Proposal for a new UArctic Thematic Network

UArctic Research Network for Microtomography of Arctic Marine Organisms

The thematic focus area of the network

The Arctic is changing at an alarming rate with warmer waters, less sea ice, and dramatic changes in species distributions. According to the United Nations Summit on Biodiversity in 2020, we are in danger of losing 80% of the world's species during our current, sixth mass extinction event.

Museum specimens will in many cases be the only available resource for information about species that once thrived in this region. We must find ways to preserve these specimens for as long and as well as possible.

The museums of UArctic member universities house a plethora of specimens from the Arctic. With this project, we want to establish a network that connects Arctic natural history museums with next generation digitizing techniques to push the limits of museum specimen-based research and move the research front of collection specimen-based research forward.

Fig. 1. Unpublished data produced during the first project period (2022-2023) funded by UiT. On the left is a specimen of the priapulid *Priapulopsis bicaudatus* showing the external (left) and internal morphology (middle left). This specimen is around 3 cm long and has been imaged at the microtomography facility at Luleå University in November 2022. On the right side are images of the external morphology of the kinorhynch *Echinoderes* sp. This specimen is around 350 µm (0,35 mm) long.

Physical Museum specimens are vulnerable to degradation, loss from pests, humidity, fire and the simple ravages of time. Digital specimens reduce the risk of loss or damage and allow for safe long-term data storage and accessibility. Digitizing museum collections using state of the art digitization equipment such as X-ray microscopes can be a way of providing open access information for cross-disciplinary research. Online access to digitized specimens allows for

research from anywhere in the world, and digitized specimens offer new and more interactive possibilities for outreach activities.

Meiofauna (from the Greek word *meion* – smaller) are tiny animals which live in marine sands and muds. A very diverse but poorly known guild of animals, many meiofaunal taxa have acquired remarkable and extreme adaptations to cope with life in the sediments. Nowhere are meiofauna more poorly known than in polar regions such as the Arctic Ocean, where climate change is affecting the ecosystem at an alarming rate. A vast, unknown part of the Arctic ecosystem could be lost forever as meiofaunal species go extinct, and specimens can be difficult to store in museum collections due to their small size and fragility. To document the meiofaunal animals of the Arctic Ocean for future generations, we want to scan specimens and reconstruct them digitally through microtomography. This will allow us to make a 'digital collection' of Arctic meiofauna, describe new species, discover new anatomical and morphological characters, and make museum exhibitions for the public based on digital or 3D-printed reconstructions of these animals.

What are the goals and planned activities of the network?

The network has several concrete deliverables that will be of benefit both to the scientific community and to the public.

Enhanced knowledge of Arctic biodiversity

Microscopic animals such as meiofauna are an essential part of Arctic marine and limnic ecosystems and play a role in the cycling and sequestering of carbon and nutrients. Despite this, the biology and precise ecological functions of small, benthic organisms represent missing pieces of a larger Arctic puzzle that needs to be solved rapidly due to the looming threat of climate change. This network will deliver new knowledge of the biodiversity of Arctic marine meiofauna that will be critical in understanding the rapidly changing polar ecosystem, which threatens many of these unknown species with extinction. The need for thoroughly documenting Arctic biodiversity has never been more urgent.

A greater understanding of the morphology and evolution of Arctic animals

Many meiofaunal groups remain obscure even to scientists, with polar taxa being the least known of all. Even though many groups occupy critical positions in the tree of life, they have been largely neglected by researchers interested in the evolution of animals in favor of species that are larger and easier to acquire and study. Critically, the small size and fragility of meiofaunal animals has prevented us from gaining insight into their internal anatomy and organization. With the advent of X-ray computed microtomography (µCT and nCT) in the biological sciences, a new door has been opened for inquiries into meiofaunal anatomy, which can now be documented in precise detail. X-rays penetrate the tissues and permit visualization without the need for prior coating or other treatments, which allows for digitizing even unique specimens such as holotypes and precious, fragile collections. However, the process is not yet perfected, and new methods that increase contrast and resolution need to be developed.

Digitized specimens – a form of scientific output uniquely suited for public outreach

Conveying research findings to the public in an effective way is often a challenge for scientists. For researchers in the Arctic, the additional problem of addressing a public desensitized to repeated warnings of climate change has arisen; we believe that this can be overcome by better informing the public of the beauty of Arctic ecosystems, and what stands to be lost. In this context, the creation of digitized specimens as virtual 3D models could help visualize the otherwise inconspicuous and obscure animals that inhabit the seafloor of the Arctic Ocean and bring their largely unknown diversity into the spotlight. Compared to their physical counterparts, specimens digitized as 3D models can be stored indefinitely with all details preserved, without degradation or loss of character. As an additional benefit, the virtual 3D models can be made publicly available and are easily adapted for outreach and classroom teaching by 3D printing.

Network among arctic university museums and research institutions

This network of arctic university museums and research institutions will develop standards for digitizing small museum specimens using next generation imaging techniques and promote scientific explorations of alpha-taxonomy of marine animals in the Arctic. The network plans to apply for additional funding from other sources and to submit a EU Horizon application in 2024.

How Indigenous issues are included in TN's operation

The TN would like to achieve Indigenous representation, however, so far this has not been established as it has proved difficult to find indigenous representatives who have time to join the network. It was mentioned at the last Arctic Frontiers Conference in 2023 that it is difficult for indigenous groups to be represented in all research projects as there are more invitations than the capacity to participate. As the outcomes of this research TN have no direct influence on Indigenous peoples, nor their right to self-determination in matters of governance and leadership, the research network can currently achieve its aims without Indigenous representation.

Quality control at the network

How TN defines the quality on its own terms

The network team consists of eight individuals from four UArctic institutions. Project progress and evaluation will be ensured by monthly meetings of the project team. The evaluation criteria are: progress according to the time plan, quality of the specimen scans, timely publication of high-quality results, excellent internal communication, and public outreach activities.

How UArctic member organizations and institutions will benefit from the new TN, what is the added value in establishing such a network?

Scientific publications

The project will lead to several scientific publications, one setting out a standard and recommendations on how to digitize museum specimens using X-ray microscopy, and several others describing the internal anatomy and morphology of unknown/new, or poorly understood species. Scientific results stemming from the project activities will also be presented orally at suitable domestic and international conferences and workshops.

Museum exhibitions

The digital specimens produced in this project will be included in outreach projects at the Arctic University Museum of Norway, and the Natural History Museum of Denmark. This could be exhibitions, outreach at schools, family activities and presentations to the wider public.

Free and open access to digital specimens

The digitized specimens will be openly accessible through zenodo.org or DataverseNO, thus making them available for research and outreach for anyone, anywhere in the world. This fits well into Norway's digitization strategy, as outlined in Digitaliseringsrundskrivet 2022.

New collaborations

The TN is open to collaborations with other TNs and interested individuals or institutions.

The TN will facilitate new collaborations among UArctic members from different research fields that have previously not cooperated. We aim to move the research front for specimen collection-based research forward by introducing digital twins in addition to the physical specimens that are stored in the museum collections. Digital specimens will enable collaboration, easy access, and secure long-term availability of the scanned individuals.

X-ray tomography microscopes go beyond the resolution of traditional micro computed tomography machines (µCTs). They use electromagnetic radiation of the soft X-ray band to produce magnified 3D images of objects. Since X-rays penetrate most objects, there is no need to prepare them in any special way for X-ray microscopy. The versatility of these instruments for natural history collections is enormous but as of yet unrealized, and the Zeiss Versa represents a new generation of µCT scanners (nanoCT) with the ability to zoom into objects and produce high-resolution images of small and large objects (from µm size up to several cm).

Has network already been awarded some funding? If so, for what activities?

The network received UArctic funding from Norway in 2022. This has been used to buy scan-time at the nano-CT facility in Luleå as well as hardware and software for 3D data analyses.

List the names of partners and their home organizations and email address, name and contact information of the host organization and leader.

Name	Role	Organization	e-mail
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For the website to be established, please provide also: Short description on the Overall goal, Main Activities, Current and Planned Activities and a photo for top banner

Natural history museum collections provide historical records of species in place and time. This is especially relevant for the Arctic, where climate change is affecting the ecosystem at an alarming rate. A vastly unknown part of the Arctic ecosystem could be lost forever as species go extinct, and some specimens can be difficult to store in museum collections due to their small size and fragility. To document animals of the Arctic Ocean for future generations, we want to scan specimens and reconstruct them digitally through X-ray microtomography. This will allow us to make a 'digital collection' of the Arctic fauna, to describe new species, discover new anatomical and morphological characters, facilitate open science, and to make museum exhibitions for the public based on digital or 3D-printed reconstructions of individual animals. The digital specimens will be openly accessible for everyone to use in research and education.

Photo for the top banner

UiT The Arctic University of Norway

Date: 27.02.2023

To
UArctic Vice President Networks
Kirsi Latola

Letter of support for establishing an UArctic Research Network for Microtomography of Arctic Marine Organisms

To Whom It May Concern

With this letter I express my support for Dr. Altenburger's application to establish an UArctic Research Network for Microtomography of Arctic Marine Organisms. The project contributes to UArctic's vision of a strong, engaged, informed, and dynamic North and contributes to the UN Sustainable Development Goals of life below water as well as increase of human competence and capacity. The North is currently facing several challenges. Establishment of the research network will help us to acquire and share knowledge about small marine organisms to the benefit of humanity. The projects fits well into UiTs strategy Eallju – Developing the High North, and I highly recommend you to include it in the UArctic Thematic Networks.

Sincerely,

Dag Rune Olsen
Rector

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