2017 PACIFIC ARCTIC GROUP (PAG) FALL MEETING MINUTES

Date: Nov. 6th (13:30-17:00) and 7th (9:00-17:00), 2017
Venue: NOAA/PMEL, Seattle, U.S.

CITATION: SHINJI HIDA, TAKASHI KIKUCHI, and JACKIE GREBMEIER (EDS), 2017 PAG FALL MEETING MINUTES, JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY (JAMSTEC), April 2018.

After a welcome address and logistic information presentation by Sue Moore, the PAG Overview and agenda review was presented by Takashi Kikuchi, who mentioned that the PAG 2017 fall meeting focuses on the previous summer activities of the year.

1. Country report: results from 2017 season and future planning

1.1 China: [PPT1] Jianfeng He (presented by Takashi Kikuchi)

The presentation was composed of three parts: basic information, preliminary results, and plans for the coming years. In the explanation of basic information, the following three items were presented as investigation contents:

- Arctic Passage environment
- Sea ice and marine acidification
- Marine biodiversity and its response to environmental variation

There were 7 investigation phases highlighted from the end of July to the end of September, which aggregates to 83 days and 20,590 nautical miles in total. The regions of sampling covered the Bering Sea, Chukchi Sea, Central Arctic Ocean, Nordic Sea, Baffin Bay and Northwest Passage. Briefly, 8 transects, 58 Conductivity-Temperature-Depth (CTD) stations and 7 ice camps as well as 10 ice buoy and 3 mooring systems deployments were carried out during the expeditions.

The following diagrams were shown as the preliminary results of the observation study:

1. Sea ice distribution and thickness
2. CTD profiles in the central Arctic Ocean
3. Chlorophyll concentration in Canada Basin
4. Time series Temperature (T)/Salinity (S) records in Bearing Sea

Regarding the plan for the coming years, it was mentioned that the icebreaker Xuelong 2 is under construction in Jiannan Shipyard, Shanghai, China and that a test cruise will be conducted in summer of 2019. In addition, the cruise plan of Xuelong 1 and Xuelong 2 for the coming 3 years was presented in a table.

Lastly, as the contributions to the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) as a fuel supplement to the RV Polarstern, the possibility of deploying a buoy array of unmanned ice stations and GPS buoys, etc. was raised.

1.2 **Russia: [PPT2] Igor Semiletov (presented by Takashi Kikuchi)**

Results from 2016/2017 and future planning in the East Siberian Arctic Shelf (ESAS) was presented. It was explained that the ESAS accumulates fresh water from 6 Arctic Siberian Rivers and it is major ice factory of the Arctic Ocean, with a basic component of the ESAS environment being sub-sea permafrost. Additionally, the presentation touched on past accomplishments, including the 30 all-seasonal expeditions, with more than 2,000 oceanographic stations, etc. and the study focus on the contribution of marine Siberian sources of CH4 and CO2 vs. their terrestrial sources as a focus between 2016 and 2020. The presentation indicated the expedition onboard the RV Academician Lavrentiev was accomplished from 24 September-2nd November 2016, which conducted measurements such as seismo-accoustic profiling, sediment coring as well as Photosynthetic Active Radiation (PAR), T, and S measurements in the surface water.

1.3 **Canada: [PPT3] [PPT4] Bill Williams**

On the CCGS Louis S. St-Laurent, the 15th expedition was carried out from 7 September to 2 October 2017, deploying mooring systems, CTD, etc. as well as 3 ice stations. The study indicated that the oceanography changes in the Canada Basin as one goes south to north and from the north to south it shows an accumulation of surface water offshore. Also, the cruise participants deployed spot messenger surface drifters in the continental shelf current.

Bill also explained the objectives of the charter vessel F/V Frosti, focused on sampling for coastal habitat and food web studies. In addition, the vessel was operated in the Canadian Beaufort Sea: Marine Ecosystem Assessment (CBS-MEA), a 3 year program, with the first cruise from 29 July to 13 Sept. 2017.

He next presented an overview on the expedition by the CCGS Sir Wilfrid Laurier for investigating Marine Hazards by ocean monitoring from 15 Sept. to 10 Oct., 2017. The study plan includes year-round data collections via moorings and buoys to document marine climate, specifically norms, natural variation, extremes, and progressive change through investigations of sea ice (thickness, drift), sea surface, ocean current, ocean water mass and ambient sound, etc.

In addition, he presented on the Distributed Biological Observatory (DBO)/Canada's Three Oceans (C3O) activities in July 2017 on the CCGS Sir Wilfrid Laurier. Science of NE Pacific crossing (July 3-10) included twice daily CTD/Rosette casts to 1,000m, water collection for micro-plastic, water filtration for Fukushima Cesium measurements,

as well as continuous monitoring of surface water properties (5m intake depth) for T, S, fluorescence, oxygen, and nitrogen content. Once departing Dutch Harbor, Alaska (July 14 -22), the multidisciplinary science components sampled the DBO1-5 transects for standard observing measurements, resulting in 62 CTD stations with rosette water column collections for multiple parameters, 45 Bongo net hauls, 42 benthic macrofaunal and sediments collections, along with seabird observations.

1.4 **Japan: [PPT5] Shigeto Nishino**

Shigeto presented a summary of the Japanese Arctic cruises undertaken in 2017 by T/S Oshoro maru and R/V Mirai.

The 2017 Arctic Ocean cruise by the R/V Mirai was conducted under the “Arctic Challenge for Sustainability Project (ArCS)” program that is funded by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT). The cruise period was 25 days with 9 themes from Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Scripps Institute of Oceanography (SIO), National Institute of Polar Research (NIPR), Hokkaido University, International Arctic Research Center (IARC) and others. Meteorological and hydrographic surveys including marine biogeochemical samplings were conducted in the northern Bering Sea and the Arctic Ocean. In addition, moorings and sediment traps were recovered and redeployed in the Chukchi Sea and the Canada Basin. At an ice-edge area, a small working boat (Zodiac) approached to the sea ice and carried out unique surveys using a UCTD sensor, fluorometer, water sampler, and plankton net.
As for the 2017 field results, he focused on a subsurface temperature maximum over the Siberian shelf slope that might be related to sea ice recovery, warmer water in 2017 than in 2016 over the Chukchi shelf slope, and an autumn bloom in the DBO3 site that was probably maintained by regenerated nutrients from the bottom.

Another Japanese-led cruise in 2017 was the T/S Oshoro-maru expedition in the northern Bering Sea, including CTD, optical properties, benthic ecology, marine mammal survey, mooring observation, etc. He also showed the time series of chlorophyll at the surface and near bottom in the Bering Strait.
He then introduced planned observations and sampling activities for the Oshoro-maru cruise plan in 2018, which are similar to those undertaken in 2017, but with a plan to use a small beam trawl and dredge in the North Bering Sea Climate Resilience Area (NBSCRA) for sampling of benthos and demersal fish.

In addition, as undertaken in other activities, he introduced Hokkaido University activities researcher collaborated with the University of Alaska, Fairbanks (UAF) for zooplankton samplings onboard the R/V Sikuliaq, and for conducting sea-Ice and oceanographic mooring operations off Barrow. Lastly, he announced that the SGLI/GCOM-C satellite will be launched soon, which is a Japanese contribution to satellite communities.

1.5 **Korea: [PPT6] Sung-Ho Kang**

Sung-Ho presented on the 2017 Korean Arctic Ocean Expedition (70 day length) by the RV ARAON in the Chukchi Sea, Beaufort Sea (Canadian EEZ), and E. Siberian Sea. The 1st leg was conducted in August from Nome to Barrow with 52 scientists from 11 countries with scientific aims such as to identify key environmental parameters (physical and biogeochemical) in rapid transition due to the sea-ice decrease in the Pacific Central Arctic Ocean (CAO) and to predict environmental change patterns as well as to understand sea ice dynamics and the sea ice ecosystem. The physical oceanography part in the expedition had an objective to investigate the variation of water mass distribution around the Chukchi Borderland to the East Siberian Sea, with 2 mooring stations for recovery and deployment of sediment traps, but unfortunately they were unable to recover one of them. It also included pop-up data shuttle current pressure inverted echo sounders (PDS-CPIES) deployment. For the chemical oceanography part, multiple measurements were carried out such as for parameters of the inorganic carbon system as well as gas measurements, nutrients and organic carbon components, UV compounds, microplastics (MPs), and nitrogen source identification.

He continued introducing the other science conducted on the cruise, such as biological oceanography (pelagic ecosystem, phytoplankton physiology and zooplankton acoustic survey), sediment trap deployed in 100 meter and 320 meter depths with future collaboration with JAMSTEC (Naomi Harada), sea ice physics conducted in 2 ice camps in collaboration with U.K., China, Spain, France, Germany and U.S., underwater sea ice physics, physical parameters, atmospheric observations such as black carbon with collaboration with Japan, etc.

The 2nd Leg of the ARAON was called Arctic MArine Geoscience Expedition (AMAGE) and was carried out from the end of Aug. to mid-Sep. in the Beaufort Sea from Barrow to Nome with the aim of the cruise as follows:

- To map geological features/structures in the Arctic continental margin
- To understand geological processes related to melting subsea permafrost and gas

hydrate in the Arctic
- To evaluate the interactions and linkages in terms of methane cycle in the Arctic
The survey included measurements, including sub bottom profiles, Autonomous Underwater Vehicle (AUV) mapping, and sampling by a Remotely Operated Vehicle (ROV).

He also introduced other research activities such as sea ice ecosystem studies in the Atlantic and Canadian Arctic, Cambridge Bay, as well as paleoceanography in the Atlantic Arctic.

1.6 **United States: [PPT7] Jackie Grebmeier**

First, Jackie explained the outline of the Distributed Biological Observatory (DBO) program and showed the 2018 PAG and DBO cruise draft plan. Then she explained specific DBO related activities as follows:

- The Arctic Shelf Growth, Advection, Respiration and Deposition Rate Experiments (ASGARD) Project comprised of process studies and synoptic surveys conducted in 2017 and will be conducted in 2018 on R/V Sikuliaq.
- Bering Strait Mooring program deployed 3 moorings in the DBO3 region in July 2017 that has recently found the Chukchi Sea to be remarkably warm.
- Canada's Three Oceans (C30) and DBO on CCGS Sir Wildfrid Laurier was conducted via U. S. and Canada collaboration in July 10 – 22, 2017 with the scientific focus on sampling along latitudinal transect lines developed as a "change detection array" for consistent monitoring of biophysical responses to changing environmental conditions, with data collections such as seawater temperature and salinity, nutrients, phytoplankton, zooplankton, benthic macrofauna, sediments, and marine mammal and sea birds observations. Data will be presented during the subsequent 4th DBO data workshop following the PAG meeting.
- Arctic Marine Biodiversity Observing Network (AMBON) on the RV Norseman2. This program collected samples including CTD/rosette for physical oceanography, nutrients and chlorophyll, all taxonomic levels from microbes to plankton, benthic faunal, marine mammals and seabirds.
- NE Chukchi Ecosystem observatory (CEO) is a time series mooring array initiated in 2015 that collects measurements such as pressure, temperature, salinity, wave height and direction, fluorescence, water collections as well as a 24 bottle sediment trap array.
- Beaufort shelf break ecology on the R/V Sikuliaq collected 184 CTD casts, plankton, fish, and belugas observations to investigate potential changes in this

ecosystem.

- DBO-NCIS (Northern Chukchi Sea Integrated Study) is a NOAA Arctic Research Program (WHOI, UMCES and NOAA PMEL) conducted from the end of Aug. to mid-Sep. in 2017 in the Chukchi Sea, with the objectives of: (1) to occupy DBO lines 3-5 in the Chukchi Sea for a suite of water column and benthic measurements; and (2) undertake a process study of the NE Chukchi shelf to understand the physical-biological links that result in the biological hot spots in this region. It has multiple measurements, such as microfauna, dissolved nitrous oxide, stable isotopes, hydrography, and zooplankton, fish and benthic sampling.
- Multiple seabird surveys were carried out in 2017 on Canadian icebreaker cruises in the North Bering Sea, Chukchi Sea and Beaufort Sea and are planned annually until 2020.

Lastly, she explained that for science access during subsistence whaling (April-May and Sept-Oct periods) along the Alaska coast, you need to interface with coastal communities through the new Arctic Waterway Safety Committee because it is important time for local community to make them aware for discussion with information exchange.

2. PAG Joint Research Activities

2.1 2018 Pacific Arctic field activities

2.1.1 [PPT8] NOAA Arctic Research Program update (Jeremy Mathis)

Jeremy explained that NOAA's Arctic mission is to determine how the Arctic system is changing on time scales of weeks to decades, particularly with respect to the consequences that the loss of sea ice may have on Arctic ecosystems, coastal management, economic development and northern hemisphere severe weather events.

The following are NOAA's Arctic priorities:

1. Develop sustained Arctic observing and data management capabilities to improve coupled ocean-sea ice-atmosphere monitoring and modeling efforts in order to advance understanding of climate impacts on ecosystems and biological resources.
2. Enhance the scientific framework and capabilities forming the foundation for navigation services and spill response, to support increased ship traffic and commercial development across the Arctic Basin.

In addition, he laid out 5 Arctic research programs such as the Distributed Biological

observatory (DBO) lines 1-5, Arctic SailDrones, the International Arctic Systems for Observing the Atmosphere (IASOA) program, support for expanded modeling of climate, sea ice, and ecosystems as well as the U.S. Arctic Observing Network (AON).

2.1.2 NPRB Arctic Integrated Ecosystem Research Program update (Danielle Dickson & Seth Danielson)

2.1.2.1 [PPT9] Arctic IERP Introduction (Danielle Dickson)

As background information, the North Pacific Research Board (NPRB) developed the Arctic Integrated Ecosystem Research Program in partnership with BOEM, the North Slope Borough/Shell Baseline Studies Program, ONR Marine Mammals & Biology Program, NSF, UAF, and NOAA, and including in-kind contributions, the Arctic IERP represents a total investment of >$ 18.6M in 2016 – 2021. The overarching question is to study how reductions in Arctic sea ice and the associated changes in the physical environment will influence the flow of energy through the ecosystem in the northern Bering and Chukchi Seas that influence parameters such as current transport, seasonal composition and distribution of multiple taxa, and production of phytoplankton,, zooplankton, fishes, benthic invertebrates, seabirds, and marine mammals.

The University of Alaska Fairbanks is leading cruises aboard the RV *Sikuliaq* in northern Bering and southern Chukchi Seas in June 2017 and planned for June 2018 with a research focus on rate process measurements, including physical, chemical, biological oceanography, and fish sampling. NOAA is leading cruises aboard the RV *Ocean Starr* in the western Beaufort and Chukchi Seas in August – October 2017 and 2019 with a research focus on factors driving the distribution of fish, especially Arctic and saffron cod, as well as pink and chum salmon. The Arctic IERP also includes a social science study on Chukchi Coastal Communities: Understanding of and Responses to Environmental Change. An integrated work plan document is available on the website (www.nprb.org/arctic) that describes the scope of the program, including specific hypotheses and cruise plans.

2.1.2.2 [PPT10] ASGARD June surveys for Arctic IERP (Seth Danielson)

The June 2017 NPRB Arctic Integrated Ecosystem Research Program cruise (mentioned above by Danielle Dickson) led by UAF is entitled ASGARD. The cruise SKQ2017 on the RV Sikuliaq included measurements such as carbon uptake experiments, mesozooplankton (incubation experiments), marine mammal observations, benthic and midwater trawls, multi-core sediment

collections for various parameters. In addition, SKQ201709S expedition conducted mooring deployments, CTDs, mid-water zooplankton collections, and epibenthic trawls and multi-core deployments.

In late summer NOAA-led research surveys occurred in 2017 and are planned for 2019 in the Chukchi Sea using the R/V Ocean Starr, of which preliminary results can be seen on the Arctic Integrated Ecosystem Research Program website (www.nprb.org/arctic). Lack of sea-ice due to incredibly warm weather in the summer of 2017 was mentioned.

Finally, research plans were explained for the integrated ecosystem research cruises in the northern Bering Sea and the Arctic planned for 2018 and 2019.

2.1.3 [PPT11] Field Program on Upwelling on the Beaufort Shelf (Carin Ashjian)

The basic questions of this research program are “Why are beluga whales often found at the transition from shallow to deep water (shelf break) in the Beaufort Sea?” and “Are beluga whales found along the shelf break because they can find high abundances of their Arctic cod prey there and are these abundances driven by shelf break upwelling of plankton?”

It was explained that two upwelling events occurred during the 2017 cruise during which the vertical distribution of salinity indicated upwelling of water at the shelf break, where nitrate was brought onto the shelf and remained there for a period afterwards, and bottom salinity and temperature showed movement of salty, cold water onto the shelf. Offshore zooplankton were seen far onto the shelf during and after these upwelling events. Also, larger catches of young, small cod were obtained during and after upwelling, and during the cruise, they usually saw dense patches of fish at about 250m depth along the shelf break and fish were also very dense near the seafloor in this patch during daylight, but migrated upwards at night.

In addition, flow cam imagery showed the presence of the potentially toxic dinoflagellate *Alexandrium* sp. which was seen in the Chukchi in mid-September within warm water as well as north of Barrow in late August.

It was also mentioned that four year-long moorings were deployed along the shelf break equipped with physical sensors.

2.2 [PPT12] 2017 Atmospheric State and Experimental Weather Forecast in the Arctic (Joo-Hong Kim)

With respect to the atmospheric state along the IBRV ARAON cruise track in 2017, atmospheric conditions were not harsh, except in the middle of August in the deployed ice camp. Wind speed, direction, and air pressure were measured and ice was moving southeast. Scientists on the RV ARAON observed inter-annual variability of Arctic atmospheric state near-surface winds. Radiosondes were used to take upper air observations three times during the IBRV ARAON cruise from Aug. to Sept. with the total number of launches being ~50 in the first period of the cruise and 136 launches in the last period of the cruise with GTS broadcasting.

In 2017 near real-time forecasts were made during the period of the Arctic cruise, producing 9 forecast sets. Regarding forecast verification along the ARAON observation locations, reference Sea Level Pressure (SLP) data as well as error distribution analysis were conducted. During the extreme weather events during the cruise, the values were averaged for nine forecasts, such as RMSEs (Sea level pressure) and correlations (Sea level pressure).

Future plans were laid out, including reducing model biases, sensitivity to the forecast boundary conditions, increasing the number of forecasts in 2018 and use of weather forecasts as boundary conditions for a sea ice prediction model indicating that if the forecast errors of surface winds are high, accuracy of sea ice drift cannot be high.

2.3 [PPT13] Sea-Ice Prediction Modelling Relative Contributions of Atmospheric Energy transport and sea-ice loss to the recent warm Arctic winter (Baek- Min Kim)

As the introduction, atmospheric data such as longwave radiation, air temperature, and specific humidity are highly uncertain especially in the polar region.
The objective of the study is to address questions as below:
1. Among those variables, which variable is the most uncertain?
2. Among these, which variables is the most controlling one for sea-ice?

We can see uncertainty of reanalysis data such as temperature, relative humidity, specific humidity and speed, which gives important implications, but needs more surface data to calculate energy transfer through radiation.
Uncertainties in the reanalysis data such as thermo-dynamical Forcing, dynamical forcing, and hydrological forcing during summer time makes big differences, but is

reduced in annual analyses.

Also, with respect of the impact of atmospheric forcing on the sea ice model, low winds will increase sea ice volume, which is effective for sea-ice biomass.

Below is a summary of the KOPRI study program:

3. KOPRI is currently studying CICE5 model response to various atmospheric forcings.
4. Reanalysis dataset which is commonly used as forcing data for the conventional sea-ice model is highly uncertain especially in the Arctic region.
5. In a series of sensitivity experiments, we find that longwave radiation is one of dominant controlling factors for Arctic sea-ice.
6. In spite of the importance of longwave radiation, we find those measurement are one of most uncertain variables among those atmospheric variables collected during the studies.
7. KOPRI has a plan for measuring in-situ longwave radiation via the ARAON and to validate CICE5 model's performance over PAG sector in next year.

2.4 [PPT14] Seasonal prediction of Arctic sea-ice concentration using S-EOF (Seasonally reliant Empirical Orthogonal Function) technique (Jeehoon Jeong)

It was explained that there are practical needs for the Arctic sea ice prediction in seasonal time-scales such as for seasonal climate prediction and expectation for the Arctic transportation routes as well as determining Arctic sea ice extent that is decreasing continuously.. However, it is a difficult task to predict regional sea ice conditions, which varies greatly year-to-year. Still, it was pointed out that dynamic models, such as Global Circulation Models (GCMs), have large bias as in forecasting events in Sept. 2007. The statistical prediction model for Arctic sea-ice concentration (SIC) was explained via four steps as outlined below:

STEP1: Extracting major spatio-temporal variation patterns from historical sea ice concentration (SIC) observations using the Season-reliant EOF (Empirical Orthogonal Functions (S-EOF)

STEP2: Estimating the current state of SIC with observed SIC anomalies for the last 12 months

STEP3: Projecting the future evolution of SIC using S-EOFS and the current

STEP4: Corrections with atmospheric circulation, surface radiation

All the above steps will lead to sea ice concentration anomalies over the Arctic with monthly average forecasts up to 12 months with half degree resolution.

In addition, the other slides such as presented forecast examples in 2007 and 2012, Arctic SIE prediction skill (in correlation), statistical model and dynamic model, corrections using atmospheric circulation, radiations, and higher resolution test using SSMI/SMIS, etc. were explained.

Finally, it was summarized as below:

- JNU-KOPRI developed a prototype of Arctic sea ice statistical prediction model for ~12 months SIC predictions. A dynamical and hybrid model is being developed.
- Forecasts for this winter (initialized at Oct 2017) were shown in the slide.

2.5 **[PPT15] Satellite observations (Hyun-Cheol Kim)**

Hyun-Cheol presented an outline of a new project entitled “Research on analytical techniques for satellite observation of Arctic sea ice” with a budget of 3 M USD/year during the period from 2017 to 2019. The aim is the development of satellite observations and analysis for Arctic sea ice data, such as a prototype satellite data archive/manage system for Arctic sea ice (ASI), Arctic sea ice remote satellite (ASI RS) data processing and analysis technique, and an international satellite observing network for the Arctic. He went on to explaining KOPRI’s vision (2016-2019) of 3 missions such as arctic sea ice through satellite, and STAR system which is similar to the NASA system web base. In addition, KOMPSAT-5, South Korea’s first satellite equipped with SAR, launched on Aug. 22, 2013 with strong important to polar research, including high resolution SAR imaging, a capability of imaging twice a day, applicable ice and snow observations, and feasibility of quickly imaging.

K-5 “Eyes on the Arctic” near-real time KOMPSAT-5 image acquisition system makes continuous collections of sea ice images over the East Siberian, Chukchi and Beaufort Seas, and the KPMPSAT-2, 3 for Arctic produces High resolution imagery to show how the sea ice is moving, with micro scales, were presented.

2.6 **[PPT16] Arctic Sea Ice Ocean Model (Haoguo Hu)**

Haoguo presented on some preliminary results of the Arctic sea ice ocean model, showing the model domain, sphere coordinate system rotated from Lon/Lat system, an unstructured grid, and surface currents in narrow channels. Temperature and salinity sections and sea-ice thickness were also explained.

3. Status report on PAG-endorsed projects

3.1 [PPT17] Pacific Arctic Climate Ecosystem Observatory (PACEO) (Sung-Ho Kang-lead)

Brief overview of 2017 PACEO results in context of prior years from national and international members

3.2.1 [PPT18] Kyoung-Ho Cho: Physical oceanography 'PACEO: KOPRI's PO Activity in 2017

The research objectives of the Pacific Arctic Climate Ecosystem Observatory (PACEO) program, are:

- To identify key environmental parameters (physical and biogeochemcial) in rapid transition due to the sea-ice decrease in the Pacific Central Arctic Ocean (CAO) and predict environmental change patterns
- To understand sea ice dynamics and sea ice ecosystem is to understand water mass distribution and its variability,.

The 2017 IB R/V ARAON Arctic cruise was carried out from the northern Chukchi Sea and over the Chukchi Borderlands into the Canada Basin with multiple stations sampled for physical, biochemical and biological measurements. In addition, 5 sites at two ice camps were sampled with equipment including ADCP, microCAT CTD, temperature logger and hydrophone measurements. Briefly, the T-S diagrams show the density of summer water types, with higher salinity water with below zero temperature across the region. According to CBL Observation (CTD-T, S) at 75 °N in 2016 and 2017, the summer water layer disappeared in 2017. The distribution of summer and winter water between 2016 and 2017 was explained using an anomaly correlation. Lastly, Kyoung-Ho showed the 2018 ARAON cruise plan station map for the period from Aug. to Sept. that will included standard observations and mooring deployments.

3.2.2 [PPT19] Jinyoung Jung: Interannual variability of dissolved organic carbon (chemical oceanography)

Jinyoung explained that if dissolved organic carbon (DOC) from Arctic rivers is indeed more labile than previous thought, then continuous monitoring of organic carbon in the Arctic Ocean is required. His presentation indicated the research stations surveyed in 2015 and 2016, with the objectives including: 1. Investigating the distributions of dissolved organic carbon in the Chukchi Sea, 2. Estimating the contribution of terrigenous dissolved organic carbon to the observed dissolved organic carbon, and 3. Understanding dynamics of dissolved organic carbon in the

Chukchi Sea. Distributions of DOC and particulate organic carbon (POC) in 2015 and 2016 showed similar results, but DOC concentrations were much higher in 2016, and comparison of surface water characteristics between 2015 and 2016 observed relatively high salinity in the western sites. From the observation of heterotrophic bacteria vs. riverine DOC, it was suggested that heterotrophic bacterial abundance in surface water in 2015 was higher than that in 2016, and that relatively low heterotrophic bacterial abundances were observed in the stations where riverine DOC concentrations were high.

In 2015 DOC concentrations observed in the northern Chukchi Sea showed a positive relationship with bacterial abundance, suggesting that DOC was bioavailable and used by bacteria for their growth. In 2016, bacterial abundances were lower than those in 2015, although there was a positive relationship between bacterial abundance and DOC concentrations, suggesting that DOC observed in 2016 was more refractory. Future plans include analysis of DOC samples collected in 2017 as well as use of an excitation emission matrix (EEM) spectroscopy analysis for the samples collected in 2015, 2016 and 2017 to estimate sources of DOC (e.g. protein-like)..

3.2.3 [PPT20] Keyhong Park: Climate gases dissolved in seawater

Keyhong introduced results from the 2017 Arctic cruise undertaken in August which conducted measurements of inorganic chemical components in the ice-free zone and sea ice zone (PACEO program), such as dimethyl sulfide (DMS), dissolved oxygen (DO), net community production (NCP) and pCO_2 in seawater, and CO, O_3, volatile organic compounds (VOCs) and aerosols in the atmosphere. Keyhong provided an introduction to the R/V ARAON capabilities, such as the analytical chemistry lab and instruments available for chemical oceanography. The results showed that in the southern part of Chukchi Sea salinity decreases in the eastern Alaska Coastal water and that there is special concentration of these chemicals in the Bering Strait area. In comparison with 2016 data, low DMS was observed in the sea ice zone whereas extremely high DMS occurred in the southern Chukchi Sea.

3.2.4 [PPT21] Youngju Lee: Phytoplankton community distribution in Chukchi and East Siberian Sea

Youngju explained the influence of sea ice concentration on phytoplankton community distributions in the Chukchi and East Siberian Seas using sea ice concentration on Aug. 2012 and 2015, with lower sea ice coverage in 2015. Also, the results of environmental variables in 2012 and 2015 showed that parameters

such as sea surface temperature, salinity, etc. have dropped in value in 2015. Additionally, Youngju raised the question of how phytoplankton communities and primary production will be affected by changes in sea ice and water mass distributions in the Chukchi and East Siberian Sea. To answer the question, surveys have been conducted by the IBRV ARAON in the Chukchi Sea over the last few years. Preliminary results Indicates that sea surface temperature increased whereas sea surface salinity declined from 2015 to 2017. And phytoplankton biomass and CHEMTAX group distribution in 2015-2017 indicated an increase in chl, micro chl-a, and diatoms. Studies in the future will: 1. Investigate the phytoplankton community structure and primary production, and 2. Assess the responses of the phytoplankton community to various light conditions and nutrients enrichment.

3.2.5 [PPT22] Jisoo Park: Spatial distributions of phytoplankton physiological status “Arctic cruises and stations for physiological parameters”

To measure physiological parameters of phytoplankton, the Fluorescence Induction and Relaxation system (FIRe) technique was introduced, which provides a comprehensive suite of physiological characteristics of phytoplankton. This technique of *in vivo* chlorophyll fluorescence analysis was first introduced to biological oceanography by Carl Lorenzen in1966, and further developed for a wide range of conditions and various applications. In addition, the analysis of sea ice extent in 2015 vs. 2016 indicates that it is likely the reduced freshening and strong mixing within the upper water column in Chukchi Sea influences the relatively higher *F*v/*F*m values observed in the later year.

Then, the hypothesis was set up that sea ice melting and physiological changes that light/nutrient conditions (limitations) can alter the phytoplankton physiology in the Chukchi Sea. In summary, Arctic sea is severely nitrogen limited in late summer. For instance, for both years, nitrate was depleted in the northern Chukchi Sea, and unexpectedly, Fv/Fm values were not low in the upper layer in 2015. So, freshwater input promotes water column stratification.

Furthermore, Jisoo added new instruments/parameters in 2017 such as Mini-FIRe(more sensitive), PicoLif (Picosecond lifetime fluorometer) and Chlorophyll + PAR sensors (X4) as well as a mooring of biological sensors.
Last of all, future plans were explained as follows:
-Continuous observation of physiological parameters
-More sophisticated design for N & light stress experiment

-Recovery & re-deployment of biological sensors in mooring line.

3.2.6 [PPT23] Hyoung Sul La: Zooplankton acoustics

Hyoung Sul presented on acoustic obs. for marine biology. For the field activities in 2017, vessel-based acoustic system was utilized to understand:

- Horizontal and vertical distribution of zooplankton abundance
- Zooplankton community and planktonic fish eggs using microscope and NGS.

In addition, a mooring-based acoustic system was utilized to understand:
Temporal variability of zooplankton vertical distribution related to seasonal varying sea ice condition to evaluate seasonal and temporal variability using multiple sensors, including and Acoustic Zooplankton Fish Profiler (AZFP), Ice Profiling Sonar (IPS), Acoustic Doppler Current Profiler (ADCP), and a Sediment trap)

Preliminary results in 2016 were presented as below:
1. Spatial distribution of mesozooplankton based on vessel-based acoustic system:
-Horizontal and vertical distribution of dominant mesozooplankton abundance
-Calanoid copepods are major mesozooplaknton group in the all net stations
2. Acoustic identification of copepods: Fish, macrozooplankton, and mesozooplankton can be classified with their different acoustic signatures based on multifrequency data
3. Horizontal distribution of copepods abundance: Horizontal distribution of copepods abundance can be estimated from depth-integrated acoustic backscatter data with net samples
4. Vertical distribution of copepods abundance: High-resolution vertical habitats of copepods can be observed by vertical profile of acoustic backscatter data.

A future plan is to evaluate copepod abundance in relation to water mass distribution, specifically to verify the relationship between copepods abundance and vertical habitats and water masses.

3.2.7 [PPT24] Joo-Hong Kim: Arctic Sea-ice Field Activities in Summer 2017

The survey was conducted in two sea ice stations in 2017 utilizing IMBs (Ice Mass Balance buoys) with the EU ICE-ARC program. Multiple measurements were carried out, including IMB temperature profiles, boundary detection and drifting tracks.

In addition, physical properties of melt ponds such as temperature were taken. As for the other survey, SATICE from ICM-CSIC (Spain), which is the first high-rate, high-precision positioning experiment on sea ice in the Arctic Ocean as well as IAOOS (Ice, Atmosphere, Arctic Ocean Observing System) makes autonomous measurements of ocean temperature, salinity, oxygen profile, snow & sea ice thickness, clouds, solar radiation, T/RH, and optical depth..

3.2.8 [PPT25] So Young Kim: Palynological analysis of recent marine sediments from the western Arctic Ocean: Results from a preliminary investigation

Research objectives were introduced to investigate environmental and climatic controls on the spatio-temporal distribution of fossilized microflora and biogeochemical components in seafloor sediments of the western Arctic Ocean.

Field activities included use of a box corer for sediment sampling at 6 sites in 2016 and 2017.Analysis were made of sediment subsamples to analyze dinoflogellate cysts and other microfossils, geochemical properties, physical properties and age dating. Preliminary results indicate total dinoflagellate cyst concentrations were high in two regions and much less in the other sites. Species varied in abundance with variable sea ice types. Other surface sediment and downcore analyses are leading to a better understanding of marine-terrestrial processes affected by environmental changes in the Pacific sector of the Arctic Ocean.

3.2.9 [PPT26] Hyun-Cheol Kim: p-WebGIS

Hyun-Choel presented on KOPRI's activities in the Arctic ocean information and data management system, which has two objectives: 1) developing a standard data management scheme in the Arctic oceans, and 2) utilizing Arctic ocean data via information system methods, ultimately leading to development of a one-stop data portal of Arctic ocean research information called "p-WebGIS".

The objectives are supported by four tasks as outlined below:

1. Develop a portal system for Arctic ocean data
2. Create Arctic ocean data sharing system
3. Provide various research data
4. Develop a practical system

In addition, four-year long roadmap was shown for the system development beginning in 2017, of which this year's primary goal is to standardize ocean observation data and to develop user friendly information/visualization/sharing

system.

Furthermore, 5 key contents were introduced as follows:

1. Integrated observation information database based on marine data standard
2. Providing customized data by users
3. Ocean data classification and collection template
4. Export data in various formats
5. Data visualization

Lastly, after a set moratorium period for PI data use only, the ARAON data is to be open to the public via this new data portal.

3.2.10 [PPT27] Sediment trap mooring (Jonaotaro Onodera)

Based on the significant relationship between changing physical oceanographic conditions and biogeochemical cycles, Jonaotaro introduced preliminary results from the two sediment trap stations deployed by JAMSTEC.

From the mooring station north of Barrow Canyon (16t) and northern Hanna Canyon (nHC), he indicated that warm Pacific water was observed I Nov.-Dec. 2016 as well as an increase of shelf materials in the sediment trap arrays.

In addition, he outlined the plan for recovery of the sediment trap moorings next summer (2018) to be turned around by the ARAON.

3.2 Distributed Biological Observatory (DBO) (Jackie Grebmeier-lead)

This session included brief overviews of 2017 DBO field results in the context of prior years from both U.S. national and international members.

3.3.3 Brief overview of 2017 DBO field results in context of prior years from national and international members

3.3.3.1 [PPT28] Jackie Grebmeier: SWL17, AMBON17, HY1702

Jackie explained that data collected during the SWL 2017 DBO1-5 sites were focused on regions of high macrofaunal benthic biomass hotspot areas. She also presented results of SWL17 and AMBON17 data product, including water column and sediment grain size.

In addition, Jackie explained that decadal times series of benthic biomass and dominant macrofaunal type in the northern Bering Sea (DBO1) indicated

macrofaunal biomass decrease in the southern times series sites in the region while an increase in the northern time series sites. Similarly, times series of benthic biomass and dominant macrofaunal type were highest in the northern stations in the composite SE Chukchi Sea (DBO3) region.

3.3.3.2 [PPT29] John Nelson: zooplankton: Genetic results update

John introduced research findings conducted in collaboration with the University of Victoria and SeaStar Biotech, Inc. in Canada which focuses on the tracking approach of zooplankton observations and current flows into the Arctic basin along the continental slope. The *Calanus glacialis* 16s ribosomal DNA gene is distributed from as far away as the Aleutian Island and Pacific Ocean, which are categorized as Pacific type species, Arctic type, and *Calanus marshallae*. It was also pointed out that the genetic boundary between migrates faster than populations. From data from the RUSALCA (Russian-American Long-term Census of the Arctic) project and the JOIS (Joint Ocean Ice study)/BGOS (Beaufort Gyre Observing System) it appears the genetic boundary between Pacific and Arctic species seems to be penetrating the Bering Strait through the Chukchi Sea into the Arctic basin.

3.3.3.3 [PPT30] Kathy Kuletz: Seabirds surveys in Pacific Arctic in 2017

Kathy presented a summary of seabirds surveys, and the future plan for the 2018 – 2020 period using a variety of vessel-based projects, such as ASGARD, AIERP, C30, NBS, Oshoromaru and others. Seabirds surveys in the Pacific Arctic in 2017 were highlighted, with the total effort in the region from 2007-2015 having been about 90,000 km, with most effort in the Chukchi Sea, followed by Northern Bering Sea. USFWS (US Fish and Wildlife Service) conducted fewer surveys in the Beaufort Sea, though the ARCSS (US NSF Arctic System Science) survey in Aug/Sept had good coverage in the western Beaufort/Beaufort shelf.

She presented results of seabird species communities through spatial and temporal patterns, using data of 25-50 species per given cruise, that indicates that some species are spatially selective and others are widely dispersed. These data indicated that the northern Bering Sea marks the regions of highest species richness followed by the Chukchi Sea and Beaufort Sea. Seabird communities in the Pacific Arctic by cluster analysis using at-sea survey data from 2007-2015 shows that six main clusters of species appear to align with shelf domains, major currents, and regional feature. In addition, she highlighted short-tailed shearwaters-distribution based on seabird surveys.

3.3.3.4 [PPT31] Sue Moore: Marine mammal surveys: Watches vs. Standard Surveys

Sue explained the difference between watch effort and a standard survey: the former is done by 1-2 people with handheld binoculars, excel form, or mini-Wincruz, and the latter done by a 3-person team with big eye binoculars and Wincruz program.

She then showed highlights of the 2017 DBO-NCIS Marine Mammal Watch over DBO regions 3-5 and indicated key species as follows:
-DBO 3: gray whale hotspot stations 3.5-3.8; 80 hump-back whales SE sector
-DBO 4: few walruses (due to zero ice), ship-curious
-DBO 5: gray whale 'hotspot' stations 5.1-5.2 w/'juvenile cluster' SE sector
-9 Sep: bowhead and gray whales, seals and thousands of shearwaters were observed in the DBO4 hotspot near the UAF/CEO mooring.

She also showed the table of DBO Marine Mammal Watches and Surveys in 2010-2017, and asked PAG colleagues for any additional survey input.

In addition, Sue explained that year-round passive acoustic sampling for marine mammal calls via moored recorders by multiple organizations has been done, using 2014 as an example figure. Lastly, she explained that marine mammals are essential ocean variables in the Global Ocean Observing System (GOOS).

3.3.3.5 [PPT32] Phyllis Stabeno: Arctic Moorings in 2017-2018

Phyllis explained that 80 moorings are located in the Pacific Arctic region, including both ecosystem moorings as well as long-term moorings deployed from Bering Strait into Chukchi shelf. She also mentioned that the mooring spreadsheet on the PAG website will be updated from the 2017 cruise activities.

3.3.3.6 [PPT33] Jessica Cross: autonomous vehicles: DBO 2017

Jessica explained that the focus for using autonomous vehicles through the ITAE (Innovative Technology for Arctic Exploration) consortium in the Arctic is two-fold: one that it is a rapidly changing region and a globally important environment, and two, that it is a technically challenging place to work. The key tool her component is currently working with is the Saildrone, which is 20 feet long and 20 feet tall craft that can handle a big payload, with launch and recovery from the dock. It is wind propelled with cruising speed above 5 knot, solar powered and solely self-reliant.

As for 2017 field deployments, the Saildrone deployment started from Dutch Harbor, Alaska and collected data in DBO 1 through 5, passing through Bering Strait. Calibration activities were conducted with a camera attached to the Saildrone. Data was also collected again from DBO 3 to 5 and over to DBO7 in the Beaufort Sea. In 2018, the plan is to measure CO_2 and currents via an ADCP sensor, with a joint study planned in Aug. – Sept. next year. Other than that, although it transmits Automatic Identification System (AIS), it is not noisy and does not threaten whales. Ball park speed is 2-3 knot, drifting with the ocean current. When there is wind, the vehicle speed goes up to 7 or 8 knots, adding that it recorded over 9 knots this year. However, during that high wind speed time, the data was not very good in time of rough sea condition.

3.3.3.7 [PPT34] Kyoung-Ho Cho and Jinyoung Jung: Korean results for the 2017 field season and earlier

They presented on IB R/V ARAON Arctic cruise in Aug. 2017 which included 35 CTD and 30 XCTD deployments in the Chukchi Sea. Data taken from hydrographic stations sampled in DBO3 indicated a bit higher salinity this year compared to previous years, and results of physical observations (CTD-T, S) from 2014 to 2017 were also shown. Also, various parameters indicated high nutrient and DOC concentrations were much higher in 2016 compared to previous years and in 2017.

3.3.3.8 [PPT35] Shige Nishino: Summary of Japan's DBO activities

Shige presented on DBO 3 mooring results that included fall phytoplankton blooms, ocean acidification, and zooplankton dynamics in the southern Chukchi Sea (Hope Valley) hotspot. He also explained that the seasonal variation of $CaCO_3$ saturation state of bottom water in the southern Chukchi Sea occurred between July 2012 and Aug. 2013. He explained that the interannual variability of fluxes in Barrow Canyon for 2010-2015 for the DBO-5 repeat sections were evaluated to examine volume and heat fluxes in Barrow Canyon as an updated to the summer 2010 seasonal study using 6 occupations of DBO-5 repeat hydrographic section in the same year. Heat flux over the multiple year analysis was consistent with that estimated from a mooring (T) and wind data obtained nearby the DBO5 section. Also, in the relation between fluxes, wind and Alaska Coastla Water (ACW) temperatures, DBO-5 volume transport and along-coast wind are well correlated, and from the 2010 data, he cited similar results of Itoh et al. (2015) that the DBO-5 heat flux is well estimated from along coast wind and ACW temperature at mooring site.

In addition, from year to year variations of flow fields in early Sept., it was observed

that flow fields and water properties in 2013 were completely different from those in 2010 and 2011 and that time series studies of volume and heat transports are useful to understand these year to year variations. When he showed the time series of volume and heat flux, he mentioned that estimated fluxes are well correlated with DBO-5 data, and that estimations would be important to understand the mechanism of annual and interannual variations and their effects on water characteristics observed in DBO-5 line.

Furthermore, he explained that mooring observations in the Barrow Canyon, measured T, S, V for 2000-2008 and 2010, and that from 2016 onwards several chemical sensors (DO, Chl-a, pH) were also attached to the mooring array. Lastly, he showed volume, fresh water and heat fluxes, in addition to time series of T, S, DO, current for Sept 2016 – Sept 2017, as well as vertical sections along a 500m depth isobaths from 2016 and 2017 field results.

3.3.4 [PPT36] Introduction and agenda of DBO 4th Data workshop on Nov. 8-9 and Update on Atlantic DBO, DBO lines in Canadian Beaufort Sea and Baffin Bay (Jackie Grebmeier)

Jackie explained the outline of the upcoming 4th DBO data meeting agenda that will includes sessions on a developing conceptual model, the developing Atlantic DBO that was inspired by the Pacific DBO, and a discussion on modeling.

The Atlantic DBO workshop suggested five Atlantic-DBO transect lines. The discussions and tasks includes items as below:

- Project leader established
- Core parameters identified
- Relevant process studies identified
- Metadata overview of existing data
- Organizational home is needed
- Need to make an implementation plan, etc.

In addition, it was informed that interest was expressed for developing DBO-type series in Baffin Bay and more detailed update to be provided at the 2018 spring meeting.

3.3.5 [PPT37] Deep Sea Research - DBO Special Issue update (Jackie Grebmeier)

Jackie presented on the special DSR issue entitled “The DBO: A Change Detection

Array in the Pacific Arctic Region" that will include satellite observations, sea ice and physical oceanography, hydrography, phytoplankton, zooplankton, benthos, and marine fishes, birds and mammals.

3.4 Any other updates or proposals for new activities

3.4.1 [PPT38] Development of DBO conceptual model-Arctic Marine Pulses (AMP) with planned use of DBO data (Sue Moore)

Sue explained the way of building the Arctic Marine Pulses (AMP) conceptual model by trying to put together existing models, with DBO regions 1-4 being benthic-dominated in the past and pelagic dominated in the future.The AMP conceptual model shows advection and upwelling in summer with a large inflow of Pacific water, and ecological and seasonal ice zone domains in winter. Sue mentioned DBO data and the AMP model with DBO 1-4 as under advective forcing and pelagic -benghic coupling, Bering Strait inflow measurements from long-term moorings, and DBO6-8 as influenced by both advection and upwelling events..
The AMP model provides a foundation to help us communicate the key physical drivers and ecosystem response occurring within those systems.

3.4.2 [PPT39] Presentation and discussion of Pew Central Arctic Ocean Science Needs White Paper (Jackie Grebmeier/Henry Huntington)

Jackie explained the importance of science needs in the Central Arctic Ocean (CAO), such as key environmental drivers that influence ecosystem dynamics of the CAO and shelf-basin interactions:

- Decrease in sea ice extent and duration
- Seasonal warming seawater temperatures
- Change in prey concentrations
- Northward movement of some lower to upper trophic level species

These changes have regional to global implications related to climate change, light penetration and availability, productivity, northward migration of biological organisms and biodiversity, and future development of commercial fisheries.

She laid out the summary and future directions as follows:

- dramatic reductions in the proportions of multi-year sea ice in the CAO relative to first year ice, significant seasonal declines in sea ice extent, and warming water column temperatures
- these changes have regional to global implications with respect to climate change, light penetration and availability, productivity, northward migration of biological

organisms and biodiversity, as well as future development of commercial fisheries

- the 5 Arctic states, along with 5 other non-Arctic states, are working towards an international agreement to monitor and regulate potential fisheries that could develop in the CAO beyond national boundaries
- there is a need for coordinated, multi-national and interdisciplinary program to provide an interannual time series suite of climate, ecosystem and fisheries data from shelf-to-basin and into central Arctic Ocean that allows for joint analysis and assessment via approved mechanisms and management goals

Then she explained a proposed step-wise path forward as below:

- We propose a step-wise approach for basic monitoring to detect ecosystem component status and trends in the CAO and boundary slope regions, including any significant changes
- Once a designated “significant change” is observed the level of research and monitoring can be increased to better track fish stocks (Van Pelt et al. 2017)
- This approach will facilitate determining if and when more intensive efforts are needed to gather data on fish population dynamics, specific ecosystem components, and likely outcomes of different levels of fishing activity in the region
- Such a pathway provides a plausible approach to fisheries-related research in the central Arctic Ocean and is likely to produce information of great interest and value to other fields of interest as well

Also, she provided examples of PAG-related research programs with fish studies as listed below:

1. Arctic Ecosystem Integrated Survey: ArcticEIS2 (NOAA/NPRB)-August/Sept 2017 and 2019
2. AMBON 2015 and 2017 program: larval fish and epibenthos
3. Beaufort Shelf Break Ecology-Plankton, Fish and Belugas (Ashjian et al.)
4. Canadian shelf-slope-basin fish studies (post BREA and Transboundary)
5. PAG Ecosystem level studies- RV Mirai, ARAON, CHINARE, Healy DBO-NCIS, but no fish studies

4. Interactions with other organizations and activities

4.1 [PPT40] Central Arctic Ocean: ICES/PICS/PAME Working Group on Ecosystem Assessment of the Central Arctic Ocean (WGICA) (John Bengston)

The Committee on Scientific Experts on Fish Stocks in the Central Arctic Ocean (FiSCAO) initiated a summary of the scientific information gathering activities to

support international fisheries negotiations on regulation of potential commercial fishing in international waters in High Seas of the central Arctic and adjacent waters. The committee met in 2011, 2013, 2015, 2016 and Oct 2017, including participation by Norway, United States, Denmark/Greenland, Russia, Canada, China, Japan, Korea, Iceland, and the EU.

The ICES/PICES/PAME Working Group on Integrated Ecosystem Assessment for the Central Arctic Ocean (WGICA) has the following key scientific questions:

1. What projected shifts in climate and oceanography are likely to impact ecosystems in the Central Arctic Ocean?
2. What is the productivity of plankton, benthic organisms, and sea ice biota in the Central Arctic Ocean?
3. What is the potential productivity of fish stocks in the Central Arctic Ocean?
4. What is the vulnerability of ice-associated marine mammals and birds in the Central Arctic Ocean to climate change, shipping, potential commercial fishing, and other anthropogenic activities?

CAFF (Conservation of Arctic Flora and Fauna) is an international expert network of fish, seabirds, marine mammals, improving detection, understanding, reporting on Arctic biodiversity trends with expert monitoring groups of Marine, Freshwater, Terrestrial & Coastal components. It also implements a joint program of scientific research and monitoring with input by FiSCAO, WGICA, CBMP Marine, PAG (possibly), and other potential groups and national programs.

PAG will contribute to supporting the new CAO fisheries agreement by providing scientific input to integrated ecosystem assessments and responding to scientific questions posed in the future

4.2 [PPT41] Sustaining Arctic Observing Networks initiative of the Arctic Council (Hajo Eicken)

Hajo introduced the overall framework of Arctic Observing Summit (AOS). Its goals are to:

- Provide community-driven, science-based guidance for the design, implementation, coordination and sustained long-term (decades) operation of an international network of Arctic observing systems that serves a wide spectrum of needs
- Create a forum for coordination and exchange between academia, government agencies, local communities, industry, non-governmental organizations and

other Arctic stakeholders involved in or in need of long-term observations.

As the products and outcome, he showed several items including the Arctic Observing system definition and implementation document and findings and recommendations aimed at policy- and decision-makers, including goals, implementation pathways, points of engagement, etc.

In addition, he introduced the AOS 2018 to be held in Davos, Switzerland in combination with the Arctic Science Summit Week (ASSW) and POLAR 2018 Symposium, to cover various perspective such as the ongoing preparation status as well as AOS 2018 guiding recommendation which includes the following items:

- Propose to highest levels of government a business case for comprehensive pan-Arctic observing system
- Assess costs & societal benefits, with implementation building on present assets & past planning
- Identify resources needed (infrastructure, instrumentation, human capacity, financing strategy)
- Develop international funding strategy & mechanisms

Also, AOS 2018 sub-themes were presented as below:

- Need for Observing System
  - ✓ Societal Benefits – Long & short term perspective (e.g., UN-SDG, emergency response)
- System Implementation
  - ✓ Funding/support models
  - ✓ Optimization of existing platforms & technologies
  - ✓ New technologies to increase efficiency & impact
  - ✓ Role of data management
- Operating Observing Systems
  - ✓ Success stories & lessons learned
  - ✓ Use

With the AOS process and the linkage with PAG, he explained some points such as AOS 2018 would be an opportunity for taking next steps in further coordination & advance planning of sustained observations in Pacific Arctic region, and observing asset coordination, tracking & deployment planning, including defining societal benefits & business case.

He continued by presenting on the study "*Subseasonal to seasonal forecasting by analog methods" (Brettschneider, Walsh)* conducted under the Experimental Arctic Prediction Initiative (EAPI) at IARC-UAF in collaboration with NOAA/NWS and other partners, as an analog forecast for the Pacific Arctic Sector.

As other examples, he identified SAON (Sustaining Arctic Observing Network), a joint initiative of Arctic Council and ION), one of whose goals is to bridge the loss or gap of what is difficult to cover in studies at the national level, as well as RISE (Research and Innovation Staff Exchange) under HORIZON 2020 program to provide opportunities to ship time for ice breaker, such as the CCGS Amundsen of Canada and the RV Siquliak of the USA, adding that those interested can send proposals for the coming 4 years.

4.3 [PPT42] The 5th International Symposium on Arctic Science (ISAR-5) (Yuji Kodama presented by Takashi Kikuchi)

Takashi presented on the overall outline of the 5th Symposium on Arctic Science (ISAR-5) to be held 15 -18 January 2018 in Tokyo, providing a brief draft schedule, list of keynote speakers, leads of presentation sessions, and breakout sessions themes.

4.4 [PPT43] Synoptic Arctic Survey update (Carin Ashjian): pan-Arctic program

Carin gave a presentation on the Synoptic Arctic Survey (SAS) on behalf of the SAS team. SAS is a bottom-up, researcher driven, initiative that seeks to describe the present state of the Arctic Ocean and understand the major ongoing transformations, with an emphasis on water masses, the ecosystems and carbon cycle. The goal is to complete a characterization of the Arctic Ocean hydrography and biological and carbon systems on a pan-Arctic scale that will be a unique reference to track the impacts of climate change in the future. Plans include a recommendation for repeat pan-Arctic sampling on a decadal time scale to detect change.

To detect the changes, a baseline understanding of key parameters at the Pan-Arctic scale is essential; however, there are problems such as limited preset data due to significant convolution of spatial and temporal variability, as well as uneven data quality for most variables other than temperature and salinity.

She continued to explain the premise that it will not be possible to assess either the consequences or the range of ongoing system changes unless necessary empirical

data are collected, analyzed and understood in concert each other. Thus, to best sample and understand the far-reaching changes in the Arctic Ocean, a synoptic survey across the ocean is needed, but this is beyond the scope of any single nation.

SAS's central question is "what is the present state and major ongoing transformations of the Arctic marine system?" Using a system approach there are three key foci for study: 1) Physical drivers of importance to the ecosystem and carbon cycle, 2) Ecosystem response and 3) Carbon cycle.

In addition, a Pan-Arctic, synoptic field program was introduced to be conducted potentially in 2020 with multiple ships and nations. As to the approach, the program has core parameters for each focus area, common methodology of techniques and spatial and temporal sampling frequencies across ships, intercomparisons between ships (if possible), and modeling and data synthesis to pull the measurements together to address the questions.

Countries currently interested in the SAS activities include Norway, Sweden, USA, Canada, Japan, Korea, Russia, Denmark, Germany, UK, and Iceland. Currently US scientists are beginning to set up a US network to develop a collaborative program and to seek funding for US participation. SAS, although relying on some new resources, seeks to coordinate Arctic Ocean activities that may regularly occur around the Arctic.

4.5 [PPT44] 2018 AGU/ASLO/TOS Ocean Sciences Meeting (OSM): DBO session and IARPC Marine Ecosystem Town Hall (Jackie Grebmeier)

Jackie briefly introduced several meeting opportunities, such as the DBO oral and poster sessions planned during the Ocean Science Meeting (OSM) in 2018, which will occur on Monday Feb. 12, 2018. There is also a OSM 2018 US Interagency Arctic Research Policy Committee (IARPC) Marine Ecosystem Collaborative Team (MECT) Town Hall with the title "Activities of the Marine Ecosystems Collaboration Team within the US Interagency Arctic Research Policy Committee" to be held Feb. 14. All session occur at the Oregon Convention Center, in Portland, Oregon, USA. Also, she said mentioned that DBO will be involved in workshop entitled "Antarctic and Arctic Ecosystems and their Functioning" in Davos, Switzerland on June 17, 2018.

5. PAG Synthesis activities

5.1 [PPT45] PAG input to Pacific regional synthesis for the Central Arctic Ocean and Shelf-Basin Interactions (WGICA) (Jackie Grebmeier, Chair WGICA Pacific subgroup)

Jackie started by explaining the goal of the WGICA is to produce an Integrated Ecosystem Assessment (IEA) for the CAO with its work plans. She mentioned that two assessment teams below were established to initiate work on the development of integrated assessments on a sub-regional basis, then combine in a final report, in addition to developing an ecosystem status report of each geographic based on literature review. The assessment will extend from the gateways (Pacific and Atlantic), including shelf-basin exchange studies and extending into the CAO.

1. Amerasian Basin/Pacific gateway team
2. Eurasian Basin/Atlantic gateway team

Jackie then introduced several scientific activities related to the WGICA, including graphics on pan-Arctic trends in annual sea ice persistence 1979-2016, trends in annual sea ice persistence in relation to DBO 1-8, the surface distribution of aragonite saturation states, ecosystem data, including the Arctic Marine Biodiversity Monitoring Plan within the Arctic Council CAFF working group.

Regarding PAG Synthesis activities, she added that PAG continues to develop and implement long-term monitoring activities such as the:

- Distributed Biological Observatory (DBO), and
- Pacific Arctic Climate Ecosystem Observatory (PACEO).

She also introduced the Pacific Marine Arctic Regional Synthesis (PacMARS) in which various data types, such as chlorophyll, primary production, hydrography, currents, and winds were mapped into multiple GIS layers, as well as mid-depth fish trawl surveys of 2012-2014.

Lastly, she asked one or two PAG participants from each country to participate in WGICA Pacific subgroup synthesis effort, and asked to provide the name(s) to Jackie by e-mail.

5.2 [PPT46] Beaufort Gyre special issue for JGR-Oceans (Bill Williams)

Bill explained the overall framework of the JGR Oceans Special section: “FAMOS: Beaufort Gyre phenomenon” (by Canada), saying that it was proposed by Andrey Proshuntinsky to publish major results of both FAMOS (Forum for Arctic Modeling &

Observational Synthesis) and BGEP (Beaufort Gyre Exploration Project) focusing on the synthesis of observations and modeling in the Beaufort Gyre region. FAMOS phase 2 is focused on the synthesis of modeling and observations with high resolution.

Also, BGEP has a 15-year time series data set with information about sea ice, ocean physical characteristics and bio-geochemistry. All participants of the FAMOS different themes (ice, ocean, ecosystems, geochemistry, Atlantic, mixing, eddies, freshwater, CRFs, etc.) have been invited to contribute to the special issue, with a focus on BG problems and using BG data, and of course all participants of the BG observational teams (ice, ocean, atmosphere, freshwater, geochemistry and ecosystems, etc.) have been invited to contribute results of their analyses, changes and hypotheses. He asked meeting participants to distribute this information widely, adding that papers using model results and observations are encouraged.
If interested please contact Andrey (aproshutinsky@whoi.edu) with a preliminary title of your paper and date when you think the paper will be ready for submission.

6. PAG structure

Participants reconfirmed the rotation plan of PAG chair and secretariat after Japan will move to China (2018-2020) followed by Canada (2020-2022).

7. Future PAG meetings

ASSW 2018 - Davos, Switzerland (June 18th, 2018)

Note that a room for the PAG 2018 Spring meeting has already arranged on that day by IASC secretary. Please see http://www.polar2018.org/side-meetingsschedule.html.

Fall 2018

Takashi announced that the meeting place is under consideration in such cities as Hakodate, Sapporo in Hokkaido, or another place in Japan in late Oct. or early Nov.

End of the meeting

8. Appendix

8.1 Participants List

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8.2 Acronyms

Acronym	Meaning
AARI	Arctic and Antarctic Research Institution of Russia
ABL	Alaska Fisheries Science Center's Auke Bay Laboratories
ADCP	Acoustic Doppler Current Profiler
AICC	Arctic Icebreaker Coordinating Committee
AMBON	Arctic Marine Biodiversity Monitoring Network

Acronym	Meaning
AON	Arctic Observing Network
AOOS	Alaska Ocean Observing System
ART	Arctic in Rapid Transition
ASCOS	Arctic Summer Cloud Ocean Study
ASR	Arctic Sea Route
BAS	British Antarctic Survey
BGOS	Beaufort Gyre Observing System
CAA	Chinese Arctic & Antarctic Administration
CAFF	Conservation of Arctic Flora and Fauna
CBL	Chesapeake Biological Laboratory
CBMP	Circumpolar Biodiversity Monitoring Program
CS	Chukchi Sea
DBO	Distributed Biological Observatory
DFO	Department of Fisheries and Ocean Canada
DSR II	Deep Sea Research II
ECS	Early Career Scientists
EEZ	Exclusive Economic Zone
EPB	European Polar Board
ESS	East Siberian Sea
FARO	Forum of Arctic Research Operators
FIO	First Institute of Oceanography
IACE	Institute of Arctic Climate and Environment Research
IARC	International Arctic Research Center, UAF
IARPC	Interagency Arctic Research and Policy Committee
IASC	International Arctic Science Committee
IASOA	International Arctic Systems for Observing the Atmosphere
ICARP III	Third International Conference on Arctic Research Planning
INSROP	International Northern Sea Route Programme
ISTAS	Integrating Spatial and Temporal scales in the changing Arctic System
ITP	Ice Tethered Profiler
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JOIS	Joint Ocean Ice Studies
KOPRI	Korea Polar Research Institute
MIZ	Marginal Ice Zone
MOSAiC	Multidisciplinary drifting Observatory for the Study of Arctic Climate
NMEMC	National Marine Environmental Monitoring Center, China

Acronym	Meaning
NOAA	National Oceanic and Atmospheric Administration
NPRB	North Pacific Research Board
NSF	National Science Foundation
NUIST	Nanjing University of Information Science and Technology
OUC	Ocean University of China
PACEO	Pacific Arctic Climate Ecosystem Observatory
PPP	Polar Prediction Project
PRB	Polar Research Board
PRIC	Polar Research Institute of China
RUSALCA	Russian American Long-term Census of the Arctic
SAMS	The Scottish Association for Marine Science
SAON	Sustaining Arctic Observing Network
SIO	Second Institute of Oceanography
SOA	State Oceanic Administration
TRANSSIZ	Transitions in the Arctic Seasonal Sea Ice Zone
TOA	Third Institute of Oceanography
TUMSAT	Tokyo University of Marine and Science Technology
UAF	University of Alaska Fairbanks
UMCES	University of Maryland Center for Environment Sciences
USCG	US Coast Guard
UW	University of Washington
WHOI	Woods Hole Oceanography Institute
YOPP	Year of Polar Prediction