4th SHELF-BASIN INTERACTIONS (SBI) PAN-ARCTIC MEETING

"Shelf-Basin Exchange at the Margins of the Arctic: IPY and Beyond"

26-29 September, 2006
Sopot, Poland

Sponsored by the U.S. National Science Foundation Arctic System Science Program, SBI Project Office

and

Institute of Oceanology Polish Academy of Sciences

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Goals of the 4th Shelf-Basin Interactions (SBI) Pan-Arctic Meeting

"Shelf-Basin Exchange at the Margins of the Arctic: IPY and Beyond"

The U.S. Western Arctic Shelf-Basin Interactions (SBI) Project Office and the Institute of Oceanology of the Polish Academy of Sciences (IOPAS) are pleased to co-sponsor the 4th Shelf-Basin Interactions Pan-Arctic Meeting to be held in Sopot, Poland, 26-29 September 2006. The meeting will be held at the Hotel Haffner, Sopot, Poland, with special events at the nearby IOPAS facility. The goal of the SBI Pan-Arctic meetings is to encourage open discussion of Arctic science in a forum that will foster international collaboration on topics relevant "to providing a clear understanding of the physical and biogeochemical connections between the Arctic shelves, slopes and deep basin. That understanding will in turn allow realistic assessment both of the potential responses of the Arctic system to global change, and of the role of these interactive processes on the global system" (SBI Science Plan, 1998; http://sbi.utk.edu).

The challenge to the 2006 meeting participants is to evaluate and coordinate developing circum-arctic studies of Shelf-Basin Exchange (SBE) for both the upcoming International Polar Year (IPY) 2007-2008 and development of longer-term collaborative international efforts as planned under the umbrella of the International Study of Arctic Change (ISAC), Study of Environmental Arctic Change (SEARCH), and the International Conference on Arctic Research Planning (ICARP) II Working Group 5 (Arctic margins and gateways) science plan. To this end, the 4th SBI Pan-Arctic Meeting will focus on two sub-themes:

1) Evaluation of ongoing and planned circum-Arctic shelf-basin exchange and boundary current studies as part of the "ARCTIC SNAPSHOT" approach developed for the IPY (see http://sbi.utk.edu/InternationalPolarYear.htm), and
2) Coordination of short-term SBE IPY implementation planning activities with proposed longer-term efforts to better evaluate pan-Arctic margin and gateways dynamics and environmental change (see http://www.icarp.de/).

INSTITUTE OF OCEANOLOGY
POLISH ACADEMY OF SCIENCES

Agenda for the 4th SBI Pan-Arctic Meeting 26-29 Sept. 2006, Sopot, Poland
"Shelf-Basin Exchange at the Margins of the Arctic: IPY and Beyond"

Sun./Mon. 24/25-arrival to Sopot, Poland
Monday: Sept. 25:
1330-1700-AOSB SBE/ICARP working group meeting, at IOPAS, 1900-dinner
1700-1800-Pan-Arctic meeting registration outside Sopot Hall (Kim Harmon)

Tuesday: Sept. 26-Plenary: Shelf-Basin Exchange and Arctic Change (Sopot Hall)
morning

0730-0830:	Registration outside of Sopot Hall (Kim Harmon)
0830-0840	Welcome to Sopot: Prof. Stanislaw Massel, Director IOPAS
0840-0845	Local logistics: Jan Piechura/IOPAS
0845-0900	Goals of meeting and agenda: Jackie Grebmeier (USA)
0900-0930:	Wieslaw Maslowski-Modeling shelf-basin exchanges critical to Pan-Arctic
0930-1000:	Leif Anderson-Arctic Ocean Shelf – Basin Interaction, Evidence of an Active Continental Shelf CO_2 Pump
1000-1030:	Break
1030-1100:	Koji Shimada-The year before IPY – What is going onin the Pacific sector of the Arctic Ocean?
1130-1200:	Vladimir Ivanov-Four Years of NABOS Operation: What is Done and What is Next?
1200-1330:	Lunch at Polish Institute of Oceanology (IOPAS), set up posters

afternoon

1330-1400	Ursula Schauer-Warmer Atlantic Water in the Eurasian Basin-Does It Affect Shelf/Basin Exchange?
1400-1430	Jan Piechura- Recent Warming of the Atlantic Water and Its Possible Reflection in Shelf-Basin Exchange
1430-1500	Sue Moore-Arctic Marine Mammals as Sentinels and Icons
1500-1530	Break
1530-1700	***Poster presentation overview: 5 minutes (2 slides)***
	Irina Repina-Air-Ice Interaction Observations in the Arctic Seas
	Jinping Zhao-Core region of Arctic Oscillation and the Main Atmospheric Events Impacted on Arctic
	Finlo Robert Cottier- Capturing Arctic Shelf Processes: 4 years of linked physical and Biogeochemical Sampling Using a Moored Array in Svalbard (a UK-Nordic co-operation)
	Vladimir Ivanov-Shelf-Basin Water Exchanged Triggered by Dense Water Cascading
	Jackie Clement Kinney-On the Processes Affecting Shelf-Basin Exchange in the Bering Sea
	Stephen Okkonen-Shelf/Slope Hydrography Near Barrow, Alaska: Summers 2005 and 2006
	Victoria Hill-1-Primary Productivity in the Eastern Chukchi Sea and 2-The Impact of Absorption of light by Coloured dissolved organic material on the heating budget of Arctic shelf seas
	Carin Ashjian-Transport of Plankton and Particles between the Chukchi and Beaufort Seas
	Jeremy Mathis-Eddy Transport of Organic Carbon and Nutrients from the Chukchi Shelf: Impact on the Upper Halocline of the Western Arctic Ocean
	Marit Reigstad – Does Phaocystis spp. Contribute Significantly to Vertical Export of Organic Carbon?

Karol Kulinski-Biogeochemical Fluxes in the Arctic Front Zone
Ilona Goszczko-Volume, Heat and Salt Exchange through the Storfjordrenna
Ksenia Kosobokova-Regional Variations of the Zooplankton Composition and Quantitative Distribution in the Eastern Arctic Ocean
Agata Zaborska- Sediment Burial Processes in an Arctic Marginal Sea
Lee Cooper-Sedimentation and Water Column Indicators of Organic Carbon Processing in the northern Bering and Chukchi Seas
Jackie Grebmeier-1. Ecosystem Dynamics and Shelf-Basin Exchange on the Arctic Margins of the Northern Bering and Chukchi Seas, 2. Jim Moore: UCAR SBE Data Management
Eddy Carmack-1. COME: The Canadian Ocean Monitoring Experiment-A Proposed IPY Effort; 2. CAME: The Canadian Arctic Margin Expedition-A Proposed IPY Effort; 3. Food Webs And Physical-Biological Coupling on Pan-Arctic Shelves: Concepts and Perspectives (Jackie Grebmeier-brief slide overview)

1730-1830 Poster session at IOPAS (5 minute walk from hotel); also available during lunch periods
1840-1900 Transport from IOPAS to forest for Reception/BBQ
1900-2130 Reception/BBQ in forest outside Sopot
2130- Return to hotel

Wednesday: Sept. 27, Sopot Hall

morning *SBE and IPY*
0800-0830 Registration in front of Sopot Hall (Kim Harmon)
0830-0900 Jackie Grebmeier-U.S. International Polar Year Activities and the Shelf-Basin Exchange (SBE) "Arctic Snapshot"
0900-0930 Paul Wassmann-IPY and SBE relevant oceanographic activities in Norway: an overview on conditionally supported and planned projects
0930-1000 Heide Marie Kassens-Germany and IPY
1000-1030 Break
1030-1100 Terry Whitledge-Russian-American Long-term Census of the Arctic (RUSALCA) 2004-2006: Looking Toward IPY 2008
1100-1130 Jinping Zhao-Chinese Action Plan for Arctic Expedition during and after IPY
1130-1200 Martin Fortier-Canada SBE and IPY
1200-1300 Lunch at IOPAS
1300-1500 Departure (1300) to Malbork Castle, walking tour
1500-1700 Explore Malbork Castle/tour
1730-2030 Dinner at the Malbork Castle restaurant
2030-2200 Return to hotel

Thursday: Sept. 28

morning **International programs**
0830-1000 Plenary Panel: IASC, ICARP and IPY: how do we utilize international organizations and focus to enhance network of shelf-basin exchange studies during and after IPY?
-Jackie Grebmeier (SBE, Working Group=WG5 for ICARP2)-moderator
-Vladimir Ivanov (MAOOS)
-Heide Kassens (SBE, WG6)
-Ksenia Kosokobokova (WG5)
-Wieslaw Maslowski (SBE, WG5, WG6)
-Sue Moore (WG5, affiliate WG6)
-Marit Reigstad (WG5)
-Ursula Schauer (WG5)

	-Koji Shimada (SBE, WG5)
	-Paul Wassmann (SBE, WG6)
	-Terry Whitledge (US-Russia RUSALCA)
	-Jinping Zhao (SBE and WG6)
	-Martin Fortier (SBE)
1000-1030	Break
1030-1200	Continuation of panel and audience discussion: what needs to be done internationally to move forward development of a coordinated IPY pan-Arctic network for SBE and boundary current studies
1200-1330	Lunch at IOPAS
1330-1500	Break out groups-assignment: How do we take short-term SBE IPY implementation planning activities and develop them into a longer-term ICARP efforts to better evaluate pan-Arctic margin/gateway dynamics and environmental change?
1500-1530	Break
1530-1700	Continue break out groups: Need to identify 2-3 focused, doable projects related to shelf-basin exchange, gateway flow, and boundary currents to move our efforts forward?
1700	End of day, dinner on own

Friday: September 29-Sopot Hall

Morning

0830-1000	Reports by breakout groups and further plenary discussion of issues
1000-1030	Break
1030-1200	Final summary of 4th pan-Arctic meeting and future plans (Grebmeier), open discussions
1200	Meeting ends

PLENARY SPEAKER EXTENDED ABSTRACTS

POSTER PRESENTER ABSTRACTS

ARCTIC OCEAN SHELF – BASIN INTERACTION, EVIDENCE OF AN ACTIVE CONTINENTAL SHELF CO_2 PUMP

Leif G Anderson, *Dept. of Chemistry, Göteborg University, SE-412 96 Göteborg, Sweden, leifand@chem.gu.se*

Please contact author for access to abstract.

CANADA SBE AND IPY

Martin Fortier, *University Laval, Quebec City,QC, Canada*

U.S. INTERNATIONAL POLAR YEAR ACTIVITIES AND THE SHELF-BASIN EXCHANGE (SBE) "ARCTIC SNAPSHOT"

Jackie M. Grebmeier, *Department of Ecology and Evolutionary Biology, The University of Tennessee, Knoxville, TN 37932, USA,* jgrebmei@utk.edu

The Arctic Ocean continental margins are the key transformation zone between the shelf and deep basin regions, acting as a dynamic boundary for cross-slope shelf-basin exchange. The margins play a major role in the ventilation of the deep basins by transporting dense, brine-enriched shelf waters and associated organic and inorganic carbon to abyssal depths and into the North Atlantic. From the pan-Arctic perspective, the margins are the main avenues for boundary current transport and the overall large-scale ocean mechanism that transports heat, salt, fresh water, biogeochemical properties and sediments around the Arctic Ocean. The international Shelf-Basin Exchange (SBE) working group is located within the International Polar Year (IPY)-endorsed cluster "integrated Arctic Ocean Observing System (iAOOS)". SBE is sponsored by the Arctic Ocean Sciences Board (AOSB) and WCRP Climate and Cryosphere program. It envisions a coordinated research effort through a framework of time-series moorings situated on radial circum-arctic SBE transect lines, linked to coordinated international process studies in the water column and in the sediments (Fig. 1).

The SBE project has been developed through extensive planning with an overall objective of illuminating the connectivity between

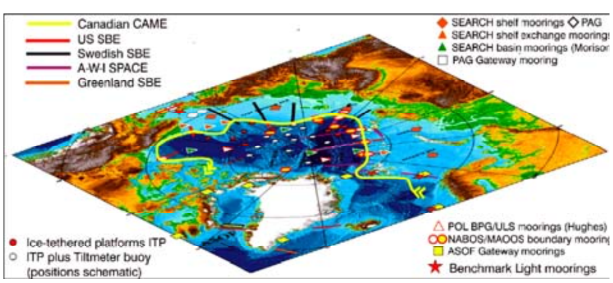

Fig. 1. Map illustrating the integration of CAME (yellow line) with other iAOOS activities, including SBE, various sponsored moorings (shelf-to-basin and gateways) (from Dickson 2006).

physical forcing and ecosystem response at the continental margins in a changing Arctic. The combination of atmospheric, ice, oceanographic and biological measurements proposed as part of the iAOOS, with an emphasis on physical-to-biological influences within the circum-Arctic SBE program, will produce an "Arctic Snapshot" of key parameters influencing the Arctic ecosystem. Ultimately, this coordinated network of sampling and sensor emplacement will provide a legacy for the IPY 2007-2009 intensive field efforts. The projects coordinated through the SBE network will enable collaborative, standardized measurements with a circum-arctic geographical distribution, including many planned international projects, including:

CAME (Canadian Arctic Margin Expedition) and COME (Canadian Ocean Monitoring Experiment), both led by Dr. Eddy Carmack, Canada

CFL (Canadian Flaw Lead Polynya) project, led by Dave Barber, Canada

JPAC (Joint Pacific Arctic Climate Study), led by Koji Shimada, Japan

MAOOS (Mooring-based Arctic Ocean Observational System), led by Igor Polyakov, USA/Russia

Nordic LSBI (Nordic Land-Shelf-Basin Interactions), led by Leif Anderson, Sweden under the Norway iAOOS "Closing the Loop" project (lead: Cecilie Mauritzen)

Russian American Long-term Census of Marine Life in the Arctic (RUSALCA), led by Terry Whitledge, USA

SPACE (Synoptic Pan-Arctic Climate and Environment Study), led by Ursula Schauer, Germany

US-SBE (US-Shelf Basin Exchange), led by Jackie Grebmeier, USA

All are funded or pending IPY projects that are either being mounted under the SBE umbrella or have scientific affiliation with SBE objectives.

International science planning as part of the coordinated ICARP II (International Conference on Arctic Research Planning II) Working Group (WG) 5 identified key scientific objectives for study at the Arctic margins and gateways during IPY (Grebmeier et al. 2006). Specific to the IPY period and over the next decade, this international community-generated science plan outlines a general time-frame and direction for time-series oceanographic sections and moorings as part of a circumarctic effort to provide continuity for scientific measurements and international collaboration during IPY and beyond. These data will substantially improve our understanding of margin processes and their influence on the coupled geo-bio-physical system both regionally and within a pan-Arctic context.

An education component is also planned to coordinate teacher immersion in research opportunities with educational payoffs. SBE is a critical part of the ICARP II WG5 and we expect that results from the international SBE transect lines will be used within circum-arctic modeling studies for a better understanding of the Arctic Ocean margin system and its variability over time.

International SBE within iAOOS
The overall research plan of the international SBE network is to make standard measurements at the shelf-break, both during IPY (IPY SBE Expression of Interest and beyond (ICARP II WG5 report-Grebmeier et al. 2006; also see http://sbi.utk.edu/InternationalPolarYear.htm).

Specifically, the international SBE plan will:
1. Carry out synoptic pan-Arctic ice and ocean surveys focused on the physical, chemical and biological dynamics of the shelf break and margin to provide information required to properly model key forcing processes at the margins. These cooperating programs, pan-Arctic in scale, will be coordinated under the iAOOS umbrella and in coordination with other international SBE projects.

2. Undertake a standard suite of sediment measurements as part of a coordinated survey of circumpolar shelf-break and slope sediments to evaluate records of shelf-to-interior ocean exchange recorded in the sediments and benthic communities, and assist in the development of models that can properly reproduce and assimilate past and modern observations in order to place future change into context by providing field data.

U.S. SBE Component
A system-scale observation network is required to describe the Arctic Ocean circulation, ice cover, and ecosystem in order to predict its variability and future change. Focused studies at the margins of the Arctic Ocean, and a pan-Arctic framework that includes ocean observation capabilities in the Bering Strait region, have been recommended as important elements in this network (National Research Council [NRC], 2006). Within the SEARCH (Study of Environmental Arctic Change) Implementation Planning effort shelf-slope, ship-based oceanographic sections were also identified as important for marine observational efforts (SEARCH 2005). The proposed U.S. SBE component would occupy three transect lines in an observational mode, of which one-two lines become time-series transects within the SEARCH and COME programs (Fig. 2).

The internationally coordinated effort is designed to simultaneously undertake hydrographic and process oceanographic measurements on parameters appropriate for observations of physical-to-biological system variables throughout the Arctic Ocean during the IPY period and beyond.

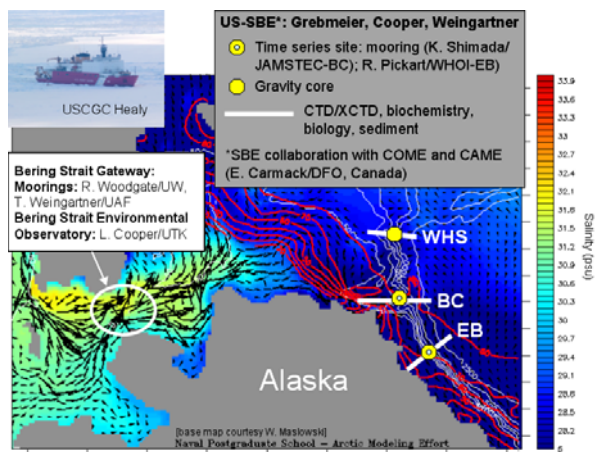

Fig. 2. Schematic of proposed US-SBE field work on the USCGC *Healy*. Transect lines in white are identified as West Hanna Shoal (WHS), Barrow Canyon (BC), and East Barrow (EB). Slope moorings are currently in place on the BC line (K. Shimada, pers. comm.) and EB line (R. Pickart, pers. comm.), with a biochemical-enhanced mooring being proposed during IPY for the EB line.

The US-SBE project will focuses on 3 of the 6 themes identified by the US National Committee (USNC), specifically:

1. Determine *environmental status* by studying spatial and temporal variability,
2. Quantify past and present *environmental and human change*, and
3. Advance understanding of *polar-global teleconnections.* (NRC, 2004).

Within the six USNC observational goals, four have relevancy to US-SBE activities within the iAOOS planning process: 1. Produce a synoptic set of multidisciplinary observations to establish the *status* of the polar environment, 2. Acquire key data sets to understand *factors controlling change* in the polar environment, 3. Establish a legacy of *multidisciplinary observational networks*, and 4. Launch *internationally coordinated, multidisciplinary expeditions* into new scientific frontiers.

International mooring arrays

A series of mooring arrays focused at the shelf break band around the Arctic and in the gateways will yield essential time series studies of physical, biochemical and biological parameters. Standardized measurements (e.g., temperature, salinity, velocity, oxygen, ice thickness, nutrients, fluorescence, and transmissivity, and if feasible, sediment traps, near-bottom benthic sensors, and profiling mixed layer biochemical measurement sensors) will form the "backbone" to the pan-Arctic evaluation. In the Chukchi and Beaufort Seas these moorings are planned for Barrow Canyon (Koji Shimada, pers. comm.). East Barrow (R. Pickart) and Herald Canyon (proposed to NOAA-RUSALCA in 2007 by PI Weingartner in Herald Canyon and by Igor Polyakov for the basin north of Herald Canyon in 2007 and 2008). In addition, Igor Polyakov maintains a suite of moorings along the slope in the Russian Arctic (NABOS/MAOSS) and Leif Anderson (Nordic LSBI/Sweden) has a pending national IPY proposal to extend that collaboration by initiating SBE transect lines from the Laptev to the western Chukchi Sea, all in Russian waters.

Modeling Collaboration

As part of the SBE and ICARPII WG5 planning, modeling efforts (e.g., process-specific, coupled biophysical regional and pan-Arctic models) were identified as essential to synthesize past and current data to extrapolate the "Arctic Snapshot" for the pan-Arctic SBE effort during IPY so that it is practical to evaluate present and future scenarios of Arctic change. Modeling efforts will be required as synthesis tools for understanding the multi-scale observations to be made and to enable scenario building and prediction of climate change impacts on shelf-basin and gateway exchanges.

Data Archiving and Management

Both the SEARCH and ICSU IPY planning documents provide guidelines for data submission and sharing and coincident poster describes a potential scheme for this (see Moore and Grebmeier poster).

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Dickson, B. (2006). The integrated Arctic Ocean Observing System (iAOOS): an AOSB-CliC observing plan for the International Polar Year. *Oceanologica,* 48 (1), 5-21.
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Acknowledgements. This presentation is a summary of the SBE and ICARPII WG5 committee members discussions. We would like to thank the Arctic Ocean Science Board and the ICARP leadership for their support of this international community effort.

FOUR YEARS OF NABOS OPERATION: WHAT IS DONE AND WHAT IS NEXT?

Vladimir Ivanov, *Igor Plolyakov and Igor Dmitrenko International Arctic Research Center, University of Alaska, Fairbanks, AK, 99775 USA; vivanov@iarc.uaf.edu*

NABOS (Nansen and Amundsen Basins Observational System) is one of the major International Arctic Research Center (IARC, University of Alaska) initiatives. NABOS is a large-scale long-term project launched in 2002. This project is aimed on providing a quantitative, observationally based assessment of circulation, water mass transformations, and their temporal variability along the principal pathways transporting water from the Nordic Seas into the central Arctic Basin. The basic approach is to get continuous time series of water properties in specific locations along the Eurasian continental slope. The measurements in the water column are carried out at autonomous anchored moorings, operating for one year at a time, with replacement every year. Most of moorings are equipped with McLane Mooring Profiler (MMP). Located along the major pathways of water, heat, and salt transport, the moorings capture climatically important changes in oceanic conditions. Within four years, the number of moorings increased and the geographical coverage of monitoring extended. Having started from a single mooring at the Laptev Sea slope in 2002, there are now four deep-water moorings (three in the Laptev Sea and one at the northern Barents Sea slope) and two shallow-water moorings. Seven deep-water and three shallow-water moorings are going to be deployed during the 2006 field season. Among the most striking results provided by the NABOS moorings is the rapid warming of Atlantic origin water (about 0.8 deg. C over the climate mean) detected at the Laptev Sea slope in February 2004. Joint analysis of the NABOS data together with the temperature time series from Fram Strait and Svinoy section complemented by CTD sections data from around the Arctic Ocean allowed tracing the origin of this temperature anomaly in the Nordic Seas and its propagation along the Siberian continental slope. Under the stimulus of the International Polar Year (2007–09), IARC proposed a coordinated large-scale Mooring-based Arctic Ocean Observational System, thus calling for extended international cooperation. Our intention is to strengthen existent cooperative links with the other observational programs (e.g. SEARCH, DAMOCLES etc.), and institutions (AARI, AWI, IOS etc.) and to establish new ones in order to advance in understanding and prediction of the Arctic climate system.

GERMANY AND IPY

Heidi Maire Kassens, *Kiel University, Kiel, Germany*

MODELING SHELF-BASIN EXCHANGES CRITICAL TO PAN-ARCTIC

Wieslaw Maslowski, *Naval Postgraduate School, Monterey, CA, USA*

The Arctic Ocean operates on three basic principles. First, it receives the heat and buoyancy fluxes from the atmosphere at the surface and from lower latitude oceans via northward advection of water mass and properties. The communication with the lower latitude oceans is limited by narrow and/or shallow passages, such as Bering, Denmark, Fram straits, Barents and Chukchi shelves, and the Canadian Archipelago. In addition, river runoff contributes significant freshwater input locally onto shelves. Second, the net heat and buoyancy sources together with dynamic wind forcing modulate the state of sea ice cover, determining variability in multi-year and first-year ice distribution, regions of net growth/melt of sea ice and the amount of total freshwater content. Most of the first year sea ice production takes place over the shelves where brines due to sea ice formation change sea water density and this seasonal signal is communicated to the basin across the slope. Third, the wind- and thermohaline-driven circulation redistributes the sea ice and water masses within the Arctic Ocean and controls their export out to the North Atlantic. Most of the freshwater signal is confined to the upper water column, which is determined via shelf-basin and atmosphere-ice-ocean exchanges. It is believed that the freshwater export from the Arctic can exert a critical role on the rate of deep-water formation in the northern North Atlantic, which in turn dominates the strength of meridional overturning circulation in the North Atlantic and the global ocean thermohaline circulation. The latter, contributes to the global heat re-distribution and climate variability at longer time scales.

It is clear from the above summary that continental margins and shelf-basin exchange are critical to all three principles. However, details of the operation and variability of each of the above principles and their interaction are not well known from observations and they have posed great challenges to global climate models. For example, the advection of oceanic heat northward through Fram Strait still remains a challenge for most global ocean and climate models. The general tendency in low resolution models is to transport most of Atlantic Water via the Barents Sea and to have Fram Strait experience outflow to the south only. This presents a problem as most of the heat entering the Barents Sea is lost to the atmosphere before entering the central Arctic Ocean, which means that oceanic heat input to the eastern Arctic might be significantly under-represented. Similarly, the inflow of Pacific Summer Water through narrow (~100 km) Bering Strait and its circulation over the Chukchi Shelf and in the Beaufort Sea is not realistic in low resolution models, which creates problems in the western Arctic. Another challenge for global climate models is representation of narrow (10-100 km) coastal and boundary currents, which in the Arctic Ocean constitute main circulation features. Also understanding of the circulation and variability of river runoff advected from near the coast and shelf into the basin requires a coordinated circum-Arctic field and modeling research.

The oceanic heat, in addition to atmospheric radiative and sensible heat input, contributes to sea ice melt, which in recent years have accelerated, especially in regions coincident directly downstream of oceanic heat advection from the Pacific and Atlantic oceans. Recent reduction of the Arctic ice pack has been primarily associated with anomalies of surface air temperature and circulation over the Arctic and those in turn have been linked to the Arctic Oscillation (AO). Such studies typically assume the dominant role of external atmospheric forcing and neglect effects of processes internal to the Arctic Ocean. Especially overlooked tends to be the oceanic thermodynamic control of sea ice through the under-ice ablation and lateral melt along marginal ice zones. However, those ice-ocean interactions may act to de-correlate AO forcing, which could help explain some of the timing issues between AO/atmospheric forcing and sea ice variability.

The combined contribution from sea ice, river runoff, and net precipitation determines the freshwater content and its variability in the Arctic Ocean. The upper-ocean mixing and circulation redistributes water masses from the shelves, throughout the basin, and out to the North Atlantic. The freshwater export through Fram Strait and the Canadian Archipelago (CAA), its rate and variability presents another big challenge to global ocean and climate models. The pathway through the CAA is usually not accounted properly due to a low model grid cell resolution, which means most of the freshwater is advected out from the Arctic Ocean via Fram Strait. However, the recirculation of Atlantic Water in the Greenland, Norwegian, and Iceland seas diffuses a significant portion of the freshwater signal as it flows along the East Greenland Current and downstream through Denmark Strait before it reaches the northern North Atlantic. This may significantly reduce the effect of freshwater on the rate of deep-water formation and the meridional overturning circulation in the North Atlantic.

In my talk, I will overview and provide examples of the above mentioned problems related to the three principles of the operation of the Arctic Ocean with emphasis on shelf-basin exchange and their large scale impact. Results from a high-resolution regional coupled ice-ocean model driven with realistic atmospheric forcing will be used to suggest possible focus for future field studies and improvements in representation of this region in climate models.

ARCTIC MARINE MAMMALS AS SENTINELS AND ICONS

Sue E. Moore, *NOAA/AFSC @ APL-University of Washington, Seattle, WA 98115 USA*
sue.moore@noaa.gov

Marine mammals are apex predators in the short food chains common to the Arctic (Fig. 1). This, combined with their requirement to forage on dense prey aggregations, results in their ability to identify production 'hot spots' in benthic and pelagic communities. Although the bio-physical mechanisms that result in prey aggregations are often poorly described, correspondence between marine mammal habitat selection and identifiable bathymetric and oceanographic features (e.g., continental slope, Bering Strait transport, eddies) can provide linkages to multi-disciplinary investigations of ecosystem variability. In the Arctic, marine mammals also serve the nutritive, economic and spiritual needs of Native communities, as a primary source of food and as *cultural keystones*. Thus, environmental changes that affect marine mammals also directly affect the health and well being of human inhabitants of the Arctic. Through inclusion of marine mammals in multi-disciplinary Arctic research programs, we can explore ecosystem variability from the 'top down', while providing a nexus between bio-physical and human-focused studies of climate change.

Marine mammals are ecosystem **sentinels**, reflecting areas of high productivity via seasonal distribution and relative abundance and demonstrating biochemical variability across their geographic range via the isotopes and contaminants contained in their tissues. Success in using marine mammals as Arctic ecosystem sentinels will depend on selecting appropriate indicator species, ideally those with extant population time series and/or routine availability for tissue sampling. Tracking population-level and bio-chemical signals in one or more species from ice-obligate, ice-associated and seasonally migrant categories will provide a strong integrative framework to facilitate links between bio-physical and human-based investigations of Arctic ecosystems (Moore and Huntington in press). Because marine mammals also serve as **icons** of the Arctic (i.e., polar bear, walrus, seals and whales appeal to humans worldwide), results of 'sentinel investigations' can enhance education and outreach programs due to human concern for these species.

At least four programs provide opportunities to integrate marine mammal research within the Shelf-Basin Exchange (SBE) 'Arctic Snapshot' during the International Polar Year (IPY), including the: (1) Pan-Arctic Tracking of Belugas (PATOB), (2) Global Warming and Arctic Marine Mammals (GWAMM); (3) Canadian Flaw Lead (CFL), and (4) Russian-American Long-term Census of the Arctic (RUSALCA). National funding for the marine mammal component of these programs is required, but not yet assured. If funding can be obtained, anticipated marine mammal 'Sentinel Snapshots' include: (1) Pan-Arctic selection of shelf, slope and basin habitats by belugas; (2) regional distribution, habitat selection and tissue sampling for polar bear, ringed and bearded seals, walrus, bowhead, beluga and killer whales; (3) integration of bowhead whale tracking and ringed seal tissue sampling to over-winter oceanographic sampling in the flaw-lead polynya system of Banks Island and Amundsen Gulf, and (4) investigation of bowhead occurrence and gray whale prey selection in the southern Chukchi Sea. These snapshots build on existing data suggesting: (1) strong affinity by belugas for slope and basin habitats in the Alaskan Arctic (Moore et al. 2000; Suydam et al. 2001), (2) negative impacts of sea ice reductions on some polar bear and ringed seal populations in the Canadian Arctic (Stirling and Comiso 2006; Harwood et al. 2000), (3) signs of healthy population growth in western Arctic bowhead whale population coincident with reductions in sea ice(Moore and Laidre 2006), and (4) visual and acoustic data suggesting that gray whales have shifted to predominant use of the southern Chukchi Sea for feeding, coincident with changes to the northern Bering ecosystem (Grebmeier et al. 2006), and are capable of over-wintering in the Beaufort Sea (Moore et al. 2006).

Of the four programs, the PATOB is the best 'match' to the SBE IPY plan (Fig. 2), as synoptic sampling of shelf-basin exchange along proposed transect lines and moorings would provide the foundation for interpretation of beluga movements and habitat selection. The PATOB program also provides the potential for links and outreach to eight of the eleven research themes of the International Conference on Arctic Research Planning II (ICARP II), specifically: Indigenous Peoples (WG2), Coastal Processes (WG 3), Deep Basins (WG 4), Margins and Gateways (WG5), Shelf Seas (WG 6), Ecosystem Modeling and Prediction (WG 9), Resilience, Vulnerability and Rapid Change (WG 10), and Science in the Public Interest (WG 11). The SBE IPY plan will set the stage for sampling at Arctic gateways and margins, as envisioned in the ICARP II Working Group 5 report. In addition to PATOB, the integration of marine mammal research during the RUSALCA IPY program could enhance understanding of the effects of the dynamic Bering Strait gateway on the southern Chukchi Sea ecosystem. Similarly, sampling of marine mammals during IPY-GWAMM and CFL programs will provided needed background for investigation of polynya processes, as envisioned in the ICARP WG6 science plan. Overall, active incorporation of marine mammal research within IPY and subsequent ICARP II programs will provide a foundation and the nexus to achieve the "holistic and multidimensional perspective in the Arctic", as envisioned in the Conference Statement from the November 2005 ICARPII planning meeting.

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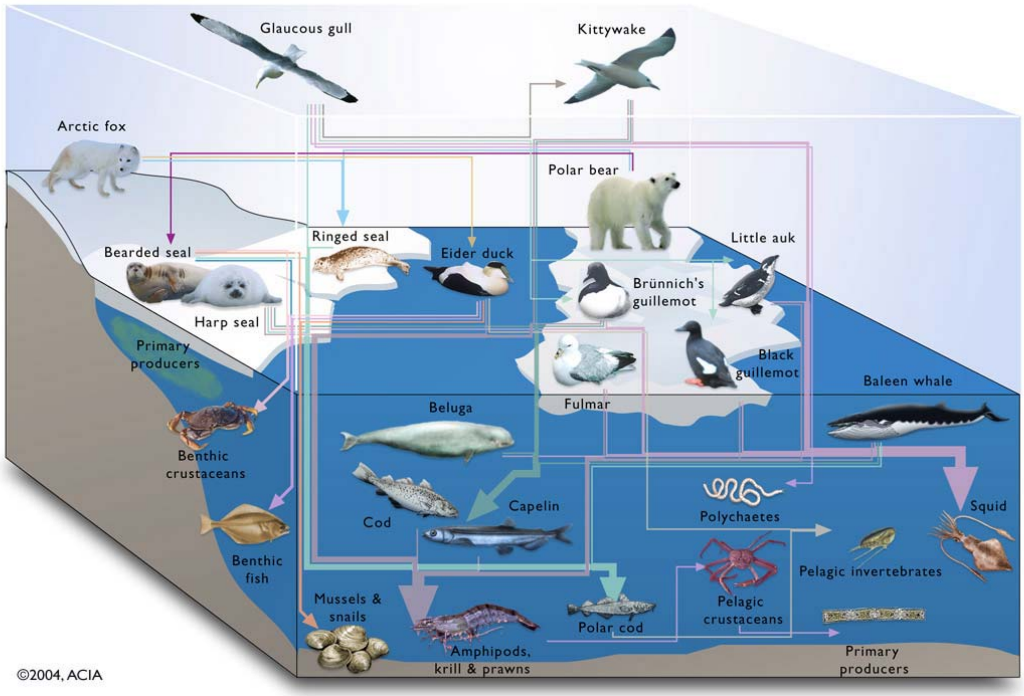


Where are the humans in this diagram?

Figure 1. Marine mammals are ***iconic*** Arctic animals, therefore the 'best' links to humans -- Arctic residents and non-residents alike. Their distribution and movements often reflect 'production hotspots' and they integrate bio-chemical signals (isotopes, fatty acids and contaminants) in their tissues and thus can act as ***sentinels*** to changes in the trophic dynamics of Arctic ecosystems.

Figure 2. The Pan-Arctic Tracking of Belugas (PATOB; IPY Project no. 430) envisions a synoptic study of belugas from all stocks across the Arctic and sub-Arctic in one season and to examine movements and habitat selection in relation to oceanographic conditions including: sea ice, sea surface temperature, primary productivity and bathymetry. Primary points of contact: Mads Peter Heide-Jorgensen (Denmark) and Rod Hobbs (USA).

RECENT WARMING OF THE ATLANTIC WATER AND ITS POSSIBLE REFLECTION IN SHELF-BASIN EXCHANGE

Jan Piechura, *Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland, e-mail: piechura@iopan.gda.pl*

Every summer (except summer 1990) since 1987 Institute of Oceanology of Polish Academy of Sciences has curried out Oceanographic research in the Norwegian-Atlantic Current and the Westspitsbergen Current domains along the Barents Sea and western Svalbard shelf break from Norway up to Fram Strait. The main subject of research is Atlantic Water, its volume, heat and salt transport and variability. This research will be continued and extended during the IPY 2007-2009 exercise. The main additional goals will be:

Boundary currents along the shelf brake in the Arctic Ocean; an MMP installation at the 1500m depth north of Seviernaja Ziemlja (within the EU DAMOCLES Project);

Air-ice-ocean exchange in the Artic Ocean, 3 ITPs installation (EU DAMOCLES and iOOAS

High resolution measurements in the Storfjordrena and western Svalbard shelf breake (EU DAMOCLES, IPY-CARE).

Role of mesoscale structures in mass and energy transport and exchange (IPY-CARE).

Changes in plankton species composition in the WSC domain and western Svalbard fiords, and shelf.

All together Poland plan to join 37 different IPY projects, ranging from atmospheric chemistry to glaciology, permafrost research, botany etc. Polish Committee for Polar Research estimates over 100 scientists will be active in IPY4.

At least seven different marine IPY project will have Polish participants from Universities, Polish Academy of Sciences Institutes and Ministerial research institutes. Two permanent Polish Polar Stations (King George Island, Antarctic and Hornsund in Arctic) and research vessel OCEANIA, shall serve as large scale facilities for planned projects.

Collected so far data in the Westspitsbergen Current (WSC) area show significant interannual variabilities. Warm anomalies in the WSC were particularly pronounced during last 3 summers (fig.1).

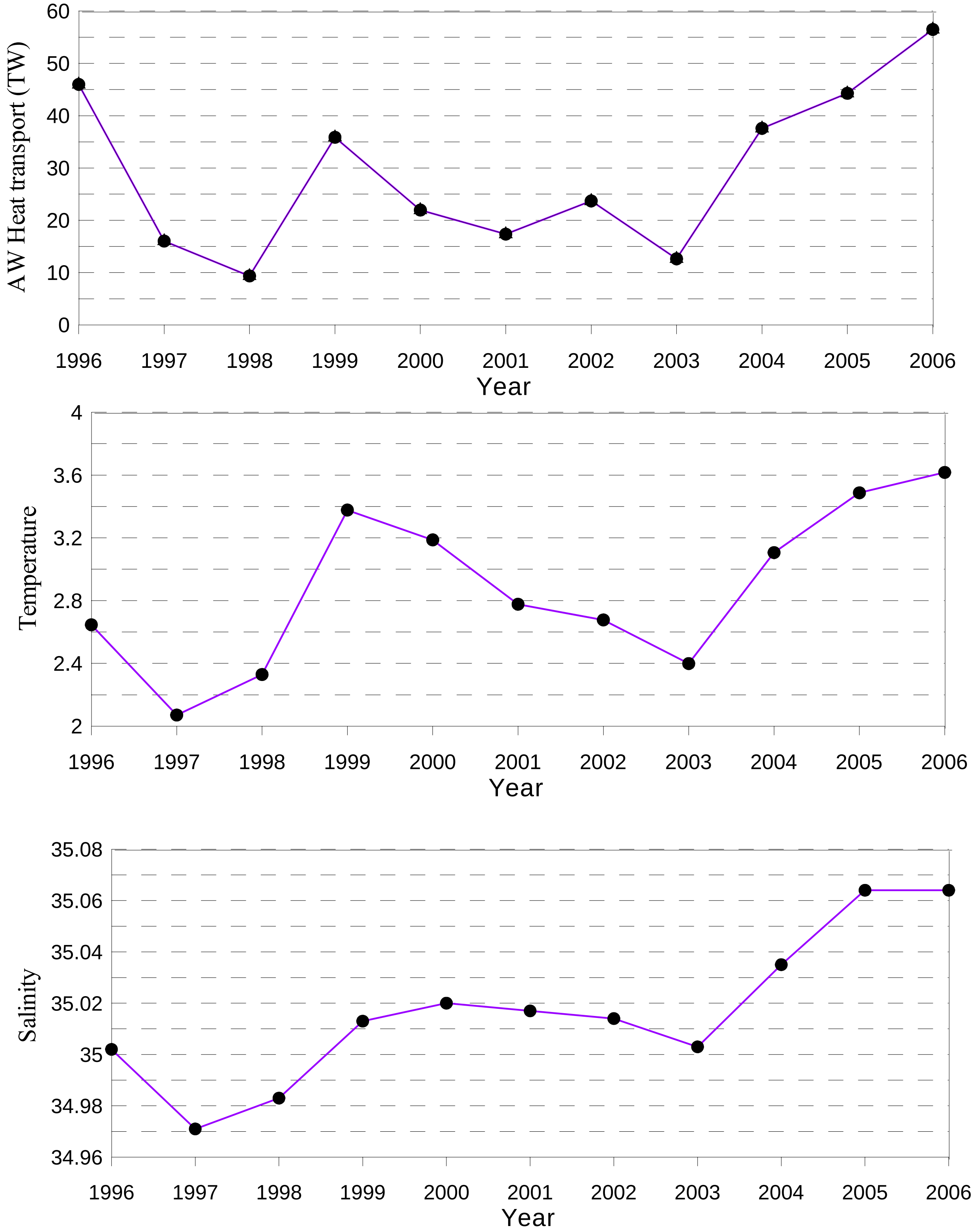


Fig. 1. Variability of mean temperature, salinity and heat transport of Atlantic Water at Latitude 76°30'N.

The mean temperature of this part of the Norwegian - Greenland Seas in June-July 2000-2005 was about 1,5^{o}C higher then climatology.

Measurements during last 11 years along the 76°30'N parallel reveal a significant increase in the temperature and salinity of AW: T and S of AW measured in summer at 200 m, averaged between longitude 009° and 012°E, have increased during 11 years by over 1°C and 0.06 PSU respectively.

The heat content anomalies in the AW layer show that positive heat anomalies usually had the structure of an anticyclonic eddy of 100-150 km in diameter, whereas negative ones displayed a cyclonic circulation pattern. In summer 2005 the AW occupying the entire investigated region was unusually warm and saline. Two anticyclonic anomalies over the submarine ridges were especially intensive. 2006 data show farther increase of AW temperature and head contents, the 5^{o}C isotherm at 100m depth reach very far to the north and climbed on the Svalbard Shelf. The heat content in the AW layer has been increasing since 2001, and since 2003 this rise has been very rapid (fig.1). At the same time the volume of AW has decreased slightly, which means that the increasing heat content during the last years was due to the higher temperature of AW.

Our results show that heat transport has a pulsating nature and that the spatial structure of currents varies. There are years when the eastern branch is dominant (2002 in the entire study area, 2004 in its northern part), but the currents picture in 2005 was really quite different: substantial transport by the western branch, coupled with intensive transport along the shelf break. Moreover, the circulation pattern in the Fram Strait differed from the usual one. In warm years, like 2004, AW inflow to the Arctic Ocean was concentrated along the shelf break in the Svalbard Branch. In 2005, however, the high temperature and salinity signal was shifted slightly to the west and was seen in broad area. There was a pronounced Svalbard Branch inflow, as well as a northward flow along the western border of the Yermak Plateau.

2006 situation was different from that of 2005, nearly whole AW transport was concentrated in the slope branch of the WSC, and its temperature reached highest values - over 7^{o}C in the core, as far north as Fram Strait.

Processes of exchange with the Barents Sea Shelf, western Svalbard Shelf and fjords and the Arctic Ocean were investigated and described. Main flow of AW into the Barents Sea take place through the Byaornoya Trough; much less amount comes through the Storfjordrena and very little through the Kveitehola Canyon. Brine water produced in Storfjord and cascading along the slope of the Storfjordrena and down the continental slope into the depth of the Greenland Sea during spring and summer time is observed. Collision of warm, salty Atlantic Water carried by the WSC with cold, fresh water of the Eastspitsbergen Current in vicinity of Sorkapp and/or with shelf waters from fjords produce intensive mixing and complicated water circulation and frequent mesoscale eddies, both cyclonic and anticyclonic. Exchange between Western Svalbard fjords: Kongsfjord, Isfjord, Bellsund and Hornsund and the Greenland Sea is investigated as well. Due to the worming process change of plankton composition, from cold to warm species was observed.

WARMER ATLANTIC WATER IN THE EURASIAN BASIN- DOES IT AFFECT SHELF-BASIN EXCHANGE?

Ursula Schauer, *Alfred Wegener Institute, Bremerhaven, Germany*

THE YEAR BEFORE IPY- WHAT IS GOING ON IN THE PACIFIC SECTOR OF THE ARCTIC OCEAN? -

Koji Shimada, Takashi Kamoshida, Motoyo Itoh, Shigeto Nishino, *Institute of Observational Research for Global Change, Japan Agency for Marine-Earth Science and Technology*, *Yokosuka 237-0061, Japan*

Eddy Carmack, Fiona McLaughlin, Sarah Zimmermann, Michiyo Kawai-Yamamoto, *Institute of Ocean Sciences, Sidney, B.C. V8L 4B2, Canada*

Andrey Proshutinsky, *Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA*

Mechanism on the sustainable less sea ice condition in the Pacific sector of the Arctic Ocean (Shimada et al., 2006)

Recently observed reduction in sea ice cover in the Arctic Ocean is not spatially uniform but rather is disproportionately large in the Pacific sector of the Arctic Ocean (Figure 1). The spatial pattern of ice reduction is similar to the spatial distribution of warm Pacific Summer Water (PSW) that interflows the upper portion of halocline north of the Chukchi Sea. The reduction rate of the sea ice cover in the Pacific Sector of the Arctic Ocean was not uniform, but showed a catastrophic change (Figure 2a) during 1997-1998 without any correlations with changes in atmospheric parameters, e.g. Arctic Oscillation index (Figure 2b). In the area where the huge sea ice reduction was observed, the temporal change in the sea ice cover (concentration) was well correlated with the change in temperature of PSW (Figure 2b). These coherent changes observed in both sea ice cover and PSW are evidences that indicate the significant linkage between the regional Shelf Basin Exchange and the large-scale Arctic climate changes. The warming of PSW in the western Canada Basin is not directly correlated with the variation in upstream temperature in the vicinity of the Bering Strait (Figure 2d). The warming of PSW in the basin is mainly caused by the increase of heat transportation associated with the strengthening of upper ocean circulation driven by torque of sea ice motion (curl of sea ice motion). In the Canada Basin, a catastrophic change in the sea ice motion was observed during the identical period when the catastrophic reduction of sea ice and abrupt warming of PSW (Figure 2e), even the wind curl did not show such kind of catastrophic change (Figure 2f?). The reason why the sea ice motion was accelerated is in the change in boundary condition of sea ice motion along the coast. After the catastrophic change, wintertime sea ice concentration near the coast has been decreased. This condition reduced the stress from the coastal boundary and thus allowed a more efficient coupling of wind forcing to the upper ocean via the sea ice motion. We proposed a new positive feedback mechanism (Figure 3) why the disproportional sea ice reduction has been occurred and sustained in the Pacific sector of the Arctic Ocean.

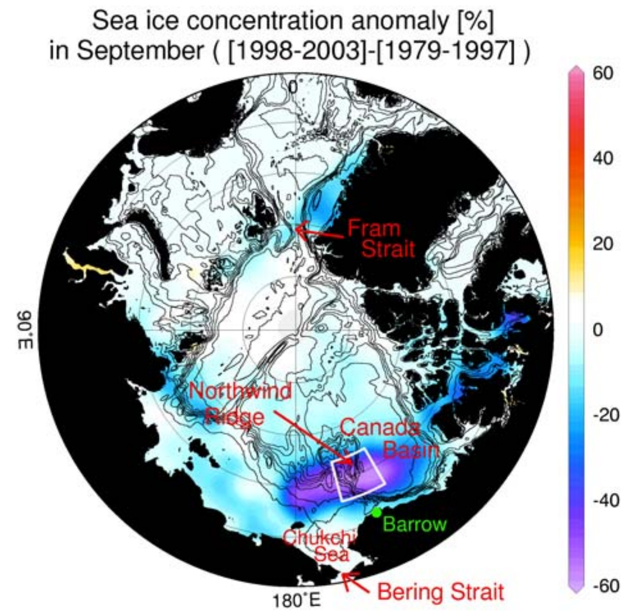


Figure 1. Sea-ice concentration anomaly (%): September 1998-2003 mean minus September 1979-1997 mean. Contours show bathymetry. The area outlined by the white box shows the area for which the time series of sea-ice concentration and PSW temperature, shown in Figures 2 were calculated.

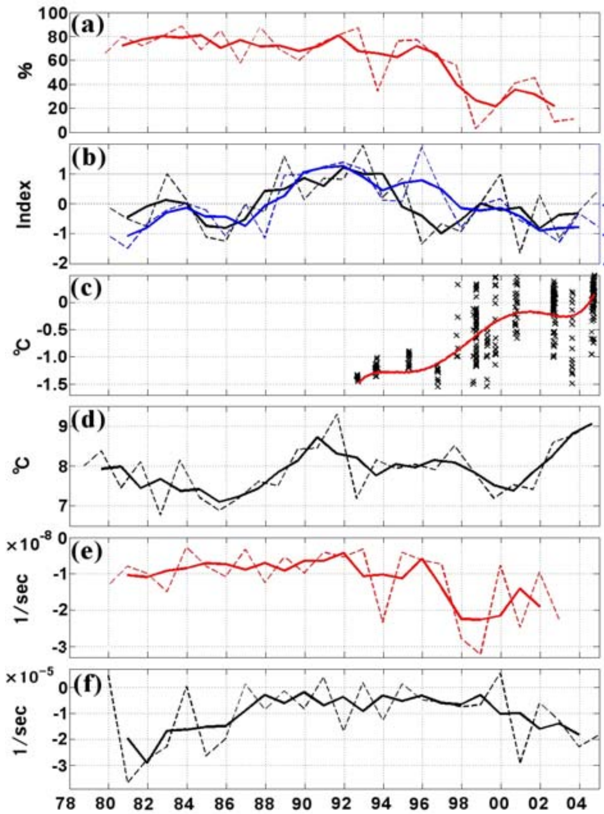


Figure 2. Time series of (a) sea-ice concentration in September, 73-77°N, 150-165°W; (b) Arctic Oscillation index, November to January shown in black (index provided by the Climate Prediction Center at 39Hhttp://www.cpc.ncep.noaa.gov); the blue line shows the wind component (93.5T) along the first EOF direction of sea-ice motion in the Beaufort Sea in a box: 71°N-140°W, 72°N-140°W, 73°N-155°W, 72°N-155°W; (c) potential temperature on S=31.3, 73-77°N, 150-165°W (white box in Figure 1); (d) sea surface temperature in the northeastern Bering Shelf: 62-66°N, 164-170°W; (e) curl of sea-ice motion in the Canada Basin east of the Northwind Ridge: 74-75°N, 130-160°W; (f) curl of wind in the same area as for (e); solid curves denote three-year running mean values and dashed curves are annual values for (a),(b),(d),(e); the solid red curve in (c) is a fifth degree polynomial fit.

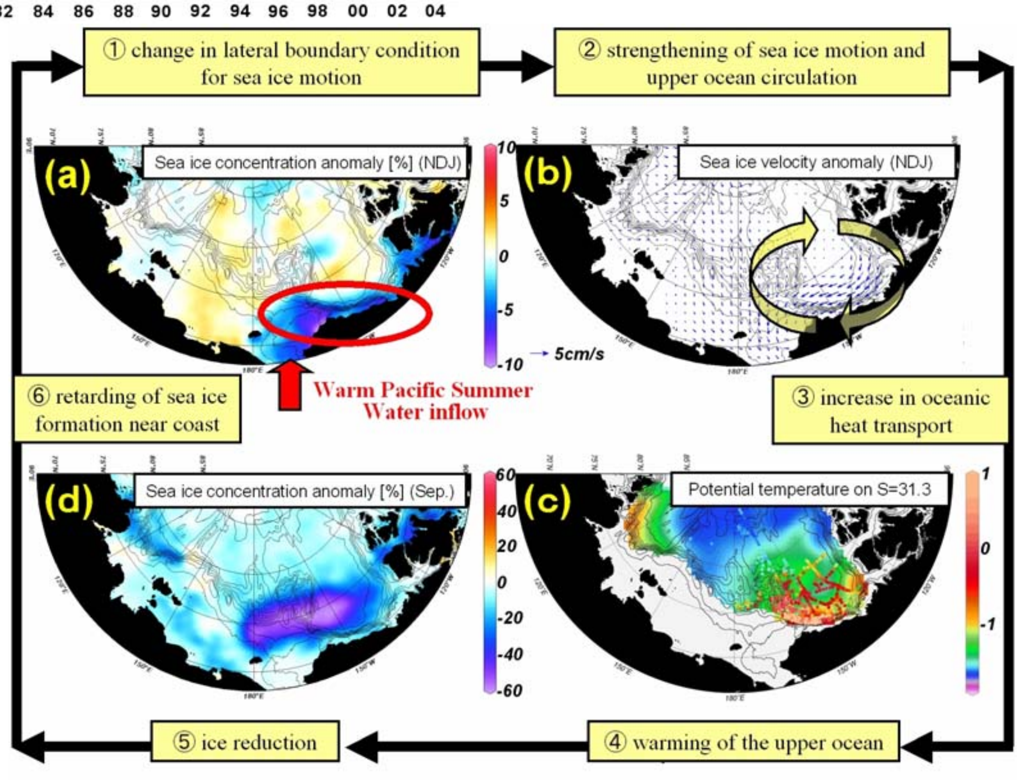


Figure 3. Feedback system. (a) Sea ice concentration anomaly for November through January [(1997 Nov.~2003 Jan.) – (1979~1997 Jan.)] (b) Sea ice velocity anomaly for November through January [(1997 Nov.~2003 Jan.) – (1979 Nov.~1997 Jan.)] (c) Potential temperature on S=31.3. Background color is climatology from EWG Arctic Ocean Atlas and doted circles are from 1998-2004. (d) Sea ice concentration anomaly for September [(1998~2003)-(1979~1997)].

Emergence of open-ocean polynya in the summer of 2006

In early 2006, huge amount of multi year ice entered into the Chukchi Shelf. This unusual condition caused heavy ice condition due to piling up of sea ice near the coast of the Chukchi Sea and western Beaufort Sea. The sea ice near the coast is too thick to be melted by the end of this summer. In the offshore area centered on the Northwind Ridge, however, the above mechanical thickening of sea ice was not efficient, the influence of PSW on the sea ice is still going on. As the results, an open-ocean polynya emerged there after middle of August (Figure 4). The size of the Northwind Polynya is comparable to the half size of well-known “Weddell Polynya” in the Weddell Sea observed in mid-1970s. Here we call this ocean-ocean polynya as “Northwind Polynya”. Fortunately, a warm PSW pool just below the surface mixed layer was observed simultaneously in the area of the Northwind Polynya (Figure 5), relation between open-ocean polynya and PSW was evidenced. The emergence of huge open-ocean polynya, which is sustained by oceanic conditions, would suggest an unexpected Arctic change is now begun. The unexpected change would not only occur in the physical environment, but would extend to biogeochemical and ecological environments. The IPY 2007-2008 is quite important event not only for the Arctic scientist, but also for all environmental scientist and all nations.

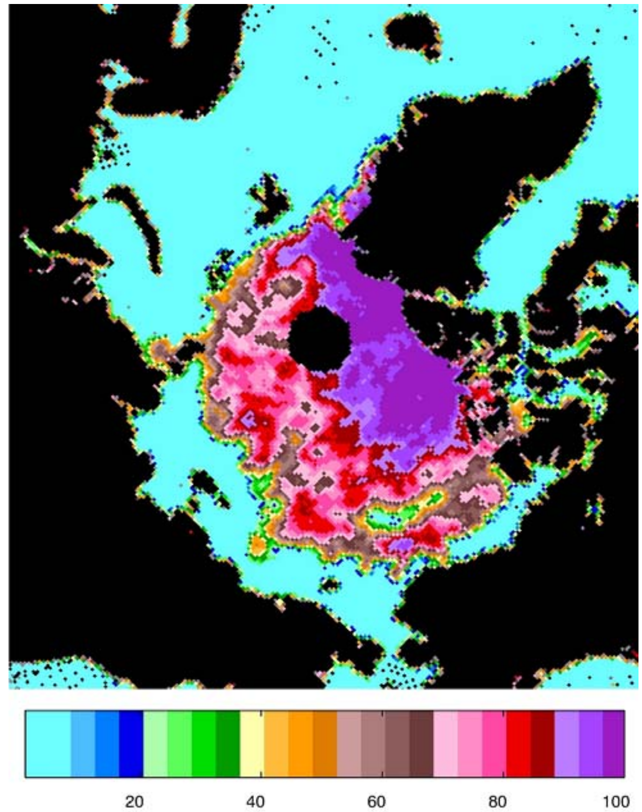
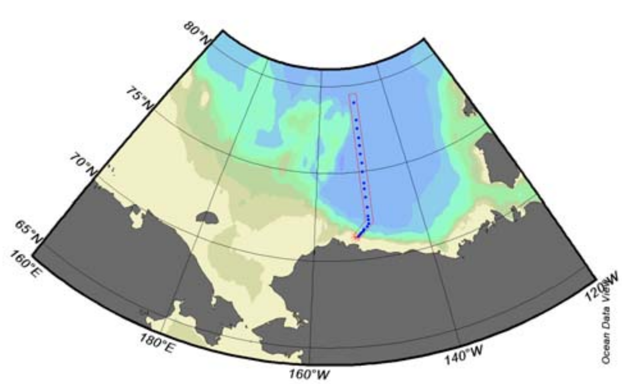


Figure 4. Sea ice concentration on August 27, 2006. A huge open-water polynya was observed



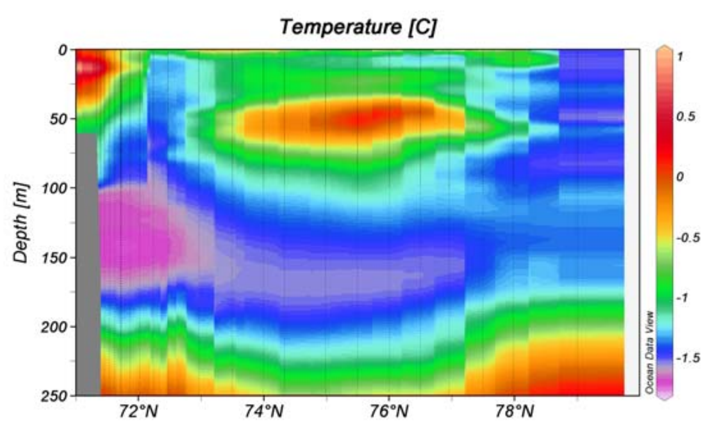


Figure 5. Vertical section of temperature across the “Northwind Polynya” along 150W occupied in late August in 2006. A warm PSW pool was observed just beneath the surface mixed layer where the Northwind Polynya was observed. The hydrographic data was collected aboard CCGS Louis S. St-Laurent.

IPY AND SBE RELEVANT OCEANOGRAPHIC ACTIVITIES IN NORWAY: AN OVERVIEW ON CONDITIONALLY SUPPORTED AND PLANNED PROJECTS

Paul Wassmann, *Norwegian College of Fishery Science, University of Tromsø, Norway, paulw@nfh.uit.no*

Among the IPY and SBE relevant oceanographic activities planned to be carried out in Norway belong primarily "iAOOS-Norway: Closing the loop" and the intensive field activities of the ARCTOS Centre of Excellence. While the first has received conditional support and is considered as one of Norway's IPY flagships, the ARCTOS CoE is pending. Both initiatives will know for sure if they are funded and their budget by the end of December. "iAOOS-Norway: Closing the loop" is based entirely on the international IPY proposal iAOOS (*Integrated Arctic Ocean Observing System)*. iAOOS-Norway will contribute a share to iAOOS through building on pieces of an ocean – atmosphere – cryosphere - biosphere observing system already in place in Norway (funded through national agencies), and broadening this system - geographically, technologically and in scope - for IPY.

An overview of the most relevant activities in iAOOS-Norway Work Package 1 (*in situ* observations) and 3 (process experiments) will be presented. Fig. 1 indicates some of the transects and cruise lines for 2007-08. The overview continues by presenting the main field activities of ARCTOS CoE, which tentatively are illustrated in Fig. 2. Also here investigations rest upon projects and observations already in place in Norway.

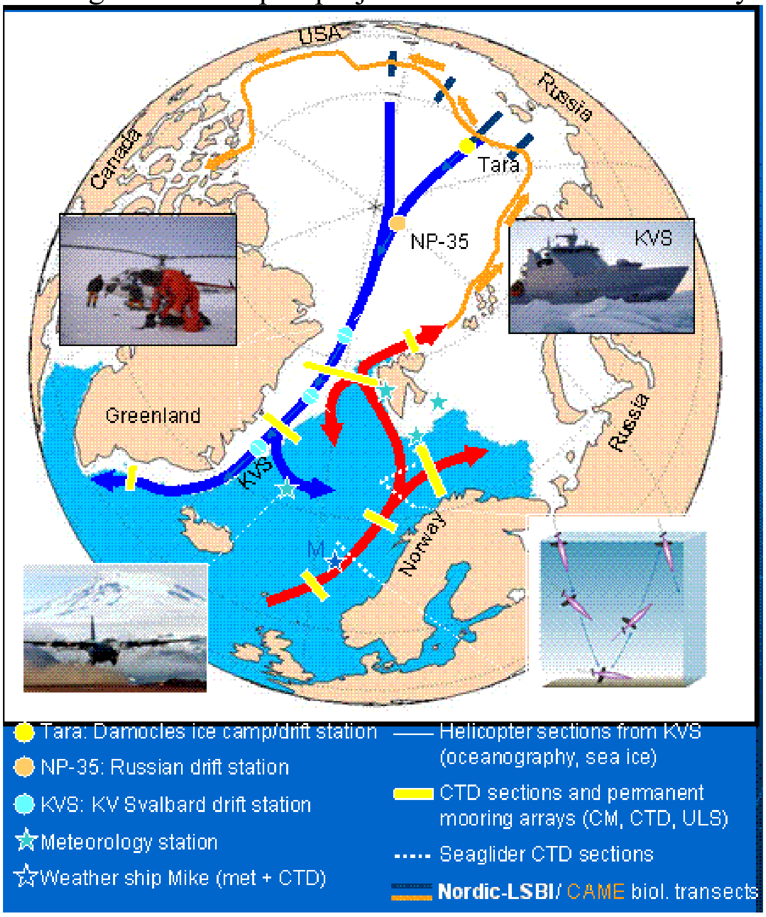


Figure 1. Schematic overview over the iAOOS-Norway activities

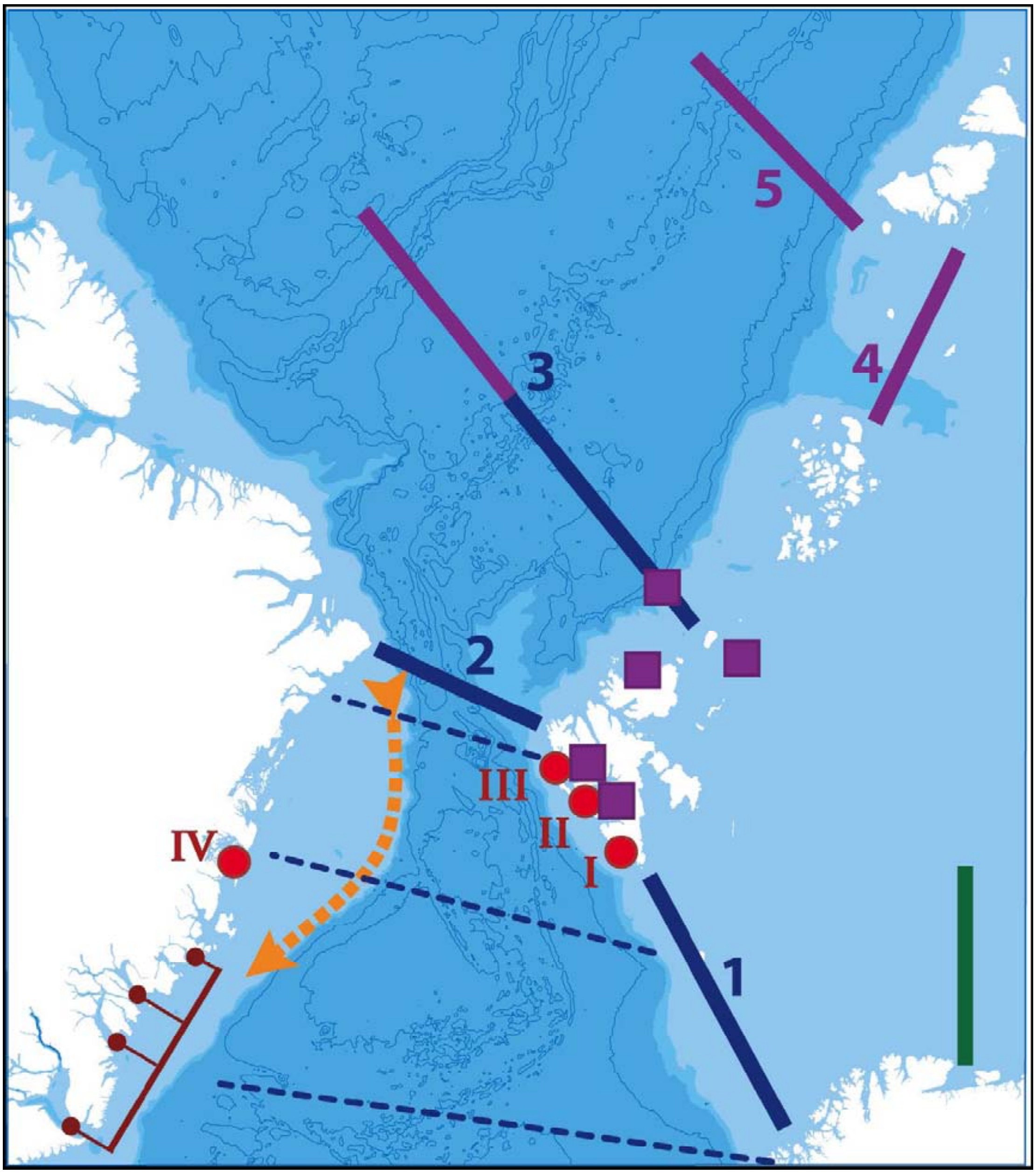


Fig. 2 Maps of the ARCTOS CoE research area. Field stations Hornsund (I), Longyearbyen (II), Ny-Ålesund (III) and Zackenberg (IV) (filled red circles). Transects to be covered by the ice-enforced research vessels *Lance* and *Jan Mayen* (bold blue). Transects to be covered in cooperation with the Russian Academy of Sciences and on Russian icebreakers (bold purple). Observatories deployed and managed in cooperation with DAMOCLES, iAOOS, and the Scottish Association of Marine Sciences (purple squares). Fjord and shelf stations on east Greenland that are visited every second year (small red filled circles). Also shown are three transects across the Norwegian and Greenland Seas (blue dotted lines) from related projects studying plankton and sedimentary geology. A 6-week drift cruise in the Arctic Ocean outflow to take place in 2007 and 2008 (Norwegian iAOOS, orange line).

RUSSIAN-AMERICAN LONG-TERM CENSUS OF THE ARCTIC (RUSALCA) 2004-2006: LOOKING TOWARD IPY 2008

Terry E. Whitledge, *Institute of Marine Science, University of Alaska Fairbanks*

The long-term goal of the RUSALCA program is to obtain continuous and comprehensive monitoring within Bering Strait and northwards through the Chukchi Sea to the shelf break for several years which requires routine access to EEZ's of the US and the Russian Federation. The resulting Russian-US collaborations offer an integrated program to investigate the potential effects of climate change on the physical circulation and a broad range of trophic levels including plankton, benthos and nekton. Hydrographic, biochemical and productivity sampling was integrated for all stations sampled and the data from US and Russian collaborators were combined for the joint assessment of climate change, water mass properties and census of marine life in the Arctic. In order to detect possible changes, it is intended that repetitive sampling occur at least every four years. A summary of the measurements collected follows for multidisciplinary cruise in 2004 and the mooring turnaround cruises in 2005-2006.

2004 RUSALCA Measurement Program

The Russian and US teams deployed two moorings in western Bering Strait to be recovered in 2005. The US mooring deployed in the center of the western channel of Bering Strait contained an Aanderra RCM9 acoustic current meter at approximately 34 m water depth for measuring velocity and a SeaCat with attached optical sensors for the temperature, salinity, fluorescence and transmissivity measurements. The Russian mooring with a current meter was deployed approximately 7 miles to the east, also in the western channel, to provide some resolution of cross-strait differences in water mass transport.

A series of hydrographic transects encompassing 77 CTD stations and 14 comprehensive biological stations were taken to allow sampling of a range of water masses during this summer period (Fig. 1). A high priority of the hydrographic survey was to collect samples across Bering Strait in support of the Russian and American mooring(s) in western Bering Strait, to collect a series of high-speed transects across Herald Valley and to enhance the knowledge of faunal distributions for census of marine life.

A CTD profiler was equipped with a transmissometer, fluorometer, altimeter, dissolved oxygen sensor, dual 300 KHz lowered ADCP, 21 position rosette with 10 liter Nisken bottles and a mini-video plankton recorder.

Water samples were collected at all stations and were analyzed for nutrients/plant pigments onboard for a total of 476 nutrients and 513 chlorophyll samples. To estimate carbon and nitrogen uptake of phytoplankton at different locations, productivity experiments were executed by incubating phytoplankton for 4-7 hours after inoculating with carbon and nitrogen stable isotopes. Ten productivity stations with 6 light depths were sampled. A total of 87 phytoplankton samples were collected for taxonomy and enumeration.

A comprehensive survey and census of zooplankton species in the Bering Strait were collected through central Chukchi Sea at 33 stations using plankton nets of 150 and 53 µm mesh with analysis to involve a combination of traditional taxonomic enumeration and identification, along with comprehensive molecular sequencing. Egg production experiments were conducted at 22 stations with several of the dominant copepod species in this region (i.e. primarily *Pseudocalanus* spp., with variable contributions by *Metridia pacifica*, *Eucalanus bungii*, and *Calanus marshallae*).

Van Veen benthic grabs (0.1m^2) were taken for the University of Tennessee at eleven stations (five grabs per station) for benthic community structure analysis. Four of these grabs were used for quantitative analysis of infaunal communities, and the fifth grab was used to obtain surface sediment measurements. Three grabs for Russian colleagues were taken at all the stations plus an three additional stations. Benthic dredges were taken at three stations in the Bering Strait instead of van Veen grabs for qualitative study.

Benthic invertebrate epifauna were collected at 17 stations. At 15 of those stations, a beam trawl (2.26 m effective opening) was towed between 1-10 minutes bottom-time at 1 knot towing speed. A total of 62 water samples, 40 surface sediment samples, 143 plankton samples and 2165 tissue samples of infaunal and epibenthic organisms were taken for stable isotope analysis.

At 17 sites, larval and juvenile fishes were collected using a bottom trawl which caught 1,307 fishes of at least 31 species. Up to 35 individuals of each common species of fishes caught by the larval fish trawl or otter trawl were frozen from each site for trace metals analysis of otoliths. Ten to twenty fish of the most common species were frozen for fatty acid analysis. Larval fish were also sampled with a Bongo net and the samples are still being analyzed.

A 7.1 m otter trawl with 3.7 cm stretch mesh was towed to collect benthic fishes. Twenty-seven tows at depths from 33 to 101 m collected a total of 1881 individuals representing at least 24 species of the approximately 97 known to occur in the sampling area. It is believed the collections included at least several minor range extensions: a small (125 mm total length, TL) specimen of *Hippoglossoides robustus* (Bering flounder) collected at Station 85 (ca. 72^o 18' N) extends the northernmost record from 71^o 49' N in the eastern Chukchi Sea. A *Theragra chalcogramma* (walleye pollock) collected at Station 61 represents a similar extension of known range to the north: at 71^o 23' N compared to the previous record of 69^o 26' N. Our collections also may include some individuals of rare snailfish (Liparidae) species.

The Intershelf ROV was lowered to the seafloor eleven times. The sedimentary environments ranged from cobbled, to soft clays. Water column conditions included 1.7 knot currents and regions containing high plankton concentrations, underneath large chunks of multiyear ice.

2005-2006 Mooring Turnaround and Measurements

The expedition had the primary goal of recovering the three moorings (A1-1, A1-2 and A1-3) that were deployed in western Bering Strait in August 2005 and to deploy three replacement moorings in similar locations. A secondary goal was to collect CTD profiles/water samples/benthic samples across both US and Russian territorial waters of Bering Strait, a northern transect from Point Hope to Cape Netten and a transect across the southern part of Bering Strait from Point Seroy to Cape York.

After mooring recoveries and deployments were accomplished four transects of CTD/water sampling and bottom sampling were taken in the study area. The first transect of 17 stations was taken across Bering Strait with only CTD/water sampling. The second transect of seven stations across the Chukchi Sea was taken from Point Hope to Cape Netten with CTD/ water sampling and three benthic samples on each station. The third transect of five stations was taken from Cape Netten to the northwest and included CTD/water sampling and three benthic samples on each station. The final transect of seven stations was taken from Point Seroy to Cape York with only CTD/water sampling. A SeaBird SBE25 CTD was lowered by the starboard winch with wire cable to approximately three meters above the bottom on each cast. A bottom-trip Niskin sampling bottle was hung below the CTD to obtain a near bottom water sample on each station. Two additional Niskin bottles were hung on the wire at approximately 15 and 30m depths on each station. A surface water sample was obtained on each station from a surface bucket. Nutrient and chlorophyll samples were taken from all water samples

2008 Proposed Measurement Program and International Collaboration(s)

It is proposed that the RUSALCA 2008 cruise for IPY repeat measurements collected on the RUSALCA 2004 cruise, sample at locations which were planned but could not be sampled because of ice, plus extend the measurements to the shelf edge (Fig. 2). The proposed research cruise is planned to collaborate with the NABOS program that will probably be utilizing a separate vessel. International collaboration with the 2008 RUSALCA/IPY cruise is desired and ongoing discussions have been undertaken program managers of the NOAA Office of Arctic Research and some RUSALCA science team members through Arctic Science Summit Week, Pacific Arctic Group and other international organizational meetings.

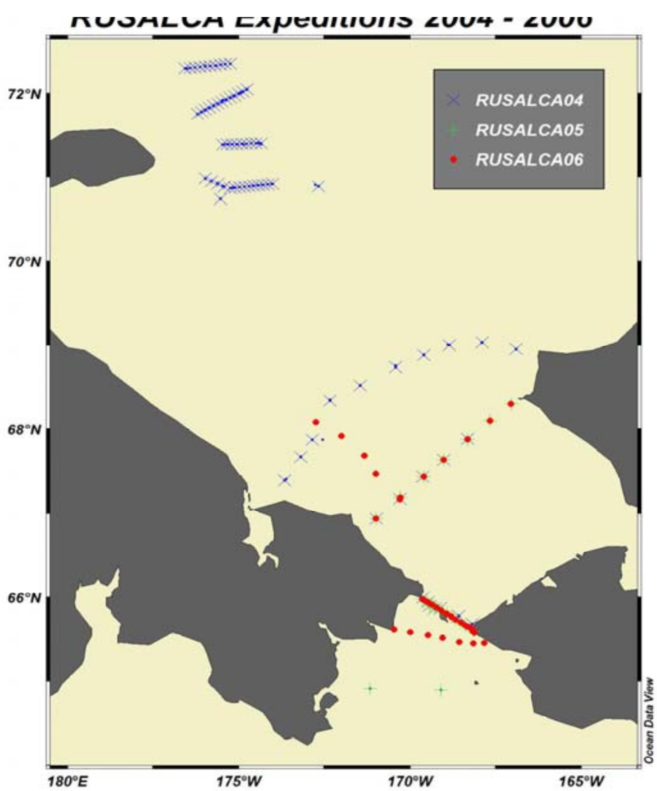


Fig. 1 RUSALCA sampling stations for 2004, 2005 and 2006

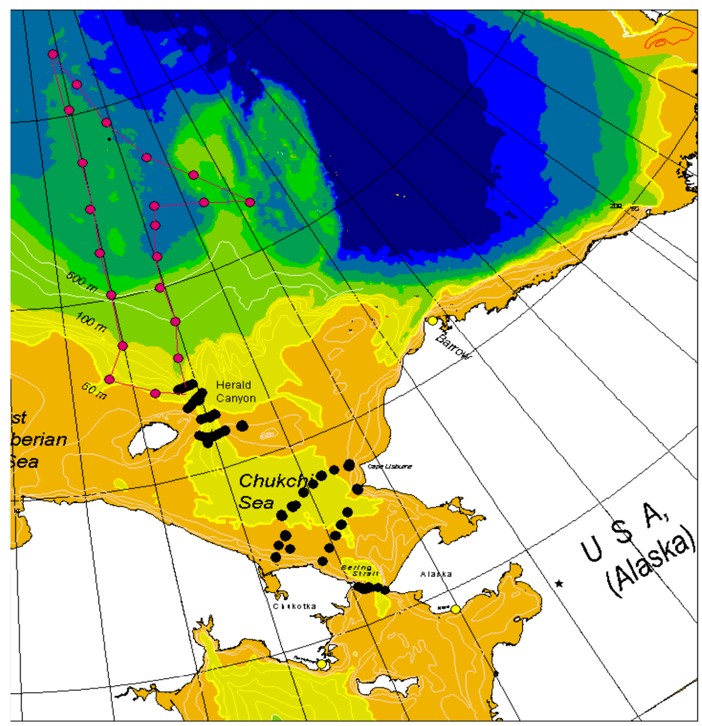


Fig. 2 Proposed sampling sites for RUSALCA/IPY 2008. Black stations are repeat locations from 2004 and red stations are extended sampling sites

CHINESE ACTION PLAN FOR ARCTIC EXPEDITION DURING AND AFTER IPY

Jinping Zhao[1] *and Zhaihai Zhang*[2]
1.Ocean University of China, jpzhao@ouc.edu.cn;
2. Chinese Polar Research Institute, zhangzhanhai@pric.gov.cn

1. Outline of China's plan during and after IPY

By the two years' effort, Chinese government has agreed to provide special funding for IPY to implement enhanced observations in both Arctic and Antarctic. The main work of China during IPY will focus on the Antarctic, called PANDA (Prize Bay, Amery ice shelf, DOME-A), which would be an over 3000 km section and links the oceanographic, ecological, glaciological, and climatologic researches together to implement an integrated observation. Two cruises will be carried out during later 2007 and 2008.

At least one Arctic cruise will be conducted. China's icebreaker will navigate to the Pacific Arctic in 2008. The concerned region is the Chukchi Sea, Beaufort Sea, Chukchi Plateau, Mendeleyev Ridge and Canadian Basin. An integrated survey for marine science, atmospheric science, air-ice-sea interaction, and sea ice variability will be implemented.

If an international agreement for the collaboration in whole Pacific Sector of Arctic Ocean is reached, China will participate the collaborated plan and share the shiptime with other country's scientists. It is also possible that China could provide the rental of an icebreaker to survey the area of East Siberian Sea and other interested area.

A 2009 cruise to Arctic is also possible, but not sure yet. It all depends on the final plan of 2008 cruise.

Other actions are the collaborations with other country in 2007 and 2009. China encourages scientist to come to the other icebreakers or ice camp to work on biological, ecological, optical, sea ice, and geological observation in both Pacific and Atlantic sectors. The interested areas are the Chukchi Sea, Beaufort Sea, East Siberian Sea, Greenland Sea, Barents Sea, Fram Strait, and the deep basins.

2. Organization

A Chinese committee for IPY activities has been organized. Chinese Arctic and Antarctic Administration in charge of the national and international IPY works. All the scientists from various institutions have been asked to provide their suggestions in IPY.

3. Funding

The funding application is corresponding to the governmental fiscal policy for special activities. The next year's activities must be applied by the October of this year and get approval before December. By this way, more indefinitivity exists and preparation time for in situ work is usually not enough. However, it would be approved if a feasible implementation plan were well organized.

4. Scientific issues

China's scientific activities are consistent with the plan with that of WG-5 (margins and gateways) and WG-6 (marginal seas) of ICARP II Planning Meeting, and also consistent with IPY clusters iAOOS-2 Shelf-basin Exchange. The scientific topics we will focus on are

- Arctic circumpolar boundary current
- Dispersion of Pacific water in Canadian basin

- Multiyear variation of ice cover in Arctic
- Arctic halocline and barrier layer
- Optical profile and heating caused by biological processes.
- Heat exchange in the air-ice-sea interface
- Change of ecological environment during Arctic warming
- Long-term record of climatological change

5. Action plan
2006
China sent a two-people group participate the summer cruise of Canada in icebreaker LSSL to carry out optical observation down to 110 meters.
2007
China will send a group to Arctic via Canada to deploy an unrecovered mooring on the ice sheet north of Canadian Arctic Archipelago.
Some scientists hope to participate the cruises of other country's.
2008
China's icebreaker will survey Bering Sea, Chukchi Sea, Beaufort Sea, Chukchi Plateau and Canadian Basin as a part of China's IPY activity. The scientific works are physical oceanography, ecology, tracer chemistry, marine chemistry, marine biology, pale oceanography, sea ice physics, ice movement, climate, air-ice-sea interaction, satellite meteorology, and atmospheric chemistry.
2009
There is a possible Arctic expedition in 2009, but it depends on the expenses in 2008 expedition.

6. International collaboration
China suggests an international collaboration cruise in the Pacific Arctic sector. Attached is a map, in which some interesting regions are listed in Table 1 and shown in Figure 1. China plans to implement some of them as marked by 'Y' in the right column of the table. The other countries are welcomed to be involved into the joint cruise. It will be an intriguing activity to understand the circulation, water mass, substance transport, and the impact of Pacific water on Arctic Ocean for complete Pacific sector. If an international plan is determined before 2008, China will provide necessary support and contribution to the joint cruise.

Table 1 Possible international collaboration regions in Pacific Arctic sector

Area	Name of the area	Work of China In 2008
T	Permanent ice covered region	
X	Lomonosov Basin	
M	Mendeleyev Ridge and Trough	Y
P	Chukchi Plateau and surrounding water	Y
D	Canadian Basin	Y
A	Boundary current out of East Siberian Sea	
S	Boundary current between Chukchi Sea and Chukchi plateau	Y
B	Beaufort Sea and boundary current	Y
N	Throughflow from Laptev Sea	
E	East Siberian Sea	

L	Long Strait and surrounding water	
W	West Chukchi sea	
R	Repeated section	Y
C	East Chukchi Sea	Y

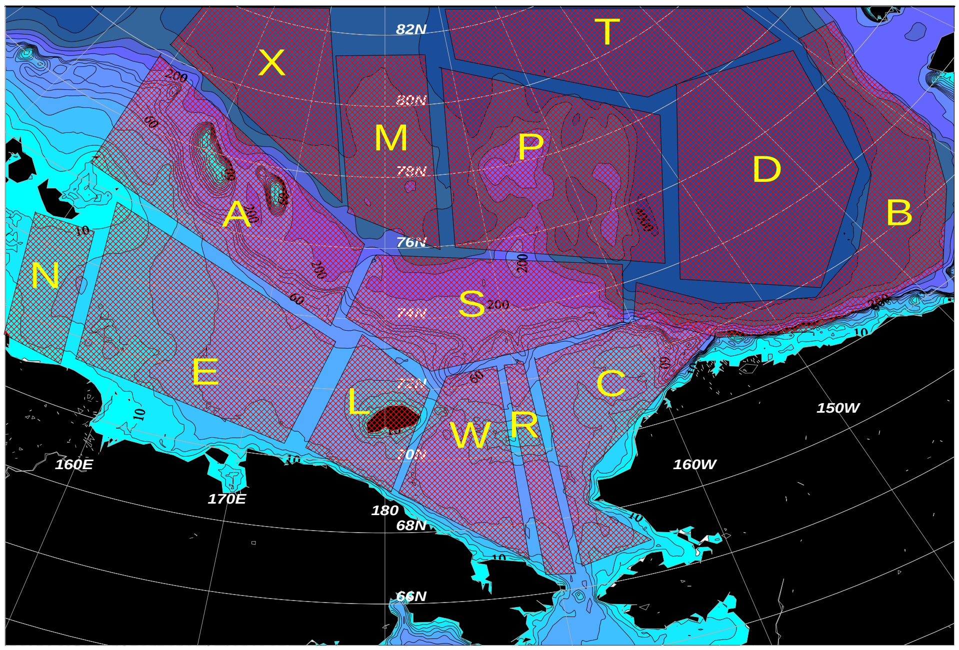


Figure 1 Possible observation regions in Pacific Arctic sector

TRANSPORT OF PLANKTON AND PARTICLES BETWEEN THE CHUKCHI AND BEAUFORT SEAS

Carin J. Ashjian, *Woods Hole Oceanographic Institution, Woods Hole, MA, USA, cashjian@whoi.edu*
Gallager, S.M., Woods Hole Oceanographic Institution, Woods Hole, MA, USA, sgallager@whoi.edu
Plourde, S., Institute Maurice-Lamontagne, Department of Fisheries and Oceans, Mont-Joli, Québec, CANADA, PLOURDES@dfo-mpo.gc.ca

A key goal of the Western Arctic Shelf Basin Interactions program is to understand how physical and biological processes together impact shelf-basin exchange of biological, chemical, and physical properties. High-resolution vertical distributions of plankton and particles were obtained using an Auto Video Plankton Recorder from 29 locations on the Chukchi Shelf, in the deep Beaufort Sea, and across the Beaufort-Chukchi shelf-break during a cruise on the *USCGC Healy* in July-August, 2002. Coincident velocity estimates were collected using hull-mounted acoustic Doppler current profilers. Images of plankton and particles were extracted automatically and identified manually to taxa and type. Copepods, diatom chains, decaying diatoms, marine snow, and radiolarians were the most abundant categories observed. Distinct regional differences in abundance were observed that were associated with different oceanographic regimes and with the prevailing circulation in the region. Vertical distributions were closely associated with the physical structure of the water column. A sharp horizontal discontinuity in abundance of all categories between shelf and basin was observed, located over the shelf-break and potentially established and maintained by transport of plankton and particles along-shelf to the east rather than northwards towards the basin. Barrow Canyon and the shelf and shelf-break east of Barrow Canyon had very high concentrations of plankton and particles, especially marine snow, that may have resulted from elevated production on the eastern Chukchi Shelf that subsequently was advected out of Barrow Canyon and to the east. Comparisons of downward flux, estimated from particle sinking rates based on individual marine snow particle size, and horizontal velocities suggested that much of the marine snow carbon was sinking to the benthos of the Chukchi Sea prior to being advected off-shelf. Velocities and plankton concentrations together indicated that little off-shelf flux of plankton or particles to the basin was occurring except in an eddy located off of the Beaufort Shelf.

CAME: THE CANADIAN ARCTIC MARGIN EXPEDITION – A PROPOSED IPY EFFORT

Eddy Carmack *and Robie Macdonald, Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney B.C. V8L 4B2 (carmacke@dfo-mpo.gc.ca)*

The objective of the Canadian Arctic Margin Expedition (CAME) aims to advance a panarctic perspective on the impact of climate change on (1) freshwater (sources, pathways, storage and export controls); (2) sea ice extent, thickness, duration and flux regulation; and (3) the Arctic food web (productivity, spatial variability, trophic dynamics and internal cycling of carbon). This objective will be achieved by an icebreaker mission carrying an interdisciplinary team azimuthally around the continental margin of the arctic basin to acquire a snapshot of the arctic system, its water masses and circulation, and its dynamical couplings under current climate conditions. As such, CAME aspires a fully panarctic, interdisciplinary perspective, and is thus a key component of the iAOOS IPY cluster 2. For three reasons the focus of CAME is the panarctic continental margin. *First*, the Arctic Ocean is ~50% shelf, unique among the world's ocean. Thus far, however, major studies have all taken a regional view, and it is clear that an understanding of processes dominating one shelf cannot necessarily be transferred to another, and hence a panarctic view is required. *Second*, the material products of continental shelves, including freshwater, geochemical constituents and biota, must necessarily cross the margin domain to reach the basin, but the rates and controlling mechanisms of such exchange remain poorly documented (ICARP II - WG5, 2005).
Third, an abrupt increase in shelf/basin exchange may occur when the marginal ice zone in summer routinely retreats beyond the shelf break, exposing the margin to increased wind mixing and upwelling. The CAME expedition will occupy ~50 stations at ~120 km spacing along the ~ 6000 km circumpolar margin and additional ~5 stations on each of six cross-slope transects over a radial transect distance of ~200 km. The CAME strategy is based on a 'layering of disciplines' - this strategy recognizes that no one study is an entity onto itself, but instead is a component of the three overarching and interconnected goals: freshwater, sea ice and the food web. As such, 7 research elements are recognized: 1. Sea-ice dynamics; 2. Water Masses, Circulation and Tracer Geochemistry; 3. Plankton Ecology; 4. Pelagic-Benthic Coupling and Sediment Tracers; 5. Organic carbon; 6. Shelf to basin flux and transport; 7. Modelling and Prediction. CAME will involve scientists from Canada, Norway, Japan, the UK, the USA and Poland (and others?).

COME: THE CANADIAN OCEAN MONITORING EXPERIMENT – A PROPOSED IPY EFFORT

Eddy Carmack *and Svein Vagle, Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney B.C. V8L 4B2,* carmacke@dfo-mpo.gc.ca

The oceans surrounding Canada are comprised of an interconnected arctic and subarctic domains. As such, the impacts of climate change will be associated both with changes within domains and by the shifting of ocean domains and boundaries. The scientific basis for this latter condition is laid out in Sarmiento et al., 2004, who used satellite data and coupled models to classify the major biomes of the global ocean, identify diagnostics that characterize these domains, and then predict the consequences of climate warming. A major result of this work was to show that the relative areas of ocean biomes will be altered by climate change, and that the high-latitude seas will be especially impacted. It is critical to monitor the biomes and their boundaries in the oceans surrounding Canada.
The objective of the Canada Ocean Monitoring Experiment (COME) is to initiate a long-term, program to observe and monitor the linkages among the subarctic and arctic waters around the North American Continent, including their biogeographic and ecological domains and their response to climate change. Canada has the longest coastline in the world. The task of understanding and managing the marine resources in the oceans surrounding Canada and the North American continent under scenarios of global change is indeed immense. Two facts, however, offer a strategy that will help meet this challenge. *First,* the three oceans that border Canada are, in fact, interconnected by water masses flowing from the North Pacific to the Arctic and into the North Atlantic; this ocean 'continuum' offers a *conceptual framework* for integrated, climate-scale research. *Second,* two science-capable icebreakers of the Canadian Coast Guard – the *Louis S, St-Laurent* and the *Sir Wilfrid Laurier* - currently carry out Arctic missions that, together, encircle Canada and follow these though-flowing water masses; these existing missions offer a key *logistical framework* from which to for base ancillary science programs. *The* approach for COME is divided into two main categories of research effort. The first is the so-called 'long-lines' of hydrographic and biogeographical sections spanning the North Pacific, Arctic and North Atlantic sectors of the transect to identify water mass domains and biomes. The second is the set of regional, site specific studies aimed towards better understanding of processes underlying physical-biological coupling. The two categories are in fact connected in that the long-lines provide the large-scale framework for regional studies and a basis for interpretation of local change by global forcing, while the site specific studies will focus on socially relevant issues and provide observations to constrain and validate models.

FOOD WEBS AND PHYSICAL-BIOLOGICAL COUPLING ON PAN-ARCTIC SHELVES: CONCEPTS AND PERSPECTIVES

Eddy Carmack, *Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney B.C. V8L 4B2* carmacke@dfo-mpo.gc.ca
Paul Wassmann, Norwegian College of Fishery Science, University of Tromsø.

Perhaps more than in any other major ocean, our understanding of the continental shelves of the Arctic Mediterranean is decidedly disciplinary, regional and fractured, and this shortcoming must be addressed if we are to face and prepare for climate change. A fundamental flaw is that while excellent process studies exist, and while recent ship-based expeditions have added greatly to our collective body of knowledge, an integrated and fully pan-Arctic perspective on the structure and function of food webs on Arctic shelves is lacking. To build a perspective that inter-connects the various shelf regions we suggest three unifying *typologies* affecting food webs that will hopefully allow inter-comparison of regional investigations. The first typology is for shelf geography, wherein shelves are classified according to their role in the Arctic throughflow and effects on foodweb function. This typology is further developed to distinguish between deep (Barents) and shallow (Bering and Chukchi) inflow shelves, the wide (Kara, Laptev and East Siberian) and shallow (Beaufort) interior shelves and the longitudinal (East Greenland) and networked (Canadian Arctic Archipelago) outflow shelves. The second typology is for ice climate wherein various ice regimes are examined for their specific impacts on food web dynamics. The third typology is for stratification where it is argued that the source of buoyancy, thermal or haline, is recognized as impacting production and the vertical carbon flux. This typology derives from the so-called alpha/beta ocean distinction (Carmack, 2006). The physical habitat and biota of the pan-Arctic is coupled to the World Ocean via its thermohaline (estuarine) exchanges with the Atlantic and Pacific. As such the Arctic and its shelves act as a double estuary, wherein incoming waters become both lighter (positive estuary) by mixing with freshwater sources, and heavier (negative estuary) by cooling and brine release, and shelves are central to such transformations. The resulting coupling of the Arctic Ocean to its sub-Arctic (and more productive) neighbors demands that food webs be considered through a macroecological view that includes an ecology of advection. Here it is useful to think in terms of *contiguous* domains, wherein physical habitats are defined by common attributes that allow inter-comparisons over large (climate) scales.: examples include: Seasonal Ice Zone (SIZ), Riverine Coastal Domain (RCD), Pacific Arctic Domain (PAD and Pan-arctic Margin Domain (PMD). Each of these domains shares common features while at the same time span large climatic gradients.

Carmack E.C. 2006. The alpha/beta ocean distinction: a perspective on freshwater fluxes, ventilation, nutrients and primary productivity in high-latitude seas. **Deep-Sea Research**, in press

SEDIMENTATION AND WATER COLUMN INDICATORS OF ORGANIC CARBON PROCESSING IN THE NORTHERN BERING AND CHUKCHI SEAS

Lee W. Cooper, *Catherine Lalande, Rebecca Pirtle-Levy and Jacqueline M. Grebmeier, Department of Ecology and Evolutionary Biology, The University of Tennessee, Knoxville, TN 37932, USA*

The Pacific-influenced waters that pass northward over the shallow continental shelves of the northern Bering and Chukchi Seas are utilized and influenced by underlying rich benthic faunal communities as well as processing within the water column. Past studies have shown that organic sedimentation is highly variable seasonally, with maximal organic sedimentation shortly after the dissolution of seasonal ice cover. Organic sedimentation is also regionally variable with high localized deposition from waters with high productivity and nutrient burdens. While the large recent retreat of seasonal ice coverage in this decade has stimulated interest in how this productive ecosystem will respond to possibly irreversible changes in the seasonal sea-ice regime, understanding ecosystem response as a whole has been hampered because ecosystem and oceanographic studies cannot routinely sample on both sides of the political boundary shared by the United States and Russia in the Amerasian Arctic. The Russian-American Long-term Census of Marine Life (RUSALCA) is the first multidisciplinary collaboration by groups of U.S. and Russian scientists in more than a decade in the Chukchi Sea

The combination of some of the results of this bilaterally supported program with work undertaken on several biologically-oriented research programs in U.S. waters, including the Western Arctic Shelf-Basin Interactions (SBI) and the Bering Strait Environmental Observatory (BSEO), is facilitating the first shelf-wide evaluation of Chukchi Sea ecosystem status since the seasonal sea-ice regime shifted at the beginning of this decade. We present here data relevant to the quality and quantity of organic material deposited to the benthos in the northern Bering Sea and in the Chukchi Sea, using the stable carbon isotopic composition of organic material in the water column and within the sediments, short-lived radiotracers that are that are associated with particle deposition, and the inventories of chlorophyll a present in the water column and surface sediments. The available data confirm that the Russian Chukchi Sea remains highly productive under the influence of waters upwelled on to the shelf from the Gulf of Anadyr. However, there are some indications that the Bering Strait regional ecosystem may no longer be as productive as was reported in past studies in the 1980's and 1990's. Maximum water column and sediment chlorophyll inventories at the time of sea ice retreat are lower than in the past, and chlorophyll inventories during the open-water summer period do not appear to reflect a previously observed, continuous "chemostat" supply of nutrients to support high productivity southwest of St. Lawrence Island in the northern Bering Sea.

CAPTURING ARCTIC SHELF PROCESSES: 4 YEARS OF LINKED PHYSICAL AND BIOGEOCHEMICAL SAMPLING USING A MOORED ARRAY IN SVALBARD (A UK-NORDIC CO-OPERATION)

Finlo R. Cottier, *Scottish Association for Marine Science, Oban, Scotland PA37 1QA; fcott@sams.ac.uk*
Shimmield, G. B., Scottish Association for Marine Science, Oban, Scotland; gbs@sams.ac.uk
Falk-Petersen, S., Norwegian Polar Institute, 9296 Tromsø, Norway; falk-petersen@npolar.no
Nilsen, F., The University Centre in Svalbard, N-9171 Longyearbyen, Norway; frank.nilsen@unis.no
Svendsen, H., Geophysical Institute, 5007 Bergen, Norway; harald.svendsen@gfi.uib.no

The Scottish Association for Marine Science, in close cooperation with Norwegian institutes, has maintained a near-continuous capacity for moored observations in Kongsfjorden, NW Spitsbergen since April 2002. The instrumentation has enabled physical, biological and geochemical datasets to be collected and coupled to allow cross-disciplinary studies of shelf-fjordic processes. The oceanography of the West Spitsbergen Shelf is strongly influenced by the Atlantic Water transported in the off-shelf West Spitsbergen Current (WSC). Here we describe the key scientific results that have emerged from this dataset which link the interactions between the WSC and the shelf. Specifically we shall present observations of a wind-driven shelf-basin exchange mechanism that results in a massive seasonal shift in hydrography on the shelf and its impact on sea ice formation in the coastal zone (Cottier et al, 2005). Also we will present data that links the physical process of shelf exchange with a switch in the zooplankton community which has implications for the structuring of higher trophic levels (Willis et al, 2006). Finally, we assess how the datasets may be exploited across other areas of marine science and with international research groups to answer new questions on shelf-basin interactions and responses.

Cottier FR, et al. (2005) Water mass modification in an Arctic fjord through cross-shelf exchange: The seasonal hydrography of Kongsfjorden, Svalbard. J. of Geophys. Res. 110, C12005

Willis KJ, et al. (2006) The influence of advection on zooplankton community composition in an Arctic fjord (Kongsfjorden, Svalbard). J. Mar. Sys. 61, 39-54

ECOSYSTEM DYNAMICS AND SHELF-BASIN EXCHANGE ON THE ARCTIC MARGINS OF THE NORTHERN BERING AND CHUKCHI SEAS

Jacqueline M. Grebmeier, *Rebecca Pirtle-Levy, and Lee W. Cooper*
Marine Biogeochemistry and Ecology Group, Dept. of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN, 37932, USA; jgrebmei@utk.edu

Pacific-influenced waters transiting northward over the shallow continental shelves of the northern Bering and Chukchi Seas impact the underlying benthic faunal communities. The 2002-2006 period has seen the largest decrease in the extent of Arctic sea-ice in the satellite record, and this seasonal sea ice retreat has been particularly dramatic in the shelf to basin region studied as part of several biologically-oriented programs, Western Arctic Shelf-Basin Interactions (SBI), the Bering Strait Environmental Observatory (BSEO), and the Russian-American Long-term Census of Marine Life (RUSALCA). These programs have permitted a broad scale view of biological dynamics that have direct influence on both ecosystem productivity on the shelves and downstream transport of nutrients and organic carbon to the Arctic basin. The shallow continental shelves and slope of the Amerasian Arctic are strongly influenced by nutrient-rich Pacific waters advected over the shelves northward from the northern Bering Sea into the Arctic Ocean. These high-latitude shelf systems are highly productive both as the ice melts and during the open-water period. The duration and extent of seasonal sea ice, seawater temperature, and water mass structure are critical controls on water column production, organic carbon cycling, and pelagic-benthic coupling. Short food chains and shallow depths are characteristic of high productivity areas in this region, so changes in lower trophic levels can impact higher trophic organisms rapidly, including pelagic- and benthic-feeding marine mammals and seabirds. Subsistence harvesting of many of these animals is locally important for human consumption. The vulnerability of the ecosystem to environmental change is thought to be high, particularly as sea ice extent declines and seawater warms. Both primary and secondary production are enhanced in specific regions that we discuss here, with the northern Bering and Chukchi Seas sustaining some of the highest water column production and benthic faunal soft-bottom biomass in the world ocean. In addition, these organic carbon-rich Pacific waters are advected downstream into regions of the nearshore northern Bering, Chukchi and Beaufort Seas off Alaska and periodically into the East Siberian Sea, all of which have lower productivity on an annual basis. Thus, these near shore areas are intimately tied to nutrients and advected particulate organic carbon from the Pacific influenced Bering Shelf-Anadyr water. Given the short food chains and dependence of many apex predators on sea ice, recent reductions in sea ice in the Pacific-influenced sector of the Arctic has the potential to cause an ecosystem reorganization that may alter this benthic-oriented system to one more dominated by pelagic processes.

A PERSPECTIVE ON INTERNATIONAL PAN-ARCTIC DATA COORDINATION

James A. Moore[1] & **Jacqueline M. Grebmeier**[2], [1]*NCAR Earth Observing Laboratory, Boulder CO, USA and* [2]*Marine Biogeochemistry and Ecology Group, Dept. of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN, USA 37932; jgrebmei@utk.edu*

The scientific success of internationally coordinated pan-Arctic research as part of the International Polar Year (IPY) will depend in some part on the data management strategy that enhances international access to and exchange of the rich data sets to come from each of these efforts. Projects such as the integrated Arctic Ocean Observing System (iAOOS) are an unprecedented opportunity to combine international resources and measurement tools to document atmosphere, ice and ocean components of the cryosphere in the Arctic as a complete system. One can anticipate building a broad international dataset from a diverse set of research and operational platforms. These data must be integrated in order to address key science questions and provide a "benchmark" assessment of changes to the system. Early attention to and acceptance of key components of this strategy will permit procedures to be in place that facilitate the building of this rich data legacy. Having such a strategy in place will have as its primary goal to facilitate the collection, archive and exchange of iAOOS datasets and results among the international research and lay communities. One can anticipate components to include free and open access encouraged by international organizations such as the World Meteorological Organization (WMO), common format and documentation guidelines, data transfer protocols among the participating archive centers and encouraging data access for education and outreach activities. A process must be in place to help assure success of iAOOS components such as the "ARCTIC SNAPSHOT" observing network proposed by the International Shelf Basin Exchange (SBE) planning group. The authors will discuss the benefits, challenges and opportunities of such a comprehensive data management strategy. They will also describe implementation of key components of this approach in the context of on-going projects, including the Western Arctic Shelf Basin Interactions (SBI) and Study of Environmental Arctic Change (SEARCH) projects.

VOLUME, HEAT AND SALT EXCHANGE THROUGH THE STORFJORDRENNA

Ilona Goszczko, *Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland;*ilona_g@iopan.gda.pl
*Waldemar Walczowski, Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland;*walczows@iopan.gda.pl
*Jan Piechura, Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland;*piechura@iopan.gda.pl
*Paweł Schlichtholz, Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland;*schlicht@iopan.gda.pl
*Piotr Wieczorek, Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland;*wpeter@iopan.gda.pl

Storfjordrenna is very important channel through which main volume, heat and salt exchange between shelf and deep continental slope regions of the Barents Sea occurs. Appearance, mechanisms of formation and cascading run-off process of dense winter water from Storfjorden to the Greenland Sea were described in detail in a lot of works (Quadfasel et al., 1988; Shauer, 1995; Piechura, 1996; Shauer and Fahrbach, 1999, Fer et al., 2003; Skogseth et al., 2004). Results of numerical simulations (Jungclaus et al., 1995) and interannual variability (Maus, 2003) are described too. Our study is based on 8 hydrographic surveys taken in summer 1998-2006 by Polish research vessel *Oceania* south of Spitsbergen where CTD measurements were performed at high resolution transects. Two hydrological sections illustrate situation along and across the trough: the first lengthwise section presents the central part of the Storfjordrenna, the second crosswise section demonstrates hydrological conditions between Sørkapp and the Bear Island. At this time three principal water masses were observed: brine-enriched shelf water in the plume of less dense water (BSW, $\theta<0$ºC and $S>34.8$ psu or $\sigma_\theta>27.95$ kg m^{-3}), intermediate salt and warm Atlantic water (AW, $\theta>0$ºC and $S>34.8$) and fresh surface Arctic water (ArW, $S<34.8$). In every separated water mass the same parameters were analysed: average potential temperature, salinity, density and layer thickness. Furthermore, the following extreme parameters were compared: maximum salinity and minimum temperature of BSW, maximum salinity of AW and minimum salinity of ArW. The year 2006 was the most saline and warm in the Atlantic Water domain. However, the situation in BSW and ArW masses is different, since we observe minimum temperature and salinity this year. For general view, distribution of hydrological parameters in the West Spitsbergen Current in extreme years is presented as well.

PRIMARY PRODUCTIVITY IN THE EASTERN CHUKCHI SEA

Victoria J. Hill, *Department Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, Virginia, 23508, USA*.

Primary production measurements were made on the Chukchi shelf area during the summer of 1993 and 2000 as well as the spring and summer of 2002 and 2004. These observations place this area among the most productive of arctic shelf seas, with average daily production values of up to 1.8 gC m^{-2} d^{-1} in the spring when ice cover is widespread and 3.5 gC m^{-2} d^{-1} in the summer. Water from the Bering Strait flows along the Alaskan coastline and exits the shelf via Barrow Canyon, the dynamics of the canyon appear to act as a “nutrient trap” fueling extremely high production. Rates observed at the head of the canyon reached 8.6 gC m^{-2} d^{-1} in 2004, coupled with oxygen supersaturation of up to 50%. These intense blooms, triggered by the increase in water column irradiance due to retreat of sea ice can provide considerable material to the benthic communities. This, together with increases in production observed at the slope break in the summer of 2002 and 2004 have interesting consequences for the export of carbon from the shelf to the basin.

THE IMPACT OF ABSORPTION OF LIGHT BY COLOURED DISSOLVED ORGANIC MATERIAL ON THE HEATING BUDGET OF ARCTIC SHELF SEAS

Victoria J. Hill, *Department Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, Virginia, 23508, USA*.

Recent observations from the Chukchi Sea; a shelf sea in the western Arctic Ocean have revealed that the attenuation of visible light in surface waters is greater than previously assumed. This is attributed to the high levels of coloured dissolved organic material (CDOM) present in Arctic Ocean waters. This material is produced in small quantities in situ from biological processes, but the concentrations measured here are an indication of the importance of terrestrial sources from riverine and coastal inputs. Data from the western Arctic were used to model the amount of energy absorbed in surface waters due to CDOM. Results show that CDOM can increase energy absorption in the surface mixed layer by 40% over pure seawater. This results in approximately 99% of solar radiation being trapped in the mixed layer where it is then available for heating, melting of sea ice and loss back to the atmosphere. The absorption of energy by CDOM is crucial in the development of a positive net heat flux into the mixed layer during the spring preventing large scale ice formation over recently opened leads, and possibly increasing the speed of ice retreat. Climate change in the arctic is manifesting in the thawing of permafrost and increases in riverine discharge, mobilising previously frozen terrigenous dissolved organic material (DOM). With this in mind CDOM could become an increasingly influential mechanism for surface heating.

SHELF-BASIN WATER EXCHANGE TRIGGERED BY DENSE WATER CASCADING

Vladimir Ivanov, *International Arctic Research Center, University of Alaska, Fairbanks, AK, 99775 USA; vivanov@iarc.uaf.edu*

It is well established that formation of dense water on the Arctic shelves is initiated by bursts of freezing and consequent brine 'rain', which occurs in winter within the ice-free areas (polynyas) surrounded by consolidated fast and pack ice. After the dense water had accumulated on shelf it starts moving out of the production zone, cascading down-slope and turning to the right of the down-slope direction under the influence of Coriolis force. Numerical experiments, carried out on a primitive-equation regional model has shown that this along- and down-slope motion of dense water invokes an opposite-directed up-slope motion (upwelling) of lighter water from the deep. On the average, this uplifted water moves above the near-bottom dense flow and eventually replenishes the upper layer in the production zone. Two oppositely-directed flows create a circulation loop with denser outflow near the bottom and lighter inflow near the surface. A probable example of this process was revealed in hydrographic observations in the northwestern Laptev Sea. In the Arctic Ocean the ambient water is warmer and typically saltier than the dense water produced on shelves. This suggests that compensatory upwelling might provide an important feedback affecting the cascade. An influx of warm and salty water originating in the Atlantic layer is able to cease ice formation and/or to melt the ice that had formed on or was transported onto the shelf. Hence, the overall effect of upwelling would be additional openings in the ice cover, which under favorable meteorological conditions may provide enhanced heat loss followed by new ice formation and salt ejection, thus maintaining the parent cascade.

ON THE PROCESSES AFFECTING SHELF-BASIN EXCHANGE IN THE BERING SEA

Jaclyn Clement Kinney, *W. Maslowski, Naval Postgraduate School Monterey, CA 93943 USA; jlclemen@nps.edu*
S. Okkonen
Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, AK 99775 USA

We use a 9-km pan-Arctic ice-ocean model (Maslowski et al., 2004) to better understand the circulation and exchanges in the Bering Sea, particularly near the shelf break. This region has, historically, been undersampled for physical, chemical and biological properties. Very little is known about how water from the deep basin reaches the large, shallow Bering Sea shelf. This understanding is critical to gain insight into effects the Bering Sea has on the Arctic Ocean, especially in regard to recent indications of a warming climate in this region. The Bering Sea shelf break region is characterized by the northwestward flowing Bering Slope Current. Previously, is was thought that once this current approached the Siberian coast, it split into two branches with one of them making a sharp turn northward and encircling the Gulf of Anadyr in an anticyclonic fashion. Our model results indicate a significantly different circulation scheme whereby water from the deep basin is periodically moved northward onto the shelf by mesoscale processes, such as eddies, along the shelf break. There appears to be a few locations (e.g. certain canyons) that are more prone to eddy activity and, therefore, show higher rates of on-shelf transport. The 9-km horizontal resolution of the model allows for the representation of eddies with diameters greater than 36 km, however we are unable to resolve the smaller eddies. An even higher resolution model is planned for the future.

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REGIONAL VARIATIONS OF THE ZOOPLANKTON COMPOSITION AND QUANTITATIVE DISTRIBUTION IN THE EASTERN ARCTIC OCEAN

Ksenia Kosobokova, *Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia;* xkosobokova@ocean.ru
Hirche,H.-J., Alfred-Wegener Institute for Polar and Marine Research, Bremerhaven, Germany; hhirche@awi-bremerhaven.de

Zooplankton composition and spatial distribution of the zooplankton biomass was studied in the Eastern Arctic Basin using plankton collections obtained in 1993-1998 during four expeditions of the RV *Polarstern*. Zooplankton was collected along 9 transects from the shelves of the Kara, Laptev and East-Siberian seas over the continental slope into adjacent deep Nansen, Amundsen and Makarov basins, at one transect across the Lomonosov Ridge at 82°N, and in the deep central Amundsen and Makarov basins. Stratified sampling of the entire water column from the bottom to the surface was performed with a multinet (0.25 m^2 mouth opening, 150 µm mesh size). Total zooplankton biomass ranged from 4.2 to 15.3 mg/m^2 dry weight in the slope region (depth 500 - 2500 m) and from 1.9 to 5.5 mg/m^2 in the deep basins (depth >3000 m). Copepods dominated biomass contributing from 77 to 87% in the continental slope region, and from 87 to 97% in the deep basins. Chaetognaths were the second group important in terms of biomass, contributing 8-16% near the slope and 1-7% in the deep basins, respectively. Pronounced regional differences with a strong gradient of biomass along the Eurasian slope from the west to the east were observed within the studied area. They were related to the inflow of the Atlantic water and advection of the Atlantic pelagic populations into the Arctic Ocean. The eastward decrease of copepod biomass was mostly related to decrease of abundance of the Atlantic species *Calanus finmarchicus* and some other allochthonous Atlantic copepod populations. Similar pattern in the chaetognaths' distribution was related to the eastward decrease of abundance of *Eukrochnia hamata*. A decrease of biomass from the Siberian continental slope northward, to the centers of deep basins, was related to a decrease of abundance of both local and allochthonous zooplankton populations in the permanently ice-covered areas. The results of the present study indicate that advection of rich pelagic fauna from the Greenland and Barents seas is an important factor shaping the spatial zooplankton distribution within the Eurasian Basin.

BIOGEOCHEMICAL FLUXES IN THE ARCTIC FRONT ZONE

Janusz Pempkowiak, Institute of Oceanology, PO Box 197, Sopot, Poland; pempa@iopan.gda.pl
Karol Kuliński, *Institute of Oceanology, PO Box 197, Sopot, Poland; kroll@iopan.gda.pl*
Agata Zaborska, Institute of Oceanology, PO Box 197, Sopot, Poland; agata@iopan.gda.pl
Jolanta Lewandowska, Institute of Oceanology, PO Box 197, Sopot, Poland; lewand@iopan.gda.pl
Mariola Łotocka, Institute of Oceanology, PO Box 197, Sopot, Poland; lotocka@iopan.gda.pl
Ryszard Hapter, Institute of Oceanology, PO Box 197, Sopot, Poland; hapter@iopan.gda.pl
Piotr Wieczorek , Institute of Oceanology, PO Box 197, Sopot, Poland; wpeter@iopan.gda.pl
Waldemar Walczowski, Institute of Oceanology, PO Box 197, Sopot, Poland; walczows@iopan.gda.pl

In the period from 2004 to 2006 properties of suspended matter collected in the surface and twilight zone, on the Atlantic and Arctic side of the Arctic Front, were measured (concentration; organic matter proportion; 13C; elemental composition-C,N,H,S). Moreover primary production, phytoplankton species composition, and phytoplankton pigments: carotenoids and chlorophyll, were assessed in the surface samples. At least three sampling stations situated in the 'atlantic' and 'arctic' side of the front were selected and sampled in June, each year. Samples collected from the water depth up to 1000m (0, 25, 50, 100, 250, 500, 1000; m) were investigated. The aim for the study is to assess differences in the quality of organic matter there, kinetics of organic matter changes in the course of sinking, on both sides of the front, and dynamics of organic carbon fluxes caused by shifts of the front.
Basing on the characteristics obtained for the 2004 and 2005 samples, it is concluded that in the investigated area, phytoplankton species composition do not differ much, while the phytoplankton density and primary production are different. Substantial differences of organic matter concentrations among the stations were noticed. Profiles of the measured properties indicated different organic matter characteristics, suggesting different kinetics of organic matter biochemical degradation. Downward fluxes of organic carbon were calculated, and possible changes of the fluxes due to shifts of the front are assessed.
The study will continue till 2008.

EDDY TRANSPORT OF ORGANIC CARBON AND NUTRIENTS FROM THE CHUKCHI SHELF: IMPACT ON THE UPPER HALOCLINE OF THE WESTERN ARCTIC OCEAN

Jeremy T. Mathis, *University of Miami – RSMAS, Miami, Florida, USA; jmathis@rsmas.miami.edu.*
Pickart, R.S., Woods Hole Oceanographic Institute, Massachusetts, USA; rpickart@whoi.edu.
Hansell, D.A,, University of Miami – RSMAS, Miami, Florida, USA; dhansell@rsmas.miami.edu.
Kadko, D., University of Miami – RSMAS, Miami, Florida, USA; dkadko@rsmas.miami.edu.
Llinas, L., University of Miami – RSMAS, Miami, Florida, USA; LLlinas@aol.com.

A survey of a carbon-enriched cold core eddy in the western Arctic Ocean showed that eddies are capable of transporting large amounts of organic carbon from the Chukchi shelf into the deep Canada Basin (2.52 x 10^{11} moles) and that the remineralization of this organic carbon requires 6.70×10^{10} moles of O_2. If eddies are ubiquitous features of this region, then this process has significant impacts on both shelf and basin ventilation and biogeochemical dynamics of the Arctic Ocean. The preconditioning of the water before it is entrained in an eddy is necessary in the Chukchi Sea for any significant shelf-basin exchange of carbon to occur. In this case, the core water in the surveyed eddy had been previously enriched with carbon through sinking particles from primary production and interactions with the carbon-rich sediments of the Chukchi shelf. The biogeochemical processes that affect the conditioning of shelf waters are an important control of the magnitude of carbon transport offshore.

SHELF/SLOPE HYDROGRAPHY NEAR BARROW, ALASKA: SUMMERS 2005 AND 2006

Stephen Okkonen, *Institute of Marine Science, University of Alaska Fairbanks, Kasilof, Alaska 99610 USA;* okkonen@alaska.net
Ashjian, C., Woods Hole Oceanographic Institution, Woods Hole, MA 02543 USA; cashjian@whoi.edu
Alatalo, P., Woods Hole Oceanographic Institution, Woods Hole, MA 02543 USA; palatalo@whoi.edu
Campbell, R.G., Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02874 USA; campbell@gso.uri.edu
Hartz, A., College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331 USA; ahartz@coas.oregonstate.edu
Moore, S., NOAA/AFSC Applied Physics Laboratory-University of Washington, Seattle, WA 98105 USA; sue.moore@noaa.gov
Sherr, E., College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331 USA; sherre@coas.oregonstate.edu
Sherr, B., College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331 USA; sherrb@coas.oregonstate.edu

Temperature, salinity, and chlorophyll fluorescence measurements were acquired across the mouth of Barrow Canyon and over the adjacent shelf in the southern Beaufort Sea during August-September 2005 and 2006 as part of the NSF-funded project “Environmental Variability, Bowhead Whale Distributions, and Iñupiat Subsistence Whaling—Linkages and Resilience of an Alaskan Coastal System”. Sea ice was largely absent from the study area in 2005, whereas one-tenth to two-tenths ice concentrations were common in 2006. The presence of sea ice meltwater contributed to water column conditions that were characteristically cooler, fresher, and more stratified in 2006 than in 2005. Downwelling-favorable (westerly component) winds promoted movement of Bering Sea Summer Water (BSSW) onto the shelf, whereas prevailing, upwelling-favorable (easterly component) winds moved BSSW seaward over the upper continental shelf. Maximum chlorophyll concentrations were generally observed within the pycnocline in both years although maximum concentrations were typically greater in 2006 than in 2005.

AIR-ICE INTERACTION OBSERVATIONS IN THE ARCTIC SEAS

Irina Repina, *A.M. Obukhov Institute for Atmospheric Physics RAS, Pyzhevski 3, Moscow,119017, Russia,* repina@ifaran.ru

There are many methods reliable enough to determine the components of the energy balance for an old ice cover. However, over the areas of young thin ice and especially over open water areas in polynyas and leads, the conditions of heat exchange change: all the components of heat balance increase rapidly, and the turbulent heat flux changes its sign. Till now there are no reliable parameterizations of these processes. The present work is focused on studying the effects of structural and thermal non-uniformity at the ice covered surface on heat ad momentum exchange between atmosphere and underlaying surface. Transformation of air flow caused by change of the underlaying surface type (ice – open water, fast ice - thin one year ice) is also envisaged. During different polar experiments our team carried out the following tasks:
- Research of energy exchange of an atmosphere and surface (open water, ice) by measurements of turbulent heat and momentum fluxes in subsurface layer of atmosphere.
- The determination of coefficient for parametric methods of calculating turbulent fluxes. The data are used for determinations of heat and momentum fluxes, as well as roughness parameter of a surface. The measurements were carried out both during a course of a vessel, and at ice stations; measurement of spatial distribution of surface temperature in IR-range.

Vertical turbulent fluxes in the polar regions essentially depend on the type of the underlying surface. Eddy-covariance method allows direct measurements of turbulent fluxes under various background conditions. This method proved to be reliable both in the Arctic and in the Antarctic. Exchange coefficients, calculated using direct measurements do not correlate with any single meteorological parameter, but rather depend on an ensemble of factors, which are usually difficult to estimate. Profile method of turbulent flux calculation provides results, which coincide with direct measurements only under the conditions when Monin-Obukhov theory is valid. Calculation of turbulent fluxes in the confined area with irregular underlying surface requires careful selection of method of calculation and type of parameterization of coefficients. Measurements of the atmospheric turbulence characteristics directly from ice, in the absence of the ship effect and vibration, allow to receive more accurate results, especially at small values of turbulent fluxes.

When breaks are formed in ice, strong outgoing fluxes are formed due to a large difference in temperature. The heat fluxes over polynyas are one or two orders of magnitude greater than those over the pack ice. However, up to 50% of the whole turbulent exchange between the ocean and atmosphere occurs over this small area.

The value of the drag coefficient C_D experimentally obtained for polynyas was 1.49×10^{-3}, which is smaller than that for ice covered with hummocks, but greater than that for the open ocean.

The effect of the bottom relief in the shallow water on the processes in the near-surface layer of the atmosphere is discussed. In particular, the energy exchange processes were found to be intensified in the region of the shelf edge.

The air-sea-ice investigations in polar regions are considered in the IPY tasks frame.

SEDIMENT BURIAL PROCESSES IN AN ARCTIC MARGINAL SEA

Carroll, J, , Akvaplan-nivaAS, Polar Environmental Centre, Tromsø, Norway
Agata Zaborska, *, Polish Academy of Sciences, Institute of Oceanology, Sopot, Poland*
Papucci, C, , ENEA- Marine Environment Research Centre, La Spezia, Italy
Pempkowiak, J, , Polish Academy of Sciences, Institute of Oceanology, Sopot, Poland

The Barents Sea marginal ice zone undergoes extreme variability in physical conditions over multiple time-scales. How these variations influence the structure and function of Arctic benthic biological communities is currently under investigation. In this context, sediment profiles of ^{234}Th, ^{210}Pb, and ^{137}Cs are being used to distinguish seasonal and longer time-scale patterns in burial processes and to characterize site-to-site variability in benthic habitats at seven stations along a North- South gradient from 75–80° N; 30° E. ^{210}Pb-based sediment accumulation rates are remarkably consistent at all stations above 78° N where we find steady-state accumulation (0.7 +/- 0.1 mm/yr) with little evidence of sediment mixing events. Below 78° N, sediment burial rates differ among sites, ranging from 0.4-1.3 mm/yr and there is evidence of mixing at some locations. The observed differences in benthic community responses between southern and northern stations are linked to the physical and biological composition of the benthos and the prevailing patterns in ice extent and water mass transport in this Arctic marginal sea.

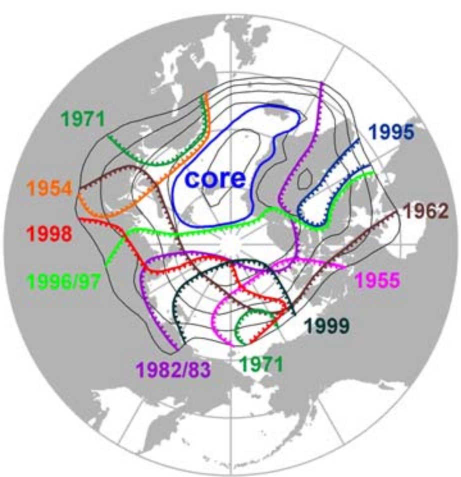
CORE REGION OF ARCTIC OSCILLATION AND THE MAIN ATMOSPHERIC EVENTS IMPACTED ON ARCTIC

Jinping Zhao, *Yong Cao, and Jiuxin Shi, (Ocean University of China, Qingdao, 266003,China)*

The Arctic region is experiencing obviously climatological warming at a rate which is nearly twice of the global average during the past decades. Most climatological indicators show a linear trend. The notable ones include the decline of the perennial ice coverage and the thinning of the ice. However, the Arctic Oscillation (AO) behaves differently from such regularities. In AO, instead, an oscillation is still dominant.

AO is a seesaw pattern in which sea level pressure (SLP) at the polar and middle latitudes in North Hemisphere fluctuates between positive and negative phases. It has been used as a representative atmospheric circulation index to express climate change. This paper provides a new insight to look at the mechanism of the variation of AO.

Most researches on AO are based on the EOF decomposition, which is a popular approach to analyze spatiotemporal signal. The result of EOF is benefit to present various oscillations. However, oscillation reflected by the EOF pattern of SLP sometimes is not a real oscillation, but is a result caused by the position swinging and intensity changing of the air pressure system. In this study, the running correlation method is used instead. The running correlation coefficient (RCC) can reveal the inconsistent duration between two variables. We have uncovered a special region called here Arctic Oscillation Core Region (AOCR), where the RCC between gridded SLP and AO index are all negative. The averaged SLP of this region correlates significantly with AO index. The correlations between local SLPs and AO index outside of AOCR are weaker than those inside. RCC analysis reveals several strong discrepant events different from AO. These events occurred in the years of 1954, 1955, 1962, 1971, 1982/83, 1995, 1996/97, 1998, and 1999. By comparison of ENSO and PDO indices, the events in 1982/83 and 1998 are probably associated with the ENOS processes. Events centered other years are likely connected with PDO, which reached its minima in 1950, 1955, 1962 and 1971. It seems that the coincidence of the discrepancy events is more frequent with negative PDO events that with El Niňos. These events are episodic ones, once per decade before the 1990s, and became more frequent in the late 1990s. When these events were absent, SLP variation in Arctic is still controlled primarily by AO process. The impacts coming from lower latitude must be caused by the complicated dynamic process of atmospheric circulation, which is still unclear and needs to be revealed.



Arctic Oscillation Core Region and the main atmospheric events impacted on Arctic

PARTICIPANTS LIST

Anderson, Leif
Department of Chemistry
Goteborg University
S412 96 Goteborg, Sweden
Phone: + 46 31 772 27 74
Fax: + 46 31 772 27 85
leifand@chem.gu.se

Ashjian, Carin
MS#33
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: + 1 508-289-3457
Fax: +1 508-457-2134
cashjian@whoi.edu

Cooper, Lee
University of Tennessee
Marine Ecology Group
10515 Research Drive
Bldg A, Suite 100
Knoxville, TN 37932
Phone: +1 865-974-2990
Fax: +1 865-974-7896
lcooper1@utk.edu

Cottier, Finlo Robert
Scottish Association for Marine Science
Oban, Argyll
PA37 1QA, Scotland
Phone: +
Fax: +
fcott@sams.ac.uk

Fortier, Martin
Executive Director – ArcticNet
(Network of Centres of Excellence of Canada)
Room 4081, Pavillon Vachon
Universite Laval
Quebec, Quebec G1K 7P4
Phone: + 1 418-656-5233
Fax: + 1 418-656-2334
martin.fortier@arcticnet.ulaval.ca

Goszczko, Ilona
Powstancow Warszawy 55
Sopot, Poland 81-712
Phone: + 48 58 551 72 81
Fax: + 48 58 551 21 30
Ilona_g@iopan.gda.pl

Grebmeier, Jackie
University of Tennessee
Marine Ecology Group
10515 Research Drive
Bldg A, Suite 100
Knoxville, TN 37932
Phone: +1 865-974-2592
Fax: +1 865-974-7896
jgrebmei@utk.edu

Harmon, Kim
University of Tennessee
Marine Ecology Group
10515 Research Drive
Bldg. A, Suite 100
Knoxville, TN 37932
Phone: +1 865-974-8621
Fax: +1 865-974-7896
kcox2@utk.edu

Ivanov, Vladimir
727-B North Chandalar
PO Box 750243
Fairbanks, AK 99775
Phone: + 1 907-474-2678
Fax: +1 907-474-2643
vivanov@iarc.uaf.edu

Hill, Victoria
4600 Elkhorn Ave
OEAS, RM 406
Old Dominion University
Norfolk, VA 23529
Phone: +1 757-683-4911
vhill@odu.edu

PARTICIPANTS LIST

Kassens, Heide Marie
Forschungszentrum GEOMAR
Wischhofstrasse 1-3, Geb. 4
Kiel, Germany D24148
Phone: + 0049 431 600 2850
Fax: + 0049 431 600 2850
hkassens@ifm-geomar.de

Katarzyna, Dmoch
Powstancow Warszawy 55
Sopot, Poland 81-712
Phone: + 48 58 551 7283
kasiadm@iopan.gda.pl

Kinney, Jaclyn Clement
Naval Postgradutate School
Department of Oceanography
833 Dyer Rd.
Monterey, CA 93943
Phone: +1 831-656-3226
Fax: +1 831-656-2712
jlclemen@nps.edu

Kosobokova, Ksenia
P.P. Shirshov Institute of Oceanology
Russian Academy of Sciences
36 Nakhimova Ave.
Moscow, Russia 117997
Phone: + 7 495 124 77 49
Fax: + 7 495 124 59 83
xkosobokova@ocean.ru

Kulinski, Karol
ul. Powstancow Warszawy 55
81-712 Sopot, P.O Box 68
Phone: +48 608 825 580
Fax: +48 58 551 21 30
kroll@iopan.gda.pl

Maslowski, Wieslaw
Naval Postgraduate School
Oceanography Department
833 Dyer Rd.
Monterey, CA 93943
Phone: +1 831-656-3162
Fax: +1 831-656-2712
maslowsk@nps.navy.mil

Mathis, Jeremy
Marine and Atmospheric Chemistry
4600 Rickenbacker CSWY
Miami, FL 33149
Phone: + 1 305-338-0570
Fax: + 1 305-421-4689
jmathis@rsmas.miami.edu

Moore, Sue
NOAA/AFSC @ APL-UW
1013 NE 40th Street
Seattle, WA 98105-6698
Phone: + 1 206-685-2125
Fax: + 1 206-543-6785
sue.moore@noaa.gov

Okkonen, Stephen
Box 1025
Kasilof, AK 99610
Phone: + 1 907-283-3234
Fax: + 1 907-283-3234
okkonen@alaska.net

Piechura, Jan
55 Powstancow Warszawy str
Sopot, Poland
81-712
Phone: +48 58 5517281
Fax: +48 58 5512130
piechura@iopan.gda.pl

Reigstad, Marit
Norwegian College of Fishery Science
University of Tromsø
Tromsø, Norway N-9037
Phone: + 47 776 44525
Fax: + 47 776 46020
Marit.Reigstad@nfh.uit.no

Repina, Irina
Pyzhevski 3
Moscow, Russia 119017
Phone: + 7 4959518549
Fax: + 7 4959531652
repina@ifaran.ru

PARTICIPANTS LIST

Schauer, Ursula
Stiftung Alfred-Wegener-Institute fur Polar – und
Meeresforschng BussestraBe 24
Bremerhaven, Germany D27570
Phone: + 49 471 48311817
Fax: + 49 471 48311797
uschauer@awi-bremerhaven.de

Shimada, Koji
2-15 Natshushima
Yokosuka, Japan
237-0061
Phone: +81 46 867 9485
Fax: +81 46 967 9455
shimadak@jamstec.go.jp

Walczowski, Waldemar
Sienkiewicza 32/2
Gdynia, Poland 81-712
Phone: + 48 58 551 72 81
Fax: + 48 58 551 21 30
walczows@iopan.gda.pl

Wassmann, Paul
Norwegian College of Fishery Science
N-9037 Tromsø
Norway
Phone: +47 776 44459
Fax: + 47 776 46020
Paul.Wassmann@nfh.uit.no

Whitledge, Terry
Institute of Marine Science
PO Box 757220
University of Alaska, Fairbanks
Fairbanks, AK 99775-7220
phone: 907-474-7229
fax: 907-474-7204
terry@ims.uaf.edu

Wiktor, Jozef
Tr. Sw. Wojciecha 331b
Gdansk, Poland 80-001
Phone: + 48 58 309 0242
Wiktor@iopan.gda.pl

Zaborska, Agata
Powstancow Warszawy 55
Sopot, Poland 81-712
Phone: + 48 58 551 7283
agata@iopan.gda.pl

Zhao, Jinping
College of Physical and Environmental Oceanography
5 Yushan Road
Qingdao, Shandong/China 266003
Phone/Fax: + 86 532 8203 2096
jpzhao@ouc.edu.cn