HiAOOS 2025 Cruise: Executive Summary report

Nansen and Amundsen Basins
22 July -17 August 2025

Photo: The scientists and crew onboard KV Svalbard, 2025 (Photo: KV Svalbard)

Version: 21 August 2025

TITLE: **HiAOOS 2025 Cruise: Executive Summary report**	**REPORT IDENTIFICATION** DOI: 10.5281/zenodo.16893765
CLIENT Research and Innovation Action under EC Horizon Europe Norwegian Research Council Office of Naval Research WMO	**CONTRACT** Grant Agreement no. 101094621 Project number 337245 and 309612 NIUVT SEED 56 N/A

Investigators onboard KV Svalbard:

Nansen Environmental and Remote Sensing Center (NERSC), Norway: Hanne Sagen (Cruise leader), Espen Storheim (Deputy leader), Vår Dundas.

Institute of Oceanology of the Polish Academy of Sciences (IOPAN), Poland, Agnieszka Beszczynska-Möller, Piotr Wieczorek

University of Bergen (UiB), Norway: Håkon J Sandven, Karl Arvid Fritze, Torbjørn Wigum Arbo

Norwegian Meteorological Institute (MET), Norway: Malte Müller, Alessio M. Canclini

Alfred Wegener Institute for Polar and Marine Research (AWI): Normen Lochthofen

NAXYS/Kongsberg Discovery (NAXYS): Terje Ystebø, Christoffer Aaseth

University of Rhode Island (URI), USA: Luis O. Pomales Velazquez, Savannah R. Passaretti-Fina

HOW TO CITE	**AVAILABILITY**
Sagen, H., Storheim, E., Dundas, V., Beszczynska-Möller, A., Wieczorek, P., Sandven, H., Fritze, K. A., Arbo, T. W., Müller, M., Canclini, A. M., Lochthofen, N., Ystebø, T., Aaseth, C., Velazquez, L. O. P., & Passaretti-Fina, S. R. P.-F. (2025). HiAOOS 2025 Cruise: Executive Summary report. Zenodo. https://doi.org/10.5281/zenodo.16893765	OPEN Approved by Commanding Officer Geir Martin Leinebø, and Cruise Leader Hanne Sagen.

This report is an executive summary of the HiAOOS 2025 cruise (22 July-18 August 2025). The cruise supports several projects: HiAOOS, SFI Smart Ocean, Useful Arctic Knowledge, a program at University of Rhode Island funded by ONR, and a WMO project at the Norwegian Meteorological Institute. The Commanding Officer at KV Svalbard was Geir Martin Leinebø, and cruise leader was Hanne Sagen, NERSC.

HiAOOS 2025 Cruise Summary

During the four-week (22 July-17 August) cruise aboard *KV Svalbard*, fifteen students, scientists and engineers participated in the deployment of oceanographic moorings and the collection of environmental data to support ongoing research under the EU project **High Arctic Ocean Observation System (HiAOOS)** and **SFI Smart Ocean funded by the Research Council of Norway (RCN)**. The **RCN** provided support for field participation by master's students from the University of Bergen and the University of Rhode Island through the **Useful Arctic Knowledge (UAK)** project. The work performed by scientists from the Norwegian Meteorological Institute was funded by the World Meteorological Organization (WMO).

Multipurpose Mooring Network

A team of scientists and engineers from NERSC, IOPAN, AWI, and NAXYS recovered one mooring in Kongsfjorden, and deployed three moorings north of Svalbard and in the Nansen Basin. These moorings are strategically placed to collect year-round data on temperature, salinity, dissolved oxygen, and ocean currents at various depths within the upper 1000 meters of the ocean—where climate change signals are expected to be most pronounced. The moorings are heavily equipped with acoustic and oceanographic instruments.

Together with the four moorings deployed during HiAOOS cruise in 2024, the new installations form a unique, multipurpose mooring network—the first of its kind in the region—providing critical insights into Arctic oceanographic conditions. Unlike conventional moorings, most HiAOOS moorings are equipped with hydrophone arrays several hundred meters long. These acoustic sensors are expected to deliver valuable data on vocalizing marine mammals, sea ice melting and interaction, seismic activity, and ship presence in the Nansen and Amundsen Basins throughout the year.

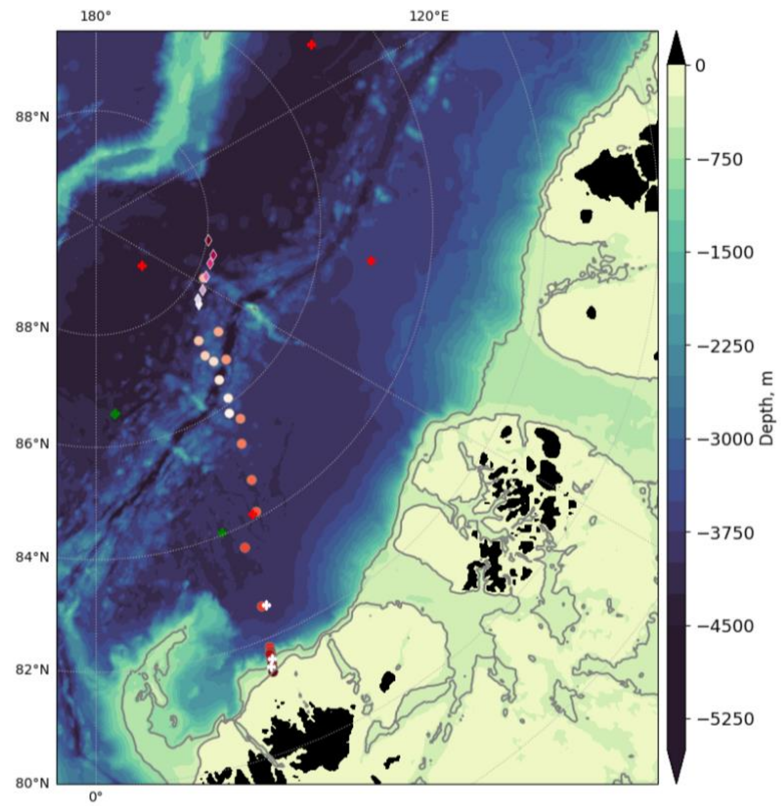

Figure 1. This map shows the configuration of CTD stations, ice stations, and moorings deployed in 2024 (markings red) and the moorings deployed in 2025 are marked with white crosses. The Green markings show the Norwegian Polar Institute moorings. All moorings will be recovered in 2026.

Three of the moorings deployed last year include low-frequency acoustic sources that transmit signals at precise intervals every other day. These signals are received by all moorings, enabling scientists to measure the time it takes for sound to travel between them. This technique, known as acoustic thermometry, allows for large-scale estimation of mean ocean temperature across the region. During the cruise several listening stations were performed, and it was confirmed that all acoustic sources are transmitting according to schedule.

The thermometry measurements, together with several traditional sensors for point measurements of temperature, salinity, dissolved oxygen, and sea ice drift and draft, and profiles of ocean currents makes the mooring network unique.

While mooring systems provide continuous observations, data access is typically delayed until recovery. To address this bottleneck, the HiAOOS project is testing new technologies for remote data retrieval. One mooring deployed during the cruise incorporates advanced receiver technology from NAXYS with ROV docking systems from Stinger AS. This system is designed to enable remote data download and battery recharging, which will be tested during an upcoming cruise with *Kronprins Haakon* in the autumn.

Another innovative approach, under development by AWI and IOPAN, involves a profiling unit at the subsurface mooring top to which data from instruments located below are transmitted acoustically. This unit periodically ascends to the surface to transmit data in real time via satellite, offering a promising solution for near-real-time access to subsurface observations.

It is worth mentioning that the new Winch from LEBUS worked as planned, and the spare winch rented from Woods Hole Oceanographic Institution was not used.

The HiAOOS mooring network (Fig 1) will deliver essential baseline observations of both the sea ice and the ocean environment beneath it. Long-term operation of the network is crucial for improved climate monitoring and prediction. Sustaining the system into the next decade is therefore of high importance, as it will contribute to the objectives of the fifth International Polar Year (IPY) and support other long-term climate and environmental initiatives.

Underwater Positioning and Communication Technologies

The same acoustic signals used for thermometry also support an underwater positioning system (UW-GPS) for autonomous vehicles equipped with hydrophones. Before sending expensive vehicles on missions under the ice, it is important to understand the capabilities of such a system. Therefore, a key objective of this cruise was the deployment of a drifting acoustic receiver buoy developed by NAXYS to collect acoustic recordings throughout the year. The recordings start at the time the signals are sent from the three acoustic sources. By comparing acoustically derived positions with GPS data, HiAOOS researchers aim to assess the accuracy of UW-GPS—a promising technology with broad applications for autonomous ocean observation platforms. All HiAOOS moorings are scheduled for recovery next year, making the period before August 2026 the final opportunity for the float community to conduct additional tests. An initial test of a profiling float equipped with a hydrophone was conducted by students from the University of Rhode Island, as part of the UAK project. Nevertheless, the HiAOOS consortium is actively seeking funding to support the continuation and further development of the system beyond the current project timeline.

As part of SFI Smart Ocean, the feasibility of underwater communication at various ranges beneath the sea ice was tested. This experiment involved installing an ice-tethered buoy with a 100-meter-long receiver array suspended below. The ship then moved away from the receiver buoy, stopping every 10 nautical miles for three hours to transmit coded signals using sources with different center frequencies (500 Hz, 900, and 1400 Hz), suspended to 60 m depth. The maximum distance from the receiver buoy was 60 nautical miles. The recorded signals will be analyzed to determine how effectively and how far acoustic communication can be achieved underwater. High-resolution SAR data will be used to assess how sea ice conditions influence communication performance. This was the first field test of both the source system and the receiving buoy, and the experiment will provide important information for future deployments. Together with UW-GPS, the quality of acoustic communication is critical to send messages underwater is essential for the future operation of autonomous observing systems in polar environments.

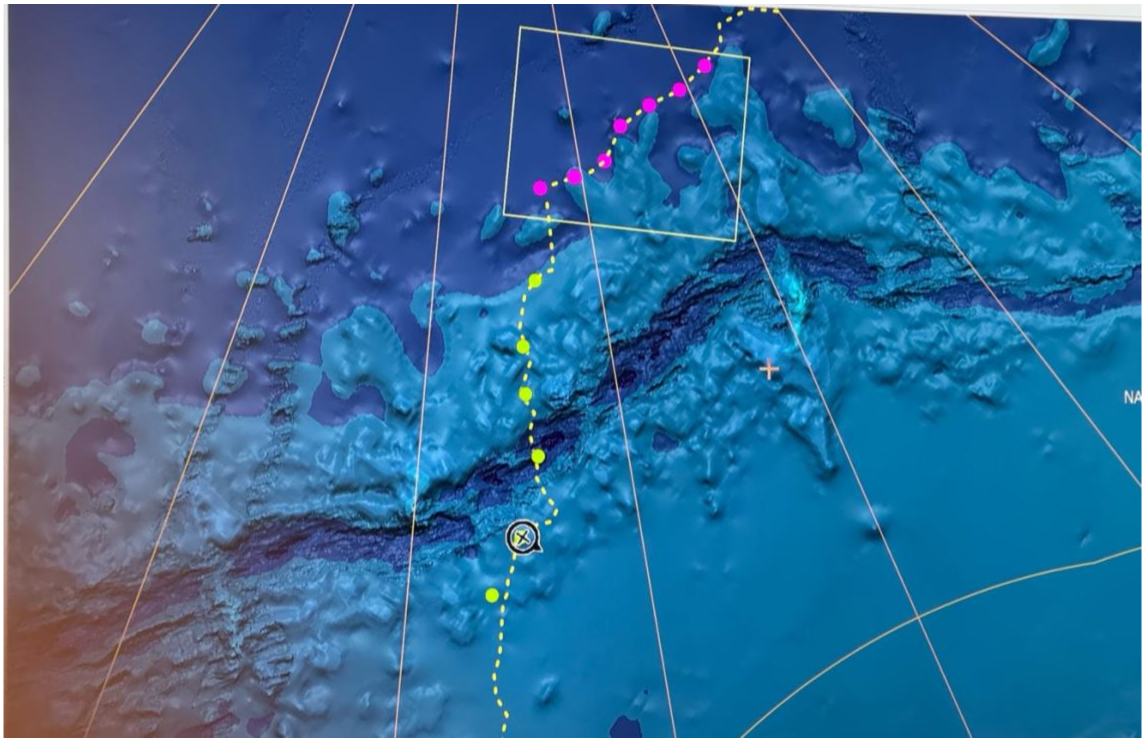

Figure 2. The map in the above panel shows the planned CTD with water bottles (in green) and XCTD stations (in pink) across the Gakkel ridge. The XCTD stations are taken at the locations of the acoustic communication stations. The lower left shows the deployment of the ice tethered buoy with the 100 m long hydrophone array. To the right is a picture of one of the acoustic sources that was used to send communication signals. (Photos by H. Sagen, NERSC, Map by KV Svalbard)

Optical measurements of water column structure and sea ice.

A key component of the cruise was the collection of **optical measurements at sea ice stations**, led by the University of Bergen. This data collection supports two master's research projects focused on understanding how light availability under ice influences biological processes in the Arctic Ocean.

One student is investigating how light is transmitted through sea ice using radiative measurements at various depths. Light provides energy for photosynthesis, and its penetration through ice-covered waters is important for Arctic marine ecosystems, from phytoplankton to fish. The second student is analyzing water samples from various depths to characterize the origin and properties of different water masses. These measurements can help tracking the freshwater composition in the central Arctic and estimate how the various water masses affect the underwater light environment.

The ice stations were established along a transect crossing the Nansen Basin, over the Gakkel Ridge, and into the Amundsen Basin. Concurrent *in situ* fluorescence and backscatter measurements yield further information about the phytoplankton biomass. Combined with CTD and XCTD measurements, the resulting dataset will provide a valuable snapshot of current oceanographic and ecological conditions in the region.

During the last few days of the cruise, we also got the opportunity to conduct bio-optical and CTD stations in Smeerenburgfjorden and Magdalenafjorden. We completed a total of 27 stations over 1.5 days, including 10 water samples for CDOM absorption, potentially yielding new insights into fjords with meltwater glaciers and providing a valuable contrast betweenoptical properties of Svalbard terrestrial run-off and the Transpolar drift. This activity was led by UiB with contribution from NERSC.

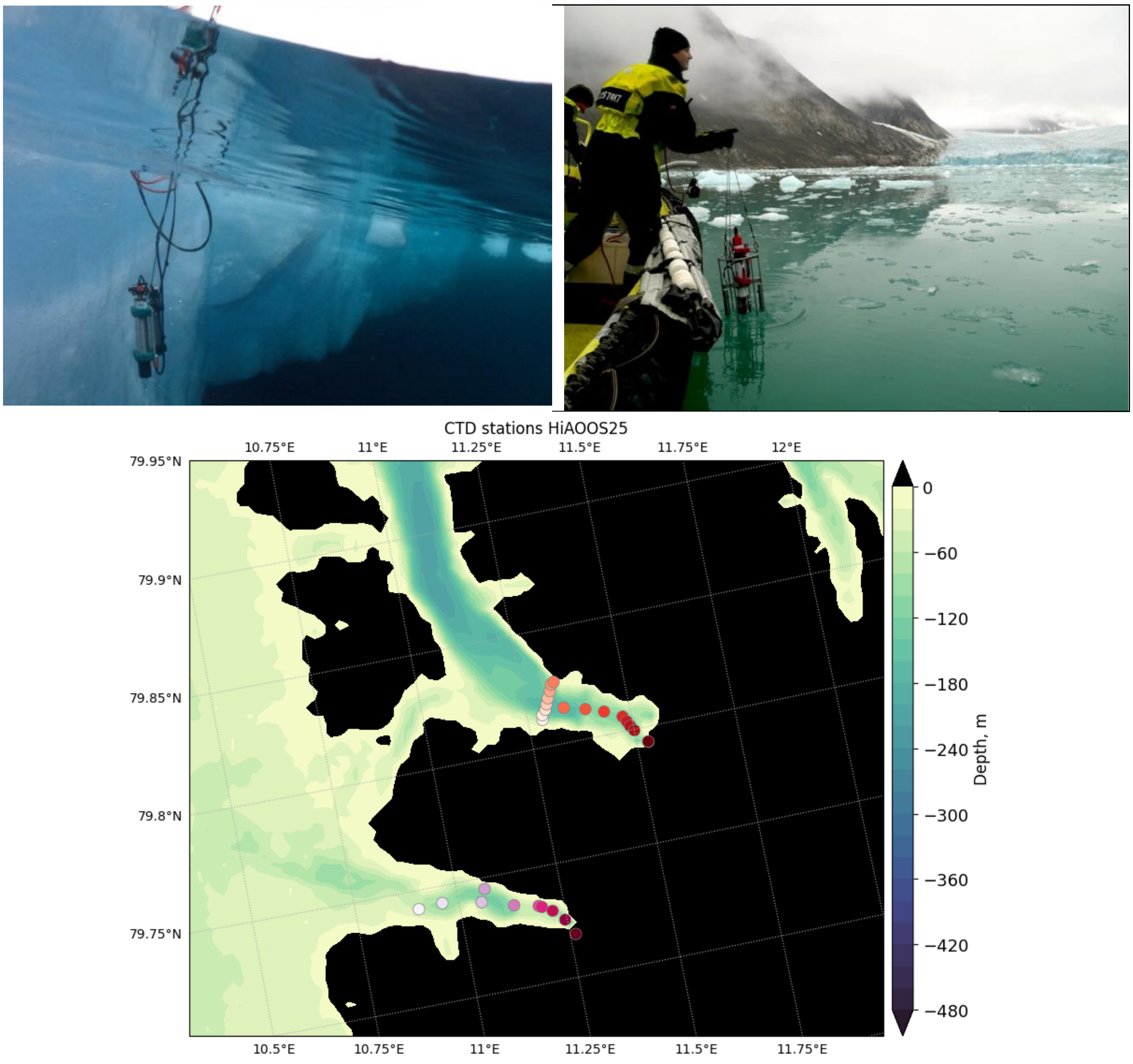

Figure 3. The photo to the left shows a radiometer hanging under the ice. This instrument measures the amount of light at different wavelengths. The picture to the right is taken in Magdalena fjord and showing the CTD on its way up. Map of the stations in the two fjords – Magdalenafjord in the south and Smeerenburgfjord in the north. Photos by H.Sandven, UiB and map by V. Dundas, NERSC.

Oceanographic section across the Amundsen and Nansen Basin.

A total of 31 CTD profiles were taken in the region between the southernmost IOPAS15 mooring (81°30'N, 22 E) in the south and the NAXYS buoy in the north (88° N, 50 E). The section crosses the shelf break, continental slope, and the Gakkel Ridge, and thus captures both the cross-shelf variability in the eastward Atlantic Water inflow and front structures between the Nansen and Amundsen basins. This section provides valuable information about the oceanographic conditions between the four moorings deployed during the HiAOOS cruise in 2024. While CTD sections provide a snapshot of the conditions, it will be helpful to have this reference when investigating the mooring data that after recovery in 2026. The acoustic data will be used to infer the average temperature between the moorings through tomography, and thus it is important to have information about the spatial variability in hydrography in the region.

The section consists of 23 profiles taken with a CTD rosette from the KV Svalbard, and seven profiles collected using XCTD probes (see Fig 1). The rosette was lowered to 700 m and thus CTD measurements capture the main structure of the water column and the bulk of the Atlantic Water layer. The XCTD probes recorded data down to 1100 m. Several of the CTD stations were taken in parallel with ice stations, and thus the observations gained can be used for both oceanographic studies and as a support dataset for the optical observations taken under the ice. The oceanographic section was carried out by NERSC, IOPAN and UiB. The oceanographic data will be processed, quality controlled and published in NMDC.

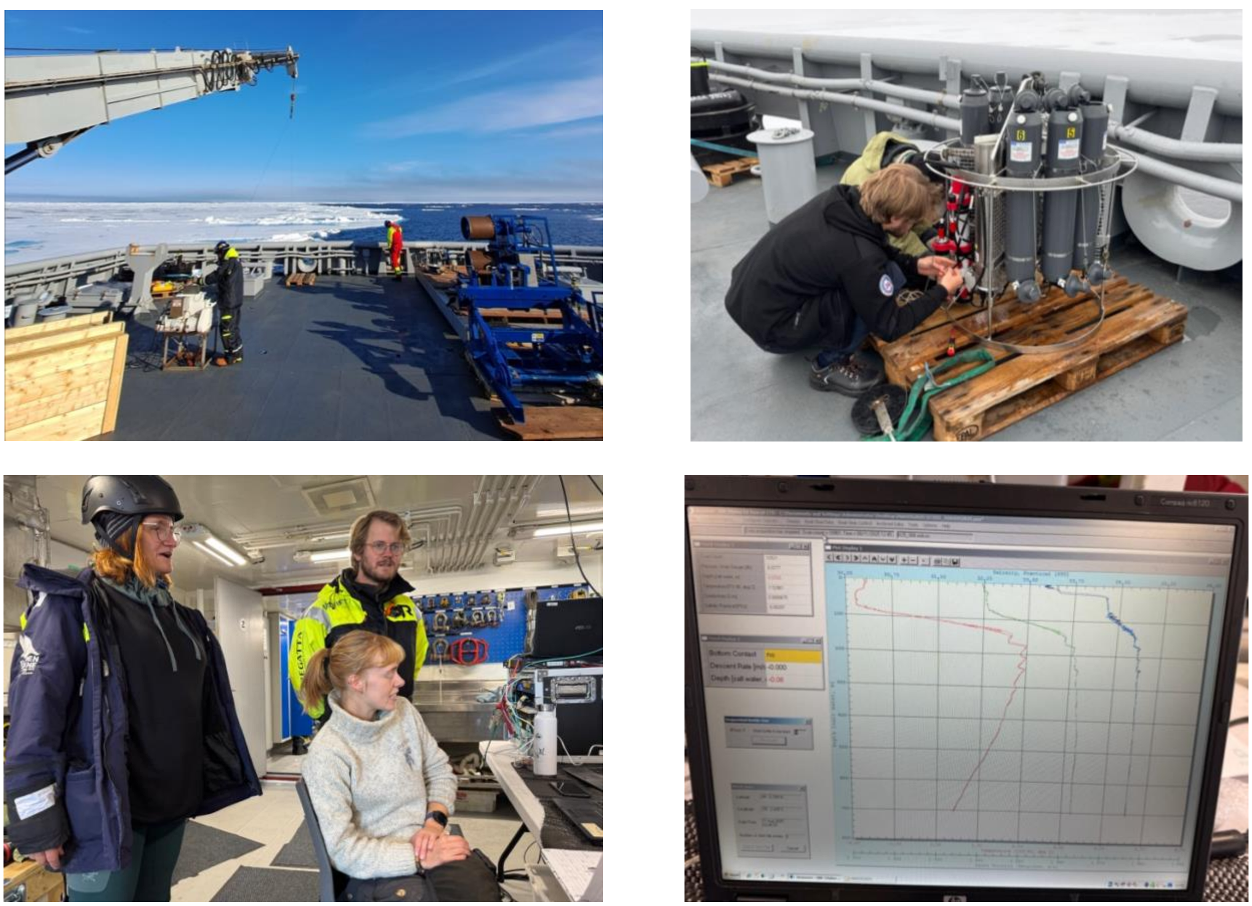

Figure 4. The CTD team in action running the winch, collecting water samples, and checking out the data in the lab. Lower right shows a typical Arctic Ocean profile. Photos by V. Dundas and H. Sagen, NERSC

Ice Drift Monitoring and Buoy Deployment

Monitoring ice drift is critical during icebreaker operations, particularly for mooring deployment and recovery. The Norwegian Meteorological Institute has developed cost-effective OpenMetBuoys (OMB) to observe atmospheric, ice, and ocean interactions and track ice movement year-round. During the HiAOOS 2025 cruise, 16 OMBs were deployed along a transect from 82.5°N, 25°E to 88°N, 80°E, with three additional units to be deployed later in the season by the Swedish icebreaker *Oden*.

The OMB is capable of high-quality GPS-based drift tracking every hour and motion-sensor-derived wave spectra. For this campaign, buoys were equipped with additional thermodynamic sensors, including a 1-m air temperature probe, an infrared snow surface temperature sensor, and a temperature string through the snow and sea ice. Snow depth and ice thickness were also measured at each site.

All buoy positions, drift tracks, and wave spectra are accessible through the OceanVirtualLaboratory portal, allowing near-real-time monitoring and integration with satellite data. Please visit https://openmetbuoy-arctic.com/arctsum2025.html. These measurements support validation of remote sensing products and coupled forecast models, contributing to improved Arctic prediction capabilities and operational planning in ice-covered waters.

Figure 5. The MET team on the ice deploying the ice buoy. (Photo by C. Aaseth)

Float Your Boat

In collaboration with the International Arctic Buoy Program, two ice balls were deployed on separate ice floes north of 87°N. These ice balls transmit live position data and record surface air temperature and pressure. Several hundred small wooden boats, decorated by schoolchildren in Norway and the US, were put around each ice ball as part of the **Float Your Boat** initiative. Please visit the https://iabp.apl.uw.edu/IABP_Maps.html to follow the Buoy number 141 and 142.

Earlier this spring, we visited several schools to talk about the Arctic, the ocean, climate, and sea ice. After the discussions, each student decorated a boat, which is now drifting with the sea ice. As the ice floes move through the Arctic, the buoys send location updates, allowing teachers and students to track their boats at floatboat.org. This initiative keeps the conversation and interest in the ocean alive throughout the school year, as the buoys take diverse paths through the Arctic. The participants are recommended to follow updates at https://www.floatboat.org.

Figure 6. Float Your Boat an excellent example of international collaboration at different levels: project wise, between researchers and with school classes. (Photo by H. Sagen)

Cruise Summary –Deployment and Observations

- Recovered one AWI mooring in Kongsfjorden, Svalbard.
- Deployed 3 of 4 planned moorings; the fourth will be deployed during the 2026 Polarstern cruise. (HiAOOS)
- Deployed one ice-tethered acoustic buoy for later recovery in the Fram Strait. (HiAOOS)
- Deployed and recovered an ice station with two ice-tethered buoys (acoustic arrays) and a Met Station. (SFI Smart Ocean)
- Conducted acoustic communication experiments at 6 transmission stations each supported with XCTD profiles. (SFI Smart Ocean)
- Performed a short transmission loss experiment in open ocean north of Svalbard. (SFI Smart Ocean)
- Initial test of a profiling float equipped with a hydrophone. (UAK master project, URI)
- Deployed 16 Met.no ice buoys. (WMO project)
- Installed 2 ice balls for the International Arctic Buoy Program together with 400 decorated wooden boats for the Float Your Boat initiative. (UAK and HiAOOS)
- Completed 9 ice stations with optical measurements and collected 109 water samples from the Polar Ocean. (UAK master project, UiB)
- Conducted 31 CTD stations with water sampling in the central Polar Ocean. (HiAOOS)
- Collected data from 27 CTD stations and 10 water samples over 1.5 days in Smeerenburgfjorden and Magdalenafjorden. (UAK master project, UiB

Funded by the European Union Horizon Europe Programme, Grant Agreement No.101094621. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Special thanks to the Norwegian Coast Guard and KV Svalbard for ship time and outstanding support during the HiAOOS 2025