IMBeR REPORTING FORM 2021

Please return completed form to imber@dal.ca **by 2nd April.**

REPORTING PERIOD:

PRIMARILY - What you have done since the annual report submitted for the SSC meeting held virtually in May/June 2020

BUT ALSO – Where indicated, highlights from last 5 years (i.e. 2016-2021) to feed into SCOR's 5-year review of IMBeR
Link to past annual reports

PLANNED ACTIVITIES: extended to cover the next 5 years (until September 2025)

We understand that activities may not be planned this far ahead, but please provide as much information as you can about what you have planned over the next 5 years.
This will also feed into the SCOR 5-year review.

Thank you.

Ecosystem Studies of the Subarctic and Arctic Seas (ESSAS)

Naomi Harada, Franz Mueter, Benjamin Planque

1. Ongoing activities, in line with the IMBeR Grand and Innovation Challenges

(Among other uses, information will be used to update the Grand Challenge Factsheets)

1.a. Grand Challenge I

Understanding and quantifying the state and variability of marine ecosystems

Understanding variability in high-latitude marine ecosystems in response to climate variability and change is a central goal of ESSAS. A major initiative by ESSAS to further this goal was the Resilience and Adaptive Capacity of Arctic marine ecosystems (RACArctic) project, which was supported by the Belmont Forum and involved collaborators in Japan, Norway and the US. The project has been completed and final reports have been submitted to national funding agencies. Four synthesis papers have been submitted to the ICES Journal of Marine Science and are currently undergoing revisions.

A number of national programs endorsed by or related to ESSAS continue monitoring marine ecosystems and conduct research in both the Pacific Arctic and Atlantic Arctic, in particular the northern Bering Sea / Chukchi Sea (Japan, USA, Korea), the Barents Sea / Fram Strait (Norway, Russia), the waters around Iceland, and the Northwest Atlantic (Canada, Greenland). Major ESSAS-related research activities in the member countries are described in this 2019 report, most of which are ongoing. In 2020, a number of planned cruises were cancelled due to COVID-19. The ESSAS annual meeting typically provides a forum for information exchange about these national programs

to build connections among researchers working on high-latitude marine ecosystems. Unfortunately, the 2020 Annual Meeting had to be cancelled.

To foster a better understanding of high-latitude changes and their consequences for humans, ESSAS co-chair Naomi Harada has been working over the last year with a local steering committee in Japan to hold a virtual meeting in June 2021 under the theme of "*Linking past and present marine ecosystems to inform future fisheries and aquaculture*". The meeting was originally planned as an in-person meeting to be held in Sapporo, Japan, but was converted to a virtual meeting and postponed from 2020 to 2021. A total of 32 abstracts have been submitted. Some collaborative, inter-disciplinary studies involving natural, economic and/or social sciences are included in the submitted abstracts. In addition, a stakeholder meeting is scheduled as part of the ESSAS annual meeting because both academic communities and local stakeholders in Sapporo, Hokkaido are interested in and concerned about 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 discussions at the stakeholder meeting are also expected to contribute to the "Grand Challenge III" and "Innovation Challenge 4".

We provide a few additional examples of new or ongoing ESSAS related and endorsed studies addressing Grand Challenge I. The first is the latest fieldworks conducted during the current fiscal year on the project "**Saroma-ko Lagoon Observations for sea ice Physico-chemistry and Ecosystems in 2021 (SLOPE 2021)**" led by Prof. Daiki Nomura, Hokkaido University, Japan. The Saroma-ko Lagoon Observations for sea ice Physico-chemistry and Ecosystems in 2021 (SLOPE 2021) was conducted for the period between 26 February and 9 March, 2021 in Saroma-ko Lagoon, Hokkaido, Japan (Fig. 1). The purpose of this campaign was to 1) examine the physical, chemical, and ecosystems of sea ice, 2) inter-compare different methods for air-ice gas flux measurement performed with different sensors, 3) test equipment for future Arctic and Antarctic expeditions, such as air–sea ice CO2/CH4 flux chamber, eddy covariance, under-ice turbulent heat flux systems, and a pump for under-ice water sampling (Fig. 2), and 4) train and educate students and young scientists for future polar expeditions.

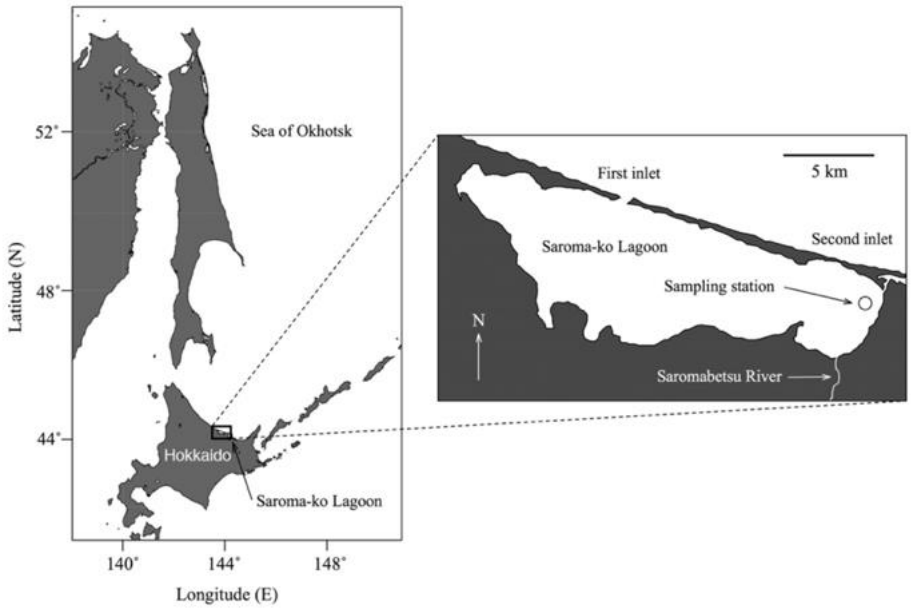

Fig. 1 Location of Saroma-ko Lagoon

Fig. 2 Photo of the experiment site in Saroma-ko Lagoon.

A second project "**Arctic Challenge for Sustainability II**" was launched in 2020 in Japan (https://www.nipr.ac.jp/arcs2/e/). This project is a Japanese flagship project for the Arctic involving natural, economic and social scientists and continues to 2025. The project is composed of 4 strategic goals, 1) Advanced observation of Arctic environmental change; 2) Improvement of weather and climate prediction; 3) Impact of environmental change on society; 4) Legal/policy response and research implementation for a sustainable Arctic. The sub-theme of "Research and Public Dataset Production on the Arctic Marine Environment" which belongs to strategic goal 1), is most closely related to IMBeR. The background and outline of this sub-theme is as follows: Knowledge regarding ocean heat transport, marine ecosystem, and biogeochemical cycles in the Arctic central basins and marginal ice zones is still insufficient, and studying these topics is a pressing task in order to achieve sustainable utilization of the rapidly changing polar region. This research program aims to clarify the Arctic marine environment, following three sub-programs:

1. Ocean Heat/Freshwater Transport and Biogeochemical Cycles in Seasonal and Multi-Year Sea-Ice Zones
2. Vulnerability and Resilience of Marine Ecosystem in Response to Rapid Sea-Ice Retreat
3. Air–Sea (Including Waves) Interactions Related to Sea Ice

Each of the team members participates in multiple sub-programs, and the program will aim to create an overall picture of the Arctic marine environment by exchanging information with related other groups. Programm's efforts with advanced observation systems to approach the marginal and multi-year ice zones - which despite being important areas had thus far been difficult to access - represent a major progression from the previous Japanese Arctic research projects such as GRENE-Arctic and

ArCS. As one means to provide valuable findings related with human society, the program will release public datasets on the Arctic marine environment.

The third project is a continuation of the **Alaska Marine Biodiversity Observation Network** (AMBON Phase II, see also 1e, Innovation Challenge 2). Phase I was an ESSAS endorsed project led by Dr. Katrin Iken at the University of Alaska Fairbanks with the aim of developing a sustainable Arctic monitoring program in coordination with and as an extension of other efforts such as the Distributed Biological Observatory. Two advances under this project were to include eDNA sampling and fish sampling to the suite of variables that have been monitored as part of the DBO and through short-term research projects to achieve a true 'microbes to whales' observation program. Under phase II of the project, we were able to conduct ecosystem sampling in the Chukchi Sea in the fall of 2020 on the *R/V Healy* to continue at least some existing time series during a field season that was heavily curtailed due to COVID 19.

1.b. Grand Challenge II

Improving scenarios, predictions and projections of future ocean-human systems at multiple scales

The ESSAS-led RACArctic project (see 1a) focused on developing plausible scenarios for anticipated changes in high-latitude marine ecosystems, and in particular its consequences for fish populations and fisheries, based on a review of available literature, including qualitative predictions and available projections. Four manuscripts have been submitted and are currently in review.

At the national level, ESSAS members are involved in many relevant projects that have benefitted from or were a direct result of previous collaborations developed through ESSAS. This includes, among others, the following recent and ongoing activities:

1. Japan-US collaboration on shifting biodiversity patterns in the Pacific Arctic (e.g. Alabia et al. 2021, Global Change Biology, accepted), involving researchers at Hokkaido University and the University of Alaska Fairbanks (F. Mueter).
2. A new Norwegian Research project on "Arctic ecosystem impact assessment to oil in ice" (ACTION, Lead-PI: Frode Vikebø) supported by the Research Council of Norway. The project includes a collaboration with US-based ESSAS members B. Laurel (Co-chair, Bioenergetics Working Group) and F. Mueter (ESSAS Co-Chair)
3. Collaboration across multiple Institutions and Arctic countries on a new research proposal "Winners and losers in the climate casino: Arctic marine resources under climate change", led by S. Kvamsdal from Norway and submitted to the Research Council of Norway. The project involves a number of researchers that are currently or have been affiliated with ESSAS, including Alan Haynie (USA, Chair of ESSAS Human Dimensions Working Group, HDWG), K. Drinkwater (Norway, previous ESSAS Co-Chair) and F. Mueter (current ESSAS Co-Chair).
4. George Hunt (former ESSAS Co-Chair) recently led a Special Issue for Deep-Sea Research II (see publications) that focused on the rapidly changing Northern Bering Sea region and involved contributions from, among others, researchers from Japan, Korea, Russia and the US. Several of the authors were invited to contribute based on research presentations at ESSAS sponsored activities.
5. Ongoing collaborative ARICE project (2019-2022) between the Alfred Wegener Institute in Germany, the University of Alaska Fairbanks, and researchers in the Netherlands, Belgium

and Russia. The project focuses on the role of newly-formed ice in the fall for polar cod and other ice-associated fauna and resulted from connections established during a 2018 ESSAS-sponsored workshop in Fairbanks, Alaska.

6. Ongoing activities in the Norwegian Nansen Legacy project (2018-2023), which aims to provide integrated scientific knowledge on the rapidly changing Barents Sea climate and ecosystem to support sustainable management through the 21st century. B. Planque is involved in the research foci "the future Barents Sea" which includes the development of forecasting and scenarios for climate and ecosystem.

1.c. Grand Challenge III

Improving and achieving sustainable ocean governance

One of three RACArctic synthesis papers, led by HDWG Chair A. Haynie, will assess the ability of current management structures in the Pacific and Atlantic Arctic to address challenges associated with the effects of climate change on marine systems.

The proposed collaborative project "Winners and losers in the climate casino: Arctic marine resources under climate change" (see 1b.) includes two work packages focusing on international governance of the Arctic.

Integrated Ecosystem Assessments that are being developed for several Arctic and Subarctic regions with the active involvement of several ESSAS members (see 1e), are designed and intended to support sustainable ocean governance in these regions.

The recent project in the Barents Sea led by Mette Skern-Mauritzen and Geir Ottersen from Norway seeks to assess the risks of cumulative impacts on the Barents Sea ecosystem and its services (BarentsRISK). The projects is developed in direct collaboration with stakeholders and managers. In addition to researchers from Norway, the project involves Dr. Alan Haynie, chair of the ESSAS HDWG. This project was recently endorsed by ESSAS.

1.d. Innovation Challenge 1

To enhance understanding of the role of metabolic diversity and evolution in marine biogeochemical cycling and ocean ecosystem processes

N/A

1.e. Innovation Challenge 2

To contribute to the development of a global ecosystem observational and modelling network that provides essential ocean variables (EOVs) and to improve marine data and information management

ESSAS-endorsed national projects provide observations of EOVs in high-latitude marine ecosystems. For example, the Arctic Marine Biological Observation Network (AMBON), an ESSAS endorsed project, is developing a long-term observing program in the Chukchi Sea to monitor EOVs and biodiversity at all trophic levels, from microbes to whales. Similarly, several Japanese programs routinely contribute to sampling standard transect lines in the northern Bering Sea and Chukchi Sea that together form the 'Distributed Biological Observatory' (DBO). Through these projects we have developed strong working relationships with the Pacific Arctic Group and the DBO community.

ESSAS members are active in the development of 'Integrated Ecosystem Assessments (IEAs)' for at least three Arctic and Subarctic regions that have been informed by and have contributed to earlier ESSAS activities. Former ESSAS co-chair S.-I. Saitoh and current co-chair F. Mueter continued participation in a joint PICES/ICES/PAME working group focused on developing an IEA for the Central Arctic Ocean, F. Mueter and several AMBON researchers took part in initial meetings of a new PICES/ICES Working Group on Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea (WG 44) and continue to be involved as members of or observers to the Working Group. The next meeting of the working group is planned as a virtual meeting for April 14, 2021 (Agenda included as Appendix 1). Co-chair B. Planque is involved in the ICES IEA groups for the Norwegian Sea and the Barents seas, which report on the ecological status of these two regions annually. B. Planque is also co-chairing the ICES working group on integrated trend analyses and the ICES/PICES working group on common ecological reference points. Both groups contribute to delivering observational data that are robust and tailored to the need of end-users/managers.

1.f. Innovation Challenge 3

To advance understanding of ecological feedbacks in the Earth System

N/A

1.g. Innovation Challenge 4

To advance and improve the use of social science data for ocean management, decision making and policy development

Alan Haynie (NOAA, USA), chair of the Human Dimensions Working Group, continues to be active at the national and international levels to develop better approaches to using economic data for supporting decision making in fishery management. Activities include:

- Participation in the Climate Fisheries Initiative, which is working to plan how NOAA and partners couple ocean modeling and fisheries management over the coming decade. Alan's experiences in ESSAS and RACARctic were valuable experiences for his contributions in this effort.
- Co-PI of the Alaska Climate Integrated Modeling (ACLIM) Project, an effort that partners NOAA and university partners to make fisheries management in the North Pacific "climate ready." ESSAS and the IMBER Open Science meetings have been valuable contributors to this work.
- Participation in international research proposals and projects such as the BarentsRISK project (see 1b) and the proposed RCN project ""Winners and losers in the climate casino: Arctic marine resources under climate change" (see 1b.)"

2. Selected highlights

2.a.i. Selected scientific highlights since last report (1-3)

Last report was submitted to SSC meeting, May/June 2020

1. A major transformation is underway in the marine ecosystems of major Pacific and Atlantic gateways into the Arctic, at the transition zone between Subarctic and Arctic marine ecosystems (e.g. Huntington et al. 2020, Nature Climate Change 10: 342-348, https://doi.org/10.1038/s41558-020-0695-2). This transformation affects all ecosystem components, including major commercial fish stocks and the people that depend on them.

The primary mechanisms driving changes in these fish stocks appear to be changes in growth rates and recruitment associated with the impacts of temperature and sea ice conditions on food availability. Responses to cold and warm conditions differ between the Atlantic and Pacific gateways into the Arctic (Mueter et al., ICES Journal of Marine Science, In Review). While major changes in commercially important cod species (Atlantic cod in the Northeast Atlantic and walleye pollock and Pacific cod in the Bering Sea) appear to be food-mediated, declines in the quality and quantity of lipid-rich zooplankton prey during recent warm conditions, and their effects on the survival of juveniles and adults, has been associated with the collapse of an important Pacific cod stock in the Gulf of Alaska and with large declines in eastern Bering Sea walleye pollock. In contrast, Atlantic cod appear to be thriving during recent warm conditions, in spite of changes in the Barents Sea zooplankton community mediated by declining sea ice and increased advection of warmer Atlantic water.

2.a.ii. Selected scientific highlights over last 5 years (1-5)

(2016-2021)

1. A major science highlight from ESSAS regions, in particular the marine systems of both the Pacific Arctic (Bering Sea and Chukchi Sea) and the Atlantic Arctic (with a focus on the Barents Sea) has been the increasing 'borealization' of the Arctic, which describes the northward expansions of boreal species into Arctic regions, including phytoplankton, zooplankton, fish and mammals. In recent years, these shifts were particularly stark in the Pacific Arctic, where a key Arctic fish species, the polar cod (*Boreogadus saida*) has retreated northward as larger, commercial species such as Pacific cod (*Gadus macrocephalus*) and walleye pollock (*G. theragrammus*) have shifted their centers of distribution into the northern Bering Sea (e.g. Marsh et al. 2020, Bulletin of the American Meteorological Society 101(8): S254-S256. https://doi.org/10.1175/BAMS-D-20-0086.1). Similar shifts are evident in the Atlantic (Fossheim et al. 2015, Nature Climate Change 5: 673-677, https://doi.org/10.1038/nclimate2647; Thorson et al. 2019, http://www.arctic.noaa.gov/Report-Card; Marsh et al. 2020). In spite of these dramatic shifts in some species, models of species distribution for the eastern Bering Sea and Chukchi Sea suggest that shifts in the distribution of most fish species (so far) lag behind changes in climate and the pace of change differs substantially among species (Alabia et al. 2018, Diversity and Distributions 24: 1183-1197, https://doi.org/10.1111/ddi.12788). Subarctic species are more sensitive to habitat changes than Arctic species but often shift in unexpected ways and climate velocity (the rate of climate shifts) is poorly correlated with observed shifts in species distribution. This study highlighted the importance of understanding species-specific responses when predicting range shifts.
2. Two special issues on polar cod (*Boregadus saida*), a keystone species in Arctic marine ecosystems with a circumpolar distribution, have greatly expanded our understanding of the life history and ecology of this important species (Mueter et al. 2016, Polar Biology 39: 961-967, https://doi.org/10.1007/s00300-016-1965-3; Mueter et al. 2020, Polar Biology 43(8): 945-950. https://doi.org/10.1007/s00300-020-02696-1; and references therein). Both special issues were the result of ESSAS workshops and some of the scientific highlights include: (a) the population structure of polar cod, based on genetic evidence and distributional studies, suggests the existence of at least four major groups in the Alaskan Arctic (northern Bering Sea to western Beaufort Sea), western Canadian waters (Beaufort Sea and Amundsen Gulf), eastern Canadian waters (Resolute Bay to Gulf of St. Lawrence), and European waters including the Greenland, Iceland and the Laptev Sea. There is evidence for additional population differentiation in the Barents Sea with two distinct spawning

populations in the southeastern Barents Sea (Pechora Sea) and in the northwestern Barents Sea east of Svalbard, respectively; and (b) a combination of bottom-up processes, the lack of phenotypic plasticity, and competitive interactions with other species will likely result in declining abundances of polar cod populations in many Arctic regions, especially at the southern limits of their range, and increasingly at higher latitudes. Earlier ice retreat and warmer summer temperatures directly and indirectly affect growth and condition of young polar cod. Direct effects result from temperature-dependent effects on physiological rates, while indirect effects are mediated by prey availability, likely limiting survival at the larval and juvenile stages beyond a critical temperature threshold. Furthermore, competitive interactions with sympatric or Subarctic species that are more resilient to higher temperatures limit replacement of this key forage species in many regions. The replacement of polar cod by other species will have unknown consequences for seabirds, marine mammals and ultimately people living in Arctic and Subarctic regions where cultural identity, food security and socioeconomic systems are closely linked with marine ecosystems.

3. Variability in high-latitude marine ecosystems is closely linked to large-scale atmospheric variability, including the Arctic Oscillation and major ocean-atmospheric patterns in the North Pacific and North Atlantic. For example, Atlantic Arctic ecosystems responded in dramatic ways to a cold period in the Northeast Atlantic in the 1970s and 1980s, linked to the Atlantic Multidecadal Oscillation (AMO) (Drinkwater and Kristiansen, 2018, ICES Journal of Marine Science 75: 2325-2341, https://doi.org/10.1093/icesjms/fsy077). During this period, below average air and sea temperatures, expanded sea-ice cover and reduced Atlantic inflow into the Northeast Atlantic Ocean led to decreased primary production, a general southward expansion of arctic and boreal zooplankton and fish species, and a southward retreat of temperate species. These changes, along with fishing pressure, led to the collapse of several important fisheries at the northern end of their distribution, including the Atlantic cod fishery off Greenland and Labrador/northern Newfoundland and the Norwegian spring-spawning herring off Iceland and Norway.
4. Other ESSAS related issues are catastrophic sea ice reduction and its impact on CO2 uptake, and marine ecosystems. Yasunaka et al., 2016 (Polar Science 10, 323–334, https://doi.org/10.1016/j.polar.2016.03.006.) and 2018 (Biogeosciences 15, 1643–1661. https://doi.org/10.5194/bg-15-1643-2018) reported the spatial and temporal distributions of CO2 flux in the Arctic Ocean and its adjacent seas for 18 years between 1997 and 2014. These results revealed that the annual CO2 uptake is 180 ± 130 TgC, which corresponds to approximately 10% of the total uptake in the world's oceans. In terms of lower trophic level ecosystem, Nishiono et al., 2016 (Biogeosciences 13, 2563–2578. https://doi.org/10.5194/bg-13-2563-2016) reported that not only spring season but also fall season has been active production season in the western Arctic Ocean. They also suggested that the fall bloom was likely maintained by high nutrient content associated with a dome-like structure of the bottom water that could supply nutrients from the bottom. Sea ice reduction is considered to give a big impact on sea ice algae production. Watanabe et al. 2019 (Journal of Geophysical Research -Oceans 124, 9053–9084. https://doi.org/10.1029/2019JC015143.) conducted a multi-model intercomparison of Arctic ice-algal productivity under the biogeochemical working group of the Forum for Arctic Ocean Modeling and Observational Synthesis (FAMOS) project. The simulated results of ice-algal productivity showed that the amplitude of interannual variability was much larger than that of long-term changes, and that there was no statistically significant long-term trend in most sub-sea areas and models. As positive and negative correlations were found between annual primary production and sea-ice thickness in early spring, it was quantitatively shown that a

balance in stable habitat and sufficient light transmitted to the bottom of the sea ice was necessary to maintain the ice-algal productivity. Improvement of coupled sea ice-ocean ecosystem models is expected to reduce the simulated uncertainties on the pan-Arctic and decadal scales.

5. Another novel finding from ESSAS related research is the discovery of nitrogen fixation in the polar oceans. Shiozaki et al., 2018 (Limnol. Oceanogr. 63, 2191–2205. https://doi.org/10.1002/lno.10933) found how nitrogen fixation contributes to the nitrogen cycle in the Arctic Ocean. They reported that extensive nitrogen fixation occurs in the western Arctic Ocean and Southern Ocean, Antarctica (Shiozaki et al., 2020 Nature Geoscience https://doi.org/10.1038/s41561-020-00651-7). These reports reveal that nitrogen fixation occurs even in non-oligotrophic waters such as subtropical and tropical oceans and this is a robust biogeochemical system apparent throughout the global ocean.

2.b. Publications since last report

Please add all publications since last report to the table below (see notes for details on "Class" and "Activity" fields).

***Publication** with DOI*	***Class 1, 2, 3***	***Activity****
Hambrecht, G., Feeley, F., Smiarowski, K., Hicks, M., Harrison, R., Brewington, S., ... & Gibbons, K. (2019). A millennium of Icelandic archaeological fish data examined against marine climate records. Quaternary Research. https://doi.org/10.1017/qua.2019.35	*(1)*	*PESAS Special Issue in Quaternary Research based on PESAS workshops*
Clark, C. T., Horstmann, L., de Vernal, A., Jensen, A. M., & Misarti, N. (2019). Pacific walrus diet across 4000 years of changing sea ice conditions. Quaternary Research. https://doi.org/10.1017/qua.2018.140	*(1)*	*PESAS Special Issue, Quaternary Research*
Holm, P., Ludlow, F., Scherer, C., Travis, C., Allaire, B., Brito, C., ... & Nicholls, J. (2019). The North Atlantic Fish Revolution (ca. AD 1500). Quaternary Research. https://doi.org/10.1017/qua.2018.153	*(1)*	*PESAS Special Issue, Quaternary Research*
Edvardsson, R., Patterson, W. P., Bárðarson, H., Timsic, S., & Ólafsdóttir, G. Á. (2019). Change in Atlantic cod migrations and adaptability of early land-based fishers to severe climate variation in the North Atlantic. Quaternary Research. https://doi.org/10.1017/qua.2018.147	*(1)*	*PESAS Special Issue, Quaternary Research*
Jørgensen, E. K., Pesonen, P., & Tallavaara, M. (2019). Climatic changes cause synchronous population dynamics and adaptive strategies among coastal hunter-gatherers in Holocene northern Europe. Quaternary Research. https://doi.org/10.1017/qua.2019.86	*(1)*	*PESAS Special Issue, Quaternary Research*
Khasanov, B. F., Fitzhugh, B., Nakamura, T., Okuno, M., Hatfield, V., Krylovich, O. A., ... & Savinetsky, A. B. (2020) New data and synthesis of ΔR estimates from the northern Pacific Ocean. Quaternary Research. https://doi.org/10.1017/qua.2020.27	*(1)*	*PESAS Special Issue, Quaternary Research*
West, C. F., Etnier, M. A., Barbeaux, S., Partlow, M. A., & Orlov, A. M. (2020) Size distribution of Pacific cod (Gadus	*(1)*	*PESAS Special Issue, Quaternary Research*

macrocephalus) in the North Pacific Ocean over 6 millennia. Quaternary Research. https://doi.org/10.1017/qua.2020.70		
Thorson, J. T., Fossheim, M., Mueter, F. J., Olsen, E., Lauth, R. R., Primicerio, R., Husson, B., Marsh, J, Dolgov, A, Zador, S.G., 2019. Comparison of near-bottom fish densities show rapid community and population shifts in Bering and Barents seas. Department of Commerce, NOAA, http://www.arctic.noaa.gov/Report-Card	*(2)*	*Collaborations established at the 2019 IMBER / ESSAS meetings in Brest*
Levine, R., De Robertis, A., Grünbaum, D., Woodgate, R., Mordy, C., Mueter, F., Cokelet, E., Lawrence-Slavas, N., Tabisola, H. (2021) Repeat autonomous vehicle surveys indicate that age-0 Arctic cod are largely retained over the Chukchi Sea shelf in summer 2018. Limnology and Oceanography. https://doi.org/10.1002/lno.11671	*(2)*	*Arctic Gadid workshop, Fairbanks, June 2018*
Alabia, I. D., García Molinos, J., Saitoh, S.-I., Hirata, T., Hirawake, T., Mueter, F. J., (2020). Multiple facets of marine biodiversity in the Pacific Arctic under future climate, Science of the Total Environment, 744, 140913. https://doi.org/10.1016/j.scitotenv.2020.140913	*(2)*	*Collaboration directly resulting from ESSAS Annual meetings in 2018 and 2019*
Alabia, I.D., García Molinos, J., Saitoh, S.-I., Hirata, T., Mueter, F. J., Hirawake, T., (2021) Marine biodiversity refugia in a climate-sensitive subarctic shelf, Global Change Biology (accepted).	*(2)*	*Collaboration directly resulting from ESSAS Annual meetings in 2018 and 2019*
Hirawake, T., and Hunt, G. L. 2020. Impacts of unusually light sea-ice cover in winter 2017-2018 on the northern Bering Sea marine ecosystem – An introduction. Deep Sea Research Part II: Topical Studies in Oceanography, 181–182: 104908. https://doi.org/10.1016/j.dsr2.2020.104908	(2)	*Special issue in part arising from ESSAS collaborations between Japanese, Russian and US-based researchers*
Bouchard C, Charbogne A, Baumgartner F, Maes S (2020) West Greenland ichthyoplankton and how melting glaciers could allow Arctic cod larvae to survive extreme summer temperatures. Arctic Science 7: 217-239. https://doi.org/10.1139/as-2020-0019	(2)	
Drinkwater, K.F., S. Sundby, P. Wiebe and W. Melle. 2020. Exploring the Hydrography of the Boreal/Arctic domains of North Atlantic seas: Results from the 2013 BASIN cruise. Deep-Sea Research II 180,104880. https://doi.org/10.1016/j.dsr2.2020.104880	(3)	
Naustvoll, L.J., W. Melle, T. Klevjer, K.F. Drinkwater, E. Strand and T. Knutsen. 2020. Structure and functioning of four North Atlantic ecosystems – A comparative study. Deep-Sea Research II 180,104890. https://doi.org/10.1016/j.dsr2.2020.104890	(3)	
Melle, W., T. Klevjer, W. Melle, K.F. Drinkwater, E. Strand, Naustvoll, L.J., P. Wiebe, D.L. Aksnes, T. Knutsen, S. Sundby, A. Slotte, N. Dupont, A.G.V. Salvanes, R. Korneliussen and G. Huse. 2020. Structure and functioning of four North Atlantic ecosystems – A comparative study. Deep-Sea Research II 180,10489038. https://doi.org/10.1016/j.dsr2.2020.104838		

Sutton L., Iken, K., Bluhm, B.A., Mueter, F.J. (2020) Comparison of functional diversity of two Alaskan Arctic shelf epibenthic communities. Marine Ecology Progress Series, 651: 1–21. https://doi.org/10.3354/meps13478	*(3)*	
Hirawake, T., Uchida, M., Abe, H., Alabia, I. D., Hoshino, T., Masumoto, S., Mori, A., Nishioka, J., Nishizawa, B., Ooki, A., Takahashi, A., Tanabe, Y. , Tojo, M., Tsuji, M., Ueno, H., Waga, H., Watanabe, Y., Yamaguchi, A., Yamashita, Y., Response and biodiversity of Arctic ecosystems to environmental change: Findings from the ArCS project, Polar Science, doi: 10.1016/j.polar.2020.100533. (in press)	*(3)*	
Marsh, J. M., Mueter, F. J., Thorson, J. T., Britt, L., and S., Z. 2020. Shifting fish distributions in the Bering Sea. In: State of the Climate 2019. Bulletin of the American Meteorological Society, 101: S254–S256. https://doi.org/10.1175/BAMS-D-20-0086.1	*(3)*	
Shiozaki, T., Itoh, F., Hirose, Y., Onodera, J., Kuwata, A., and Harada, N., 2021. A DNA metabarcoding approach for recovering plankton communities from archived samples fixed in formalin. PLOS ONE (accepted)	*(3)*	
Waga, H., Hirawake, T., Grebmeier, J. M., 2020. Recent change in benthic macrofaunal community composition in relation to physical forcing in the Pacific Arctic, Polar Biology, 43, 285-294. https://doi.org/10.1007/s00300-020-02632-3	*(3)*	
Waga, H., Hirawake, T., 2020. Changing occurrences of fall blooms associated with variations in phytoplankton size structure in the Pacific Arctic, Frontiers in Marine Science, 7, 209. https://doi.org/10.3389/fmars.2020.00209	*(3)*	
Waga, H., Hirawake, T., Nakaoka, M., 2020. Influences of size structure and post-bloom supply of phytoplankton on body size variations in a common Pacific Arctic bivalve (*Macoma calcarea*), Polar Science, in press. https://doi.org/10.1016/j.polar.2020.100554	*(3)*	
Yamaguchi, A., Kimura, F., Fukai, Y., Abe, Y., Matsuno, K., Ooki, A., Hirawake, T., 2020. Between-year comparison of interactions between environmental parameters and various plankton stocks in the northern Bering Sea during the summers of 2017 and 2018: Effect of anomalous ice conditions during the 2017-2018 winter on the planktonic food web, Polar Science, in press. https://doi.org/10.1016/j.polar.2020.100555	*(3)*	

**If appropriate, please list the IMBeR activity through / by / from / during which the publication arose*

2.c. Events, Meetings, and Workshops

List all international and national events, meetings and workshops. Describe the level of participation: e.g. chairing session/workshop, organising meeting. Include Regional Programme / Working Group committee meetings and workshops.

The 2020 ESSAS Annual Science Meeting planned for Sapporo, Japan was postponed to 2021 and changed to a virtual format due to COVID-19. No formal sessions or meetings were sponsored by ESSAS since the 2020 report. Working Group activities continued via e-mail and conference calls, including planning for the 2021 Meeting.

3. International collaboration and links

ESSAS members are based in countries around the circumpolar North and have established working relationships among agencies and institutions within and among these countries. ESSAS Annual Science Meetings, which are the primary means of information exchange and establishing collaborations, are typically organized by one of the countries and institutions listed below, but may involve formal and informal participation from many other organizations.

- Japan: Arctic Climate Centre, Hokkaido University, Sapporo, Dr. Sei-Ichi Saitoh, Dr. Irene Alabia; Graduate School of Fisheries Sciences at Hokkaido University in Hakodate, Dr. Toru Hirawake; Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Dr. Naomi Harada.
- Korea: Korea Polar Research Institute (KOPRI), Incheon, South Korea, Dr. Hyun-Cheol Kim.
- USA: University of Alaska, Fairbanks, Dr. Franz Mueter; University of Washington, Seattle, Washington, Dr. George Hunt and Dr. Ben Fitzhugh; NOAA, Dr. Alan Haynie, Dr. Benjamin Laurel.
- Canada: Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Dr. Kumiko Azetsu-Scott.
- Greenland: Greenland Institute of Natural Resources (GNIR), Nuuk, Dr. Caroline Bouchard.
- Norway: Institute of Marine Research, Bergen, Dr. Ken Drinkwater, Dr. Samuel Rastrick; Institute of Marine Research, Tromsø, Dr. Benjamin Planque; Arctic University of Norway, Tromsø, Dr. Arne Eide

In addition, through our Annual Science Meetings and sponsored sessions we have established working relationships and collaborations with researchers working in the Subarctic, Arctic, Antarctic and elsewhere. The annual meetings attract approximately 40-100 scientists, including many students, from the circumpolar Arctic and have led to and inspired many collaborative efforts among early career scientists and between early career and more senior scientists. We have collected testimonies from several early career scientists describing how they benefitted from engagement with IMBER. Additional working relationships have resulted from our involvement with IMBER. For example, ESSAS contributed to a recent synthesis paper led by IMBER SSC member Ingrid van Putten from CSIRO, Australia.

4. Input to management and policy

4.a. Input to management and policy over the last year

(Add anything that is not covered under "1.c. Grand Challenge III")

No specific activity over the last year beyond the general roles described below (4.b.)

4.b. Input to management and policy – Highlights from past 5 years

ESSAS members serve on national and international scientific advisory bodies and in other roles to provide input on management and policy issues that are directly or indirectly informed by ESSAS activities.

- In the US, Franz Mueter and George Hunt serve on the Scientific and Statistical Committee of the North Pacific Fishery Management Council and Alan Haynie serves on the Bering Sea Plan Team. Through these committees, they provide direct advice to fishery managers, including the determination of acceptable biological catch limits. The Council meets five times each year to review stock assessment, regulatory analyses, and other analyses in support of fishery management. As members of these Committees, they were also involved in developing the US Fishery Management Plan for marine resources in the Arctic and provide advice and input on updating this plan. For example, management-relevant changes to the description of Essential Fish Habitat for polar cod (*Boregadus saida*) and other species in the plan are currently being updated and draw on the information in the most recent Special Issue on Arctic Gadids. They also helped shape the recently completed Bering Sea Fishery Ecosystem Plan (FEP) and several policy-informing Action Modules within the plan. Their input on these plans and actions are directly informed by their work with ESSAS.
- B. Planque serves in the ICES working groups for the integrated ecosystem assessments of the Norwegian and Barents Sea. These groups prepare the advice formally provided by ICES on ecosystem overviews for these two oceans.
- Other SSC members are engaged in national management and policy forums relating to climate policy (e.g. K. Azetsu-Scott, Canada, DFO, N. Harada, JAMSTEC, Japan) and fisheries management (e.g. Caroline Bouchard, Greenland) in Arctic waters.

5. Education and outreach

Although ESSAS does not routinely conduct dedicated Education and Outreach activities, our Annual Meetings and other sponsored events have frequently included outreach to the broader scientific community and engagement of stakeholders. Although few education and outreach activity took place in the last year due to COVID-19, we highlight the following workshop held at the Hakodate campus of Hokkaido University, Japan:

Copepod fisheries workshop, Graduate School of Global Food Resources, Fisheries Management

Objective: The fisheries resources are finite. Especially, capture fisheries production has plateaued since the 1990's. Meanwhile, the global demand for fisheries products has been increasing rapidly, and aquaculture production has been compensating for this. However, it takes three to five times as much food to raise farmed fish, and 20% of the capture fisheries production are used to aquaculture as feed. The efficiency of ecological conversion (the energy that is transferred from one trophic level to another) is 10%. Energy can be used more efficiently if lower trophic level organisms are used directly. Copepods have been suggested as a candidate organism to be used as the target of lower tropic level organisms fisheries, and some fisheries have been attempted. However, in general, for developing the sustainable fisheries as a business, people, goods, money and information must be circulated appropriately. The solution of various issues such as human resource development, resource management, fishing gear technology development, conservation and processing

technology, and supply chain will be the prerequisite for the establishment of the fishery. In this workshop, we will think about the requirements for the establishment of the fishery from an interdisciplinary point of view, and consider the way to realize the copepod fishery.

The workshop is aimed at MS and PhD students and is held in English. See Appendix 2 for a detailed workshop schedule.

6. Planned activities up to September 2025

6.a. Activities and Outreach (including, but not limited to convening sessions, meetings, summer schools, workshops, etc) and how they link to the Challenges

Annual Science Meetings rotate between member countries. The hosting country and themes for the Annual Meeting are typically established one or two years in advance at the ESSAS SSC meeting, which is held in conjunction with the Annual Science Meeting. Annual Meetings are typically held in plenary session only to foster cross-fertilization and interdisciplinarity and include between one and three workshops organized by ESSAS working groups. In addition, ESSAS has hosted larger Open Science Meetings (200+ participants) every 5-8 years (in place of the Annual Science Meeting) and has sponsored 2-4 sessions at scientific meetings such as the PICES or ICES annual meetings, the ASLO/AGU Ocean Sciences Meeting, the IMBER Open Science Conference and other international symposia.

Over the next 5 years, ESSAS plans to continue holding Annual Science Meetings with themes and workshops that largely have yet to be developed.

The following list provides a very tentative outline of possible activities. Locations beyond 2021 are to be determined (TBD) and will likely include a location in the eastern Atlantic (e.g. Halifax, Canada), in Norway (e.g. Tromsø), in Japan (e.g. Sapporo, Hakodate, or Yokohama) and in the US (e.g. Seattle, WA or Anchorage, AK).

2021 Location: Virtual Meeting
Type: Annual Science Meeting
Theme: **Linking past and present marine ecosystems to inform future fisheries and aquaculture**. See Appendix 3 for announcement and draft agenda.
Workshop: Contributions to overall theme from PESAS and AnalogueART working groups and open discussion on linking paleo- and neo-data to inform climate change research (conceptual and methodological issues). See Appendix 4 for draft agenda.
Links to IMBER Challenges: The meeting will explore the use of paleo-ecological data to inform our understanding of current and future climate-related ecosystem changes. As such, the meeting relates to all three Grand Challenges

2022 Location: US West Coast
Type: Annual Science Meeting
Theme: TBD
Workshop: (tentative: (1) Potential impacts of oil and gas development on Arctic marine ecosystems; (2) Connecting paleo- and neo-ecology to understand the impacts of climate change on future ecosystems)
Links to IMBER Challenges: The first tentative workshop relates to the human-ecological system in high-latitude regions that may see increased oil and gas development and

therefore related to Grand Challenge II. The second tentative workshop further explores the use of paleo-ecological data to inform our understanding of current and future climate-related ecosystem changes; therefor it relates to all three Grand Challenges.

2023 Location: (Norway)
Type: Annual Science Meeting
Theme and workshops: TBD

2024 Location: (Japan)
Type: Open Science Meeting
Theme, specific sessions and workshops: TBD

2025 Location (Eastern Canada)
Type: Annual Science Meeting
Theme and workshops: TBD

In addition, our goal is to organize at least 2-3 scientific sessions and/or workshops each year at scientific meetings or symposia such as annual ICES and PICES meetings. Themes for these sessions and workshops for the upcoming year are typically determined at the annual ESSAS SSC meeting.

6.b. Upcoming papers (Community-Position-Review-etc)

The following papers from the RACArctic project are currently in preparation, in revision, or in review:

Drinkwater, K. F., Harada, N., Nishino, S., Cherici, M., Danielson, S. L., Invaldsen, R. B., Kristiansen, T. et al. 2021. Possible future scenarios in the Gateways to the Arctic for Subarctic and Arctic marine systems: I. Climate and physical–chemical oceanography. ICES Journal of Marine Science (In Review).

Mueter, F. J., Planque, B., Hunt Jr, G. L., Alabia, I. D., Hirawake, T., Eisner, L., Dalpadado, P., Drinkwater, K. F., Harada, N., Arneberg, P., Saitoh, S.-I. Possible future scenarios in the Gateways to the Arctic for Subarctic and Arctic marine systems: II. Prey resources, food webs, fish and fisheries. ICES Journal of Marine Science (In Review).

Haynie, A.C., Huntington, H. P., Eide, A. Faig, A., Hoel, A. H., Makino, M., Morishita, J. et al. 2021. Possible future scenarios in the Gateways to the Arctic for Subarctic and Arctic marine systems: III. Are Northern Fishery Management Systems Prepared for Change? A Comparison of Management Systems and Challenges in Alaska, Norway, and Japan. ICES Journal of Marine Science (In Prep)

In addition, two ESSAS SSC members, highlighted below, contributed to the following Synthesis:

Van Putten, Elizabeth Ingrid; Rachel Kelly, Rachel Dawn Cavanagh, Eugene J Murphy, Annette Breckwoldt, Stephanie Brodie, Christopher Cvitanovic, Mark Dickey-Collas, Lisa Maddison, Jess Melbourne-Thomas, Haritz Arrizabalaga, **Kumiko Azetsu-Scott**, Lynnath Elizabeth Beckley, Richard Bellerby, Andrew Constable, Greg Cowie, Karen Evans, Marion Glaser, Julie Hall, Alistair James Hobday, Nadine M Johnston, Joel Llopiz, **Franz J. Mueter**, Frank Edgar Muller-Karger, Kevin Weng, Dieter Alfred Wolf-Gladrow, José C Xavier (In Review). Advancing inter- and transdisciplinary regional ocean science through global networks: Lessons from the Integrated Marine Biosphere Research project. Frontiers in Marine Science.

7. Funding

7.a. Funding from external sources

None

7.b. Funding proposals in progress or planned

We typically seek travel support from the IASC Marine Working Group for Early Career Scientists to participate in ESSAS Annual Science Meetings. Dr. Franz Mueter submitted two unsuccessful proposals for support of an ESSAS project office at the University of Alaska Fairbanks. Dr. Benjamin Planque, ESSAS co-chair, submitted a proposal to the Institute of Marine Research in Norway to support an annual science meeting in Norway.

7.c. Funding requested from IMBeR for 2021-2022

Include a brief budget and justify requests.

We request a total of $8,000 for full or partial travel support for 3-4 ESSAS SSC members that do not have support from a grant or employer to participate in the Annual Science Meeting.

8. Changes to Organisational Structure (e.g. SSC) of RP / WG / IMECaN

None

9. Images / Figures

*****It is always good to have some recent photos / figures / infographics to create more exposure for the Regional Programmes, Working Groups, etc. These can range from those suitable for a very scientific audience, to those that would engage the general public. IMBeR would use these, on the website (e.g. http://www.imber.info/ and http://www.imber.info/en/news), in tweets (@imber_ipo), in presentations, etc. In addition, Future Earth (one of our sponsors) regularly asks us to provide high quality images for their glossy reports. These can highlight the activities of IMBeR and their other Global Research Projects (see pdfs of past Future Earth reports here https://futureearth.org/publications/annual-reports/)*

*So, please provide any images that you might think are useful. These can be pasted in this document or emailed as an attachment to imber@dal.ca.*****

10. Update on Action Items from 2020 SSC meetings

Please update the table of Action Items

11. Anything not covered above

N/A

12. How to improve this form

Please give suggestions on how to improve this form and make it better next time.

13. Appendices

Add appropriate meeting / workshop reports and include URLs (this helps to track where online content is missing)

Appendix 1: Agenda for virtual meeting of PICES WG 44, April 14, 2021

INTEGRATED ECOSYSTEM ASSESSMENT OF THE NORTHERN BERING SEA – CHUKCHI SEA (NBS-CS) (WG 44)

FIRST WORKING GROUP MEETING

APRIL 14, 2021

15:00-18:00 PACIFIC DAYLIGHT TIME (UTC-7)

ZOOM MEETING (DETAILS ON PAGE 2)

AGENDA

Chairs: Yury Zuenko and Libby Logerwell

Item	Minutes
Welcome, adoption of agenda, appointment of rapporteur (Chairs)	5
Introductions, new members and guests (Chairs)	10
Metadata, status and upcoming milestones (Ferguson, Rand and Zuenko)	20
Approach and methodology, status and upcoming milestones (Holsman, Daniel, Stram)	20
Indigenous knowledge sharing, status and upcoming milestones (Wise)	20
Revised timeline due to COVID restrictions (Chairs)	10
Break	15
ICES IEA projects, workshops, etc. (Jörn Schmidt)	20
NOAA IEA proposal (Holsman)	10
NPRB synthesis proposal (Logerwell)	10
Arctic Council PAME Ecosystem Approach Expert Group (Logerwell)	10
New surveys, IEA projects or other information:	
Canada (TBD)	5
China (Zhongyon Gao)	5

Japan (Shigeto Nishino)	5
Korea (Su la Hyoung)	5
Russia (Yury Zuenko)	5
US (Kathy Kuletz)	5

Appendix 2: Schedule for Copepod fisheries workshop

Dates: 12(Thu)-13(Fri) November 2020

Place: 404 Seminar Room, Main Building, Hakodate Campus

12 (Thu) 10:45 Mini Lecture, Assignment Explanation

13(Fri) 05:45 Excursion

08:45-12:00: Group discussion, presentation preparation

15:00-: Presentations

1) Mini-lecture (in English with Japanese on the slides)

1. On the requirements for the establishment of sustainable fisheries (Matsuishi) 10 minutes
2. The possibility of catching low trophic level organisms (Yamaguchi)
3. Biology of copepods (Yamaguchi) Total 30 min.
4. Estimation of copepods' abundance (Mukai) 10 minutes
5. Fishing gear (Fujimori) 10 minutes
6. Compositional characteristics analysis (Beppu, Hosokawa) 10 minutes

2) Group work

1. Explanation of the assignment (Matsuishi) 10 minutes
2. Group discussion (Facilitator, Matsuishi and Yamaguchi)
3. Create a presentation
4. Presentations: 3 x 10 minutes, general discussion (all participants)

3) Excursions 11/13 05:45- 08:30 (tentative)

1. Visit the wholesale market for marine products in Hakodate
2. Hakodate Morning Market (Seafood Bowl for breakfast)
3. Breakfast, own expenses

Enrolled students: MC students of GFR, PhD students of the Graduate School of Fisheries Science (about 13 students) Language: English

Appendix 3: Announcement and draft agenda for 2021 ESSAS Annual Science Meeting

1st circular of Program 2021 ESSAS Annual Science Meeting

“Linking past and present marine ecosystems to inform future fisheries and aquaculture”

Webinar at http://xxxxxxx
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 to the following URL, https://ainu-upopoy.jp/en/ and click the YouTube mark on the top page of website for vertical excursion in the museum.

We look forward to productive discussions with many participants!

* https://ainu-upopoy.jp/en/

- Deadline for abstract submission: 31 January, 2021
- Deadline for registration on the website: 30 April, 2021
- For registration & abstract submission, please go to:

https://essas.arc.hokudai.ac.jp/what_s_new/2021-essas-annual-science-meeting/

- Registration fee: Free

Program: (Date and time in Japan Standard Time)

30 May (Sun)

18:00–19:00 (Live, in Japanese)
Public session "Marine Mammal (tentative title)" by Dr. Yoko Mitani, Associate Prof., Hokkaido University

31 May (Mon)

Contribution from ESSAS community to the local communities in Japan

Live (L), In Japanese (J), In English (E),
Simultaneous translation of Japanese-English (J-E or E-J), On−demand contents in English (ODE)

09:00–10:25 JST = 17:00–18:25 Pacific Daylight Time = 02:00–03:25 Central European Summer Time
13:00–15:00 JST = 21:00–23:00 PDT = 06:00–08:00 CEST

09:00–09:05	Welcome address by Prof. Fukamachi, Director of Arctic Research Center, Hokkaido University (L, J, J-E)
09:10–09:35	Keynote talk 1 "The song of the spring, the story of the wind: Relationships among air, sea, ice, people and Pacific herring (*Clupea pallasii*) in the past, present and future" Dr. Naoki Tojo Assistant Prof. Hokkaido University (L, J, ODE)
09:35–10:00	Keynote talk 2 "Assessing and managing fish stocks in a rapidly changing environment" Dr. Franz Mueter, Professor of Fisheries, University of Alaska Fairbanks (L, E, E-J)
10:00–10:25	Keynote talk 3 "Community resilience under rapid socio-environmental change. But how can we enhance it?" Dr. Aoi Sugimoto, Researcher, National Research Institute of Fisheries Science (L, J, ODE)
10:25–13:00	Lunch break
13:00–15:00	Discussion led by Prof. Makino (Identify key issues & challenges; identify ways to enhance collaborations between scientists and stakeholders) (L, J, J-E/E-J)

1 June (Tue)

Contribution from ESSAS community to the Japanese ESSAS related community

Three hours general sessions will be held in the morning and evening.
05:00–08:00 JST = 13:00–16:00 PDT = 22:00–01:00 CEST
15:00–18:00 JST = 23:00–02:00 PDT = 08:00–11:00 CEST

05:00–06:15	General Session (15min x 5 talks)
06:15–06:35	Break
06:35–07:50	General Session (15min x 5 talks)

15:00–16:15 General Session (15min x 5 talks)
16:15–16:35 Coffee break
16:35–17:50 General Session (15min x 5 talks)

2 June (Wed)

Contribution from ESSAS working group (PESSAS and AnalogueArt)
Leader of the working group will decide schedule and time.

Plenary talks based on sharing methods and data sets available (PESAS and AnalogueArt)
Open discussion (on potential challenges and strategies for connecting paleo-and neo-data sets with reference to conceptual and methodological issues e.g., working assumptions, chronological resolution, averaging, scaled and unscaled variables…)

3 June (Thu) (Only SSC)

05:00–08:00 ESSAS SSC meeting
05:00–08:00 JST = 13:00–16:00 PDT = 22:00–01:00 CEST

Virtual Excursion

UPOPOY, National Ainu Museum and Park opened on 24 April, 2020 in Shiraoi, Hokkaido
Japanese site https://ainu-upopoy.jp/library/
English site https://ainu-upopoy.jp/en/
Sites in Chinese, Taiwanese, Korean, Thai and Russian are available.

Schedule of ESSAS ASM Webinar

	30-May	31-May	1-Jun	2-Jun	4-Jun
AM		Stakeholder Meeting (Presentation)	General Session	Working Group Session	SSC
PM	Preparation of webinar Public Session	Stakeholder Meeting (Discussion)	General Session	Working Group Session	
Host place	Arctic Res. Center, Hokkaido Univ.	Arctic Res. Center, Hokkaido Univ.	Arctic Res. Center, Hokkaido Univ.	Arctic Res. Center, Hokkaido Univ.	Arctic Res. Center, Hokkaido Univ.

Appendix 4: Draft plan for joint workshop of ESSAS working groups AnalogART and PESAS

2021 ESSAS Virtual Meeting

Step 1 – Prior to Workshop: Recruit speakers to record 5-10 minute talks addressing the following questions. Post recorded talks and provide to WG and ESSAS members/participants at least 24 hours before the WG session.

A. What can we learn from spatial and temporal gradients of different scales? What are the advantages and disadvantages of such studies into contemporary and paleo-data? Introduction to AnalogART and PESAS. (Possible presenters: Kumiko/Sam; Nicole/Ben)
B. How do we link biological responses to environmental variables across spatial and temporal dimensions … with the goal of future projections/scenario building/ model parameterization? (possible presenters: AnalogART: Tina; Kumiko; Melissa; PESAS: Catherine/Nicole/…)
C. How can we study/what have we learned about the plasticity of organisms to adapt to environmental changes based on spatial and temporal patterns? (Presenters: AnalogART: Sam; PESAS: ???)
D. How can we put people into the picture and add societal relevance to our working groups? How do we scale from biological analogs to societies and future relevance? (AnalogART: Jason Harspenser; PESAS: Ben/Stefani…?)

Step 2 – Workshop: 2 hour discussions starting with presenters briefly reviewing/contextualizing their recorded presentations, then discussion of the four questions. Two sessions to manage time zone differences, with as many people as possible joining both. Ben and Sam will be at both and will summarize the state of discussion from Session 1 at the Session 2 meeting. Presenters come to one or both as they can.

A. Session 1:
    a. Japan, 6am-8am (June 2)
    b. Bergen 11pm-1am (June 1-2);
    c. North America EDT: 6pm (June 1)
    d. North America PDT: 2pm (June 1)
    e. Alaska D. Time: 1pm (June 1)
B. Session 2:
    a. Japan, 3pm (June 2)
    b. Bergen 8am (June 2);
    c. North America EDT: 2am (June 2)
    d. North America PDT: 11pm (June 1)
    e. Alaska D. Time: 10pm (June 1)

Workshop sessions: General plan is to cover at least 2 of the 4 questions, 1/hour, but to touch on the other two to the extent possible.

Overall outcome/goal: explore and cross-fertilize the spatial and temporal approaches of AnalogART and PESAS. Consider potential for a collaborative publication on the use of analogs in space and time for future scenarios of climate, ocean, biology, and human sustainability.