Book of Abstracts

Joint ART-APECS Science Workshop

"Overcoming challenges of observation to model integration in marine ecosystem response to sea ice transitions"

23-26 October.2012, Sopot, Poland

http://www.iarc.uaf.edu/ART

PRESENTATIONS AT A GLANCE

PLENARY PRESENTATIONS		
Date	**Presenter**	**Title**
Tuesday, 23rd	Alexey Pavlov	Career development and the importance of interdisciplinarity.
Wednesday, 24th	Wieslaw Maslowski	Advancements in Arctic Climate System Modeling.
Thursday, 25th	Gijs de Boer	Observational Needs for Climate Models in Polar Regions.
Thursday, 25th	Ingrid Ellingsen	Arctic marine models: some challenges and future directions
Thursday, 25th	Katrina Bennet	Changing Extreme Events in the Arctic and Sub-Arctic Regions of Alaska: Building Science Frameworks to Support Social and Economic Analysis of Climate Change Impacts on Extreme Events in Alaska.
Thursday, 25th	Juliane Müller	Lessons from the past to improve the understanding and modelling of Arctic sea ice changes.
Thursday, 25th	Jean-Éric Tremblay	Nitrogen cycling and the conditioning of primary production in the Arctic Ocean: concepts, issues and research avenues.
Friday, 26th	Gesine Mollenhauer	Land-coast-ocean interaction studies along the Eurasian Arctic shelf.
Friday, 26th	Ilka Peeken	The ART-AWI collaborative field campaign: the TRANSSIZ program
Friday, 26th	Michael Tjernström	Multidisciplinary drifting Observatory for the Study of Arctic Climate – MOSAiC.
Friday, 26th	Helen Findlay	Ocean Acidification in Arctic Waters: Long-term monitoring & future modelling strategies.
Friday, 26th	Jacqueline Grebmeier	Developing a distributed biological observatory in the western Arctic.

PARALLEL SEMINARS AND PRACTICALS		
BLOCK 1, Tuesday, 23rd October		
Session	**Title**	**Presenters**
1	Arctic marine ecosystem evolution from a geological perspective.	Anne de Vernal and Kirstin Werner
2	The dynamics of Arctic sea ice decline and consequences for heat and carbon fluxes.	Walt Meier and Brent Else
3	Observing and modeling physical changes of the Arctic Ocean hydrography.	Waldemar Walczowksi and Ilona Goszko
4	Ecological consequences of changing sea ice conditions on pelagic-benthic systems.	Jan Marcin Weslawski and Nathalie Morata
5	Integrating the human dimension in studies of the past, present and future arctic marine environment.	Lize-Marié van der Watt
BLOCK 2, Wednesday, 24th October		
Session	**Title**	**Presenters**
1	Paleo-models and high-resolution simulations of the ocean and sea ice in the Arctic and North Atlantic.	Alan Condron and Axel Wagner
2	Advancing food web reconstruction by merging observations with modeling.	Dick van Oevelen and Charlotte Moritz
3	Coupling the physic and biology through dynamic modeling: from one to multiple dimensions.	Georgina Gibson and Alexandre Forest

POSTER PRESENTATIONS	
Wednesday, 17:30 - 19:00 and Thursday, 16:30 - 18:00	
Presenter	**Title**
Emily Choy	The Offshore Diet of the Eastern Beaufort Sea Beluga Population and the Energetic Effects of Climate Change.
David Carmen	Variability of under-ice habitats and communities in Central Arctic Ocean
Renate Degen	A Pan-Arctic Database to assess present and future Arctic Biosphere.
Steve Duerksen	Spatial variation of the trophodynamic lipid flux in zooplankton during the ice algal spring bloom in the Canadian High Arctic.
Helen Findlay	Ocean Acidification in Arctic Waters: Long-term monitoring & future modelling strategies.
Vera Fofonova	The simulations of circulation in the Laptev Sea using FVCOM.
Alexandre Forest	Coupling an Arctic planktonic food web model with a module on carbonate chemistry: results from a 1-d physical-biological simulation in the Beaufort Sea
Matthias Forwick	Sea-ice fluctuations in central Isfjorden, Svalbard, during the past c. 11,200 years
Georgina Gibson	Modeling processes controlling the on-shelf transport of oceanic mesozooplankton populations in the Eastern Bering Sea.
Oskar Głowacki	Deformation rates of the Arctic Ocean ice cover: trends, variability and relationship with large-scale wind forcing.
Barbara Górska	Meiofauna of deep Arctic Ocean – temporal changes
Ilona Goszczko	Physico-chemical structure of the eastern Greenland Sea's upper layer - horizontal and vertical distribution of water parameters.
Maija Heikkila	Seasonal signatures of dinoflagellate cyst production in Hudson Bay based on monthly sediment trap data.
Anna Kaczmarska	Long Term Variability of Sea Surface Height in the Nordic Seas.
Monika Kedra	Benthic population dynamics and diversity in the changing ecosystems of the Bering and Chukchi Seas.
Dubrava Kirievskaya	The vulnerability assessment of the Chukchi Sea bottom ecosystem: anthropogenic impact case.
Meri Korhonen	The surface layer in the Arctic Ocean is seasonally modified by the freezing and melting of sea ice.
Magdalena Łącka	Atlantic Water advection to the European Arctic in Holocene. Paleoceanographic record of the West Spitsbergen Current fluctuations
Benjamin Lange	Impacts of climate change have been most pronounced in Polar Regions.
Michał Laska	Internal accumulation and meltwater percolation in snow cover on tidewater glacier (Hansbreen).
Maciej Miernecki	New L-band missions and possibility of sea ice thickness estimation.
Nathalie Morata	ECOTAB: Effect of Climate change On The Arctic Benthos.
Charlotte Moritz	Habitat suitability mapping.
Mateusz Moskalik	Bathymetry and slope gradients of Brepollen (Hornsund, Spitsbergen).
Monika Izabela Orchowska	Changes in Ocean Chemistry due to Ocean Acidification in the western Arctic Ocean.
Joanna Pawłowska	Paleometagentics of Arctic Foraminifera.
Anna Piszewska	Benthic fauna distribution changes (Hornsund, Spitsbergen) as an indicator of the global climate change.
Kasia Piwosz	Sea ice protists are key organisms for functioning of this unique habitat.
Joanna Przytarska	Paleoenvironmental and paleoecological reconstructions of the marine condition during the last 13 750cal yr BP in the European Arctic (Hornsund, Spitsbergen).
Anna Silyakova	The effect of increasing pCO2 and C:N stoichiometry on biogeochemistry and phytoplankton production in the future Arctic Ocean.
Ehouarn Simon	Estimation of positive sum-to-one constrained zooplankton grazing preferences with ensemble-based Kalman filters.

Ivan Sudakov	New approaches in mathematics theory of sea ice.
Kirstin Werner	Seawater-derived Neodymium isotope tracers – a method applicable to reconstruct Holocene deepwater sources in the eastern Fram Strait?
Agata Weydmann	Inter-annual and spatial zooplankton variability in the West Spitsbergen Current.
Christie Wood	Optical Characteristics and Photoreactivity of Chromophoric Dissolved Organic Matter Associated with Sea Ice Melt in the Chukchi and Beaufort Seas.

PLENARY PRESENTATION ABSTRACTS

Plenery presentation abstracts are in listed in alphabetic order.

CHANGING EXTREME EVENTS IN THE ARCTIC AND SUB-ARCTIC REGIONS OF ALASKA: BUILDING SCIENCE FRAMEWORKS TO SUPPORT SOCIAL AND ECONOMIC ANALYSIS OF CLIMATE CHANGE IMPACTS ON EXTREME EVENTS IN ALASKA

Katrina E. Bennett, Larry Hinzman, Jessica Cherry, and John Walsh, International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, Alaska, kebennett@alaska.edu

Sub-Arctic and Arctic human and ecological systems are anticipated to experience significant change owing to polar climate amplification; the severe consequences of these impacts requires clear delineation for policy makers and planners to understand the extent, uncertainties and feedbacks associated with this change. A number of collaborative science efforts are underway to quantify Arctic climate change at a systems level and to demarcate the shifts across complex, permafrost dominated landscapes of Alaska. Researchers working with the Alaska Climate Science Center, the Alaska Center for Climate Assessment and Policy, the Scenario Network for Adaptation and Planning, and the International Arctic Research Center have built interdisciplinary teams to address this challenge and present science results in a context that is accessible to social and economic planners. Examples from recent work on extreme hydro-climate events and the exploration of these changes in the framework of forecasting and planning tools utilized by the National Weather Services' Alaska Pacific River Forecast Center will be presented and discussed.

OBSERVATIONAL NEEDS FOR CLIMATE MODELS IN POLAR REGIONS

Gijs de Boer, CIRES/NOAA ESRL, USA, gijs.deboer@colorado.edu

Observations are essential for motivating and establishing improvement in the representation of polar processes within climate models. Often, however, barriers exist preventing the efficient integration of collected datasets into model development. Explicit documentation of current methods used to develop and evaluate climate models with observations will help inform and improve collaborations between the observational and climate modeling communities. Here, information presented reflects experience working on the Community Earth System Model (CESM) project, and is at present focused mainly on atmospheric, sea ice, and ocean processes. Topics included for presentation include finding a common language shared both by the observational and modeling communities, the use and collection of both process-scale and climate-scale observations, the importance and sources of observational uncertainty, and limited discussion on common practices. It is hoped that a document outlining these ideas will evolve and expand with continued community feedback. The ART workshop provides us with a unique opportunity to discuss implications on this material on data collection and modeling of the ocean ecosystem. Additionally, ART's background as a group driven by early career scientists provides a unique opportunity to directly engage those responsible for the future of Arctic science. Feedback from the ART and APECS communities will be directly integrated into this working document, and we hope this presentation inspires new and useful interactions, eventually resulting in improved pathways for development and evaluation of polar climate models.

ARCTIC MARINE MODELS: SOME CHALLENGES AND FUTURE DIRECTIONS

Ingrid Ellingsen, SINTEF Fisheries and Aquaculture, Norway, Ingrid.Ellingsen@sintef.no

There has been increased activity in recent years on applying coupled biophysical models to simulate Arctic marine ecosystems. An overview of these models will be given. I will focus, in particular, on our model system SINMOD to discuss some of the challenges we face and how the models can be improved. The ecosystem module in SINMOD covers the lower trophical levels in the food web. Complexity increases when we want to include species higher up in the food chain. I will present some of the issues that I think we need to take into consideration. There are further several ways we can couple and combine models for end-to-end studies and the selection of approach should depend on what we aim to use the model for.

OCEAN ACIDIFICATION IN ARCTIC WATERS: LONG-TERM MONITORING & FUTURE MODELLING STRATEGIES

Helen S. Findlay, Plymouth Marine Laboratory, UK, hefi@pml.ac.uk

The oceans are becoming more acidic as a result of increasing levels of carbon dioxide being absorbed into the surface waters. This is well documented globally, and predicted to occur most rapidly in the cold Polar Regions. These predictions are based on models and observations, yet the observations are limited in the Arctic Ocean to just a few studies carried out between the late spring and early autumn. Whats more the models do not account for all the ice-associated processes that can influence the flux of CO_2 into, or out of, the ocean and therefore generally misrepresent the seasonal cycle of carbon in the surface ocean. Sea ice plays an important role physically in determining the flux of CO_2, but additionally influences biological and chemical processes. In addition to ocean acidification, summer ice loss, as well as ocean warming, will alter biogeochemical regimes in the Arctic. While it is becoming clear that long-term monitoring is necessary to establish rates of change, mitigation and adaptation, the technological developments necessary to allow us to monitor the remote Arctic are still lagging other ocean regions. In this talk I discuss ocean acidification and its relevance, what is known about ocean acidification in the Arctic, some processes and knowledge gaps, and what direction future research should take, including the initiative of a global network for long-term monitoring of ocean acidification and ecosystem response, which looks to incorporate chemical, biological and modelling strategies to monitor this issue.

DEVELOPING A DISTRIBUTED BIOLOGICAL OBSERVATORY IN THE WESTERN ARCTIC

Jacqueline M. Grebmeier, University of Maryland Center for Environmental Science, USA,
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The Pacific sector of the Arctic Ocean is experiencing major changes in the timing of sea ice formation and retreat, along with increasing seawater temperatures, which are driving shifts in hydrographic conditions, biological processes and marine species composition. These changes may signal the start of large-scale marine ecosystem reorganization. In recent years, the timing of seasonal sea ice retreat in the northern Bering Sea has been highly variable, but to the north in the neighboring Chukchi Sea ecosystem there has been a consistent and significant earlier summertime retreat and a delay in sea ice formation in the autumn. This latitudinal gradient in sea ice persistence, and its effects on chlorophyll biomass and carbon export to the sediments has adirect impact on ecosystem structure in this subarctic-arctic complex. Potential biological impacts include shifts in species composition, abundance and biomass, trophic transfer efficiency, and northward range expansions. One consequence might be a shift from a benthic-dominated northern Bering and Chukchi shelf region to a more pelagic-dominated system, with a direct impact on higher trophic level productivity. Several programs undertaken during the International Polar Year, including the U.S. Bering Sea Research Program, Canada's Three Oceans, and the Russian-US Long-term Census of the Arctic are providing insights into the key processes influencing ecosystem function and change in this region. Based upon these initial efforts, a network of international partners are coordinating standardized hydrographic measurements and biological observations of select trophic levels as part of a Distributed Biological Observatory (DBO) initiative at key regions of high biological production, biodiversity and observed areas of change. The DBO is envisioned as a change detection array for the identification and consistent monitoring of biophysical responses. Data from this observational DBO program will be discussed as part of the overall evaluation of the biological response s to sea ice changes.

ADVANCEMENTS IN ARCTIC CLIMATE SYSTEM MODELING

Wieslaw Maslowski, Naval Postgraduate School, Monterey, CA, USA, maslowsk@nps.edu

The Arctic System has experienced major changes including declining cryosphere, warmer air and ocean temperatures and ecosystem shifts. Understanding and prediction of such changes is critical since this region is a key player of the Earth System, influencing the global surface energy and moisture budget, atmospheric and oceanic circulation and feedbacks. Such changes could have significant ramifications for global sea level, the ocean thermohaline and atmospheric circulation, the global surface energy and moisture budgets, and geosphere-biosphere feedbacks as well as native coastal communities, and commercial activities. However, a system-level understanding of critical Arctic processes and feedbacks is still lacking.
Global Climate and Earth System Models (GC/EaSMs) have proven to be useful tools for climate studies, however relatively coarse (> 1 deg) resolution limits their ability to realistically represent some smaller scale processes and feedbacks and thus results in sizeable errors in the Arctic. The Regional Arctic System Model (RASM) has been developed for a pan-Arctic domain with the overarching goal of advancing understanding of past and present states of Arctic climate and improving seasonal to decadal predictions. RASM consist of a polar-optimized version of the atmospheric Weather Research and Forecasting (WRF) model, the Los Alamos Parallel Ocean Program (POP), the Community Ice Code (CICE) sea-ice model and the Variable Infiltration Capacity (VIC) land model. The NCAR flux coupler, CPL7, links the components and also provides a gateway for linking additional model components that are CPL7-ready. RASM capability is expanded to include ice sheets, glaciers and ice caps, and dynamic vegetation.
This presentation will summarize up-to-date progress with RASM, including how it improves on the modeling of the Arctic versus other simulations and further challenges for simulating the Arctic system well.

LAND-COAST-OCEAN INTERACTION STUDIES ALONG THE EURASIAN ARCTIC SHELF

Gesine Mollenhauer, Alfred-Wegener-Institute, Germany, gesine.mollenhauer@awi.de

About 24% of the northern hemisphere land area is underlain by permafrost storing roughly 1700 Pg of carbon, and 34% of the global coastline is located in permafrost areas. Much of the carbon stored in permafrost deposits is fossil, and its release to the ocean and atmosphere has the potential to increase greenhouse gas concentrations. Carbon can be released in particulate, dissolved and gaseous form and in response to, e.g., changes in air temperature, flooding, storm activity, and wave action along the coasts.
Earlier studies addressing the input of terrigenous organic matter to the Eurasian Arctic shelf areas have concentrated on quantifying the amount of organic carbon released to the ocean and on estimating the relative contributions of river discharge versus coastal erosion, where the latter was found to contribute much more sediment but less organic matter. Locally, e.g., in the Laptev Sea, the relative contribution of organic matter by coastal erosion can, however, be higher than that from rivers.
More recent studies are now aiming at quantifying the individual contributions of carbon from fossil, i.e., Pleistocene deposits to total organic matter discharge. In these studies, stable carbon isotopes and radiocarbon measurements are often used. Here I will report on published and own results obtained on dissolved and particulate organic matter transported by rivers and on shallow water shelf sediments collected from the Eurasian Arctic Shelf seas. I will present current estimates on the amount of annual activation of old carbon from permafrost deposits and describe ongoing research projects.

LESSONS FROM THE PAST TO IMPROVE THE UNDERSTANDING AND MODELLING OF ARCTIC SEA ICE CHANGES

Juliane Müller, Alfred Wegener Institute for Polar and Marine Research, Germany, juliane.mueller@awi.de

Fluctuations in the Arctic Ocean sea ice budget are not only a consequence of climate change; they also contribute to shifts in regional (and even global) climate systems through the impact of the ice on oceanic and atmospheric feedback mechanisms.
The uncertainty in a majority of numerical climate models to properly represent the current and recent sea ice coverage in the High Latitudes thus calls for an improvement of the respective climate simulations. Such an improvement may be achieved through comparison and cross-evaluation attempts between proxy-based palaeo sea ice reconstructions and model experiments.
Besides sea ice related microfossil or sedimentological data, the novel sea ice biomarker IP25 - a direct indicator of past (spring) sea ice coverage - seems to provide a unique opportunity to satisfactorily track palaeo sea ice variations. In fact, this biomarker repeatedly has been applied to reconstruct the various sea ice conditions that characterised the Arctic Ocean during e.g. glacial, deglacial and Holocene times. With the further development of the PIP25 index even a quantitative assessment of palaeo sea ice coverage could be enabled. Ideally, these palaeo sea ice data may either serve for comparative purposes to validate palaeo sea ice models or they may even display boundary conditions for simulations of sea ice associated changes in oceanic and/or atmospheric circulation patterns. In this regard, major issues that require consideration and discussion are the understanding and the applicability of suitable proxies, the definition of model boundary conditions, and the spatial and temporal resolution that may be covered by proxy and model attempts.

CAREER DEVELOPMENT AND THE IMPORTANCE OF INTERDISCIPLINARITY IN ARCTIC SCIENCES

Alexey Pavlov, Association of Polar Early Career Scientists, Tromsø, Norway, pavlov.alexey.k@gmail.com

The Arctic Ocean is a unique region. Its high latitude location between continents with large areas covered in sea ice, high river run-off relative to the volume of the Arctic Ocean and a fragile marine ecosystem, make it a complex system with numerous feedback mechanisms. Only through international and interdisciplinary cooperation combined with modern technologies, techniques and participation of a new generation of Polar researchers will it be possible to achieve progress in understanding the Arctic Oceans current state and predict its future.
This presentation will provide a general overview of the Arctic Ocean system. Current gaps in knowledge and future research directions will be highlighted including a description of recent large research programs as well as upcoming initiatives in the Arctic. The necessity of nurturing the next generation of skilled and experienced polar researchers will be discussed with a particular emphasis on career development opportunities that the Association of Polar Early Career Scientists (APECS) is providing for early career scientists.

THE ART-AWI COLLABORATIVE FIELD CAMPAIGN: THE TRANSSIZ PROGRAM

Ilka Peeken, AWI/MARUM, Germany, ilka.peeken@awi.de

Despite advances in understanding sea ice dynamics in the Arctic over the past decade, the connection between sea ice, ocean circulation and ecosystem changes remains poorly established. Primary productivity is one of the components where we lack basic knowledge about spatial variability, seasonality, the role of ice algae versus planktonic algae, and community composition. How these variables will respond to future scenarios, given less ice and more light but uncertain nutrient conditions, is a significant unknown required for planning socio-economic impacts of Arctic change. To date, studies on biogeochemical cycling and ecosystem dynamics between the fall freeze-up and spring thaw are lacking in the European Arctic. Targeted studies on these time periods are imperative for defining annual rates, how changes in seasonal timing impact ecosystem structure, and how winter conditions influence biogeochemical cycling. All of these responses are tightly linked to ocean circulation and the physical structure of the water column. In a similar manner, proxies used for paleoceanographic reconstructions need to be calibrated against modern observations. To be able to study the missing time periods the European ART members participated in a call for ship time proposals of the German icebreaker *Polarstern* (http://www.awi.de/en/infrastructure/ships/polarstern/submission_of_proposals/). In the main ART proposal: *Transitions in the Arctic Seasonal Sea Ice Zone (***TRANSSIZ),** we want to address the above mentioned themes through process-based studies of productivity, ecosystem dynamics and biogeochemical cycling at the end of the winter season (April/May) along two shelf-to-basin transects of the European Arctic margin. To be able to study the fall freeze-up period we participated in the Trans-Arctic Survey of the Arctic Ocean in Transition (TRANSARC II) cruise proposal led by Ursula Schauer (AWI). During this cruise (planned for 2015) the **ART** team will study the impact of river run off and nutrient supply on the primary production and standing stocks of algae and how it affects the biodiversity of the arctic ecosystem. By comparing sea ice, under-ice water and sediments samples the current understanding of paleo-reconstructions to link recent findings with geological records will be improved.

MULTIDISCIPLINARY DRIFTING OBSERVATORY FOR THE STUDY OF ARCTIC CLIMATE – MOSAIC

An international drifting research station to study atmosphere-ocean-sea-ice processes in the central Arctic icepack

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The climate in the Arctic is changing faster than in other regions of the Earth. Near surface temperature is rising more than twice as fast as the global average and the perennial sea-ice cover is shrinking fast, especially in summer. The Arctic is on its way to a new climate regime, dominated by first year-ice. At the same time, the scientific understanding on processes and feedbacks causing this rapid change is poor and climate modeling in the Arctic remains a challenge.

Our understanding is limited by the lack of observations over the Arctic Ocean, limited for logistical and practical reasons. To obtain these urgently needed observations, a manned drifting station will be deployed in the sea-ice in the far western Arctic Ocean and proceed through the transpolar drift towards the Fram Strait over the course of 1-2 years. A target deployment date of autumn 2017 has been proposed.

The motivations for a new international observatory for detailed process-level observations in the central Arctic – MOSAiC – may be summarized in a few points:

Models are critical for understanding climate and climate change. However, current weather and climate models have significant problems in reproducing the current state and are unable to develop known system interactions. There is therefore a need for observations to constrain new process-based sub-grid scale parameterizations for improving the basic tools for prediction of weather and sea-ice, as well as for climate projections.

As the Arctic changes rapidly, the new system with potential changes in predominant processes or appearances of new processes never before observed, challenges our already limited predictive capacity. This happens at a time when these changes simultaneously open up new areas for resource exploitation and commerce, thus increasing the need for science-based advice on adaptation and mitigation from large-scale circulation impacts, ecosystem changes, new climate states, and commercial interests.

The several observational programs over the past 20 years have all had important limitations. Few were long enough to sample the large inherent variability in the system, and most were deployed in the old Arctic climate system, were not interdisciplinary enough and certainly not sufficiently detailed.

The overarching goal is to perform sustained observations to understand climate-relevant processes of the Arctic Ocean climate system, cutting across many disciplines including atmosphere, sea-ice, ocean and biosphere driven by the importance for the climate system. Special consideration will be on the “New Arctic”: The new climate state dominated by first-year ice. The dramatic transformation of the sea ice will be an underlying theme and used as an integrator of change. A special objective will be to understand and quantify the many feedbacks between components in the system and the manifestation of these processes over all seasons of the year, which needs year-round observations.

Modeling will be an integrated activity and active collaboration with the World Climate and World Weather Research Programs (WCRP & WWRP) Polar Prediction projects will be a cornerstone to success. Pre-field program model simulations will identify specific gaps and needs, support the planning and logistical implementation. Operational forecasting will be necessary for both safety and optimal use of resources. Coordinated regional and global modeling and intercomparison projects, including data assimilation, will benefit from near real-time access to data. MOSAiC will also provide a wealth of detailed data for model studies at a variety of scales, ranging from large eddy and cloud-resolving simulations to regional and global climate models, and provide the detailed observations needed as a test bed for the Year of Polar Prediction (YOPP) proposed by WWRP. MOSAiC can also serve as a test bed for developing new technology to advance capabilities of automated or satellite-based observations over the Arctic Ocean.

NITROGEN CYCLING AND THE CONDITIONING OF PRIMARY PRODUCTION IN THE ARCTIC OCEAN: CONCEPTS, ISSUES AND RESEARCH AVENUES

Jean-Éric Tremblay, Takuvik, Québec-Océan and ArcticNet, Université Laval, Canada, jean-eric.tremblay@bio.ulaval.ca

Marine primary production is intimately linked to nitrogen (N) cycling. The N cycle is complex and subject to several physical and microbial processes that alter the availability of different forms of N for phytoplankton. While current research focuses on the vertical processes that resupply nitrogen to the euphotic zone in the Arctic Ocean, imbalances in the biological pathways that mediate gains or losses of N relative to other nutrients as well as N partitioning between different organic and inorganic pools may prove equally crucial in regulating ecosystem productivity in the long term. This presentation will review the main nitrogen cycling pathways and their susceptibility to environmental perturbations at different space and time scales, highlighting connectivity and functional differences between different sectors of the Arctic. The practical applications of nutrient measurements will be considered and research avenues linking observations to practical remote sensing and modeling applications will be evoked.

MENTOR SESSION ABSTRACTS

Parallel seminars and practical training session abstracts are in listed by block.

BLOCK 1: Tuesday October 23rd.

SESSION 1: ARCTIC MARINE ECOSYSTEM EVOLUTION FROM A GEOLOGICAL PERSPECTIVE

Anne de Vernal, GEOTOP, Université du Québec à Montréal, Canada, devernal.anne@uqam.ca
Kirstin Werner, GEOMAR, Helmholtz Centre for Ocean Research Kiel, Germany, kwerner@geomar.de

From a geological perspective, the most salient feature of the Arctic is the multiyear sea-ice cover, another is the development of land ice caps, both having determinant linkages with the global hydrological cycle, ocean circulation and climate. Hence important questions are addressed by the geoscientist community with the aim to understand the dynamics of the cryosphere and to provide clues on the possible future of the Earth without Arctic ice. Some of these questions can be asked as follows :

- Why, how and when perennial ice developed in the Arctic Ocean?
- What about the stability-instabilities of circum-Arctic ice caps such as the Greenland ice sheet?
- How exceptional is the recent decline of Arctic sea-ice cover extent ?

The training activity will be placed in such as perspective. It will be divided in 3 parts of about 20-25 minutes each after a brief introduction providing an overview of the Cenozoic evolution of the Arctic, with focus on the cryosphere.
Part 1 – From Greenhouse to Icehouse : the onset of multiyear pack-ice, ice sheet development, and glacial to interglacial variability
Part 2 – The ice-ocean-climate variations of the Arctic during the present interglacial (about 10 000 years) : Eastern vs. Western Arctic, from Bering to Fram Straits, synchronism of changes and regionalism of the trends

Part 3 – From Past to Future : Comparing the modern trend with the recent past, the response times of the different components of the system (land ice, sea-ice, permafrost, ocean, biota), and the key issues to be addressed for long term forecasting of the Arctic ecosystem.

The three publications below are recommended reading before attending this session.

DeConto, R.M., Pollard, D., Wilson, P.A., Pälike, H. Lear, C.H., Pagani, M., 2008. Thresholds for Cenozoic bipolar glaciations, nature. Vol 455 (2), 652-657, doi:10.1038/nature07337

Kinnard, C., Zdanowicz, C.M., Fisher, D.A., Isaksson, E., Vernal A., Thompson, A.G., 2011. Reconstructed changes in Arctic sea ice over the past 1,450 years. Nature. 479, 509–512, doi:10.1038/nature10581

Schiermeier, Q., 2011. Ice loss shifts Arctic cycles. Nature. 489, 185-186, doi:10.1038/nature10581

SESSION 2: THE DYNAMICS OF ARCTIC SEA ICE DECLINE AND CONSEQUENCES FOR HEAT AND CARBON FLUXES

Walt Meier, National Snow and Ice Data Center, USA, walt@nsidc.org
Brent Else, Centre for Earth Observation Science, University of Manitoba, Canada, b_else@umanitoba.ca

The ongoing decline of Arctic sea ice has captured the attention of scientists and the media alike, particularly in this year of pronounced ice retreat. Understanding these drastic changes - and the broad-ranging impacts they might have - requires an interdisciplinary approach such as the one modelled by ART. This training session is intended to examine some of the issues surrounding Arctic sea ice decline by presenting the following:

-An overview of the various methods used to observe sea ice.
-A summary of the observed changes (focusing on the satellite record), and the reasons for those changes.
-A review of the role of sea ice in the Arctic climate system, ecosystem, and biogeochemical system.
-A discussion of the potential impact of the changing sea ice cover on those systems.

The training session will consist of a joint lecture presented by Dr. Meier and Dr. Else, where questions and discussion from the participants will be strongly encouraged

SESSION 3: OBSERVING AND MODELING PHYSICAL CHANGES OF THE ARCTIC OCEAN HYDROGRAPHY

Waldemar Walczowksi, Physical Oceanography Department, IOPAS, Poland, walczows@iopan.gda.pl
Ilona Goszczko, Physical Oceanography Department, IOPAS, Poland, ilona_g@iopan.gda.pl

Obviously, physical properties of the environment shape other aspects of life - from biosphere to human activity. Several subjects concerning both shifts in the Arctic Ocean's physical conditions and changes in our understanding of this unique environment will be debated. Discussion and questions during the session are greatly welcome. The part applying to the Arctic Ocean physical environment will include a short history of ideas as well as a review of the main scientific problems. The part concerning modelling will refer to the Arctic Ocean's models. We would like to consider why we need models and who can be a model user in fact. We will talk over the Arctic Ocean's circulation in various time and space scales, possible phenomena occurring in the future Arctic hydrography and new challenges for modellers. As a practical exercise we plan to design a hypothetical hydrographical experiment taking into account all the required stages. We want to share our experience and show a few interesting artifacts from our laboratory. We invite participants from all specializations.

SESSION 4: ECOLOGICAL CONSEQUENCES OF CHANGING SEA ICE CONDITIONS ON PELAGIC-BENTHIC SYSTEMS

Jan Marcin Weslawski, Institute of Oceanology Polish Academy of Sciences, weslaw@iopan.gda.pl
Nathalie Morata, LEMAR/CNRS, France, nathalie.morata@gmail.com

The Arctic is warming at two to three times the global rate. Atmospheric warming has increased Arctic Ocean temperature and resulted in decreased extent and thickness of sea ice. The sea ice extent is now decreasing at a rate of 10% per decade prompting concern that the Arctic Ocean could be ice-free in summer by 2050. Because of the ice-dependent character of Arctic marine ecosystems, climate-induced changes in sea-ice cover are expected to lead to shifts in primary production and changes in sea water chemistry. Those changes will have repercussions on the entire ecosystem functioning and carbon cycling. It is in particular hypothesized that the previous benthic-oriented system might switch to a more pelagic one.

The goal of this section is to therefore to discuss the direct and indirect effects of changes in sea ice for the Arctic ecosystem, at organisms, population, and ecosystem levels. We will also try to identify the key organisms and processes that needs to be studied (and how to study them) in ordered to better understand through space and time "the ecological consequences of changing sea ice conditions on pelagic-benthic systems".

SESSION 5: INTEGRATING THE HUMAN DIMENSION IN STUDIES OF THE PAST, PRESENT AND FUTURE ARCTIC MARINE ENVIRONMENT.

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In this seminar we will discuss the question of integrating the human dimension in studies of the past, present and future arctic environment, with special focus on the marine environment. Firstly, drawing on the emerging field of environmental humanities, we will address the deceptively simple question of what we mean with the 'human dimension.' What impact does including the 'human dimension' – and those fields mainly concerned with humans: social sciences and the humanities – have on studies of arctic transition? Secondly, we will explore the integration of the 'human dimension' from a science planning perspective. How do we work toward improving communication between scientists and other arctic stakeholders (including, but not restricted to, arctic communities, policy makers, governments and the private sector), in terms of identifying relevant research questions and research agendas that foster partnerships between stakeholders and scientific programmes?

BLOCK 2: Wednesday October 24th.

SESSION 1: PALEO-MODELS AND HIGH-RESOLUTION SIMULATIONS OF THE OCEAN AND SEA ICE IN THE ARCTIC AND NORTH ATLANTIC

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This session will discuss how numerical models can be used to simulate glacial and interglacial climates in the Earths past. The first part of the session will be led by Alan Condron and will start by looking at how different solar forcings and atmospheric greenhouse gases caused the Earth to have a climate that was significantly colder and icier than today. We will then go on to examine how state-of-the-art high-resolution numerical model are now being used to simulate the circulation of the ocean and sea ice in the Arctic and North Atlantic at unprecedented detail during glacial periods. Here we focus on a suite of experiments that suggest that during these times, the Arctic might have been covered by sea ice ~10 times thicker than present day. We will then go on to discuss how high resolution models are being used to help us understand how large glacial meltwater floods (such as those from Glacial Lake Agassiz) triggered abrupt climate change events in the past, such as the 8.2-kyr-event and the Younger Dryas. The second part of the session led by Axel Wagner will focus in detail on how sea ice models are used to simulate the ice cover of the Arctic during glacial and interglacial

times. We will take a closer look how sensitive Arctic sea-ice models react on varying atmospheric boundary conditions, e.g. low and high resolved atmospheric forcing fields. The focus is than drawn on atmosphere-ocean interaction processes as e.g. air-sea fluxes. Here we will provide a fundamental understanding of how these fluxes are influenced by modifying the characteristics (number of modeled layers) of the sea-ice layer.
The practical session that follows (~ 1 hour duration) will allow those attending the session to us a 2-D thermodynamic model for sea ice formation and growth to explore how changes in cloud cover, ice albedo, and ocean heat fluxes alter the final thickness of ice cover in the Arctic.

For this session on sea ice and ocean modelling, it is useful to have the software Matlab (Mathworks, USA) installed on your computer. For those that do not have Matlab, a free alternative is the open-source Octave (http://www.gnu.org/software/octave/). However, please note that Matlab scripts used in this session have not been tested in Octave yet.

SESSION 2: ADVANCING FOOD WEB RECONSTRUCTION BY MERGING OBSERVATIONS WITH MODELLING

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The food web concept forms a cornerstone of modern ecology as it describes the exchange of matter—the so-called food web flows—among different compartments within an ecosystem. Analysis of food web components and flows in natural food webs has revealed important features of food web functioning and stability (De Ruiter et al. 1995, Rooney et al. 2006). A vital step in food web research is to develop a systematic and standardized method to quantify food web flows, in order to fully explore their structure and properties (Woodward et al. 2005). In the last two decades, a number of modelling approaches have emerged that are particularly suited for the quantification of flows of matter and energy in ecosystems. Two well-known examples are the Ecopath ecosystem modelling and linear inverse modelling. The basic strategy of these approaches is that empirical data (for instance the biomass of biological organisms) are merged in an optimal way for quantification of matter or energy flows. This workshop will focus on linear inverse modelling, which has several advantages over other methods: 1) a free package in R is available to build and solve Linear Inverse Models (LIMs), 2) LIMs is very flexible in the types of data that can be included and 3) when data sets are incomplete, the solution methodology propagates data uncertainty onto the solution.
The workshop will consist of the following components:

1. A presentation on linear inverse modelling will be given to i) briefly compare it with the other biological modelling workshops, ii) introduce the methodology, iii) show the developments of last 5 years and iv) discuss future applications.
2. The core of the workshop will be on the development by the participants of a simple LIM of an Arctic food web that depends on phytoplankton, ice-algae and riverine detritus.
3. LIMs are very flexible with respect to the types of data that can be included and this will be exemplified by the incorporation of natural abundance stable isotope data.
4. Provided sufficient time is available, additional properties of the model will be analyzed through network analysis and dynamical simulations.

For the workshop, it is useful to have R and Tinn-R (or Rstudio) installed on your computer. The manual that comes along with the R-package "LIM" will be used during the workshop.

The three publications below are recommended reading before attending this session.

De Ruiter, P. C., A. M. Neutel, and J. C. Moore. 1995. Energetics, patterns of interaction strengths, and stability in real ecosystems. Science **269**:1257-1260.
Rooney, N., K. McCann, G. Gellner, and J. C. Moore. 2006. Structural asymmetry and the stability of diverse food webs. Nature **442**:265-269.
Woodward, G., D. C. Speirs, and A. G. Hildrew. 2005. Quantification and resolution of a complex, size-structured food web. Advances in Ecological Research **36**:85-135.

SESSION 3: COUPLING THE PHYSIC AND BIOLOGY THROUGH DYNAMIC MODELING: FROM ONE TO MULTIPLE DIMENSIONS

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The Arctic ecosystem is a very dynamic system. Dynamic biogeochemical models attempt to capture the interactions between physics and biology and the cycling of the biochemical (i.e., living) and geochemical (i.e., non-living) parts of an ecosystem. These dynamic models are formulated as a combination of a series of differential and algebraic equations and a set of parameters which together describe the change in time of key components of an ecosystem. The simplest such model is a nutrient-phytoplankton-zooplankton (NPZ) model. Biogeochemical models have been used for several decades in an attempt to explain, analyze, and predict what we can only sparsely measure. With their ability to extend over spatial and temporal scales far beyond what we can observe, models are useful tools in scientific research.
In the first half of this session we will illustrate the development of biogeochemical models from one-dimensional (1-D) to high-resolution three-dimensional regional models and up to global earth system modeling. The importance of model validation and parameter sensitivity and appropriate choice of model will be discussed. It is common for multiple ecosystem models to be independently developed for a region. The Framework for Aquatic Biogeochemical Models (FABM) is a general framework that provides the “glue” between an arbitrary physical host model (usually a spatially explicit hydrodynamic model), and any number of arbitrary biogeochemical models. In the second half of this session we will provide an overview of FABM, which is a community-based open-source program. FABM capabilities will be demonstrated using a one-dimensional General Ocean Turbulence Model (GOTM)-FABM model. Participants will be able to play with simple test simulations within the GOTM-FABM interface using a virtual machine installed on their own laptop PC (Windows or Linux). Prior to this session, participants should download and install the appropriate version of the free VMware Player available on this web site: http://www.vmware.com/products/player/

In addition, the publication below is recommended reading before attending this session.

Burchard, H., Bolding, K., Kuhn, W., et al. 2006. Description of a flexible and extendable physical-biogeochemical model system for the water column. Journal of Marine Systems **61**:180-211.

POSTER SESSION ABSTRACTS

Poster session abstracts are listed in alphabetic order.
There are two poster sessions Wednesday, Oct 24th 17:30-19:00 and Thursday, Oct 25th 16:30-18:00.

THE OFFSHORE DIET OF THE EASTERN BEAUFORT SEA BELUGA POPULATION AND THE ENERGETIC EFFECTS OF CLIMATE CHANGE

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As the most abundant Arctic cetacean with a circumpolar distribution, beluga whales (Delphinapterus leucas) are an important indicator species for Arctic climate change. The Beaufort Sea beluga population is one of the world’s largest and is an important traditional food to the subsistent lifestyle of people from the Inuvialuit Settlement Region. During the summer, belugas migrate from the Bering to the Beaufort Sea and segregate by sex, reproductive status, and size into different habitats based on sea ice concentration. The differences in habitat use are defined largely by beluga length and predict their diets and exposure to mercury. Comparison

of fatty acid profiles have revealed Arctic cod (Boreogadus saida), a sea ice associated fish, to be an important prey, but the contribution of other prey to the diet of Beaufort Sea belugas remains unknown. Diet is the main pathway of contaminant exposure to belugas. High levels of contaminants in belugas are of concern to Inuvialuit subsistence hunters, especially given the temporal increase in mercury observed in this population. Changes in sea ice as a result of climate change may have indirect effects on the primary production and trophic couplings of Arctic food webs, which are predicted to affect prey availability to belugas. Declines in prey availability combined with other stressors such as contaminants may have an overall adverse impact on the health of beluga populations. My first objective is to identify the seasonal diet of the Beaufort Sea beluga population. I will collect and survey the abundance and distribution of prey species in the offshore pelagic ecosystem of the Beaufort Sea using a fish trawling program anticipated to receive support from the Beaufort Regional Environmental Assessment. Beluga tissues will be sampled during summer subsistence hunts and information on sex, physical condition, and life stage will be recorded. I will also collaborate with the North Slope Borough during the subsistence harvests of the Alaskan Inupiat people to identify the spring and fall diet of the belugas. Partnered harvests collections will help provide a more complete seasonal dietary context. Stomach contents of belugas, stable isotopes, and fatty acid profiles will be used to establish food web linkages and determine prey contribution to beluga diet. My overall objective will be to provide a better description of diet for future comparisons to assess the impacts of climate change on the Beaufort Sea beluga population and marine ecosystem.

VARIABILITY OF UNDER-ICE HABITATS AND COMMUNITIES IN THE CENTRAL ARCTIC OCEAN

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During RV Polarstern cruise ARK XXVII/3 a major objective of the HGF Young Investigators Group *Iceflux* was to investigate the relationship of the under-ice community with physical habitat properties using a Surface and Under-Ice Trawl (SUIT; van Franeker et al. 2009), equipped with a bio-environmental sensor array. During 2 August-7 October 2012 data was collected at 15 stations, 3 were conducted in open water, and 12 were conducted under various types of sea ice, including multi-year ice and scattered ice floes. The average ice coverage of the under-ice hauls was 57%. Modal ice thickness ranged between 60 cm in first-year floes, and 105 cm in multi-year ice floes. The species composition of SUIT samples indicated a clear distinction between open water and under-ice communities. Under sea ice, samples were dominated in density by the ice-associated amphipod *Apherusa glacialis*. In open water, the pelagic amphipod *Themisto libellula* was most abundant. The average density of polar cod, *Boreogadus saida*, was 1.9 ind.100 m^{-2} under sea ice, and 0.2 ind.100 m^{-2} in open water, with a size range from 54 to 140 mm total length. At several stations both in open water and under sea ice, the ctenophores *Beroe cucumis* and *Mertensia ovum* occurred in very high densities. This first trawl survey of under-ice macro fauna in the Arctic Ocean gives evidence of a rich and diverse under-ice community, emphasising key species correlated with sea ice properties. The association of this community with the under-ice habitat indicates a possibly important role of ice algal production in the Arctic ecosystem.

A PAN-ARCTIC DATABASE TO ASSESS PRESENT AND FUTURE ARCTIC BIOSPHERE

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Environmental changes like rising sea water temperature and reduction in sea ice extent affect organisms and through their interactions the Arctic ecosystem as a whole. Changing patterns have been recently reported for some well sampled arctic regions, e.g. the northern Bering Sea and Chukchi Sea (Grebmeier 2012), but so far our knowledge of overall Arctic ecosystem structure and functioning is still insufficient to predict forthcoming changes. One major reason is the lack of a reliable pan-Arctic biosphere database with sufficient taxonomic, functional and spatial resolution and coverage. Such a data base would enable us to describe the ecological status quo in terms of inventory and functional properties, and thus is essential for scenarios of future, global change driven development of the Arctic system.

In this project we want to tackle this challenge for one compartment of the Arctic biosphere, namely the macrozoobenthos. First because macrobenthos is a suitable indicator of change owing to its size spectrum and low intrinsic mobility. Second because a reasonable amount of data is directly available and more should be compiled via potential future collaborations.

The first step is to interest potential collaborators in this project and consolidate all available data on Arctic macrozoobenthos in one geo-referenced data management system that will be made available to the scientific community. Further we want to model the spatially explicit distribution of biogeography, biodiversity, community properties and energetics of Arctic macrobenthic communities in order to identify major spatial patterns and trends. This spatial distribution patterns shall be linked to environmental parameters to identify potential environmental drivers of change. Finally spatially explicit trophic community models shall be developed and tested for their sensitivity to climate change effects.

SPATIAL VARIATION OF THE TROPHODYNAMIC LIPID FLUX IN ZOOPLANKTON DURING THE ICE ALGAL SPRING BLOOM IN THE CANADIAN HIGH ARCTIC.

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Arctic marine food webs are highly dependent on the production and transfer of lipids to maintain their structure and biodiversity. Herbivorous zooplankton, particularly copepods, act as a key link between higher trophic levels and primary producers. While lipids present in these primary consumers originate from both lipid and nonlipid sources, essential polyunsaturated n-3 and n-6 fatty acids (EFAs) must be obtained from diet. Ice-associated primary production provides a pulse of EFAs early in the spring before open water production is prevalent. There has been little research into the spatial distribution of ice-associated EFAs and the impact this has on lipid flux to higher trophic levels. This study therefore investigated the variation in fatty acid composition of ice-based primary producers and primary consumers over several spatial scales, particularly in regards to EFAs. Ice algae and zooplankton were collected at 48 stations around Cornwallis Island in the Canadian Arctic Archipelago in the spring of 2011 and 2012. Samples were analyzed for their lipid content and fatty acid composition. Bulk carbon and nitrogen stable isotope ratios were also analyzed to help determine the original production source of lipids. There were minor differences in the EFA eicosapentaenoic acid (20:5n-3) between zooplankton size classes (11.5 to 17.2%). Docosahexaenoic acid (22:6n-3), a flagellate biomarker EFA, was present in lower amounts (4.2 to 7.8%) but significantly increased with zooplankton size. There was significant variation in algal lipid signatures across stations, particularly in regards to the diatom marker 16:1n-7 (22.8 ± 11.8%). Although warming-induced ice loss is already affecting many Arctic species, there is still a lack of knowledge about how ice covered ecosystems function and are supported. Our findings provide insights into the effects of primary producer spatial distribution on the trophodynamic lipid flux to higher consumers.

THE SIMULATIONS OF CIRCULATION IN THE LAPTEV SEA USING FVCOM

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The Lena delta region of Laptev Sea can serve as an indicator of climate changing. A large number of observed data in this region suggests a strong climate change and biological data for the last thirty years. Unfortunately we still have not fully answer about extent of the changes and their causes in this region. One of the goals of my modeling is simulation of ecosystem dynamics in the Lena Delta region of the Laptev Sea. The dynamics are sensitive to the temperature and salinity variability and thus are connected to the ocean circulation dynamics. We explore them with the help of the Finite Volume Coastal Ocean Model. Local patterns of temperature and salinity in the mixed layer (up to 50 meters) in the Lena Delta Region of the Laptev Sea are analyzed for different regimes of atmospheric circulation (anticyclonic and cyclonic) with time scales of 5 – 30 days. We also assess the influence of Lena runoff temperature, local wind pattern and tidal dynamics on the temperature and salinity variability in the area. A particular attention is paid to the impact of local bathymetry data to temperature and salinity local pattern. May of 2008 and 2009 were chosen as test periods. Simulations were carried out with the Finite Volume Coastal Ocean Model (FVCOM). FVCOM is a prognostic, unstructured-grid, finite-volume, free-surface, 3-D primitive equation coastal ocean circulation model. It was used by us in a variant including wetting and drying, GOTM (turbulence model) and nudging of temperature and salinity at open boundaries. We used a high quality unstructured mesh, which allowed us to take into account the complex structure of coastline and bathymetry and other aspects of the problem (the necessity to refine mesh elements along main ways of Lena fresh water plumb). Element sizes vary from 400m to 3 km. The mesh has 6 vertical sigma layers with 250000 nodes on each of them. The input data (bathymetry, coastline, atmospheric forcing, initial temperature and salinity, climatological values for nudging at the open boundary, and runoff) are taken from NOAA, GEBKO and several other institutions.

COUPLING AN ARCTIC PLANKTONIC FOOD WEB MODEL WITH A MODULE ON CARBONATE CHEMISTRY: RESULTS FROM A 1-D PHYSICAL-BIOLOGICAL SIMULATION IN THE BEAUFORT SEA

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Arctic marine ecosystems are on the verge of critical transition, owed to rapid climate change and sea ice decline. In the Beaufort Sea, a trend toward an increased high-pressure regime has been observed over the last years, a phenomenon supporting the potential for more persistent easterly winds and more frequent coastal upwelling. However, those events act as a double-edged sword on Arctic marine ecosystems. On the one hand, an increased on-shelf flux of new nutrients boosts primary production and associated vertical carbon export. On the other hand, upwelling brings upward deep acidic waters from the Pacific Halocline that might affect the life cycle of key organisms and outgas CO2 back to the atmosphere. Here, we present the first results of a biogeochemical model developed for the Beaufort Sea and coupled with a module on CO2 chemistry. This model has been assembled within the Framework for Aquatic Biogeochemical Models (FABM, http://fabm.sourceforge.net/), a community-based open-source program that aims at facilitating the coupling between any kind of geochemical/ecosystem modules and a hydrodynamic model. The physical host for our biological model is the 1-D turbulence model GOTM with has the capacity to integrate real-world datasets to produce realistic runs. Our scenario corresponds to a mooring station located on the Eastern Mackenzie Shelf and makes use of prescribed horizontal advection (from an ADCP), tides, sea ice concentration, and meteorological forcings. We show that this model is able to reproduce the annual cycle in food web functioning

and carbonate dynamics in the Beaufort Sea. We further plan to use this model to constrain a carbon budget (inorganic and organic) for the region. Future work will also focus in the development of supplementary FABM drivers adapted for 3-D numerical simulations in Canadian Arctic waters.

SEA-ICE FLUCTUATIONS IN CENTRAL ISFJORDEN, SVALBARD, DURING THE PAST C. 11,200 YEARS

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Lithological data (amount of ice-rafted debris and roundness of grains) and benthic foraminifera fauna from one sediment core reveal that sea-ice cover and sea-ice rafting in central Isfjorden, Svalbard, varied significantly during the past c. 11,200 years. Even though ice rafting was dominated by icebergs during the final phase of the last deglaciation of Isfjorden, sea-ice cover was dense shortly prior to 11,200 years BP (calendar years before the present). A period of more seasonal sea-ice cover from 11,200 to 11,000 years BP was followed by denser sea-ice cover between c. 11,000 and 10,500. Relatively warm climatic conditions and enhanced inflow of relatively warm and saline Atlantic Water led to significantly reduced to almost absent sea-ice rafting between 10,200 and 9000 years BP. However, some sea ice most probably formed during winter.
After c. 9000/8800 and until 4000 years BP the formation of sea ice generally intensified, related to decreasing insolation and reduced influence of colder Atlantic Water. However, periods of enhanced inflow of warmer Atlantic Water and, thus, reduced sea-ice formation and open-water conditions occurred. Significantly reduced sea-ice rafting and low accumulation rates of benthic foraminifera between 4000 and 2000 years BP are interpreted to reflect the coldest conditions during the past c. 11,200 years, leading to the enhanced formation of shore-fast sea ice and/or more permanent sea-ice cover that, in consequence, suppressed ice rafting and biological productivity. The influence of Atlantic Water increased during the past c. 2000 years leading again to more seasonal sea-ice cover in central Isfjorden.
The results indicate that the formation in sea ice in Spitsbergen fjords is largely influenced by the inflow of Atlantic Water, atmospheric variations, as well as local factors. Furthermore, they show that lithological data and benthic foraminifera fauna are useful proxies that can be used to reconstruct sea-ice changes in Spitsbergen fjords. However, even though they reveal the general long-term trends, minor discrepancies on shorter time scales occur.
References:
Forwick, M. & Vorren, T.O., 2009. Late Weichselian and Holocene sedimentary environments and ice rafting in Isfjorden, Spitsbergen. Palaeogeography, Palaeoclimatology, Palaeoecology 280, 258-274.
Rasmussen, T.L., Forwick, M. & Mackensen, A., 2012. Reconstruction of inflow of Atlantic Water to Isfjorden, Svalbard during the Holocene: Correlation to climate and seasonality. Marine Micropaleontology 94-95, 80-90.

MODELING PROCESSES CONTROLLING THE ON-SHELF TRANSPORT OF OCEANIC MESOZOOPLANKTON POPULATIONS IN THE EASTERN BERING SEA

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The Eastern Bering Sea shelf is divided into distinct hydrographic domains by structural fronts. Despite the frontal obstructions to cross shelf transport, each year large oceanic copepods, primarily Neocalanus spp., are known to dominate the biomass of the outer-shelf zooplankton communities and in some years are advected into the middle shelf domain. Using ROMS (Regional Ocean Modeling System) coupled to a particle tracking algorithm designed to represent ontogenetic vertical migration behavior of Neocalanus, we explored the mechanisms, timing and location of transport of oceanic zooplankton onto the eastern Bering Sea shelf from overwintering sources along the Gulf of Alaska and Bering Sea shelf breaks under a variety of environmental conditions. While the percentage of overwintering zooplankton transported onto the shelf may not vary significantly year to year the timing of on-shelf transport and distribution of oceanic zooplankton on the shelf can vary substantially between years. Wind is the primary factor controlling inter-annual variability in on-shelf transport of Neocalanus. Zooplankton transport across the northern and southern shelf responds in opposite directions to inter-annual differences in wind forcing. Meridonal winds over the Bering Sea are more important than zonal winds in driving on-shelf float transport. Southerly wind enhances on-shelf transport of oceanic zooplankton on the southeastern shelf while suppressing on-shelf transport over the northern shelf. Conversely, northerly wind suppresses on-shelf zooplankton transport onto the southern shelf but promote strong transport onto the northern shelf. Transport of zooplankton onto the shelf can be very episodic, reflecting the short duration of winds promoting on-shelf transport. Relatively short (days to weeks) periods of southerly wind between January and June can significantly impact the number of zooplankton transported onto the shelf. The relative importance of different source areas in supplying oceanic zooplankton to the Bering Sea shelf did not vary much from year to year. Oceanic zooplankton on the southern shelf most likely originate from sites in the Alaska Stream or the Eastern Bering Sea shelf break south of the Pribilof islands. Oceanic zooplankton on the northern shelf most likely originate from sites north of the Pribilof islands.

DEFORMATION RATES OF THE ARCTIC OCEAN ICE COVER: TRENDS, VARIABILITY AND RELATIONSHIP WITH LARGE-SCALE WIND FORCING

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Deformation mechanisms of the Arctic Ocean ice sheet are characterized by high spatial and temporal variability, in which ice ridges and leads tend to be concentrated in elongated, narrow zones. Present state-of-the-art numerical models, especially those based on various versions of viscous-plastic rheology, are still far from perfection in terms of reproducing localized and intermittent characteristics of sea ice deformation. In this study, the relationship (and its variability) between scaling properties of sea ice deformation and 10-m wind speed is analyzed. We used NCEP-DOE Reanalysis 2 data to determine area-averaged atmospheric drag force. Gridded sea ice total deformation rates from Radarsat Geophysical Processor System (RGPS) data were obtained from the NASA Jet Propulsion Laboratory, with a time resolution of 3 days and a spatial resolution of 12.55 km. Our analysis covers 11 winter seasons from 1996/1997 to 2007/2008. We calculated the moments *mq,L* of probability distribution functions (pdfs) of total sea ice deformation rates for a range of spatial scales *L*. The logarithms of the moments are significantly correlated with basin-scale wind forcing, especially for low values of *q* (with Pearson correlation coefficient reaching 0.7). It can be well-described by simplified momentum equations and a very general rheology model. Furthermore, the strength of this relationship varies seasonally and reaches its minimum in March, due to changeable thickness and consolidation of the Arctic Ocean ice sheet. This effect is clearly seen in comparison with trend lines of time-varying values of moments. Finally, there is a positive trend in seasonally-averaged power of correlation, which is probably associated with decreasing area of the multi-year ice. As a result, the course of sea ice deformation process in the Arctic is a possible indicator of climate change.

MEIOFAUNA OF DEEP ARCTIC OCEAN – TEMPORAL CHANGES

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The deep-sea floor is the largest ecosystem on this planet, however we know much less about the deep-sea fauna than other ecosystems. Nowadays, when climate changes occur, investigations of these deep-sea ecosystems seem to be of major importance. Thus, our study was focused on the impact of changes in food supply, on the smallest sized bottom fauna- meiobenthos, in the region which is highly exposed to environmental changes- the Marginal Ice Zone of the Fram Strait. In comparison to other polar regions, in the area of investigations there has been a large inflow of organic matter to the sea floor, which translates into high meiofaunal densities along the bathymetric gradient, covering a depth from 1 200m to 5 569m. The highest meiofaunal density (on average 2 424 indv.·10cm-2) was noticed at 1 200m water depth, then the density decreases with increasing water depth up to 4 000m. However, on the two deepest stations an increase in meiofaunal densities was observed. This situation is probably connected with the location of these stations, which are situated in depression (Molloy Hole). It seems to be a big sediment trap reached by higher amount of organic matter being a food source for benthic organisms. In comparison to other deep-sea regions, Molloy Hole can be described as abyssal eutrophic area. Summing up the results of the long-time research, it should be noted that changes in the pelagic zone, such as increase in temperature and lack of sea ice cover, cause the increase in primary production, what influence benthic organisms inhabiting deep ocean.

PHYSICO-CHEMICAL STRUCTURE OF THE EASTERN GREENLAND SEA'S UPPER LAYER - HORIZONTAL AND VERTICAL DISTRIBUTION OF WATER PARAMETERS.

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In the eastern Greenland Sea inflowing warm and salt Atlantic water meets colder and fresher Arctic originated water. In the upper layer temperature, salinity, nutrient content and amount of dissolved gases differ considerably over the whole area, particularly in the frontal zones which appear in the warm and cold ocean currents' boundaries or are maintained by bathymetry. Here, the West Spitsbergen Current, East Spitsbergen Current and East Greenland Current together with smaller hydrographical phenomena create dynamical but also coherent system. In the specific regions, horizontal and vertical gradients of physical and chemical parameters might be large. Furthermore, sea-ice cover of the Arctic Ocean, shrinking during the last few decades, contributes to changes in the water mass properties and structure. Observed increasing inflow of the warm Atlantic water to the north adds to that. Changing physical and chemical conditions have a strong effect on the Arctic ecosystems.
Nutrients (phosphate, nitrate, nitrite, ammonium and silicate) distribution in the upper 200 m layer has been investigated during the last summer cruises performed by IOPAS on board R/V Oceania near the Spitsbergen besides standard hydrographical measurements. Also, oxygen saturation and fluorescein have been measured in situ. Water samples were collected in a wide range which previously covered the whole research area and then was fitted for three sections which represents southern, middle and northern part and crosses shelf, slope and the open ocean. Preliminary results show differences between water masses as well as between particular components and their ratios which allows to divide the whole region for initially more and less valuable zones for the biological life.

SEASONAL SIGNATURES OF DINOFLAGELLATE CYST PRODUCTION IN HUDSON BAY BASED ON MONTHLY SEDIMENT TRAP DATA

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Phytoplankters, microscopic primary producers of oceans, tend to divide frequently due to their small size, and are therefore capable of responding rapidly to environmental fluctuations. Fast phytoplankton growth maybe balanced out by equally fast consumption by herbivorous grazers. In high-latitude marine systems, seasonal fluctuations in plankton biomass are tightly linked to light regime controlled by waxing and waning sea-ice cover. Furthermore, limited nutrient inventories of surface waters, seasonal changes in temperature and freshwater inputs may play important roles.
In cold-water seas, many planktonic organisms cope with seasonal harshness by the production of dormant stages that enable them to reduce respiration rates to a minimum and sink to the seafloor. Dinoflagellates are a diverse group of single-celled plankton, constituting major marine primary producers, as well as herbivorous grazers of the microbial loop. Many dinoflagellate species produce highly resistant, organic-walled resting cysts that have been increasingly used to reconstruct past environmental conditions, e.g., sea-surface temperature and salinity, productivity, ice-cover and eutrophication. Paleoenvironmental reconstrutions are typically based on marine sediment core sequences with slow accumulation rates and high mixing rates; characteristically the top centimeter of surface sediment from an arctic shelf corresponds to several years or decades of deposition. Consequently, it is impossible to tease out seasonal bloom dynamics or triggers of cyst formation solely based on sediment samples.
We used two particle-intercepting sediment traps moored in eastern and western Hudson Bay, respectively, to study monthly fluctuations in dinoflagellate cyst production from October 2005 to September 2006. The traps were deployed close to the seafloor and recovered during the ArcticNet annual expeditions onboard the CCGS Amundsen in 2005 and the CCGS Pierre Radisson in 2006. We document the seasonal succession of dinoflagellate cyst taxa, together with cyst species composition, diversity and fluxes. We compare dinoflagellate cyst phenology to that of environmental parameters. Despite the challenges related to sediment trap studies in the Arctic and Subarctic, e.g., low accumulation rates and resuspension of surface sediments, they provide a solid means to study the seasonal behaviour of cyst-producing dinoflagellates and help providing a firmer ecological foundation for sediment core studies.

LONG TERM VARIABILITY OF SEA SURFACE HEIGHT IN THE NORDIC SEAS

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An understanding of the Nordic Seas circulation and its variability is needed to determine how changes in the high latitude climate affect the global thermohaline circulation and the regional and global climate. Although, the summer circulation in the region is known from in-situ and other measurements, knowledge about the winter circulation is limited because of the unavailability of data from the ice-covered seas. However, Peacock and Laxon (2004, J Geophys Res, 109, C07001) showed that it is possible to derive sea surface height anomaly (SSHA) from satellite altimeter in the ice-covered seas. Here, we make use of these novel satellite data derived from ice-covered seas combined with the altimeter records from the open ocean in 2002-2009. For the first time the variability of the sea level is described in the ice-covered part of the Nordic Seas and over such a long record. Satellite data show that sea level varies greatly seasonally and interannually in the ice-covered regions, especially in the autumn and winter. This proves that most of the existing measurements are biased towards the least variable season what also results in the underestimation of the interannual variability in those regions. Empirical Orthogonal Functions were used to identify the most important modes of variability. It was found that the mean seasonal cycle was a large contributor to the variance of SSHA (36%). The three first EOFs explained 49% of the total variance, and regionally up to 80% in the deep basins and at the

Greenland continental shelf, demonstrating the importance of seasonal cycle at those locations. Possible explanations behind the observed variability were hypothesized and addressed by the statistical analysis of the SSHA and freshwater, heat and momentum fluxes. Similarity between the phases of the atmospheric fields and SSHA suggested that the ocean responds simultaneously or with 1-2 months lag to the seasonal atmospheric forcing and therefore its response is mainly barotropic. Furthermore, it was found that the timing of the maximum wind stress curl is the same as the timing of the local SSHA at the northern Greenland continental shelf. The analysis showed that wind forcing plays a major role in driving the first three EOFs of SSHA and can explain a large percentage of variance in the SSHA at annual frequency. In the central Nordic Seas the SSHA spins up/down at the same time as wind stress curl increases/decreases, which indicates a barotropic response to the wind forcing in the area. The strongest forcing occurs seasonally, however other frequencies are also important in the central Nordic Seas and at the Greenland continental shelf where the sea-ice is present. The analysis also showed that the 2nd EOF of SSHA is driven/influenced by the NAO-related atmospheric forcing at the annual and other frequencies and the 3rd EOF of SSHA is caused by a response of the ocean to the wind stress curl, which affects SSHA at the eastern and western boundaries of the Nordic Seas, and heat and freshwater fluxes, which affect mainly the eastern boundary.

BENTHIC POPULATION DYNAMICS AND DIVERSITY IN THE CHANGING ECOSYSTEMS OF THE BERING AND CHUKCHI SEAS

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The seasonally ice-covered Bering and Chukchi Sea shelves are currently exposed to increasing seawater temperatures and experiencing major reductions in sea ice cover. In these Pacific-influenced ecosystems, high biomass, abundance and diversity of benthic organisms are observed, mainly due to high water column production and tight benthic pelagic coupling in the continental shelf. Changes in sea ice extent, thickness and duration can be expected to affect the annual primary production of ice algae and phytoplankton. Therefore there will be critical consequences for benthic populations that directly influence the functioning of the ecosystem, its trophic dynamics and organic carbon cycling.

The main aim of this study was to examine structure, function and diversity of benthic infaunal organisms in the diversity and biomass “hot spot” areas of the Bering and Chukchi Seas and determine their vulnerability to increasing temperatures and sea ice reduction, as well as predict potential changes to marine food webs. Samples were taken in four high diversity and productivity areas (southwest of St. Lawrence Island, the Chirikov Basin north of St. Lawrence Island, in the southeastern Chukchi Sea north of Bering Strait, and within the head of Barrow Canyon) resulting in a collection of about 200 van Veen grabs from depths ranging from 35 -130 m. Samples were collected at the same stations in both 2010 and 2011. Benthic infaunal diversity, abundance, biomass and production were determined in relationship with physical and chemical data. A longer existing data set was also used to compare time-series results over the last 30 years. Changes observed include decline and a switch in dominant bivalves species (Nuculana radiata and Ennucula tenuis) in the St. Lawrence Island area, a decline in tube dwelling amphipods (Ampelisca macrocephala and other Ampelisca species) while some tube dwelling polychaetes (Ampharete spp.) increased in abundance and biomass in the SW Chirikov Basin. There are also indications of a decline in biomass in the southeastern Chukchi Sea and some indications of a possible change from a mussel-dominated (Musculus spp.) community to polychaete-dominated (maldanids) population in a localized region of upper Barrow Canyon. All of the observed changes have implications for the ecosystem functioning and energy transfer to higher tropic levels.

This study was undertaken as a pilot phase of the Distributed Biological Observatory Initiative (further information at http://www.arctic.noaa.gov/dbo/index.html) and it was also mounted in coordination with Canada's Three Oceans project during the International Polar Year.

THE VULNERABILITY ASSESSMENT OF THE CHUKCHI SEA BOTTOM ECOSYSTEM: ANTHROPOGENIC IMPACT CASE

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The key threat for deterioration of conditions of Arctic sea ecosystems is anthropogenic impact as a result of developing oil and natural gas deposits. For example the Chukchi region still needs doing further research because the region is vulnerable to pollution as a result of activities in Alaska industrial sector and on Russian coast of the Chukchi Peninsula.
The bottom ecosystem can be a key indicator of the Chukchi Sea state and to serve the instrument of vulnerability assessment of the Chukchi Sea in whole.
In this project we propose following steps: the first we have estimated current state of bottom ecosystem of the Chukchi Sea and as the second step we will develop the techniques of vulnerability assessment of the Chukchi Sea bottom ecosystem in case of anthropogenic impact.
According to the results of analysis of distribution of chemical elements in bottom sediments, geo-morphological and litho-chemical characteristics, calculation of total index of pollution of bottom sediments, estimations of probability of forming stable concentrations of pollutants and condition of benthos, results of comparison with implications of previous researches and data on other Arctic seas the Chukchi Sea can be considered as resistant to chemical pollution. However, stability of biocenosis can be considered as relatively vulnerable because in eastern part of the sea and along the coast of the Chukchi Peninsula relatively favorable conditions for accumulation of pollutants are observed. In the series of resistance of Arctic seas to chemical pollution the Chukchi Sea takes first place.
We can list some factors that can seriously influence condition of bottom ecosystem of the Chukchi Sea in future:
- developing of the shelf and sea port construction in the Chukchi Sea can lead to increase a number of geo-morphological traps which are places where pollutants are accumulated.
- increase of concentration of mobile forms of heavy metals in bottom sediments (as a result of climate changes and man-caused pressures on the environment) will lead to their active migration into food chains.
- increase in near-bottom temperature as a result of climate changes can lead to re-distribution of the described benthic communities.
- exceeding modern level of heavy metals concentration (for example – as a result of resuming shipping along Northern Sea Route, building military bases, developing the shelf, etc.) can stimulate degrading researched bottom communities off.
Actually, as the next step we are creating the maps of vulnerabilities based on GIS. We introduce to GIS series of data such as biomasses and biodiversity index. We indicate it through the rating system: from less vulnerability to extremely vulnerabilities whereas the expert estimation.

THE SURFACE LAYER IN THE ARCTIC OCEAN IS SEASONALLY MODIFIED BY THE FREEZING AND MELTING OF SEA ICE

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During winter the surface layer becomes homogenised by convection, triggered by ice formation and subsequent brine rejection. The temperature of this Winter Mixed Layer is at the freezing point respective to the local salinity. Due to the large freshwater flux into the Arctic Ocean the convection becomes limited by buoyancy. In the less saline Amerasian Basin the convection remains shallow, 30-40 m, while in the Nansen Basin it may reach deeper than 100 m. When the solar insolation begins to warm the ocean surface and melt the sea ice, freshwater is released from the melting sea ice and stability increases. Since the wind-induced mixing does not reach as deep as the buoyancy driven mixing, the properties of winter surface water are assumed to be conserved at the base of the Winter Mixed Layer throughout the melt season. Consequently the depth of the previous winter convection is marked by temperature minimum. The presence of this minimum, close to the freezing point temperature, also indicates that no oceanic heat is transported up toward the sea ice from the underlying warm water masses. With the year-round data Ice-Tethered Profilers have provided during the past eight years it is possible to assess whether the depth of the temperature minimum found from the summertime observations indeed corresponds, and if so, with which accuracy, to the depth of last winter convection. Also the average warming of this minimum is determined.

ATLANTIC WATER ADVECTION TO THE EUROPEAN ARCTIC IN HOLOCENE. PALEOCEANOGRAPHIC RECORD OF THE WEST SPITSBERGEN CURRENT FLUCTUATIONS

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The main direction of Atlantic waters inflow to high latitudes is relatively well known. The North Atlantic Current (NAC) is monitored during S/Y "*Oceania*" cruises (IOPAS, AREX program) for over 10 years. As NAC is the most important source of heat in the Arctic the results clearly show that there is an significant intensification of its flow causing sea ice-cover disappearing in the spring/summer season as well as sea ice-cover decreasing in fiords during winter time. In the past, Atlantic waters were distributed along the western coasts of Svalbard to the north, seasonally reaching Hinlopen Strait, enriching in relatively warmer and more saline waters eastern parts of Svalbard. The records indicate that these inflows must have occurred repeatedly in the last 12 ka. Therefore *Mytilus edulis*, the thermophilic mollusc is widely distributed in the raised Holocene beach deposits from the western and northern coasts of Svalbard and from the Barents region. However, its distribution even up to Nordauslandet is very well-founded by the period of warming and inflows of Atlantic waters to Hinlopen Strait, the presence of this species on western Edgøya is unclear. Hansen et al. (2011) suggests that small branch of warm Atlantic water south of Svalbard may have reached Edgøya at that time. In the paper from 2011, Akimova et al. describes the water column in Storfjorden as composed from four main water masses, comprising warm and saline Atlantic Water as occupying the layer between 50 and 70 meters water depth in Storfjorden and down to 200 meters in Storfjordrenna. Although, penetration of NAW in this fiord became a fact, we still don't know how it may looked like during the Holocene. The actual state of knowledge about hydrological regime in Storfjorden has encouraged authors of this paper to investigate hydrological changes in this area during the Holocene.

IMPACTS OF CLIMATE CHANGE HAVE BEEN MOST PRONOUNCED IN POLAR REGIONS

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Most alarming is the accelerating decline in Arctic sea ice cover. The changing ice cover has implications for sea ice-associated ecosystems because they rely primarily on carbon produced by ice-associated algae. In order to fully understand these ecosystems and to be able to accurately represent them in models there is a need to understand both the physical and biological components of the ecosystem. This study is part of a larger project Iceflux which takes an interdisciplinary approach to quantify the trophic carbon flux within sea ice associated ecosystems in the Arctic and Antarctic. Here we will present preliminary results from the ARK XXVII/3 Polarstern Cruise. Biological samples were acquired from the under-ice surface waters using the Surface and Under-Ice Trawl (SUIT) and from within the sea ice by extracting ice cores. To characterize the biophysical properties of the sea ice and under-ice environments several sensors were mounted on the SUIT including: spectral radiometer, ADCP, CTD, fluorometer, altimeter (distance to ice bottom) and video camera.

Observations include ice thickness, biological diversity, biomass, light transmission, under-ice water properties and chlorophyll a content (in- and under-ice). Preliminary results will provide a description of the local- to meso-scale spatial variability of biological abundance in and under the ice and the relationship with different sea ice characteristics. During the cruise testing of sensors and equipment will be conducted in order to prepare for the deployment of two Autonomous Bio-Physical Sea Ice Observatory (ABiPSO) stations in the Weddell Sea during the ANT XXIX/6 cruise June 2013. A description of the system and testing of the sensors will be presented highlighting challenges and lessons learned.

INTERNAL ACCUMULATION AND MELTWATER PERCOLATION IN SNOW COVER ON TIDEWATER GLACIER (HANSBREEN)

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Meltwater from snow cover deposited on glaciers is an important component supplying the Arctic Ocean. It transports organic matter and improve heat flux flow through glacial basins. During percolation, meltwater can refreeze, creating internal ice masses and crusts. Those layers, such a superimposed ice on glacier ice surface, are forming barrier delaying water transport in vertical profile of Arctic glaciers. Recognition of internal accumulation processes and characterization of meltwater retention time in snow cover were main objectives of this paper.
Field works were conducted from April to July 2010 on Hansbreen (South Spitsbergen), located 2 km NE from Polish Polar Station. Tidewater character of glacier front enables direct outflow to the Hornsund Fiord. Snow pits were taken near mass-balance stakes T4 (179 m a.s.l.) and T6 (299 m a.s.l.) for internal accumulation observation in various time of ablation period. At the end of accumulation season electrical conductivity and temperature sensors were mounted at the glacier ice surface to measure percolation of the meltwater through snow pack.
Snow pit performed on 25.06.2010, close to equilibrium line zone (T6) confirmed existence of superimposed ice 5 cm thickness. In upper parts of the glacier it can permanently supply glacier mass if it remains after the ablation season. In ablation zone (T4) rapid increase of temperature at the bottom of snow cover (+3.3°C in 1 hour period) indicate release of latent heat from refreezing meltwater and creating superimposed ice as well. Drainage of meltwater through the snow pack in the ablation zone lasted about 12 days to reach glacier surface, while at the equilibrium line zone about 5 days. Longer retention in the lower parts of the glacier was caused by intensive insolation and higher amount of thin ice layers inside snow cover. Obtained results are important to estimate the dynamic of processes intensity like basal sliding of the glaciers or organic matter distribution to the Arctic Ocean. Water retention in snow cover affects the delay in glacial drainage systems, and as a result of its outflow. Multidisciplinary view is obligatory to understand interaction between glacier ice and sea water.

NEW L-BAND MISSIONS AND POSSIBILITY OF SEA ICE THICKNESS ESTIMATION

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In the past three decades average sea ice thickness in the Arctic has dropped dramatically. Furthermore the loss of summer ice is more rapid than any model predictions. This new conditions enable the usage of new sea routes like the Northwest Passage, and exploitation of natural resources. This increased commercial activity will be having an impact on the environment. Therefore systems of monitoring and protection must be established with the help of satellite products. Increased demand for reliable sea ice predictions will be expected also from the private sector. Satellite sea ice products based on passive microwave are well established navigation aid. Those techniques are useful in estimating ice concentration however, the thickness is not measured. New L-band (1.4 GHz) missions (ESA SMOS, NASA Aquarius, NASA SMAP) could supplement this data with direct measurements of the sea ice thickness up to 0.6 m. This thin sea ice is important from the scientific point of view, since it controls the gas and heat exchange in Ocean- atmosphere system. Knowing the thickness of the ice together with its concentration will also allow to extend the short navigation season for vessels strengthened hull. Promising results presented by Kaleschke et. al 2012, encouraged me to make a general study of possible advantages and disadvantages of each mission with respect to sea ice measurements. Although none of those missions was originally designed for this particular purpose such usage of the data would be an interesting scientific and commercial project.

ECOTAB: EFFECT OF CLIMATE CHANGE ON THE ARCTIC BENTHOS

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It is now generally admitted that effects of climate change are enhanced in polar areas. Because of the ice-dependent character of Arctic marine ecosystems, climate-induced changes in sea-ice cover are expected to lead to shifts in primary production (decrease of ice algal production, increase in phytoplankton and microphytobenthos production) and changes in sea water chemistry (lower salinity and pH, higher temperature). Those changes will have repercussions on the entire ecosystem functioning and carbon cycling, although it is yet unclear how benthic organisms will respond to those changes in food sources and environmental conditions.

Although recent Arctic ecosystem studies have focused on describing the present state of either the "pelagic" or "benthic" compartment, the link between those two compartments, the "pelagic-benthic" coupling has often been underestimated. Moreover very few studies have included experimental approach in order to predict future scenarios, while this knowledge is crucial if we are to understand possible future changes and create models.

The overarching goal of this study is to investigate how climate-induced changes in biological (food sources) and environmental conditions will impact the Arctic benthos. This project will combine existing data, new field data, and a new experimental approach which will test various scenarios of food (i.e. high food quality, low food quality) and environmental parameters (pH, salinity, temperature) therefore improving understanding of present state Arctic coastal ecosystem function, and prediction of possible feedback scenarios of the ecosystem to changes in a less ice-rich Arctic due to climate warming. The work will be separated in 4 tasks:

- Description in great details of the seasonal variability in pelagic-benthic coupling, combining both pelagic and benthic perspectives
- Study experimentally the impact of changes in food quality for the benthos
- Study experimentally the impact of changes in temperature, pH and salinity, on key bivalves species
- Development and calibration of models of carbon and energy fluxes in the ecosystem and in the key bivalves species

HABITAT SUITABILITY MAPPING

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Given the increasing international pressure towards the reduction of the impacts of fishing on the ecosystem, Canada must develop research programs to evaluate the influence of fisheries and design innovative fishing gears preserving the seabed. Epi-benthic macrofauna was monitored at 758 stations in the lower estuary and northern Gulf of St. Lawrence each summer between 2006 and 2009. This first large-scale characterization of benthic macrofauna using multivariate, geostatistical, and mapping approach aims at 1) describing spatial distribution of benthic communities and their species composition, 2) analyzing links between communities and environmental parameters (such as depth, temperature, oxygen saturation, bottom current), and 3) using a habitat suitability model to create a full coverage map. Results from the prediction model allows the identification of zones of greater and lesser suitability for specific species and community types. The resulting maps can be used to evaluate the impacts of fisheries on the seabed habitat structure, and therefore used for management of the marine space and conservation of both fishing stocks and vulnerable non-fished species.

BATHYMETRY AND SLOPE GRADIENTS OF BREPOLLEN (HORNSUND, SPITSBERGEN)

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The presented swath-bathymetry data and slope gradients from the bay Brepollen, Svalbard, were collected during two multibeam echo sounder surveys:
1) University of Tromsø, Norway, with R/V “Jan Mayen” (now “Helmer Hanssen”) in the central part of Brepollen (Forwick, 2007);
2) Institute of Geophysics Polish Academy of Sciences and Gdynia Maritime University, Poland, on R/V “Horyzont II” in 2010, extending the data set from 2007.
Survey in 2010 were possible due to previously modeled bathymetry of Brepollen based on single-beam echosounder profiles interpolation (Moskalik, 2012; Moskalik et al., unpubl.). The combination of both surveys resulted in a map covers all parts of the bay, except costal zone, being too shallow to be mapped by the research vessels.

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Moskalik M., Grabowiecki P., Tegowski J., Żulichowska M. Bathymetry and geographical regionalization of Brepollen (Hornsund, Spitsbergen) based on bathymetric profiles interpolations. (unpublished)

CHANGES IN OCEAN CHEMISTRY DUE TO OCEAN ACIDIFICATION IN THE WESTERN ARCTIC OCEAN

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Arctic Ocean constitutes only around 4% of the global ocean area but it contributes significantly to the global ocean uptake of atmospheric carbon dioxide (CO2) by as much as 5-14% of the annual global carbon sink makes the region very important. Ocean acidification (OA), which results from the uptake of anthropogenic carbon dioxide (CO2) into the surface ocean, may already be impacting the Arctic Ocean with potentially corrosive water present on coastal shelf seas present during the summertime. Here, we evaluate the state of the summer CO2 system and impact of ocean acidification in the Arctic Ocean shelf seas, we measured dissolved inorganic carbon (DIC), total alkalinity (TA) and computed partial pressure of CO2 (pCO2) and saturation states (Ω) of calcite (Ωaragonite) and aragonite (Ωcalcite) for years 2009, 2010 and 2011. This study reveals lower than expected Ωaragonite and Ωcalcite values in the Chukchi Sea and Canada Basin with significant decreases in the last few years, especially in the bottom waters. Large areas of under-saturation and shoaling of the saturation depth ($\Omega < 1$) were observed in that region with OA changes occur much faster than expected for the Arctic. The rapid sea ice loss might enhance the “Phytoplankton-Carbonate Saturation State” (“PhyCaSS”) interaction causing negative feedback enhancing CO2 absorption and ocean acidification and thereby contribute to further deterioration of the Arctic marine environment and biodiversity of calcifying organisms. Study of the variability of saturation states of CaCO3 minerals is essential to assess the ocean acidification impact on Arctic Ocean marine biodiversity.

PALEOMETAGENTICS OF ARCTIC FORAMINIFERA

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Foraminifera are wildely used for reconstructing past and present environmental changes in all marine environments. Common use of foraminifera as ecological proxies is based on excellent preservation of hard-shelled foraminifera species in fossil material. However, in some marine habitats, such as polar regions, the foraminiferal fauna is dominated by soft-walled non-fossilized species that are rarely encountered in fossil assemblages. In order to include this overlooked group into paleoecological study of Arctic foraminifera, the total foraminifera assemblage was analysed using metagenetic approach, which consists in specific amplification of selected genes from environmental DNA samples. Ancient DNA was directly extracted from the sediment core and a 3' fragment of the SSU rDNA was amplified using foraminifera specific primers. Moreover, morphological analysis of hard-shelled foraminifera, sediment grainsize, stable isotope content and hydrological properties of water column were analysed. Succesfull DNA extraction and amplification proved that genetic material is well preserved in downcore sediment samples and environmental DNA approach may be used in reconstruction of past environmental changes. Monothalamous foraminifera made up more than 50% of all assigned sequences, what suggests that using only hard – shelled (fossiliazable) taxa in paleoenvironmental studies leads to underestimation of a real biodiversity of foraminiferal assemblage. Changes in foraminiferal abundance and diversity in both paleontological and ancient DNA record correspond well with environmental changes shown by sediment properties. The project opened new perspectives for using foraminifera as environmental proxies. By included soft-walled species in foraminiferal assemblages interfered from DNA approach, the number of potential proxy species increased.

BENTHIC FAUNA DISTRIBUTION CHANGES (HORNSUND,SPITSBERGEN) AS AN INDICATOR OF THE GLOBAL CLIMATE CHANGE

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In 2010, European Union signed another (after Gothenburg, 2001) declaration on the prevention of decline in biodiversity. Since the issues of biodiversity and climate change are closely linked, and the archipelago of Svalbard is the most rapidly warming region of the Northern hemisphere, complex and accurate studies of this particular region is of great importance. The aim of presented studies is to determine how the environmental changes and inflow of boreal taxa from the Norwegian Sea, related to progressive climate change, affects the distribution of selected species of Arctic benthic fauna in the Hornsund fjord of Spitsbergen. Since the benthic organisms have long life cycles and limited dispersion ability they are, in contrast to plankton good indicators of long-term, medium environmental conditions.
Proposed hypotheses shall determine whether species distribution is controlled by occurrence of low temperature in fjord, or alternatively by the occurrence of boreal competitors in warmed up places. In effect, possible scenarios of changes in the Arctic ecosystems under the influence of climate change will be developed. The verification of the hypothesis will be conducted with the use of geographic information system (GIS) and species distribution modelling technique. Since 1996 there is a wealth of physical and biological data collected by IO PAS expeditions in the Spitsbergen fjords, that makes a unique available data bank for this particular studies. Only long living (perennial) benthic fauna species with determined biogeographic affinity (arctic, boreal, widely distributed) and defined mobility (sessile, discretely motile, motile) will be selected for the analysis. The physical environment background will cover the depth, fetch, salinity, temperature of near bottom

waters and the sediment properties. In order to obtain the best results of modelling, appropriate methods, algorithms and validation techniques will be selected during the analysis with taking into account species distribution, environmental preferences and data availability (number of sampling points).
Implementation of modelling and GIS techniques not only will let to visualize results of long-term studies and verify potential distribution of selected benthic fauna species but also predict patterns of biodiversity, predict species invasions, identify areas at risk and improve our understanding of species-habitat relationships in space and time.

SEA ICE PROTISTS ARE KEY ORGANISMS FOR FUNCTIONING OF THIS UNIQUE HABITAT

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The main research focus has been laid on dominant primary producers: diatoms that dominate spring algal bloom in sea ice. These algae are the main food source for ice associated crustaceans. In contrast, picoeukaryotes (here defined here as protists smaller than 5 μm) that are very numerous in sea ice, are believed to be main bacterial grazers. However, due to methodological constrains, their community composition and other potential roles in sea ice remain understudied. Here, we investigated distribution of 12 picoeukaryotic lineages in the first year sea ice of Canadian Arctic Archipelago: at three stations in Barrow Strait and ten stations in waters in vicinity of Cornwallis Island (McDougall Sound and Resolute Passage). We applied Catalysed Reporter Deposition - Fluorescence in situ Hybridization and specific oligonucleotide probes to identify selected groups of picoeukaryotes at the single cell level. Algea from groups of chlorophytes and cryptophytes were found to be most numerous from the investigated lineages. For the first time Bolidophytes, and Marine Stramenopiles from groups MAST-1, MAST-2 and MAST-6 were discovered and enumerated in sea ice. Thickness of snow cover seemed to positively influence the total numbers of picoeukaryotes, chlorophytes and MAST-2 stramenopiles, but had no influence on other groups. Based on phylogenetic affiliation, we showed that picoeukaryotes may play various role in sea ice. Representatives of autotrophs (chlorophytes), phagotrophic mixotrophs (cryptophytes, haptophytes, pedinellids, bolidophytes), phagotrophic heterotrophs (MAST-1, MAST-2 and MAST-6 stramenopiles) and parasitic heterotrophs (Amoebophryidae) were documented to be present. However, still > 50 % of picoeukaryotes remained unidentified.

PALEOENVIRONMENTAL AND PALEOECOLOGICAL RECONSTRUCTIONS OF THE MARINE CONDITION DURING THE LAST 13 750CAL YR BP IN THE EUROPEAN ARCTIC (HORNSUND, SPITSBERGEN)

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The Svalbard Archipelago is a climatically sensitive area and the balance between water masses is a key factor determining climate in this region. Convergence of waters from three principal sources: Atlantic, Arctic, and glacial melt water occurs in the Nordic Seas. The balance between those components is responsible for heat transport, thermohaline circulation and deep-water formation. Thereby, this area is recognized as a suitable place to detect changes in the foraminiferal fauna as bio-indicators respond for environmental variability. The sediment core HR-4 (450 cm long) was retrieved from the foreground of Hornsund fjord from the position 76°53.66'N and 14°41.17'E (148 m water depth) during the cruise on R/V Jan Mayen in July 2007. The age model was created on the ground C14 ages measured on the carbonate material (bivalves' shells) and the core's bottom, the age was estimated to 13 750 cal yr BP. The proxy records generated in my project rely on common techniques used in similar reconstructions of climate change in the Arctic region including benthic and planktonic foraminiferal assemblages and biodiversity, and also using individual Foraminifera species as marine condition indicators, IRD and foraminiferal fluxes, oxygen and carbon stable isotopes, paleotemperature records and grain-size analysis. The obtained results were applied to the transitional period between glacier and interglacial condition Bölling/Allerød, cold Younger Dryas and in general ‘Atlantic’ condition of Holocene. During the second part of Bölling/Allerød and Younger Dryas there took place an important inflow of Atlantic Waters. Nevertheless, Arctic Waters plays important role in the south-western Svalbard shelf, confirmed by high values of analyzing biodiversity indices. Cold environmental conditions during the first part of the Younger Dryas were probably caused by a weakened inflow of Atlantic Water and in consequence an intensified inflow of Arctic Water. The biodiversity indices showed lower values. During the Holocene period two abrupt coolings were observed: first one during the Early Holocene (event 8700 cal. yr BP) and second during the Late Holocene (Little Ice Age). In these two periods decrease of biodiversity indices values were noticed and in both cases those coolings were connected with changes in the ocean circulation as a result of weak inflow of Atlantic Water in the south-western Svalbard shelf. Besides, in the middle part of Holocene (9000-6000 cal. yr BP) was observed the Holocene Thermal Maximum. The presence of large numbers of planktonic and benthic Foraminifera individuals, suggest that warming in the Early Holocene was not just the effect of solar isolation, but also stronger transport of the Atlantic Water. Present results help to understand not only the past environmental variability, but also explain current climate change. This kind of research put important information about functioning of Arctic marine ecosystems in the past, like also predict changes in the future ecosystem structures.

THE EFFECT OF INCREASING PCO2 AND C:N STOICHIOMETRY ON BIOGEOCHEMISTRY AND PHYTOPLANKTON PRODUCTION IN THE FUTURE ARCTIC OCEAN

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With a modeling approach we have studied carbon cycling and primary production (PP) development in the Arctic Ocean under increasing atmospheric partial pressure of carbon dioxide, CO2 (pCO2atm). Previous in situ experiments (mesocosm studies) showed an enhanced carbon production relative to nitrogen consumption under high pCO2 conditions. Parameterizing this finding into the model simulation, we assess the role of carbon to nitrogen stoichiometry for the biogeochemistry and the productivity of the Arctic Ocean during the 21st century. We used a coupled physical-biogeochemical ecosystem model – SINMOD (SINtef MODel), forced by climate and CO2 A1B IPCC scenarios. Two types of carbon to nitrogen stoichiometry were tested – 1) C:N ratio fixed at value 7.6, and 2) C:N ratio increasing with higher atmospheric pCO2. Experimental simulations showed an increase in both PP and export production (EP) in the Arctic ocean during 21st century. The increase in PP and EP was higher when C:N was coupled with pCO2atm (8% in PP, and 9% in EP). There was an apparent connection between dynamics of primary production and carbon chemistry in entire water column. Due to increased CO2 consumption by phytoplankton in the surface Arctic Ocean, there was a lower sea water pCO2 when C:N ratio was coupled with pCO2atm. Due to higher EP in case of coupled pCO2atm and C:N ratio, pH and saturation of aragonite (Ω aragonite) of the deep waters were lower than in case of fixed C:N ratio.

ESTIMATION OF POSITIVE SUM-TO-ONE CONSTRAINED ZOOPLANKTON GRAZING PREFERENCES WITH ENSEMBLE-BASED KALMAN FILTERS

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We consider the estimation of the grazing preferences parameters of zooplankton in ocean ecosystem models with ensemble-based Kalman filters. These parameters are introduced to model the relative diet composition of zooplankton that consists of phytoplankton, small size-classes of zooplankton and detritus. They are positive values and their sum is equal to one. However, the sum-to-one constraint cannot be guaranteed by ensemble-

based Kalman filters when parameters are bounded. Therefore, a reformulation of the parameterization is proposed. We investigate two types of variable transformations for the estimation of positive sum-to-one constrained parameters. These transformations are discussed with twin experiments performed with the 1-D coupled model GOTM- NORWECOM with Gaussian anamorphosis extensions of the deterministic ensemble Kalman filter.

NEW APPROACHES IN MATHEMATICS THEORY OF SEA ICE

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Sea ice is key component of the climate system related to climate change. On the other hand we can look on sea ice as a composite material, a fluid dynamics key factor, an interface as well as a nonlinear element of dynamical system. So, mathematically, for sea ice studies we can use all specters of PDEs methods (especially equations of mathematical physics and qualitative analysis of PDEs). In our paper (I.A.Sudakov, S.A.Vakulenko, Mathematical Modeling Positive Carbon-Climate Feedback: Permafrost Lake Methane Emission case, Earth Syst. Dynam. Discuss., 3, 235-257, 2012.) was introduced new important methods for studies of phase transitions in the Earth Science. It's so-called the Ginzburg-Landau theory, is a mathematical theory used to describe superconductivity. Usually, we can interpret the processes of melting and thawing in the Earth system dynamics as the Stefan Problem. It is a particular kind of boundary value problem for a PDE, adapted to the case in which a phase boundary can move with time. this problem we should apply to calculations of melt pond melting dynamics. Why we would like to formulate the non-classical Stefan problem in the Ginzburg-Landau formalism. Of course, it will be help us to finnd a multidimensional solution of the Stefan problem for melt ponds at least using robust and simple numerical techniques.

SEAWATER-DERIVED NEODYMIUM ISOTOPE TRACERS – A METHOD APPLICABLE TO RECONSTRUCT HOLOCENE DEEPWATER SOURCES IN THE EASTERN FRAM STRAIT?

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The West Spitsbergen Current (WSC) represents the major means of northward heat transport to the Arctic Ocean via eastern Fram Strait. While the upper layers of the WSC are fed by warm and saline Atlantic Water (AW) derived from the North Atlantic Current, deepwater inflow through eastern Fram Strait is still a matter of debate. Primary purpose of this study is to reconstruct Holocene variability of bottom water sources in the Arctic Gateway by means of seawater-derived neodymium (Nd) isotope ratios of sediment coatings. This method has increasingly been used in paleoceanographic reconstructions to derive information on the past variability of deepwater sources and mixing. Dissolved Nd in seawater originates from weathering processes of the continental crust and is delivered to the oceans through boundary exchange processes or in particulate or dissolved form through riverine input (Frank, 2002). The average ocean residence time of Nd is similar to the global mixing time of oceans (ca 400 – 2,000 years) and enables the use of radiogenic Nd isotopes as oceanic tracers.
In this study, modern seawater Nd isotope signatures in the eastern Fram Strait are compared to Nd isotope ratios of both core-top and Holocene sediment samples (leachates and detritus). In addition, a multitude of proxy indicators for the climatic and oceanographic variability in the eastern Fram Strait during the past 8,500 years can facilitate the interpretation of radiogenic isotope data. Less radiogenic Nd isotope ratios of present-day intermediate and deep water in the area reveal an Atlantic source of the deepwater. This is in contrast to relatively radiogenic Nd isotope ratios of the leached fraction since the late Holocene suggesting a contribution of fine lithic grains transported by sediment-laden sea ice from the East Siberian shelves to the Fram Strait

(Dethleff and Kuhlmann, 2009). We therefore suggest input and transport of sediment material with preformed sediment coatings from source areas on the Siberian shelf to the Central Arctic and the eastern Fram Strait as an alternative explanation for the late Holocene to modern Nd isotope signatures.

INTER-ANNUAL AND SPATIAL ZOOPLANKTON VARIABILITY IN THE WEST SPITSBERGEN CURRENT

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We studied summer mesozooplankton composition between 2001 and 2009, in the West Spitsbergen Current (WSC) and adjacent areas, which are a transition zone between the warm Atlantic and cold Arctic domains. In terms on hydrography and species composition this region was divided into four main parts: western and eastern branches of the WSC, the Greenland Sea and Fram Strait part to the west, and the Barents Sea shelf part to the east of the WSC. Due to the large geographical area covered by the study, the amount of species variation explained by their spatial distribution is considerably higher than by environmental factors, among which water temperature and sea depth were found the most important ones. The new spatial analysis method of principal coordinates of neighbor matrices (PCNM) was applied to disentangle the contributions of studied predictors. Zooplankton community was quite stable over the study years, with differences observed between cold and warm years, rather than along any temporal linear trend. In the study area the most abundant species was Oithona similis and the most important in regards of biomass was Calanus finmarchicus, both present at all stations. Changes in zooplankton seemed to follow the Atlantic Water fluctuations, including 5-6 years cycle observed in the hydrographical conditions of the WSC, and among zooplankton changes in Pseudocalanus spp. fitted the best to this cycle. The variability displayed by the most important species was tested using a semi-parametric approach within the Generalized Additive Models in order to find more sensitive indicators of change in the pelagic system. Most relationships between the copepods community and temperature proved to be gradual and not abrupt, except for the biomass of Calanus glacialis that appeared to have a threshold response around 6,5 °C.

OPTICAL CHARACTERISTICS AND PHOTOREACTIVITY OF CHROMOPHORIC DISSOLVED ORGANIC MATTER ASSOCIATED WITH SEA ICE MELT IN THE CHUKCHI AND BEAUFORT SEAS

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Dissolved organic matter (DOM) plays an important role in marine ecosystems as both a carbon source for the microbial food web and as a light inhibitor. For example, chromophoric DOM (CDOM) has been shown to have a significant impact on the attenuation of photosynthetically active radiation and ultraviolet (UV) radiation but it can also be susceptible to photochemical degradation. The optical properties of CDOM make it possible to compare both the quality and quantity of DOM. Here we analyze the optical characteristics of CDOM associated with sea ice during the summer melt season and how these properties may be altered by photochemical degradation. We collected samples from the under-ice water column, ice cores and surface melt ponds at 21 sites in the Chukchi and Beaufort Seas during June and July of 2010 and July of 2011 as part of the United States National Aeronautics and Space Administration program on Impacts of Climate Change on the Ecosystems and Chemistry of the Arctic Pacific Environment (ICESCAPE) mission. CDOM absorbance was measured on a UV-visible spectrophotometer between 200 and 800nm, with absorbance values and log-transformed spectral slopes compared among sample types and sampling sites. The proportion of melted sea ice in water column samples was assessed in part from the oxygen isotope composition of sampled waters.

Overall, the under-ice water column samples absorbed more light in the UV than the ice core or melt pond samples. This indicates higher concentrations of CDOM in the under-ice waters and suggests that sea ice may not be an important source of CDOM in this region, but rather dilutes the under-ice water column CDOM upon sea ice melt. Furthermore, under-ice water column samples at the three westernmost ice stations in 2011 exhibited shallower spectral slopes than at any other ice station, suggesting the presence of higher molecular weight material that may have been associated with a significant under-ice phytoplankton bloom also observed at the same locations. The occurrence of under-ice blooms could therefore have a measurable effect on CDOM in the under-ice water column. Many of the samples from both 2010 and 2011 had absorption spectra that differed from typical exponential decay signatures, and instead exhibited distinct shoulders and peaks in the 260 to 400 nm spectral ranges that are likely associated with mycosporine-like and aromatic amino acids. In 2010 these signals occurred in both the ice cores and the upper few meters of the under-ice water column, whereas in 2011 these signals only occurred in the ice core samples. This suggests that these signals are likely associated with sea ice algae and only enter the water column upon sea ice melt when cells containing these amino acids lyse. Additional water samples were collected from directly below the ice and tested for photoreactivity by exposure to UV and visible light in a solar simulator. Initial results show that these samples are susceptible to photochemical degradation, with absorbance at 254nm decreasing by more than 50% over a 72 hour period, indicating that decreases in sea ice cover could change the quality and quantity of CDOM from the under-ice water column in a warming climate.