Pacific Arctic Group (PAG) 2022 Fall Meeting

PAG Meeting Agenda
December 5-6, 2022
Victoria, British Columbia
http://pag.arcticportal.org/

The PAG Fall Meeting is hosted at various locations in alternating PAG countries after the field season and is focused on review of accomplishments during the previous summer and outlooks for the future. The PAG 2022 Fall Meeting was held on December 5 and 6 in-person at the Parkside Hotel in Victoria, British Columbia and online via a Zoom meeting.

Business Meeting: We report on and discuss here: the 2022 field activities and future plans, PAG endorsed projects (DBO, PACEO, CAO), joint research activities, interaction with other organizations/projects, PAG organizational issues and other business issues.

12/5/2022, PAG, DAY 1

*Bill Williams (Fisheries and Oceans Canada) [*PPT1*]*

Bill provided opening remarks and meeting participants introduced themselves.

COUNTRY REPORTS:

*Bill Williams (Fisheries and Oceans Canada) – Canadian Arctic Marine Science 2022 [*PPT2*]*
Bill discussed the CCGS Louis S. St-Laurent USA-Canada collaboration that has existed for 20 years and is funded until 2024. He provided an Arctic Sea Ice Extent graph of ocean area with at least 15% sea ice and its general decline over these 20 years. He also discussed the 2022 Joint Ocean Ice Study (JOIS)/ Arctic Observing Network-Beaufort Gyre Observing System (BGOS) providing a list of the data sampling and observations. Ocean Data View (ODV) graphs were shown for the 140W section for various parameters, including temperature and nitrate for example as well as a map of buoy deployments. Underway measurement examples of Mackenzie River Water traced by salinity, CDOM, and alkalinity were shown, as well as freshwater content of the Beaufort Gyre since 2003, including PWW, PSW, and surface waters indicating increased freshwater content over time.

Jackie Grebmeier (UMCES CBL) – US Country Report-Research Cruises [*[PPT3](#)*]
Jackie provided a slide of the 2022 PAG and DBO cruise plan table as of 12/1/22 and hopes people will provide updates. She also provided updates on DBO data collections from the July 2022 CCGC Sir Wilfrid Laurier cruise including parameters such as temperature, salinity, nutrients, chl a, benthic macrofaunalabundance/biomass, and marine mammal and seabird surveys. As examples of other 2022 projects/research, she showed slides from Craig Lee (to present later) on Stratified Ocean Dynamics of the Arctic (SODA) project. Results suggest a new understanding of several topics such as ice-ocean drag and the role of sea ice melt water in modulating freeze-up as examples. She also showed slides of ongoing to completed projects for 2022 and those planned for 2023, including the Arctic Mobile Observing System (AMOS) – a persistent, year-round monitoring, event-driven sampling/response system. The Arctic Argo Pilot project was also highlighted as new tech development. She also showed a slide from Bob Pickart (presented later) about a project investigating Phytoplankton blooms in the warming Chukchi Sea from two cruises on the R/V Norseman II 2022 where extensive physical and biogeochemical sampling of the water column and sediments, including 435 CTD stations, 120 surface sediment grabs, 15 multi-cores, and 47 phytoplankton net tows occurred over two legs from July-September 2022. Carin Ashjian, et. al. (presented later) bio-physical drivers of bowhead whale distribution on the Alaskan Beaufort Shelf during a period of rapid environmental change was highlighted, including data collection such as currents, CTD, zooplankton, krill/copepods, marine mammal, and bird distributions as examples. Rebecca Woodgate and Cecilia Peralta-Ferriz Bering Strait Mooring Project was also shown, including 32+ years (starting in 1990) of year-round moorings and physical data (hourly or better) for temperature, salinity, and velocity for example. Rebecca is interested in collaborations and requests people get in touch with her. Some key results include: 2021 being remarkable cold as compared to 2018 warmest, 2021 and 2020 were remarkable salty, and combined: heat flux was down, as low as prior lowest years and freshwater flux was down, though still higher than 2000s. A summary the Synoptic Arctic Survey cruise on the USCGS Healy, from Sept. 4-Oct. 28, 2022 (~60 days), which Carin discusses later, was also shown, including a graph of ice thickness and concentration increasing over time. An update on the Arctic Marine Biodiversity Observing Network (AMBON) Aug-Sept. 2022 cruise was also provided on behalf of Seth Danielson (to present later), including the Chukchi Ecosystem Observatory (CEO), where year-round data is collected in one location. Monitoring of the Western Arctic Boundary Current in a changing climate from a late season cruise on the R/V Sikuliaq on behalf of Bob Pickart (to present later) was also shown, which will carry out hydrographic/velocity/tracer survey of the boundary current system from Bering Strait to the Canadian Beaufort. Jackie also provided a slide to illustrate Michael Steele's presentation on saildrones sampled across the DBO from July-Aug 2022. Finally, Jackie provided slides outlining the 2023 planned R/V Sikuliaq cruise from Sept. 10-Oct. 4 which is a collaboration with AMBON and CEO. They will investigate the impacts of seawater warming and declining sea ice on ecosystems components, from prey in the water and sediments to marine mammal and seabird consumers. What are these ecosystem changes in the northern Bering and Chukchi seas and what conditions cause marine animal populations to vary? Kevin Arrigo will also investigate: "the tale of three systems: primary production in the Chukchi Sea" from June 16-July 30, 2023.

Motoyo Itoh (JAMSTEC) – Japan Country Report [*[PPT4](#)*]
Motoyo presented a summary of the Mirai cruise in 2022 and plans for 2023, as well as the plans for the Oshoro-Maru cruise in July 2023. Research themes for the R/V Mirai 2022 cruise included: ocean observational studies of environmental change, distribution/abundance of microplastics, nutrient transport, underwater drone technology, paleoclimate, sea-air interaction, ship-borne observations of trace gases/aeosols and atmospheric greenhouse gases, and observation of water vapor isotopes. The Mirai also occupied three shelf-basin sections in the Beaufort Sea as part of the SAS, 2020-2022 summer

cruises. Additionally, studies of phytoplankton, zooplankton, and environmental DNA were done to understand spatial distribution of fish species and responses to recent Arctic change. Floating, sea floor sediment and sea water microplastic studies were performed. Investigation of volume, heat, and freshwater transports from the Pacific to the Arctic Ocean through Barrow Canyon and lateral transportation. Interactions between ocean waves and sea ice in marginal ice areas in the northeastern Canada Basin were investigated using 15 wave buoy deployments, drone flights, radar, and cameras. A trial of an under-the-ice drone developed by JAMSTEC was conducted through the Challenge of Observation and Measurement under Arctic Ice (COMAI) project designed for automated cruise and observations in the sea ice areas in the future. Evaluation of natural environmental changes over the past 2,000 years and identification of anthropogenic environmental changes was conducted using sediment sampling for paleo-oceanographic study, as well as aerosol and precipitation sampling being performed to investigate the roles of atmospheric aerosols in the marine atmosphere in relation to climate change. Plans for the R/V Mirai 2023 cruise and research topics were also provided.

PAG-RELATED JOINT RESEARCH ACTIVITIES

To the North Pole:

Anna Nikolopoulos (Norwegian Polar Institute), The NPI Arctic Ocean 2022 Cruise [*PPT5*]
Anna presented the program and it's collaborators research into the physical, chemical, and biological observations of the ocean and sea ice in the Amundsen and Nansen Basins. She provided a series of maps showing underway sampling and the shipboard measurements collected, sea ice stations and basket operations, equipment installed and left, as well as the main CTD transect that consists of 67 stations at 10nm intervals. She also noted fishing activities including: pelagic trawl sampling, net sampling, and acoustic fishery surveys, as well as mooring deployments in both basins and investigations of ice thickness from late July to mid-August 2022 noting that they didn't have to do much ice-breaking and when they did the ice was thinner and they did not get stuck. A series of temperature and salinity profiles were shown for a transect along the Gakkel Ridge, as well as a comparison of those parameters for both basins. Anna also provided links to both the cruise report and the CTD data respectively: https://hdl.handle.net/11250/3013026 and https://data.npolar.no/dataset/d1e609e2-08ff-4638-843c-28d039c9d33c .

Carin Ashjian (WHOI), The 2022 US Synoptic Arctic Survey North Pole Cruise, USCGC Healy [*PPT6*]
Carin presented a summary of activities from the 2022 US SAS cruise, including a map of the 51 stations and they type of data collected. Two transects to the North Pole included collections of the following: 1. Annual turnover of CEO Mooring (NPRB), 2. High-spatial resolution survey along Shelf-Basin Interactions (2002-2004) EHS line, 3. Broad-spatial resolution survey, augmented with XCTD and XBT, along two transect lines sampled previously by the AOS (1994) and GEOTRACES (2015), 4. High-spatial resolution survey in the Hanna Canyon Region, and 5. Station at DBO3.8 on the way south. It was noted that the track aligned fairly well with the 2015 GEOTRACES cruise. She also listed the many variables that were measured such as chemistry, fauna, and marine mammal as examples. It was also noted that there were many leads and ice was not that thick. Other observations included that net community production differed between ice covered and ice free waters as well as there being regional variation in surface carbon characteristics. She ended with an explanation about the "Float your Boat Program" (https://www.floatboat.org/follow-your-boat) that they participated in.

Seth Danielson (University of Alaska Fairbanks) [[PPT7](#)]
Seth provided an update on the status, activities and results of the Chukchi Ecosystem Observatory (CEO). He explained the Alaska Region Ecosystem Moorings vision as: "A distributed network of moored observatories that monitor Alaska's Large Marine Ecosystems with year-round, high-resolution, co-located, multi-disciplinary, and multi trophic-level measurements," and well as the CEO objectives, including: improving mechanistic understanding of the Arctic shelf marine ecosystem, fostering coordination and cooperation among research programs, enhancing information availability with scientific data, analyses, and products, and siting based on ecological, economic, cultural, scientific, and management considerations. He provided the year-round measurements collected, including: fish, marine mammals, benthos, microbes, phytoplankton, zooplankton, and physics/bio-geochemistry. Sediment trap, (re)constructing the year-round history of Arctic shelf plankton and particulate matter, as well as passive and active acoustic results were provided.

Bob Pickart (WHOI) [[PPT8](#)]
Bob presented "Phytoplankton blooms in the warming Chukchi Sea" based on two cruises on the R/V Norseman II in 2022. The goals of the projects included: improve our understanding of phytoplankton dynamics in the Chukchi Sea, identify locations and quantify the magnitude of harmful algal blooms (HABs), map the distribution of HAB cysts in the sediments, and understand how the circulation, water properties, and atmospheric forcing influence these things. He provided the shipboard sampling parameters for physical oceanography, HABs, and biogeochemistry, followed by maps of distributions of *Alexandrium catenella* throughout the cruise. He also compared cell concentrations of the cruise between late July and mid-August showing them to be much higher in August, especially in Kotzebue Sound, as well as maps of potential density throughout the northern Chukchi shelf during leg 2 of the cruise. Bob also presented summaries of data collection from the R/V Sikuliaq during the late season, "Monitoring the Western Arctic Boundary Current in a Changing Climate". The goals of this research were to: service the long-term mooring located in the Beaufort Sea boundary current east of Pt Barrow, carry out a hydrographic/velocity/tracer survey of the boundary current system from Bering Strait to the Canadian Beaufort, and provide a platform for ancillary programs, including underway biogeochemistry, HABs, oxygen isotopes in the water column and air, sediment coring, and black carbon. He showed maps of the hydrographic stations and the Beaufort shelf/upper-slope sections as well as results of distinguishing component water masses using isotopes $\delta^{18}O$, δD (deuterium excess). Bob jokingly noted his dedication to visitng DBO sites for Jackie and thanked Bill for his collaboration along with the Coast Guard for help acquiring real-time imagery service.

Virtual presentation from Korea, and Japan including Country Reports and PAG-endorsed projections. <mark>Ppts: 9 (Yang),), 10 (Kim), 11 (Cho), La (12) and 13 (Ko) are missing</mark>

KOREA: Eun-Jin Yang (KOPRI) <mark>[PPT9 – missing]</mark>
Eun provided updates on the 2022 Korean Arctic Research Activity and as well as summaries of R/V Araon plans for 2010-2022 and they types of data collection. Plans for 2021-2026 were also provided as well as results from the DBO3 and PACEO line. Data collected included: atmospheric observations, physical oceanography, chemical oceanography, seasonal variation of particle flux, and biological oceanography.

PACIFIC ARCTIC CLIMATE ECOSYSTEM OBSERVATORY (PACEO)

Jee-Hoon Kim (KOPRI) <mark>**[PPT10 – missing]**</mark>
Jee-Hoon presented internannual patterns of summer mesozooplankton, including comparisons of change in C. glacialis and Pseudocalanus sp. sp. Carin asked about untangling species variability and what is really impacted (because there are 4 species) and should consider when moving forward. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021JC018074

Kyoung-Ho Cho (KOPRI) <mark>**[PPT11 – missing]**</mark>
Kyoung-Ho provided updated on PACEO 2022, including a composite slide of some results as well as temperature/salinity scatterplots from 2019-2022 by water mass type.

Hyoung Sul La (KOPRI) <mark>**[PPT12 – missing]**</mark>
Hyoung reported on PACEO and Korean biological activity research for 2022, including major observations, materials and methods, and preliminary results of phytoplankton. Kate Stafford noted issues with automatically classifying and identifying animals from acoustic signals so it would be nice to collaborate with ideas. KOPRI are working on unsupervised learning methods and their own detector which is working at broad classifications even though they don't know what some of it is, it's useful for the next step, but there is not much research yet.

Eun-Ho Ko (KOPRI) <mark>**[PPT13 – missing]**</mark>
Eun-Ho provided summaries of variability of phytoplankton from 2015-2018, including investigating what factors affect phytoplankton physiology in the SCM layer. Research goals and the study area were provided as well as comparisons between the NW Chukchi and the NEC. They found low PAR in the east and high PAR in the west. Rebecca Woodgate noted that she has a paper that supports the results of this work in this area to which Jackie replied "win win".

DISTRIBUTED BIOLOGICAL OBSERVATORY (DBO)

Jackie Grebmeier (UMCES/CBL) [*PPT14*]
Jackie provided an update on the DBO: a change detection array in the Pacific Arctic including the types of sampling that are used to link physics to biology within the DBO regional "hotspots". She provided a summary of DBO-related cruises from 2022 and those planned for 2023 by Canada, Japan, Korea, and the USA. Graphs of sea ice persistence, break-up, formation and annual primary production for DBO transects 1-5 per Karen Frey, et al. (2022) were provided from 2010-2019, as well as macrofaunal biomass and dominant taxa type for those same transects and regions. She highlighted a few examples of results including: a time series of benthic biomass (carbon) for DBO3 from 2010-2019, potential impacts of strikes on baleen whales with increased shipping, and HABs as an environmental stressor, particularly blooms of *Alexandrium* sp. Topics such as sea ice, hydrography, microbial and plankton dynamics, export production, benthic populations, sediments, marine mammals, and seabirds were highlights of the 2nd DBO PLOS Special Issue which was completed in 2022. She also provide a list of US Pacific Arctic DBO Data Access, such the Arctic Data Center for NSF projects (https://arcticdata.io/catalog/portals/DBO). Jackie also highlighted developing Atlantic sector DBOs and noted that Craig Lee will discuss the Davis Strait Region, as well as, noting Igor Polyakov and Clara Deal's work on DBO in the Laptev/East Siberian seas of the Arctic Ocean. In summary: seasonal and annual DBO time series sampling are helping to identify and track environmental and ecosystem changes with

climate warming and developing pan-Arctic DBOs via Atlantic DBO, Davis Strait/Baffin Bay DBO, and East Siberian Sea DBO.

Amane Fujiwara (JAMSTEC) [PPT15]
Amane provided recent updates on Japanese Arctic cruises from 2015-2024. Incubation results were provided including noting that diatom cells on the sea floor are capable of re-seeding with a comparison of 2017 and 2018. They also examined microplastic spread (floating) with the highest in Bering Strait. Upcoming topic for the 2021 Mirai were also provided. Carin noted that we should all be careful collecting microplastics because some of those plastics come from the nets used.

Kohei Matsumo (JAMSTEC) [PPT16]
Kohei provided the cruise plans for the 2023 training ship Oshoro Maru, including Bering and Chukchi Sea observations. Dates for the three legs lasting from June 10 – August 3, 2023. Sampling will include canvas kite trawl nets, mud sampling, sediment multiple corer, and G.S. type core sampler (Asyura). Jackie asked that they not trawl the bottom directly on any DBO GPS transects (nearby is ok though).

CENTRAL ARCTIC OCEAN (CAO)

Haiyan Jin [PPT17 - missing]

Shigeto Nishino (JAMSTEC) [PPT18]
Shigeto provided a report on a session of the CAO fisheries agreement in Arctic Circle Assembly, including questions to be addressed by the Joint Program of Scientific Research and Monitoring (JPSRM).

Jihoon Jeong [PPT19 - missing]

12/6/2022, PAG, DAY 2

CONTINUED PAG-RELATED JOINT RESEARCH ACTIVITIES: REPORTS, SUMMARIES, RESULTS, PLANS

Craig Lee (UW) [PPT20]
Craig presented on Ocean, Ice and Atmosphere in the Changing Arctic: Science and Technology Development in the Office of Naval Research Arctic Program including results from the Marginal Ice Zone (MIZ) and Stratified Ocean Dynamics in the Arctic Ocean (SODA) programs. ONR major Arctic Research Initiatives from 2012-present were provided. Results for the new understanding of the SODA project include: ice-ocean drag parameterizations, role of sea ice melt water in modulating freeze-up, seasonal modulation of near-inertial motions within mixed layer, episodic offshore heat transport within filaments. Observations of ice-ocean drag across a range of ice shape are important for improving forecasts of sea ice evolution and ocean currents and included the following results: Ice-ocean drag coefficient varies seasonally and spatially, bulk parameterizations for ice geometry produce poor fits to observed ice-ocean drag, can explain and predict these variations if ice geometry is known, variability primarily driven by keel shapes, and dominance of first year over multi-year ice will drive large changes. Small-scale circulation of meltwater accelerates freeze-up and sea ice meltwater advection hastens freeze up. Craig discussed the Arctic Mobile Observing System (AMOS) and how persistent, year-round monitoring, event-driven sampling/response. Also presented was acoustic nav and comms for autonomous platforms in ice-covered environments. Surface ducting in many polar regions limits LF

acoustic range to ~100 km. Warm Pacific layer in Beaufort creates sound channel, allows long-range propagation. Craig also provided and update on 35 Hz VLF geolocation developments as well as results of a year of data collection by glider in the Central Beaufort Sea. A summary of AMOS field operations for 2022 from the USCGC Healy and R/V Sikuliaq were presented as well as continued plans for AMOS 2023/2024. Float position error and reporting interval was estimated using ASTE. As the ability to surface in partial ice cover is valuable, it was found that there is a high probability of surfacing multiple times per year, and in regions of multi-year ice, floats may drift for years, until they move to area of seasonal ice cover. APEX float developments were also discussed as well as tech development for the Arctic Argo Pilot study.

Mike Steele (UW) [PPT21]
Mike discussed buoys for the Pacific Arctic Waters including the NASA project, Salinity and Stratification at the Sea Ice Edge (SASSIE) that run from 2021-2024. He showed the three main phases of the 2022 field campaign over August (ice melt), September (transition), and October (freeze-up) using wave gliders, ship/aircraft, buoys/floats, and satellite/modeling where Mike contributed 11 buoys and 7 floats. Open water – ice transition in early September 2022 indicated salinity within sea ice is more uniform and there is strong spatial variability south of the ice edge. Mike then discussed results (and the death of) SASSIE buoys as well as all buoys are in ice now with some still reporting. He also discussed the Seasonal Ice Zone Reconnaissance Surveys (SIZRS) taking place from 2012-2024 and are synoptically collected monthly from June to October across frontal boundaries to study: ice/ocean circulation and air-sea exchange. He showed a video of the SIZRS buoy deployment in October 2022 being dropped in the air from a plane successfully. NOAA project Arctic Heat II and APL's microSwift were mentioned. Accomplishments for 2022 included: 8 deployed AXBTs along DBO3 shorty after ice retreat and 3 microSWIFT wave buoys off Prudhoe Bay in collaboration with Maddie Smith (APL) in June and 24 AXBTs (AOC) and 7 AXCTDs (APL) across the shelf break, ~30 dropsondes in collaboration with Zheng Liu (APL), and test run of the Lidar observational system LATIS ins collaboration with John Gutherie (APL) in July-August flights.

EURASIAN ARCTIC OCEAN

Mike Steele (UW) [PPT22]
Mike also discussed the role of the Russian Shelf in seasonal and interannual variability of Arctic Sea Surface Salinity and Freshwater Content which research done with colleagues from the University of South Carolina and is review for publication as Hall et al. (2022, JGR). The premise based on the fact that the Arctic Ocean is very stratified (Carmack et al., 2015, JGR) and where freshwater content is function of salinity and thickness in the upper layer. There are MANY papers on Arctic freshwater content/volume. Mike showed maps of patterns and changes of FWC for the 1990s, 2000s, and 2010s that was published by Pnyushkov et al. in 2022, noting that there is lack of in situ observations for the Russian shelf and asks what are we missing when we neglect it. The researchers used Satellite Sea Surface Salinity and reanalysis as tools for investigation and concluded the ORAS5 model was best and suggests that there might be lots of influence in the Russian Shelf based on analysis from 1979-2018.

Igor Polyakov (University of Alaska Fairbanks) [PPT23]
Igor provided an update on the status, activities, and results of the Nansen and Amundsen Basins Observational System (NABOS) program and the history of the "atlantification" (temperature anomalies) of the Arctic observed over time. The halocline becomes weaker and weaker with increases in heat flux in the Eurasian basin in recent years. The funding cycle for NABOS is from 2021-2025 from NSF with the

goal being a NABOS II. There has been as escalation of Russian limitations in recent years and leaving it excluded from data collection and analysis (eg. Can't use Russian ships). The effects of "atlantification" are traceable in temperature at the 150m line to the 200-250m line in recent years.

Ignatius Rigor (UW) [PPT24]

Ignatius presented updates on the Arctic Buoy Programme (IABP) which includes weather, sea ice and oceanographic buoys deployed spring, summer and fall. The IABP maintains the fundamental Arctic Observing Network observing ice/ocean circulation, surface meteorology, and oceanography and has been running since 1979. He also discussed the Nansen and Amundsen Basin Observing System (NABOS) whose objective is to service moorings, CTD surveys, and deploy autonomous and ice-based assets as well as the US-IABP/AARI collaboration using Russian ice breakers Akademic Fedorov and Mikhail Somov deploying Marlin Yug buoys. Igor also mentioned using "icebreakers of opportunity"! His IABP summary included: 1) enormous spatial gap in Arctic Observing Network in Eurasian Sector, a) changes in ice/ocean circulation quicky transport buoys away, b) logistics have always been sparse, but will be even sparser given the Ukrainian/Russian War, 2) the Eurasian Sector is the center of many of the changes in Arctic Climate (e.g. AO/NAO, Makarov Basin), 3) need more ice breakers, and flights to help fill the gaps especially in the Eurasian sector of the Arctic Ocean, and 4) USIABP/IABP can also provide some buoys to support science.

MODELLING

Nadia Steiner (Institute of Ocean Sciences) [PPT25]

Nadia provided an update on the CMIP6 evaluation of marine ecosystem stressors in the Arctic. A multi-stressor analysis was performed because: species performance is primarily a function of temperature, species concentrate in habitats where performance is optimal, and Pfortner & Farell, 2008 suggest that the thermal window is narrowed by additional stressors – decreasing the range of optimal performance. A multi-model analysis was done because: model uncertainty remains a key factor of uncertainty for biogeochemical variables, multi-model analysis provide a measure of this uncertainty, and limited runs in model downscaling efforts can then be put into context with ESM-multi-model analysis. Nadia provided graphs of 10 model results for 14 regions investigating regional difference in temperature, 02 , and sea ice. The Arctic shows distinct regional differences, with most advanced ocean acidification (lowest pH and $CaCO_3$ saturation states) in the East Siberian and Laptev Seas. Models show distinct regional differences in trends and large spread among models (increasing over time). Subregional differences are greatest in the middle period when large sea-ice changes are occurring at different rates. Models show distinct regional differences in trends with increasing spread over time following the T-trend pattern. CanESM comparison indicates that despite consistent T-trends O2 trends show varying trend biases by region. This indicates that the model differences in O2 are not solely due to the physical parametrizations driving T, but to some extent based on the biogeochemical model (e.g. CMOC vs CanOE). Models show regional differences in trends with decreasing spread over time. CanESM comparison indicates that Ω trends show varying trend biases by region. This indicates that the model differences in Ω are to some extent based on the biogeochemical model (e.g. CMOC vs CanOE). Ocean acidification until ~2035 is already defined by past emissions after which higher emission scenarios show faster acidification progression. For regions with most advanced acidification aragonite undersaturation will be reached in all scenarios, for other regions lower emissions can avoid undersaturation. Clear increase in temperature seasonality in the upper 50m due to sea-ice retreat and warming. Large regional differences and high model uncertainty. Seasonality remains weak although some shift to a

later max is visible. Note that models without representation of the sea-ice carbon pump significantly underestimate the seasonal cycle in the surface ocean. Models show a range of timing for threshold crossings, but consistent regional differences. Key messages included: there is significant regional variability in the Arctic with somewhat consistent patterns across models. Models show variations in trends and initial biases among models: reduced spread/ lower uncertainty in Arctic ocean acidification over time (with decreasing sea-ice). Model spread/uncertainty is increasing for temperature and O2 patterns. Some biases are related to the biogeochemical model/parametrizations; annual cycles, relevant for ecosystems, are generally increasing in amplitude over time, particularly in the top 50m. In many cases a seasonal cycle is a "new" feature. This is particularly obvious for O2 where a pronounced September minimum is developing. Some shifts in timing of max/mins are also indicated, particularly for OA (note, missing sea-ice carbon pump underrepresents seasonal cycle); and, environmental changes until ~2035 are already defined by past emissions after which higher emission scenarios show faster progression (acidification/warming/ice retreat).

Yuanxin Zhang (JAMSTEC) [PPT26]

Yuanxin discussed the Arctic marine biogeochemical modeling in the ArCSII project. The Arctic Challenge for Sustainability II called the "ArCS II project" is a Japanese national flagship project operated from June 2020 to March 2025 and fosters various Arctic research covering both natural and social sciences. One of the research programs focused on the ocean is "Research and Public Data Production on the Arctic Marine Environment". Here group is composed of three sub-programs.
First, "Ocean heat/freshwater transport and biogeochemical cycles in seasonal and multi-year sea-ice zones". Second, "Vulnerability and resilience of marine ecosystem in response to rapid sea-ice retreat". Third, "Air-sea interactions related to sea ice". For all three topics, we conducted different simulation experiments using a coupled of pan-Arctic sea ice–ocean ecosystem model. The physical model is a pan-Arctic sea ice-ocean general circulation model "COCO".
Biogeochemical component is Arctic NEMURO-C, representing three nutrients, ice algae, five plankton groups, and carbonate chemical processes. Particle resuspension from seafloor was recently incorporated only in the high-resolution version. For the resuspended particle topic, we perform interannual experiments from 2001 to 2020 using 5-km resolution version. For the riverine impact topic, 25-km resolution version is integrated from 1979 to 2018. For the ice algae topic, decadal simulation forced by JRA55-based atmospheric forcing starts in 1958. Other experimental designs such as model domain and lateral boundary conditions are basically same. In topic B, we focus on impacts of riverine geochemical inflow on marine environment. Future work includes: estimate the effects of terrestrial organic matter/permafrost thawing on Ocean Acidification and primary production in the different Arctic Seas, simulation using different atmospheric forcing datasets to compare ice-PP under various future climate conditions (scenarios SSP5-8.5/1-2.6), multi-model intercomparison on seasonal, interannual, and decadal timescales of ice-PP among 3 Earth System Models and 2 regional models to estimate the uncertainties of different model behaviors (Hayashida et al., 2021), and quantify the impact of ice-PP on the Arctic primary production of phytoplankton and carbon cycle

Jia Wang (NOAA) [PPT27A, PPT27B, PPT27C]

Jia provided recent updates on Arctic research and products, which include: Interannual and decadal variability in Arctic summer sea ice, Arctic amplification, teleconnections, and ice/ocean albedo feedback loop:

- Hindcast of Arctic summer sea ice using regression models (potential for seasonal forecast)
- GLERL-CIGLR Arctic sea-route nowcast/forecast System (GCAS) (5-day prediction)
- ALaska Coastal Ocean Forecast System (ALCOFS) (5-day prediction)
- Great Lakes coupled FVCOM_ice_wave model

o   Summary of future efforts

Accelerated Summer Arctic Sea Ice Decline during 1850-2017 due to positive ice/ocean albedo feedback exerted by the amplified Arctic warming driven simultaneously by both global warming and the warming caused by teleconnection patterns during the recent decades (Cai et al. 2021a, ERL, 2021b, JC). Objectives for the Hindcast of Arctic summer sea ice using regression models (potential for seasonal forecast) include: using monthly teleconnection pattern indices, hindcasting September Arctic sea ice extent using regression models, and projecting Sep. minimum sea ice using teleconnection pattern indices observed before Sep.

PROPOSALS FOR NEW RESEARCH ACTIVITIES

Takashi Kikuchi (JAMSTEC) ==*[PPT28 - missing]*==
Takashi provided information about early career scientist opportunities as well as and updated on Japan's new icebreaker and related symposium. He also showed a video introducing the new icebreaker.

Anna Nikolpoulos (Norwegian Polar Institute) [[PPT29](#)*]*
Anna discussed the Pan-Arctic Observing System of Systems: Implementing Observations for Societal needs on behalf of Michael Karcher and the Arctic PASSION team. General objectives include: Co-create a **coherent, integrated and sustainable pan-Arctic Observing System of Systems**
Meaningful collaboration with **Arctic communities, Indigenous Peoples and organisations**
Expand the monitoring capabilities to **support predictions and risk assessments,** through **broad inclusion of Indigenous Knowledge and Local Knowledge**;
Improve **data interoperability** and simplify access to 'application-ready' environmental data for the benefit of all users. The work package structure includes: strengthening core observing system elements, decision-making support, and synthesis and outreach. The nine top-level objectives for Arctic PASSION are each related to a work packages.
Current highlights:
1.   Shared Arctic Variables (WP1, WP6; plus WP4 PS1, PS2, PS4, PS6; plus WP8)
2.   Atlantic Distributed Biological Observatory (WP1; plus WP8)
3.   Collaboration and co-creation with Indigenous Communities (WP1, WP4 PS1, PS2, PS7; plus WP6, WP8, WP9)
    Sub-national Policy and Decision-making support (WP7; plus WP6, WP8, WP9)
To improve access to essential information services for communities, industry and governments, eight Pilot Services (PS) will be developed to **support emergency preparedness, food security, responses to climate and socio-economic changes**.
Existing services, such as those from Copernicus and ESA services will also be integrated to AW.
www.arcticpassion.eu

SYNTHESIS ACTIVITIES

Danielle Dickson (NPRB) [[PPT30](#)*]*
Danielle provided details about the Integrated Ecosystem Research Program (IERP), including background, structure, and funding sources (www.nprb.org/arctic-program). The Arctic IERP Synthesis work is currently funded until 2025 and covers two synthesis projects: Pelagic-Benthic Decoupling? Ecosystem Restructuring in the Northern Bering and Chukchi Seas (2022-2025)
Logerwell et al.

Seas the Change: A Sea-Scale Effort to Assess Sensitivity to Change in Nutrients and Ecosystems within the Pacific Arctic (2022-2024)
Kelly et al. Future IERP activities include opportunities for collaboration and will focus on the Northern Bering Sea. NPRB is seeking partners to co-fund this future work, which is in the early stages of development with an undetermined timeline, though field work is anticipated during 2027-2029. Please contact Danielle about partnerships and collaboration (Danielle.Dickson@nprb.org Matthew.Baker@nprb.org).

*Jackie Grebmeier (UMCES CBL) [*PPT14 *– DBO update]*
See previous section

*Motoyo Itoh (JAMSTEC) [*PPT32*]*
Motoyo showed the articles published as part of the JGR-Ocean special issue whose deadline for submission was March 2022. Seventeen manuscripts have been published.

UPDATES/OTHER DISCUSSIONS [PPT33 **;** PPT34**]**
Details about upcoming conferences and sessions were provided by Jackie [PPT33] and Shige [PPT34] including the ASSW2023 in Vienna, Austria, the ISAR-7 in Tokyo, Japan with sessions about SAS and Marine Ecosystems.

Chair and Secretariat rotates very 2 years at the end of the Fall Meeting

Bill provided a list of the previous chairs and future years that still require assignments. The current PAG chair is now Jessica Cross (NOAA)
- 2012-2014 – USA (Jackie Grebmeier, UMCES)
- 2014-2016 - Korea (Sung-Ho Kang, KOPRI)
- 2016-2018 - Japan (Takashi Kikuchi, JAMSTEC)
- 2018-2020 - China (Jianfeng He, PRIC)
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Past and Future PAG Meetings:

Spring meetings at ASSW:
- 2012: IPY, Montreal, Canada
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- 2016: Fairbanks, Alaska, Japan
- 2017: Prague, Czech Republic
- 2018: Davos, Switzerland
- 2019: Arkhangelsk, Russia
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- 2021: Lisbon, Portugal (online)
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- 2024: Edinburgh, UK
- 2025: Boulder, Colorado, USA

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- 2017: USA, Seattle
- 2018: Japan, Hakodate
- 2019: China, Hangzhou
- 2020: Online
- 2021: Online
- 2022: Canada, Victoria, Canada (hybrid)
- 2023: ??
- 2024: ??
- 2025: ??

Executive committee composed of:
- PAG Chair: *Jessica Cross* (USA)
- Vice-Chairs (one representative from each PAG member nation):
    - *Bill Williams (Canada)*
    - *Shigeto Nishino* (Japan)
    - *Eun-Jin Yang* (Korea)
    - *Jianfeng He* (China)
- Leads from each of PAG activities:
    - DBO: *Jackie Grebmeier*
    - PACEO: *Kyoung-Ho Cho*
    - CAO: *Shigeto Nishino*

End of PAG Meeting.

Pacific Arctic Group (PAG) 2022 Fall Meeting

PAG Meeting Agenda
December 5-6, 2022
Victoria, British Columbia
http://pag.arcticportal.org/

The PAG Fall Meeting is hosted at various locations in alternating PAG countries after the field season and is focused on review of accomplishments during the previous summer and outlooks for the future. The PAG 2022 Fall Meeting will be held on December 5 and 6 in-person at the Parkside Hotel in Victoria, British Columbia and online via a Zoom meeting.

Business Meeting: We report on and discuss: 2022 field activities and future plans, PAG endorsed projects (DBO, PACEO, CAO), joint research activities, interaction with other organizations/projects, PAG organizational issues and other business issues.

Science Workshop: In addition to the Business Meeting, we invite presentations reporting results, summaries and plans for the PAG endorsed projects and PAG related activities.

Virtual Zoom meeting:

https://us02web.zoom.us/j/81996838458?pwd=WWZ4a25VUUsyanBlSnNvbHYzeXQ4dz09

Please download the .ics file for your calendar:

https://us02web.zoom.us/meeting/tZUkfu-grTMuH9zBxvDzKUJZtCm4_wPvpRq5/ics?icsToken=98tyKuGppzIsEtedtByPRpwcHYr4M_zztlxbgvpHvgfzJzp4VynMIsFPZo1oIM7A

Dates and times:

Monday December 5th:	**Tuesday December 6th:**
Arrive: 0830-0845	Arrive: 0830-0845
Start: 0900	Start: 0900
Coffee: 1030-1045	Coffee: 1030-1045
Lunch: 1200-1330	Lunch: 1200-1330
Coffee: 1500-1515	Finish: 1500 to 1700 as needed
Finish: 1700	

*Times are Pacific Time (PST)

AGENDA

Monday Dec 5th

[0900] **1. Welcome and Introduction** *(Bill Williams)***-**ppt1
Welcome
Internet connection: Wireless: Parkside   Password: marshmallow
Online Zoom meeting instructions
DFO covid protocol
Overview of PAG
Agenda Review
Introduction of participants

[0915] **2. Country reports: Activities during the 2022 field season and plans for 2023 (15 mins each):**
- Canada: *Bill Williams*, ppt2
- United States: *Jackie Grebmeier*, ppt3
- Japan: *Motoyo Itoh,* ppt4
- Korea: ☻moved to afternoon virtual presentation session.
- China: ☻moved to afternoon virtual presentation session.

[1000] **3. PAG-related joint research activities: reports, summaries, results, plans (15mins each + 5mins questions):**

To the North Pole:
- *Anna Nikolopoulos*: The NPI Arctic Ocean 2022 Cruise, ppt5
- *Carin Ashjian*: The 2022 US Synoptic Arctic Survey North Pole Cruise on *USCGC Healy,* ppt6

[1040 - 1100] Coffee break

Chukchi Sea, Beaufort Sea and the Canada Basin:
- *Seth Danielson*: Update on status, activities and results of the Chukchi Ecosystem Observatory (CEO) installation on the NE Chukchi shelf. ppt7
- *Bob Pickart*: ppt8
    - Phytoplankton blooms in the warming Chukchi Sea: two cruises on *R/V Norseman II*
    - Monitoring the Western Arctic Boundary Current in a changing climate: A late-season cruise on *R/V Sikuliaq*

[1200:1330] Lunch

4. Virtual presentations from China, Korea and Japan including Country Reports and PAG endorsed projects (15mins + 5min questions):

- **Virtual country reports:**
  - Korea: *Eun-Jin Yang* [virtual], ppt9
  - China: *Jianfeng He* [virtual], none

- **Pacific Arctic Climate Ecosystem Observatory (PACEO):**
  - *Jee-Hoon Kim* [virtual]: Interannual Patterns of Summer Mesozooplankton Community Structures in the Pacific Arctic Ocean, ppt10
  - *Kyoung-Ho Cho* [virtual]: Pacific Arctic Climate Ecosystem Observatory (PACEO) : Korean Physical Oceanography activity in 2022, ppt11
  - *Hyoung Sul La* [virtual]: Pacific Arctic Climate Ecosystem Observatory (PACEO) : Korean Biological Oceanography activity in 2022, ppt12
  - *Eun-Ho Ko* [virtual]: Inaugural meeting of the Conference Of the Parties(COP) to the agreement to prevent unregulated High Seas Fisheries in the Central Arctic Ocean, ppt13

- **Distributed Biological Observatory (DBO):**
  - *Jackie Grebmeier*: Summary of DBO activities, ppt14
  - *Amane Fujiwara* [virtual]: DBO results from Japan, ppt15
  - *Kohei Matsuno* [virtual]: Oshoro-Maru July 2023 cruise plan (5 mins), ppt16

- **Central Arctic Ocean (CAO):**
  - *Haiyan Jin* [virtual]: Biomarkers as indicators in the study of the biological pump in the Western Arctic Ocean. ppt17
  - *Shige Nishino* [virtual]: Report on a session of the CAO fisheries agreement in the Arctic Circle Assembly. ppt18
  - *Jihoon Jeong* [virtual]: Inaugural meeting of the conference of the parties (COP) to the agreement to prevent unregulated High Seas Fisheries in the Central Arctic Ocean. ppt19

[1700] Finish

Tuesday
[0900] **Continued: 3. PAG-related joint research activities: reports, summaries, results, plans (15mins each + 5mins questions):**

- *Craig Lee*: Results from the MIZ and SODA programs and Arctic technological developments. ppt20
- *Mike Steele*: Buoys and SST/SSS Remote Sensing for Pacific Arctic Waters. ppt21

Eurasian Arctic Ocean:

- Sarah B. Hall, Bulusu Subrahmanyam, and *Mike Steele:* The Role of the Russian Shelf in Seasonal and Interannual Variability of Arctic Sea Surface Salinity and Freshwater Content, ppt22
- *Igor Polyakov* [virtual]: Update on status, activities and results of NABOS. ppt23

[1030 - 1045] Coffee break

- *Ignatius Rigor*: Gaps in the International Arctic Buoy Program (IABP) Arctic Observing Network (AON) on the Eurasian side of the Arctic Ocean, ppt24

Modelling:
- *Nadia Steiner*: Biogeochemical Projections in the Pacific Arctic Region, ppt25
- *Yuanxin Zhang*: Arctic marine biogeochemical modeling in the Japanese ArCSII Project, ppt26
- *Jia Wang* [virtual]: Recent update of research and products, ppt27a,b,c

[1200 - 1330] Lunch

[1330] **5. Proposals for new research activities:**

- *Takashi Kikuchi* [virtual]: Report on Early Career Scientist Opportunities, Japan's new icebreaker and related symposium. ppt28
- *Anna Nikolopoulos*: Arctic PASSION - an EU project to support coordination and enhancement of an Arctic Observing System of Systems. ppt29

[1400] **6. Synthesis Activities:**

- *Danielle Dickson*: Update on AEIRP. ppt30
- *Jackie Grebmeier*: Special issue report. included in ppt14 DBO update
- *Motoyo Itoh*: JGR special issue report. ppt32

[1430] **7. Updates/Other discussions:**

- ASSW2023 (17-24 Feb, Vienna, Austria. Hybrid): ppt33
  - o 1-day DBO Workshop (Business Meetings)
  - o DBO science session (Science Symposium)
  - o SAS science session (Science Symposium)
- ISAR-7 (6-10 March; Seventh International Symposium on Arctic Research, Tokyo, Japan. Hybrid)
  - o SAS Session, *Shige Nishino* [virtual]- -ppt34
  - o Marine Ecosystem Session, *Jackie Grebmeier,* included in ppt33

[1445] **8. Chair and Secretariat rotates every 2 years at the end of the Fall Meeting:**

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[1500 – 1700] **11. End of PAG Meeting.**