

2010

PAG MEETING



**NATIONAL INSTITUTE OF
POLAR RESEARCH
TOKYO, JAPAN
10-11 DECEMBER 2010**

FINAL REPORT

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1.0 WELCOME & INTRODUCTION

Dr. Hiroshi Kanda gave a warm welcome introduction to all PAG participants attending the PAG 2010 Meeting in Tokyo, Japan. He continued to express his pleasure in hosting the group at the new National Institute for Polar Research (NIPR) facility in Tachikawa, Japan.

2.0 REVIEW OF 2010 CRUISE PLANS & BEYOND

To begin the fall 2010 PAG Meeting the first priority on the agenda was to review 2010 cruise operations and look ahead to future plans. Each nation, in alphabetical order was given an opportunity to present.

2.1 CANADA

A thorough overview of the Canadian Arctic Ocean Science Program 2010 was presented by Dr. Robert Fudge from the Department of Fisheries and Oceans Canada.

The main priorities that drive the Canadian Arctic Ocean Science Program in the PAG Region are:

1. Understanding ecosystem science and climate change
2. Marine Protected Areas (MPA), specifically the Beaufort Sea
3. Oil and gas industry exploration and development
4. United Nations Convention on the Law of the Sea (UNCLOS) – (Canada has until 2013 to fulfill obligations).

Continued and growing partnerships, such as universities networked internationally through ArcticNet and Canadian/US industry relations, are critical to the growth, sustainability, and success of the Canadian program.

The Canadian Arctic Ocean Science Program has made it a priority to understand ecosystem science and climate change in the Arctic Ocean and has announced plans to invest in infrastructure in the high arctic to carry out science activities to support this. The planned research station at Cambridge Bay is set for construction beginning in 2012-2013, and is the future location for the high arctic research station. It will be the largest stop for passenger and research vessels traveling the Northwest Passage.

Maintaining and governing MPAs is also a priority for the Canadian Arctic Ocean Science Program. On August 26th, 2010 Canada officially announced plans to establish the Tarium Niryutait MPA. It is Canada's first arctic MPA and consists of three individual areas called Niaqunnaq, Okeevik, and Kittigaryuit. Together these three areas cover approximately 1,800 km² of the Mackenzie River Delta and estuary in the Beaufort Sea.

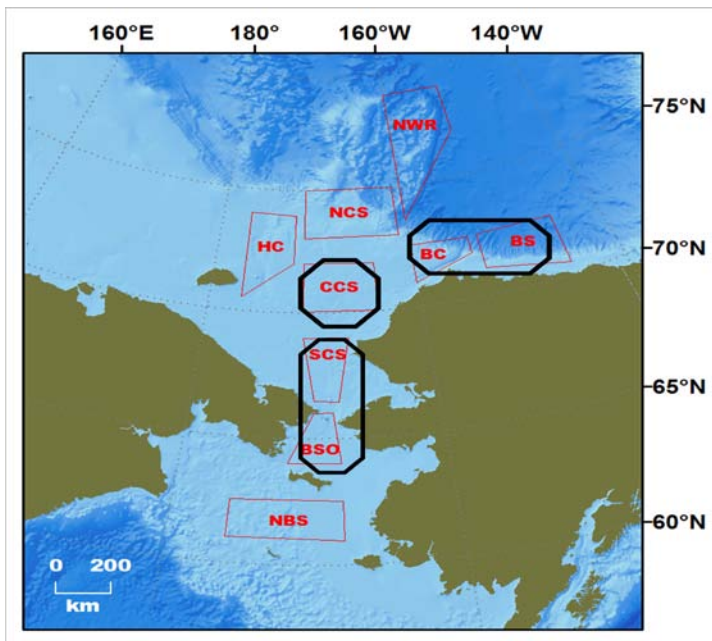
The Tarium Niryutait MPA was created through a collaborative effort by Fisheries and Oceans Canada, the Inuvialuit people, private industry, local stakeholders and governments.

The purpose of the Tarium Niryutait MPA is to conserve and protect the biological resources within the MPA and to support the viability of a healthy population of beluga whales. This area is particularly important to the Beaufort Sea beluga whale stock that travels to the Mackenzie Estuary during the summer months. These whales come to this area for socializing, rearing calves, molting, feeding and for energetics (i.e. thermal advantage).

The Tarium Niryutait MPA has traditionally been used by the Inuvialuit and is important from a cultural, subsistence and economic perspective. The MPA will protect harvesting traditions central to the Inuvialuit culture in the communities of Aklavik, Inuvik and Tuktoyaktuk. It will balance the cultural and economic aspirations of northerners, while advancing the Government's environmental conservation plans. Another priority that drives the Canadian Arctic Ocean Science Program is oil and gas exploration and development, specifically in the Beaufort Sea. Currently, the Canadian government and Industry are working together to gather environmental data and assess risks in the Beaufort Sea where lease holdings currently exist. A five year program, Beaufort Regional Environmental Assessment, has been initiated by Indian and Northern Affairs Canada.

Canadian priorities in Arctic Ocean Science are observed internationally with active participation in Arctic Council activities. Canada is a member of the Arctic Monitoring and Assessment Programme (ocean acidification assessment, contaminants, climate change), as well as the Circumpolar Biodiversity Monitoring Program (Arctic Marine Biodiversity Monitoring Plan (approved September 2010 by the Conservation of Arctic Flora and Fauna Board)).

As a member of the Pacific Arctic Group, Canada participates in the Distributed Biological Observatory (DBO) project. The Canadian program has nine zones established for standardized and seasonal observations, and contributes to the 3 DBO zones indicated in black.



Canada has an active 2010 field program within the Pacific Arctic region. These include:

- Canada's Three Oceans – “Turbo”
 - Sir Wilfrid Laurier (16 days – 3.5 days for Science)
 - Victoria to Barrow, July 6 to July 22
 - The number of stations increased from the previous year
- Joint Ocean-Ice Study (JOIS)/BG/AON
 - Louis S. St-Laurent (30 days for Science)
 - Kugluktuk to Kugluktuk, September 15 to October 15
- AIM (Arctic Ice Monitoring) / MGH (Mackenzie Gas Hydrate)
 - Sir Wilfrid Laurier (15 days – 5 days for Science)
 - Cambridge Bay to Nome, September 21 to October 8
- ArcticNet Industry Program – Western Arctic
 - Amundsen August 12 to October 7
 - Work done in partnership with Industry
- Continental Shelf Mapping (UNCLOS)
 - Louis S. St-Laurent (August 04 to September 15) & US Healy

2.1.1 Cruise Tracks 2010

Canada's Three Oceans – Atlantic/Arctic

CCGS Louis S. St-Laurent

- Leg 1: St. John's – Resolute (July 20-27, 2010)
- Leg 2: Resolute - Kugluktuk (July 27-August 03, 2010)

Science Activities

- CTD/Rosette casts at 26 stations
- 16 XCTD (expendable temperature, salinity and depth profiler) casts
- 206 Water samples
- 16 zooplankton vertical (bongo) net hauls
- 47 drift bottles deployed at two locations. Each drift bottle contained a message with serial number and reporting contact information. Drift bottles were launched at selected locations along the ship's track. The drop locations were logged, and when finds are reported this provides information on ocean surface drift trajectories. A website is maintained at the Institute for Ocean Sciences (IOS) to document all drops and finds, and map the results.
 - 2010/08/01 03:00 DRIF DRIF-1 68.808167 -107.7725 bottle serials 1-32 except 8,19,23,31
 - 2010/08/02 03:01 DRIF DRIF-2 68.329667 -113.33417 bottle serials 8,19,23,31,33-4
- Seabird Surveys - 2458 birds were observed
 - Dovekie's were the species most commonly observed (29% of the total), followed by Northern fulmars (16%) and Thick-billed murres (14.5%). The species composition changed as they moved north and then west through the Northwest Passage.
 - Upon departing St John's, Newfoundland, the most common species encountered were Atlantic puffins, murres and Northern gannets. As they moved further offshore, storm petrels were most commonly seen (both Wilson's and Leach's), as well as Greater shearwaters.
 - In the Labrador Sea and Davis Strait, Northern fulmars were most common, followed by Black-legged kittiwakes. Large numbers of Thick-billed murres and dovekie's were observed in Lancaster Sound, as well as Northern fulmars and Blacklegged kittiwakes.
 - As they moved down Peel Sound, very few alcids were seen. Glaucous gulls and Thayer's gulls (especially in the Bellot Strait) were most common in this area.
 - Red phalaropes were observed in large groups as they approached Lancaster Sound. Very few birds were observed from Franklin Strait to Kugluktuk.

Canada's Three Oceans – Pacific/Arctic

CCGS Sir Wilfrid Laurier

- Victoria to Barrow - July 6 to July 22, 2010

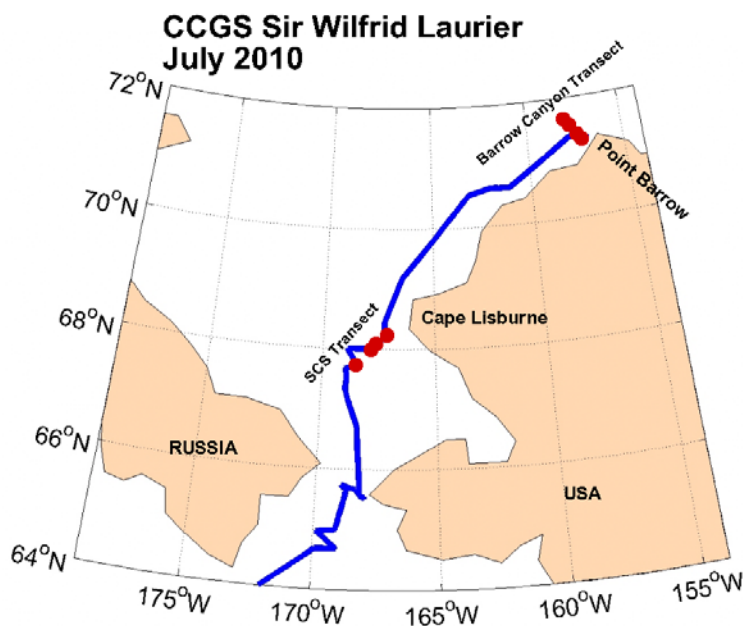
Science Activities

During this cruise aboard the CCGS Sir Wilfrid Laurier data were collected on the physical, biological and geochemical properties of ocean waters across the North Pacific Ocean, and the shelf regions of the Bering and Chukchi Seas. Data were also collected on the benthic ecosystems in the Bering & Chukchi Seas. In total, 43 science stations were completed and activities include:

- 43 science stations
- 43 CTD/Rosette casts,
- 32 150 kHz ADCP/dual-frequency backscatter deployments
- 29 Bongo plankton net hauls
- 15 Benthic sampling stations
- 3 Argo floats deployed
- Continuous sea surface water monitoring
- Bird and mammal observations during the day

Distributed Biological Observatory (DBO)

The Barrow Canyon DBO hotspot hydrographic transect and Southern Chukchi Sea transect were occupied during the C3O program on Leg 1 of the CCGS Sir Wilfrid Laurier from July 19-21, 2010.



Station	Cast #	Cast Time (UTC)	Latitude (N)	Longitude (W)	Water depth (m)
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SCS transects:

UTN-6	34	2010/07/19 18:39	67 44.17	168 26.29	51
PAG-1	36	2010/07/20 01:39	68 0.75	167 52.38	55
PAG-2	37	2010/07/20 03:26	68 7.60	167 29.89	51
PAG-3	38	2010/07/20 05:55	68 14.42	167 7.56	44

Barrow Canyon transects:

PAG-6	42	2010/07/21 15:43	71 34.65	157 50.37	67
PAG-5	41	2010/07/21 14:16	71 29.76	157 40.21	89
BC-2	40	2010/07/21 12:50	71 24.74	157 30.04	128
PAG-4	43	2010/07/21 20:09	71 19.82	157 19.61	93

On Leg 3 of the C30, mooring and oceanographic sampling operations took place. The Conductivity/Temperature/Depth (CTD) package consisted of a Seabird pressure and dual temperature/conductivity sensors, Wet Labs transmissometer, Chelsea chlorophyll fluorometer, Wet Labs colored dissolved organic matter (CDOM) fluorometer, Seabird dissolved oxygen sensor, Biospherical photosynthetic active radiation (PAR) sensor, and Benthos altimeter. These were mounted on a 22-position Rosette with 10-liter Niskin bottles.

CCGS Amundsen ArcticNet 2010 Cruise Track

Leg 1 (2 July – 12 August): ArcticNET

Hudson Strait, Foxe Basin, Hudson Bay & the Northwest Passage (July 02 – August 12)

Science Activities

The vessel conducted mooring and oceanographic sampling operations at designated stations in Hudson Strait, Foxe Basin, Hudson Bay and the Northwest Passage.

Leg 2&3a (12 August – 7 October): ArcticNET/Industry

Beaufort Sea/Mackenzie Shelf/Amundsen Gulf

Science Activities

These legs were conducted in partnership with the Oil and Gas industry (BP). The collaborative agreement with BP aimed at increasing the diversity, temporal and spatial coverage of environmental data collected by the ArcticNet network and hence contributed to a better understanding of the ecosystem processes in the Beaufort Sea/Mackenzie Shelf/Amundsen Gulf region with a special focus placed on the region's offshore exploration licenses recently awarded by the Government of Canada.

Leg 3b & 3c (7 October -31 October): ArcticNET

Viscount-Melville Sound, Barrow Strait, Lancaster Sound, Baffin Bay & 4 Labrador Fjords

Science Activities

Leaving Paulatuk on October 07, the ship headed back east through Prince of Wales Strait to carry out mooring and oceanographic sampling operations in Viscount-Melville Sound, Barrow Strait, Lancaster Sound, Baffin Bay and 4 Labrador Fjords. The ship returned to Quebec City on October 31.

2.1.2 Canadian Arctic Ocean Science Plans 2011

It is expected that the 2011 Canadian Arctic Ocean Science Plans for 2011 will look very similar to the 2010 Plans.

- Canada's Three Oceans – "Turbo"
 - Limited station stops planned for the 2011 missions aboard Louis S St-Laurent and Sir Wilfrid Laurier. Mostly underway sampling.
- Joint Ocean-Ice Study (JOIS)/BG/AON
 - Louis S. St-Laurent (30 days for Science)
 - Kugluktuk to Kugluktuk, September 15 to October 15
- AIM (Arctic Ice Monitoring)
- Sir Wilfrid Laurier (18 days – 8 days for Science)
- Cambridge Bay to Nome, September 24 to October 12
- UNCLOS – Joint mission with Healy again, 6 weeks before JOIS
- ArcticNet – Planning an industry collaboration
- August 6 – September 24 requested

Potential New Programs for 2011 that are under development:

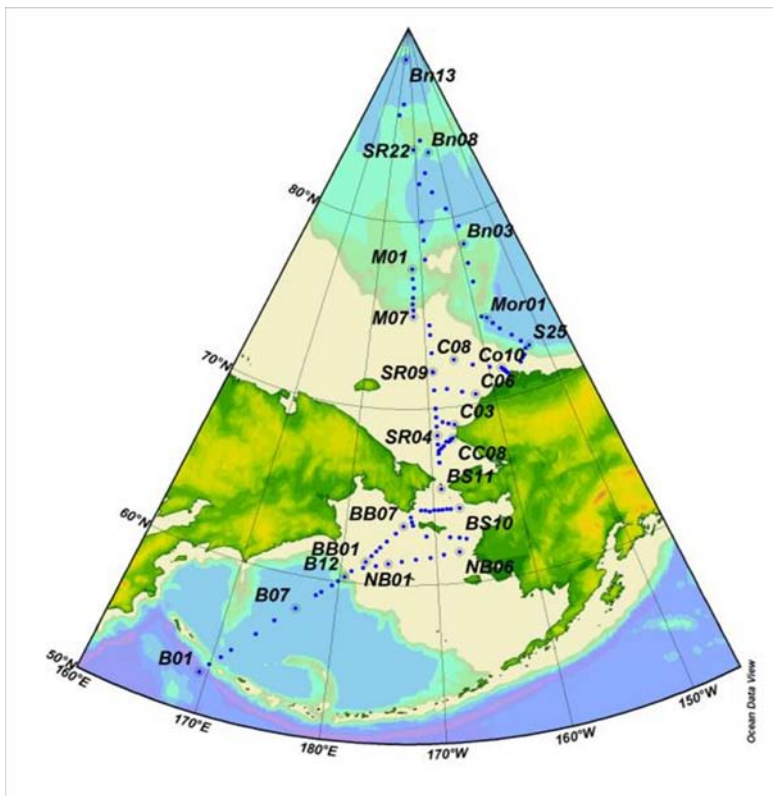
- Beaufort Sea Monitoring
 - Private 60ft ice strengthened Vessel
 - The "Aurora Magnetica"
 - 2 weeks in July/August in Beaufort Sea under neg.
 - Programming beyond 2 weeks (for hire?)
 - Must transit from Victoria to Arctic (for hire?)
 - Will overwinter in the Arctic winter 2011

2.2 CHINA

Dr. Jianfeng He from the Polar Research Institute of China (PRIC) in Shanghai provided an overview of their 2010 Arctic Ocean cruise plan. They employed the Xuelong for the period between July 1st to September 20th, 2010 in the area of the Bering Sea and the Arctic Ocean. The goal of the 2010 mission was to understand the mechanisms associated with rapid sea ice changes in the Arctic Ocean, as well as the response of marine ecosystems to that change.

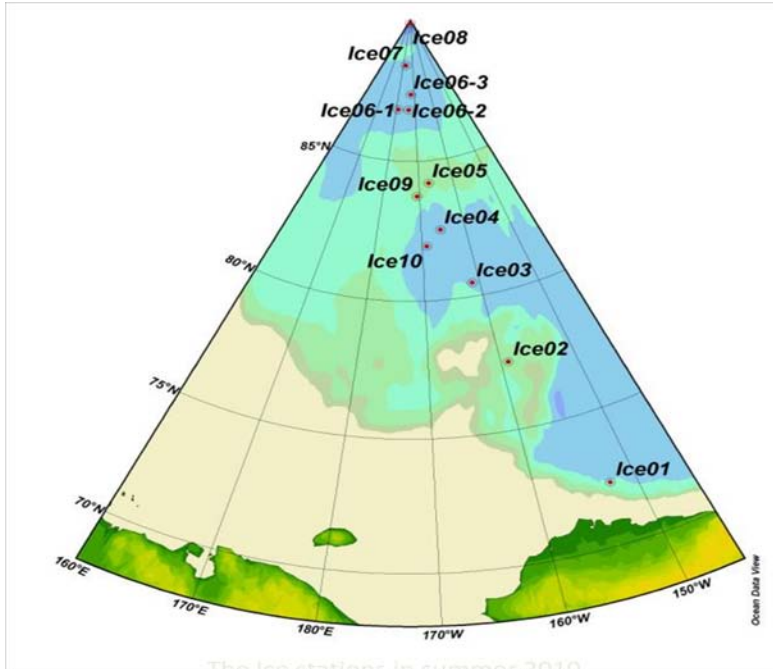
In total 134 sampling stations were completed with 50 in the Bering Sea and 84 in the Arctic Ocean. Station measurements included physical, hydrographic, plankton and sediment samples. Subsets of stations were occupied for sea ice studies over the Chukchi Borderlands.

2010 Xuelong Summer Sampling Stations (including CTD and water column measurements):



The sampling Stations in summer 2010

Location of ice stations occupied in summer 2010 by the Xuelong:



The ice stations in summer 2010

2.3 KOREA

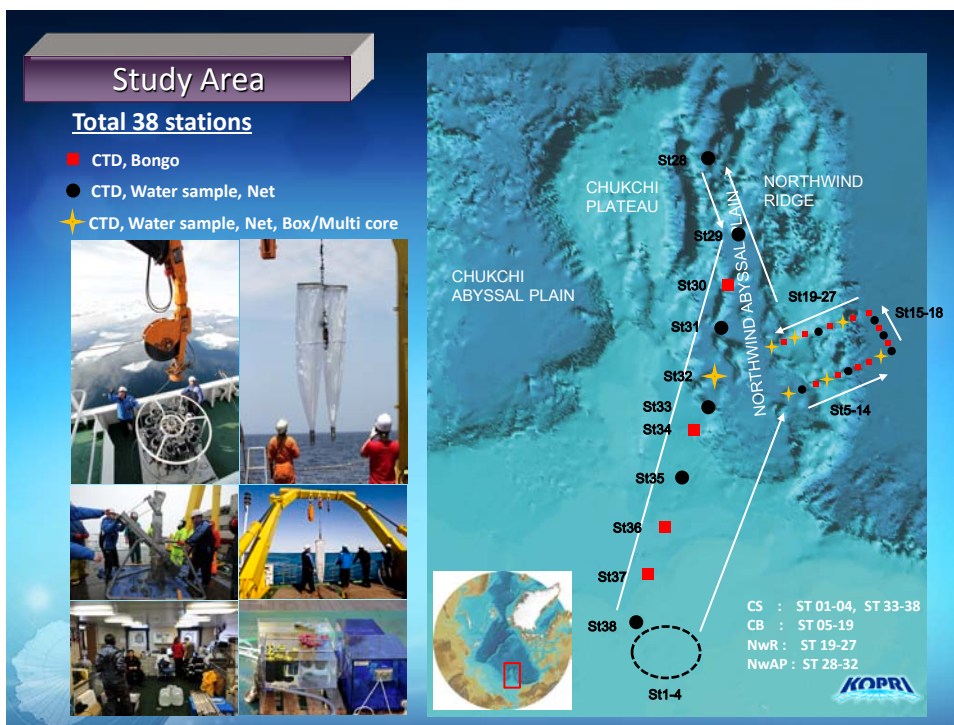
2.3.1 KOPRI 2010 Cruise Operation Plan

- July 1-13, 2010 – Incheon – Nome
- July 14-16, 2010 – Nome (calling port)
- July 17-August 12, 2010 – Arctic Ocean Cruise
- August 13-14, 2010 – Nome
- August 14-15, 2010 – Nome -Busan



In total there were 45 participants present on the 2010 KOPRI cruise, 34 Koreans and 11 foreigners.

The study area focused mainly on the western boundary of the Canadian Basin. In total, 38 stations were sampled.



2010 Research theme: OCEAN

1. Biogeochemical cycles of bio-gas
 - Inorganic carbon system of water column
 - CO₂ flux between the seawater and the atmospheres
 - Sea ice melt-water input
2. Microbial diversity and community structure
 - 16S rRNA gene sequence of bacterioplankton
 - 16S rDNA gene sequence of bacterioplankton
 - Influences of various environmental parameters on the community structure
3. Diversity and biogeography of diatoms
 - Collection & Isolation of diatoms
 - Morphology and 16S rDNA gene sequence
4. Phytoplankton ecology and physiology
 - Pigments, biomass and species composition
 - Carbon & nitrogen uptake rate
 - Physiological status, nutritional condition, and bio-optical properties
5. Heterotrophic protozoan community structure, grazing impact
 - Protozoan abundance & diversity
 - Role of protozoa as herbivores
6. Population dynamics and trophic role of zooplankton
 - Collection of Copepods
 - Morphology and lipid marker
7. Glacial history and paleoceanographic changes
 - Reconstruction glacial history and paleoceanographic changes during the last 60 ka
 - Chronostratigraphy during the late Quaternary
 - Characteristics & origin of organic matters in deposited marine sediment

The Nome region was the study area for the Ocean Theme. Sampling parameters included:

- Phytoplankton pigments (HPLC samples)
- In vivo chlorophyll a, Temperature, Salinity
- Nutrients (SiO₂, NO₃+NO₂, NH₄, PO₄)
- Physiological parameters (Fv/Fm, σ PSII, 1/ τ PSII)
- Air-sea fluxes of trace gases, CO₂, CH₄, N₂O, CO, H₂ and other sulfur compounds

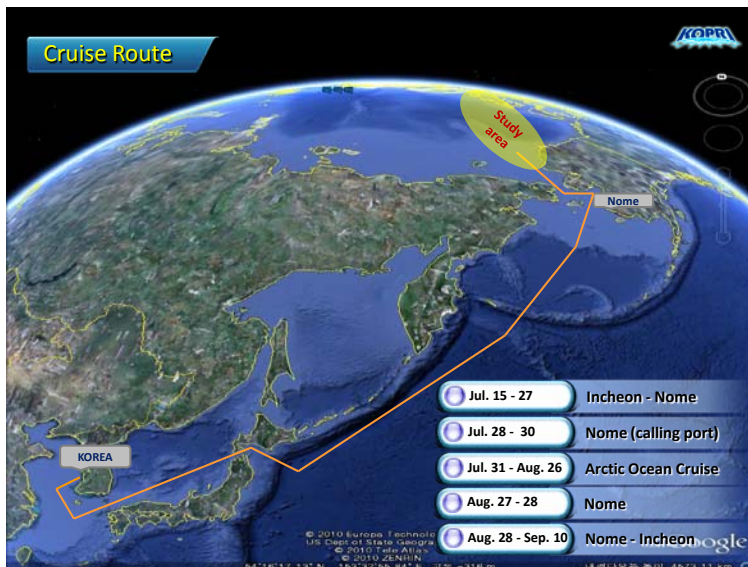
2010 Research theme: SEA ICE

- Sea ice thickness & snow depth
- Sea ice temperature & salinity
- Temperature, salinity, nutrient, phytoplankton biomass, diversity, chl-*a*, pigment, primary production of melting pond and under sea-ice layer

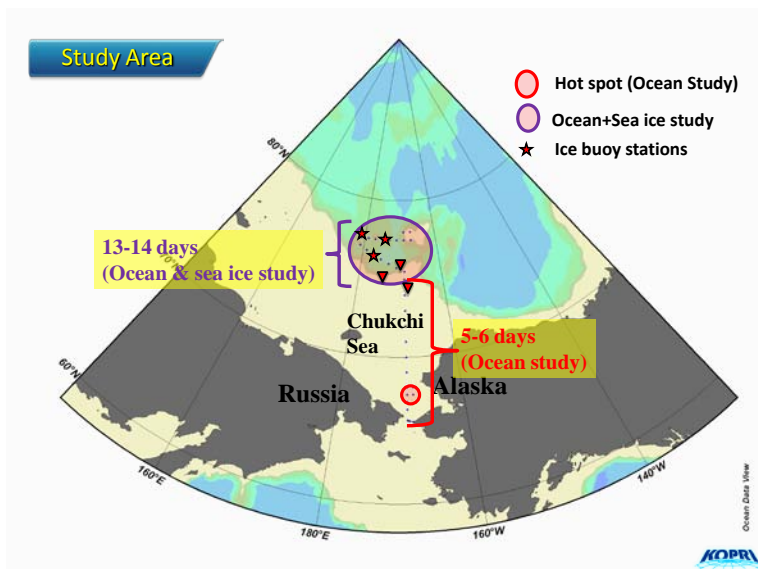
Much of the work completed under the Sea Ice Theme required international cooperation and collaboration with the Scottish Association for Marine Science (SAMS), UK, the US, and China.

KOPRI 2011 Cruise Operation Plan (Tentative)

- July 15-27, 2011 Incheon-Nome
- July 28-30, 2011 – Nome (calling port)
- July 31-August 26, 2011 – Arctic Ocean Cruise
- August 27-28, 2011 – Nome
- August 28-September 10, 2011 – Nome-Incheon



The study area will focus mainly on the western boundary of the Canadian Basin:



2011 Research theme: OCEAN

- Thermohaline structure of water masses (T, S) and transport pattern (velocity profile)
- Nutrients dynamics and reservoirs
- Diversity and biogeography of diatoms
- Structural plankton communities, bio-optics and physiological variability
- Variation of carbon and nitrogen uptakes and species composition of phytoplankton and ice algae
- Protozoan community & grazing impact

2011 Research theme: SEA ICE

- Sea ice physical properties (thickness & density)
- Salinity, temperature and nutrients distributions in sea ice
- Light intensity measurements under sea ice
- C/N productions and photosynthetic products of ice algae and phytoplankton under sea ice
- Species compositions of phytoplankton, ice algae, and cryosphere animals
- Melt pond ecosystem study

Much of the work to be completed under the Sea Ice Theme will require international cooperation and collaboration with SAMS, UK. KOPRI proposes to deploy one automated weather station and 6 Sea Ice Mass Balance Array (SIMBA) systems at different ice features. The purpose of this work is to investigate the thermodynamic processes (melt/growth rates) between different ice features.

2.3.2 Korean Icebreaker AARON

Mission:

- 1. To execute multidisciplinary research surveys in both polar regions**
- 2. Logistics support for the Antarctic stations (King Sejong, Jangbogo)**

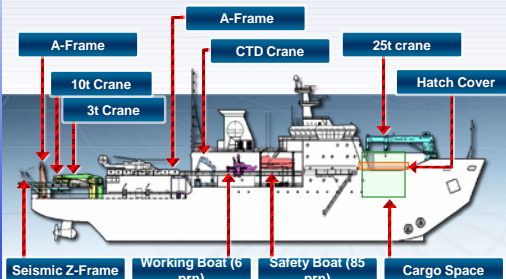
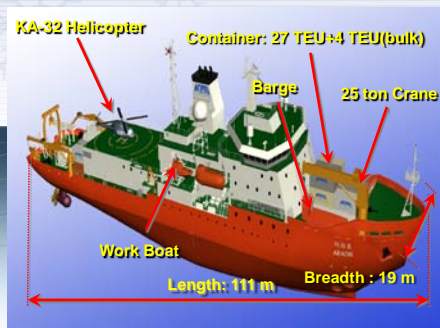
Equipment:

- Oceanographic Research
 - CTD/Water Sampler (Niskin bottles), X-BT, Thermo-Salinograph, etc.
- Acoustic Research
 - Multi-Beam Echo Sounder, ADCP, Deep Tow Side Scan Sonar, acoustic synchronizer etc.
- Geophysics Research
 - Multichannel Seismic System, Sub-Bottom Profiler, Marine Gravity Meter, Magneto Meter, etc.
- Marine/Biological Research

- Mocness, Net Sonde, Bongo Net, RMT, Sea Soar etc.
- Observation & Monitoring Equipment
 - Weather Station, Weather Satellite Receiver, Underway Measurement System, Wave Meter, etc.
- Marine Data Management System, Underwater Positioning System, etc.



General description



- | | |
|--|--|
| • Dimension: L(110.0m) x B(19.0m) x H(9.9m) | • Service Speed: 12 knots(max.16) |
| • Ship Type: KR (=DnV) PL10
(1m thick icebreaking in 3 knot) | • Endurance: 70 days(20,000 nm) |
| • Gross Tonnage: 7,487 tones | • Cargo: 31 TEU of 20ft container |
| • Accommodation: 85 persons
(25 crews + 60 researchers) | • Propulsion: 2 Azimuth thruster(main)
2 tunnel thruster |

2.4 JAPAN

Dr. Motoyo Itoh from Japan Agency for Marine-Earth Science Technology (JAMSTEC) provided an overview of JAMSTEC research activities on the Arctic Ocean climate system in 2010.

JAMSTEC observational activities in 2010 included:

- Drifting buoy operation at the North Pole Environmental Observatory (NPEO)
- R/V Mirai 2010 cruise in the Pacific Arctic Ocean (MR10-05)
- Participation in R/V Johan Hjort (IMR, Norway) cruise in the Barents Sea

The objective these activities were to understand the on-going Arctic climate change and its impact for global climate and ecosystem. Their goal was to expand their observations to include physical oceanography and also meteorology and bio-geochemistry in the Arctic Ocean. To do this, their objectives were:

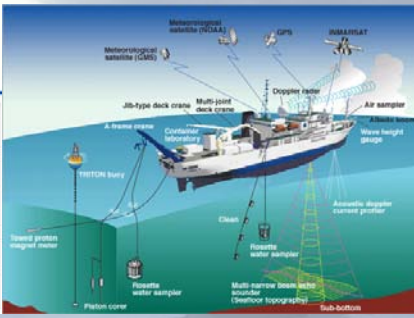
- To quantify on-going changes in ocean, atmosphere, and bio- geochemistry of the Arctic Ocean, which are related to the recent Arctic warming and sea ice reduction
- To clarify important processes and interaction among atmosphere, ocean, and bio-geochemistry behind changes of the Arctic Ocean
- To collect and distribute data for understanding the effects of Arctic Ocean changes on global climate

2.4.1 The R/V Mirai

Dr. Itoh provided a brief overview of the R/V Mirai and explained that it is an ice-strengthened ship, rather than an ice-breaker. The R/V Mirai is a large vessel able to perform observational studies over wide areas under rough weather conditions, and is one of the largest classes of research vessels in the world.

R/V Mirai (JAMSTEC)
Ice-strengthened ship (not ice-breaker)


Principal specifications	
Length	128 m
Beam	19 m
Depth	10.5 m
Draft	6.9 m
Gross tonnage	6,087 tons
Cruising speed	Approx. 16 knots
Range	Approx. 12,000 nautical miles
Accommodation	80 (34 crew, 46 research personnel)
Main propulsion system	Diesel engines: 1,830kW × 4 Electric propulsion systems: 700kW × 2
Main propulsion method	Controllable pitch propeller × 2



A large vessel able to perform observational studies over wide areas under rough weather conditions, MIRAI is one of the largest class of research vessels in the world.

Equipped with large observation instruments

Equipped with Doppler radar, MIRAI is able to carry large observation instruments, including 14 large-scale buoys (TRITON buoys), as well as large water samplers and piston corers.



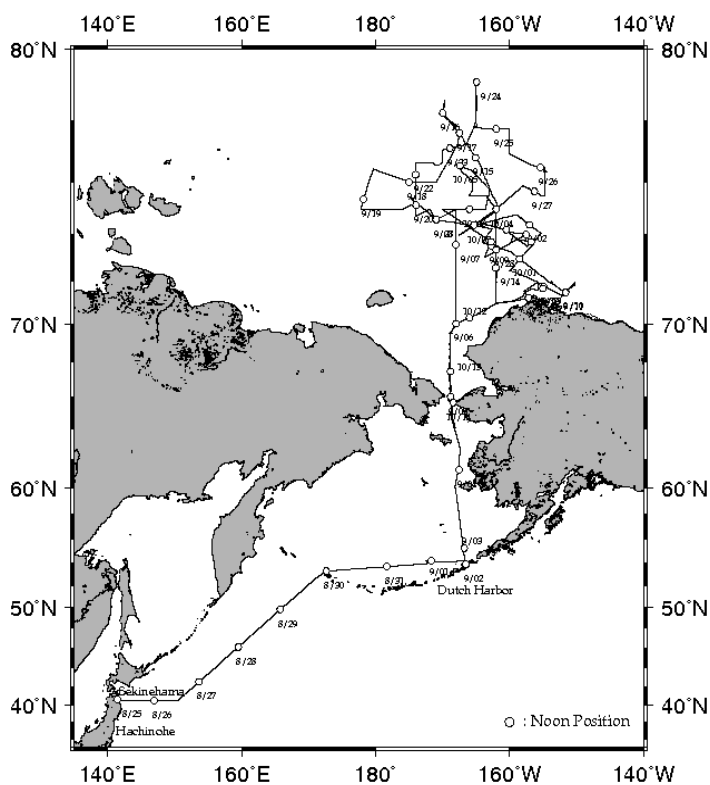
The Mirai is equipped with large observation instruments. It has Doppler radar capability and is able to carry large observation instruments, including 14 large-scale buoys (TRITON buoys), as well as large water samplers and piston corers.

2.4.2 Mirai 2010 Arctic Cruise Activities

The Mirai Arctic cruise activities in 2010 included:

- 24 Aug, Sekinehama, Japan
 - Pacific Ocean (9 days)
- 1-2 Sept, Dutch Harbor, Alaska, USA
 - Arctic Ocean (45days)
- 16 Oct, Dutch Harbor, Alaska, USA

MR10-05 Cruise Track



Summary of measurements of R/V Mirai 2010 include:

- Radiosonde, Doppler radar, cloud radar, other meteorological observations
- CTD with LADCP, XCTD
- Turbulence measurements by TurboMAP
- Mooring operations
- Surface buoy operations (Collaboration with Dr. I. Rigor)

- Water sampling for Sal, Oxy, Nut, Chl-a, alkalinity, TOC, POC, del-O18
- Carbon uptake experiments
- Underway measurement by ship-mounted ADCP, surface water monitoring system (T,S,DO etc), surface meteorology monitoring
- Bio-optical observation - PI: Dr. Hirawake@Hokkaido.Univ
- Zooplankton net tows - PI: Dr. Yamaguchi@Hokkaido.Univ
- Sediment trap mooring operation – PI: Dr. Harada@JAMSTEC
- Microbial communities observation – PI: Dr. Utsumi@Tsukuba.Univ
- Piston coring - PI: Dr. Uchida@NIES
- Aerosol sampling - PI: Dr. Kondoh@Tokyo.Univ
 - ✓ 215 Radiosonde
 - 6 hourly & 162W section: 9/13, 9/27,10/11,168W section: 9/8
 - ✓ 177 CTD/LADCP, 168 XCTD
 - ✓ 30 TurboMAP measurements
 - ✓ 6 mooring deployment
 - BCC-10, BCE-10, BCW-10,
 - CAP-10, CAP-10t, NAP-10t
 - ✓ 3 SVP deployments
 - ✓ 4 Piston core stations

Many observations were made during the 2010 summary field study. Evidence from satellite data suggests anticyclonic eddy formation trapping warmer Pacific summer water and transporting it into the basin, hence increasing sea surface temperatures of the Arctic Ocean in certain areas. Heat will then be released once winter convection starts.

2.4.3 Future JAMSTEC Arctic Cruise Activities

JAMSTEC has future plans in the Pacific Arctic. These include the next Mirai Arctic cruise expedition, planned for 2013 in the same, as well as expanded areas in the Arctic Ocean. In 2011, JAMSTEC plans to do XCTD observation in the Canadian Basin. There, they will collaborate with Drs. A. Proshutinsky and R. Krishfield at Woods Hole Oceanographic Institute (WHOI), and Drs. E. Carmack and W. Williams at the Institute for Ocean Sciences (IOS). Also in 2011, JAMSTEC will conduct mooring operations in the Barrow Canyon and Chukchi and North wind Abyssal Plains. Collaborators on this project will be Dr. R. Pickart at WHOI and Dr. H. Melling at IOS.

A suggestion was made that JAMSTEC consider repeating DBO lines during their future plans in the Pacific Arctic.

2.5 RUSSIA

2.5.1 International Arctic Marine Observations Group (IAMOG)

Dr. Igor Semiletov from the Far Eastern Branch, Russian Academy of Science (FEBRAS) in Vladivostok, Russia and currently at the International Arctic Research Center in Fairbanks,

Alaska, gave a very detailed overview of the International collaboration in the East Siberian Shelf exploration: present and future. He began by giving an overview of the carbon cycle in the Arctic Ocean and its understanding is a main objective of the study.

The goal of the International Arctic Marine Observations Group (IAMOG) is to study the changes observed in the Arctic Ocean by using a combination of advanced observational methods. Reaching this goal is a necessary step for reducing uncertainties in prediction of the future state of the Arctic climate through the integration and synthesis.

During IPY (2007-2008) and beyond, IAMOG focused on one key component of the Arctic carbon system: Carbon flux between the atmosphere, land, and shelf with an emphasis on trace gas emission from/beneath thawing submarine permafrost, and transport/fate of eroded and river carbon across the shelf-shelf slope.

IAMOG research highlights include:

- Significant release of methane and carbon dioxide from the East Siberian Arctic Shelf (ESAS) to the atmosphere was detected. ESAS is considered as a potential source of methane for an abrupt release to the atmosphere.
- The average loss of DOC in the East Siberian Shelf was calculated to be ~50% for DOC from both below and above the halocline with a clear pattern of higher losses further east in the area where the FW component is oldest, while in the area with short FW residence time (heavily influenced by rivers) DOC behavior is conservative (vs. salinity)
- The net ecosystem metabolism of the East Siberian shelves is likely to function as a heterotrophic dominated ecosystem with net CO₂ release into the atmosphere being 19 Tg C- CO₂. This is roughly equivalent to the amount of CO₂ absorbed into the Barents and Chukchi seas.

The Arctic Ocean is an important component of the Arctic climate system in terms of heat and fresh water (FW) dynamics and is also linked to the rest of the globe biogeochemically via carbon. The Arctic Ocean is surrounded by offshore and onshore permafrost which is degrading at increasing rates under climate warming. Degrading permafrost releases a large amount of old terrestrial organic material (OM). Thawing permafrost is most pronounced in the East Siberian part of the SAS, which is the most under-sampled area in the Eurasian sector of the Arctic Ocean.

The ESAS includes almost 90% of the Arctic sub-sea permafrost which is the most fragile component of the modern cryosphere; release of ~1% of the expected hydrate deposits from this shallow seafloor into the atmosphere can greatly increase the amount of methane in the atmosphere.

The ESAS (>2 mln sq. km) represents the broadest and shallowest shelf in the World Ocean which accumulates the fresh water and carbon signals from the Eurasian continent via the Great Siberian Rivers: Lena, Indigirka, and Kolyma. Those rivers integrate

geochemical signal from their vast watersheds (>3mln sq km) located in changing permafrost zone. The huge pool of vulnerable carbon in the ESAS (~1750Gt) is comparable to the carbon pool contained in the upper 3m of shore permafrost. Increasing land-shelf transport of carbon is expected. One consequence could be enhanced acidification of the ocean in this region.

For more detailed information on these activities please refer to the presentation titled *International collaboration in the East Siberian Shelf: present and future*, on the PAG website: <http://pag.arcticportal.org/>

2.5.2 Russian American Long-Term Census of the Arctic (RUSALCA) – The Russian Federation

Dr. Aleksey Ostrovskiy from the Russian Federation organization, Group Alliance, provided a thorough overview of the Russian role in the Russian-American Long-term Census of the Arctic (RUSALCA).

The acronym RUSALCA means “mermaid” in Russian. The program was developed between the Russian Federation and USA. At the end of the Cold War, many power structures fell, especially in the USSR. Old government-to-government agreements lapsed, and regulations crumbled. The US Department of Defense and other agencies took a leadership role in partnering with Russian Oceanographic Institutions to help facilitate collaborative Arctic Ocean research of benefit to both nations.

The two countries share the Pacific gateway to the Arctic. This gateway covers the area from just south of the Bering Strait to the largish area north of the Bering Strait and north of Russia and Alaska.

One of the biggest drivers of the RUSALCA program is the loss of sea ice cover. The main goals of the RUSALCA program are to:

1. Take observations where Arctic sea ice reduction is a maximum
2. Monitor fresh water, heat, nutrient fluxes, and transport pathways through the Pacific gateway
3. Monitor ecosystem indicators of climate change
4. Model and forecast changes in ecosystems and Arctic wide physical systems that impact global climate and ecosystem stability.
5. Improve Russian-US Arctic science relations
6. Explore the unknown Arctic

An umbrella coordination between the US and Russia exists, and has included new countries, such as Korea, Germany, Denmark, and Bermuda, along the way.

RUSALCA organization is based on bilateral agreements and employs a Private Public Partnerships (PPP) Company, “Group Alliance”, to manage its collaboration. Group Alliance is a private company based in Moscow. They have the ability to transcend and

neatly bypass traditional biases in terms of which research groups to be involved (like a neutral broker). Russian Agencies and Institutions involved are the Russian Academy of Sciences and Russian Navy Leadership, and Roshydromet and the Ministry of Natural Resources. US Agencies and Institutions are led by NOAA Leadership.

RUSALCA Russian Government Partners

Russian Academy of Sciences

- Shirshov Institute of Oceanology
- Zoological Institute
- Institute of Microbiology
- Pacific Oceanological Institute

Roshydromet

- Arctic and Antarctic Research Institute (AARI)
- FEHRI

Ministry of Defense

- Russian Federation Navy

Ministry of Natural Resources

- VNIIOkeangeologica

Ministry of Sciences

Foreign Ministry

RUSALCA US Partners

- NSF- Bering Strait Moorings
- NOAA funded (CPO, OER, NMFS)
 - CIFAR- University of Alaska
 - Smithsonian Institution
 - Pt. Stephens Research
 - University of Maryland
 - University of Washington
 - Woods Hole Oceanographic Institution
 - Bermuda Institution of Oceanography
 - Oregon State University
 - Additional Assistance by the Department of State and the US Coast Guard

Structure of Shipboard Operations

ROSHYDROMET: Captain, Crew, Scientists

RUSSIAN FEDERATION NAVY: Chief of Expedition

RUSALCA MISSION COORDINATORS: K. Crane USA; M. Zhdanov, A. Ostrovskiy, Russia

CHIEF SCIENTISTS: Terry Whitledge, University of Alaska Fairbanks, Rebecca Woodgate, University of Washington

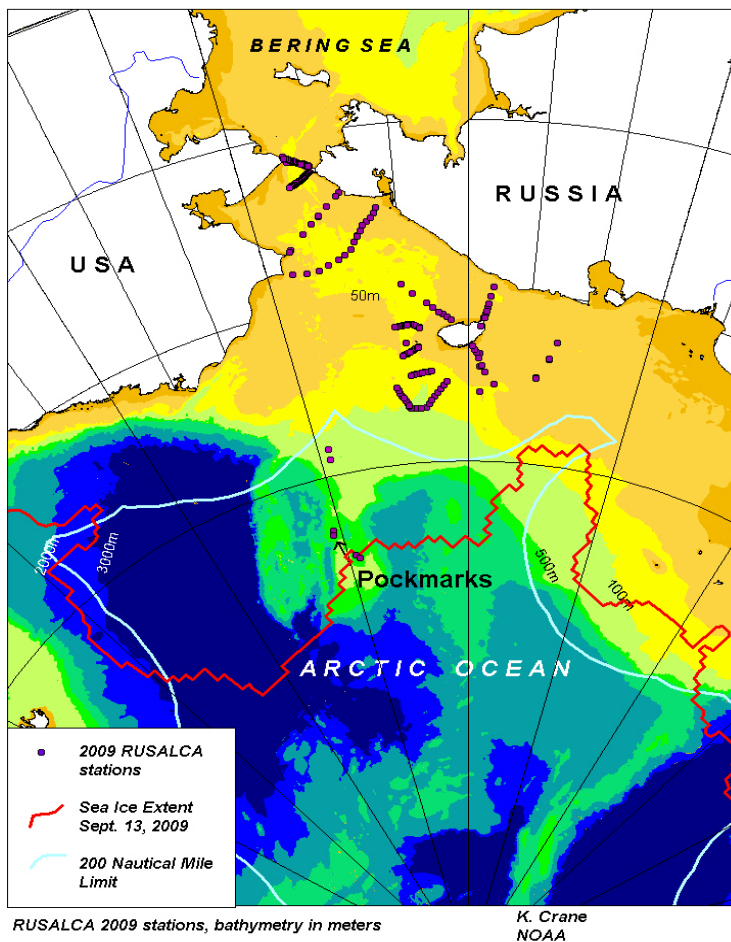
The scientific parties of RUSALCA missions consist of more than 50 scientists who have been funded by their own funding agencies:

- Russians – to the Russian Academy of Sciences
- US – to NOAA's, Arctic Research Program, Ocean Exploration & Research, and/or the National Science Foundation.

Most teams have both Russian and American Partners. The teams are:

- ocean acidification
- benthic and epibenthic census and processes
- zooplankton census
- biodiversity of fish and assessment
- nutrients and productivity
- physical and chemical oceanography (Bering Strait Fluxes)
- paleoceanography, geology, and seafloor-ocean fluxes
- seafloor permafrost stability
- methane
- marine mammal census

2009 Station Locations:



2.6 THE UNITED STATES

2.6.1 *Russian American Long-Term Census of the Arctic (RUSULCA) – The United States*

Following on the heels of Dr. Ostrovskiy's presentation on the organization and goals of the RUSULCA program, Dr. Kathleen Crane, of the US National Oceanic & Atmospheric Administration's (NOAA)'s Arctic Research Program gave an insightful overview of US-International observing in the Pacific Arctic, with a special emphasis on the RUSALCA program.

Rapid reduction of September sea ice extent has been observed since the 1950's, with the greatest decline to date observed in September 2007. Recent environmental changes in the Arctic are both large and rapid. Because of this there is general agreement in the international scientific community who study's Arctic climate change, that significant advancements in observations of Arctic environmental conditions are required.

To help address this, a US interagency Arctic Observing Network (AON) was created by the National Science Foundation (NSF) as a system of atmospheric, land- and ocean-based environmental monitoring capabilities--from ocean buoys to satellites--that will significantly advance our observations of Arctic environmental conditions. Data from the AON will enable the interagency US government initiative--the Study of Environmental Arctic Change (SEARCH)--to get a handle on the wide-ranging series of significant and rapid changes occurring in the Arctic.

As the lead agency for SEARCH and Interagency Arctic Research Policy Committee, NSF is working with the NOAA to identify current observing assets, assess future needs, and improve coordination among research and operational agencies.

NOAA's contribution to AON from 2002-2007 involved collaboration with Russia, Japan, China, Korea and Canada, and included such activities as:

- Methane-gas flux
- Arctic atmospheric observatories
- Long-term moorings
- Bering Strait moorings
- CTD's and ecological observations
- Ice buoy deployment
- Arctic Ocean exploration
- Fisheries surveys
- Tidewater level stations
- NWS buoys

The Bering and Chukchi Seas and the life within are thought to be particularly sensitive to global climate change because they are centers where steep thermohaline and nutrient gradients in the ocean coincide with steep thermal gradients in the atmosphere. The Bering Strait acts as the only Pacific gateway into and out of the Arctic Ocean and as such

is critical for the flux of heat between the Arctic and the rest of the world. Monitoring the flux of fresh and salt water as well as establishing benchmark information about the distribution and migration patterns of the life in these seas are also critical pieces of information needed prior to the placement of a climate-monitoring network in this region.

Twelve research proposals have been funded from 2004-2013 to support these goals in the Chukchi and Bering Sea's. As well, funds have gone toward The Bering Strait Mooring Observatory:

- Physical and chemical oceanography
- Observations of Seafloor fluxes, Carbon, CH₄ Observations of Atmospheric fluxes and contaminants
- Seafloor mapping and paleoceanography
- Benthic ecosystems observations
- Water column observations of biota
- Nutrients and Productivity
- Fish ecosystems
- Ice biology

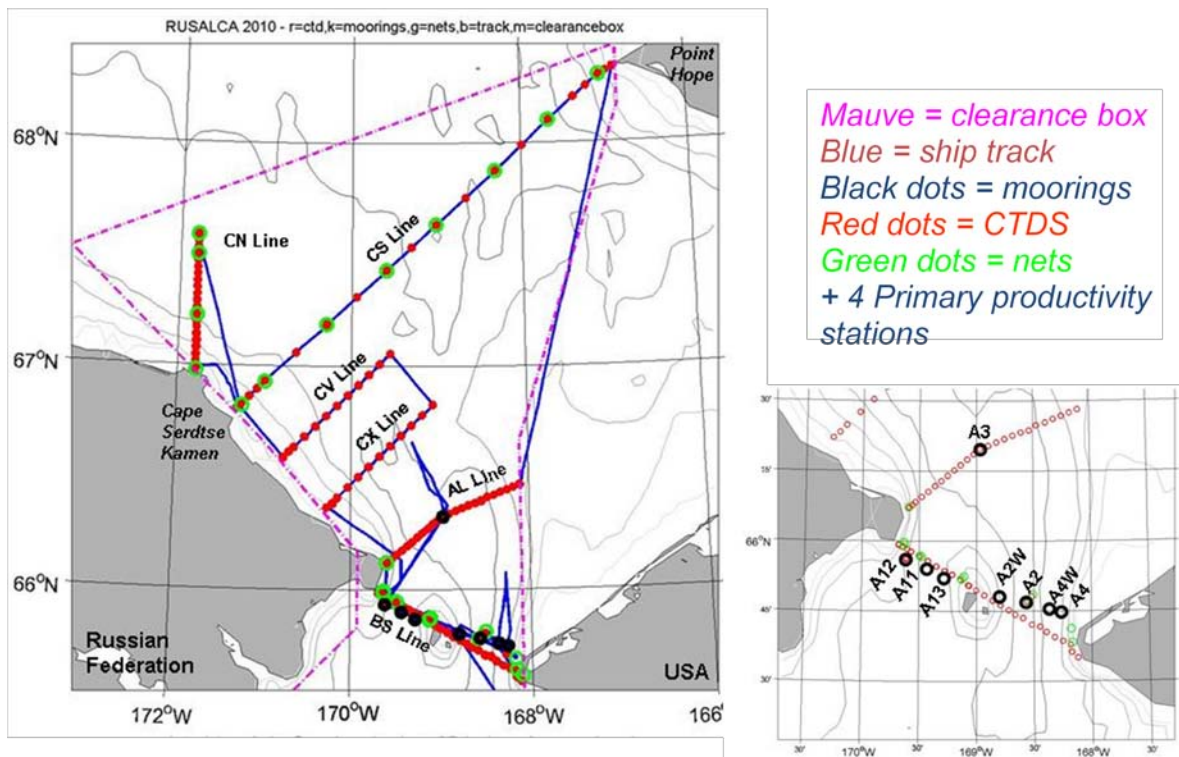
The Bering Strait Mooring Observatory is one of the most difficult programs to carry out due to political restraints between governments. Currently 8 moorings exist, with upper and lower sensors. They are also equipped with whale recorders, as well as pH and pCO₂ sensors.

These moorings help the scientific community better understand how the melt back of sea ice in the Pacific Arctic reflects flow pathways of different water masses, such as that observed in the Harold Canyon.

As well, these moorings have been used to link ice cover to ecosystem structure of benthic and pelagic species. In the Northern Bering and Chukchi Seas there is an abundance of sea ice, with a greater abundance of ice algae and less phyto- and zoo-plankton in the water column. Hence there is greater abundance of benthos to support demersal fish, diving ducks, walrus, gray whales, and bearded seals. Conversely, in the Southern Bering Sea there is limited sea ice, with a greater abundance of pelagic species and more phyto and zooplankton in the water column. Therefore there is greater abundance of pelagic species to support sea birds, pelagic fish, as well as bowhead and gray whales.

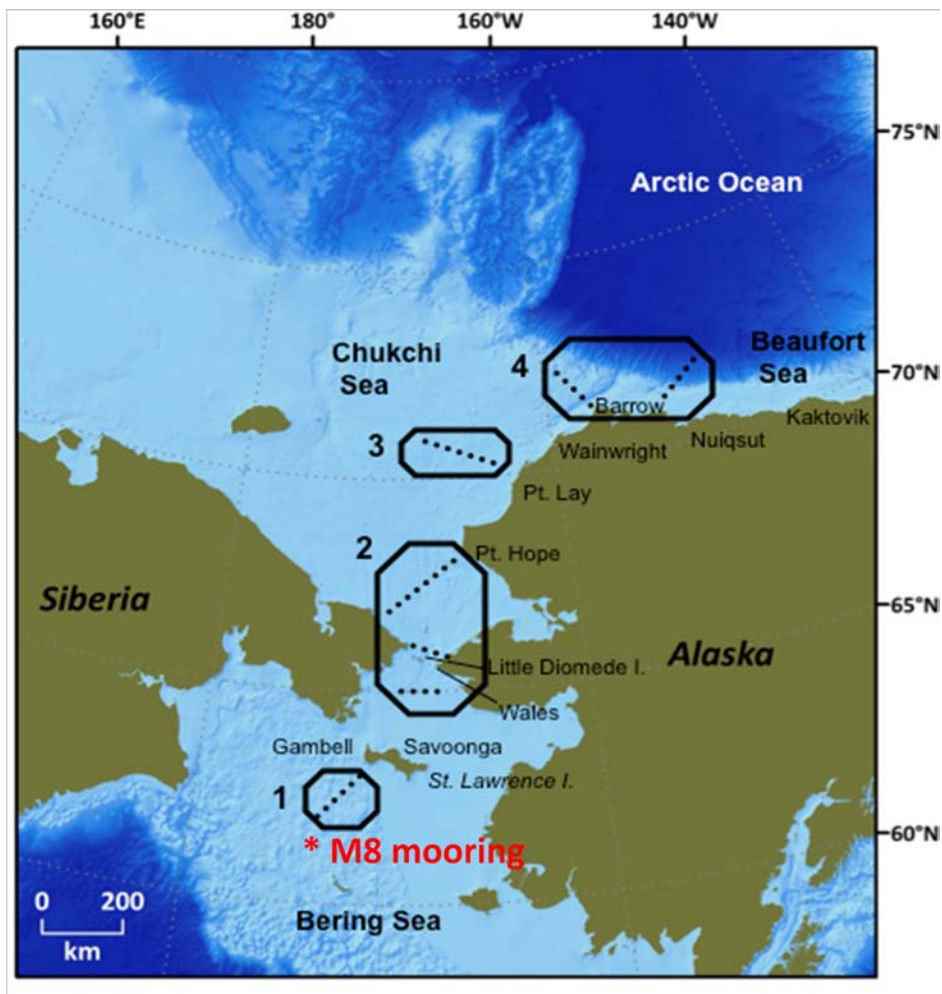
Physical and chemical changes in the ocean will have ecosystem consequences of importance, such as species migration and transport to new locations north.

RUSALCA 2010 Cruise Track, July 31-August 11, 2010:



2.6.2 Distributed Biological Observatory (DBO)

Dr. Jackie Grebmeier from the Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science presented an initiative underway within PAG to establish a DBO in the Pacific Arctic sector. She explained that although recent major changes in the physical domain of the Arctic are well documented, such as extreme retreats of summer sea ice since 2007, large uncertainties remain regarding potential responses in the biological domain. She noted that observed changes have occurred at both lower prey and higher trophic predator levels, including shifts in species ranges for zooplankton, benthos, and fish, and loss of sea ice as habitat and platform for marine mammal species. DBO aims to increase our understanding of potential ecosystem changes under further loss of sea ice. The DBO is focused on known regional “hotspot” locations along a latitudinal gradient from the northern Bering to the western Beaufort Seas. It is envisioned as a change detection array for the identification and consistent monitoring of biophysical responses in pivotal geographic areas that exhibit high productivity, biodiversity and rates of change. The proposed regions are the: 1) northern Bering Sea, 2) Bering Strait/SE Chukchi Sea, 3) Central Chukchi Sea, and 4) Barrow Arc, although other regions (such as the western Chukchi Sea, Chukchi Borderland and Canada Basin) are also future areas of DBO locations as international ship-access become more regular in occurrence.



A suite of primary standard station measurements are proposed for each of the DBO stations to be occupied by multiple international ships and dedicated national programs. Core standardized measurements include seawater temperature, salinity, chlorophyll and nutrients. Biological measurements would include biomass and composition of phytoplankton and zooplankton on an annual basis, biomass and composition of benthic fauna on a 1-3 year time basis, and seabird and marine mammal observations in transect mode during each cruise. A second tier of sampling would include fishery acoustics and bottom trawling surveys every 3-5 years. Multidisciplinary moorings and satellite observations at focused regional locations would also be encouraged.

During her presentation Dr. Grebmeier chose to first to discuss the *Benthic Ecosystem Response to Changing Ice Cover in the Bering Sea*, as part of the Bering Sea Ecosystem Study (BEST) program, funded by the US National Science Foundation and North Pacific Research Board.

The objectives were:

- To track spring production to benthos

- Understand carbon supply via sediment oxygen uptake rates
- Understand benthic infaunal population structure and biomass
- Implement a benthic camera for epifauna walrus-prey patch dynamics (BSIERP)
- Study sediment tracers (TOC, chl a, Be-7, grain size)

In 2010 there was a BEST (USCGC Polar Sea) cruise from March-April, along with other BEST interdisciplinary cruises on other ships.

Dr. Grebmeier also reviewed Canada's Three Oceans (C3O) program. The C3O program combines efforts by Canadian and US universities and government laboratories to monitor physical, biological and geochemical factors affecting changes in climate. Aboard, they collect data on distribution of physical, biological, geochemical parameters from the ocean water column along the ship's annual track from Victoria to its Arctic operations area as part of climate monitoring. In addition, plankton and benthic sampling occur at sites in the Bering Sea north and south of Bering Strait, including occupation of >20 yr time series studies for detecting ecosystem change. Longer-term integration of oceanographic change is reflected in many water column and sediment indices as well as changes in top predator populations (marine mammals, seabirds and fish).

Sampling includes:

- Daily water sampling and zooplankton collection stations on Pacific great circle transit
- Cross shelf water sampling sections south of Aleutians, in the southern Bering Sea and across the Bering Strait
- Stations in Bering and Chukchi Seas (max 300m) with water sampling, plankton nets and sediment sampling
- Underwater measurements for wildlife observations, weather, in-lab seawater system

Dr. Svein Vagle from the Institute of Ocean Sciences in Canada was the Chief Scientist for C3O aboard the CGCS Sir Wilfrid Laurier from July 6-21, 2010.

Next, Dr. Grebmeier provided an overview of an Ecological Study of the Benthos of the Chukchi Sea (COMIDA CAB), a set of Minerals Management Study (MMS) cruises. The objectives are to 1) conduct open-water baseline measurements of benthic chemical and biological resources, with specific focus on trophic structure and the potential for bio-accumulation of anthropogenic chemicals into food webs; and 2) examine the current spatial structure of the ecosystem to better understand the seasonal, inter-annual, and long-term climate change impacts on the ecosystem.

Project tasks include:

- Collect data on sediment chemistry and hydrocarbons
- Develop a conceptual food web model
- Examine the spatial variability in benthic biota

- Conduct geostatistical modeling

Dr. Grebmeier was the Chief Scientist on both 2009 and 2010 MMS cruises. They ran from:

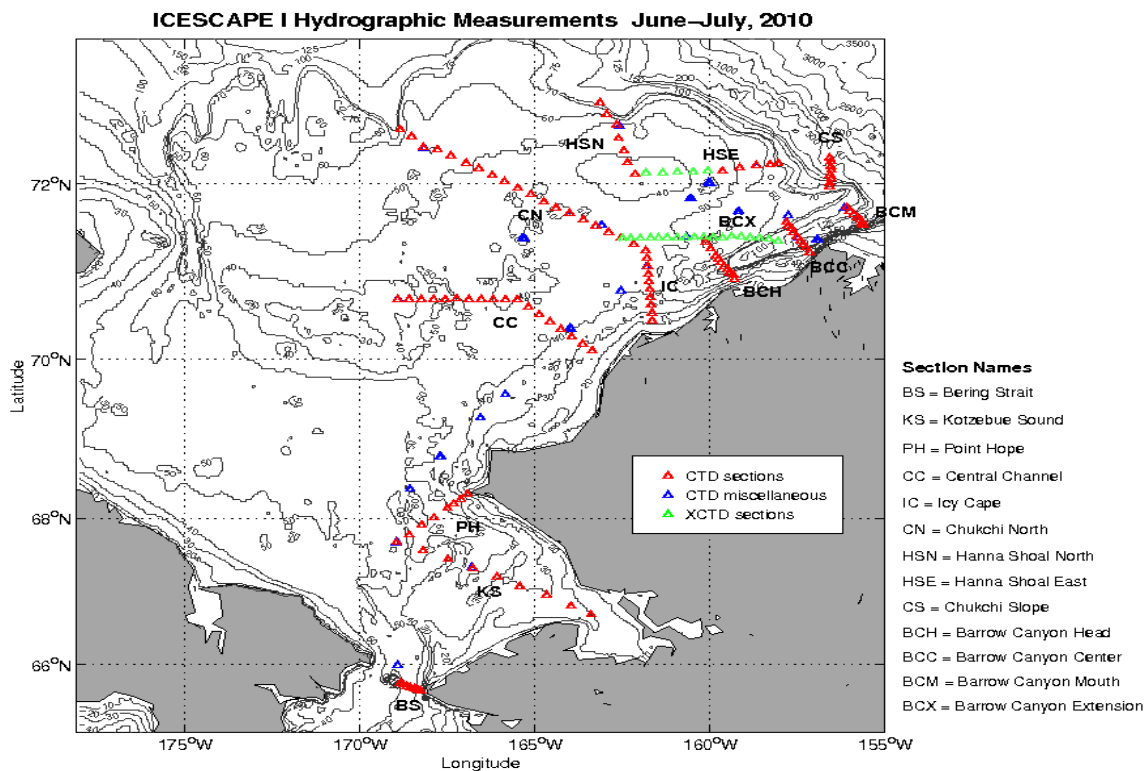
- July 24-August 12, 2009 MV Alpha Helix
- July 24-August 12, 2010 MV Moana Wave

Dr. Robert Pickart from Woods Hole Oceanographic Institute (WHOI) continued with a summary of 2010 DBO efforts, in the Chukchi and Beaufort Seas following Dr. Grebmeier's overview.

As an introduction, Dr. Pickart provided an overview of Pacific water inflow to the Arctic, through the Bering Strait, splitting in two directions: 1) veering left along the Russian coast, up and through Herald Canyon, and 2) veering right along the Alaskan coast, up and through Barrow Canyon. All three pathways meet again along the Alaskan coast, flowing around the Beaufort Sea.

Herald Canyon

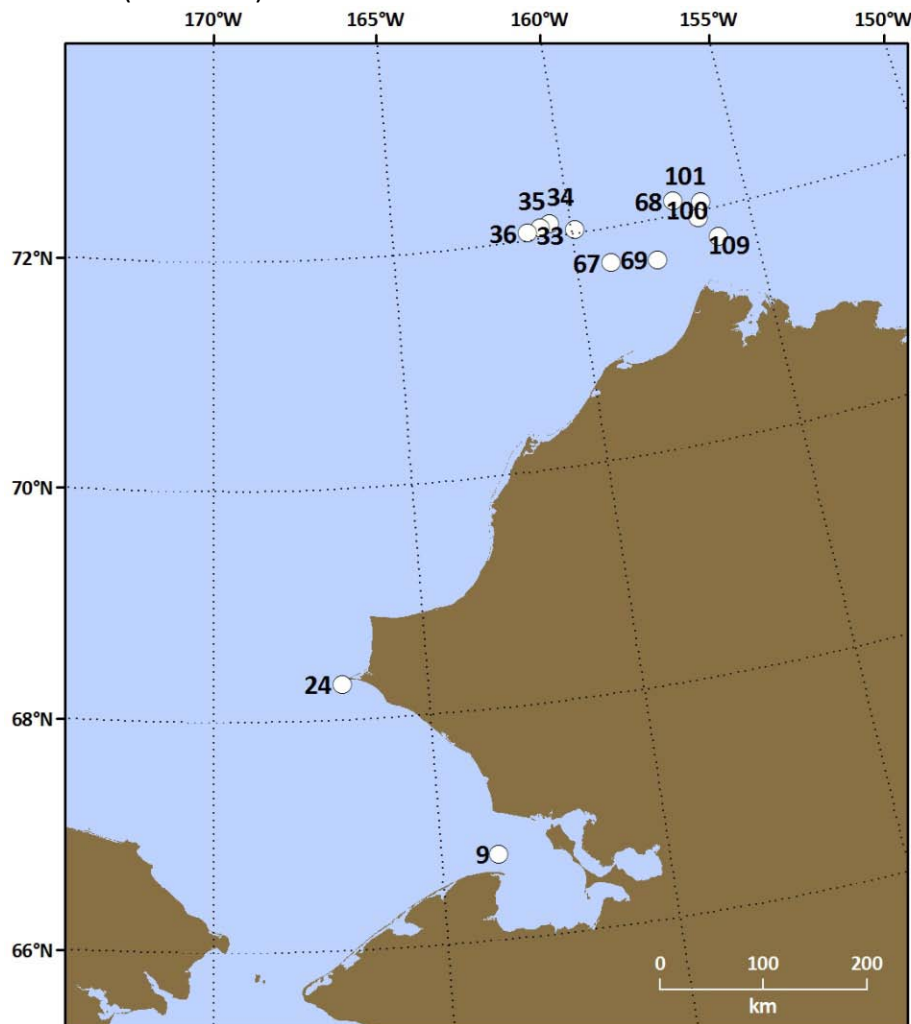
HLY1001 (ICESCAPE), a hydrographic study, investigated the impacts of climate on ecosystems and chemistry of the Arctic Pacific Environment.



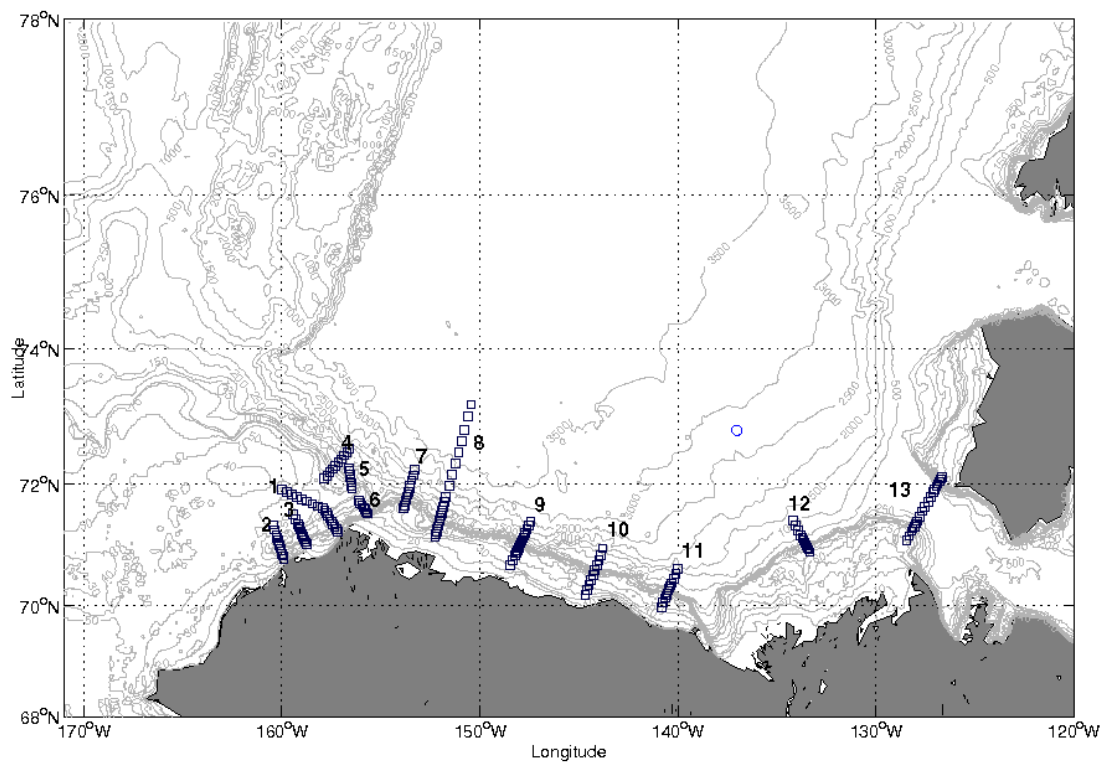
On the HY1001 (ICESCAPE) cruise, biological, chemical, and optical studies were conducted:

- Nutrients
- DIC and Alkalinity
- Chlorophyll a
- POC, POP, TPP, DOP, BSi, HPLC-pigments
- Algal physiology bio-assay experiments
- IOP and AOP (via small boat deployments)
- Microplankton assemblage composition
- aCDOM, TSM
- Bacterial Production
- CDOM absorption
- Biogeochemical cycling of dissolved organic matter

HL1001 (ICESCAPE) ice stations included:

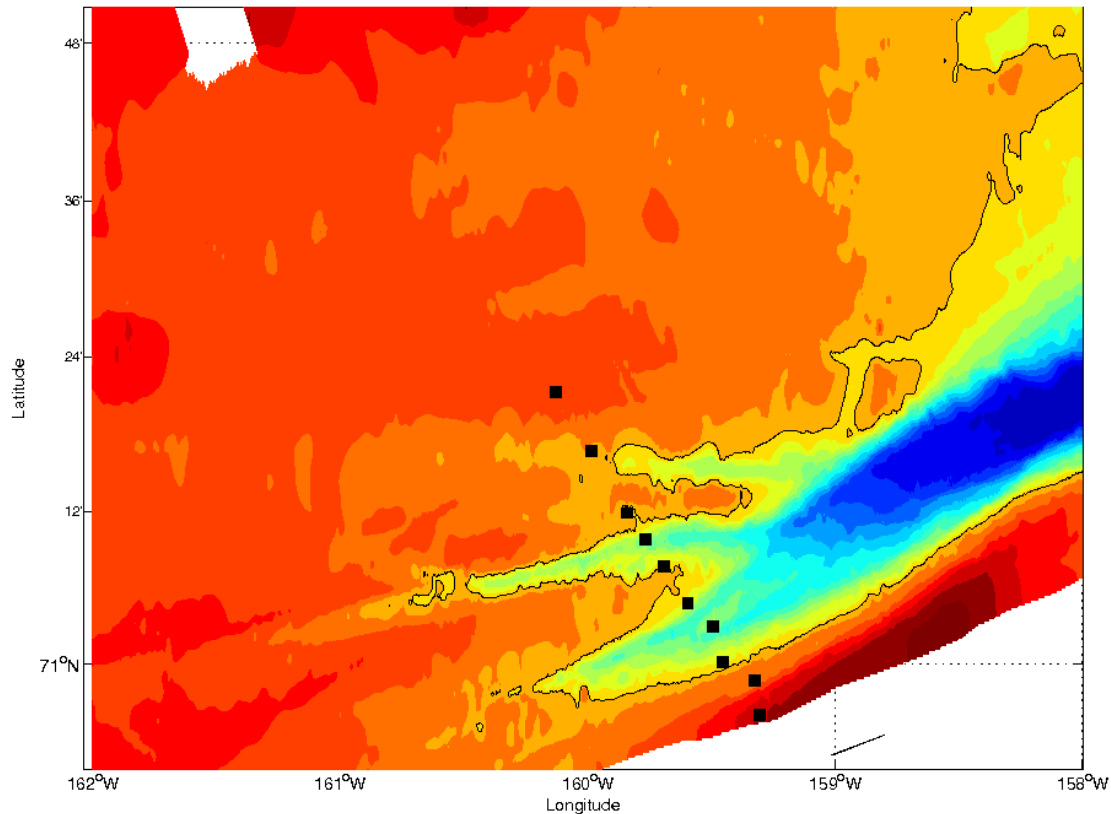


HLY1003 was an Arctic Observing Network (AON) study, assessing the Western Arctic boundary current and its role in the Arctic ecosystem and climate change.



Barrow Canyon

Dr. Pickart reviewed bathymetry in Barrow Canyon, taken from multi-beat data up to September 2010. He pointed out three branches of warmer water at the head of the Canyon, as well as a straight lined series of ten NASAICESCAPE stations spanning the length of branches.



A total of 39 moorings were deployed in the vicinity of Barrow Canyon in the summer of 2010. These included physical/chemical and marine mammal moorings. Institutions deploying these moorings include Hokkaido University (SIZONet), JAMSTEC, University of Alaska, Fairbanks (MMS), WHOI (NSF-AON), University of Washington (NSF-AON), WHOI (Bowfest), University of Washington (NOAA), NOAA (CHAOZ), and SCRIPPS.

Thoughts for 2011 and Beyond

The goal for 2011 will be to repeat 2010 DBO stations. Two Healy NASA/NSF cruises will take place in 2011. In addition there will be a continuation of the AON study, with similar studies though plans are in the works to add additional mooring arrays in gap areas at deep sill depths.

In 2012, additional mooring locations are need to add to the RUSALCA II September 2009 sampling stations, though there is still a need for a recovery platform in the summer of 2013.

2.6.3 Ice-Tethered Profiler (ITP)

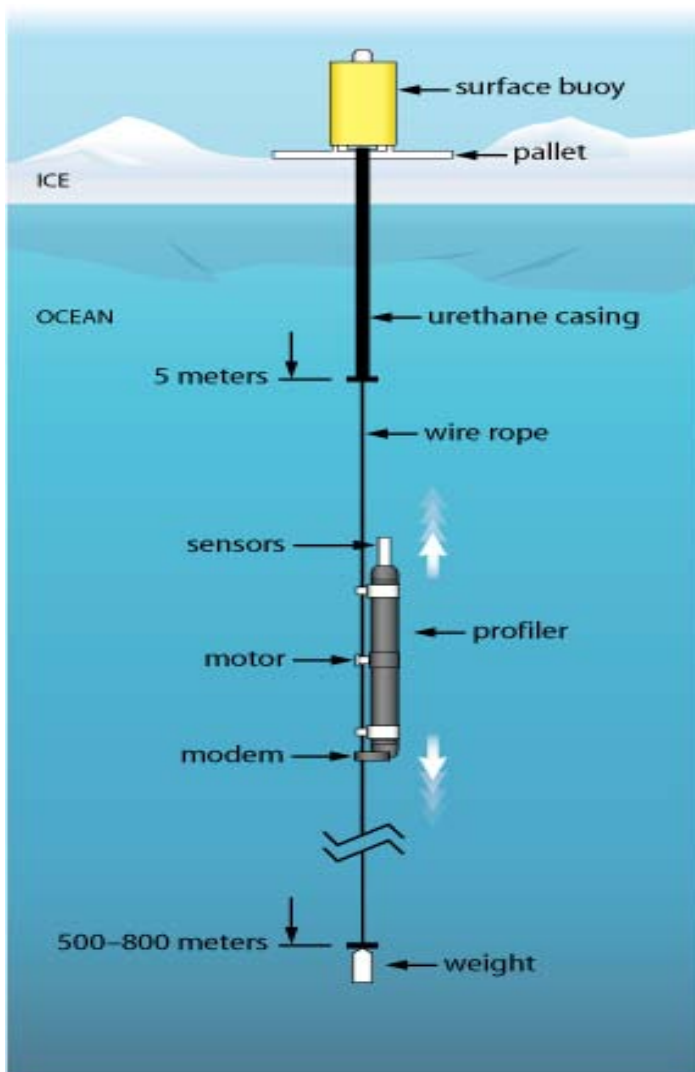
Dr. Rick Krishfeld from WHOI provided an insightful overview of the Ice-Tethered Profiler, an autonomous instrument for sustain observation of the Arctic Ocean.

Recent studies indicate that the Arctic may be both a sensitive indicator and an active agent of climate variability and change. While progress has been made in understanding the Arctic's coupled atmosphere-ice-ocean system, documentation of its evolution has been hindered by a sparse data archive. This observational gap represents a critical shortcoming of the 'global' ocean observing system. Addressing this gap, a new instrument, the 'Ice-Tethered Profiler' (ITP) was conceived to repeatedly sample the properties of the ice-covered Arctic Ocean at high vertical resolution over time periods of up to three years. Analogous to the international Argo float program that is employing autonomous profiling floats to return real-time seawater property data from the temperate oceans, Dr. Krishfeld's group is working together with fellow North American, European and Asian investigators to maintain a loose array of ITPs and other similar instruments throughout the ice-covered Arctic. They hope that the analysis of data from these instruments will lead to better understanding of the Arctic Ocean's response and role in global climate change.

The ITP system consists of a small surface capsule that sits atop an ice flow and supports a plastic-jacketed wire rope tether that extends through the ice and down into the ocean, ending with a weight (intended to keep the wire vertical). A cylindrical underwater instrument (in shape and size much like an Argo float) mounts on this tether and cycles vertically along it, carrying oceanographic sensors through the water column. Water property data are telemetered from the ITP to shore in near-real time.

Future modification could include the addition of sensors to monitor biogeochemically-relevant ocean properties such as dissolved oxygen levels, phytoplankton biomass, and dissolved organic matter concentrations.

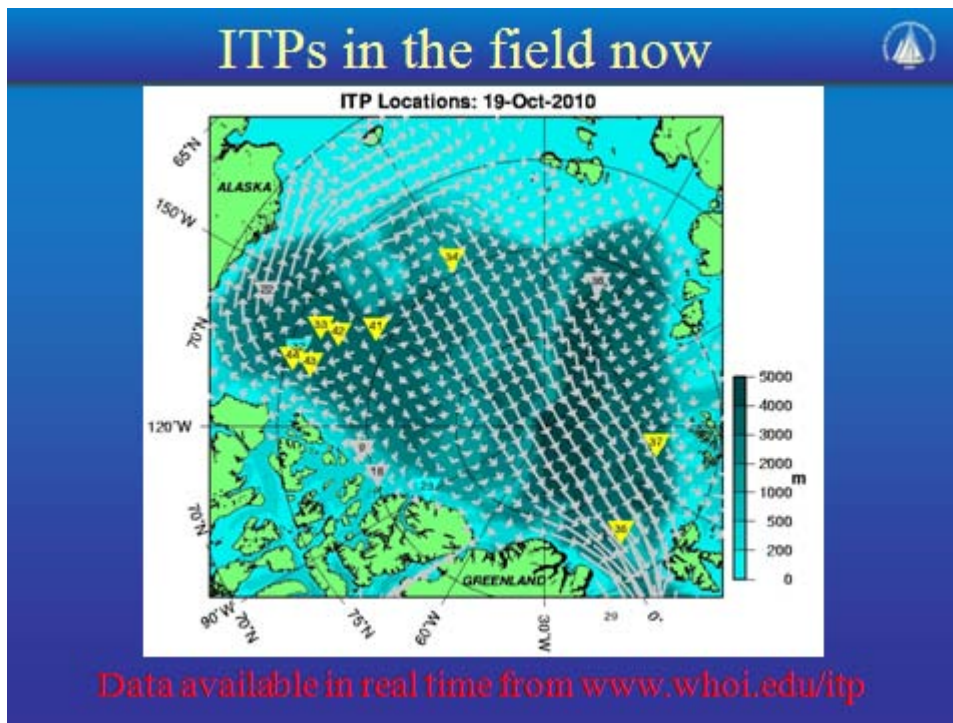
Ice-Tethered Profiler:



- Sensors: temperature, salinity and O2 now, prototypes with fluorometer, OBS, PAR, with a MAVS current probe.
- Data acquisition: 2-4 profiles per day between 10 and 760 m.
- Real-time data telemetry: Inductive modem profiler -> surface Iridium from surface -> lab
- Duration: 3 years (1.5 million meters)

Data from the ITP field is available in real time from www.whoi.edu/itp. As much as 17 months of data can be collected from one ITP. Deployment of ITP's can be done with relative ease. Scientists can be trained for deployment, making this technology cost-effective.

ITPs in the field now:



Status of the ITP Program:

- First prototype deployed August 2004 (from LSSL)
- 41 ITPs deployed in Arctic to date (22 from LSSL)
- 1 ITP deployed in Southern Ocean (Antarctica)
- 1 LMP (modified ITP) deployed in Crater Lake, Oregon
- 1 ITP to be deployed in McMurdo Sound, Antarctic in November.
- 6 complete ITPs recovered to date (all from LSSL)
- 3 partial ITPs recovered (1 by Des Groseilliers)
- Funded to build and deploy 6 ITPs in the Arctic per year through 2014.
- 2 LMPs to be deployed in Flathead Lake, Montana next year.
- Continuing to collaborate with other investigators to field and maintain an array of multi-sensor Ice-Based Observatories

The ITP Program would like further collaboration with the Asian vessels.

3.0 Pacific Arctic Region (PAR) Synthesis

Dr. Grebmeier presented an overview of the Pacific Arctic Region (PAR) Synthesis effort, which is a contribution of the PAG to the post-IPY legacy. PAG defines the Pacific sector of the Arctic as the marine area from the Northern Bering Sea into the Chukchi Sea and adjacent Seas, and extending into the deep basins of the Arctic Ocean, with model

boundaries from Aleutian Island and deep Bering Sea northward to the Canada Basin.

Objectives of the PAR Synthesis are to:

1. Present results from research, observation and modeling activities related to the PAG area, both retrospective and IPY efforts
2. Share information on current modeling activities covering the PAG synthesis area; work toward a shared modeling system
3. Identify status trends, and major new findings and understanding of state and processes in the PAG area
4. Using best available model projections, prepare hypotheses regarding the future evolution of the physics and biology of the region
5. Prepare scientific conclusions and recommendations to guide future PAG science activities
6. Specifically for the PAG region, identify critical marine components of a future Arctic Observing Network

While presenting the overview of the PAR Synthesis effort and objectives, Dr. Grebmeier also discussed elements of the PAR Syntheses that are important components for consideration. These include:

- The geographic area over which data is to be considered: Upstream (Bering Sea) to downstream (Chukchi Sea, portions East Siberian and Beaufort Sea, Canadian Arctic Archipelago, Arctic Ocean)
- The time period to be considered: Decades leading up to IPY, IPY, and build scenarios decades past IPY
- Science questions to be addressed by the synthesis and types of data to be included in the synthesis: Pacific-influenced Arctic system status and trends in atmosphere, sea ice, physical forcing, and biogeochemical/biological ecosystem response
- Linkage between observational data and modeling: Results from PAG Modeling/data fusion workshop and other chapters
- The products: Special book volume confirmed by Springer for PAG synthesis chapters; special science volumes: a) published Chinese Journal of Polar Science, b) in progress DSR (Wei-Jun Cai et al.), also likely post Oslo 2010
- The scope: Synthesis through workshops and invited participants
- Who the synthesis is endorsed by: IASC, AOSB, and the ICSU IPY project office as an IPY legacy effort

Many successes have come out of the PAR Synthesis workshops to date. A PAR Modeling Workshop held in Sanya, China, in January 2008 resulted in a special issue of Chinese Journal of Polar Science, Vol.9, 2008. Additionally, a PAR Biology Workshop held in May 2009 in Seattle, WA, USA resulted in a feature article for EOS (May 4 2010) and 2 chapters for the Springer book in progress). Furthermore, a PAR Marine Carbon Cycling Workshop held in June 2009 in Xiamen, China resulted in development of a special issue *Deep Sea-*

Research (in progress, Wei-Jun Cai *et al.*). More recently in 2010, two orals sessions focusing on ecosystem change in the Pacific Arctic in relation to the Pan-Arctic system took place, one at the AGU Ocean Sciences Meeting in February and the other at the International Polar Year Conference in Oslo in June. The anticipated target groups were disciplinary and interdisciplinary Arctic marine scientists, from physical, biogeochemical and biological oceanographers to higher trophic organism specialists, as well as climate and ecosystem modelers. In both sessions the rooms were filled to over capacity. Dr. Grebmeier provided an overview of the outline and status of the PAG Synthesis, with a special emphasis on Chapter 5, 8, 9, 11, 14, and 15 as examples.

Dr. Grebmeier presented an overview of the PAR Synthesis time line starting at its inception, with a special emphasis on upcoming dates and action items of importance. Chapter authors presented summaries at the IPY symposium in June 2010 in Oslo, Norway. A workshop was held for lead authors in Oslo, Norway on June 12, 2010 following the IPY conference. Chapters continue to arrive for peer-review, revision and final form. An executive summary (white paper) will be completed in fall 2011, with a publication by the end of 2011 (Springer PAG Synthesis Special Issue). Dr. Grebmeier will request a 2nd PAR synthesis special session during the 2012 IPY conference in Canada. Dr. Grebmeier suggested using the next Arctic Science Summit Week (ASSW) meeting in Seoul, Korea, March 28th – April 1st, 2011 as an opportunity to meet and discuss the status of the PAR Synthesis.

4.0 Arctic Marine Biodiversity Monitoring Plan (AMBMP)

Dr. Crane, Co-Chair of the Circumpolar Marine Biodiversity Monitoring Program (CBMP) Arctic Marine Biodiversity Monitoring Plan (AMBMP) provided a brief background and update of current status of the plan.

In August 2008 the CBMP activated a Marine Expert Monitoring Group (MEMG) to develop a marine integrated monitoring plan. The MEMG consisted of experts from Norway and the US (Co-leads), Canada, Russia, Greenland/Denmark, Iceland, Aleut International Association (AIA), Circumpolar Arctic Flora and Fauna (CAFF), Arctic Monitoring and Assessment Program (AMAP), and Protection of Arctic Marine Environment (PAME).

The goals of the MEMG are to promote, facilitate, coordinate and harmonize marine biodiversity monitoring activities among circumpolar countries, and to improve ongoing communication amongst and between scientists, community experts, managers and disciplines both inside and outside of the Arctic.

A background paper was produced on 2008, and two subsequent expert workshops were held in 2009 in Tromso, Norway, and Coral Gables, USA. The first and second drafts of the implementation plan were completed in January and June of 2010. The plan is now in the process of receiving Arctic Council endorsement and implementation.

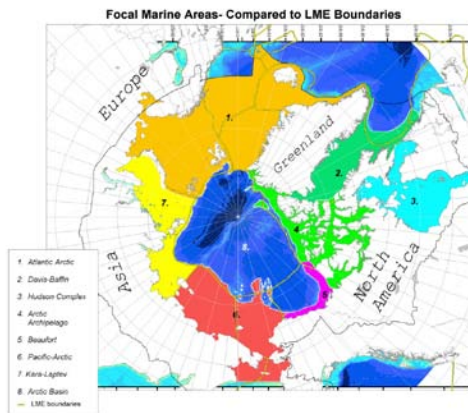
An overview of the Arctic Marine Areas (AMA's) was presented:



CIRCUMPOLAR BIODIVERSITY MONITORING PROGRAM



Arctic Marine Areas (AMA's)



The MEMG is made up of network groups (NG). These are Marine Mammals, Polar Bear Steering Group, Sea Birds, Fish, Plankton, Sea-ice Biota, and Benthos. Using a bathymetric map of the Arctic Ocean, Dr. Crane reviewed the sentinel stations for each NG.

There are AMBMP observations to be done in the PAR in relation to DBO. Core standardized ship-based sampling could be done. These include:

- CTD
- Chlorophyll
- Nutrients
- Ice algae/Phytoplankton (size, biomass and composition)
- Zooplankton (size, biomass and composition)
- Benthos (size, biomass and composition)
- Seabird (standard transects, no additional ship time)
- Marine mammal observations

The information collected from DBO would provide a “Change detection array”. The same measurements taken annually, with information processed in near real time (<6 months), regime shifts in rapid changes could be detected.

Other observations include second tier ship-based sampling:

- Fishery acoustics (less effort than standardized bottom trawling)
- Bottom trawling (every 3-5 years)

AMBMP mandates to report on trends in a timely and compelling manner, with data reporting focused on the “Art of the Possible”. There will be systems to facilitate improved access to existing biodiversity data. As well, there will be integrations of these data between disciplines. Data management support will be provided by participating countries. Support from the CAFF data manager will facilitate this by adoption of common data and metadata standards.

CBMP is in the process of creating a publically accessible efficient and transparent platform to house information on the status and trends in Arctic biodiversity. To do so they will have a web-based portal for distributed data management. Discipline nodes for input of data will be established. Each node will be supported by the CAFF data manager. CBMP will establish data entry interface. The database will be located at an organization of the expert’s choosing.

The start up phase for the implementation of the AMBMP is 2011-2015. Following this start up phase will be the integration of input from other ‘observer’ nations. Expert Discipline Networks supported by the nations will be established by the Marine Expert Monitoring Advisory Committee (MEMAC) (supported by nations).

Discipline Networks will establish “baselines” from historical data and aggregate existing Pan Arctic data sets (including those contributed by non-Arctic countries). Trends will be documented to determine natural variability (seasons, decades, etc.). Arctic wide maps of baselines and trends will be completed, as well as an update of AMAs as new information becomes available.

Discipline Networks will need to find co-located data or make an assessment of not co-located data, as well as address the seasonal variability to decadal variability.

The reporting timeline will be 2012, 2013, 2015 (to include participation of non-Arctic Nations), 2020, and 2025.

5.0 Sustained Arctic Observing Network (SAON)

Dr. John Calder from the US National Oceanic & Atmospheric Administration’s Arctic Research Program provided an insightful overview of the current status of The Sustained Arctic Observing Networks (SAON). Dr. Calder explained that SAON is a process that has been underway since early 2007. Its purpose is to support and strengthen the development of multinational engagement for sustained and coordinated pan-Arctic observing and data sharing systems that serve societal needs, particularly related to environmental, social, economic and cultural issues. SAON promotes the vision that users should have access to free, open and high quality data that will realize pan-Arctic and global value-added services and provide societal benefits. Its goal is to enhance Arctic-wide observing activities by facilitating partnerships and synergies among existing observing and data networks (“building blocks”), and promoting sharing and synthesis of

data and information. SAON itself will not undertake observations, archive data, or provide funds for these efforts, which will remain the responsibility of either the ongoing networks or the organizations that support them.

The history of development of SAON parallels the development of the International Polar Year 2007-2009. The scoping document for the IPY called for a legacy of sustained Arctic observing. The Arctic Council recognized its potential role in creating this legacy and included in its Salekhard Declaration (2006) the request for Arctic states and partners to work toward such a capability, leading to creation of the SAON Initiating Group (IG) and its report

After three large community workshops to explore the need for and scope of SAON, the IG agreed the proposed role of SAON was worthy and produced 4 recommendations:

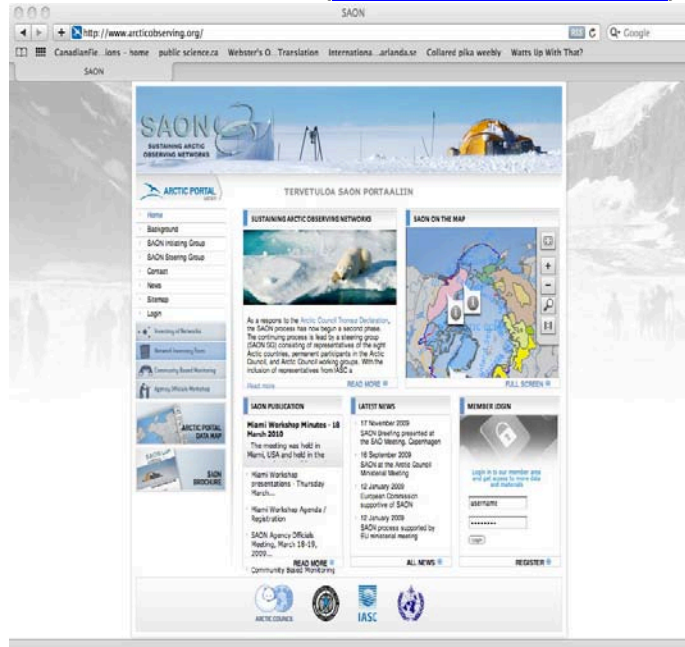
1. Arctic Council should take the lead role in further development of SAON;
2. AC member states should sustain and increase their efforts for Arctic observing and data management;
3. Each Arctic state should create a national inter-agency group to promote internal coordination and cooperation;
4. Arctic states should welcome non-Arctic states to take part in SAON.

The AC accepted the recommendations of the SAON IG and agreed to form the SAON Steering Group to carry things forward.

The Council reiterated its desire for international approach to sustained Arctic observing in the Council's Tromso Declaration (2009), which established a defined SAON Steering Group (SG) to guide the effort.

The SAON SG agreed on 5 priority actions:

1. Enhance SAON website (www.arcticobserving.org)



2. Prepare national inventory of on-going Arctic observing activities in the eight Arctic countries

- **All 8 Arctic countries have provided** an inventory of established networks and data archives.
 - Focus on long-term networks initially;
 - Information available on the SAON web site;
 - New and updated information will be added to this list on an ongoing basis;
 - Expand list to include other observing and data management activities.

3. Engage practitioners of community-based-monitoring and explore its role in SAON

- **Subgroup of SAON Steering Group** collected information on existing CBM and local/traditional knowledge activities;
- **Explore map-based registry** developed by ELOKA for SAON inventory and website;
- **Collaboration with the Inuit Circumpolar Council and Aleut International Association** and other indigenous people's organizations.

4. Engage officials of funding and implementing agencies to determine their views and priorities for SAON

- SAON-SG sponsored a workshop in Miami in March 2010 focused on defining benefits from and means to improve coordination and collaboration in funding and performing Arctic observations.
- SAON obtained the views and support of the many funding and implementing organizations that deal with observations on the Arctic region.

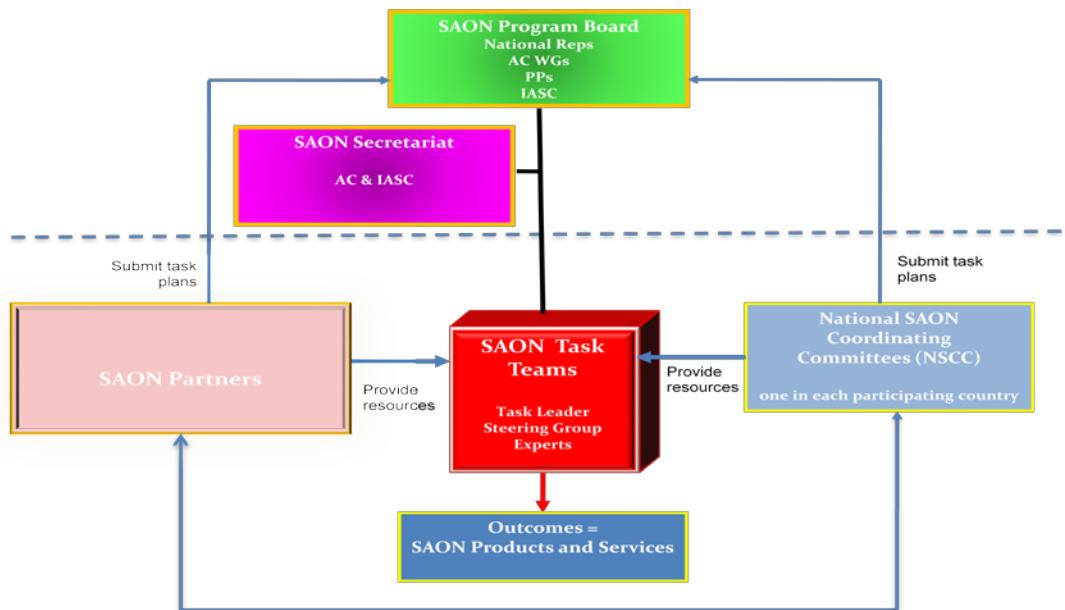
5. Engage the data management community to determine gaps and priorities for SAON consideration

- **IPY *State of Polar Data Report*** reviews current state of technology and support for discovering, accessing, and sharing polar/Arctic data;
- What **processes** should be used to design and implement the optimal (minimal?) system for single entry, Arctic-wide data discovery, access, and sharing?
- **SAON and IPY Data Management Committee hosted a joint workshop at Oslo IPY OSC in June 2010 to:**
- **Promote interoperability** of observing and data management systems and identify improvements;
- **Identify useful approach** for developing “union catalog” of data sets (e.g. Polar Information Commons, ICSU, CODATA Task Group, WMO Information System, etc).

Following discussions at the SAO meeting of April 2010 and at the Deputy Ministers Meeting of May 2010, the SAON Steering Group proposes that SAON undergo a transition from planning process to implementation. A key component of this proposal is that all countries are invited to participate in SAON on an equal basis.

Both the AC and the IASC will be asked to co-sponsor the implementation phase of SAON, which is proposed to be created outside of both the IASC and the AC, but operate with oversight from both.

AC and IASC will decide in spring 2011 on this proposal. Below is a proposed structure for SAON, which is currently awaiting approval by the AC.



5.1 SAON Initiative

Dr. Takashi Kikuchi of JAMSTEC, a partner of an important SAON Initiative, gave a presentation on the Arctic Ocean structure during the period of IPY.

The objective of the SAON initiative was to acquire available data from the Arctic Ocean during the IPY period, process the data, and assemble them into an integrated database. A number of datasets from the US and Russia have already been obtained, and all from those two countries are hypothetically available. Datasets in Japan, China, Sweden, Canada, Germany, and other countries, covering temperature, salinity, ocean velocity, and satellite SLH anomaly, are desired. The initiative also has five subtasks:

Subtask 1:

Compile complete metadata for each available dataset, convert them to a common format, if necessary, and post the metadata on the internet.

Subtask 2:

Acquire the original observational data in their final QC form, convert to a common format if necessary, and post the original observational data on the internet to make them available to the international science community. To demonstrate the value of the integrated dataset, a few initial products will be produced.

Subtask 3:

The integrated database will be used to produce mean temperature and salinity fields for the summer and winter period, using statistical and interpolation method.

Subtask 4:

The integrated database will be used to calculate characteristics and produce fields or patterns of the upper layer, halocline, Atlantic layer, and bottom layer.

Subtask 5:

The integrated metadata base will include search, filtering, and extracting software tools. It will also include the packages for downloading the T/S gridded 3D fields needed for numerical modeling and/or 4 dimensional data assimilation studies.

Dr. Kikuchi proposed that there be the development of an international metadata database for the period of IPY. To begin, he suggested that the database:

- Assemble in situ observations (T, S, velocity) from the open data sources: National and university data bases. Conduct preliminary analysis and QC of the in-situ observations.
- Assemble references for in-situ observations from the secured data sources.
- Assemble and pre-process the satellite observations of the sea surface temperature and sea surface height anomaly.

This project will result in the development of an oceanographic IPY metadata base that will include the major portion of the in-situ and satellite observations in the Arctic Ocean. The database will be available to the international scientific community.

Efficient search, filtering, extracting, and interpolation software will be an essential part of the database.

The metadata base will include the information and references for non-open data sources, which can be requested by potential users themselves.

Conventional analysis of the compiled database will result in the development of an Arctic Ocean 2007-2010 hydrographic atlas, which will include the maps of spatial distributions of T, S, and related oceanographic parameters as well as the patterns of these characteristics along the key transects.

6.0 THE NORTH PACIFIC MARINE SCIENCE ORGANIZATION TECHNICAL COMMITTEE ON MONITORING (PICES/MONITOR)

Dr. Hiroya Sugisaki of JAMTEC provided an overview of The North Pacific Marine Science Organization Technical Committee on Monitoring (PICES/MONITOR).

The objectives of the PICES/MONITOR technical committee are to:

1. Identify principal monitoring needs of the PICES region, and develop approaches to meet these needs, including training and capacity building;
2. Serve as a forum for coordination and development of inter-regional and international components of the North Pacific Ocean Observing Systems, including the GLOBAL Ocean Observing System, GOOS. Facilitate method development and inter-comparison workshops to promote calibration, standardization and harmonization of data sets;

3. Contribute to the development of the North Pacific Ecosystem Status Report, advising editors and lead authors on monitoring issues, identifying the need for particular time series and their continuities, the period on which they need to be updated for the FUTURE forecast products, and recommend to Science Board that they endorse the need to establish or maintain particular time series;
4. Recommend interim meetings to address monitoring needs and PICES–GOOS activities;
5. Provide annual reports to Science Board and the Secretariat on monitoring activities in relation to PICES;
6. Interact with TCODE on management issues of monitoring data

PICES membership consists of International Council for the Exploration of the Sea (ICES) and non-ICES countries. Members from ICES countries come from the Belgium, Canada, Denmark (including Greenland and Faroe Islands), Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Lithuania, the Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, the United Kingdom, and the United States of America. There are also numerous countries that have affiliate status with ICES. The Affiliate Countries are: Australia, Chile, Peru, and South Africa. Members from non-ICES countries come from China, Japan, and Korea.

Some examples of PICES activities include:

- The Alaska Ocean Observing System (AOOS)
- Fisheries monitoring stations
- Service awards (PICES Ocean Monitoring Service Award (POMA))
- Status reports (i.e., North Pacific Ecosystem Status Report II)

Ocean monitoring and observations are a critical component of the PICES program, particularly as they move forward in implementing their strategy in the FUTURE program. Achieving the goals of FUTURE requires that climate change, anthropogenic stressors, and ecosystem responses be measured systematically in appropriate monitoring systems. A major MONITOR requirement is to develop the necessary timely observation delivery system to support Status Reports, Outlooks, and Forecasts.

Several significant events have occurred in the last decade that influence how the ocean will be studied during FUTURE. First, is the emergence of new technologies for ocean observing since the CCCC program began. Second, the entrainment of the output of observing systems into data assimilating numerical models is placing greater demands on the availability of data from comprehensive observing systems and access to high-speed computers to run the models. It will be the responsibility of the PICES MONITOR Technical Committee and the Technical Committee on Data Exchange to review existing and planned monitoring systems and data management systems, including GOOS, and coordinate activities to incorporate the requirements of FUTURE in the implementation of these observing and data assimilation systems.

7.0 ASIAN FORUM FOR POLAR SCIENCES (AFoPS)

Dr. Jianfeng He of China provided a brief overview of the Asian Forum for Polar Science (AFoPS).

AFoPS started in 2003 and membership consists of China, Japan, Malaysia, India, Korea, as well as observer countries.

The objectives of AFoPS are:

- Recognizing the importance of international cooperation and aiming to serve the common interests in polar sciences, member countries work together
- To provide a foundation for cooperative research activities
- To present Asian achievements toward international polar communities
- To encourage Asian countries' involvements in polar research

AFoPS is organized consists of a Chairman (Japan → Korea → China → India), National Representatives, National Coordinators, Secretary, as well as Working Groups (Earth Science, Life Sciences, Planetary Sciences, Engineering and Logistics, as well as Public Relations & Data Management, respectively).

Major AFoPS activities include:

- Provide a forum to seek a common view on polar affairs among member countries
- Develop and support cooperative programs on polar research
- Convene joint symposia and workshops for polar sciences
- Support Asian countries to develop their national polar programs
- Produce joint publications on polar sciences

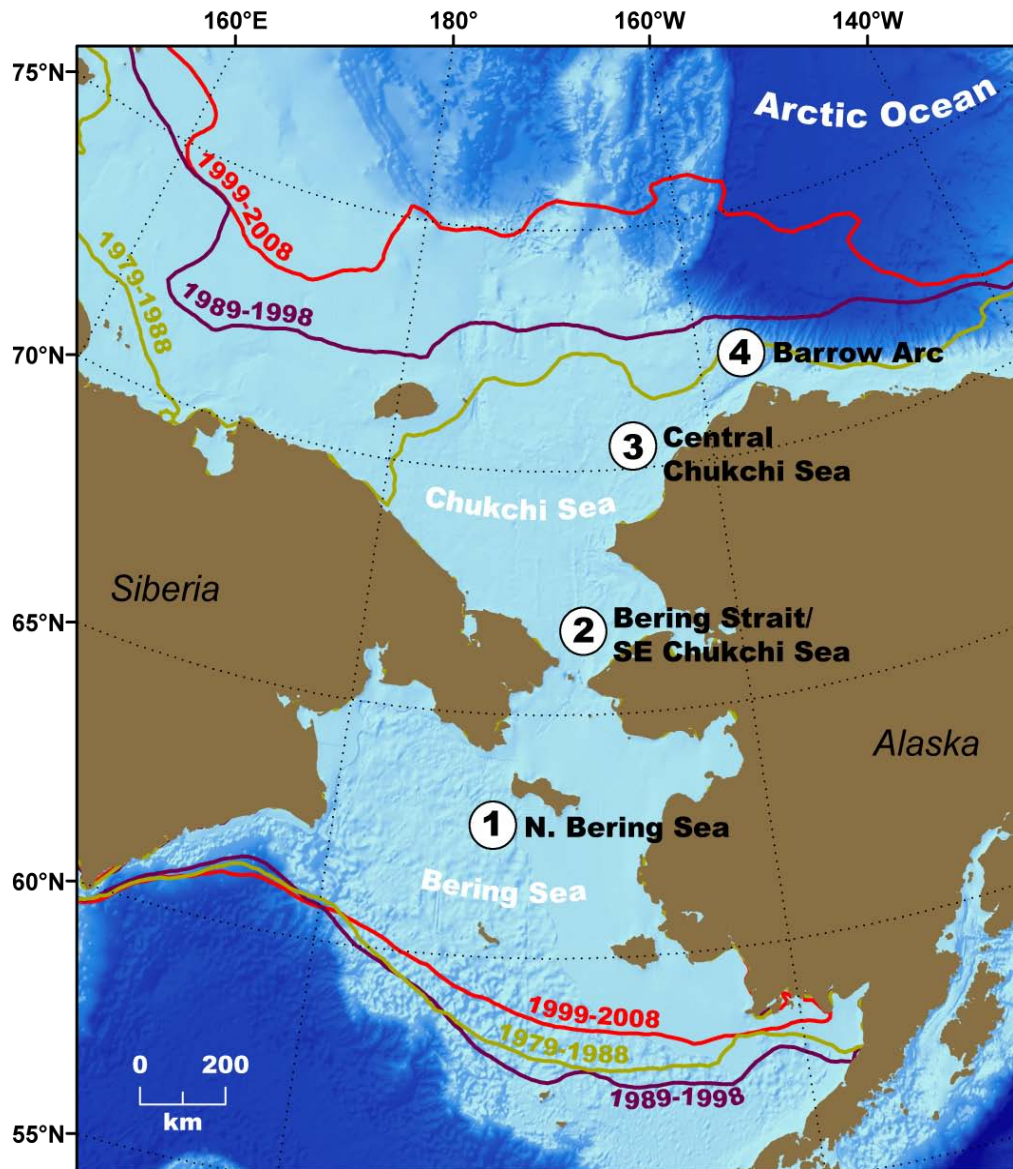
The most recent AFoPS forum took place in Suzhou, China on July 8-9, 2010. The next AFoPS forum will be held in India in 2011. For more information you may visit the following website: www.afops.org

8.0 DBO 2010 PILOT PROGRAM, DATA PLANS, & THE FUTURE

Dr. Grebmeier led a discussion on the DBO 2010 Pilot Program, Data Plans, and the Future. The goal of this section of the PAG meeting was to review the DBO concept (discussed in a previous section under DBO), discuss a summary matrix of the 2010 measurements for the pilot field program, review DBO data templates, discuss the concept of integrated databases and how it might be achieved, and discuss a possible joint analysis of data in the integrated databases.

The DBO will focus on four regional “hotspot” locations along a latitudinal gradient. These are regions that exhibit high productivity, biodiversity, and overall rates of change. The DBO will serve as a *change detection array* for the identification and consistent monitoring of biophysical responses.

Linking Physics and Biology: DBOs along longitudinal gradients:

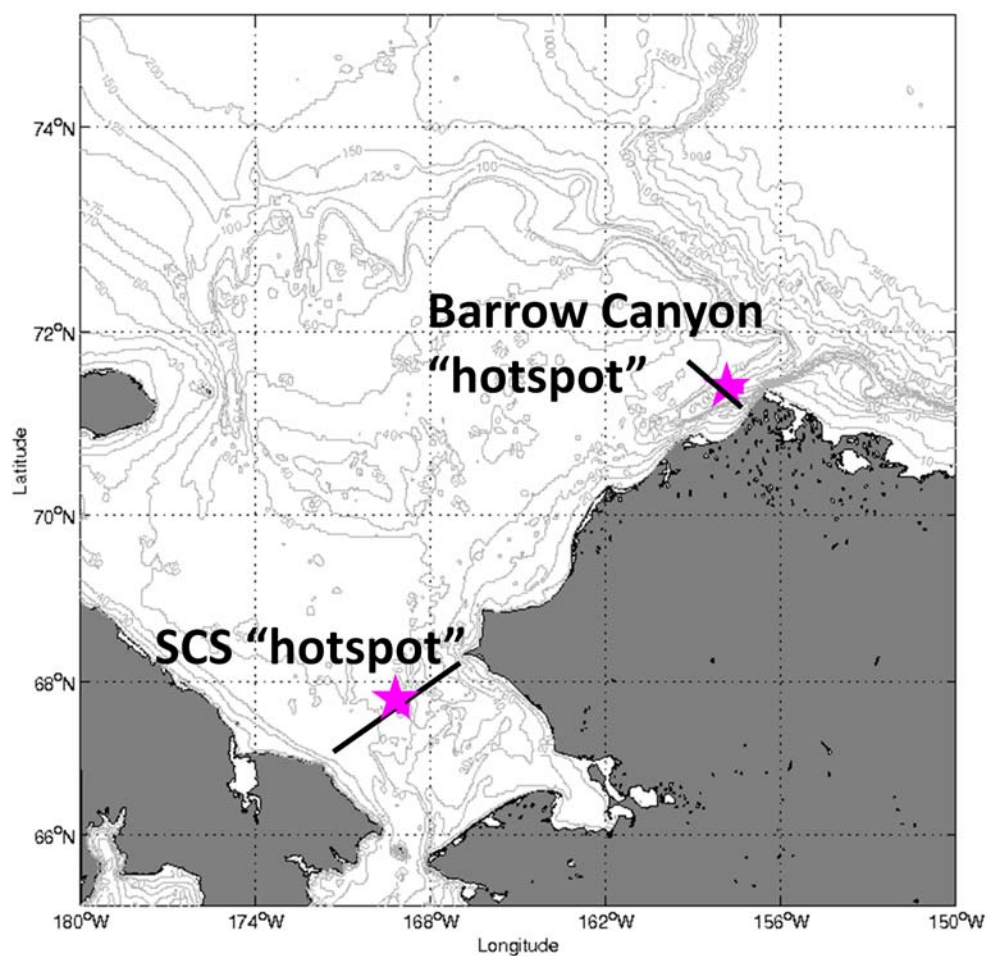


Dr. Grebmeier pointed out that DBOs are repeated oceanographic sampling stations of hydrographic and biological parameters with links to community-based ‘research partnerships’. The partnership integrates local knowledge about the environment into scientific observations, to build a network of local community involvement.

Based on SMMR and SSM/I satellite-derived sea ice concentrations (1979-2008), ice seasonality shifts at DBOs have been observed, with early spring sea ice retreat, and later fall ice formation. As well, based on SSM/I sea ice concentrations and the GlobColour

(SeaWiFS, MODIS, MERIS) satellite time series, shifts in sea ice persistence and Chl-a concentration has been observed, with less ice and more productivity.

DBO 2010 “Pilot” Season: International cruises to Pacific Arctic



<i>Vessel</i>	<i>Country</i>	<i>PI</i>
<i>Moana Wave</i>	<i>USA</i>	<i>Grebmeier</i>
<i>Xue Long</i>	<i>China</i>	<i>Zhao</i>
<i>Mirai</i>	<i>Japan</i>	<i>Itoh</i>
<i>Laurier</i>	<i>Canada</i>	<i>Fudge</i>
<i>Healy</i>	<i>USA</i>	<i>Arrigo</i>
<i>Healy</i>	<i>USA</i>	<i>Pickart</i>
<i>Annika Marie</i>	<i>USA</i>	<i>Ashjian</i>
<i>Khromov</i>	<i>USA & Russia</i>	<i>Woodgate</i>

The **VISION** for the DBO:

1. Core standardized ship-based sampling:
 - CTD
 - Chlorophyll
 - Nutrients
 - Ice algae/Phytoplankton (size, biomass and composition)
 - Zooplankton (size, biomass and composition)
 - Benthos (size, biomass and composition)
 - Seabird (standard transects, no additional ship time)
 - Marine mammal observations (no additional ship time)
2. “Change detection array” – same measurements every year, process information in near real time <6 months; detect regime shifts in rapid changes
3. Second tier ship-based sampling:
 - Fishery acoustics (less effort than standardized bottom trawling)
 - Bottom trawling (every 3-5 years)
4. Additional leveraged programs both domestic and international

There are rich benthic communities on the western side of the Bering and Chukchi Sea systems. Macrofaunal biomasses are evaluated, which provide a “foot print” for regions of high organic carbon deposition to the benthos as indicated by higher benthic biomass in the underlying sediments. The dominant benthic animal types in the sediments result from variations in food supply, sediment grain size and predator-prey interactions. The high bivalve, amphipod and polychaete regions provide food for higher trophic organisms, such as diving sea ducks, walrus, gray whales and demersal fishes.

8.1 DBO Barrow Canyon Line Pilot Study 2010

Dr. Pickard briefly reviewed the DBO Barrow Canyon Line Pilot Study 2010. There are many positives to conducting such a study:

- The concept can work! (6 cruises by 4 nations in 2010: Canada, China, Japan, and USA).
- Immediate data sharing is advantageous.
- The more occupations the better to help sort out seasonal versus interannual variability.
- The information can help with the interpretation of individual studies by providing temporal context.

Challenges:

- Requires coordination and commitment (e.g. might have had 8 occupations in 2010)
- Data quality and processing.
- Dedicated funding for incremental ship time, data processing, analysis.

8.2 DBO SE Chukchi Sea Line Pilot Study 2010

Note that 4 cruises by 4 nations occupied the SE Chukchi Sea line: Canada, China, USA and Russia during 2010 and those data are also being analyzed.

8.3 Draft DBO Data Templates:

1. DBO matrix, with highlight box to click to go to raw data and perhaps composite maps
2. Data templates:
 - a. T, S, CTD (cnv files)
 - b. Chemical parameters-see matrix (e.g., nutrients, DO)
 - c. Biological parameters-see matrix (e.g., chl, phyto, zoop, benthos ID, abundance, biomass, size)
3. Need examples templates
 - a. 2010 CTD data format: Bob Pickart (cvn files)
 - b. Masterstn file (Grebmeier)-separate file (xls)
 - c. Specific data files (need examples from different members)-jg example
 - d. Readme files as metadata (jg file)
4. Timeline for data for DBO use by countries?

Dr. Grebmeier led the group through an open discussion about DBO data templates following the outline of the template above. She pointed out that the DBO data matrix is a composite of various parameters and that it was important to have multiple data templates for individual disciplines. One idea is to have a matrix on the PAG site listing the data types and a link to the lead PIs for access to that data, thus a “virtual” data portal for the DBO. This concept will be discussed at the DBO workshop in Seoul, Korea on Mar. 27, 2011.

An important topic for future discussion is setting standard sampling types (net size, mesh and sieve size, as well as quality control and assurance of data analyses to compare data sets. This will also be a topic in Seoul.

8.4 ACTION ITEMS: Lessons Learned from 2010 & Ways Forward

1. ***Successful transfer of hydrographic data from one Chief Scientist to the next in DBO time field. There is a need to designate a group to analyze, publish, and present these results; also there is a need to coordinate biological measurement component; names:***

- Definition of the minimum datasets is needed (nutrient, velocity, hydrographic).
 - A suggestion was made that 2 small working groups be formulated:
 - Biology group – Jackie Grebmeier, Russ Hopcroft, Sue Moore, John Nelson, Ksenia Kosobokova, and Jiafeng He
 - Hydrographic group – Bob Pickart Motoyo Itoh
 - Start small (up to 6 people)
 - NAMES: Bob Pickart, Motoyo Itoh, Jia Wang
 - ACTION: Once roles are determined, Gillian Lichota will contact each person an email detailing his/her role.
- 2. *Continue to develop the DBO at latitudinal hotspot and transect sites. Continue to use international ship/science collaboration: Status of Grebmeier and Pickart as Chief Scientists?***
- There was general consensus among the participants that Dr. Grebmeier and Dr. Pickart will continue to be DBO Chief Scientists.
- 3. *Discuss the need for deep Canada Basin observatory (CBO) to track ongoing dramatic sea ice retreat, hydrography, freshwater loading, biochemical and biological response, need lead person or group people: Koji Shimada et al. to coordinate)***
- There was general agreement that there is a need for deep Canada Basin Observatories (CBO)
 - Koji Shimada agreed to lead the coordination of this effort
 - Dr. Koji Shimada and Dr. Kyung Ho Chung from KOPRI will write a white paper on the international, sustained, long-term collaboration of CBO
 - The suggestion was made that a biologist team up with Dr. Shimada to complete this task
 - There will be a need to specify zonal areas and measurements taken
 - There is a need for a long-term hydrographic section (greater than 5 years)
 - Sea ice dynamics is another important component that will need to be examined
 - Dr. Crane, Co-Chair of the AMBMP, presented an overhead graphic of plankton sentinel stations proposed by Canada for the Canadian Basin.
- 4. *Suggestion: Need physical, biochemical and biological international data synthesis activities leading to presentations and publications at:***
- March 27 PAG/IASC MWG-AOSB workshop, Seoul, Korea-provide interim report
 - March 28 PAG/IASC MWG-AOSB joint meeting, Seoul, Korea: updates on DBO and other plans 2011, status DBO data analyses, including publication plans
 - March 29-31 ASSW2011 Science symposium: submit abstracts for DBO data presentations on focused DBO results: all components

- 5. *Suggestion: Each country should send Gillian Lichota names/contact information for people in country working with data sets to initiate joint synthesis activities***

9.0 PAG BUSINESS

Dr. Calder lead a discussion related to the joint PAG/AOSB DBO workshop to be held in Seoul, Korea on March 27-28th, 2011 prior to the start of ASSW.

A review of the provisional agenda was discussed. *Please see the provisional agenda.* Anyone with comments on the provisional agenda was encouraged to contact Sara Bowden, Executive Officer of IASC/AOSB, and/or Gillian Lichota, Executive Secretary of PAG.

The meeting on the 27th will function as a DBO workshop. The meeting will be open and everyone is invited to attend. Invited guests from Alaska will be attending to provide input on community-based-monitoring. An AICC document was just released for scientists on how to engage with communities. Dr. Grebmeier will provide this for everyone and it will be place on the PAG website.

There will be a joint AOSB/PAG dinner on the 27th. More information will be provided by Gillian Lichota as the date approaches.

There will be no PAG-related business meeting or country reporting on the 28th due to the limited time allotted for the meeting. Instead there will be topical discussions. More detailed information will be provided at the start of the New Year.

9.1 Officers

An election of new Officers will be held in April of 2012 during the ASSW meeting in Canada. At that time, the PAG Secretariat might move to a new location. Dr. John Calder will remain the Chair of PAG, and Gillian Lichota will remain the PAG Executive Secretary until spring of 2012.

9.2 Website & Other Communication Needs

A concerted effort is needed to update and reshape the face of the PAG website. Gillian Lichota plans to place this endeavor as a priority for 2011. She will work with the web management team in Iceland to accomplish this task.

9.3 Links to Other Groups

PAG has links to other groups such as IASC, AFOPS, and PICES, to name a few. Of concern is how PAG should be represented on the IASC Marine Working Group (MWG/AOSB). A suggestion was made and accepted by the group, that PAG should encourage participation of MWG/AOSB members at meetings to encourage cross-over discussions and to strengthen relationships and collaboration. This will be a topic of discussion at the joint

PAG/IASC MWG AOSB meeting on the afternoon of the 28th, prior to the start of ASSW in Korea.

9.4 Schedule of Future PAG Meetings

- KOREA –March 27-28th, 2011 prior to the start of Arctic Science Summit Week (ASSW) in Seoul, Korea.
- CANADA – Dr. Bob Fudge and Gillian Lichota will work together to plan a fall 2011 PAG meeting in Western Canada, at the Institute for Ocean Sciences, in Sydney, British Columbia. A tentative timeframe for this meeting will be mid-late November (14-19, 2011).
- CANADA - April 2012 ASSW / 2012 International Polar Year (IPY) Conference in Montreal

10.0 APPENDIX

2010 PACIFIC ARCTIC GROUP PARTICIPANTS

TOKYO, JAPAN

DECEMBER 10-11, 2010



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