significantly by season in terms of their functional traits (such as abundance and body size). The average CPUEs for the *Harpadon nehereus*, Planktivore, Shrimp, and Crab decreased over the study period by an average of 68%; the average CPUEs for the *Amblychaeturichthys hexanema* and Invertivore increased by 360%. The average sizes for all the functional groups except *Harpadon nehereus* decreased by 58%. The size distribution of these groups varied significantly by season. The decreasing numbers of large size species (such as *Harpadon nehereus* and Crab) and increasing numbers of small size species (such as *Amblychaeturichthys hexanema* and Invertivore) from autumn to spring were observed. Temperature, cumulative fishing pressure and water stratification, explained 20% and 8% for temporal variation of the functional group traits (abundance and size, respectively) in the two seasons. Our results suggest that seasonal size dynamics of marine community are likely driven by the reproduction strategy related to temperature and changes in fishing pressure resulting from the summer fishing moratorium.

November 1, 16:20 (S2-13536)

A predictive modeling approach for single stocks, fish community and fisheries ecosystems

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A predictive understanding of ecological processes driving population dynamics remains a challenge in fisheries research. Increasing evidence shows that biological populations often exhibit nonlinearity wherein associations among variables depend on changing ecosystem states. However, most standard models fail to capture the complexity of ecological processes and are typically grounded in the concept of linear and equilibrium systems having constant associations. Nonlinear time series (NLTS) models using nonparametric empirical dynamic methods (EDM) exhibit considerable promise in modeling complex dynamics and deciphering causal mechanisms and have been broadly applied to ecological research. In this presentation, we will focus on an overview of recent applications of the NLTS models to fisheries ecosystem research, which includes forecasting relative abundance indices of Red snapper (*Lutjanus campechanus*) in the U.S. Gulf of Mexico, examining nonlinear dynamic features and structure of fish communities on Georges Bank, and exploring dynamic associations between zooplankton and fish linked to environmental variability and the driving processes of ecosystem dynamics on the Northeast Atlantic continental shelf.

November 1, 16:40 (S2-13512)

Future of nutrients, fish, and fisheries in the California and Kuroshio Currents: A multi-model approach

Tyler D. Eddy and Ryan R. **Rykaczewski**

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There are many different representations of how nutrients and energy flow through marine ecosystems and become available for fish and fisheries. To address how different approaches in earth system models contribute to variability in future fisheries projections, we use climate change projections from two different model intercomparison projects (MIPs); CMIP and Fish-MIP. First, we examine nutrient supply to the California and Kuroshio Current ecosystems in earth system models to understand the underlying mechanisms and assumptions leading to variability in climate change projections. Secondly, we use global fisheries and marine ecosystem projections from Fish-MIP to describe how variability in nutrient flux among ESMs propagates to projections of fisheries productivity. We then quantify the relative amount of variability in fisheries production that is attributable to choice of fish model.

November 1, 17:00 (S2-13787)

Defining isoscapes in the Northeast Pacific as an index of ocean productivity

Boris **Espinasse**[1,2], Brian Hunt[1,2,3], Sonia Batten[4] and Evgeny Pakhomov[1,2,3]

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4 CPR Survey, Marine Biological Association, Nanaimo, Canada

While high seas are the feeding grounds of many important fish species, the costs and the logistical difficulties of working far from the coast have historically limited research in this area hampering our understanding of this ecosystem. The CPR and Line-P programs have collected samples from the coast to the open ocean in the NE Pacific over the last two decades. We used these data as a basis to build a model describing the spatial distribution of the carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope signatures of large zooplankton species. Satellite data provided a set of predictors that allowed us to generate maps for $\delta^{13}C$ and $\delta^{15}N$ and to investigate the interannual variability in their distributions. Distance to the coast, sea level anomaly, and sea surface temperature were selected as significant parameters to model $\delta^{13}C$ while mixed layer depth was also important for $\delta^{15}N$. The generation of isoscapes over several years showed a large interannual variability in distribution pattern, although a coast/offshore gradient, more or less steep depending on the presence of along slope eddies, was always observable. The $\delta^{15}N$ distribution showed more variability in the Gulf of Alaska whereas low production resulted in relatively stable $\delta^{13}C$ values. Large zooplankton abundances were mapped on isoscapes to investigate if they can be used efficiently as an ocean productivity index. This type of approach will help to better understand the conditions experienced by foraging fish, such as Pacific salmon, and detail the link between large-scale climate change and high seas fisheries production.

November 1, 17:20 (S2-13456) CANCELLED

Food sources and trophic structure of fishes and benthic macroinvertebrates in a subtropical seagrass meadow revealed by stable isotope analysis

Jianguo **Du**, Zehao Chen, and Meiling Xie

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Stable carbon and nitrogen isotope analysis was used to examine the food sources and trophic structure of 25 fish and 31 benthic macroinvertebrates in a seagrass meadow in Hainan Province, China. The seagrass, their associated epiphytes, sediment organic matter (SOM) and particulate organic matter (POM) were identified to be the food sources, with $\delta^{13}C$ values ranging from −23.35 (POM) to −9.56‰ (seagrass). The $\delta^{13}C$ of the 56 fauna taxa were wide, between −22.65 and −10.57‰, indicated the variety of food sources. For bivalves, SOM and epiphytes are the main sources of organic carbon. For most gastropods and fish, epiphytes and seagrass are the main contributors. These findings show that seagrass and their epiphytes are consumed by most of the fish and benthic macroinvertebrates, and are important for a large portion of the food web in seagrass meadows in the subtropical areas.

November 1, 17:40 (S2-13565)

Modeling seasonal and inter-annual variability of trophic transfer and ^{15}N stable isotope enrichment within the planktonic food chain

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The stable isotope ^{15}N is widely used an indicator of trophic level, and has been incorporated into ecosystem models in order to understand nitrogen cycling and trophic transfer. However, such studies typically consider only the average enrichment per trophic level. We present a recently developed Trophic Level Variability (TLV) model of the dynamic fractionation of the stable isotope ^{15}N in lower-trophic ecosystems of the North Pacific. The model accounts for the dynamics of trophic transfer from nutrients (nitrate and ammonium) to phytoplankton, and to two idealized zooplankton compartments representing herbivores and carnivores, respectively. The $d^{15}N$ signal of herbivores tracks that of phytoplankton, with a nearly constant offset, i.e., enrichment by a nearly constant factor. However, the modeled $d^{15}N$ difference between carnivores and herbivores varies seasonally, and depends on the mortality rate (turnover time or effective lifespan) of the carnivores. Seasonal variations of modeled $d^{15}N$ signals differ with trophic level because carnivores integrate the signal from their ^{15}N uptake over longer timescales compared to herbivores. Thus, the model reproduces the lower observed variability of $d^{15}N$ for carnivorous zooplankton (chaetognaths) and the more variable $d^{15}N$ for largely herbivorous zooplankton (copepods). Our results imply that for interpreting observed $d^{15}N$ values, it is important to consider not only the average enrichment per trophic level, but also the dynamics of ^{15}N fractionation and the timing of observations. We will also present some simulations illustrating how this modeling framework can be used to project changes in trophic transfer under climate change scenarios.

S3: Science communication for North Pacific marine science

November 1, (S3-13823)-Plenary

Reaching our audience: How do we better communicate interdisciplinary marine science? Lessons and challenges from the U.S. North Pacific and beyond

Alan **Haynie**

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Even the best scientific research has little impact if it is not effectively communicated. In PICES, ICES, and other national and international marine science and management organizations, there is growing recognition that humans are central actors in marine systems who must be included to accurately capture any ecosystem's dynamics. Research and data about human behavior and preferences are being incorporated into marine science and management through many new vehicles and tools. Increasingly common among these tools are Integrated Ecosystem Assessments (IEAs), which attempt to describe the diversity of interactions that occur within an ecosystem, including human uses, impacts, and benefits. The development of these new tools raises a number of questions and communications challenges. How do scientists develop trust with resource users to better understand how stakeholders relate to the environment? How do scientists work across disciplines to effectively conduct interdisciplinary work? How do managers trade-off economic and biological impacts of management actions and how do they weigh benefits to different user groups? How much information do managers need or want to understand ecosystem processes? This talk attempts to address these questions and discusses the incorporation and communication of human activities in several large interdisciplinary projects and IEAs in the U.S. North Pacific and in other countries. These diverse experiences provide a roadmap for how social and natural scientists can more effectively communicate with diverse stakeholders to improve IEAs and interdisciplinary projects, with the goal of improving marine science and resource management.

November 1, 11:00 (S3-13274)

From evidence to action: Challenges and solutions for working across the science-policy interface

Abigail **McQuatters-Gollop**

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Good policy decisions about the marine environment are based on scientific evidence. Working across the science-policy interface is challenging, however, as these two different communities have separate objectives, ways of communicating, areas of expertise, and even disparate languages. Understanding and communicating ocean acidification (OA)-driven changes is particularly complex, as for example, laboratory and mesocosm results may not agree with empirical observations from ocean time-series, and OA-related changes are occurring in parallel with changes caused by direct human impacts and warming. For policy makers to make informed decisions about marine management, robust scientific information about the ecological and societal effects of OA are needed, despite these scientific challenges. This talk uses a case study from the successful science-policy project, EcApRHA (Applying an Ecosystem Approach to (sub) Regional Habitat Assessment), to present challenges and solutions to communicating OA across the science-policy interface. From project conception through to policy assessment, innovative and active engagement methods were used to gain policy feedback, help frame the science in policy terms, and gather consensus from the wider scientific research community. Open communication and trust between scientists and decision-makers was instrumental to project success, which required compromises and altered ways of working on both sides of the science-policy interface. Project results are now underpinning implementation of a pan-European piece of marine biodiversity policy. The lessons learned through this science-policy collaboration are wide ranging and applicable across multiple spatial and political scales.

November 1, 11:20 (S3-13307)

Fate of antibiotic resistance in estuaries and marine environment

Guangshui **Na**[1], Linxiao Zhang[1,2] , Hui Gao[1], Ruijing Li[1], Shuaichen Jin[1], Qianwei Li[1,3], Caixia Wang[1,3] and Wanli Zhang[1,3]

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2 College of Biological Engineering, Dalian Polytechnic University, Dalian, PR China
3 College of Marine Sciences, Shanghai Ocean University, Shanghai, PR China

As antibiotic resistance is an exacerbating global problem, the environmental behaviors and migration patterns of antibiotic resistance have attracted considerable interest. Estuaries and marine environment are key areas for understanding the fate of antibiotic resistance after release into aquatic environments. In order to investigate the distribution of antibiotic resistance in estuaries and marine environment and effect of environmental conditions, the Liaohe Estuary, Daliaohe Estuary and Laizhou Bay were selected as the representative areas of estuaries and marine environment. The results showed that: (1) Sulfonamides and quinolone antibiotics are commonly found in the estuaries and marine environment, but the concentrations of antibiotics were much lower than those in the inland environment such as rivers and urban sewage. (2) Although the concentrations of antibiotics were very low, antibiotic resistance pollution was widespread in the estuaries and coastal marine environment. The detection rates of *sul1* and *sul2* were 100%, and *sul3*, *aac(6')-Ib* and *qnrS* also have been detected. The average resistance levels of *E. coli* in the Liaohe and Daliaohe estuaries and Laizhou Bay were 35.5% and 26.0%, respectively. The distribution of antibiotic resistance in the process from river to ocean was decreasing. (3)The contribution of antibiotics on the distribution and migration of antibiotic resistance in the estuaries and marine environment was lower than those of heavy metals and physicochemical parameters (salinity, temperature, and pH).

November 1,11:40 (S3-13511)

Citizen engagement through shoreline cleanup litter data: British Columbia case study

Vanessa R. **Fladmark**, Cassandra Konecny, and Santiago J. De La Puente

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The Great Canadian Shoreline Cleanup is a citizen science program that has been collecting shoreline litter data for over a decade since the organization's conception in 1994. However, these data had never been analyzed or visualized until an ambitious group of UBC graduate students tackled the problem of organizing and analyzing the dataset. This project compiled data on volunteer effort, engagement and the different types and sources of litter found on the coast of British Columbia, Canada. Results indicated that litter type and quantity were consistent throughout time, highlighting positive impacts of physical removal of debris but also the need to create more beneficial changes in communities, local waste policies and global plastic use. Additionally, a novel, web-based Shiny app was created with these data, in an effort to further engage the public on how they can influence shorelines. Through advocating for changes in policy, participating in cleanups, changing their behaviour and limiting plastic use. The app aims to facilitate these changes, demonstrating the impacts that altering littering habits and improving management can have on shoreline litter by displaying the data in an interactive and freely accessible format. Furthermore, "on the ground" work needs to be continued and amplified, as cleanups enhance a sense of marine citizenship and responsibility in the public to protect their beaches and oceans. Informal avenues for engagement and discussion, through social media and face-to-face interactions at shoreline cleanups, are incredibly powerful ways for scientists to discuss crucial issues affecting ocean health and create public awareness.

November 1,12:00 (S3-13684)

Outreach program for encouraging sustainable use of fish stock resources by consumers around Japan: Sustainable, Healthy and "*Umai*" Nippon seafood (SH"U"N) Project

Yoshioki **Oozeki**[1], Toyomitsu Horii[1], Tatsu Kishida[2], Ryutaro Kamiyama[2], Mitsutaku Makino[2], Mai Miyamoto[3], Nami Miyamoto[2], Yuko Murata[2], Takumi Mitani[2], Aigo Takeshige[3], Yasuji Tamaki[2], Shinji Uehara[2], Hiroki Wakamatsu[2], Shingo Watari[2] and Shiroh Yonezaki[3]

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"Sustainability" is one of the key themes of SDGs. Fisheries eco-label is a tool to attract consumers' attention to the "Sustainability" of fisheries products. In the Tokyo Olympic games 2020, several fisheries eco-labels such as MSC or a Japanese program (MEL-Japan) are accepted as the official certificate. The SH"U"N project, launched by the Japan Fisheries Research and Education Agency (FRA) on 2016, deliver a comprehensive and peer-reviewed evaluation on the sustainability of the fisheries products around Japan. Based on the four science-based essential pillars for fisheries sustainability, i.e., stock status, ecosystem impact, socio-economic influences, and governance performances, a transparent evaluation procedure was designed following the criteria of the United Nation's Food and Agriculture Organization's Code of Conduct and eco-labelling guidelines. The SH"U"N Project has provided comprehensive information on the sustainability of 10 species at 12 regions and evaluation reports of 17 species are in the line of reviewing process at present. This project also serves an outreach smartphone application for making the concept of sustainability seem closer to the consumers based on the results of evaluation. We hope the scientific information provided by this project will enhance the consciousness of consumers, and be utilized by fishers or companies for the applications to the fisheries eco-labels such as MEL-Japan, MSC, etc. Communication with users (fishers' organization, local government, MSC, MEL-Japan, etc.) has started. Their opinions are the key for the better science outreach.

November 1,12:20 (S3-13786) CANCELLED

Bridging fisheries knowledge and documenting socio-ecological change in Alaska fishing communities

Sarah P. **Wise**

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This paper focuses on several methods used to integrate and co-produce socio-ecological knowledge of the changing marine environment in Alaska. Fishing communities in the North Pacific are directly affected by a rapidly changing marine environment. These communities rely heavily on living marine resources, and are experiencing threats to food security, subsistence practice, and cultural sustainability. These same communities have enduring historical, social, and ecological ties to the coastal environment and have gathered local and traditional knowledge (L&TK) on ecosystems and marine resources undergoing environmental change. Although there has been interest among resource managers to consider L&TK, in addition to conventional science, in developing management strategies, the methods of equitable inclusion continue to be debated. The paper identifies specific approaches used by Alaska Fisheries Science Center researchers to communicate complex social and ecological concepts, while engaging experts in collaborative processes of knowledge production. Knowledge exchange workshops, oral histories, and story mapping have been used by Alaska Fisheries Science Center researchers to integrate and operationalize diverse expert knowledge toward shared socio-ecological sustainability objectives. These methods are designed to bring key resource users, scientists, managers, and experts together in multiple ways to share knowledge and document changing conditions over time. Drawing from select socio-ecological research projects conducted among Alaska fishing communities, this paper identifies methods in which expert knowledge is shared and outlines lessons learned for future work.

November 1,12:40 (S3-13794)

An overview of stakeholder directed communication in the Pacific Islands

Siri **Hakala**[1], Jamison Gove[1], and Rebecca Ingram[1,2]

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The US Pacific Islands Region is comprised of over 40 islands and atolls spanning 45° of latitude and 60° of longitude, encompassing areas from the Commonwealth of the Northern Marianas Islands, to American Samoa, to the Hawaiian Islands. These island-communities are strongly impacted by changes in climate and to their ecosystems. NOAA's Pacific Islands Fisheries Science Center (PIFSC) engages in a variety of ecosystem assessments in which stakeholder engagement is an important component, including efforts to communicate the science that informs marine resource management decisions. This talk will highlight an Integrated Ecosystem Assessment (IEA) that incorporates input from resource managers, scientists, and community members to inform the structure of the assessment (e.g., what is assessed) and provides mechanisms for feedback of the assessment results once completed. The successes and challenges of this project will be examined, as well as how it fits into the overall efforts of a U.S. federal science center to listen, engage, and educate our stakeholders.

S4: Indicators for assessing and monitoring biodiversity of biogenic habitats

October 30, 11:00 (S4-13832) Invited

Identifying mechanistic indicators of coral reef resilience

Yves-Marie **Bozec**

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Coastal biogenic habitats are vulnerable to disturbances that affect the ecology and dynamics of foundation (habitat forming) species. Efficient ecosystem management requires the continued assessments of the abundance, diversity and function of foundation species, but also a good understanding of their dynamics and responses to environmental forcing and ecological controls, including the feedbacks that may emerge from the provision of functional habitats. While many ecological indicators inform on the current state of biogenic habitats (e.g., benthic cover, habitat structural complexity) and associated fauna (e.g., fish density and biomass), these alone are often insufficient to evaluate the ability of the ecosystem to persist. Indicators of population dynamics (e.g., recruitment and growth) and ecological interactions affecting the demographics of foundation species (e.g., competition, consumption) are more informative about the functioning of biogenic habitats and their potential response to disturbances. This talk will summarize recent research aiming at developing mechanistic indicators of the dynamics of coral reef habitats under multiple disturbances (e.g., overfishing, global warming). Combining field-based indicators of coral reef state and functioning allows explaining recent habitat dynamics with ecological processes. Integrating these indicators into mechanistic modeling provides a framework that helps predicting the resilience of coral reef habitats to different scenarios of disturbance, i.e. their capacity to recover or shift into an alternative state. This framework offers the strongest support to reef monitoring and management.

October 30, 11:30 (S4-13749)

Assessment of species diversity and dominance of shallow water corals using environmental DNA

Go **Suzuki**[1], Hiroshi Yamashita[1], Yuna Zayasu[2], and Chuya Shinzato[3]

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For easier assessment of the species diversity of reef building corals, we developed a novel method for monitoring of *Acropora* corals from environmental DNA (eDNA) in seawater using next generation sequencing technology (NGS). We performed a tank experiment with running seawater using 19 *Acropora* species. Complete mitochondrial genomes of all the *Acropora* species were assembled to create a database and major types of their *Symbiodinium* symbionts were identified. Then eDNA was isolated by filtering inlet and outlet seawater from the tanks. We detected all of the tested *Acropora* types from eDNA samples. Proportions and numbers of DNA sequences were both positively correlated with masses of corals in the tanks. In this trial, we detected DNA sequences from as little as 0.04 kg of *Acropora* colony, suggesting that existence of at least one adult *Acropora* colony (30 cm diameter = 1 kg) per m^2 at depths <10m could be detected using eDNA in the field. Although this is the initial attempt to detect coral and *Symbiodinium* simultaneously from eDNA in seawater, this method may allow us to perform high-frequency, high-density coral reef monitoring of coral species composition and their health conditions without specialized skills to identify coral species using morphological traits.

October 30, 11:50 (S4-13697)

Application of association analysis for identifying VME indicator taxa based on sea-floor visual images

Mai **Miyamoto**[1] and Masashi Kiyota[2]

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Some species of cold-water corals are known to form complex reef-like structure and provide habitats to other animals on the deep sea-floor in several areas of the world ocean. Due to their slow growth, long life span and slow recovery from physical damage, as well as the habitat forming property, cold-water corals are considered as important components of the vulnerable marine ecosystems (VMEs). We analyzed the visual images of the sea-floor observation surveys using the drop camera system collected by R/V Kaiyo-maru in the past eight years to identify effective indicators of benthic community diversity in the Emperor Seamounts area. The benthic animals taken in each sea-floor footage were identified to family or order levels, and their occurrence frequencies were calculated. Using the density of benthic taxa in sampling locations as multivariate distance data, we classified the sea-floor photographing sites or benthic taxa into clusters according to Ward's method to characterize the benthic community in the study area. Then association analysis, which is commonly used for discovering hidden relationships among purchased items in market transaction data, was applied to the occurrence data per sea-floor photographing site to explore the co-occurring relationships of benthic animals as association rules that represent strong relationship like A (condition part) →B (conclusion part) are extracted.

October 30, 12:10 (S4-13705)

Marine biogenic habitats: Assessing benthic cover and species-habitat associations

Tse-Lynn Loh, Stephanie K. Archer, and Anya **Dunham**

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Biogenic habitats play a number of important ecosystem roles, including the provision of physical structure, modification of wave and current patterns, contribution to biogeochemical cycling, and the facilitation of primary, secondary, and tertiary production. Many biogenic habitats also host a range of commercially important species at higher densities than surrounding habitats. However, the functional linkages between these commercially important species and habitat presence, extent, and quality are not well understood, particularly in deep sea ecosystems. Determining these linkages is necessary for understanding the role of biogenic habitats in sustainable fisheries production and for selecting ecologically relevant indicators for conservation and monitoring. In this paper, we (1) review methods used for quantifying structure-forming organism cover in biogenic habitats in general, (2) review and classify the types of documented functional associations between commercially important species and biogenic habitats, with a focus on the North Pacific, (3) present a protocol to quantitatively assess a newly discovered biogenic habitat type (glass sponge reefs), and (4) discuss implications for indicator development, while identifying knowledge gaps and future research needs for marine benthic assessments.

October 30, 12:30 (S4-13513) CANCELLED

Patterns in fish associations with corals and sponges and diversity in two divergent ecosystems in Alaska

Christopher N. **Rooper**, Pam Goddard, and Rachel Wilborn

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The role of deep-sea coral and sponge communities as habitat for marine fishes has been widely deliberated. Almost all studies that have looked for associations between corals and sponges and fishes (especially rockfishes) have found significant relationships. However, rockfishes also thrive in areas largely devoid of corals and sponges. The objective of this study was to compare the association of fish species with deep-sea coral and sponges and other available benthic structure across different spatial scales in the eastern Bering Sea (EBS) and Aleutian Islands (AI). The two ecosystems were found to have much different abundances of corals and sponges (with the AI densities roughly 3 orders of magnitude higher than the EBS). At broad scales, the results showed that rockfish species and Pacific cod were significantly correlated to structured seafloors. At smaller scales (the scale of individual fish) only Pacific cod, northern rockfish and Pacific Ocean perch had significant associations with structure. We used stereo imagery to measure the distance between fish and structure, and found that the strength of associations (measured by distance to and overall affinity to structure) was weak for fish >40 cm. The size of the structure did not appear to matter to fish. We also found that rockfish preferred sponge to other structure, when all were available. These relationships were consistent across ecosystems, indicating that even though rockfish densities and coral and sponge abundance were very different between the EBS and AI, the ecological processes guiding habitat use by rockfish was consistent.

October 30, 14:00 (S4-13454)

Modelling the environmental niche space and distributions of cold-water corals and sponges in the northeast Pacific Ocean

Jackson W.F. **Chu**[1], Jessica Nephin[1], Samuel Georgian[2], Anders Knudby[3], Chris Rooper[4] and Katie S.P. Gale[1]

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Cold water corals and sponges (CWCS) have important roles in deep-sea habitat formation, local biodiversity enhancement, and nutrient cycling. Because of their biological traits, CWCS are indicators of vulnerable marine ecosystems (VMEs) and used to identify targets for marine conservation and fisheries management. Although the Northeast Pacific region of Canada (NEPC) is notable for having several unique CWCS communities, the extent of potential CWCS-defined VMEs in this region are unknown. We analyzed a compilation of n=7,842 occurrence records for six groups of habitat forming CWCS (demosponges, glass sponges, black corals, soft corals, stony corals, sea pens) with a suite of 1 km^2 gridded environmental layers (n=31) to examine niche space differences, develop individual species distribution models, and generate spatial predictions of CWCS habitat suitability in the NEPC. While all CWCS groups differed in niche space and breadth, black corals fall out as having a wide niche breadth over a relatively rare habitat type in this region. Among influential environmental variables, silicic acid was the top predictor for sponges, while low dissolved oxygen levels were important for all CWCS groups. When we compared our predicted maps of CWCS HS with sites delineated using ecologically and biologically significant area (EBSA) criteria, there was a substantial spatial overlap among areas of high CWCS HS with the EBSA polygons. Our results highlight broad scale factors that influence the distributions of CWCS in the NEPC and are the pre-requisite in identifying additional marine conservation targets using VME criteria.

October 30, 14:20 (S4-13474) CANCELLED

Building the indicator system to assess the ecosystem health of Laizhou Bay based on Analytic Hierarchy Process (AHP)

Fangyuan **Qu**

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Laizhou Bay, knowing as a famous feeding and spawning ground for marine economic animals of China, has been suffering from the pollution stress since 1970s with the rapid development of fishing industry, agriculture, oil and gas industry, mariculture and transportation. Trace metal pollution has been recognized as the major pollutants in the Laizhou Bay, along with other pollutants. This reduced environment has led to the alteration of Laizhou Bay ecosystem. Shift in dominant fish species and the reduction in fish size has been recorded from 1959 to 2008. The dominant fish species of high economic value and large-size have been replaced by the short-lived, low-trophic-level planktivorous pelagic species since the 1980s. Thus, it is urgent to develop a method to assess the ecosystem health of Laizhou Bay. The indicator system we established had three levels, 16 different indicators. These indicators can comprehensively reflect the various aspects of Laizhou Bay ecosystem health, such as: physic-chemical environment, community structure and ecosystem status. The weight of each indicator was determined by Analytic Hierarchy Process. We applied this system to assess the ecosystem health of Laizhou Bay by utilizing environmental and biological data of a Aug. 2013 cruise. The Comprehensive ecosystem health index of Laizhou Bay in Aug. 2013 was 0.51 which indicated a moderate ecosystem health status. This result was in accordance with the current status of Laizhou Bay. This indicator system has implications for Laizhou Bay ecosystem rehabilitation and conservation.

October 30, 14:40 (S4-13380) CANCELLED

Ecosystem health assessment: Indicators and models

Weiwei **Yu**, Bin Chen, Wenjia Hu and Xiaofen Zhu

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Ecosystem health assessment is essential for ecosystem management. In this study, a quantitative approach was developed and applied to assess ecosystem health of Daya Bay, China. (1) A set of indicators were proposed based on PSR framework. Pressure indicators included physical and chemical pressures. A framework of state indicators was developed based on key ecosystem services derived from coastal bay ecosystem, including supporting, providing, regulating, and cultural services. Response indicators encompassed protected area construction, sewage treatment, and employment rate. (2) The conceptual model and equation was proposed including two parts: present status assessment and future status prediction. For the former, a comprehensive index of present status was calculated based on state indicators, with value ranging from 0 to 100 where a higher score implied a healthier ecosystem. For the latter, pressure and response were incorporated to characterize the nearly-future potential impact, which then was combined with the present status to predict the future status. (3) The results of case study in Daya Bay demonstrated that present status score was 79.38, while only tiny increase of about 1.54 occured for future status in nearly 5 years. This study provides a means for calculating and mapping ecosystem health, which is essential tool for ecosystem assessment, may be applied widely for marine ecosystem-based assessment.

October 30, 15:00 (S4-13312)

Comparison of nematode assemblages associated with *Sargassum muticum* in its native range in South Korea and as an invasive species in the English Channel

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Canopy-forming algae are important habitat providers in coastal ecosystems. Several canopy-forming species are invasive and have spread outside their native geographic range. The role that these invasive algae play in providing habitat for meiofaunal species was investigated. *Sargassum muticum* is a native species in East Asia and has been a successful invasive species of North America and European coasts. The nematode assemblages living in intertidal *S. muticum* on the English Channel coast in Europe, where it is an invasive species, were compared to those in within its native range on the southern coasts of Korea. Nematode assemblages were sampled using a nested survey design (replicates nested within patches within shores within regions within coastlines in each country). Significant differences between countries were found in nematode assemblages in terms of both taxonomic and functional diversity. The abundance of nematodes and species diversity were higher in Korea than in the British Isles. Despite differences in assemblage structures between countries, some cosmopolitan nematode species were present in both countries. These nematode species might possibly have come from Asia to Europe with *S. muticum*.

S5: Seasonal to interannual variations of meso-/submeso-scale processes in the North Pacific

October 30, (S5-13446)-Plenary

Potential impact of ocean circulation on Japanese eel larvae migration

Yu-Lin Eda **Chang**[1], Yasumasa Miyazawa[1], Michael J. Miller[2] and Katsumi Tsukamoto[2]

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Recruitment of Japanese eels, *Anguilla japonica*, has declined in recent decades possibly due to both anthropogenic and ocean-atmosphere factors. The potential impact of ocean circulation on the decreasing Japanese eel catches, as well as the eel larvae migration in the western North Pacific was examined based on a three-dimensional (3D) particle-tracking method, in which virtual larvae (v-larvae) were programmed to swim horizontally and vertically, in addition to being transported by ocean. The dispersion of v-larvae towards East Asia decreased in the last two decades. In recent years, instead of entering the Kuroshio and moving towards East Asia as in the 1990s', more v-larvae tended to enter the southern areas due to the weakening of the NEC and strengthening of subsurface southward flow near the spawning area. This suggests that decadal changes in ocean circulation have occurred that affect the larval migration success of the Japanese eel to their recruitment areas. In addition, the physical and biological roles of mesoscale eddies in v-larvae migration are investigated using the idealized bio-physical coupled model and the 3D particle tracking method. V-larvae can be kept in eddies passively due to the nonlinearity of mesoscale eddies and/or stay in eddies actively due to the rich food supply. Physical trapping dominates the retention of slow-swimming v-larvae, whereas biological food-attraction takes over in fast swimming cases. Fish larvae that are retained for a longer period in cold eddies (shorter in warm eddies) are able to get more food and potentially grow faster, thus enhancing their survival.

October 30, 11:00 (S5-13388) Invited

Seasonality in transition scale from balanced to unbalanced motions in the World Ocean

Bo **Qiu**[1], Shuiming Chen[1], Patrice Klein[2], Jinbo Wang[2], Hector Torres[2], Lee-Lueng Fu[2], and Dimitris Menemenlis[2]

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The transition scale Lt from balanced geostrophic motions to unbalanced wave motions, including near-inertial flows, internal tides and inertia-gravity waves, is explored using the output from the global 1/48° horizontal resolution MITgcm simulation. Defined at the wavelength with equal balanced and unbalanced motion kinetic energy (KE) spectral density, Lt is detected to be geographically highly inhomogeneous: it falls below 40km in the western boundary current and Antarctic Circumpolar Current regions, increases to 40-100km in the interior subtropical and subpolar gyres, and exceeds, in general, 200km in the tropical oceans. With the exception of the Pacific and Indian Ocean sectors of the Southern Ocean, the seasonal balanced and unbalanced motion KE levels fluctuate out-of-phase due to occurrence of mixed layer instability in winter and trapping of unbalanced motion KE in shallow mixed layer in summer. The combined effect of these seasonal changes renders Lt to be < 20km during winter in 80% of the Northern Hemisphere oceans between 25°-45°N and all of the Southern-Hemisphere oceans south of 25°S. The transition scale's geographical and seasonal changes are highly relevant to the forthcoming Surface Water and Ocean Topography (SWOT) mission. To improve the detection of balanced submesoscale signals, especially in the tropical oceans, from SWOT, effort to remove stationary internal tidal signals is called for.

October 30, 11:30 (S5-13573)

Formation and interannual variations of baroclinic quasi-stationary jets in the transitional domain between the subtropical and subarctic gyres in the western North Pacific

Humio **Mitsudera**[1], Toru Miyama[2], Hajime Nishigaki[3], Takuya Nakanowatari[4], Hatsumi Nishikawa[1], Tomohiro Nakamura[1], Taku Wagawa[5], Ryo Furue[2], Yosuke Fujii[6], and Shin-Ichi Ito[7]

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7 University of Tokyo, Kashiwa, Japan.

Sea surface temperature (SST) and sea surface salinity (SSS) exhibit complex mesoscale structures in the transitional domain between the subtropical and subarctic gyres in the western North Pacific. Markedly sharp SST and SSS fronts form between the cold and fresh water of Oyashio's extension and the recently-found quasi-stationary jets that advect warm and saline waters originating in the Kuroshio northeastward. Here we present a mechanism of the jet formation paying attention to the propagation of baroclinic Rossby waves that is deflected by eddy-driven barotropic flows over bottom rises, although their height is low (~ 500 m) compared with the depth of the North Pacific Ocean (~ 6000 m). Steered by the barotropic flows, Rossby waves bring a thicker upper layer from the subtropical gyre and a thinner upper layer from the subarctic gyre, thereby creating a thickness jump, hence a baroclinic jet, where they converge. We also present interannual variability of the quasi-stationary jets and associated mesoscale SST and SSS variations. This study reveals an overlooked role of low-rise bottom topography in regulating SST and SSS anomalies of interannual time scales in subpolar oceans.

October 30, 11:50 (S5-13581)

Regional turbulent characteristics of the satellite-sensed submesoscale surface chlorophyll concentrations

Eun Ae Lee and Sung Yong **Kim**

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The regional variability and turbulent characteristics of submesoscale surface chlorophyll concentrations are examined with hourly maps of geostationary ocean color imagery-derived chlorophyll concentrations at a 0.5-km resolution for a period of five years (2011 to 2015) over the East/Japan Sea with concurrent mesoscale and submesoscale observations. Two seasonal blooms occur in the spring and fall within 250 km off the coast that are associated with constructive combinations of light exposure, nutrients, and vertical stratification. Another bloom occurs in the summer and is closely related to regional wind-driven upwelling events. The spring and fall blooms are more significant near the coast (within 40 km from the coast) than offshore because of the more energetic submesoscale horizontal shear and vortical phenomena onshore as well as their propagation in the cross-shore direction. In addition, the regional spring bloom starts offshore and migrate onshore with a time delay of one month, which may result from the onshore propagation of geostrophic currents, the deepening of the mixed layer, and favorable nutrient fluxes from the subsurface. The wavenumber-domain energy spectra of chlorophyll concentrations exhibit anisotropy, which may be closely related to bathymetric effects and regional circulations. The spectral decay slopes change from k^{-5/3}$ to k^{-1} at the {\it O}(10) km scales and from k^{-1} to $k^{\leq -3}$ at the {\it O}(1) km scales and have weak seasonality. These results are consistent with the two-dimensional quasi-geostrophic turbulence theory and can be interpreted with the baroclinic instability energized from the moderate seasonal mixed layer under mesoscale regional circulations.

October 30, 12:10 (S5-13685)

Mesoscale and large-scale dynamic features and the spatial distribution of sardine and mackerels east of the Kuril Islands in early and late summer

Elena **Ustinova**, Mikhail Kuznetsov, Eugeny Basyuk, and Eugeny Syrovatkin

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Effects of mesoscale and large-scale oceanographic conditions on spatial distribution of sardine (*Sardinops melanostictus*), and mackerels (*Scomber japonicus* and *Scomber australasicus*) were analyzed using the data sets from the CTD and acoustic-trawl surveys conducted by TINRO-Center R/Vs in early and late summer in the Northwest Pacific east of the Kuril Islands. The sardine and mackerels spatial distributions during their feeding migration are substantially affected by mesoscale fronts and seasonal thermocline topography. In June, mackerel and sardines high concentrations were confined to the high-gradient zone of the Northern Subarctic Front, mostly from the warmer water side and the 8°C isotherm was their northern habitat limit. In July, the large majority of both species migrated for feeding to the subarctic area. High mackerel concentration was found in an anticyclonic eddy off the Bussol Strait. However, the concentration was decreased at the northern, eastern, and southern sides of the eddy due to the intrusion of the Kuril Current Second Branch. In late summer mackerel avoided transformed subtropical waters. The aggregations followed topography of the thermocline upper boundary. In the daytime, mackerel formed mobile small and dense schools (3-6 m in height and 12-30 m of length). Sardine schools had dimensions of 8-15 m in height and 60-120 m of the horizontal extent. At night, the mackerels were scattered as continuous belts or interrupted clusters of variable density and their highest concentration was deeper than in the daytime. Conversely, sardine still moved in schools at nights but they were looser than in the daytime.

October 30, 12:30 (S5-13281)

Preliminarily study of MLD and SCML in the SCS using 3-D physical-biogeochemical model

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In the South China Sea (SCS), under the combination influence of continental shelf, Asia monsoon, upwelling, meso-eddies, typhoons and plenty of fisheries, there exists a strong horizontal and vertical variability of plankton activities from seasonal to decadal time scales. On the basis of a regional ocean modeling system (ROMS), a three dimensional physical-biogeochemical model with a resolution of 1/12˚×1/12˚ is established to investigate the physical variations and ecosystem response in the SCS. The ROMS-Nutrient Phytoplankton Zooplankton Detritus (NPZD) model is derived by the daily air-sea fluxes (wind stress, long wave radiation, short wave radiation, sensible heat and latent heat, freshwater fluxes) derived from the National Centers for Environmental Prediction (NCEP) reanalysis2 from 2001 to 2012. The results show that the correlation coefficients are 0.98 and 0.51 compared with the MGDSST and ESA-oceancolor chlorophylly-*a* data, which means the coupled model has a capability to reproduce the observed seasonal variation features over the same period in the SCS. The surface chlorophyll-*a* over the entire SCS reveals a strong seasonal cycle, double-peak characteristic, with the highest concentration at winter and a following value at late summer. The variability of MLD was analyzed by the Empirical Orthogonal Function (EOF). The first mod shows that the variability is same in the whole area of SCS basically with a 42.8% proportion. The second mode shows that the variability is dipole-type, and has a positive correlation with a rate of 0.58 when MEI leads 2 month. The third mode performs a positive-negative-positive distribution from south to north, and has a negative correlation with PDO index with a rate of -0.6. The MLD and SCML perform an opposite seasonal variation with a same double-peak feature, and the correlation coefficient is -0.68 between each other. The 12 a mean value of SCML is about 48.04m, and MLD is 24.69m. The 12 a subsurface chlorophyll-*a* maximum value is about 0.39mg m-3, and has a positive relation with the wind. The Correlation coefficient between subsurface chlorophyll-*a* maximum value and wind is 0.70.
Key words: Physical-biogeochemical model, MLD, SCML, EOF

October 30, 14:00 (S5-13294)

Mesoscale dynamics and walleye pollock catches in the Navarin Canyon area of the Bering Sea

Andrey G. **Andreev**, Maxim V. Budyansky, Michael Yu. Uleysky and Sergey V. Prants

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The mesoscale dynamics in the Navarin Canyon area of the Bering Sea are studied with the help of the AVISO satellite altimetry, drifters, Argo buoys and shipborne data. We demonstrate that the strength of anticyclonic eddies along the shelf slope in spring and summer is determined by the wind stress in March – April. The increased southward wind stress in the central Bering Sea forced a supply of low temperature and low salinity outer shelf water to the deep basin and formation of the anticyclonic mesoscale circulation seaward of the Navarin Canyon. Enhanced northwestward advection of the Bering Slope Current water leads to increase in an ice-free area in March and April and increased bottom layer temperature at the outer shelf. The strong (weak) northwestward advection of the eastern Bering Sea waters, determined by eastern winds in spring, creates favorable (unfavorable) conditions for the pollock abundance in the western Navarin Canyon area in summer.

October 30, 14:20 (S5-13376)

Short-lived anomalies of hydrophysical characteristics at the continental slope off the Russian coast in the northwestern Japan/East Sea from spring through early fall

Olga **Trusenkova**[1], Alexander Ostrovskii[2], Alexander Lazaryuk[1], Vyacheslav Dubina[1], Svetlana Ladychenko[1], and Vyacheslav Lobanov[1]

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The continental slope off the Russian coast in the northwestern Japan/East Sea is an extremely dynamically active zone, with the Primorye (Liman) Current flowing southwestward, slope eddies developing inshore of it, propagating Kelvin/coastal/shelf waves, mesoscale eddies supplying warm water from the southwest, south, and east. To study this variability the moored Aqualog profiler was deployed at the location (42.5° N, 133.8° E, 440 m of depth) from April 18 through October 15, 2015. The previous analysis of the Aqualog data revealed vertical isopycnal displacement with periods of 2–3.5, 8–13, and 18–22 days. Here, we consider variability of hydrophysical characteristics along the isopycnals in spring, summer, and early fall. To link this variability to dynamic structures, NOAA/AVHRR and Suomi-NPP/VIIRS infrared satellite imagery is used. Throughout the record, short-lived positive temperature anomalies occurred along the shallowing isopycnals, which can be related to warm water intrusions at the edges of anticyclonic eddies. Kinetic energy fluctuations were coherent in the profiled layer, with alternating shorter energetic events and longer stagnant intervals. Cold water was detected in the upper pycnocline on April 21–27, which can be explained by the offshore excursion of the Primorye Current water, accompanied by the isopycnal deepening and kinetic energy decrease. In June strong easterly winds caused by the Okhotsk High resulted in energetic bursts, including strong inertial oscillations. Conversely, stagnation occurred from mid through late September, followed by the energy increase and strong inertial oscillations in early October due to cooling after the cyclone passage.

October 30, 14:40 (S5-13558)

Spatio-temporal variation of anticyclonic eddies in the western subarctic North Pacific

Hiromu Ishiyama, Isao Fujita and Hiromichi **Ueno**

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Spatio-temporal variation of anticyclonic eddies in the western subarctic North Pacific was investigated though analysis of eddy trajectory data. Eddies with lifetimes of 4 weeks or longer formed throughout the western subarctic North Pacific and the formation frequency was relatively uniform. On the other hand, their mean lifetimes varied widely from place to place: it was especially long in the area south of the Aleutian Islands between 170°E and 175°E, where Aleutian eddies formed. In this area, short-lived (< 100 days) eddies dominated in formation number, but long-lived (> 100 days) eddies dominated in the accumulated eddy-existing days. The formation number of the Aleutian eddy varied interannually, e.g. no eddy formed in 2007 and 5 eddies formed in 1997. The number of living Aleutian eddy also varied interannually, but the variation did not correspond to that of formation, e.g. the number of living Aleutian eddy in 2007 was 3 times as large as that in 1997 because long-lived eddies formed in 2005 and 2006 and were alive in 2007. These results suggest that long-lived eddies play an important role in the Aleutian eddy area.

October 30, 15:00 (S5-13433)

An extremely long lived Ulleung Warm Eddy from 2014 to 2017 (UWE 2014-II) in the southwestern East Sea (Japan Sea)

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It is known that mesoscale eddies and their evolutional processes have a significant role in transporting and redistributing heat, energy, and materials in the marginal seas as well as global ocean. However, our understanding on basic characteristics and evolutional processes of the mesoscale eddies in the East Sea (Japan Sea) is far from complete. Thus, we analyzed both ship-based in-situ hydrographic data and 1/4° gridded satellite altimeter data along with an application of hybrid eddy detection method. The results demonstrate, for the first time, the evolutional processes of an extremely long lived anticyclonic (warm) eddy in the southwestern part of the East Sea. The anticyclonic eddy is named Ulleung Warm Eddy 2014-II (UWE 2014-II) as formed in fall 2014 and disappeared in August 2017. Life-time mean values of amplitude, intensity, and radius of the UWE 2014-II are 9 cm, 0.0073 $m^2/s^2 \cdot km^2$, and 59 km, respectively, which are nearly doubled of those of other typical mesoscale eddies found within the East Sea. Main axis direction of the eddy rotates clockwise with time and the rotation period becomes shorter from 8 to 6 months. Our results suggest that the anticyclonic eddy in the southwestern East Sea (known as UWE) can have extremely long lifetime of up to three years as re-intensified by nearby eddies and inflow into the East Sea.

October 30, 15:20 (S5-13527)

Surface drifter observations in the Korea Strait in spring

Jun **Choi**, Wonkook Kim, Kyu Min Song, Joon Seong Park, and Young Gyu Park

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We report the dynamics of Lagrangian surface drifters deployed in spring in the Korea Strait, lied between the East China Sea and the southbound of Korea when a strong semidiurnal tidal forcing with a moderate stratification is present. Total 35 surface drifters were released in late April 2018 adjacent to the Jeju island, and nearly 21 drifters were tracked about a month until they reached the eastern exit of the strait. During the period, 25% of drifters were landed on shore, and the overall dispersion coefficient reached 100 m^2/ in 10 days with a corresponding length scale of 22 km. The slopes of relative dispersion and FSLE are observed to follow 1.5 and 0.5 scalings, respectively, which are possibly induced by semidiurnal tidal current strongly biased in zonal direction. The Lagrangian statistics are also compared with the Eulerian ones derived from HF radar and chlorophyll-a concentration. Ultimately, we aim to compare this data set, strongly influenced by tidal forcing, to the ones expected to embrace the interaction of tides and submesoscale processes under an unstratified condition, and the seasonal comparison will be made by conducting additional drifter experiment planning in 2018 November at the same location.

October 30, 15:40 (S5-13303)

Effects of seasonal variation in oceanography on invertebrate larval assemblages in the northern Monterey Bay, California upwelling system

Erin V. **Satterthwaite**[1], Steven G. Morgan[1], John P. Ryan[2], Julio B.J. Harvey[2] and Robert C. Vrijenhoek[2]

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Marine larval dispersal is crucial to the evolution and ecology of marine animals. Understanding the factors that affect marine larvae and the spatial and temporal scales over which they operate is integral to effectively manage marine populations, especially as related to ecosystem-based management and marine spatial planning. Yet, a barrier to this understanding is the extreme variability in the supply of marine larvae over time. Upwelling is one of the most important seasonal oceanographic processes that acts on coastal marine systems, dramatically affecting larval dispersal and the ecology of marine organism. We surveyed horizontal and vertical distributions of benthic invertebrate larvae and physical factors along a cross-shelf transect in northern Monterey Bay, California, during the summer and fall of 2013 to examine how the seasonal transition from more frequent upwelling to an increased influence of the California Current affects the resulting larval assemblage in Monterey Bay, CA. Seasonal differences in water masses were related to different invertebrate meroplankton assemblages. These seasonal transitions within upwelling regions and the associated water masses are characterized by different meroplankton assemblages that are related to the life history characteristics of the meroplankton community.

October 30, 16:20 (S5-13514)

The diurnal cycling of submesoscale circulations: A Lagrangian and Eulerian perspective

Annalisa **Bracco**[1], Daoxun Sun[1], and Jun Choi[2]

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This talk will investigate the imprinting of diurnal variations in submesoscale circulations on the statistics of surface Lagrangian tracers through numerical simulations with different set-ups, forcing and resolution. The submesoscale diurnal cycling follows changes in short-wave radiation and thus vertical mixing, and affects dynamical quantities such as lateral divergence, relative vorticity and strain in the Eulerian fields. Horizontal divergence increases whenever vertical mixing decreases, while the cycling of relative vorticity is inversely proportional to that of the mixed-layer depth, with a delay of about two hours with respect to changes in horizontal divergence. The cycling is amplified in the Lagrangian statistics. The impacts of seasonal and interannual variability is investigated with an analysis spanning conditions representative of 2015 and 2016 in the northern Gulf of Mexico, but conditions are generic for coastal areas impacted by riverine freshwater fluxes.

October 30, 16:40 (S5-13528)

Fine-scale structure and mixing across the front between the Tsugaru Warm and Oyashio Currents in summer along the Sanriku Coast, east of Japan

Sachihiko **Itoh**[1], Hitoshi Kaneko[2], Miho Ishizu[3], Daigo Yanagimoto[1], Takeshi Okunishi[2], Hajime Nishigaki[4] and Kiyoshi Tanaka[1]

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High-resolution shipboard observations were made across the front between the Tsugaru Warm Current (TWC) and the Oyashio in July 2013. Fine structure in the frontal zones were successfully captured with an Underway Conductivity–Temperature–Depth (UCTD) profiler deployed with a typical horizontal interval of 2–3 nautical miles. The front characterized by marked horizontal gradients in temperature and salinity extended from the subsurface onto the shelf. Along this frontal layer, the minimum frequency for internal waves became substantially lower than the local inertial frequency, mainly due to the strong vertical shear of the geostrophic velocity. Turbulent energy dissipation rates ε (vertical diffusivity K_ρ) were frequently elevated along the front and its offshore side up to 3×10^{-8} W kg^{-1} (10^{-4} m^2 s^{-1}), which may have been caused by an "internal tide chimney", trapping low-frequency internal waves within the band of strong shear. At the onshore side of the TWC on the shelf, strong mixing with ε (K_ρ) exceeding 10^{-6} W kg^{-1} (10^{-3} m^2 s^{-1}) was also observed. A large portion of the water columns in the frontal area provided suitable conditions for double diffusion; in some layers with moderate turbulence, temperature microstructures indicative of double diffusion were observed. The vigorous mixing processes around the front are likely to modify the properties of the TWC downstream, which could then produce a latitudinal gradient in environments along the coast.

October 30, 17:00 (S5-13615)

Aquarius reveals eddy stirring after a heavy precipitation event in the subtropical North Pacific

Hiroto **Abe**[1,2,3], Naoto Ebuchi[2], Hiromichi Ueno[1], Hiromu Ishiyama[2], and Yoshimasa Matsumura[2,4]

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4 The University of Tokyo, Kashiwa, Japan

This research presents a case study that examines an upper-ocean salinity response to intense rainfall using four years of observed salinity data from the Aquarius and Argo floats. The Aquarius sea surface salinity (SSS) in the subtropical region of the North Pacific reveals a notable event in which SSS is locally freshened by intense rainfall. Although the SSS pattern shortly after the rainfall reflects the atmospheric pattern, its final form reflects ocean's dynamic structure; low-salinity water distributes in the shape of an anticyclonic eddy. Observations using Argo profiling floats confirm that low-salinity water dominates the entire water column of the eddy above 70 m. We found that an eddy stirring effect would play an important role in forming the eddy-shaped low-salinity water. As a precondition, intense rainfall on the tropical side enhances meridional gradient of background SSS with freshened low-salinity water to the south and saline water to the north. The anticyclonic eddy located at the enhanced SSS front stirs the water in a clockwise direction. Specifically, northward flow in the western side of the eddy transports fresh water, whereas southward flow in the eastern side transports saline water. As this northward–southward flow moves the eddy to the west where the transported fresh water is dominant as a baroclinic Rossby wave, this dynamic process would form the eddy-shaped low-salinity water. This clear view of such eddy stirring is due to the inherent nature of the subtropical region that is characterized by less frequent precipitation.

October 30, 17:20 (S5-13610)

Impacts of eddy variability on phytoplankton dynamics in the Kuroshio Extension region

Eko **Siswanto** and Yoshikazu Sasai

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A 13-year (2000 ~ 2012) remote sensing dataset was used to comprehend how the eddies influence phytoplankton dynamics in the Kuroshio Extension region. Based on sea surface height anomaly (SSHa) along the 32.5°N, cyclonic eddies (negative SSHa) were dominant mainly from 2005 to 2009, whereas anti-cyclonic eddies (positive SSHa) were dominant mainly from 2002 to 2004. Eddies propagated westward and took place approximately 1~1.5 years from 160°E to 140°E. Occurrences of negative SSHa and positive phytoplankton chlorophyll anomaly (CHLa) were observed, indicating cyclonic eddies likely upwelled nutrients to promote surface phytoplankton growth, though it was not always the case, as other factors like vertical mixing and stratification also control nutrient availability. Pooling CHLa from negative SSHa periods separately from positive SSHa periods, a meandering high CHLa between 32.5°N and 36.0°N band was obvious and clearly associated with cyclonic eddies. We expect not only was phytoplankton CHLa affected by the eddies, but phytoplankton phenology (e.g., spring bloom timing), a variable largely controls fish recruitment, would also be affected. For the future works, we will, therefore, investigate the followings; how the eddies would alter the spring bloom timing; when the eddies would play a role in determining CHLa more than other physical factors (through season-based analysis); and how the eddy activity-related phytoplankton dynamics might link to decadal climate variability.

October 30, 17:40 (S5-13378)

Seasonal and interannual variations in the spread of the Razdolnaya and Tumannaya Rivers runoffs (Peter the Great Bay, Japan/East Sea) according to the satellite data on SST and ocean color

Elena A. **Shtraikhert** and Sergey P. Zakharkov

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Satellite data on the SST (Sea Surface Temperature) and ocean color allow observe the structures caused by the circulations of the rivers runoffs. These circulations are influenced by variation in the density water. It is due to variations of the wind speed and direction, the continental runoff at the atmospheric precipitation, and in the spring – the ice and snow melting. It influences on the sedimentation and, consequently, the water hypoxia formation. These processes appear in the distribution of phytoplankton cells, organic and suspended matter in the surface layer of water. The aim of this work is to characterize the seasonal and interannual variations in structures formed under the Razdolnaya (RR) and Tumannaya (TR) Rivers runoffs influence that appear on satellite distributions of the SST and the chlorophyll-*a*, organics and suspended matter contents indicators, for 2010-2014. In order to do this, we compared these distributions to change of the wind speed and direction, the precipitation quantity. In our study we used the data from the MODIS-Aqua and GOCI-COMS satellite sensors. They were taken from the site – http://oceancolor.gsfc.nasa.gov. These data we processed using the SeaDAS software of version 7.3. Data on wind speed and direction, and quantity of atmospheric precipitation were obtained for hydrometeorological stations “Vladivostok” and “Posiet” via site – http://rp5.ru. It is noted that during the floods on the RR at the northern winds, the influence of this river water with smaller rivers located along the western coast of the Amur Bay (AB) can reach the Gamow Cape. At winds of southern directions, in the northern AB part the front separating the areas having high and low values of SST and ocean color characteristics is observed. Runoff of the TR spreads, as a rule, on a distance of up to 30 km in the direction determined by the flow rate of the runoff current, wind speed and direction, Coriolis force. The greatest extension of the TR water toward the open Japan/East Sea part (about 80 km) was observed in 2010. Structures from this water in the open sea part observed on the distribution of SST and indicators of the chlorophyll-*a*, organics and suspended matter contents after 10 days from the summer flood. In the autumn period with a decrease in the discharge of the RR at the strong northwestern wind from about 5-7 m/s in the northern part of the AB the cyclonic structures were revealed.

S7: Ecological responses to variable climate changes and their applicability to ecosystem predictions

October 30, (S7-13814) Plenary

Twelve years of forecasting the spring bloom in the Strait of Georgia: Lessons learned

Susan **Allen**, Doug Latornell and Rich Pawlowicz

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The Strait of Georgia is a deep, semi-enclosed large estuary on the west coast of Canada. In this productive, temperate region the phytoplankton have a large spring bloom, moderate production through the summer and usually a smaller fall bloom. The timing of the peak of the spring bloom in the Strait of Georgia varies by over 6 weeks inter-annually. Using a vertical one-dimensional model, tuned using data from 2002-2005 field campaign we have been predicting the spring bloom since 2006. The model is mechanistic and the relationships between the timing of the bloom and physical forcing such as winds, light changes due to cloud cover, river flow and temperature were investigated. We hindcast the spring bloom back to 1968 covering many years for which data were not available. This allowed other researchers to investigate the impact of the timing of spring bloom on higher trophic levels.

Since 2006, in most years, an observational date for the spring bloom has been obtained, allowing a near continuous evaluation of the prediction. In this presentation, we will describe the model, our mechanistic understanding of the spring bloom process and the model dynamics, the prediction automation that allows continued prediction with minimal effort and the benefit that continued prediction allows through analysis of "model failure" years.

October 30, 11:00 (S7-13708)

Optimal tropical precursors of US West Coast marine warming

Antonietta **Capotondi**[1,2] and Prashant D. Sardeshmukh[1,2]

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The rich US West Coast (USWC) marine ecosystem supports activities of large economical and societal value. Warmer than average conditions in this area are associated with reduced upwelling and reduced productivity, negatively impacting marine ecosystem dynamics. Positive tropical Pacific sea surface temperature (SST) anomalies associated with El Niño events usually lead to warm conditions along the USWC a few months later due to atmospheric and oceanic teleconnections. However, the exceptionally warm conditions in the northeast Pacific and USWC from the Fall of 2013 to the Winter of 2015 were associated with only weak positive SST anomalies in the tropical Pacific, suggesting that SST patterns associated with canonical El Niño events may not be the most influential on the USWC.

In this study, we use multiple linear regressions and singular value decomposition to identify the tropical oceanic state – sensitivity pattern - that can optimally force US West Coast SST anomalies at some later time. As such, the sensitivity pattern provides the conditions that most likely lead to extreme anomalies along the USWC. Our results show that the optimal SST patterns do not coincide with a mature El Niño pattern, but include anomalies in the western equatorial Pacific and in the extra-equatorial tropics resembling some of the El Niño precursors. Large anomalies along the USWC, including the 2013-2015 warming, are indeed characterized by tropical conditions with a large projection on these sensitivity patterns, which thus represent more skillful predictors of the USWC conditions than traditional El Niño Southern Oscillation indices.

October 30, 11:20 (S7-13755)

Interhemispheric teleconnection between Yellow and East China Seas and tropical southeast Pacific sea surface temperatures through a recent change in El Niño-Southern Oscillation in the boreal summer

Yong Sun **Kim**[1], Minho Kwon[1, 2] and Chan Joo Jang[1, 2]

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

Whether and how the El Niño-Southern Oscillation (ENSO) exerts an influence on summer sea surface temperature (SST) variance in the Yellow and East China Sea (YECS) is under debate. Such a debate is mainly due to the complexity of multivariate oceanic and atmospheric processes in evolving YECS and tropical Pacific climate. Using reconstructed SST datasets for the period 1982−2016, we found that there is a decadal change between YECS and tropical southeastern Pacific (SEP) SST anomalies in early 2000s. The interannual YECS SST variance in the period 1982−2002 seems to be largely determined by local oceanic advection with its marginal coupling to the equatorial Pacific. In contrast, a robust interhemispheric teleconnection between the YECS and the SEP SSTs has been identified during the recent years since 2003. This teleconnection might be attributed to the combination mode of the ENSO with enhanced SST loadings over the SEP, as well as the decreased canonical ENSO signature, through modulation in large-scale atmospheric circulation and rainfall in recent summers. This result indicates, in the other word, that the observed interhemispheric connection between the YECS and the SEP SSTs in the boreal summer reflects coincident, localized responses in the southern and northern hemispheres to the changes in precipitation and convective heating pattern in the tropical Pacific. A potential implication of this decadal environmental change on the marine ecosystem of the YECS will be discussed in this talk.

October 30, 11:40 (S7-13648)

Decadal predictability linked to teleconnections between the Kuroshio Extension and North Pacific Meridional Modes

Youngji **Joh** and Emanuele Di Lorenzo

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The Kuroshio Extension (KE), an eastward-flowing jet of wind driven western boundary current, exhibits prominent decadal fluctuations that impact marine populations in the North Pacific Transition Zone (NPTZ). Using available observations, we show that KE decadal modulations impact the subtropical footprint of sea surface temperatures (SST), known as the North Pacific Meridional Mode (NPMM). After removing the signatures of ENSO, we find that the KE and NPMM have significant lead/lag relationships at multi-decadal timescale. Specifically, we show that the KE downstream atmospheric forcing (e.g. wind stress curl) response can initiate an oceanic signature of NPMM with a ~3 months lead time. Subsequently, the NPMM can also drive changes in KE state through atmospheric forcing that excite large-scale Rossby waves in the central and eastern North Pacific, which propagate eastward impacting the KE 2-3 years later. Consistent with these findings the cross-correlation function between KE and NPMM indices exhibits a sinusoidal shape corresponding to a preferred spectral power at decadal timescales. This finding provides a basis for decadal predictability of biophysical environment in the NPTZ since the KE and NPMM both exert significant influences on SST and regional water mass formation and transformation processes. Analyses of CMIP5 models show that the variance of KE decadal modulation is increasing in a warmer climate, suggesting that the linkage between KE-NPMM may amplify under anthropogenic forcing and lead to stronger decadal fluctuations of biophysical quantities (e.g., salinity, oxygen, chlorophyll-A) in the NPTZ.

October 30, 12:00 (S7-13774)

Mechanisms of marine ecosystem predictability along U.S. coasts

Michael G. **Jacox**[1, 2] and the NOAA/MAPP Marine Prediction Task Force

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Marine ecosystem forecasts, designed to support proactive decision making by stakeholders including managers, fishers, and the general public, are currently in a phase of rapid development. In contrast to climate projections, which are used to explore long-term trends and changes, forecasts aim to predict conditions at a specific location and time. Significant forecast skill (or the potential for it) has now been demonstrated for a range of physical, biogeochemical, and ecological variables on timescales ranging from days to a decade. However, understanding of the mechanisms underlying marine forecast skill has lagged behind the development and assessment of the forecasts themselves. As many forecasts rely on empirical relationships, especially for higher trophic levels, concerns of nonstationarity drive a need to better understand and exploit prediction mechanisms. In this talk we bring together findings from a large group of researchers, comprising the NOAA Marine Prediction Task Force, who are developing seasonal (1-12 month) forecasts for coastal sea levels and living marine resources along U.S. coastlines. We discuss known mechanisms of predictability including persistence, advection, and wave propagation, and give examples of how they are being exploited in statistical and dynamical forecast systems along U.S. coasts. We also present key challenges and priority developments for advancing the skill and usability of marine ecosystem forecasts moving forward.

October 30, 12:20 (S7-13601)

Using a coupled biogeochemical/physical data assimilation system in the California Current System to study ecosystem impacts from variable climate

Christopher A. **Edwards**, J. Paul Mattern, Patrick T. Drake, Jerome Fiechter, Andrew M. Moore

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A coupled biogoechemical and physical 4-dimensional variational data assimilation system applied to the California Current System has been running operationally in near real-time for several years. Ocean state estimates are obtained using the Regional Ocean Modeling System as the base platform. In the most recent version, biogeochemical fields are obtained from the NEMURO ecosystem model using a modified lognormal 4D-Var approach to account for non-Gaussian statistics of the assimilated satellite-derived chlorophyll observations. This system offers a data-constrained 4-dimensional estimate of the physical and biogeochemical ocean state to study how the modeled ecosystem responds to variable climate conditions. In this talk, we use a reanalysis of the recent warm blob episode of the eastern North Pacific as a case study, quantifying the anomalously low chlorophyll biomass that can be traced through the system to nutrient supply and surface forcing. The potential for studying longer term trends and variability using a multi-decadal reanalysis will also be discussed.

October 30, 14:00 (S7-13691)

Predicting fish movement and migration in response to changing climate

Kenneth **Rose**

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Shifting spatial distributions of fish in response to variable climate has been well-documented. There has also been a recent acceleration of ideas about how management can adapt to these shifting distributions. Many of these management-based analyses assume the new spatial distributions or migration patterns are known, can be represented very simply using environmental-ecological correlations, or can be assumed to be the same as how habitat changes. I suggest that with recent parallel advances in movement modeling and in data collection of individual trajectories the time is now to develop and test predictive models of behavioral movement. These models can be then used to generate spatially-rich predictions of the changing spatial distributions. Recently, there has been an explosion of interest in collecting data and modeling of how organisms move through dynamic multi-factor environmental fields. The collection of individual movements (whether simulated or based on field data) leads to higher-order emergent properties such as population biomass and distributional changes, as well as food web-level responses. It is time to better integrate movement ecology, modeling, and fisheries into a single system where growth, mortality, and reproduction are explicitly two-way linked to movement decision-making and resultant movement behaviors. Such modeling offers an opportunity for prediction of the complexity of how individuals will respond to changing environmental conditions and better understanding the processes that underlie environmental-habitat-organism relationships. I will present some examples that illustrate a few of the recent advances in modeling and briefly describe the exploding field of movement ecology and measurements.

October 30, 14:20 (S7-13759)

Development of the ocean mid-range prediction system for the seas around Korea

Heeseok **Jung**[1] and Chan Joo Jang[1,2]

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

Due to a decline of total catch production and more frequent extreme phenomena in Korean waters during the recent decades, a mid-range (2−6 months) prediction of ocean conditions has emerged as an important tool for the management, recovery and disaster preparation of fishery resources. In this study, we report on a newly developed ocean mid-range prediction system for the Northwest Pacific focusing on the seas around Korea. Three-month reforecast experiments were conducted by using atmospheric forcing and open boundary condition from Climate Forecast System version 2 (CFSv2) operational forecast data. We analyzed the last month (March, June, September, and October 2016) of the simulation output and assessed the performance of the model's prediction skill in terms of sea surface temperature. Although the reforecasts tend to overestimate SST especially in the warm current regions include the Kuroshio and the East Korea Warm Current. The spatial SST patterns are generally similar to observation. Based on the preliminary analysis for the three-month reforecast experiments in 2016, we can conclude that the mid-range prediction system has the measurable skill for the seas around Korea on the mid-range timescale. Our future plan is to couple the ocean prediction model with a biological model and to apply the model to a prediction of fishery resources on a mid-range.

October 30, 14:40 (S7-13476)

Dynamics of walleye pollock recruitment at Primorye (Japan/East Sea) under climate change

Yury **Zuenko** and Vladimir Nuzhdin

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Year-to-year dynamics of walleye pollock *Gadus chalcogrammus* Pallas recruitment is considered on the data of bottom trawl surveys for the population at Primorye (northwestern Japan Sea) with the main spawning ground in Peter the Great Bay. It is distinguished by 5-11-years cyclic fluctuations reasoned by negative relationship between the recruitment and stock because of overloading the carrying capacity of the biotope for the species. This relationship is approximated by nonlinear function with the parameters, including the carrying capacity that is negatively depended on water temperature in the pollock habitat (Intermediate water). Besides, the abundance of 1-2 strong year-classes, which are formed once in a cycle in conditions of the minimal stock, depends directly on winter SST, negatively as well. Frequency of these strong year-classes appearance also depends on carrying capacity: the larger the capacity – the shorter the cycles and more frequent the blooms. Modern environmental changes distinguished by warming in all layers of the Japan Sea, in particular in the Intermediate layer, are unfavorable for the pollock reproduction because of the carrying capacity decreasing. On the base of these regularities, the pollock stock changes in the next decade are forecasted using a simple population model: the stock growth is expected until 2019 when it will exceed 100,000 t, then it will go down below 80,000 t in the middle 2020s, and possibly will not restore again if warming of the Intermediate water will continue.

October 30, 15:00 (S7-13756)

Present and future dynamics of herring stocks in the Northwest Pacific in association with large-scale climate variability

Boris Kotenev, Nikolay Antonov, Oleg Bulatov, Kirill **Kivva**, Andrey Krovnin, and George Moury

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The decadal and multidecadal fluctuations in abundance of mass objects of the Russian fishery in the Northwest Pacific reveal close relationships with the corresponding climate variations within the whole Northern Hemisphere. In particular, the quasi-decadal variability of the Arctic Oscillation (AO) determined considerably state of the atmospheric North Pacific Oscillation (NPO) with a time lag of 2 years and, finally, phase of the North Pacific Gyre Oscillation (NPGO). First of all, this is evident in the SST anomaly field in the North Pacific (NP). Many researchers showed close relations of the NPGO index with water temperature and salinity variations in the eastern NP. However, our research revealed the close statistical relations of this index with quasi-decadal variations of SST and recruitment of some commercial fishes in the NW Pacific, including walleye pollock in the northern Sea of Okhotsk, Far East salmons, and cod in the NW Bering Sea. The main purpose of this report is to investigate long-term relations between NPGO/NPO and herring stocks in the Bering and Okhotsk Seas. This will allow us to make projection of the future stocks for the next two decades.

October 30, 15:20 (S7-13382)

The PDO, The Blob and juvenile coho salmon growth in the Northern California Current 2000 - 2017

Brian **Beckman**[1], Cheryl Morgan[2], and Meredith Journey[3]

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Since 2000, the Northern California Current Ecosystem (NCCE) has experienced positive (warm) and negative (cool) phases of the Pacific Decadal Oscillation (PDO), with characteristic biological responses to each phase shift. An unexpected ecosystem disturbance resulted from the formation of "The Blob", a large area of anomalously warm water in the Northeast Pacific Ocean (2014 – 2015).

We have assessed growth of juvenile coho salmon in the NCCE since 2000. Growth was indexed by measuring the hormone insulin-like growth factor 1 (IGF1), a primary component of the endocrine system in all vertebrates. IGF1 exhibits a strong correlation with growth rate of juvenile salmon in controlled laboratory conditions. IGF1 was correlated with abundance of salmon prey in this time series, suggesting that variations in growth are directly tied to variation in feeding opportunity. The prey field index consists of total biomass (mg C) of prey items commonly found in the stomachs of juvenile salmon (crab larvae, amphipods, euphausiids, copepods, juvenile fish). IGF1 and the prey field index were each negatively correlated with the PDO (higher growth with negative PDO). However, during The Blob, a period of strongly positive PDO, we measured the highest IGF1 and prey field indices in the time series. These results show that The Blob generated a disruption of the relationship between the PDO and juvenile salmon ecology, with high growth rates found during a period of anomalously warm water. Thus, biological responses to unexpected environmental change may not always be predicted based on previously established relationships.

October 30, 15:40 (S7-13519)

Fluctuating interaction network and time-varying stability of a natural fish community

Masayuki Ushio[1,2,3,4], Chih-hao **Hsieh**[5,6,7], Reiji Masuda[8], Ethan R Deyle[9], Hao Ye[9,10], Chun-Wei Chang[6], George Sugihara[9], and Michio Kondoh[1]

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Ecological theory suggests that large-scale patterns such as community stability can be influenced by changes in interspecific interactions, arising from time-varying behavioral and/or physiological responses of individual species. Although this view is supported by a few simplified manipulative experiments, evidence from natural ecosystems is lacking. The challenge here is in tracking rapid changes in interspecific interactions (known to occur on timescales much shorter than a generation time), and then identifying the effect of such changes on the resulting large-scale community dynamics. Here, using tools for analyzing nonlinear time series (empirical dynamics), and an extensive, 12-year, fortnightly dataset of observations on a natural marine fish community in Maizuru Bay in Kyoto, Japan, we present evidence that short-term changes in the interaction network influence the overall community dynamics. Among the 15 dominant species, we identify 14 interspecific interactions to construct a dynamic interaction network. We show that the interaction strengths and even signs change with time and develop a time-varying stability measure based on local Lyapunov stability for attractor dynamics in non-equilibrium nonlinear systems. This dynamic stability measure is used to examine the linkage between the time-varying interaction network and community stability. We find seasonal patterns in dynamic stability for this fish community that broadly support expectations of current ecological theory. Specifically, the dominance of weak interactions and higher species diversity during summer months is associated with higher dynamic stability and smaller population fluctuations. We suggest that interspecific interactions, community network structure and even community stability are dynamic properties, and that linking fluctuating interaction networks to community-level dynamic properties is key to understanding the maintenance of ecological communities in nature.

October 30, 16:20 (S7-13825)

Multi-model inter-comparison study for elucidating uncertainty and mechanistic understanding of climate change impacts on Bering Sea fishery resources

Anne B. **Hollowed**[1], Kerim Aydin[1], Alan Haynie[1], Kirstin Holsman[1], Paul Spencer[1], Jonathan Reum[2], Andrew Whitehouse[2]

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In the Bering Sea, regional and large-scale climate forcing impacts a range of physical and ecological characteristics including temperature, stratification, ocean circulation, biogeochemical properties, and primary and secondary production. These characteristics, in turn, can impact the distribution, composition, and productivity of fisheries resources. The short-term (seasonal) forecasting skill of coupled bio-physical models differs amongst species. Stock exhibiting sporadic recruitment time series are linked to complex suites of mechanisms. The Alaska Climate Integrated Modeling (ACLIM) project seeks to use a multi-model ensemble to understand the uncertainty associated with climate-ecological relationships. This talk will compare projections of flatfish and gadids under a suite of climate change scenarios and models of differing complexity. Results reveal the risks associated with the use of simple bio-climate window models for projecting long-term productivity of Bering Sea resources. This comparison of short-term and longer-term projections clarifies predictable properties that show promise for use in ecosystem based fishery management and identification of climate informed biological reference points for management.

October 30, 16:40 (S7-13607)

Climate regime cycle affects the productivity of a pursuit-diving seabird and its predation on forage fish

Yutaka **Watanuki**[1], Mariko Yamamoto[1], Jumpei Okado[1] and William Sydeman[2]

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[2] Farallon Institute, Petaluma, CA, USA

In the Japan Sea, cold/warm regime shifts impact species and biomass of forage fish, a key component of marine ecosystem, and hence productivity of its predators. We monitored the diet and productivity of chicks of piscivorous Rhinoceros Auklet (RHAU, *Cerorhinca monocerata*) at Teuri Island located in the Japan Sea, northwestern Hokkaido since 1984, and also the diet of adults in 2004 – 2005 (warm regime) and 2014 – 2015 (presumed cold regime). Then we estimated prey consumption using simple bioenergetic model. RHAU changed diet from cold-water species (sardine *Sardinops melanostictus*, sandlance *Ammodytes personatus*) to variety of species in 1992. RHAU, then, shifted diet to warm-water species (Japanese anchovy *Engraulis japonicus*) and increased chick productivity in 1997/1998 when Pacific Decadal Oscillation index changed to be negative and SST in the Japan Sea shifted to be warm phase. RHAU then shifted diet again to cold-water species (juvenile greenling *Pleurogrammus azonus*) and decreased chick productivity dramatically in 2011-2014 when PDO shifted to be positive, though SST in the Japan Sea might not change. Diet for parents and that for chicks was similar during the warm regime but was different during the presumed cold regime. We found significant impact of climate change on prey consumption; high consumption of greenling juvenile and salmon fry after 2014. These indicate that the regime shift, presumably with the changes of ocean water currents, not only affect diet and productivity of predator but also can change the predation rate on forage fish by forcing the predator to switch prey species.

October 30, 17:00 (S7-13263) CANCELLED

Spatial heterogeneity of phytoplankton bloom timing in a marginal sea: Patterns and potential drivers

Hongjun **Song**[1], Rubao Ji[2] and Zhaohui Zhang[1]

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The seasonal phytoplankton blooms and associated biological-physical drivers have been studied in various marine systems globally, often without paying much attention to the scale of spatial heterogeneity in bloom dynamics. This study examined the spatial heterogeneity in the timing and magnitude of phytoplankton blooms in the Yellow Sea (YS, a marginal sea in the northwestern Pacific Ocean) in relation to local and remote physical processes. The satellite ocean color data reveal that monthly chlorophyll maximum could occur at all four seasons over different sub-regions of the YS, with a general pattern of spring peak in the central trough, summer peak off the estuary regions, autumn peak near the southeast corner and winter peak in the southern YS. The mean chlorophyll concentration during bloom timing presents a general spatial pattern of inshore progression with a increasing trend, and the strongest blooms occur in the waters off the estuaries. The statistical analysis of field data (available in the western YS) suggests that the variability of environmental factors driven by various physical processes could explain most of these spatial heterogeneity in blooms, both the timing and magnitude. Cold water mass, river discharge and warm current exert controls on phytoplankton blooms dynamics through affecting thermal and haline stratifications, nutrient availability, and temperature upon phytoplankton growth in different seasons. Seasonal warming/cooling also appears to be an important factor in the spatial variability of blooms. Our results imply that the spatial heterogeneity of marginal seas needed to be carefully considered when assessing phytoplankton responses in the context of climate change, due to the uncertainty and complexity of the underlying mechanisms.

October 30, 17:20 (S7-13391)

Spatio-temporal analysis of environmental drivers and patterns of satellite-derived chlorophyll *a* in the Strait of Georgia, Canada, from 2003-2016

Karyn D. **Suchy**[1,2], Andrea Hilborn[1], Maycira Costa[1] and R. Ian Perry[2,3]

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The Strait of Georgia (SoG) is a dynamic region with substantial spatio-temporal variability at lower trophic levels. This variability, in turn, may directly impact resident and migratory fish populations that are of major economic importance. Here, we examine the relationships between environmental drivers and satellite-derived chlorophyll *a* (chl *a*) from 2003-2016 in the Northern and Central SoG. Positive SST anomalies predominated between 2003-2006 and 2013-2016, with the highest anomalies occurring in spring 2015. Strong positive anomalies in Fraser River discharge, coupled with strong negative wind anomalies, led to early stratification during spring 2005 and 2015, which resulted in strong positive chl *a* anomalies and early spring blooms (mid-February). In contrast, later than average (late April) spring blooms occurred in 2007 and 2008 due to low Fraser River discharge and low wind speeds. Chl *a* in the Northern SoG was most highly correlated with SST and PAR ($r = 0.396$, $p<0.01$ and $r = 0.378$, $p<0.01$, respectively); chl *a* in the Central SoG was most highly correlated with wind speed ($r = -0.313$, $p<0.01$) and Fraser River discharge ($r = 0.298$, $p<0.05$). Additionally, significant relationships were found between annual median Chl a anomalies in the Northern SoG and large-scale climate indices (PDO, NPGO, SOI); however, no such relationships were observed in the Central SoG. Results from this study will be paired with zooplankton data to provide insight into how changes in the seasonal patterns of lower trophic levels may influence the growth and survival of salmon populations in the region.

October 30, 17:40 (S7-13350)

Expansion of *Cochlodinium Polykrikoides* in Chinese coastal waters, what can be linked to?

Douding **Lu**, Pengbin **Wang**, Xinfeng Dai, Feng Zhou and Fei Chai

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Water samples of *Cochlodinium polykrikoides* were collected in different locations of China seas. The isolated strains of targeted species were analyzed by using light microcopy, laser scanning confocal microscopy, scanning electron microscopy. Molecular identification was also performed by using LSU rDNA region. The phylogenetic relation between *C. polykrikoides* and other relative species were clarified. Our studies suggest that the targeted strains found so far in China are belonged to the East Asian ribotype of *C. polykrikoides*. The HABs caused by *C. polykrikoides* were rare in China before 2000' and only a few blooms were recorded in the South China Sea. With the change of marine environment, the record of *C. polykrikoides* and its blooms show an increasing trend in the coastal waters of China. Biogeographic distribution pattern of this species shows that it has been expending from the South China Sea to the almost whole Chinese coastal waters including the Bohai Sea in the last two decades. In the meantime, sea surface temperature in China Seas has remarkably increased in the past five decades. Since *C. polykrikoides* is a warm water species, whether the expending mechanism of the species is linked to the signal of climate change remains to be further explored.

S8: Internal tides, nonlinear internal waves, and their impacts on biogeochemistry, climate and marine ecosystems via ocean turbulent mixing processes

November 1, (S8-13695) Plenary

Fate of internal waves on a shallow shelf

Kristen A. **Davis**[1], Robert S. Arthur[2], Justin Rogers[3], Oliver Fringer[3], Emma C. Reid[1], Thomas M. DeCarlo[4], and Anne L. Cohen[5]

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Internal waves strongly influence the physical and chemical environment of coastal ecosystems worldwide. We report novel observations from a distributed temperature sensing (DTS) system that tracked the transformation of internal waves from the shelf break to the surf zone over a shelf-slope region in the South China Sea. The spatially-continuous view of temperature fields provides a perspective of physical processes previously available only in laboratory settings or numerical models, including internal wave reflection off a natural slope, shoreward transport of dense fluid within trapped cores, internal "tide pools" (dense water left behind after the retreat of an internal wave), and the transport of internal wave upwelled water on to a shallow reef. Analysis shows that the fate of internal waves on this shelf – whether transmitted into shallow waters or reflected back offshore –is mediated by local water column density and shear structure, with important implications for the distribution of energy, heat, and nutrients on the shelf.

November 1, 11:00 (S8-13590) Invited

Progress report. Ocean mixing processes: Impact on biogeochemistry, climate and ecosystems (OMIX)

Ichiro **Yasuda**

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A progress report is presented for the 5-year Japanese project 'Ocean mixing processes: impact on biogeochemistry, climate and ecosystem (OMIX)' which are launched in July 2015 and plans and first year results were presented in 2016 PICES annual meeting. A new turbulence observing system using fast response thermistors is developed and contributes to widen microstructure measurements which begin to show basin-scale surface-bottom turbulence distribution in the western North Pacific. The data also helps to revise the model turbulence field. Those large numbers of in-situ turbulence observations and modelling including biogeochemical parameters lead to findings such as turbulence hot spots in the Kuroshio and the Oyashio and roles of turbulent fluxes of macro- and micro-nutrients on ecosystem. Microscale otolith stable isotope analysis is developed to elucidate the life history of *chub mackerel*. These results are now being synthesized to models with vertical mixing distribution and its 18.6-year period modulation, which could make clear how mixing impacts on ocean circulation, ecosystem, climate and their long-term variability.

November 1, 11:30 (S8-13492) Invited

Role of turbulent mixing in plankton dynamics simulated by large eddy simulation (LES)

Yign **Noh**

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Turbulent mixing in the upper ocean plays an important role in plankton dynamics as well as in climate dynamics and ocean pollution. Large eddy simulation (LES), which reproduces small-scale turbulent structure realistically, provides us information on fluctuating three-dimensional turbulent mixing under the ideal condition, which has been unavailable so far. The LES model of the ocean mixed layer, in which wave breaking and Langmuir circulation (LC) are realized, is developed, and applied to investigate the roles of wave breaking, LC, wind stress, convection and the Coriolis force in the vertical mixing of the upper ocean, and to parameterize their effects in the ocean mixed layer model. We can also clarify the settling and dispersion of suspended particles in the upper ocean, which is critical to understand the biogeochemical process in the upper ocean, by analyzing the motion of Lagrangian particles in the turbulent field simulated by LES. Recently a LES ecosystem model is developed, in which nutrient is treated as a passive scalar and phytoplanktons are represented by Lagrangian particles. The variation of phytoplankton biomass by the biological process is realized by the variation of the weighting factor on each Lagrangian particle. The model allows us to investigate plankton dynamics directly by following the life cycle of each phytoplankton particle as it grows, decays and eventually settles to the deeper ocean.

November 1, 12:00 (S8-13463)

The scaling of the mixed layer depth under surface heating by using LES

Yeonju **Choi** and Y. Noh

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In a recent paper, Pearson et al. (2015) suggested, using LES, that the depth of a diurnal thermocline h can be estimated by the Monin-Obukhov scale $L_{MO}(=u_*^3/Q_0)$ and the depth of a preexisting thermocline h_0, where u_* is the frictional velocity and Q_0 is the surface buoyancy flux. However, our analysis of LES results reveals that the Coriolis force plays a critical role in the formation of a diurnal thermocline as well as the formation of a seasonal thermocline, contrary to their proposition. Accordingly, the depth of a diurnal thermocline h should be scaled by the Zilitinkevich scale $L_Z(=u_*^2/(fQ_0)^{1/2})$, not by the Monin-Obukhov length scale $L_{MO.}$ It is also shown that h is not affected by h_0 as long as h_0 is sufficiently larger than h*, the depth of a diurnal thermocline when there is no preexisting thermocline. On the other hand, as h* approaches h_0, h becomes affected by h_0. h can become even larger than h_0, but increase of h is ultimately suppressed by h_0 because the thermocline suppresses the downward transport of heat.

November 1, 12:20 (S8-13367)

Diapycnal nutrient flux caused by the Kuroshio induced turbulence in the Tokara Strait

Takeyoshi **Nagai**[1], Daisuke Hasegawa[2], Hirohiko Nakamura[3], Ayako Nishina[3], Toru Kobari[3], Naoki Yoshie[4], Ryuichiro Inoue[5] and Eisuke Tsutsumi[6]

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The Kuroshio carries not only a large amount of heat and salt, but also nutrients from the south as a Kuroshio nutrient stream. The relatively high nutrient concentrations in the Kuroshio compared to that of ambient water of the same density may imply the diapycnal nutrient flux along the Kuroshio path. Such diapycnal nutrient flux of large amplitude is most plausible in the upstream Kuroshio, where the Kuroshio flows near the shallow continental shelf and through the chains of islands and seamounts in the Okinawa Trough and the Tokara Strait. Using the-state-of-the-art tow-yo microstructure profiler data every 1 km, we have observed the 100-1000-fold enhancement in turbulent kinetic energy dissipation rates accompanied by bands of internal wave shear, over 100 km wide along the Kuroshio near the seamounts in the Tokara Strat. Although the observed strong turbulence near the seamounts

plausibly induces a large nutrient flux, it has been elusive how much nutrients can be injected to the photic zone in the Tokara Strait as a whole, because the direct nitrate flux measurements have been made only at a few locations. In this study, we attempt to quantify the diapycnal nitrate flux in the entire Tokara Strait, combining the nested high-resolution numerical simulation coupled with an ecosystem model and in-situ observed turbulence data.

November 1, 14:00 (S8-13479)

The interactions between phytoplankton, nutrients and turbulence simulated by a large-eddy simulation (LES) ecosystem model with Lagrangian phytoplankton

Ashley **Brereton** and Yign Noh

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A large-eddy simulation (LES) model is coupled to a simplified ecosystem model to investigate biological-physical interactions in the upper ocean. Here, the nutrients are treated as a passive scalar and phytoplankton are represented by Lagrangian particles. The variation of phytoplankton biomass is realized by the variation of the weighting factor on each Lagrangian particle. The model allows us to follow the life cycle of each phytoplankton particle as it grows, decays and eventually settles to the deeper ocean. Investigation is focused on how phytoplankton biomass is affected by nutrient entrainment, as well as by three-dimensional turbulent structures such as Langmuir circulations and convection. We compare findings to field measurements and other model results.

November 1, 14:20 (S8-13766)

Internal waves, tides, eddies and wind-driven currents across the inner shelf

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The inner shelf, the region inshore of the 50-m isobath and lying between the wind-forced continental shelf and the breaking-wave surfzone, connects the coast and open ocean. During September to October 2017, an intensive field experiment was conducted from the mid-continental shelf, through the inner shelf and into the surfzone near Point Sal, California, USA (35N). We used satellite, airborne, shore- and ship-based remote sensing, in-water moored and ship-based sampling, and numerical ocean circulation models forced by winds, waves and tides to investigate the exchange of water, momentum and energy across this region. Of interest are the forcing by wind, surface waves and internal gravity waves, and the interactions between these processes. The field study was designed to resolve the propagation, transformation and dissipation of Non-Linear Internal Waves (NLIWs) from the mid-shelf and across the inner shelf, as well as cross-shelf eddy fluxes between the mid and inner shelf created by flow instabilities in both shelf and surfzone alongshore flows. We deployed 80 moorings with high-vertical resolution temperature and velocity over the inner shelf at various horizontal separations and 70 moorings in the surfzone. We used five oceanographic vessels from 30 to 240-feet in length operating at the same time to sample the mid shelf to the surfzone. We present a 3-dimensional look at the transformation of NLIWs during shoaling across the inner shelf and evaluate how they impact inner-shelf stratification and circulation. The low-frequency wind-driven circulation and eddies are examined using both shipboard and mooring data.

November 1, 14:40 (S8-13400)

Mixing and transports induced by nonlinear internal wave breaking in coastal regions

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Mass transports form coastal areas to the open oceans are essential for maintaining ocean ecosystems. Breaking internal waves are one of the major contributors to induce mass transports in coastal regions. It is well known that mixing due to internal wave breaking causes an offshore ward convergent flow on the slope, which results in offshore ward nutrients supplies. However, details of internal wave breaking and associated transport process have not been understood well. This study introduces mechanisms of internal wave breaking and mass/sediment transports investigated with numerical simulations. Two dimensional simplified numerical simulations show that mixing and sediment resuspension/transports are enhanced in low internal Iribarren number conditions. The internal Iribarren number is the ratio of the topographic slope and internal wave steepness. We also investigated transport processes associate with nonlinar internal wave over the Izu-Ogasawara Ridge, off the Japan mainland, using a 3D numerical model. Both of semidiurnal (~M^2) and diurnal (~K^1) internal tides enhance bottom shear stress leading to sediment resuspension. Suspended sediments are transported by strong mixing induced by nonlinear internal wave breaking via an offshore ward convergent flow on the main pycnolince, which results in intermediate nepheloid layers. This convergent flow cause baroclinic (BC) residual circulations in the study area. The current speed due to the BC residual circulations reaches 0.2 m s^{-1}. The kinetic energy due to the BC residual circulations contribute to 5% of the total kinetic energy. BC residual circulations are supposed to play an important role in sediment/nutrient transports in coastal regions.

November 1, 15:00 (S8-13311)

Near-inertial waves advected by the Kuroshio from observation and simulation

Chanhyung **Jeon**[1], Jae-Hun Park[1], Hirohiko Nakamura[2], Ayako Nishina[2], Xiao-Hua Zhu[3], Hong Sik Min[4], Dong Guk Kim[4], Sok Kuh Kang[4], Hanna Na[5], and Naoki Hirose[6]

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Advection of near-inertial waves (NIWs) by background currents has been predicted using numerical simulations, while supporting in-situ observations were rare. A pair of tall current moorings, deployed around 26°N and 125°E in Okinawa Trough from June 2015 to June 2016, provides a clear evidence exhibiting NIWs advected by the Kuroshio. Energetic NIWs are observed after two-typhoon passages in early August and late September 2015. Both typhoon passages occurred across the Kuroshio east of Taiwan upstream of the observation sites about 250-km southwest with a difference of about 2-degree in latitude. One site (KCM1), relatively close to the center of the Kuroshio axis, exhibits more energetic NIWs than near the edge of the Kuroshio (KCM2), ~32 km away from KCM1. The frequency of NIWs shifts to the lower band from the local inertial frequency (0.91*f*), inferring propagation from the south. The data-assimilative three-dimensional numerical model forced by 3-hourly atmospheric forcings including tides and oceanic circulation demonstrates local NIW generation is weak at observation sites during and after typhoon passages, while its generation upstream of observation sites is quite energetic. Current patterns and frequency shifts of NIWs between observation and simulation agree well at observation sites. Analyses of simulation provide that negative relative vorticity region along the right side of the Kuroshio traps NIWs and is likely to produce waveguide for NIW propagation to the north, and therefore energetic NIWs generated in the Kuroshio upstream are advected to the observation sites by the Kuroshio.

November 1, 15:20 (S8-13354)

Observations on internal wave modulations under varying mesoscale variability for 18 years from 2000 to 2017 off the east coast Korea

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Energy exchange between the internal waves and mesoscale flow is believed to be an important sink of eddy energy. Moored time-series observations, designed to continuously observe flow variability at 400 m, capture tens of events of enhanced near-inertial waves (NIWs, waves at frequencies of 0.8-1.3*f* where *f* is the local Coriolis frequency) and continuum frequency waves (CFWs, 2.0-10.0*f*) for 18 years from 2000 to 2017 in the southwestern East Sea (Japan Sea). We focus on the interactions between internal waves at the two frequency bands (NIWs and CFWs) observed at 400 m and mesoscale flow fields constructed from satellite altimetry-derived sea surface height. Permanent energy transfer occurs from the mesoscale fields to NIWs induced by local wind forcing under the presence of background strain (normal strain S_n and shear strain S_s). The energy transfer efficiency (ETE) is proportional to total strain variance (TSV=S_n^2+S_s^2) divided by magnitude of the effective Coriolis frequency (ECF). The efficiency is used here as a criterion (ETE > 0.01) to define totally 17 events. The NIW modulations are clear in 10 among the 17 events with 3 events accompanying the intensification of CFWs when TSV is higher than relative vorticity ζ (or positive Okubo-Weiss parameter, i.e., S_n^2+S_s^2–ζ^2 >0). Both NIWs and CFWs were significantly enhanced in 2003 and explained by the positive Okubo-Weiss parameter due to large S_n associated with a decaying anticyclonic eddy. This study supports the idea that the mesoscale fields play a decisive role in modulating internal wave energies in upper ocean.

November 1, 15:40 (S8-13645)

Thermocline dynamics and modulation of a nutrient exposure for Eastern Pacific kelp forests in Southern California

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Internal tides dominate coastal internal gravity wave fields and are generated when barotropic (astronomical) tides encounter steep or abrupt bathymetry, with the rate of barotropic to baroclinic energy conversion proportional to the product of tidal velocity and topographic slope. In a topographically complex region such as the Southern California Bight, internal tides may be generated both at the steep shelf-break and at numerous smaller topographic features inshore. As these waves propagate onshore, they refract due to changes in water depth and ambient stratification, creating a spatially complex pattern of nutrient exposure and flux at inshore sites including kelp forests. The high productivity of kelp forest along the west coast of North America requires consistent and significant supply of inorganic nutrients, particularly bio-available forms of nitrogen. The primary sources of oceanic inorganic nitrogen includes nitrate delivery by wind-driven upwelling of cold water along the coast and higher frequency upwelling associated with diurnal to semi-diurnal internal waves. In this project, high resolution water column temperature time series data were collected from multiple sites along the coastline of San Diego, California and analyzed to investigate variability in nitrate exposure across space and through time including an anomalous, regional scale warming event in 2015/16. Results show strong spatial heterogeneity in high frequency temperature variability, and variations among seasons and years associated with regional warming that markedly altered patterns of nutrient exposure at kelp forest sites along shore. These observations illustrate regional oceanographic control on nutrient availability for inshore coastal ecosystems.

November 1, 16:20 (S8-13659)

Linking internal wave dynamics and the structure and function of coral reef ecosystems

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Coral reefs are gravely threatened by global warming, with predictions of significant ecosystem alteration or loss in the coming decades. We will discuss ways in which internal waves may influence coral reef systems across the Pacific, particularly by increasing sub-surface temperature variability. In Funauki Bay on the west coast of Iriomote-jima, Japan reefs are subject to semi-diurnal cooling during the summer (up to 7°C per day at 42 m). This internal wave cooling occurred in deep to shallow habitats across the bay (including at the bay head ~6 km from the mouth) and reduced the duration of severe bleaching conditions (from weeks to days at 8 m depth) during the 2016 El Niño event. Such moderate internal wave oscillations may thus help preserve reefs in a warming climate. However, extreme internal wave activity may represent a stress and thus limit reef development. This seems to be the case for deeper habitats (>30 m) at Dongsha Atoll in the northern South China Sea, where the highly dynamic internal wave climate leads to daily temperature variability up to 13°C at 42m. Strong internal wave upwelling may also influence reef nutrient supply and ecosystem structure at a range of scales, such as by determining the relative abundances of auto- and hetero-trophic organisms which are being quantified with a range of isotope biomarkers. Increased stratification and internal wave cooling of shallow reefs under a warming climate may offer hope for many reef ecosystems threatened by climate change.

November 1, 16:40 (S8-13546)

Numerical study on impacts of the 18.6-year modulation of tide-induced mixing on biogeochemical variables based on ESTOC

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Many studies have reported that biogeochemical variables, such as oxygen and nutrient concentrations, and even biomass of zooplankton, show bi-decadal variability in the North Pacific. It is hypothesized that a part of those bi-decadal variations are related to the 18.6-year modulation of the tide-induced vertical mixing around the steep topographic features, like sills in the Kuril Straits and the Aleutian Passes. However, even qualitatively, it is still unclear whether the modulation of mixing can explain those variations. In order to test this hypothesis, we, for the first time, conducted a comparative numerical experiment using a biogeochemical model, based on our long-term ocean state estimation, ESTOC, which is consisting of an oceanic general circulation model and a pelagic lower trophic level ecosystem model. In our model, the modulation of mixing induces 18.6-year period anomalies of isopycnal oxygen concentration in the intermediate layer, which is by and large consistent with the observed bi-decadal variations in the Oyashio region, and this anomaly moves eastward along boundary between the subarctic and subtropical gyres. In the presentation, we will show the impacts on the other biogeochemical variables in our model, and discuss the relation with the observed bi-decadal variations.

November 1, 17:00 (S8-13280)

On energy and matter exchange between near-shore and out-of-shelf waters defining shelf ecosystems state

Vadim **Navrotsky**

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Continental shelves are the most productive and the most susceptible to harmful anthropogenic impacts. The both phenomena strongly depend on dynamic processes and sources of mineral and organic matter. Analysis of daily satellite data on chlorophyll-*a* concentration in the Peter the Great Gulf of the Sea of Japan for the period 2008-2017 reveals seasonal changes in its spatial distributions, which are related to seasonality of dynamic processes in the region. It is shown that specific features of chlorophyll-*a* spatial distributions are formed under impact of interactions between large-scale and small-scale dynamic processes in the continental slope and near-shore regions. The key role in these interactions play internal waves (IW), which are generated mainly by tides, eddies, and currents over the continental slope and are the main energetic agent between off-shelf and near-shore regions. Analysis of processes of IW generation, propagation, transformation and breaking, and heat, momentum and energy fluxes is made using numerical modelling and results of complex experiments in the near-shore region of the Peter the Great Gulf. It is shown that multi-scale land-ocean interactions lead to the result that in shelf regions ocean exchanges its energy for terrigenous matter, which is of great importance for productivity and ecological state of shelf and adjacent to shelf open sea waters.

November 1, 17:20 (S8-13288)

Turbulent nitrate flux stimulates plankton productivity and trophodynamics even in the oligotrophic Kuroshio

Toru **Kobari**[1], Taiga Honma[2], Gen Kume[1], Daisuke Hasegawa[3], Koji Suzuki[4], and Naoki Yoshie[5], Xinyu Guo[5], Hirohiko Nakamura[1], Ayako Nishina[1], Eisuke Tsutsumi[6] and Takeshi Matsuno[6]

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Many migratory fishes show a risky life history to spend vulnerable life stages even under low food availability around the oligotrophic Kuroshio (i.e., the Kuroshio paradox). Here we report plankton productivity and rapid trophic transfer stimulated by ambient nitrate flux by turbulent mixing at the Tokara Strait in the Kuroshio based on the bottle incubation experiments. All size-fractionated phytoplankton demonstrated a logarithmic increase of apparent growth rate with nutrients concentrations and positive growths under the range of the ambient nitrate flux. Apparent growth rates were lower for pico- and nano-autotrophs than those for micro-autotrophs, indicating selective microzooplankton grazing in the bottles. While significant increase was not found for tintinnids and copepod nauplii, naked ciliates increased their biomass in the bottles for 3-days incubations. Mesozooplankton filtering rates were positive for athecate flagellates and naked ciliates, represented by major food items for mesozooplankton community. These results suggest that phytoplankton productivity and subsequent trophic transfer to zooplankton are elevated by turbulent nitrate flux. Such biogeochemical processes have been underestimated in the oligotrophic Kuroshio and might be a key to solve the Kuroshio Paradox.

November 1, 17:40 (S8-13404)

Phytoplankton distribution at a meter scale and a millimeter scale

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Phytoplankton requires both light and nutrient, thus requires staying in the upper ocean where turbulence stirs water column. Turbulence mixes oceanic properties, such as salinity and temperature. How does it mix phytoplankton? How do they distribute in space. Traditionally, biologists use Niskin Bottle (~1 m) to sample water in order to identify phytoplankton cells and measure the average concentration of chlorophyll. Therefore, no information is available how phytoplankton distributes below one-meter scale. A conventional CTD mounted cage may caries a Seapoint chlorophyll fluorometer that allows a fine scale observation of fluorescence. But the configuration of the probe prevents without disturbing the phytoplankton natural distribution. We have developed two types of fluorescence probe, LED (~2 cm resolution) and laser (~2 mm resolution) and mounted these probes on a free-fall microstructure profiler (TurboMAP-L). Both probes measure phytoplankton distribution without agitating the field. We have found the LED data are significantly different from the laser data that exhibit highly intermittent features. The LED fluorescence signals exhibit a lognormal distribution, but the laser fluorescence signals show a Gumbel distribution (extreme value distribution). High peak-to-peak signals follow the Poisson process, but when intermediate peaks are included in peak signals, the peak-to-peak intervals do not follow the Poisson process. The variability may be quantified by the coefficient of variation (CV=standard deviation/mean). The CV is high in open water and tends to be low in estuary and bay. The implication of micro-scale phytoplankton distribution is presented.

S9: Integration of science and policy for sustainable marine ecosystem services

October 30, 11:00 (S9-13733)

Arctic Council and ecosystem approach to management: Integrating ecosystem service science into guidelines

Elizabeth **Logerwell**[1] and Hein Rune Skjoldal[2]

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The Arctic Council is a high level intergovernmental forum to provide a means for promoting cooperation, coordination and interactions among the Arctic States, with the involvement of the Arctic Indigenous communities and other Arctic inhabitants. One of the Expert Groups of the Arctic Council is the "Ecosystem Approach Expert Group (EA-EG)". This Expert Group was formed in 2007 and is currently chaired by a Norwegian and a US scientist. One of the current tasks of the EA-EG is to develop guidelines for implementing the Ecosystem Approach to Management in Arctic ecosystems. The guidelines are based on a six-element framework: 1) Identify the geographic extent of the ecosystem; 2) Describe the biological and physical components and processes of the ecosystem; 3) Set ecological objectives that define sustainability of the ecosystem; 4) Assess the current state of the ecosystem (Integrated Ecosystem Assessment); 5) Value the cultural, social and economic goods produced by the ecosystem; 6) Manage human activities to sustain the ecosystem. The 5th element, Valuation, has proven to be a challenge. This presentation details current and ongoing efforts by the EA-EG to understand and conduct valuation of ecosystem services in the Arctic. We describe the challenges faced and seek input from participants in this session on how to achieve our goals.

October 30, 11:20 (S9-13268)

Evolution of district marine policies in China: The case of Shandong Province

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Shandong Province is among China's major marine provinces. The annual total output value of the province's marine economy has been ranked second in the country since 2013. This paper presents an evaluation of the marine district policies of Shandong Province. These policies can be divided into three stages according to the time sequence of policy promulgation: the fishery production and resource management period, the marine integrated utilization management period, and the marine ecological management period. The evolution of Shandong's marine policies was analyzed accordingly. Overall, the regional marine industry is on a good development track. However, many challenges remain regarding the formulation and implementation of the province's marine policies in the future.

October 30, 11:40 (S9-13272)

System analysis of Xiangshan bay ecological vulnerability assessment system based on VSD model

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This paper established the vulnerability assessment system of ecosystem in Xiangshan Bay based on the concept model of VSD. Through analysis and calculation, it is concluded that the vulnerability of ecosystem in Xiangshan Bay is in a moderate degree and the main stress factors are the development of port industry and aquaculture activities; System sensitivity factor is marine biodiversity index; The best adaptation strategy is to continuously improve the environmental protection laws and management mechanism and Strengthen environmental remediation

and increase investment in the third industry; The results showed that the assessment of ecological vulnerability in Xiangshan Bay is of great significance to the rational exploitation of natural resources and environmental protection in the economic construction. This paper collected the natural and social economic data of Xiangshan Bay, evaluated and analysed its Ecosystem vulnerability, in order to provide theoretical reference for the rational use of ecological resources in the development and construction of environmental protection, and provide the basis for ecological restoration work and regional sustainable development.

October 30, 12:00 (S9-13322)

Vulnerability to impacts of climate change on marine fisheries and food security

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Assessment of fisheries vulnerability to climate change is an important step for enhancing the understanding and decision-making to reduce such vulnerability. This study aimed to provide an analysis of country level vulnerability focusing on food security implications of climatic disturbances on marine fisheries. The comparative magnitude and distribution of potential food security impacts of climatic disturbances on marine fisheries were assessed for 109 countries by scoring and ranking countries against a set of vulnerability criteria including metrics of national exposure, sensitivity and adaptive capacity, highlighting the contribution of marine fisheries to national food and nutrition security. Results showed that developing countries in Africa, Asia, Oceania, and Latin America appeared to be most vulnerable, and the key sources of vulnerability differed considerably among the countries. For countries most vulnerable to climate-induced effects on marine fisheries, more than two-thirds of them depended on domestic marine fisheries as a main source of fish supply. Developing appropriate adaptation policies and management plans to reduce the impacts of changing climate is of great importance to sustain food security in these highly vulnerable and heavy marine fisheries-dependent countries.

October 30, 12:20 (S9-13351)

Environment and culture in an island community: Some insights for re-building the framework of cultural ecosystem service

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Ecosystem service is one of the most important concepts for both scientists and policy makes in natural resource management/conservation. Recently, there is a growing argument that cultural ecosystem services need to be better captured (Pascual et al. 2017). In spite of this growing discussion, however, ‘culture’ is a fairly broad concept. For sociologists and anthropologists, it is nearly equivalent to the concept of ‘society’ itself (Giddens 1982). Accordingly, the discussion for better addressing ‘cultural ecosystem service’ has been challenging. Given this circumstance, my work presents empirical evidence demonstrating how ecosystem and culture are interacted each other. I use an ethnographic case study of Shiraho village, Okinawan island, Japan.

Shiraho is a coastal village of Ishigaki island, with approximately 1600 population. Fishers in the community are mainly immigrants, who have been regarded as outsiders. However, results show that the interaction with coastal resources helped some immigrant fishers to be integrated in the community because 1) they have contributed to the community livelihood by providing seafoods, 2) they have build social interaction in the community by exchanging seafoods, and 3) they have learned socio-cultural manners through the use and exchange of seafoods. In other words, seafoods (coastal resources) are functioning as an intermediate for constructing the ‘culture’ and ‘society (community)’ itself in Shiraho village. This case study implies that we should re-build the framework of cultural ecosystem service, which will be achieved by cross-cultural/regional exploration over the ways ecosystem and culture are interacted each other.

October 30, 14:00 (S9-13435) CANCELLED

Ecological vulnerability based marine spatial planning: An implement in Xiamen Bay, China

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Marine and coastal ecosystems are vulnerable to the anthropogenic stressors and climate change. To protect those ecologically vulnerable and sensitive areas and to maintain the ecosystem services they provide, strict marine spatial planning called Marine Ecological Red Line (MERL) was proposed by the State Council of China. An integrated framework for marine ecosystem vulnerability assessment was developed to support the MERL system, including biotic and ecological factors as well as environmental features. Under this framework 29 indicators were proposed to measure the ecosystem vulnerability, meanwhile a ranking system was established to interpret the different priorities of ecological protection. Potential MERLs can be selected and subdivided into two grades according to the evaluation results. In the case of Xiamen Bay, 7.3% of the total area was identified as extremely high vulnerable and sensitive area, which will be managed as prohibited development zones (First grade MERLs). 12.5% of the total area was identified as high vulnerable and sensitive area, in which a policy of restricted development will be carried out (Second grade MERLs). This vulnerability based approach can be applied in the effective marine spatial planning, and to facilitate the ecosystem-based coastal management as well.

October 30, 14:20 (S9-13480)

Study on eco-compensation mechanism based on valuation of ecosystem services in marine protected areas

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Eco-compensation mechanism (EM) plays a critical role in the preparation and operation of marine protected areas (MPAs) which can effectively coordinate the conflict between economic interests and ecological interests in the environment protection. The ecosystem services as well as the spatial characteristics of ecosystem services supply and consumption of typical MPAs were analyzed. This paper discussed the subjects, objects and standards of eco-compensation in marine protected areas according to the related regulations and the result of ecosystem services valuation analysis of typical MPAs. As the result shows, the principles of EM-MPAs should follow the "beneficiary-paying" and "preserver being repaid" principle and encourage ecological protection behavior. The subjects of EM-MPAs are upper governments, and some designated government departments could be the agency of upper government to fulfill the obligations of eco-compensation. The objects of EM-MPAs are local government, local residents and the administrator of MPAs. The eco-compensation standards for local residents are confirmed based on the value loss of ecosystem services after the establishment of MPAs. The eco-compensation standards for local government and the administrator of MPAs depend on the increment in spillover value of ecosystem services of MPAs. Through a case study and theoretical analysis, we found the ecosystem services indicators related with eco-compensation standards of EM-MPAs are only including material supply, waste disposal, climate regulation and recreation. Finally, financial source, eco-compensation process of EM-MPAs and the credibility of eco-compensation standards were put forward for further studies.

Keywords: ecological compensation mechanism; marine protected areas; ecosystem services valuation

October 30, 14:40 (S9-13518)

Estimating the potential of Japanese fisheries: Upside Bioeconomic Analysis

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A fisheries policy reform plan by Japanese Fishery Agency proposes the move to maximum sustainable yield (MSY) based fisheries management by setting the total allowable catch for covering 80% of the total marine capturing fisheries production in Japan, and leasable individual quota to rationalize Japanese fisheries economically. To see the potential outcomes of the reform for biomass stocks and economic well-being of the fisheries sector, we conduct policy simulations applying the "upside" bio-economic analysis. Prefectural-level production and price information were extracted from Japanese Fisheries Agency's official statistics to construct a stock-level dataset for 96 stocks. With this dataset, a limited-data strategy is applied to estimate biomass that achieves the maximums sustainable yield (i.e. Bmsy). Given our Bmsy estimates, we simulate three possible policy scenarios: business-as-usual (BAU), a scenario that achieves the maximum harvest (Fmsy), and scenario that maximize the long-term economic gain (economic optimal). The simulation illustrates the 50-year projection of biomass level, harvests, and economic profit for each stock. We find that higher biomass level is achieved under economic scenario while BAU and Fmsy scenario yields similar biomass trajectories. While the economic optimal scenario allows Japanese fisheries to achieve the highest stock level, harvest, and profit in the long-run, many of fisheries are projected to face reduced harvests and profits in the short-run after shifting from BAU to economically optimal management. Our results demonstrate the possible trade-off of policy choice Japan may face in the near future.

October 30, 15:00 (S9-13627) CANCELLED

Valuation of marine ecosystem services: Experiences and lessons

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Marine ecosystem services (MES) are the benefits human beings obtain from marine ecosystem, which consist of the four services, i.e. the provisioning, regulating, cultural and supporting services. Some cases on valuation of MES all around the world have been checked and analyzed. The total value of MES ranks from million USD to ten millions USD. The provisioning services are the major of MES in many sea area at medium spatial scale while cultural services play the major role in the onshore and nearshore sea area at the small spatial scale. The value of MES shows the decreasing pattern from onshore to offshore. The value of MES highly depends on the sea use manners. There are some lessons from existing MES valuation cases. Firstly, there is misunderstanding on constituent of each ecosystem service in some cases. Secondly the identification process of each service is sometimes neglected in many cases. Thirdly, the method of reference, esp. The unit price or value per area or weight, is sometimes mis-used in many cases. The paper suggests the comprehensive understanding of MES valuation methods and their application conditions.

October 30, 15:20 (S9-13704)

Maritime special planning in Russia: Problems and prospective

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Russia is the great maritime power having the enormous resource potential which concentrated in a coastal zone. Geographic conditions of the areas washing Russia differ by an extreme variety. This defines different degree of their land reclamation, the involvement into economic circulation, vulnerability and sensitivity to anthropogenic influence. Economic activity in Russian Federation coastal zone is regulated on the basis of departmental approach and formed by the standards and legal base developed at the different state levels. High resources concentration, cross-border position, different degree of land reclamation leads to emergence of the conflicts. But it can't be settled within the current legislation. Thus the search of an optimal ways is necessary for environmental safety management in view of not only interstate interests and also international experience in the maritime special planning field. Maritime special planning system develops successfully in many countries of the world. However this question remains open in Russia. The analysis of activity in a coastal zone of Russia has shown that environmental management efficiency is low here. Russian Federation performs several obligations for using maritime spatial planning tools but only in the Baltic and Barents seas linked areas. Maritime special planning regulations only begins to be formed. Also interdepartmental cooperation will promote to successful realization of this process.

October 30, 15:40 (S9-13742) CANCELLED

Chinese experiences with the implementation of Marine Functional Zoning

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Marine functional zoning (MFZ) plays an essential role in controlling the use of the sea area, protect the marine ecological environment, and promote the rational development of the sea area and the sustainable development of marine economy. The Chinese government has adopted a series of laws, policies, technical standards and dynamic monitoring and management system to guide the use of sea areas and ensure the successful implementation of MFZ. Three generations of MFZ have been compiled and implemented. China's MFZ is divided into three levels: national, provincial and municipal according to geographical conditions, and two levels: 8 zones and 22 sub-zones according to their functional features. The implementation process of China's MFZ includes data collection, analysis and evaluation, zoning compilation, public participation, achievements review, zoning implementation, and monitoring and evaluation. Since the implementation of MFZ in China, marine economy has maintained steady growth; the structure of traditional marine industry (fishery, ports, oil and gas exploitation) and emerging marine industries (offshore renewable energy and sea water desalination) has been optimized; and more than 270 marine protected areas with a total area of more than 12 million hectares have been established, *etc*. The experience of implementing MFZ in China proves that it is an effective approach to carry out the ecosystem-based integrated marine resources management. National Ocean Technology Center (NOTC) hopes for the international cooperation in the field of marine functional zoning or marine spatial planning to promote the blue economy development and marine ecosystem protection.

October 30, 16:20 (S9-13772)

Crafting science-based ocean policy for sustained ecosystem services: Balancing place, people, and profits

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As stewards for ecosystem services, government resource agencies are responsible for establishing robust and comprehensive policy to guide management strategies that support and sustain the delivery of these services in the face of environmental change. Such policy must be based on sound science that considers diverse user sectors and emphasizes stewardship for sustainable ecosystem, societal, and economic benefits (place, people, and profits). This presentation will review the history of ocean and coastal policy development and implementation in the United States over the past two decades and reflect on its successes, challenges, and lessons learned, as it has evolved in response to political, social, and scientific changes. This policy has been shaped by: 1) the growing recognition of the intrinsic value of ecosystems; (2) better integration of natural and social sciences; (3) greater public engagement and public-private partnerships; (4) a transition to cross-sectoral and ecosystem-based management; (5) managing ecosystem services in the context of cumulative natural and human impacts; and (6) a greater incorporation of science into the decision making process. The transition to operational, science-based management that is compliant with Federal and other jurisdictional statutes and authorities remains a challenge to effective and continued delivery of ecosystem services.

October 30, 16:40 (S9-13776)

Using choice models to assess the economic value of large marine protected areas off the U.S. west coast

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Ecosystem services are generally thought to be the outcomes of ecosystem functions that provide value to people. Identifying and valuing these services through ecosystem service valuation (ESV) can facilitate the use of marine management paradigms as well as specific strategies that require an analysis of trade-offs associated with multiple, and sometimes conflicting, objectives. In this paper we contribute to the growing literature on ecosystem service valuation by presenting economic values associated with Large Marine Protected Areas (LMPAs) off the U.S. West Coast. Understanding these types of values is essential for assessing the costs and benefits of designating protected areas in the open ocean, and can facilitate the use of management frameworks such as Ecosystem-based Management, which explicitly considers competing objectives and their associated trade-offs in decision-making. Using data from over 3,000 randomly selected households in California, Oregon, and Washington we estimate choice models and calculate economic values (willingness-to-pay) for a suite of different size-use LMPA configurations. Our results show that designating ~15.6% of west coast Federal waters as a mixed-use MPA yields the highest economic value. Results also underscore the significance of the use regime allowed within MPA boundaries, demonstrating considerably different threshold sizes above which diminishing returns and negative economic values are derived from no-access, no-take, and limited use MPAs. Our results should be useful for marine managers desiring stakeholder input on marine conservation and managing the multiple uses of the open ocean.

S10: Ocean acidification and deoxygenation and their impact on ocean ecosystems: Synthesis and next steps

November 1, (S10-13644)-Plenary

O_2 trends in the last six decades

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Recent studies (Schmidtko et al. 2017 Nature; Ito et al. 2017 GRL) have revealed that global ocean has experienced substantial decline of ocean oxygen or the ocean deoxygenation, and the North Pacific is one of the basins where the largest oxygen decline occurred. The magnitude of oxygen reduction is stronger than simulated in climate models, indicating that it is important to understand the mechanisms of the past changes to assess the ability of the climate models and to improve them, to which we must rely on future projections. In the present study, I analyze global O2 trends with several aspects including O2 trends at z-coordinates and those at density-coordinates, by analyzing gridded O2 data with a focus of attention on the North Pacific. Both gridded data are produced in our laboratory. Consistent with previous studies, strong oxygen reduction trend is likely to be originated from the Okhotsk Sea at 26.8 and 27.0 density surfaces, but local maxima of negative trend at shallower levels are also found in mid-latitude eastern North Pacific and in the Bering Sea on the both coordinates. These results suggest that major mechanisms of the deoxygenation in the North Pacific may be different in the different regions.

November 1, 11:00 (S10-13688)

The large-scale distribution of dissolved inorganic carbon, alkalinity and oxygen in the North Pacific: A global ocean modelling perspective

James R. **Christian**[1], A.M. Holdsworth[1], W.G. Lee[2], O.G.J. Riche[1], A. Shao[3], N. Swart[2], and D. Yang[2].

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The North Pacific is one of the most difficult regions of the world ocean for global circulation-biogeochemistry models to accurately simulate, for a variety of reasons including its extreme geochemical stratification and the importance of tidal mixing and excess precipitation for ventilation. The Canadian Centre for Climate Modelling and Analysis has developed several new ocean biogeochemistry modules for use with the NEMO modelling system, and conducted global ocean simulations with these at several different model resolutions. The results show that models still have difficulty simulating realistically the extent of the eastern Pacific oxygen minimum zones, and that the distribution of alkalinity is distorted by overly simplistic representations of $CaCO_3$ export used in some CMIP5 models. Implications of these model errors for regional downscaling model experiments will be discussed.

November 1, 11:20 (S10-13657)

Long-term variability in the Oxygen Minimum Zone and carbonate chemistry in the North East Pacific and potential impacts on seamount communities

Tetjana **Ross**[1], Cherisse Du Preez[1], Debby Ianson[1], Tammy Norgard[2] and Marie Robert[1]

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The world's oceans are losing oxygen and acidifying, and the North East Pacific (NEP) is no exception. This region already has a relatively shallow hypoxic/anoxic zone that impacts marine ecosystems. In 2007, researchers showed that the upper boundary of the Oxygen Minimum Zone (OMZ) had shoaled from about 400 m to 300 m since 1956 in the NEP. This broadening of the OMZ was due to a combination of reduced ventilation of deep waters in the far field and increased stratification decreasing the amount of oxygen available below the upper mixed layer. Here we extend this previous analysis to lengthen the time series of OMZ along the Line P transect in the NEP to the present, showing that while the OMZ is no longer broadening as quickly, it still occupies a much larger portion of the water column than earlier in the record. Variability in the OMZ is highly relevant to seamounts in an offshore marine protected area that Canada is considering. Thus, we also estimate the impact of the broadening OMZ to the number of seamounts in that area that would have or will experience hypoxic conditions over time and show that one class of seamount community is at risk of disappearing entirely. In addition, we investigate trends in carbonate chemistry in the region and discuss their potential impacts on the seamount communities.

November 1, 11:40 (S10-13243)

Ocean acidification impacts on biogeochemistry and the decadal variability of Total Alkalinity in the North Pacific

Jessica N. **Cross**[1], Brendan R. Carter[2], Samantha A. Siedlecki[3], Simone R. Alin[1], Nina Bednarsek[4], Andrew G. Dickson[5], Richard A. Feely[1], Richard H. Wanninkhof[6], Alison M. Macdonald[7], Sabine Mecking[8], and Lynne D. Talley[5]

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Recent observations of acidification-driven shoaling of the calcium carbonate saturation horizon in the North Pacific have prompted new interest in carbonate cycling related to impacts on biogenic calcification at the surface layer in this region. Acidification can decrease biogenic precipitation and increase dissolution of some carbonate minerals, leading to increases in ocean alkalinity. Some estimates project that these impacts of OA on alkalinity cycling are now beginning to emerge. Here, we present total alkalinity concentrations from over a period of three decades for the North Pacific. Extremely precise measurement techniques used during the extended time series (WOCE, CLIVAR, U.S. GO-SHIP) reveals extremely fine-scale variability related to decadal circulation oscillations, ocean biogeochemical cycles such as the carbonate pump, and global change processes such as ocean acidification and uptake of anthropogenic CO_2. We compare our recent results to previous projections and models to scale potential coming changes.

November 1, 12:00 (S10-13810)

A model simulation of future biogeochemical conditions along the British Columbia Continental Shelf

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The British Columbia (BC) shelf is at the northern end of the California Current System and is influenced by summer coastal upwelling, mesoscale eddies, and freshwater inputs. A regional coupled circulation-biogeochemical (ROMS) model of this region has been developed to gain a better understanding of the processes determining the temporal and spatial distribution of low oxygen and CO_2-rich waters in the BC coast. The model is also being used to evaluate the potential impact of climate change on the biogeochemistry of the region. This talk will present initial results from simulations of present and future conditions. In particular, we will focus on changes in ocean acidification, oxygen distribution and the biological carbon pump.

November 1, 12:20 (S10-13653)

High resolution biogeochemical modelling of Canadian Northeast Pacific waters

Amber M. **Holdsworth**, James R. Christian, and Youyu Lu

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A high resolution regional con guration of NEMO 3:6 has been developed for the Northeast Paci c Ocean incorporating the Canadian Ocean Ecosystem Model (CanOE). The Northeast Paci c (NEP36) model has a resolution of 1=36 (2 3) km and includes the e ects of tidal mixing. The ocean is forced with atmospheric elds from the Canadian Regional Climate Model (CanRCM4). A simulation representing an historical 1986 2005 climatology is compared with one representing a future 2046 2065 climate using the RCP4.5 emissions scenario. We examine changes in strati cation, productivity, oxygen content, dis-tribution of nutrients and carbon chemistry in the diverse regions of the Canadian Paci c Coast including Juan De Fuca Strait, Queen Charlotte Sound, and the oceans surrounding Haida Gwaii.

November 1, 14:00 (S10-13831) Invited

Confronting the complexities of ecological responses to ocean acidification

Christopher D.G. **Harley**

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Ocean acidification (OA) is a substantial threat to marine species and ecosystems, but its effects will range from subtle to substantial depending on the environmental context, the physiology and genetic diversity of the affected species, and the ecological relationships among species within an ecological community. I will present a framework for moving beyond single-species, single-stressor studies in order to appropriately capture this complexity. Specifically, I will consider the roles of 1) multiple stressors, 2) intra- and inter-generational population effects, and 3) species interactions. Although multiple stressor effects, most notably between temperature, oxygen, and OA, have a certain degree of physiological theory underpinning our understanding of their combined action, current results do not always agree well with existing theory. Population dynamic effects highlight the importance of thresholds and tipping points, and emphasize the importance of considering genetic diversity and multiple life history stages. Interspecific interactions ranging from prey abundance to predator effects to biogenic habitat availability may all be relevant, and understanding these effects are especially important for certain species and in certain contexts. I will illustrate these ideas with examples from marine invertebrate species, which are often economically valuable, ecologically important, and experimentally tractable. Although ocean acidification effects are challenging to generalize, there are key attributes of species and systems that may make them more or less vulnerable and can serve as a starting point for anticipating future change.

November 1, 14:30 (S10-13315)

Effects of ocean acidification on phytoplankton physiology and primary productivity

Kunshan **Gao**

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When exposed to CO_2 concentrations projected for the end of this century, surface-water phytoplankton assemblages in the South China Sea (SCS) responded with decreased photosynthetic carbon fixation, increased non-photochemical quenching (NPQ) and declined abundance of diatoms. When diatoms were grown at different CO_2 concentrations under varying levels (5-100%) of solar radiation, growth rates in the high CO_2-grown cells were inversely related to light levels, and exhibited reduced thresholds at which PAR becomes excessive, leading to higher NPQ. That is, elevated CO_2 concentrations (lowered pH) impaired the specific growth rate of diatoms at high, but enhanced it at low to moderate levels of solar radiation. These puzzling results are explained as follows: elevated CO_2 concentrations down-regulate the uptake capacity (CO_2 concentrating mechanisms) of the cells for dissolved inorganic carbon, so that energy, which is used for the active uptake mechanism, is saved and the diatoms' growth at low irradiances is augmented; on the other hand, at high levels of solar radiation, the saved light energy could add to enhance photoinhibition and photorespiration. Additionally, OA increases contents of phenolic compounds in phytoplankton and in zooplankton assemblages fed with OA-grown phytoplankton cells. The observed accumulation of the toxic phenolic compounds in primary and secondary producers can have profound consequences for marine ecosystem and seafood quality, with a possibility that fisheries industries could be influenced due to progressive ocean changes.

(based on the results published at *Nat Clim Change, Nat Comm*, to download the full papers: *http://mel.xmu.edu.cn/staff_publications.asp?tid=35*)

November 1, 14:50 (S10-13260)

Increase in acidifying water in the western Arctic Ocean

Di **Qi**[1,2], Liqi Chen[1], Baoshan Chen[3,4], Zhongyong Gao[1], Wenli Zhong[5], Richard A. Feely[6], Leif G. Anderson[7], Heng Sun[1], Jianfang Chen[8], Min Chen[2], Liyang Zhan[1], Yuanhui Zhang[1], Wei-Jun Cai[3, 4*]

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The uptake of anthropogenic CO_2 from the atmosphere by the ocean has decreased seawater pH and carbonate mineral saturation state, a process known as Ocean Acidification (OA), which could be detrimental to marine organisms and their associated ecosystems[1,2]. It has been reported that the Arctic Ocean is particularly sensitive to climate change[3] and that the aragonite mineral saturation state (Ω_{arag}) will become undersaturated sooner than in other oceans[4]. The extent and expansion rate of OA, however, are still unknown. Here we show that low Ω_{arag} waters were largely confined to 50-150 m depth and south of 80ºN in the 1990's, but data from multiple trans-western Arctic Ocean cruises show that the extent of low Ω_{arag} waters has since expanded to 50-250 m and to 85ºN. The vertical distribution of the Ω_{arag}<1 water has increased by about six-fold between the 1990's and 2010 (from 5 to 31% of the total area in the upper 250 m north of 70ºN). Tracer data and model simulations suggest that the recent increase in Pacific Winter Water (PWW) transport, driven by anomalous circulation pattern and sea-ice retreat, is primarily responsible for the rapid expansion of the low Ω_{arag} water. Local carbon recycling and anthropogenic CO_2 uptake have also played roles in increasing the extent of the affected area. Our new results indicate that rapid acidification has happened in the Arctic Ocean and is far more serious than that in the Pacific and Atlantic Oceans where decadal OA trends have recently been reported[5-8], making the western Arctic Ocean the first open-ocean region with such a large-scale expansion of "acidified" water directly observed in the upper water column.

November 1, 15:10 (S10-13498)

Evaluation and prediction of the influences of ocean acidification to the subarctic coast

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As ocean acidification proceeds, it is concerned difficult for calcium carbonate and magnesium carbonate to be produced in the ocean, and calcifying organisms such as corals and shellfish having these skeletons and shells may be adversely affected. Moreover, the diurnal, seasonal and interannual fluctuation are all considered more prominent in coasts than in the open ocean, because of relatively larger amount of sea grass beds and more direct and significant terrestrial impacts. On the other hand, in the subarctic coastal region, it is difficult to maintain observation due to stormy weather in winter, which yields paucity of observational data. In this study, long-term continuous monitoring of physical and biogeochemical parameters was conducted in Oshoro Bay, Otaru City, Hokkaido. Our results show that the timing of increase and decrease of pH and dissolved oxygen almost coincided with each other, and the diurnal variation of pH was larger in spring and summer than in fall and winter. The diurnal variation of pH was 0.1 or more on average from May to August. The variation was 0.15 on average and 0.26 at the maximum, respectively, in August. That was 0.03 on average and 0.07 at the maximum, respectively, in November. Thus, the seasonal difference in the diurnal variation was clear, suggesting significant effects of the photosynthesis in the daytime and the respiration in the nighttime by primary producers. The results suggest relatively predominant biological effects with larger biomass and higher solar radiation in summer compared to those in winter.

November 1, 15:30 (S10-13726)

Effects of ocean freshening and acidification on benthic animals of Antarctica

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Climate change poses a big threat to the Antarctic ecosystem. Warming induces glacier retreat and eventually salinity of seawater can decrease by melting water. Also increased CO_2 induced by human activity can decrease the seawater pH in the Antarctica. Here we were interested in how the marine benthic ecosystems in the Marian Cove will change in response to freshening and acidification. We selected Antarctic amphipods (*Gondogeneis Antarctica*) living in the shallow water and limpets (*Nacella concinna*) living in the intertidal region as model animals to predict the fate of benthic animals in future. We exposed them to 4 treatments combined with 2 salinity (34 and 27 psu) and 2 pH regimes (pH 8.0 and 7.6). Though many behavioral aspects remained same under changed conditions, shelter using behavior of amphipods were retarded and moving distance of limpets decreased in the low pH and low salinity treatment. In order to investigate if ocean acidification influence the Antarctic clams *Laternula elliptica* in Antarctica, change from during 1993 ~ 2010, degree of corrosion of the shells and composition were measured using Scanning Electron Microscope (SEM) and X-Ray Diffractometer (XRD). The degree of corrosion of the shell (white pixels / total pixels ratio) increased from 1993 to 2010. The composition ratio of XRD samples changed as the aragonite ratio decreased from 1993 to 2010.We suspect that multiple stressors of climate changes can induce behavioral changes in the marine benthos in the Antarctica and eventually this may result in breaking the balance in the ecosystems in the Antarctica.

November 1, 15:50 (S10-13712)

Effects of ocean warming and acidification on the growth and toxicity of *Pseudo-nitzschia australis* from the California Current Upwelling system

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An ecologically and economically disruptive bloom of *Pseudo-nitzschia australis* Frenguelli affected much of the California eastern boundary upwelling system (EBUS) during the prolonged anomalously warm conditions of 2015. Two critically important changes observed in these EBUS coastal waters - increased temperature and elevated CO_2 levels - were examined in controlled laboratory studies of *P. australis* isolated from this massive bloom. Non-axenic strains of *P. australis* were exposed to a range of ecologically-relevant temperatures, and four pH levels (8.1, 8.0, 7.9 and 7.8) regulated by direct injection of compressed CO_2/air mixture into culture flasks over a complete growth cycle of nutrient-replete exponential growth, and nutrient-limited stationary growth. Maximal growth rates were reached at 17–18 °C, with specific growth rates increasing by 3-fold from 5 to 17 °C. Production rates of the potent neurotoxin, domoic acid (DA), did not increase as fast as specific growth rates, resulting in less toxic, but greater cell abundances at higher temperatures. In the pH study, stationary phase cells increased DA production as pH declined, and particulate DA was 3-fold greater at pH 7.8 compared to pH 8.1. However, exponential growth rates were not affected by pH until a critical pH of 7.8 was reached, and growth rates declined by 30%. These laboratory results reveal the adaptive capability of this pennate diatom to rapidly increase its growth potential in warmer waters, and to become increasingly toxic in more acidic waters - environmental conditions expected in the California EBUS due to CO_2-induced ocean acidification and greenhouse warming.

November 1, 16:30 (S10-13453)

Evaluation of carbon chemistry along the near-shore coast of Japan

Haruko. **Kurihara**[1], Naoko Yasuda[1], Michiyo Yamamoto-Kawai[2], Shota Shimizu[3], Masahiro Nakaoka[4] and Hyojin Ahn[4]

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Increase of atmospheric CO_2 causes change of seawater carbon chemistry which is now called as Ocean acidification (OA, IPPC 2007). When CO_2 dissolve into the seawater, proton is released and concentration of carbon ion (CO_3^{2-}) decrease. Because calcium carbonate saturation (Ω) is defined by the concentration of CO_3^{2-}, OA is also known to cause the decrease of Ω. Seawater pH and Ω decrease has been demonstrated that can directly affect the physiology of marine organisms, particularly marine calcifires (Kleypas et al. 2005, Fabry et al. 2008). Hence, there is now a strong need for evaluation the ocean carbon chemistry to predict the potential effects of OA on marine ecosystems. However, although open water carbon chemistry is relatively well studied (Doney et al. 2010), presently there is very few long-term carbon chemistry data at coastal water. At near shore water, biological metabolic feedback is proposed to strongly affect the seawater carbon chemistry, and hence show dynamic diurnal and seasonal variation (Feely et al. 2008). Additionally, coastal water shows highest productivity and biodiversity in the ocean, where we also depend on most of our marine food sources.

In this study, for the aim of understanding the OA effect along the coast of Japan, here we first present a long-term carbon chemistry data obtained from 3 sites, extending from sub-arctic region (Hokkaido) to sub-tropical region (Okinawa). Data demonstrate that all 3 sites show highly different pattern of carbon chemistry, with highest seasonal variation at sub-arctic region. Annual average Ω was 3.73, 3.26 and 1.96 at Okinawa, Chiba and Hokkaido respectively, Potential biological implication will also be discussed.

November 1, 16:50 (S10-13582)

Photosynthetic activity of early successional phytobenthos at a shallow CO_2 seep off Shikine Island, Japan

Shigeki **Wada**[1], Agostini Sylvain[1], Ben Harvey[1], Yuko Omori[2], Jason Hall-Spencer[1,3]

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Emission of anthropogenic CO_2 is causing ocean acidification. Shallow CO_2 seeps have been used as natural analogues of ocean acidification to evaluate the impact on ecosystem, and we discovered novel CO_2 seeps in Shikine Island in Japan a few years ago. There is a change in community composition of the benthic flora along the CO_2 gradient, which may affect primary production. Here, we deployed settlement plates at acidified and control sites to collect early successional stages of the benthic algal community. Amounts of chlorophyll *a* on each plate was comparable between the two sites, suggesting similar standing biomass across CO_2 treatments. The plates were incubated in light vs. dark conditions to measure photosynthesis. Photosynthetic activity was significantly higher at the acidified site. This is explained by the fact that on plates collected from acidified site, diatoms covered most of substratum and that these diatom were easily flushed off by wave action. At ambient levels of CO_2 the plates had a mixed assemblage of algae, with more firmly attached macrophytes. Therefore, the carbon fixed by photosynthesis in the high CO_2 environment is more easily transported away and does not accumulate as biomass in the coastal region.

November 1, 17:10 (S10-13278)

The ecological effects of ocean acidification in the North Pacific Ocean

Jason **Hall-Spencer**, Ben Harvey, Shigeki Wada, Koetsu Kon, Marco Milazzo, Kazuo Inaba, Sylvain Agostini

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To assess the likely ecological effects of ocean acidification we compared intertidal and subtidal marine communities at increasing levels of pCO_2 at recently discovered volcanic seeps off the Pacific coast of Japan (34°N). This study region is of particular interest for ocean acidification research as it has naturally low levels of seawater pCO_2 (280-320µatm) and is located at a transition zone between temperate and sub-tropical communities. We assess the effects of ocean acidification at the temperate/tropical biogeographic boundary. Marine communities exposed to mean levels of pCO_2 predicted by 2050 experienced periods of low aragonite saturation and high dissolved inorganic carbon. These two factors combined to cause marked community shifts and a major decline in biodiversity, including the loss of key habitat-forming species, with even more extreme community changes expected by 2100. Our results provide empirical evidence that near-future levels of pCO_2 shift sub-tropical ecosystems from carbonate to fleshy algal dominated systems, accompanied by biodiversity loss and major simplification of the ecosystem.

November 1, 17:30 (S10-13540)

Effects of ocean acidification on net community production in coastal ecosystems: *In situ* assessment in natural CO_2 seeps

Shingo **Kurosawa**[1], Shigeki Wada[1], Sylvain Agostini[1], Ben Harvey[1], Marco Milazzo[2] and Jason Hall-Spencer[1, 3]

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Primary producers play a fundamental role in marine ecosystems. Anthropogenic CO_2 emissions are causing ocean acidification which is rapidly changing the carbonate chemistry of surface seawater worldwide. In high CO_2 world, it is expected that plant and algal growth will be enhanced both in the sea and on land due to greater carbon availability for photosynthesis. Submarine volcanic CO_2 seeps can provide natural analogues of ocean acidification where ecosystems have had chronic exposure to high CO_2. Here, we focused on CO_2 seeps off Shikine Island, Japan, where macroalgae are the dominant primary producers. We haphazardly placed a transparent flexible chamber with a dissolved oxygen sensor at acidified and a reference sites to evaluate daytime *in situ* photosynthesis. We calculated the net photosynthetic rates per area based on the slope of linear regression (dissolved oxygen vs incubation time). As expected, photosynthesis rates per area increased significantly with increases in solar irradiance. The slope of the regression lines (net photosynthesis vs solar irradiance) implies community production normalized by solar irradiance, and the values were 0.99 - 2.2 × 10^{-2} and 0.97 - 3.4×10^{-2} (mol O_2/mol photons) in acidified and control sites, respectively. As a result, the slope values in the acidified site were 143, 92, 72, and 58% of those in reference site in June, November, December and January, respectively. Against expectations, community production normalized by solar irradiance did not increase in the acidified conditions, despite high CO_2 conditions.

November 1, 17:50 (S10-13436)

Dissolution: The Achilles' heel of gastropods in an acidifying ocean

Ben P. **Harvey**[1], Sylvain Agostini[1], Shigeki Wada[1], Kazuo Inaba[1] and Jason M. Hall-Spencer[1, 2]

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Ocean acidification is expected to negatively impact many calcifying marine organisms by impairing their ability to build their protective shells and skeletons, and by causing dissolution and erosion. Here we investigated the large predatory 'Triton shell' gastropod *Charonia lampas* in acidified conditions near CO_2 seeps off Shikine-jima (Japan) and compared them with individuals from an adjacent bay with ambient seawater pH. By using computed tomography and electron microscopy we show that acidification negatively impacts their thickness, density and shell structure, causing visible deterioration to the shell surface. Periods of aragonite undersaturation caused the loss of the apex region, exposing body tissues. While gross calcification rates were likely reduced near CO_2 seeps, the corrosive effects of acidification were far more pronounced around the oldest parts of the shell. As a result, the capacity of many marine gastropods to maintain their shells under ocean acidification may be strongly driven by abiotic dissolution and erosion, and not under biological control of the calcification process. Understanding the response of marine calcifying organisms and their ability to build and maintain their protective shells and skeletons will be important for our understanding of future marine ecosystems.

S11: Influence of climate and environmental variability on pelagic and forage species

November 1, 11:00 (S11-13812) Invited

Present situation and future prospects of study on sardine and climate change

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More than 30 years has passed since the effects of climate on sardine stock have been pointed out. I'll introduce a recent study on the climate impacts on variation in abundance of Japanese sardine (*Sardinops melanostictus*) and what is the problem about that left for future.

An empirical model can mostly reproduce the sardine recruitment rate with sea surface temperature (SST) in the Kuroshio and density effect for passed 30 years. But how the SST controls the recruitment? And what is the density effect? There are other unanswered questions. The recruitment variation of sardine is 'mostly' explained by above two factors then, how about the influence of other factors? Interannual variation of the spawning behavior may have some impacts on the recruitment success, because the spawning grounds and season of the Japanese sardine vary drastically depending on the stock level. How do we think of the species replacement between sardine and anchovy? Some studies implied the opposite response of sardine and anchovy on the climate change. However, a recent study that reproduced millennial scale stock variation of sardine and anchovy suggests that the species replacement rarely occurred. Another recent study shows a reliable evidence of the interspecific competition between sardine and anchovy. The climate change impact on the sardine is not simple and here are many possible controlling factors. In the next step, it is necessary to know the detailed role and function of climate change among interacting multiple controlling factors.

November 1, 11:30 (S11-13667)

Practical procedure for potential fishing zone prediction of neon flying squid (*Ommastrephes bartramii*) in the north western North Pacific

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The neon flying squid (*Ommastrephes bartramii*) has a wide-spread distribution in subtropical and temperate waters in the North Pacific, which plays an important role in the pelagic ecosystem and is one of the major targets in Japanese squid fisheries. We have constructed a habitat suitability index (HSI) model for neon flying squid using the Japanese commercial fishery dataset collected in winter, January-March, during 2001-2011 and 4D-VAR ocean reanalysis data set MOVE. We employed maximum entropy (MaxEnt) as a habitat model. There were two oceanographic conditions, eddy develop and eddy non-develop, during 2001-2011. The predictive performance of models was evaluated based on area under the ROC curve (AUC) computed from independent data projections (January-March 2017, eddy develop year). Mean AUCs obtained for eddy year, non-eddy year, and overall year models, showed that eddy year model was highest. We propose a practical procedure to use synchronize the model for eddy year or non-eddy year. In the case of 2017, eddy year, in advance two months before fishing season, we can identify eddy develop or eddy non-develop, then we can advise fisher to decide to go to off Sanriku to catch neon flying squid, not to go to Japan Sea to catch common flying squid as fishing strategy. This practical procedure could be useful for economic catch planning and tactical fisheries activities management.

November 1, 11:50 (S11-13531)

Recent decline in winter stock of Japanese flying squid, *Todarodes pacificus* related to climate change during winter-spring

Yasunori **Sakurai**

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Japanese flying squid, *Todarodes pacificus* is a nerito-oceanic squid. There are subpopulations with different peak spawning seasons and areas, of which autumn and winter spawning populations are the largest and commercially most important. Annual catches of *T. pacificus,* especially of the winter spawning population decreased during the cool regime period from the late-1970s to late-1980s, while Japanese sardine, *Sardinopsis japonicus* increased exponentially. After the late-1980s warm regime period, squid catch had increased and sustained the Japanese squid markets. Recently, after 2016 the catch of winter population has extremely declined while after 2010 the catch of Japanese sardine has increased, which is very similar to "species replacement phenomenon". We can map the inferred spawning grounds defined using the SST areas between 18-24ºC, especially between 19.5-23ºC and within a specific range of bottom topography (100-500m depth). Here we used the relative status of inferred spawning grounds to explain the recent winter stock decline and the possibility of species replacement to cool adaptive sardine. After the winter of 2016, the inferred spawning areas of the winter stock in the East China Sea shrank and reduced to the continental edge off the Kyushu Island and the Nansei Islands. The climate change after 2016 introduced anomalous cold water induced by a strong winter monsoon. Hence the recent winter stock decline is thought to have occurred because the inferred spawning areas in winter were covered by cold sea surface water below 18ºC, which severely affects the survival of hatchlings.

November 1, 12:10 (S11-13506)

Analysis of monthly variation of fishing zone for Pacific saury using Multi-Sensor satellite and fishery data

Yang **Liu**[1], YongJun Tian[1], Hao Tian[1], Guanyu Chen[1], Jianchao Li[1], Shigang Liu[1], Luxin Yan[1], Yuan Li[2] and Long-Shan Lin[2]

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Pacific saury (*Cololabis saira*) is one of the most important commercial pelagic fish species being harvested in the northwestern Pacific Ocean region. Spatial and temporal dynamic monitoring of fishing boats has become an important data source for understanding the distributional dynamics of fisheries. Visible infrared imaging radiometer suite (VIIRS) Day / night band (DNB) night-time remote sensing images can be used to monitor fishing activities at night. The results shown that, spike detection and threshold segmentation techniques were the best method to identify night light of fishing boats. GIS tools could be used to extract and analyze the fishing boat position and operation status. Combined with environment factors (SST, Chl-a concentration and wind velocity), fishery data and generalized additive model to detect habitat preferences of Pacific saury, we understand the seasonal variations of fishing zone associated with marine environment change.The method proposed in this study can effectively identify the location and operation status of Pacific saury fishing boats, and provide useful information for understanding the spatial distribution and dynamics of Pacific saury fishing zone in the northwest Pacific region. In the future, this information could be useful to forecast the Pacific saury fishing zone and to assess the fishery resources.

November 1, 12:30 (S11-13482)

Spatial distributions and catch rates variability of Bigeye tuna (*Thunnus obesus*) cohorts related to oceanographic and climatic indices in the Pacific Ocean

Tzu-Hsiang **Lin** and Kuo-Wei Lan

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The bigeye tuna (*Thunnus obesus*, BET) is one of the important commercial species for longline fisheries in Pacific Ocean. In this study, we collected the long-term (2002-2012) records of bigeye tuna catch rates, length data of longline fisheries and divided into immature and mature group. The generalized additive models (GAMs) were used to investigate the relationships between environmental variables and catch rates for evaluating the fishing condition of the immature group and mature group of BET. The model selection processes showed the cumulative deviances explained by selected GAMs were 32.9% and 38.1% in immature group and mature group respectively. The result showed the catch rates were significantly correlated with the temporal (year and month), spatial (longitude and latitude), environmental variables of sea surface temperature (SST), chlorophyll-a concentration (CHL) , mixed layer depth (MLD), sea surface height (SSH) and climate index (Pacific Decadal Oscillation and North Pacific Gyre Oscillation). A similar pattern of immature and mature group revealed positive correlations for the catch rates and SST in the range 26-28□, 0.1-0.2mg/m^3 of CHL, 0.4-0.5 m of SSH, and 60-100 m of MLD. However, the MLD explained the greatest amount of deviance for the immature group, but the greatest amount of deviance was CHL for the mature group. As a result, we speculating that the movement patterns of tunas are under the control of the environmental conditions, because the time and areas strata favorable for spawning and for feeding are limited and variable in time and space.

November 1, 14:00 (S11-13824)

Climate and potential impacts on distribution and life history: Arctic cod and saffron cod, and Pacific sand lance and Pacific herring

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Environmental conditions have important influence on the distribution and life history of pelagic fishes. Directional shifts in climate or persistent climate phases may have profound effects on the relative distribution and competitive interactions between species within similar diet guilds and in similar trophic position. Pelagic forage fishes are known to exhibit dramatic shifts in relative abundance and, with few exceptions, are generally categorized as data-poor species. This presents challenges to understanding the dynamics of these species. Using observed shifts in distribution of these fishes to periodic warm and cold periods and the influence of the recent anomalous warming in the eastern Pacific, this talk considers the effects of a warming climate on four species – Arctic and saffron cod and Pacific herring and Pacific sand lance. Known differences in growth rates and temperature tolerances for the two Arctic gadids are compared to interpret shifts in distribution 2000-2017 and to project how these species might react to a warming Arctic. Distribution patterns in Pacific herring and life history trends across latitudes and experimental studies on temperature tolerance thresholds in Pacific sand lance are also used to consider how two ecologically important Pacific forage species might respond to warming conditions.

November 1, 14:20 (S11-13698)

Biogeographic patterns of marine communities in the Pacific Arctic under a warming ocean

Irene D. **Alabia**[1], Jorge García Molinos[1], Sei-Ichi Saitoh[1], Takafumi Hirata[2], Toru Hirawake[1], and Franz J. Mueter[4]

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4 University of Alaska Fairbanks, Juneau, AK, USA

Climate changes alter species distributions and diversity patterns in marine ecosystems. Here, we investigated possible consequences of changes in habitat and diversity patterns of fish and invertebrate taxa due to ocean warming and sea ice loss in continental shelves of Eastern Bering and Southern Chukchi seas. Changes in the present-day species-specific habitat patterns and biodiversity components were examined under two contrasting CMIP5 emission scenarios. The ensemble habitat models were developed using species occurrences from the NOAA summer (June-August, 1993-2016) bottom trawl surveys and environmental factors (winter sea surface temperature, sea ice concentration, and depth). Comparative analyses between the current and future habitat and diversity patterns highlighted notable potential habitat changes concomitant with biogeographic shifts, dependent on the period and magnitude of warming. Specifically, warm and sea ice-free waters led to the emergence of suitable habitat for warm-adapted species in the north that will likely become accessible with the projected decay of the cold pool feature under such climatic conditions. More importantly, these climate-driven biogeographic shifts resulted to the redistribution of biodiversity, defined by homogenization and diversification of marine communities in the subarctic and Arctic regions, respectively.

November 1, 14:40 (S11-13735)

Ecosystem stress test: What an ice-free winter might mean for the eastern Bering Sea

Janet Duffy-Anderson[1], Elizabeth **Siddon**[2], Phyllis Stabeno[3], Alex Andrews[2], Ali Deary[1], Corey Fugate[2], Colleen Harpold[1], David Kimmel[1], Jesse Lamb[1] and Steve Porter[1]

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During the winter of 2017-2018, the Bering Sea experienced the lowest recorded sea ice extent in the satellite era (1978-present). This drastic decline in ice extent resulted in a complete lack of ice melt over the southern shelf and the potential for minimal sea ice-mediated productivity. Our mechanistic understanding of recruitment controls for juvenile fish indicate bottom-up forces drive cohort success (or failure) in years with above-average water temperatures. We provide real-time ecosystem observations of the influence of an ice-free winter, the progression of ocean heating, and impacts to system-wide productivity. Spring surveys in April and May of 2018 documented reduced stratification, a month-long delay in the timing of the spring bloom, and low abundance and quality of crustacean zooplankton. However, the production of larval walleye pollock (*Gadus chalcogrammus*) remained high, indicating a potential temporal mismatch with lower trophic level productivity. A reduction in trophic transfer could subsequently impact adult fish, bird, and marine mammal species. A late-summer survey in August and September of 2018 will provide information on survival and condition of key zooplankton prey taxa and forage fish species. In the near-term, these ecosystem observations and indicators enable climate-informed stock assessments; in the long-term, this research elucidates mechanisms linking climate with recruitment dynamics and provides a glimpse of the Bering Sea ecosystem under future projections of limited sea ice.

November 1, 15:00 (S11-13673)

Community and trophic impacts of the unprecedented North Pacific marine heatwave on forage taxa in the northern California Current

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Forage taxa play a central role in transferring energy from lower to higher trophic levels. Ocean conditions may influence this energy pathway in the northern California Current (NCC) ecosystem. The recent unprecedented warming in the NCC provides a unique opportunity to better understand the connection between ocean conditions and forage taxa abundance, distribution patterns, and feeding. We present findings from two studies that suggest that the extended warming period associated with the 'Warm Blob' and El Niño affected forage taxa to a dramatic degree. Pelagic trawl surveys were conducted off Oregon and Washington during early summer of 2011 and 2013-2016 and examined for interannual changes in spatial distribution of fish and invertebrate taxa. The community was significantly different in both 2015 and 2016 than the earlier cool years. Crustacean plankton densities were extremely low in both years, and the invertebrate composition became dominated by gelatinous zooplankton. Stomach collections of multiple forage fishes off the Washington and Oregon coasts were examined from June during recent warm years (2015 and 2016) and compared to previous collections from 2000, 2002, 2011, and 2012 (average or cool years). Fish feeding habits and stable isotope signatures varied significantly between cold and warm periods. Euphausiids, decapods, and copepods were the main prey items of the forage fishes in cool years, however gelatinous zooplankton were consumed in higher quantities in warm years. The substantial reorganization of the pelagic forage community has the potential to lead to major alterations in trophic functioning in this normally productive ecosystem.

November 1, 15:20 (S11-13448)

Application of time series analysis to detect the effect of multi-scale climate indices on global yellowfin tuna population

Yan-Lun **Wu** and Kuo-Wei Lan

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The biophysical effects of large-scale environment and climatic indices play a critical role in controlling tuna distribution and abundance. In this study, we collected Taiwanese longline fishery data to investigate the yellowfin tuna distributions and fluctuation of catch rate based on global scales the period of 1980-2010 by using advanced time series analysis, including the state-space approach to remove seasonality, wavelet analysis to investigate transient relationship and multiple regression to revealed significant climate indices from each area. Cross-wavelet coherence of the standardized CPUE in western and eastern Pacific Ocean were found to have a periodicity of 2~3 year and 2~6 year with Atlantic Ocean and Indian Ocean, repectively. Results of multiple regression revealed the Atlantic Multi-decadal Oscillation (AMO), Pacific Decadal Oscillation (PDO) and the North Pacific Gyre Oscillation (NPGO) were significantly influenced the standardized CPUE and gravity of fishing grounds of global yellowfin tuna. In additional, longitudinal gravity of fishing grounds revealed significantly correlated with the Dipole Mode Index (DMI) and Ocean Nino Index (ONI) in Indian Ocean and Pacific Ocean. The results suggested the long-term decadal climate indices such as AMO, PDO and NPGO will affect the population abundances, however, interrannual variability (e.g., DMI and ONI) only lead to the spatial variations of fishing grounds.

November 1, 15:40 (S11-13650)

Long-term variations and hotspots in habitat of Japanese-Spanish mackerel (*Scomberomorus niphonius*) based on spatial analysis

Peng **Lian**[1], Yongjun Tian[1,2], Jianchao Li[1], Haiqing Yu[1], Yang Liu[1], Caihong Fu[3], Xindong Pan[1], Qinghuan Zhu[1], Chi Zhang[1], and Zhenjiang Ye[1]

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Japanese-Spanish mackerel *(Scomberomorus niphonius)*, with high yield of more than 400,000 tons in recent years, is one of the major targets of fishing in coastal waters of China. However, in spite of the dramatic population fluctuations as well as the significant descending trend in catch of its prey (e.g., *Engraulis spp.* and *Clupea spp.*), the mackerel maintains the relatively sustained high catch regardless of the co-effects of overfishing and climate change. To better understand the relationship between population dynamics of Japanese-Spanish mackerel and climate change, machine learning were used to identify the hotspots of distribution and classify the regional environmental change index for potential shifts in the habitat. An integrated environmental database (Regional Ocean Modeling System & remote sensing data) was established, connected with long-term time series catch data of different seas and CPUE (catch per unit effort) data. The results indicated that Japanese-Spanish mackerel have a dramatic response to warming upper water. It was also found that the catch in southwestern East China Sea and Japan Sea have a counterbalance which highly matched with habitat shift. It can be inferred from our findings that the distribution of Japanese-Spanish mackerel may have a profound change caused by the variabilities of habitat. The method used in this study may also provide some implications for other species in this region.

November 1, 16:20 (S11-13796)

The potential effects of climate change on suitable habitat for the fourfinger threadfin (*Eleutheronema rhadinum*) in the coastal waters of Taiwan

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Fourfinger threadfin, *Eleutheronema rhadinum*, is one of the most important commercial and high values species in the coastal fisheries of Taiwan. This aims to understand for fishing activity of gillnet fishery and community structure of fishery resources in coastal waters off western Taiwan. In this study, we collected logbook of sampling gillnet vessel, environmental data (i.e. Sea Surface Temperature, chlorophyll-a concentration, bathymetry and current velocity). We also investigated abundance and spatial distribution of hot spot for species that regularly released in recent years, and analyzed annual variation on community structure of fishery resources for species. Through *ArcMap 10.1*, spatial distribution of fourfinger threadfin showed widespread in each season. Previous studies have suggested that marine species (i.e. gray mullet and striped marlin) are affected by multi-scale climatic forces (Lan et al., 2014; Su et al., 2015). The optimal habitat (HSI >0.6) was found in areas with satellite-derived temperatures within the range of 26.1-28.8°C, current velocity of 0.011-0.51 m s^{-1}, bathymetry of 40-55 m, and 0.098-1.76 of Chl-a concentrations. Therefore, it is necessary and urgent to explore and identify the fourfinger threadfin potential habitat hotspots in the coastal waters of Taiwan. Through the habitat model, we provide the scientific assessment to set the effective management strategy and may provide the references for the further study on fingerling released for our government or fishery management organization.

November 1, 16:40 (S11-13427)

Climate variability with impacts on habitat suitability of chub mackerel *Scomber japonicus* in the East China Sea

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An integrated habitat suitability index (HSI) model was constructed to examine habitat suitability of *Scomber japonicus* in the East China Sea, and evaluate the relationship with the El Niño and La Niña events, with crucial environmental variables (sea surface temperature (SST), sea surface height (SSH) and net primary production (NPP)) as predictors. Results showed that the HSI model with the best model performance yielded robust predictions of habitat suitability for *S. japonicus*. The decreasing catch and CPUE of *S. japonicus* during 2006-2015 were highly consistent with substantial shrinkage of suitable and optimal habitats, and enlargement of normal and poor habitats. Similar movement pattern was found between the latitudinal gravity centers of fishing effort for *S. japonicus* fishery and the gravity centers of potential habitat. In addition, spatial correlation analysis indicated that the HSI value was significantly positively related to the SST anomaly (SSTA) and negatively correlated with the SSH anomaly (SSHA) and NPP anomaly (NPPA). Furthermore, various intensity of the El Niño and La Niña event may lead to different variations in the habitat suitability of *S. japonicus*. Comparing to the very strong El Niño, the moderate El Niño events would yield rising SSTA and lowing SSHA and NPPA, leading to dramatically enlarged suitable habitat of *S. japonicus*. The habitat quality in La Niña events with different intensity depended on the local environmental variability on the fishing ground. Our findings suggested that the impacts of each anomalous climatic event on habitat suitability of *S. japonicus* varied with the intensities.

November 1, 17:00 (S11-13665)

Application of bulk and compound specific isotopes to resolving regional productivity regimes experienced by Pacific Herring (*Clupea pallasii*) on the coast of British Columbia, Canada

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Despite a precautionary harvest policy, all five major stocks of Pacific herring in BC experienced marked declines in the 2000's. The Haida Gwaii (HG), Central Coast (CC), and West Coast of Vancouver Island (WCVI) stocks all dropped below the biomass limit reference point (BLRP) during this period. Limited recovery was observed despite fishing closures, indicating that some factor other than fisheries is driving recruitment in these areas. Despite also showing declines in in the 2000's, the Strait of Georgia (SOG) stock stands apart for consistently remaining above the BLRP, and showing a rapid increase to record levels since 2010. The relative success of the SOG herring indicates that this stock has had refuge from the forcing function impacting HG, CC and WCVI. One of the factors potentially driving stock trajectories is regional differences in coastal productivity. Large-scale studies on productivity are costly, and linking productivity to herring is challenging. Here we test the approach of using the herring themselves as samplers of their ocean environment. We collected muscle tissue from herring across the five major BC stocks, and used these to characterize stock specific bulk stable carbon and nitrogen isotopes signatures. Bulk isotopes alone do not inform differences in the productivity of food webs supporting herring, as changes may be influenced by both productivity and the trophic level that the fish are feeding at. Using Compound Specific Isotope Analysis however, we demonstrate that herring occupy a consistent trophic level (~ TP 3) across all BC stocks, pointing to differences in productivity as the driver or differences in bulk isotopes. This approach underscores the potential of routine stable isotopes measurements as a herring ecology observation tool.

November 1, 17:20 (S11-13342)

Seasonal dynamics in pelagic fish abundance around Set-net in Kochi prefecture

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Japan is one of the world's top producers of fishery products, although the fishery is decline. Therefore, it is necessary to conduct sustainable fishery even in the present situation. To figure out how to product fishing efficiently, we need to find out the relationship between fish abundance with marine environment to estimate the fish distribution accurately. In our study, we conducted the survey in Suzu of the Kochi coastal area, where continuation of the set-net fishery becomes the urgent problem by aging problems and instability of the fishery. We researched in four seasons from 2017/5 to 2018/2 at surrounding area of set-net by fishing boat (9.91 gross tonnage). A dense system of survey transects allowed determination of the acoustic index (volume backscattering strength S_v and area backscattering coefficient S_a) for fish abundance with high precision by quantitative echo sounder (KSE300 SONIC, 38kHz). Marine environment was measured by CTD (ASTD102 JFE ADVANTECH). Relationship of acoustic index and marine environment were analyzed by generalized additive model (GAM). Through the acoustic data, every season showed similar trends that the fish densities were high around 500m and 2000m from shore and tended to be strong in 30 m depth (P<0.05). Also, fish densities were high in the thermocline during stratification period (spring and summer). Marine environments suggest that high phytoplankton concentration caused high fish density in the thermocline. Therefore, fish catches probably will be increase if set-net put towards outer sea area or leader-net are extended in offshore for a certain extent.

November 1, 17:40 (S11-13583)

Long-lived marine fish employing broadcast spawning may be resilient to environmental variability: A selective sieve hypothesis

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Pacific Ocean Perch (POP) support a prominent commercial fishery in the Gulf of Alaska. They are a long-lived species characterized by widespread larval dispersal in their first year and lifespan of over 100 years. In order to understand how early marine dispersal affects the POP survival and population structure, I used Restriction Site Associated DNA sequencing (RADseq) technique to obtain 11,146 single nucleotide polymorphic (SNPs) sites from 401 Pacific Ocean perch (POP) young of the year (YOY) collected during the 2014 (19 stations) and 2015 (4 stations) NOAA led surveys in the Eastern Gulf of Alaska. Maximum likelihood based clustering (STRUCTURE) analysis showed that the POP samples represented four distinct ancestral populations. These larvae are most likely from various, distinct parturition locations mixing during their pelagic dispersal life stage. Latent factor mixed models were used for genome-wide association study and revealed that POP are facing significant selection forces during their first year at sea as indicated by the gene variants associated with spatial and physiological heterogeneities. These findings support the idea of a *Selective Sieve Hypothesis* where the strongest selection occurs during this critical life stage in response to environmental conditions, food availability, predator abundances, and other external factors. Each adult cohort's DNA sequences are the result of the environmental conditions experienced during their first year at sea. Long-lived species relying on broadcast spawning strategies, may therefore be uniquely resilient to environmental variability by maintaining a portfolio of cohort specific adaptive genotypes.

November 2, 09:00 (S11-13734)

The effect of oceanographic variability on pelagic larval fishes of the Northern Bering and Chukchi Seas

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This work is part of the Arctic Integrated Ecosystem Survey (Arctic IES) – a multi-disciplinary investigation of the ecosystem through oceanography, plankton, and fisheries surveys. Surveys were conducted in the Chukchi and Northern Bering Seas from August to September 2012, 2013 and 2017. Ocean currents, phytoplankton and zooplankton distributions were very different between the years. We investigated whether the distribution of larval fish reflected these differences. The larval fish community was dominated by Arctic cod, Bering flounder, yellowfin sole and capelin. Yellowfin sole and capelin larvae were associated with Alaska Coastal Water, likely because they were advected north from nearshore spawning areas in the Bering Sea. Arctic cod and Bering flounder spawn in the Chukchi Sea and were associated with Anadyr/Bering Sea/Chukchi Sea Water and with Chukchi Winter Water. These water masses had moderate to high phytoplankton and zooplankton concentrations, so we hypothesize that the result was favorable foraging for larval fishes. Statistical models of a suite of relevant oceanographic variables were developed to test these hypotheses and to examine the effects of interannual oceanographic variability. Our results increase the knowledge of the mechanistic links between oceanography and the early life history of fish. Ocean processes such as advection and the formation and retreat of sea-ice have been and likely will continue to be impacted by climate change. Because growth and survival of early life stages of fish often drives population change, our results contribute to the understanding of the impacts of climate change on Arctic fish populations.

November 2, 09:20 (S11-13781)

Effects of environmental variabilities on the early life stage of Pacific chub mackerel *Scomber japonicus* in the Northwest Pacific

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Pacific chub mackerel (*Scomber japonicus*) is a small pelagic and important commercial fish species widely distributed throughout the coastal areas of the Indo-Pacific. Because the large inter-annual variations of recruitment and total biomass in previous decades are considered to link to the changing ocean environments, we developed a growth-migration model for chub mackerel to track the environment fish experienced and evaluate the effects on the growth and migration from environmental variabilities. The early life history of 2010-year class individuals was simulated in the Northwest Pacific under satellite derived environments. The growth was evaluated by a bioenergetics model which developed by reviewing and analyzing data from previous studies and new respiration experiment. The migration, which was decided by ocean current and predicted swimming behavior after metamorphosis, was calculated by Lagrangian approach. The model results showed significant difference of growth characteristic among the larval and juvenile groups characterized by different transport routes, indicating the importance of sea surface current on the distribution and fitness of chub mackerel in the early stage. The group initially located around Izu Islands, which is the main spawning ground of chub mackerel, experienced the stable environment both in temperature and prey environment, and had moderate growth. This fact may be a hint that the reason of chub mackerel spawning around the Izu Islands that this area may provide stable habitat condition for larvae and juvenile of chub mackerel.

November 2, 09:40 (S11-13377)

Influence of climate warming for migration, growth and survival of Japanese chum salmon in the North Pacific Ocean and the Okhotsk Sea

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Population size of Japanese chum salmon (*Oncorhynchus keta*) has showed marked decrease trend since the 2010s. To evaluate the climate warming effect on migration, growth, and survival of Japanese chum salmon, we analyzed ocean condition, especially sea surface temperature (SST) in the North Pacific Ocean including the Okhotsk Sea using the objective analysis data "COBE-SST" (Ishii et al. 2005) operated by the Japan Meteorological Agency and the NCEP/NCAR data of NOAA (Kalnay and Coauthors 1996), and growth of juvenile chum salmon by the scale back-calculation method. In the 2010s, the area of adaptable temperature (AT: 5-12 ºC) for chum salmon markedly decreased in the Okhotsk Sea and the Gulf of Alaska. And the area of optimum temperature (OT: 8-12 ºC) has quietly departed from Hokkaido Island in July when juvenile migrate to the Okhotsk Sea. The area of OT in August gradually decreased since the 1990s and became less than half in the 2010s. The estimated fork length of chum salmon at the age 1 well synchronized with the survival rate and decreased since the early 2010s. Relationship between SST of the southern Okhotsk Sea in July and survival rate of Hokkaido chum salmon has a significant positive correlation within the OT, but a negative correlation over the OT. These results suggest that the climate warming have profound effects on migration route, growth, and survival of Japanese chum salmon in the North Pacific Ocean around Japan and the Okhotsk Sea.

November 2, 10:00 (S11-13647) CANCELLED

Potential environmental drivers of Japanese anchovy (*Engraulis japonicus*) recruitment in the Yellow Sea

Haiqing **Yu**[1], Huaming Yu[1], Shin-ichi Ito[2], Yongjun Tian[1] and Yang Liu[1]

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Water temperature and food availability are believed to be major environmental factors controlling the growth and survival of many fish species, especially in their larval or juvenile stages, during which the survival rate may further determine the recruitment. In this study, the environmental effects influencing the recruitment of Japanese anchovy *Engraulis japonicus* in the Yellow Sea (YS) and associated dynamical processes are discussed. The log recruitment residual (LNRR) from the Ricker model pertaining to the Japanese anchovy population within the YS is compared with marine environments derived from a coupled physical and lower-trophic-level ecosystem data assimilative model. The results show that the LNRR is significantly negatively correlated with sea surface temperature (SST) in the traditional spawning ground south to Shandong Peninsula, China (i.e. a notable temperature-sensitive area) in July months. Meanwhile, LNRR is also significantly positively correlated with surface small zooplankton biomass (i.e. main prey for anchovy larvae) in some specific regions in the YS (i.e. a food-sensitive area) within summer seasons for a 15-year period (1987 - 2001). These findings imply that the recruitment of Japanese anchovy in the YS is likely regulated both by water temperature and food availability in summer timeframes. The negative temperature-recruitment relationship in the temperature-sensitive area can be explained both by "spawning temperature optima" and "optimal growth temperature" hypotheses, meaning that water temperature may influence Japanese anchovy recruitment in the YS by regulating either the egg abundance or larval growth rates, or both. Furthermore, it is also found that the interannual variation of the modelled surface small zooplankton biomass in the food-sensitive area during summer months is mainly determined by nutrient supply, by which both vertical stratification and horizontal advection would make direct contributions. This study highlights the feasibility of using a coupled physical and lower-trophic-level ecosystem model with data assimilation to investigate the effects of the marine environment on the recruitment of small pelagic fish. In return, the results can provide implications for recruitment prediction and fishery management of the Japanese anchovy in the YS.

November 2, 10:40 (S11-13386)

Large zooplankton abundance as an indicator of Walleye Pollock recruitment in the southeastern Bering Sea

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Interannual variations in large zooplankton abundance (sum of the most abundant large taxa, typically important in age-0 pollock diets) were compared to age-3 walleye pollock (*Gadus chalcogrammus*) abundance for year classes 2002-2012 and 2014 in the southeastern Bering Sea. Data were collected on fishery oceanography surveys from mid-August through September for warm (low sea ice) and cold (high sea ice) climate stanzas. We implemented a spatial delta-generalized linear mixed model using the Vector Autoregressive Spatio-Temporal (VAST) package in R (Thorson et al. 2015) to estimate annual abundances of 1) *Calanus glacialis/marshallae* (*Calanus* spp.), 2) large zooplankton throughout the water column, and 3) an annual index for composition of *Calanus* spp. in the diets of age-0 pollock.

A key result was the positive significant linear relationship between both mean abundance of large zooplankton and *Calanus* spp. during the age-0 stage of pollock versus estimated abundance of age-3 pollock. Increases in sea ice was associated with increases in *Calanus* spp. (the dominant large zooplankton taxa) in net tows and in age-0 pollock diets, leading to high overwinter survival of age-0 pollock and subsequent recruitment into the fishery at age-3. Accordingly, this index may be used to predict future recruitment success of pollock three years in advance. This provides support for the revised oscillating control hypothesis that suggests as the climate warms, reductions in sea ice (and reduced availably of ice-associated algae, an early spring food source) could be detrimental to large crustacean zooplankton and to the pollock fishery in this region.

November 2, 11:00 (S11-13732)

Calanus sinicus and its relationship with climate variability in the northern Yellow Sea

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The spatio-temporal distribution pattern of *Calanus sinicus*, a key copepod species, was examined in the northern Yellow Sea (YS). Compared with 1959 and 1982, there was a significant increase in the abundance of *C. sinicus* in the spring, summer, and autumn of 2011 and winter of 2014. The percentage of *C. sinicus* in the zooplankton assemblages ranging from 45.6% to 75.8% in different seasons of 2011-2014 was significantly higher than that in 1982. Two different spatial distribution patterns of *C. sinicus* were observed, with higher abundance occurring nearshore during the cold season (e.g., January) and offshore in the central portion of the northern YS in the warm season (e.g., May, July, and October). The Yellow Sea Cold Water Mass in the central portion of the northern YS likely provides an important over-summering site for the species. Additionally, a greater increase of the abundance of *C. sinicus* was found in the northern portion (northern YS) of its spatial distribution during the past half century. This study has an implication on the climate-driven shifts in zooplankton community in the northern YS, highlighting the importance of *C. sinicus* in the warm-temperate ecosystem of Chinese coastal seas.

November 2, 11:20 (S11-13295)

Contrasting the relative contribution of species sorting and dispersal limitation to marine macrozooplankton community diversity in coastal Bohai Sea

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Understanding ecological communities and their determinants are crucial to predict biological response to future environmental change, and thus knowledge also provides insights for environmental monitoring programs. Coastal marine ecosystems are highly variable and suffering from negative influence caused by anthropogenic activities and global climate change. However, the mechanisms structuring spatial variation of biological communities in coastal marine realms are still unclear. Here, we combined information on species composition, environmental and spatial factorss to analyze the spatial variation of macrozooplankton communities, which were collected from five regions of Bohai Sea. In this study, a total of 49 macrozooplankon species (excluding zooplankton larva and juveniles, fish eggs and fish larvae) were identified morphologically in the five coastal regions and the community structures varied significantly among the five regions. The RDA model showed that environmental and spatial predictors explained 53.37% variations of zooplankton community structure, indicating that species sorting and dispersal limitation were major factors for the macrozooplankton community structure variations. After participating variance, environmental predictors purely explained 22.03% of community structure variations, about three time larger than that by spatial variations, which purely accounted for 7.18% of the variations in zooplankton structure, suggesting that species sorting played major roles in structuring the macrozooplankton community in the coastal marine regions of Bohai Sea. Our results would promote the comprehensively understanding of marine zooplankton assembly and also provide insights to predict biotic response to future environmental changes caused by human activities and global climate change.

Key words: Zooplankton community, Species sorting, Dispersal, Redundancy analysis

November 2, 11:40 (S11-13497)

Physical factors influencing the recapture rate and yield of the edible jellyfish in the Liaodong Bay, China

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A coupled individual based model for jellyfish *Rhopilema esculentum* was developed for the first time to research the physical factors that influence the yield of the jellyfish. Within the coupled model, virtual particles representing the jellyfish were capable of growth, mortality, diel-vertical migration and were passively moved by the marine physical process such as advection and diffusion. The physical factors were extracted from an operational ocean circulation-surface wave coupled forecasting system for the seas off China and adjacent areas (OFS-C). Transport simulation indicated that the top of the bay is better than the eastern and western coasts for jellyfish fishing and the site near WFD is not an advisable location for jellyfish release. Comparing the model result with the reported jellyfish yield information in years 2008 to 2010, it indicated that the yield of the jellyfish is controlled by the recapture rate and the mean individual quality. Model results showed that the ocean current and indirect wind impact are the main drivers controlling the jellyfish transport, and further can influence the recapture rate. In addition, the temperature at releasing and the natural mortality rate can both influence the recapture rate. The individual quality of the jellyfish is affected by the growth time, the ambient temperature of the jellyfish and the salinity. The model results showed that a longer growth time, higher temperature and lower salinity can improve the individual jellyfish quality.

November 2, 12:00 (S11-13542)

Seabird density relative to their prey and water mass distributions around St. Lawrence Island, northern Bering Sea during summer

Bungo **Nishizawa**, Haruka Hayashi, Nodoka Yamada, Hiromichi Ueno, Tohru Mukai, Toru Hirawake, and Yutaka Watanuki

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The marine ecosystem of the Bering Sea is experiencing rapid changes due to reductions in seasonal sea ice. In the northern Bering Sea, several water masses can be discerned, which are likely to influence the distribution of zooplankton and fish, thereby, distributions of their predators i.e., seabirds. Understanding the links between seabirds, their prey, and water masses are crucial to predicting ecosystem changes. To examine distribution of seabirds, their prey, and water masses we conducted boat-based seabird observations concurrently with acoustic surveys (zooplankton and fish biomass) and CTD measurements around St. Lawrence Island in the northern Bering Sea during July 2017. Three distinct water masses were identified based on salinity; Alaska Coastal Water (ACW, <31.8 psu), Bering Shelf Water (BSW, 31.8–32.5 psu), and Anadyr Water (AW, >32.5 psu). Surface omnivores (fulmars and storm-petrels) occurred throughout the study region. Divers, however, showed stronger relationships with water masses. The density of planktivorous divers (auklets) was highest in AW (22.8 birds n.mile^{-1}) than BSW (0.8) and ACW (0) and was higher in areas where zooplankton biomass (10-20 m depth) was high. On the other hands, the density of piscivorous divers (murres and puffins) was highest in BSW (11.9 birds n.mile-1) than AW (4.2) and ACW (0.7) and was not significantly correlated with fish biomass. Our study suggests that divers, which are tightly associated with specific water mass, might be more affected than surface omnivores by climate-induced changes in water masses in seasonal sea-ice regions of the northern Bering Sea.

S12: Applying ecosystem considerations in science advice for managing highly migratory species

October 30, (S12-13813)-Plenary

Challenge and opportunity for fisheries stock assessment in changing environments

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The complex, nonlinear and dynamic human-natural interactions in fisheries hinder full understanding of fisheries population dynamics, causing management decisions to be made in the face of large uncertainty. Climate change has further increased the level of complexity and uncertainty in ecosystems. As a result, we are often unsure of fish population dynamics and possible consequences from management regulations. To reduce the likelihood of unintended damages to marine ecosystems, we need to reduce the uncertainty associated with our understanding of dynamics of target fish populations and their ecosystems. In this presentation, I will discuss possible challenges facing fisheries stock assessment in changing environments and identify some of the opportunities we have to improve our understanding of fisheries dynamics. In particular, I will discuss the use of environmental data to improve stock assessment. Drawing from research conducted in previous studies, I will show how we can identify research avenues to address some of the challenges facing fisheries stock assessment in a changing environment.

October 30, 11:00 (S12-13603)

Effects of global warming on spawning behavior of the Pacific bluefin tuna based on otolith oxygen stable isotope analysis

Shingo **Kimura**[1], Yulina Hane[1], Yusuke Yokoyama[1], Yosuke Miyairi[1], Takayuki Ushikubo[2] and Nobuhiro Ogawa[1]

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The Pacific bluefin tuna (*Thunnus orientalis*) spawn mainly in waters around the Okinawa region. This species is typical of fishes that spawn seasonally in small, limited areas. Any marked change in the marine environment of the spawning grounds, such as global warming, is likely to have a direct impact on larval survival and growth. According to previous numerical simulation based on IPCC climate scenario, the predicted survival rates of larvae arriving in Japanese coastal waters in 2100 would decline to 36% of present recruitment levels. To avoid this effect, this species may change the main spawning ground from the Okinawa region to the Sea of Japan. In fact, its landing at fishing ports facing to the Sea of Japan is increasing recently. However, it is very difficult to estimate the spawning rate. Thus, focusing on different spawning temperatures in the two spawning regions, we have developed a method based on otolith oxygen stable isotope ratio ($\delta^{18}O$) using the Secondary Ion Mass Spectrometry (SIMS) techniques. The spatial resolution near the core region resulted 10 times higher than the conventional method. As a result, 1-2‰ $\delta^{18}O$ increase around the first annulus (800μm~) indicates experience of lower water temperature in autumn and winter. The 0.5‰ difference in $\delta^{18}O$ among the samples was measured and this difference suggests the spawning temperature difference experienced by fish in the Sea of Japan and the Okinawa region. In conclusion, it is clarified that this method using SIMS can estimate spawning water temperature preciously.

October 30, 11:20 (S12-13700)

Development of male-specific DNA markers in the Pacific bluefin tuna (*Thunnus orientalis*): Potential applications for sex ratio control in aquaculture and contribution to tuna resource management

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The Pacific bluefin tuna, *Thunnus orientalis*, is a highly migratory species that is widely distributed in the North Pacific Ocean. The recent significant decrease in the population of this species is affecting the Japanese fishery economy. Japan is one of the largest tuna product producing countries, and thus, efficient management of tuna is crucial. Developing an efficient full-life-cycle aquaculture is one of the countermeasures to conserve natural resources. However, determining the optimum sex ratio in aquaculture to collect a stable number of fertilized eggs is difficult because the Pacific bluefin tuna does not exhibit sexual dimorphism externally. Advancements in genomic techniques over the past decade have allowed collecting genome-wide data on non-model species to determine genetic sex. Effective, simple, and accurate methods for sex identification are desired in aquaculture and fishery surveys. Therefore, here, we report the construction of an improved draft genome and the identification of male-specific DNA markers in the Pacific bluefin tuna. Male-specific DNA markers were developed via a genome-wide association study by using re-sequencing data of 15 males and 16 females and used for PCR primer designing. The sex of 131 individuals (87 males and 59 females; the sex was diagnosed by visual examination of the gonads) was correctly identified by using a PCR-based method. This easy, accurate, and practical technique allows determination of sex ratio in tuna farming. Furthermore, this method is powerful for estimating the sex ratio and/or the growth rate of juveniles in natural populations.

October 30, 11:40 (S12-13363)

Spatio-temporal distribution of albacore *Thunnus alalunga* and its relationship with environmental changes in the Pacific Ocean

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Albacore tuna *Thunnus alalunga* is one of the most important commercial fish species caught worldwide. Since the catch of albacore tuna has doubled in the past 60 years in the Pacific, clarifying the interannual variability of their distribution is essential for fisheries resource management of highly migratory species. This study aims to elucidate the spatio-temporal variation of albacore distribution, particularly focusing on relationships between albacore distribution and environmental changes by applying empirical orthogonal function (EOF) analysis based on Japanese longline fishery data. According to EOF1, the distribution shifted from east to west of the north Pacific in the 1990s. Time series of the score showed a significant correlation with catch fluctuation of the prey species such as Japanese sardine *Sardinops melanostictus* and Japanese anchovy *Engraulis japonicus*. The catch of sardine sharply decreased, and the catch of anchovy began to increase in the north Pacific in the 1990s. This great species alternation is generally termed as the regime shift. Due to the drastic resource decline, the distribution of sardine shrunk from the central and western Pacific to a limited area off Japan. On the other hand, the result of EOF2 showed a relationship between the distribution and El Niño–Southern Oscillation (ENSO) events. The score showed two peaks in 1982–1983 and 1997, which were both consistent with years when a strong El Niño occurred. As shown in a previous study, albacore distribution probably has concentrated in an area where water temperature has increased due to El Niño events.

October 30, 12:00 (S12-13510)

Migration paths and habitat use of albacore in the eastern North Pacific, with implications for surface fisheries

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Albacore (*Thunnus alalunga*) migrate throughout much of the North Pacific Ocean, including the California Current Ecosystem (CCE). Their abundance in the CCE, and local availability to fishing fleets, has varied strongly historically, at both interannual and decadal-scales. In this study, we use fishery-dependent catch data to show how albacore use thermal migration corridors across the North Pacific, and how oceanographic variability drives changes in their availability to U.S. and Canadian surface fishing fleets. We also relate albacore distribution to spatiotemporal variability in assemblages of their major prey species in the CCE, determined from gut content analyses. Our results have relevance for the development of ecosystem models for the CCE, and for the future prediction of albacore movements across international management boundaries, at seasonal to centennial timescales.

October 30, 12:20 (S12-13799)

A management strategy evaluation framework to assess robustness of harvest guidelines for North Pacific Albacore tuna to variable productivity and distribution

Desiree Tommasi[1,2], Barbara Muhling[1,2], Steve Teo[1] and Gerard **DiNardo**[1]

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Changes in ocean conditions are known to affect the productivity (recruitment, growth, survival) and distribution of many valuable marine fish, including highly migratory species like Albacore tuna (*Thunnus alalunga*). Both climate variability and change are expected to alter North Pacific Albacore tuna (NPALB) productivity and availability, with implications for fisheries management. To maintain resilience of the NPALB population under climate change and limit sociological and economics impacts, future fishery management advice needs to be robust to uncertainty in productivity and distribution. Here we outline a Management Strategy Evaluation (MSE) framework based on the Stock Synthesis software and designed to assess the consequences of uncertainty in NPALB productivity and distribution for achieving NPALB management objectives. Effectiveness in meeting predefined management objectives under shifting recruitment, time-varying growth, and time varying age-selectivity is compared across a range of harvest guidelines and reference points.

October 30, 12:40 (S12-13266)

Evaluating the performance of two methods for estimating fishing mortality rate of Fang's blenny (*Pholis fangi*) based on size frequency data

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Fishery stock assessment usually requires catch-at-age data to estimate parameters, whereas such data are often unavailable to many of the existing fisheries. Meanwhile, size frequency data may carry useful information for the status of fishery stocks, and they are the most accessible for even data-poor stocks. However, the performance of estimation methods based on size-frequency data has been rarely evaluated and less understood in relevant studies. This study used length-based assessment methods implemented by the s6model and TropFishR R packages to estimate F and FMSY using five years of survey data for the unassessed Fang's blenny (*Pholis fangi*) stock in Haizhou Bay, China. We evaluate the performance of the method by examining the sensitivity of estimated values to (1) amount of data and (2) season of data collection. The results showed that when the amount of data increase, estimations of F and Fmsy with s6model and TropFishR have the same trend of change. Be specific indicated that s6model tended to be more influenced by sample size, to which TropFishR showed a constrained responses. Both s6model and TropFishR estimated a higher fishing intensity from spring data compared to fall, and the seasonal effect was larger for s6model than for TropFishR. We concluded that TropFishR could provide satisfactory estimation of F and Fmsy when survey data are limited. When a time series of data were available, s6model performed better for estimating fishing mortality. The study highlighted the usefulness of size-frequency based methods in stock assessment and provided suggestions for their applications.

October 30, 13:00 (S12-13306)

Commercial stock assessment and forecast of northern shrimp *Pandalus eous* on the south-western Kamchatka

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Russian fishing of commercial northern shrimp near southwestern coast of Kamchatka has been conducted since 1998. Regulation of the fishery implies this annual establishing the total allowable catch (TAC). The TAC has been usually evaluated on the survey data about current state of the stock. Mean times there were no data about the age of the shrimp available at the beginning of forecasting, and the assessment was direct, implying the same stock for 2 years. One methodical improving later, when reading the age composition, based on the sizes, has been possible, virtual population analysis (VPA) was applied. At present, the model "Synthesis" (Ilyin et al., 2014) is used to estimate the state of the stock and to prediction. The model one of comparatively simple statistical cohort models with a separable representation of fishing mortality. It takes into account the specifics of fishing statistics and allows obtaining detailed description of the dynamics of the age structure of the estimated stock.

October 30, 13:20 (S12-13383)

Life-history connectivity in a highly migratory fish, Japanese Spanish mackerel (*Scomberomorus niphonius*), implications from otolith chemistry

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Connectivity is a vital component of metapopulation and fishery resource ecology, influencing fundamental processes such as population dynamics, evolution, and community responses to climate change. In populations with highly migratory abilities, connectivity is not only limited to dispersal in the pelagic larval stage but throughout the whole life history. In the present study, connectivity in the Japanese Spanish mackerel, *Scomberomorus niphonius*, a highly migration species whose distribution covered the temperate and subtropical waters of China seas, was investigated using LA-ICP-MS otolith microchemistry. Otoliths from adults (age 1) were examined from four spawning areas along a latitudinal gradient spanning much of the known species range in the Yellow Sea and the East China Sea. In each sampled life stage, otolith trace elements are similar among fish from different capture locations, but otolith compositions vary greatly between life stages. Ba:Ca ratio indicates ontogenetic migrations from relatively low salinity water during early life to high salinity waters with increasing age. Large-scale connectivity in all life stages suggests that *S.niphonius* individuals spawned in the same western coastal area have complex natal origins and fish caught off northern Yellow Sea may even be of Southern East China Sea origin. The immature fish mix to a large extent when they feed and overwinter in the extensive offshore waters in the eastern area. From these results, it was suggested that the local mackerel assemblages on which fisheries rely are collectively influenced by the recruitment of all the spawning assemblages along China coastal waters instead of self-sustaining.

Biological Oceanography Committee Paper Session

November 2, 09:00 (BIO-P-13709)

De novo transcriptome assembly of the mixotrophic dinoflagellate *Ansanella granifera*: Spotlight on flagellum-associated genes

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Many dinoflagellates are known to cause red tides and often outgrow non-motile diatoms and motile small flagellates through active vertical migration between well-lit surface and eutrophic deep waters and/or by locating and ingesting prey cells. Their flagellum play important roles in these critical behaviors. However, the structural and functional genes of dinoflagellate flagella are very little known. Thus, a *de novo* assembly of the transcriptome of the fast-swimming dinoflagellate *Ansanella granifera* were conducted and its flagellum genes were characterized and compared with those of other dinoflagellates, motile small flagellates, and non-motile protist species. Based on assembled data using Trinity/CLC combined strategy, 83,652 transcripts of *A. granifera* were identified and annotated to the NCBI non-redundant (nr), InterProScan, Gene Ontology, and KEGG pathway analyses. Moreover, 71 structural and 35 functional flagellum-associated genes expressed were identified. The number of expressed flagellar structural and functional genes of *A. granifera* was not markedly different from those of other dinoflagellates or motile small flagellates, but much greater than those of non-motile species. Furthermore, in flagellar gene based dinoflagellate phylogenetic trees, the long-branch attraction artifacts, which previously reported in the ribosomal gene based phylogeny, was resolved. Moreover, the species in the order Peridiniales or Gymnodiniales were revealed to belong to a big clade of each order. Therefore, the phylogenetic tree based on the flagellar genes is likely to give a clue to resolve the problem of separation in a big clade of a dinoflagellate order, which has existed in the phylogeny based on ribosomal DNA.

November 2, 09:20 (BIO-P-13319)

Reproductive isolation in oceanic copepods revealed by genome-wide SNP data

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An appropriate evaluation of reproductive isolation is important to determine species boundary and population structure of marine planktonic copepods, leading to further understandings of global biodiversity. The molecular technique using mitochondrial DNA (mtDNA) marker has been widely used in copepods, and cryptic species and basin-scale population structures have been detected even in oceanic areas without clear physiological barriers. However, reproductive isolations cannot be evaluated only by mtDNA maker (e.g. COI), due to maternal inheritance of mtDNA. Common nuclear DNA makers (e.g. ITS and rDNA), on the other hand, show slow mutation rates, and their sequence variations are insufficient to reveal reproductive isolations of copepods. To this end, restriction site-associated DNA sequencing (RAD-Seq) method was applied to oceanic copepods in this study, and genome-wide single nucleotide polymorphisms (SNPs) data were analyzed to reveal reproductive isolations. First, species-level isolations were investigated using *Pleuromamma abdominalis* with multiple COI clades at single sampling site. The genetic clades based on SNP data were corresponded with those based on COI sequences, supporting species-level isolations among mtDNA clades. Second, population-level isolations were investigated using *Cosmocalanus darwni* collected in North and South Pacific subtropical gyres. Although there were no sequence variations in COI sequences, SNP data revealed distinct population-level isolations between North and South Pacific. These results show that genome-wide SNP data provide new insights on species boundary and population structure of oceanic copepods. This study also suggested that both species and genetic diversity of oceanic copepods are higher than previously recognized.

November 2, 09:40 (BIO-P-13405)

Diversity of marine planktonic ostracods in South China Sea: A DNA taxonomy approach

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Ostracods (Crustacea, Ostracoda) are small bivalved crustaceans, contributing over 200 described species to the marine zooplankton community. They are widely distributed and are relatively abundant components of the mesozooplankton, playing an important role in the transport of organic matter to deep layers. Previous fragmentary taxonomic studies of ostracods in the South China Sea, were based solely on morphology. Here, by analyzing the mitochondrial COI gene, we explore the taxa across the South China Sea using molecular tools for the first time. Our results show that sequence divergence among species varies within a large range, from 12.93% to 35.82%. Sixteen of the taxonomic units recovered by DNA taxonomy agree well with morphology, but *Paraconchoecia oblonga*, *Conchoecia magna* and *Halocypris brevirostris* split into two clades each, each of which contains cryptic species. By analysing the mitochondrial COI gene, we explore the population genetic structure and haplotype pattern of *Porroecia spinirostris* which is dominant species of ostracods in South China Sea. Our data suggest that *P.spinirostris* can achieve long distance dispersal and specific haplotypes were successful in colonizing habitats from Xisha area to Nansha area. A total of 36 haplotypes were defined from 85 individuals, with most of them being existing only one time. The dominant haplotype was found in twelve sampling sites. The largest distance between two sampling sites harbouring this haplotype is more than 700km. Our findings of long distance dispersal in South China Sea combined with mild genetic differentiation among populations (average Φ_{ST} = 0.167) are in line with a scenario where population genetic structure is strongly impacted by colonization patterns.

Keywords: DNA taxonomy, COI, ostracods, genetic differentiation, South China Sea

November 2, 10:00 (BIO-P-13364)

Sampling efficiency of ichthyoplankton in the northern Bering Sea: An inter-gear comparison

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We compared sampling efficiency and size-selectivity of three gears for ichthyoplankton survey in the northern Bering Sea adjacent to the Bering Strait and St. Laurence Island. The gears compared were: bongo net (0.7 m diameter, 0.505 mm mesh), MOHT (Matsuda-Oozeki-Hu-Trawl net; 2 m^2 mouth opening, 1.4 mm mesh), and ring larvae net (1.3 m diameter, 2.0 and 0.33mm mesh). Of these, bongo and MOHT nets were towed obliquely from surface to 15 m and 10 m above the sea floor, respectively. The ring net was towed sea surface horizontally for 10 min. These gears were towed sequentially at each of 13 stations during the daytime.

Bongo net was most effective in terms of total numerical density despite the smallest mouth opening; average density obtained by the bongo net was 4- and 36-fold higher when compared with MOHT (p<0.02) and ring net (p<0.001), respectively. Species composition also differed by gear, with higher fraction of *Hippoglossoides* spp. in bongo samples (permanova, P<0.001). Furthermore, comparison of body sizes revealed that bongo net collected larvae with smaller body sizes than MOHT (e.g. 8.5 mm vs 10.7 mm in average for *Hippoglossoides* spp.; P<0.001, t-test) Thus, we concluded that i) the 1.3 m ring net was inadequate in ichthyoplankton sampling in the present study area, ii) bongo (MOHT) net is recommended when larvae with body lengths of <10 mm (>10 mm) are targeted.

November 2, 10:40 (BIO-P-13443)

Seasonal variation of micro-copepod assembages and impact of ichthyplankon in South China Sea

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Pelagic micro-copepod (<1mm in length) are the important diets of fish larvae and some carnivorous or omnivorous macro-zooplankton. The micro-copepod assembages and impact factors were analyzed using the net data obtained during seasons of 2014. Sixty-seven taxa were identified, low abundance (159.39±75 individuals m^{-3}) were observed compared with coastal zones, with was the similar with oceanic zones in Pacific Ocean. Abundance and distributions changed seasonally along with the surface current driven by a monsoon reversal. The micro-copepod community was affected by season, temperature, salinity, lattitude, chl *a* and larval fishes. Larval squids and hyperiid distributions related to five dominant taxa that were *Oithona similis*, *O. tenuis*, *O. plumifera*, *Farranula gibbula* and *Calocalanus styliremis* and larval fishes distribution related to *Farranula*, hyperiid and krill were verified by generalized additive models. Those indicated that micro-copepod pumped enough nutrition into larval fishes and larval squids and the abundance of larval squids would predicted by some micro-copepod taxa in the central South China Sea.

November 2, 11:00 (BIO-P-13550)

Microzooplankton selective grazing on phytoplankton in the subtropical North Pacific Ocean

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The major pathway for phytoplankton primary production engaging in the marine food web and supporting the higher trophic levels is microzooplankton (20-200μm) grazing. Previous studies reported microzooplankton could consume 67% of phytoplankton production on global scale. However, this averaged value is incapable of reflecting microzooplankton grazing in very extensive open ocean since the studies are still limited and the grazing mechanism was sensitive to environmental conditions and could vary even in stable oligotrophic waters.

For figuring out the variation of microzooplankton grazing and its impact on transferring primary production, we carried out trans-Pacific cruise in the most unstudied subtropical North Pacific gyre (23ºN, 137ºE to 120ºW) in summer 2017. Using dilution experiment, the growth and grazing mortality rates of phytoplankton community and specific groups (diatoms, haptophytes, pelagophytes, *Synechococcus* and *Prochlorococcus*, represented by pigment markers of fucoxanthin, 19'-hexanoyloxyfucoxanthin, 19'-butanoyloxyfucoxanthin, zeaxanthin and divinyl chlorophyll *a*) due to microzooplankton grazing were estimated.

The phytoplankton community growth (indicated by chlorophyll *a*) was decoupled with mortality but positively correlated to net growth rate (growth minus mortality, $p<0.01$), indicated the bottom-up control. However, the phytoplankton community showed relatively high net growth rate (0.34±0.29 d^{-1}) under the serious nitrogen limitation (concentrations of NO_2^- and NO_3^- were generally lower than the detection limit of 3 nM). It can be attributed to the dominant prokaryotic phytoplankton, especially *Prochlorococcus*, which were accustomed to the circumstance with lower nutrient. Both higher growth and lower mortality of *Prochlorococcus* rendered their higher net growth (0.63±0.36 d^{-1}) and much contribution to the community biomass accumulation. On the contrary, lower net growth rates (averaged 0.11 d^{-1}) of three eukaryotic phytoplankton groups (diatoms, haptophytes and pelagophytes) indicated less contribution to the community biomass. Further, their mortalities were positively correlated to each other, also implied the different grazing process of microzooplankton on eukaryotic and prokaryotic phytoplankton.

November 2, 11:20 (BIO-P-13490)

Contribution of different organic carbon sources to the food web of a subtropical mangrove ecosystem, China

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Mangroves, one of the most productive natural ecosystems in the world, have quantity of leaves that fall into the surrounding water every year. Assessing how the organic carbon sources derived from mangrove forests is utilized by consumers and its rate of utilization in the food web has been received much attention. To this end, we conducted a study using stable isotopes in September 2016 (rainy season) and March 2017 (dry season) in the Zhanjiang Mangrove National Nature Reserve of China. Our results showed that the primary organic carbon sources of the consumers in the mangrove food web were benthic algae, followed by particulate organic matter in water bodies, while the mangrove leaves made a minor contribution. And the contribution of mangrove leaves and benthic algae to consumers in dry season were higher than those in the rainy season, but the particulate organic matter was lower, which might be related to the C/N ratio of these organic carbon sources. Estimates of consumer trophic positions indicated ~4 trophic levels. Mollusks occupied lower trophic levels, while crustaceans and fishes varied from intermediate to top consumers. And for the 18 species of co-occurring consumers in two seasons, trophic positions of fishes were higher in dry season compare with the same species in rainy season except *Sparus latus*, whereas mollusks and crustaceans were lower except *Cerithidea ornata*. The seasonal variation of trophic positions suggesting that the consumers exhibit plasticity in their feeding strategies to utilized the organic carbon sources.

November 2, 11:40 (BIO-P-13437)

Mixing, stratification and spring bloom in an oligotrophic sea

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The processes determining the timing of spring phytoplankton blooms are still debated. The subtropical oligotrophic Gulf of Aqaba, northern Red Sea, is a unique water body, where convective mixing during winter reaches hundreds of meters in depth. Using a 30 year-long time series and in situ experiments, we found that neither the Sverdrup's Critical Depth mechanism nor the Dilution-Recoupling hypotheses explain the timing of the spring phytoplankton bloom. Instead, we propose a simple alternative, the "Dispersion-Confinement Mechanism": During mixing, phytoplankton cells that photosynthesize and grow in the upper (illuminated) layer are homogeneously dispersed by vertical mixing. Thereby the deepening of the mixed layer leads to the dilution of the cells with plankton-free water from below, keeping their concentration low. In the spring, once mixing stops, the cells are no longer vertically dispersed, allowing their accumulation in the upper layer, generating a bloom. High specific growth rates, necessary to maintain the increase of the entire (integrated) phytoplankton biomass during the deepening of the mixed layer (the "Dispersion Phase") as well as supporting their rapid growth during the bloom (the "Confinement Phase") are possible due to the entrainment of nutrients by the deep vertical mixing. Although this mechanism is proposed here for the case of a subtropical, oligotrophic sea, its relevance for temperate oceans deserves further consideration.

November 2, 12:00 (BIO-P-13368)

Spatial and temporal variability of coccolithophore blooms in the eastern Bering Sea

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Coccolithophores are a widespread group of marine phytoplankton that produce plates of calcium carbonate that cover their cells. Large blooms of coccolithophores may significantly influence the biogeochemical properties of the ocean and atmosphere and trophic dynamics of the marine ecosystem. Because of the important implications of coccolithophore blooms, their timely monitoring and reporting is necessary for ecosystem management. To communicate with ecosystem management stakeholders, we developed an annual Coccolithophore Bloom Index (CBI) for the eastern Bering Sea shelf using satellite ocean color data. Comparisons between in situ and satellite data and the CBI (years 1997-2017) were used to examine hypotheses regarding environmental influences on interannual bloom variability. A significant non-linear relationship with summer stratification was found: the CBI was higher during years with either very low or very high stratification. In addition, while the blooms usually occurred over the middle shelf (50 – 100 m depth), more of the bloom was located over the shallow (30 – 50 m) inner shelf when stratification was low. Spatial correspondence between nutrient concentrations (nitrate, ammonium) and the areal extent of the coccolithophore bloom provide tantalizing but non-conclusive evidence that nutrient availability plays a role in bloom formation and location.

Fisheries Science Committee Paper Session

November 2, 09:00 (FIS-P-13672)

Reproductive biology and fishery management of snow and Tanner crabs in the eastern Bering Sea

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Snow (*Chionoecetes opilio*) and Tanner crab (*C. bairdi*) stocks support boom-and-bust fisheries in the eastern Bering Sea. Management of these male-only crab fisheries may be enhanced by improved understanding of functional relationships between male harvest and female reproductive potential. In the genus *Chionoecetes*, females possess paired spermathecae, an organ for sperm storage from previous matings. For Tanner crab in Southeast Alaska, mean sperm cell counts of primiparous females by location were negatively correlated with an exploitation rate index, suggesting that male-only harvest decrease levels of stored sperm available for fertilization of a subsequent clutch. For Tanner crab in the eastern Bering Sea, a 13-14 year cycle in recruitment and total population size may indicate that long-term environmental variability mediates recruitment strength. However, this cycle is also approximately double the estimated mean age of maturity, suggesting the possibility of an endogenous rhythm associated with a stock-recruit relationship. For snow crab, fecundity increases with increasing female size and decreases for older multipara (age) likely due to senescence. We report on attempts to improve upon estimates of reproductive potential, which are affected by relationships with life history, female size, shell condition, temperature during embryogenesis, and other factors. Additionally, we pursue ongoing research to determine whether structures in *Chionoecetes* are retained through molting and whether band counts in these structures correspond to age. If so, results would provide a boon to estimates of age at maturity and rates of natural mortality and growth, which are critical for sustainable fishery management of these stocks.

November 2, 09:20 (FIS-P-13270)

The dynamics of the biomass of the bottom fish major families in the eastern part of the Sea of Okhotsk in 1960-2017

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The West Kamchatkan shelf typically demonstrates high biodiversity, including more than 150 species and subspecies, representing 32 families of fish. The basis of the fish biomass (over 93%) in the depth range 15-300 m is currently made up of 4 families: *Gadidae*, *Pleuronectidae*, *Cottidae* and *Clupeidae*.

In 1989 the maximal value of the total biomass of the bottom fish for examined period (1960-2017) exceeded 2000 million. tons. The average level of the total biomass for mentioned period was 690.8 thous.tons. The average total biomass of *Pleuronectidae* was 406.6 thous.tons, *Cottidae* — 203.6 thous.tons, *Gadidae* — 148.3 thous.tons.

For today (2008-2017) the total biomass of the bottom fish on West Kamchatka exceeded the level of the 1980s. However, the contribution of the basis families changed visibly. For instance, Gadidae and Cottidae, respectively contributed 1.3 and 1.5 times less comparing in the 1980s. Although Pleuronectidae contributed 1.4 times more.

Increasing biomass of Pleuronectidae in 1980-1990 was due to significant growth of the biomass of yellowfin sole, when it made up over 70.0%. In 2008-2017 the basis of the biomass of Pleuronectidae was reprecented by Sakhalin dab, which contributed 53% into the total biomass of the family in 2014. Recent decade in the whole period of observations can be characterized by consequent decrease of the Pacific cod stock to a very low level (26.8 thous. tons in 2016) and explosive growth of saffron cod biomass (198.6 thous.tons in 2015).

November 2, 09:40 (FIS-P-13355)

Application of DNA metabarcoding on biodiversity research of nekton community

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The main members of nekton (swimming animals) are fish, marine mammals, cephalopods and crustaceans. Most of the swimming animals are the final products of the water productivity, which accounts for about 90% of the total amount of aquatic products in the world. It is an important source of animal protein in human food. Therefore, species identification and diversity conservation of swimming animals are of special importance to mankind. Based on the recent literatures of DNA metabarcoding in fishery resources, this paper reviewed the development of DNA metabarcoding as it originated from DNA barcode, the combination with high-throughput sequencing technologies and its performance in the nekton biodiversity, and the characteristic on how to identify multi-species automatically from a large sample containing an entire organism or decayed DNA of sediment, water, waste, etc. Some applications had been compiled and discussed in detail about biodiversity monitoring, resource survey, diet analysis, endangered species protection and management of alien species invasion. Some obstacles are still existed in the mismatch of common primers for DNA metabarcoding, decayed DNA on the exposure in external environment, and inappropriate DNA extraction method. However, DNA metabarcoding could be a great candidate to study on species diversity. It's also suggested that advances of DNA metabarcoding should focus on co-building a nekton DNA metabarcoding database, sharing the information platform and performing the wideness of third high-throughput sequencing generation in nekton.

November 2, 10:00 (FIS-P-13530)

Estimation of a temperature-dependent Gompertz-Laird growth equation of chub mackerel (*Scomber japonicus*) larvae

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Chub mackerel are one of the most commercially important species in the Korean waters. Variations in water temperature and growth during the early life stages are critical factors determining the recruitment and potential catch of chub mackerel, but yet no study has explicitly provided a temperature-dependent growth equation for chub mackerel larvae. Here we propose a Gompertz-Laird growth equation as a function of ambient water temperature in Celsius (T) for chub mackerel larvae by utilizing the experimental data reported by Hunter and Kimbrell (1980). The derived equation was , where L_t is standard length in cm, t is age in days, and . We expect that our derived growth equation can be useful in evaluating and projecting climate-change effects on the recruitment, spatial distribution and potential catch of chub mackerel by developing and applying bio-physical coupling models.

November 2, 10:40 (FIS-P-13399)

Biological monitoring of Pacific salmon at the hatcheries of Kamchatka region

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Complex researches are provided at salmon hatcheries of Kamchatka region every year. The work consists of basis components, including evaluation of epizootic situation at the hatcheries; control of biological conditions of juvenile salmons; otolith marking of juvenile fish before releases; identification of hatchery salmons in the control and commercial catches; evaluation of the efficiency of the hatcheries; estimation of the maximum possible releases in view of carrying capacity of the acceptor-rivers. The purpose of the monitoring is to figure out general biological principles, allowing to improve practical recommendations to enhance efficiency of the Pacific salmon artificial production.

November 2, 11:00 (FIS-P-13419)

Effects of sample size and distribution characteristics of survey data on estimation of abundance index of fish population using delta-distribution model

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Delta-distribution model is widely used for estimating abundance indices of fish populations especially when many extreme values occur in the survey data. In order to examine the impacts of sampling efforts and distribution characteristics of survey data on abundance estimate using delta-distribution model, simulated data were generated by resampling the original survey data and analyzed to estimate fish abundance index with different sample sizes and distribution characteristics using delta-distribution model. The performances of delta-distribution model varied with sample sizes and was also affected by the distribution characteristics of the original survey data. Delta-distribution model could get relatively precise abundance index estimates at relatively small sample size when the original survey data was relatively evenly distributed and at large sample size when the original data were rightly-skewed. Distribution characteristics of survey data obviously influenced the performances of the delta-distribution model for estimating abundance index. Increase of zero values proportion, skewness of non-zero values or coefficient of variation would cause decline in stability and accuracy for estimating abundance indices using delta-distribution model. The effects of any of these factors on the estimation of abundance index could not be described by simple linear function. The formula of delta-distribution model determined that the estimates would be affected by complex factors including several elements. Such a post-survey analysis could improve the precision of abundance index estimate using delta-distribution model.

November 2, 11:20 (FIS-P-13548)

Stock assessment of Pacific anchovy (*Engraulis japonicus*) biomass in the Korea Strait based on Simulation-based yield-per-recruit analysis

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Pacific anchovy *Engraulis japonicus* is one of the most commercially important species in the Korea Strait. In Korea, Anchovy catch biomass has steadily increased since the 1950's and it showed sudden decrease in the early 2010's. To providing biological reference point consider to short life cycle (maximum age is 2 years) of Pacific anchovy, we developed and applied a daily simulation-based yield-per-recruit (Y/R) model that considered 1) temperature-dependent growth, and 2) size-dependent mortality, including the life cycle from egg to adult stages. Assuming annually-constant daily egg production of anchovy during the spawning season, we estimated potential yield and egg production with respect to varying biological reference points of 1) the instantaneous fishing mortality, and 2) the length at first capture in fork length (Lc) with the two alternative fisheries regulation scenarios 1) a minimum Lc to protect larval and juvenile anchovy, 2) a maximum Lc to protect adult anchovy. Our Y/R model showed that potential yield could be maximized when the minimum Lc ranges between 42-60 mm (annual catch = ca. 1.2 million tons) and the maximum Lc > 88 mm (annual catch = ca. 0.8 million tons). The study results suggest that to protecting small size population is more efficient than to protecting big size population for fishery management. Also, Our method can be applied to other small pelagic species that difficult to apply the traditional Beverton-Holt Y/R model.

November 2, 11:40 (FIS-P-13428)

Habitat suitability modeling reveals climate-driven abundance variability and geographical distribution shift of winter-spring cohort of neon flying squid in the Northwest Pacific Ocean

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A habitat suitability index (HSI) model was developed to examine the climate-related habitat variations and the relationship with abundance and distribution of neon flying squid *Ommastrephes bartramii* in the Northwest Pacific Ocean. The HSI model was constructed and validated using the fishery data during 2006-2015 with three crucial environmental variables including sea surface temperature (SST), photosynthetically active radiation (PAR) and sea surface height anomaly (SSHA). Results indicated that the catch-per-unit-effort (CPUE) of *O. bartramii* gradually decreased during 2006-2015, the latitudinal gravity centers of fishing effort (LATG) shifted southward. Correlation analyses suggested that the CPUE was positively correlated with SST, PAR and the areas of suitable (HSI≥0.6) and optimal (HSI≥0.8) habitats occupying the whole fishing ground, but negatively related to the SSHA. Significantly positive correlation was found between the LATG and the average latitude of the most preferred SST, PAR, and the average latitude of the area with the HSI between 0.9-1.0. The annually declining CPUE over 2006-2015 were highly consistent with the expansive poor habitats and contractive suitable and optimal habitats. Meanwhile, the south-approaching LATG coincided with the southward migration pattern of the latitude of area with HSI in the range of 0.9-1.0. Moreover, comparing to the El Niño events, La Niña events yielded higher CPUE and enlarged suitable habitat areas for *O. bartramii*, the LATG moved toward further north. Our findings suggested that variability in the abundance and distribution of *O. bartramii* were largely attributed to climate-induced massive environmental variations and further habitat changes on the fishing ground.

November 2, 12:00 (FIS-P-13344)

Evaluating the effect of data manipulation on clustering analysis on fish abundance

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Clustering is commonly used in many disciplines, however, the reliability and stability of the methods have rarely been studied in the practical applications in fisheries, regarding technical details such as data transformation, optimization of cluster number, and minimum of data sizes. This study presents an intensive comparison of three common clustering methods, Hierarchical cluster, K-means and Expectation-Maximization method (EM) in identifying meaningful ecoregions based on fisheries community surveys in the coastal waters of Shandong. We evaluate the performance of the three methods in various scenarios of clusters number, data size and data transformation, focusing on the consistency validation with an index of Average Proportion of Non-overlap (APN). The major findings include: (1) the three methods are inconsistent in the optimal number of clusters, and data pre-processing approaches, including scaling, square-root and log-transformation, show different influence on the clustering results. (2) EM have good performances to avoid extremely unbalanced classification, whereas Hierarchical and K-means provide more stable results. Besides, the pre-processing also influenced the stability of clustering, and scaling tends to provide more stable solution at the same cluster number. (3) The APN value decreased with increasing size of data, indicating an improved stability, whereas the changing rates level off over 70 samples, depending on the clustering methods. We conclude that the best method depends on the aim of the clustering and the number of cluster, whereas K-means tended to be robust in this study. We also provide some recommendations for the application of clustering in fisheries data.

Human Dimension Committee Paper Session

November 2, 09:00 (HD-P-13580)

Historical and contemporary Indigenous marine conservation strategies in the North Pacific

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Global marine biodiversity is declining, and strategies to reduce, halt and reverse such declines are urgently needed. Coastal Indigenous peoples have been managing their marine territories for thousands of years, including conservation strategies that are applicable to contemporary conservation. We reviewed, coded, and synthesized historical and contemporary marine conservation strategies by the Kitasoo/Xai'xais First Nation in British Columbia, Canada, using the Conservation Measures Partnership conservation actions classification system. We found that the Kitasoo/Xai'xais First Nation applied all first-order conservation actions in historical and contemporary conservation, with Hereditary Chiefs' responsibilities of managing their marine territories playing a key role. A conservation ethic permeates Kitasoo/Xai'xais culture, and Indigenous resource management and conservation existed not only in the past but continues strongly despite extreme efforts by colonizers to suppress all Indigenous practices. The Kitasoo/Xai'xais' embodiment of all conservation actions as part of their worldview, rather than seeing conservation as requiring actions separate from everyday life as is the norm in non-Indigenous conservation, was missing from the conservation action classification system. The Kitasoo/Xai'xais are one of many First Nations in coastal British Columbia and elsewhere who are working to revitalize their governance and management authorities. With the Canadian government's declared willingness to work towards reconciliation, there is an opportunity for the government to enable First Nations to lead on marine and other conservation efforts. Global conservation efforts would also benefit from enhanced support for Indigenous conservation approaches, as it may broaden the toolbox and ways of thinking about conservation.

November 2, 09:20 (HD-P-13589)

Observing Canada's Pacific coastal ocean: Networks, programs and pathways to operationalization

S. Kim **Juniper**[1], Akash Sastri[1], Charles Hannah[2], Jennifer Jackson[3] and Bryan Hunt[3]

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Canada's complex Pacific coast environment is characterized by regional contrasts in human pressures and requirements for ocean monitoring. Major oceanographic features of the region include the inland Salish Sea, sheltered and exposed archipelago, fjords and coastal inlets, and open coast facing the northeast Pacific. The federal Department of Fisheries and Oceans (DFO), Ocean Networks Canada (ONC), and the Hakai Institute (Hakai) are the principal operators of ocean observing programs and observing platforms in the region. DFO's vessel-based observing programs maintain long time series in the Salish Sea to support ocean productivity research. Other vessel-based observing programs are operated by ONC (ferry routes) and Hakai (Calvert Island). ONC maintains an extensive network of cabled observing platforms that provide real-time ocean data and imagery to an online, open-access data centre. Hakai's growing sensor networks around Calvert and Quadra Islands monitor fresh and marine water properties. Marine mammal activity and ocean soundscapes throughout the region are monitored by hydrophones operated by ONC, DFO and private and not-for-profit interests. High frequency coastal radars operated by ONC and DFO provide information on surface ocean conditions in some locations. The primary mission of all of these observing programs and networks has been basic and applied research. Looking ahead to increasing requirements for real-time operational ocean information, we will examine the observational data requirements for maritime safety, marine mammal conservation and ocean health monitoring. These cases studies will illustrate the technical challenges and data-collection gaps related to operationalizing ocean observing on Canada's Pacific coast.

November 2, 09:40 (HD-P-13690)

Development of Sustainable Integrated Multi Tropic Aquaculture (IMTA) as a Model of Sato Umi Concept in the Coastal Area of Indonesia

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As the largest archipelago in the world, Indonesia has coastline reaches 95.181 km with sea area of 5.4 million km^2. Indonesia has also 1.2 million hectares (ha) of brackish water pond area and 4.5 million ha of marine culture area. Among them, it is only 37.5% and 2 % used for aquaculture activities, respectively. The low utilization of brackish water pond and marine culture area are generally caused by the environmental degradation due to the excessive exploitation by intensive aquaculture activities during the period of 1980s and mismanagement of the coastal resources. By applying the Sustainable Integrated Multi Tropic Aquaculture (IMTA) Sato Umi model on the bases of bio-recycle system, the waste that arises from aquaculture can be reduced, as the result productivity of the brackish water pond can be improved optimally. An experiment of the IMTA in the brackish water pond as a close system model (CSIMTA) has shown a good performance on the production of multi species fisheries commodities as well as water quality stability. On the onshore area, developing of open system model of IMTA (OSIMTA) by combining seaweed culture and floating cage of multi species fisheries commodities seem also has a good prospective to improve productivity of coastal area. The application of Sato Umi concept is being expanded to the west (Sabang) and eastern coastal area of Indonesia (Raja Ampat) from the first experiment area in the northern coastal area of Karawang, West Java.

Keywords: Sustainable IMTA Model, Sato Umi, Coastal Area Indonesia

November 2, 10:00 (HD-P-13829) CANCELLED

Evaluating the ecosystem services of Rudong coastal wetland using a rapid assessment approach

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Wetlands make important and diverse benefits to human beings around the world. However, recognition of these contributions is often lacking in decision-making and sustainable policy. Evaluation of ecosystem services of wetlands can effectively inform decision-making in ways that support the transformation of how development is planned and acted upon towards sustainable solutions, depending on certain features of the valuation exercise. Despite a plenty of available assessment techniques, very few approaches are rapid, applicable across different wetland types or consider the realities of time and money resource constraints. We used a Rapid Assessment of Wetland Ecosystem Services approach to evaluate the ecosystem services of Rudong wetland in China. This method is based on a variety of field indicators in order to assess the positive or negative contribution over 30 wetland ecosystem services provided at local, region or global scales. Outputs are simplified, signaling to decision-makers the diversity of interlinked ecosystem service outcomes consequent from management policies and actions.

November 2, 10:40 (HD-P-13575)

Successes and failures of regulatory requirements to rebuild depleted stocks in U.S. fisheries

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Under the 1996 and 2006 reauthorizations of the MSA, RFMCs have been required to assess the status of each FMP stock and to develop rebuilding plans for each stock that is "overfished". Initially, the number of "overfished" stocks increased as more extensive assessments determined stock status. The number of overfished stocks began to decline as overfishing was ended and rebuilding plans came into force. Yet, a number of "overfished" stocks have not recovered under stock rebuilding plans even where those plans called for cessation of all fishing.

November 2, 11:00 (HD-P-13576)

Attenuating durable use rights to public resources

Keith R. **Criddle**[1] and Arthur R. Wardle[2]

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Federal and state governments issue permits—conditional use rights—for commercial and recreational exploitation of extractive and amenity services of natural resources. Examples include fishing permits and quotas, grazing rights, logging permits, mineral rights, water rights, guiding permits and other visitor service concessions, and recreation permits (fishing, hunting, camping, hiking, rafting, etc.). Legislation that authorizes the issuance of these use permits typically stipulates that permit holders not be entitled to compensation when those use rights are "taken"—attenuated, not renewed, or extinguished—even where those use rights have been issued for a long or even indefinite term. However, government-issued licenses, permits, intellectual property, and benefit programs are increasingly accorded legal protections historically reserved for real property. Thus, state and federal resource agencies often facilitate mechanisms that provide public or private compensation for substantive diminutions of durable use rights to natural resources. However, informal recognition of comprehensive property rights invites rent-seeking and litigation costs that diminish net social benefits. These costs could be avoided through issuing permits vested rights.

November 2, 11:20 (HD-P-13769)

Developments, challenges and policy recommendations for marine fishery resources in China

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Over the past 60 years China's fishery industry has made brilliant achievements, and the output of fish production is the largest in the world. However, with the enhancement of the development ability of marine fishery resources, the total amount of marine fishery resources has gradually increased year by year. Under the condition of the limited reproduction and regeneration capacity of marine fishery resources, the marine fishery resource is declined rapidly and ecological environment along the coast of China sea is deteriorated. How to develop scientifically and use rationally marine fishery resources to promote the sustainable development of marine fisheries? It is urgent to solve problems and adopt more targeted policies. This paper analyses the remarkable characteristics, effects and reasons of the exploitation and utilization of marine fishery resources in China since 1949. On this basis, We put forward the following policy recommendations: the property rights system of marine fishery resources should put into practice as soon as possible. First, on the basis of the system of total Allowable catch, the system of fishing quota rights for major fishery resources should be established. Second, the traditional marine fishermen and commercial fisheries should be empowered differential rights for resources development; third, according to

the development of marine fisheries resources, natural conditions, ecological characteristics, the different offshore and coastal areas should be taken differential measures for governance; fourth, to strengthen assessment and statistical monitor of the resources, which will be good support for the implantation of source property system.

November 2, 11:40 (HD-P-13493)

Bioeconomic consequences of stow net selectivity in Haizhou bay, China

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Stow net is a major fishing gear using in nearshore fisheries, over 18% catch composition are captured by stow net in Haizhou bay. Fish body size is a key factor to affect the value of landing catch and fishermen's economic yield. Optimal mesh size of fishing gears can provide the maximal economic value and improve sustainable utilization of fisheries resources. Here we designed an experiment to evaluate that which mesh size of stow net is optimal to nearshore fisheries. We compared different mesh size in terms of catch composition, value per unit effort and body length across species based on experimental data. We found that the catch in no size-selective fishing was significantly smaller by individual value, total length and weight than those in size-selective fishing. But the catch and value per unit effort in no size-selective fishing were larger than those in size-selective fishing. These findings show that large mesh size cannot get maximal economic yield, and size-selective fishing impacts of fish individual body size and price. Our results have important implications for sustainable utilization of nearshore fisheries resources. Furthermore, more attention requires to pay on landing catch individual value and stow net fisheries management.

Marine Environmental Quality Committee Paper Session

October 30, 16:20 (MEQ-P-13299)

Retrospect and prospect of status of coastal eutrophication in China Seas

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Along with China's rapid economic and social development, anthropogenic emissions accelerated the external inputs of nutrients to coastal waters, which in turn, resulted in severe coastal eutrophication in the China Seas. The evolution processes of coastal eutrophication in the China Seas are analysed and summarized after 40 years of reform and opening up. Results showed that the riverine concentrations of nitrogen and phosphorus have increased rapidly while dissolved silicate decreased in the main large rivers since the end of the 1970s. As responses to elevated nutrient levels and changed compositions, phytoplankton biomass increased significantly and the proportion of flagellates increased in species composition in coastal water of the China Seas. The frequency and affected area of harmful algal blooms increased rapidly, and other symptoms of coastal eutrophication also worsened such as coastal hypoxia, loss of benthons, and problems of macroalgae.

Analysis demonstrated that the evolution of coastal eutrophication was closely related to China's GDP scale or growth rate, developmental pattern, and environmental policies etc. The status of coastal eutrophication was not so serious but it worsened rapidly from the end of the 1980s to the beginning of 21st century because of high speed of growth rate as well as the resource consuming developmental pattern. The worsening trend has been curbed in the recent decade but the status of coastal eutrophication has not been improved essentially, and it is still a long way to go for the control and renovation of coastal eutrophication in the China Seas.

October 30, 16:35 (MEQ-P-13571)

Spatial variability of the main contaminations in seawater environment in Xiamen Bay

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Based on the investigation about water quality of coastal waters in Xiamen Bay during 2010, cluster analysis and principal component analysis were carried out to investigate the spatial distribution and source of coastal water pollution, and pollution control measures were also proposed. The results are as follows: (1) The sampling sites were classified into two clusters, the low and high polluted. Nutrients of first cluster were higher than the other, while suspended solids was on the contrary; (2) 87.34% and 90.14% of the total variance can be explained for first and second cluster respectively based on PCA. The two clusters can extract three and two principal components (PCs) respectively; (3) First PC of the first cluster come mainly from the river input and agricultural wastewater, the second one come from livestock and poultry, and the 3rd one was derived from organic pollutant of domestic sewage. The two PCs of second cluster mainly come from industrial wastewater, sewage and agricultural wastewater emissions; (4) The focus of water pollution control in Xiamen Bay was how to control land-based pollution, to strengthen the management of land-based sewage outfall, and the watershed comprehensive management, and reducing human interference on the ecosystem of the river and sea was also important.

October 30, 16:50 (MEQ-P-13599)

Persistent organic pollutants in bottom and pelagic fish from the Sea of Okhotsk

Olga N. **Lukyanova**[1, 2], Vasiliy Yu. Tsygankov[2] and Margarita D. Boyarova[2]

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Organochlorine pesticides (OCP) and polychlorinated biphenyls (PCBs) are the most dangerous among persistent organic pollutants (POPs) in terms of widely distribution and impact on biota. The final links in the POPs accumulation are often marine ecosystems. Fish are able to accumulate POPs in their organs POPs and may be used as indicators of the environment conditions. Monitoring of POPs using bottom (flounder) and pelagic (Pacific salmon) fish of the Sea of Okhotsk was carried out in 2017. Flounders were caught near south-western Kamchatka and offshore Kuril Islands, salmon – in the south part of the Sea of Okhotsk. Pesticides and PCBs concentrations in fish muscle were determined by GCMS and GC. Total pesticide concentration in flounders ranged from 11 to 430 ng/g lipid, PCB – from 23 to 280 ng/g lipid. beta-HCH, DDD and DDE were dominated compounds. 101, 118 and 153 congeners prevailed among PCB. OCP concentration in pink and chum ranged from 61 to 715 and from 56 to 4223 ng/g lipid, respectively. OCP concentration in chum was significantly higher than in pink ($p \leq 0.05$). Bottom fish reflect local pollution, while pelagic fish indicate the widespread distribution of toxic substances. It can be assumed that the main sources of pesticide input to the Sea of Okhotsk are atmospheric transport and ocean currents. The Russian Science Foundation (agreement No. 18-14-00120) supported this work.

October 30, 17:05 (MEQ-P-13568)

Fate of floating debris released from Major rivers around Korea

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Using a Lagrangian particle tracking model, the trajectories of floating debris that are originated from seven major rivers around Korea peninsula (five rivers in Korea: the Han, Keum, Youngsan, Seomjin, and Nakdong Rivers; two rivers in China: the Yangtze and Yellow Rivers) are investigated. Daily ocean current data of HYCOM analysis and wind data of ECMWF reanalysis were used in the particle model. We assumed that the amount of the debris released from each river is linearly proportional to the population over catchment area of the river. Particles are released daily from each river for six years. There is no convergent zone in waters around Korea. The main part of particles land on the coast near the originating river. For particle traveling long distances, the final destination is governed by ocean currents, of course. Although the main portion of the particles from the Chinese rivers lands on the Chines coast, the number of particles overwhelms those from the Korean ones and the Chines Rivers especially Yangtze could have a large impact on Korea peninsula and Japan.

October 30, 17:20 (MEQ-P-13765) (CANCELLED)

A preliminary study of the Yangtze River terrigenous inputs change and response of the estuary ecological environment

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Terrigenous inputs played an important role in the Yangtze Estuary and the East China Sea ecosystems. In recent years, however, human activities, particularly dam construction, produced tremendous impacts on the Yangtze River inputs into the estuary, thus induced environmental changes in the estuary ecosystem. Since 1950, annual runoff of the Yangtze River has kept equilibrium, while the difference between flood and dry seasons shrunk. The sediment load significantly reduced, which was attributed to dam construction in the Yangtze River basin, and the construction of the Three Gorges Project (TGP) was the main reason for sediment load reduction in recent years. River runoff and estuary surface salinity were negatively related. During years with similar annual runoff, the salinity contours moved towards east in May after the TGP construction, while towards west in November. The content of suspended particulate matter after the TGP construction experienced substantial reduction, meanwhile, its high-value region moved towards southwest, indicating that sediment load from the Hangzhou Bay became dominant. The behavior of silicate and nitrate in the estuary were conservative, while phosphate was also affected by the particulate matter. In spring, nutrients were negatively related to runoff in high chlorophyll a region, while were positively related in other areas. The relationship between nutrients and sediment showed the opposite distribution pattern. In autumn, phytoplankton growth became weakened, and nutrients were positively related to runoff, while were negatively related to sediment.

October 30, 17:35 (MEQ-P-13271) CANCELLED

Analysis of water quality change characteristics in Fujian Bay based on time-space matrix method

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Based on the water environment monitoring data in 2005-2011, August and in 2012-2015, May, August, principal component analysis result of water quality index was applied to divide into the environmental units in the Gulf of Fujian, then characteristics of Fujian bay water quality was analyzed by the time-space matrix method. The results show that, (1) through principal component analysis, four water quality indexes were clustered into 2 types of components, phosphate and chlorophyll-a was clustered into one principal component, and nitrate and dissolved oxygen was clustered into another principal component; (2) the weight value as the coordinates, the surface water of Fujian was divided into six environment units, and the time series matrix of relative content of water quality index was established in order to analyze water quality condition on Fujian bay; (3) the time-space matrix of water quality index showed the certain cycle trend, index changing pattern of adjacent environment unit was synchronous, the absolute value of index change content increased slightly from chlorophyll-*a* to nutrient salt to dissolved oxygen. (4) Two principal component has a certain correlation, nutrition level influenced nutrient-phytoplankton dynamics, when the phosphate content was higher than 0.03mg/L the nitrate content was higher than 0.25mg/L and the nutrient cycle time changed significantly ,a linkage effect on the comparative changes of nutrient and chlorophyll-*a* (5) the water productivity of Fujian Gulf was low in summer, at the same time, a large amount of organic matter was input and degraded, the content of dissolved oxygen in surface layer decreased obviously; (6) the water environmental condition in Fujian Gulf was influenced by two different kinds of water bodies one is the river runoff that was rich in high nutrient, which affect the environmental units of the estuaries and adjacent sea areas; Fujian southern gulf was mainly affected by the Taiwan warm current and upwelling, which was an important source of phosphate in the East China Sea.

Key words: Time-space matrix method, Environmental unit, Principal component analysis, Fujian Bay, water quality index, characteristic analysis.

November 1, 14:00 (MEQ-P-13275)

The Plankton Index: A regional pelagic biodiversity indicator for ecosystem-based management

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Ecological time-series data are essential for informing management and policy, particularly in supporting the new generation of marine legislative drivers, which take a holistic ecosystem approach to management. From a pelagic habitats perspective, such management approaches must recognise the importance of plankton communities in marine ecosystems; ecological data at the appropriate spatial, temporal and taxonomic scales are therefore required for successful policy implementation. At the base of the marine food web, plankton time-series play an important role in the informing of biodiversity indicators, the setting of targets against a background of climate change and the provision of supporting information used to interpret change in non-plankton indicators. The Plankton Index, a trait-based indicator of change in plankton functional groups, allows the use of plankton data from multiple monitoring surveys with disparate methods of sample collection and plankton identification. Changes in the PI reflect multiple stressors on pelagic communities across spatial and temporal scales, such as natural variability, temperature increases, and changes in nutrient concentrations. The first regional policy application of this indicator in Northeast Atlantic waters revealed that plankton communities underwent broad spatially-consistent, but significant, changes in plankton functional groups during the past decade. These results directly informed national and regional management efforts towards ecosystem-based management through an integrated assessment for the Northeast Atlantic. Assessing pelagic biodiversity change using a common indicator at this scale for the first time is a significant step towards quantitatively evaluating the environmental status of regional marine ecosystems.

November 1, 14:15 (MEQ-P-13805)

Are zooplankton ingesting microplastics in the Arctic?

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Microplastics (<5 mm) are increasingly recognized as an emerging contaminant in the world's oceans; found from surface to seabed in the form of fragments, fibres, or granules. Evidence for unintentional ingestion of microplastics exists for a variety of organisms including: zooplankton, bivalves, and fishes, raising concern about potential effects in marine food webs. While a few studies have reported microplastics in the remote Arctic, data are nonexistent on the ingestion of microplastics and associated biological effects in natural populations of calanoid copepods in the Arctic. In the summer of 2017, zooplankton samples were collected at 56 stations spanning the Northeast Pacific and Arctic Oceans. To isolate microplastics, zooplankton samples (0.5 g WW) were digested according to a newly developed method using Corolase and KOH (10%), and filtered through a 20 µm polycarbonate filter. Using light microscopy, microplastics were quantified and characterized, for the first time, in marine copepods of the genera *Calanus* and *Neocalanus*. Polymer identity was determined for each microplastic particle or fibre isolated using state of the art Fourier-transform infrared spectrometry (FTIR). Using RNA:DNA ratio as a biochemical index of growth and condition, zooplankton health is being assessed and examined in relation to microplastics ingestion. These results will shed light on microplastic contamination at the base of the Arctic food chain, two genera that are key for Arctic ecosystems.

November 1, 14:30 (MEQ-P-13325)

Harmful algal blooms (HABs) may trigger and accelerate hypoxia zone formation at the Pearl River Estuary

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Observations of harmful algal blooms (HABs) are increasing around the world's coastal ocean, with a growing number of reports indicating anthropogenic influences. These phenomena are caused by blooms of microscopic algae. Excessive microalgae growth in response to nutrient increases and/or shifts in nutrient ratios can result in a HABs of a single or several species that has negative ecosystem impacts. As HABs occur and result in the depletion of oxygen (hypoxia) in the water, fishery disasters were reported by many countries. To study the relationship of HABs and hypoxia, we conducted a study on 34 sites via cruise at the Pearl River Estuary from July 10-21, 2017. The temperature and salinity of surface water ranged from 27.9-30.8□ and 5.4-33.9psu, respectively. The dissolved oxygen (DO) of surface water was from 6.1 to 11.7, while the DO of bottom water was lowest reach to 1.3 and the highest DO were just 7.4, an obvious hypoxia and low oxygen zone were detected. At the same time a wide range of phytoplankton bloom in surface water were observed over 10 study sites over 5000cells/ml and with maximum 45560 cells/ml at site F201. After the principal component analysis, there showed a positive correlation between phytoplankton abundance of surface water and DO of surface water, and a negative correlation were shown between phytoplankton abundance of surface water and DO at bottom layer. Further, with the analysis of Next Generation Sequencing on bacteria composition of sediment, we have detected several typical bacteria may related HABs and hypoxia, such as family Saprospiraceae and class Clostridia, which give some evidence on HABs and its coupled benthic microbial community may trigger and accelerate hypoxia zone formation at the Pearl River Estuary.

November 1, 14:45 (MEQ-P-13677)

Characterization of oceanic Noctiluca blooms not associated with hypoxia in the Northeastern Arabian Sea

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Intense blooms of the heterotrophic dinoflagellate, green *Noctiluca scintillans,* have been reported annually in the Northern Arabian Sea since the early 2000s. Although not known to produce organic toxins, these blooms are still categorized as a harmful due to their association with massive fish mortalities. Recent work has attributed these blooms to the vertical expansion of the oxygen minimum zone, driven by cultural eutrophication from major coastal cities in western India. As diatoms are preferred prey of green *Noctiluca scintillans,* more frequent blooms of this mixotroph will likely impact the productivity of important fisheries in the region. The present study uses a satellite algorithm to determine the distribution of both diatom and green *Noctiluca* blooms in the Northeastern Arabian Sea from 2009 to 2016. The results from shipboard microscopy of phytoplankton community composition were used to validate the satellite estimates. The satellite algorithm showed 76% accuracy for detection of green *Noctiluca* and 92% for diatoms. Shipboard measurements and data from biogeochemical-Argo floats were used to assess the relationship between oxygen concentrations and green *Noctiluca* blooms in the Northeastern Arabian Sea. Regardless of the presence of a *Noctiluca* bloom, the dissolved oxygen in the photic zone was always >70% saturated, with an average oxygen saturation >90%. The variability in the relative abundance of diatoms and green *Noctiluca* is not correlated with changes in oxygen concentration. These findings provide no evidence that cultural eutrophication has contributed to the decadal scale shifts in plankton composition in the Northeastern Arabian Sea oceanic waters. Conversely, the climatic warming of surface waters would have intensified stratification, thereby reducing net nutrient flux to the photic zone and decreasing silicate to nitrate ratios (Si:N); both factors that could increase the competitive advantage of the mixotroph, green *Noctiluca*, over diatoms. If so, the decadal-scale trajectory of phytoplankton community composition in the Northeastern Arabian Sea may be a harbinger of future climate-driven change in other productive oceanic systems.

November 1, 15:00 (MEQ-P-13283)

2017 Red Tide in China

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About 68 events of marine red tides with an affected area of 3,680 km^2 were witnessed along Chinese coastline. The events of red tides were the same as in the previous year but the cumulative occurrence area decreased by 51% compared with that in 2016. The highest frequency was 40 times, with the largest cumulative area of 2,189 km^2 occurred in the East China Sea. High incidences of red tide mainly occurred in June. Red tides were caused by a total of 34 species. Among them, *Karenia mikimotoi* was the first dominant species, which caused the outbreak of as many as 12 red tides. In June, the red tide caused by *Gymnodinium catenatum* occurred in the coastal waters of southern Fujian Province, and PSP was detected in mussels and oysters. The occurrence area of green tides, *Enteromorpha prolifera*, has been the smallest in the past five years.

November 1, 15:15 (MEQ-P-13357)

Increase in anthropogenic nitrogen and mercury in marginal sea sediments of the Northwest Pacific Ocean

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Marginal seas adjacent to northeast Asian countries are under the increasing influence of anthropogenic nitrogen (N^{ANTH}) and mercury (Hg^{ANTH}) resulting from fossil fuel combustion and fertilizer use. Sediments of the East China and the Yellow seas sampled adjacent to continental China were found to have a lower $\delta^{15}N$ ratio (5.0 ~5.4‰) concomitant with a higher level of Hg^{ANTH} flux (8.1 μg m^{-2} yr^{-1}), a clear signature of the presence of N^{ANTH} and Hg^{ANTH} from China. In contrast, the western Arctic sediments, the sampling zone furthest from China, showed a higher $\delta^{15}N$ value (8‰) and a lower Hg^{ANTH} flux (0.9 μg m^{-2} yr^{-1}); closer to those of natural background. Across the sites sampled, the levels of sediment $\delta^{15}N$ ratios increased and Hg^{ANTH} flux decreased with increasing distance from the source continent. These results show that the effect of N^{ANTH} and Hg^{ANTH} has extended beyond the ocean water column into the deep sedimentary environment, presumably via the biological assimilation of N^{ANTH} and the formation of organic-mercury complexes followed by deposition. Further, the findings indicate that N^{ANTH} is taking over from the conventional paradigm of nitrate flux from nitrate-rich deep water as the primary driver of biological export production and the input of Hg^{ANTH} may be impacting organisms in the water column as well as those in sedimentary environments in the Northwest Pacific Ocean.

November 1, 15:30 (MEQ-P-13516)

Fukushima-derived ^{137}Cs and ^{134}Cs in the Northwest Pacific Ocean in 2017

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Fukushima Daiichi Nuclear Power Plant Accident (FDNNPA) aroused a worldwide anxiety and concern. To understand the transport of the radioactive contaminants released from FDNNPA in the northwest Pacific, 2 monitoring cruises were performed per year by the State Oceanic Administration of China from 2011. In 2017, more than 80 stations and 12 nekton samples in the Northwest Pacific Ocean were monitored. Here we report the corresponding results.

The monitoring result of seawater samples showed that the activity concentrations of ^{137}Cs and ^{134}Cs in the Northwest Pacific Ocean were ND- 4.80 Bq/m^3 and ND-0.95 Bq/m^3 by the September of 2017. Compared to 2011, the activity level of ^{137}Cs and ^{134}Cs has decreased largely. However, it was a little higher than that of 2016. ^{134}Cs could be detected in 11.7% of the seawater sample even after more than 3 half-lives passed. ^{137}Cs activity level in 50% of the seawater were 1.5~3 times higher than that before FDNNPA. Fukushima derived ^{137}Cs were mainly concentrated in the depth between100m and 500 with the estimated inventory of 1×10^{15} Bq in the monitoring area.

As for the nekton samples, what we analyzed were squids. The result showed that ^{134}Cs was undetectable and ^{137}Cs ranged from 0.014 Bq/kg$_{\text{fresh weight}}$ to 0.16 Bq/kg$_{\text{fresh weight}}$ with the average of 0.035 Bq/m^3, which suggested that the ^{137}Cs and ^{134}Cs activity levels had decreased to the level before FDNPPA.

November 1, 15:45 (MEQ-P-13461)

Marine Environmental monitoring with GF satellite data

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GaoFen is the Chinese civilian remote sensing satellites series of high resolution. This paper presents some typical applications on marine environmental monitoring with high resolution and wide swath satellite data, especial on the marine disaster monitoring such as oil spill, sea ice, and red tide. With these data, we can get the detailed information about different disaster.

Key words: GF satellite, marine disaster, monitoring

November 1, 16:20 (MEQ-P-13353)

Technology of assessing marine fishery losses caused by oil spills in China

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According to statistics, the worldwide offshore oil spills occurred in the amount of more than 5000 tons of large-scale accidents nearly 200 each year, most of which from shipping accidents, accounting for more than 70%. Oil spills occupies 0.5% of global oil production. Marine oil spill accidents not only result in huge economic losses for ecological environments and tourism, but also serious damages of fisheries and aquaculture. 9 calculating methods including “direct calculation method”, “comparison method”, “fixed sampling station capture method”, “expert evaluation method”, “fish eggs -larvae evaluation method”, “statistical estimation method”, “investigation-statistics method”, “production method” and “production statistics method” on the economic fishery losses caused by the oil spills in China were introduced. Also, how to choose appropriate methods according to polluted waters, polluted marine organism, degree of contamination, historical survey data and monitoring data, and some case studies were addressed.

November 1, 16:35 (MEQ-P-13321)

Impact of Water-Sediment Regulation Scheme on seasonal and spatial variations of biogeochemical factors in the Yellow River Estuary

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Seasonal and spatial distributions of nutrients and chlorophyll-*a* (Chl-*a*), together with temperature, salinity and total suspended matter (TSM), were investigated in the Yellow River estuary to examine the biogeochemical influence of the "Water and Sediment Regulation Scheme (WSRS)" that is used to manage outflows from the river. The results showed that nutrient species could be divided into two major groups. One group included NO_3^-, dissolved organic nitrogen (DON) and $Si(OH)_4$, primarily from freshwater discharge. The other group included dissolved inorganic phosphorus (DIP), dissolved organic phosphorus (DOP), NO_2^-, and NH_4^+. The WSRS not only shifted the seasonal patterns of nutrients in the estuary, with high concentrations moved from autumn to June and July, but also promoted the nutrient spread to the south central part of the Bohai Sea. Spatial distribution of Chlorophyll-*a* (Chl-*a*) was influenced by the WSRS, with high concentrations being found in the river mouth in June and September, flanking the river mouth in July, and in the south central part of the Bohai Sea in September. Although Chl-*a* concentrations increased in June and July, the seasonal patterns did not change. The highest concentrations were found in September. Nutrient loadings during the WSRS relieved DIP and $Si(OH)_4$ limitation, causing an excess of DIN and disrupting the balance of DIN/DIP in the estuary and Bohai Sea. The WSRS was also shown to have changed the topography of the estuary, as evident by the presence of a newly formed delta observed in August 2013.

November 1, 16:50 (MEQ-P-13797)

An assessment of the marine eco-civilization performance in Oujiang River Estuary Area, Zhejiang, China

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An estuary area usually experiences the most intensive anthropogenic influence of the coastal areas due to its geographical and physical attributes. It takes an important part of the "marine eco-civilization construction" in China. it is thus necessary to assess the performance of marine eco-civilization in the estuaries. There are however very few methodologies or cases studies related to marine eco-civilization assessment. Taking the Oujiang River Estuary area as a research area, this study aims to formulate an index system and an evaluation model for assessing the performance of marine eco-civilization in the estuary areas. The index system consists of six angles including coastal community, economy, resources, ecology, culture and governance based on the requirements of "marine eco-civilization construction" as well as the attributes of the estuary area. The evaluation model is developed based on the 3-D space state model. The preliminary results of the case study shows that the overall performance of marine eco-civilization construction in Oujiang River Estuary was getting better, but the development of six angles were not balanced. The local government could focus on the development of marine culture and the restoration of marine ecological environment in the future.

November 1, 17:05 (MEQ-P-13418) CANCELLED

The potential of alkyl amides as novel biomarkers and their application to paleocultural deposits in China

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A series of alkyl amides was detected and identified in the sedimentary record from an archaeological site at Yuchisi, Mengcheng, Anhui, China. The alkyl amides profiles change abruptly at the depth corresponding to the transition between two prehistoric cultures, which also corresponds to an abrupt change in the fatty acid ratio $C_{18:2}/C_{18:0}$. The different patterns of variation of the longer and shorter chain alkyl amides at the depth of the cultural transition may reflect differences in their response to external environmental changes, as well as different sources. This is the first study of the stratigraphic variation of alkyl amides in sediments, and their first application to assess paleoenvironmental changes. We suggest that alkyl amides may have potential as new biomarkers in archeological and paleoenvironmental studies.

November 1, 17:20 (MEQ-P-13424)

Long-term temporal and spatial variation of macrobenthos in a semi-enclosed bay under human disturbance

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Macrobenthos play an important role in marine ecosystem dynamics. The long-term dynamics of macrobenhos could help us to gain an insight into the functioning of bay ecosystems, which is essential for implementation of integrated bay management. Daya bay is a semi-enclosed bay, located in the northern South China Sea. During the recent decades, industrial and urban developments, resulted in anthropogenic activities increased in Daya Bay. However, few studies were conducted to analyze the long-term variation of macrobenthos in this area. Environmental factors and macrobenthos were collected during wet season from1988 to 2015. Results indicated a substantial change of communities. Large-sized molluscs species and Echinoidea species were dominated in 1988-2004, then small-sized bivalve species-*Timoclea scabra* and polychaeta species increased and became dominated after 2004. Non-parametric analysis indicated that significantly differenated (Kruskal-Wallis, $p<0.05$) at the measures of the number of species (S), Shannon diversity (*H*' log2), Variations in taxonomic distinctness (Λ^+) and abundance between years. However, there was no significant difference in Pielou's evenness (*J*') and Average taxonomic distinctness (Δ^+) temporally. Lower *H*' and Δ^+ were calculated from inner bay and the surrounding area of the nuclear power plant. Spearman correlation analysis showed that S, abundance, *H*' and Λ^+ were negatively related with the temperature and the content of silicates (SiO_3-Si) in the bottom water and *J*' was positively related with the salinity. We concluded that the natural factors and anthropogenic impacts at spatiotemporal scales, influenced the characteristics of the macrobenthos.

November 1, 17:35 (MEQ-P-12735) CANCELLED

Development of physicochemical and spectroscopic methods to characterize the *in-situ* chemical speciation of the inorganic contaminants and innovative technologies for remediation of water and environmental pollution by catalytic oxidants

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In the present investigations the efforts are focused to develop physicochemical and spectroscopic methods to characterize the in-situ chemical speciation of the inorganic contaminants and develop technologies for remediation of water & environmental pollution by catalytic oxidants. Also, to discuss strategies to save marine life through the control of Water & Environmental pollution resulting due to toxin, toxic gases, GHG (Green House Gases), by making use of Catalytic oxides of first row transition metal oxides. Next, to control Global Warming and save marine life (Under Water) by inhibiting the and remediation of Water treatment process by making use of catalytic oxidants.

The oxidation process would be employed to treat Groundwater contaminants by making use of the chemical oxidants viz. hydrogen peroxide, persulfate, permanganate & ozone. These oxidants have been able to cause the rapid and complete chemical destruction of many toxic organic chemicals; other organics are amenable to partial degradation as an aid to subsequent bioremediation. Its presumed that catalytic oxides of first row transition metal oxides e.g. Cobalt oxide should optimize the process of subsurface remediation and above-ground water treatment systems depending on a variety of site-specific conditions e.g. reaction rate kinetics.

Also, to correlate Physico-chemical properties of these catalytic oxidants involving chemical oxidation be applied in subsurface systems and in above ground water treatment systems involving chemical oxidation regeneration of granular activated carbon (GAC).

Water gets polluted due to toxin & toxic gases. There are generally four types of toxic entities; chemical, biological, physical and radiation In order to control marine environmental pollution, subsurface systems and in above ground water treatment systems, the present investigations are focused to develop innovative methods to entrap toxins, Chemical toxicants include inorganic substances such as, lead, mercury, hydrofluoric acid, and chlorine gas, and organic compounds such as methyl alcohol, by developing High Affinity Toxin Receptors (HART) & convert GHG (Methane, CO2,) to ethanol by catalytic processes and develop hybrid fuels like bio-ethanol and bio-diesel and go for electricity from biomass.

Next, to evaluate correlation of chemical oxidants with chemical species associated with soil and aquifer materials, and with target and non-target contaminants during water treatment processes.

November 1, 17:50 (MEQ-P-13547)

Research on indicator species of bio-blogging on Nuclear Power Cold Source Water

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Nuclear power has been vigorously developed in China for its high efficiency, safety, economy and cleanliness. The operation of nuclear power will change the hydrodynamic power and ecological environment to a certain extent; In recent years, many domestic and alien marine biological invasion events have affected the normal operation of the coastal nuclear power cooling system, then lead to nuclear power plant reactor shutdown, huge economic losses and frightening security risks.Therefore, it is very important to research on the monitoring of the typical disaster - causing organisms and the prevention and control measures to ensure the safety of the cold source water. This study is based on the emergency of the Ningde nuclear power plant reactor 3 unit reactor shutdown caused by marine organisms in August 8, 2015 .The major caused organisms were identified ,the related field survey ,laboratory physiological and ecological experiment were made for the disaster causing organisms,Combining the biological factors of the disaster causing organisms and the related environmental factors to analyse the clogging reasons. The related marine biological control methods were consulted to study the prevention and control measures of the disaster causing organisms.

Physical Oceanography and Climate Committee Paper Session

November 2, 09:00 (POC-P-13477)

Recent changes in producing of the Intermediate water in the Okhotsk Sea

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Data of long-term observations on cold intrusions in the warm Intermediate layer of the Okhotsk Sea are overviewed. They are formed in the process of the high-density Bottom Shelf water cascading from the northwestern shelf, mainly at northeastern Sakhalin. These new-formed portions of the Intermediate water are traced in the cyclonic circulation from this area to the southern Kuril Straits that takes from 2.5 to 6 years. Similar intrusions are found in the Pacific, mainly at southern Kuril Islands, where they penetrate presumably through the Vries Strait. Volume and density of the Bottom Shelf water depend on winter severity that could be quantitatively explained by the ice cover; all these parameters decrease recently. Salinity of the new-formed intermediate water has similar changes. Besides, tidal mixing influences on the salinity, so the tidal 18.6-years cycle is presented in its variations. On the contrary, variations of the minimal temperature in the cold-water lenses of the fresh Intermediate water do not correlate with changes in their production because of auto-compensatory effect for temperature in the process of cascading. The same effect is obviously applied to dissolved oxygen, that's why the oxygen content in the upper Intermediate layer at the area of cascading is rather stable. However, ventilation of deeper parts of the Intermediate layer becomes weaker on the background of recent lowering of the Intermediate water production, in particularly for $\sigma_q \geq 26.8$. On a distance from the area of cascading, the tendency to deoxygenizing spreads over the whole Intermediate layer of the Okhotsk Sea.

November 2, 09:20 (POC-P-13485)

Stirring and up-lifting of deep water at the entrance straits of Sea of Okhotsk (shown by data including flagged 'questionable' or 'bad')

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The reported evidence of global warming in the Sea of Okhotsk is the 50-yrs warming/increasing salinity/decreasing DO trends in the intermediate layer, of which possible mechanism is suggested to be relative enhancement of contribution of Deep water in formation process of Okhotsk Sea Intermediate Water, accompanying weakening of cooling by ventilation (Kashiwai, PICES-2016). The key processes can be up-lifting of Deep Water and stirring/mixing with Intermediate Water. At the Kuril Straits, it is well known that there are many data flagged as '*questionable*' or '*bad*', because failed in checks of range (outlier), inversion, or gradient, and not used in climatological analyses. However, the outliers, density inversions or large gradients can be the signs of strong stirring or up-lifting, expected in the water with strong current with steep bottom topography. Thus, the occurrences of σ_0 at the depth ranks of the Kuril Straits water were examined by ODV using WOD13 bottle data, including flagged '*questionable*' or '*bad*'. The obtained occurrences of σ_0 at depth ranks of 200m interval indicates that the watermass boundary between Intermediate Water ($\sigma_0 = 26.4 – 27.1$) and Deep Water ($\sigma_0 = 27.1 – 28.0$) is steady at the 600m depth through 4 seasons, while the boundary between Surface Water ($\sigma_0 = 23.0 – 26.4$) and Intermediate Water shows considerable seasonal changes. The Deep Water occurrence in the upper 600m is ca. 10%, which indicates that the Deep Water is stirred and up-lifted at the Kuril Straits up to the surface. This result suggests that rejecting abnormal data is in danger of missing important evidences, especially at the watermass formation sites.

November 2, 09:40 (POC-P-13780)

Sub-surface temperature variability along the west coast of Canada

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An array of instrumented moorings is being implemented along the west coast of Canada from Juan de Fuca Strait to Dixon Entrance. This array is the northward extension of the moorings that the Institute of Ocean Sciences has maintained on the Vancouver Island shelf for the last 30 years. The first year of data, which extends north into Queen Charlotte Sound, shows that the wind driven mixing in the fall and winter is a dominant feature of the annual cycle of sub-surface temperature on the shelf. For example, at 50 m depth the temperature maximum occurs in late November or early December and the temperature minimum occurs sometime between January and April. In the winter, near isothermal temperatures extend to about 100 m or 150 m and a weak salinity stratification is maintained. These patterns will be tested against the second year of data. In addition we will explore whether 1) satellite observation of sea surface temperature are a reasonable proxy for the observed temperatures between 15 m and 150 m in winter; and 2) can the long time series of coastal temperature observations be used as a proxy to compute trends in winter-time bottom temperature along the BC continental shelf?

November 2, 10:00 (POC-P-12740) CANCELLED

Uncertainty of linear trend in global SST due to multi-scale internal variation

Tao **Lian**

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In most parts of the global ocean, the magnitude of the long-term linear trend in sea surface temperature (SST) is much smaller than the amplitude of multi-scale internal variation. One can thus use a specific period in a much longer record to arbitrarily determine the sign of long-term trend, which is statistically significant, in regional SST. This could lead to a controversial conclusion on how global SST responded to the anthropogenic forcing in the recent history. In this study, the uncertainty in the linear trend due to multi-scale internal variation is theoretically investigated. It is found that the estimated trend will not change its sign only when its magnitude is greater than a theoretical threshold that scales the influence from the multi-scale internal variation. Otherwise, the sign of the estimated trend may depend on the period used. The new criterion is found to be superior over the existing methods when the de-trended time series is dominated by the oscillatory term. This new criterion is applied to a global SST reconstruction from 1881 to 2013. It is found that the warming trends in the western boundary regions, the South Atlantic, and the tropical and southern-most Indian Ocean are robust. However, robust trends are not found in the North Pacific, the North Atlantic, or the South Indian Ocean. These results indicate that great care is required when interpreting SST trends using the available records in certain regions and indices.

November 2, 10:40 (POC-P-13524)

Subduction and mixing processes of the front between the Oyashio and the Tsugaru Warm Current

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Off the southern Hokkaido to off Sanriku, in the nothwestern boundary of the Pacific Ocean, two main current systems, the Oyashio and the Tsugaru Warm Current encounter and form a prominent oceanic front. It has been long known by fishermen that the fishing grounds are often formed along this front; however, the mechanisms of the fishing ground formation in the area are still unclear. In the summer of 2017, we conducted intensive field observations focusing on the physical processes along the front between the Oyashio and the Tsugaru Warm Current (O-T) by using the *R/V* Wakataka-maru (692t equipped with a shipboard 38 kHz ADCP, a turbulence profiler and Underway-CTD system) and Slocum G2 Glider (equipped with a turbulence sensor, ADCP, CTD and bio-optical sensors). Both the shipboard and the glider based surveys were consisted with zigzag lines crossing the O-T front from the merging point: off the Cape Erimo to the downstream: off Sanriku to reveal the detailed

interactions between the two current systems at the front. From the front to the Tsugaru Warm Current side, the fresh and cold Oyashio water subducted under the warm and salty Tsugaru Warm Current water, and above the cold and salty Cold Layer water along 26.5 to 26.8 sigma-theta. The resulted vertical profiles of temperature and salinity were favorable to the double diffusive convections, and corresponding enhanced vertical mixing of K_t ~ O(10^{-2} m^2/s) was observed around the subducted Oyashio layer.

November 2, 11:00 (POC-P-13471) CANCELLED

Structure and impact of the Kuroshio nutrient stream

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Recently the Kuroshio draws attentions as an important supply route of nutrient in the western North Pacific. However it has been unknown even whether or not nutrient concentration is enhanced along the jet on isopycnal surfaces, as is found as the "Nutrient Stream" along the Gulf Stream. We aim to ascertain the structure of nutrient concentration maximized along the jet in the Kuroshio and to estimate impact of nutrient transported downstream by the Kuroshio to the Kuroshio-Oyashio interfrontal zone (KOIZ) which is highly productive and well known as one of the major fishing grounds of the world. Recent multiple-transects and retrospective analyses of historical hydrographic data reveal that the along-jet maximum of nitrate concentration appears only in spring on the isopycnal surface (potential density=25-26) in the downstream region of the Kuroshio. The Kuroshio nutrient stream contributes sufficiently to productivity in the euphotic layer on the way to the downstream in conjunction with enhanced vertical turbulence. It also presents a non-negligible potential to impact significantly on the high productivity in KOIZ by analyzing the budget of the epipycnal nitrate transport across transects which enclosed KOIZ.

November 2, 11:20 (POC-P-13535)

Data assimilation of physical and chlorophyll-a observations in the California Current System using two biogeochemical models

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Biogeochemical numerical models coupled to physical ocean circulation models are commonly combined with data assimilation in order to improve the models' state or parameter estimates. Yet much still needs to be learned about important aspects of biogeochemical data assimilation, such as the effect of model complexity and the importance of more realistic model formulations on assimilation results. In this study, 4D-Var-based state estimation is applied to two biogeochemical ocean models: a simple NPZD model with 4 biogeochemical variables and the more complex NEMURO model, containing 11 biogeochemical. Both models are coupled to a 3-dimensional physical ocean circulation model of the U.S. west coast based on the Regional Ocean Modelling System (ROMS). Chlorophyll satellite observations and physical observations are assimilated into the model, yielding substantial improvements in state estimates for the observed physical and biogeochemical variables in both model formulations. In comparison to the simpler NPZD model, NEMURO shows a better overall fit to the observations. The assimilation also results in small improvements for simulated nitrate concentrations in both models and no apparent degradation of the output for other unobserved variables. The forecasting skill of the biogeochemical models is strongly linked to model performance without data assimilation: for both models, the improved fit obtained through assimilation degrades at similar relative rates, but drops to different absolute levels. Despite the better performance of NEMURO in our experiments, the choice of model and desired level of complexity should depend on the model application and the data available for assimilation.

November 2, 11:40 (POC-P-13469)

Chinese ocean satellites and application

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The ocean satellite planning of China is developing ocean satellite in three series, they are the ocean color environment satellite (HY-1), ocean dynamic environment satellite (HY-2) and ocean radar satellite (HY-3). The sensors of HY-1 include ocean color scanner and coastal zone imager. This series satellite is used to observe sea optical characteristics, chlorophyll concentration, sea surface temperature, river estuarial coastline and sediment source evolvement. China's first ocean satellite HY-1A was launched on 15 May 2002 and stopped working on 2004. China's second ocean satellite HY-1B was launch on Apr. 11, 2007 and stopped working on 2016, almost 9 years.

The sensors of HY-2 include microwave scatterometer, radar altimeter, scanning microwave radiometer. With this kind of satellite, we can obtain the information of global sea surface wind field, sea surface height, significant wave heights and sea surface temperature. China's first ocean dynamic satellite, HY-2A was launched on August 16, 2011.

November 2, 12:00 (POC-P-13736)

Winter season submeso-scale processes at the Peter the Great Bay, northwestern Japan Sea: Direct observations of deep cascading

Vyacheslav **Lobanov**, Aleksandr Sergeev, Igor Gorin, Aleksandr Voronin, Pavel Semkin and Elena Pavlova

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Cascading of dense shelf water along the slope (slope convection) at Peter the Great Bay in the northwestern Japan Sea in winter is one of the key mechanisms of ventilation of the Japan Sea interior. To study a spatial and temporal variability of cascading in the Peter the Great Bay three bottom mooring stations were deployed at its upper, middle and lower parts in the depth range from 94 to 2940 m along the central canyon (around 131°48' E) in winter periods of 2016-2017 and 2017-2018. The mooring stations located at 1.5-2.0 m above the bottom were equipped with the sensors of temperature, salinity and currents with sampling interval of 0.5 hours. These observations have demonstrated a presence of extremely cold water with temperature below zero at the shelf edge that could cascade down the slope during quite long period – from early January through early May. Nine episodes of cascading events were registered at 651 m depth since January 2 through March 25 (2018). At middle shelf (1136 and 1166 m) a few cascading events were observed both in 2017 and 2018. Two events were registered at 1967 m in 2018. Duration of the event was from a few hours to two days. Meanwhile there was no clear signal of cascading at the bottom of the slope (2965 m). Thus a cascading process make important impact on intermediate, deep and bottom waters physical and biogeochemical structure in winter season.

W1: Ecological roles of gelatinous zooplankton: Evaluation, integration and future prospects in a more gelatinous ocean

October 25, 09:10 (W1-13646) Invited

Gelatinous zooplankton in Alaskan waters: from nets to ROVs

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For the past two decades, we have collected detailed data on the full range of gelatinous zooplankton in the Arctic and subarctic waters surrounding Alaska. Although classically considered copepod-dominated ecosystems, pelagic tunicates can contribute significantly to the grazer community, while ctenophores, cnidarians and cheatognaths typically form the bulk of the predatory biomass. These gelatinous communities alone can define different water masses. We compare what has been learned from traditional plankton nets, commercial trawls, ROV surveys and molecular sequencing, highlighting the strengths and weaknesses of each. In particular, we highlight recent exploration with an ROV equipped with an Ultra-high Definition video camera to explore and quantify the macrozooplankton communities over the bathymetrically complex Chukchi Borderlands region in the Pacific-Arctic. There, in addition to establishing vertical zonation of species, at least 6 undescribed ctenophore species have been encountered, several in the benthopelagic zone where plankton nets fear to tread.

October 25, 09:50 (W1-13815) Invited

The perils of bad taxonomy for leading edge science: A case study with the genus *Aegina,* and the consequences for Deep Learning

Dhugal J. **Lindsay**[1], Mary Grossmann, Mitsuko Hidaka-Umetsu[1,2], Jun Nishikawa[3], Hiroshi Miyake[2], Ryo Minemizu[4], Russell Hopcroft[5], Bastian Bentlage[6], Allen Collins[7], Takehisa Yamakita[1], Hiroyuki Yamamoto[1]

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Online biogeographic databases are increasingly being used to characterize global patterns and predictors of marine biodiversity and to identify areas of ecological significance in the open oceans and deep seas. However, the utility of such databases is entirely dependent on the quality of the data they contain. We present a case study that evaluated online information available for a hydrozoan narcomedusan jellyfish, *Aegina citrea*. Online resources such as the Global Biodiversity Information Facility (GBIF) and the Ocean Biogeographic Information System (OBIS) suggested that *A. citrea* was broadly distributed throughout the world's oceans. However, lack of traceability to information from original providers made it impossible to validate the great majority of records in online resources, casting doubt on species identification. A new systematic investigation of *A. citrea* was therefore undertaken, with our morphological and molecular phylogenetic analyses finding that the genus *Aegina* and the family Aeginidae were polyphyletic. Two new families, three new genera, and one new species were therefore described. In light of our integrative systematic study, we found that many past conclusions about the biology of '*Aegina citrea*', from life history to ecology to distributions, are compromised because observations of more than one species were applied to a single name, highlighting how systematics and taxonomy provide the foundation upon which all other biological science is built.

We have recently been applying Deep Learning techniques to automate species identifications of gelatinous zooplankton. The effects of training sets compromised by species mis-identifications and skewed taxon sampling are introduced and discussed.

October 25, 10:50 (W1-13440)

Ecological importance and new findings of phaeodarians and radiolarians in the North Pacific region

Yasuhide **Nakamura** and Akihiro Tuji

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Phaeodarians and radiolarians are unicellular zooplankton bearing siliceous skeletons, and some of them possess fragile skeletons which can be broken during the sampling by the ordinary plankton net. This fragile skeleton could be a reason why their abundance has been underestimated. This study aimed to clarify the ecological importance of phaeodarians and radiolarians, and investigated their abundance, distribution and species diversity in the North Pacific region. Plankton samples were collected from 2011 to 2018 at ca. 30 stations in the North Pacific, using plankton nets (mesh size: 100 μm and 330 μm) with bottle-type cod ends. At the offshore stations, plankton were sampled in different depth layers, from the surface to deep waters. The biomass of major zooplankton was estimated by measuring the number and body size, and phylogenetic analysis was conducted for radiolarians and phaeodarians. The analysis on zooplankton community revealed that rhizarians with fragile skeletons can be locally abundant in the North Pacific. Phaeodarians were abundant in the deep layers (250–3,000 m) of the Sea of Japan (7.7–71.9% of the total zooplankton biovolume) and the surface layers of the East China Sea (10.2–13.9%). The high biomass was detected also for collodarians in the eastern North Pacific. Phaeodarians would change their floating depth depending on the ontogenetic stages. A part of the phaeodarian skeleton was found in the gut contents of some planktonic crustaceans, suggesting that phaeodarians contribute to the local food web. Their species diversity (including some undescribed species) and reproduction style were partly clarified.

October 25, 11:10 (W1-13517)

Gelatinous zooplankton in Pacific Canadian Waters since 1990: Trends and ecosystem implications

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According to the scientific literature, abundances of gelatinous zooplankton in global marine systems have been either increasing, decreasing, or undergoing oscillations with approximately a 20-yr periodicity. Since the 1990's, however, the trend globally appears to have been increasing. We present data on gelatinous zooplankton obtained from regular and repeated bongo net surveys since the early 1990s off the west coast of Vancouver Island and in the Strait of Georgia, Canada. First we present the species composition and interannual trends of gelatinous zooplankton for the continental shelf and oceanic waters west of Vancouver Island, and compare these with trends in crustacean and total zooplankton biomass, and with environmental conditions. Next, we present species composition and trends of gelatinous zooplankton in the semi-enclosed Strait of Georgia, which is perhaps Canada's most human-dominated marine ecosystems, and compare these with their potential source populations off the west coast of Vancouver Island. Finally, we compare patterns in gelatinous zooplankton functional groups (predators and prey) off the west coast of Vancouver Island, with a focus on large outbreaks of *Dolioletta gegenbauri* that occurred in 2016 and 2017, and their interactions with that marine ecosystem. We conclude with a discussion of the implications of these interannual changes to the structure and functioning of these Pacific Canadian marine ecosystems.

October 25, 11:30 (W1-13675)

Identification of pelagic and demersal fish predators on gelatinous zooplankton in the Northeast Pacifc Ocean

Richard D. **Brodeur**[1], Troy W. Buckley[2], Richard E. Hibpshman[3], John C. Buchanan[1], and Douglas L. Draper[1]

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Pelagic coelenterates (Cnidaria and Ctenophora) and urochordates (salps and appendicularians) have been considered important consumers or predators in marine food webs for many years but have only more recently have they been recognized as being important prey for many marine species. We summarize data obtained from > 100 Northeast Pacific fish predators based on extensive food habits analsysis (~350,000 stomachs examined) from broad-scale surveys of pelagic and demersal fishes ranging from the Bering Sea to the Southern California Current. In the Bering Sea, we identified 16 predators on coelenterates and 14 on thaliaceans. In the Aleutian Islands, 16 and 18 predators were identified for the two jellyfish groups and a total of 15 and 24 predators, respectively, were found in the Gulf of Alaska. In the California Current, we identifed 12 coelenterate predators and 4 thaliacean predators. We identified several hitherto unknown predators of jellyfish and examined factors related to predation on jellyfish. Dominant pelagic consumers of coelenterates include dogfish, rockfish, hake, medusafish, and saury and consumers of thaliacians included salmon, walleye pollock, and sablefish. We also show that the occurrence of coelenterate prey is generally much higher in stomachs of several fish species examined fresh at sea compared with that found in stomachs of the same species examined in the laboratory following preservation. Differences were less pronounced with the more durable salp prey. We suggest that many existing estimates of predation on readily digested gelatinous prey may underestimate the true predation rate and their importance in marine food webs.

October 25, 11:50 (W1-13559)

Using Unmanned Aerial Vehicles (UAV's) to measure jellyfish aggregations: An inter comparison with net sampling

Brian P.V. **Hunt**[1,2,3], Jessica Schaub[1,2], Lucy Quayle[3], Evgeny A. Pakhomov[1,2,3], Keith Holmes[3] and Yuhao Lu[4]

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Unmanned Aerial Vehicles (UAV's, or drones) are becoming increasingly common as tools to perform high resolution but broad-scale measurements of habitats and populations simultaneously. In this study we tested the application of UAVs to aerial surveys of jellyfish, and their suitability for measuring and monitoring aggregations. We paired net hauls with linear image transects taken by a UAV to measure five *Aurelia* spp. aggregations over the course of one day in Pruth Bay, British Columbia, Canada. Georeferenced image transects were processed to determine aggregation areal extent and estimate percent cover of jellyfish. The percent cover estimates and net haul density data were highly comparable for all aggregations. Combining UAV derived surface area estimates and net haul biomass estimates, we calculated that jellyfish aggregation size ranged from 65 to 117 tons wet weight biomass. We discuss the potential for additional UAV based measurements including jellyfish abundance and individual size. The study demonstrates the potential of UAVs as powerful tools for characterizing and researching jellyfish aggregations in situ. Finally, we compare biomass estimates from the UAV survey with those of a routine jellyfish monitoring program that conducts fortnightly horizontal surface tows of 5 minute duration in Pruth Bay.

October 25, 12:10 (W1-13592)

Trophic ecology of the neustonic cnidarian *Velella velella* in the northern California Current during an extensive bloom year: insights from gut contents and stable isotope analysis

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Aggregations of the neustonic hydrozoan *Velella velella* occur periodically in the northern California Current. Despite the regular occurrence of notable bloom events in this productive upwelling zone, little is known about their trophic ecology. We used gut content and stable isotope analyses (SIA) to elucidate *V. velella* feeding and potential impacts on the marine ecosystem. The dominant prey items ingested by *V. velella* colonies were cladocerans and Northern Anchovy eggs. However, mixing models indicated that *Velella* diet consisted mostly of small plankton, including euphausiid eggs and cladocerans; and that fish eggs were a small fraction of their diet. Even with uncertainties surrounding stable isotope mixing models, gut contents revealed that *Velella* ingest large amounts of non-motile prey, including northern anchovy (*Engraulis mordax*) eggs, and removal rates of this prey resource could be magnified in bloom years and in areas of high spawning biomass. Stable isotope analysis revealed differences in isotopic niche width among *V.velella* based on location of sampling and to a lesser extent size of predator, and demonstrates the need for continued work to fully understand the trophic ecology of this unique neustonic organism.

October 25, 14:00 (W1-13416) NO SHOW

Temporal variations in abundance and sizes of *Nemopilema nomurai* in the northern East China Sea between 2006 and 2017

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We investigated distribution and size of *Nemopilema nomurai* medusae in the northern East China Sea (nECS) using midwater trawls between 2006 and 2017. Samplings were conducted seasonally in January-February, April, June, July and October. The medusae were found abundantly in June and July, rarely in October, and was not found between January and May during the years without 2008 and 2011 in which they were not seen throughout the year, suggesting that they appear mainly during the summer. The medusae propagated in June and July in nECS would disperse due to the oceanic current and would disappear in October. The abundance in June and July had a large annual variation from 0 in 2008 and 2011 to 62.1 individuals per 10^6 m^2 in 2006 at the repetitively observed stations close to the main habitat of *N. nomurai* (30°20'-31°20'N, 124-126°E). This annual pattern of abundance accord with the southern Yellow Sea but not with the northern Bohai Sea suggesting that the fluctuation did not occur simultaneously in the marginal seas of East Asia. Size of the medusae was comparable in June but smaller in 2006, 2007, 2009, and 2010 in July. This small bell diameter might be ascribable to later strobilation of the medusae in 2006 and slower growth of the medusae due to low food availability in 2007, 2009 and 2010 than the other years.

October 25, 14:20 (W1-13545)

Hyposalinity and incremental micro-zooplankton supply in early-developed *Nemopilema nomurai* polyp survival, growth, and podocyst reproduction

Song **Feng**[1], Jianing Lin[2], Song Sun[1], Fang Zhang[1], Chaolun Li[1]

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Early-developed polyps of the giant jellyfish *Nemopilema nomurai* that are sexually produced during the rainy season form the principal recruitment for benthic population stages, regulating the mass outbreaks of medusae that occur in east Asian marginal seas. Their survival, development and subsequent asexual reproduction are likely facilitated by hyposaline seawater and potentially enhanced micro-zooplankton around the estuaries that comprise the major nurseries of medusae. In this study, 8-tentacled polyps that developed from planulae were incubated at 11 salinities from low to high with 3 feeding frequencies at a constant temperature (19°C). Survival rate of early-developed polyps increased 3-fold at salinities 11 to 20, >80% greater than at salinities 25 to 33. The composition of fully developed polyps, somatic growth, and podocyst diameter positively depended on food supply, except at salinity 8. The potential podocyst production of polyp colonization reached normal peak at salinity 20 in the group that was fed once every 3 d. Excystments were significantly restricted at salinity <20. These findings confirm that estuarine areas with salinities from 11 to 20 are appropriate for N. nomurai polyp colonization, where prospectively increasing micro-zooplankton supply rooted in frequent eutrophication may benefit polyps. An asexual reproduction strategy also corresponded with autumn salinity fluctuations. The intensity of diluted water and monsoonal rainfall, as well as plankton supply around the estuaries in autumn may fundamentally affect polyp abundance and size, determining the population size of medusae in the following spring.

October 25, 14:40 (W1-13643) CANCELLED

Index of climate change: Interannual change of giant jellyfish *Nemopilema nomurai* in China coastal waters

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Jellyfish outbreaks occurred globally in many marine ecosystems in recent decades, as a regional increasing case, *Nemopilema nomurai* have formed increasingly blooms during summer and fall since the end of the 1990s in East Asia waters. This research focuses on finding the index of inter-annual change of *N. nomurai*, which could indicate climate change. The index including biomass, abundance, growth rate, bell diameter, gonad size et al. We made a statistic to analyze and the index of ecological character of *N. nomurai* and climate change. The reason of this change may be related to the amount of Kuroshio current entering the continental see area. Other mode of mechanism and human activity also to be analyze.

October 25, 15:00 (W1-13718)

Monitoring of Two Scyphozoan jellyfish species in the adjacent waters of a power plant, Liaodong Bay, China

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In recent years, jellyfish bloom usually cause enormous ecological, economic and societal problems in Bohai Sea. By far, the baseline knowledge such as biomass, geographical distribution pattern of large jellyfish is still far from clear in the adjacent waters of power plant, Liaodong Bay, China. During May and June 2018, the population abundances and distributions of two scyphozoan jellyfish species *Nemopelima nomurai* and *Aurelia coerulea* were examined by trawl surveys once per month along with the investigation of the metrological conditions, water temperatures, salinities, chlorophyll a concentrations and the zooplankton abundances. Ephyrae of *Nemopelima nomurai* were only collected in the northern part of the survey area in May, metephyra and juvenile medusa were collected in the whole survey area in June. The bell diameter of *Nemopelima nomurai* collected in the south station is larger than that in the north station. Larval of *Nemopelima nomurai* transport by the clockwise current in Liaodong Bay, expand southward to the whole survey area, including inlet of the power plant. Ephyrae of *Aurelia coerulea* were collected in both May and June in the coastal station, high abundance centers are formed in both north and south of the power plant.

Keywords: *Nemopilema nomurai*, *Aurelia coerulea*, Population dynamics, Geographical distribution, Power plant

October 25, 15:20 (W1-13538)

Blooms and non-blooms of the giant jellyfish *Nemopilema nomurai* in the East Asian Marginal Seas: 12-year monitoring using ships of opportunity

Shin-ichi **Uye**[1], Hideki Ikeda[1], Mariko Takao[1], Hiroko Okawachi[1], Miwa Hayashi[1], Manabu Shimizu[2], Takashi Setou[2]

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The giant jellyfish *Nemopilema nomurai* showed a propensity for occasional population explosions, particularly in the last two decades. The Changjiang River estuary and adjoining coastal waters are considered the major habitat of *N. nomurai* polyps, which release ephyrae in the spring. Young medusae spread over the Yellow Sea and northern East China Sea in early summer, and then are transported to the Sea of Japan by the Tsushima Current. Each year, medusae begin to appear in May/June, reach an annual peak density in July, and then almost die out by November. Monitoring of medusae in these waters was conducted for 12 years from 2006 to 2017, using ships of opportunity. The medusa population size differed by 4 orders of magnitude; average density in the Yellow Sea in July ranged from 0.0005 medusae 100 m^{-2} in 2014, a non-bloom year, to 3.17 medusae 100 m^{-2} in 2007, a big-bloom year that devastated local fisheries. Although detailed mechanisms that cause such year-to-year variations are still unknown, their numbers correlated positively with three polyp habitat parameters: (1) sea surface temperature in February, (2) west wind velocity in May, and (3) south wind velocity in June. Hence, acquisition of these parameters from satellites, in addition to monitoring of young medusae from ships enabled us to forecast the annual bloom intensity by July, 1-3 months prior to their peak occurrence in Japanese waters. Reliable forecast information has proven to be very valuable for Japanese fishers, as they can take proper countermeasures against a big bloom.

W2: PICES contribution to Central Arctic Ocean (CAO) ecosystem assessment

October 25, 09:10 (W2-13798) Invited

Integrated Ecosystem Assessment of the Central Arctic Ocean – Work of an ICES/PICES/PAME working group

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Integrated Ecosystem Assessment (IEA) is an integral component of the Ecosystem Approach to management. ICES in cooperation with PICES and PAME has established a working group to carry out an IEA for the central Arctic Ocean (CAO). The IEA focuses on the basins and slopes of the CAO including influences through Atlantic and Pacific gateways. We aim to publish the IEA report by the end of the year, with sections on oceanography, sea ice, plankton, benthos, sea ice biota, fish, birds, and mammals, emphasizing spatial aspects and trophic linkages. In addition, we address vulnerability of species and habitats to various stressors such as climate change and transpolar shipping. The CAO as an ecosystem is undergoing large changes. The loss of summer sea ice is already at about ¾ by volume, with a change to mostly annual ice for the part remaining. The level of primary production is low, with an average annual production possibly of order 10 g C m^{-2}. Production increases with more open water, but the CAO is expected to remain a low productive ocean due to the strong stratification. Around 40 species of fish are found in the CAO, with eelpouts, sculpins and snailfishes as the families with most species. Polar bear, ringed seal, beluga, narwhal, and bowhead whale are marine mammals that use habitats in the CAO on a seasonal basis. Ivory gull and Ross's gull occur with most of their global populations in the marginal ice zone of the CAO in late summer and autumn.

October 25, 09:40 (W2-13686)

PICES contribution to WGICA: Climate, physical and chemical oceanographic, and lower trophic level ecosystem aspects in the Pacific gateway of the Arctic Ocean

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The warming trend in the Arctic is almost twice as large as the global average in recent decades. The warming is accelerating sea ice reduction in the Arctic Ocean, which further causes the ocean warming, freshening, oligotrophication/eutrophication, and ocean acidification. Such changes in ocean environments could impact on the Arctic marine ecosystem. Here, existing information are synthesized from previously published studies on climate change effects in marine areas of the Pacific Arctic region (PAR), which extends from the northern Bering Sea, across the Chukchi Sea to the East Siberian and Beaufort seas, and contains shallow continental shelves culminating in the deep Canada Basin. The contents of the presentation are as follows.1. Arctic warming and sea ice reduction 2. Atmospheric and ocean circulation 3. Bering Strait throughflow and water masses 4. Nutrients and primary production 5. Carbon/biogeochemical cycles and ocean acidification

October 25, 10:00 (W2-13618)

Carbon uptake in bi-polar regions and their responses to climate change

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Carbon uptake data sea were integrated from the 1999 to 2017 not only in the Southern Ocean, especially in the Prydz Bay, Antarctic, but also in Chukchi Sea and Canada Basin, in the Western Arctic Ocean. Both ere summer cruises of the Chinese National Arctic and Antarctic Research Expedition (CHINARE). Parameters including CO_2 system parameters etc., were well measured. Bering carbon sink, Arctic carbon sink, and the Southern carbon sink were all well calculated during the past two decades. Both Bi-polar carbon sink including Chukchi Sea and Canada Basin and Prydz Bay were well compared with each other. Results showed distinguished differences between the bi-polar ocean carbon sink. Due to rapid Arctic Change, Chukchi Sea's carbon sink was remained strong uptake during the past two decades, where nutrients was supplied well by the Pacific inflow, however, the other regions such as Canda Basin where there were not nutrients supply was different change. Long term ice station observation has revealed the carbon uptake change with the ice melting. In Contrast, the Southern Ocean carbon sink was response to the climate change in December, however, there was negative feedback was observed during Astral Summer season due to the bio-production, especially in Prydz Bay, Antarctic. Acknowledgement This Work is supported by Fujian Science Fund for Leading talents of science and technology innovation and National Natural Science Foundation of China (NO. 40976173).

October 25, 10:40 (W2-13784) (CANCELLED)

Poorly known and changing 'mid trophic level' in the Pacific side of the Central Arctic Ocean; Summary of selected literature

Hyoung Chul Shin[1], Hyoung Sul **La**[1], Eun Jin Yang[1], Sei-Ichi Saitoh[2], Hyun-cheol Kim[1], and Sung-Ho Kang[1]

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The rapid loss of sea ice is opening up the Central Arctic Ocean (CAO) for potential fishing. Scientific research in the CAO, however, remains too scarce to inform and support policy decisions. An attempt was made to compile the recent zooplankton literature in the Pacific sector of the CAO in order to aid ecosystem assessment. Zooplankton surveys have not been frequent enough to provide a general description of the abundance and distribution of the major species over the high seas portion of the Pacific Arctic. Nonetheless, information from net sampling, acoustic observations and moored traps all point to calanoid copepods as the major zooplankton. Large calanoids are likely the major trophic link to connect the producers and the upper level consumers. Abundance vary widely in time and space, with summer usually being the high season. Northward shift in the copepod distribution is seen, but migration and establishment of populations in the Arctic waters are not substantiated, and genetic analyses indicate that this is yet to be the case. Migration from sub-Arctic to Arctic might well be possible in the future but there is neither a strong indication nor an ecological basis to drive and sustain such shifts, at present. It appears feasible to identify and establish target monitoring locations in the shelf zone outside EEZs (off east Siberia and over the shelf of Chukchi Sea) where enhanced biological production is frequently detectable. Sustained observations and long-term data on population changes and control processes are needed.

October 25, 11:00 (W2-13348)

Evaluating current and future Arctic marine fisheries in Canada under scenarios of climate change

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Canada's Arctic remains some of the least exploited marine regions in the world yet global climate change is altering seascapes, increasing the interest and potential development for new commercial fisheries. Countries have taken a precautionary stance and most of the Arctic remains closed to commercial fishing until a better understanding is developed for these ecosystems, especially with the rapid onset of global change and stressors placed on individuals, populations, and ecosystems. In this study, we used a dynamic bioclimatic envelope model to simulate potential current and future abundance and distribution of 72 commercially valuable species across Canada's four large marine ecosystems under a high and low climate change scenario. Current estimates of sustainable fisheries potential were more than 3.5 times greater than the reported annual tonnage of 188,000 tonnes. Future fisheries catch and landed value (in 2091-2100) were projected to increase by 63% (1.2 million tonnes) and 71% ($980 million USD), respectively, under the high climate change scenario. Under the low climate changes scenario, both catch and landed value were projected to increase by only 6.5% by the end of the century. Canada's east Arctic and Hudson Bay comprised the majority of fisheries at over 95% under either scenario. Capelin and Atlantic cod had the highest current and future catches and landed values. While these results are not substitutes for proper stock assessments, they contribute to the research and understanding to evaluate the resilience and sustainability of Canada's Arctic fisheries.

October 25, 11:20 (W2-13719)

Characteristics of environmental risks caused by navigation of the Central Arctic Ocean

Natsuhiko Otsuka[1], Lawson Brigham[2], Xiaoyang **Li**[1] and Sei-Ichi Saitoh[1]

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Based on the prediction of long term trend of sea ice retreat, the Central Arctic Ocean(hereinafter referred to as CAO) might become the first-year ice field in the future. Due to actual sailing activity along the Northern Sea Route in recent years, many ice class ships were sailing under light ice condition without icebreaker, and with icebreaker support under medium ice condition of the first-year ice field. This means that it would be possible for certain ice class ships, other than special icebreakers, to navigate into the CAO, if it becomes the first- year ice field. Against the back ground of this, authors investigate environmental risks caused by ship navigation in the CAO. Taking into account of the characteristics of marine ecosystem in the CAO, environmental risk caused by ship navigation in ice covered water is investigated. Here, risks of discharges, emissions, accidental release of fuels and cargo materials, and other risks by ship operation are considered. And these risks are applied and contrasted to the current regulation for protection of ocean environment against ship navigation in polar waters.

October 25, 11:40 (W2-13785) (CANCELLED)

Aligning science in preparation for the Central Arctic Ocean high seas fisheries agreement

Hyoung Chul **Shin**[1], Sei-Ichi Saitoh[2], Hyun-cheol Kim[1], and Sung-Ho Kang[1]

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Potential impacts unmanaged fisheries might cause in the melting Central Arctic Ocean (CAO) prompted the interested 10 governments to develop a new system of governance in these international waters. The recently concluded Central Arctic Ocean high seas fisheries agreement has set a novel precedent with 'precautionary principle' and 'ecosystem approach' embedded in it. The agreement adopted a stepwise approach that places an immediate restriction as well as a path to a properly developed management scheme if fisheries have to occur. A special role has been created for collaborative scientific research to support the aims of the agreement with an explicit request to develop joint programs. Currently there are a number of research initiatives in the region, and significant baseline efforts have been made, for example FiSCAO (Meeting of Scientific Experts on Fish Stocks in the Central Arctic Ocean) deliberations and the three-party (ICES-PICES-PAME) CAO ecosystem assessment. The next step will be to coordinate research expeditions and to digest accumulated information by priorities. In this presentation, a review of current status is provided, and a case will be made for a dedicated scientific leadership with a definite Arctic focus that might make a modest start but is ready to evolve to accommodate future needs.

October 25, 12:00 (W2-13722)

Improvement or deviation? Assessing the agreement on unregulated fishing in the Central Arctic Ocean from the perspective of international politics

Fujio **Ohnishi**

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Five Arctic coastal states (Canada, Denmark, Norway, Russia, US) and Five non-Arctic coastal players (China, the European Union, Iceland, Japan and South Korea) completed negotiations on an agreement to prevent unregulated commercial fishing in the high seas area of the central Arctic Ocean on 30 November 2017. From the perspective of international politics, this agreement was an unique product of international collaboration in a sense that it negotiated through five-plus-five format of the participatory countries for the first time in in the history of international cooperation in the Arctic region. While the irregular international negotiation mainly attributed to a new U.S. diplomatic initiative U.S. diplomacy during the Obama administration aiming a legacy in combating with climate change issues, it may impact the existing international order or established regional patterns of international activities among the Eight Arctic states. Therefore, it is further unclear whether this agreement has positive or negative effect for Arctic governance in political sense. This paper shows the process of negotiation of the agreement on unregulated fishing and considers how the agreement is distinct in a making process from other Arctic cooperation. It also discusses its political implications in international governance in the region.

W3: Development of a systematic approach to data management in PICES

October 25, 09:05 (W3-13293)

The marine data resources management strategy under the background of big data era

Chun-hua **Han**

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Marine data is an important national basic strategic resource, managing marine data resources with big data thinking has become a megatrend in the new era. This report analyzes the current status and existing problems of the domestic and international marine data resource management, and the demands of marine data resources management, sharing, and application, then proposes the marine data resources management strategies, including unified planning and design of marine resource management, establishing multi-source tridimensional marine data acquisition system, constructing classification and gradation marine data resources management system, strengthening marine big data analysis, processing and application research, and promoting the sharing of marine data resources that serves the multi-user. It is of great significance to innovate the management of marine information resources, promoting data integration in the sea-related fields, and effectively improving the marine management and service level under the background big data in the new era.

October 25, 09:30 (W3-13655)

Future of TCODE

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TCODE, started with WG4 “Data collection and quality control”, was replaced by PICES technical committee in 1994 by Science Board recommendation 94/S/4. Since 1994, when TCODE started its activities, there have been many developments in the field of marine observation and data management. In particular, the data-related field is one of the fastest-changing fields with the recent trend of big data and deep learning. In this presentation, I will review the TCODE’s past activities over 20 years, and present future directions of TCODE.

October 25, 10:50 (W3-13522)-Invited

Enhancing collaborations between PICES and IOC/IODE in open data access

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Co-Chair of International Oceanographic Data and Information Exchange (IODE) of IOC

International Oceanographic Data and Information Exchange (IODE) was established in 1961 as one of the initial programmes of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. IODE is aiming at promoting international free and unrestricted exchange of oceanographic data and information to support, as an infrastructure for all ocean and marine activities led by IOC, ocean sciences and services such as forecasting of ocean conditions and early warning of marine hazards. IODE’s most essential activity is to promote open access to oceanographic data and information based on the IOC’s International Oceanographic Data Exchange Policy, whose current version was adopted in 2003 at the 23rd Session of IOC Assembly, and through international network of National Oceanographic Data Centers (NODCs) and associated components of IODE. IODE has been keeping close and effective cooperation with related international organizations, programmes, and projects including PICES. Having served the community for more than 50 years, IODE is now well-positioned to respond to the challenge of: emerging issues in ocean sciences; the increased focus on products and services; and a rapidly evolving international marine community. IODE will be very much pleased to enhance collaborations with PICES in ensuring open access to oceanographic data and information particularly in the North Pacific Region.

October 25, 11:20 (W3-13616)

PICES metadata federation: Past, present, and future

Daniil Glushenko[1], Georgy Moiseenko[2] and Igor **Shevchenko**[3]

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One of the PICES objectives is «to promote the collection and exchange of information and data related to marine scientific research in the area concerned». In order to partially accomplish it, the PICES Technical Committee on Data Exchange (TCODE) initiated a metadata federation of the member countries. Metadata is a description of essential characteristics of data, information or services that allows making a preliminary conclusion by a searcher about their utility. It is used by search engines and should eventually lead to the corresponding data files, detailed pieces of information themselves, or to entry points of the corresponding data or information services. Beforehand, metadata records are to be somehow (usually manually) created, posted, edited and maintained. And only then, they are made spatially searchable by particular groups of end-users on the Internet with the use of standards and software packages. The goal of the project was to implement a one-stop web utility for preparing and searching metadata on data, information and services related to marine ecosystems of the North Pacific and make it usable by the PICES community. Initially, the project was based on the FGDC metadata format and the NSDI Clearinghouse Network. Then, the team moved to the international standards for spatial metadata representation. Also, an instance of GeoNetwork opensource was installed on a rented server as the PICES TCODE geospatial portal. Not only members of the PICES expert groups but all interested in sharing geo-referenced data, information and services got an opportunity to register and run their own metadata collections on the portal or contribute to the existing categories. As the past and present show, for many reasons, the project is not a success and its goals are not achieved. Our talk will address lessons learned from the project history and certain aspects of sharing «small science» data, information and services in PICES in the future.

October 25, 11:45 (W3-13551)

Contribution PICES data activities to global data products

Toru **Suzuki**

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Section on Carbon and Climate (S-CC) of PICES has established since 2005 carried on Working Group on Carbon Dioxide in the North Pacific (WG-13; 1997-2001) and Working Group on Biogeochemical data Integration and Synthesis (WG-17; 2001-2005). Based on PICNIC (PICES CO_2 Related Data Integration for the North Pacific), one of achievement by WG-17, and enlightenment of GLODAP (Global Ocean Data Analysis Project) and CARINA (Carbon Dioxide in the Atlantic Ocean), S-CC has released PACIFICA (Pacific Ocean Interior Carbon) dataset in 2013. PACIFICA was merged to GLODAPv2 in 2015 with GLODAP, CARINA and other new cruises in all basins. SOCAT (Surface Ocean CO_2 Atlas), the other CO2 related global data products, has released in 2011 and it is updated annually or biennially. In particular Trans-Pacific Volunteer Observing Ship Survey Program by National Institute for Environmental Studies, Japan, PICES 2014 Ocean Monitoring Service Award winner, contribute massive and high quality underway CO_2 data in the North Pacific to SOCAT. IQuOD (International Quality-controlled Ocean Database) is one of new projects for making a unified and highly quality controlled global ocean sub-surface temperature dataset managed by IOC/IODE and SCOR WG-148. It is important that PICES TCODE and other related expert groups should take the initiative and coordinate contribution from PICES member countries to global data assembly and analysis activities.

October 25, 12:10 (W3-13676)

The Data Management System for Working Group 35: The Third North Pacific Ecosystem Status Report (WG-NPESR3)

Peter **Chandler**[1] and Jeanette Gann[2]

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[2] Jeanette Gann, NOAA Alaska Fisheries Science Center, Auke Bay, Juneau, Alaska, USA

One of the objectives of Working Group 35-NPESR3 (Third North Pacific Ecosystem Status Report) is to establish an internet based management system for a database of Ecosystem Time Series Observations (ETSOs). These ETSOs will form the basis of the written material comprising the NPESR3 report, and are intended to reduce the effort previously required by authors to access relevant data in order to write the report. Three phases of development for this data management system will be discussed: 1) the functional design of the website that provides for sufficient metadata to be collected to organise the submitted data and allocate the submission to the appropriate reviewer, 2) the review process that provides for an exchange between the submitter and the reviewer to confirm the data is adequately explained and version control applied if changes are made, and 3) the maintenance of the dataset in order to keep the ETSOs up-to-date for the use of PICES members and future NPESRs.

October 25, 14:00 (W3-13345)

Data from the North Pacific Continuous Plankton Recorder Survey

Sonia **Batten**

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The North Pacific Continuous Plankton Recorder (CPR) Survey which began in 2000 was one of the first PICES projects to collect field observations. The data for the most part are spatially and temporally referenced observations of plankton abundances, categorized into taxonomic entities. In the latter years in situ physical data from onboard loggers have also been collected. These data have been made discoverable through the PICES website since the survey began, and summary products and updates have also been presented. This presentation describes the data collected, the issues that are common to many types of biological observations as well as issues specific to CPR data. It will also describe what has been done to date to make the data available, and what could be done to make the data more useful.

October 25, 14:25 (W3-13738)

ADRIFT (Assessing Debris Related Impact From Tsunami) Project – Outline and legacy products

Cathryn Clarke Murray[1,2], Thomas W. Therriault[2], Nancy Wallace[3], Hideaki **Maki**[4], and Alexander Bychkov[1]

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[3] National Oceanic and Atmospheric Administration (NOAA), USA
[4] National Institute for Environmental Studies (NIES), Japan

The Great East Japan Earthquake on March 11, 2011 caused a devastating tsunami that washed millions of tons of debris from terrestrial and coastal environment into the North Pacific Ocean. Within a year, Japanese Tsunami Marine Debris (JTMD) began arriving on the shores of the Pacific coast of North America and the Hawaiian Islands carrying hundreds of living coastal Japanese species. Scientists from multiple disciplines were involved in rigorous research activities to document and evaluate the potential impacts from JTMD and associated non-indigenous species (NIS) to coastal ecosystems in Pacific North America and Hawaii. The ADRIFT project, funded by the Japanese Ministry of the Environment through PICES, focused on three major themes: 1) modeling movement of marine debris in the North Pacific to forecast and hindcast JTMD trajectories and landings; 2) surveillance and detection of JTMD landfall and accumulation, and 3) characterizing and assessing the invasion risk of NIS transported on JTMD.

Legacy products of the project are now available for public use:

– ***JTMD species database***, accessible through the Smithsonian Institution online portal NEMESIS (National

Exotic Marine and Estuarine Species Information System), is an important resource for improving our basic understanding of species transport and attributes related to invasion success for selected marine invertebrates and algae from the Northwestern Pacific, including those associated with JTMD, and can contribute to risk assessments.

– ***JTMD specimen archive*** – the biological collection of over 1,000 individual samples (marine invertebrates) from 650 registered JTMD objects, housed and curated at the Royal British Columbia Museum (Victoria, Canada), will allow researchers world-wide to access this unique resource in years to come, especially with the advance of new analytical techniques.

– *Products from aerial surveys of the British Columbia outer coast and the main Hawaiian Islands* (aerial photographs, debris ranking segments and maps), accessible through online sources, provide baselines of marine debris for vast, uninhabited shorelines.

October 25, 14:50 (W3-13818) CANCELLED

PICES WG-21 – Overview, data products and challenges

Thomas W. **Therriault** (on behalf of PICES WG-21)

Fisheries and Oceans Canada, Pacific Biological Station, Canada

Aquatic non-indigenous species (NIS) continue to threaten marine ecosystems, including seafood safety and security. To inform risk assessments predicting the likelihood and consequences of new invasions, it is critical to understand global NIS distributions, habitat tolerances/preferences, potential dispersal vectors and probable impacts related to new incursions. To this end, the North Pacific Marine Science Organization (PICES) Working Group on Non-Indigenous Aquatic Species (WG-21), with funding from the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan through the Fisheries Agency of Japan, developed a NIS database that summarizes large-scale data which can be used by managers to develop monitoring programs for early detection or rapid response, and to make mitigation plans for higher-risk NIS to limit the impacts on native biodiversity, including commercially important species, and ecosystem structure and function. Some of the challenges related to development, use, and sustainability will be discussed.

Further, a key product of WG-21's database effort was The Atlas of Non-indigenous Marine and Estuarine Species in the North Pacific, which synthesizes information from a variety of sources and can serve as a valuable resource for agencies and scientists tasked with managing and researching NIS in the North Pacific. Information included in the Atlas can help to identify and prioritize potential high-risk NIS and/or high-risk locations which can allow limited funding to be used effectively. The usefulness of the Atlas was illustrated most recently by the arrival of a large floating dock in Newport, Oregon, USA that had been set adrift by the 2011 Great East Japan Earthquake and tsunami – this document was consulted by experts to aid in the identification and ecological risk assessment of organisms attached to the dock and was the precursor to the PICES ADRIFT project.

October 25, 15:15 (W3-13707)

Data from the PICES Project on Marine Ecosystem Health and Human Well-being (MarWeB)

Mitsutaku **Makino**

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In 2012, PICES started an integrated 5-year research project named "Marine Ecosystem Health and Human Well-Being (MarWeB)", which was funded by the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF). The key questions of the project were: (a) How do marine ecosystems support human well-being? and (b) How do human communities support sustainable and productive marine ecosystems? One of the output from this project is the MarWeB Database, which includes following four types of data: 1) Data for the comparative well-being analysis in PICES member countries and Indonesia, 2) Data from the 2014, 2015 and 2016 Aquaculture Pond Experiments in Indonesia, 3) Electronic clicker survey data for the community needs assessments in Las Lisas and Monterrico in Guatemala, 4) Bibliography on the key concepts used in the project: social-ecological systems/ human well-being and Sato-umi. This presentation briefly introduces the contents of the MarWeB database.

W4: Synthesizing projected climate change impacts in the North Pacific

October 28, 09:15 (W4-13839) Invited

Building confidence in projecting future marine biodiversity and fisheries under climate change

William W.L. **Cheung**

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Climate change is affecting fish stocks worldwide as their abundance and productivity (including invertebrates and fishes) are sensitive to changes in ocean variables such as warming, deoxygenation, acidification, and alteration of primary production under increasing greenhouse gas concentrations. These changing ocean conditions are affecting human activities such as fisheries and have now become an important challenge for effective management and conservation of living marine resources. Unfortunately, we do not have a crystal ball to tell us exactly what will happen in the future to advise human interventions to reduce climate impacts. Instead, we could better understand and characterize uncertainties to inform the design of resource management and other adaptation measures to cope with such uncertainties. This presentation aims to discuss ways and initiatives that characterize uncertainties in assessing future changes in living marine resources, approaches to utilize such information to develop adaptation strategies, and the challenges of their implementation at multiple spatial and organizational scales. Particularly, I examine the use of scenario planning for coupled human-natural marine systems as a way to develop climate-adaptation strategies under global change, with particular focus on its applications in the Pacific region.

October 28, 09:35 (W4-13830) Invited

Diagnostically projected future changes of phytoplankton community structure and their growth limitation based on a multi-model ensemble

Taketo **Hashioka**[1], Takafumi Hirata[2], Maki N. Aita[1], Sanae Chiba[1]

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In this decade, a multi-model ensemble in future projection could be available even for biogeochemical variables (typically primary production and chlorophyll concentration) according to the progress of model inter-comparison projects such as CMIP5 (Coupled Model Intercomparison Project) and MAREMIP (Marine Ecosystem Model Inter-comparison Project). On the other hand, projections of plankton community structure and their controlling mechanism still have large uncertainties. In this study, first, we show the projections of 8 to 12 different ecosystem models of CMIP5 and MAREMIP as the current state. Then we projected future changes of phytoplankton community structure and of their growth limitation as diagnostic estimation (to reduce the uncertainties of model projections) based on the multi-model ensemble. We compiled that information as one map as one of comprehensive view like Longhurst's biogeography. Through this, we showed robust or sensitive regions to climate change, and we also projected a new biogeochemical region that does not currently exist. This kind of information might be useful for designing of future observation plan, or to show the spatio-temporal representativeness of the observed data.

October 28, 10:15 (W4-13760) (changed to POSTER)

Projected changes in the sea surface wind in the East Asian marginal seas from regional climate models

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Sea surface wind plays a crucial role in coastal safety including flooding and coastal erosion mainly by changing sea level height and ocean waves. This study aims to investigate regional characteristics in the future changes in sea surface wind due to global warming in the East Asian Marginal Seas (EAMS) projected by four different regional climate models contributing to CORDEX-EA (COordinated Regional climate Downscaling EXperiment-East Asia) downscaling project, by using daily mean winds for the present (historical experiment for 1980-2004) and the future climate (RCP4.5 scenario for 2025-2049). In general, the projected changes in the climatological-mean wind speed shows a considerable seasonal contrast: a decrease up to 30% in winter and an increase up to 40% in summer. This contrast may indicate seasonally different large-scale atmospheric responses to global warming in the EAMS. The prevailing wind direction, a critical factor in coastal erosion in the EAMS, is projected to be significantly changed in both winter and summer. The seasonal difference in wind changes contribute to a decrease in the amplitude of seasonal variation. Extreme winds, defined as an annual maximum of the wind speed, show negligible changes in all CORDEX models. However, variation of the changes in extreme wind is considerably large among the models, indicating inconsistent future projection in the spatial distribution of extreme winds. Our findings suggest that future changes in sea surface wind in the EAMS can be considerably different depending on seasons and models.

W5: Identifying common reference points and leading indicators of ecosystem change

October 25, (W5-13828)-Invited

Marine ecosystem responses to anthropogenic and environmental pressures: Linear or nonlinear?

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Marine ecosystems are influenced by interacting pressures including climatic, oceanographic, ecological, and anthropogenic (e.g., fishing) changes. At species level, these pressures may affect the biological processes of survival, growth, and reproduction, which cascade up to influence communities and the entire ecosystem due to complex species interactions. Ecosystem responses to these pressures can either be linear or nonlinear depending on a number of factors including the type, extent, and interactions of pressures as well as the type of indicators explored. In this study, with an ecosystem model (OSMOSE, Object-oriented Simulator of Marine Ecosystems) developed for the Pacific North Coast ecosystem off western Canada, a series of simulation experiments are conducted to mimic environmental and anthropogenic pressures and their impacts on the ecosystem. A number of ecological indicators, including pelagic to demersal ratio, system biomass, productivity, mean length, mean trophic level, species richness, and diversity, are explored to assess their responses to a single and combined cumulative pressures. Dynamic factor analysis, generalized additive models, and gradient forest analysis are employed to identify ecosystem trends, importance of environmental and anthropogenic pressures on ecosystem dynamics, and ecosystem-level thresholds beyond which the ecosystem responds abruptly to a small change in pressure variables. Simulation experiments indicate that ecological indicators with more explicit trophic levels and predation-prey interactions tend to manifest more nonlinear responses and are thus worthy of more attention. The ecosystem thresholds of these ecological indicators are helpful to inform the development of climate-oriented and trophic-specific management strategies under ecosystem-based fisheries management.

W6: Regional evaluation of secondary production observations and application of methodology in the North Pacific

October 25, 14:10 (W6-13425)-Invited

Traditional approaches for estimating zooplankton production rate and food requirement in the neritic area of the North Pacific

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In traditional methods, estimation of zooplankton production rate needs parameters such as abundance, individual weight and growth rates, which can be determined by incubation. When there is no available growth data, growth rate can be calculated using empirical models from a few easily measurable parameters (i.e. temperature, individual weight). Here, one question arises: which models are more applicable? We compared several empirical models for metazoan mesozooplankters, using data set obtained in the neritic area of Sagami Bay, Japan, from January 2006 to December 2017. Consequently, three models were applied for copepods, appendicularians and all other taxonomic groups, based on the basic balanced equations between production rate and food requirement, which was separately estimated from respiration rate. In Sagami Bay, the depth-integrated primary production rate in the euphotic zone (PP) was 0.02–5.43 (mean: 1.05) g C m^{-2} d^{-1}. Mesozooplankton daily production rates were estimated to be 0.12–15.91 (mean: 2.31) mg C m^{-3} d^{-1}. The mean depth-integrated rates of mesozooplankton secondary and tertiary production (MSP and MTP, respectively) were estimated to be 0.108 and 0.022 g C m^{-2} d^{-1}, while mean transfer efficiencies from PP to MSP and MTP were 10.3% (copepods: 3.7%; non-copepods: 6.6%) and 2.0% (copepods: 0.6%; non-copepods: 1.4%), respectively. The mean depth-integrated food requirements of mesozooplankton secondary and tertiary producers were estimated to be 0.320 and 0.068 g C m^{-2} d^{-1}, corresponding to 30.6% (copepods: 12.9%; non-copepods: 17.7%) and 6.4% (copepods: 2.0%; non-copepods: 4.4%) of PP, respectively.

October 25, 14:50 (W6-13557)

Spatial and temporal variation of mesozooplankotn productivity in the Seto Inland Sea, Japan

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The Seto Inland Sea is one of the most important fisheries grounds in Japan. Although eutrophication was a serious problem in the Seto Inland Sea in past years, nutrient concentration has decreased since the end of the 1980s because of limiting of the discharge. Fishery production (or Catch amount of fishes) also has decreased since the 1980s. The decreasing of nutrient concentration is suspected as one of the causes of decrease in fish production. However, the mechanisms have not been clarified. Mesozooplankton is an important prey for fishes. Therefore, the study of the productivity of mesozooplankotn is necessary to understand the change in fishery production. We studied the productivity of mesozooplankton from 2016 to 2017 in the Seto Inland Sea. Mesozoopankton was collected by vertical haul of Remodeled NORPAC net (45cm diameter, 0.1mm mesh size) from seafloor to surface. Samples were analyzed by using stereo microscope and counted abundance by species level. The body length was also measured to estimate the body weight. By using this information, we estimated the productivity of mesozooplankton according to equation of Ikeda and Motoda (1978). Seasonal variation of community structure in mesozooplakton was synchronized in the eastern (Osaka Bay, Harima-nada) and western (Hiroshima Bay) regions. The productivity was low from January to June, and increased from July and peaked in September. *Oithona similis* was dominant species from January to June. On the other hand the *Microsetella norvegica* and *Paracalanus parvus* were dominant in September. We will discuss the decadal scale variation of the mesozooplakton productivity in the presentation.

October 25, 15:10 (W6-13298)

Copepod community growth rates in relation to body size, temperature, and food availability in the East China Sea: A test of metabolic theory of ecology

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Zooplankton play an essential role in marine food webs, and understanding how community-level growth rates of zooplankton vary in the field is critical for predicting how marine ecosystem function may vary in the face of environmental changes. Here, we used the artificial cohort method to examine the effects of temperature, body size, and chlorophyll concentration (a proxy for food) on weight-specific growth rates for copepod communities in the East China Sea. Specifically, we tested the hypothesis that copepod community growth rates can be described by the metabolic theory of ecology (MTE), linking spatio-temporal variation of copepod growth rate with temperature and their body size. Our results generally agree with predictions made by the MTE and demonstrate that weight-specific growth rates of copepod communities in our study area are positively related with temperature and negatively related to body size. However, the regression coefficients of body size do not approach the theoretical predictions. Furthermore, we find that the deviation from the MTE predictions may be partly attributed to the effect of food availability (which is not explicitly accounted for by the MTE). In addition, significant difference in the coefficients of temperature and body size exists among taxonomic groups. Our results suggest that considering the effects of food limitation and taxonomy is necessary to better understand copepod growth rates under in situ conditions, and such effects on the MTE-based prediction needs further investigation.

October 25, 15:30 (W6-13335)

An overview of artificial cohort method for estimating zooplankton production in the ocean

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Knowledge of the functioning of marine ecosystems ultimately relies on exact estimates of rate processes of key organisms, such as zooplankton in the ocean. While a set of traditional methods (e.g. natural cohort, artificial cohort, molting rate, etc.) has been applied for measuring zooplankton rate processes, until now no method has been accepted as a standard in the field. Generally, for a given species, zooplankton production is estimated from the product of specific growth rate and standing biomass. Given numerous zooplankton taxa in the ocean, the approach can be expanded to estimates of zooplankton production at community levels. Compared to the increasing availability of time- and site-specific composition, abundance and biomass of zooplankton, *in situ* growth rates remain a bottleneck for the exact estimates of zooplankton production. Despite the time consuming and labor intensive nature, as one of the most practical approaches artificial cohort method has been broadly applied in tropical and subarctic waters for estimating zooplankton growth rates. We present an overview of the artificial cohort method and its biases along with its practicality as for estimating zooplankton production in the ocean.

October 25, 16:10 (W6-13577)

Evaluation of the application of empirical growth rate models toward a long-term zooplankton biomass/production time-series on the southern shelf of Vancouver Island

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Estimating the biomass of marine zooplankton assemblages from the contents of plankton net collections is widespread and has yielded valuable long-term time-series' comparable across the world's oceans. Similar time-series for zooplankton production rates, however, are not common since rate estimates (typically specific growth rates) are varied in their routine field applicability. The PICES working group (WG37) on zooplankton production methods seeks to identify the advantages and limitations of traditional and biochemical methods. A singular issue with in situ growth rate methods is that they cannot be applied retrospectively to long-term time-series of biomass to estimate production rate (product of specific growth rate and biomass). However, empirical models based on the synthesis of in situ growth rate measurements offer potential resolution to this issue. Empirical models vary in their complexity and typically require one or all of temperature, body size, and phytoplankton (food proxy) to estimate specific growth rate. Here, we take advantage of a long-term (1979-2017) time-series of zooplankton biomass on the southern shelf of the west coast of Vancouver Island to compare production rate estimates using a variety of empirical growth rate models. We seek to identify advantages and limitations of each model application with a particular emphasis on: 1) whether or not variability of these production rates estimates are simply reformulations of biomass; and 2) whether such production rate estimates would be better served by selecting specific groups/taxa during seasons when growth is assumed be occurring.

October 25, 16:30 (W6-13578)

A status report on Canadian marine zooplankton production rate measurements

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The PICES working group on "Zooplankton Production Methodologies, Applications and Measurements in PICES Regions" (WG37) seeks to identify the advantages and limitations of traditional and biochemical methods for in situ measurements of marine zooplankton production rates. The working group activities include the promotion of international collaboration among zooplankton production research groups and a synthesis of historical production rate and/or related growth rate measurements from each country. Here we report on the current status of marine zooplankton productivity measurements for Canadian waters. Our report distinguishes between both the number and type of rate estimate (fecundity, somatic growth, or total production), methodology employed (e.g. cohort, incubation, biochemical), the duration of study, and sampling location. Our objective is to direct attention to type- and location-specific gaps and make recommendations for future measurements in Canadian waters.

October 25, 16:45 (W6-13284)

Status report on zooplankton productivity measurements in the western North Pacific Ocean and its neighboring waters

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Japanese coastal areas are the "hot-spots" where zooplankton production measurements were frequently conducted in the world oceans during 1980s to 1990s. Information on zooplankton productivity has been also accumulated in more pelagic sites like Oyashio, Kuroshio and Japan Sea. Most of these previous measurements were based on the traditional methods, but various approaches like natural cohort, artificial cohort, molting rate, egg production, physiological model and empirical models were applied for zooplankton population or community in nature. Such traditional-methods-based measurements have been gradually declined during the last decade because of the low cost performance to study objectives and goals. As alternative methodologies to provide fine temporal and spatial resolutions, biochemical approaches using nucleic acids and protein synthetase activity have been recently applied. Major target groups are biased for metazoan crustaceans, in particular for copepods, and thus other taxonomic groups like protozoans and gelatinous forms are minor for the measurements. To take both advantages of traditional (direct measurements) and biochemical methods (good replicability and wide applicability), calibration of the zooplankton productivity measurements between the traditional methods and biochemical approaches would be encouraged.

October 25, 17:00 (W6-13301)

An intercalibration of chitobiase and biomass size spectra zooplankton production estimates

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Production can be defined as the increase in biomass of a given population through time due to both somatic and reproductive growth. While many estimates of primary production exist in the literature, those of zooplankton secondary production are much more limited. Relating primary production to higher trophic level production thus remains difficult as estimates of secondary production are rare. To date, several direct (i.e., cohort method, moult rate method, egg production method) and indirect (i.e., empirical models, metabolic theory, physiological method, biochemical models) methods have been applied to quantify secondary production. However, cross-validations between these different approaches are still lacking. In the last two decades, the chitobiase (crustacean moulting enzyme) approach has gained increasingly more traction due to its relative simplicity in providing instantaneous measurement of in situ crustacean production. Recent studies have also begun using zooplankton size spectra models to quantify zooplankton production, which is unique in that it incorporates the whole zooplankton community. Here, we provide a direct comparison of zooplankton production derived using the chitobiase approach and production modelled using the biomass spectra theory. Zooplankton and chitobiase samples were collected between March and August in Saanich Inlet, BC, Canada (48°35'N, 123°30'W) in 2010 and 2011. This comparison is instrumental in validating the biomass spectra approach. Ultimately, the biomass spectra model may be applied to historical net-samples, optic data, and acoustic data in order to investigate long-term trends in zooplankton production.

October 25, 17:20 (W6-13594)

Calanus marshallae and *Calanus pacificus* egg production in relation to environmental variables in a productive upwelling zone in the northern California Current

Samantha M. **Zeman**, William Peterson, Jennifer Fisher and Jay Peterson

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Calanus pacificus and *Calanus marshallae* egg production rates (EPRs) were quantified from *in situ* incubations completed in 2001-2016. These data represent a unique time series exploring zooplankton production in a coastal upwelling zone. EPRs (eggs female^{-1} day^{-1}) were similar for both *Calanus* species over years and season. Egg production was lowest in early summer (19 ± 12 eggs female^{-1} day^{-1}) and highest (38 ± 16 eggs female^{-1} day^{-1}) in April, before the onset of the upwelling season. The summer reduction in EPR for both species reflects a decrease in *Calanus* density suggesting egg production is density dependent. EPRs were negatively correlated with surface and deep temperature and positively correlated with oxygen. In transitional months (October and April), nutrient loads were positively correlated with higher EPRs. Chlorophyll *a* concentrations were correlated with higher EPRs, especially in the winter months when primary production was minimal. For *Calanus marshallae*, summer EPRs (May-Sept) were correlated with negative PDO years, but local-scale upwelling indices did not explain enhanced EPRs for either species. The lack of relationship between *Calanus* egg production and upwelling events suggests these species are not food limited, but instead the upwelling season, with an accompanying rise in primary production, creates ample nutrition for optimal egg laying.

W7: Diets, consumption, and abundance of marine birds and mammals in the North Pacific

October 25, 09:10 (W7-13783)

Reconstructed and actual weight of stomach contents of the Steller sea lion to estimate their food consumption during wintering in Japan

Yoko **Goto**

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Although there is abundant knowledge regarding the diets of Steller sea lions (SSLs), the food consumption of these that have migrated to Hokkaido, Japan is still unclear. The population number of these wintering SSLs has been previously estimated; moreover, recently, the biomass of SSLs based on group composition and energy intake based on their prey composition are being examined. In the present study, weight of stomach contents of SSLs were reconstructed by using standard methods. For example, using the formula to determine the relationship between residual fish otolith remained in the stomach contents and their estimated body weight. These collected SSLs samples were caught by hunting for population control or entangled by fishery during 2005 – 2016. In addition, the actual weight of undigested stomach contents was measured. The ratio of reconstructed stomach contents weight against body weight were 2.1±3.8(S.D.)% (N=63, 0.1–28.9) in males, and 3.2±2.4(S.D.) %(N=32, 0.3–11.9) in females. Meanwhile, the ratio of actual weight of stomach contents against body weight were 2.4±1.6(S.D.)% (N=42, 0.1–8.8) in males, and 3.2±2.4(S.D.)% (N=32, 0.3–11.9) in females. These values that were obtained from free ranging animals, will be helpful for estimating food consumption of SSLs in Hokkaido during wintering, which is a non-breeding season.

October 25, 09:30 (W7-13484)

Spatial estimation of prey consumption by Bryde's whales in the western North Pacific during the summers of 2008 – 2009: Density surface model approach

Hiroko **Sasaki**[1], Tsutomu Tamura[2], Takashi Hakamada[2], Koji Matsuoka[2], Hiroto Murase[1] and Toshihide Kitakado[3]

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The BIO workshop of PICES 2016 on "Consumption of North Pacific forage species by marine birds and mammals" recommended undertaking detailed analysis of prey consumption of sei, Bryde's and Minke whales. To estimate prey consumption in a spatial context, a reliable estimation of spatial abundance as a function of environmental covariates with an appropriate spatiotemporal scale is required. Last year, we applied a density surface model (DSM) to sighting data of sei whales to estimate abundance in a spatial context. This year, we applied a DSM to sighting data of Bryde's whale. The data were obtained in JARPNII conducted in 2008 and 2009. The DSM consisted of two levels. At the first level, detection function (probability of detecting a school of Bryde's whale given its distance from the transect) was modeled with visibility and Beaufort scale as covariates. Density surface (i.e. spatial abundance estimation) was estimated using a generalized additive model (GAM). Daily water temperature was used as a covariate of the GAM. The data were derived from an ocean forecast system developed by the Japan Fisheries Research and Education Agency based on the Regional Ocean Modeling System (FRA-ROMS). Depth was also used as a covariate. As in the previous year, the amount of prey consumed by individual Bryde's whales was estimated by GAM using the same environmental covariates mentioned above. The product of the DSM and individual consumption models yielded the spatial pattern of prey consumption in the survey area.

October 25, 09:50 (W7-13597) CANCELLED

Prey consumption by marine mammals and seabirds off northern British Columbia (Canada): Estimates from ecosystem models

Szymon **Surma** and Tony J. Pitcher

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The present study employed mass-balanced ecosystem models built in Ecopath to estimate prey consumption by marine mammals and seabirds off northern British Columbia (Canada), in the southeastern Gulf of Alaska. Three models were constructed representing local ecosystem states existing in 1900, 1950, and currently. Input mammal and seabird biomasses were obtained from field surveys (current model) and surplus production models for large whales (historical models). Consumption per biomass rates were derived from bioenergetic calculations and empirical rules. Diet compositions were obtained from stomach contents and field observations, adjusted in the historical models using relative prey biomasses. Each model produced a consumption estimate for each predator-prey interaction. These yielded total annual consumption per predator, as well as consumption by each predator as a proportion of total annual prey production. Results suggest that marine mammals are notable consumers in the northern British Columbia marine ecosystem. Particularly important marine mammal predators currently include harbor seals (*Phoca vitulina*), Steller sea lions (*Eumetopias jubatus*), humpback whales (*Megaptera novaeangliae*), and several small odontocetes. The current marine mammal guild primarily consumes forage fish (notably Pacific herring, *Clupea pallasii*), squid, krill, groundfish, and salmon. Consumption by seabirds is negligible on an ecosystem scale, consisting mainly of forage fish, krill, and squid. In 1900, unexploited fin whales consumed notable fractions of forage fish and krill production, as sperm whales did for squid and demersal fish. With ongoing and future recovery of depleted whale populations, the importance of these large mammals as consumers will likely continue to rise.

October 25, 10:10 (W7-13608)

Summer prey consumption by three species of seabirds breeding in Japan

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Thirty-eight species of seabirds breed at ~160 sites along Japanese archipelago. Among them, Streaked Shearwaters SKSH *Calonectris leucomelas*, (>100x10^4 nests), Black-tailed Gulls BTGU *Larus crassirostris* (13x10^4 nests), and Rhinoceros Auklets RHAU *Cerorhinca monocerata* (55x10^4 nests) are most abundant. Population of SKSH seemed to be stable except one large colony of Mikura Island that recently showed decreasing trend. BTGU and RHAU showed decreasing and increasing trends, respectively. Using samples collected in 1984 to 2016 for RHAU, 1984 to 2000 for BTGU at Teuri Island and opportunistic samples from some other colonies of these two species, 2003 to 2006 for SKSH at Sangan, Milkura and 2010 to 2011 at Awa Islands, we analyzed prey species brought back to chicks. Published data from other studies were used also. SKSH fed on epipelagic fish including Japanese anchovy *Engraulis japonicus*, Pacific Saury *Cololabis saira*, Bullet tuna *Auxis rochei*, Sardine *Sardinops melanostictus* and Common squid *Todarodes pacificus*, BTGU on epipelagic fish including sandlance *Ammodytes personatus* and Japanese anchovy, and RHAU on epipelagic fish including sandlance, Japanese anchovy, sardine, and juvenile greenling *Pleurogrammus azonus*. Using the number of birds breeding and diet composition we estimate prey consumption of these species.

October 25, 11:00 (W7-13661)-Invited

Preliminary estimates of prey consumption by seals and sea lions in the North Pacific

Andrew W. **Trites**

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Seals and sea lions are an important component of the North Pacific ecosystem that consume many important commercials species of fish and invertebrates. Significant increases and decreases have occurred in pinniped numbers since the 1990s when prey requirements were last estimated (Hunt et al. 2000). However, changes in amounts consumed and the potential impacts on North Pacific ecosystems are unknown. I compiled recent (2010-2017) dietary information and population estimates in 14 PICES sub-regions for 3 species of otarids (Steller sea lion, northern fur seal, California sea lion) and 6 species phocids (bearded seal, harbor seal, ribbon seal, ringed seal, spotted seal, northern elephant seal). I then applied new generalized models based on the cost of living for each species (low, medium and high; Trites unpubl. data) to predict the amounts of food that each consumed annually by region. Comparing these estimates with those from 25 years earlier shows significant shifts in amounts of prey consumed that have implications for commercial and recreational fisheries, and well as for management of marine mammals.

October 25, 11:30 (W7-13438)

Estimation of prey consumption by marine mammals in the PICES regions -Update to Hunt *et al.* (2000)

Tsutomu **Tamura**[1], Kenji Konishi[1], Koji Matsuoka[1] and Takashi Hakamada[1] and Andrew W. Trites[2]

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Hunt *et al*. (2000) estimated prey consumption for 135 species of seabirds and 47 species of marine mammals in the PICES region. They estimated energy requirements of sea birds and mammals using simple equations that scaled energy requirements as a function of body mass. In 2016, S-MBM in PICES recommended that the Hunt *et al*. (2000) report be updated with data collected over the past 2 decades to answer the overarching question, "how much do marine mammals consume." In this study, the assessment of prey consumption was based on 1) recently available abundance estimates of cetaceans (after 2000), 2) daily prey consumption rates of cetaceans estimated by simple models, 3) estimated biomass of cetaceans by use of average body weight and abundance, and 4) composition of prey species of cetaceans. These new results can be used to derive estimates of prey consumption for species of marine mammal with unknown energy requirements in the North Pacific.

W8: Taking Stock of Marine Ecosystem Services in the North Pacific—exploring examples and examining methods

October 25, 09:20 (W8-13450)

Study on Eco-compensation Mechanism based on valuation of ecosystem services in marine protected areas

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Eco-compensation mechanism (EM) plays a critical role in the preparation and operation of marine protected areas (MPAs) which can effectively coordinate the conflict between economic interests and ecological interests in the environment protection. Based on the related literatures, the connotation of eco-compensation was summarized; the fundamentals of eco-compensation mechanism in marine protected areas (EM-MPAs) were introduced; the ecosystem services as well as the spatial characteristics of ecosystem services supply and consumption of typical MPAs were analyzed. Then, according to the related regulations and the result of ecosystem services valuation analysis of typical MPAs, this paper discussed the subjects, objects and standards of eco-compensation in marine protected areas. As the result shows, the principles of EM-MPAs should follow the "beneficiary-paying" and "preserver being repaid" principle and encourage ecological protection behavior. The subjects of EM-MPAs are upper governments, and some designated government departments could be the agency of upper government to fulfill the obligations of eco-compensation. The objects of EM-MPAs are local government, local residents and the administrator of MPAs. The eco-compensation standards for local residents are confirmed based on the value loss of ecosystem services after the establishment of MPAs. The eco-compensation standards for local government and the administrator of MPAs depend on the increment in spillover value of ecosystem services of MPAs. Through a case study and theoretical analysis, we found the ecosystem services indicators related with eco-compensation standards of EM-MPAs are only including material supply, waste disposal, climate regulation and recreation. Finally, financial source, eco-compensation process of EM-MPAs and the credibility of eco-compensation standards were put forward for further studies.

Keywords: ecological compensation mechanism; marine protected areas; ecosystem services valuation

October 25, 09:40 (W8-13472)

Labor situation of kelp farmers and the change in farming practice

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This report states the labor situation of kelp farmers and the change in practice introduced in Fukushima district, Hokkaido, Japan, in 2018. The new practice involves shipping kelp which had been discarded because of thinning. This report provides the analysis of the factors that were considered when the new farming practice was introduced in the Fukushima district.

The annual schedule of kelp farming is as follows: November: seeding, December - June: Underwater breeding, July - August: Harvesting, and September - October: Packing and shipping. The number of workers required per day is 8–20 during the harvesting period, and 1–2 during other periods. Among the workers in the harvest period, two are family workers, including fishermen, and others are employees. The workers in the other periods are either fishermen or family workers.

There was no major change in expenses because it was the family workforce that performed the thinning. Furthermore, there was no need to considerably change the conventional work process to ship thinned kelp. These are important factors to be considered when establishing new farming practices.

The new practice is adopted between March and May. Before it was introduced, fishermen earned an income only between September - January. Now, they will be able to earn an income from March until May.

In conclusion, this new approach is effective for the small scale fishers. In this case, fishers could increase their income without increasing their labor cost. The balance between cost and profit is important for sustainable coastal fishery.

October 25, 10:00 (W8-13664)

Ecological damage assessment of green tide blooms based on double-bounded dichotomous bias correction model

Jingmei **Li** and Jingzhu Dan

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The double-bounded dichotomous contingent valuation method is a internationally-recognized method which can improve the efficiency, but it will also cause anchoring and shift effect. This paper uses Jiaozhou Bay as a focal area and applies double-bounded dichotomous contingent valuation methods, to evaluate the ecological damage from green tide blooms, based on the data from 813 effective samples obtained from the actual survey in 2017 results show the ecological damage cost from green tide blooms in Jiaozhou Bay is 439 million CNY per year. At the same time, this paper uses heterogeneous anchoring effect model to analyze the determinants of the willingness-to-pay. The result showed income, level of education and some concerns for green tide blooms have significant positive impact on the willingness-to-pay.

October 25, 10:40 (W8-13668) CANCELLED

Integrating values of ecosystem services into decision making in coastal management in Xiamen

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This study presents three concrete case studies of integrating coastal ecosystem services' value into decision-making in Xiamen under the Integrated coastal management (ICM) framework. Xiamen's experiences show that integrating the values of ecosystem services into decision making can harmonize coastal economic development, environmental protection, and local stakeholders' concern in preserving the ecosystems they depend on. Scientists play a very important role in integrating the values of ecosystem services into decision making by convincing policy makers and concerned stakeholders the benefits and costs of development and conservation of ecosystems. On the other hand, Integrated Coastal Management (ICM) provides the needed operational framework and policy mechanism for incorporating ecosystem services and their values into decision making, especially in time of market and institutional failure.

Keywords: Integrated coastal management, Ecosystem services, Decision making, Xiamen

October 25, 11:00 (W8-13775)

Challenges and opportunities for using ecosystem service values in NOAA Fisheries

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In recent years several U.S. policy directives, including the National Ocean Policy Implementation Plan and the Executive Memorandum on Incorporating Ecosystem Services into Federal Decision Making, have recognized the need to include ecosystem service values (ESV) in decision-making. The U.S. National Oceanic and Atmospheric Administration (NOAA) has made progress in broadening its views of marine management to include ESV, though challenges remain. A report on NOAA's use of ESV from the agency's Science Advisory Board recognized several of these challenges. The report noted the fact that "the use of comprehensive ESV (outside of a few targeted services) is rarely implemented" and identified important challenges including (1) understanding whether and how ESV is relevant to different decision contexts, and (2) how ESV can be integrated as an organic and core part of NOAA's mission. To address these, NOAA Fisheries established an Ecosystem Service Valuation Working Group, which has undertaken two initial projects: an assessment of the literature on marine ecosystem service values and a survey of key agency and Fishery Management Council staff to understand their preferences towards the use of ESV in research and management. This paper will present on the latter project, focusing on the

survey evelopment and implementation process, the key areas and questions contained in the survey instrument, and, potentially, preliminary results. We anticipate that, even without results, the presentation will generate lively discussion among participants that may reveal common barriers and challenges related to ecosystem service values and valuation in marine research and management.

October 25, 11:20 (W8-13654)

Marine ecosystem service values and valuation in the U.S.: An Assessment of the literature through the lens of recent best practice guidelines

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In the U.S., there is momentum building towards increasing usage of ecosystem-based management (EBM) approaches, which require understanding the multiplicity of ecosystem goods and services and how they affect and are affected by human users of the environment. To assess the trade-offs involved between competing users and components of an ecosystem, which are at the core of an EBM framework, decision-makers often need information on the economic value and preferences users have for ecosystem goods and services. Numerous ecosystem service values provided by marine environments have been measured using stated preference (SP) valuation approaches. In this presentation, we review the literature on U.S. marine ecosystem service values that employ SP methods and evaluate it with respect to a recent best practices guidance to identify weaknesses and strengths of the accumulated studies. Our focus is on U.S. studies for ecosystem service values of most significance to federal fisheries management, and we identify numerous gaps in the literature and challenges to valuing marine ecosystem services, as well as discuss several areas for potential improvement and inquiry.

Posters

S1: Toward integrated understanding of ecosystem variability in the North Pacific

S1-P1 (13339)

The decomposition of wind-forced upwelling variability in the California Current though the application of cyclostationary empirical orthogonal functions

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The intensity, seasonality, and location of winds in eastern boundary current systems are critical factors influencing ecosystem processes. Interannual variability in upwelling is influenced, in part, by large-scale ocean-atmosphere processes, both locally and remotely. Anomalies in upwelling-favorable winds have been associated with different modes of atmospheric variability, such as with El Niño-Southern Oscillation, Pacific Decadal Oscillation and other lower-frequency atmospheric patterns. Here, we used cyclostationary empirical orthogonal functions to investigate how different climatic fluctuations might influence the seasonal timing, location, and magnitude of these winds in the California Current Upwelling System. Estimates of upwelling were derived from data provided by the National Oceanic and Atmospheric Administration and the Japanese Meteorological Association. We compare our results with those of earlier researchers who have taken different analytical approaches. A major advantage our technique has is the ability to look at the spatial anomalies in winds throughout the seasonal cycle. In general, our findings are consistent with previous analyses investigating the relationship between large-scale climate conditions and upwelling winds, but the approach we applied offers some new perspectives. In the North Pacific, both El Niño-Southern Oscillation events and lower-frequency atmospheric variability are correlated with modifications in upwelling. Our study suggests that this correlation results from modulations of the seasonal cycle and intensity of winds, both of which are dependent on location. Understanding the relationships between climate processes and upwelling-favorable winds is crucial to accurately forecast the responses of these important biological communities with an ever-changing climate.

S1-P2 (13369)

The importance of peak river flow timing to copepod abundance in the Fraser River Estuary, Canada

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The seasonal delivery of freshwater to estuaries is changing, particularly for snowmelt-dominated systems. Earlier peak river discharge and increasing temperatures can affect production, population dynamics, and seasonality of estuarine zooplankton, shifting or abbreviating their temporal distribution relative to those of prey and predators. These changes would result in an altered feeding landscape for planktivorous fishes and could favour the success of non-indigenous taxa. The annual hydrograph of the Fraser River, Canada, is characterized by a large late-spring peak in discharge (the freshet) that is predicted to occur earlier as the local climate warms and snowmelt occurs earlier. Despite being among the most productive salmon and forage fish bearing rivers in the world, the zooplankton in the Fraser River Estuary (FRE) remain largely unstudied. To describe copepod dynamics in the estuary, we conducted twice-monthly sampling of zooplankton and associated environmental variables from August 2013 to May 2016. We observed large decreases (> 60%) in copepod abundances during the freshet, which suggests that the resulting low water residence times effectively terminated the spring growth period in the estuary. Earlier snowmelt would therefore result in a narrower spring growth period and reduced reproductive capacity in the estuary, leading to lower food resources for planktivorous fishes. Our research in the Fraser River Estuary enhances the understanding of zooplankton dynamics in estuaries with snowmelt-dominated basins and increases our ability to predict ecosystem responses to climate change.

S1-P4 (13669)

Capabilities of remote monitoring systems for assessing the state of marine ecosystems

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Recently, work on methodical and hardware support of remote environmental studies has been intensively carried out. Methods and algorithms for computer analysis of two-dimensional images of the earth's surface are being developed. Work is underway to build models for the formation of these two-dimensional fields and problems of classification of phenomena and analysis of images in the space under study are solved.

From a practical point of view, it is important to synthesize an integrated system for collecting and processing information about the environment, which combines remote and contact measurements that form the basis of remote monitoring systems.

These systems the important place is occupied with the systems focused on studying of marine systems. The technique of detection offered in given work and identification of the abnormal phenomena in the marine environment combines presence with application of possibilities of remote measurements algorithmic and the software, allowing to solve measurement and detection problems in real time.

In this paper presented, a remote monitoring system for detecting anomalies on the sea surface is considered. Its block diagram is analyzed, which consists of a Holder, Resolver and Searcher. Estimates of the effectiveness of a multichannel solver are obtained. As an informative sign of waiting for the detection of anomalies on the sea surface, a model of the "spotting" of the surveyed surface was developed on the basis of empirical data. The experimental verification of the effectiveness of the algorithms considered is based on data from the Kosmos-1500 satellite for the North Pacific regions.

S1-P5 (13670)

About an adaptive optical technology for monitoring aquatic ecosystem

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Unlike the microwave region of the electromagnetic spectrum, the visible range is used more efficiently in water body monitoring systems. This is due to the fact that the energy of solar radiation or artificial light fluxes interacts intensely with the aqueous medium. Different parts of the spectrum of solar radiation are absorbed by water in different ways. The minimum of light absorption is observed at a wavelength of 470 nm, in the blue part of the spectrum, whose energy is halved already at a depth of 47 m.

Ellipsometry refers to optical technologies that use a change in the polarization of the light flux when it is reflected from a surface or refracted during a passage through a liquid. In this paper, an adaptive optical instrumental-information system for the diagnostics of water systems is provided. The system consists of a spectrophotometer and a spectroellipsometer, an information interface, a set of algorithms for identifying spectral images, a database of spectral standards, algorithms for solving inverse problems of spectrophotometry, spectroellipsometry, and an algorithm for learning the recognition of spectral images. The system can be used by water supply services when solving problems of operative diagnostics of the quality of natural, drinking and waste water. The modern manufacturing capabilities of many companies engaged in the manufacture of laser technology, can make this system in the form of an autonomous device with its installation in the sewage channel. The system can also be implemented as a portable device with the help of which the operator can perform real-time control of the quality of water resources without taking samples and conducting chemical analyzes in the laboratory.

S1-P6 (13710)

Newly discovered role of heterotrophic nanoflagellate *Katablepharis japonica*, a predator of toxic or harmful dinoflagellates and raphidophytes and its interactions with common heterotrophic protists

So Jin **Kim**[1], Hae Jin Jeong[1, 2] and Se Hyeon Jang[1]

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Heterotrophic nanoflagellates (HNFs) are ubiquitous and known to be major predators of bacteria, however, the feeding of HNFs on phytoplankton is poorly understood, although these two components usually co-exist. To investigate the feeding and ecological roles of major heterotrophic nanoflagellates *Katablepharis* spp., the feeding ability of *Katablepharis japonica* on bacteria and phytoplankton species and the type of the prey that *K. japonica* can feed on were explored. Furthermore, the growth and ingestion rates of *K. japonica* of the dinoflagellate *Akashiwo sanguinea*, heterotrophic bacteria, and the cyanobacteria *Synechococcus* sp., as a function of prey concentration were determined. *A. sanguinea* supported positive growth of *K. japonica*, but neither heterotrophic bacteria nor *Synechococcus* sp. supported growth. Consequently, *K. japonica* is a predator of diverse phytoplankton, including toxic or harmful algae, and may also affect the dynamics of red tides caused by these prey species. However, if there are effective predators feeding on *K. japonica*, its effect on red-tide dynamics may be reduced. To investigate potential effective protist predators of *K. japonica*, feeding by the heterotrophic dinoflagellates and the naked ciliates on *K. japonica* was explored. None of these heterotrophic protists fed on actively swimming *K. japonica* was found. Our findings suggest that the effect of predation by heterotrophic protists on *K. japonica* might be negligible. Thus, the effect of grazing by *K. japonica* on populations of red-tide species may not be reduced by mortality due to predation by protists.

S1-P7 (13711)

Ichthyotoxic *Cochlodinium polykrikoides* red tides offshore in the South Sea, Korea in 2014: Temporal variations in three-dimensional distributions of red-tide organisms and environmental factors

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The *Cochlodinium polykrikoides* red tides have caused great economic losses in the aquaculture industry in the Korea and other countries. To explore the processes of *Cochlodinium* red tides, red tide organisms and environmental parameters were investigated from May to Nov, 2014 in the South Sea of Korea. The *Cochlodinium* patches were observed from Aug 21 until Oct 9. Prior to the occurrence of large *C. polykrikoides* red tides, the phototrophic dinoflagellates *Prorocentrum donghaiense*, *Ceratium furca*, and *Alexandrium fraterculus* formed red tides in sequence, and diatom red tides 2–3 times. The sequence of the maximum growth rates of red tide species may be responsible for the red tides in the inner stations following high nutrients input in the surface waters because of heavy rains. Furthermore, *Cochlodinium* red tides formed and persisted at the outer stations when NO_3 concentrations of the surface waters were <2 μM and thermocline depths were >20 m with the retreat of deep cold waters. The sequence of the maximum swimming speeds and thus potential reachable depths may be responsible for the *C. polykrikoides* red tides. Thus, *C. polykrikoidess* is likely to outgrow over the competitors at the outer stations by taking nutrients up from deep cold waters. Thus, to predict the process of *Cochlodinium* red tides, temporal variations in 3-D distributions of red tide organisms and environmental parameters showing major nutrient sources, formation and depth of thermoclines, intrusion and retreat of deep cold waters, and the abundance of competing red tide species should be well understood.

S1-P8 (13762)

Effects of fishing and environmental change on the ecosystem of the Bohai Sea

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Using a 1982 model of the Bohai Sea as the starting state, an Ecosim model was constructed for the Bohai Sea, including the 17 functional groups. Using time series of catch per unit effort (CPUE) and relative fishing effort as the driving factors, this model simulated the dynamic changes in the different developmental stages of the Bohai Sea ecosystem and the impact of fishing on this ecosystem. The effects of climate change on the fishery resources of the Bohai Sea ecosystem were analyzed based on the environmental time series data. From 1982 to 2008, the biomass of *Oratosquilla oratoria* showed an increasing trend, the biomasses of some species of high economic value showed decreasing trends, including *Pseudosciaena polyactis*, *Scomberomorus niphonius*, *Engraulis japonicus*, *Lateolabrax japonicus*, and *Setipinna taty*, and the biomasses of shrimp, crabs, and cephalopods were relatively stable. The mean trophic level of the catch clearly decreased from 1982 to 2008, and correlated significantly negatively with the total catch. The fishing-in-balance (FIB) index followed the same trends as the total catch, increasing after 1984. The Q-90 diversity index fluctuated slightly from 1982 to 1987, maintaining a growth trend in 1988-1994, followed by a rapid decline after 1994, from 2.5 to around 0.5, and the fishing biodiversity decreased. The surface salinity, surface temperature, and Yellow River runoff significantly affected the fishing production in the Bohai Sea. Fishing and environmental changes were the main factors affecting the changes in the fishery resources in the Bohai Sea ecosystem.

S1-P9 (13789)

Fish condition and implications for recruitment in the Northeast Pacific

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Ecosystem responses to climate change vary across space and time in the North Pacific. Increasing water temperatures and changes in lower trophic level productivity have implications for fish growth on both regional and basin scales. Responses of fish growth to environmental drivers can be examined by comparing fish condition over time and space. Fish condition, measured as length-weight residuals, is an indicator of somatic growth and ecosystem productivity, and a fish's condition has implications for its survival and recruitment. Condition was compared among fish species and ecosystems in the Northeast Pacific - from the Bering Sea to the northern California Current. For example, in the Eastern Bering Sea, there has been a negative trend in Pacific cod condition since 2003, and age 2+ walleye Pollock condition in 2017 was the second lowest on record. For most species, condition metrics varied over space and time. Fish were generally in better condition on the outer shelf, compared to shallower regions. There is an absence of consistent trends within species among different areas, but within an area, condition often is observed to change in synchrony among species, suggesting that local conditions might be driving observed patterns for multiple species.

S2: Fish production through food web dynamics in the boundary current systems

S2-P1 (13285)

Trophic sources and links of mesozooplankton and fish larvae in the Kuroshio based on stable isotope ratios

Kanako **Saito**[1], Toru Kobari[1], Maharu Shinyashiki[1], Gen Kume[1], Minoru Kitamura[2], Maki Aita-Noguchi[2], Fujio Hyodo[3], Hiroomi Miyamoto[4] and Yuji Okazaki[4]

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Food availability to support survival of early life stages is crucial for many migratory fishes reproducing and recruiting around the Kuroshio. Microbial food web in the Kuroshio has been believed to be predominant due to oligotrophic conditions, but there is limited information on structure and trophodynamics of plankton food web. Here, we characterize trophic sources and links of mesozooplankton and fish larvae in the Kuroshio based on carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope ratios. Similar positive slopes of regression lines were found for a scatter diagram on $\delta^{15}N$ to $\delta^{13}C$ of mesozooplankton community among the different sites in the Kuroshio, while relative ratios of $\delta^{15}N$ to $\delta^{13}C$ were low for mesozooplankton community at southern or offshore sites. The $\delta^{15}N$ and $\delta^{13}C$ of colony-forming diatoms and cyanobacteria were apart from the scatter diagram of $\delta^{15}N$ to $\delta^{13}C$ for potential prey of mesozooplankton community in the Kuroshio. Fish larvae appearing in the Kuroshio demonstrated the high $\delta^{15}N$ and $\delta^{13}C$ along the regression lines on scatter diagram of $\delta^{15}N$ to $\delta^{13}C$ for the mesozooplankton community. The $\delta^{15}N$ and $\delta^{13}C$ of their potential prey were similar to those of small copepods like *Paracalanus*, *Temora*, *Clausocalanus* and *Oncaea* copepods. These results suggest that large phytoplankton is minor as a trophic source of mesozooplankton community in the Kuroshio and major prey items of fish larvae are small copepods.

S2-P2 (13286)

Trophic sources and linkages of mesozooplankton and fish larvae in the Kuroshio based on metabarcoding analysis

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Trophic sources and linkages to support survival of early life stages is important for many migratory fishes reproducing and recruiting around the oligotrophic Kuroshio. Due to the high biodiversity of plankton community and no practical methodology, however, there is limited information on structure and trophodynamics of plankton food web in the Kuroshio. Here, we explore trophic sources and linkages of mesozooplankton and fish larvae in the Kuroshio and its neighboring sites based on their gut contents using metabarcoding analysis. Dinoflagellates, diatoms, radiolarians and fungi were found for gut contents of the particle-feeding copepods and appendicularians. These gut contents demonstrated the regional patterns, large contribution of fungi at the coastal sites and radiolarians at the offshore of the Kuroshio path. Major food items of the fish larvae were particle-feeding calanoid copepods including *Calanidae*, *Clausocalanidae*, *Eucalanidae*, *Metrididae* and *Paracalanidae*. While *Calanidae* and *Eucalanidae* similarly contributed to their gut contents at the coastal sites, *Clausocalanidae* and *Eucalanidae* demonstrated large contributions in the Kuroshio. Prey-predator maps based on their gut contents suggest that dinoflagellates, fungi and appendicularians are major trophic sources and calanoid copepods are an important linkage for trophodynamics to fish larvae.

S2-P3 (13290)

Mesozooplankton feeding on phytoplankton and protozoans in the Kuroshio

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Many migratory fishes reproducing and recruiting around the Kuroshio risk encountering low food availability under the oligotrophic conditions. While mesozooplankton standing stocks and productivity equivalent to the continental shelf have been found in the Kuroshio path, there is limited information on trophic source and links to support mesozooplankton community and fish larvae. Here, we evaluate mesozooplankton feeding on protists by removal bottle experiments in the ECS-Kuroshio. Throughout the study sites across the continental shelf, Kuroshio path and outside, pico- and nanophytoplankton dominated total chlorophyll *a* concentrations and calanoids and poecilostomatoids composed more than 60% of mesozooplankton biomass. Athecate flagellates, naked ciliates and tintinnids were declined in the bottles with mesozooplankton after the incubations, indicating major food items. Mesozooplankton clearance rates on size-fractionated chlorophyll *a* were significantly positive for nano-autotrophs (-1~109 ml μgC^{-1} day^{-1}) and negative for micro-autotrophs (-121~9 ml μgC^{-1} day^{-1}), but demonstrated a significantly positive correlation to in situ chlorophyll-*a*. These results suggest that trophic cascading effects of mesozooplankton feeding on nano-autotrophs and ciliates enhance increase of micro-autotrophs by the redundant nutrients and decline of pico-autotrophs by protozoan predation. Therefore, pico-autotrophs through ciliates and nano-autotrophs to copepods are likely major trophic links to support mesozooplankton standing stocks and productivity in the ECS-Kuroshio.

S2-P4 (13291)

Impact of microzooplankton grazing on phytoplankton community in the Kuroshio: A major trophic pathway of plankton food web

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Many migratory fishes spend their vulnerable life stages even under low food availability in the oligotrophic Kuroshio. Whereas microbial food web has been known as a major trophic pathway in the North Pacific Subtropical Gyre, there is limited knowledge on trophodynamics of plankton food web including fish larvae in the Kuroshio of the East China Sea (ECS-Kuroshio). Here, we evaluate microzooplankton grazing impacts on phytoplankton community using dilution technique in the ECS-Kuroshio. Based on the size fractionated chlorophyll-*a* concentrations, phytoplankton community was dominated by pico- to nano-autotrophs. Phytoplankton growths were ranged from 0.46 to 1.07 day^{-1} and limited under low nutrients in the Kuroshio path and the offshore sites. Naked ciliates were the most predominant among microzooplankton biomass throughout the stations. Microzooplankton grazing rates were higher for nano-autotrophs (0.28~1.45 day^{-1}) compared with those for pico- (0.18~1.06 day^{-1}) and micro-autotrophs (0.06~0.91 day^{-1}). Grazing impacts of microzooplankton on phytoplankton community were equivalent to 41 to 122% of primary production and independent on in situ chlorophyll-*a*. These results suggest that pico- and nano-autotrophs to ciliates is a major trophic pathway in plankton food web and support trophodynamics to mesozooplankton and fish larvae in the ECS-Kuroshio.

S2-P5 (13304)

Using topological network to identify keystone species in the food web of Haizhou Bay, China

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Keystone species play a critical role in building community-based organizations and ecosystem functions by interacting directly and/or indirectly with other species. Studies on the keystone species will contribute to the understanding of community stability, biodiversity maintenance and ecosystem degradation mechanism. Based on the survey data collected from five bottom trawl surveys in Haizhou Bay and adjacent waters in 2011, the topological network was constructed according to the predator-prey relationships of species in the food web. The topological network was analyzed to calculate 11 topological indices of the network to identify the keystone species, and the removal analysis was carried out to examine the impacts of keystone species extinction on the food web. The Kendall rank correlation analysis of these 11 indices showed that there were significant correlations between most pair of these indices ($P<0.05$). According to the result of principal component analysis of all these indices, several species such as *Leptochela gracilis*, *Loligo* sp., *Larimichthys polyactis*, *Alpheus japonicus*, and *Oratosquilla oratoria* were identified as keystone species in the Haizhou Bay food web. The removal analysis suggested that the absence of keystone species may have great impacts on the complexity and stability of food web in Haizhou Bay. It is necessary to be given priority to protect keystone species.

S2-P6 (13328)

The influence of sporadic oceanic water inflow into Kagoshima Bay, southern Japan on larval fish assemblage

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Larval fish assemblages are typically different between the inner and outer parts of Kagoshima Bay, southern Japan throughout the year. Meanwhile, the oceanic water sporadically inflows into Kagoshima Bay during the winter and spring months. In the present study, we clarify how the larval fish assemblage in Kagoshima Bay is influenced by the sporadic oceanic water inflow. The contour figures of water temperature and salinity indicated that the oceanic water, which is characterized by high water temperature and salinity, intruded into the middle part of the bay on 7-9 January 2017. In the survey, a total of 2,024 larvae were collected. Clupeiformes spp., Lampanyctinae spp., *Champsodon* spp., *Notoscopelus japonicus*, Myctophidae spp., Triglidae spp., *Myctophum asperum*, *Diaphus* spp., *Bregmaceros* sp. and *Lipolagus ochotensis* were dominant species groups in decreasing order of number. *Champsodon* spp., *Myctophum asperum*, *Notoscopelus japonicas* and *Lipolagus ochotensis* are typically dominant species groups in the outer part of the bay, suggesting that these larvae would have been transported into the inner part from the outer part of the bay by the sporadic event.

S2-P7 (13333)

Feeding habits of larval fish in the mouth of Kagoshima Bay, southern Japan

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In the mouth of Kagoshima Bay where is physically and biologically affected by the Kuroshio, larval mesopelagic fish are abundantly co-occurring with larvae of fishery-targeting small pelagic fish. In the present study, we examined the diet of larval small pelagic (*Engraulis japonicus*, *Trachurus japonicus*), coastal (*Sebastiscus* spp., Triglidae spp.) and mesopelagic species (*Sigmops gracilis*, *Myctophum asperum*), which are dominant species in winter and spring months in the subject area, and explored the possibility of competition for prey resources among species groups. Based on the morphological and DNA meta-barcoding analysis for gut contents, main prey species were calanoid copepods for all six species groups. Larvae of *T. japonicus* fed actively on Oithonidae and Oncaeidae spp. as well as calanoid copepods. Appendicularians were substantially found in the gut of larval *S. gracilis* and *M. asperum* as well as calanoid copepods. The stable-isotope analysis showed that $\delta^{13}C$ values of appendicularians were lower than those of copepods. $\delta^{13}C$ values of larval *S. gracilis* and *M. asperum*, which fed on appendicularians more frequently than other fish species, were also somewhat lower than those of other species. On the other hand, the values of $\delta^{13}C$ and $\delta^{15}N$ were not clearly different among the five species groups except for Triglidae spp., suggesting that interspecific competition for prey species would be occurring among them.

S2-P8 (13334)

The assemblages and feeding habits of larval fish in the Kuroshio and the adjacent waters, southern Japan

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In the present study, we elucidate how the Kuroshio spatially influence larval fish assemblages in the Satsunan area, southern Japan and clarify feeding habits of dominant larval fish species in the Kuroshio and the adjacent waters to understand the plankton food web in the subject area. In the survey, 3,218 larvae were collected, 48.7% of which were mesopelagic fish. *Sigmops gracilis*, *Cyclothone alba* and *Cyclothone* spp. were dominant species groups in decreasing order of number. Larval fish assemblages were classified into six groups: sea shelf 1, sea shelf 2, inner part of Kuroshio (< 300 m), Kuroshio (< 300 m), outer part of the Kuroshio (< 300 m), deep layer (> 300 m). For *S. gracilis* and *C. alba* which were most dominant species in the shallow (< 300 m) and deep (> 300 m) layers in the Kuroshio and the adjacent waters, respectively, we examined the diet of both species using the morphological and DNA meta-barcoding analysis for gut contents and the stable-isotope analysis for larvae. The main prey items of *C. alba* were copepods and their diet composition was not different between the survey stations. On the other hand, main prey items of *S. gracilis* were copepods and appendicularians and the importance of the latter was increasing in the Kuroshio and the outer part of the Kuroshio. Our results indicated that the microbial loop would play more important role in the plankton food web of the Kuroshio and the outer part of the Kuroshio.

S2-P9 (13417)

Dense occurrence of *Fritillaria pellucida* (Appendicularia:Fritillaridae) around the Kuroshio

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We investigated the seasonal variation, vertical distribution and reproductive condition of *Fritillaria pellucida* population, one of the dominant appendicularian species around Japan. Abundance of *F. pellucida* has never exceeded 500 inds m^{-2} in the south of the Kuroshio except in August, when the abundance was below 1000 inds m^{-2}. High abundance was observed in the Kuroshio area to the coast of Honshu Island, where abundance of >1000 inds m^{-2} was often observed in March to May. More than 60% of the *F. pellucida* was distributed in 0-50 m, suggesting that the species utilizes the spring phytoplankton bloom in the surface layer for growth and spatially co-exists with the larva and juveniles of pelagic fishes like sardine, anchovy or mackerel. In transect observation across the Kuroshio at longitude of 138˚E, *F. pellucida* was observed to form several populations that can be recognized from body size and reproductive condition. In the April 2012, a population of semi-mature individuals of 0.5–1.0 TL (trunk length) was occurred from the coast to 34˚N, that of mature individuals of 1.0–1.75 TL from 34˚N to the Kuroshio axis, and that of immature individuals of <0.75 TL in the south of the Kuroshio. The population structure suggests that the individuals of *F. pellucida* were not belonged to genuine single population. Considering that the Kuroshio flows across the transect, population around the Kuroshio was suggested to have its source in the upstream region of the Kuroshio.

S2-P10 (13441)

Numerical experiments using a coupled physical–biochemical ocean model to study the Kuroshio-induced nutrient supply on the shelf and slope region south of Japan: Case study of Tosa Bay facing the Kuroshio

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We developed a triply nested 1/50° ocean model coupled with a lower trophic level ecosystem model and conducted numerical experiments to identify the major processes that supply nutrients on the shelf and slope region north of the Kuroshio. Tosa Bay facing the Kuroshio, was selected for our experiment. Comparisons of numerical simulations using different grid sizes revealed that a grid size of no larger than 1/50° was essential to reproduce a time-independent density structure related to the Kuroshio jet that uplifted nitrate from subsurface waters into the euphotic zone north of the Kuroshio front. The monthly mean budget of nitrate within the euphotic zone on the shelf showed that primary production was nearly balanced by physical advection and biochemical supply of nitrate via mechanisms such as remineralization of detritus. Eddy advection of nitrate based on Reynolds decomposition, attributable primarily to submesoscale variations, had both positive and negative values within the bay, the indication being that eddy advection functioned regionally to supply or remove nitrate. Lagrangian particle-tracking experiments were performed to examine the major pathways of the nitrate used for primary production in Tosa Bay during the summer, when subsurface maxima of primary production typically appeared. The experiments revealed that when the Kuroshio took a stable nearshore path, nitrate was frequently uplifted around the Kuroshio front and horizontally transported along the front and into the bay via the counterclockwise circulation within the bay.

S2-P11 (13452)

Dietary patterns of walleye pollock, *Gadus chalcogramma* inhabiting the East/Japan Sea: the influences of water depth, fish size and season

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A dietary analysis is a key to understanding the prey choice and the niche breadth of a predator's diet, which ultimately identifies the functional role of the predators in an ecosystem. Dietary patterns for walleye pollock, *Gadus chalcogramma* collected monthly between 2016 and 2017 in the middle coast of the East/Japan Sea, Korea, were examined for the presence of such dietary niche and influences of potential predictors. Based on stomach content analyses, walleye pollock was shown to be bottom feeding carnivores that consumed mainly benthic crustaceans (particularly carid shrimps and euphausiids) and teleosts, with cephalopods also being important in the diets of the larger individuals. The most frequently observed prey species were *Euphausia pacifica* (euphausiids), *Themisto japonicus* (amphipods), *Pandalus borealis* (carids), *Watasenia scintillans* (cephalopods) and *Bothrocara hollandi* (teleosts). Dietary pattern analyses based on gravimetric contributions of different prey taxa to the stomach contents revealed significant differences in dietary composition in relation to fish size and water depth, implying dietary segregations. Euphausiids dominated the diets of smaller individuals, whereas the contributions of carid shrimps, teleosts and cephalopods increased as body size increased. Similarly, the latter prey items were dominant food resources as habitat gradually deeper. Spatio-temporal and size-related changes in dietary composition were each significant for the species, but there were no two- or three-way interactions among factors, excepting size-depth interaction. The coupling effect of size and depth is indicative depth dependent differences of size distribution. Seasonal and interannual variations in water column structures were also evident among seasons, which may in part account for diet seasonality observed from the stomach content analysis.

S2-P12 (13478)

Distribution characteristics of primary feed in typical oceanic ranches and its response to the environmental changes

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Bohai sea is an important spawning and breeding ground for developing fishery. However, it has been greatly affected by the intensification of human activities and changes in the environment. To study the primary productivity and feeding needs in the habitat of fishery population in early life history, and elucidate the long-term changing characteristics of primary productivity, we conducted a survey on the spatial and temporal distribution of phytoplankton and zooplankton diversity in the Bohai Sea. We found that the abundance of phytoplankton ranged from 12.09 cells/L to 9526.73 cells/L, and it presented a higher trend near the coastal area, a lower trend in the center of the Bohai Sea. The dominant species in the Bohai Sea are mainly about *Pesudo-nitzschia pungens*, *Chaetoceros* sp., *Thalassionema frauenfeldii*, *Paralia sulcata* and *Noctiluca scientillans*. There was a significant correlation between the abundance and sunlight, temperature and nutrients. For the distribution of zooplankton, we found that the biomass and species diversity of zooplankton in the northeast of Bohai bay were significantly higher than that in other areas. Among them, the species that cause big difference mainly include *Oithona similis*, *Centropages mcmurrichi*, *Calanus sinicus*, *Oithona similis* and *Nauplius larva*. It was found that water temperature and depth play an important role in controlling the abundance of zooplankton. Our research will provide theoretical basis for the comprehensive survey and observation of biological resources and environmental ecology in the Bohai sea.

Key words: Phytoplankton, Zooplankton, Primary feed, Oceanic ranches

S2-P13 (13541)

Effects of photophysiology and chlorophyll *a* abundance on phytoplankton group-specific primary production in Japanese waters using remote sensing

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To evaluate variability in the group-specific primary production of diatoms, haptophytes and cyanobacteria in Japanese waters, a novel satellite observation methodology using the SeaStar/SeaWiFS satellite instrument was developed. The results obtained from this technique showed that the derived quantum yield index for primary production was higher for diatoms than haptophytes and cyanobacteria in the region. Furthermore, intraspecific variation in the quantum yield index emerged as a latitudinal gradient: the quantum yield index of cyanobacteria increased towards higher latitudes. The group-specific primary production showed that the regional climatological average of 134, 72 and 40 mg C m^{-2} day^{-1} for diatoms, haptophytes and cyanobacteria, respectively. A comparison among variability of the group-specific primary production, the quantum yield index, and the absorption coefficient suggested that variability in the primary production due to diatoms was mainly driven by variability in their abundance rather than their photophysiology, whereas that due to cyanobacteria was by their photophysiology rather than their abundance. Variability in the primary production due to haptophytes was seasonally regulated by both abundance and photophysiology.

S2-P14 (13555)

Distribution, reproduction, and feeding of *Symbolophorus californiensis* (*Teleostei: Myctophidae*) mature adults in the Kuroshio region during late winter: Evidence of a southward spawning migration

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Symbolophorus californiensis is a typical trans-Pacific transitional water myctophid, occurring from off Japan to North America, and is one of the dominant mesopelagic fishes in the transition region of the western North Pacific. This species has been considered to spawn in the warm southern part of the transition region during early spring. This study firstly reports the occurrence of mature adults of *S. californiensis* (89.7–118.5 mm standard length) in the Kuroshio region, south of the transition region, during late winter, based on 111 specimens (1.56:1 F:M) collected in the surface layer at night. More than 30% of females had ovaries containing migratory nucleus oocytes or postovulatory follicles, suggesting that spawning occurred in the Kuroshio region. They would spawn multiple batches in a spawning season (i.e., multiple spawners), with a spawning frequency of approximately 3 days and mean relative batch fecundity of 505 eggs g^{-1}. Stomach content analysis revealed that *S. californiensis* adults feed actively during the spawning season, showing characteristics of multiple spawners. The nighttime ration was estimated to be 1.4–3.0% of the myctophid body dry weight. They predated heavily on copepods (mainly *Candacia bipinnata* and *Calanus sinicus*) and euphausiids (mainly *Euphausia similis*). Our study suggests that at least a part of the *S. ca*liforniensis adult population undergoes a southward spawning migration from the feeding ground in the northern part of the transition region to the Kuroshio region during late winter. Such a migration of myctophids would potentially contribute to the energy flow between these adjacent ecosystems.

S2-P15 (13696)

Relationship between abundance of young-of-the-year black sea bream *Acanthopagrus schlegelii* and eelgrass bed *Zostera marina* vegetation in central Seto Inland Sea, Japan

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The black sea bream *Acanthopagrus schlegelii* is widely distributed in coastal waters of western North Pacific and is as target for commercial fisheries and game fishing. Adult black sea bream spawns waters with 20-50 m and the larvae are transported to surf zone of sandy beaches. The juveniles have been reported to inhabit seagrass bed in coastal waters the Sea of Japan. However, ecological information on the juvenile is very limited in the Seto Inland Sea, southwestern Japan. Recent field surveys conducted in the central Seto Inland Sea indicated that juvenile black sea bream dominate fish community in seagrass bed. In the present study, to test the hypothesis that black sea bream is highly dependent on seagrass bed during the juvenile stage, field survey was conducted in the seagrass bed off Ikuno Island, Hiroshima Prefecture. Fish were collected using a round seine net (4 mm mesh) during summer from 2008 to 2017. Water temperature, salinity, seagrass shoot density and leaf length were measured at the collection. Juvenile black sea bream dominated the fish community in the seagrass bed in several years. Body lengths of majority of the juvenile black sea bream collected in the seagrass bed were > 30 mm. There was a significant positive correlation between mean seagrass shoot density and juvenile abundance for each year. These results suggest that the seagrass bed is one of the essential habitats for juvenile black sea bream > 30 mm.

S2-P16 (13745)

Spatial variations in community structure of haptophytes across the Kuroshio front in the Tokara Strait

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Haptophytes are important members of marine microbial community with high diversities in taxonomy and ecological function. However, little is known about the distribution and diversity of this algal group in and around the Kuroshio, which is the western boundary current of the North Pacific. Here, we present a fine-scale community structure and diversity of haptophytes in the Kuroshio waters off southern Japan. Seawater samples were collected from the surface and deep chlorophyll maximum (DCM) layers across the Kuroshio Current in the Tokara strait in November 2012. Phytoplankton pigment analysis with high-performance liquid chromatography (HPLC) revealed that the haptophytes were the most dominant phytoplankton group in the current axis and offshore side of the Kuroshio, whereas diatoms dominated the phytoplankton assemblages in the inshore water. Water samples were divided into three main groups (i.e., oceanic surface, oceanic DCM, and coastal waters) by the cluster analysis on the basis of community structure of haptophytes, which was estimated from high throughput sequencing of 18S rRNA gene fragment. Haptophyte operational taxonomic unit (OTU) richness based on Chao1 index was greater in the oceanic DCM waters than in the oceanic surface and coastal waters. Additionally, Chao1 richness, Shannon diversity, and Pielou evenness indices tended to increase around the Kuroshio axis, possibly due to the advective input of haptophyte taxa from the upstream region. Our results underscore the importance of physical properties such as advection and diffusion of water mass on regulating haptophyte community structure in Kuroshio ecosystems.

S4: Indicators for assessing and monitoring biodiversity of biogenic habitats

S4-P1 (13262)

Transcriptome study of scleractinian coral *Alveopora japonia*

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The colonial stony coral *Alveopora japonica* is a zooxanthellate scleractinian coral in the family Acroporidae. The natural habitat of this uncommon species is also highly likely to be reduced by a combination of factors, including coral removal and harvesting for the curio trade, for display in aquaria. Jeju Island is located in the southwest of the Korean peninsula (33°24′N, 126°32′E) and is characterized by a warm temperate climate, an effect of the Kuroshio Current, which circulates from the tropical Philippines to subtropical Taiwan and into the temperate region of Japan. Because the KC is rapidly warming, some reef-building corals may expand their habitats northward in response to increasing temperatures, although the Jeju Island coast does not have an appropriate environment for coral reef formation. This species may benefit from the recent increase in seawater temperature, and may shift from a kelp-forest habitat to a coral-dominated habitat, disrupting *the competitive interactions among benthic taxa around Jeju Island.* The transcriptome was sequenced with the Illumina HiSeq 2000 Sequencing System. A total of 31,921,488 read pairs (100 bp) in the FASTQ format were produced and the short-read dataset has been deposited in GenBank. This procedure extracted 5,949,582,694 bp from 30,449,429 read. The genes most similar to many *A. japonica* coding sequences were from other marine invertebrates, such as *Acropora digitifera* (stony coral; 26.5%), *Orbicella faveolata* (stony coral; 15.37%), *Amphimedon queenslandica* (sponge; 14.89%), and *Stylophora pistillata* (stony coral; 9.58%).

S4-P2 (13439)

Predictive modeling methods for deep-sea sponges in the North Pacific Ocean

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Knowledge of deep-sea species and their ecosystems is limited due to the inaccessibility of the areas and the prohibitive cost of conducting large-scale field studies. This study focuses on species distribution modeling methods to map hexactinellid sponge habitat extent in the North Pacific, as a contribution to PICES WG32 ‘Biodiversity of Biogenic Habitats’. A MaxEnt model based on sponge presence data from the eastern Pacific and Hawaii, in conjunction with 19 environmental variables, was created to map existing sponge habitats. It suggested sponge habitat preference values within each variable. Since this model was projected for two areas: the North Pacific basin as well as a regional area containing the coast of British Columbia, sponge absence data has become available. Thus, in an attempt to advance this research and increase the accuracy of the results, the species and environmental data from this model will be applied to multiple different presence-absence (PA) models to ascertain which is most appropriate for use in ocean-basin scale studies. This comparison will include the following models: generalized linear models (GLMs), random forest (RF), boosted regression tree (BRT) and a Bayesian model. The outputs from these models will be evaluated using methods such as the AUC or the remaining per-observation deviance, to provide suggestions on which method is most accurate, to increase the knowledge of benthic species in the North Pacific Ocean.

S4-P3 (13666)

Changes in the fish community in seagrass bed on the Pacific coast of northeastern Japan before and after (2009-2017) the tsunami following the 2011 off the Pacific coast of Tohoku Earthquake

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Seagrass bed is called “cradle of the sea” and plays an important role such as feeding place, spawning ground and shelter for fish due to high prey abundance and complexity of three-dimensional structure of the habitat. The seagrass bed on the Pacific coast of northeastern Japan had received significant disturbance by the tsunami and ground subsidence following the Pacific coast of Tohoku Earthquake in March 2011. In this study, we compared the effects of disturbance by the tsunami on vegetation and fish community of seagrass bed among three sites with different levels of disturbance. In the summer from 2009 to 2017, the water temperature, salinity, seagrass density and leaf length were measured in Funakoshi Bay, Otsuchi Bay and Mangoku-ura Bay. Fish sampling was conducted using a round seine net (4 mm mesh) at 4 sites in each bay. To clarify the difference in species composition depending on their habitat or life cycle, fishes were divided into three groups: pelagic or migratory species (PM), sand or mud bottom-associated species (SM) and seagrass (*Zostera marina*)- or substrate-associated species (ZS). The succession in seagrass vegetation and fish community after the tunami differed among the three sites reflecting the difference in the levels of disturvance. In Funakoshi Bay and Otsuchi Bay, recovery of the seagrass vegetation was slower because the disturbance by the tsunami was larger than in Mangoku-ura Bay. The percentage of ZS type fish was higher before the tsunami, while the proportion of SM type fish increased thereafter. Proportio of ZS type fish has increased with the recovery of the seagrass vegetation for recent two years.

S5: Seasonal to interannual variations of meso-/submeso-scale processes in the North Pacific

S5-P1 (13341)

Characteristic of subsurface oxygen maximum in oligotrophic western North Pacific

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Over the subtropics in the western North Pacific where nutrients are depleted in surface layer in summer, subsurface oxygen maximum (SOM) develops in the seasonal thermocline in summer. The thickness of SOM, defined as the layer with oxygen supersaturation, is typically about 50 m, thereby discrete bottle samples taken every tens of meter in depth have deficient resolution to understand the variability of SOM. In 2010, Japan Meteorological Agency has started to use a rapid response dissolved oxygen sensor "RINKO" on CTD multi-sampler for their hydrographic measurements with which we can collect data of dissolved oxygen at every 1 dbar with a precision of about 1 μmol kg^{-1}. Until 2016, more than 1500 profiles of dissolved oxygen have been obtained in the subtropical western North Pacific (20-30ºN). Here, we summarize the seasonal variation in SOM in 24-25ºN where a large number of data have been collected. SOM was almost absent from January to April. As seasonal thermocline developed, SOM appeared under the surface mixed layer in May. In many cases, column excess oxygen peaked in August and September. After that, column excess oxygen decreased as upper part of SOM was entrained into the surface mixed layer. However, the peak of SOM grew until November. Excess oxygen from saturation reached as large as 25 μmol kg^{-1} at the peak and 1000 mmolO_2 m^{-2} in the water column. Both were larger compared with those observed at Station ALOHA of Hawaii Ocean Time-series (HOT) located at nearly the same latitude.

S5-P2 (13375)

Variability of the Pacific North Equatorial Current Based on a 1/8˚ Pacific Model Simulation

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Based on a multi-decadal Pacific basin model simulation, inter-annual variations of the North Equatorial Current (NEC) are investigated. The model reproduces well the characteristics of the NEC and its inter-annual variability. The magnitude and standard deviation of the NEC transport increase from 46.5 and 3.9 Sv at 175° E to 66.7 and 6.5 Sv at 130° E, respectively, and both peak around 132 º E prior to entering the separation region. The NEC transport tends to be higher during positive ONI years but lower during negative ONI years with the maximum difference of more than 20 Sv. The inter-annual variability of the NEC transport is closely related to changes of the SSH in the tropical Pacific Ocean, and the increase of the NEC is mostly balanced by the increase in the North Equatorial Counter Current on the tropical gyre side. The present study further suggests a long-term decline of the NEC transport from 1993 to 2012, which is consistent with the patterns in the trend of wind stress curl. Transport anomalies reconstructed from the normal modes of zonal velocity suggest that the 1st baroclinic mode captures about 95% of the variance in the NEC transport, while the 2nd mode adds only additional 3-4%. A 1.5-layer reduced gravity model further reveals that the 1st (2nd) baroclinic mode is driven primarily by the wind (thermal) forcing, respectively, and that the wind forcing plays a predominant role in determining the inter-annual variability in the NEC transport while the effect of the thermal forcing is rather limited.

S5-P3 (13393)

Submesoscale dynamics in the Northeastern Subtropical Pacific Ocean

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Oceanic submesoscales (O(1-10km)), ubiquituous on satellite images, are now recognized to play a key role in the ocean energy and carbon export budgets. Our North Pacific simulation with a 1/30° horizontal resolution highlights in winter the expected presence of energetic submesoscales around the Kuroshio Extension and subtropical countercurrent. However, energetic winter submesoscales are also observed in the northeastern Subtropical Pacific, which was unexpected. They are located along the region where the subtropical cell subducts. We show that the combination of the unstable mean baroclinic current (associated with a large-scale seasonal meridional density gradient) with relatively deep winter mixed-layer is responsible for the production of these energetic submesoscales through mixed layer instabilities. Future satellite altimetry missions (such as the SWOT mission), with a resolution ten times higher than conventional altimeters, should allow confirming the seasonal energetic submesocale dynamics in this Northeastern Subtropical Pacific region still poorly documented.

S5-P4 (13444)

Interannual variability of marine ecosystem in the Kuroshio Extension region

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Interannual variability of marine ecosystem in the Kuroshio Extension (KE) region is investigated using an eddy-resolving coupled physical-biological model. The model reproduces the observed interannual variability of sea surface height anomaly (SSHA) in the KE region along a zonal band of 32 – 34 ˚N from 2000 to 2012. The negative SSHA (KE unstable state) is shown in 2000 to 2002, 2006 to 2010, and 2012, and the positive SSHA (KE stable state) is shown in 2003 to 2005, and 2011. Distributions of high (low) nitrate and phytoplankton concentrations correspond to negative (positive) SSHA. Cyclonic eddies (negative SSHA) are found to detach from the KE jet near 150˚E and 158˚E, and propagate westward. The westward propagating cyclonic eddies lift the nutrient-rich water into the euphotic zone, and maintain high levels of phytoplankton concentration in summer to fall. When the passing of strong cyclonic eddies (strong negative SSHA), especially, in 2012, the high nitrate water is lifted close to the surface layer, and appears the high surface phytoplankton concentration. Every winter, deep convection inside the eddy entrains high levels of nutrients into the mixed layer, increasing production, resulting in high phytoplankton concentration throughout the surface mixed layer. By contrast, anticyclonic eddies (positive SSHA) depress the nutrient-rich water (maintain oligotrophic condition), and the surface phytoplankton concentration in summer remains low, in 2003 to 2005.

S5-P5 (13509) CANCELLED

Instabilities of an anticyclonic eddy in its growing and decaying phase

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Recent high-resolution realistic simulations reveal that the anticyclonic eddy in the growing phase usually has a smaller size but very strong intensity, and it becomes unstable and dissipative with a larger size when the eddy starts to decay. The puzzling piece here is that the growing eddy with strong negative vorticity should be easily subject to inertial instability but the fact is the other way around. It is growing stably and behaves more like a barotropic vortex. By analyzing a typical anticyclonic eddy from a high-resolution model in the South China Sea, it is shown that the stratification and viscosity effects help stabilize the eddy in its growing phase even the inertial instability criterion is met somewhere inside it. When the eddy turns to decaying, the intensity of the eddy decreases but the generalized Rayleigh discriminant could still be negative. Complex structures emerge inside the eddy at this stage partly due to the inertial instability. Other kinds of instabilities such as anticyclonic ageostrophic instability may also arise and play an important part in eddy decaying.

S5-P6 (13525) CANCELLED

Two types of anticyclonic eddies eastward from Japan: An origin, characteristics, influence on fishery

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On the base of satellite data analysis, the Oyashio interaction with warm anticyclonic eddies is considered as the basic process conditioning the squid fishery. Large (100-120 miles in diameter) anticyclonic eddies are permanently observed in the area off Pacific coast of Hokkaido Island. They have various origin, size, thermohaline and dynamic structure, so their influence on fish distribution is different. Parameters of anticyclonic eddies of various origin are described for 2004 and 2005, taking into account both infrared and altimetry data, and compared with the neon flying squid fishing grounds location.

In 2004, the eddy A24 was traced which was generated from the Kuroshio meander in 2002 and crossed the subarctic front in early 2003. In October 2004, it had the size 80x100 miles, homogeneous warm core with SST 15-16°C, and rotation velocity about 47 cm/s. The eddy was surrounded with cold waters of the 2nd branch of Oyashio. squid shoals located along border of the eddy.

The eddy A28 was generated in the Subarctic frontal zone in 2005 as a result of impact of two eddies. It moved to the north with the speed 1.6 miles/day. In October 2005, the eddy had the size 80x90 miles, SST in the core about 16°C, rotation velocity about 64 cm/s. Warm and cold streamers had penetrated inside the eddy. neon flying squid fishing grounds were formed in the center of the eddy.

S7: Ecological responses to variable climate changes and their applicability to ecosystem predictions

S7-P1 (13356)

Assessing the oceanographic variability impact in the western North Pacific on fishery resources in Japan using FORA-WNP30

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Previous studies have suggested that the inter-annual and decadal variabilities in the North Pacific not only affect the physical and biogeochemical oceanography but also modulate the fish abundance, fishing and migrations of several marine species in the Pacific Ocean. Such variabilities include but not limited to those caused by Pacific Decadal Oscillation (PDO) and the North Pacific Gyre Oscillation (NPGO). Both of these are influenced by the Aleutian low variability, which is remotely forced by eastern Pacific canonical El Niño-Southern Oscillation (ENSO) through atmospheric bridge. The dominant decadal fluctuations of the North Pacific sea surface temperature and gyre-scale circulation of the NPGO are dynamically linked to the Central Pacific Warming El Niño. During this ENSO event the bifurcation of the North Equatorial Current (NEC), off Philippines Islands, may alter important northward pathways for heat, salt, and nutrient through the Kuroshio Current, responsible current for Japan's plentiful marine bounty. Even though this oceanographic modulation can have a large impact on fishery resources, the direct association to shifts in the dynamics of coastal fishes and mechanisms linking them are still largely obscure. This is due to lack of comparison of fishery data with subsurface ocean observations. In this study, we use Four-dimensional Variational Ocean ReAnalysis for the Western North Pacific over 30 years (FORA-WNP30) to investigate how the weekly, monthly, seasonally and inter-annual variabilities in the physical properties near Japan affect the fish catch, comparing daily three-dimensional hydrography and lateral flow fields available in FORA with the available fishery data.

S7-P2 (13442)

Characterizing time-series of bioacoustics, physical and biogeochemical properties in Saanich inlet (British Columbia, Canada): multi-scale temporal dynamics, causal relationships and forecasting

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Zooplankton dynamics in Saanich Inlet, an inverse estuary at the southeastern end of Vancouver Island (British Columbia, Canada), have been monitored using an Acoustic Zooplankton Fish Profiler (AZFP) mounted on a cabled observatory system platform since 2006. Measurements of environmental and oceanographic indices (e.g. temperature, salinity, oxygen and tide height) are recorded via multiple sensors from the same observatory system concurrently. These twelve-year (2006-2018) high-resolution time-series allow for the first characterization of zooplankton dynamical features and exploration of the driving factors and processes on multiple time scales using Empirical Dynamic Modeling. The fluctuations in acoustically measured migration zooplankton biomass (dominated by *Euphausia pacifica*) and variations in measured non-biological indices display significant nonlinearity ($\theta > 0$) on weekly, biweekly, monthly and quarterly scales. Temperature, salinity and oxygen were identified as significant causal factors of nonlinear dynamics in the migratory zooplankton biomass time series on quarterly and monthly scales in this system, while tidal height significantly drove the nonlinear dynamics on weekly and biweekly scales. In addition, we demonstrate and compare forecasting capabilities of migratory zooplankton biomass between using a single time series (bioacoustics) and using multiple time series (bioacoustics and environmental indices) for state space reconstruction. The biweekly and monthly scales were identified as appropriate scales for characterizing euphausiid population dynamics and for better short-term forecasting potential in Saanich Inlet.

S7-P3 (13595) CANCELLED

Long term ichthyoplankton assemblage structure and its relationship between with environmental variation in the Yangtze Estuary

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The ichthyoplankton assemblage structure in the Yangtze Estuary was analyzed based on survey from 1998 to 2009. For springs, 42 ichthyoplankton species belonging to 23 families were collected. Engraulidae was the most abundant family. The structure of the ichthyoplankton spring community persisted on annual basis, with the dominant species reappearing consistently even though their abundance fluctuated from year to year. This inter-annual variation probably reflects variable environmental condition influenced by the bloom of jellyfish, the declining river flow, and the overfishing. Canonical correspondence analysis indicated a spatial structure of the ichthyoplankton assemblage in three areas: inner assemblage, central assemblage, shelf assemblage. The pattern observed in ichthyoplankton assemblage structure appears to be strongly influenced by depth, salinity and suspended particulate matter gradients. For autumns, 33 ichthyoplankton species belonging to 19 families were collected. Engraulidae, Gobiidae, Salangidae were the most abundant family. The structure of the ichthyoplankton autumn community persisted on annual basis, with the dominant species reappearing consistently even though their abundance fluctuated from year to year. Canonical correspondence analysis indicated a spatial structure of the ichthyoplankton assemblage in three areas: estuarine assemblage, coastal assemblag and offshelf assemblage. The pattern observed in ichthyoplankton assemblage structure appears to be strongly influenced by salinity and suspended particulate matter gradients.

S7-P4 (13614)

Sediment-associated phytoplankton release from the seafloor in response to wind-induced currents in the Bering Strait

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Bering Strait, the single gateway between the Arctic and Pacific Ocean, is local spot of strong ocean currents, whose speed can reach up to 100 cm s^{-1}. Although massive spring phytoplankton bloom and the subsequent production of particulate organic matter that sinks to the seafloor are observed in the surrounding regions of the Bering Strait, an impact of this locally strong currents on horizontal and vertical transport of the particles is unclear. Based on this background, we conducted year-round mooring measurements from 2016 to 2017 with a focus on near-bottom process associated with ocean currents. Our time-series analysis showed that high-turbidity events near the seafloor occurred through all seasons, which were triggered by strong barotropic currents (speed: 50 cm s^{-1}–100 cm s^{-1}). In response to these events, fluorescence sensor detected highly concentrated chlorophyll *a* in the resuspended sediment; however, the amount of chlorophyll *a* released was seasonal, with larger and smaller amounts released during warm and cold seasons, respectively. The latter of these might be due to the sediments containing smaller amounts of phytoplankton owing to the organic matter decomposition by bacteria under no-light conditions. The barotropic currents were modulated by surface winds associated with an intercontinental atmospheric pattern with a 5000-km spatial scale at a timescale of 6 days. This unique feature found in the Bering Strait, i.e., upward transport of sediment along with subsequent horizontal transport, may play a vital role in formation of biological hotspots in the southern Chukchi Sea.

S7-P5 (13757) CANCELLED

Geographic regions in the Bering Sea based on in situ oceanographic data

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Global Ocean is structured by seascapes (marine landscapes) of various scales. Understanding of their spatial organization, hierarchy and temporal dynamics is crucial for multiple research fields including evolutionary studies, data synthesis efforts, and marine resource management. Seascapes are shaped by physical processes and reflected in distribution of species, biomass, primary production and, consequently, biogeochemical parameters. The objective of present work is to delineate major geographic regions in the Bering Sea. The study is based on all available August-September station data with dissolved oxygen, dissolved inorganic phosphorus and silicate measurements in 0-50 m layer from 1970-2015. Vertical distribution of temperature and salinity is also considered. Initial data is vertically interpolated and distributed into hexagonal geodetic bins with size of about 50 km. Spatial averaging of data with Gaussian function is performed in order to fill the gaps and smooth the data. Period of August-September is chosen because it is better covered with data. August-September nutrient and dissolved oxygen distribution in the upper 50-m layer is believed to keep signature of winter mixing and spring-summer nutrient drawdown. Resulted set of data is normalized and clustered by several methods of hierarchical clustering which reveal similar spatial distribution of clusters. Analysis revealed 8 geographic regions in the Bering Sea. The suggested scheme of regions may be used for oceanographic biogeochemical data synthesis. Correspondence of suggested regions to distribution of biota and biological parameters is yet to be addressed in future research.

S7-P6 (13763)

Responses of Japanese anchovy (*Engraulis japonica*) catch to environmental changes in the South Sea of Korea in recent decades: a generalized additive model approach

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Japanese anchovy (*Engraulis japonica*) is commercially and biologically important small pelagic fish in Korea. In relation to a decrease in the production of coastal fisheries in Korean waters in recent years, the understanding of a relationship between fish resources and environmental factors of their habitat can help establish the strategies of fisheries management. This study investigates the relationships between anchovy catch and ocean environment during 1980-2010 in the South Sea of Korea, the main fishing ground of anchovy in Korea, by applying a generalized additive model (GAM) to primary/secondary production and oceanographic data including temperature and salinity. Based on GAM results shows that the zooplankton biomass, mixed layer depth, 5m depth seawater temperature, and Arctic Oscillation Index explain a large part (more than 80%) of variability of annual anchovy catchment. This finding suggests that in recent three decades, zooplankton biomass is a main contributor to the interannual variability of anchovy catchment in the South Sea of Korea.

S7-P7 (13788)

Reconstructing foraging conditions experienced by salmon on the high seas

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Decline in Pacific salmon stocks, including sockeye and to a lesser extent chum and pink, have been observed in the south part of the NE Pacific over the last two decades. For example, Rivers Inlet sockeye, historically one of the major British Columbia stocks, collapsed to near zero levels in the early 1990's and have shown only limited signs of recovery despite the fisheries having been closed since 1996. The reasons for this decline still remain unclear, particularly with respect to the high seas "black box" life phase. Here we have developed a new approach to shed light on the high seas life phase of Pacific salmon. Interannual variability of salmon stable isotope (SI) signatures was investigated using scales archives. While $\delta^{15}N$ values were quite stable before the stock decline began, greater variation was observed in recent years implying changes in foraging location, salmon diet, or the SI baseline. The correlation between $\delta^{13}C$ and sea surface temperature allowed us to estimate the location of salmon during the 9 months prior to capture. Concurrently, we have described the feeding conditions experienced by salmon using the SI of the prey field in the NE Pacific region. Combining these approaches provides a powerful tool for determining the high seas ocean conditions experienced by salmon stocks, and a means to asses how these conditions can affect salmon fitness (e.g., condition factor, spawning success, juvenile survival rate).

S7-P8 (13790)

Simple Bio-Optical Proxies for Phytoplankton Abundance and Compositions in Complex Coastal Waters

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Coastal waters are productive, dynamic and biologically complex. This diversity complicates optical proxies of phytoplankton dynamics. For example, uncertainty arises in quantifying chlorophyll-*a* concentrations from in-situ fluorometers because different factors influence the relationship between fluorescence and chlorophyll-*a*. These factors arise from changes in taxonomy, light exposure, nutrient availability, and cell size. Other simple optical measures, such as beam attenuation which is a measure of bulk particulate concentrations, can provide further information on phytoplankton abundance and compositions; however, the use of beam attenuation is complicated in coastal regions where there can be high concentrations of non-algal particles. Nonetheless, recent research has shown that coupling multiple optical proxies can potentially provide high-resolution information on phytoplankton taxonomy, physiology and non-photochemical quenching. Since 2012, the Hakai Institute has collected high frequency oceanographic data, including discrete chlorophyll a (from extracted fluorometric and HPLC), phytoplankton microscopy, nutrients, and CTD profiles with fluorescence, beam attenuation and photosynthetically active radiation sensors. Here we present unique high resolution timeseries of these data from two stations on the British Columbia coast. In addition to investigating phytoplankton dynamics from the discrete samples, we assess the use of optical measures such as fluorescence and beam attenuation as proxies for resolving phytoplankton dynamics in-situ.

S7-P9 (13791) CANCELLED

Dynamics governing upwelling and nutrient availability along the BC central coast

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Upwelling of North Pacific Ocean waters onto the North American continental shelf is a major contributor to biological productivity of marine ecosystems in this domain. During spring and summer, winds shift and draw nutrient-rich, low-oxygen, low-pH, cold, dense water from the deep Pacific towards the coast. Recent work suggests that the British Columbia central coast is distinct from other North Pacific upwelling regions. These differences are investigated using a combination of high-temporal-resolution hydrographic and nutrient data from near-shore locations in recent years, a multi-decadal archive of hydrographic data on the shelf, and velocity records from four moorings deployed from 2016 to present. Additionally, an autonomous ocean glider will be used during a field campaign in 2018 to collect high-resolution measurements of salinity, temperature, oxygen, bio-optical water properties and rates of turbulent mixing. The physical mechanisms governing the timing of arrival, seasonal cycle, and spatial variability of upwelled water properties are examined and found to be markedly different from those in the Strait of Georgia to the south. Related differences are found for nutrient availability in the sunlit upper ocean in Queen Charlotte Sound, with implications for plankton community composition. Links with coastal ecosystems, and migrating juvenile salmon in particular, are discussed.

S8: Internal tides, nonlinear internal waves, and their impacts on biogeochemistry, climate and marine ecosystems via ocean turbulent mixing processes

S8-P1 (13292)

Response of plankton standing stocks and productivity to turbulent nitrate flux in the Kuroshio across the Tokara Strait

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Despite spawning and nursery grounds for many migratory fishes, biological productivity has been thought to be low in the Kuroshio due to oligotrophic conditions by strong thermal stratification and low standing stocks of plankton community. In recent years, some researchers propose large nutrients supplies by micro- to mesoscale physics like turbulence, frontal eddy and meandering, in particular the narrow and shallow Tokara Strait. Here, we evaluate response of standing stocks and productivity of phytoplankton and microzooplankton to turbulent nitrate flux based on enriched bottle incubations. Apparent growth rates of all size-fractionated phytoplankton demonstrated a logarithmical increase with nutrients enriched and were positive at the upper ranges of the turbulent nitrate flux measured in the Tokara Strait. Growth rates of pico- and nanophytoplankton were lower for those of microphytoplankton, indicating microzooplankton feeding on smaller autotrophs. These results suggest that phytoplankton productivity is stimulated by turbulent nitrate flux at the Tokara Strait even in the oligotrophic Kuroshio. We will discuss the responses of plankton community to turbulent nitrate flux including microzooplankton standing stocks and growth.

S8-P2 (13359)

Effects of strong turbulent mixing on phytoplankton around the Tokara strait

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In recent years, effects of strong turbulent mixing on lower-trophic level ecosystem have received a lot of attention in the Tokara strait, where many seamounts and small islands exit within the route of the Kuroshio in the East China Sea. To investigate these effects, we observed the spatiotemporal distributions of the nutrient concentrations and size structure of the phytoplankton assemblage around the Tokara Strait in the autumn of 2015. Two observational transections across the Kuroshio were designed to detect the ecosystem changes associated with the Kuroshio passing of the Tokara strait. A-line was upper stream side just before the passing, and B-line was down-stream side just after the passing. We compared the three size fraction of phytoplankton assemblage between A-line and B-line. The responses of phytoplankton to the passing the strait were quite different by their body size, nano-phytoplankton increased by about 46%, micro-phytoplankton increased by about 28%, and pico-phytoplankton increased by about 5%. These results suggest that the size structure of the phytoplankton assemblage in the Kuroshio region is significantly affected by the strong turbulent mixing around the Tokara strait.

S8-P3 (13362)

Characteristics of mode-1 and mode-2 nonlinear internal waves observed in the northern East China Sea

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Oceanic nonlinear internal waves (NLIWs) have been known to have a profound impact on climate, biogeochemistry, and ecosystems, contributing to the transport, redistribution, and, mixing of heat, energy, and materials. In northern East China Sea, various types of NLIWs are generated and propagate influencing local biogeochemistry and ecosystem. Here, we present an analysis of high quality data collected using more than 1,000 underway Conductivity-Temperature-Depth (CTD) profiling, standard CTD profiling, and moored temperature sensors via the SAVEX-15 (Shallow-water Acoustic Variability Experiment, 2015) conducted from May 14 to 28, 2015 to characterize first- and second-mode NLIWs. The observational results based on two-layered Kordeweg-de Vries (KdV) theory demonstrate that the mode-1 NLIWs having an amplitude of 4-8 m and characteristic width of 438-908 m propagate into multiple directions but predominantly southwestward in a speed of 0.58-0.61 m/s. The mode-2 NLIWs having similar amplitude and shorter characteristic width of 479~646 m are newly found to propagate eastward in a slower speed of 0.27 m/s. This study provides basic characteristics of NLIWs to better understand mixing and biogeochemistry in the region.

S8-P4 (13370)

Amplified diurnal currents over the shallow banks and 18.6-year variability of salinity of the intermediate waters in the Western Subarctic Pacific

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The south-flowing waters of the Kamchatka and Oyashio currents are key components of the western subarctic Pacific gyre. The dissipation of tidal energy in shallow and coastal regions of these currents and the attendant mixing are the important processes that affect the upper layer temperature and salinity. Examples of the impact of tidal currents on water temperature and salinity are the persistent tide-driven mixing around the Kashevarov and Kruzenshtern banks. The Kruzenshtern Bank is a shallow submarine bank stretchingalong the eastern continental slope of the Kuril Islands with the minimum depth of 86 m. Surface drifters observations are used to determine the characteristics of tidal currents, and the circulation over these banks. New software that allows more versatility in the harmonic analysis is used for drifter's data. The two banks have similar features. The variations in current velocities are dominated by the diurnal signals. The K_1 and O_1 tidal ellipses over the banks are the largest and clockwise. The enhanced tidal currents suggest that the formation of cold and saline water in summer is due to mixing of water column over the banks with intermediate waters. Variations of tidal ellipses over the bank may explain the formation of polynya at the western end of the Kashevarov Bank. We found that the 18.6-year lunar nodal cycle is a significant characteristic of salinity variation at the temperature minimum in the eddies eastward of the Boussole Strait over the period 1990-2015.

S8-P5 (13408)

Size distributions of marine aggregates in different aquatic systems

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Marine aggregates are formed through the coagulation of small biogenic and non-biogenic components. Visible aggregates, known as marine snow, are typically in the 0.5 to few mm size range. Aggregates are well recognized as hotspots of microbial and planktonic activities. Aggregates formation is and important pathway for transferring organic matter from surface to the deep ocean, hence the impacts of aggregates in carbon flux is significant. Because aggregates sinking velocity and carbon mass content is size dependent, size distribution of aggregates is fundamental to better understand the contribution of aggregates in the biological carbon pump. However, the size distribution of naturally occurring aggregates has not fully investigated in observational studies.

In this study, we analysed in-situ observation of aggregates in various aquatic systems using a digital still logger camera (DSL camera). Digital images that DSL camera collected were subsequently used to determine aggregates size distributions. Fluorescence and turbulence were simultaneously measured by a microstructure profiler, TurboMAP-L. Size distributions showed 2-slopes structures for all surveys, although the locations were different. Kolmogorov scale estimated from averaged turbulence suggested that the 2-slopes structure is associated with the strength of turbulence. Direct comparison of fluorescence and size distribution showed that aggregates in open water contain more chlorophyll-a than the ones in coastal water for given size.

S8-P6 (13529)

Elevated mixing in the Tsugaru Strait through internal hydraulic jump

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The Tsugaru Strait throughflow is an eastward current between the Hokkaido and Honshu Island, Japan, and is considered to occur vigorous watermass mixing before flowing out to the Pacific side where good fishing ground exists. The mixing intensity, however, has not been reported in the strait on the basis of turbulence measurements, so we conducted a microstructure observation across a sill off the Tappi Cape in Sep. 2017 in order to quantify turbulent mixing intensity and clarify relevant physical processes. A large amplitude internal wave was observed near the lee edge of the sill, which accompanied with elevated turbulent mixing reaching $\varepsilon = O(10^{-6}$ W/kg) and $Kz = O(10^{-3}$ m^2/s). Density inversion layers also emerged near the lee edge, and the subsurface stratification was weakened in the downstream. The echogram captured the isopycnal jump near the lee edge, and the layer Froude number became supercritical, indicating the occurrence of internal hydraulic jump. The subsurface nutrient concentration was elevated in the downstream, so the impact of hydraulic jump to the local and downstream environment deserves to be examined by future studies.

S8-P7 (13569)

The Influence of Yellow Sea Cold Water Mass on the Early Life History Process of Young Pacific cod (*Gadus macrocephalus*)

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Yellow Sea Cold Water Mass (YSCWM), as a typical oceanic feature with characteristic thermocline and internal waves, provides a suitable habitat for cold-water species, such as Pacific cod, a demersal species whose resource shows incredible interdecadal fluctuation. Its life history is strongly influenced by the seasonal variation of YSCWM, especially for young-of-year Pacific cod (YOY). Meanwhile, the hydrodynamic structure within YSCWM is not uniform and characterized in "two cold cores" pattern, with relatively intense tidal current and inertial oscillation in the west core. Therefore, we carry out research on how the inhomogeneous hydrological structure of YSCWM influences the life history process of YOY according to the seasonal bottom trawl survey in Yellow Sea in 2017 and historical mooring observation. The result shows that the YOY distribution was restricted by the two cold cores in summer. In particular, the length of YOY is longer in the west cold core with strong current and shallower depth. In addition, from the distribution of YOY in spring indicated two migration routes in their larva stages. Combined with otolith microstructure analysis of YOY samples in spring and summer, the otolith daily increment patterns in the two cold cores illustrated faster growth rate in the west, owning to the shallower depth and better mixing. As a result, the intensity and range of west cold core of YSCWM is vital for better recruitment of Pacific cod, and internal wave mixing reveals its crucial role on YSCWM ecosystem with strong stratification and weak water exchange.

S9: Integration of science and policy for sustainable marine ecosystem services

S9-P1 (13267)

Preliminary analysis of the Jimo coastal ecosystem with the Ecopath model

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The Jimo coast encompasses an area of 2,157 km^2, the ecosystem is valuable both socially and economically with regional fisheries substantially contributing to the value. A mass-balanced trophic model consisting of 15 functional ecological groups was developed for the coastal ecosystem using the Ecopath model in Ecopath with Ecosim (EwE) software (version 6.4.3). The results of the model simulations indicated that the trophic levels of the functional groups varied between 1.0 and 3.76, the total production of the system was estimated to be 5,112.733 t km^{-2} yr^{-1} with a total energy transfer efficiency of 17.6%. The proportion of the total flow originating from detritus was estimated to be 48%, whereas that from primary producers was 52%, indicating that the grazing food chain dominated the energy flow. The fin cycling index and the mean path length of the energy flow were 4.92% and 2.57%, respectively, which indicated that the ecosystem exhibits relatively low maturity and stability. The mixed trophic impact (MTI) procedure suggested that the ecological groups at lower trophic levels dominated the feeding dynamics in the Jimo coastal ecosystem. Overfishing is thought to be the primary reason for the degeneration of the Jimo coastal ecosystem, resulting in a decline in the abundance of pelagic and demersal fish species and a subsequent shift to the predominance of lower-trophic-level functional groups. Finally, we offered some recommendations for improving current fishery management practices.

S9-P2 (13587)

The value of ecosystem services of the West Bering Sea

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The West Bering Sea (WBS) Large Marine Ecosystem (LME) was chosen for the evaluation due to its high primary productivity and economic significance for the Russian Far East and North Pacific. At present time, rapid changes in the Arctic environment affect subarctic seas, so there is a critical need for identifying and monitoring the ecosystem services of these areas on different scales. The cost of the following services was estimated: food production, raw materials, genetic resources, biological control, climate regulation and gas regulation, primary production, nutrient cycling. The food production and raw materials services were measured using the market price method, biological control, genetic resources and nutrient cycling services were evaluated using expert evaluation method. Climate regulation, gas regulation and primary productivity were evaluated using the methods described by Wang *et al*., 2016. The total value of these ecosystem services was $70{,}05 \times 10^9$ USD per year. Food production, primary production and gas regulation services were the most valuable; their value was $13{,}59 \times 10^9$ USD (19,4%), $25{,}76 \times 10^9$ USD (36,7%) and $14{,}59 \times 10^9$ USD (20,8%) of total cost, while the raw materials service was the lower value - $0{,}16 \times 10^9$ USD (0,23%). These quantitative estimates can be a useful basis for decision-making processes for the sustainable development of the subarctic marine region.

S10: Ocean acidification and deoxygenation and their impact on ocean ecosystems: Synthesis and next steps

S10-P1 (13313)

Communicating Ocean Acidification in East Asia: What are the key messages for policy makers and society?

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Ocean acidification (OA) is already impacting marine ecosystems, with shifts in food webs and biodiversity changes, less coastal protection, and reduced ecosystem complexity. Such changes are expected to continue into the future; marine CO_2 seeps in Japan provide insight into what East Asian marine ecosystems could look like under increasing OA conditions. Limited awareness of OA impacts, however, exists among fishers, shellfishers, and seaweed farmers/harvesters or among local and regional policy makers and managers. Scientific information on OA in East Asia is mostly published in English or only available through the scientific literature, which limits access. We seek to produce a clearly written, non-technical publication tailoring key messages about OA to East Asian ecosystems, fisheries, and policy needs. The publication will promote understanding of OA challenges and opportunities, based on scientific knowledge, among these key groups, and will be published in Mandarin and Japanese as well as English. This information will enable key sectors to adapt to challenges and take advantage of upcoming opportunities. A clear connection between OA impacts and East Asian society will support policy decision-making around fishery and harvesting management, and will explicitly link OA-related ecosystem changes to international policy drivers. We invite the PICES community to provide feedback on our draft document: Have we chosen the right messages? Are we communicating them clearly? What could we do better?

S10-P2 (13401)

Recent deoxygenation in the Japan Sea Proper Water in the northeastern Japan Basin

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We investigated the temporal variability in the properties of the Japan Sea Proper Water (JSPW) in the northeastern Japan Basin of the Japan Sea where the water depth exceeds 3500 m, using high-quality data of ship-based measurements being conducted each year since 2010 by the Japan Meteorological Agency. From the vertical profiles of potential temperature (θ) and dissolved oxygen (O_2) and their temporal variabilities, the JSPW is classified into three distinctive layers such as the Upper JSPW, the Deep Water and the Bottom Water. The largest O_2 decreases (11 to 18 μmol/kg for 2010–2017) was observed in the Upper JSPW between 500 m and 1000 m. Consequently, an O_2 minimum layer emerged at around 1000 m in 2013 and is being developed to date. The decrease of O_2 in the Upper JSPW accompanied the increase of nitrate. The decrease of O_2 and warming (4 μmol/kg and 0.01°C, respectively, for the same period) were also observed on σ_θ=27.349 kg/m^3 in the deeper Bottom Water below 2500 m where the water is vertically uniform. The results of this study are helpful in understanding the difference of circulation structure in the Japan Basin, the formation of JSPW, and mixing and biological process. Further examination is also necessary to reveal the variability and its mechanism of warming and deoxygenation in the JSPW by analysis of a comparable high-quality data in the Japan Sea.

S10-P3 (13409)

Temporal variation of the saturation state of carbonate in intermediate waters of western North Pacific

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Many studies have investigated the acidification of surface waters, but only few information exist for acidification state of sub-surface waters. Response of mesopelagic organisms against sub-surface acidification has also remained almost unknown. In 1997, we had investigated the saturation state of carbonate in the intermediate waters of western North Pacific, as well as the vertical distribution and morphology of *Globorotalia scitula*, a typical mesopelagic-floating foraminifer. Repeated observation was then carried out in 2016-2017, and the 20-years difference of carbonate saturation state and vertical distribution of *G. scitula* were evaluated.

DIC had significantly increased in the waters above the isopycnals of sq = 27.0, and the saturation horizon of aragonite had shoaled from the isopycnals of sq = 26.9 in 1997 to that of sq

26.8 in 2016-2017. In the waters between sq = 27.1 to 27.4, on the other hand, slight decrease of DIC from 1997 to 2016-2017 were observed as well as significant increase of water temperature and salinity. As this result, the saturation horizon of calcite had deepened from the isopycnals of sq = 27.2 in 1997 to that of sq = 27.3 in 2016-2017. Vertical maximum of *G. scitula* population had moved from the density range of sq = 27.1 – 27.2 in 1997 to that of sq = 27.2 – 27.3 in 2016-2017. This may indicate that *G. scitula* had changed its main habitat along with the temporal shift of the saturation horizon of calcite.

S10-P4 (13447)

A marine carbon model coupled with an operational ocean model product for ocean acidification studies in the North Western Pacific

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Ocean acidification causes serious damages to marine ecosystems such as coral reefs in the subtropical region and species or groups of organisms in the polar region. Damages due to increasing the ocean acidity are further predicted to affect broader areas and bring about great risks of marine organisms. We recently have developed a marine carbon model coupled with an operational ocean model product (JCOPE), aiming at investigating ongoing ocean acidification processes in the North Western Pacific, focusing on their associated physical-biogeochemical processes and social risks. The latest version of the model successfully reproduced reasonable chlorophyll-a, nutrients and pH values, after a lot of improvements including initial conditions of carbon parameters and multiple parameter optimization. Simulated seasonal variability, however, shows some problems yet, especially for chlorophyll-a variation in the subarctic region. We will solve these issues in future and will provide the information on the present status of the carbon cycle in the marginal/coastal sea areas around Japan.

S10-P5 (13631) CANCELLED

Development and persistence of hypoxia and related environmental parameters at Jinhae Bay, south coast of Korea in 2011-2015

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Jinhae Bay, a semi-enclosed embayment located in south coast of Korea is major aquaculture area of shellfish and a nursery ground for commercially important fishes. Since late 1960's industrial and domestic waste from adjacent cities and industrial complexes have loaded and resulted in chronic hypoxia in Jinhae Bay. As a nation-wide environmental monitoring for aquaculture in Korea, Jinhae Bay was surveyed every two month (half month in hypoxia season) and observed seawater properties as well as meteorological conditions. During the study periods, hypoxia was usually developed on late May~June from innermost small bays, extended out into the Jinhae on August and weakened and/or disappeared by late September~October from the Jinhae to inner small bays sequentially. Duration and intensity (expressed as oxygen deficiency index) of hypoxia in 2012 were higher (19.8 weeks and 102.3), and averages of water temperature and salinity during the hypoxia period were also higher and lower, respectively than in other years. It means that strong stratification (expressed as stability index) in water column caused by high temperature and low salinity in surface water might be an important factor for development and persistence of hypoxia in Jinhae Bay. If high (> 0.1) levels of stability index lasts more than 2~4 weeks on May~June, thermodynamic conditions are ready to develop a hypoxia in Jinhae Bay. Next steps of hypoxia studies in Jinhae Bay will be focused on prediction and forecasting the hypoxia in future climate change using a simple numerical model based on temporally high-resolution measurements.

S10-P6 (13640)

Long-term Trends in surface ocean pCO_2 seasonality in the northwestern North Pacific

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Long-term trends in surface ocean pCO_2 seasonality in the northwestern North Pacific is investigated by using monthly mapped datasets over two decades. Surface pCO_2 varies seasonally, higher in winter and lower in summer in the subarctic region. In contrast, it varies lower during winter and higher during summer in the subtropical region. The purpose of this study is to examine the area where the seasonal fluctuation of surface pCO_2 is increasing over long-term by investigating the trend (increase rate) in winter (March) and summer (September), respectively. The difference of surface pCO_2 increase trends in September and March is remarkably high in the subtropical-subarctic transition region between 35°N and 42°N and in the subarctic area between 42°N and around 46°N. In the southern subarctic area between 42°N and around 46°N, high surface pCO_2 trend region extends zonally, resulting in the seasonal amplitude becoming larger. In the subtropical-subarctic transition region, $pCO2$ trend in September is higher that in March, resulting in the seasonal amplitude becoming larger as well. The long-term trends of seasonal temperature and dissolved inorganic carbon changes are presented to explain these characteristic features.

S11: Influence of climate and environmental variability on pelagic and forage species

S11-P1 (13323)

Spatiotemporal variations of chaetognaths associated with hydrographic features in the coastal waters off southwestern Taiwan

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The hydrography of coastal waters off southwestern Taiwan shows apparently seasonal changes, and is usually interactively influenced by seasonal precipitation, river runoffs, and the intrusion of different water masses. It is thus characterized by complex hydrographical conditions that affect zooplankton communities and their distribution. Based on our investigations of three seasonal cruises from September 2016 to June 2017, we identified 21 chaetognath taxa belonging to 10 genera and 3 families, with mean abundance of 2466 ± 460 inds./100m^3. *Flaccisagitta enflata* (providing 32.4% of the total abundance of chaetognaths), *Aidanosagitta neglecta* (with 19.6%), and *Aidanosagitta regularis* (with 14.4%) were the three dominant taxa. Chaetognaths were common in this study area, and generally showed higher abundance and species richness in cold and dry winters (January), but lower abundances were often found near the estuary. The distribution patterns of the chaetognath assemblages were closely linked to the hydrographic features in the study area, with other zooplankton taxa, Chl*a*, and salinity being the three most important factors.

S11-P2 (13381)

Why the body size of walleye pollock larvae in Funka Bay and the adjacent waters, Hokkaido was large in 2016?

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The body size of larva is considered an important factor for survival, especially for the Japanese Pacific stock of walleye pollock *Gadus chalcogrammus*. This stock is known to spawn from December to March in and around the Funka Bay, and larvae are distributed in these waters until May. This study aims to explain the variation of larval size in April by the marine environment around spawning ground in winter. Eggs were collected by vertical hauls of a ring net monthly from December (or January) to March in 2005-2016. Larvae were collected by horizontal hauls of a frame trawl net in mid-April since 2005 except 2011, draw ~100 larvae from each trawl catch and measured their standard lengths. Their spawning season peaked in January, except for 2005 and 2007 (peaked in December). The mean standard length of larvae(mean±SD) were ranged from 11.7±1.9mm to 18.0±2.8mm, larvae in 2016 was the largest and in 2013 was the smallest. The mean sea surface temperature from January to March in 2016 was 7.4□, it is 2□ or more higher than the value in other years. The peak of spawning season was similar after 2008, therefore it was suggested that the largest size of larvae in 2016 was caused by the exceptionally highest water temperature in winter. In the next step, we will examine the effect of the body size of larvae on predation mortality of them.

S11-P3 (13398)

Changes in the fish species composition seasonality and in the coastal zones of the Tsushima warm current during periods of climate change: Observations from the set-net fishery of Chiba Prefecture in Japan

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In order to understand the impact of climate change on coastal fisheries in Japan, this study collected a long-term data set of set-net catches, reported from the Chiba Prefecture in Japan to analyze catch composition. The Chiba Prefecture is located at main current of Kuroshio Current (KC) flows through the area. The increase or decrease of the trend of the KC has important impact on fishery resources. In the study, we has been selected to three area to collection and compute the SST and SSTA. And, we used SSTA and CPUE of dominant species to analyze the regression analysis. The results analyses showed that the study period could be divided into three periods. In the catch composition, the main catch species is pelagic fishes during the period 1965-2013 (catch ratio about 89.96%). The catch composition is difference in different periods. In the 1965-1970, the main catch species is warm-water species (catch ratio about 45.47%). In the 1971-1996, the main catch species change from warm-water species to cold-water species (catch ratio about 38.41%). After 1997, the main catch species change from cold-water species to warm-water species again (catch ratio about 51.27%). Pearson regression analysis result also showed that change of catch composition was associated with changes in intensities of the KC.

S11-P4 (13515) CANCELLED

Linkages between pelagic temperature and zooplankton abundance, and growth and recruitment of Pacific Ocean perch in Alaska

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Pacific Ocean perch (POP, *Sebastes alutus*) are a broadly distributed, abundant and commercially important species in the Gulf of Alaska (GOA). During early-late juvenile stages they inhabit rocky habitats at depths from 85 - 245 m along mostly the continental shelf and consume primarily zooplankton species. We constructed a bioenergetics model for juvenile POP driven by monthly mean temperatures and the duration of the growing season inferred from continuous plankton recorder data. Spatially explicit growth potential was predicted for 1987-2016 and was found to be highest in the eastern GOA (where water temperatures are generally higher in the summer) and lowest westward of Kodiak. This spatial pattern was consistent across most years, but the temporal pattern was highly variable. The interannual variability is a combination of the interplay between the duration of the zooplankton bloom and water temperature during that bloom. For example, in 2005, there was an extremely short duration for the zooplankton bloom, yet water temperatures in the spring were the highest in the time series. This resulted in about average growth potential for the year. In contrast, 2002 and 2003 had two of the longest durations of the zooplankton bloom and about average water temperatures, which resulted in two years of very high growth potential across the Gulf of Alaska. A stock-recruit model was constructed that incorporated growth potential and it was found that growth explained 33% of the variability in POP recruitment (about four times the variability explained by spawning stock size alone).

S11-P5 (13591)

On the relationship between sea temperature and fishing ground formations of chub mackerel in the region off Sanriku, northwestern Pacific

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The chub mackerel, *Scomber japonicus*, is one of the most commercially utilized fish spices in the northwestern Pacific. For efficient fisheries, it has been long demanded by fishermen that the important environmental factors impacting on the fish distributions should be identified to predict the locations and the timings of the fishing ground to be formed. In this study, the relationships between the purse seine fisheries record of chub mackerel and oceanographic conditions in the region off Sanriku, northeastern Japan were examined for the fishing season of August to October by using data from 1995 to 2015. The geographical location of the offshore Oyashio front, the surface layer (0-50 m depth) temperature distributions, and the fishing ground distributions had large interannual fluctuations. When the offshore Oyashio front shifts south (north) during early spring and summer, sea temperature in the southern region off Sanriku becomes relatively low before fishing season in spring, then the fishing grounds locate relatively in the southern (northern) region off Sanriku during summer and autumn. This result indicates that there is a predictability of main region of chub mackerel fishing grounds based on the oceanographic conditions before the fishing season.

S11-P6 (13636)

Occurrence of Japanese whiting *Sillago japonica* in the shallow coastal waters of the central Seto Inland Sea

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Japanese whiting *Sillago japonica* is widely distributed in coastal waters of Japan, and is one of the important targets for fishery and game fishing. The spawning season of this species is from June to October and the female lays tens of thousands of eggs per spawning. Spawning behavior has been observed almost every day at water temperature >26□. Information on early life history of the species has been accumulated in the sandy beaches of Tokyo bay. However, the information on spawning and early life history in nature in other areas is very limited. In the present study, we investigated seasonal occurrence of juvenile and adult Japanese whiting and their body length in the central Seto Inland Sea, southwestern Japan. Field survey was conducted one to two times per month from June 2017 to April 2018. Japanese whiting were collected from early June 2017 to December 2017 with a highest abundance in late August. Abundance of adult fish decreased after late August when juveniles started to occur in the survey site. Growth of the juveniles were analyzed by the use of otolith daily increments. Possible effect of water temperature experienced by each juvenile on recent growth rate was investigated.

S11-P7 (13651)

Assessing the availability and accessibility of prey for the Southern Resident Killer Whales

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The Southern Resident Killer Whales are listed as endangered in Canada and the United States. The population numbers 75 individuals and has declined by more than 10% since 2005. Reduction of prey, specifically Chinook salmon, has been identified as a threat to the recovery of the Southern Resident Killer Whale population. However, little is known about the availability of Chinook and whether there are sufficient fish for them to prey upon during summer when this population of killer whales has traditionally come to the Salish Sea to feed. We conducted ship-based hydroacoustic surveys, combined with hydrographic measurements and visual surveys for marine mammals, to examine the fine-scale vertical and horizontal distributions and organization of plankton, forage fish, and salmon in areas designated as critical habitats for Southern Resident Killer Whales. Our study addresses a critical knowledge gap in predator-prey interactions, and provides insights into the future management options that might be implemented to facilitate recovery of the Southern Resident Killer Whale population.

S11-P8 (13679)

Photobehaviors of the marine calanoid copepod *Calanus sinicus* under wavelength-specific light

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The effects of wavelength-specific visible light, white light, and ultraviolet-B (UV-B, 280–315 nm) on selected behaviors, spawning rate, and hatching rate of the marine copepod *Calanus sinicus* collected from the Yellow Sea were studied. *Calanus sinicus* placed in a partitioned experimental system responded positively to blue and green light but negatively to yellow light and UV-B. No obvious dodge activity was found among *C. sinicus* irradiated with <0.005 mW/cm^2 UV-B. Under 0.20, 0.30 and 0.50 mW/cm^2 UV-B radiation, the lethal half times of individuals were 30.47, 2.86, and 1.96 hours, respectively. Grazing of *C. sinicus* was restrained at >0.10 mW/cm^2 UV-B, whereas yellow light stimulated grazing. Egg production was highest at a white-light intensity of 1.58 mW/cm^2, with an average rate of 10.04 eggs/(female·d). These results are consistent with the observed phenomenon that *C. sinicus* in the Yellow Sea mostly spawn near dawn. We propose that both the light intensity and spectrum are the most important factors influencing the diel vertical migration of *C. sinicus* under natural conditions in the sea.

S11-P9 (13702)

Salmon and people in a changing world: Introducing the International Year of the Salmon (IYS)

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The International Year of the Salmon (IYS) is a unique opportunity for the peoples of the Northern Hemisphere to "sign up for salmon" in order to emphasize and explore the close link between the health of the planet and these iconic species. The North Pacific Anadromous Fish Commission (NPAFC) and the North Atlantic Salmon Conservation Organization (NASCO) invite everyone - from schoolchildren to scientists and political leaders - to participate in research and outreach activities focusing on the relationship between salmon and people. Starting in 2018 through to 2022, these activities will search for ways to understand and minimize the impact of climate change and other threats to salmon while celebrating the importance of these international animals. Teams of experts will be brought together under each IYS theme (status of salmon, salmon in a changing salmosphere, new frontiers, human dimension, information systems and outreach and communication) to consider ideas for innovative projects that will bring about measurable change. A Signature Project in the North Pacific aims to bring salmon research back to the high seas through a coordinated effort of multiple countries during the winter. Salmon Connections is another concept under development that aims to quantitatively describe and predict salmon production in the ocean within a model framework facilitating regional comparisons between and within oceans. Beyond targeted outreach and research projects, there is something for everyone in the IYS. If interested in learning more or becoming involved, please contact the NPAFC Secretariat at secretariat@npafc.org or the NASCO Secretariat at hq@nasco.int.

S11-P10 (13714)

Distribution of demersal fishes in the southern Chukchi Sea and Northern Bering Sea after low ice conditions

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In 2017-2018 winter, sea ice extent was at record low in both Bering and Chukchi Seas. The unprecedented low-ice condition continued through April, when melt-out (<10% ice extent) occurred in the Bering Sea four weeks earlier than any other year except 2017. Such a condition would have affected entire ecosystem through high water temperature, low extent of cold pool, and change in lower-level productions. We will conduct a trawl survey in the northern Bering Sea and Southern Chukchi Sea in June – July 2008 onboard T/S *Oshoro-maru*. The distribution of demersal fishes including Arctic cod will be examined and compared with results from previous years (1990, 2008 and 2013) in relation to the environmental conditions.

S11-P11 (13838)

Effects of climate variability on body condition of forage fish sampled by puffins in the Gulf of Alaska

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Changing food webs and energy transfer efficiencies are substantial threats of climate change to marine vertebrates today. Few previous studies, however, had time series long enough to examine interannual or lower-frequency variation in prey quality in the North Pacific. Here, we utilize long-term time series of seabird diets in Alaska to investigate variability in forage fish body condition as a proxy to the nutritional value of these prey to predators. We test the hypothesis that forage fish body condition varies in relation to ocean conditions that regulate ecosystem productivity. To test this hypothesis, we used morphometric data for capelin (*Mallotus villosus*) and Pacific sand lance (PSL; *Ammodytes personatus*) captured by rhinoceros auklets (*Cerorhinca monocerata*) and brought to breeding colonies, where they were collected and measured. From length and mass of each fish, we calculated Fulton's K index of body condition for two sites in the Gulf of Alaska and related it to regional (SST and stratification) and large-scale (PDO and NPGO) ocean conditions. Forage fish body condition varied interannually and between sites, though this depended on age class. Condition of both species at both sites was negatively related to the PDO; there was no significant model found for age-0 PSL at one site. Significant models with regional environmental drivers included negative relationships with seasonal SST and positive relationships with stratification. Such environmental drivers of forage fish body condition are thus important to trophic relationships and upper trophic level predator productivity and populations in the Gulf of Alaska.

S12: Applying ecosystem considerations in science advice for managing highly migratory species

S12-P1 (13330)

Changes in Pacific cod (*Gadus macrocephalus*) size distribution in the North Pacific Ocean over 6 millennia: Possible impacts of fishing pressure or environmental variability

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Fish size distributions are widely used to understand the role of harvesting and changing environmental conditions on fish population dynamics. In the North Pacific Ocean, contemporary size data are used in stock assessments to determine the health of the Pacific cod (*Gadus macrocephalus*) population and evaluate effects of commercial fishing. Zooarchaeological data are available that track cod size variability over thousands of years, recording the impacts of environmental variability, as well as possible anthropogenic forcing such as climate change and overfishing. However, this broad measure - mean body size - masks variability across and within cod populations. In this paper, we compile estimates of cod size distributions based on zooarchaeological data and contemporary length-frequency data to look at size composition through time across the North Pacific from the Kuril Islands to Southeast Alaska. The results suggest that while cod length varies in both modern and ancient datasets across this region, this variability and overall cod length have been consistent for 6 ka.

S12-P2 (13449)

Variation in the catch rate and distribution of swordtip squid (Uroteuthis edulis) associated with factors of the oceanic environment in the southern East China Sea

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Predictions from species distribution models are utilized to parameterize the environmental factors that influence the biology, distribution, and habitats of a species of interest. This study fitted generalized additive models (GAMs) to spatiotemporal fishery data of light fishing from 2009 to 2013 to investigate the catch rates of swordtip squid in relation to changes in oceanographic conditions and developed a habitat preference model. A high Jensen–Shannon divergence (JSD) is considered to be an index of a thermal front. The results obtained using the selected GAMs revealed that the explained deviances in the catch rates pertaining to the oceanographic conditions was 45.10% throughout the year. All the variables used, the sea surface temperature (SST), chlorophyll-a, sea surface height anomaly, and JSD, were statistically significant predictors ($p < 0.05$), and the JSD explained the greatest amount of deviance (17.70%). The model predicted relatively high abundance of swordtip squid at 27–28°N in the southern East China Sea during spring and a decrease from June to August. The high abundance occurred again in September and extended to southwest ward to a region including coastal Mainland China. This demonstrated that the high abundance occurred in the 20.0–26.0°C SST range and 0.35–0.5 JSD range during spring around 27–28°N and movement towards southwest corresponding with shifts in the Kuroshio front (26°C isotherm) in summer and autumn.

S12-P3 (13544)

Review of stock status of Japanese domestic fisheries and new harvest control rule in Japanese domestic fisheries management

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This presentation reviews the stock status relative to management reference points based on maximum sustainable yield (MSY) for 37 Japanese stocks. Those stocks contribute to 61% of the total marine capture production in Japan. We estimated biomass and exploitation rates achieving MSY (B_{MSY} and U_{MSY}, respectively) for the 37 stocks by assuming hockey-stick stock-recruitment relationships. We found that, during 2011–2013, exploitation rates of approximately half of the stocks were over U_{MSY}, while spawning biomass of approximately half of the stocks were less than $0.5B_{MSY}$. Nevertheless, exploitation rates steadily decreased and spawning biomass increased on average over the past 15 years. Historically, Japanese fisheries stock management have not referred to MSY-based biomass reference points because of some critiques on MSY with high uncertainties. However, in response to worldwide accumulation of best practices on stock rebuilding with explicit management targets, Fisheries Agency declared a new direction to define explicit MSY-based target biomass in 2017. We devised a new harvest control rule based on stochastic MSY. It will be applied to Japanese domestic fisheries management in the near future.

S12-P4 (13621)

Role of shallow channel to space-time variation of coastal fisheries resources -Relationship between coastal fisheries resources and oceanographic condition in Hyuga-Nada, Japan-

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We have studied the relationship between coastal fisheries resources and oceanographic condition in Hyuga-Nada, Japan. This report outlines the analysis results, and we propose the following hypothesis that the shallow Bungo channel affected space-time variation of coast fisheries resources at Miyazaki prefecture. The increase of high nutrient and low temperature at low layer in Hyuga-Nada does not contribute to primary production of Hyuga-Nada directly. However, Bungo channel becomes high primary production because of the nutrient supply from low layer to surface layer by tidal convection after bottom intrusion (the high nutrient and low temperature at low layer) from Hyug-Nada. After that, the increased coast fisheries resources (e.g. *Pagrus major*) due to high food spreads the habitat area to Hyuga-Nada.

Biological Oceanography Committee Paper Session

BIO-P1 (13371)

Biomass and community composition of microzooplankton with reference to their nutritional mode in the North Pacific Ocean

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Microzooplankton are important components in the marine ecosystems as the primary grazers on phytoplankton, as major secondary producers, and as intermediaries between primary producers and copepods. A large part of microzooplankton are basically heterotrophic, but they also include many photoautotrophic or mixotrophic species, indicating that they also function as the primary producers. Despite of their importance in the marine ecosystems, the information of biomass and community composition is little known in open water, especially of the North Pacific. This study aimed to clarify the geographical variation in the microzooplankton community, particularly focusing on their taxonomic composition and nutritional form (heterotrophic or mixotrophic). Investigations were conducted at 30 stations located in the subarctic and subtropical areas in the North Pacific from June to October, 2017 during two cruises (KH-17-3 and KH17-4). At the all stations, water samples were collected from three depths: 0, 10 and 50 m and fixed with 2 % acid–Lugol solution. An aliquant of samples also preserved in 1 % glutaraldehyde stained with DAPI to determine the proportion of nutritional mode of each taxon. Microzooplankton were identified under an inverted microscope, and the number and size of each taxonomic group was measured. The biomass of ciliates was high in the subarctic samples, while radiolarians were abundant in the subtropical waters. Dinoflagellates constantly occurred in most of the stations. The abundance of mixotrophic ciliates and radiolarians was higher in the western Pacific rather than in eastern Pacific. The factors controlling the geographic variation of the composition and nutrition mode in microzooplankton will be discussed in relation to oceanographic data.

BIO-P2 (13374)

Community structure of mesozooplankton during spring and summer in the Ulleung island, Korea

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We investigated the temporal changes in the structure of mesozooplankton community around Ulleung-island, Korea during spring and summer of 2017. Study stations at Ulleung-island consist of 6 coastal stations around Ulleung-island and 6 stations on transect from Ulleung-island to open-sea. Mesozooplankton samples were collected in the surface mixed layer (SML) by vertical hauls using a standard type net. The average SML depths were ~28 m in spring and ~24 m in summer. The vertical distribution of temperature ranged 11.3-17.8°C (average = 16.5°C) during spring and temperature ranged 16.1-26.1°C (average = 22.8°C) during summer. Relatively cold water (~12.3°C) was observed at 25 m depth at st.30 during spring. The abundance of mesozooplankton ranged between 917-10,648 inds.m^{-3}, peaked at st.30 during spring and ranged between 960-7,175 inds.m^{-3}, peaked at st.50 during summer. The average abundance for mesozooplankton was 1.6 times higher in spring than summer. The mesozooplankton community was numerically dominated by copepods which comprised 82.7%(spring) and 45.7%(summer). The next dominant groups were appendicularians (13.1%) and cirripedians (1.9%) during spring, and *Noctiluca scintillans* (26.4%), thaliaceans (10.1%), cladocerans(6.5%) and foraminiferans (6.5%) during summer. The results of cluster analysis based on Bray-Curtis index showed that mesozooplankton community were classified into 3 groups at 35% (spring) and 42% (summer) similarity. The dominant appendicularians (*Oikopleura* spp.) appeared only in spring while *N. scintillans* appeared only in summer, indicating that those taxa may have environmental preference with the temperature. Present study will discuss more about the temporal occurrence of mesozooplankton and the related environmental factors around Ulleung-island.

BIO-P3 (13406)

The role of ammonium excretion of small planktonic copepods in epipelagic nitrogen cycle in the subtropical North Pacific Ocean

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In the subtropical ecosystem where nitrogen depleted, biological production is generally sustained by regenerated production, and copepods are important players in nutrient regeneration. Accurate evaluation of the nitrogen excretion by planktonic copepod is, therefore, pivotal to understand the biogeochemical cycle in the subtropical oceans. However, the evaluation of excretion in small copepods (<1 mm) which numerically dominate the mesozooplankton community have not been determined due to methodological constraints: generally, the rates of small copepods by incubation experiment at species level is difficult due to its lower excretion than the detection limit of traditional analytical methods. In this study, we attempted to measure the excretion rates in small copepods individually by using highly sensitive analytical methods during the cruise which transected the subtropical North Pacific Ocean. The individual rates of small copepods including the genus of *Acartia*, *Calocalanus*, *Clausocalanus*, *Corycaeus*, *Oithona*, and *Oncaea* (Day: 111 ind., Night: 92 ind.) were successfully determined. We also measured the rate of large copepods including the genus of *Centropages*, *Cosmocalanus*, *Eucalanus*, *Labidocera*, *Neocalanus*, *Pontella*, and *Sapphirina* (Day: 49 ind., Night: 90 ind.). The diel variation of the rate was not observed in the most genus including *Acartia*, *Clausocalanus*, *Corycaeus*, *Oithona*, *Oncaea*, and *Cosmocalanus* (29–30□). Based on these data, we will present the total ammonium excretion from copepod community during day and at night to evaluate their role in the nitrogen regeneration in the epipelagic subtropical Pacific.

BIO-P4 (13421)

Appearance characteristics of harmful algal bloom species related with coastal environments caused by different water mass in southern sea of Korea

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From the last several decades, HABs (harmful algal blooms) have increased steadily in both species complexity and geographical extent all over the world. In the present study, we investigated the appearance characteristics of the harmful algal blooms (HABs) and non-HABs and its relationship to environmental factors during late spring and summer in the southern sea of Korea in 2016. Also, we divided into three different zones based on cluster analysis and non-metric multidimensional scaling (MDS), which focused on phytoplankton geo-oceanographic characteristics. In late spring, strong upwelling event was occurred in Zone II that the surface seawater temperature (SST) and nutrients were abnormally low and high, respectively. In summer, an unusually high temperature (c.a.30°C) and low salinity (c.a.29) levels were measured in offshore areas of Zone III, indicating that.a large amount of the Changjiang diluted water from Changjiang River of China had a great environmental and biological effect on the southern sea of Korea. In particular, most of inshore and coastal stations during late spring were affected by Korean river discharges, namely Nakdong River and Kahwa River, whereas most of offshore stations during summer were strongly influenced by Chinese Changjiang diluted water. Due to these two different hydro-oceanographic characteristics, non-HABs (i.e., diatoms) in inshore waters and HABs (i.e., dinoflagellates) in offshore waters had a conflicting appearances caused by suitable habitat distribution, which was depended on the abiotic factors such as nutrient and salinity. According to canonical correspondence analysis, dominant HABs dinoflagelltes genus *Karenia* appeared in upwelling areas with high nutritional content while *Gymnodinium*, *Gyrodinium* and *Prorocentrum* appeared in areas of low nutrient condition in late spring, and *Gymnodinium*, *Gyrodinium*, *Karenia*, *Prorocentrum* and *Scrippsiella* showed an equivalent tendency to appear at high water temperature and low saline level in summer, Our results implicated that hydro-oceanographic characteristics such as coastal nutrient-rich-water providing event by upwelling in late spring and dominating the Changjiang diluted water in summer have play an important roles in determining the potential appearance characteristics of HABs and non-HABs in southern sea of Korea, particularly in aqua-culture farming area of Tongyeong-Geoje.

BIO-P5 (13422)

Succession phenomenon of *Cochlodinium polykrikoides* and *Alexandrium affine* related with changes of coastal environments in the southern sea of Korea in summer

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Among the harmful algal blooms (HABs) species, the dinoflagellate *Cochlodinium*, and *Alexandrium* species have been studied widely, due to their serious damages to the aquaculture industry. The present study investigated the appearance and succession patterns of HABs in the Korean coasts, and performed the bioassay using *Cochlodinium polykrikoides* and *Alexandrium affine* cultures to evaluate their competitive relationship and explain the succession phenomenon of HABs. From June to August, surface water temperature increased from 20.3°C to 26.8°C and the salinity decrease from 33.9 to 31.8 psu, and the stratification developed strongly. In this time, nutrient concentrations were kept low in surface layer, then dinoflagellate HABs species, *C. polykrikoides*, dominated in zone I, but *A. affine* dominated both zone I and II in middle August. In growth experiments, *C. polykrikoides* did not grow at 20 psu of 25 °C and 27°C, and it was dead within 2 days in all cultivation of 30°C. The maximum growth rate (μ_{max}) of *C. polykrikoides* was 0.31 d^{-1} at 25°C of 32 psu. *A. affine* showed negative growth rates at 15°C, but it grew well in all salinity at 20 °C to 30 °C. The maximum growth rate (μ_{max}) of *A. affine* was 0.43 d^{-1} at 25 °C of 30 psu. In co-cultivation, *A. affine* had a competitive advantage at all temperatures, which of 1: 1 ratio of initial cell density of both species. In co-cultivations of gradient initial cell density (1:3 1:10 and 1:100), the species had higher initial cell density showed a competitive advantage, except for 30°C. Although the initial concentration of *A. affine* was lower, it was dominated due to extinction of *C. polykrikoides* in 30°C. All field data and bioassay indicated that *Alexandrium* prevailed over *Cochlodinium* in relatively lower salinity and higher temperature levels, which may have an important role in determining the succession of both HABs.

BIO-P6 (13423)

The rapid kit and its digital reader for harmful algal detection

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We have challenged to develop the immunochromatography based rapid kit for microalgae detection for developing more quick, accurate, and efficient method which could have predictive and prognostic function to overcome the difficulties of conventional method for microorganisms monitoring. As a result, a rapid kit using monoclonal antibodies (mAbs) raised against α-tubulin of *Heterocapsa triquetra*, a candidate of harmful algal bloom species in the coast of Korea. The rapid kit showed a positive signal at about 5,000 cells of *H. triquetra*; 50,000 cells of *H. pygmaea* and *Cochlodinium polykrikoides*; and so on. The mAb against RuBisCo (Ribulose-1.5-bisphosphate carboxylase /oxygenase) large subunit and Photosystem I subunit 9 of *Alexandrium tamarense*, which produces paralytic shellfish, were also raised. We also developed a digital reader for the rapid kit for quantitative prediction of microalgal cells in a sample.

BIO-P7 (13432)

Copepod community structure and energy flow around subpolar front in the East Sea (Japan Sea)

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Difficult access to specie-specific differences in resource utilization and feeding habitat of copepods limits the information on the effect of global warming on the energy flow in pelagic ecosystems. We investigated inter- and intraspecific differences in the resource uses and feeding migration ranges among copepods within the epipelagic zone in the south and north regions of the subpolar front (SPF) in the East Sea (Japan Sea) in the spring using stable isotope analysis (SIA). SIA indicated that interspecific difference in resource utilization and vertical segregation of feeding migration range among copepods could promote niche partitioning among sympatric copepod species across SPF. Moreover, we found remarkable differences in copepod species composition and resource utilization of copepods across SPF. South region showed higher copepod species richness than north region, while copepod body size which fed mainly on particulate organic matter (POM) in surface and subsurface chlorophyll maximum layers was smaller in south region. These revealed that food chain length between primary producer and higher trophic levels was longer in south region of SPF. Additionally, $\delta^{13}C$ and $\delta^{15}N$ values of copepods increased gradually with increase of body size, while $\delta^{15}N$ values in north region showed reverse trend. Latter results could result from consumption of deep layer POM in small copepods in north region. We suggest that northward shifts in copepod distribution under global warming may decrease energy efficiency in pelagic ecosystem. Moreover, we suggest that species-based approach to trophic position can provide more detailed information on plankton food web than size-based approach.

BIO-P8 (13434)

Geographical variation of UV protective compounds in zooplankton in the subtropical North Pacific Ocean

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Ultraviolet radiation, especially UV-B, is harmful to living organisms because it can cause DNA damage. In particular, epipelagic organisms in the subtropical ocean need to adapt to high levels of sea-surface UV-B radiation and relatively deep transparency throughout the year, suggesting that UV-B is an important environmental factor that can affect plankton distribution and production. In previous studies of freshwater systems, some zooplankton tended to accumulate photo-protective compounds, such as carotenoids or mycosporine-like amino acids (MAAs) as protection from UV damage. However, the function of these photo-protective compounds in zooplankton in subtropical marine ecosystems still requires further investigation. Therefore, this research aims to reveal the geographic variation of UV-B protective compounds in zooplankton in relation to the environmental variables in the subtropical north Pacific. Research was conducted at 12 stations during the cruise (KH17-4) along the 23ºN transect. Surface and subsurface UV radiation was measured at noon with a PUV-500/510. Phytoplankton and zooplankton samples were collected in the surface layer (0 – 100 m) throughout the cruise in order to determine the carotenoids and MAAs contents. Our results showed that UV penetration depth had an increasing trend from east to west along the transect. Carotenoid content in epipelagic copepods was relatively low at eastern stations, and relatively high at four of the western stations while overall distribution patterns did not relate to UV attenuation. The relationship to other environmental factors such as Chl-*a*, mixed layer depth, and PAR penetration in relation to the distribution of photo-protective compounds will be also discussed.

BIO-P9 (13473)

Seasonal occurrences and diel color changes of planktonic copepods Sapphirinidae (Copepoda, Cyclopoida) in Sagami Bay, Japan

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Two genera 18 species belonging to the family Sapphirinidae have been reported around Japanese water, and its adult males exhibit iridescence. Adult males of *Sapphirina nigromaculata* are known to show diel color changes under continuous darkness. The first purpose of this study is to clarify seasonal occurrences of Sapphirinidae species in Sagami Bay to decide species for later color-change experiments. The second aim is to confirm whether the adult males, including *S. nigromaculata*, show diel color changes under 24-hour light/dark cycle condition. Samples for seasonal occurrences were collected from January 2015 to November 2017 and the incubation experiments were conducted from May 2016 to July 2017. We collected 2 genera 9 species of Sapphirinidae in Sagami Bay. *Sapphirina* species were collected from spring and *Copilia* species occurred from early summer. Both genera continued to be collected until December and disappeared during winter. This result suggests that Sapphirinidae is not permanent residents inside of the bay and might be supplied from the outside by seasonal inflows, such as branch currents of the Kuroshio. We conducted the experiments on 8 species. Among these, 5 species did not show any diel color changes. Although *S. nigromaculata* showed the diel color change, there was no difference between continuous dark and light/dark cycle conditions, raising possibility that the change is controlled by circadian rhythm. In addition, *S. intestinata* and *C. mirabilis* showed the similar color changes. (231words)

BIO-P10 (13475)

Plankton diversity and community structure based on a cabled observatory data

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Classic problems in plankton ecology addressing communities' structure, function and variability demand a high resolution and multidisciplinary observational approach. In this context, we examined the interactions between the coastal environment and the plankton community of Izu-Oshima, Japan, thorough a multi-parameter cabled-observatory (OCEANS) composed of biological, physical, chemical and imaging – Continuous Plankton Imaging and Classification Sensor (CPICS) – sensors. Analyses of plankton community composition and alpha diversity over the scope of almost 2 years reviewed the following: a. plankton alpha diversity showed a seasonal pattern and decreased towards winter; b. an inter-annual variability in diversity was correlated to a difference in water mass composition; c. the alpha diversity power spectrum density showed a 1/f power law signature ("pink noise") slope, with peaks at a daily frequency that were correlated with zooplankton diurnal vertical migration; d. marine aggregate dominated with at least 75% of the total particle abundance. These findings are novel in the scientific literature and represent the value of a high-frequency observational approach; an essential step to identify future changes in the marine environment. The project is still in progress where the automatic classified plankton images data is being manually validated.

BIO-P11 (13491)

Nitrogen isotope landscape in primary producers in the Pacific Ocean

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We investigated geographical variability of nitrogen sources of primary production in the Pacific Ocean by examining $\delta^{15}N$ of particulate organic matter (POM, >0.6 μm) as a proxy of phytoplankton, and nitrogen fixation. Samples were collected from the surface layer at 510 stations in the Pacific covering from the equatorial to subarctic region, and $\delta^{15}N$ of POM in literatures was also used (n = 174). $\delta^{15}N$ of POM in the Pacific Ocean was within the range between −3 and 15‰. In regions other than subtropical waters, $\delta^{15}N$ varied below 8‰, and was negatively correlated with nitrate concentration, indicating nitrate below the euphotic layer mainly supported primary production. In the subtropical regions, three distinct areas were recognized: I) low $\delta^{15}N$ (< 2‰) with active nitrogen fixation (>1 nmol N L^{-1} day^{-1}), II) high $\delta^{15}N$ (>8‰), and III) low $\delta^{15}N$ with inactive nitrogen fixation. Area I located in the central area of the subtropical gyres in the North Pacific and the western South Pacific. Area II occurred in the neighboring waters of the equatorial upwelling and eastern South Pacific. The high $\delta^{15}N$ indicated contribution of horizontally advected nitrate from the equatorial upwelling via Ekman transport in addition to the upwelled denitrified nitrogen. Area III was found in the western North Pacific. Sources of the light nitrogen in this region is discussed.

BIO-P12 (13533)

Can an embayment copepod accumulate energy in the body?

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Food concentration in the embayment area varies abruptly. The calanoid copepod *Acartia steueri* is a dominant embayment species in the temperate coastal waters of Sagami Bay, Japan. In this study, we examined the biological responses of *A. steueri* raised under an abrupt decrease in food concentration and subsequent starvation in the laboratory. Unlike other neritic species, *A. steueri* survived for 18 days and continued to produce eggs for 15 days under starvation. Almost all females which were raised under high food condition for 5 days produced eggs even under starvation condition unlike females under high food condition for 2 days. The difference in egg production between high food period for 2 days and 5 days was caused by the 3-day difference in the high food period. Dry weight, carbon weight, and C/N ratio of *A. steueri* under the high food condition were much higher than those of other *Acartia* copepods, while the body length of *A. steueri* were similar. Oil-like droplets in oceanic copepods were observed in the body cavity of *A. steueri* raised at the high food condition for more than 10 days. In the field, the rapid accumulation of lipids during sporadic high food conditions might contribute to continue the metabolism and egg production under low food conditions until they encounter favorable food conditions again. Thus, the survival strategy to abrupt changes in food concentration or starvation might support the population of *A. steueri* in the embayment. (241 words)

BIO-P13 (13570) CANCELLED

Impact of Nature and Antrophogenic Forcing to Chlorophyll-a Variability at Aru Sea, Indonesia

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Aru Sea has a high fertility rate, viewed from the abundance of chlorophyll-a through the year. This study aims to determine the variability of chlorophyll-a concentration in Aru Sea and connect with nature phenomenon like a wind, ENSO, and IOD and also rainfall. This study using MODIS Aqua satellite data level 3 start from 2003 to 2016. This researh divided two zone that is A zone (along Kaimana Beach to Timika Beach) and B zone (along Timika Beach to Merauke Beach).

The results show that the dominant periods of concentration of chlorophyll-a in A zone and B zone are 6-month periods and the period of 12-months. Concentration of chlorophyll-a at A zone has one peak type in one year, in June- August while B zone has two peak types in one year, in January-March and September-November. The value of concentration of chlorophyll-a at A zone in the temporal scale is high when the condition of SST is low with correlation is -0.57, while the concentration of chlorophyll-a at B zone is high when the condition of SST is high with correlation is 0.10. The concentration value of chlorophyll-a in the spatial scale at A zone is high due to upwelling, while at B zone high rainfall and river discharge. The correlation concentration value of chlorophyll-a with sea surface temperature in Aru Sea is strong enough, reaching -0.69. The influences of ENSO and IOD phenomenon in Aru Sea are low, with the correlation value of chlorophyll-a - DMI about 0.08 and the correlation value of chlorophyll-a - ONI about 0.03 and. Strong El Niño and positive IOD phenomenom influence the increasing concentration of chlorophyll-a. The high rainfall is assumed to cause a greater runoff of river water carrying nutrients to sea waters, that causes the high concentration of chlorophyll-a especially in waters near the coast (B zone).

BIO-P14 (13579)

Distribution and environmental characteristics of harmful dinoflagellate *Karenia digitata* on the coast of Japan

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Red tide of dinoflagellate *Karenia digitata* occurred and caused massive fishery damages in coastal areas of Japan and Hong Kong in the late 1990s. However, *K. digitata* had rarely occurred since 2006, in Japan. Therefore, information on the ecology and distribution of this species on the coast of Japan was limited. After 2012, the red tide which seems to be *K. digitata* occurred in several regions of western Japan again, and mortality of fish was observed. In this research, we aimed to clarify the distribution of *K. digitata* on the coast of Japan, and to organize the environmental characteristics when the species occurred. First, to easily and accurately identify *K. digitata*, we established the LAMP (Loop-Mediated Isothermal Amplification) method to detect the species-specific rRNA gene. Using the LAMP method, as the results of analyzing seawater samples and culture strains obtained from several regions of Western Japan in 2014-2015, *K. digitata* was detected in the Kii Channel, the Seto Inland Sea, the Bungo Channel, the Yatsushiro Sea and the Sea of Japan. The species has occurred mainly in June-July and October-November, the distribution at high density was observed in the water depth of 0-5 m, and water temperature and salinity ranges at the occurrence were 19.2-22.6 °C and 17.8-33.2, respectively. These results suggest that *K. digitata* exists extensively from the Kii Channel to western Japan and may occur at a temperature around 20 °C in a wide salinity range.

BIO-P15 (13600)

Molecular Phylogenetic of *Oithona* based on mitochondrial COI and 18S gene

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The genus *Oithona* is one of small size cyclopoid copepods which widely distributed and occurs in all kinds of marine environments (estuarine, coastal and oceanic waters). However, identification of *Oithona* based on micro-morphological characters is extremely difficult and time-consuming. Previous fragmentary taxonomic studies of *Oithona* in the South China Sea, were based solely on morphology. Here, we started with a survey of species diversity in the genus *Oithona* in South China Sea using a morphological approach, then obtained sequences from mitochondrial COI gene and 18S gene from several individuals of different species. DNA taxonomy was performed using ABGD and GMYC on COI data sets. Phylogenetic trees were built with COI gene and 18S gene including the sequences download from DNA database. The results of delimitation using ABGD and GMYC model were consistent with morphological approach. The genetic divergence based on COI data sets within species was 0-1.6% while among species varies within a large range, from 17.7% to 44.5%. However, the genetic divergence based on 18S gene is 0.1% -5%. Phylogenetic trees showed that each species was clustered together as a monophyletic group. *O.simplex* fist separated from others species indicated pioneer speciation in *Oithona*. Two cryptic species were found in *O.similis* and *O.plumifera*, which were from South China Sea and Mediterranean, Korea Strait and North Sea, the K2P genetic divergence were 18.6% and 22.9%, respectively.

BIO-P16 (13611)

Pelagic ostracods in Suruga Bay, Japan: their species diversity and population dynamics

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Pelagic ostracods include over 200 species in the world. Previous studies have examined their distribution and/or life history in various parts of the world ocean. However, relatively little detailed knowledge has been accumulated for those around the Japanese waters, especially those in the Pacific. The aim of this study is to clarify species composition, the population dynamics, and the community structure of pelagic ostracods in Suruga Bay, Japan. Samples were collected at a station by the oblique hauls of the ORI net (335 μm mesh) to cover ca. 0–1000 m water column from January to December 2016. Abundance of ostracods increased during spring and autumn, and decreased during summer. On the other hand, species richness, the diversity index, Shannon-Wiener's *H'* and the evenness, Pielou's *J'* did not show apparent seasonal patterns and relatively constant throughout the year. This suggests that the species diversity of ostracods in this deep bay may be in the state of equilibrium. In total, 63 species were found from a single location, indicating high local diversity in the bay compared with other locations. Three species, *Mikroconchoecia acuticosta*, *Conchoecissa imbricata* and *Mollicia amblypostha*, dominated numerically. While these dominant species exhibited similar patterns in seasonal occurrence, their body sizes and/or vertical distributions were different between species. These results imply that coexistence of these dominant species may be maintained by the segregation of habitats and/or resource partitioning.

BIO-P17 (136260

Local forage fish availability and the reproductive performance of Rhinoceros Auklets in Hokkaido, Japan

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Within a region, local variation of ocean current and seawater temperature affects the local availability of forage fish, that in turn influences the diet and reproductive performance of seabirds. Rhinoceros Auklets *Cerorhinca monocerata* RHAU is a dominant piscivorous seabirds in Hokkaido which fed on Japanese Anchovy *Engraulis japonicus* predominantly in 1990s-2010 and kept high productivity. After 2014, however, the anchovy has not been available in Hokkaido. We investigated diets and the body condition of the chicks of RHAU at 4 colonies (three are under influence of Tsushima current TC but different position and one under Oysahio current OC) in Hokkaido in 2016-2017. The birds fed on walleye pollock *Gadus chalcogrammus* at Matsumae Island (south of TC), juvenile (0+) greenling *Pleurogrammus azonus* and sandlance *Ammodytes personatus* at Todo Island (north of TC) and Teuri Island (middle of TC) and salmon juvenile *Oncorhynchus keta* at Daikoku Island (OC). There was no difference in energy density between these prey species (4.90-5.68 kJ/g), but the load size in Todo (25 g) was heavier than other colonies (17-19 g), which resulted in a better chick condition in Todo. The SST around Todo(9-16 □) was colder than Teuri(11-18 □) and Matsumae(15-21 □) due to the later arrival of the Tsushima warm current, making the cold-water related greenling and sandlance available for birds at Todo. Current system and induced local SST might affect the distribution of forage fish and hence chick body condition of RHAU.

BIO-P18 (13628)

Food concentration as an explanatory variable for naupliar ingestion rates

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Copepod nauplii are ubiquitous and occurs from equatorial to polar waters and from surface to deep-sea waters. Their ingestion rates vary against individual carbon weight, water temperature and food concentration. The effects of food concentration can be explained by functional models but the models obtained from the feeding experiments using constant developing stage and water temperature cannot be directly applied to a field condition which is different with those of the experiments. This study aims to estimate naupliar ingestion rates using food concentration in addition to individual carbon weight and water temperature. Ingestion rates of *Acartia steueri* nauplii NIII–NVI collected from an embayment water at Sagami Bay in Japan were determined under several food concentrations. The effect of water temperature was also examined for *A. steueri* nauplii NV. An empirical model including individual carbon weight and food concentration as explanatory variables was constructed and the applicability of the construction process to other species was assessed by using a dataset quoted from a previous study. A temperature quotient Q_{10} was determined as 2.37 for a temperature correction. The ingestion rates estimated by applying the empirical model and the Q_{10} were minimally 1/100 and maximally 12 times of those estimated by using a previous method which does not include food concentration. This study would contribute to the estimation of naupliar ingestion rates in the regions where the prey environment largely varies.

BIO-P19 (13629)

Nitrogen fixation and diazotroph community structure in the high latitude region around Hokkaido, northern Japan

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Nitrogen fixing microorganism (diazotroph) plays an important role in controlling marine productivity by converting nitrogen gas into biologically available form, ammonia. This activity has been considered to occur mainly in warm oligotrophic waters. However, this paradigm was challenged by recent observations of nitrogen fixation activity and diazotroph community in colder and/or nutrient-rich waters. To our best knowledge, there has been no report of diazotroph activity in cold waters of northern Japan. In this study therefore we investigated nitrogen fixation activity, primary production and diazotroph community structure around Hokkaido in order to elucidate its geographical variation. The onboard experiments were conducted at surface water at 19 stations covering the Sea of Okhotsk, the Sea of Japan and Pacific Ocean. We also conducted the same set of experiments at four additional light depths to determine the vertical profiles of diazotroph activity at three stations. Nitrogen fixation activity was detected from various regions around Hokkaido including the Sea of Japan, the Sea of Okhotsk and Pacific Ocean. The highest nitrogen fixation rate (~0.71 nMd^{-1}) was detected in the southernmost station in the Sea of Japan, suggesting that influence of Tsushima Warm Current which transported diazotrophs from Kuroshio region. Further discussion about the geographic variation of diazotrophic activity in relation to its community structures and environmental parameters will be presented.

BIO-P20 (13632) CANCELLED

The influence of oceanic conditions on the occurrence of *Cochlodinium polykrikoides* blooms in the East Sea, Korea

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Harmful dinoflagellate *Cochlodinium polykrikoides* blooms have been frequently occurred in coastal areas of the Southwestern East Sea since 1995. We compared the oceanic conditions in years 1995, 2001 and 2003 when the *C. polykrikoides* bloom was strong, and in years 1998 and 2004 when the *C. polykrikoides* bloom was not developed as well as variations of upwelling and geostrophic currents on the western channel of Korean Strait, an entrance of the East Sea. The period and occurrence of *C. polykrikoides* bloom were depended on variation of upwelling and geostrophic current. Southward current was dominant near the coast on August in 1998 and 2000, whereas northward current was dominant near and off the coast in 1995 and 2003 when the *C. polykrikoides* bloom was strong. When compared dominant phytoplankton in each year, Kuroshio indicator species *Rhizosolenia alata* and *Chaetoceros affine* were dominant in 2001 and 2003, respectively. However, the dominant species was variable at each coastal area in 1998 and 2000. Especially in 2003, the abundance of *Sagitta elegans* which is known as the cold water indicator was low, but the abundance of *S. enflata,* warm water indicator, was very high in Gangneung compared to Sokcho. In conclusion, it was estimated that the distribution of *C. polykrikoides* bloom in the coastal area of East Sea was closely related with the strength of East Korea Warm Current and upwelling. Also, developments of bloom in recent years will be discussed at the meeting.

BIO-P21 (13750)

Breeding performance and diet of Black-tailed gulls on Hongdo Island, Republic of Korea

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This study has been conducted to investigate the relationship between breeding performance and diet of Black-tailed gulls (*Larus crassirostris*) on Hongdo Island, South Korea. We used long-term data of commercial fish catch near breeding colony, 1998~2018 to assume the diet change of Black-tailed gulls. Black-tailed gulls are opportunistic predators and often follow commercial fishing boats to obtain food. Their main diet is the Japanese anchovy on Hongdo Island. Egg volume of Black-tailed gulls on Hongdo Island seems to be declined for last 20 years. Clutch size of them have declined after 2007. Although annual anchovy catch has been stable near Hongdo Island, it varied through the season. In early breeding season of Black-tailed gulls, it tended to decline. It may affect breeding performance of Black-tailed gulls.

BIO-P22 (13758)

Adrenal gland morphology of the sea otters *Enhydra lutris*

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The sea otter is important a representative of the family Mustelidae from the coasts of the North Pacific Ocean, which included the IUCN Red List. Studies on the biology of this species are fragmentary, and information about endocrine glands is absent. Adrenal glands are the most important in the regulation of metabolism and in the adaptation of the organism to adverse environmental conditions. The adrenal gland was collected from freshly dead specimens in October-December 1989 on Bering Island, fixed in 10% formaldehyde or mercury chloride solutions. The adrenal glands of sea otter are paired endocrine glands located on the cranial side of each kidney and consisted of 2 layers: cortex and medulla. Cytoplasm of zona glomerulosa adrenocorticocytes was granular and light eosinophilic, their diameter was 23.7 μm ± 3.5 SD. Zona fasciculata cells had prismatic shape, granular and eosinophilic cytoplasm and diameter 22.0 μm ± 1.7 SD. Dark adrenocorticocytes of zona reticularis were prevailed in this area. Diameter of dark and light adrenocorticocytes was 21.8 ± 5.0 SD. The nuclei of all cortex cells were round with a diameter 9.75 μm ± 1.3 SD. Epinephrine cells were located mainly on the periphery of medulla and norepinephrine cells closer to the blood vessels in the central part. Both type of cells had the same diameter 23.4 μm ± 4 SD and basophilic cytoplasm. Epinephrine cell nuclei were bigger (10.8 μm ±1.4 SD) and light-colored then nuclei of norepinephrine cells (9.5 μm ± 1.1 SD), which was darker.

BIO-P23 (13804)

A new Long-term Ecological Research (LTER) site in the Northern Gulf of Alaska

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The new Northern Gulf of Alaska (NGA) LTER site is exploring the ecological and oceanographic underpinnings of a highly-productive coastal subarctic ecosystem. The NGA LTER program expands on multi-decadal time series of physical oceanographic observations at GAK1 and multidisciplinary studies along the 300 km-long Seward Line that stretches from the coast well into oceanic waters. This observational window now encompasses several El Niño events, anomalously cold years, and the recent marine heat wave. LTER hypotheses and process work will initially focus on major production drivers: the spring bloom, and summer-fall inputs of freshwater to the shelf. Our ecological framework postulates that intense environmental variability, both within and between years, has led to the evolution of resilience, as embodied in species- and community-level properties. This poster will share time series data, and our modeling approaches, along with an overview of the site and the expanded sampling program.

BIO-P24 (13816)

Functional variants of the melanocortin-4 receptor associated with the Odontoceti and Mysticeti suborders of cetaceans

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Cetaceans, a group of mammals adapted to the aquatic environment that descended from terrestrial artiodactyls, exhibit tremendous interspecific differences in a number of phenotypes, including feeding behavior, such as filter feeding in the Mysticeti vs prey-hunting Odontoceti, and size, with the smallest cetacean, the vaquita, at 1.4 meters and the largest, the blue whale, reaching 33 meters. The Melanocortin-4 receptor (MC4R) regulates food intake, energy balance, and somatic growth in both mammals and teleosts. In this study, we examined allelic variants of the MC4R in cetaceans. We sequenced the MC4R from 20 cetaceans, and pharmacologically characterized 17 of these protein products. Results identified a single variation at amino acid 156 in the MC4R from representative species of major cetacean lineages uniquely associated with the toothed whales or Odontoceti (arginine at 156) and baleen whales or Mysticeti (glutamine at 156). The Q156 receptor variant found in the larger baleen whales was functionally less responsive to its endogenous anorexigenic ligand, α-MSH. Furthermore, the R156 receptor variant showed greater constitutive activity and a higher affinity for ligand. These data suggest that the MC4R may be one gene involved in the evolution of feeding ecology, energy balance, and body size in cetaceans.

BIO-P25 (13819)

Analysis of phytoplankton community change according to continuous observation pattern of chlorophyll-*a* concentration

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To understand the changes in chlorophyll-*a* concentration and phytoplankton community in Tongyeong coastal waters, Korea, we continuously monitored chlorophyll-*a* concentrations using a fluorescence sensor from July 29 to September 28, 2017(62 days). Furthermore, phytoplankton analyses were conducted periodically to monitor changes in dominant species affected by variations in chlorophyll-*a* concentrations. In the presented study, chlorophyll-*a* concentrations increased rapidly three times(event 1~3). During the first event(August 6 to 14), rapid and repeated increases in chlorophyll-*a* concentration during every 14:00 to 16:00 pm were the result of the diel vertical migration of *Alexandrium affine*(the dominant species during the event). The second and third events occurred from August 24 to 30 and September 12 to 17, respectively. During these events, increases in chlorophyll-*a* concentrations were caused by diatoms(common species: *Chaetoceros curvisetus*, *Skeletonema marinoi-dohrnii* complex etc.). Unlike event 1, we did not observe any characteristic changes such as vertical migration of *A. affine* during these events. Therefore, the continuous monitoring of chlorophyll-*a* concentrations using a real-time detection device, such as a fluorescence sensor, is necessary and important because of the variations that occur in chlorophyll-*a* concentration and phytoplankton community in the short-term.

BIO-P26 (13820)

Mapping distribution of cysts of recent dinoflagellate and *Cochlodinium polykrikoides* using next-generation sequencing and morphological approaches in South Sea, Korea

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The total dinoflagellate cyst community and the cysts of *Cochlodinium polykrikoides* in the surface sediments of South Sea (Tongyeong coast), South Korea, were analysed using next-generation sequencing (NGS) and morphological approaches. Dinoflagellate cysts can be highly abundant (111–4,087 cysts g^{-1} dry weight) and have diverse species composition. A total of 35 taxa of dinoflagellate cysts representing 16 genera, 21 species (including four unconfirmed species), and 14 complex species were identified by NGS analysis. Cysts of *Scrippsiella* spp (mostly *Scrippsiella trochoidea*) were the most dominant and *Polykrikos schwartzii*, *Pentapharsodinium dalei*, *Ensiculifera carinata*, and *Alexandrium catenella/tamarense* were common. Thus, a combination of NGS and morphological analysis is effective for studying the cyst communities present in a given environment. Although *C. polykrikoides* developed massive blooms during 2013-2014, microscopy revealed low density of their cysts, whereas no cysts were detected by NGS. However, the vegetative *C. polykrikoides* not appeared during 2015-2017 in spite of the observation of *C. polykrikoides* cysts. This suggests that the *C. polykrikoides* blooms were not due to development of their cysts but to other factors such as currents transporting them to a marine environment suitable for their growth.

BIO-P27 (13821)

Effects of temperature and nutrients on changes in genetic diversity of bacterioplankton communities in a semi-closed bay, South Korea

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Bacterioplankton communities in a semi-closed bay (Jangmok Bay, South Korea) were analysed using a 16S rDNA multiplex 454 pyrosequencing approach. Diversity and operational taxonomic units of bacterioplankton communities in the Jangmok Bay are highest in coldwater seasons and lowest inwarmwater ones. During cold seasons, α-proteobacteria respond rapidly to pulses of the concentration of inorganic nutrients, while γ-proteobacteria during warm water seasons are the most active type of bacterioplankton resent in the prevailing conditions, which include high dissolved organic carbon, chemical oxygen demand and primary production. Cyanobacteria, a minor group constituting 4.58% of the total bacterioplankton, are more abundant at low temperature. Flavobacteria are more abundant in nutrient-rich conditions and the abundance of this group also demonstrated a delayed decline following summer phytoplankton blooms. The pronounced seasonal oscillations in phosphorus concentration and temperature exert strong selection pressure on bacterioplankton communities.

BIO-P28 (13822)

Changes in environmental factors and bacteria community caused by harmful algal blooms of *Akashiwo sanguinea* (Dinophyta)

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To investigate changes in environmental factors and bacteria community during *Akashiwo sanguinea* blooms, we conducted daily monitoring for 41 days (Nov. 14, 2016 – Feb. 27, 2017), in in Jangmok Bay, a semi-closed bay on the southern coast of South Korea. *A. sanguinea* was first observed on Oct. 31, 2016, and up to 2,935 cells mL^{-1} appeared on Nov. 18, 2016, and *A. sanguinea* disappeared on Jan. 30, 2018. The mean temperature and salinity were 14.4°C and 32.2 at the occurrence of *A. sanguinea* blooms. Dissolved inorganic phosphorus and dissolved silica increased during the blooming period, while dissolved inorganic nitrogen decreased. Dissolved organic carbon was similar pattern to that of *A. sanguinea* and showed a maximum of 7.56 mg L^{-1}. The time-lag changes in

bacteria abundances might be associated with fluctuation in *A. sanguinea* blooms. In particular, when we analyzed separately from the bacteria community attached to *A. sanguinea* and the free-living bacteria in seawater, Attached bacteria in *A. sanguinea* were mainly found in Flavobacteriales whereas free-living bacteria showed difference in Alpha-proteobacteria. Therefore, there was a difference in bacterial populations due to the occurrence of *A. sanguinea* blooms and further research is needed to solve how these bacterial populations affect the occurrence of *A. sanguinea* blooms.

BIO-P29 (13835)

Variation of microsatellite loci in herring *(Clupea pallasii)* from the Japan and Okhotsk seas

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Pacific herring refers to the subspecies of eastern or low-vertebrate herring - *Clupea pallasii pallasii Val.* and dwells within the continental shelf and adjacent inland areas and forms local herds that differ in biological, ecological, morphological characteristics, numbers, and areas of spawning and foraging. Studies of the population structure using molecular genetic markers are not numerous, despite long-term studies of herring in the whole range of habitats. The material for this work was provided by 9 selections collected in 2007-2010 in the spawning grounds of the Japan and Okhotsk seas during the spawning season. The number of samples was 366 copies and 11 microsatellite loci were used for research. After PCR, the resulting microsatellite locus amplification product was separated using the "ABI 3100 Genetic analyzer" capillary electrophoresis system. All the microsatellite loci studied were sufficiently polymorphic. The number of alleles varies from 6 to 17. Deviations from the Hardy-Weinberg equilibrium were not observed. The Fst values were calculated from the allele frequencies of the microsatellite loci and varied from 0 to 0.78 to assess genetic differentiation. Significant differences between the lake group of herring (Ainu Lake) and herrings of the Sea of Japan and the Sea of Okhotsk were identified. Also, the statistical estimates obtained not only indicate a genetic differentiation between the herring population living in the south of the Sea of Japan from those living in the north, but also the intensive migration of herring from the Sea of Okhotsk to the Sea of Japan.

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BIO-P30 (13836)

Mitochondrial DNA polymorphism of the Far Eastern sardine (*Sardinops melanostictus*) in the northwestern Pacific Ocean and Sea of Japan

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Sardinops melanostictus (Far Eastern Sardine) is a mass epipelagic fish of the subtropical complex. It has the capacity for significant fluctuations in abundance and associated widening or shrinking of the habitat for both parts of the areas of the Far Eastern sardine: the Sea of Japan and the northwestern part of the Pacific Ocean. Known that sardina of Sea of Japan and the Pacific Ocean are parts of a single population and have a connection across the straits. Two selections of sardines from the Russian coastal zone of the Sea of Japan and the northwestern part of the Pacific Ocean were taken in autumn 2016 for the study. We performed amplification of the first subunit of the 550 cytochrome oxidase COI gene. We obtained the aligned nucleotide sequences of the region of the C0I gene of the mtDNA at two selections sardines (40 samples from each). This allowed to build a phylogenetic network. As a result, 10 haplotypes were identified in 79 individuals of the mtDNA COI gene fragmen site. One mass haplotype is characteristic for 69 individuals and the remaining 9 haplotypes are unique (occur in a single specimen in one of the selections) and the differences are due to one nucleotide substitution. Haplotypes grid leads us to assume that the sardine of the Sea of Japan and the Pacific Ocean has a common origin. The numerous haplotypes, which differ by single nucleotide substitutions from the central phylogroup, is typical for species that exponential grew in recent times.

Fisheries Science Committee Paper Session

FIS-P1 (13269)

The Bering Sea pollock environmentally-dependent spawning diversity, fluctuation of recruitment, migration and spatial distribution

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Pollock spawning diversity and recruitment, spatial distribution and migrations have high variability depends on environment condition, population abundant. The reproduction of the eastern Bering Sea pollock are distributed in a very wide geographical area from continental slope off the central and eastern Aleutian Islands, the southeastern Bering Sea shelf to northern Anadyr Bay in the northwest. The main reproductive areas of the eastern Bering Sea pollock are located in the southeastern Bering Sea.

The two ecologically different reproductive pollock stocks were found in the Bering Sea by multiyear research – the shelf spawning stock in th e eastern and western Bering Sea shelf and the deep-water spawning stock located off eastern (Bogoslof Island area) and central (Kanaga Sound) Aleutian Islands. Reproduction of shelf spawning stock varies annually depends on short-term variability ecological condition but reproduction deep-water stock fluctuates basically by influence long-term environment change. Reproduction of pollock shelf stock relatively sustainable and it abundance basically stable at relatively high or average level but abundance of deep-spawning pollock usually stay at low level and it reproduction and abundance could be potentially rapidly increase just in periods of big shift of ecological condition. Pollock of deep-water spawning stock are distributed in postspawning period along Aleutian Islands and migrates also into Aleutian and Commandor basins just in period of high abundance. Scale of shelf spawning pollock seasonal northward migrations into northwestern Bering Sea in feeding period basically depends on the population biomass and abundance, species composition, spatial differentiation of zooplankton, and water temperature. Resilience strategy of pollock behavior in the Bering Sea in periods with low trophic level due low abundance of large zooplankton are early and fast active northward feeding migrations from winter habits and spawning grounds as well as early beginning back southward migrations – by the end of summer.

FIS-P2 (13279)

The distribution and the size composition of *Myoxocephalus jaok* cuvier, 1829 and *M. polyacanthocephalus* pallas, 1814 on the west coast of Kamchatka

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According to modern assessments, the biomass of the representatives of the family on the west coast of Kamchatka is about 250 thous. t, where more than 70% are provided by two species - *Myoxocephalus jaok* and *Myoxocephalus polyacanthocephalus*.

The data on the size structure of *Cottidae* in the area of the research were limited, and hence having newly data about distribution and size composition of two species mentioned above is very important. The research carried out in June-July of 2017 on the west coast of Kamchatka was to compensate current gap.

On our data, *M. jaok* was observed most frequently at the depth from 75 m (min – 14 m, max – 123 m). The maximal catches per unit effort (CPUE) were at the depth from 50 m. About 70% of the catches of this species were recorded at the temperatures near the bottom from 0 to 3°C. Aggregations of medium and highdensity were observed everywhere along thye coast. The body length varied from 9 to 65 cm (averaged 40.4 cm).

M. polyacanthocephalus demonstrated the highest frequency at the depth from 50 to 250 m (min – 16 m, max – 356 m). The maximal CPUEs were observed at the depth range 50-150 m. Over 77% of the catches were in the area where the temperature near the bottom was from 0 to 2°C. Mediate and highly dense aggregations were obsered in the southern and northern parts of the shepf. The body length varied from 10 to 79 cm (averaged 39.2 cm).

FIS-P3 (13282)

The review of the fisheries of pacific capelin *(Mallotus villosus catervarius)* in Russian Far Eastern Seas in 2010–2017

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West Kamchatkan and Sakhalin capelin is the resource potential for the coastal fisheris, impressive and simple in harvesting. The catch in the commercial fishery subzones of the Far Eastern basin in 2010–2017 varied in the ranges 270.6–9730.4 t, averged taking 3315.1 t. According to the average annual data the maximum catch (32.66%) was provided in the East Sakhalin subzone, while the catches in the West Kamchatkan and West Sakhalin subzones were respectively 28.97 and 22.58%. Capelin stocks were poor used almost in all commercial zones. The fishery campaign in the commercial districts of Far East, based on cone-net fishing, seining and trap seining, operates in spring and summer in the course of spawning.

The body length of capelin (18.0 cm) in the catches in the Sea of Okhotsk is similar to the length of capelin of the Bering Sea (18.0 cm), but the weight of the fish is gretly higher (41.2 g vs. 14.6 g). Capelin of the Sea of Japan (the West Sakhalin commercial district) is the biggest, having the body length up to 21.0 cm and the body weight 59.0 g.

Based on said above, the West Kamchatkan and Sakhalin shelf is the most promising area for the isheries of capelin in the Russian Far Eastern seas.

FIS-P4 (13331)

Population complexes of sockeye salmon (*Oncorhynchus nerka*) on the Asian Pacific Coast

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Population structure of sockeye salmon from the Kamchatka Peninsula, Chukotka and the North-West coast of the Sea of Okhotsk was studied. Variability of 45 SNP loci in 17 samples from 10 major sockeye salmon spawning watersheds of the Russian Far East was examined. The general pattern of genetic heterogeneity of sockeye salmon is well corresponded to the spatial-geographic structure of the species. In particular all samples can be divided into a South group and a North group. Populations from subperipheral watersheds of the North of the Sea of Okhotks coast (Okhota River, Palana River) are much differentiated from so called nuclear populations (i.e. major stock of the Asian cost) of Ozernaja River, Kamchatka River, and a group of numerical secondary stocks of lake-river systems of the Karjak upland and Chukotka. Five population complexes were identified: two stocks from Palana River and Okhota River, as well as a South-West Kamchatka complex, and a North-East Kamchatka and Chukotka group, and Kamchatka River metapopulation were separated. Possible causes of high divergence of the North Okhotsk Sea populations are discussed. The most probable factor of Palana River population distinction seems to be a local adaptation as a result of directional selection at some loci under specific reproductive environments. On the other hand, for the Okhota River population a different pattern can be hypothesized. Considerable decrease in genetic diversity in this sample is likely to indicate a recent decline in the effective population size, rather than the effect of selection.

FIS-P5 (13332)

Adaptive variability at MHC class II gene *Onne-DAB* in two largest sockeye salmon (*Oncorhynchus nerka*) populations in Asia

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Variability of *Onne-DAB* gene, encoding β*1*-chain of class II Major Histocompatibility Complex (MHCII) molecule, using *One_MHC2_109*, *One_MHC2_190v2* and *One_MHC2_251v2* single-nucleotide substitutions (SNP) in two largest Asian populations of sockeye salmon, reproduced in Kurilskoe Lake and Kamchatka River watersheds, was studied. Differences in inheritance pattern and degree of polymorphism of *One_MHC2_190v2* and *One_MHC2_251v2* were observed in samples from both lake-river systems, whereas *One_MHC2_109* was poorly informative. Samples collected from lake and river spawning grounds of Kurilskoe Lake were characterized by high estimates of intrapopulation genetic diversity, whereas no inter-sample differences in the frequencies of haplotypes of the joint *MHC2* locus were revealed. That can be interpreted as the result of balancing selection in sequences encoding the MHCII peptide-binding region in this population. On the contrary, in the samples of early (spring) sockeye salmon from the Kamchatka River basin low genetic diversity estimates and significant heterogeneity of haplotypic frequencies at the *MHC2* locus were observed, apparently due to the action of directional pathogen-induced selection in *Onne-DAB* gene in some localities of the lake-river system. By the results of Factor Analysis (PCA) two principal components (PC), explained in sum 72% of general variability of genetic characteristics in the Kamchatka River samples, were extracted. A significant correlation between the second PC (33.4%) values and geographical distances from the specified tributary to Azabachya creek near the Kamchatka River mouth was revealed. Moreover a highly significant correlation between the second PC and Diphyllobothrium sp. plerocercoids prevalence in fish from the tributaries was derived.

FIS-P6 (13361)

Development and application of DNA barcode electronic microarray for species identification of fishes of the family *Clupeidae* (*Osteichthyes: Clupeiformes*)

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Clupeidae is a family of teleost fish including many species with important economic value in fisheries, some of which are the most important food fishes in the world, and others are also commonly caught for production of fish oil and fish meal. Species identification of the clupeids is a critical issue with certain obstacles for their wide variety and great difference of morphological characteristics in different growth stages. In recent years, DNA-based identification methods offer an analytically powerful addition or even an alternative tool with the development of molecular biology. To construct an identification method on Clupeidae species accurately and rapidly, a DNA barcode of COI gene of Clupeidae species were analyzed and screened their characteristics of sequence structure by software Oligo Array 2.1. Sixty-seven specific probes of 33 species were founded in the first round screen from 53 species 26 genus in Clupeidae. After optimizing with software Oligonucleotide Properties Calculator, some probes were removed as they had a tendency to make a hairpin, stem-loop or homo-dimers. Other 50 probes of 30 species were performed into DNA barcode electronic microarrays which were hybridized with the target sequences of Clupeidae. In the end, 42 probes from 25 species of Clupeidae were further confirmed to indicate a feasible identification rate of 83.33% (25/30) at species level. These results had favorably provided a challenging choice to identify species as compared with morphological classification method.

FIS-P7 (13390)

Genomic sequence diversity and population structure of Longfin Smelt (*Spirinchus thaleichthys*) in the Nooksack River using 2b-RAD

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Longfin Smelt (*Spirinchus thaleichthys*) are a relatively small forage fish ranging from San Francisco Bay, California to Prince William Sound, Alaska. The ecological importance of forage fishes in the Salish Sea has been emphasized in recent years, but most research effort has gone toward other species (e.g., Pacific Herring, *Clupea pallasii*). The Longfins, which are found in the diets of culturally and commercially important species of salmonids and marine mammals, are not actively monitored in the state of Washington. The Nooksack River has probably the best-known of the anadromous populations in Washington, and it draws a large crowd of fishermen from diverse backgrounds each fall as adults return to their spawning grounds for a period of approximately 10 days in November. A license is not required for harvest, and each year there are many reports of overharvesting and poaching of ESA-listed fishes. Longfins are a culturally-important food source for several area tribes, including the Lummi people whose reservation the Nooksack River passes through. The objective of this study is to collect data on the genomic diversity of the population as a baseline for future monitoring efforts. In addition, as Longfins are approximately two years old when they return, and year-to-year returns seem to fluctuate widely, another goal of the study is to determine whether population structure exists between even and odd year returns. These data are being assessed with the knowledge and partnership of the Lummi people in order to facilitate a culturally appropriate harvest management plan.

FIS-P8 (13402) CANCELLED

Energy-based ecosystem modelling illuminates the ecological role of Northeast Pacific herring

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The ecological importance of Pacific herring (*Clupea pallasii*) in the Northeast Pacific was re-evaluated by accounting for its high average energy content. An existing mass-balanced Ecopath food web model representing waters off northern British Columbia (Canada) was converted into a set of energy-balanced models using published energy content ranges for all functional groups. Size spectrum slopes, proportions of herring in predator diets, and proportions of several large ecological categories in total ecosystem biomass and energy pools were compared across models. Trophic effects of depleted whale population recovery were reassessed using dynamic simulations in both mass- and energy-balanced ecosystem models. The model assuming higher energy content for all functional groups required a noticeable but non-significant increase in size spectrum slope compared to the original mass-balanced model. This could reflect energy content overestimates for large organisms, but more likely indicates underestimated planktonic group energy content and/or biomass. Herring proportions in predator diets were noticeably higher in energy-balanced models, while pelagic groups represented higher proportions of total ecosystem energy than total biomass. Trophic effects of whale recovery on several active, endothermic predators were visibly stronger in the energy-balanced models. However, most energy-balanced model outputs agreed qualitatively with mass-balanced model results. These findings illuminate the potential for improved analysis of ecosystem structure and function, and forage fish trophodynamics, using energy-balanced ecosystem models. They also support the hypothesis that reduced average energy content of the copepod assemblage off northern BC in 1990-2006 may have inhibited the recovery of local herring, salmon, and groundfish stocks.

FIS-P9 (13412)

A statistical approach to estimate optimal habitat suitability of walleye pollock off the northeastern coast of Japan

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An accurate estimate of a potential habitat of fish species enables us not only to understand the response of species to environmental changes but also to utilize it for an efficient use of fish resources. Walleye pollock (*Theragra chalcogramma*) is one of the most abundant fish in the North Pacific Ocean, and found near the bottom and mid-water depths above the continental shelf and slope. The population of this species distributed off the northeastern coast of Honshu island (Tohoku area) belongs to the Japanese Pacific stock, which mainly spawns in the waters adjacent to the mouth of Funka Bay in winter and migrates to this area. We developed the habitat suitability index (HSI) models for this population by applying GAM and Random Forest (RF) algorithm, and used following datasets; Japanese commercial fishery dataset including trawling catch data of demersal fishes, an ocean reanalysis dataset FORA-WNP30 which can provide realistic fields of 3-dimensional ocean environments including ocean bottom layers up to 1500m depth, and the estimated biomass of this stock derived from trawl surveys. We investigated the HSI response of this species to ocean environmental changes occurring in this area. The results indicated the Oyashio intrusion from the northern part of the North Pacific is related to higher HSI in winter. And the time series of the CPUE of this species during 1997-2014 were well reproduced by the GAM and RF. In addition, these models were improved by adding a term fluctuating with the stock amount of this species.

FIS-P10 (13455)

Transpacific distribution of micronektonic fish community in the subtropical open water

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We investigated the biomass, abundance and community composition of micronektonic fish along the transpacific transect (23ºN) from 120ºW to 138ºE in order to reveal its geographical variation. All samples were collected at 0-500 m depth at night with the Masuda-Oozeki-Hu midwater Trawl (2 m^2 mouth opening with 1.95 mm mesh size) at 12 stations along the transect during July-October, 2017. Samples were immediately frozen on board and were identified based on morphological characteristics and DNA metabarcoding. Throughout the cruise, a total of 757 individuals belonging to 12 orders, 32 families, 55 genera and 80 species were collected. Two families (Myctophiformes and Stomiiformes) accounted for more than 70% and 80% of total wet weight and abundance, respectively. Both of biomass and abundance were highest at 150ºE where the chl. *a* concentration was highest probably due to the nutrient supply below the euphotic zone, while no significant relations between biomass and abundance, and the environmental variables were found in most of other stations. Cluster analysis for community structure based on morphological identification revealed that the micronekton community were separated into five groups largely depending on the abundance of dominant species; largest group dominated by *Ceratoscopelus warmingii* was found in five eastern stations (130-170°W), while *Vinciguerria nimbaria* was dominant at remote 2 stations (120°W and 150°E) where vertical mixing was evident. These results suggest that the community structure of micronektonic fish is not uniform along longitude in subtropical North Pacific. Further discussion about effect of environmental variables on their distribution will be presented.

FIS-P11 (13457)

Characterizing spatial structures of larval fish assemblages at multiple scales in relation to environmental heterogeneity in the Strait of Georgia (British Columbia, Canada)

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The Strait of Georgia (SoG) is an important nursery ground for commercially valuable fish species on the west coast of Canada. Spatial structures of larval fish in the SoG were quantified based on spatially intensive field surveys in the spring of 2009 and 2010 to investigate linkages to environmental heterogeneity at multiple scales. By applying a multiscale approach, Principal Coordinate Neighborhood Matrices (PCNM), spatial variability was decomposed into three predefined scale categories: broad scale (>40 km), medium scale (20~40 km) and fine scale (< 20km). Spatial variations in larval density of the three dominant fish taxa with different early life-histories (Pacific herring, Pacific hake and northern smoothtongue) were mainly structured at broad and medium scales, with scale-dependent associations with environmental descriptors varying interannually and among species. Larval distributions in the central-southern Strait were mainly associated with salinity, temperature and vertical stability of the top 50 m of the water column on the medium scale. Our results emphasize the critical role of local estuarine circulation, especially at medium spatial scale, in structuring hierarchical spatial distributions of fish larvae in the Strait of Georgia, and suggest the role of fundamental differences in life history traits in influencing the formation and maintenance of larval spatial structures.

FIS-P12 (13458)

Seasonal distribution of walleye pollock in the south Kuril Region

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Features of pollock distribution in the spawning and feeding periods are submitted. The data of trawl-acoustic surveys in March 2015 and July 2016 were used.

The spatial distribution of pollock varied significantly in spring and summer. Immature and mature pollock was distributed over the considerable area from the Pacific side of the South Kuril region in spring. The area of these concentrations decreased, and the density increased in several times in summer. Another situation was observed from the Okhotsk Sea side, where the basic spawning grounds of pollock are located. Immature pollock was concentrated in the Okhotsk Sea waters in spring and was practically not observed here in summer. Mature pollock was concentrated on spawning grounds in spring and distributed more evenly here in summer. Walleye pollock has moved deeper in summer in comparison with spring distribution, especially mature fishes.

Oyasio current and cold Okhotsk Sea waters define conditions in the South Kuril region in spring. Walleye pollock is widely distributed on all region during this period. The warm Soya current considerably impact on temperature conditions in summer, especially from the Okhotsk Sea side. Therefore pollock concentrates from the Pacific side in Oyasio current waters in summer. Also biomass of zooplankton was 2-2,5 times higher in the Pacific waters in summer 2016, than in the Okhotsk Sea waters. Thus, pollock seasonal distribution are connected with changes of environment and feeding conditions in the South Kuril region.

FIS-P13 (13556)

Interannual variations in distribution and abundance of yellowtail *Seriola quinqueradiata* larvae in the East China Sea: southward expansion of spawning ground

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The biomass of the yellowtail *Seriola quinqueradiata*, which is one of the most important fishery resources in Japan, has increased about threefold over the past 20 years to ca. 300 thousand metric tons. We examined the interannual variations in distribution and abundance of *S. quinqueradiata* larvae, based on sampling surveys over a broad area of the shelf-break region of the East China Sea (ECS) in April, the main spawning period, for 15 years from 2001 to 2015. High abundances of larvae were found in the northern ECS off the southwestern and western coast of Kyushu Island throughout the study period. After 2010, the larvae began to occur abundantly also in the southern ECS south of 29°30'N, indicating a southward expansion of the spawning ground. There has been a significant positive trend of larval abundance over the whole ECS during the 15 years, which was mainly due to a sharp increase of larval abundance in the southern ECS after 2010. Although interannual variation in larval abundance was not related to environmental conditions (temperature, salinity, and chlorophyll *a* concentration), it was closely correlated with the spawning stock biomass in Japanese waters. This indicates that the increase in egg production in the ECS was related to the increasing trend of larvae. Also, the larval abundance showed a weak positive correlation with the recruitment, suggesting that the increased larval abundance has, in part, contributed to high recruitment during the stock increase phase.

FIS-P14 (13561)

Pacific Flatnose (*Antimora microlepis*, *Moridae, Gadiformes*) in the North Pacific: an overview of their distribution, genetic diversity, otoliths, and parasites

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The genus Antimora (Moridae, Gadiformes) is represented by two species, Pacific flatnose A. microlepis and blue antimora A. rostrata. Both species are widely distributed mainly in deep temperate and cold waters: Pacific flatnose in the North Pacific and blue antimora in the rest part of the world oceans. Here we present a new data on distribution of Pacific flatnose within the entire range, consider genetic diversity, describe variations of otoliths shape and relationships between sizes of fish and otoliths, and provide some data on parasites.

We analysed haplotypic composition of samples using mtDNA gene CO1 as a genetic marker: Imperor Seamounts, British Columbia, Southeastern Sakhalin, Pacific Ocean waters off Honshu (Japan), US west coast (Washington, Oregon, California).

Attempt was made to evaluate intra-species structure based on results of comparative otolith shape analysis and comparison of relationships between length and weight of fish and those of otoliths. The composition of parasites, the data on intensity and extent of infection of fish caught off southeastern Sakhalin (Sea of Okhotsk) and in waters of British Columbia (Canada) are also provided.

The origination of A. microlepis in the North Pacific is probably related to its isolation after Panama Strait closing and change of the system of currents. The increasing of number and length of its gill filaments may be a consequence of adaptation to existence in conditions of oxygen deficiency.

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FIS-P15 (13584)

Interactions within fisheries eco-/econo-system and impact of participatory research in a coastal community: In the model area of Indonesia

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More than 90 percent of world population is depending upon the capture fisheries or fisheries industries based on the small-scale fisheries in developing countries. Many livelihoods of the population face to the dynamics of coastal marine environment and under influences of human activities. Sustainability would be attained by continuous efforts to balance activities in the given dynamics, but it is not easy task for locals to precisely find the optimal in changing environment and economics without assistances of sciences. Also, resiliency of communities has been discussed as one of the important factors to respond well to external factors around their livelihood, but discussions of resiliency has not really been made in the levels of self-involvement of fishers. In the Project "Fish GIS", a citizen-science approach has been taken to monitor environment and small-scale fisheries by fishers themselves with the cumulated scientific knowledges from the North pacific while assisting motivation for self-sustainability of communities in Indonesian fields. Firstly, we aim to explore the present state of eco-/econo-system of the one of model areas, Indramayu in Indonesia, with the productions and interactions of the functional groups and fishers with fair estimations. Then, we quantitatively conceptualize the expected state based on the interviewed information in economic utilities. Finally, we expect to examine the changes after the participatory research activities in the Project in the interaction model.

FIS-P16 (13585)

Participatory research in resource production for sustainable fisheries and estimation of option value in Indoramayu Indonesia.

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Major fishing targets are often found in near-shore over continental shelf, and coastal fishers have sustained their livelihoods upon those resources. Demand of fisheries resources are increasing globally although more than half of resources are already utilized by present fishing activities. Sustainability has been one of the common goals for coastal fisheries though uncertainties associated changes of climate and marine environment are challenging. Resource biological informations are fundamental references for sustainable fishery management. Applications

of scientific approach is more expected to contribute in the management measures. However, such scientific management methods by scientists are often costly, and developed measures may not be inacceptable for coastal fishers because of the difference in their perspectives over the obtained information. It is probably practical to involve locals to their own fisheries management through co-workings. In the Project "Fish GIS" of the North Pacific Science Organization (PICES), participatory research efforts have been made to enhance motivation of local fishers toward sustainable future. A village of Indramayu, Indonesia was selected as the model area in our study. We expect to analyze necessary biological information collected from fishers, such as size and weight. We estimate future returns as the partial option value from target fishes in two scenarios: (1) no change in fishing/ present management and (2) applying suggested measures from fishers during the Project using this scientific information. Communication over the analyses are planned to be made frequently with fishers directly and electrically through the planned activities in the Project .

FIS-P17 (13609)

Changes in the specific gravity of Pacific cod *Gadus macrocephalus*, during the early life stages

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It has been known that Pacific cod *Gadus macrocephalus* (P. cod hereafter), lay demersal eggs, and hatching larvae rise toward the surface layer of ocean for feeding. The changing pattern of specific gravity of eggs and larvae was investigated to hypothesized vertical distribution and movement in water column. The specific gravities of fertilized eggs and various size classes of larvae were measured using a Density Gradient Apparatus(Martin Instruments Co. LTD., UK). Totals of 146 eggs and 225 larvae were used for the instantaneous specific gravity measurement. To prevent any disturbance in the gradient water column due to larval movement, about 0.004 % MS222 was used for anesthesia. Due to the high specific gravity, eggs spawned were deposited over the sea-bed of spawning ground. Specific gravity of hatching larvae decreased abruptly. However, P. cod larvae still showed a comparatively higher specific gravity at hatching (1.03655±0.00146 g/cm^3, n=4, mean SL=3.62 mm), and their specific gravities tended to decrease as they got bigger. The specific gravity seemed to have stabilized six days after hatching (1.02590±0.00212 g/cm^3, n=15, mean SL=4.67 mm), and the cod larvae were able to float in the water column.

FIS-P18 (13692)

Increase in abundance of mottled spinefoot *Siganus fuscescens* in seagrass bed in central Seto Inland Sea, Japan, for recent years

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Mottled spinefoot *Siganus fuscescens* is widely distributed in tropical to temperate waters in the western North Pacific and inhabits seagrass *Zostera marina* bed during early life. To understand recent trends in habitat condition and fish community structure, vegetation and fish assemblage were investigated in a seagrass bed off Ikuno Island, Hiroshima Prefecture, central Seto Inland Sea. Fish were collected by a round seine net (4 mm mesh) in at least four separate locations within the seagrass bed during summer from 2007 to 2017. Collected fishes were identified and were sorted by species in the laboratory. Mottled spinefoot were enumerated, then measured in total length and wet weight. After 2015, abundance of mottled spinefoot has increased while seagrass vegetation coverage has decreased. Because the mottled spinefoot do not spawn around the survey site and are more abundant in southern waters with higher temperature, it seems that opportunity of transportation to the central Seto Inland Sea has been increasing during the early life stages of the species. Information on occurrence of mottled spinefoot in other areas of the Seto Inland Sea and coastal waters of Japan was summarized and used for discussion on possible effects of increase in water temperature and recent changes in physical properties of oceanic waters on the occurrence of the species in the western North Pacific.

FIS-P19 (13693)

Day-night change in fish community in sandy shore in the central Seto Inland Sea, Japan

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Sandy shore has been considered as an essential habitat for a variety of fish species which are important as coastal fisheries resources. Day-night change in fish community structure was examined in a sandy shore off eastern coast of Ikuno Island, Hiroshima Prefecture, central Seto Inalnd Sea, Japan. Fish were collected by a round seine net (4 mm mesh) during daytime (1400-1600h) on 14 May 2018 and nighttime (0200-0400h) on 15 May 2018 (four replicates for each). Water temperature and salinity were measure at each collection. Fish were identified, enumerated and weighed in wet weight. A total of 368 fishes were collected. Sharp-nosed sand goby *Favonigobius gymnauchen* and Japanese black rockfish *Sebastes* spp. dominated the fish community by number during daytime and nighttime, respectively. Mean species richness (no. fish species), fish abundance (no. fish 100 m^{-2}) and fish biomass (wet weight 100 m^{-2}) during nighttime (5.0 species, 17.5 individuals and 36.0 g) were significantly higher (u-test, $p<0.05$ for all) than those during daytime (9.3 species, 74.5 individuals and 212.9 g). These results suggest that fish community structure and trophic flow differ between day and night in sandy shore as previously reported in other essential fish habitats such as seagrass bed in the central Seto Inaldn Sea.

FIS-P20 (13720)

Species variation of early growth history pattern of grey mullet in Taiwan

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The study focused on the early life history of 3 cryptic species (NWP1-3) of *Mugil cephalus* juvenile in the estuaries around Taiwan. Monthly juvenile samples were collected from varied estuaries, and genotyping for species discrimination were applied to understand spatial-temporal distribution and otolith daily increment and microchemistry were then analyzed. The most abundant species is NWP2 (81%), and exists in most estuaries over spawning season. NWP1 accounts of 17% overall, and increases with month in Yilan. Only 2% of mullet juvenile is NWP3. Both daily age (50 ± 11 days) and duration before settle down (32 ± 6 days) of NWP2 is smaller than NWP1. The linear relationship between daily rings and total length demonstrates that growth rate of NWP2 is higher than NWP1. Otolith increment widths of NWP2 in Checheng estuary are wilder than other estuaries, which indicate the different growth rate between species and various estuaries. Back-calculated hatching dates of 3 species mullets were back-calculated. Hatching months of NWP1 are from December to the next February, and peak is January. NWP2 hatching months are from September to the next January and peak is December. Otolith microstructure and microchemistry analyses early life history of the mullet juveniles can be divided into three stages, including drifting, transition and stable growth stage. Both drifting and transition stage of NWP1 generally longer than NWP2. This study shows the habitat change of mullet at different life stage through detailed information recorded in otolith.

FIS-P21 (13721)

Using otolith microchemistry to discriminate wild and released red snapper

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The red snapper, *Lutjanus argentimaculatus* is one of the restocking species in Blue Economic Program in Taiwan. This study is aimed to establish an effective and sensitive natural tag for discriminate method. The composition of trace-element in fish otoliths will be affected by the compositions of water they grow, while the releasing juvenile fish come from aquaculture farms, which is different from the natural seawater of wild populations. We collected wild and cultured *Lutjanus argentimaculatus* to understand whether there is a difference in the otolith core elements. The composition of otoliths was analyzed by inductively coupled plasma mass spectrometry (ICP-MS). Firstly, whether the otolith micro-sampling method between MicroMill and laser ablation has difference were tested. Then analyzed the composition in the otolith core to the edge, and compared the difference of elemental values in different time interval. The results showed that, there is significant difference between the sampling methods. It was suggested to use the same analysis method to facilitate comparison in the future. Wild and cultured fish otolith element values have a significant difference at the otolith distance of 600-700 um from the core, indicating this interval can be used as a basis to distinguish fish sources. According to the composition of otolith, 100% can be correctly. This result showed its an effective discriminating tool to distinguish cultured and wild individuals.

FIS-P22 (13740)

Recovery of Pacific oyster, *Crassostrea gigas* raised in an intertidal rack-suspended culture system in terms of growth and reproduction 3 years after the *Hebei Spirit* oil spill accident off the west coast of Korea.

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In December 2007, the oil tanker *Hebei Spirit* collided with a crane barge 10 miles off the Taean coast on the west coast of Korea, leaking 10,800 tons of crude oil. The spilled crude oil covered the entire coast of Taean and destroyed the intertidal oyster aquaculture facilities. In an attempt to resume the oyster culture in the oil spill area, we monitored growth and reproductive condition of the Pacific oyster *Crassostrea gigas* raised in an intertidal rack-suspended culture system at Uihangri beach in Taean, one of the most heavily damaged beaches by the spilled oil. The oyster spats were harvested from Uihangri beach during the post-spawning season in September 2011 using mussel shell as substrate. The oysters were then hardened for 10 months in upper inter-tidal zone and before they are transplanted into the culture system for grow-out in May 2012. The gamotogenic condition of individual oysters was examined using histology. Reproductive effort of female oysters was estimated using an indirect enzyme-linked immunosorbent assay (ELISA), where the rabbit anti-oyster egg protein IgG was served as the primary antibody. In September 2013, the 2 years old oysters reached to 6.5 cm in shell length and 5.8 in somatic tissue wet weight. Histology indicated that the 2 year old oysters spawned during July and September. An indirect-ELISA indicated that the fully ripe oysters produced 20-23 % of their body weight as egg prior to spawn, while the amount of egg produced from the wild oysters occurring in the beach ranged 17-20 %. Reproductive effort and the annual gametogenic pattern of the rack suspended cultured oysters in the oil spilled area measured in this study was similar to the pattern of normal oysters in oil-spill free areas. Consequently, it was believed that oyster aquaculture in Taean coast could be resumed.

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MEQ-P1 (13264)

Marine environment quality assessment of the coastal areas around Vladivostok, using biological and chemical data analyses (the Sea of Japan/East Sea)

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The Golden Horn and Diomid Inlets, as well as adjacent areas of East Bosphorus Strait, are extremely unfavorable for the existence of bottom fauna. These coastal areas are exposed to long-term, chronic pollution by toxic elements and compounds - metals, petroleum hydrocarbons, phenols, and pesticides. In general there are no places where the habitat would not be unfavorable for the bottom populations in these areas.

The minimum values of ecological indicators such as species richness, diversity, evenness, are observed in the most polluted areas of the Golden Horn and Diomid Inlets, which reflect a high level of anthropogenic impact. The deterioration of the ecological state of benthos in these areas, as well as in the eastern part of the Amursky Bay, is caused not only by the level of chemical pollution of the environment, but also by the oxygen demand.

At an extreme and strong level of chemical pollution, communities with a reduced species composition are formed. Almost all of the species found in these areas are positive indicators of pollution and eutrophication. As the anthropogenic impact is decreased, the macrozoobenthos communities become more diverse. Such communities of macrozoobenthos exist on the investigated areas for many decades in conditions of a relatively stable and high level of chemical pollution.

MEQ-P2 (13273)

Community and distribution of *coccolithophores* in the Yellow Sea and East China Sea

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We conducted a community-based survey on the distribution of *coccolithophores* in the Chinese Yellow Sea waters during the summer (July 20–September 1) and winter (December 23–February 5) of 2015. During summer, 21 species of *coccolithophores* were found in the Chinese Yellow Sea waters of the survey area dominated by *E. huxleyi*, *G. oceanica*, *U. tenuis*, and *F. profunda*. The *coccolithophore* cell abundance was between 0.23×10^3 cells/L and 17.62×10^3 cells/L, with an average of 2.84×10^3 cells/L. During winter, 20 species of *coccolithophores* were found in the Chinese Yellow Sea waters of the survey area dominated by *E. huxleyi*, *G. oceanica*, *F. profunda*, and *U. tenuis*. The *coccolithophore* cell abundance was between 0.12×10^3 cells/L and 35.35×10^3 cells/L, with an average of 3.84×10^3 cells/L. We systematically described and analyzed the distribution of *coccolithophores* in the Yellow Sea and East China Sea to study their community distribution in the Chinese sea.

MEQ-P3 (13300)

Abundance and community structure of ammonium monooxygenase (*amoA*) genes in Liaohe estuary sediments, China

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Ammonia oxidation is the first step and the rate-limiting step of nitrification, which is an important part of the global nitrogen cycle. Ammonia-oxidizing archaea (AOA) and ammonia-oxidizing bacteria (AOB) are important players in the ammoxidation process. In this study, 13 sediment samples from the Liaohe River estuary were collected. The abundances of 16S rRNA and *amoA* genes were detected by real-time fluorescence quantitative PCR. The diversity and community structure of AOA and AOB were investigated by constructing clone libraries. Quantitative PCR results showed that the 16S rRNA gene abundances of archaea and bacteria were $1.05 \times 10^8 \sim 1.31 \times 10^9$ and $3.05 \times 10^{10} \sim 1.37 \times 10^{12}$ copies/g wet sediment, respectively. The AOA and AOB *amoA* gene abundances ranged from $3.10 \times 10^6 \sim 2.85 \times 10^7$ and 6.59×10^5 to 1.20×10^7 copies/g wet deposit, respectively. At all stations, AOA abundance was greater than AOB. Phylogenetic analysis showed that the AOA *amoA* sequences were mainly Nitrosophaera and Nitrosopumilus, and the AOB *amoA* sequences were mainly clustered into two branches, one is Nitrosomonas, and the other is unclassified locating in estuarine sediments and wetland soils. In addition, canonical correspondence analysis showed that the environmental factors affecting AOA community distribution were salinity, pH, ammonia (NH_4^+), conductivity, total phosphorus, sand, and silt content, while the sand and silt content had a significant effect on AOB community structure.

MEQ-P4 (13318)

Trends of sediment accretion and carbon sequestration in Liaohe estuarine wetland

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From a radionuclide-based analytical approach, combining parameters such as TOC and TN, the sedimentation rates and sedimentary organic carbon (SOC) accumulation characteristics of reed marsh and bare beach at different elevation were studied, the carbon sequestration function of Liaohe estuarine wetland was thereby unveiled. The result showed that, the sedimentation rates of reed marsh and bare beach in study area increased with time based on $^{210}Pb_{ex}$ and ^{137}Cs chronology methods, the average sedimentation rate of bare beach on the same time scale was higher than that of reed marsh, Liaohe estuarine wetland has been showing siltation tendency over the past 100 years, and the siltation degree weakened with the rise of elevation. Using the change of sediment mass accumulation rate (MAR) over time, it was shown that the evolution of sediment accretion in Liaohe estuarine wetland was affected by terrestrial input and tidewater intrusion, resulting in the alternation of siltation and erosion, and the evolution in bare beach was more dramatic. Utilizing the temporal and spatial distribution of total organic carbon (TOC) and C/N ratio, it was ascertained that the source of organic matter in Liaohe estuarine wetland was dominated by terrestrial input. Affected by vegetation, SOC in shallow reed marsh was significantly higher than that of bare beach, but the accumulation rate of SOC (AR-SOC) in bare beach was still higher than that of reed marsh. Comparing to vegetation input, the higher MAR had a more noticeable effect on the AR-SOC in the study area of Liaohe estuarine wetland.

MEQ-P5 (13373)

Spatial characteristics of microplastic in the zooplankton samples collected from the Yellow Sea

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We investigated abundance and composition of microplastics in archived zooplankton samples collected from the Yellow Sea, where samples were acquired at five different layers in 12 stations using a closing net (mesh size: 200 μm) in April and August 2013. Total microplastic abundances in the surface waters (0-10m) were most dominant (8.71~25.22 particles/m^3 in April, 3.77~9.44 particles/m^3 in August), while those in the lower layers (40~90m) were relatively low (0.00~9.98 particles/m^3 in April, 0.00~7.34 particles/m^3 in August).

Types of the microplastic were fiber, sphere, hard plastic, other foamed and paint particles, of which polymer types were polypropylene, polyester, cotton, polystyrene, polyethylene, polyethylene terepthalate and alkyd. Among the polymer types, polypropylene dominated to total microplastic in the surface waters, while polyester dominated in the lower waters during the study. The fiber accounted for 59.2% (Avg. 5.1 particles/m^3) in April and 72.8% (Avg. 2.5 particles/m^3) in August of the total microplastics. The polymer types of fibers consisted of polypropylene, polyester and cotton, of which polypropylene was dominant type as 48.1% in April, and 52.9% in August. The ratio of microplastic-to-zooplankton, indicating "encounter rate" ranged generally higher in the surface waters compared to other strata during the study. These results indicated that vulnerability of plankton or planktivores to numerically dominant fibers is likely to be high in the surface waters of the Yellow Sea.

MEQ-P6 (13430)

Atmospheric long-range transport of microplastics: A preliminary result of atmospheric fall-out samples from a remote island (Daecheong Is.), South Korea

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Recently, there has been an increasing interest in microplastics (MPs), which have been investigated in various media. In aquatic ecosystems, high concentrations of MPs was observed not only in the human activated areas (such as rivers and marine), but also in polar regions where human activity is extremely rare. Although atmospheric fall-out is suspected as another transport pathway of MPs, their long range transport mechanisms has not been investigated so far. In the present study, we determined the presence of MPs in atmospheric dry/wet deposited samples to elucidate their atmospheric transport potentials. For that, atmospheric fall-out samples were periodically collected every two weeks throughout one year from April 2017 to May 2018 at a remote island (Daecheong Is.) which locates at the westernmost part of Korean peninsula and is on the way for atmospheric pollutants originating from China to transport to Korea. Our preliminary results showed the occurrence of fibrous MPs as well as other various types of MPs (such as bead and fragment) in atmospheric fall-out samples. Through further analysis, we will characterize MPs present in atmospheric sample and calculate their deposition rates. Finally, we present the origin of MPs in air using the Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) provided by NOAA (National Oceanic and Atmospheric Administration).

MEQ-P7 (13467)

Stimulated phosphorus utilization by possible increase of dust deposition in the western North Pacific

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Future climate change is predicted to increase dust deposition to oligotrophic oceans and thus influence biological activities of marine microbial communities, because dust is a primary source of trace metals constructing reaction centers of various enzymes in microbes. Alkaline phosphatase is one of these metalloenzymes requiring either zinc or iron, and plays a crucial role in phosphorus acquisition by organisms, although roles of trace metal in the marine phosphorus cycle is not understood in detail. In this study, we examined the effect of zinc/iron/phosphate addition on alkaline phosphatase activity (APA) through on-board enrichment experiments conducted at 4 stations along an east-west transect (23°N) in the subtropical North Pacific Ocean. Initially, particularly high APA was observed at the westernmost station (140°E) simultaneously with depleted phosphate. APA was suppressed after phosphate addition which revealed that phosphate limited region distributed from 140°E to 170°W and the greatest positive response of zinc/iron addition on APA (2.5/1.5 folds higher than control) was observed at a station (160°E) located therein. Enhancement of APA by addition of iron and zinc was also observed at the westernmost (140°E) and central part (170°W) stations, respectively. These results suggest that limiting factors of APA gradually shifted from iron to zinc with distance from the Asian Continent. This is the first report of co-limitation of phosphate and trace metals in the western North Pacific Ocean and suggests that phosphorus consumption in this region will be stimulated by future increase of dust events, resulting in progress of oligotrophication.

MEQ-P8 (13486)

Toxicity and affecting of toxic dinoflagellates on plankton and bacterial community

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The increasingly frequent of harmful algal bloom(HAB) have been aggravated the deterioration of the coastal ecological environment on the worldwide and caused huge losses to the aquatic economy in coastal countries. Some harmful algae can produce phycotoxins, which may cause poisoning or death to human beings, marine animals and even aquaculture organisms. These toxic microalgae can also poison the marine organisms coexisting in the same ecosystem. How do these poisons, especially to marine plankton and micro-organisms, affect the marine ecological structure, and what are the risks to the ecosystems? In the past, more attention was paid to the harm of phycotoxins in marine food to human. In this paper, 3 species of toxic dinoflagellates, *Protoceratium reticulatum*, *Prorocentrum lima* and *Alexandrium nimutum*, which widely have distributed in the coastal waters of China, were studied. The relationship between toxic effects and quantitative responses to plankton (zooplankton and phytoplankton) and marine young fish have been studied. The affecting of these three spices of toxic dinoflagellates on the bacterial community and their diversity have also been studied. The possible ecological risk was estimated by the species sensitivity evaluation method, and these results may lay the foundation for the in-depth study and evaluation of the harm and risk of toxic dinoflagellates to the marine ecosystem.

MEQ-P11 (13596)

Distribution of harmful algae, nutrients and iron in Bungo Channel, western Seto Inland Sea, Japan

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Iron is an especially essential element for the growth of microalgae and its deficiency is well known to suppress primary productivity in marine ecosystem. Therefore, elucidating the distribution of iron in seawater is significantly important for understanding the marine biogeochemical cycle. We investigated the harmful algal species composition and the concentration of dissolved nutrients, iron (DFe), and total iron (TFe) in surface, intermediate and bottom water samples at seventeen stations in Bungo Channel, western Seto Inland Sea. Samplings were carried out in July 2017 using the research vessel "Shirafuji-Maru". Concentration of dissolved inorganic nitrogen (DIN, NO_3-N+NO_2-N+NH_4-N), phosphate (DIP), and silicate (DSi) were determined using an auto-analyzer. DFe concentration was measured by spectrophotometry using PDTS (ferrozine) method with a long-path liquid-waveguide capillary cell. Prior to analysis, samples for TFe determination were irradiated with UV-A by a 400-W low-pressure Hg lamp for 2 h to decompose interfering organic compounds. The bioelement concentration ranged from 0.33 to 4.1 μM for DIN, 0.01-0.44 μM for DIP, 0.24-14 μM for DSi, and 1.03-129 nM for DFe, respectively. As compared to Redfield ratio, these concentration distributions suggest DIN limitation for microalgae in almost every region. During the investigation period, bloom of harmful dinoflagellate *Karenia mikimotoi* (up to 1,535 cells ml^{-1}) was observed. Given the iron cell quota of *K. mikimotoi*, we here point out that particulate iron is an important factor for harmful dinoflagellate bloom in Bungo Channel in summer. This research was supported in part by Project for addressing red tides and oxygen-depleted water masses.

MEQ-P12 (13620) CANCELLED

Statistical analysis of seasonal water pollutants affecting phytoplankton proliferation on the South Korean coasts

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An analysis of the water quality of South Korean coastal regions was conducted considering their geographical characteristics and including the major seasonal factors that determine water pollution, using a statistical method. The pollution indices of the South Korean coast generally indicate oligotrophy, but an indices value > 1 may occur during a red tide on west coast of the Korean Peninsula. The components of riverine water quality that affect the coastal water quality include total nitrogen (TN) > chemical oxygen demand (COD) > total phosphorus (TP), in this order of impact ($R2 \geq 0.55$). The primary factors affecting chlorophyll-a (Chl-a) were salinity (S) and pollutant load (COD, TN, and TP) as indicated by the factor analysis method. Temperature was considered a secondary factor. Furthermore, S and TP were indicated as regulatory components in the multiple regression model of Chl-a. The pollution indicators, TN and TP, were significant components of loading in accordance with river discharge, and TP, which was presented as the main component that controlled proliferation of phytoplankton during seasons such as spring and autumn, can be seen to have a great effect as well. Moreover, multiple linear regression results provided the smallest prediction error, and provided effective performance.

MEQ-P13 (13639)

Radiological investigation in the Far Eastern seas of Russia

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Monitoring of the radiation situation in the operational areas of the economic zone of Russia in the Japan, Okhotsk and Bering seas are conducted during marine expeditions on RNs of TINRO-Center. In 2015 from March to November it was done 6500 measurements of background radiation in air, seawater and catches. Background radiation was 5 to 12 mcR/h, i.e., was normal. The results of the investigation of concentration of artificial radionuclides in seawater samples from the field showed that the concentration Cs-137 and Sr-90 within each sea is slightly differed according to the stations (within the error of determination). Average annual radionuclide concentrations are decreased from the Japan to the Bering Sea: from 1, 5 to 1.2 Bq/m^3 for Cs-137 and from 1.2 to 0.9 Bq/m^3 for Sr-90. We can conclude that the average annual concentration in surface waters in areas of observation in 2015 due to the artificial radionuclides Cs-137 and Sr-90 were within the regional technological level due to global contamination of the hydrosphere. It was examined the main commercial fish of the Far Eastern basin on the content of toxic radionuclides Cs-137 and Sr-90 in the sea of Japan, three species of flatfishes, Pollock, Atka fish, in the sea of Okhotsk – is Pollock, Pacific herring, Pink salmon, in the Bering sea is Pollock, Cod. The content of Cs-137 and Sr-90 were not significantly different in the samples from different fish species: the specific activity of Cs-137 ranged between 0.4 - 1.2 Bq/kg and Sr-90 from 0.6 to 1.0 Bq/kg w. w. well below the allowable levels of radionuclides Cs-137 and Sr-90 at the sanitary standards of the Russian Federation (130 and 100 Bq/kg, accordingly) and corresponds to the Uniform sanitary and epidemiological and hygienic requirements approved by decision of customs Union Commission dated May 28, 2010 № 299.

Thus, the radiation environment in fishing waters of the Far Eastern seas of Russia is assessed as sufficiently safe in the radiation-hygienic attitude.

MEQ-P14 (13680) (also TALK)

Assessing the Severe Eutrophication Status and Spatial Trend in the Coastal Waters of Zhejiang Province (China)

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The eutrophication of the coastal waters of Zhejiang Province has become one of the main contamination threats to the region's coastal marine ecosystems. Accordingly, the comprehensive characterization of the eutrophication status in terms of improved quantitative methods is valuable for local risk assessment and policy making. A novelty of this work is that the spatial distributions of chemical oxygen demand, dissolved inorganic nitrogen and dissolved inorganic phosphorus were estimated across space by the Bayesian maximum entropy (BME) method. The BME estimates were found to have the best cross-validation performance compared to ordinary kriging and inverse distance weighted techniques. Based on the BME maps, it was found that about 25.95, 19.18, 20.53 and 34.34% of these coastal waters were oligotrophic, mesotrophic, eutrophic and hypereutrophic. Another novelty of the present work is that comprehensive stochastic site indicators (SSI) were introduced in the quantitative characterization of the eutrophication risk under conditions of in-situ uncertainty. The results showed that the level of the eutrophication index (EI) increased almost linearly with increasing threshold values; and that 71, 51 and 19% of coastal locations separated by various spatial lags experience considerable mesotrophic, eutrophic and hypereutrophic risks, respectively. Elasticity analysis of eutrophication indicators offered a quantitative measure of the excess eutrophication change caused by a threshold change (the larger the elasticity is, the more sensitive eutrophication is to threshold changes). The above findings can contribute to an improved understanding of seawater quality and provide a practical approach for the identification of critical coastal water regions.

MEQ-P15 (13715)

Macro- and microelement composition of marine commercial fishes from the Far Eastern Seas

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For the last years the observation of content of macro- and microelements in the tissues of commercial species of fish caught in the fishery areas of Far Eastern Seas was carried out. It is known, that marine organisms indirectly reflect environmental condition, so samples of sea water from the catchment areas also were sampled for the laboratory analysis. The concentrations of Ag, Al, As, Ba, Ca, Cd, Co, Cu, Cr, Fe, K, Mg, Mo, Mn, Ni, Pb, Sb, Se, Th, Tl, U, V, Zn in the muscle and liver tissues of fish and sea water were determined by method of mass-spectrometry with inductively coupled plasma (ICP-MS). Levels of concentration of above-mentioned elements in the marine environment and fish from Bering, Okhotsk and north-western part of Japan/East Seas are poorly studied or unknown. The data acquired due to recent research allows to establish the background levels of essential and toxic elements in pristine areas of Far Eastern Seas, to find temporal and spatial differences reflecting biogeochemical processes in the sea. It was found, that pelagic plankton-feeders (herring, pollock) accumulated rather low concentrations of toxic elements, but benthophages (flatfishes, cod) showed elevated concentrations of trace elements due to close relation to bottom sediments. These findings are necessary to predict quality and safety of marine bioresources, as valuable food source.

MEQ-P16 (13724) CANCELLED

Hypoxia of Jinhae Bay in the southeastern coast of Korea

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Some coastal semi-enclosed regions in Korea, such as Jinhae Bay and Gamak Bay, have suffered from hypoxia since the 1970s and this phenomenon continues to the present day. Especially, in Jinhae Bay, severe hypoxia occurs in the bottom waters from May to November, although the occurrence periods of hypoxia are different in every year. In order to understand the temporal and spatial distribution of hypoxia in Jinhae Bay, we investigated various environmental parameters including temperature, salinity, and dissolved oxygen at 30 stations in this bay during hypoxic events periods in 2010-2017. The first development of hypoxia was in May when the bottom water temperature was approximately 15°C and when the temperature difference between the surface and bottom waters was 4~6°C due to thermal stratification developed gradually by solar heating. Hypoxic bottom waters persist during summer, along with strong thermal stratification. The termination of hypoxia was in late October and early November when the bottom water temperature was decreased from approximately 28°C in summer to about 20°C in autumn due to the thermal cooling. Considering the spatial distribution of hypoxia, high frequency of hypoxia occurrence was observed in Jindong Bay, Danddong Bay, and around Gajo Island, where the large-scale shellfish and ascidian farms are concentrated, relative to other regions. Hypoxia water mass was mainly distributed in the edge of bay during spring tide and in the center part of the bay during neap tide. This result suggests that the spatial distribution of hypoxia is dependent on the tidal current.

MEQ-P17 (13751)

Impacts of marine debris on seabirds in South Korea

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It has been reported that about 60-80% of the marine debris is plastic, and over 50 trillion of plastics are floating in the ocean. Seabirds living in the marine environment are exposed to numerous plastic debris which cause damages. The main types of damage by plastic debris are 'entanglement' and 'ingestion' on seabirds. In this study, we investigated the cases of seabird damage caused by plastic debris in four breeding colonies of Black-tailed gulls *(Larus crassirostris*) in South Korea from 2010 to 2018. The study areas are Hongdo Island in south sea of Korea, Nando Island and Hwangseodo Island in west sea of Korea and Dok-do Island in east sea of Korea. We visited these breeding colonies during the breeding season and collected dead birds or investigated the impacts of plastic debris on adults and juveniles of Black-tailed gulls. As a result, the main types of plastic debris that cause damages to Black-tailed gulls were filament-form (long and thin), fishing net and fishing line. Plastics as fishing nets and traps from fishing boats are often floating and staying for a long time in the sea. Those items easily entangled with a part of seabird bodies (e.g. beak, wings, and legs). Because Black-tailed gulls often follow the fishing boat to obtain food and catch fish near the sea surface, they can be much vulnerable on fishing line or net. It is required to monitor impact of plastic debris (macro and micro plastics) on seabirds.

MEQ-P18 (13617)

Distributions of organic matter and heavy metal in Korean coastal sediments and their pollution assessment

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We measured grain size, organic matter (COD, AVS), and heavy metals (As, Cd, Cu, Hg, Pb and Zn) in intertidal sediments collected from 1,042 stations of 77 intertidal sectors in 2008-2013 and in sublittoral sediments collected at 218 stations in 2014 to evaluate the organic matter and metal contamination in Korean coastal sediments. The finer sediments in intertidal and sublittoral sediments are mainly distributed in the southwestern and southeastern coasts, respectively. The concentrations of organic matter and heavy metals in both sediments were much higher in southeastern coast, where many industrial complexes and large-scale fish and shellfish farms are concentrated, compared to the other coasts. This implies that the concentrations of organic matter and heavy metal in Korean coastal sediments are dependent on anthropogenic inputs associated with human activities in the coastal zone. Also, the concentrations of organic matter and heavy metals were relatively higher in sublittoral sediments than in intertidal sediments. As the results of pollution assessment using sediment quality guidelines (SQGs) and geoaccumulation index (I_{geo}), Korean coastal sediments were moderately polluted for As unlike other metals and were little polluted for organic matter. Especially, the results of pollution assessment using pollution load index (PLI) and ecological risk index (ERI) showed that the intertidal and sublittoral sediments in the southeastern coast of Korea were significantly polluted for heavy metals. This result suggests that the high metal concentrations in the southeastern coast could have a considerable adverse impact on the aquatic and benthic organisms.

Physical Oceanography and Climate Committee Paper Session

POC-P1 (13276)

Summertime Bottom Cold Water Transports in the Northern Bohai Strait, China

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Summer hypoxia has become a serious environmental problem in the Bohai Sea (BS). Functioning as an incubator, persistent stratification of the water column is essential for the development of hypoxia in these areas. As a shallow marginal sea, the maintenance of the thermal stratification in the BS depended greatly on the inflow of cold bottom water from the Northern Yellow Sea (NYS) through the Bohai Strait. The summer bottom circulation in the Bohai Strait and associated water transports were investigated with observational data and numerical means. In the horizontal directions, the bottom circulation formed a sub-basin scale anti-clockwise gyre. Inflows of bottom water from the NYS to BS were found in the northern and southern Bohai Strait, and outflows were found in the central Bohai Strait. The special circulation pattern determined the passage of bottom cold water transports inside the BS. Bottom water was transported into the southern and western depressions neighboring to the Central Shallow Bank (CSB) along the 25m isobaths in the southern BS. Direct northward transports of the bottom water from the NYS to the central depression in the LiaoDong Bay (LDB) suggested in previous studies were not confirmed by either current observations or model results.

POC-P2 (13309)

Estimation of the hydrodynamic regime of water in the spring transitional season for half a century in the Kamchatsky Strait (the Aleutian island system)

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The surface water circulation in the deep-water Kamchatka Strait (Нmax=4420 m) in the Aleutian archipelago was calculated in the transitional spring season for the period 1950 - present on the basis of numerical modeling. The spring season was used as an example of the transition from the winter to the summer due to its poor knowledge. The model takes into account temperature and salinity at sea surface, spatial distribution of water density, atmospheric influence, bottom relief, coast orography and water exchange through straits. Sources of data are GEBCO (depth), NCEI (Sea Level Pressure Monthly Mean at Surface), WOD. The temperature and salinity on the sea surface are calculated using ODV (Ocean Data View) algorithms. The uniform grid 5'×5' was used for calculations. The modeling results showed the average spring pattern of the currents over more than half a century.Thus, the cyclonic activity and runoff of the cold Bering Sea waters, which are connected to the waters of the Kamchatka Current, generally prevail in the strait. The anticyclonic character of water movement is observed near Bering Island from the side of the Pacific Ocean, the main factor of which is the advection of waters from the Pacific Ocean.The presence of these hydrodynamic structures contributes to the formation of a frontal zone in the strait. It can be concluded that in the Kamchatka Strait winter hydrodynamic regime prevails due to the inertia of the water masses.

POC-P3 (13310) (Also TALK)

The role of regional atmospheric processes in the formation of the structure of currents in region of the straits surrounding Urup island (Kuril island system)

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The role of regional atmospheric processes in formation of the structure of current in the region of Urup Island in the Kuril Islands Systemunder of influence north-western wind for period 1949-1994 on the basis of the hydrodynamic model is shown. It is concluded that the nature of the variability of the hydrodynamic and atmospheric processes are well correlated to seasonal: its maximum falls on the autumn-winter period, the minimum at the spring-summer period. The revealed two-month phase shift of the dynamics of the compared processes can be explained by the existence of a threshold of occurrence of the dependence of the formation of hydrodynamic structures on the force of the wind effect, as well as the difference in inertial keeping of the formed water and air masses.

POC-P4 (13316)

The South Okhotsk Sea water thermal regime variability under influence of the water dynamic and atmospheric circulation in summer

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The investigations were made in the important economical region of the South Okhotsk Sea, but at the same time in the active dynamic zone. Intricate nature of hydrological regime of this area is caused by the presence of zones of exchange through the LaPerous (Soya) and Kuril Straits by the different origin waters (Japan Sea - Okhotsk Sea - Pacific ocean) transferred by streams of the currents of the South Okhotsk Sea. On the base of summary of multi-year observations the water thermal regime variability in the investigation area as related to water dynamic and atmospheric circulation were studied. On the background of warming tendency in the 1985-2017 increasing fluctuations of summer surface temperature were revealed. The links between the thermal regime in the South Okhotsk Sea and Okhotsk High development were found. It was shown, that extreme warm regimes are conditioned by the Okhotsk High weakening and Soya current intensification. Abnormally cold thermal regime in summer is formed in the period of strong Okhotsk High and the East-Sakhalin current system development and Soya current reduction. The obtained results can be used for decision of the fishery and ecologies problems and for developing the forecasts of hydrological conditions in this area.

POC-P5 (13317)

Water characteristics peculiarities formed by tides in the South Okhotsk Straits and adjacent areas

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Based on the data summary of multi-year research cruises observations in the areas investigation (Soya (LaPerous) and Kuril Straits) the tides influence on the water thermohaline structure peculiarities forming were studied. Such factor as sharply distinct tidal events and connected with them significant currents speed combining with complicated relief of bottom and climate conditions are forming specific water structure in the Straits zones. It was found that the portions of the Okhotsk Sea water, while penetrating into the Straits zones as a rule with the vortex formations, form the lens–shape areas of the coldest and law-salty waters. As the vortices, some volumes of the cold water can exist for a long time. In eddies and also in the currents system streams that carry and preserve own parameters it is observed location of homogeneous cores of minimal temperature in cold intermediate layer. The temperature breach and anomalies dynamics in the Straits zones as related to the tides were analyzed. The water structure local peculiarity forming mechanisms were determined. It was shown that the tides are the dominant factor, which determines water dynamic in the straits and water structure alterations.

POC-P6 (13324)

Temperature change along the Russian coast of the Japan Sea from 1991 to 2017

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It is the analysis of the variability of average annual water and air temperature according instrumental observations of coastal weather stations in Primorye. A comparative analysis of the temperature variability of the two boundary decades (1991–2000 and 2001–2010) between themselves and with the climatic norm (1961–1990) is carried out. The average monthly temperature of water and air, average temperature for warm and average temperature for cold periods of the last three five years (2001–2005, 2006–2010, 2011–2015) are compared with each other. The results of these studies show an uneven increase in temperature in the region under study during the period under review.

POC-P7 (13389)

Kuroshio warm water intrusion observed by high-resolution survey

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The Kuroshio coastal area, which is located between the south coast of Japanese islands and the Kuroshio, is nutrient-rich and becomes a major spawning grounds of various fishes. The Kuroshio south of Japan has three typical paths and took large meander path in August 2017 twelve years after the last time. Kuroshio warm water intrusions into the Kuroshio coastal area, which are accompanied by the large meander, greatly influence the fisheries there because the intrusions raise temperature and salinity, and tide rapidly. While the impact of Kuroshio warm water intrusions on fisheries is a deep concern, studies of its generation and evolution mechanism are very limited. Satellite observations imply that Kuroshio warm water intrusions occur near the eastern trough of the meander where surface anticyclonic vorticity is strong. To approach vertical structure and mechanism of Kuroshio warm water intrusions using in situ data, we conducted several high-resolution surveys using CTD, XCTD and ADCP near the eastern trough of the meander in August, September 2017 and April 2018, respectively. Hydrographic and velocity sections revealed that the warm water intrusions are associated with ageostrophic flow, cause rapid water mass transport, and have horizontal scales of O(10 km). The dynamical structures further suggested that intrusions are induced by centrifugal force and interpreted as one of the submesoscale phenomena (scales of O(1-10 km)).

POC-P8 (13411)

Mechanisms of future upwelling change in the equatorial Pacific using CMIP5 models

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Equatorial upwelling play an important role in oxygen via advection of oxygen and transport of nutrient to the euphotic zone used by biological production. Previous studies showed that climate models project the weakening of equatorial upwelling in the Pacific, and the main suggested responsible mechanisms are Ekman pumping near surface and equatorial undercurrent (EUC) change at depth. However, how much of upwelling reduction was not explained by each mechanism quantitatively. Therefore, in order to understand better the mechanisms of upwelling change, we analyze output data from 24 CMIP5 models in the equatorial Pacific until 2100 under RCP8.5.

In order to obtain better physical explanation, we divide total upwelling into isopycnal upwelling (vertical velocity component of current velocity parallel to isopycnal surfaces) and diapycnal upwelling (difference between total and isopycnal upwelling). The total upwelling decreases in the equatorial Pacific about 50-200m depth until 2100. Three-fourths of total upwelling reduction in the eastern equatorial Pacific at 100m depth, where there is a boundary of euphotic zone, is explained by the isopycnal upwelling change. Further division indicate that 71% of isopycnal upwelling change there is caused by the zonal isopycnal gradient change. Thus, it is shown that about a half of equatorial upwelling reduction in the eastern equatorial Pacific is induced by the EUC flattening.

POC-P9 (13415)

A numerical study on the circulation, wave and suspended sediment in the Yellow and East China Seas

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We summarize in this work a recent development of a three-dimensional numerical model for the Yellow and East China Seas equipped with multiple-scale circulation, wave and multiple-size suspended sediment modules. The hydrodynamic numerical model SELFE that solves equations for the circulation, the wave action and sand transport on the unstructured grids has been used as a base model. Some important improvements have been made. To deal with the multiple-scale circulation including tide, wind and oceanic circulation, we have introduced an open boundary condition to obtain stable solutions in the presence of multi-scale circulation. Hydrodynamic results have been verified using tidal elevations around the Yellow Sea have, while wave results have been verified using wave measurements in coastal seas southwest of Korean Peninsula. We have extended the non-cohesive sediment module of SELFE to the form applicable to mixture of cohesive and non-cohesive sedimentary regimes by implementing an extended form of erosional rate and a flocculation model for the determination of settling velocity of cohesive flocs. The exchange of sediment between the bed and the flow is modeled using sink and source terms acting on the bottom computational cell. These terms represent the processes of sediment entering the flow due to erosion flux and the sediment settling down due to the depositional flux. For the mixture of cohesive and non-cohesive sediments we follow the assumptions based on the parameter of critical cohesive sediment fraction in the bed. Erosion of mixtures of cohesive (mud) and non-cohesive sediments (sand) is independent if clay content is below critical. Above critical clay content the bed behaves cohesively. In the non-cohesive regime exchange of sand and mud with bottom is independent, whereas in cohesive regime an erosion of mud and sand occurs simultaneously as cohesive sediment. The deposition is independent process for cohesive and non-cohesive sediments. Results of suspended sediment distributions in the Yellow Sea computed without wave and with wave have been compared with newly constructed GOCI images.

POC-P10 (13470)

Sea Ice Extent Retrieval with HY-2A Scatterometer data and its Assessment

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A sea ice extent retrieval algorithm over the polar area based on scatterometer data of HY-2A satellite has been established. Four parameters are used for distinguishing between sea ice and ocean with Fisher's linear discriminant analysis method. The method is used to generate polar sea ice extent maps of the Arctic and Antarctic regions of the full 2013-2014 from the scatterometer aboard HY-2A (HY-2A-SCAT) backscatter data. The time series of the ice mapped imagery shows ice edge evolution and indicates a similar seasonal change trend with total ice area from DMSP-F17 Special Sensor Microwave Imager/Sounder (SSMIS) sea ice concentration data. For both hemispheres, the HY-2A-SCAT extent correlates very well with SSMIS 15% extent for the whole year period. Compared with Synthetic Aperture Radar (SAR) imagery, the HY-2A-SCAT ice extent shows good correlation with the Sentinel-1 SAR ice edge. Over some ice edge area, the difference is very evident because sea ice edges can be very dynamic and move several kilometers in a single day.

POC-P11 (13483)

The real-time warning system against rip currents occurred at Korean peninsula

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Starting with Haeundae Beach at Busan, Korea, in 2011, the Korea Hydrographic and Oceanographic Agency(KHOA) has been operating a real-time warning system against rip currents that occurred at some beaches at Korea peninsula. A rip current is a stream of seawater gathering in one place as the waves break down, and a narrow, fast stream of sea water quickly moves a sea urchin into a deep sea. Accordingly, the KHOA uses real-time observations such as the wave height, wave period and direction by ocean buoy and the sea level height of the tidal station and the forecast algorithms extracted based on the simulation data according to the oceanographic environment scenario. It is currently operating five new beaches in Busan Haeundae(2011), Chungnam Daecheon (2014), Jeju Jungmun (2015), Gangwon Gyeongpo (2016), and Busan Songjeong (2017). This notification and information system is available as a web page which shows observations, current velocity, tidal elevation, water temperature and 4 CCTV showing the each beach status. We also support SMS to coast guard, that include rip current risk rank, index, wave height, water temperature, wind speed and so on. KHOA supports this system to Korea coast guards and National rescue service and it helps their action a lot.

While it is impossible to eliminate the physical cause of the rip current, safety accidents can be prevented in advance by utilizing the system with improved predictive accuracy. In addition, using the in-flow forecast information, coast guards can quickly rescue swimmers caught in the rip currents.

POC-P12 (13487)

Seasonal and longer-term variation of the Kuroshio temperature and salinity based on repeat observation along 138˚E

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The Kuroshio is a western boundary current in the north Pacific subtropical gyre, which flows northeastward off the southern coast of Japan Islands. Temperature or salinity change in long-term such as decadal or century scale in the north Pacific subtropical gyre has been reported based on some databases or Argo data by previous studies, but description about smaller time-spatial scale change is needed for the further understandings of the long-term variability. We will describe the time change of the Kuroshio temperature and salinity based on the data obtained by seasonally repeated observation along 138˚E (O-line) during 2000 to 2017. Temperature, salinity and density on the Kuroshio axis on the O-line shows the seasonal variability clearly in the upper layers with some phase-delay and amplitude-damping to deeper layers. The seasonal mean temperature at 10 m depth reaches the maximum (minimum) in August (March), and the mean salinity at 10 m depth reaches the maximum (minimum) in January (August). As to longer-term variation, annual mean temperature and salinity on the Kuroshio axis didn't seem to have a significant change for the observation period. The indicative isotherm for the Kuroshio axis was suggested to be 15˚C at 200 m depth according to Kawai (1969), whereas the mean temperature at 200 m depth below the surface geostrophic current maximum around the Kuroshio was estimated to be 15.5˚C.

POC-P13 (13488)

Reproducing the sea level in the last 30 years to predict in the Northwest Pacific using a numerical model

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The sea level of the Korean coast has risen at a rate of 2.96 mm/year since 1989 (KHOA, 2017), which is slightly higher than the global average of 2.0 mm/year by the IPCC (2013). Recently, the rate of sea level rise is accelerating with time, further implying rapid increase of sea level in near future. This study aims to predict rising trend of sea level using Regional Climate Ocean Model (RCOM) with ROMS. This model with high resolution of 1/20° horizontally and 40 layers vertically has been established for reproduction and long term forecast of sea-level rise in the Northwest Pacific, including marginal seas around Korea. To produce optimal boundary values for the RCOM, we evaluated six variables (i.e., RMSEs and trend of upper layer heat content, SST, and SSH) of 41 global climate model (CMIP5) results. EC-EARTH and NorESMI-M showed best performance in the Northwest Pacific and global ocean, respectively. However, ensemble mean of top seven model results is better than the one best model in the performance. In order to evaluate the performance of the RCOM, we have quantitatively evaluated the errors between the observation and the model results for last 30 years. According to the results, our RCOM well reproduced the seasonal changes of SSH, SST, salinity, and current velocities in the Northwest Pacific. It also well reproduced phenomena such as long-term change of SST, the trajectory of the Yangtze River diluted water, transport in the major straits. Future work will focus on predicting the next 100 years of sea level change based on IPCC climate change scenario (RCP 2.6, 4.5, 8.5).

POC-P14 (13494)

Impact of ARGO observation data on a sub meso-scale forecast based on ROMS

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Impact of ARGO float data on a short-term range forecast has been investigated. The Argo observation network is a major device to monitor some changes of ocean conditions above 2000m depth in real time. This has enabled the data to be routinely utilized as initialization tools of some eddy-resolving ocean forecast systems such as FRA-ROMS with a horizontal grid size 10km, which has been assimilated with satellite SSH/SST and hydrographic data by the 3D variational assimilation scheme, and this leads to effectively improve the forecast score on the meso-scale range. In this study, the sensitivity experiments has been carried out to assess the impact of ARGO data on a sub meso-scale model instead of meso-scale model such as the FRA-ROMS, which model is based on ROMS (Regional Ocean Modeling System) with a horizontal grid size 2km and a variational assimilation method south of Japan. Consequently, the introduction of the ARGO data enabled to finely represent hydrographic events such as the warm water intrusion and the propagation of frontal wave on the northern edge of the Kuroshio current and to remarkably improve the sub meso-scale on the short term range forecast (about 10days) in continental shelf region.

POC-P15 (13526) CANCELLED

Swell-dominant surface waves inherent in the coastal shape of rias bays facing the western North Pacific

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Real-time monitoring of wind and surface waves in Otsuchi Bay, a ria located in the northeastern portion of Japan, had been continued over four years since October 2012, using a mooring buoy with an ultrasonic anemometer and a single-mode GPS wave sensor. We analyzed two-dimensional energy spectra of the surface waves and the wind data monitored hourly, in order to elucidate the mechanism determining the variability of surface waves inside rias bays that face the western North Pacific. Regardless of season, surface waves inside Otsuchi Bay are predominantly affected by swells propagating southwestward, which are suggested to be originated mainly from the northeastern offshore region where the component of the wind velocity directed to Otsuchi Bay is correlated significantly with the significant wave height observed inside the bay. Moreover, the significant wave height observed inside the other rias bays close to Otsuchi Bay reveals also a significant correlation with the component of the offshore wind velocity toward each bay. Interestingly, the significant correlation distributes dependently on the direction extended from the mouth of each bay, indicating that the horizontal distribution of the offshore wind field which has dominant effects on coastal surface waves in the rias bays depends heavily on the topographic shape of the bay.

POC-P16 (13539)

Features of cyclonic activity over the Pacific Ocean and the Far Eastern Seas in spring and summer in 1995-2015

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A comparison was made of the average annual quantity and intensity of cyclones for different areas of the Asia-Pacific region: the Japan, Okhotsk, Bering Seas, the Kurile area, the northern part of the Pacific and off the east coast of Japan. It turned out that the highest values both repeatability and intensity of cyclones in warm seasons is observed in the east of the Bering Sea, also over the ocean and near Japan. The lowest cyclonic activity in warm seasons is observed over the Sea of Japan.

From the mid-1990th to the mid-2010th the frequency of cyclones over the Pacific Ocean and east of Japan increased, but they became less deep. On the contrary, over all the Far Eastern Seas, the number of cyclones gradually decreased, and the intensity increased. The reason for this was the formation over the Commander Islands of an area of increased atmospheric pressure (positive hPa anomalies). As a consequence, the cyclones became active to the west and east of this area, special over the Sea of Okhotsk and the eastern regions of the Bering Sea.

In different areas, the effect of cyclones on the thermal regime is not the same. In the Okhotsk and Japan Seas, in the Kurile region, deep cyclones cause an increase water temperature, in the Bering Sea and in the Pacific Ocean they contribute to a cooling of the thermal regime.

POC-P17 (13563)

Climate-related decadal sea level and heat content shifts in the tropical Pacific

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Since the early 1990s, sea level trends in the western tropical Pacific (WTP) have risen rapidly and trends in the eastern tropical Pacific (ETP) have fallen slowly or been near zero. However, the sea levels were flipped into a downward trend in the WTP and an upward trend in the ETP over the recent few years. In order to identify whether this trend reversal is a short-term shift associated with the strong El-Niño (2015/16) or a long-term shift associated with Pacific decadal oscillation (PDO), we used an ensemble empirical mode decomposition method that decomposes the signal into ones with different time scales. Our analysis showed that the recent sea level shift is closely associated with a weakening of trade winds, which is consistent with a PDO shift to a positive trend around 2011. We also used an ocean circulation model to determine how the ocean dynamically responds to the climate-related surface wind forcing. The model results showed that the recent weakening of trade wind played an important role in the decreasing (increasing) of the upper-ocean heat in the western (eastern) tropical Pacific during the past few years due to ocean dynamics. Additional model experiment demonstrated the dynamical responses of decadal ocean heat redistribution and sea level fluctuation to climate-related wind forcing.

POC-P18 (13564)

Effect of surface gravity waves on upper-ocean mixing in the northern East China Sea in summer using an ocean-wave coupled modeling system

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Vertical mixing in upper oceans can affect the vertical temperature distribution and mixed layer depth, which plays a key role in air-sea interaction exchanging the heat and moisture in the air-sea interface. The vertical mixing may be influenced by many factors including the wave-induced procedure such as Langmuir circulation, Stokes-Coriolis, and breaking wave. In a numerical simulation, it is important to consider the effect of waves on vertical mixing for accurate modeling of the temperature distribution in the upper ocean. In this study, we aim to evaluate the effect of breaking wave on the upper-ocean thermal structure using an ocean-wave coupled modeling system. The simulation results were compared to the in-situ observations which were conducted in the northern East China Sea in summer 2017. In the ocean model, the breaking wave-induced vertical mixing was incorporated as the flux of turbulent kinetic energy (TKE) in vertical mixing scheme. The numerical experiments with and without wave effect revealed a significant enhancement of vertical mixing with a deepening mixed layer depth when the breaking wave effect was considered. Moreover, a sensitivity experiment for two different parameterizations of the breaking wave effect through the TKE were performed; one is wind-based TKE flux from an ocean model and the other is based on the wave dissipation-based TKE flux from a coupled wave model. The comparison results show that the breaking-wave effect prescribed by the wave dissipation energy from a wave model can simulate more realistic upper-ocean temperature structure by generating a stronger TKE flux than the wind-based parameterizations.

POC-P19 (13604)

Decadal salinity variation in the western North Pacific correlated with the North Pacific Gyre Oscillation and the strength of the Kuroshio Extension

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Decadal changes in salinity around the density (~26.8), of North Pacific Intermediate Water (NPIW) were investigated in the north regions of the Kuroshio Extension (KE), based on the long-term-data-sets provided from numerical reanalysis and shipboard observations. Focusing on the decadal variation of KE stability calculated from the zonal average (142–165°E) of the meridional gradient of the sea surface height (34.5–37.0°E) as the KE strength (KES), and we made lag-correlation analysis between the salinity and KES concerning the observational lines. The results showed that signals of significant negative correlation appeared around the density from Hokkaido to the north region of KE. Based on the reanalysis data provided by an ocean forecast system of the Japan Fisheries Research and Education Agency (FRA-ROMS; 1992–2012, horizontal resolutions of 0.1°), we found that the prominent signals of the negative anomalies at the density moved from Sanriku to the north region of the KE (to the downstream) with the increase of the lag. KES was significantly correlated with NPGO with 2-years-lag. While previous studies focused on the relationships between KE strengths and changes south of the KE, the changes north of the KE revealed in this study also might modify the decadal changes around the KE.

POC-P20 (13605)

Instrumental observations in Peter the Great Bay during more than 100 years: What changed?

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There are used data and information sources since 1887 on 2017 included in POI FEB RAS DBs. There is carried out the comparative analysis of vertical and spatial distributions of hydrological parameters for available years or bunched years. There are created and comprehensively investigated some various extent time series for some Peter the Great Bay subregions. As a result there is estimated variability of environmental conditions year by year and decade by decade. There are revealed the key external factors that shape a change and extent of their influence on the marine environment – from local to global.

POC-P21 (13701)

Spatio-temporal fusion of multi-resolution satellite sea surface salinity (SSS) products using Bayesian Maximum Entropy method

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Sea surface salinity (SSS) is an important parameter to understand the uncertainties for forecasting El Nifio-Southern Oscillation, global warming, and other climate variations, yet its remote estimation, especially in coastal waters, has been difficult because satellite sensors lack sufficient resolution and coverage. Integrating multiple SSS products is an effective way to improve the spatial resolution and completeness. The Bayesian Maximum Entropy method, a nonlinear geostatistical methodology, is applied to blend the satellite SSS derived from the SMOS and the Aquarius/SAC_D. The SMOS SSSs are processed as probability soft data and the Aquarius/SAC_D SSSs are taken as hard data. Two kinds of SSS data are then merged in the BME paradigm to produce SSS with a spatial resolution of 8 km and a temporal resolution of 24 hours. The merged SSSs are validated by using the Argo records and the comparison shows that the merged SSSs are accurate and the bias and root-mean-square errors for the comparison are 0.3 psu and 0.62 psu, respectively. In addition, the blended SSS dataset has a complete spatial coverage. The results demonstrate the blending potential of BME for multiple scales satellite derived products integration.

POC-P22 (13739) CANCELLED

Ocean environmental monitoring using a wave glider

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Continuous observation under the extreme condition give the chance the understanding the process of air-ocean interaction. Recently, from the new technology, we can measure the extreme sea conditions far from the coast. The unmanned surface vehicle, a wave glider, is a hybrid vehicle that consists of a surface float and a submerged glider tethered to it by an umbilical cable. It measured continuous observation with various onboard atmosphere and ocean sensors and control the location and data remotely and in real time with satellite communication. We used the wave glider to monitor the effect of the Typhoon Talim (Sep. 9 – Sep. 18, 2017), which have 940hPa and max. wind speed 47m/s. It started to grow as it headed northwest and developed into a typhoon as it changed the track with northeast (Sep. 15, 2017). According to the best track data provided by ECMWF, we started the deployment of the wave glider into the track of typhoon. The wave glider made its closest approach to Typhoon at around Sep. 16-17, 2017. The atmosphere pressure dropped into 995hPa, wind speed was up to 25 m/s, and significant wave height was 9.1 m. However, we need more analysis retrieved from raw-data of the wave glider but this experiment provides a new study of atmosphere-ocean interaction process in a typhoon.

POC-P23 (13744) CANCELLED

Extended ferry based monitoring lines in the western PICES Area

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The Ferry based monitoring is an automated system for measuring of physical and bio-geochemical parameters in surface waters. It is mounted on 'ships of opportunity', such as ferries or container ships, on their regular routes across the Sea or on shore-based installations. Water is pumped from a subsurface inlet into the measuring circuit of multiple sensors. Data are transmitted and made available after each transect via the Internet.

An instrumented ferry made two transects per day across two current systems which are the northward East Korean Warm Current (EKWC) and southward North Korean Cold Current (NKCC) since August 2012 from Gangneung to Ulleungdo in the southwestern boundary area of the JES. Another route from Incheon to Bakryeongdo in the middle eastern boundary area of the Yellow Sea also made transects since February 2016. Sea surface water properties of these transects were measured with high spatial and temporal resolution for an extended period of time.

In recent, we have established 4 monitoring ferry routes such as Jeju Strait, Donghae(Korea)-Vladivostok(Russia), Donghae-Sakaiminato(Japan) and Busan(Korea)-Simonoseki(Japan). The principal goal of this ferry based monitoring is the construction of a long-term observatory within the NEAR-GOOS and western PICES area.

POC-P24 (13764)

Evaluation of mixed layer depth in the northern Indian Ocean simulated by CMIP5 climate models

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Many studies have been extensively using the fifth Coupled Models Intercomparison Project (CMIP5) experiments to investigate the climate variability and its future change both of which are crucial for developing the mitigation and adaption strategies. In this study, we examine the mixed layer depth (MLD) simulated by 19 CMIP5 models in order to find the underlying bias dynamics that might lead to inaccurate climate prediction over the northern Indian Ocean (NIO). All models show a systematic deep MLD bias in winter especially in the northern Arabian Sea (NAS) where the deepest bias is situated. The relationship of MLD with related variables showed that cold surface air temperature bias accompanied by north-easterly winds from the landmass northern of the Arabian Sea plays an important role on the bias development. This cold bias leads to more intense surface cooling over the NAS in winter, indicated by overestimation of wind stress and evaporation, and the underestimation of sea surface temperature, air surface temperature, and net heat flux which are favourable for MLD deepening. In addition, we also found a tendency of upper layer stratification of each model that seems to have a secondary role to control MLD from excessive deepening. Our findings suggest that improvements in atmospheric forcing parameterization of CMIP5 models, especially surface air temperature bias, may have a significant impact to reduce the deep MLD bias over the NAS.

POC-P25 (13792)

70 year long time series analysis of Bute Inlet water properties in British Columbia

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Bute Inlet is a typical fjord along the west coast of British Columbia where oceanographic data have been collected since the 1950s. But Inet is about 75 km long and has an average width of 4 km, a maximum depth of 650m and a 370m depth sill at its mouth. At the surface, the fjord water properties are influenced by incoming freshwater from the Homathko and Southgate Rivers, which create highly stratified waters. River runoff is generally stronger over the spring and summer and reduced over the winter. At deeper depth, waters are more influenced by the saline waters coming the Strait of Georgia at the mouth of the Inlet. We present the temperature, salinity and dissolved oxygen concentration temporal variability at different depths and distinguish their seasonal, inter-annual and long term variability. The result time series is a combination of the Pacific Ocean group (1948), University of British Columbia (1950-1993), the Institute of Ocean Science (1998-2013), the Pacific Biological Station (1998-2016) and the Hakai Institute (2017-2018) datasets. Together, these data are examined to gain a better understanding of physical properties in Bute Inlet and how these may have changed over time.

POC-P26 (13802)

Interannual to decadal variability of the upper-ocean heat content in the western North Pacific and its relationship to oceanic and atmospheric variability

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Three-dimensional oceanic thermal structures and variability in the western North Pacific (NP) are examined on the interannual to decadal time scales and their relationship to oceanic and atmospheric variability is discussed by analyzing observation and reanalysis data for 45 years (1964–2008), which is much longer than the satellite-altimetry period. It is shown that the meridional shift of the Kuroshio Extension (KE) and subarctic frontal zone (SAFZ) is associated with the overall cooling/warming over the KE and SAFZ region (KE–SAFZ mode). It appears, however, that changes in KE strength induce different signs of thermal anomalies to the south and north of the KE, not extended to the SAFZ (KE mode), possibly contributing to noncoherent variability between the KE and SAFZ. Thus, the KE and SAFZ are dependent on each other in the context of the KE–SAFZ mode, while the KE is independent of the SAFZ in terms of the KE mode. This intricate relationship is associated with different linkages to atmospheric variability; the KE–SAFZ mode exhibits a relatively fast response to the large-scale wind stress curl forcing in the NP, whereas the KE mode is related to a delayed response to the atmospheric forcing via jet-trapped baroclinic Rossby wave propagation. It is suggested that further knowledge of the underlying mechanisms of the two modes would contribute to understanding ocean–atmosphere feedback as well as potential predictability over the western boundary current region in the NP.

POC-P27 (13834)

Evolution of chemical properties in the bottom shelf water during its movement across the shelf of Peter the Great Bay

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Chemical properties of the Bottom Shelf Water (BSW) were investigated on the section across the shelf of Peter the Great Bay in March 2018. During BSW movement across the shelf, its temperature had increased in 0.15°, salinity decreased in 0.14‰, oxygen content increased in 0.22 mL/L, pH increased in 0.69, nutrients concentrations increased (Si in 10.81 μM/L, DIP at 0.22 μM/L, DIN at 0.48 μM/L), total organics content decreased in 1.7 mg /L, and total iron content decreased in 0.005 mg/L. The oxygen change was conditioned by its consumption to oxidation of organics and its influx from the upper layer. This two components are evaluated separately with a 2D model of BSW transformation based on the mixing mechanism. The nutrients behavior in BSW was analyzed, too. The nutrients concentrations changed disproportionately to oxygen content. High biochemical consumption of oxygen in initial stage of BSW movement was reasoned by high content of organic matter in the coastal waters and bottom sediments, but this loss of oxygen was mainly compensated by mixing during further movement. There is concluded that independently on biochemical consumption the oxygen content in BSW on the lower shelf is rather stable and high, so efficiency of the Japan Sea bottom layer ventilation depends mostly on volume of BSW that reaches the shelf edge and cascades down the slope. In the case of winter 2018, BSW did not reach the shelf edge, so the bottom layer was not ventilated.

W1: Ecological roles of gelatinous zooplankton: Evaluation, integration and future prospects in a more gelatinous ocean

W1-P1 (13554)

Ecological impact of jellyfish fishery on symbionts of jellyfish in Thailand

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In Thailand, two large-sized rhizostome species, *Rhopilema hispidum* and *Lobonemoides robustus*, are commercially harvested. These jellyfishes frequently harbor shrimp scads *Alepes djedaba*, Christ crabs *Charybdis feriata*, caridean shrimps *Latreutes anoplonyx*, and ophiuroids *Ophiocnemis marmorata*. Fishermen use gears such as coarse-meshed scoop nets and hooks to catch these jellyfishes which resulted in, escaping out some of the associated fish juveniles through the mesh. However, they seem to pay no attention to the symbiotic invertebrates during the fishing. Especially, almost all ophiuroids are probably killed by jellyfish fishing, because they are firmly attached to the host with terminal hooks of the arms. The negative effect of jellyfish fishery on these symbionts was estimated based on the ecological data of the jellyfish and their symbionts obtained from a field survey, and the FAO statistics. The results indicated that the most affected symbiont invertebrate was *O. marmorata*, which was estimated to be killed at the rate of 12-16 million individuals per year by the jellyfish fisheries in Thailand. It is likely that such a by-catch killing greatly influences the benthic communities. For conservation of marine ecosystems, new alternative collection methods should be proposed.

W1-P2 (13606)

Morphological and molecular examination of *Aurelia* sp. in Orido Bay, Japan

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Molecular studies have revealed that the semaeostome jellyfish, *Aurelia aurita* s. l. includes 11 cryptic species. Among them, *Aurelia* species distributed in Japan (e.g. Tokyo Bay) was treated as "*Aurelia* sp. 1". Recently, Scorrano et al. (2016) examined *Aurelia* spp. in the Mediterranean Sea using both morphological and molecular methods, and concluded that *Aurelia* sp. 1 was identified as *Aurelia coerulea* von Lendenfeld. Orido Bay is located in the Pacific coast of Japan, and medusae of *Aurelia* sp. can be abundant during the summer. We carried out the detailed morphological examinations in three lifecycle stages, i.e. polyps, ephyrae, and medusae, of *Aurelia* sp. found in Orido Bay to compare them with those reported in Scorrano et al. Molecular analysis was also made to identify this Japanese *Aurelia*. Among the 19 morphometric measures used in Scorrano et al., 8/14 in medusae, 3/3 in polyps and 2/2 in ephylae showed the closest values with those in the Mediterranean *A. coerulea*. Moreover, both number of lappets and the color of bell margin were fit with those in *A. coerulea*. Phylogenetic analysis based on the COI sequences using a neighbor-joining method indicated that all individuals in Orido Bay belonged to the same single-clade with those in *Aurelia* sp. 1 from other part of Japan, the Mediterranean, and the United States, and were different from other *Aurelia* sp. (sp. 2–10 and *A. aurita*). Those results suggested that *Aurelia* sp. in Orido Bay were both morphologically and molecularly same species with the Mediterranean *A. coerulea*.

W1-P3 (13619)

Degradation of gelatinous zooplankton carcass by microbial community in seawater

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Blooms of gelatinous zooplankton have occurred in various locations, however, effects of these blooms on ecosystem and biogeochemical cycles in the ocean have not been revealed well, especially for microbial degradation process of the carcass and their effect to microbial community. Here, we report rapid degradation and utilization of carcasses of two gelatinous zooplankton, *Aurelia coerulea* (Cnidaria) and *Beroe cucumis* s.l., (Ctenophora), by microbial community in seawater.

We conducted microcosm experiments to monitor microbial degradation of these carcasses. A piece of carcass of *Aurelia* (8–13 g/L) or a whole body of *Beroe* (2–3 g/L) was put into freshly collected seawater including natural microbial community, and incubated. During the experiments, water samples were subtracted to measure organic carbon concentration (OC), abundance and community structure of prokaryotes, and extracellular protease activities in the water.

In the microcosms with carcass, 1) OC was much higher than that in the control at the beginning and decreased with time, 2) prokaryotes increased drastically during the first several days, 3) extracellular protease activities were much higher than the control at the early stage, 4) different bacterial taxa were dominant between *Aurelia* and *Beroe* bottles, 5) taxonomic succession was observed in prokaryotic community, 6) unidentified heterotrophic unicellular eukaryotes increased at the mid-stage of the experiment of *Aurelia*. These results suggested that carcasses of these gelatinous zooplankton supplied immediate available organic matters for bacteria, and as a consequence, not only bacteria but also whole microbial community in seawater were activated via microbial food web.

W1-P4 (13641)

Carbon distribution strategy of *Aurelia coerulea* polyps in the strobilation process in relation to temperature and food supply

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Strobilation directly determines the initial population size of adult jellyfsh, but energy distribution during the strobilation process is not well understood. The di□erent stages in the strobilation process, including polyp budding, strobilation and body growth, were investigated at six temperature levels (8, 10, 13, 15, 17 and 19°C) and fve food supply levels (0, 30, 60, 100 and 150 μg C/L). The results showed that the duration of strobilation preparation stage (SP) remarkably decreased with increasing temperature. Food level positively a□ected the production of buds and ephyrae and the body growth of parent polyps. Of the six temperatures tested, 13°C was optimal for strobilation. At 13°C, strobilation activity was enhanced, and this treatment resulted in the greatest energy distribution, highest ephyrae production and longest duration of strobilation stage (SS). Polyps tended to allocate 6.58%–20.49% carbon to buds with sufcient food supply regardless of temperature. The body growth of parent polyps was highest at lower temperatures and higher food levels. This study is the frst to provide information on carbon-based energy distribution strategy in the polyp strobilation process. We concluded that budding reproduction is a lower-risk strategy for *A. coerulea* polyps to increase populations. Even during strobilation season, polyps prioritize budding, but at the optimal strobilation temperature, polyps utilize a portion of the energy stored for budding to release ephyrae. The body carbon content of parent polyps may be considered as strategic energy reserves, which could help to support budding activities and strobilation during harsh conditions.

W1-P5 (13642)

Jellyfish fauna changes before and after 2011 Tohoku earthquake and tsunami in southern part of Sanriku coast, Iwate, Japan

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The Great Tsunami also disturbed seafloor and much of Tsunami debris flowed out. We have been studying seasonal occurrence of jellyfishes in Ofunato bay and Okirai bay in southern part of Sanriku coast, Iwate, Japan since 2008. In 2012, jellyfish fauna was almost same before the tsunami. After recovery and reconstruction of fishing ports or coastal facilities and for coastal safety began from late 2012, however, occurrence of jellyfish fauna have been changed. *Eutonina indicans* and *Tiaropsis multicirrata* in Ofunato bay and *Nemopsis dofleini* in Okirai bay did not appear. Much of *Cladonema paficica* occuured on the gross seaweed on new walls of piers in Okirai bay in 2014. Jellyfish fauna in 2015 was similar that in 2014, however, bloom of a species like *Cl. pacifica* was not observed. This regulation may be caused by the increase of biodiversity of sessile organisms on the walls of pier and finish the construction of fishing ports. Reconstraction of fishing port finished in 2015. From 2016, *N. dofleini* was observed in Okirai bay. From 2017, *Eutonina indicans* observed and *Sarsia tublosa* and *Dipleurosoma typicum* ocuured as before earthquake in Ofunato bay. A parasitic sea anemone, *Peachia quinquecapitata* was observed on the subumbrella of *Aequorea coerulescens* for the first time since 2012. Jellyfish fauna occurrence was affected seriously not so much by the tsunami as by human activity such as recovery and reconstruction of coastal area.

W6: Regional evaluation of secondary production observations and application of methodology in the North Pacific

W6-P1 (13302)

Zooplankton secondary production in high nutrient low chlorophyll (HNLC) and seasonally productive regions in the North Pacific

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Zooplankton play a key role in marine food webs, linking primary producers and commercially valuable fisheries. The rate of increase in biomass, which is dependent on growth and mortality, is referred to as zooplankton secondary production. Because ecological rate processes (i.e., growth and mortality) are largely size and temperature dependent, zooplankton secondary production can be measured using biomass size spectra (distribution of biomass by body size). We analyzed zooplankton samples from the Fisheries and Oceans Canada (DFO) long term monitoring voyage (Line P), which were collected over three seasons (winter, summer and fall) from 1995-2017. Samples were run through a laser optic particle counter (LOPC) in the laboratory to produced normalized biomass size spectra (NBSS). NBSS were then used to quantify zooplankton production along Line P by first empirically deriving growth rate, and then applying NBSS to predict mortality rate. Preliminary estimates of abundance, biomass, growth, mortality, and secondary production over the past two decades will be presented. Zooplankton secondary production ranged from 0.06 to 15 $mgCm^{-2}day^{-1}$ along Line P. These results were used in combination with environmental parameters to model and predict climate driven changes in the pelagic ecosystem along Line P. This project is part of a strategic National Sciences and Engineering Research Council (NSERC) grant in collaboration with DFO, the University of Victoria, the University of British Columbia, the Hakai Institute/Tula Foundation, Sir Alister Hardy Foundation and Oregon State University.

W6-P2 (13465)

Estimation of egg production rate of *Calanus sinicus* from preserved samples

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Calanus sinicus is one of the dominant planktonic copepods in coastal zooplankton communities and plays important role of the secondary production in the mid latitude area of the Northwestern Pacific. In a congeneric species of *Calanus finmarchicus*, Niehoff and Runge (2003) reported that egg production rate (EPR) can be predictable from gonad development stages (GS) of formalin-preserved female specimens. In this study, to estimate EPR of *C. sinicus* from GS, we investigated season changes in both *in situ* EPR by 24 hrs female incubation experiments and GS of the adult female in formalin-preserved samples collected at the same time. The experiments and sample collections were conducted every moth during 2 years from March 2014 and April 2016 in Sagami Bay, Japan. Using the monthly formalin-preserved samples, we measured prosome length (PL) of each adult female and frequencies of GS4, i.e., matured gonad stage, females (GS4%) in each sample. Monthly averages of *in situ* EPR, GS4% and PL varied from 0 to 44.9 egg $female^{-1}$ day^{-1}, 0 to 75.9% and 1.95 to 2.44 mm, respectively. From a step-wise multiple regression analysis, our EPR prediction model for *C. sinicus* was proposed as follows;

$$EPR = 0.43 + 24.12GS4\% - 1.53T + 19.34PL,\ R^2 = 0.46,\ (T = \text{Ave. water temperature}).$$

Our result suggests that the model would be useful to restore past secondary production of *C. sinicus* from preserved long-term monitoring samples collected around the East Asia areas. (230 words)

W6-P3 (13468)

Diel rhythm of egg spawning of the planktonic copepod *Calanus sinicus* in Sagami Bay, Japan

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Calanus sinicus and other congeneric species are dominant zooplankton in mid and high latitude oceans around the world. Several authors reported that these *Calanus* species spawned their eggs during nighttime. In the Seto Inland Sea, *C. sinicus* is known to spawn mainly from 2200 to 0600. However, in Sagami Bay, our recent preliminary study raised possibility that *C. sinicus* spawns eggs during both day and night. To investigate the possibility, this study examined seasonal changes in egg production rates (EPR) and egg spawning rhythms of *C. sinicus*. Sample collections for EPR experiments were conducted from April 2017 and February 2018 in Sagami Bay. After starting each 24-hrs EPR experiment in the afternoon, we counted and transferred spawned eggs at 1800, 0600 and the end of each experiment. The mean of EPR during the study period was 20.65 egg/female/day, which varied from 41.26 (April, 2017) to 1.00 egg/female/day (February, 2018). The mean of clutch (no. of eggs in each spawning event) was 20.91 egg/female and the highest and lowest values were 63 and 1 egg/female, respectively. The mean values of EPR in day or night were 10.38 and 10.24 egg/female/12-hrs, respectively. Twenty inds. of the females spawned only in day and 36 inds. spawned only in night. Forty-three inds of the females spawned both in day and night. Among the sampling moths, a significant difference of EPR between day and night was only found in August 2018. Our result suggests that *C. sinicus* might not have a diel rhythm of egg spawning.

W6-P4 (13782)

Individual growth rate (IGR) measurements negatively correlate with aminoacyl-tRNA synthetases (AARS) activity in North Pacific krill, *Euphausia pacifica*

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Zooplankton growth is an important parameter, e.g., in determining secondary production and ecosystem functioning, but is extremely difficult to estimate *in situ*.

Aminoacyl-tRNA synthetases (AARS) are enzymes that catalyse the first step of protein synthesis, and an AARS activity assay has been developed to estimate zooplankton growth rate quickly and easily. In this study we estimated growth rate of adult female North Pacific krill, *Euphausia pacifica*, collected in Puget Sound, WA, using individual growth rate (IGR) experiments and AARS activity assays on the same individuals. In this application, growth rate estimated with IGR showed the expected negative relationship with body size (smaller adults grew faster than larger adults when normalized to size), while growth rate estimated with AARS activity showed a positive relationship with body size, leading to a negative correlation between the two measures of growth. Other studies have found a correlation between AARS activity and growth rate, but often relied on experimentally manipulating growth rate through large changes in temperature or diet. This is the first time the AARS method has been used to determine *in situ* growth rates of individual zooplankton to our knowledge. In light of our results, we encourage discussion of the biochemistry underlying the AARS activity assay, the relative errors and time scales of the different metrics, and suggest the AARS assay should be used with caution for this application.

W8: Taking Stock of Marine Ecosystem Services in the North Pacific—exploring examples and examining methods

W8-P1 (13277)

An index to assess the health and benefits of the global ocean

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The ocean plays a critical role in supporting human well-being, from providing food, livelihoods and recreational opportunities to regulating the global climate. Sustainable management aimed at maintaining the flow of a broad range of benefits from the ocean requires a comprehensive and quantitative method to measure and monitor the health of coupled human–ocean systems. The Ocean Health Index, which is used to comprising ten diverse public goals for a healthy coupled human–ocean system and calculated the index for China. The index provides a powerful tool to raise public awareness, direct resource management, improve policy and prioritize scientific research.

W8-P2 (13593)

Economic value of ecosystem services and utility of coastal fisheries in Indramayu, Indonesia

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Ecosystem provide benefit to people as a variety of services. Services from coastal aquatic systems, such as lagoon and estuaries, associated to coastal forests is essential for coastal fishers' livelihoods. Especially, the contributions from coastal mangrove forest cannot be negligible for coastal fishing and fisheries communities in tropical and subtropical coast of the Pacific Rim. We aim to quantify services from coastal aquatic ecosystem to small-scale fishing community, especially with mangrove and coastal aquatic vegetations. The selected model area, a local village in the western Indramayu, Indonesia is under influence of the coastal environmental changes and industrialization in recent years, and fishers concern sustainability of their fishing and households. Younger fishers prefer to continuously have benefits that they have received from the environment around lagoon, but they are not sure to be satisfied from the changing environment and lives with fishing in the recent urbanization. In the FishGIS project, we involved local fishers to examine the environment with fisheries then have made efforts to find sustainable future alternatives based on the scientific knowledges from the North Pacific and the economic utility of local fishers. The present and future ecosystem services to the community should be quantified with fishers, and sustainable alternatives should be explored with their satisfactions. We also compare among the economic utility before the project activities, the economic utility after the project activities and the utility in expected future alternatives.

General Poster Session

GP-P1 (13337) CANCELLED

Temperature mediated effect on productivity-diversity relationship in marine pelagic ecosystems: a modeling study

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The global diversity crisis driven by climate change has generated great concerns about the influence of diversity on ecosystem functioning and has motivated to explore the relationships between diversity and productivity in marine pelagic ecosystems. Generally, on a global scale, productivity-diversity relationship (PDR) of plankton has been suggested to be unimodal. However, empirical studies have identified various PDR patterns on a local scale and the underlying mechanisms remain unclear. To overcome the scarcity of observation data and to address the local PDR patterns, we use a size-structured global ecosystem model including a multi-trophic plankton community and temperature traits. The results show that local temperature fluctuation differently affects the biological rates of different trophic levels and modulates the ecological interactions. These temperature-mediated changes in interaction strength and abundances of interacting species lead to changes in the magnitude of local top-down control and the local community composition, eventually resulting in various PDRs (e.g. the peak diversity shifts from low to intermediate to high productivity depending on whether the magnitude of top-down control is low, intermediate or high). These results reconcile empirical findings and support the expectation of spatial heterogeneity in the response of biotic interactions to global warming.

GP-P2 (13340)

Age determination and growth estimation of the white-spotted conger eel, *Conger myriaster* (Brevoort, 1856) in marine waters of South Korea

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The present study is to provide the age and growth of the white-spotted conger eel, *Conger myriaster* in the Southern sea of Korea. This study investigated about age, growth and reproductive traits of the white-spotted conger eel. Samples were collected by trap, shrimp trawl and bottom trawl from April 2009 to November 2011 in Geoje Island.

Age validation is observed by UV light and the relative growth is estimated based on the total length, weight and otolith readings. The age structure is estimated by defining the relationship between otoliths measurements and age. The age of 212 otoliths ranged from 1 to 13 years. The age composition of congers in coastal water of Geoje Island is dominant from 1 to 3 years old while that in offshore of southern sea ranged from 3 to 13 years old. Conger eel showed a wide variation of total length in the same age composition. The parameters of von Bertalanffy growth function were estimated from three-methods by non-linear regression: back-calculation method, mean total length at age and otolith weight at age. The results of adjusted coefficient of determination nearly matched with estimated values for the three methods (r^2>0.97). The best fitted result was estimated as following VBGF parameters; L_∞=127.95 cm, K=0.102, t_0=-0.922.

Maximum oocyte diameter ranged from 50 to 430 μm. Reproductive traits of ovaries showed positive relationship between GSI and MOD in the regression of power function. It is suggested that oogenesis begins to develop from 4 years old at 45 cm TL.

GP-P3 (13352) CANCELLED

Modelling Environmental Impacts And Adaptation On Sustainable Climate And Marine Ecosystems In The North-Atlantic Coast

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The global climate change influence marine animals through the ocean warming, acidification and oxygenation. This has affected the socioeconomic aspect of acquaculture through changes in seawater chemistry, sediment transport, decrease in seawater pH (acidification) etc. The study was conducted in the Gulf of Guinea region of the North Atlantic which stretches from the Senegal in the West to Gabon to the South-Eastern part of Africa. It is home to a large number people and economic activities with over fifty (50) million African population. In order to ensure the preservation of preserving natural resources and marine ecological features, a modified methodological approached was developed to evaluate risk of marine ecosystem. The ASTER, MODIS and LANDSAT satellite images were acquired to extract emissivity and temperature and spatial modelling, that are in combination with historical estuary evolution and field observation was applied for effective management and conservation the ecosystem features of the area. It was then observed that the climate change impacts on aquaculture is highly predominant in tropical and subtropical climatic regions of the world, thus there is need to assess the implications of future scenarios in terms of climate change and research development in the areas of aquaculture. The recommendations from this research thus improve strategies and policy measures needed to fight the observable and projected climate change impacts on fisheries and aquaculture, so as to protect the livelihoods of the fishing communities and food security. Finally, Integrating the needs of fish famers and acquaculturists into adaptation planning is very essential.

Keywords : Influence, Climate, Population, Ecosystem

GP-P4 (13358)

The environmental analysis for sustainable seaweed aquaculture management in Ariake Sea, Japan

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The Ariake Sea is a semi-enclosed bay which has a length of 96 km, an average width of 18 km, a catchment area of about 1700 km^2 in the western part of Japan. The Ariake Sea is most important places in seaweed aquaculture and the over 50 percent of the total seaweeds yield in Japan. Thus, healthy and sustainable seaweed aquaculture production is most important. However, decline in production of seaweed has frequently occurred due to discoloration damage. And the discoloration damage is caused by effect of several reason; variation of water temperature or the duration of sunshine, decreasing of the amount of nutrient salts, influence of seawater from the open sea and occurring red tide and so on. Although a lot of observation data is being made in Ariake sea, the reason of seaweed discoloration has not yet been explained clearly. Because it has a difficult finding cause of discoloration since there are many parameters to consider when choosing for analysis. In spite of that Artificial Intelligence (AI) is excellent in analysis using the big data, such researches in coastal area are few. Therefore, for establishing sustainable seaweed aquaculture management, we examined the effect of using AI as new analysis approach.

GP-P5 (13366)

Fishery biology of whitespotted conger Conger myriaster in the Yellow and East China Seas

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The biological characteristics of whitespotted conger *Conger myriaster* were studied on the basis of samples collected from October 2016 to April 2017 in the Yellow and East China Seas. A total of 554 specimens were collected with ages ranging from 1+ to 6+ years. The individuals of 1+ to 2+ years old distributed in the coastal water of China Sea, and the elders preferred deeper waters. The parameters of von Bertalanffy growth equation L_{∞} and K were 947.60 mm and 0.249 yr^{-1}, respectively. The sex ratio of the samples was 96:3 (female: male) in the whole survey area, 88:0 in the East China Sea and 8:3 in the central Yellow Sea. The development of ovary ranged from peri-nucleolus stage to secondary yolk globule stage, and the testis of two males was at mid-meiotic stage. The gonads somatic index (GSI) increased with gonads development stage, wherein the fish begin migrating from coastal water towards southern and deeper waters. Crustacean was the major prey for conger of small length, and food source shift to fish with body growth. The ontogenetic diet shift of *C. myriaster* might be attributed to the nutritional demand of gonads development.

Key words: *Conger myrisater*, age and growth, gonad development, stomach contents

GP-P6 (13392)

Results of a long-term monitoring of the hatchery marked juvenile pacific salmon identification during autumn migrations in the basin of the Sea of Okhotsk

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The basis data pool for the analysis consisted otolith samples of juvenile pink and chum salmon, collected in 2011–2017 during autumn complex trawl surveys in the Sea of Okhotsk. The paper demonstrates results of a long-term monitoring of the hatchery marked juvenile Pacific salmon identified. Data analysis and generalization of the patterns of distribution and migration of hatchery juvenile pink and chum salmon in the Sea of Okhotsk in autumn was provided.

GP-P7 (13394)

Assessment of reproductive development in female Pacific halibut (*Hippoglossus stenolepis*)

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Current maturity estimates in female Pacific halibut are derived from macroscopic visual criteria of the ovaries collected in the field. In order to improve maturity estimates and to provide updated estimates of maturity-at-age, the International Pacific Halibut Commission (IPHC) is conducting studies destined to improve our knowledge on reproductive development in female Pacific halibut. In an initial study, Pacific halibut females from three geographical locations throughout the distribution range of the species were collected during the summer, or non-spawning season, and during the winter, or spawning season. Histological examination of ovaries of winter- and summer-caught females evidenced differences in oocyte size distribution and predominant oocyte stages that appeared to be relatively consistent with females sexually maturing in the winter and with females undergoing vitellogenesis in the summer, as a prerequisite for spawning in the winter. Current studies are devoted to describe the entire annual reproductive cycle of the species and to study in detail morphological, histological, endocrine and functional changes in both female and male gonads. These studies will lead to a better understanding of the temporal and spatial progression of sexual maturation in Pacific halibut females, and to a better estimate of maturity for stock assessment purposes.

GP-P8 (13395)

Identification of molecular growth signatures in skeletal muscle of juvenile Pacific halibut (*Hippoglossus stenolepis*) for monitoring growth patterns in the Pacific halibut population

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The International Pacific Halibut Commission has reported changes in the size-at-age (SAA) of Pacific halibut (*Hippoglossus stenolepis*) caught in the commercial fishery as well as in its own survey research for almost 100 years. However, our understanding of the potential causes for the long-term variability in SAA is still rather scarce. Although a number of factors could be contributing to this variability, recent analyses have suggested that temperature variation may have been a contributing factor to the observed changes in SAA in the Pacific halibut. Therefore, there is an urgent need to better understand the physiological effects of temperature on growth in this species. In order to address this issue, we have conducted studies investigating the transcriptomic effects of temperature on white skeletal muscle in juvenile Pacific halibut acclimated for 8 weeks to 2°C and 9°C. Acclimation at 2°C resulted in a significant reduction in the specific growth rate (SGR) of juvenile Pacific halibut when compared to fish acclimated at 9°C. At the end of this acclimation period, fish previously acclimated at 2°C were gradually brought up to 9°C and held at 9°C for 6 additional weeks. This resulted in a significant increase in SGR when compared to fish that were constantly held at 9°C. The transcriptomic responses of white skeletal muscle from fish experiencing temperature-induced growth suppression and growth compensation were analyzed by RNA sequencing (Illumina). The resulting molecular signatures of temperature-regulated growth will be useful to investigate potential changes in growth patterns in Pacific halibut.

GP-P9 (13396)

Electronically monitoring release method as a proxy for Pacific halibut discard mortality rates in the directed Pacific halibut longline fishery

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Due to regulatory requirements, all Pacific halibut that are of sublegal size in the directed fishery cannot be retained and must be returned to the sea with minimal injury. Through the process of capture and release, Pacific halibut incur a range of injuries and are subjected to a variety of factors that will affect their survival potential after release. Accurate understanding of the types and relative levels of injuries and stresses that Pacific halibut are exposed to during the discarding process in relation to the biological characteristics of the fish can be instrumental in helping better estimate the probability of mortality resulting from the discarding process. Discard mortality rates (DMRs; a measurement of potential mortality) in the Pacific halibut longline fishery are currently estimated from injury or vitality data obtained on observed trips. The small vessel (<57') longline fleet in Alaska is currently developing electronic monitoring (EM) capabilities, but determining vitality codes requires handling of the animal, something that cannot be achieved with cameras. EM provides information on hook release techniques for close to 95% of events, however the suite of injuries incurred by each hook release technique is unknown. We have conducted a field study to begin developing an injury profile for different hook release techniques with associated physiological condition measures, which could then be used to calculate DMRs on vessels carrying EM systems rather than observers. The results of this study will be used to further refine the estimation of DMRs by each hook release category.

GP-P10 (13397)

Effects of biocides of antifouling paints and by-products from vessels on embryos of a sea urchin, *Strongylocentrotus nudus*

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In this study, we aimed to assess the toxicity of biocides included in antifouling paints and by-products from vessels on embryos of a sea urchin, *Strongyrocentrotus nudus*. In this study evaluated toxicity on the 3 kinds of biocide (Sea-nine 211, Diuron, Irgarol 1051), wastes from a water jet cleaning from the R/V Eardo of KIOST and the waste extractions with MeOH. The fertilization rate of embryos exposed on biocides such as Diuron and Irgarol was more than 96% at the concentration of 1000 μg/L, but that exposed on the Sea-nine was less than 15% at the exposure concentration of 10 μg/L. The EC_{50} values of Diuron, Irgarol, and Sea-nine were 10.8 mg/L, 4.5 mg/L, and 8.1 μg/L, respectively. The fertilization rate of water jet was 79±5.8% at 0.001% solution, and the fertilization rate in 0.1% and 0.01% solutions were 0.4±0.6% and 0.2±0.5%, respectively, statistically different from the control. The water jet sample had a low fertilization rate of less than 50% even at 800-fold diluted solution with sea water (0.00125%). The extracts with MeOH showed 0% at all concentrations of 10%, 100%, and 1,000-fold dilutions and at 100,000-fold diluted solution, the fertilization rate reached at 90%. In the case of larval development test, normal hatching of over 80% was observed at the concentration of up to 1,000 μg/L of Diuron and Irgarol whereas normal pluteus larvae did not hatch at exposure concentrations of 100 μg/L of Sea-nine. The expected EC_{50} values for Sea-nine, Diuron, and Irgarol were 31.6 μg/L, 3.04 mg/L, and 2.35 mg/L, respectively. No normal pluteus larvae were hatched when exposed on the MeOH extract and the 1,000-fold dilution of the water jet samples. From this study, Sea-nine was the most toxic among three biocides but the antifouling paint deployed on the R/V Eardo of KIOST was also very toxic to the sea urchin embryos.

GP-P11 (13403)

The influence of moisture content on cloud growth when *Tropical Cyclones* occur in the maritime continent of Indonesia

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Indonesia, which is located in the equator, literally can't be crossed by *Tropical Cyclones*. This is due to the physical characteristics of *Tropical Cyclones* that always move away from the equator because of the influence of *Coriolis force*. However, by the end of 2017 and early 2018 there were anomalous occurrence of *Tropical Cyclones* such as Cempaka, Dahlia, and Flamboyan which grown at the same time in the territory of Indonesia. This encourages the authors to conduct the research which related to the occurrence of *Tropical Cyclones*, especially the moisture transport. Moisture transport has an important role in determining where the clouds form.

This research using data of ECMWF model and HMW-8 satellite IR imagery. The analysis includes the distribution and transport of surface water vapor, surface wind analysis, and distribution and cloud type analysis. The result can be concluded that the moisture content gives the impact for the growth of clouds (> 1000 kg/ms^{-1}). The movement and distribution of water vapor, clouds, and winds have the same pattern of moving toward to cyclonic vortex of *Tropical Cyclones*. The clouds is dominated by convective with top temperatures reached -70 ° C. The wind conditions showed very high speeds was up to 46 knots.

Key words: *Tropical Cyclones*, moisture transport, wind, cloud

GP-P12 (13413)

Integrated Assessment of Island Ecosystem in China

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A systematic assessment of island ecosystems in China has not been reported, and the knowledge on the Chinese islands is limited. In this study, we established an integrated island ecosystem assessment method with 34 indicators of 11 aspects, based on ecosystem characteristics, which was applied to assess the status of Chinese islands at a national scale, using 44 typical islands, based on the data from the project of Chinese offshore investigation and assessment (908 special project). The environmental quality index (I_{env}) ranged from 60.70 to 94.80. The main polluting chemical factors in the seawater surrounding the islands were inorganic nitrogen (DIN) and active phosphate (PO_4-P), whereas those polluting the intertidal organisms were Pb and Zn. The average value of the biological status index (I_{bio}) was 65.86. Main determining factors were vegetation coverage and marine biodiversity in the intertidal and subtidal zones. The average value of the landscape ecological status index (I_{land}) was 72.36. Anthropogenic exploitation affected the inhabited islands, and natural landscapes in large areas were transformed into artificial. The comprehensive index of island ecosystem status (CI (T)) varied (52.33 - 89.53), and the overall status was “good”. The anthropogenic disturbance intensity was among the key impact factors. The large islands close to the mainland had a worsened status due to the longer and more intensive exploitation, unlike the smaller and located farther.

GP-P13 (13414)

Assessing the vulnerability on fishes in the Yellow Sea and Bohai Sea

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The Yellow Sea and Bohai Sea is an important fishing area in China and plays vital role in supporting fish immigrations such as spawning, feeding and overwintering. Using data from bottom trawls during 2014-2015, we assess the vulnerability on fishes in the Yellow Sea and Bohai Sea. Here, we identified 31 species that contributed over 95 % of the total relative resources density among which 9 were pelagic and 22 were demersal. For each species, the sensitivity, adaptive capacity and vulnerability were calculated respectively using the methods of fuzzy logic expert system. Four levels were divided regarding vulnerability including low, moderate, high and very high. Among the 31 species, *Lophius litulon* (Jordan 1902) and *Muraenesox cinereus* (Forsskål, 1775) were found to have the vulnerability of very high while *Engraulis japonicas* Temminck & Schlegel 1846 and *Erisphex pottii* (Steindachner 1896) had the low level. The average index of vulnerability for demersal species was 42, which was higher than that (30) for pelagic species.In subsequent study, factors such as climate change and fishing pressure will be taken into consideration in the future assessment to help us obtain a better understanding of the potential effects that climate change and human activities have on fishery resources.

GP-P14 (13420)

Ocean deoxygenation enhances the efficiency of CO_2 concentrating mechanisms in a diatom with stimulated photosynthetic performances

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Oxygen is essential to respiration of most marine organisms. However, the oxygen content of seawater has been being declining both in open oceans as well as in coastal waters, known as deoxygenation, during past decades as a consequence of global warming and coastal eutrophication. As a result, the oxygen minimum zone is expanding. Deoxygenation is likely to have severe effects on most marine organisms, but it is still unknown how O_2-evolving primary producers will respond to such climate forcing. Here, we show that the diatom *Thalassiosira weissflogi* grows faster, respires less and evolves more O_2, with its CO_2 concentrating mechanisms (CCMs) significantly up-regulated, under experimental deoxygenation conditions. Such stimulation of CCMs are associated with inhibition of photorespiration, a consequence of Rubisco-catalyzed carboxylation and oxygenation shifting to favor CO_2 fixation, that in turn enhances photosynthesis and net O_2 production. Our results imply that marine primary producers can benefit from ocean deoxygenation, therefore playing a counteractive role against it.

GP-P15 (13429) CANCELLED

Coastal fishing of Pacific halibut (*Hippoglossus stenolepis*) and its prospects of development in the Asian part of the areal

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In the far East of Russia, from the beginning of 90-s of the last century, there were repeated attempts of the organization of specialized coastal fishing for pacific cod, atka mackerel and Pacific halibut. In each of the regions the definite methods of coastal fishing of characteristic and most accessible species of hydrobionts often any one species were developed. For example, it`s longline and net fishing of atka mackerel in Avacha Gulf of the coast of Kamchatka or longline fishing of Pacific halibut in the Karaginsky Gulf (Western part of the Bering sea) and Pritauysky region (Eastern part of the Okhotsk sea).

The attempts to organize fishing of Pacific halibut in the coast of the Kamchatka, the Magadan region, the Kuril Islands and Chukotka were made with different intensity in the researched period, and they are currently continuing. Inspite of the high performance in some local areas and in a certain season (summer and autumn), specialized coastal fishing of Pacific halibut has not acquired the character of stable fishing. Such fishing of the coast of Kamchatka and in the other nearby regions is implemented episodically, and the main part of Pacific halibut in the coastal waters of Kamchatka is caught now, as before (since the 20s of the last century), in the form of bycatch of the fishery of walleye pollock, pacific cod, flatfish from small and medium vessels.

GP-P16 (13460)

Community organization of macrobenthic sessile organisms responding to the submerging time of artificial panels in the embayment of the East China Sea, South Korea

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This study was conducted to compare the variation of dominant species and community structure of sessile organisms on the two types of vacant artificial panels submerged in different seasons. The artificial panels were submerged at seasonal intervals from April, 2011 to January, 2012 and maintained for 6 months at the KIOST research pier in Jangmok Bay, Geoje Island, South Korea. The two types of artificial panels, rough surface tile (20 cm x 20 cm) and smooth surface PVC panel (20 cm x 15 cm), were used and submerged at depths of 0.5 m and 4 m. The highest species number was observed in mollusks at all panels submerged in spring and summer while the species richness of ascidians was highest in autumn and winter. The highest density of mollusks was observed in all seasons at the surface layer, whereas barnacles were abundant at panels submerged in July regardless of the substrates. In the bottom layer, the highest density of mollusks was observed only in spring, but barnacles showed the highest density in summer and ascidians in autumn and winter at all panels. The highest proportion of biomass was contributed by mollusks in spring, but it was changed by barnacles and ascidians occurred in summer and autumn and winter, respectively regardless of substrate and depth. From the results of both the non-metric multidimensional scaling ordination and the cluster analysis, the similarity of faunal composition based on the biomass data was high regardless of substrate and depth, but the difference in the faunal composition appeared at summer pvc panels and at autumn tile panels. *Mytilus galloprovincialis* and *Amphibalanus amphitrite* appeared as the most dominant species on the surface layer tiles. However, ascidiaceans appeared only on the panels at the bottom layer due to the negative phototaxis of their larvae. The dominant species showed a slight difference according to depth, regardless of substrate. At the surface layer, *Mytilus galloprovincialis* was recruited in spring and remained as dominant species with the high population biomass while both *Ciona intestinalis* recruited in autumn and *Ascidiellela scabra* recruited in winter remained as dominant species at the bottom layer. From the result of this study, the species composition of the sessile organisms or the organization processes of benthic communities on hard bottoms were more influenced by their biological life history and the water depth and submerging time of vacant habitat supply rather than substrate types.

GP-P17 (13464)

Behavior of Microplastics in Primary, Secondary, Tertiary, and Sludge Treatment Processes in Wastewater Treatment Plants in Japan

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In recent years, pollution of microplastics (MPs) in water environment has been pointed out. MPs are small plastics which particles size are less than 5 mm. A part of MPs is considered to be contained in wastewater and flowed into the wastewater treatment plants (WWTPs). However, the information about existence and behavior of MPs in WWTP is limited. Main objective of this study is to understand occurrence and behavior of MPs which diameters are more than 100 μm in each treatment process of WWTPs in Japan. Field surveys were carried out in WWTPs (n = 4) from Nov. 14, 2017 to Feb. 15, 2018. Water samples (n = 27), sludge samples (n = 9) and scum samples (n = 6) were collected by sweep pump, steel bucket and dipper. Organic matter decomposition and specific gravity separation were conducted for the samples as pretreatment. After that, MPs were detected by using microscope and fourier-transform infrared spectroscopy (FTIR). Microbeads and fragments are detected from samples. And the load of MPs in each treatment process was calculated with flow rate and detected number. As a result, it was estimated that 120 million MPs flowed in day and 0.4 million MPs were discharged to water environment. The removal rate from influent to effluent was 99.64%. In addition, it was suggested that MPs were removed in the sedimentations and circulated through the bioreaction tank via returned sludge.

GP-P18 (13466)

Morphology and phylogeny of bloom-forming *Takayama* sp. associated with the recent fish kill events in the Philippines

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A series of devastating fish kill events were documented in fish farming sites of Bolinao (May 2016 and 2018) and Bulacan (May 2018) in Philippines. Cells of *Takayama* sp. isolated from the bloom in Bolinao (May 2017) were observed using light microscope, SEM and TEM, and the phylogenetic position was inferred from sequences of LSU rDNA and ITS region. Cells measured 12.0–18.8 µm in length and 9.5–17.6 µm in width, and having the sigmoid apical structure complex, a large spherical pyrenoid located in the hyposome, and a finger-like small sulcal intrusion in the episome. It has a large chloroplast connecting the spherical pyrenoid and 14–22 small chloroplasts. Nucleus was usually located in the episome and the shape was rather variable; elliptical laterally elongated, C-shaped along the dorsal side, and sometimes developed an extension into left in the hyposome. TEM showed the chloroplast was bounded by two membranes and all small chloroplast lacked pyrenoid. Phylogenetic trees showed the Bolinao strains were related to *T. xiamenensis* from China, *T. acrotrocha* from Italy and Singapore, and *T.* cf. *pulchella* from New Zealand. The Bolinao strain was different from *T. acrotrocha* and *T. pulchella*, which have an embedded pyrenoid in each small chloroplast and lack the large spherical pyrenoid. It also differed from *T. xiamenensis*, which is large (20.0–27.0 µm in length), having the large numbers of chloroplasts (30–40) and several large pyrenoids.

GP-P19 (13481)

Statistical modeling for exploring diel vertical distribution and spatial correlations of marine fish species — A new perspective to look at species interactions

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A prerequisite for ecosystem-based fisheries management is to understand the processes of environmental controls and species interactions that determine which species could occur together. Most multi-species ecological models for studying these issues are often non-spatially-explicit or ignore that species interactions could vary in vertical space and daily timing. In this study, geostatistical delta-generalized linear mixed models were used to quantify diel variations in the encounter probability (p) and positive catch rates (λ) of nine dominant fish or shrimp species by fisheries-independent bottom trawl surveys in the Yellow Sea and predict the expected density distribution of each species at coarse scale by year during the falls of 2006 to 2017. We then calculated between-species correlations in species distribution with the estimated densities for the nine species. Results showed these species exhibited three different patterns of diel variation in p or λ, indicating they possibly alternatively utilize the water column swept by the survey bottom trawl at different times of a day. Moreover, two major fishery-targeted species (i.e., small yellow croaker and largehead hairtail) with continuously high productions demonstrated generally weak or negative spatial correlations with other species, especially yellow goosefish and Tanaka's snailfish. Furthermore, pointhead flounder, yellow goosefish and Tanaka's snailfish at relatively high trophic levels had generally strong positive spatial correlations with each other and sand shrimp. These three species either differ in major prey or appeared active in the bottom water column at different daily timing. Conclusively, this study provides with a new perspective to look into species interactions.

GP-P20 (13489)

Unarmored dinoflagellate *Kapelodinium* sp. with chloroplast derived from haptophyte *Chrysochromulina sp.*

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In an unarmored dinoflagellate *Kapelodinium*, only a heterotrophic species *K. vestifici*, which had commonly been reported as *Katodinium glaucum*, was assigned to this genus previously. In the present study, a culture strain of photosynthetic *Kapelodinium* sp. was established from Japan, and was observed under light and transmission electron microscopy (TEM). Pigment profile of the chloroplast was analyzed by HPLC, and host and chloroplast phylogeny was inferred from nucleus- (SSU, ITS and LSU rDNA) and chloroplast- (SSU rDNA, *psaA*, *psbA*, *psbC*) encoded genes. Cells of this species were fusiform with the posteriorly located cingulum, and were 15.3–22.4 µm long and smaller than *K. vestifici* (16–57 µm long). Chloroplasts were yellow and spherical to ribbon shaped. Under TEM, chloroplasts included several electron dense pyrenoids embedded in chloroplast matrix were observed. The pyrenoids were penetrated by a tube-like thylakoid, as seen in haptophyte chloroplasts. No eukaryotic nucleus of symbiont was observed under TEM. In HPLC, the chloroplasts of this species contained fucoxanthin and 19'-hexanoyloxyfucoxanthin (19'-Hex) as major accessory pigments, and peridinin, which is typical to photosynthetic dinoflagellates, was not detected. In host dinoflagellate phylogeny, this species was sister to a heterotrophic species *K. vestifici*. In chloroplast phylogeny, chloroplast of *Kapelodinium* sp. was clustered within *Chrysochromulina* in haptophytes, and the sister was *C. apheles*. Both in host and chloroplast phylogeny, this species was not related to the other dinoflagellate group having haptophyte-derived chloroplast (family Kareniaceae), suggesting acquisition of permanent chloroplast from haptophytes had taken place twice in dinoflagellates.

GP-P21 (13496)

Temporal and spatial characteristics of bacterial diversity in the environments of cage and kelp cultural area in Xiangshan Bay, China

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The microbial diversity and community structure are sensitive to the change of environment, so they are always used as an index for assessment of restoration effect of ecosystem. In order to investigate the restoration effect of kelp culture to eutrophication in Xiangshan Bay in Zhejiang Provence, China, We collected sediment and water samples from cage culture, kelp culture and non-culture areas in winter and summer respectively, and the physical and chemical environmental factors were also detected. The V3-V4 regions of 16S rRNA genes were amplified and sequenced on illumina Hisiq-2500. The bacterial community structures and the relationships with other environmental factors were analyzed. The results indicated that the difference of bacterial community structures between cultural areas were bigger than that of between seasons in the sediment environment. While in the water environment, the difference was more significant between seasons than that of different cultural areas; The bacterial alpha-diversity in cage cultural environments was higher than that of kelp cultural and non-cultural environments, with the average shannon-wina indexes 6.25, 5.76, 5.83, respectively The C/N ratio and phosphate were the main factors to influence the distribution of bacteria in sediment and water aquaculture environment.

GP-P22 (13499)

Assessing the outcomes of stocking hatchery-reared juveniles of *Girella punctate* in the northeastern coast of Taiwan

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Stocking of hatchery-reared juvenile is a common enhancement and recovery strategy across jurisdictions around the coastal of Taiwan, however, its impact remains uncertain. *Girella punctate* is an important commercial fish species in the northeastern coast of Taiwan. We investigate the potential effectiveness of stocking system where approximately 35000 fry of *Girella punctate* are released from 2015~2018. The observed catch rate of *Girella punctate* were significant increased from 0.36 (kg/boat/day) to 0.76(kg/boat/day, after enhancement) and the recaptured effectiveness by gill net was 8~26 months after releasing. Furthermore, environmental variables and ecosystem tropical level characteristics were used to fit predictive models for wild *Girella punctate* densities using Partial Least Squares Regression. The results showed the catch rate was significant correlated with sea surface temperature, sea surface height, and typhoon strike days. The observed catch rates of stocked sites was similar with predicted before releasing of fish fries and found to be significantly higher than predicted after releasing of fish fries for 8~10 months In particular, the observed catch rates for were found to be higher than predicted 1.57~2.29 time in the second half of 2017 and the first quarter of 2018, and suggesting stocking of *Girella punctate* has been effective in increasing in the studied stocked sites.

GP-P23 (13503) CANCELLED

The state of red tide of China in 2017

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Red tide events were observed 68 times in 2017 over an area of 3,679 km2. The highest frequency was 40 times, with the largest cumulative area of 2189 km2 occurred in the East China Sea. High incidences of red tide mainly occurred in June. The frequency was the same as that in the previous year, but the cumulative area decreased 3805 km2. Compared with those in the past five years, the frequency increased 13 times, and the cumulative area decreased 1387 km2. Red tides were caused by a total of 34 species. Among them, *Karenia mikimotoi* was the first dominant species, which caused the outbreak of as many as 12 red tides. *Prorocentrum donghaiense* was the second, which caused 10 red tides. *Scrippsiella trochoidea*, *Phaeocystis globosa*, and *Mesodinium rubrum* caused six red tides each. *Skeletonema costatum*, *Gonyaulax spinifera*, and *Noctiluca scintillans* caused four red tides each. *Gymnodinium catenatum* caused three red tides. *Chaetoceros curvisetus*, *Nitzschia* sp., and *Ceratium furca* caused two red tides each; *Thalassiosira pacifica*, *Thalassiosira rotula*, *Azadinium* sp., *Gonyaulax polygramma*, *Gonyaulax verior*, *Gymnodinium impudicum*, and *Heterosigma akashiwo* caused 1 red tide each.

GP-P24 (13505)

Age and growth of the herbivorous fish, *Kyphosus bigibbus*, determined by accurate age determination techniques, for elucidating the effects on algal ecosystem in the Northwest coast of Kyushu, Japan

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Age and growth of *Kyphosus bigibbus,* an herbivorous fish that impacts the algal ecosystem, were examined using individuals collected from the Northwest coast of Kyushu, Japan. This study is the first worldwide to investigate the age, growth, and age at maturity of genus *Kyphosus*. Comparing scales and otoliths revealed that scales are not reliable to determine age, because the periodicity of growth ring formation could not be confirmed. The reading errors were large, and the age of individuals 6 years and older was underestimated. In contrast, age assessment using otolith growth rings was possible from carefully prepared sections because reading errors were quite low and growth rings of otolith were confirmed annuli. Age assessment based on otolith sections showed that the maximum observed age was 46 years for females and 32 years for males. According to the von Bertalanffy growth curves, fork lengths were close to the asymptotic length after 15 and 10 years for females and males, respectively. The age at 50% sexual maturity was calculated as 3.2 years for females and 1.9 years for males and is extremely short compared to their long lifespan. The early maturation and long lifespan for *K. bigibbus* enables a protracted number of years for breeding and increased opportunity to contribute offspring to future generations. Estimation of the birth year of each individual irrespective of the year of collection showed that the proportion of individuals born after 1999 increased suddenly. This implies that the total number of individuals increased after 1999.

GP-P25 (13507)

Use of empirical orthogonal functions for monitoring coccolithophores in the upper layer of sea water

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Empirical orthogonal functions (EOFs), derived from the annual array of remote sensing reflectance (Rrs) spectra, are used for monitoring coccolithophores blooms in the upper layer of sea water. Coefficients of expansion of the remote sensing reflectance into a series with EOFs as a basis allow for a qualitative and quantitative analysis of the phenomenon under study. The annual set of MODIS Aqua data was used to calculate EOFs. A comparison with the results obtained by other methods is given.

GP-P26 (13523)

Ultrastructure and phylogeny of *Chattonella subsalsa* and *C. marina/ovata/antiqua* collected from various countries

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Seventeen clonal cultures of harmful raphidophyte *Chattonella* spp. were established from Japan, Indonesia, Malaysia, Philippines, Singapore and Thailand during 2010–2018. Cells were observed under light microscope and transmission electron microscope, and LSU rDNA and ITS sequences were determined. Although cell size range varies in some strains, cell shape of all strains are common; i.e., ellipsoidal or teardrop-shaped with the posterior tail, two heterodynamic flagella located anteriorly, many brown chloroplasts with a pyrenoid facing inward, and two different sizes granules covering the cell surface. Number of the larger granule was various, and not found in some cultures. Cell ultrastructure under TEM were different in thylakoid number penetrating into the pyrenoid matrix; three appressed thylakoids were found in Indonesian, Japanese and Malaysian strains, while many profiles of single tubular thylakoid were found from Thailand strain. Presence of mucocyst also varies among strains; i.e. found in Malaysian and Philippines strains. Phylogenetic trees inferred from sequences of LSU rDNA and ITS region revealed there was five strains of *Chattonella subsalsa*, ten strains of *C. marina/ovata/antiqua* and two strains were not fit into those two subclades.

GP-P27 (13553)

Accumulation of tsunami debris on the seafloor depends on tsunami impact, bathymetry and ocean velocity

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The tsunami generated by the Great East Japan Earthquake in 2011 washed a lot of debris into the surrounding sea. Tsunami debris accumulated on the bottom of the seafloor would damage fishing gears including trawl nets although some of the debris may act as an artificial reef. After the disaster, it is desirable to efficiently advance the minesweeping work of tsunami debris in order to reduce the possible impact on human activities in coastal and offshore areas such as fishery. In this research, we constructed a model to estimate where tsunami debris will accumulate on the bottom of the seafloor.

The model showed that more debris dispersed into the surrounding area from the coast where the higher wave of the tsunami was recorded. The debris flowed out was likely to accumulate on the bottom of which topography was bumpy. Despite the flat topography in the estuary, more debris tended to be located. It is because the rivers flooded by the tsunami would transport more debris to the estuary. The deposition of the tsunami debris on the seabed did not necessarily decay along the distance from the coast at the relatively small scale (within several tens of kilometers from the coast). Wave height of the tsunami and the topological complexity can affect more strongly the accumulation of the debris. Some of the debris that flowed out to the coast also migrated on the ocean current. Future research is welcome to clarify their sedimentation process and movements on the seabed.

GP-P28 (13560) CANCELLED

The Okhotsk Sea de-oxygenizing influence on deep-water fishes

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Some deep-water species distribution in the Okhotsk Sea are considered for the period since 1963 on the data of scientific surveys and observers aboard fishing vessels. The most of flounders and other species which inhabits the depths above 300 m did not change their distribution, in general, whereas the densest concentrations of adult greenland halibut *Reinhardius hippoglossoides* were at 600-700 m depth until 2000s but shifted to 500-600 m recently. This shift could be reasoned by lowering of dissolved oxygen content in the intermediate layer below 500 m because of limited ventilation in condition of warm winters – the recent lowering reached 0.6 mL/L per decade. However, the upper part of the intermediate layer is still well-ventilated, so the de-oxygenizing is not dangerous for mass commercial species of the upper continental slope.

GP-P29 (13612)

Can a deep-sea copepod trophically utilize bacterial bioluminescence and chitinolysis?

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The mesopelagic, detritivorous calanoid copepod *Cephalophanes refulgens* has a pair of highly developed naupliar eyes with parabolic reflectors. It was suggested that these eyes detect bioluminescence of bacteria growing on crustacean detrital matter, their food source. Actually, the copepod guts were often packed with crustacean remains and contained hard, semi-transparent matters in the anterior caecum. We speculate the following scenario of this specialized feeding habit of the copepod: (1) after detection and ingestion of crustacean detrital matters covered with bioluminescent bacteria, these are digested with the aid of bacterial chitinase in the gut; (2) digested fluid chitins are moved to the anterior caecum by a peristaltic motion of the gut and then solidified for preservation. The first step in their feeding habit was suggested by the presence of enteric, bioluminescent/chitinolytic bacteria in their gut. Their presence was confirmed using chitinolysis test with chitin marine agar and by 16SrDNA sequence analyses of isolated strains using Sanger sequencing method and bacterial universal primers 341F and 907R. Calcofluor white staining and GC-MS analyses of the hard material in the caecum revealed that it was composed mainly of chitin. Therefore, the copepod likely utilizes bacterial physiological activities for food detection and digestion.

GP-P30 (13622)

Characteristics of Dissolved Organic Matter in Submarine Groundwater Discharge (SGD) in Jeju Island

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In order to evaluation the distribution of dissolved organic matter in the submarine groundwater discharge, dissolved organic carbon (DOC) and colored dissolved organic matter (CDOM) were measured in Woljeongri, Pyoseon, and Kwakgi beaches of Jeju lsland, Korea, in three sampling campaigns (June, July, and October 2016). The concentrations of DOC in groundwater were in the range of 11–182 mM and were about 40% higher in Woljeongri and Pyoseon beaches than in Kwakgi beach. In addition, the concentrations of CDOM (C and M peaks) in the groundwater of Woljeongri and Pyoseon beaches were relatively higher than those of Kwakgi beach. The relatively higher DOC concentrations in the coastal groundwater of Woljeongri and Pyoseon, with higher CDOM concentrations, seem to be mainly from anthropogenic sources such as local pollution sources (i.e., aquaculture wastewater or domestic sewage). Correlations between salinity and DOC in all beaches showed a relatively positive trend in October rather than in June and July. This result indicates that conservative mixing of DOC depending on salinity in subterranean estuary is well due to rapid SGD rates closely linked to heavy rainfall.

GP-P31 (13623)

Monthly Distributions of Organic Matter in Precipitation of Jeju Island

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In order to evaluate the distribution of organic matter in the atmosphere, dissolved organic carbon (DOC), dissolved organic nitrogen (DON), particulate organic carbon (POC) were measured in Jeju Island, Korea, from January 2018 to April 2018. The concentrations of POC, DOC, and DON were in the range of 22 - 233 μM, 24 - 991 μM, and 0.47 - 255 μM, respectively. The highest concentration of POC, DOC, and DON was found in January 2018. This highest organic matter seems to be associated with incomplete combustion of fossil-fuel during winter. In order to understand the behavior of organic matter in the atmosphere, extensive studies are necessary in the future over greater time–scales using various chemical tracers.

GP-P32 (13624)

Microplastic Pollution in Freshwater Ecosystem - A Case study of Inland Lakes in Japan

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Occurrence and distribution of microplastics (MP) have been reported worldwide. However, most studies have been focused on coastal and marine environment, and little information is available on inland water areas so far. In this study, we investigated the status of pollution of MP in urban lake ecosystem, such as water, sediment and organisms in Kumamoto. As the results, high concentrations of MP were identified in sediments from Lake Ezu, ranging from 124-2,091 piece/kg. Polyethylene (PE), polypropylene (PP) and polyvinyl acetate (PVAc) were dominant components in sediment, occupying 72-80% of total MP identified. To understand the potential source of MP in this lake, plastic toys inserted in lake sand were mixed for 0.5 to 30 min under laboratory condition, and the number of plastic were counted. The small pieces of MP (approx.. 100-500 mm) were identified (max: 109 piece) in sand, suggesting that usage of toys by kids might be one of source of MP in inland lakes. These results imply ubiquitous contamination of MP in freshwater ecosystems in Japan.

GP-P33 (13625)

Identification of Terrestrial Sources of Microplastics into the Aquatic Environment

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In recent years, the occurrence and pollution of microplastics (MPs) have been reported in the world. The high concentrations of MP were identified in coastal and marine ecosystems, but little information is available on the source of MP into the aquatic environment. In this study, we focused on road dusts and rain runoff as a potential source of MP from terrestrial to coastal environment. As the results, MP were identified in road dusts collected from Kumamoto and Okinawa in Japan at the mean concentrations of 96 and 68 piece/kg, respectively. The numbers of MP and traffic density were significantly corelated in Okinawa samples, suggesting that automobile may be a potential source of MP in road dusts. MP was detected in a rain runoff collected in Kumamoto, at the concentration of 182 piece/m^3. These results strongly suggest that road dust may be one of significant potential source of MP from terrestrial into coastal areas.

GP-P34 (13660)

Using Blue Carbon in Climate Regulation

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Climate change greatly affect global marine environment, resulting from seawater temperature rise, sea level rise, and ocean acidification. Carbon dioxide emission control is an important way to solve the problems of climate change and global warming. There is a critical role of the oceans and apply blue carbon in deal with climate change. Recently, emissions' reductions are currently at the climate change discussions, Blue carbon play important role in reducing atmospheric CO2 levels through sequestration and also through reducing the rate of marine and coastal ecosystem degradation. There we need recognized blue carbon, apply assessment method in evaluation of carbon storage ability in Seagrasses, mangroves and salt marshes, and put forward the enhancement storage capability enhancement, preservation techniques, and management. We conducts interdisciplinary research on marine-climate interaction, global marine sustainable development, and proposes to utilize blue carbon source to absorb carbon dioxides in the atmosphere. This leading proposal attempts to fix carbon dioxides in the ocean by carbon sources from marine sediment, sea weed and fishery, so as to control the atmospheric carbon dioxides concentration.

GP-P35 (13663)

The toxic dinoflagellate *Prorocentrum foraminosum* and its associated bacteria from the culture collection "Marine Biobank" NSCMB FEB RAS

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The harmful dinoflagellate *Prorocentrum foraminosum* Faust found worldwide in both cold and warm marine waters. In culture, this dinoflagellate produces diarrhetic shellfish toxins (DTX-1). Recent data suggest that marine bacteria could be involved in dinoflagellate toxicity. Clones of *P. foraminosum* (MBRU- PrRUS_7) and its associated bacteria from the culture collection "Marine Biobank" of the NSCMB FEB RAS (*http://marbank.dvo.ru*) were analyzed after a twelve months cultivation as batch cultures. An integrated study, using different microscopy and molecular techniques, Raman microspectroscopy and high resolution liquid chromatography-mass spectrometry (HR LC-MS), was undertaken to elucidate biological aspects, and identify main metabolites including toxins. The first data on the use of specific and universal molecular genetic markers for 16S rDNA, 23S rDNA and some genes of polyketide synthases (PKS) for determining the symbiotic composition of microorganisms associated with cultures of *P. foraminosum* were presented. The fatty acid composition of lipids and pigments of dinoflagellates and bacteria have been studied. Our data provides evidence for an association between this dinoflagellate and bacteria. The role of associated bacteria in DTX-1 production is discussed.

This work was supported by the RFBR project 17-04-01394 and project FEB RAS "Far East" 18-5-074.

GP-P36 (13681)

Taxonomic profiles in metagenomic analyses of marine dinoflagellate communities in Jinhae Bay, Korea.

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High-resolution 18S rRNA tag NGS (Next generation sequencing) was used to obtain two seasons (summer, winter) snapshots of the dinoflagellate diversity and community structure at two locations in Jinhae Bay (South Sea, Korea) in two seasons. Seasonal sampling from the water column at each site revealed highly diverse marine algae communities containing up to 700 estimated Operational Taxonomic Units (OTUs). The DNA libraries from samples collected during two seasons were sequenced using NGS. The number of reads was 52,048 in March (spring), 54,353 in June (summer). Species identification indicated that *Karlodinium* sp*., Protoperidinium* sp. and *Akashiwo* sp. were most common species in winter sample, while *Alexandrium* sp. and *Dinophysis* sp. were common in summer. These results suggest that seasonal changes in water environment contribute to the dynamic structure of the marine dinoflagellate community in study area. The information presented here will be useful for comparative analyses with other marine algae communities also it is possible to detect a small amount of harmful algae which cannot be detected by a microscope.

GP-P37 (13682)

Absolute quantification of *Oxyrrhis marina* and *Oxyrrhis maritima* in Korean waters using chip-based digital PCR (dPCR) as a novel detection method

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Estimating distribution and abundance of the harmful marine dinoflagellates in natural seawater via quantitative real-time PCR (qPCR) analysis is commonly used method. However, qPCR lacks the accuracy and sensitivity because of the limit for relative quantification and PCR inhibitors in seawater. Here, we established absolute quantification of *Oxyrrhis marina* and O. *maritima* strain in both laboratory culture and environmental samples using chip-based digital PCR (dPCR), an advanced technique adding aspects of fluorescence-activated sorting. dPCR assay detected the population of O. *marina* and O. *maritima* even if there was a dramatically low concentration in samples. Result of gene copy number calculated via dPCR showed that the copy of O. *marina* per a single cell was 144 ± 6.9 while O. *maritima* was 177 ± 9.2. Thus, it suggests that dPCR system can provide the early detection and precise monitoring of the harmful algae, so may useful for predicting harmful algal blooms.

GP-P38 (13683)

Influence of submarine groundwater discharge on feeding and growth of fish

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Recent studies have revealed that submarine groundwater discharge (SGD) contributes greatly to biological production in coastal waters due to higher concentration of nutrients compared to river water. However, most studies have focused on the relationship between SGD and biological production of low-order trophic level, while there are few studies on the impact on productivity of higher-order trophic levels worldwide. In the present study, a cage experiment were conducted in coastal waters of the Seto Inland Sea, Japan, to evaluate the influence of the SGD on feeding and growth of fish. Based on the preliminary survey of radon (^{222}Rn) concentration as an indicator of SGD, two sites were selected in coastal waters off Hiroshima Prefecture; site A: Takehara, Japan, as a site with more SGD and site B: Aba Island, an unpopulated island as a site with less SGD. Individual marbled sole *Pleuronectes yokohamae* juveniles (mean body length: 63.5 mm) was kept in a cage (0.45x0.45x0.3 m) for two weeks. A total of sixteen cages were set at each site. Water temperature and salinity were monitored by data loggers. Production of benthic microalgae and abundance of epi-benthic crustacean as major prey source for the juveniles were compared between the two sites. At site A, stomach content weight and growth rate were greater than at site B. Higher production of the benthic microalgae and higher abundance of gammarids at site A were suggested to have contributed to the greater feeding and growth of the juveniles during the experiment.

GP-P39 (13706)

Influence of ammonium derived from hot spring drainage on downriver and estuarine ecosystems

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In the Beppu area, it has suggested that nutrients and heat produced by hot spring wastewater promoted growth of adherent algae and Nile tilapia, *Oreochromis niloticus*, in the downstream and estuarine area. However, there is no detailed information on them. In the present study, we evaluated the influence of hot spring drainage on downriver and estuarine ecosystems using nitrogen stable isotope ratio ($\delta^{15}N$). On August 30-31, 2017, river water, wastewater and attached periphyton were collected in two contrasting rivers running through Beppu City: Hirata River (significant effect of hot spring) and Haruki River (less effect of hot spring). Tilapias were collected in the downstream area. Stomach contents and $\delta^{15}N$ of fish muscle were analyzed. Concentrations and ^{15}N of $NH4^+$ decreased and increased from the upper to downstream with an isotope fractionation of -18.1‰. This value approximated to that of $NH4^+$ uptake by adherent algae, while the $\delta^{15}N$ of algae in Haruki River was higher than the other. These results suggested that major source of nitrogen differs between the two rivers. The difference was also reflected in the $\delta^{15}N$ of tilapias. Estimation of possible origin of nitrogen source by the use of $\delta^{15}N$ of algae, $NO3^-$and $NH4^+$ indicated that 64% of $NH4^+$ were consumed in Hirata River while 96% of $NO3^-$ were consumed in Haruki River. It was suggested that $NH4^+$ supplied from hot spring supported the downriver and estuarine ecosystems in Hirata River through the utilization by adherent algae and supported a nutritional base for river ecosystems in Hirata River.

GP-P40 (13716) CANCELLED

Changes of nitrogen and carbon budget by effluent of land-based aquaculture farm in the coastal area of Jeju, Korea

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Approximately 350 land-based aquaculture farms (LAF) have developed in Jeju, pollutions of coastal environment by the effluent discharge have recently become an issue. The effluent has high nutrient concentration and high organic matter content, which has a serious impact on the coastal ecosystem. We set up a demonstration area (850,000 m^2) in the Handong coastal area (HCA) to identify the nitrogen (N) and carbon (C) budget. The amount of effluent from the LAF to the HCA is 780,000 m^3/day. The average dissolved inorganic nitrogen (DIN) and particulate organic carbon (POC) concentrations in effluents are 72.86 mmol/L and 375.02 mg/m^{-3}, respectively. The DIN and POC loads into HCA, calculated using concentrations and nominal flow of the effluents, amount to 796 and 293 kg/day, respectively. The amounts of dissolved organic nitrogen (DON) and dissolved organic carbon (DOC) discharged into the HCA are 254 and 655 kg/day, respectively. The N and C contents of effluent water are 9 and 2 times higher than that of the original cultured water, respectively. The N and C inputs to the coastal area are dominated by effluent (72% and 75%), followed by submarine groundwater (SG) discharge (26% and 9%), and benthic flux (2% and 16%). Outputs are dominated by primary production (70% and 69%), followed by cultured water (22% and 19%), benthic deposition (7% and 8%), and benthic macroalgae (1% and 4%). In the coastal area of Jeju, the effluent of LAF plays a crucial role in the accumulation of N and C.

GP-P41 (13717)

Distribution and population structure of *Euphausia pacifica* in Korean waters.

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Distribution and population structure of euphausiids were investigated in Korean waters based on monthly collected samples in 2016. Water temperature and salinity were measured during the sampling. Water masses were largely divided from four to six groups including Jeju Warm Current, North Korean Cold Current, the Yellow Sea water and coastal water, using K-means clustering based on mean temperature and salinity. A total of 8 species of euphausiids was recognized. *Euphausia pacifica* was most dominant species (mean density: 1.86 inds.m^{-3}), followed by *Pseudeuphausia latifrons* (mean density: 0.07 inds.m^{-3}), *Stylocheiron carniatum* (mean density: 0.04 inds.m^{-3}). The density of *E. pacifica* was highest in June, and lowest in October. *E. pacifica* were preferentially found in cold and low salinity water such as Yellow Sea water. Eggs, furcilia and calyptopis of euphausiids occurred during the entire sampling period except February. The relative proportions of eggs were higher in Kuroshio Current in March and September, peaked in North Korean Cold Current in October, and were highest in March in coastal water. The relative proportions of calyptopis and furcilia were increased after March in all areas. The density of adults was highest in the Yellow Sea in February and March. This study suggests that distribution patterns and recruitment of euphausiids varied with water mass characteristics.

GP-P42 (13737)

VoCC: A new R package for calculating the Velocity of Climate Change and related landscape climatic metrics.

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The velocity of climate change and related metrics examine the spatial change of climatic variables over time, from which exposure to climate change can be estimated and the scope of species' range-shift responses inferred. Because they are easy to calculate and conceptually simple, these metrics have been extensively used in research and can provide useful information for conservation management. Applications include reconstruction and prediction of climate-driven species distribution shifts, description of endemism patterns, identification of climate refugia and climate connectivity analysis. Multiple extensions to the original concept of climate velocity have been proposed since first presented nearly a decade ago. Our new R package 'VoCC' gives easy access to a comprehensive collection of functions to calculate these metrics from their initial formulation to the latest expansions and developments.

GP-P43 (13743) CANCELLED

The study of change of marine environment in the sea near Ieodo Ocean Reasearch Station (IORS) using wave glider

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This study investigates the environmental properties of the sea near Ieodo Ocean Research Station (IORS) before and after the typhoon using in-situ observations and remote sensing data. The IORS is located in the northern part of the East China Sea. The data used for the investigation area near the IORS are stationary observation data of IORS and shipboard-serial observation by the National Fisheries Research and Development Institute (NFRDI), and remote observations by wave glider and satellite. The investigation area was influenced by typhoon Talim in September, 2017. At that time, along with the field data of IORS and wave glider, we observed the strong gust wind of more than 20m/s and the wave heights of more than 9m. We analyzed ocean currents such as water temperature, salinity and chlorophyll, and ocean current data observed through ADCP, from the field observation data and remotely sensed data from before and after the Talim.

GP-P44 (13747)

NEAR-GOOS: Developing sustained ocean observations for enhanced services in the northeastern Asian marginal seas

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The North-East Asian Regional-Global Ocean Observing System (NEAR-GOOS) is the first regional pilot project of GOOS. This presentation describes its success and challenges over the last 20 years. Initiated in 1996, NEAR-GOOS aimed to facilitate the sharing of oceanographic data in the marginal seas bordered by the partner countries: China, Japan, Korea and Russia. Its development has been coordinated by the UNESCO/IOC Sub-Commission for the Western Pacific (IOC/WESTPAC) through its Coordinating Committee for NEAR-GOOS. The major achievement of NEAR-GOOS at its first phase features the establishment of a network of real-time and delayed mode databases accessible online free-of-charge, with these databases being operated by designated national agencies. Despite some restrictions on oceanographic data exchange in some member states, NEAR-GOOS archives now contain 59 types of data with total volume of 210 GB (as of Jun. 2018). A challenge for NEAR-GOOS at its second phase (after 2003) was to advance from data management to jointly developing sustained regional integrated ocean observations and delivering enhanced services, for a wide range of users in the region. This advancement requires not only continued improvements of the existing data and information exchange mechanisms, but also an enhancement in its observations, and delivering more user-friendly services in the region and beyond. Currently, NEAR-GOOS has three working groups on data management, products, and ocean forecasting system (OFS). Recent NEAR-GOOS projects include Cross Basin Climate Monitoring Section implemented by Japan and Russia since 2011, enhancement of OFS since 2016, and ferry box monitoring since 2018.

GP-P45 (13795)

Influence of variability of thermal conditions on the development of shellfish on marine farms (North-Western part of the Sea of Japan)

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Global warming of a climate on all planet influences cycles of development of mollusks. There is also a tendency for the larvae period to become shorter; the duration of the settlement period exhibits the least variability. Under comparison of duration of all four periods in development of Japanese scallop Misuchopecten yessoensis (Jay) for 1970–2012, it can be noted that the duration itself did not change, but the difference between the maximum and minimum duration value decreased. Thus, it is obvious, that climate change at the present stage is reflected in functioning of the ecosystems, and there are changes in biological cycles. To study these changes carrying out of the biological parameters monitoring in marine farms is necessary.

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