Photo credit: Callum Whyte

Changing Arctic Ocean Programme

Poster Abstracts

Changing Arctic Ocean

SPONSORED BY THE Federal Ministry of Education and Research

UKRI Natural Environment Research Council

ARCTIC CONNECTIONS BETWEEN SEA ICE, OCEAN DYNAMICS AND BIOGEOCHEMISTRY IN THE UK EARTH SYSTEM MODEL (UK ESM1): PRESENT CLIMATE AND FUTURE SCENARIOS

Yevgeny Aksenov[1], Andrew Yool[1], Julien Palmieri[1], Katya Popova[1], Myriel Vredenborg[2], Benjamin Rabe[2], Sinhue Torres-Valdés[2], Stephen Kelly[1], Stefanie Rynders[1], David Schroeder[3], and Bablu Sinha[1]

[1] *National Oceanography Centre, UK*

[2] *Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Bremerhaven, Germany*

[3] *Centre for Polar Observation and Modelling, University of Reading, UK*

Corresponding author: yka@noc.ac.uk

We present analysis of Arctic sea ice and ocean dynamics in the ensemble of the UK Earth System Model (UK ESM1) simulations completed under the Coupled Model Intercomparison Project Phase 6 (CMIP6) protocol [1,2]. The focus of the current investigation is on the current and future changes in the Arctic sea ice and oceanic connections and on the impact of the nutrient advection on the Arctic marine biogeochemistry and ecosystems[3]. Changes in the balance of the oceanic inflows from the North Atlantic and North Pacific Oceans are found to have a first order effect on the watermasses and nutrients balances in the central Arctic Ocean. The simulations show that the total primary production in the Arctic Ocean is increased by 100% in the 2090s as compared to the present climate. This is caused by higher nutrients availability in the Atlantic inflowing waters and prolonged ice- free season.

Model projections suggest an ~50% spin-up of the upper ocean currents along the mid-ocean ridges and boundary currents, with most of the change happening in winter. This can increase seasonality of the upper ocean and in nutrient fluxes and promote stronger mixing along the shelf slopes.

The faster connections through the Arctic and milder oceanic environment allows species to survive through the winter and from the second half of the century the Arctic Ocean could become a key oceanic gateway connecting the global oceans.

The study is supported from the the project “Advective Pathways of nutrients and key Ecological substances in the Arctic (APEAR)” (NE/R012865/1, NE/R012865/2, #03V01461), part of the Changing Arctic Ocean Programme, jointly funded by the UKRI Natural Environment Research Council (NERC) and the German Federal Ministry of Education and Research (BMBF) and from the NERC ACSIS Programme (NE/N018044/1).

[1]. Robson, J., Aksenov, Y., ...and L.J., Wilcox (2020). The evaluation of the North Atlantic climate system in UKESM1 historical simulations for CMIP6. Journal of Advances in Modeling Earth Systems, 12(9), e2020MS002126, 10.1029/2020MS002126.

[2]. Yool, A., Palmiéri, J., Jones, C.G., de Mora, L., Kuhlbrodt, T., Popova, E.E., Nurser, A.J., Hirschi, J., Blaker, A.T., Coward, A.C. and , E.W., Blockley (2021). Evaluating the physical and biogeochemical state of the global ocean component of UKESM1 in CMIP6 historical simulations. Geoscientific Model Development, 14(6), pp.3437-3472.

[3]. Vredenborg, M., Rabe, B., and Torres-Valdès, S.: Advective pathways of nutrients and key ecological substances in the Arctic, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-15538, https://doi.org/10.5194/egusphere-egu21-15538, 2021.

AUTONOMOUS PROFILER REVEALS LIGHT INTENSITY TRIGGERING THE SEASONAL MIGRATION OF ARCTIC ZOOPLANKTON

H. Flores[1*], J.P. Wilkinson[2], G. Veyssiere[2], G. Castellani[1], M. Hoppmann[1], M. Karcher1[,3], M. Nicolaus[1], J.C. Stroeve[4,5,6], J-H. Kim[7], E-J. Yang[7], L. Valcic[8]

[1]*Alfred Wegener Institute, Am Handelshafen 12, 27570, Bremerhaven, Germany*
[2]*British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK*
[3]*O.A.Sys-Ocean Atmosphere Systems GmbH, Tewessteg 4, 20249 Hamburg, Germany*
[4]*University College London, Earth Science Department, Gower Street, WC1E 6BT, UK*
[5]*University of Manitoba, Centre for Earth Observation Science, 535 Wallace Building, Winnipeg R3T 2N2, Canada*
[6]*National Snow and Ice Data Center, University of Colorado, 1540 30th Street, Boulder, CO 80302, USA*
[7]*Korea Polar Research Institute, 26 Songdomirae-ro, Yeonsu-gu, Incheon 21990, Republic of Korea*
[8]*Bruncin, Lastovska ul. 4, 1000 Zagreb, Croatia*

Corresponding author: hauke.flores@awi.de

With rapid sea-ice decline, ocean warming, and increasing Atlantic inflow, the ecosystem of the Central Arctic Ocean (CAO) is experiencing an unprecedented, potentially disruptive transformation. While this transformation is affecting the biodiversity of marine communities and the ecosystem functions they fulfill, major knowledge gaps about the distribution of pelagic macrofauna (zooplankton and fish) complicate the assessment of the impact of this transformation on biodiversity and marine resources. The largest blind spot remains in the central Arctic Basin, which has been difficult to sample with large sampling gear such as fishing nets due to a year-round ice coverage. In the present study we developed an autonomous sea-ice observatory comprising a new autonomous Acoustic Zooplankton and Fish Profiler (AZFP) that was deployed in the CAO in September 2020, shortly before the end of the MOSAiC expedition. First data show a light-induced change of the vertical distribution of scatterers, transitioning from deep distribution during the polar day, through a short period of diel vertical migration during the polar twilight period, to a constant presence of scatterers in the surface layer in the polar night. The present data collected by the EcoLight AZFP demonstrate the feasibility of year-round automated monitoring of macrofauna in the CAO in relation to environmental properties. Similar autonomous devices may serve as key elements in the future monitoring of biological resources in the CAO and other inaccessible areas.

Changing Arctic Ocean – TBC

CHANGING ARCTIC OCEAN DATA MANAGEMENT

Robyn Owen, *British Oceanographic Data Centre*

Corresponding author: rowen@bodc.ac.uk

As the Changing Arctic Ocean (CAO) programme is funded by both NERC and BMBF a number of data centres have come together to manage the vast amounts of data produced by the programme. In the UK the data have been managed jointly between NOC British Oceanographic Data Centre and BAS Polar Data Centre with Pangea being the primary data centre for any German funded datasets. This poster looks at how the data were managed across the programme, how to discover and request data and key dataset statistics. It will also show how Digital Object Identifiers (DOI) have been key to managing CAO data whilst crediting all scientists involved in the data collection and analysis through citations.

DO MICROBIAL SUBSTRATE REGIMES IN THE FRAM STRAIT DIFFER BETWEEN SUMMER AND FALL?

Anabel von Jackowski[1], Kevin W. Becker[1], Birthe Zäncker[2], Matthias Wietz[3,4], Christina Bienhold[3,4], Eva-Maria Nöthig[4] and Anja Engel[1]

[1] GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[2] Marine Biological Association of the UK, The Laboratory, Citadel Hill, Plymouth, UK
[3] Max Planck Institute for Marine Microbiology, Bremen, Germany
[4] Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

Corresponding author: Anabel von Jackowski (ajackowski@geomar.de)

In the Arctic Ocean, the extreme conditions govern phytoplankton productivity, which create episodic influxes of organic matter for heterotrophic microorganisms. Past research has greatly contributed towards understanding the Arctic microbial foodweb but questions concerning the role of substrate availability on microbial abundance and diversity remain unanswered. Here, we link the seasonal associations in phytoplankton-derived biopolymers with microbial abundance and composition during summer and fall. The use of flow cytometry demonstrated a shift in the autotrophic community from picoeukaryotes in summer to Synechococcus by fall. Furthermore, a significant decline in the concentrations of biopolymers was linked to an increase in microbial diversity and a community shift in fall. The seasonal shift in the microbial community indicates distinct metabolic preferences with a higher relative abundance of polysaccharide-degrading genera in summer and genera targeting monomeric semi-labile dissolved organic matter in fall. Our results provide important baseline data of microbe-substrate relationships over the seasonal cycle in the Fram Strait and suggest unique impacts of microbe-organic matter interactions on high-latitude carbon cycling.

VARIABILITY OF SURFACE TRANSPORT PATHWAYS AND HOW THEY AFFECT BASIN-WIDE CONNECTIVITY AND NUTRIENTS.

Chris Wilson[1], Yevgeny Aksenov[1], Stefanie Rynders[1], Stephen J. Kelly[1], Thomas Krumpen[2] and Andrew C. Coward[1]

[1] National Oceanography Centre, UK

[2] Alfred Wegener Institute, Bremerhaven, Germany

Corresponding author: cwi@noc.ac.uk

The Arctic Ocean is of central importance for the global climate and ecosystem. It is a region undergoing rapid climate change, with a dramatic decrease in sea ice cover over recent decades. Surface advective pathways connect the transport of nutrients, freshwater, carbon and contaminants with their sources and sinks. Pathways of drifting material are deformed under velocity strain, due to atmosphere-ocean-ice coupling. Deformation is largest at fine space- and time-scales and is associated with a loss of potential predictability, analogous to weather often becoming unpredictable as synoptic-scale eddies interact and deform. However, neither satellite observations nor climate model projections resolve fine-scale ocean velocity structure. Here, we use a high-resolution ocean model hindcast and coarser satellite-derived ice velocities, to show: that ensemble-mean pathways within the Transpolar Drift during 2004–14 have large interannual variability and that both saddle-like flow structures and the presence of fine-scale velocity gradients are important for basin-wide connectivity and crossing time, pathway bifurcation, and also for predictability and dispersion (the latter are covered in an associated paper, https://doi.org/10.1038/s43247-021-00237-0).

The saddle-points in the flow and their neighbouring streamlines define flow separatrices, which partition the surface Arctic into separate regions of connected transport properties. The separatrix streamlines vary interannually and identify periods when the East Siberian Arctic Shelf, an important source of terragenic minerals, carbon and nutrients, is either connected or disconnected with Fram Strait and the North Atlantic. We explore the implications of this transport connectivity, with our new metric - the Separatrix Curvature Index – which in this context is arguably more informative than either the Arctic Oscillation or Arctic Ocean Oscillation indices.

HIGH EXPOSURE OF PERFLUOROALKYL SUBSTANCES (PFASS) IN TWO FREE-LIVING GUILLEMOT SPECIES IN THE SUBARCTIC AND ARCTIC

<u>Rui Shen</u>[1], Ralf Ebinghaus[1], Daniel Vassao[2], Norman Ratcliffe[3], Thomas Larsen[2]

[1] *Department for Organic Environmental Chemistry, Helmholtz-Zentrum Hereon, Max Planck Str. 1, 21502 Geesthacht, Germany*

[2] *Department of Archaeology, Max Planck Institute for the Science of Human History, Kahlaishce Str. 10, 07745 Jena, Germany*

[3] *British Antarctic Survey (BAS), High Cross, Madingley Road, Cambridge CB3 0ET, UK*

Corresponding author: rui.shen@hereon.de

Arctic harbor elevated levels of environmental pollutants stemming from industrial and agricultural activities at lower latitudes. These pollutants reach the Arctic marine ecosystem via atmospheric and oceanic long-range transport, where they bioaccumulate in organisms and biomagnify through food webs. However, the knowledge about sourcing, exposure and bioaccumulation of one class of persistent pollutants, perfluoroalkyl substances (PFASs), is limited. To characterize the bioaccumulation behavior of PFASs, exposure levels were investigated in the blood plasma sampled in 2018 from two species of marine predatory seabirds, the true Arctic Brünnich's guillemots (Uria lomvia) and the temperate common guillemots (Uria aalge), from five colonies around the Icelandic coast. We evaluated the concentrations of sixteen legacy PFASs, including eleven perfluorinated carboxylates (C4-C14 PFCAs), five perfluorinated sulfonates (C4, C6-8, C10 PFSAs), and one emerging PFAS, HFPO-DA, from the group of perfluorinated ether carboxylic acids (PFECAs) as well as measured carbon and nitrogen isotope ratios to link the contamination levels to the seabirds' foraging ecology. The general exposure profile was consistent with previous studies: ΣPerfluoroctane sulfonate (PFOS) was most abundant, followed by perfluoroundecanoate (PFUnDA) and perfluorotridecanoate (PFTrA). Notably, we found for the first time evidence of HFPO-DA in sub-Arctic/Arctic seabirds. PFASs exposure levels tended to be highest in common guillemots probably due to their closer association with more southerly regions, especially during the overwintering season. We also found close correlations between stable isotope values and concentrations of PFASs underlying the heterogeneous spatial distribution of persistent pollutants in the Arctic. Our results underline the importance of the Atlantic inflow for the role of the oceanic long-range transport of PFASs and the relative importance of the Arctic-origin overflow to the subarctic ecosystems. This interdisciplinary collaboration between environmental chemists and ecologists can help to inform about the risks associated with PFASs to Arctic marine ecosystem structure and function, and consequently have implications for modern day policy and conservation issues.

HIGH-RESOLUTION BATHYMETRY MODELS FOR THE LENA DELTA AND KOLYMA GULF COASTAL ZONES

M. Fuchs[1], J. Palmtag[2], B. Juhls[1,3], P. Overduin[3], G. Grosse[1,4], A. Abdelwahab[1,4], M. Bedington[5], T. Sanders[6], O. Ogneva[1], I. V. Fedorova[7], N. S. Zimov[8], P. J. Mann[2], J. Strauss[1]

[1] *Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Potsdam, Germany*
[2] *Department of Geography & Environmental Sciences, Northumbria University, Newcastle upon Tyne, UK*
[3] *Department of Earth Sciences, Institute for Space Sciences, Freie Universität Berlin, Berlin, Germany*
[4] *Institute of Geosciences, University of Potsdam, Potsdam, Germany*
[5] *Plymouth Marine Laboratory, Plymouth, UK*
[6] *Helmholtz-Zentrum Hereon, Institute for Carbon Cycles, Geesthacht, Germany*
[7] *St. Petersburg State University, Institute of Earth Science, St. Petersburg, Russia*
[8] *North-East Scientific Station, Pacific Institute for Geography, Far-East Branch, Russian Academy of Sciences, Cherskiy, Russia*

Arctic river deltas and deltaic near-shore zones represent important land-ocean transition zones influencing sediment dynamics and nutrient fluxes from permafrost-affected terrestrial ecosystems into the coastal Arctic Ocean. To accurately model fluvial carbon and freshwater export from rapidly changing river catchments, as well assessing impacts of future change on the Arctic shelf and coastal ecosystems, we need to understand the sea floor characteristics and topographic variety of the coastal zones. To date, digital bathymetrical data from the poorly accessible, shallow and large areas of the eastern Siberian Arctic shelves are sparse. We have digitized bathymetrical information for nearly 75,000 locations from large-scale (1:25,000 – 1:500,000) current and historical nautical maps of the Lena Delta and the Kolyma Gulf region in Northeast Siberia. We present the first detailed and seamless digital models of coastal zone bathymetry for both delta/gulf regions in 50 m and 200 m spatial resolution. We validated the resulting bathymetry layers using a combination of our own water depth measurements and a collection of available depth measurements, which showed a strong correlation ($r > 0.9$). Our bathymetrical models will serve as an input for a high-resolution coupled hydrodynamic-ecosystem model to better quantify fluvial and coastal carbon fluxes to the Arctic Ocean but may be useful for a range of other studies related to Arctic delta and near-shore dynamics such as modelling of submarine permafrost, near-shore sea ice, or shelf sediment transport.

LIGHT TRANSMISSION AND ATTENUATION THROUGH VARYING ARCTIC SEA-ICE DURING LATE SPRING AND SUMMER

G. Veyssière[1*], G. Castellani[2], J.P. Wilkinson[1], M. Karcher[2,3], A. Hayward[4,5], J.C. Stroeve[6,7,8], M. Nicolaus[2], J-H. Kim[9], E-J. Yang[9], L. Valcic[10], F. Kauker[2,3], A.L. Khan[11], I. Rogers[12], J. Jung[9]

[1]*British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK*
[2]*Alfred Wegener Institute, Am Handelshafen 12, 27570, Bremerhaven, Germany*
[3]*O.A.Sys-Ocean Atmosphere Systems GmbH, Tewessteg 4, 20249 Hamburg, Germany*
[4]*National Institute of Water and Atmospheric Research, Private Bag 14901, Kilbirnie, Wellington 6241*
[5]*The University of Otago, 362 Leith Street, Dunedin 9016, New Zealand*
[6]*University College London, Earth Science Department, Gower Street, WC1E 6BT, UK*
[7]*University of Manitoba, Centre for Earth Observation Science, 535 Wallace Building, Winnipeg R3T 2N2, Canada*
[8]*National Snow and Ice Data Center, University of Colorado, 1540 30th Street, Boulder, CO 80302, USA*
[9]*Korea Polar Research Institute, 26 Songdomirae-ro, Yeonsu-gu, Incheon 21990, Republic of Korea*
[10]*Bruncin, Lastovska ul. 4, 1000 Zagreb, Croatia*
[11]*Western Washington University, Department of Environmental Sciences, 516 High St, Bellingham 98225, USA*
[12]*The George Washington University, 1918 F Street, NW Washington, DC 20052, USA*

Corresponding author: gaevey@bas.ac.uk

The unprecedented warming of the Arctic region has strong impacts on the sea-ice cover. In particular the thick multi-year ice that predominately covered the Arctic Ocean has been replaced by a regime controlled by thinner, more dynamic, first-year ice. These fundamental changes in the sea ice scape influence the under-ice light field, which is one of the main drivers of ecosystem structure and biogeochemical functioning within the Arctic marine environment. Spatial and temporal observations of the biological response to these changes are crucial but remain challenging to conduct over large spatial scales. In this study, we focus on measurements performed during two expeditions to the Chukchi Sea in August 2018 and 2019, and during the leg 4 of the Multidisciplinary drifting Observatory for the study of Arctic Climate (MOSAiC) expedition in summer 2020. Our analysis shows that, in late summer, two different states of FYI exist in this region: (i) FYI in an enhanced state of decay, and (ii) robust FYI, more likely to survive the melt season. The two FYI types have different average ice thicknesses, different average values of transmittance, and different ice extinction coefficients. Results from field measurements are used to tune parameterizations of light transmission through sea ice as used in large scale circulation models. The tuned parameterizations are applied to satellite data and model outputs to obtain large scale maps of the under-ice light field, at present and in future scenarios based on CMIP6 simulations. Changes in under-ice light field affect the phenology of sea ice algae pointing to a shift of the algal bloom earlier in the season.

LOWER TROPHIC LEVEL ECOSYSTEM RESPONSE TO CHANGE IN HIGHER TROPHIC LEVEL PRODUCTION: A MODELLING STUDY IN THE NORTH ATLANTIC/ARCTIC OCEAN

Ute Daewel[1], Corinna Schrum[1], Annette Samuelsen[2], Çağlar Yumruktepe[2]

[1] *Helmholtz-Zentrum Hereon, Institute for Coastal Systems- Analysis and Modelling*
[2] *Nansen Environmental and Remote Sensing Center*

In recent years it became more clear that simulating climate impacts on marine ecosystems requires integrated modelling systems that span several trophic levels and can connect regional ecosystems spatially and temporally. This type of model system can become quite complex and thus be limited due to computational requirements. Therefore we want to address the question whether we can use a simplified modelling approach to address food web related processes in large marine ecosystems? Here we implement a functional group type ecosystem model HYCOM-ECOSMO E2E for the North Atlantic/Arctic ecosystem with the aim to understand the feedback mechanisms between lower (LTL) and higher trophic level (HTL) production on multi year time scales. The advantage of the model is that fish and macrobenthos are implemented generalised and consistently into the NPZD type model ECOSMO, however, at the expanse of trophic complexity. We will specifically explore the role of migration strategies for changes in higher trophic level production and compare those to available observations. We further aim at studying the role of the advanced HTL formulations for simulating the ecosystem response and changes in the food web in the light of environmental changes. Thereby exploring the role of macrobenthos for nutrient cycling in the shallow shelf seas of the area and, the impacts of a dynamic representation of HTL production on zooplankton dynamics.

MODELING ECOSYSTEM RESPONSES TO CHANGES IN UNDER-ICE LIGHT FIELD

G. Castellani[1], M. Karcher[1,2], G. Veyssiere[3], J.C. Stroeve[4,5,6], J.P. Wilkinson[3]

[1]*Alfred Wegener Institute, Am Handelshafen 12, 27570, Bremerhaven, Germany*
[2]*O.A.Sys-Ocean Atmosphere Systems GmbH, Tewessteg 4, 20249 Hamburg, Germany*
[3]*British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK*
[4]*University College London, Earth Science Department, Gower Street, WC1E 6BT, UK*
[5]*University of Manitoba, Centre for Earth Observation Science, 535 Wallace Building, Winnipeg R3T 2N2, Canada*
[6]*National Snow and Ice Data Center, University of Colorado, 1540 30th Street, Boulder, CO 80302, USA*

Corresponding author: giulia.castellani@awi.de

Arctic sea ice has already experienced a substantial shift from thick MYI to thinner FYI. The ice structure is also changing, with a more porous and degraded ice characterizing the end of the summer season. Recent studies revealed that such changes lead to an increase in 200% in light transmission into the upper ocean. Light is one of the critical drivers of primary production in and under sea ice, by acting as a trigger for sea-ice algae and phytoplankton bloom. Changes in the sea-ice scape will thus affect ice algal and phytoplankton phenology on a pan Arctic scale. However, distinct changes occur in different regions, triggering different ecosystems reactions, and it is challenging to observe them locally. In the present work, we combine newly acquired knowledge on light transmission parameterizations in this new Arctic and we apply it to the large scale coupled sea-ice-ocean model FESOM to simulate the under-ice light field on a pan Arctic scale. We also use a newly adapted sea-ice biogeochemical model SIMBA2 coupled to the pelagic Regulated Ecosystem Model REcoM to quantify the reaction of the sympagic and pelagic ecosystems to changes in light field. Our final aim is to understand which regions will witness the largest change in the timing and magnitude of primary production due to changes in sea ice and, consequently, under-ice light.

MODELLING IMPACTS OF RIVERINE TERRESTRIAL ORGANIC MATTER ON THE LOWER TROPHIC LEVELS OF AN ARCTIC SHELF ECOSYSTEM

Michael Bedington[1]*, Ricardo Torres[1], Luca Polimene[1], Phillip Wallhead[2], Bennett Juhls[3,4], Juri Palmtag[5], Jens Strauss[4], and Paul J. Mann[5]

[1] *Plymouth Marine Laboratory, Plymouth, UK*
[2] *Norwegian Institute for Water Research, Bergen, Norway*
[3] *Freie Universität Berlin, Berlin, Germany*
[4] *Alfred Wegener Institute, Potsdam, Germany*
[5] *Northumbria University, Newcastle-upon-Tyne, UK*

Corresponding author: mbe@pml.ac.uk

The Arctic ocean receives 11% of the entire global river discharge via several great Arctic rivers that drain vast catchments underlain with carbon-rich permafrost. Arctic marginal shelf seas are therefore heavily influenced by terrestrial dissolved organic matter (tDOM) supply, influencing coastal biogeochemical processes and food-webs, as well as physio-chemical properties (e.g. stratification or nutrient concentrations). Future climate scenarios indicate increased quantities of riverine tDOM delivered to the near-shore, with increased freshwater runoff and greater terrestrial permafrost thaw and erosion.

Whilst carbon and associated macronutrients supplied by tDOM enhance the nutrient and carbon substrates for lower trophic levels (phytoplankton/zooplankton), promoting increased local and regional productivity, it also has opposing effects through a series of indirect processes (e.g. increased light absorption limiting light penetration through the water column). Understanding the relative importance and timing of these processes, and how they vary spatially, is necessary to identify how land-ocean interfaces currently operate and how they might change in the future.

We are using coupled hydrodynamic-biogeochemical models in the extensive shallow shelf of the Laptev sea to explore the relationship between these factors. The ecosystem model ERSEM has been adapted to explicitly include a tDOM component. This coupled model system allows us to investigate both the role of present day tDOM in an Arctic coastal ecosystem and to project the potential impacts of increased tDOM input in future.

We show that changes to supply and character of tDOM has significant impacts for the net ocean-atmosphere CO2 flux; both increased supply and shorter lifetimes of tDOM lead to the Laptev sea becoming a net source of CO2. Possible increases in primary production from nutrients are offset by light limitation and an increase in zooplankton grazing resulting in a

POSTER SESSION 2:

NET HETEROTROPHY IN HIGH ARCTIC FIRST-YEAR AND MULTI-YEAR SPRING SEA ICE

Karley Campbell[1,2], B.A. Lange[3,4], J.C. Landy[2,5], C. Katlein[6], M. Nicolaus[6], P. Anhaus[6], I. Matero[6], R. Gradinger[1], J. Charette[4], S. Duerksen[4,7], P. Tremblay[4], S. Rysgaard[8,9], M. Tranter[2], C. Haas[6,10], C. Michel[4,7]

[1]*Department of Arctic and Marine Biology, UiT The Arctic University of Norway, Tromsø, Norway*
[2]*Bristol Glaciology Centre, School of Geographical Sciences, University of Bristol, Bristol, UK*
[3]*Norwegian Polar Institute, Tromsø, Norway*
[4] *Fisheries and Oceans Canada, Freshwater Institute, Winnipeg MB, Canada*
[5]*Department of Physics and Technology, UiT The Arctic University of Norway, Tromsø, Norway*
[6]*Alfred-Wegener-Institute Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany*
[7] *Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth NS, Canada*
[8]*Centre for Earth Observation Science, University of Manitoba, Winnipeg MB, Canada*
[9]*Arctic Research Centre, Department of Bioscience, University of Aarhus, Aarhus, Denmark*
[10] *Department of Earth and Space Sciences, York University, Toronto, Canada*

The net productivity of sea ice is determined by the physical and geochemical characteristics of the ice-ocean system and the activity of microbial organisms inhabiting it. Differences in habitat suitability between first-year and multi-year sea ice can affect the ice algal community composition and acclimation state, introducing considerable variability to the primary production occurring within each ice type. In this study we characterize the biogeochemical variability between adjacent first-year and multi-year sea ice floes in the Lincoln Sea of the Canadian High Arctic, during the May 2018 *Multidisciplinary Arctic Program (MAP) – Last Ice* sampling campaign of 2018. Combining measurements of transmitted irradiance from a remotely operated underwater vehicle (ROV) with laboratory-based oxygen optode incubations, this work shows widespread heterotrophy (net oxygen uptake) in the bottom 10 cm of both ice types. This was particularly evident under thick multi-year ice (>2.4 m) and in the early morning of the 24 h day. Algal acclimation state and species composition varied between ice types, despite similar net community production between ice types as a result of widespread light and nutrient limitation. The first-year ice algal community was increasingly dominated by the potentially toxin-producing genus *Pseudonitzschia* over spring, that is acclimated to high and variable light conditions characteristic of a thinner ice habitat with a mobile snow cover. In comparison, the multi-year ice harbored more shade-acclimated algae of mixed composition. This work highlights the potential for heterotrophy in sea ice habitats of the High Arctic, including first measurements of such O_2-uptake in multi-year ice floes. Observed differences in photophysiology between sea ice types suggests that a shift towards higher light availability and a younger sea ice cover with climate change does not necessarily result in a more productive system. Instead it may favor future sea ice algal communities of different species composition, with lower photosynthetic potential but greater resilience to stronger and more variable light conditions.

NEW UNIFIED ARCTIC OCEAN HYDROGRAPHY AND BIOGEOCHEMICAL DATA BASE: IDENTIFYING PATHWAYS OF NUTRIENTS

Myriel Vredenborg[1], Benjamin Rabe[1], Sinhue Torres-Valdés[1], Stefanie Rynders[2], Yevgeny Aksenov[2]

[1] *Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Bremerhaven, Germany*
[2] *National Oceanography Centre, Southampton, UK*

Corresponding author: myriel.vredenborg@awi.de

The Arctic Ocean is undergoing remarkable environmental changes as part of global warming. The rise in the Arctic near-surface air temperature during the past decades is more than twice as high as the global average, a phenomenon known as the "Arctic Amplification". As a consequence, the Arctic summer sea ice extent has decreased by more than 40 % in recent decades, and moreover a year-round sea ice loss in extent and thickness was recorded. By opening up of large areas formerly covered by sea ice, the exchange of heat, moisture and momentum between the ocean and the atmosphere intensified. This resulted in changes in the ocean circulation and the water masses impacting the marine ecosystem. To investigate these changes, we compiled a large set of hydrographic and biogeochemical data (nutrients, oxygen and chlorofluorocarbons) of the central Arctic Ocean and performed intensive quality checks. To better quantify the current changes in the Arctic ecosystem we will compare our analysis of observational data with high-resolution biogeochemical atmosphere-ice-ocean model simulations.

NITROGEN AND STABLE ISOTOPE INVENTORIES IN THE LENA DELTA

T. Sanders[1], C.Fiencke[2,3], M. Fuchs[4], C. Haugk[4,5], G. Mollenhauer[6], O. Ogneva[6], J. Palmtag[7], J. Strauss[4], R. E. Tuerena[8], and K Dähnke[1]

[1] Helmholtz-Zentrum Hereon, Institute of Coastal Research, Max-Planck-Straße 1, 21502 Geesthacht, Germany

[2] Universität Hamburg, Institute of Soil Science, Allende-Platz 2, 20146 Hamburg, Germany

[3] Center for Earth System Research and Sustainability, Universität Hamburg, Allende-Platz 2, 20146 Hamburg, Germany

[4] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Permafrost Research Section, Telegrafenberg A 45, Potsdam, Germany

[5] Department of Environmental Science and Analytical Chemistry, Stockholm University, Svante Arrhenius Väg 8, 11418, Stockholm, Sweden

[6] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Marine Geochemistry Section, Am Handelshafen 12, 27570 Bremerhaven, Germany

[7] Department of Geography and Environmental Sciences, Northumbria University, NE1 8ST, Newcastle-upon-Tyne, UK

[8] Scottish Association for Marine Science, Dunstaffnage, Oban PA37 1QA, UK

Corresponding author: Tina Sanders, tina.sanders@hereon.de

Pan-arctic rivers transport a huge amount of nitrogen to the Arctic Ocean. The permafrost-affected soils around the Arctic Ocean contain a large reservoir of organic matter including carbon and nitrogen, which partly reach the river after permafrost thaw and erosion.

Our study aims to estimate the load of nitrogen supplied from terrestrial sources into the Arctic Ocean. Therefore, water, suspended particulate matter (SPM) and sediment samples were collected in the Lena Delta along a (~200 km) transect from the center of the Lena Delta to the open Laptev Sea in late winter (April) and in summer (August) 2019. In winter, 21 sample from 13 stations and in summer, 51 samples from 18 stations were taken. 9 of these sampling stations in the outer delta region were sampled in both seasons.

We measured organic and inorganic nitrogen and the 15N stable isotopes composition of all three sample types to determine sources, sinks and processes of nitrogen transformation during transport.

In winter, the nitrogen transported from the delta to the Laptev Sea were mainly dissolved organic nitrogen (DON) and nitrate, which occur in similar amounts. The load of nitrate increased slightly in the delta, while no changes to the isotope values of DON and nitrate were observe indicating a lack of biological activity in the winter season. However, lateral transport from soils was a likely source. In summer, nitrogen was mainly transported as DON and particulate nitrogen in the SPM fraction, including phytoplankton.

The nitrogen stable isotope values of the different nitrogen components ranges between 0.5 and 4.5°‰, and were subsequently enriched from the soils via SPM/sediment and DON to nitrate. This indicates that nitrogen in the soils mainly originates from nitrogen fixation from the atmosphere. During transport and remineralisation, biogeochemical recycling via nitrification and assimilation by phytoplankton led to an isotopic enrichment in summer from organic to inorganic components. In the coastal waters of the Laptev Sea, the river waters are slowly mixed with marine nitrate containing waters from the Arctic Ocean, and a part of the riverine organic nitrogen is buried in the sediments.

We assume that the ongoing permafrost thawing and erosion will intensify and increase the transport of reactive nitrogen to coastal waters and will affect the biogeochemical cycling, e.g. the primary production.

NITROUS OXIDE AND METHANE DISTRIBUTIONS DURING THE 2021 SYNOPTIC ARCTIC SURVEY

Ian Brown[1], Vas Kitidis[1], Andy Rees[1], Damian Arévalo-Martínez[2], Brett Thornton[3]

[1] *Plymouth Marine Laboratory*
[2] *GEOMAR – Kiel*
[3] *University of Stockholm*

Corresponding author: Ian Brown - iaian2@pml.ac.uk

During August-September 2021, we determined the distribution of N2O and CH4 in Arctic Seawater, Ice and Atmosphere onboard the Swedish Icebreaker Oden as a contribution to the 2021 Synoptic Arctic Survey. Operating in an area between the North of Greenland and the North Pole this cruise provided the opportunity to investigate the concentrations and air – sea exchange of these gases for this rarely visited region. Measurements revealed a region which largely offered a sink to atmospheric greenhouse gases, with large deficits associated with the sea-ice and occasional local hotspots of production. Full depth profiles identified localised regions of the sea bed with elevated methane concentrations reflecting the probable occurrence of methane seeps, though subsequent oxidation and dilution in the water column meant that these did not provide significant source to the atmosphere.

QUANTIFYING SEAFLOOR DYNAMICS OF ORGANIC MATTER IN THE BARENTS SEA SHELF SEDIMENTS

F.S. Freitas[1, *], K.R. Hendry[1], S. Arndt[2], S.F. Henley[3], J.C. Faust[4, 5], A.C. Tessin[6], M.A. Stevenson[7,8], G.D. Abbott[7], C. März[4]

[1]*University of Bristol, UK*
[2]*Université Libre de Bruxelles, Belgium*
[3]*University of Edinburgh, UK*
[4]*University of Leeds, UK*
[5]*University of Bremen, Germany*
[6]*Kent State University, USA*
[7]*Newcastle University, UK*
[8]*Durham University, UK*

Corresponding author: [*]felipe.salesdefreitas@bristol.ac.uk

The Barents Sea has experienced dramatic impacts associated to climate change in the past decades. Although critical for the entire ecosystem, the seafloor and its biogeochemical dynamics have received insufficient attention, which limits our ability to address key questions regarding the role of these sediments in processing and storing carbon, and its susceptibility to the ongoing changes. Here, we put the seafloor in the spotlight and try to fill some of these gaps. We use a state-of-the-art reaction-transport model approach alongside comprehensive sediment and porewater data to quantify organic matter dynamics along a south-north transect in the Barents Sea shelf. Our results show that the reactivity of organic matter has a crucial role driving diagenetic processes in these sediments. It controls degradation rates of organic matter and benthic-pelagic fluxes of nutrients. Further, it strongly influences the seafloor carbonate chemistry by promoting changes in porewater pH and carbonate saturation state. These findings allow us to systematic understand the cycling of organic matter in the seafloor at present, which enables us to predict the impact of future ecosystem changes in the Arctic Ocean.

SPATIO-TEMPORAL VARIABILITY OF THE PRIMARY AND SECONDARY PRODUCTION IN THE BARENTS SEA: FROM A 1D TO A 3D MODELLING APPROACH

Déborah Benkort[1], Ute Daewel[1], Richard Hofmeister[2] and Corinna Schrum[2]

[1] *Institute of Coastal Research, Helmholtz Zentrum Hereon*
[2]*Institute of Coastal Research, Helmholtz Zentrum Hereon and Geophysical Institute, University of Bergen*

Corresponding author: Déborah benkort, Deborah.benkort@hereon.de

With the rapid climate changes ongoing in the Arctic, the fate of the marine ecosystem still uncertain. The Barents Sea is characterized by high productivity and represents the Arctic area featuring the most severe decrease in winter sea-ice extent over the last decade. However, sea-ice plays a key role in the Barents Sea system acting both as a physical barrier for the pelagic and benthic system underneath as well as a habitat for a sympagic system, spatially sea-ice algae. In the northern Barents Sea area sea-ice algae production can represent around 20 % of the total primary production and represent consequently a source of carbon for the pelagic and benthic ecosystems. Impacts of the sea-ice decrease on the primary and secondary production phenology and amplitude remains poorly understood in the general Arctic and in the Barents Sea. To assess the regional variability of primary, secondary production and ice algal biomass within the Barents Sea, we coupled an ecosystem model ECOSMO II, including sympagic, pelagic and benthic systems to the SCHISM three dimensional high-resolution regional model. The present study showed hindcast results of the primary and secondary production over the whole Barents Sea and the Farm strait. Results showed a strong spatial and temporal variability of the ecosystem dynamics. Results also highlight a latitudinal dependency of the timing and the amplitude of the sympagic and pelagic primary and secondary productions.

SYNTHETIC SHELF SEDIMENT MAPS FOR THE GREENLAND SEA AND BARENTS SEA

Jack H. Laverick, Douglas C. Speirs, Michael R. Heath

Department of Mathematics and Statistics, University of Strathclyde

Corresponding author: jacklaverick@ymail.com

Seabed sediment maps underpin many marine research endeavours. Seabed mapping data are available for many regions, but these usually provide discrete classifications which obscure underlying continuous properties of the sediments. Other areas are poorly surveyed e.g. polar regions which are inaccessible due to ice cover. Here we focus on the inaccessible North East Greenland shelf for which there are almost no seabed sediment data. We trained a random forest model to predict sediment classes from an existing map of the well surveyed neighbouring Barents Sea, using data on bathymetry, currents, and waves. We then used our model to predict the unknown sediment distributions off East Greenland. In the process, we generated some new spatial data on previously un-mapped properties of the Barents Sea such as mean grain size, organic carbon and nitrogen content, porosity, and permeability. The maps of both regions are available to support future research activities in the Arctic e.g. the parameterisation of benthic biogeochemistry in ecosystem models, or mapping species distributions.

THE PERMAFROST THAW FINGERPRINT: PARTICULATE ORGANIC CARBON FROM THE LENA RIVER TO THE LAPTEV SEA

<u>Olga Ogneva[1]</u>, Gesine Mollenhauer[1], Tina Sanders[2], Bennet Juhls[1], Matthias Fuchs[1], Juri Palmtag[3], Hendrik Grotheer[1], Paul Mann[3] and Jens Strauss[1].

[1] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven and Potsdam, Germany

[2] Helmholtz Centre Hereon, Institute of Carbon Cycles, Geesthacht, Germany

[3] Department of Geography and Environmental Sciences, Northumbria University, NE1 8ST, Newcastle-upon-Tyne, UK

Corresponding author: Olga.Ogneva@awi.de

Rapid climate warming in Arctic region intensifies permafrost thaw, increases active layer depth in summer and enhances riverbank and coastal erosion. This causes the release of organic matter (OM) into streams and rivers and result in discharge of terrestrial OM into the Arctic Ocean.

The focus of this study is particulate OM. It consists of a complex mixture of compounds from different terrestrial and water sources with different chemical/physical resistance towards decomposition and mineralization. Particulate organic carbon (POC) transported by the Lena River represents a quantitatively important carbon pool exported to Laptev Sea. Nevertheless, its resulting quantity and quality in the Lena Delta and Laptev Nearshore are still not fully understood. In this study, our aim is to characterize the POC from the Lena River and the Lena Delta to decipher the fate of the OM on the way from permafrost catchment to the Arctic Ocean.

We determined the sources (e.g., permafrost, soil, peat, phytoplankton, vegetation, etc.), quality and age of organic carbon transported by the Lena River to understand the effects of climate change on the river watersheds as well as on the Arctic coastal nearshore zone. To assess these data, we have had an intensive fieldwork in the Russian Arctic in summer 2019. Samples were collected across a ~1500 km transect from the Yakutsk along the Lena River main channel through the center of Lena Delta to the Nearshore zone. Our study is embedded into the project "Changing Arctic Carbon cycle in the cOastal Ocean Near-shore (CACOON)".

We analysed water samples from one to three different water depths to capture stratification in the water column. In a next step, the water was filtered at Samoylov Research Station through precombusted GF/F filters (25 mm diameter). Filters with POM were stored frozen in pre-combusted glass petri dishes. Later the filters were analysed for total suspended matter, total POC concentration, stable (δ13C) and radiocarbon (Δ14C) isotopes.

We found significant qualitative and quantitative differences between the OM composition in the Lena River main channel and its delta. Further, we found that suspended matter and POC concentrations decrease during transit from the river to the Arctic Ocean. We demonstrate that deltaic POC is depleted in 13C relative to fluvial POC due to the dominance of phytoplankton and algae as its source. Riverine POC mostly occurs from the soils of the Lena watershed area. POC 14C signature for riverine and deltaic samples does not differ from each other, which suggests an additional input of old permafrost OM in the Lena delta. These observations reflect the difference in hydrological conditions between the delta and the river main channel, caused by lower flow velocity and average water depth.

EMERGING SHIFT IN SHELF-DEEP OCEAN INTERACTIONS IN THE CHANGING ARCTIC OCEAN

Yevgeny Aksenov[1*], Stefanie Rynders[1], Maria Luneva[†,2], Vladimir Ivanov[3,4], Igor Kozlov[5,6], Fedor Tuzov[3], James Harle[2], Stephen Kelly[1] and Jason Holt[2]

[1]*National Oceanography Centre Southampton, UK*
[2]*National Oceanography Centre Liverpool, UK*
[3]*Lomonosov Moscow State University, Moscow, Russian Federation*
[4]*Arctic and Antarctic Research Institute – The State Centre, St.Petersburg, Russian Federation*
[5]*Russian State Hydrometeorological University, St.Petersburg, Russian Federation*
[5]*Marine Hydrophysical Institute of RAS, Russian Academy of Sciences, Russian Federation*
[*]Corresponding author

[†]deceased

It is evident now that sea ice retreat in the Arctic affects the whole Arctic system: from ocean stratification and atmosphere-ocean interactions [1] to waves and ecosystems [2]. What is less understood, is how the exposure of the large areas of the ocean to the atmosphere can impact exchanges between the shallow shelf seas and deep Arctic Ocean with consequences for ocean heat, ventilation and carbon uptake. This study addresses the gap and examines strength of dense shelf water cascading and its role in surface waters dynamics and nutrient fluxes. From analysing recent CTD observations and eddying models we derive the regions of the intensive cascading and deduce key mechanisms controlling the preconditioning through upwelling of the Arctic Atlantic waters and shelf mixing [3]. We assert the cascading to become a key emerging mechanism impacting the water transformation, stratification and biogeochemistry of the Arctic Ocean.

The study was inspired and lead by Maria, who was a CoI in APEAR and tragically passed away in March 2020. This presentation is in Maria's memory.

The study was supported by NERC projects NE/R000085/1 and NE/T000260/1, by the project "Advective Pathways of nutrients and key Ecological substances in the Arctic (APEAR)" (NE/R012865/1, NE/R012865/2, #03V01461), part of the Changing Arctic Ocean Programme, jointly funded by the UKRI Natural Environment Research Council (NERC) and the German Federal Ministry of Education and Research (BMBF). We acknowledge the NERC funding from the CLASS, ORCHESTRA (NE/N 984 018095/1) and ACSIS (NE/N018044/1) Programmes and from the Russian Science Foundation, grant #19-17-00110, and Russian Foundation for Basic Research, grant # 18-35-20078. It was also part of the UK Arctic Office Bursary "Contribution of eddies and dense water cascading to cross-shelf exchange".

[1] Polyakov et al. J. Clim., 2020.

[2] Kelly et al., Earth's Future 2020.

[3] Luneva et al. J.Geophys.Res., 2020.

WHAT FACTORS AFFECT THE BIOSYNTHESIS OF SEA ICE ALGAL LIPIDS AND TROPHIC MARKERS?: INSIGHTS FROM AN MULTI-BIOMARKER APPROACH.

Martin Graeve[1], Eva Leu[2], Kirsten Fahl[1], Thomas Turpin-Jelfs[3], Thomas Brown, C.J. Mundy[4], Nahid Welteke[1], Karley Campbell[3,5]

[1]Alfred-Wegener-Institute Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
[2]Akvaplan-Niva, Tromsø, Norway
[3] Bristol Glaciology Centre, School of Geographical Sciences, University of Bristol, Bristol, UK
[4]Centre for Earth Observation Science, University of Manitoba, Canada
[5] Department of Arctic and Marine Biology, UiT The Arctic University of Norway, Tromsø, Norway

Sea ice algae are adapted to grow and thrive in a variety of microhabitats associated with the sea ice. This includes the surface meltwater ponds and snow, the network of brine channels within the ice interior, and especially the bottom most centimetres of the ice. The dominance of diatoms within sea ice algal blooms make these primary producers an especially important food resource for aquatic marine organisms, providing the only source of nutritionally valuable omega-3 fatty acids for higher trophic levels. These lipid-based compounds of fatty acids, together with highly branched isoprenoids and stable isotopes values of specific fatty acids also permit tracing of sea ice-based carbon through the entire marine food web. Moreover, with investigation of the stable isotope values of fatty acids we gain more insights to the transfer of algae derived carbon through the food chain.

As a contribution to the DiatomArctic project, we investigated the response of sea ice algae to environmental change. We aimed at measuring the lipid content and isotopic composition of ice algal communities from Coral Habour, Hudson Bay, Canada, along a defined transect of varying conditions based on proximity to the flow edge. In a second laboratory-based approach, we aimed at characterizing, how the lipid content and stable isotope composition of the diatom species *Nitzschia frigida* changes with light, nutrient conditions. using a multi-biomarker approach (fatty acids: FAs, highly branched isoprenoids: (HBIs), sterols and fatty acid-compound specific stable isotope ratios). Our results are important for the understanding how environmental conditions control algal lipid synthesis and composition is important for judging their nutritional value and how it may change under future conditions.