Ecosystem Studies of Subarctic and Arctic Seas (ESSAS) Annual Science Meeting 2021

Book of Abstract

Online

30 May – 3 June 2021

Ecosystem Studies of Subarctic and Arctic Seas

ESSAS

IMBeR

Integrated Marine Biosphere Research

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2021 ESSAS Webinar Annual Science Meeting in Sapporo, Japan 30 May–4 June, 2021 (Abstract submission extended)

"Linking past and present marine ecosystems to inform future fisheries and aquaculture"

Webinar at http://xxxxxxx (to be announced)
Host of webinar, Arctic Research Center, Hokkaido University
Date: 30 May – 4 June, 2021

Ecosystem Studies of Subarctic and Arctic Seas (ESSAS), one of the regional programs of the Integrated Marine Biosphere Research project (IMBeR). The goal of the ESSAS Program is to compare, quantify and predict the impact of climate variability on the productivity and sustainability of Subarctic and Arctic marine ecosystems. Although the ESSAS Annual Science Meeting (ASM) scheduled in July 2020 had to be canceled due to COVID-19, the **2021 ASM will be held as a webinar (web seminar) style meeting**.

Both academic communities and local stakeholders in Hokkaido are interested in how Arctic and sub-Arctic marine systems will change in the future. Of relevance to these concerns is information from the natural and social sciences, including economics. The 2021 ESSAS ASM will build on a previous international project funded by the Belmont Forum, which examined the resilience and adaptive capacity of Arctic and sub-Arctic marine systems. We seek to understand the mechanisms by which climate change will affect aquaculture and capture fisheries, how these changes will affect resource-dependent communities, and how management can foster resilience in these systems.

We welcome submission of abstracts to the General Session of the 2021 ASM on 1 June to address the above themes. Specifically, we seek contributions that draw on findings from all fields, including paleoecology, contemporary ecology and the social sciences, to help inform our understanding of future changes affecting fisheries and aquaculture in high-latitude marine ecosystems. In addition, we would like to invite you to the virtual excursion to renewal "UPOPOY, National Ainu Museum and Park". Please access this URL, and click the YouTube mark on the top page of website for virtual excursion in the museum.

We look forward to productive discussions with many participants!

- Deadline for abstract submission: 15 March, 2021
- Deadline for registration on the website: 30 April, 2021
- For registration & abstract submission, please click here
- Registration fee: Free

Conference Program

Contact us

For any questions about ESSAS or further information please contact any of the ESSAS Co-chairs

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Happenings

Up-coming Events

Recent Activities

Application Form for Project Endorsement by ESSAS

Welcome to ESSAS Annual Science Meeting 2021

Dr. Naomi Harada (Co-Chair)
Japan Agency for
Marine-Earth Science and Technology

Prof. Toru Hirawake (Local Organizer)
National Institute of
Polar Research

ESSAS Co-Chair and Local Organizing Committee would like to welcome you to the ESSAS Annual Science Meeting 2021. While we need to hold the meeting online due to the COVID pandemic persisting since its outbreak in 2019, we believe that you will still hear at ESSAS 2021 the best of what our colleagues has produced in a spectrum of scientific topics relevant to the subarctic and arctic seas, and even more.

We think that it is particularly important to share our scientific knowledge with not only scientific communities but also with the general public. Hence, ESSAS ASM 2021 includes both a public lecture and a stakeholder meeting for the first time in the ESSAS ASM history. We hope that you enjoy all aspects of ESSAS ASM 2021!

Co-chair and Local Organizing Committee*

*Naomi Harada (JAMSTEC), Toru Hirawake(NIPR), Sei-Ichi saitoh (Hokkaido Univ.), Mitsutaku Makino (The Univ. of Tokyo), Taka Hirata (Hokkaido Univ.)

JAMSTEC 国立研究開発法人 海洋研究開発機構
Japan Agency for Marine-Earth Science and Technology

Hokkaido University
Arctic Research Center

Arctic Challenge for Sustainability II

北極域研究共同推進拠点
J-ARC Net
Japan Arctic Research Network Center

Schedule

(Zoom URLs, different each day, are provided to registered participants only a few days before the actual meeting dates for security reasons)

	30 May (Sun)	31 May (Mon)	1 June (Tue)	2 June (Wed)	3 June (Thu)
A.M.	-	Plenary Talks	Research Presenta-tions	AnaloguART - PESAS Joint Workshop	Science Steering Committee Meeting
P.M.	Open Lecture (Live) (18-19:00)	Stake Holder Meeting	Research Presenta-tions	AnaloguART - PESAS Joint Workshop	-

Scientific Programme

【Day 1: 30 May (Sun)】 (Time in Japan Standard Time, JST)

18:00-19:00 (Live)

Open Lecture "Mammals in the sea"

Yoko Mitani (Field Science Center for Northern Biosphere, Hokkaido University)

【Day 2: 31 May (Mon)】 (Time in Japan Standard Time, JST)

09:00-09:05 Welcome Greetings

Yasushi Fukamachi (Arctic Research Center, Hokkaido University)

09:10-9:35 Plenary Talk 1

"A song of spring and a story of winds: The relationship among Pacific herring (*Clupea pallasii*) , winds, sea, ice and people from the past to the future" by Naoki Tojo (Faculty of Fisheries Sciences, Hokkaido University)

09:35-10:00 Plenary Talk 2

"Assessing and managing fish stocks in a rapidly changing environment" by Franz Mueter (College of Fisheries and Ocean Sciences, University of Alaska Fair Banks)

10:00-10:25 Plenary Talk 3

"Reframing the interface of science, policy and industry for the better ecosystem governance in the Anthropocene" by Aoi Sugimoto (Japan Fisheries Research and Education Agency)

【Day 2: 31 May (Mon) (cont.)】 (Time in Japan Standard Time, JST)

Stake Holder Meeting

13:00-15:00 ・Self-introduction of participants
・Knowledge transfer among participants
・Discussion towards co-designing of future fisheries and marine science

【Day 3: 1 June (Tue)】 (Time in Japan Standard Time, JST)

05:00-05:15 Possible future scenarios for Arctic Gateways connecting Subarctic and Arctic marine systems: I. Climate and physical-chemical oceanography (Ken Drinkwater)

05:15-05:30 Capital investments for the Norwegian Red King Crab: A Tale of Ecological and Community Resilience (Melina Kourantidou / Brooks Kaiser)

05:30-05:45 Identifying ecosystem reference states with “Chance and Necessity” model simulations (Elliot Sivel)

05:45-06:00 Arctic marine biogeochemical modeling in the ArCSII Project (Eiji Watanabe)

06:00-:6:15 Highlights of the R/V Mirai Arctic Ocean survey in 2020 (Shigeto Nishino)

06:15-06:35 Break

06:35-06:50 Inter-annual variability of phytoplankton community structure in the Pacific Arctic Region (Amane Fujiwara)

06:50-07:05 Impact of sea-ice dynamics on the spatial distribution of diatom resting stages in sediments of the Pacific-Arctic Ocean (Yuri Fukai)

07:05-07:20 Increasing zooplankton biomass associated with sea ice loss in the western Arctic Ocean and its ecological impacts (Motoyo Itoh)

07:20-7:35 Inter-annual changes of the mesozooplankton community structure in the Western Arctic Ocean during summers of 2015-2018 (Jee-Hoon Kim)

07:35-07:50 Response of zooplankton community with early sea-ice reduction in the northern Bering Sea during summers 2017, 2018 (Kohei Matsuno)

07:50-15:00 Break

【Day 3: 1 June (Tue) (cont.)】 (Time in Japan Standard Time, JST)

15:00-15:15 Comparison of population structure, vertical distribution, and growth of the sympatric, carnivorous, mesopelagic copepods Paraeuchaeta glacialis and Heterorhabdus norvegicus in the western Arctic Ocean: Occurrence of r-strategy mesopelagic copepods may be related to their specialized feeding mode (Atsushi Yamaguchi)

15:15-15:30 Distribution and shell condition of Limacina helicina in aragonite undersaturated waters of the Canada Basin (Michiyo Yamamoto-Kawai)

15:30-15:45 Impacts of riverine carbon and nutrient delivery on Arctic Ocean acidification (Yuanxin Zhang)

15:45-16:00 Underwater soundscape and its temporal variability in the East Siberian Sea (Dong-Gyun Han)

16:00-16:15 Arctic Ocean CO2uptake (Sayaka Yasunaka

16:15-16:35 Break

16:35-16:50 Changes and future predictions of Oyashio Intermediate Water, a key water mass for biological production (Vigan Mensah)

16:50-17:05 Marine Ecosystem Variations over the North Pacific and their Linkage to Large-Scale Climate Variability and Change (Shoshiro Minobe)

17:05-17:20 Optimization of salmon release operation under changing climate in the Okhotsk coast, Japan (Sei-Ichi Saitoh)

17:20-17:35 Two species of seabirds used contrasting marine habitat across the cold water belt along the coast of northern Hokkaido in the southwestern Okhotsk Sea (Bungo Nishizawa)

17:35-17:50 Foraging behavior and prey field of Short-tailed Shearwaters using northern North Pacific and Southern Ocean (Yutaka Watanuki)

【Day 4: 2 June (Wed)】 (Time in Japan Standard Time, JST)

06:00 - 8:00 **AnalogueART – PESAS Joint Workshop (First Session)**

- Advantages and challenges of using environmental gradients and mosaics as analogues of future climate change (Samuel Rastrick, Kumiko Azetsu-Scott, Melissa Chierici)
- Introduction to PESAS and the use of paleo-proxies to understand long-term dynamics and frame future scenarios (Ben Fitzhugh)
- [Title To be announced] (Ben Gaglioti)
- It's in their bones" (Paleoecology hacks for the uninitiated) (Nicole Misarti)
- Using environmental mosaics to understand the future of Norwegian coral reefs (Tina Kutti)
- Using environmental mosaics in modal parametrisation and validation (Antonio Aguera Garcia)
- [Title To Be Announced] (Laura Gemery)
- [Title To Be Announced] (Catherine West)
- (To Be Determined) (Christine Bassett)

Poster Introduction:

09:00 - 09:02 Zooplankton biomass and biodiversity on the Sofala Bank (Ceiça Chioze)

09:02 - 09:04 Climate change adaptation in aquaculture: A systematic review (Eranga Galappaththi)

09:04 - 09:06 Impacts of meltwater discharge from marine-terminating glaciers on the protist community in Inglefield Bredning, northwestern Greenland (Kohei Matsuno)

09:06 - 09:08 Studies on Limacina helicina at Mombetsu in the southern Okhotsk Sea (Kohei Matsuno)

09:10 - 09:12 Understanding the Current Status of Seawater pH Changes Near Scallop Aquaculture Facilities in Northern Japan (Ayumi Mori)

09:12 - 09:14 Social, economic, and ecological adaptation strategies of small-scale fishers in the coastal area for climate change (Mohammad Mozumder)

09:14 - 09:16 Transport and heat loss of the Pacific Summer Water in the Arctic Chukchi Sea northern slope: mooring data analysis (Miaki Muramatsu)

【Day 4: 2 June (Wed) (cont.)】 (Time in Japan Standard Time, JST)

09:16 - 09:18 Influence of physical oceanographic condition to transportation of diatom and silicoflagellate particles in the southwestern Canada Basin (Jonaotaro Onodea)

09:18 - 09:20 Stratification in the northern Bering Sea in early summer of 2017 and 2018 (Hiromichi Ueno)

09:20 – 09:22 International Convention and Prevention of Pollution:Heavy Metal Concentration in the Bay of Bengal (Abu Hena Muhammad Yousuf)

15:00 - 17:00 **AnalogueART - PESAS Joint Workshop (Second Session)**

・Using natural gradients to study the capacity of organisms to physiologically adapt to future climate change (James Brown)

・Using pteropods as a model species to investigate the effect of large scale mosaics in ocean carbonate chemistry (Melissa Chierici, Kumiko Azetsu-Scott, Agneta Fransson)

・Use of natural analogues to assess the effects of future change on ecosystem services important for society (Jason Hall-Spencer)

・Relevance of historical ecology to contemporary and future socio-ecological concerns (Ben Fitzhugh)

・(To Be Determined) (Spencer Wood)

【Day 5: 3 June (Thu)】 (Time in Japan Standard Time, JST)

05:00-08:00 ESSAS Science Steering Committee Meeting

※ <u>Virtual Excursion</u> (*any time during the meeting*)
Upopoy (English site)(https://ainu-upopoy.jp/en/)
(Chinese, Korean, Russian, Taiwanese, Thai versions are also available)

Abstract

【Plenary Talk 1】

「春の歌と風の物語: 風・海・氷・人々と太平洋ニシンとの関係—過去・現在・未来—」

A song of spring and a story of winds: The relationship among Pacific herring (*Clupea pallasii*) , winds, sea, ice and people from the past to the future

Naoki TOJO, Ph.D.

International Education Office (FDC/IEO), Faculty of Fisheries Sciences, Hokkaido University

Pacific herring (*Clupea pallasii*) distributed over the North Pacific Ocean. As one of significant fisheries resources, herring has sustained livelihoods of coastal communities of the northern Pacific Rim. In Bering Sea, sea ice and storms closes the mother sea for months in the years, herring has been the first protein source after long winter for the natives along Alaskan coast. Based on the socio-economic needs in 1990's, Dr. Gordon H. Kruse and I worked to investigate the variability of herring spawning timings and locations with Alaska Department of Fish in the coast of Bristol Bay, Alaska. Since roe of herring was highly valuable as "KAZUNOKO", it was important to predict when and from where herring comes to shore and to spawn at adequate gonad maturity for fishers. We used geographic information system (GIS) to spatio-temporally collate and analyze historical herring spawning observations and a variety of environmental variables, including sea ice total concentration from National Snow and Ice Data Center, sea surface temperature from Comprehensive Ocean-Atmosphere Data Set and time series of winds and surface air temperature from the NCEP/NCAR Reanalysis and weather stations along the coast. Significant statistical relationship was found between spawning timing and environmental variabilities, especially sea ice along dynamic herring migration pathways. Spawning locations was also variable through the survey history. Wind-driven sea ice dynamics most likely influences to herring pre-spawning behaviors. Besides, the modeled dynamic behaviors correspond to local indigenous knowledge. Recent years with se ice decline, further monitoring and updates by integrative research has been expected for sustainable relationship between herring, environment, and people of the northern Pacific Rim.

【Plenary Talk 2】

Assessing and managing fish stocks in a rapidly changing environment

Franz Mueter

College of Fisheries and Ocean Sciences, University of Alaska Fairbanks

Warming oceans, the loss of sea ice, and changes in advection drive changes in highly productive Subarctic marine ecosystems and the increasing borealization of Arctic marine ecosystems. Borealization refers to the northward shift or expansion of marine populations and communities, including commercially important fish species, into Arctic waters. These shifts have been particularly pronounced on the major Arctic inflow shelves, which are the gateways from the Atlantic and Pacific Oceans into the Central Arctic Ocean (CAO), and have the potential to fundamentally transform Arctic marine ecosystems. These changes can pose significant challenges for fisheries stock assessment and management as some Subarctic fish stocks decline and others are displaced or expand into new areas. Shifting stocks are a challenge for stock assessment surveys as species move out of historically surveyed areas, for managers as changing stock and fisheries interactions may lead to resource conflicts, and for international institutions as stocks cross national boundaries or expand into the CAO. To meet these challenges, researchers will have to adopt new and cost-effective strategies for monitoring, managers have to be flexible to adapt to rapidly changing conditions, and enhanced international cooperation will be required to address transboundary issues and ensure the conservation and sustainable management of living marine resources in the CAO. Here I review these challenges and some of the emerging responses from the research community, management agencies and international institutions and provide some recommendations for sustainable and healthy Arctic marine systems.

【Plenary Talk 3】

Reframing the interface of science, policy and industry for the better ecosystem governance in the Anthropocene

Aoi Sugimoto

Fisheries Resources Institute, Japan Fisheries Research and Education Agency

This presentation will explore the way to drive the transformative change of environmental governance in the Anthropocene, using case studies in Okinawa and Hokkaido, the most south and north part of Japan.

Global policy and science platform is increasingly recognizing the importance for engaging diverse perspectives from scientific disciplines, conservation practitioners as well as those of local and indigenous communities to achieve desirable ecosystem governance (Díaz et al. 2018; Diaz et al. 2019; Pascual et al. 2017). Plural valuations of human–nature relationships are the key for a better, more inclusive decision-making, which is demonstrated by my case study in Yaeyama archipelago applying a network analysis on qualitative text contents. Based on, and in addition to the sound scientific finding, this case study paid a strong effort for communication of those findings, such as collaborative works with artists, designers and musicians. Through this innovative process of collaboration, I became aware of the possibility of multiscale governance which goes beyond the conventional science-policy interface, reaching much wider audiences outside of academics and governments. This presentation will describe this process, clarifying the challenges and potentials of such approach to share and trigger future opportunities among diverse stakeholders related to ecosystem governance under the umbrella of IMBER. I hope that my methods and findings will be applied to other areas, especially to the local and indigenous communities of Asia-Pacific where bio-cultural diversity is extremely rich but also facing crisis, and that the transformative change of ecosystem governance in the Anthropocene can be driven.

Zooplankton biomass and biodiversity on the Sofala Bank, Mozambique

Ceiça A. Chioze[1], Bernadino S. Malauene[1] and Jenny A. Huggett[2,3]

[1] Instituto Nacional de Investigação Pesqueira, Av. Mao-Tsé-Tung 309, Maputo, Mozambique
[2] Oceans and Coastal Research, Department of Environmental Affairs, Private Bag X4390, Cape Town 8000, South Africa
[3] Department of Biological Sciences and Marine Research Institute, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa

Background: There have been relatively few zooplankton studies in the Western Indian Ocean in general, and over the Mozambique shelf in particular, although there has been interest in recent years in ecosystem functioning related to mesoscale eddies in the Mozambique Channel. Data from phytoplankton studies indicate the most productive areas over the Mozambican shelf are Delagoa Bight in the south, the central Sofala Bank, influenced by seasonal nutrient input from the Zambezi delta, and Angoche in the north. The overarching objective of this project is to investigate patterns of abundance, biomass and species diversity of zooplankton communities on the Sofala Bank during October 2017, and to explore relationships with the associated physical, chemical and biological environment.

Methods: Zooplankton sampling was conducted off the coast of Mozambique – Sofala Bank during the first IIOE-2 survey on the *SA Agulhas II* in October 2017. Samples were collected from 44 stations using a Bongo net (200 μm) towed obliquely from a maximum depth of 200 m. Samples were preserved in 4% buffered formaldehyde for later identification by microscope. In the laboratory, samples were decanted into measuring cylinders and allowed to settle for 24 hours, after which settled volume measurements were taken. Biovolume (ml/m^3) was calculated by dividing the settled volume (ml) by the volume of water filtered by the net (m^3) at each station.

Results: Mean zooplankton biovolume over the Sofala Bank (between Beira and Angoche) was 0.19 ml/m^3, ranging from 0.04 to 0.95 ml/m^3. Greatest concentrations of zooplankton were located to the south (0.95 ml/m^3) and north (0.82 ml/m^3) of the Zambezi delta, in water depths of <50m. The southern maximum was associated with a region of relatively warm (26.4°C) and fresh (34.9 PSU) water presumably related to river outflow.

Conclusions: Zooplankton biomass was greatest close to the shore in the southern sector of the Sofala Bank off the Zambezi River mouth, presumably related to the river plume, with low biomass observed offshore.

Assessing and managing fish stocks in a rapidly changing environment

Franz Mueter

College of Fisheries and Ocean Sciences, University of Alaska Fairbanks

Warming oceans, the loss of sea ice, and changes in advection drive changes in highly productive Subarctic marine ecosystems and the increasing borealization of Arctic marine ecosystems. Borealization refers to the northward shift or expansion of marine populations and communities, including commercially important fish species, into Arctic waters. These shifts have been particularly pronounced on the major Arctic inflow shelves, which are the gateways from the Atlantic and Pacific Oceans into the Central Arctic Ocean (CAO), and have the potential to fundamentally transform Arctic marine ecosystems. These changes can pose significant challenges for fisheries stock assessment and management as some Subarctic fish stocks decline and others are displaced or expand into new areas. Shifting stocks are a challenge for stock assessment surveys as species move out of historically surveyed areas, for managers as changing stock and fisheries interactions may lead to resource conflicts, and for international institutions as stocks cross national boundaries or expand into the CAO. To meet these challenges, researchers will have to adopt new and cost-effective strategies for monitoring, managers have to be flexible to adapt to rapidly changing conditions, and enhanced international cooperation will be required to address transboundary issues and ensure the conservation and sustainable management of living marine resources in the CAO. Here I review these challenges and some of the emerging responses from the research community, management agencies and international institutions and provide some recommendations for sustainable and healthy Arctic marine systems.

Inter-annual variability of phytoplankton community structure in the Pacific Arctic Region

[1]Amane Fujiwara, [1]Shigeto Nishino, [2]Toru Hirawake, [3]Koji Suzuki, [1]Takashi Kikuchi

[1]*Institute of Arctic Climate and Environment Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)*
[2]*Bioscience Group, National Institute of Polar Research Japan*
[3]*Faculty of Environmental Earth Science, Hokkaido University*

The Arctic marine ecosystem has been facing on extremely variable environmental changes (e.g., sea ice decline, warming, and freshening). The lower trophic organisms are known to response quickly to such changes because of their short life cycle. Since the Arctic marine food web forms short and efficient energy transport system, even the small changes in the lower trophic organisms can have a large cascading impact on whole marine ecosystem. In this study, we evaluated the relationship between phytoplankton community structure and environmental variables using in situ data acquired during Japanese Arctic research cruises conducted during late summers from 2008 to 2017. The phytoplankton community group were able to divided into several major clusters using pigment signatures, and each cluster showed significantly different adaptation to water mass characteristic. The most productive and diatom dominated community was found in the Bering Shelf Water (BSW) occupied shallow shelf region mostly in cold years. In contrast, less productive community with larger diversity appeared in the shelf region when the warmer Alaskan Coastal Water (ACW) spread years. The ACW adapted community can even be transported to the northern basin region in less ice years and can overtake cold adapted basin community in dominance. Our results imply that spatial prominent of water masses strongly affect phytoplankton community structure in PAR, which in turn can have a large impact on the areal biological productivity.

Impact of sea-ice dynamics on the spatial distribution of diatom resting stages in sediments of the Pacific-Arctic Ocean

Yuri Fukai[1,2], Kohei Matsuno[2,3], Amane Fujiwara[4], Koji Suzuki[1,5], Mindy Richlen[6], Evangeline Fachon[6], Donald M. Anderson[6]

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[4] *Japan Agency for Marine-Earth Science and Technology, Japan*
[5] *Faculty of Environmental Earth Science, Hokkaido University, Japan*
[6] *Biology Department, Woods Hole Oceanographic Institution, USA*

The Pacific-Arctic Ocean is characterized by seasonal sea-ice, the spatial extent and duration of which varies considerably. In this region, diatoms are the dominant phytoplankton group during spring and summer. To facilitate survival during periods that are less favorable for growth, many diatom species produce resting stages that settle to the seafloor and can serve as a potential inoculum for subsequent blooms. Since diatom assemblage composition is closely related to sea-ice dynamics, detailed studies of biophysical interactions are fundamental to understanding the lower trophic levels of ecosystems in the Pacific-Arctic Ocean. One way to explore this relationship is by comparing the distribution and abundance of diatom resting stages with patterns of sea-ice coverage. In this study, we quantified viable diatom resting stages in sediments in 2018 and explored their relationship to sea-ice extent during the previous winter. Diatom assemblages were clearly dependent on the variable timing of the sea-ice retreat and accompanying light conditions. In areas where sea-ice retreated earlier, open-water species such as *Chaetoceros* spp. and *Thalassiosira* spp. were abundant. In contrast, proportional abundances of *Attheya* spp. and pennate diatom species that are commonly observed in sea-ice were higher in areas where diatoms experienced higher light levels and longer day length in/under the sea-ice due to the late seasonal ice retreat. This study demonstrates that sea-ice dynamics are an important determinant of diatom species composition in the Pacific-Arctic.

Climate change adaptation in aquaculture: a systematic review

Eranga K. Galappaththi[1], Stephanie T. Ichien[2], Amanda A. Hyman[3], Charlotte J. Aubrac[1] and James D. Ford[4]

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[2]College of Agricultural Science, Oregon Sea Grant, Oregon State University, Corvallis, OR, USA
[3]Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN, USA
[4]Priestley International Centre for Climate, University of Leeds, Leeds, UK

This study conducts the first systematic literature review of climate change adaptation in aquaculture. We address three specific questions: (i) What is aquaculture adapting to? (ii) How is aquaculture adapting? and (iii) What research gaps need to be addressed? We identify, characterise and examine case studies published between 1990 and 2018 that lie at the intersection of the domains of climate change, adaptation and aquaculture. The main areas of documented climate change impacts relate to extreme events and the general impacts of climate change on the aquaculture sector. Three categories of adaptation to climate change are identified: coping mechanisms at the local level (e.g. water quality management techniques), multilevel adaptive strategies (e.g. changing culture practices) and management approaches (e.g. adaptation planning, community-based adaptation). We identify four potential areas for future research: research on inland aquaculture adaptation; studies at the household level; whether different groups of aquaculture farmers (e.g. indigenous people) face and adapt differently to climate change; and the use of GIS and remote sensing as cost-effective tools for developing adaptation strategies and responses. The study brings essential practical and theoretical insights to the aquaculture industry as well as to climate change adaptation research across the globe.

Underwater soundscape and its temporal variability in the East Siberian Sea

Dong-Gyun Han[1], Jongmin Joo[2], Wuju Son[1,3], Kyoung Ho Cho[1], Jee Woong Choi[4], Eun Jin Yang[1], Jeong-Hoon Kim[5], Sung-Ho Kang[1], and Hyoung Sul La[1]

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The East Siberian Sea is one of the least studied regions in the Arctic Ocean and there are many knowledge gaps in the underwater sound of the East Siberian Shelf. We measured the underwater sound in the East Siberian Sea using an autonomous passive acoustic recorder from August 2017 to August 2018. Sea ice concentration, sea ice drift speed, draft depth, ocean current speed and wind speed data were collected to derive the relationship with the underwater soundscape. We found that underwater sound level is negatively correlated with the sea ice concentration and identified its seasonal variability. The sound level was relatively high in summer when the sea ice concentration varied largely or open water conditions. The conspicuous sound sources were identified and contributions of the anthropogenic and natural physical sound source to the increased ambient noise level were estimated in a given period. In addition, the results of previous studies on the ambient noise in the Arctic Ocean were collected and the median spectra of each region were compared. From the comparison results, the East Siberian Sea was relatively quiet region in the Arctic Ocean. More details will be discussed in the meeting.

Physical manifestations and ecological implications of Arctic Atlantification

Ingvaldsen, R.B., Assmann, K. M., Dolgov, A.V., Fossheim, M., Polyakov, I. V. Primicerio, R.

The Atlantic gateway to the Arctic Ocean is strongly influenced by vigorous inflows of warm Atlantic Water, whose high-latitude impacts are rapidly strengthening. This presentation discusses various manifestations of this "Atlantification" in a hotspot region of climate change spanning from the southern Barents Sea to the Eurasian Basin. There is a host of changes associated with Atlantification, with warmer ocean, weaker stratification, enhanced upper ocean mixing, and enhanced air-ice-ocean coupling – all leading to sea ice loss. Key mechanisms driving the physical changes include reduced heat loss amplifying temperature anomalies, changes in vertical structure due to loss of sea ice, and positive ice/ocean heat feedback. Progressing Atlantification seems to be characterized by increased dominance of regional processes becoming part of the Atlantification. Arctic ecology is characterized by environmental conditions that in the past precluded colonization by boreal species and the establishment of a more diverse pelagic compartment. Atlantification promotes invasion by boreal species, which modify Arctic biodiversity, community structure, food web organization, and ecosystem functioning. This study increases the understanding and the ability to predict changes in the Arctic driven by ongoing and future climate change, which is of relevance to scientists, managers, and society at large.

Increasing zooplankton biomass associated with sea ice loss in the western Arctic Ocean and its ecological impacts

Motoyo Itoh[1], Minoru Kitamura[1], Amane Fujiwara[1], Eddy C. Carmack[2], Kazuo Amakasu[3], Koichi Ara[4], Mario Uchimiya[5], Toru Hirawake[6], Jonaotaro Onodera[1], Shigeto Nishino[1] and Takashi Kikuchi[1]

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Sea ice cover is rapidly declining due to global warming. This change is accompanied by increases in sea surface temperature and phytoplankton primary production in the western Arctic Ocean. However, their influence on marine ecosystems remains unclear, as few studies have conducted ecological monitoring at decadal time scales. Comparing mooring-based acoustic backscattering data collected during periods of both high (2000－2003) and low sea ice coverage (2010—2013) in the Chukchi Sea, western Arctic Ocean, we show that annual mean zooplankton biomass has increased 1.6-fold between the two periods. This biomass change increased the grazing pressure on phytoplankton from zooplankton based on a theoretical food requirement model. Consequently, supply of sinking carbon to benthic organisms is expected to decrease during summer, despite phytoplankton production increasing. Thus, the Chukchi Sea ecosystem is likely to be shifting away from a pelagic-benthic coupled ecosystem toward a pelagic-dominated system in which primary production is not directly connected to the benthic carbon cycle due to increased grazing by pelagic zooplankton.

Inter-annual changes of the mesozooplankton community structure in the Western Arctic Ocean during summers of 2015-2018

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The Arctic Ocean is the forefront area of climate change research, being the first to respond to climate change on a global scale and highly sensitive to tiny oceanographic changes. The frozen Arctic Ocean, covered with thick sea ice, was an inaccessible area, but research on the Arctic Ocean has been actively conducted since the construction of the icebreaker research vessel (*IBRV*). This research is the first comprehensive Arctic mesozooplankton study conducted using the Korean *IBRV* Araon. Mesozooplankton samples were collected in the western Arctic Ocean from 2015 to 2018. A total of 43 species belonging to 14 taxa were identified and analyzed for ocean biological and community ecological studies. The most predominant taxon was copepods, of which *Calanus glacialis* was the most dominant species among holozooplankton. We describe the Inter-annual composition and structure of the mesozooplankton community in the Western Arctic Ocean. The distribution and structure of the meso-zooplankton communities showed variations over large spatial scales in the western Arctic waters due to variations in environmental factors, although it appears to be determined primarily by “water mass”.

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Capital investments for the Norwegian Red King Crab: A Tale of Ecological and Community Resilience

Abstract

The importance of onshore infrastructure for supporting coastal fisheries has long been acknowledged; its role in remote and geographically challenged fishing communities in the Nordic Arctic has visibly impacted community structure and development. This paper explores the Red King Crab (RKC) fishery in Norway and the ways in which its management has been changing the socioeconomic landscape in Northern Finnmark since the beginning of commercial exploitation in the early 2000's. The RKC in the Barents Sea is an intentionally introduced species that is viewed both as a nuisance and as a valuable economic resource. This induces ambivalent preferences among local stakeholders and decision-makers in Norway. Low harvesting costs, uncertain ecosystem losses and ongoing infrastructure investment in onshore landing facilities all shape stakeholders' myopic interests in Norway in favor of a long-term management of the fishery. Simultaneously the political willingness to support local coastal communities and livelihoods in northern Norway provides significant impetus for maintaining a long-term stock, particularly in Eastern Finnmark. The ongoing infrastructure investments favor regional stakeholders over more diffuse and less clearly identified interests in the ecosystem changes induced by the invasive crab. With this paper, we highlight the path dependencies created by infrastructure development and seek to identify trade-offs inherent in the management of the invasion for ecological and community resilience.

Keywords: *Commercially Valuable Invasions, Fisheries Management, Red King Crab, Livelihood Trajectories in Northern Fisheries, Barents Sea Fisheries*

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Studies on *Limacina helicina* at Mombetsu in the southern Okhotsk Sea

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Long-term and high-frequent monitoring of hydrography and plankton have been performed from 1997 to present at the Okhotsk Tower located at Mombetsu, in the southern Okhotsk Sea off Hokkaido. The region has two unique features; south end of the seasonal sea-ice area in the northern hemisphere, many species are same to Arctic phytoplankton and zooplankton species. Because of these features, observation in winter (sea-ice coverage season) gives us good opportunities to study relation between sea-ice and lower trophic levels. Some linkages between them were already suggested at the region, but still relatively poorly understood. In this study, we will introduce outcomes regarding to lower trophic levels (especially, *Limacina helicina*) from monitoring at the tower and ship-board observation using Icebreaker Garinko II at Mombetsu in winter season.

Presentation type: poster

Impacts of meltwater discharge from marine-terminating glaciers on the protist community in Inglefield Bredning, northwestern Greenland

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To evaluate the effects of meltwater discharge from marine-terminating glaciers on a fjord protist community in northwestern Greenland during summer, we investigated the distribution, abundance and biomass of the protist community and their relationships with hydrographic parameters. In the standing stock of protists, dinoflagellates (46.4%) and oligotrich ciliates (39.5%) were dominant throughout the study region. According to the vertical distribution, oligotrich ciliates were abundant in the surface layer, mainly due to suitable food conditions (including the diatom and nanoflagellate abundances). Near glaciers, relatively high chl *a* concentrations were found in the subsurface layers associated with the low-temperature, high-turbidity and slightly high nutrient levels, indicating that the nutrient inputs from the upwelling glacial meltwater plume were driving primary production. Large-sized *Protoperidium* spp. occurred only at stations near glaciers where nutrients were abundant, and heterotrophic dinoflagellates showed strong relationships with nanoflagellates. These findings suggest that the upwelling associated with subglacial meltwater discharge can stimulate autotrophic nanoflagellate production, resulting in increases in ciliate and heterotrophic dinoflagellate production.

Presentation type: poster

Response of zooplankton community with early sea-ice reduction in the northern Bering Sea during summers 2017, 2018

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Remarkable early sea-ice reduction was observed in the northern Bering Sea during 2018. Due to the unusual hydrographic situation, several trophic levels responded; delayed phytoplankton bloom, phytoplankton community change, northward shift of fishes, but response of zooplankton community is still unclear. Thorough this study, we investigated the zooplankton community in the northern Bering Sea during summers in 2017 and 2018, and evaluate the effects of early sea-ice melt on zooplankton community and population stage structure of large copepods. Based on cluster analysis, five zooplankton communities were identified. In the Chirikov Basin, year changes on the zooplankton community were found. In 2017, the zooplankton community included abundant pacific copepods transported by Anadyr water. While in 2018, small copepods were dominated, this may be related with early sea-ice reduction. Comparison the population structure for large copepods (*Calanus glacialis/marshallae* and *Metridia pacifica*) between 2017 and 2018, clear difference was detected. In 2018, higher abundances with dominance of younger stages of them were observed. This was caused mainly the different onset timing of phytoplankton bloom associated with sea-ice melt and water stratification. Eventually, early sea-ice melt suggested delayed reproduction timing of the large copepods with late phytoplankton bloom.

Presentation type: oral

Changes and future predictions of Oyashio Intermediate Water, a key water mass for biological production

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The western subarctic Pacific exhibits major biological productivity and possesses one of the largest biological CO2 drawdown in the world. This biological productivity is fed by the Oyashio Current and its two source waters: Western Subarctic Water, which supplies nutrients from the subarctic Pacific, and cold Okhotsk Sea Intermediate Water (OSIW), which supplies iron from the Sea of Okhotsk. As iron content is a limiting factor for biological productivity, it is essential to understand and predict the variability in OYW properties in a changing climate, and specifically the content of OSIW in OYW (mixing ratio). Here, we created seasonal climatologies of water properties to understand how climate change (~50 years trend) and the 18.6-year tidal cycle affect the Oyashio Intermediate Water (OYW). We found that due to climate change, the "recipe" of OYW is modified mainly in winter via decreased OSIW outflow. This yields a warmer, and possibly less iron-rich Oyashio. Conversely, the outflow of OSIW is increased (decreased) in high-tide (low-tide) years.

We then provide a 20-year prediction of OYW temperature and mixing ratio. We predict that the opposite effects of the climate change and high tide will lead to stagnation of the OYW properties in the 2020s. However, OYW warming will be accelerated in the 2030s due to the combined effects of climate change and low-tide. Besides, we found that OYW temperature will increase by 1 °C, and the mixing ratio of OSIW in OYW will decrease by 50% between 1960 and 2040, which might greatly impact biological productivity, fisheries, and carbon drawdown in the North Pacific.

Institutional innovation for the cooperative utilization of cross-domain marine space resources in the Guangdong-Hong Kong-Macao Greater Bay Area

Chen Mingbao

At present, reclamation is no longer an effective way to expand the urban space of the Guangdong-Hong Kong-Macao Greater Bay Area（GBA）. How to efficiently use the existing marine space resources to promote the sustainable development of the marine economy and promote cooperation in the GBA? It is an urgent problem to be solved. Under the guidance of MEBM theory, this article establishes an analysis framework of institutional supply and demand for the cooperative utilization of cross-domain marine resources, combined with the institutional characteristics of the GBA, and analyzes the institutional defects and the possible space for institutional innovation in the process of cooperative utilization of marine space resources in the GBA. The research shows that marine space resources are the common development space of the GBA and also an important carrier for Hong Kong and Macao to integrate into the overall development of China. The cooperative utilization of marine space resources can promote the development of the GBA. The direction of institutional innovation for marine space resource cooperation in the GBA should be based on the requirements of common development and MEBM, break through administrative boundaries, highlight their respective advantages, and innovate new mechanisms conducive to the cooperative utilization of marine space resources in the GBA, so as to promote the utilization and protection of marine resources and realize the harmonious development of human and ocean.

Reframing the interface of science, policy and industry for the better ecosystem governance in the Anthropocene

Aoi Sugimoto

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This presentation will explore the way to drive the transformative change of environmental governance in the Anthropocene, using case studies in Okinawa and Hokkaido, the most south and north part of Japan.

Global policy and science platform is increasingly recognizing the importance for engaging diverse perspectives from scientific disciplines, conservation practitioners as well as those of local and indigenous communities to achieve desirable ecosystem governance (Díaz et al. 2018; Diaz et al. 2019; Pascual et al. 2017). Plural valuations of human–nature relationships are the key for a better, more inclusive decision-making, which is demonstrated by my case study in Yaeyama archipelago applying a network analysis on qualitative text contents. Based on, and in addition to the sound scientific finding, this case study paid a strong effort for communication of those findings, such as collaborative works with artists, designers and musicians. Through this innovative process of collaboration, I became aware of the possibility of multiscale governance which goes beyond the conventional science-policy interface, reaching much wider audiences outside of academics and governments. This presentation will describe this process, clarifying the challenges and potentials of such approach to share and trigger future opportunities among diverse stakeholders related to ecosystem governance under the umbrella of IMBER. I hope that my methods and findings will be applied to other areas, especially to the local and indigenous communities of Asia-Pacific where bio-cultural diversity is extremely rich but also facing crisis, and that the transformative change of ecosystem governance in the Anthropocene can be driven.

Marine Ecosystem Variations over the North Pacific and their Linkage to Large-Scale Climate Variability and Change

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In order to understand how North Pacific (NP) marine ecosystem have varied, 120 marine biological time series for both the western (29 time series) and eastern (91 time series) NP were analyzed with a Principal Component Analysis (PCA) for the period 1965 to 2006. This is the first attempt to conduct a multivariate analysis for a large number of marine biological data in the western and eastern NP combined. We used Monte-Carlo simulation to evaluate confidence levels of correlations and explained variance ratio of PCA modes with accounting for auto-correlation within the analyzed time series. All first mode principal components (PC1s), which are the time coefficients of the first PCA modes, calculated for the data in the whole, western, and eastern NP exhibit a long-term trend. The PC1s were associated with an overall increase of Alaskan and Japan/Russian salmon, and decreases of groundfish across the basin. This mode was closely related to the warming of sea-surface temperature over the NP and over the global oceans, thereby suggesting that the strongest mode of the NP marine ecosystem was already influenced by global warming. The eastern NP PC2, characterized by multi decadal variability, was correlated positively with salmon and negatively with groundfish. On the other hand, the western NP PC2 exhibited slightly shorter timescale interdecadal variability than the eastern NP PC2 and was negatively correlated with zooplankton and two small pelagic fish time series around Japan. The eastern NP PC2

was the most strongly related to the Pacific (inter-)Decadal Oscillation index, while the western NP PC2 was most closely related to the North Pacific Gyre Oscillation index. Consequently, the present analysis provides a new and unified view of climate change and marine ecosystem variations across the western and eastern NP. In particular, it is suggested that global warming has already substantially influenced the North Pacific marine ecosystem. It is suggested that the groundfish may suffer more than pelagic fish due to the future global warming.

Understanding the Current Status of Seawater pH Changes Near Scallop Aquaculture Facilities in Northern Japan

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In recent years, ocean acidification has gained attention, and there has been growing concern regarding the decrease of ocean pH. Although seasonal and diurnal changes in pH may be greater in coastal areas than in the open ocean, the changes are not well understood. As pH decreases, the saturation state of calcite (Ω_{Ca}), a type of calcium carbonate, decreases, affecting the survival and growth of calcifying organisms. Calcite-forming scallops (*Patinopecten yessoensis*) are one of the most important fishery resources in northern Japan. Their growth may be inhibited by decreased pH. However, the current situation remains unclear. Therefore, in this study we conducted surveys to understand the current state of pH decrease near scallop aquaculture facilities in Lake Saroma and Funka Bay in Hokkaido, as well as Mutsu Bay in Aomori, Japan. Furthermore, the observed values were used to predict pH and Ω_{Ca} values at the end of this century (2081-2100) under different RCP scenarios. The results show that seasonal pH changes were similar in the three areas, although the magnitude of change differed among sites. The largest range of pH changes (7.5-8.3) was observed in Lake Saroma, and the lowest values were observed in the bottom layer in summer when organic matter decomposition occurs. In addition, Ω_{Ca} in Lake Saroma decreased with decreasing pH, as well as a decrease in water temperature and salinity in all layers in winter. Thus, we demonstrate that the bottom layer in summer and all layers in winter should be considered for scallop growth inhibitions in Lake Saroma. Predictions based on these results showed that scallop cultivation would be still possible under RCP 2.6, but may be impossible due to significantly reduced growth in all areas and seasons under RCP 8.5.

Social, economic, and ecological adaptation strategies of small-scale fishers in the coastal area for climate change

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Small-scale fisheries are undeniably important for livelihoods, food security and income around the globe. However, they face major challenges, including global market and demographic shifts, policy changes and climate variations that may threaten the wellbeing, health, and safety of fishing communities. Climate change and extreme weather pose significant and long-term risks to fisheries in many tropical developing countries including Bangladesh, like disruption of fishing operations and fish production. Coastal fishing communities lack the economic, social, and political power to improve their resilience to these stressors. Hilsa (*Tenualosa ilisha*) is Bangladesh's most valuable fish species - nutritionally, economically, and culturally. Adoption of coping strategies to the impacts of climate change is crucial for the hilsa fishery, and the fishing communities depend on it. This research focuses on the liable determinants and dimension of hilsa fishing community beliefs of, and adaptation to, climate change and recommends policies for adaptation. The present study applies adaptation theories to shape the research and related interpretation. A mixed method research approach was used to investigate fundamental dimensions of community perception of climate change and adaptation, drawing on multiple sources of evidence: participant observation, household survey, in depth-individual interviews, focus group discussions, key informant interviews and secondary sources. Respondents had clear perceptions about climate change as a form of changes in rainfall, seasonal patterns, increased temperatures, and salinity. Such changes threaten biodiversity and could lead to changes in migration patterns of fish, declining fish stocks. Hilsa fishers believed that adaptation to climate change needs measures that simultaneously reduce poverty, protect, or restore biodiversity and ecosystem services, by getting more fishing inputs and modern equipment, awareness and information, weather observation and alternative business. It is hoped that this research will serve as a food of thought how fisher’s preferences and adaptation practices including fisher's social, economic, and traditional knowledge can be incorporated into formal adaptation policies.

Transport and heat loss of the Pacific Summer Water in the Arctic Chukchi Sea northern slope: mooring data analysis

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We investigated the transport and heat loss of the Pacific Summer Water (PSW) along the Chukchi Sea northern slope using the temperature, salinity and velocity data of the mooring time series obtained in 2003–2005 (Period 1) and 2015–2019 (Period 2). The PSW at Stations HSN and NHC on the Chukchi Sea northern slope was warmer and fresher in Period 2 than in Period 1. Results from a lag correlation analysis of the temperature time series provide quantitative evidence to suggest that the PSW was transported from Barrow Canyon to Stations HSN and NHC by the northwestward Chukchi Slope Current. The advection time was 7–87 days. The temperature and salinity mostly decreased during PSW transport. Vertical mixing with the surface cold water could be a potential factor for temperature decrease. This decrease in Period 2 were higher than that in Period 1. This large decrease was probably influenced by stratification rather than wind conditions.

Highlights of the R/V Mirai Arctic Ocean survey in 2020

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Since spatial and temporal variability is inherently large in the Arctic Ocean, we urgently need baseline data for the Arctic Ocean as a whole to prepare for the further changes to come. Critically needed understandings would be advanced from a coordinated multi-ship, multi-nation pan-Arctic ship-based sampling campaign, based on shared state-of-the-art protocols for data collections and sharing and carefully planned ship tracks during the same period. This could allow for a synoptic view of the totality of hydrographic and ecosystem changes taking place in the Arctic Ocean and facilitate advancing model development using integrated data sets to predict the future state of the Arctic. To obtain such baseline data, we have planned a pan-Arctic research program, the Synoptic Arctic Survey (SAS), with a goal of conducting it in 2020 and 2021. In 2020, under the ArCS II project in collaboration with SAS, the Research Vessel (R/V) MIRAI conducted hydrographic and biogeochemical surveys in the Chukchi Sea and the southern Canada Basin. Here we present the following 3 topics.

1) Biological hotspot in the southern Chukchi Sea was not maintained in October 2020. Surface nitrogenous nutrients were not depleted and chlorophyll concentration was lower than usual in autumn.
2) In the marginal ice zone, chlorophyll concentration was relatively high at a seasonal pycnocline (~ 20 m) and below a meltwater front.
3) Aragonite super-corrosive water was found on the Chukchi Plateau, a fishable area (< 2000 m). The corrosive water distribution may be controlled by the extent of Beaufort Gyre. Monitoring of the corrosive water in the Pacific Arctic including the fishable area is necessary under international collaborations of SAS and beyond.

Two species of seabirds used contrasting marine habitat across the cold water belt along the coast of northern Hokkaido in the southwestern Okhotsk Sea

B. Nishizawa, J. Okado, Y. Mitani, T. Nakamura, A. Yamaguchi, T. Mukai & Y. Watanuki

To understand the biophysical factors affecting density of foraging seabirds across the cold-water belt in the southwestern Okhotsk Sea, we conducted a one-day (180 km transect length) shipboard seabird survey off the northeastern coast of Hokkaido during summer in 2019, concurrently with acoustic observations of potential prey (zooplankton and fish) biomass, thermosalinograph measurements, and CTD observations. Planktivorous Short-tailed Shearwaters (*Ardenna tenuirostris*, 66% of total birds) and piscivorous Rhinoceros Auklets (*Cerorhinca monocerata*, 28%) were dominant and used contrasting foraging habitat. The large foraging flock of shearwaters was observed in the cold-water belt zone, including its fronts with coastal Soya Warm Current Water and the offshore Fresh Surface Okhotsk Sea Water, where surface chlorophyll *a* concentrations was the highest but not related to the zooplankton biomass at 3-km scale. In contrast, the density of auklets was high in the coastal Soya Warm Current Water, where acoustically-determined fish biomass was large, and showed positive relationship with the fish biomass in the surface layer. This species-specific difference in the responses to prey density might be related to prey-searching behavior i.e., Rhinoceros Auklets possibly search prey under water visually, but Short-tailed Shearwater may search using olfactory cue from phytoplankton to locate zooplankton patches in the surface.

Influence of physical oceanographic condition to transportation of diatom and silicoflagellate particles in the southwestern Canada Basin

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In order to monitor the lower-trophic marine ecosystems in changing Arctic Ocean, we have studied the relationship between physical oceanographic condition and settling particle fluxes of diatom and silicoflagellate. Sediment trap samples were collected off the north of Barrow Canyon (NBC) and the northern part of Hanna Canyon (NHC) from fall 2015 to summer 2017. Diatom settling flux increased in summer as a reflection of seasonal productivity increase. The assemblages of settling diatoms at NBC was characterized by relative dominance of *Thalassionema nitzschioides*, which is sometimes observed in southwestern Canada Basin water, for the first deployment period, and sea-ice related species such as *Fossula arctica* for the second deployment period. The relative abundance of sea-ice related species was higher at NHC, probably because of the mooring position in more nutrient-rich condition compared to that at NBC. At NBC, diatom and silicoflagellate settling-fluxes also increased with particulate organic carbon in early winter 2016/2017. This reflected the temporal lateral advection of Pacific-origin waters from shelf to basin as the result of temporal changes in atmospheric and physical oceanographic condition. The settlement of biogenic particles from shelf to basin in addition to vertical settlement of in situ biogenic particles may affect the ecosystems for deeper water mass and sea floor in the southwestern Canada Basin.

Optimization of salmon release operation under changing climate in the Okhotsk coast, Japan

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Chum salmon is one of important fishery resources in the North Pacific. Recently, under changing climate, return of chum salmon in Hokkaido tend to decrease. More precise juvenile release operation is required for adapting to changing climate including warming sea temperature with adjusting sea entry condition. It is necessary for this precise operation to predict coastal marine environment in the release period and monitor short-term change in coastal residency. We develop a supporting information system for optimization of salmon release operation in Okhotsk coast. This system was designed as web-based visualization to consist two service sites, monitoring of marine environment (marine site) and supporting of salmon release operation (release site). In marine site, we employ the output of eddy-resolving analysis model based on four-dimensional variational assimilation and a high(2-km) resolution forecast model covering Japanese coastal areas developed by Japan Meteorological Agency. We also use GCOM-C satellite SGLI data, sea surface temperature (SST) and chlorophyll-a, with 250m spatial resolution operated by JAXA. In release site, there are two functions, one is SST prediction function and the other is salmon release simulation function. In SST prediction page, we obtain three months prediction SST using autoregressive model developed by using long term over 20 years Satellite SST data sets with R package. In salmon release simulation page, when we input number of release operation, date, release fork length, and number of release salmon, we obtain mean fork length, which is one of index of survival/return rate, in the period of offshoring from coastal residency. This is a kind of release navigation tools. We will start to use the prototype system this salmon release season in spring 2021.

Identifying ecosystem reference states with “Chance and Necessity” model simulations

Eliot Sivel

Institute of Marine Research

The Barents Sea is a subarctic shelf sea in which fisheries are important. During the last five decades, variations of environmental drivers and fisheries contributed to important variations of many ecological components of the Barents Sea ecosystem. Understanding the effect of variation in external drivers on the ecosystem are essential to predict its future dynamics. Comparing observed past ecosystem states and variability with a reference, is one way to better understand the effect of external drivers on the ecosystem. One challenge is then to define the reference for ecosystem states and variability. This can be achieved by simulating ecosystem dynamics. In this study, we use “Chance and Necessity” modelling to simulate the reference variability of the Barents Sea ecosystem. The model simulates trophic interactions within a simplified food-web from plankton to whales. The prey-predator interactions are random but constrained by biological and ecological principles. We compare observed recent ecosystem states and variability to reference simulations. Our results show that the states of the Barents Sea ecosystem during the last three decades, which are characterized by high biomass of demersal fish and low biomass of marine mammals, only covers a fraction of the possible reference states. In addition, we find that inter-decadal fluctuations between top-down and bottom-up trophic control are expected features of the Barents Sea ecosystem.

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

Hiromichi Ueno, Mizuki Komatsu, Zhaoqianyi Ji, Ryo Dobashi, Miaki Muramatsu, Hiroto Abe, Keiri Imai, Atushi Ooki and Toru Hirawake

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

Distribution of Pu-239 and Pu-240 in the Eastern Chinese seas and its implications in the qualification of oceanic-derived species

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Concentrations and isotopic composition of plutonium (Pu) are widely used for its source identification and to determine transport processes of Pu-associated particulate matter and water. We investigated the concentrations of ^{239}Pu and ^{240}Pu and their ratios in a number of sediment samples from the Eastern Chinese seas (i.e., Bohai Sea (BS), Yellow Sea (YS) and East China Sea (ECS)). The $^{239+240}$Pu activity concentrations in surface sediment samples were found to range between 0.001 and 0.288, between 0.014 to 0.659 between 0.048 and 0.492 Bq kg^{-1} in the BS, YS and ECS surface sediments, respectively; the ^{240}Pu/^{239}Pu atom ratios ranged from 0.173 to 0.256, from 0.18 to 0.31 and from 0.158 to 0.297 in the BS, YS and ECS surface sediments, respectively, and were mostly higher than the mean global fallout value of 0.18 and lower than the Pacific Proving Ground (PPG) value of 0.36. These observations clearly indicate a signal of PPG close-in fallout Pu input to the Eastern Chinese seas. From the mass balance, 41% $^{239+240}$Pu (8.9×10^{9} Bq yr^{-1}) and 18% ^{210}Pb (2.4×10^{12} Bq yr^{-1}) in the NYS were transported from the Southern Yellow Sea. The PPG input appears to be the dominant source of Pu to the ECS, accounting for 45%-52% of the total inventory. Using Pu as a tracer, we can estimate that the oceanic ^{210}Pb input into the ECS to be $(1.7-2.0)\times10^{15}$ Bq. In the BS, 63% ^{210}Pb was from atmospheric deposition and 84% $^{239+240}$Pu was contributed by riverine input. It is estimated that $(1.8\text{-}2.6)\times10^{8}$ ton y^{-1} and $(3.6\text{-}3.8)\times10^{8}$ ton y^{-1} sedimentary particles could be transport from the BS to NYS and from the NYS to Southern Yellow Sea by using the export flux of $^{239+240}$Pu and ^{210}Pb$_{ex}$, respectively. Using Pu as a tracer, we estimated that the oceanic input contributed 2.0 tons y^{-1} Hg and 1.0×10^{3} tons y^{-1} Zn to the SYS sediments during 2014, which accounts for 33% and 3% of total buried Hg and Zn, respectively. Our study shows that the ^{240}Pu/^{239}Pu atom ratio is useful not only to obtain a better insight of the biogeochemistry influenced by the KC, but also to trace the long-range transport of other particle-reactive species.

Arctic marine biogeochemical modeling in the ArCSII Project

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The Arctic Challenge for Sustainability II (ArCS II) is a national flagship project operated from June 2020 to March 2025 and fosters various Arctic researches. In the ocean research program, a couple of pan-Arctic sea ice–ocean modeling studies are conducted with different experimental designs (e.g., horizontal resolution and integration period) following previous works [Park et al., 2020, Science Advances; Watanabe et al., 2019, JGR Oceans; Watanabe et al., 2017, DSR-I]. In this meeting, three topics will be briefly presented. First, we evaluate sensitivity of ocean acidification to riverine inputs of biogeochemical variables (nitrate, silicate, dissolved inorganic carbon, and total alkalinity). Numerous decadal experiments for 1979–2018 were performed using the 25-km grid version. The simulation results indicated that those riverine inputs slowed down ocean acidification in the many Arctic regions. Second, we participate in the Ice Algae Model Intercomparison Project Phase 2 (IAMIP2). In the Phase 1, seasonal, interannual, and decadal variations in the Arctic ice-algal productivity for 1980–2009 were compared under the Forum for Arctic Modeling and Observational Synthesis (FAMOS) framework. In the Phase 2, the experiment period will be extended to 150 years spanning from the mid-twentieth century to the end of the twenty-first century, using the same atmospheric forcing dataset based on outputs from the Coupled Model Intercomparison Project phase 6 (CMIP6). Third, transport processes of seafloor sediments from the Chukchi shelf to the western Arctic basin are investigated in collaboration with sediment trap measurements at four sites: Chukchi Abyssal Plain (CAP), Northwind Abyssal Plain (NAP), North of Hanna Canyon (NHC), and North of Barrow Canyon (NBC). We performed interannual experiments for 2001–2019 using the 5-km grid version which newly incorporated the resuspended particles (RP) and found that mesoscale eddies and the westward Chukchi Slope Current played an important role in the RP transport.

Foraging behavior and prey field of Short-tailed Shearwaters using northern North Pacific and Southern Ocean

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A number of seabird species make long (~10,000km) latitudinal migration and individuals from each colony often use the separate non-breeding regions repeatedly for their life. Ecological reasons of this migration have long been explored. Geographical difference in the seasonality of marine primary production is hypothesized to be a driving factor. Comparison of prey field and foraging activity between non-breeding and breeding regions will give additional clue. Short-tailed Shearwaters (*Ardenna tenuirostris*) breed in Tasmania in October – April and feed mainly in Indian Sector of Southern Ocean (ISO). During the non-breeding period (June – September) they used the south-eastern Bering Sea (BES), the south Okhotsk Sea (OHS), and southern Chukchi Sea (CKS). We investigated their foraging activity using geolocators, the prey characteristics using stable isotope value of their feathers and blood, and their relationships with the prey density using boat census and acoustics. Bird using OHS fed on prey of lower trophic level than those using BES during non-breeding, while those using ISO fed on more higher trophic during breeding. Birds showed more intense foraging activity (greater number of shorter foraging bouts, lower proportional on-water time, and longer daily moving distance) in ISO than others, and in CKS than BES and OHS. At sea density of birds was in the order as OHS>BES>ISO, while density of prey (zooplankton) in surface layer was BES>ISO>OHS. Birds tended to forage in the places where prey density was high and the association at 5-10 km bin size was stronger in OHS and ISO than BES. High energy requirements and limitation of at sea time during breeding and high energy requirements before migration may request intensive foraging in ISO and CKS, respectively. Geographical differences in marine environment also might affect relationships between prey field and foraging activity.

Comparison of population structure, vertical distribution, and growth of the sympatric, carnivorous, mesopelagic copepods *Paraeuchaeta glacialis* and *Heterorhabdus norvegicus* in the western Arctic Ocean: Occurrence of *r*-strategy mesopelagic copepods may be related to their specialized feeding mode

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Life cycles of copepods in the Arctic Ocean primarily have been studied for epipelagic omnivorous copepods and little information is available for mesopelagic carnivorous species. Here the life cycles of two mesopelagic carnivorous copepods (*Paraeuchaeta glacialis* and *Heterorhabdus norvegicus*) are described. For both, reproductions occurred between January and March, corresponding with the seasonal peak in prey abundance. Vertical distributions and inter-molt growth varied with species. Early copepodite stages and adult males of *P. glacialis*, which produces a small number of large eggs (*K*-selection), were distributed in deeper layers while late copepodite stages and adult females were in shallower layers. Since the inter-molt growth of the stages in the deeper layers was small, their growth was slow, resulting in a two-year generation time. In contrast, all life stages of *H. norvegicus*, which produce many small-sized eggs (*r*-selection), were distributed at the same depth layer but showed constant, large inter-molt growth across all stages. The faster growth of each copepodite stage may allow them to have a one-year generation time. To achieve faster growth of *H. norvagicus* in the food-limited mesopelagic layer, a specialized feeding mode (incorporating a venomous injection spine and large beak) may have an important function.

Distribution and shell condition of Limacina helicina in aragonite undersaturated waters of the Canada Basin

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Aragonite undersaturation has been observed in the surface and subsurface layers of the Canada Basin for more than a decade. In this study, we have investigated distribution of shelled pteropod, *Limacina helicina*, in the Canada Basin in September of 2019. Samples were collected using a closing NORPAC net, from 0-50 m, 50-100 m and 100-200 m layers. Juveniles of *L. helicina* were most abundant in the top 50 m layer but were less in the central Basin, where aragonite undersaturation were observed. The abundance of *L. helicina* positively correlated with both aragonite saturation state and chlorophyll a concentration. Shell density, measured by using a MXCT (Microfocus X-lay Computer Tomography), did not show clear relationship with environmental factors. Most of individuals found in aragonite undersaturated water had undamaged shells. This confirms that periostracum protects their shells from dissolution. Nevertheless, we also found samples with sever dissolution. These results suggest that although *L. helicina* is protected by periostracum, a scratch can now lead to sever shell dissolution.

Arctic Ocean CO_2 uptake

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We updated the estimates of the air–sea CO_2 flux in the Arctic to December 2017, and now obtained 252 monthly maps of the CO_2 flux in the Arctic Ocean and its adjacent seas. This was done by mapping partial pressure of CO_2 in the surface water (pCO_{2w}) using a self-organizing map (SOM) technique incorporating chlorophyll-a concentration (Chl-a), sea surface temperature, sea surface salinity, sea ice concentration, atmospheric CO_2 mixing ratio, and geographical position. The pCO_{2w} data were obtained by shipboard underway measurements or calculated from alkalinity and total inorganic carbon of surface water samples. Subsequently, we investigated the basin-wide distribution and seasonal to interannual variability of the CO_2 fluxes. The estimated annual CO_2 uptake by the Arctic Ocean was 160 ± 130 TgC yr^{-1}. The CO_2 influx was strongest in winter in the Greenland/Norwegian Seas (> 10 mmol m^{-2} day^{-1}) and the Barents Sea (> 12 mmol m^{-2} day^{-1}) because of strong winds, and strongest in autumn in the Chukchi Sea (> 7 mmol m^{-2} day^{-1}) because of the sea-ice retreat. In recent years, the CO_2 uptake has increased in the Greenland/Norwegian Sea and decreased in the southern Barents Sea, owing to increased and decreased air–sea pCO_2 differences, respectively.

We also compared our results to other mapping and model results; ETH_SOM-FFN, ECCO2Darwin, ECCO_Darwin_V4, and Arctic_NEMURO-C. Large CO_2 uptakes are commonly shown in the Norwegian Sea, the Greenland Sea and the Barents Sea in all seasons, and in the Chukchi Sea in autumn. In several results, the Arctic Ocean CO_2 uptake tends to strengthen in recent years in association with the sea ice retreat, while air–sea pCO_2 differences seems to weaken after 2007 due to the rising of the surface temperature.

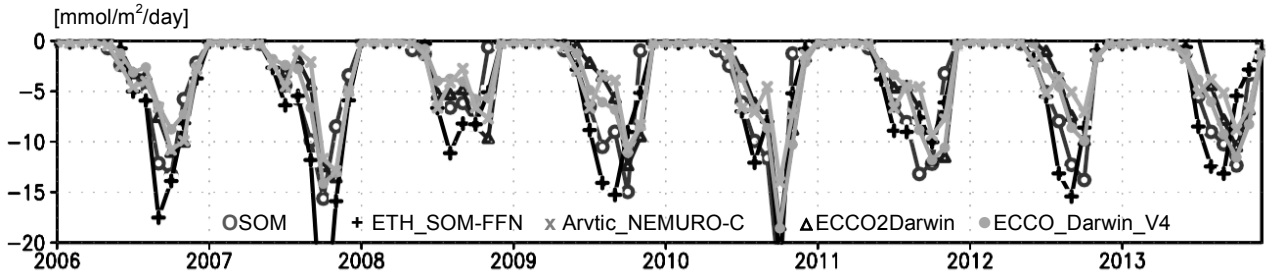

Figure 1. Air-sea CO_2 flux in the Chukchi Sea

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International Convention and Prevention of Marine Pollution: Heavy Metal Concentration in the Bay of Bengal

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Abstract

International convention on marine pollution provided less attention for the protection of the marine environment and of the high seas beyond coastal areas. The Stockholm Declaration on the Human Environment determined the concern regarding the whole marine environment, and emphatic reflection was done in the provisions of the Law of the Sea Convention. Eight heavy metals were analysed from both water and sediment samples of the Bay of Bengal (BoB). The decreasing trend of metals were observed in water samples: Zn (0.91±8.11) > Ni (0.78±0.72) > Cr (0.56±0.18) > Cu (0.16±0.24) > Pb (1.32±0.21) > As (1.14±0.95) > Hg (1.00±0.04) > Cd (0.07±0.03)µg/L and in sediment samples: Zn (46.53±23.57) > Cr (22.58±7.81) > Ni (21.17±12.17) > Pb (14.64±6.65) > Cu (13.04±8.19) > As (4.06±1.62) > Hg (0.03±0.02) > Cd (0.02±0.01)mg/kg. For the sustainability of the marine resources, the integration of Ecosystem Based Management and Marine Spatial Planning (EBM-MSP) provides a platform for different levels of governing bodies and stakeholders for the transparent, smooth and progressive decision-making process, that enables monitoring and surveillance in order to manage with future uncertain conditions.

Keywords: Marine pollution; Heavy metal; Bay of Bengal; Ecosystem Based Management; Marine Spatial Planning.

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Impacts of Riverine Carbon and Nutrient Delivery on Arctic Ocean Acidification

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KEY WORDS: Ocean Acidification・Arctic Ocean・Model Simulation・Riverine Fluxes

1. Introduction

Rapid environmental changes are happening in the Arctic Ocean, such as extensive sea ice retreat, seawater warming, ocean acidification (OA). Effect of climate change on land also affects the Arctic Ocean by increasing riverine biogeochemical delivery (carbon and nutrient) via runoff increase, permafrost thaw, and tree-line advance[1]. Changes in riverine delivery of carbon and nutrient may affect the primary production, air-sea CO_2 fluxes, and OA significantly. It was revealed that aragonite undersaturation (caused by OA) has been observed for more than one decade since 2006 in the surface waters of Arctic Ocean[2]. However, it is still unclear that to what extent the delivery of riverine biogeochemical fluxes (R_BGC) has an impact on OA, as well on primary production and marine ecosystem in the Arctic Ocean.

2. Data & Method

By using a Pan-Arctic Sea Ice-Ocean Model (COCO) coupled to an Arctic and North Pacific Model for Lower-trophic Marine Ecosystem with Carbonate Chemistry (Arctic NEMURO-C), we conducted sensitivity experiments to understand the impact of riverine biogeochemical delivery on OA (including indexes of pH, aragonite saturation state: Ω_{Ar}) in several Arctic sub-regions for 1979-2018. Four experiments are composed of 1. Without R_BGC, 2. With only R_Carbon (Riverine TA and DIC fluxes), 3. With only R_Nut (Riverine Nitrate and Silicate fluxes), 4. With R_BGC. Monthly climatological riverine carbon and nutrient data were obtained from the Arctic Great Rivers Observatory (ArcticGRO). Monthly climatological freshwater fluxes known as R-ArcticNET were obtained from the Arctic Ocean Model Inter-comparison Project (AOMIP).

3. Results & Discussion

Compared with result from in the case 1 (Without R_BGC case: only riverine freshwater fluxes were involved), it is found that R_BGC increases pH and Ω_{Ar} in waters shallower than ~100 m in almost the whole Arctic Ocean. In surface waters of the central Arctic (latitude > 83°N), mean increments during 1989-2018 of pH and Ω_{Ar} by R_BGC are ~0.01 and ~0.06, respectively, which is mostly due to delivery of R_Carbon in this region where the effect of R_Nut delivery is negligible.

Higher pH and Ω_{Ar} affected by R_BGC are shown in surface waters near the coastal regions, where large rivers enter into the Arctic Ocean, as well as along the Lomonosov Ridge, which reflects the distribution pattern of transpolar drift that transports river waters further into the central Arctic. The largest increments of pH and Ω_{Ar} by R_BGC are found in the surface waters of Laptev Sea and Kara Sea where simulation with R_BGC causes a higher pH by ~0.1 and higher Ω_{Ar} by ~0.1. In these seas, delivery of R_Nut attributes up to ~20% of pH increment and ~10% of Ω_{Ar} increment, which is a consequence of enhanced primary productivity by the riverine nutrient supply.

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