Tara Polar Station

Tara Polaris I inaugural expedition (2026-2027)

The Central Arctic Ocean (CAO) is undergoing rapid environmental changes, including declining sea ice, Atlantification of ocean waters, and increased contaminant inputs, with major implications for biogeochemical cycles, ecosystems, and climate feedbacks. Understanding these changes requires sustained, multi-year observations that capture seasonal, interannual, and long-term variability. The Tara Polar Station (TPS), to be deployed from 2026, will serve as a small, mobile, year-round observatory above latitude 85°N, capable of integrating multidisciplinary observations across the ocean, sea ice, and atmosphere. Its long-term mission will generate the datasets needed to disentangle natural variability from anthropogenic trends and to characterize key ecosystem processes in the CAO.

Sea Ice: Structure, Dynamics, and Biological Communities

The CAO's ice cover is not a static barrier but a dynamic system interacting with underlying water masses and the atmosphere. Ice formation and melt drive vertical mixing, brine release, and nutrient regeneration, sustaining sympagic microbial and algal communities that provide a critical carbon source for the pelagic and benthic ecosystems. While the Arctic has historically been a low-productivity, net-heterotrophic system, the ongoing reduction of sea ice threatens sympagic production, potentially altering carbon fluxes and trophic interactions.

Polaris I Objectives:

- Quantify the biodiversity and biomass of sympagic organisms, from microbes to macrofauna, across seasonal cycles.
- Investigate biological adaptations to extreme light, temperature, and microphysical constraints within sea ice.
- Assess the contribution of sympagic production to carbon export and its fate in pelagic and benthic food webs.
- Study interactions between sea ice communities and underlying water masses, including nutrient transfer and microbial inoculation.

Epi- and Mesopelagic Life in an Ice-Covered Ocean

Below the ice, the CAO hosts a unique pelagic ecosystem. Surface waters primarily originate from the Pacific, while deep waters come from the Atlantic, creating stratified habitats that are variably ice-covered. Nutrient carrying capacity limits primary production, and high grazing pressures maintain low algal biomass. The retreat of sea ice may shift the balance between ice algae and phytoplankton, altering carbon fluxes and food web dynamics. Biodiversity and community composition of epi- and mesopelagic organisms remain poorly known, and understanding these patterns is essential for monitoring borealization and climate impacts on higher trophic levels.

Polaris I Objectives:

- Characterize biodiversity, seasonal dynamics, and community composition of epi- and mesopelagic organisms, from microbes to fish and marine mammals.
- Investigate trophic interactions, biological rhythms, and behavior of key species across multiple trophic levels.
- Measure carbon and nitrogen fluxes between pelagic and sympagic communities and assess implications for benthic communities.
- Evaluate effects of sea ice retreat and Atlantification on net production, biomass distribution, and ecosystem functioning.

Microbial and Climate Feedback Processes in the Arctic Atmosphere

The Arctic atmosphere is both a driver and responder to climate change. Airborne microorganisms, originating from sea ice, ocean surfaces, and long-range transport, can influence cloud formation and radiative forcing through ice-nucleating particles (INPs) and cloud condensation nuclei. Changing ice cover and sea spray alter microbial emissions, creating feedback loops that link microbial dynamics with Arctic climate processes.

Polaris I Objectives:

- Quantify the diversity, abundance, and seasonal dynamics of airborne microbes, including bacteria, archaea, fungi, microalgae, and viruses.
- Investigate microbial contributions to ice-nucleating particles and cloud condensation nuclei, and their effects on radiative forcing and albedo.
- Assess local and long-range sources of airborne microbes and their potential biogeochemical impacts upon deposition.
- Examine microbial responses to climate-induced changes such as sea ice retreat, permafrost thaw, and altered wind and mixing regimes.

Contaminant Sources and Fate in the Changing CAO

The CAO is highly connected to global contaminant pathways, including oceanic inflows, riverine discharge, atmospheric deposition, and local emissions from shipping and resource extraction. Pollutants include mercury, persistent organic pollutants, and micro- and nanoplastics, which can be remobilized by melting ice or permafrost. Climate change amplifies these pathways, creating seasonal variability in contaminant transport, transformation, and bioavailability, with unknown effects on ecosystems and human health.

Polaris I Objectives:

- Monitor year-round distribution, seasonal dynamics, and sources of contaminants, including mercury, organic pollutants, and micro/nanoplastics.
- Quantify contaminant inputs from ocean currents, river discharge, atmosphere, and local anthropogenic activities.
- Investigate contaminant transformations, bioavailability, and trophic transfer across microbial, planktonic, and higher trophic levels.
- Evaluate climate-mediated pathways of contaminant mobilization, including permafrost thaw, ice melt, and boreal wildfire emissions.

The TPS Long-Term Observatory

Long-term time series are essential to distinguish anthropogenic trends from natural variability in the Arctic system. The TPS will provide multi-decadal observations of ocean-ice-atmosphere properties, biogeochemical cycles, and ecosystem structure and function. Harmonized protocols, rigorous quality control, and an integrative approach will ensure robust, FAIR-compliant datasets. The small platform size requires strong coordination between onboard scientists and onshore teams, maximizing the scientific output and enabling adaptive monitoring over successive expeditions (Polaris II, III, …).

Expected Results and Impacts

1. Advance knowledge of life in frozen marine environments, including adaptations, biological innovations, and chronobiology.
2. Clarify the role of biology in ocean-ice-atmosphere interactions, linking microbial and higher trophic processes to climate and biogeochemistry.
3. Extract robust long-term trends in climate and contaminant signals from natural variability using multi-year and multi-disciplinary observations.

The Tara Polaris programme will integrate into international ocean observation initiatives, space agencies, operational oceanography, weather forecasting, and climate modeling, contributing to global understanding of the Arctic system.