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# THE PACIFIC ARCTIC GROUP (PAG) MEETING

*Meeting  
Minutes*

**April 25, 2015  
Toyama, Japan**

Citation: SH.Kang, J.M Grebmeier J. Lee (eds). 2015 The Pacific Arctic Group (PAG) Spring Business Meeting Report. KOPRI

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**Summary of the Meeting:** The Pacific Arctic Group (PAG) is a consortium for institute and individuals with interest in the Pacific Arctic region, facilitating members to plan, coordinate and collaborate on science activities of mutual interest. The PAG Spring meeting was fruitful with the sharing of data and information for the upcoming 2015 field season from the 6 member countries of PAG Canada, China, Japan, Korea, Russia and the USA. It was noted that for countries to further enhance their coordination and collaboration of gathering and sharing data, a document with all of the ship information will be drafted. DBO is a PAG- endorsed ongoing activities and one of the new PAG endorsed activity is the Pacific Arctic Climate Ecosystem Observatory (PACEO), also contributing to the Third International Conference on Arctic Research Planning (ICARP III) process, which is slowly taking form with the 6 PAG countries signing the joint letter of intent as the first step to implementation. A short meeting prior to the fall meeting is being considered in order to share the data obtained from the Pacific Arctic Climate Line Sector from the 2015 summer expeditions. The East Siberian Sea (ESS) of the Pacific Arctic regions is an important marginal sea that is opening up with recent sea ice retreat, particularly as there is not much data available. The PAG will contribute to the knowledge base by providing valuable information of the northern Pacific influenced Arctic Ocean both to government and national agencies to assist with making critical decisions. Therefore, in order to compare and analyze the data obtained from each country, it is crucial to have synoptic and repeat surveys. The next fall meeting for the PAG is to be held on 28 - 29 October 2015, Incheon, Korea.

## Introduction and Welcome (Sung-Ho Kang, PAG Chair)

Dr. Sung-Ho Kang (PPT 1), the new PAG Chair opened the meeting and welcomed the participants to the spring meeting in Toyama, Japan. He also provided a brief history of the PAG, how it began under the International Arctic Science Committee (IASC) although it is now an independent affiliate of the IASC. The Pacific Arctic Group's mission is to serve as a Pacific Arctic regional partnership to plan, coordinate and collaborate on science activities of mutual interest.

Several Research Vessels from Japan (Mirai), China (Xuelong), Korea (Araon), USA-Russia (Khromov), Canada (CCGS Sir Wilfrid Laurier) and USA (Healy), visit the Pacific Arctic Regions. Therefore, the PAG is working to organize and share ship information to develop new programs together. Jacqueline Grebmeier has gathered the information into a table to facilitate the sharing of information on annual field activities. The table includes information on dates of port calls, name of ship, DBO region, project name, PAG contact and the chief scientist contact. In the 2014 PAG Fall meeting in Seattle, USA, it was recognized that most of the data are available in the nearshore area but with the change of sea ice, more data in the outer EEZ areas are needed. Hence one major outcome of the meeting was to engage in an expert level discussion of observing needs in the higher Pacific Arctic that could provide valuable data to forecasters and modelers of climate change impacts on and surrounding the Arctic reaching to the mid-latitudes. Koji Shimada, from TUMSAT, proposed a Pacific Arctic Climate and Ecosystem Observing Network which is an area that includes the outer shelf of the East Siberian and Chukchi Seas northward to 80°N, extending from the Makarov Basin in the West to the Canadian Basin in the East. The six PAG countries are planning to collaborate together to collect and share data. Prior to this PAG meeting in Toyama, six countries from AARI (Arctic and Antarctic Research Institution of Russia), NOAA (National Oceanic and Atmospheric Administration), DFO (Department of Fisheries and Ocean Canada), PRIC (Polar Research Institute of China), OUC (Ocean University of China), KOPRI (Korea Polar Research Institute), NIPR (National Institute for Polar Research), JAMSTEC (Japan Marine Science and Technology Center) and TUMSAT (Tokyo University of Marine and Science Technology) met to plan for the Pacific Arctic Climate Ecosystem Observatory in the upper waters and to further develop the letter of intent. [See Appendix B Joint Letter of Intent]

There are 2 PAG meetings annually in order to: (1) share information on annual field activities in the Pacific Arctic region, (2) continue the development and implementation of long-term monitoring activities such as the DBO (Distributed Biological Observatory) and the PACEO (Pacific Arctic Climate Ecosystem Observing Network), and (3) continue project development and sampling in the Pacific Arctic region to investigate climate, oceanography, air-sea ice interactions, physical oceanography and modeling. The Spring PAG meeting is held during the annual Arctic Science Summit Week and is focused on "business" issues and updates on research plans for the coming field season. The annual Fall PAG meeting reviews the accomplishments during the previous summer and outlooks for the future. These discussions are essential in developing scientific exchanges and other types of collaborations during and after field operations. After Dr. Kang introduced the agenda it was adopted as the format of the meeting.

### Agenda items

## 1. Update plans for 2015 field season

### 1.1 Canada: Bill Williams

**(PPT 2)** Bill presented the 2015 icebreaker plans in the Pacific Arctic region. The CCGS Louis S. St-Laurent, the largest Canadian icebreaker in use, has two missions. 1) The UNCLOS mission from 6 August – 17 September 2015 from Tromsø, Norway to Kugluktuk, Nunavut, Canada. Although the plans as it crosses the Arctic Ocean basins are not yet public, the activities include XCTD transect from Svalbard across the North Pole to the Beaufort Gyre and through the Canadian Arctic Archipelago. There is no plan to undertake XCTD sections along the transect from Tromsø to Svalbard but they are open to people's request for this activity. There is limited time in the cruise, hence they will focus on XCTD sections and if possible do CTD/Rosettes in the northern Longyearbyen. 2) The JOIS (Joint Ocean Ice Studies)/AON (Arctic Observing Network) BGOS (Beaufort Gyre Observing System) station locations, which are mostly fixed, and the possible times were presented. The times may be inaccurate as (1) the stations may be done in the reverse order, (2) there are 3 additional days this year for buoy deployments so there will be three days longer in the northern part of the grid than in the original plan and (3) they may be recovering the two NIPR-GRENE moorings, one over the Northwind Ridge and one over the Chukchi Abyssal Plain. If this is to take place, an additional 3 days of ship time will be required. The CCGS Sir Wilfrid Laurier will leave Victoria on 2 July and arrive at Barrow on 23 July. The transit includes stations in the DBO sites from the Bering and Chukchi Seas. Canada's icebreaker Amundsen, operated by ArcticNet, will head to the Beaufort Gyre to do the stations for GEOTRACES on 20 August to 1 October. In summary, Bill presented the 2015 overview of the expedition plan for the Beaufort Sea and Canada Basin.

On the UNCLOS cruise, Kathy asked if they will be taking biogeochemical data, fluorescence information or standard physical/chemical oceanography properties. Bill answered that there will be geochemical sampling, nutrients and organic carbon, but there is a limit of how much sampling can be done when the rosette comes onboard. If there is something that people are interested in, we can do it. Kathy commented further that the Arctic Council Working Group, CAFF (Conservation of Arctic Flora and Fauna), has suggested ships of opportunity that are going to cross the Arctic Ocean from the Svalbard outer shelf to the Canadian coastline provide an opportunity to gather ecosystem information as it is poorly observed area. Thus, it would be wonderful to have the data shared to the Circumpolar Biodiversity Monitoring Program (CBMP) in terms of nutrients. Bill replied that the data can be shared in terms of extending their sampling, all the equipment will be onboard for the JOIS-BGOS immediately following UNCLOS. So it is about can be reasonably done, including samples for bacteria, chlorophyll and microbial diversity.

One participant asked about the population of bowheads that go between Greenland and Spitsbergen that are very small and rare. Thus, this may be a reason to deploy acoustics and, Sue Moore, NOAA/PMEL would be best to contact about this issue. The potential problem is that you may not be able to collect the acoustic information. Bill replied that at that point the data can only be collected while underway, unless there is another way. Jackie asked about the participation of marine mammal or seabird observers in the cruise. However, the ship is already full. Takashi Kikuchi asked about the 2016 cruise plan to further discuss about collaboration if there is the same mission, however, this is not yet publicized. Note that the Makarov Basin has very few sections going across the Arctic Ocean although a few discrete places have been

sampled.

### 1.2 China: **Jianfeng He**

**(PPT 3)** Jianfeng presented on the 2014 Chinese Arctic Cruise and future plans. CHINARE-6 cruise was undertaken from 11 July to 24 September consisting of 128 persons with several oceanic and sea ice sampling stations. Physical oceanography investigations were carried out on a total of 12 transects, with 90 CTD stations and 89 LADCP stations. Buoys were also deployed in the Bering Sea basin to measure the ocean-atmosphere flux. Marine chemical investigations were also carried out with 89 water sampling stations and 40 nitrate profile observations, along with other parameters. He also presented the sites where sediment traps were deployed near the Chukchi Sea that also measured surface pH in the Canada basin in cooperation with an investigator from France. China also carried out marine ecosystem investigations, marine geology investigations, and sea ice investigations. Last year there was a phenomenon for many melting sea ice ponds, thus ITPs and ice buoys were deployed in 2014. There will be no cruise in 2015 but from 2016 China will carry out three cruises in order to monitor sea ice ecosystem during a new 5 year research program.

Kathy Crane requested for possible discussion about coordinating the research program for the new Pacific Arctic climate ecosystem observing system in the north in terms of ship tracks for China in the next fall meeting. Jianfeng responded positively towards this request. Participants noted that the data policy require a two year delay before data was accessible, however, data may be provided by contacting another Chinese scientist (scientist to scientist). There is an online data center that may be accessed.

### 1.3 Japan: **Takashi Kikuchi**

**(PPT 4)** Takashi gave an updated plan of the 2015 field season for Japan. The Japanese research vessel cruise, R/V Mirai, which is not an icebreaker, will visit the Pacific section of the Arctic Ocean in September – October 2015, focusing on shelf-basin interactions not only on the Beaufort but also the East Siberian shelf which is based on Dr. S. Nishino's (JAMSTEC) 2008 & 2013 papers. The papers point out the difference of the impact of sea ice on the underlying water characteristics. In the Canadian shelf much of melt water was observed, interestingly in the East Siberian shelf there was not as much impact of sea ice melt water. Such differences result in different primary production and biological impacts in the two regions. The cruise will also focus on the eddy activity and strong jet across the Alaskan coast. The route of R/V Mirai strongly depends on sea ice conditions as it is not an icebreaker. JAMSTEC has several mooring missions on the R/V Mirai in the Arctic, the moorings in the southern Chukchi Sea and Barrow Canyon will be replaced and two sediment trap moorings will be deployed. Japan will also participate in other ice-breaker cruises, such as the IBRV ARAON and CCGS Louis S. St. Laurent. One concern about this year's cruise is that there is a new regulation limiting nearshore access by Alaska, which then means that the R/V Mirai cannot complete DBO lines 3 and 5. Furthermore, the vessel cannot enter an area within 12km from the Alaskan coast and within 3km from the Bering Strait. The new rule was developed by the Alaska Maritime Prevention & Response Network to mitigate the risk of maritime incidents resulting in oil spills. Jackie Grebmeier

updated the floor about the discussion with the USCG (US Coast Guard), which will come through the IARPC interagency to resolve the issue. Lee Cooper and other USA members from PAG are actively helping to resolve this issue. Other activities include monitoring ice thickness off Barrow, Alaska and XCDT observations in the Arctic Ocean.

Bill commented that the R/V Mirai and JOIS-BGOS (CCGS Louis S. St-Laurent) will be near 150°W and so asked for the specific dates that they are expecting to be there and suggested on comparing the two stations with as much time interval as possible. Takashi Kikuchi agreed positively to best coordinate the two stations with Canada. Kathy added an action item for all the PAG countries to send their proposed 2015 summer station location to the PAG Chair and Secretariat to see the best overlapping areas. Takashi reminded the participants that RV Mirai is not an icebreaker so this is a tentative plan depending strongly on sea ice conditions. Bill commented that as the expeditions are quiet long the estimated station locations would be helpful. Tom Dunne Newbury asked if the work off the East Siberian coast is ship time or remotely sensed data. Takashi showed that in 2008 and 2010 they had such observation by RV Mirai and collected useful information.

**Action:** Each country is to send their ship information to find the overlapping stations by 15 May 2015.

#### 1.4 Korea: **Eun-Jin Yang**

**(PPT 5)** Eun-Jin presented the 2015 Korean research plans for the Arctic Ocean. ARAON will visit the Pacific Arctic Ocean to survey the Chukchi and East Siberian Sea yearly from 1 August to 23 September 2015 consisting of two legs. The first leg of the Arctic cruise aims to investigate the structure and processes in the water column and sub-bottom layers around the North Bering Sea, Chukchi Sea, and the north site of the East Siberian Sea currently experience rapid transition in sea ice and surface water temperatures. The participating nations include not only Korea but also the USA, UK, Japan, France and China. The survey area for the first leg includes the southern Chukchi Sea with the DBO line 3, the Chukchi borderland and northern part of the ESS and Mendeleev Ridge. During the cruise, a sea ice station will be set up around 80°N. Two KOPRI moorings will be deployed at two stations and two TUMSAT moorings are to be recovered. However, these plans may change with the sea ice conditions during the cruise. The research items are as follows (1) observations of atmospheric air-sea greenhouse gas fluxes, (2) water column chemistry to evaluate spatial and temporal variation with the CO<sub>2</sub> system in the Arctic Ocean, (3) plankton ecology focusing on species composition of phytoplankton, chlorophyll *a* concentration and primary production, (4) ocean color remote sensing using the spectroradiometer for above water measurements, (5) hydrographic survey to analyze water mass distribution and characteristics using CTD & LADCP, XCTD and ocean mooring systems, (6) KOPRI ocean mooring system in the Chukchi Sea and ESS, During the cruise KOPRI will collaborate with the University of Washington and SAMS to deploy the ocean buoys and recover the ocean mooring system. Additional sampling includes: (1) marine geophysics study undertaking sub-bottom profiling will be done to obtain high-resolution subsurface features and a gravity survey will be done, with the data to be shared with the Arctic Gravity Project, (2) sea ice dynamics will be done through international collaboration to deploy IAOOS (Ice and Atmospheric Observing System), ITP buoys, SATICE buoys and CRRELSIMB buoys, (3)



biogeochemical studies under sea ice, (4) a melt pond study will be continued from 2014 as they had interesting results with the research components such as plankton composition, diversity and physiology, gas interaction and biogeochemical parameters. The second leg of the 2015 KOPRI Arctic Cruise focuses on the paleoceanography in the East Siberian Sea and Chukchi Sea, aiming to characterize the paleoceanographic conditions during warm periods of the past, exemplified by the Holocene. The cruise will be conducted from Barrow to Nome on 28 August to 9 September 2015. The future Arctic research plans for KOPRI include surveying the North Bering Sea, Chukchi Sea and the East Siberian Sea. KOPRI will also cover the new Pacific Climate Line and part of the NABOS and DBO program with repeated sampling.

Takashi Kikuchi asked about the depth of sediment traps. Eun-Jin replied that the sediment trap depths will be 300m and total depths will be 500m. Takashi also asked for any information about the collaboration with MIZ. Kyung-Ho Cho answered MIZ will join this cruise, but this year there will be no glider operation. Rick Krishfield, MIZ, commented that the ITP data is online. The MIZ scientists will meet to further discuss on issues of data sharing collaboration

### 1.5 Russia: **Kathy Crane**

**(PPT 6)** Kathy gave a report on the RUSALCA (Russian-American Long-term Census of the Arctic), showing the positions of RUSALCA stations from 2004 – 2014. A synthesis of the results for the first decade is underway and will be published in September 2015 in the magazine *Oceanography*. The data from RUSALCA program from the first decade are being accumulated in the Alaska Ocean Observing System (AOOS) program in Anchorage, Alaska, USA, which will be made available publically. In 2015, RUSALCA will focus on retrieving and redeploying a mooring in the Russian section of the Bering Strait. The mooring may remain for two years, depending on the resources of Russia and the USA. The goal of this year's cruise includes the mooring operation and as well as obtaining a complete hydrographic transect of the Bering Strait, including water sampling, and marine mammal and sea bird observations. On the western side of the Bering Strait, one of the instruments is the aerial passive acoustic that is used to track marine life throughout the entire year. For those who are interested in marine mammals, we are encouraged to contact Dr. Kate Stafford from the University of Washington. The expedition will be carried out on the R/V Viktor Buyenitski following the Russian – German program. The ship dates will be confirmed after they have finished with their mooring turnarounds in the Laptev Sea.

#### 1.6.1 United States: **Jackie Grebmeier**

**(PPT 7)** Jackie briefly introduced the 2015 ship cruises and accumulation of data. An upcoming cruise from 4 – 24 July 2015 on the CCGS Sir Wilfrid Laurier will deploy argo float stations in the Gulf of Alaska and sample the 5 DBO stations. The Arctic Marine Biodiversity Monitoring Network (AMBON) will occupy the transect lines DBO 3 & 4, and is funded through the US National Ocean Partnership Program. The AMBON scientists will measure the following parameters: physical oceanography, plankton, benthos, fish, sea birds and marine mammals every year through 2017, with two subsequent analysis years. The Arctic Observing Network (AON) studies in Barrow, including the DBO 5, line led by Carin Ashjian will occur from



August to September with focus on chlorophyll fluorescence, nutrients, temperature, salinity and zooplankton. Jackie presented a composite of the accumulated information of the ship dates, region and PI contact information to enhance collaboration among the PAG countries that will be posted on the website as well. A map of the biophysical mooring in the Northeast Chukchi Sea (in courtesy of Seth Danielson/UAF) was shown. One of its objective of this project is to deploy bio-physical mooring array in the NE Chukchi Sea. There is also a HF Radar Daily Averages that provide surface current information, in a focal region for oil and gas development, and the data are available on the webpage (<http://dm.sfos.uaf.edu/chukchi-beaufort/>) providing current flow fields along with surface water temperature data in real time.

### 1.6.2 United States: Kathy Crane

**(PPT 6)** Kathy gave details of the summer cruise for the USA. The United States is not only interested in covering the whole Chukchi Sea and the potential impacts of the changing ecosystem in relation to fisheries, transportation, gas and oil in the environment, but also in gathering observations of the Arctic that have been very poorly observed. The Atlantic Water that moves eastward along the shelf slope break of the ESS, with the potential PW flowing eastward or northward, depends on various factors, such as atmospheric or ocean conditions. This region has undergone very severe sea ice loss, making it more open to increased storminess and potential mixing of the surface waters and deeper in the water column to the Atlantic Waters layer. The concern is that the enhanced mixing by storminess could lead to release of heat from both the west and south and up into the atmosphere which then impacts the ecosystem in these environment. The climate impacts from these heat fluxes on potential extreme weather events, is a key interest for the national weather stations that desire more accurate predictions of weather climate events. To understand the transformation of Pacific Water from the Chukchi Sea and out the Atlantic Water, and how it might interact with other water masses, three lines have been suggested for the science occupations in the ESS, Chukchi Sea and northward into the Makarov Basin. It is crucial for the USA to have such information of this region because this region strongly influences the climate and weather of the USA. In 2015, NOAA has agreed to fund the extension of the RUSALCA program further west with NABOS. An extension of DBO 4 line to Wrangell Island will be done in 2016 to have a complete estimate of fluxes through the Herald Canyon and Hana Shoal. In addition the NSF (National Science Foundation) have been carrying out joint operations in the tracking of Atlantic Water through Fram Strait, Bering Strait and through the Arctic. These transects have been repeated for over a decade with a few breaks in between. NOAA will work together with these programs to extend the transects into the PAG region of interest. The goal this year is to extend transects further into the Russian EEZ to understand the added transport from the shelf into the basin.

One participant asked what the range of parameters are planned by RUSALCA to analyze in the new transects in the East Siberian Sea. Kathy answered that the range of parameter are fully hydrographic stations and geochemical observations (led by Matthew Alkire from the University of Washington) which also depends on the length of time on the new Russian icebreaker. There will be no glider operations due to limited budgets. A small ecosystem observation program will also be supported and led by the RUSALCA program. A marine mammal observer will also hopefully be onboard. These parameters for 2015 will be part of a more enhanced program being organized for 2017 to develop and expand their observational and ecosystem program.

## 2. Updates for planning of PAG joint field and modeling activities

### 2.1.1 Update Chukchi Borderland/Arctic Basin joint activities in relation to developing international “Pacific Climate Line” for Canada Basin and shelf-basin lines (Koji Shimada)

**(PPT 8)** Koji introduced his ideas on the climate line section in the Arctic Ocean. A map showed only a few CTD station located in the East Siberian Sea compared to other regions in the Arctic Ocean in the 1990s, meaning that the importance of oceanic change in this region is unknown. The results from the SHEBA period (1997 – 1998) show that the Northwind Ridge is a key area where the northward Ocean flow can be observed with a large amount of heat. The vertical section of temperature identified very warm water over the Northwind Ridge and Chukchi Plateau, which is the key area delivering the Pacific Water, which has a huge amount of heat and nutrients, into the Arctic Ocean. This region can be considered to be a “hotspot” for detecting climate and biology change. However, after 1998, a huge northward retreat of sea ice was observed in the North of Bering Strait and Chukchi Borderland areas. Based on the new knowledge from the SHEBA period, they began to discuss coordinating ship operations and coverage under AOSB/SBE. In 2002 there were well-coordinated Pacific Arctic Ocean hydrographic stations by JWACS, SBI CASES projects. In order to understand the ongoing and future changes, it is crucial to collaborate together. Understanding the sea ice shrinking rate in the northern Pacific Arctic area is essential, as the ocean controlling sea ice reduction in the Pacific Sector changed dramatically after the SHEBA period. The sea ice extent from 1979 – 1997 was decreasing gradually, however, from 1998 (after SHEBA), the Arctic sea ice area started diminishing rapidly with sudden drops in 2007- 2008 due to an event of oceanic heat release. Moreover, the ice edge in the East Siberian Sea had disappeared the most over a period of 1979 – 2012, making this an Arctic hotspot due to its different feature from other regions. The maximum heat content generally appears over the borderland areas but interestingly, there was less heat content in 2007. Sea ice motion and ocean circulation of the Pacific water layer was compared with 2004, 2008, 2011 and 2012 and showed that the center of the Beaufort Gyre was found in different positions and the center of the Arctic Ocean gyre was always found in the same position in the area at 75 -77°N and 150-160°W. These sea characteristics control the large scale ocean circulation in the Pacific Arctic, meaning that the ocean current west of the center of Oceanic Beaufort Gyre, the borderland area, is always northward. These influence the Pacific Ocean and Chukchi Shelf appearing in the East Siberian Sea. In heavy sea ice the movement of ocean current was very limited compared to when there is less sea ice, allowing movement to the entire Arctic Basin. This quantitative change explains the increased drastic changes in climate and ecosystem of the Pacific Arctic sector. Koji proposed the Pacific Arctic Climate monitoring across the oceanic Beaufort Gyre to understand the shelf basin exchange over the slope. Although the minimum sea ice extent may be detected, the regional sea ice may be too heavy to allow the passage of ships. This stresses the importance of knowing the regional sea ice change as well. Rafting of thick sea ice is important for growth of sea ice thickness and sea routes.

Tom Newbury suggested that looking at the possible influence of eddies within this area would also be helpful as it is an area where eddies from North of Barrow. Most of the change is due to the Chukchi borderland interactions with upwelling events, but eddies may have a small

influence as well. Koji answered that eddy activity was analyzed with the ocean velocity data that found large eddy activity east of the Northwind Ridge, but west of the Northwind Ridge such activity diminished. This finding implies that the eddy is generated along the slope of the north eastern Chukchi Sea. Tom further commented that 2009 was a very unusual year, and the change was related to the flux of the ice through Fram Strait. Is it possible that it was also related to something unusual in the Chukchi borderland? Koji replied that 2008 and 2012 had the same situation where the upper ocean circulation was very strong leading to high pressure and not allowing the PSW to enter this area as it is like climbing a mountain. The condition of the pressure (dynamic height) field in the basin strongly affects spreading pathway flow of shelf water into the basin. As former studies did not vary dynamic height the change in the basin, we need to investigate shelf and basin exchange processes with more large-scale viewpoints. Tom also noted that the water coming through the Bering Strait is very rich relative to the Arctic, helping us to define the extent of the biological influence of the Pacific water advected into the Arctic. Koji commented that we need to argue with this issue as we often find high biological activity in the Makarov Basin and the ESS. The water mass structure is quite different from the Chukchi Sea showing us that we do not know much about this region. We should also compare and distinguish the differences between the Chukchi and the ESS. This is important, but most people only consider the Pacific Water and the ESS water and the Mendeleev area are very important to understand the environment. Bill asked if Koji was intending to have direct turbulence measurements to measure the heat flux from the PSW and the Alaskan Coastal water up into the slope of the Chukchi borderland. Koji answered that the incoming warm water through Bering Strait reaches the Chukchi borderland in middle of winter from late January to mid-February. If we can have an overwintering camp in this region we will be able to have turbulent measurement, but it is challenging and there were no overwintering ice camps after SHEBA. Koji plans to evaluate the heat flux roughly through the mooring data from ADCP and other temperature data through the winter.

Seoung-Joong Kim asked about the different heat content layers and how they are influenced. There are two types of heat type, first, between 20 -150 m, with the change in this layer being due to the influence of PSW, whereas the 0 -20 m layer is affected by solar radiation. There is a correlation between the heat content and the water layer above and below 20m. If heat content below 20m increases, then the sea ice area will disappear in the water layer between 0 – 20m. The order of the change is important, if the heat content follows the interior heat ocean content, and the sequence of the change should be understood. Seoung-Joong Kim was also interested in predicting the heat content in summer several months earlier, which means looking at the upper region. Koji explained that ocean response varies, for example, if sea ice motion stops, ocean circulation is difficult to stop within one year as there are other interactions. This delaying property of the ocean is important to use for future predictions.

### 2.1.2 Update Chukchi Borderland/Arctic Basin joint activities in relation to developing international “Pacific Climate Line” for Canada Basin and shelf-basin lines (Kathy Crane)

**(PPT 9)** Kathy provided a short overview of the coordinated efforts of the 6 PAG countries/institutes who are willing to contribute to the Pacific Arctic Group Climate Ecosystem Observing System, proposed by Koji Shimada. This is an international effort to understand the causes and consequences of sea ice loss and a hotspot of the Arctic Ocean. There was a

workshop on 21 – 22 April 2015 in Tokyo at TUMSAT with Koji Shimada as the host, to discuss the areas in which the PAG members will be able to best contribute in a coordinated effort over the Pacific Arctic region to gather information in a synoptic and repeat way from 2015 - 2020. The Pacific Arctic has undergone a major loss of sea ice and is a source of heat release. But the impact of the changes can be large to fisheries in the Bering Sea and Barents Sea as the areas open up further north, leading to an exchange of species. The members of the PAG feel strongly that this large region in the Pacific Arctic needs to be studied comprehensively in a coordinated way using the available assets from each country. Another area of interest is the changes in the Pacific Arctic hotspot release of energy that may be linked to changes in the meandering of the jet stream, bringing extreme weather events to eastern Asia and the United States with corresponding elevations of temperature affecting the economies of the world. There are statistics that link up the physical changes within this part of the Arctic Ocean and extreme weather climate events in the northern hemisphere. Although the physics of the linkages are not well understood and there are very few observations in this area as it is difficult to constrain and develop accurate forecasting techniques to predict the extreme weather. One of the goals with developing the “Pacific Climate Line” is to provide a board sweep of observations to modelers and forecasters for more precise predictions. Therefore, in order to move forward with the international Pacific Arctic Climate Observing Network, all the PAG institutes recently signed the joint letter of intent while in Toyama, Japan. The members are now making ongoing progress towards coordinating ship plans from 2015 onwards. This development of this climate-ecosystem observing system to the Pacific Arctic is expected to share valuable information to the whole global community. Kathy presented the signed joint letter of intent (Appendix C), explaining the goals of the Pacific Arctic Climate Ecosystem Observatory (PACEO) and the agreement to collaborate among AARI (Russia), DFO (Canada), KOPRI (Korea), NOAA (USA), NIPR (Japan) and PRIC (China) on 23 April 2015. The collaboration between the PAG member countries was outstanding as the 6 countries agreed to contribute to the PACEO.

Tom commented on results from two of Koji’s moorings that will no longer be maintained, asking whether it possible to rotate the responsibility among the countries rather than transferring the responsibility. Kathy replied that this is possible but moorings are expensive to carry out and keep them operational. NOAA cannot fund this effort and support will be variable from country to country and year to year. Maybe if there is a more dependable funding level to allow that, a mechanism to maintain these moorings may be made. This is still a topic under discussion. John Bengston was impressed with the effort showing interest in the ecosystem from the many different scientific components of the Pacific Arctic Climate Ecosystem Observatory. He asked for clarification of the word “ecosystem” in the phrase “carry out a repeat census of the trophics components of the ecosystem?” Jackie clarified that this means, focusing on the lower and upper trophics for example, phytoplankton, zooplankton composition, marine mammal seabird observations. The key parameters will be decided based on a biodiversity framework. John pointed out that there are also many other groups, such as ICES, the Arctic Council, a new initiative on Arctic Coastal States and so on, looking at similar objectives as PAG. Hence, he suggested on finding ways to link up with other activities that are happening to build on the strength rather than reinventing the wheel. He is interest in the upper trophics - fish, mammals and birds. Kathy agreed saying that there is a key linkage between this effort and the Circumpolar Biodiversity Monitoring Program. Also, Japan, China and Korea are now the observer countries to the Arctic Council and are requested to contribute additional information

from the coastal waters into the Arctic Ocean. Another participant also recommended that private industries may be willing to collaborate as well as they already started their activity in that area. Tom suggested another meeting by the US Arctic Research Commission, which corresponds through the meeting in July to give such presentations to catch the interest of the weather service people. Jackie also suggested on a small half day side meeting before the PAG fall meeting in Korea focusing on the PACEO for more specific plans. John made a follow up comment that he is open to discussion with PAG members who are planning to address the upper trophics that might be in cooperating in the PACEO.

## 2.2 Sea ice and atmosphere topic (Joo-Hong Kim)

**(PPT 10)** Joo-Hong talked about the atmosphere-sea ice research based on the ARAON cruise. KOPRI will enhance its meteorological observation and cloud observing instruments such as the radiosonde, LIDAR and an all-sky camera. As a legacy of the MIZ program, KOPRI will continue to observe floe-scale dynamic sea ice deformation with an autonomous platform. KOPRI atmospheric scientists participated in the N-ICE 2015 to study cloud turbulence, sea ice energy balance and atmospheric boundary layer. Clouds are the key factor controlling surface radiative fluxes. Furthermore, clouds are the largest atmospheric source of model uncertainty, largely influencing the Arctic surface energy budget, thereby affecting sea ice. KOPRI hopes to coordinate observations within YOPP (Year of Polar Prediction). Modeling scientists in KOPRI are studying the impact of intense observational data on the predictability on physical properties of the Arctic environment. In summary, KOPRI scientists will aim to have an integrated platform to study thermodynamic sea ice-atmosphere-ocean interactions and sea ice energy balance.

## 2.3 Modeling activities (Gleb Penteelev)

**(PPT 11)** Gleb presented on the SAON (Sustaining Arctic Observing Network)/NOAA international database providing the one stop for CTD observations in the Arctic Ocean during 2008 – 2010. A strong need to continue this activity and further develop the PAG database was emphasized. Reanalysis of the Northern Bering Sea from 2007 -2010 were accomplished. It was noted that through this study that a preliminary sensitivity analysis occurred and OSSE will help to increase the information content of the observation that will result in more precise estimates of the ocean states. Secondly, the HYCOM ACNFS provides accurate estimates of the Bering Strait transport and near surface circulation. The A4DVAR NCOM has been tested and thus, A4Dvar ROMS-ICE and HYCOM-ICE both need to be tested as well. Variational inversion of the biological observations using the passive tracers helped to increase the accuracy of the estimates of the biological parameters and mortality coefficient.

## 2.4 Coordination of Mooring Locations (Phyllis Stabeno)

**(PPT 13)** Jackie Grebmeier presented on behalf of Phyllis Stabeno. Phyllis is gathering the mooring data into a composite map, to avoid duplication in the Pacific Arctic Sector. Phyllis will contact people for the mooring information such as the contact person, key parameters being measured on the mooring and location. Many different types of moorings were shown. Industrial

mooring locations are not yet on the map, and so there may be more moorings present than seen. The Pacific Arctic Group members were encouraged to send mooring information to Phyllis. An update of the mooring locations will be presented in the Fall PAG meeting and also available on the website.

## 2.5 US Ship-Related Issues (Lee Cooper)

**(PPT 13)** Lee Cooper, Chair of the US Arctic Icebreaker Coordinating Committee (AICC), informed the PAG members of a potential USCG (United States Coast Guard) issue with foreign clearances that involves oil spill and other risk mitigation that has been introduced into the international clearance request for non-US vessels. Part of the concern also revolves around potential conflicts with Alaskan subsistence hunters during research cruises. He mentioned a website <http://icefloe.net/Community-Primer> developed by the AICC that provides information that chief scientists for research vessels should consider when planning cruises. PAG member countries entering this area need to be aware of the ongoing potential conflict with subsistence hunting and know how to contact the local entities, if necessary.

The related DBO/PAG ship issue involving risk reduction is that the USCG realized that there are limited capabilities to deal with shipping accidents, and oil spills in the remote parts of Alaska. Thus, clearance requests that are in part reviewed by the USCG are now evaluating this issue. Ships that are traveling in different parts of Alaska have been asked in some cases to join the Alaska Maritime Prevention and Response Network (. <http://www.ak-mprn.org/> ). However, a condition of membership is an agreement to not come within 12 nautical miles of the coast. Note that this requirement has potentially serious impacts on DBO line 3 &5, Lee and others are actively working to provide waivers for these regulations scientific cruises. Updates on recent discussions among the USCG, AICC and US agencies were given. Note: As of June 2015 clearance is being approved within 3-12 nautical miles from the Alaskan coast, with the caveat that ships sampling during the spring and fall subsistence hunt contact the local subsistence authorities to provide information on ship positions while at sea.

## 3. Status report on PAG-endorsed DBO ongoing and planned future activities (Jackie Grebmeier-lead, with results from others beyond presented in country reports)

**(PPT 14)** Jackie gave a brief highlight of science findings from the DBO pilot program, specifically examples of results from 2010-2014 during the Seattle workshop held 29 -31 October 2014. There were 52 participants from 7 countries, including Norway, attended the workshop. The IASC Marine Working Group also partly funded the workshop. The standard measurements selected for DBO data types and parameters were summarized, such as mooring data, sediment parameters and seabird and marine mammal surveys. The highest Chl *a* value observed via satellites and field data occurred in the Bering Strait and offshore in SE Chukchi Sea DBO 3 hotspot and are being used to compare with the actual field values. Jackie also gave examples of dominant benthic taxa in the Northern Bering and Chukchi Seas. New DBO lines were proposed for the Beaufort Sea as ice is retreating in the NW Chukchi Sea, further offshore in the Beaufort Sea, and the Northern Barents Sea. The question about where to position the DBO lines was finalized and are on the NOAA DBO website. Lastly DBO publications and 2015 field activities were presented. Motoyo Itoh and collaborators have published a paper on the



DBO 5 transect line in Deep Sea Research I.

#### 4. Data sharing issues

##### 4.1 Discuss IASC data policy and final DBO data policy in relation to PAG activities (Jackie Grebmeier)

**(PPT 14)** The DBO data policy can serve as a framework for international research coordination, specifically as being part of the Arctic Council Circumpolar Biodiversity Monitoring Program (CBMP) and is a recognized task of the pan-Arctic Sustaining Arctic Observing Networks (SAON) program, facilitated by the Arctic Council. Jackie described the DBO metafile for all participants and the standard metadata profile that needs to be filled in from those who collect data to know who is collecting. The DBO metadata profile can be completed by the webpage ([http://www.eol.ucar.edu/field\\_projects/dbo](http://www.eol.ucar.edu/field_projects/dbo)) to share data among the DBO team at AOOS DBO workspace. The DBO EOL data policy and metadata profile and work space platform on the AXIOM website were presented with possible examples for PAG data metadata policy aligned with the IASC data policy. The Data users have responsibilities to acknowledge the data provider and co-authorship for DBO PIs. Jackie also introduced the US IARPC (Interagency Arctic Research and Policy Committee) monthly DBO webinar that everyone is free to join (<http://www.iarpcollaborations.org/teams/Distributed-Biological-Observatory> ).

#### 5. PAG Synthesis activities

##### 5.1 DSR ARAON Special Issue- Update (Eun-Jin Yang)

As part of the PAG synthesis program, KOPRI is synthesizing papers for the DSR II (Deep Sea Research II) special issue based on the Korean Arctic expedition based on RV ARAON. Presently, 10 papers have been published and are available online, with one paper recently accepted.

##### 5.2 Biogeosciences – Special Issue Update (Takashi Kikuchi)

**(PPT 15)** There will be a special volume published in Biogeoscience from the results of the two ongoing Japanese projects for the Arctic Ocean marine ecosystem (1) “ECOARCS/GRENE” and (2) Catastrophic reduction of sea ice in the Arctic Ocean – its impact on the marine ecosystems in the polar region. Motoyo Itoh has her paper published in DSR I on DBO line 5 about seasonal physical oceanographic measurement.

#### 6. Interactions with other organizations – IASC, SAON, FARO, others

##### 6.1 ICARPIII update (Sung-Ho Kang)

**(PPT 16)** Sung-Ho gave a brief introduction of ICARP III which provides a framework to help identify Arctic science priorities for the next decade, coordinate various Arctic research agendas and to build constructive relationships between producers and users of knowledge. ICARP III does not undertake the development of new science plans but rather builds on the many comprehensive science plans that already exist and compliments those with processes to identify gaps that need attention. PAG, a partner of ICARP III, is able to participate actively in contributing valuably to the ICARP III process. Lee further added that ICARP III is based on organizations, and the ICARP III process to take the input from the different organizations and prioritize the research priorities. The development of the PACEO was submitted as an ICARP III activity.

In the upcoming ICARP III sessions, Kathy will briefly talk about the observational strategies for the activities of the Pacific Arctic Group in Session B2. One session is about the study of evolutionary structure of variability of the Pacific Water as presented above. Another session is about carrying out atmospheric - sea ice observations which will be linked to the PPP (Polar Prediction Project) to carry out the repeat census in trophic components in the ecosystem and identify the key species in relationships in forcing for biogeochemical processes. Kathy will give a presentation on behalf of PAG on the development of the climate observing system on 28 April. The joint letter of intent to move forward with this initiative was signed in Toyama and will be taken into action from this year's summer expeditions of the respective ship cruises.

#### 6.2 PAG and EPB, IASC Council and MWG, FARO, SAON (Jackie Grebmeier)

Jackie gave a short report to FARO (Forum of Arctic Research Operators) and SAON on the PAG activities. She also presented the composite document of all the ship information and PI's for the Pacific Arctic Group and received positive feedback. Jackie had also reported to the IASC Marine WG on the 2014 DBO data workshop. SAON is now developing a different structure with two main groups for observing and data. The council of the EPB (European Polar Board) has been very supportive through the MWG. ICARP III also supported the DBO workshop in Seattle. John Bengston summarized a recent April 2015 meeting where the Arctic Coastal states gathered to discuss about what might happen in the future regarding the Arctic commercial fishing and how it may also affect subsistence fishing. The interest includes looking at a variety of the ecosystems which is why the PACEO is very important. The Arctic coastal states want to develop a circumpolar monitoring system, including biophysical forcing and the upper trophic data collections. There are no interests of opening fisheries in the high sea areas right now, areas outside national jurisdictions, but they are recognizing links to coastal marine ecosystem around the Arctic. Data is necessary to form future decision either by countries managing and sustaining the elements of the upper trophic system. There were observer countries from Japan, Korea and China at the meeting. A public report from this meeting is expected to be out later this year. Sung-Ho Kang commented that the PAG activities can contribute to the decisions of the governments in the Pacific Arctic region. He further stressed that not much data was available further north of the national EEZ (Exclusive Economic Zone) areas. It was also noted that there are many groups with scientific mutual interest and so it is important for each group to work together.

### 6.3 ART (Sanna Majaneva)

**(PPT 17)** Sanna Majaneva presented the progress report and activities on behalf of the ART (Arctic in Rapid Transition) executive committee. The ART Initiative is an integrative, international, interdisciplinary pan-Arctic network that aims to bridge disciplines and time scales in order to better understand the response of Arctic marine ecosystems to climate change and sea ice transitions. The unique aspect of ART is that it is led by Early Career Scientists (ECS) and the founding members are ECS, including the members of the Executive Committee. One of the major scientific programs is the “Transitions in the Arctic Seasonal Sea Ice Zone (TRANSSIZ),” which is an initiative that began at the ASSW 2011 in Seoul, Korea. It started with a letter of intent in September 2011 and resulted in the approval of a research cruise on 19 May to 28 June 2015 after several workshops. The major ART research question is how will biogeochemical cycling respond to transitions in terrestrial, gateway and shelf-to-basin-fluxes? The approach during TRANSSIZ is process-based studies of productivity, ecosystem dynamics, paleo proxies and biogeochemical cycling along shelf to basin transects of the European Arctic. The 2<sup>nd</sup> ART Workshop with the title, “ISTAS (Integrating Spatial and Temporal Scales in the changing Arctic System): towards future research priorities was held at IUEM France on 21- 24 October 2014. There was discussion on integrating spatial and temporal scales in the Arctic to better understand the changing Arctic system as a whole. 76 participants attended this meeting from 13 countries from a multidisciplinary range of expertise. ART publications include priority sheets, which is one of the outcomes of the ISTAS workshop and also contributing to the ICARP III process. A special issue in Polar Research will be published in 2015. The future plan of ART is to expand its activities to the Pacific sector and potential collaboration with the Pacific Arctic Group.

### 7. PAG structure

The Executive committee is composed of a PAG Chair, two Vice-Chairs, and leads from each of PAG activities. The current rotation plan of Chair and Secretariat is as follows:

- 2014-2016 – Korea (Sung-Ho Kang, KOPRI)
- 2016-2018 – Japan (TBD)
- 2018-2020 – Russia, China, Canada?

### 8. Review of PAG operating procedures, MOA with IASC, and Secretariat-open discussion

A question of “Do we need science subgroups to meet related to PAG projects?” A short meeting prior to the fall meeting is to be considered to share immediately the data obtained from the Pacific Arctic Climate Line Sector. This is an important area as there is not much data available.

### 9. Future PAG meetings

- **Fall 2015 – Incheon, Korea, 28-29 October (1.5 day)**
- ASSW 2016 – Fairbanks, Alaska, 12 -18 March (<https://assw2016.org/>)
- Fall 2016 – Qingdao, China, October
- ASSW 2017 – Prague, Czech Republic
- Fall 2017 – TBD

- ASSW 2018 – Davos, Switzerland, June
- Fall 2018 – TBD

## Appendix

### A. List of Participants

	Name	Affiliation	Email
1.	Sei-Idi Saitoh	Arctic Research Center Hokkaido University	<a href="mailto:ssaitoh@arc.hokudai.ac.jp">ssaitoh@arc.hokudai.ac.jp</a>
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29.	Jackie Grebmeier	UMCES	<a href="mailto:jgrebmei@umces.edu">jgrebmei@umces.edu</a>
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## **B. Joint Letter of Intent**

### **JOINT STATEMENT**

#### **Letter of Intent**

#### **Cooperation of the Pacific Arctic Group Members on:**

#### **Developing a **Pacific Arctic Climate Ecosystem Observatory (PACEO)****

April 23, 2015

The Pacific Arctic Group (PAG) is an informal group of organizations and individuals having a Pacific perspective on Arctic science. Originally organized under the International Arctic Science Committee (IASC), the PAG is now an independent affiliate of the IASC and has as its mission to serve as a Pacific Arctic regional partnership to plan, coordinate and collaborate on science activities of mutual interest. The PAG has established five objectives:

- To identify gaps in knowledge and priority research needs across the Pacific Arctic Region and seek means to implement programs and activities that address them.
- To facilitate and coordinate science operations among PAG member countries.
- To promote and facilitate data accessibility and integrated data bases for the region.
- To serve as a forum for information exchange on Pacific Arctic Region (PAR) science programs.
- To establish and maintain a direct link between PAG and other relevant science organisations.

In October, 2014, the Pacific Arctic Group fall meeting focused on a review of accomplishments during the previous summer and outlooks for the future research plans.

One major outcome of the meeting was to engage in an expert-level discussion of observing needs in the data poor Pacific Arctic where sea ice loss has been extreme. These observations

could provide valuable information to forecasters and modelers of Arctic climate change and extreme weather impacts on the region extending to the mid-latitudes of the northern hemisphere.

The area of observing interest includes the outer shelf of the East Siberian and Chukchi Seas northwards to 80°N and extending from the Makarov Basin in the West to the Canada Basin in the East.


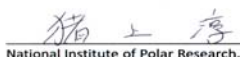
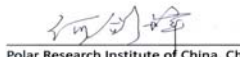


A workshop held in Tokyo prior to the Arctic Science Summit Week in 2015 was held to investigate and refine the following key future observing goals and to develop an implementation plan for action.

The goals are:

- To carry out atmospheric, sea ice and upper ocean observations to determine the causes of rapid sea ice loss in the region and its impact on ecosystems and local and global climate. This effort will also incorporate atmospheric observations to support the WMO's Polar Prediction Project (PPP).
- To study the evolution, structure, and variability of Pacific Arctic upper ocean water masses, including heat transport of Atlantic Water and its interaction with northward flowing Pacific Water.
- To carry out a repeat census of the marine ecosystem, when possible from lower to higher trophics, documenting status and trends and identifying indicator species and their relationship to physical forcing and biogeochemical conditions.
- To carry out time-series observations from long-term moorings to reveal annual and inter-annual variability.
- To coordinate this work with the vessels of our respective countries from 2015-2020 and beyond, to provide a unique suite of synoptically collected data made available for joint analysis and assessment via the mechanisms already set up within the Pacific Arctic Group. [www.pag.arcticportal.org](http://www.pag.arcticportal.org)

The PAG participants agree to collaborate on the development and implementation of this **Pacific Arctic Climate Ecosystem Observatory (PACEO)** and will:

- Contribute to the critical elements defined above,
- Contribute to the development of an implementation strategy to carry out the above,
- Contribute to annual implementation plans and work with other PAG participants to ensure the most effective possible use of available fiscal, human, and logistic resources,
- Work with other PAG participants to synthesize and analyze shared data and publish the results

 Korean Polar Research Institute, Korea	<u>SUNGHO KANG, 23 April 2015</u>
 Arctic Research Program, NOAA, USA	<u>Kathleen Crane 23 April, 2015</u>
 National Institute of Polar Research, Japan	<u>Jun Inoue, 23 April 2015</u>
 Polar Research Institute of China, China	<u>Jianfeng He 23 April 2015</u>
 Department of Fisheries and Oceans, Canada	<u>Bill Williams 23 April 2015</u>
 Arctic and Antarctic Research Institute, Russian Federation, Russia	<u>Vladimir Ivanov, 23 April 2015</u>

**JOINT STATEMENT**

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Cooperation of the Pacific Arctic Group Members on:  
Developing a Pacific Arctic Climate Ecosystem Observatory (PACEO)**

April 23, 2015  
Toyama, Japan

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- To coordinate this work with the vessels of our respective countries from 2015-2020 and beyond, **to provide a unique suite of synoptically collected data made available for joint analysis and assessment** via the mechanisms already set up within the Pacific Arctic Group.

[www.pag.arcticportal.org](http://www.pag.arcticportal.org)





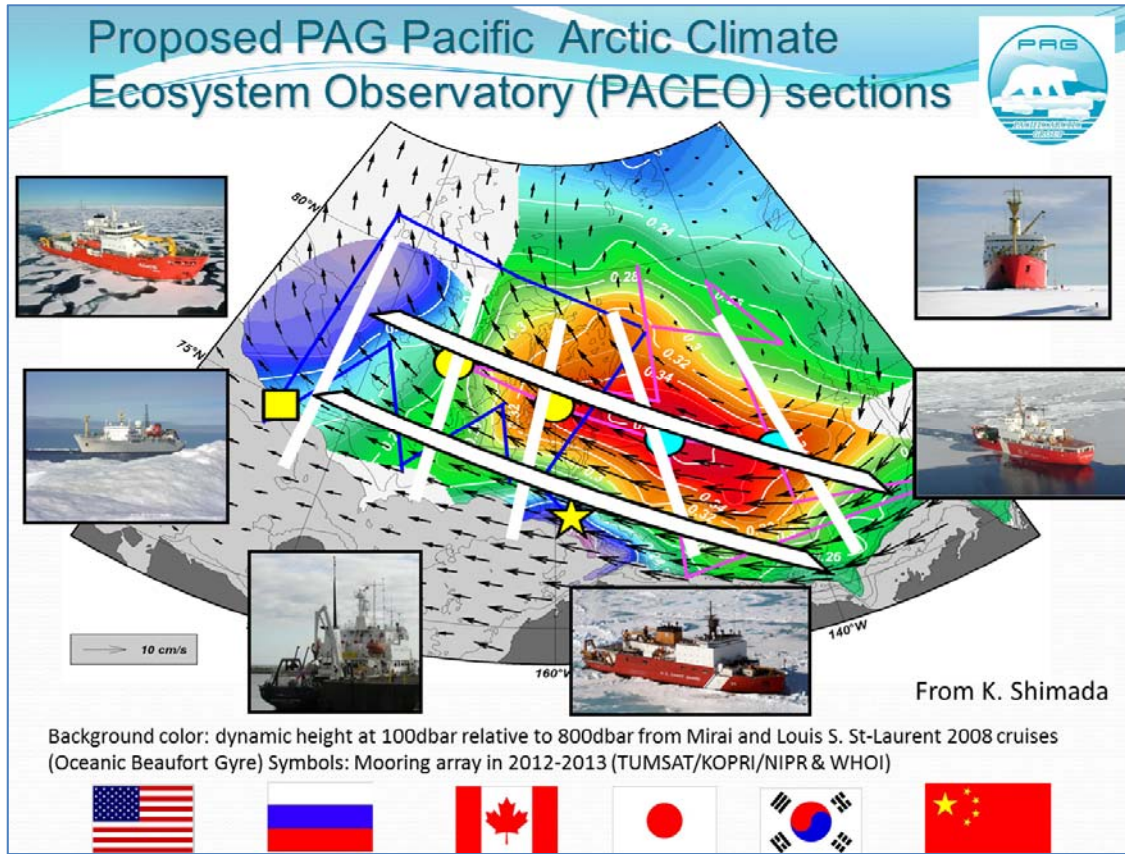









### C. Proposed PAG Pacific Arctic Climate Ecosystem Observatory (PACEO)



## Appendix D. Acronyms

AARI (Arctic and Antarctic Research Institution of Russia)

ADCP (Acoustic Doppler Current Profiler)

AICC (Arctic Icebreaker Coordinating Committee)

AMBON (Arctic Marine Biodiversity Monitoring Network)

AON (Arctic Observing Network)

AOOS (Alaska Ocean Observing System)

ART (Arctic in Rapid Transition)

ASCOS (Arctic Summer Cloud Ocean Study)

ASR (Arctic Sea Route)

BGOS (Beaufort Gyre Observing System)

CAFF (Conservation of Arctic Flora and Fauna),

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)

IACE (Institute of Arctic Climate and Environment Research)

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 Marine Science and Technology Center)

JOIS (Joint Ocean Ice Studies)

KOPRI (Korea Polar Research Institute)

MIZ (Marginal Ice Zone)

MOSAIC (Multidisciplinary drifting Observatory for the Study of Arctic Climate)

NOAA (National Oceanic and Atmospheric Administration)

NSF (National Science Foundation)

OUC (Ocean University of China)

PACEO (Pacific Arctic Climate Ecosystem Observatory)

PPP (Polar Prediction Project)

PRIC (Polar Research Institute of China)

RUSALCA (Russian American Long-term  
Census of the Arctic)

SAON (Sustaining Arctic Observing  
Network)

TRANSSIZ (Transitions in the Arctic  
Seasonal Sea Ice Zone)

TUMSAT (Tokyo University of Marine and  
Science Technology)

UMCES (University of Maryland Cener for  
Environment Sciences)

USCG (US Coast Guard)

WHOI (Woods Hole Oceanography  
Institute)

YOPP (Year of Polar Prediction)