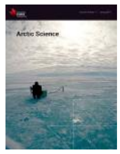
Special section of the T-MOSAiC Newsletter on Arctic Microbiomes

In this newsletter, we continue a special section with graphical abstracts and small articles focused on a specific theme, edited by the Action Group Chairs. In this edition, **Arctic Microbiomes** is the theme, and our next theme will be **Permafrost Thaw**. We look forward to your contributions to this and other themes in future newsletters.

SPECIAL ISSUES

Special T-MOSAiC Issue of Arctic Science

The T-MOSAiC special issue of *"Arctic Science"* is open for submissions until March 31st 2022. Please visit the T-MOSAiC website for updated information or contact the secretariat: https://www.t-mosaic.com/



Special T-MOSAiC Issue on Arctic Terrestrial Pollution

The Environmental Pollution Journal (IF: 6.792) is open for submissions. This special issue publication aims to provide original research on Arctic Terrestrial Pollution (including Coastal Areas). This special issue will be edit by João Canário (University of Lisbon, Portugal), Katrin Vorkamp (Aarhus University, Denmark), Mark Mallory (University of Acadia, Canada) and Scott Zolkos (Woods Hole Research Center, USA). Deadline for submissions October 15, 2021.

Special T-MOSAiC Issue on Polar and Alpine Microbiology

The Arctic Microbiomes AG is editing a special issue in journal "Frontiers in Microbiology". On the topic Digitizing Frozen Earth - Revealing Microbial Diversity and Physiology in the Cryobiosphere through ´Omics´ Tools, Volume II", this SI is now open online and ready for submissions until October 31st, 2021.

frontiers in Microbiology

The editors of this SI include Anne Jungblut, Jérôme Comte and Birgit Sattler.

Special Issues on Remote Sensing

Special joint Issue of Journal of Unmanned Vehicle Systems (changing to Drone Systems and Applications) / Arctic Science: 'Unoccupied Vehicle Systems in Arctic Research and Monitoring' All papers published in this collection will be made open access at no cost to authors with a flexible deadline of an expression of interest this summer and a deadline in the autumn. Guest Editors: Dr. Isla Myers-Smith, Dr. Jeffrey Kerby, Dr. Dustin Whalen.

Special issue of Remote Sensing: 'Advanced Technologies in Wetland and Vegetation Ecological Monitoring' with a deadline of 31 March 2022. Guest Editors: Dr. Sergio Vargas Zesati, and Dr. Jeremy May.

Special issue of JGR Biogeosciences: 'The Earth in living color: spectroscopic and thermal imaging of the Earth: NASA's Decadal Survey Surface Biology and Geology Designated Observable' with a deadline of 31 August 2022. Guest Editors: David S Schimel, Benjamin Poulter, Natasha Stavros, Phil Townsend, Nancy Glenn.

Special issue of Remote Sensing: 'Multi-Scale Analysis for Detecting the Processes, Causes, and Impacts of Permafrost Change and of Disruptive Events' with a deadline of 30 Nov 2021. Guest Editors: Michael Lim, Gonçalo Vieira and Dustin Whalen

CONFERENCES

Scientific Session at ASM2021 on Artic Microbiomes endorsed by the T-MOSAiC correspondent AG

The ArcticChange2021 conference will take place online in December 2021. The call for submission of abstracts is now open, and the Arctic Microbiomes AG is pleased to endorse a scientific session entitled, "Microbiomes as sentinels of a changing Arctic" (TER48), in the "Terrestrial" section of the meeting's topical sessions. The abstract for this session is:

"Among the life forms that live in Arctic environments, microorganisms are the major contributors to nutrient and energy cycles, biodiversity and biomass. Microbial processes underpin Arctic food webs. Therefore, understanding their dynamics and interactions is vital to understanding the ecology of the biome as a whole, especially considering the rapid warming in this region. Although the impact of climate change on microbial communities remains unclear, the unique microbial ecosystems associated with fragile Arctic environments such as glaciers, ice-covered seas and permafrost will surely be adversely affected. Changes in microbial communities can ripple throughout food webs and alter the availability and quality of resources collected by Northerners on the land, directly impacting their microbiomes. Therefore, the response of microbial communities to warming will impact not only ecosystem health but also human health. This session aims to advance our understanding of environmental and human microbiomes and how they interact and overlap in the context of a rapidly changing Arctic."

For more information, please use this *link*.

ACTION GROUP ACTIVITIES

Arctic Infrastrcutures AG

The monthly science talks have resumed on the 3rd Thursday of the month at 17:00* GMT (_9:00 Alaska _/ _13:00 Eastern US/Canada / 19:00 Western Europe / 20:00 Moscow / *18:00 GMT starting in November).

Please join us for an informal presentation and discussion on topics related to Arctic infrastructure and environmental change. The monthly series is organized by the T-MOSAiC Arctic Infrastructure Action Group to provide an online forum for researchers to share knowledge in between major conferences.

Next Talk: 21 October 2021 (17:00 GMT)

Speaker: Dr. Thomas Schneider von Deimling, Alfred Wegner Institute
Title: Timing of infrastructure failure from permafrost degradation some modeling insights
Abstract: Climate change is posing an increasing threat to infrastructure stability in cold regions. Yet it is hard to evaluate when infrastructure will fail in the future given a multitude of factors which determine ultimate infrastructure fate. In my presentation I will discuss some modelling results for a case study of a gravel road on cold continuous permafrost and will discuss differing factors impacting the failure timing. As an outlook I will speculate about potential adaptation limits for road protection.

Join Zoom Meeting: https://alaska.zoom.us/j/84495598534
Meeting ID: 844 9559 8534
(Link should stay the same from month to month)

Future Talks: See a schedule of upcoming talks.
Email jlpeirce@alaska.edu if you would like to present or suggest an Arctic infrastructure-related science talk.

Arctic Science Summit Week 2022 in Tromsø, Norway

The RATIC/T-MOSAiC Arctic Infrastructure Action Group will host a 1/2-day workshop as part of the community meeting schedule at ASSW 2022 in Tromsø. The event will most likely be planned as a hybrid event with an opportunity for online participation. We have limited travel funds available to support participation by early career, Indigenous and Russian participants. Please contact us if you are interested in applying for funds or would like to get on the mailing list to learn more about the workshop.

https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2020JG006233

Arctic Microbiomes AG

Josef Elster group is presently working on the polyphasic assessment of diversity of phototrophic microorganisms from cold environments and their bioprospection potential.

The main objectives of the proposed collaborative project are;

1. documenting, enlisting, culturing, taxonomic assessment and long-term preservation of cyanobacteria and microalgae from cold environments;

2. screening of industrially important bioactive molecules from the cyanobacterial and microalgal strains, and

3. use of phototrophic microorganisms from cold habitats for the production of biomass and/or high-value compounds connected with wastewater treatment.

Northern Community Issues AG

Scott Zolkos will conduct fieldwork in southwest Alaska in for my post-doc work on mercuryand carbon cycling across gradients of wildfire and permafrost thaw.

Brief details in the "Abstract" section, can be accessed here.

ARTICLES RELEVANT TO T-MOSAiC THEMES

- Copland, L., and Mueller, D. 2021. Climate station data from Purple Valley at the head of Milne Fiord, northern Ellesmere Island, Nunavut, Canada., v. 1 (2009-2019). Nordicana D93, doi: 10.5885/45735XD-011EA11523034D87.

- Domine, F., Lackner, G., Sarrazin, D., Poirier, M., and Belke-Brea, M. 2021. Meteorological, snow and soil data (2013-2019) from a herb tundra permafrost site at Bylot Island, Canadian high Arctic, for driving and testing snow and land surface models, Earth Syst. Sci. Data, 13, 4331-4348, https://doi.org/10.5194/essd-13-4331-2021.

- Fedorov, R., Kuklina, V., Sizov, O., Soromotin, A., Prihodko, N., Pechkin, A., Krasnenko, A., Lobanov, A., & Esau, I. (2021). Zooming in on Arctic urban nature: Green and blue space in Nadym, Siberia. Environmental Research Letters, 16(7), 075009. https://doi.org/10.1088/1748-9326/ac0fa3

- Fortier, D., and Davesne, G. 2021. Snow and temperature regime of a perennial ice patch, Ward Hunt Island, Nunavut, Canada., v. 1.0 (2017-2019). Nordicana D91, doi: 10.5885/45720CE-0F556C84D96948F7.

- Imbeau, E., Vincent, W.F., Wauthy, M., Cusson, M. and Rautio, M., 2021. Hidden stores of organic matter in northern lake ice: Selective retention of terrestrial particles, phytoplankton and labile carbon. Journal of Geophysical Research: Biogeosciences, 126, p.e2020JG006233. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2020JG006233

- Klanten, Y., Triglav, K., Marois, C. and Antoniades, D., 2021. Under-ice limnology of coastal valley lakes at the edge of the Arctic Ocean. Arctic Science, 7, https://cdnsciencepub.com/doi/full/10.1139/as-2020-0038

- Kuklina, V., Bilichenko, I., Bogdanov, V., Kobylkin, D., Petrov, A., & Shiklomanov, N. (2021). Informal road networks and sustainability ofSiberian boreal forest landscapes: Case study of the Vershina Khandy taiga. Environmental Research Letters. https://doi.org/10.1088/1748-9326/ac22bd

Special Section: Arctic Microbiomes

Edited by Jérôme Comte, Anne Jungblut and Birgit Sattler, co-chairs of the Arctic Microbiomes Action Group

The world is teeming with microorganisms. Since their first observation they have fascinated generations of scientists by their tremendous diversity and ability to colonize habitats that were deemed to be lifeless due to harsh local conditions. Arctic environments are often referred to as extreme due to low temperature, low precipitation (polar deserts), extended darkness periods and for pushing life to its limit. Thanks to the advent of molecular biology and next generation sequencing, there is now evidence that the so-called cryosphere has an unprecedented microbial diversity and richness. Genomics is allowing opening this microbial black box and started providing information on this invisible majority, tackle important questions on who they are, and how do they function under polar conditions. After millennia of adaption to Arctic conditions, microorganisms may be face new challenges to survive and respond to climate change and anthropogenic activities (e.g. plastic pollution), which make them sentinels of the Arctic biome. Understanding how the Arctic microbiome respond to climate will help predict the functional implications at the circumpolar and global scale. Some of the projects presented in this special section are addressing these important challenges. Environmental microbiology in the Arctic is also paving the way to innovative research that aims to uncover new bioactive compounds and enzymes having high catalytic activity at low temperature (extremozymes), as well as we will able to learn more about the limits of life and habitability which has implications for the search of life on other planets. A good example of the latter is presented in this section. Collectively, the Arctic Microbiomes action group aims to connect microbiological research activities in the circumpolar North and to build networks for research and science communication. We have, for example led a fascinating and inspiring session at the Arctic Science Summit Week in March 2021 and are editing Research Topic in *Frontiers in Extreme Microbiology* titled "Digitizing Frozen Earth-Revealing Microbial Diversity and Physiology in the Cryosphere Through "Omics" Tools that has received more than 12 submission with 4 manuscript already open access published to date. The extended deadline for special issue will be the October 31st and we are thus inviting you dear colleagues to submit your research on Arctic microbiomes.

We would like to thank our colleagues who have contributed to this special section and wish them great success in their research on Arctic microbiomes.

SENTINEL NORTH – LAST ICE MICROBIOMES (SN-LIM)
Last ice microbiomes and Arctic ecosystem health

Alexander Culley[1,2], Warwick F Vincent[1,3], Dermot Antoniades[1,5], Denis Boudreau[1,4], Connie Lovejoy[1,3], Raoul-Marie Couture[1,4], Jesse Greener[1,4]

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[5]Department of Geography, Université Laval

Conservation policies for the fast-changing Polar Regions are an urgent global priority in the face of ongoing climate change, yet little attention has been given to the microbial communities that underpin high latitude ecosystems and dominate biodiversity and functioning[1]. To address this gap in understanding and knowledge transfer, we target two conservation areas at the top of Canada: the Last Ice Area (LIA)[2], the band of thickest ice along the northern coast of Nunavut (under interim protection as the Marine Protected Area Tuvaijuittuq[3]), and the adjacent land-based conservation area of Quttinirpaaq National Park (Figure 1). Our overarching goal is to provide an integrated, transdisciplinary analysis of the 'Last Ice Microbiomes' of the multiyear sea ice and associated coastal and land-based ecosystems, including their physico-chemical properties, molecular microbiology and new monitoring options for the region. The project has three interlocking modules (Figure 2), with emphasis on technology innovation, novel approaches connecting disciplines, and knowledge exchange among laboratories and partner networks in the largescale international projects MOSAiC and T-MOSAiC.

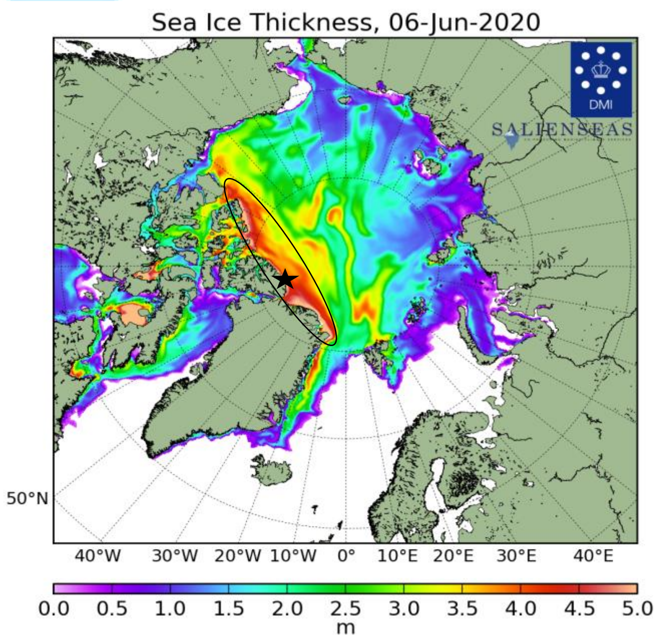

Figure 1: Sea Ice Thickness, 6 June 2020, polarportal.dk

In the Marine Module, we will test hypotheses about the genomic diversity of microbes in LIA sea ice and coastal waters, including ice-covered bays and fjords, and develop an innovative opto-microfluidic system for field flow cytometry to characterize and quantify aquatic microbes. In the Ice Module, we will evaluate the microbial, including viral, diversity of glaciers, ice shelves, ice domes, and perennial snowbanks on the landward side of the LIA, and develop an advanced microfluidic bioassay system to assess the environmental responses of microbial biofilms. In the Lakes Module, we will address questions about microbial connectivity, conceive novel biogeochemical models for lake oxygen dynamics and sulfur cycling via in situ and metagenomic studies, and apply a suite of methods, including paleo-DNA, to place the LIA region in a long-term historical context. The project will yield new transdisciplinary perspectives on cryo-biomes and will provide extensive training across research centres on Arctic environmental issues of broad significance.

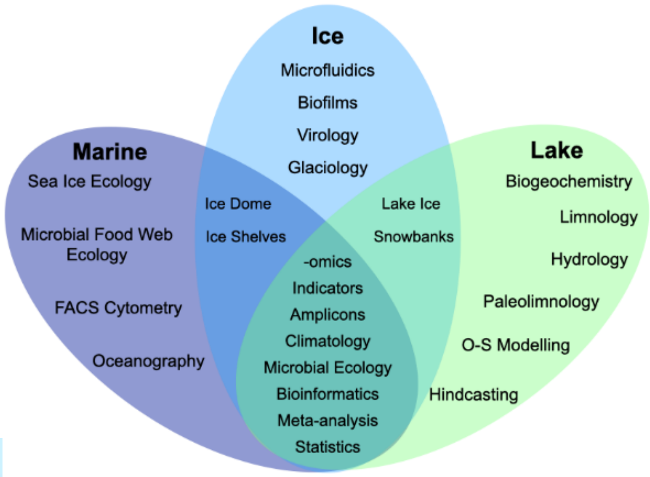

Figure 2: Presentation of Sentinel North - Last Ice Microbiomes modules

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Acknowledgements

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Ice microorganisms used as a tool for Astrobiology

Lígia F. Coelho, João Canário, Rodrigo Costa, Zita Martins
MIT-Portugal Program - CQE/iBB, Instituto Superior Técnico, University of Lisbon

Ice is one of Earth's biomes, known to harbor unique biological communities[1]. Microorganisms living in ice must be able to endure extreme conditions such as low temperatures, extreme dryness, osmotic stress, as well as radiation[2]. For this reason, it is thought that icy extraterrestrial extreme environments may provide promising targets for the search for life, and thus the polar regions are considered icy terrestrial analogs[3] used as tools in astrobiology studies. Within the framework of my PhD research, we have studied the cryosphere of the Hudson Bay's coast and its possible applications in astrobiology (Figure 1). Adding to the abovementioned list of conditions that microbial communities on ice have to tolerate, the sampled sites represent also a significant salinity fluctuation due to their estuarine character and the ice-cover effect during winter[4].

One of the experiments was to grow and isolate a collection of 175 microorganisms from ice and water samples, and then identify them using the 16S rRNA gene as a molecular marker. From the initial study of that microbial collection[5] we were able to draw two conclusions. First, we found that most isolates were closely related to extremophiles. Besides reported resilience to UV and gamma radiation, high salt concentrations, dryness, and cold temperatures[5], some were also closely related with strains that were first isolated from space-vehicles that orbited Mars[6]. Secondly, we found that ice appeared to be richer in pigmented microorganisms than water (Figure 1).

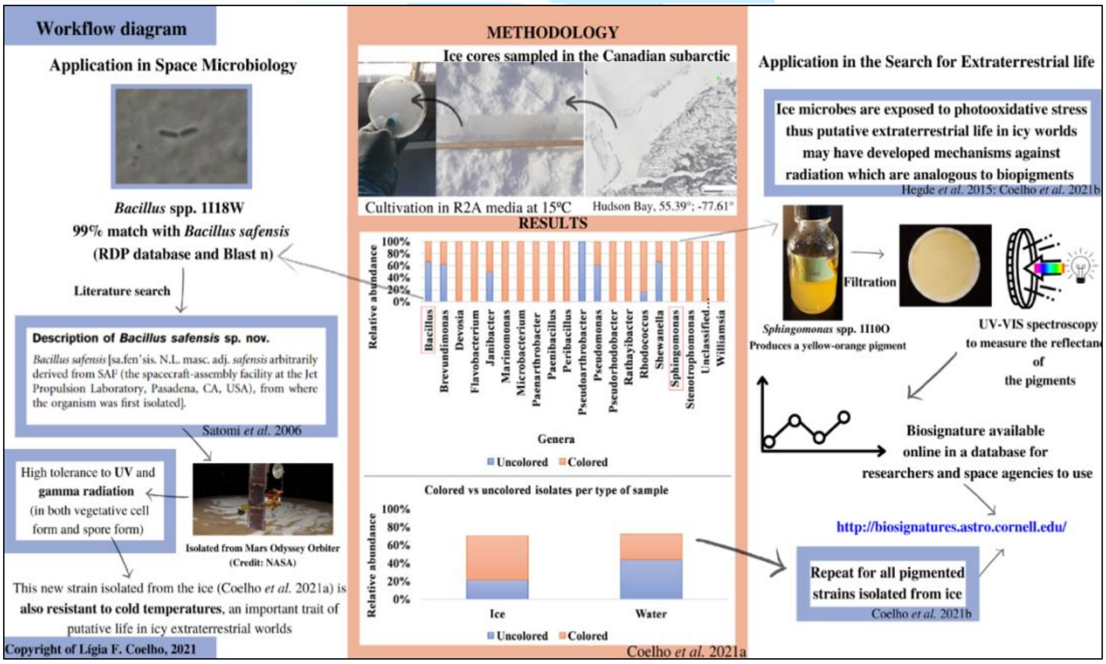

Figure 1 – Workflow diagram starting with fieldwork in the Canadian subarctic, following cultivation and identification results. Included are the astrobiology applications illustrating two branches: space microbiology and the search for extraterrestrial life.

These conclusions are relevant for two different branches of astrobiology, respectively: 1) space microbiology, which studies the response of microorganisms to space conditions, and 2) the study of biosignatures (signals of life)[7], such as the case of biopigments, to help prepare and guide future life-detection space missions to icy worlds. Some of these missions will be launched in the next few years such as ESA's JUICE mission, and NASA's Europa Clipper, which have the icy moons of Jupiter as the destination. But also, to prepare for missions aiming to explore frozen Earth-like exoplanets (planets outside the solar system that resemble Earth in size and constitution).

Exoplanet exploration depends on land-based and space-based extremely large telescopes (e.g., JWST, LUVOIR and HabEx) that will be able to look for biosignatures in the surface of the dozens of Earth-like planets already discovered (see exoplanets.nasa.gov) that may have liquid water on the surface. Searching for life in exoplanets is only possible by the spectral analysis of what telescopes can observe and resolve and thus the biosignatures studied need to comply with this limitation. Fortunately, pigmented organisms have unique reflectance signatures[8], thus, in a second study, 80 isolates (from the total 175 abovementioned) were used to build a spectral database of icy pigmented microorganisms[9]. Such databases provide a crucial tool to detect and identify potential biosignatures on icy exoplanets and exomoons. Pigment production is a biological process against photooxidative stress on Earth, not stringent to any evolutive branch[10]. Thus, pigments are possibly present on the surface of exoplanets where life has evolved since radiation exposure is a universal trait of Earth-like planets. In fact, biological pigments dominate many diverse landscapes on Earth[11] from green algae blooms to pink "watermelon" snow and including red saltern crystallizer ponds as well as heterogeneous microbial mats - all of which have been detectable from space[12,13] in the last 2 billion years[14], in case anyone has been watching us[15].

Acknowledgements: LFC was funded by the MIT-Portugal Program (MPP) through FCT (PD/BD/139840/2018). CQE acknowledges the financial support of FCT (UIDB/00100/2020). iBB acknowledges the financial support of (UIDB/04565/2020). This research is framed within Polar2E of the University of Lisbon and received support from the project PERMAMERC funded by the PROPOLAR.

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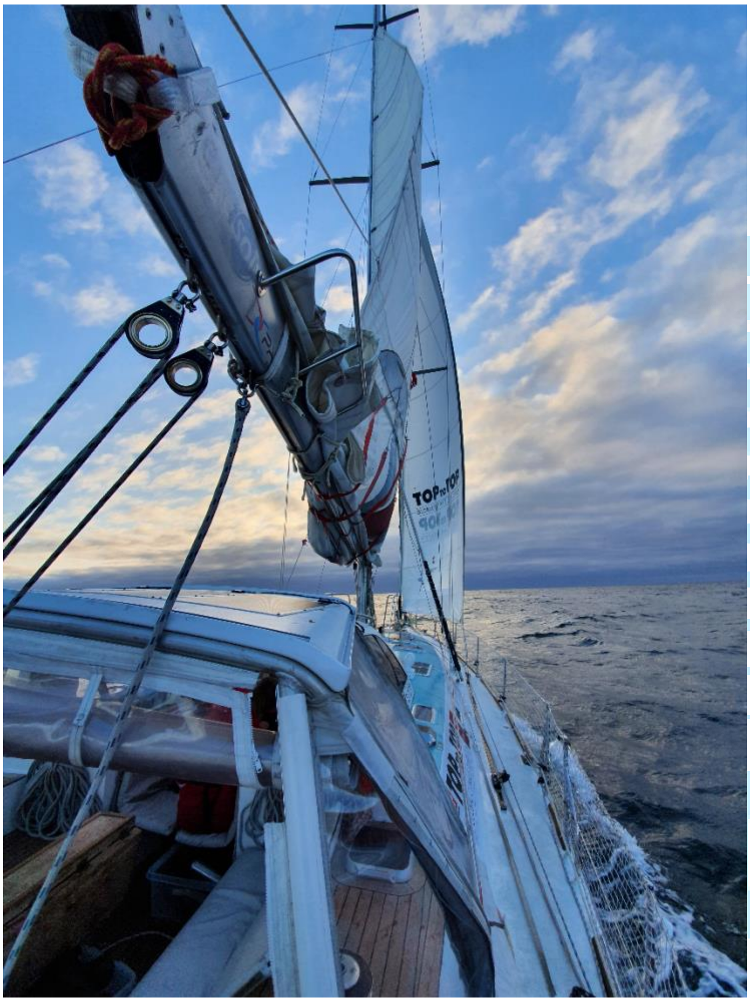
Microplastic Pollution in Arctic Cryospheric Habitats: Origin, Quality and Ecological Implications

TOPtoTOP Arctic Expedition 2021

Max Kortmann, Sebastian Pohl, Birgit Sattler – University of Innsbruck, Austria

The Arctic is facing increasing stressors under global change. Plastic pollution is starting to become a major threat to pristine Arctic environments. Yet, research concerning the quality and quantity of pollution, as well as public awareness about this issue, remains scarce.



Generally, it is thought that industrial pollutants would not reach remote areas such as the High Arctic. However, it is fact that stressors such as microplastics are to be found even in this pristine environment. The origin thereof is still not resolved to full extent: Local sources such as anthropogenic activities or long range transport via wind distribution or birds can be the cause for the deposition and can affect the cryobiota in aquatic and terrestrial habitats substantially. In detail, we distinguish between the level of anthropogenic impact, as we sailed climate neutral with the boat Pachamama (led by Dario Schwörer and his family; www.toptotop.org) around the Arctic (route: Jan Mayen - Svalbard - Arctic Ice Shelf - Greenland - Iceland). Svalbard and Iceland are characterized by a higher number of populations, high level of touristic activities and increased ship traffic, which can result in more marine debris being washed ashore. Contrary, Jan Mayen and the East-coast of Greenland are underlying less environmental stress. To get an insight of the amount of pollution we sampled along a transect of the respective field sites reaching from a glacier down to the tributary of glacial melt rivers into the fjord or the sea for various sample types: snow, ice, water, sediments, bird guano from adjacent bird colonies and air. The latter is crucial to check for wind-driven dispersal including back trajectories.

This research is a joint project for two master theses:

[Project 1] Microplastic Pollution in Arctic Cryospheric Habitats: Origin, Quality and Ecological Implications that aims to: [1] quantify and qualify microplastic burden in cryospheric habitats along transects from glaciers to the fjords in different geographic sites with varying level of anthropogenic impact, (2) investigate the potential vectors of microplastic dispersal by analysis of snow, ice, water, sediments, bird guano and air samples, (3) assess the ecological impacts on microbial living communities.

[Project 2] Mapping the exposure of Arctic marine fauna to microplastics that aims to: (1) quantify and qualify microplastic burden in Arctic waters, (2) identify species most likely to encounter the recorded debris, (3) investigate the ecological impacts on vertebrate living communities via gut analysis.

Outcomes and impacts

The abundance of microplastic particles on European mainland glaciers has been studied to some extent, as well as the abundance of MPs in the Arctic Ocean. Yet, there still is little knowledge about how far and by which means MPs are transported. The study will provide an inventory of microplastic pollutants in remote areas of which the data are extremely scarce.

As an area of rapid environmental change due to warming, species' range shifts, altering seasons, increasing extreme weather patterns and the loss of sea ice, Arctic species are particularly vulnerable. Further stressors acting on this ecosystem may have a disproportionate impact. To that effect, the aim of this project is to both quantify concentrations of marine debris and assess which species are most likely to encounter the recorded debris. Filtering environmental DNA simultaneously to the microplastics trawls will show which species co-occur with the microplastics and gut analysis will show if the debris is indeed being taken-up into the food web. Combining these methods will allow the mapping of species presence and areas of high concentration, which can highlight areas at higher risk and inform mitigation efforts.

Outreach and Awareness

Scientific research builds the foundation for understanding the world we live in. Yet, problems that arise in and out of a pluralistic society can only be solved by communal effort. To support this effort, we intend to couple our research with comprehensive outreach work. We especially aim to motivate the younger generation in various schools to learn about problem-solving capabilities.

Acknowledgements

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IASC