INSTITUTE OF OCEANOLOGY
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Results and conclusions

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REPORT

FROM THE RESEARCH CRUISE

AREX2022

RV OCEANIA

16.06.2022 - 11.09.2022

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1 Scientific background and objectives of the annual AREX field campaigns

The polar regions are the most climate-sensitive areas in the world, and temperatures in the Arctic are rising more than twice as fast as the global average. Understanding of Arctic climate processes is the main aim of the oceanographic and atmospheric studies carried on in the polar region. The Arctic region is one of the most visible indicators of the on-going changing climate. The recent Arctic sea ice decline is one of the main drivers of the extensive research activities, carried out in high latitudes. The impacts of climate change observed in the Arctic precede those observed at the lower latitudes. The effects of global warming in the Arctic include a steady temperature increase. observed both in the atmosphere and in the ocean. These changes influence both the thickness and extent of the sea ice in the sub-Arctic seas and Arctic Ocean as well as ocean climate and vulnerable Arctic ecosystems.

Large oceanic exchanges between the North Atlantic and the Arctic Ocean result in the strong conversion of water masses when warm and salty Atlantic water (AW) transported through the Nordic Seas into the Arctic Ocean mixes with surrounding local waters and undergoes cooling, freezing, and melting. As result a part of AW is transformed into freshened surface waters over the shallow shelves, sea ice and dense (and highly saline) deep waters. Southward transport of the Arctic origin waters is one of main mechanisms of the global thermohaline circulation (THC). Better understanding of the variability of volume and heat transports between the North Atlantic and Arctic Ocean as well as processes of water mass conversion is necessary for improved qualitative and quantitative estimation of the large-scale meridional overturning circulation and its role in shaping the climate change in the northern hemisphere on inter-annual to decadal time scales.

The long-term AREX observational program has been carried on by Institute of Oceanology PAN in Sopot during annual cruises on the research vessel Oceania since 1987 in the Nordic Seas and Fram Strait. Oceanographic, physical, atmospheric, and biochemical measurements aim to study and describe the processes shaping atmospheric exchanges, ocean climate and the ecosystem of subarctic and arctic regions, with particular emphasis on the European Arctic. The AREX program is focused on multidisciplinary observations in areas such as physical oceanography, optical, acoustic, biogeochemical, biological, atmospheric measurements, and ecology to study the changes of abiotic and biotic Arctic environment. All these studies are carried out under the strategic research initiative addressing the role of the ocean in changing climate, its effects on the European seas and contemporary changes of the coastal ecosystems in the shelf seas. The data collected under the observational program AREX every year in the same way over the standard grid of stations, cover more than 300 research stations in the Norwegian Sea, Greenland Sea, Barents Sea entrance, Fram Strait, West Svalbard fjords (Hornsund, Isfiord, Kongsfiord) and the southern part of the Nansen Basin. Time series, collected during over 30 years of measurements under the AREX program, provide time series of key ocean variables (EOVs, Essential Ocean Variables) which allow monitoring of changes occurring at different time and spatial scales in the physical and biological environment of the Arctic and improve existing models of the ocean, sea ice and climate in the Arctic region.

The AREX program was also IOPAN contribution to research conducted as part of international cooperation in the VEINS (Variability of Exchanges in the Nordic Seas, 1997-2000), ASOF-N (Arctic and subArctic Oceanic Fluxes North, 2003-2005), DAMOCLES (Developing Arctic Fluxes Modeling and Observing Capabilities for Long-term Environment Studies, 2006-2009), and as part of the previous edition of the Polish-Norwegian Research Programme: AWAKE, AWAKE2, PAVE, POLNOR, CLISE, CDOM-HEAT and DWARF (2013-2016). The collected data are also used in NCN and NCBR projects and in doctoral theses. Oceanographic measurements and collection of water samples during the AREX2022 cruise contributed to several IOPAN statutory research areas, international and national research projects EU H2020 INTAROS (2016-2022), EA-RISE (2018-2022), Polish-Norwegian projects (PHARMARINE, ArcticSGD, NEEDED and RAW) and other international and national projects (ACCES, PROSPECTOR, OPTYKA-BIS, ATAC-ICE, CoastDark, Alkenon, DOMinEA, SURETY, HIMERO, HIDEA, ORANGE, SeaPop2, ecoPLAST, ARK, ASCOMEA, CoastDark, TWINS). Long-term ocean observations are also IOPAN contribution to the international multidisciplinary observation program A-DBO (Arctic Atlantic Distributed Biological Observatory). The field work during the AREX2022 cruise was focused on numerous research goals, subdivided into detailed tasks. A general overview is provided in the following sections.

2 Main scientific objectives and specific tasks of the AREX2022 cruise.

2.1 Research tasks during the cruise leg I (transit, Baltic Sea, Norwegian Sea)

2.1.1 Marine aerosols and meteorology

- Describe the marine aerosols characteristics: size distribution, concentration, optical properties, chemical composition, and absorbing aerosols in the marine aerosol component (Task I.3),
- Estimate the impact of marine aerosol on radiation flux in the sea surface (Task I.3),
- Estimate the vertical CO2 fluxes in the atmospheric boundary layer (Task I.3),
- Estimate the latent and sensible heat fluxes between ocean and atmosphere (Task I.3),
- Describe the meteorological conditions during the cruise (Task I.3),
- Describe of Black Carbon concentration in the surface layer of the atmosphere (Task I.3).

2.1.2 Marine ecology

- Describe the diversity of meroplankton based on molecular methods and taxonomic analysis (HIMERO project),
- Determine concentrations of selected pharmaceuticals used in human therapy in zooplankton in the waters along the coast of Norway (PHARMARINE project, Task I.5).

2.1.3 Infrastructure optimization

- Optimization of the operation of the ship's oceanographic data acquisition system eCUDO.pl, including cooperation with the satellite link- Starlink,
- Modification of the data acquisition system with guarantees minimization of communication interruptions caused by crossing the boundaries cells/Starlink cells during the ship's movement, which results in breaking the connection (eCUDO project).

2.2 Research tasks during the cruise legs II and III (Norwegian Sea, Greenland Sea, Barents Sea Opening, Fram Strait and southern Nansen Basin)

2.2.1 Physical oceanography

- Study the variability of temperature, salinity and structure, dynamics of the Norwegian-Atlantic and West Spitsbergen Currents in the eastern part of the Norwegian Sea, the Greenland Sea, the Barents Sea Opening, Fram Strait and the Arctic Ocean boundary current in the ice-free area north of Svalbard (Task I.4),
- Estimate the volume and heat transport in the Atlantic water inflow by the Norwegian-Atlantic and West Spitsbergen Currents (Task I.4),
- Study of the impact of Atlantic Water variability and atmospheric circulation on the changing sea ice cover in the European Arctic (NCN ATAC-ICE project).

2.2.2 Marine aerosols and meteorology

- Describe the marine aerosols characteristic in the Arctic region: size distribution, concentration, optical properties, chemical composition, and proportion of absorbing aerosols in the marine aerosol component (Task I.3),
- Estimate the impact of marine aerosol on radiation flux in the sea surface (Task I.3),
- Estimate the vertical CO_2 fluxes in the atmospheric boundary layer (Task I.3),

- Estimate the latent and sensible heat fluxes between ocean and atmosphere (Task I.3),
- Describe the meteorological conditions during the cruise (Task I.3),
- Describe of Black Carbon concentration in the surface layer of the atmosphere (Task I.3).

2.2.3 Marine ecology – plankton

- Describe the qualitative-quantitative composition and pattern distribution of plankton communities (protozoan plankton and zooplankton) in the epi- and mesopelagial of the West Spitsbergen Current, in relation to environmental conditions (Task I.5),
- Assessment of genetic diversity of zooplankton organisms in the waters of the Atlantic and Arctic Nordic Seas (Task I.5),
- Describe of the diversity of meroplankton based on molecular methods and taxonomic analysis (HIMERO project),
- Study of the variability of carotenoids for key Arctic zooplankton species (Calanus copepods) and the impact on the quality of diet and condition of their main predators - plankton-eating birds (little auks) during the breeding season (NCN ORANGE project),
- Molecular analysis on several Ostracoda species collected from 3 deep stations located in the Greenland Sea (near Kongsfjorden and/or Hornsund foreland) (NCN Bi-polarity project).

2.2.4 Marine chemistry

- Describe the spatial variability of pCO_2 and the structure of the carbonate system in surface water (SURETY project, Task II.7),
- Find the relationship between the enrichment of the sea surface microlayer in CDOM and (i) CO_2 gas exchange between the sea and the atmosphere and (ii) the occurrence of various sources of organic matter in the surface layer (SURETY project, Task I.3).

2.3 Research tasks during the cruise leg IVa-IVb (Hornsund and Kongsfjorden)

2.3.1 Marine ecology – plankton (PEP)

- Describe the qualitative-quantitative composition and pattern distribution of plankton/zooplankton in the fjords and foreground of the Hornsund and Kongsfjorden in terms of environmental conditions (Task I.5),
- Determine zooplankton abundance in the feeding grounds of the little auks in the foreground of the Hornsund fjord (Task I.5),
- Describe the diversity of meroplankton based on molecular methods and taxonomic analysis in the Hornsund and Kongsfjorden fjord (HIMERO project, Task I.5),
- Extend the nuclear 18S rRNA and mitochondrial 16S rRNA genetic reference base of selected plankton organisms and estimation of zooplankton diversity from the European Arctic region based on metabarcoding (NCN HIDEA project, Task I.5),
- Comparison of habitat and food preferences between twin species of zooplankton, characterized by different areas of occurrence (arctic or boreal) in three different regions of the Polar Front: the Atlantic domain, the Arctic domain and the frontal mixing zone (TWINS project).

2.3.2 Marine ecology – plankton (PFBP)

- Study of the variability of carotenoids for key Arctic zooplankton species (Calanus copepods) and the impact on the quality of diet and condition of their main predators - plankton-eating birds (little auks) during the breeding season (NCN ORANGE project),
- Estimate the abundance of feeding grounds of little auks nesting in the Hornsund and Kongsfjorden using optical methods (LOPC) (SEAPOP II project, Task I.7),
- Study the relationship between protozoa and zooplankton at the Hornsund forefield (SEAPOP II, Task 1.7),
- Study the composition of "glacial soup" (plankton and suspensions) with the characteristics of the optical properties of water at stations located next to Torellbreen, in the Hornsund and Kongsfjorden (CoastDark project, Task I.7).

2.3.3 Marine ecology – benthos

- Identify the taxonomic composition, biomass, and abundance of macro- and meiozoobenthos, and benthos biodiversity determined by metagenomic methods at the monitoring stations in the Hornsund and Kongsfjorden fjords (MetaDiva project, Task III.1),
- Estimate the Kinorhyncha diversity and occurrence patterns, with particular emphasis on species with a wide range of occurrence, based on morphological and molecular analysis in the Hornsund fjord (Task III.1),
- Determine of the Hydrozoa species structure on the hard bottom and collect material for molecular analysis to study the phylogenetic relationship within the type of Lafoeina and Hydractinia in Kongsfjorden (ASCOMEA project, Task III.3),
- Determine of the concentration of pharmaceuticals in the tissues of benthic organisms in Kongsfjorden (Pharmarine project),
- Characterize of the food composition of marine mammals in Kongsfjorden (ARK NPI project)

2.3.4 Marine chemistry and biochemistry – WZEM

- Determine the impact of climate change on the concentration and bioavailability of mercury (Hg) by examination the concentration level of Hg in sediments and water near the melting permafrost and glaciers in the Hornsund and Bellsund fjords (Task II.8),
- Determine occurence and concentration of different forms of mercury in sea water in Kongsfjorden.

2.3.5 Marine chemistry and biochemistry – ZChiBM PBM

- Identify the groundwater sepage sites in the Hornsund, Kongsfjorden and Krossfjorden fjords (ArcticSGD project),
- Determine of the chemical composition of groundwater and impact on the marine environment (ArcticSGD project, Task II.7).

2.3.6 Physical oceanography

- Study the thermohaline and oxygen properties and distribution of water masses in the Hornsund and Kongsfjorden fjords and on the West Spitsbergen shelf (Task I.4),
- Characterize the long-term variability of temperature, salinity and structure, dynamics in the Hornsund and Kongsfjorden fjords (Task I.4).

2.3.7 Marine aerosols and meteorology

- Describe the marine aerosols characteristic in the Arctic region: size distribution, concentration, optical properties, chemical composition, and proportion of absorbing aerosols in the marine aerosol component (Task I.3),
- Estimate the impact of marine aerosol on radiation flux in the sea surface (Task I.3),
- Estimate the vertical CO2 fluxes in the atmospheric boundary layer (Task I.3),
- Estimate the latent and sensible heat fluxes between ocean and atmosphere (Task I.3),
- Describe the meteorological conditions during the cruise (Task I.3).

2.3.8 Marine optics

- Determine the optical properties of the Spitsbergen fjord waters to develop local satellite algorithms for determining the concentration of sea water components (Task II.5),
- Study the spectral characteristics of vertical profiles of solar attenuation in sea water and surface spectral reflectance distributions (COPs) (Task II.5),
- Determine of the spectral absorption coefficients and attenuation in the vertical profile and the concentration of chlorophyll a and suspension (ac9) (DOMinEA project, Task II.5),
- Characterize the variability of the actual optical properties of sea water in selected fjords of the West Spitsbergen, in relation to the concentration, composition and distribution of the population size of suspended solids in the waters (OPTYKA-BIS project),
- Determine of the effect of sea suspension of different sizes in four size fractions: pico-(0.2 µm - 2 µm), ultra- (2 µm - 5 µm), nano- (5 µm - 20 µm) and microplankton (20 µm - 200 µm) on the shape of the spectra of the light attenuation coefficient and size (ap) in the division into phytoplankton (aph) and detritus (ad) (DOMinEA, OPTYKA-BIS project),
- Describe the qualitative-quantitative composition of the dissolved organic matter using absorption and fluorescence DOM, salinity, temperature, concentration of oxygen dissolved in water - DO, DOC, concentration of chlorophyll a and other dyes, concentration of lignins as markers of land-based materials (DOMinEA project),
- Determine in the vertical profile (up to 200 m) size of the spectral absorption coefficients and attenuation coefficients of the light beam, concentration of chlorophyll a and suspension (ac9) (DOMinEA project, Task II.5),
- Determine the spectral characteristics of vertical profiles of solar attenuation in the sea water and surface spectral reflectance distributions using the profiling radiometer C-PrOPS (Biospherical) and radiometer sets Ramses (TRIOS) (Task II.5).

2.3.9 Marine acoustics

- Estimate of fish size distribution and composition in Kongsfjorden for comparison with the previous assessment in 2013-2014 (ARK NPI project).

2.4 Research tasks during the cruise leg IVc (Isfjorden)

2.4.1 Marine ecology – plankton (PFBP)

- Describe the characteristics of distribution and qualitative-quantitative composition of the plankton communities in the Isfjorden in relation to environmental factors using traditional methods (plankton nets) and optical methods (LOPC) (Task I.7),

- Identify the composition of "glacial soup" (plankton and suspended matter) with the characteristics of the optical properties of water at stations located in the Isfjorden (CoastDark project, Task I.7).

2.4.2 Marine ecology – plankton (PEP)

- Describe the diversity of meroplankton based on molecular methods and taxonomic analysis (HIMERO project).

2.4.3 Marine optics

- Determine the optical properties of the Spitsbergen fjord waters to develop local satellite algorithms for determining the concentration of sea water components (Task II.5),
- Study the spectral characteristics of vertical profiles of solar attenuation in the depths of the sea water and surface spectral reflectance distributions (COPs) (Task II.5),
- Determine of the spectral absorption coefficients and weakening of the light beam in the vertical profile and the concentration of chlorophyll a and suspension (ac9) (DOMinEA project, Task II.5),
- Determine of the effect of sea suspension of different sizes in four size fractions: pico-(0.2 µm - 2 µm), ultra- (2 µm - 5 µm), nano- (5 µm - 20 µm) and microplankton (20 µm - 200 µm) on the shape of the spectra of the light attenuation coefficient and size (ap) in the division into phytoplankton (aph) and detritus (ad) (DOMinEA, OPTYKA-BIS project),
- Describe the qualitative-quantitative composition of the dissolved organic matter using absorption and fluorescence DOM, salinity, temperature, concentration of dissolved oxygen, dissolved organic carbon DOC, concentration of chlorophyll a and other pigments, concentration of lignins as markers of land-origin materials (DOMinEA project),
- Determine in the vertical profile (up to 200 m) size of the spectral absorption coefficients and attenuation coefficients of the light beam, concentration of chlorophyll a and suspension (ac9) (DOMinEA project, Task II.5),
- Determine the spectral characteristics of vertical profiles of solar attenuation in the sea water and surface spectral reflectance distributions using the profiling radiometer C-PrOPS (Biospherical) and radiometer sets Ramses (TRIOS) (Task II.5),
- Characterize the variability of the inherent optical properties of sea water in selected fjords of the West Spitsbergen, in relation to the concentration, composition and size distribution of solid suspended matter in the water (OPTYKA-BIS project),
- Extend the empirical database for appying the trichromatic mechanism of water color perception in modern quantitative methods of studying marine environments (Task I.1).

2.4.4 Marine aerosols and meteorology

- Describe the marine aerosols characteristic in the Arctic region: size distribution, concentration, optical properties, chemical composition, and proportion of absorbing aerosols in the marine aerosol component (Task I.3),
- Estimate the impact of marine aerosol on radiation flux in the sea surface (Task I.3),
- Estimate the vertical CO2 fluxes in the atmospheric boundary layer (Task I.3),
- Estimate the latent and sensible heat fluxes between ocean and atmosphere (Task I.3),
- Describe the meteorological conditions during the cruise (Task I.3),
- Describe of Black Carbon concentration in the surface layer of the atmosphere (Task I.3).

2.4.5 Marine chemistry and biochemistry

- Identify the groundwater sepage sites in the Isfjorden. Determine of the chemical composition of groundwater and impact on the marine environment (ArcticSGD project, Task II.7),
- Describe the carbonate system variability and impact factors in the surface layer and water column (PROSPECTOR project),
- Determine of bioavailability and acid-base properties of dissolved organic matter released from sediments and supplied from land (PROSPECTOR project),
- Determine the impact of glacier recession and biogeochemical processes on ecosystem productivity (RAW project).

2.5 Research tasks during the cruise leg IVd (Isfjorden)

2.5.1 Marine ecology

- Study the impact of Arctic ice reduction on changes in the functioning and structure of fjord ecosystems (ACCES project),
- Study of the impact of Arctic ice reduction on the transport of new species on plastic garbage and changes in the littoral zone (ADAMANT project).

2.5.2 Marine optics

- Determine of the effect of sea suspension of different sizes in four size fractions: pico-(0.2 µm - 2 µm), ultra- (2 µm - 5 µm), nano- (5 µm - 20 µm) and microplankton (20 µm - 200 µm) on the shape of the spectra of the light attenuation coefficient and size (ap) in the division into phytoplankton (aph) and detritus (ad) (DOMinEA, OPTYKA-BIS project),
- Characterize the variability of the inherent optical properties of sea water in Isfjorden, in relation to the concentration, composition and size distribution of suspended solids in the waters (OPTYKA-BIS project),
- Extend the empirical database for appying the trichromatic mechanism of water color perception in modern quantitative methods of studying marine environments (Task I.1).

2.6 Research tasks during the cruise leg V (Spitsbergen shelf, Jan Mayen, Faroe Islands)

2.6.1 Paleoceanography

- Reconstruct changes in the marine environment on the Spitsbergen shelf, Jan Mayen and Faroe Islands in the period after the last ice age, using foraminifera as the basic paleo-environmental indicator, supplemented by biogeochemical and genomic indicators (NEEDED, Alkenon and reFrame project, Task III.2).

2.6.2 Research and Education about Climate and Oceans

- Extension of the data base of long-term characteristics of optical aerosol data (AERONET project),
- A holistic approach to communicate research conducted onboard RV Oceania through popular science multimedia facilities via websites and social media (Task I.9).

3 Implementation of the AREX 2022 cruise

The AREX cruise of RV Oceania, repeated every summer over the same period, in 2022 took place from June 16 to September 11. The AREX2022 cruise lasted 87 days and was focused on collection of oceanographic, meteorological, aerosol, chemical and biological observations in the eastern Norwegian and Greenland seas, Fram Strait and the southern Nansen Basin of the Arctic Ocean (ice-free area), and in the selected West Spitsbergen fjords (Hornsund, Isfjorden, Kongsfjorden). The scientific team was exchanged six times between the individual cruise legs during short stays in Longyearbyen which also served for logistic operations.

The leaders of the physical oceanography, biology, meteorology, and marine chemistry groups onboard were responsible for coordinating the cruise activities for their teams. Work was performed in a three-shift system (4-hour shifts) during the open ocean part of the cruise. During the fjord part of the cruise, the work system was adapted to the current weather conditions and sampling needs. The cruise was carried out in accordance with the AREX2022 scientific program with slight modifications, mostly regarding the order of measurements and regions. The cruise plan was based on research objectives divided into the detailed research tasks for the hydrographic, chemical, ecological, paleoceanographic, meteorological and optical measurement teams. Work other than standard CTD stations was performed mostly during the daytime, while the nighttime was used for CTD measurements, transit between stations or regions, or laying at anchor. Most of the planned measurement program was fulfilled during the AREX2022 cruise and all research regions were covered according to the planned station grid. The overall cruise schedule is presented in Table 1.

Table 1. The general schedule of the AREX2022 cruise

Cruise leg	Period	Ports of call and research areas	Cruise leg leader	Comments
I	**16.06-24.07.2022**	Gdansk – Tromsø (transit)	Przemysław Makuch	
II	**25.06-10.07.2022**	Tromsø - Longyearbyen (Norwegian and Greenland Seas, Barents Sea Opening)	Agnieszka Beszczyńska-Möller	
	11.07.2022	Longyearbyen (team exchange)		
III	**12.07-27.07.2022**	Longyearbyen – Longyearbyen (Fram Strait, Nansen Basin)	Agnieszka Beszczyńska-Möller	
	28.07.2022	Longyearbyen (team exchange)		
IVa	**29.07-06.08.2022**	Longyearbyen – Longyearbyen (Hornsund)	Mikołaj Mazurkiewicz	team exchange 6.08.2022
IVb	**06.08-14.08.2022**	Longyearbyen – Longyearbyen (Kongsfjorden)	Joanna Legeżyńska	team exchange 6.08.2022
IVc	**15.08-23.08.2022**	Longyearbyen – Longyearbyen (Isfjorden)	Karol Kuliński	team exchange 15.08.2022
IVd	**24.08-27.08.2022**	Longyearbyen – Longyearbyen (Isfjorden)	Jan Marcin Węsławski	team exchange 24.08.2022
	27.08.2022	Longyearbyen (team exchange)		
V	**28.08-11.09.2022**	Longyearbyen - Torshavn - Gdańsk	Marek Zajączkowski	

4 Work at sea during the AREX'2022 cruise

4.1 Measurements and sampling during the AREX'2022 leg I

4.1.1 General information

Research in continuous mode (chemical and aerosol) were held along the entire route from Gdańsk to Tromsø. Ecological research was to take place at three measuring stations: PhM1, PhM3, PhM5, unfortunately, due to bad conditions, too big a wave and too strong wind, it was not possible to carry out measurements at the PhM1 station.

Table 2. List of stations occupied during the leg I of the AREX2022 cruise.

Station number	Name station	Water depth	Latitude	Longitude
1	PhM3	92	62°55.46'N	005°27.34'E
2	PhM5	55	69°15.61'N	015°33.68'E

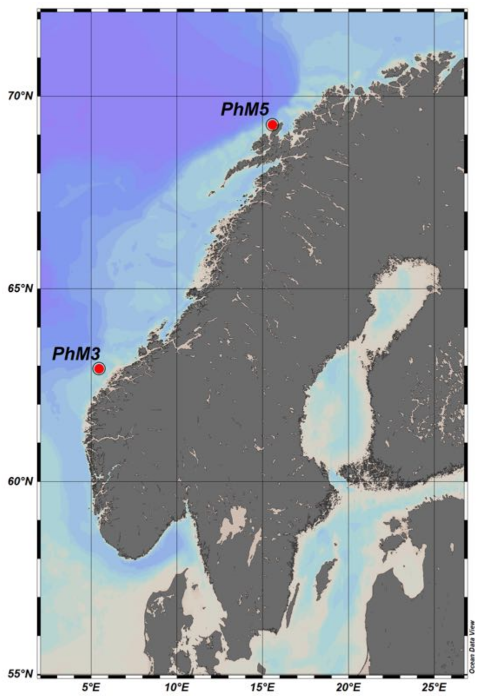

Figure 2. Stations occupied during the AREX2022 leg I cruise.

4.1.2 Aerosol and meteorological measurements

The measurements were carried out using the following measurement equipment: OPC3N - Optical Particle Counter, Li-COR 7200, AE-31 eathalometer, Vaisala WXT563 autonomous weather station, Microtops II solar photometer, Ellipse-N-G4A2-B1. The measured parameters included the distribution of aerosol particle sizes in the surface layer of the atmosphere, concentration of marigenic aerosol, CO_2 and H_2O concentration in the atmosphere, concentration of Black Carbon particles in the surface layer of the atmosphere, wind speed and direction, air temperature and humidity, and ship motion was recorded using the inertial motion detection system. The measurements were carried out continuously. All data collected during the cruise leg I were stored in the IOPAN data base.

Continuous underway measurements of pCO_2, pO_2, SST and SSS were also carried out. Parameters were measured using a measurement set consisting of a thermosalinograph, Fibox for oxygen concentration and Piccaro analyzer for measuring pCO_2 concentration in the surface water layer.

4.1.3 Plankton measurements (Pharmarine, HIMERO)

At each station, environmental conditions were measured with the CTD system. Water was collected from 5 depth levels using the watwr caroulsel (PhM3 - surface, 25m, 50m, 70m and 80m; PhM5 - surface, 15m, 25m, 40m and 54m), which was then filtered on filters of various granularity to analyze the content of chlorophyll *a*.

As part of the HIMERO project, one plankton sample was collected at each station using a Juday/56µm net from the bottom to the surface, then sample were preserved with 95% ethyl alcohol, which was replaced after 24 hours.

As part of the PHARMARINE project, 3 hauls were made at each station with the WP2/180µm plankton net, then the samples were pooled, placed in ziplock bags and frozen at -80^{o}C for further analysis for the content of pharmaceuticals in zooplankton.

4.2 Measurements and sampling during the AREX2022 legs II and III (open ocean part of the AREX cruise)

4.2.1 General information

During the first open ocean part, leg II lasting 15 days, measurements were collected between the northern end of Norway and Sorkapp. During this period, measurements were made on standard sections V1, H, K, V2, O (part of the section) and N. The second open ocean part of the AREX2022 cruise, leg III lasting 16 days, covered sections located between Sorkapp and the area north of Svalbard During the leg III, measurements the standard sections NB, WB, Y, EX, EB2, Z and S were ocucupied, and additionally, at the end of leg III, measurements were collected at two deep (westernmost) stations of the section N. During the cruise leg III, due to the weather situation the measurements were carried out starting from the sections in the north and continuing southwards. Due to the ice conditions north of Svalbard in mid-July, sections NB and WB were only partially visited (limited by location of the sea ice edge).

4.2.2 Physical oceanography measurements

Oceanographic measurements carried out during the open ocean part of the AREX'2022 cruise included:

- Full-depth measurements of temperature, salinity, dissolved oxygen, fluorescence and ocean currents in the eastern part of the Norwegian Sea, the Greenland Sea and the Barents Sea Opening, Fram Strait and southern part of the Nansen Basin (CTD, LADCP, VMADCP),
- Collection of water samples on selected stations for calibration of conductivity and oxygen sensors and for nutrient analysis.

During the AREX2022 expedition all oceanographic measurements were conducted on the station grid consisting of standard sections repeated annually since 2000, and along new sections located north of Svalbard, repeated since 2013. The hydrographic survey carried out during the cruise consisted of 13 sections (H, K, V1, V2, O, N, S, Z, EB2, EX, Y, WB, NB) extending from the outer shelf across the slope into the deep basin to cover the northward flow of Atlantic water.

During the ocean part of the AREX2022 cruise, oceanographic measurements including pressure, temperature, salinity, concentration of dissolved oxygen in sea water and fluorescence (as a proxy of chlorophyll *a* concentration) were carried out at 249 CTD stations on profiles covering the entire water column (124 CTD stations during the cruise leg II and 125 CTD stations during the leg III). On selected stations, water samples were collected for post-cruise calibration of conductivity sensors (9 stations) and oxygen sensors (4 stations). Additionally, on 19 stations water samples were collected for nutrient analysis. The samples were frozen on board and analyzed after the cruise in the IOPAN lab. For CTD measurements the SBE9/11+ CTD system (Sea-Bird Electronics) was used, providing full depth profiles of temperature (sensors SBE3 SN4670 and SBE3 SN2937), salinity (conductivity sensors SBE4 SN3342 and SBE4 SN2971), pressure (Digiquartz 410K-105 SN100967) dissolved oxygen (SeaBird SBE43 SN1620, plus optode Rinko SN72), and fluorescence (fluorimetr SeaPoint SN2935, plus altimeter Benthos PSA-916 SN 51308). The specifications of the individual sensors are provided in Table 3. In addition to CTD casts, the ocean currents were measured on each station with a Lowered Acoustic Doppler Current Profiler (LADCP, Teledyne RDI WorkHorse 300 kHz, SN21589). Data from the LADCP current meter were saved in individual files and retrieved from the device memory after each station. The CTD and LADCP system was mounted on the SeaBird water carousel equipped with 12 Niskin bottles (3x1.75 l. 9x12 l). During the entire cruise, ocean currents were measured in the upper layer of approx. 200 m along the ship route using the TRDI VM-ADCP (Vessel Mounted Acoustic Doppler Current Profiler) Ocean Surveyor 150 Hz. VM-ADCP measurements were carried out in the BroadBand mode with cell averaging of 8 m. During the leg III of the AREX2022 cruise, one Argo profiling float (WMO 3902116) was launched on the station N-14 (Argo-Polska project). The processed data are archived in the netCDF format containing a full set of metadata for each measurement and a joint DOI for the CTD data set from the leg II and III of the AREX2022 cruise. Data sets will be archived in the ODIS eCUDO database and made publicly available after two years.

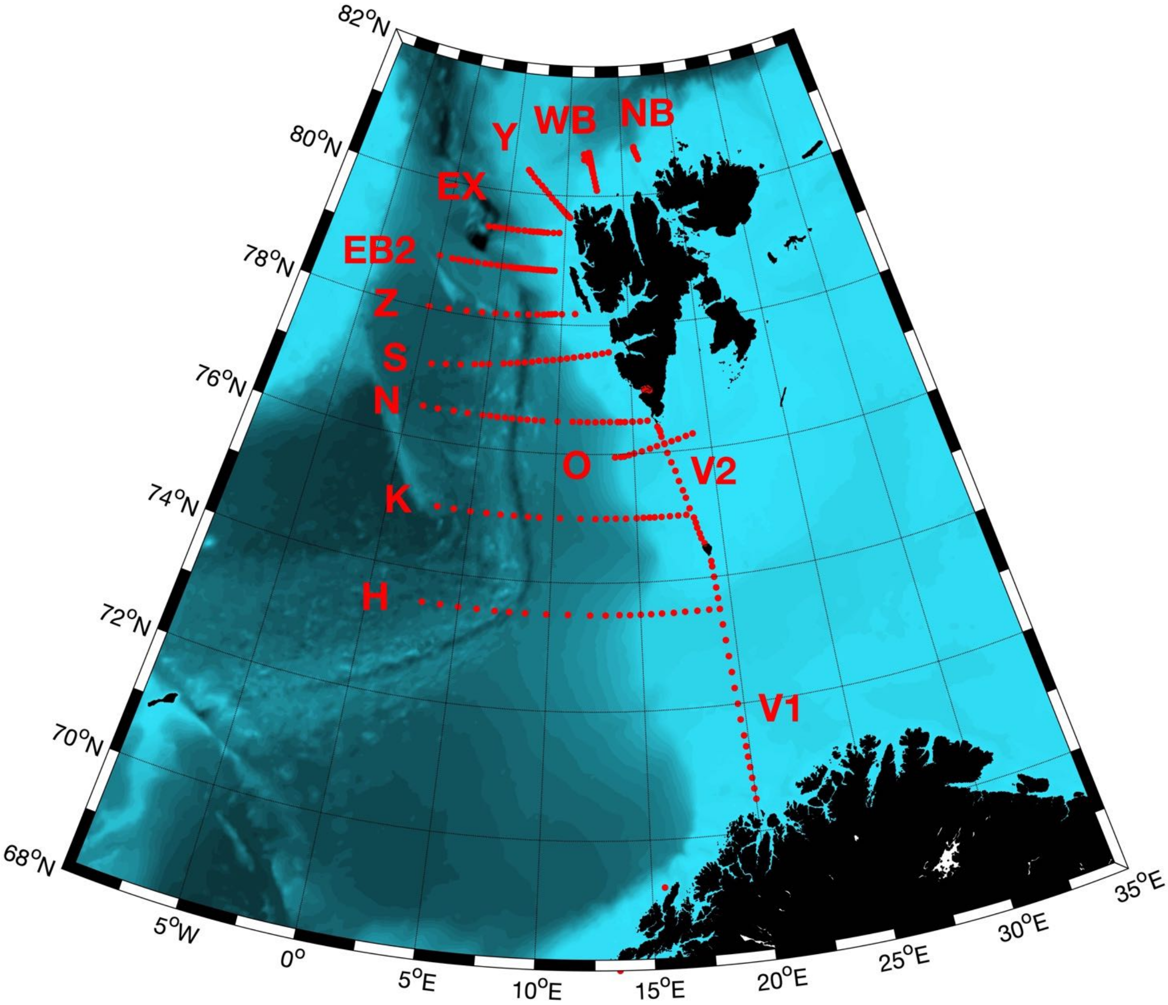

Figure 3. Map of CTD stations and sections occupied during the leg II and III of the AREX 2022 cruise.

Table 2. Specifications of the individual sensors (9/11+ CTD and CTD SBE19+ SeaCat) used for CTD measurements during the AREX2022 cruise.

CTD SBE9/11+ (new)			CTD SBE9/11+ (old)		
Sensor	**SN**	**Calibration date**	**Sensor**	**SN**	**Calibration date**
Pressure	100967	2018-04-18	Pressure	0275	2021-06-01
Conductivity	2971 3342	2022-04-05 2022-04-05	Conductivity	3322	2021-05-26
Temperature	2937 4670	2022-04-06 2022-04-06	Temperature	1409	2021-06-15
Dissolved oxygen SBE43	1620	2022-05-03			
Fluorometer	Seapoint	-			

Table 3. List of CTD stations occupied during the open ocean part (legs II and III) of the AREX2022 cruise.

File	Station	Lati-tude	Longi-tude	Water depth	Max Pres	Day	Month	Year	Hour	Min
AR22_003.awi	V1	70.502	20.008	146	135	25	6	2022	6	31
AR22_004.awi	V2	70.666	19.968	161	154	25	6	2022	8	32
AR22_005.awi	V3	70.832	19.933	184	177	25	6	2022	10	26
AR22_006.awi	V4	71.001	19.896	192	187	25	6	2022	12	15
AR22_007.awi	V5	71.165	19.868	214	212	25	6	2022	13	59
AR22_008.awi	V6	71.329	19.837	210	205	25	6	2022	16	39
AR22_009.awi	V7	71.499	19.801	239	237	25	6	2022	18	21
AR22_010.awi	V8	71.750	19.733	270	266	25	6	2022	20	32
AR22_011.awi	V9	71.998	19.683	308	315	25	6	2022	22	35
AR22_012.awi	V10	72.248	19.620	324	319	26	6	2022	0	53
AR22_013.awi	V11	72.497	19.572	388	386	26	6	2022	3	52
AR22_014.awi	V12	72.748	19.520	399	397	26	6	2022	6	7
AR22_015.awi	V13	72.999	19.467	420	415	26	6	2022	8	18
AR22_016.awi	V14	73.247	19.402	451	454	26	6	2022	10	25
AR22_017.awi	V15	73.493	19.338	480	475	26	6	2022	12	40
AR22_018.awi	V16	73.663	19.303	352	346	26	6	2022	15	5
AR22_019.awi	V17	73.831	19.273	238	232	26	6	2022	16	44
AR22_020.awi	V18	74.000	19.217	134	132	26	6	2022	18	12
AR22_021.awi	V19	74.163	19.186	80	70	26	6	2022	19	51
AR22_022.awi	V20	74.247	19.170	60	53	26	6	2022	20	38
AR22_023.awi	H1	73.499	18.751	432	428	27	6	2022	2	7
AR22_024.awi	H2	73.501	18.111	409	409	27	6	2022	3	59
AR22_025.awi	H3	73.504	17.439	428	425	27	6	2022	6	44
AR22_026.awi	H5	73.500	16.817	450	437	27	6	2022	8	36
AR22_027.awi	H6	73.500	16.166	463	459	27	6	2022	22	53
AR22_028.awi	H7	73.498	15.569	480	483	28	6	2022	0	50
AR22_029.awi	H4	73.498	15.008	674	712	28	6	2022	2	37
AR22_030.awi	H8	73.497	14.415	1021	1035	28	6	2022	4	44
AR22_031.awi	H9	73.502	13.835	1301	1307	28	6	2022	7	10
AR22_032.awi	H10	73.499	13.085	1583	1605	28	6	2022	10	17
AR22_033.awi	H11	73.500	12.231	1798	1831	28	6	2022	13	39
AR22_034.awi	H12	73.504	11.027	2062	2084	28	6	2022	18	2
AR22_035.awi	H13	73.500	9.831	2296	2325	28	6	2022	22	0
AR22_036.awi	H14	73.501	8.682	2485	2525	29	6	2022	2	18
AR22_037.awi	H15	73.500	7.804	2943	3059	29	6	2022	6	25
AR22_038.awi	H16	73.501	7.003	2417	2311	29	6	2022	10	16
AR22_039.awi	H17	73.502	6.013	2123	2155	29	6	2022	13	44
AR22_040.awi	H18	73.502	4.998	2106	2697	29	6	2022	17	41
AR22_041.awi	H19	73.502	4.010	2827	2936	29	6	2022	21	45
AR22_042.awi	H20	73.501	3.001	2288	2665	30	6	2022	2	5
AR22_043.awi	K18	75.001	3.001	2480	2431	30	6	2022	13	38
AR22_044.awi	K17	75.000	3.998	2994	3122	30	6	2022	19	43
AR22_045.awi	K16	74.998	5.003	3057	3042	30	6	2022	23	50
AR22_046.awi	K15	74.999	5.986	2816	2876	1	7	2022	4	13
AR22_047.awi	K14	74.999	6.832	2050	2017	1	7	2022	8	6

AR22_048.awi	K13	74.999	7.647	2192	2148	1	7	2022	10	51
AR22_049.awi	K12	74.999	8.494	2916	2857	1	7	2022	14	3
AR22_050.awi	K11	74.999	9.159	2601	2627	1	7	2022	18	0
AR22_051.awi	K10	74.999	10.412	2491	2535	1	7	2022	22	18
AR22_052.awi	K9	74.999	11.632	2355	2389	2	7	2022	2	11
AR22_053.awi	K8	74.998	12.521	2147	2171	2	7	2022	5	19
AR22_054.awi	K7	75.000	13.177	1982	2014	2	7	2022	8	38
AR22_055.awi	K6	74.999	13.745	1802	1687	2	7	2022	11	37
AR22_056.awi	K5	74.998	14.354	1540	1515	2	7	2022	14	25
AR22_057.awi	K4	74.997	15.000	1115	1125	2	7	2022	17	22
AR22_058.awi	K3	75.000	15.416	819	825	2	7	2022	19	39
AR22_059.awi	K2	74.999	15.773	368	354	2	7	2022	21	11
AR22_060.awi	K1	74.999	16.077	215	213	2	7	2022	22	15
AR22_061.awi	K0	74.999	16.502	245	230	2	7	2022	23	27
AR22_062.awi	K-1	74.999	16.996	131	125	3	7	2022	1	41
AR22_063.awi	K-2	75.001	17.501	121	116	3	7	2022	2	59
AR22_064.awi	K-3	74.998	17.986	155	154	3	7	2022	4	3
AR22_065.awi	V21	74.533	18.887	23	27	3	7	2022	13	54
AR22_066.awi	V22	74.616	18.736	71	65	3	7	2022	14	53
AR22_067.awi	V23	74.694	18.669	92	95	3	7	2022	16	1
AR22_068.awi	V24	74.781	18.561	222	223	3	7	2022	16	54
AR22_069.awi	V25	74.865	18.501	205	201	3	7	2022	17	52
AR22_070.awi	V26	74.946	18.421	155	70	3	7	2022	18	49
AR22_071.awi	V27	75.096	18.223	74	64	3	7	2022	20	28
AR22_072.awi	V28	75.264	18.053	64	59	3	7	2022	21	54
AR22_073.awi	V29	75.383	17.919	106	106	3	7	2022	23	1
AR22_074.awi	V30	75.532	17.722	135	126	4	7	2022	0	56
AR22_075.awi	V31	75.695	17.565	222	212	4	7	2022	2	17
AR22_076.awi	V32	75.831	17.341	293	291	4	7	2022	4	41
AR22_077.awi	V33	75.983	17.136	320	317	4	7	2022	6	15
AR22_078.awi	V34	76.124	17.002	286	283	4	7	2022	7	40
AR22_079.awi	V35	76.239	16.837	220	212	4	7	2022	9	54
AR22_080.awi	V36	76.316	16.787	110	108	4	7	2022	10	57
AR22_081.awi	V37	76.346	16.743	55	49	4	7	2022	11	27
AR22_082.awi	V38	76.399	16.626	34	33	4	7	2022	12	12
AR22_083.awi	O8	76.247	18.887	265	262	4	7	2022	16	31
AR22_084.awi	O7	76.218	18.430	251	253	4	7	2022	18	27
AR22_085.awi	O6	76.184	17.924	277	278	4	7	2022	19	50
AR22_086.awi	O5	76.157	17.468	300	306	4	7	2022	21	6
AR22_087.awi	O4	76.134	17.004	282	278	4	7	2022	22	34
AR22_088.awi	O3	76.098	16.501	342	341	5	7	2022	0	45
AR22_089.awi	O2	76.065	16.044	386	385	5	7	2022	2	11
AR22_090.awi	O1	76.030	15.516	364	363	5	7	2022	3	47
AR22_091.awi	M4	76.005	15.024	342	336	5	7	2022	5	15
AR22_092.awi	O-1	75.983	14.698	324	322	5	7	2022	6	28
AR22_093.awi	O-2	75.964	14.384	329	331	5	7	2022	7	34
AR22_094.awi	O-3	75.955	14.157	541	549	5	7	2022	9	6
AR22_095.awi	O-4	75.951	13.784	897	909	5	7	2022	10	31

AR22_096.awi	O-6	75.933	13.083	1378	1387	5	7	2022	13	2
AR22_097.awi	O-7	75.900	12.466	1701	1754	5	7	2022	15	29
AR22_098.awi	HV1	76.972	16.235	79	78	7	7	2022	6	58
AR22_099.awi	HV2	77.001	16.109	70	68	7	7	2022	7	58
AR22_100.awi	HV3	76.986	15.902	57	172	7	7	2022	8	39
AR22_101.awi	HV3t	76.987	15.866	182	166	7	7	2022	9	10
AR22_102.awi	N5	76.501	15.996	50	52	7	7	2022	13	26
AR22_103.awi	N4P	76.499	15.499	148	139	7	7	2022	14	26
AR22_104.awi	N4	76.497	15.003	164	183	7	7	2022	15	30
AR22_105.awi	N4up	76.501	14.981	188	179	7	7	2022	15	52
AR22_106.awi	N3P	76.496	14.504	238	229	7	7	2022	17	39
AR22_107.awi	N3PP	76.500	14.197	400	428	7	7	2022	18	36
AR22_108.awi	N3	76.500	14.002	748	794	7	7	2022	19	36
AR22_109.awi	N2P	76.501	13.496	1251	1281	7	7	2022	21	41
AR22_110.awi	N2	76.504	13.026	1508	1550	8	7	2022	3	24
AR22_111.awi	N1P	76.500	12.531	1715	1753	8	7	2022	5	59
AR22_112.awi	N1	76.501	12.008	1880	1907	8	7	2022	8	30
AR22_113.awi	N0P	76.501	11.506	1996	2027	8	7	2022	10	51
AR22_114.awi	N0	76.503	11.011	2074	2108	8	7	2022	13	6
AR22_115.awi	N-1	76.500	10.008	2176	2275	8	7	2022	16	30
AR22_116.awi	N-2	76.499	9.014	2256	2283	8	7	2022	19	58
AR22_117.awi	N-3	76.500	8.503	2257	2292	8	7	2022	22	56
AR22_118.awi	N-4	76.501	8.008	1828	1859	9	7	2022	1	34
AR22_119.awi	N-5	76.499	7.523	2659	2511	9	7	2022	3	57
AR22_120.awi	N-6	76.499	6.997	2846	2809	9	7	2022	7	32
AR22_121.awi	N-7	76.501	6.505	2427	2454	9	7	2022	10	39
AR22_122.awi	N-8	76.501	6.003	2528	2463	9	7	2022	13	43
AR22_123.awi	N-9	76.505	5.521	2567	2593	9	7	2022	16	26
AR22_124.awi	N-10	76.501	5.007	2371	2387	9	7	2022	19	23
AR22_125.awi	N-11	76.501	3.997	2430	2629	9	7	2022	23	7
AR22_126.awi	N-12	76.504	3.060	2785	2853	10	7	2022	3	2
AR22_127.awi	NB1	80.553	16.538	53	43	12	7	2022	20	42
AR22_128.awi	NB2	80.614	16.414	125	124	12	7	2022	21	33
AR22_129.awi	NB3	80.648	16.336	161	156	12	7	2022	22	25
AR22_130.awi	NB4	80.678	16.240	167	171	12	7	2022	23	39
AR22_131.awi	NB5	80.694	16.216	186	304	13	7	2022	0	30
AR22_132.awi	NB6	80.710	16.186	569	623	13	7	2022	1	46
AR22_133.awi	NB7	80.724	16.171	650	688	13	7	2022	2	47
AR22_134.awi	NB8P	80.743	16.187	739	885	13	7	2022	3	47
AR22_135.awi	WB1	80.090	12.658	183	185	13	7	2022	10	33
AR22_136.awi	WB2	80.152	12.585	179	177	13	7	2022	11	25
AR22_137.awi	WB3	80.218	12.503	180	196	13	7	2022	12	15
AR22_138.awi	WB4	80.285	12.406	200	182	13	7	2022	13	53
AR22_139.awi	WB5	80.347	12.330	176	161	13	7	2022	14	41
AR22_140.awi	WB6	80.378	12.279	184	179	13	7	2022	15	14
AR22_141.awi	WB7	80.413	12.235	220	224	13	7	2022	16	34
AR22_142.awi	WB8	80.430	12.224	329	375	13	7	2022	17	5
AR22_143.awi	WB9	80.447	12.205	453	476	13	7	2022	17	44

AR22_144.awi	WB10	80.466	12.188	573	574	13	7	2022	18	48
AR22_145.awi	WB11	80.482	12.165	650	651	13	7	2022	19	37
AR22_146.awi	WB12	80.514	12.127	794	799	13	7	2022	20	28
AR22_147.awi	WB13	80.544	12.088	924	931	13	7	2022	21	38
AR22_148.awi	WB14	80.579	12.057	1033	1039	13	7	2022	22	51
AR22_149.awi	WB15	80.627	11.995	1170	1191	14	7	2022	0	38
AR22_150.awi	WB16	80.672	11.935	1278	1319	14	7	2022	2	4
AR22_151.awi	WBY1	80.647	11.468	1183	1180	14	7	2022	4	13
AR22_152.awi	WBY2	80.562	11.493	954	953	14	7	2022	6	16
AR22_153.awi	WBY3	80.520	11.933	835	827	14	7	2022	7	50
AR22_154.awi	Y16	80.357	6.402	568	567	14	7	2022	15	59
AR22_155.awi	Y15	80.315	6.661	564	560	14	7	2022	17	12
AR22_156.awi	Y14	80.251	6.995	581	579	14	7	2022	18	51
AR22_157.awi	Y13	80.192	7.329	560	564	14	7	2022	20	11
AR22_158.awi	Y12	80.131	7.716	537	535	14	7	2022	22	4
AR22_159.awi	Y11	80.077	8.043	514	511	14	7	2022	23	54
AR22_160.awi	Y10	80.016	8.365	498	497	15	7	2022	1	18
AR22_161.awi	Y1	79.661	10.365	36	31	16	7	2022	7	42
AR22_162.awi	Y2	79.683	10.248	80	80	16	7	2022	8	11
AR22_163.awi	Y3	79.707	10.096	137	129	16	7	2022	8	48
AR22_164.awi	Y4	79.731	9.975	307	306	16	7	2022	9	50
AR22_165.awi	Y5	79.755	9.835	373	371	16	7	2022	10	28
AR22_166.awi	Y6	79.796	9.610	427	426	16	7	2022	12	10
AR22_167.awi	Y7	79.840	9.370	456	453	16	7	2022	13	9
AR22_168.awi	Y8	79.893	9.048	459	457	16	7	2022	14	16
AR22_169.awi	Y9	79.950	8.716	480	479	16	7	2022	15	21
AR22_170.awi	EX1	79.421	9.491	124	123	16	7	2022	20	26
AR22_171.awi	EX2	79.418	9.005	131	125	16	7	2022	21	26
AR22_172.awi	EX3	79.416	8.498	191	190	16	7	2022	22	25
AR22_173.awi	EX3P	79.416	8.171	268	285	17	7	2022	0	5
AR22_174.awi	EX4	79.417	7.916	513	522	17	7	2022	1	1
AR22_175.awi	EX4P	79.418	7.672	768	709	17	7	2022	2	25
AR22_176.awi	EX5	79.413	7.322	1039	1013	17	7	2022	4	59
AR22_177.awi	EX6	79.414	7.011	1195	1190	17	7	2022	11	57
AR22_178.awi	EX7	79.416	6.567	1387	1462	17	7	2022	14	4
AR22_179.awi	EX7P	79.415	6.027	1760	1807	17	7	2022	16	25
AR22_180.awi	EX8	79.418	5.513	2180	2272	17	7	2022	18	27
AR22_181.awi	EX8P	79.417	5.011	2451	2488	17	7	2022	20	39
AR22_182.awi	EX9	79.418	4.505	2514	2535	17	7	2022	23	20
AR22_183.awi	EX10	79.417	4.022	3135	3443	18	7	2022	2	14
AR22_184.awi	EX11	79.414	3.523	2973	2970	18	7	2022	5	34
AR22_185.awi	EB2-1	78.833	9.268	203	202	19	7	2022	7	57
AR22_186.awi	EB2-1P	78.833	9.023	210	207	19	7	2022	9	31
AR22_187.awi	EB2-2	78.834	8.767	215	211	19	7	2022	10	19
AR22_188.awi	EB2-2P	78.833	8.603	389	377	19	7	2022	11	6
AR22_189.awi	EB2-3	78.833	8.437	653	665	19	7	2022	12	1
AR22_190.awi	EB2-3P	78.834	8.273	830	845	19	7	2022	13	19
AR22_191.awi	EB2-4	78.832	8.118	937	961	19	7	2022	14	33

AR22_192.awi	EB2-4P	78.833	7.871	1053	1065	19	7	2022	16	0
AR22_193.awi	EB2-5	78.833	7.599	1106	1109	19	7	2022	19	55
AR22_194.awi	EB2-5P	78.833	7.354	1198	1193	20	7	2022	0	39
AR22_195.awi	EB2-6	78.836	7.096	1347	1353	20	7	2022	2	46
AR22_196.awi	EB2-6P	78.835	6.902	1543	1555	20	7	2022	4	56
AR22_197.awi	EB2-7	78.834	6.664	1745	1770	20	7	2022	7	1
AR22_198.awi	EB2-7P	78.833	6.425	2032	2088	20	7	2022	8	42
AR22_199.awi	EB2-8	78.832	6.170	2312	2358	20	7	2022	10	37
AR22_200.awi	EB2-8P	78.832	5.914	2452	2493	20	7	2022	13	6
AR22_201.awi	EB2-9	78.833	5.684	2516	2563	20	7	2022	15	28
AR22_202.awi	EB2-10	78.833	5.176	2584	2630	20	7	2022	18	29
AR22_203.awi	EB2-10P	78.834	4.689	2536	2560	20	7	2022	21	41
AR22_204.awi	EB2-11	78.837	4.155	2366	2387	21	7	2022	0	30
AR22_205.awi	EB2-11P	78.832	3.685	2238	2293	21	7	2022	4	6
AR22_206.awi	EB2-12	78.833	3.093	2401	2433	21	7	2022	6	44
AR22_207.awi	EB2-12P	78.834	2.504	2472	2515	21	7	2022	9	26
AR22_208.awi	EB2-13	78.832	2.022	2497	2537	21	7	2022	12	9
AR22_209.awi	EB2-14	78.833	1.530	2491	2519	21	7	2022	14	51
AR22_210.awi	EB2-14P	78.830	1.028	2444	2426	21	7	2022	17	35
AR22_211.awi	EB2-15	78.834	0.015	2587	2624	21	7	2022	20	55
AR22_212.awi	Z15	78.032	0.029	3010	3092	22	7	2022	3	56
AR22_213.awi	Z15	78.029	0.002	3010	3088	22	7	2022	7	58
AR22_214.awi	Z14	78.050	1.504	3056	3118	22	7	2022	12	55
AR22_215.awi	Z13	78.066	2.833	2990	1463	22	7	2022	18	26
AR22_216.awi	Z12	78.084	4.004	2826	1499	22	7	2022	21	53
AR22_217.awi	Z11	78.092	4.992	2424	1448	23	7	2022	1	55
AR22_218.awi	Z10	78.098	5.817	2486	1618	23	7	2022	5	20
AR22_219.awi	Z9	78.117	6.674	2529	1694	23	7	2022	8	22
AR22_220.awi	Z8	78.130	7.500	3412	1579	23	7	2022	11	31
AR22_221.awi	Z7	78.138	8.162	2170	1599	23	7	2022	14	15
AR22_222.awi	Z6	78.142	8.639	1597	1555	23	7	2022	16	42
AR22_223.awi	Z5	78.156	9.004	1272	1084	23	7	2022	18	52
AR22_224.awi	Z4	78.159	9.240	703	691	23	7	2022	20	22
AR22_225.awi	Z3	78.162	9.492	256	264	23	7	2022	21	42
AR22_226.awi	Z2	78.166	9.999	267	263	23	7	2022	22	59
AR22_227.awi	Z1	78.174	10.991	257	258	24	7	2022	1	18
AR22_228.awi	S0	77.583	13.491	145	141	24	7	2022	7	23
AR22_229.awi	S1	77.567	13.021	135	131	24	7	2022	8	28
AR22_230.awi	S2	77.550	12.510	100	94	24	7	2022	9	33
AR22_231.awi	S3	77.534	11.992	176	170	24	7	2022	10	35
AR22_232.awi	S4	77.516	11.505	275	273	24	7	2022	12	17
AR22_233.awi	S5	77.500	10.997	706	702	24	7	2022	13	33
AR22_234.awi	S6	77.483	10.499	1245	1251	24	7	2022	15	11
AR22_235.awi	S7	77.466	10.024	1583	1600	24	7	2022	17	4
AR22_236.awi	S7P	77.450	9.511	1912	1936	24	7	2022	19	32
AR22_237.awi	S8	77.438	9.012	2062	2079	24	7	2022	21	51
AR22_238.awi	S8P	77.425	8.491	1558	1608	25	7	2022	0	58
AR22_239.awi	S9	77.400	8.027	2163	2325	25	7	2022	3	36

AR22_240.awi	S9P	77.383	7.506	3579	3631	25	7	2022	6	21
AR22_241.awi	S10	77.367	6.999	2655	2696	25	7	2022	10	30
AR22_242.awi	S11	77.350	6.501	2099	2140	25	7	2022	13	39
AR22_243.awi	S12	77.334	6.019	2568	2610	25	7	2022	16	21
AR22_244.awi	S13	77.300	5.014	2420	2395	25	7	2022	20	0
AR22_245.awi	S14	77.282	4.501	2261	2290	25	7	2022	22	41
AR22_246.awi	S15	77.266	4.004	2533	2598	26	7	2022	1	14
AR22_247.awi	S16	77.231	3.030	2841	2918	26	7	2022	4	43
AR22_248.awi	S17	77.200	2.006	3179	3238	26	7	2022	8	42
AR22_249.awi	S18	77.167	1.007	3173	3233	26	7	2022	12	52
AR22_250.awi	N-14	76.500	1.000	3195	3256	26	7	2022	19	58
AR22_251.awi	N-15	76.501	1.998	3195	3259	27	7	2022	0	51

4.2.3 Aerosol and meteorological measurements

The measurements were carried out using the following measurement equipment: OPC3N - Optical Particle Counter, Li-COR 7200, AE-31 eathalometer, Vaisala WXT563 autonomous weather station, Microtops II solar photometer, Ellipse-N-G4A2-B1. The measured parameters included the distribution of aerosol particle sizes in the surface layer of the atmosphere, concentration of marigenic aerosol, CO_2 and H_2O concentration in the atmosphere, concentration of Black Carbon particles in the surface layer of the atmosphere, wind speed and direction, air temperature and humidity, and ship motion was recorded using the inertial motion detection system. The measurements were carried out continuously. All data collected during the cruise leg II and III were stored in the IOPAN data base.

Measurements of pCO_2, pO_2, SST and SSS were also carried out. These parameters were measured using a measurement set consisting of a thermosalinograph, Fibox for measuring oxygen concentration and Piccaro analyzer for measuring pCO_2 concentration in the surface water layer.

At selected stations, water samples were collected from the surface microlayer (for surface active substances - surfactants) using a Garrett net (1-2 m below the surface). At 29 stations, water samples from the surface layer (subsurface at a depth of approx. 1-2 m) were collected using a bathymetric rosette for the analysis of surfactants. Samples from each station were filtered, preserved, and then frozen.

4.2.4 Plankton measurements

During the leg II-III of the AREX expedition plankton samples were collected at the selected stations in the open ocean part. At each station, zooplankton samples were collected while the ship was in a drift. Sampling was planned in vertical hauls, from the upper 200-meter layer (from the epipelagic), in layers, in hauls from layers determined in relation to the thermal and salinity structure of the water column prevailing at the station. Based on the results of previous hydrographic studies, the collection of zooplankton samples is planned in a typical situation in three layers: in the surface layer, with the same temperature and salinity values, in the thermo- and halocline layer and in the extending below layer to the epipelagic limit a layer with uniform changes in temperature and salinity with depth. On selected stations, plankton (zooplankton) samples were collected with sampling nets -WP2/180 and WP3/64.

For the collection of zooplankton samples, 49 standard stations were selected a total of 211 zooplankton net samples, 187 filter samples and 3 water samples were collected. Samples were collected for long-term zooplankton monitoring (Task I.5) and for the following projects: HIMERO (21 stations), HIDEA (14 stations), ORANGE (3 stations), BIPOLARITY (3 stations) PHARMARINE (11 stations).

A detailed list of samples collected as part of long-term monitoring and research projects includes:

- Monitoring (Task I.4) - 2-3-4 net hauls WP2-180 layers with CTD (up to 200m) at each station, 141 samples in total; stations V15, H10, H13, H18, K16, K10, K7, K4, K0, K-3, V29, V31, O8, O4, 0-2, O-7, N4, N3, N2, N0, N-2 , N-11, NB3, NB5, WB3, WB6, WB9, WB12, Y15, Y12, Y5, Y9, EX3, EX6, EX9, EB2-1, EB2-3, EB2-5, EB2-7, EB2-10 , EB2-14, Z7, Z4, Z2, S3, S6, S8, S10, S16;
- Project ORANGE - a total of 6 WP2-180 nets (2x50-0m at each station), 2x protozoa (20 micron net) 0-25m, integrated water protozoa x3, water filtration from 5 layers, integrated carotenoids at each of the 3 stations, total: 8 net samples + 3 water samples + 3 filter samples; K-3, K4, K0;
- Project HIMERO – 20x Juday-56 net bottom-to-surface meroplankton haul (+1 additional WP2-180 0-200m), water from 5 layers per chlorophyll per station, total: 21 nets samples + 100 filter samples; stations PhM3, PhM5, V1, V5, V10, V18, K-3, V22, V26, V29, V31, O4, N4, NB3, WB3, Y5, EX3, EB2-1, Z2, S3, S16,
- Project HIDEA – 14x 2x50-0m WP2-180 net, 1l water from layers: 0, 25, 50m for bacterioplankton and protozoan plankton, total: 28 net samples + 84 filter samples; stations H10, H18, K16, K4, N2, N-11, NB5, WB6, Y9, EX6, EB2-5, EB2-14, S6, S16,
- Project Bi-Polarity – 3 nets 0-1000m WP2-180 split, total: 6 net samples; stations N2P, EB2-4P, EB2-5,
- Project PHARMARINE - 11 net WP2-180 0-60m, frozen for pharmaceuticals + for testing, total: 11 net samples; stations PHM3, PHM5, K7, O4, N4, N-11, NB3, WB3, WB6, S6, S8.

Zooplankton samples for PHARMARINE research, zooplankton mass samples, zooplankton biomass samples to measure the types and concentrations of selected pharmaceuticals used in human therapy in zooplankton organisms, were collected with the WP-2 (180) network in vertical hauls from the top 50 m layers of water. A total of 11 zooplankton bulk samples were collected for the PHARMARINE program. Zooplankton samples for the study of meroplankton diversity based on molecular methods and taxonomic analysis were collected with the Juday network (64) in vertical hauls, in the water layer from the bottom to the surface on shelf stations (maximum depth - 400 m). A total of 21 samples were collected for the study of meroplankton diversity. Zooplankton samples to supplement the genetic reference base of planktonic organisms (HIDEA project) were collected with the WP-2 (180) network in vertical hauls, in the 50-0 m water layer, at selected plankton stations. A total of 28 samples were collected of testing genetic diversity.

4.3 Measurements and sampling during the AREX'2022 leg IVa (Hornsund)

4.3.1 General information

During the leg IVa of the AREX'2022 cruise, measurements and water and sediment samples were collected in the West Spitsbergen fjords Hornsund and Belsund.

Table 4. The station list and details of the measurements with responsible IOPAN labs during the leg IVa of the AREX2022 cruise.

File CTD	Name station	Depth water (m)	Data	Time UTC	Lat	Lon	Measurement	IOPAN labs responsible					
								ZDM OOLab	ZEM Bentos	ZChiBM	ZFM Optics	ZEM PEP	ZEM PFBP
AR22_252	**Hans2**	40	30.07.22	10:32	77 00.647	15 37.921	CTD, water samples, gemax	x		x			
AR22_253	**Hans1**	40	30.07.22	11:37	77 00.455	15 37.321	CTD, water samples, gemax	x		x			
AR22_254	**Hans3**	22	30.07.22	13:00	77 00.224	15 37.663	CTD, water samples	x		x			
AR22_255	**Fugle3**	19	30.07.22	14:02	76 59.845	15 35.303	CTD, water samples, gemax	x		x			
AR22_256	**Fugle2**	13	30.07.22	14:32	76 59.953	15 35.054	CTD, HydroScat-4, surface water for SPM, Chla, POC, HPLC, fik, PSD, ap	x			x		
AR22_257	**Fugle1**	12	30.07.22	15:10	77 00.022	15 34.652	CTD	x					
AR22_258	**HB1/SGD1**	120	30.07.22	18:57	77 00.022	16 27.530	CTD, water samples, gemax (x3), van veen (x5), box corer (x6), gravity corer	x	x	x			
AR22_259	**R12/H3**	138	31.07.22	06:47	77 00.535	16 29.000	CTD, water samples (chl, SPM, protozoa), plankton, SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation, WP2 100x 3, LOPC-CTD-O-F-T, net	x			x	x	X
AR22_260	**R12/H3**	125	31.07.22	07:30	77 00.528	16 28.999	CTD, water samples, plankton, C-Ops, ac9plus, radiation	x			x		X
AR22_261	**R12/H3**	125	31.07.22	08:50	77 00.526	16 29.004	CTD, water samples, plankton, SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins	x			x		X
AR22_262	**R13/HB1**	58	31.07.22	10:00	77 02.590	16 29.90	CTD, water samples (chl, SPM, protozoa), WP2 100x 3, LOPC-CTD-O-F-T, net (phyto)	x			x		x
AR22_263	**R13**	79	31.07.22	11:01	77 02.083	16 30.521	CTD	x					x
AR22_264	**R11**	120	31.07.22	12:05	76 59.940	16 25.522	CTD	x					x
AR22_265	**R10**	118	31.07.22	12:41	76 59.432	16 20.966	CTD	x					x
AR22_266	**R9**	115	31.07.22	13:23	76 58.835	16 14.444	CTD	x					x
AR22_267	**R8**	48	31.07.22	14:10	76 59.245	16 07.643	CTD DO F	x					x
AR22_268	**R7**	78	31.07.22	14:37	76 59.640	16 04.440	CTD DO F	x					x
AR22_269	**R5**	176	31.07.22	15:43	76 59.508	15 52.402	CTD DO F	x					x
AR22_270	**R3**	108	31.07.22	16:50	76 58.357	15 37.668	CTD DO F	x					x
AR22_271	**R2**		31.07.22	17:50	76 57.718	15 31 657	CTD DO F	x					x
AR22_272	**HB3**	238	31.07.22	20:50	76 58.090	15 44.356	CTD, van veen, box corer, HydroScat-4, surface water for SPM, Chla, POC, HPLC, fik, PSD, ap, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation	x	x		x		
AR22_273	**HB2/SGD2**	70	01.08.22	00:05	77 00.028	16 05.752	CTD DO F, water samples, van veen,	x	x	x			

							gemax (x3), boxcorer (x6), gravity corer						
AR22_274	**HB2/SGD3**	74	01.08.22	03:52	77 00 032	16 05.186	CTD DO F	x					
AR22_275	**HB2/H3**	108	01.08.22	06:22	56 59.436	16 18.902	CTD DO F water samples (chl, SPM, protozoa), WP2-180, SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation, LOPC-CTD-O-F-T, WP2-100	x			x		x
AR22_276	**R6/H4**	104	01.08.22	08:47	77 00.103	15 59.903	CTD DO F, WP2-180, Juday_56x1 SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation	x			x	x	x
AR22_277	**R6/H4**	102	01.08.22	09:00	77 00.500	15 59.830	CTD DO F, WP2-180, SPM, apl, Chla, HPLC, fractions, PSD,CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation, LOPC-CTD-O-F-T, WP2-100	x			x	x	x
AR22_278	**R6/H4**	102	01.08.22	09:46	77 00.05	15 59.830	CTD DO F, WP2-180, SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation, WP2 100x3, water samples (chl, SPM, protozoa)	x			x	x	x
AR22_279	**R4/H2**	220	01.08.22	14:00	76 58.826	15 45.914	CTD DO F, water samples, POC, chl a, caretonoids, SPM, protozoa, Mnet180, Mnet60, WP3-1000, Juday6, WP2-180, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation, WP2-100, LOPC-CTD-O-F-T,	x			x	x	x
AR22_280	**Hans4**	25	01.08.22	22:20	76 59.979	15 37.476	CTD, water samples	x					
AR22_281	**Hornsund1**	121	01.08.22	23:52	76 58.332	15 24.247	CTD, water samples	x					
AR22_282	**Rm1**	78	02.08.22	01:05	76 59.566	15 14.266	CTD	x					x
AR22_283	**RM2**	134	02.08.22	01:46	76 58.704	15 15.079	CTD	x					x
AR22_284	**RM3**	165	02.08.22	02:30	76 57.81	15 17.668	CTD	x					x
AR22_285	**RM4**	162	02.08.22	03:25	76 57.036	15 18.456	CTD	x					x
AR22_286	**RM5**	130	02.08.22	04:06	76 55.295	15 22.972	CTD	x					x
AR22_287	**RM6**	82	02.08.22	04:44	76 54.700	15 25.062	CTD	x					x
AR22_288	**R1**	122	02.08.22	05:25	76 56.922	15 25.780	CTD	x					x
AR22_289	**R0/H1/ AUK1**	162	02.08.22	09:33	76 56.196	15 22.033	CTD DO F, water samples (SPM, chl, protozoa, bacteria), Mnet-180, WP2-500, WP2-180, SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation, van venn, LOPC-CTD-O-F-T, WP2 100 x 3	x	x		x	x	x
AR22_290	**Auk2**	84	02.08.22	13:52	76 52.086	14 45.086	CTD DO F, water samples, WP2-500,	x			x	x?	

							HydroScat-4, surface water for PM, Chla, POC, HPLC, fik, PSD, ap, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation, WP2 180						
AR22_291	**Auk3**	92	02.08.22	17:18	76 46.847	14 05.959	CTD DO F, WP2-500, HydroScat-4, surface water for SPM, Chla, POC, HPLC, fik, PSD, ap, WP2-180	x			x	x	
AR22_292	**Auk4**	204	02.08.22	18:40	76 42.464	13 33.336	CTD DO F, water samples, WP2-500 x1, SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation, WP2-180	x			x	X	
AR22_293	**Auk7**	200	02.08.22	21:58	76 30.046	13 26.628	CTD DO F, water samples, WP2-500, WP2-180, net (phyto)	x				x	x
AR22_294	**Auk9**	200	03.08.22	02:35	76 34.817	14 06.566	CTD DO F, WP2-500, WP2 180	x				X	x
AR22_295	**Auk10**	210	03 0 2022	04:46	76 38.282	14 28.640	CTD DO F, WP2-500, WP2 180	x				X	x
AR22_296	**Auk11/H6**	210	03.08.22	07:20	76 41.132	14 48.270	CTD DO F, water samples, POC, Chla, caretonoids, WP2-500, Mnet180, Mnet60, Juday60, WP3-1000, SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, WP2-180, net (phyto), HydroScat-4, surface water for SPM, Chla, POC, HPLC, fik, PSD, ap	x			x	x	x
AR22_297	**Auk12**	50	03.08.22	16:35	76 45.136	15 18.164	CTD DO F, water sample, WP2-500, Juday-60, HydroScat-4, surface water for SPM, Chla, POC, HPLC, fik, PSD, ap, WP2 180, net (phyto)	x				X	x
AR22_298	**Auk13**	34	03.08.22	19:09	76 35.621	15 47.555	CTD DO F, WP2-500, WP2-180	x				X	X
AR22_299	**Auk14**	88	03.08.22	21:08	76 33.054	15 27.863	CTD DO F, WP2-500, Juday6, WP2 180	x				X	X
AR22_300	**Auk15**	181	03.08.22	23:50	76 28.451	15 04.181	CTD DO F, water samples (5,15, 25,35,50), WP2-500, WP2-180, net (phyto)	x				X	X
AR22_301	**Auk16**	625	04.08.22	02:58	76 24.606	14 39.781	CTD DO F, WP2-500, WP2-180	x				X	x
AR22_302	**Auk19**	322	04.08.22	04:29	76 18.884	14 58.352	CTD DO F, WP2-500, WP2-180	x				X	x
AR22_303	**Auk20**	140	04.08.22	06:03	76 22.510	15 27.408	CTD DO F, WP2-500, WP2-180	x				X	X
AR22_304	**Auk21**	90	04.08.22	07:12	76 25.726	15 48.455	CTD DO F, water samples (5,15,25, 35,50)), WP2-500, WP2-180, net (phyto)	x				X	x
AR22_305	**Auk22**	31	04.08.22	08:41	76 26.972	16 08.231	CTD DO F, WP2-500, Juday-60.	x				X	
-	**BRY2**	220	04.08.22	13:19	76 51.579	15 00.730	triangle dredge	x	x				

-	**BRY2**	220	04.08.22	13:49	76 51.737	15 01.191	triangle dredge	x	x				
-	**BRY2**	150	04.08.22	14:25	76 51.661	14 59.952	triangle dredge	x	x				
AR22_306	**Belsund6**	52	04.08.22	19:01	77 18.123	13 44.557	CTD, water samples, van veen, LOPC-CTD-O-F-T, ac9	x		x			x
AR22_307	**Belsund1**		04.08.22	20:14	77 28.144	13 53.154	CTD, water samples, van veen	x		x			
AR22_308	**Belsund5**	119	04.08.22	22:29	77 34.147	14 39.186	CTD, water samples, van veen, LOPC-CTD-O-F-T	x		x			x
-	**Belsund3**	99	05.08.22	00:15	77 31	14 37.5	LOPC-CTD-O-F-T	x					x

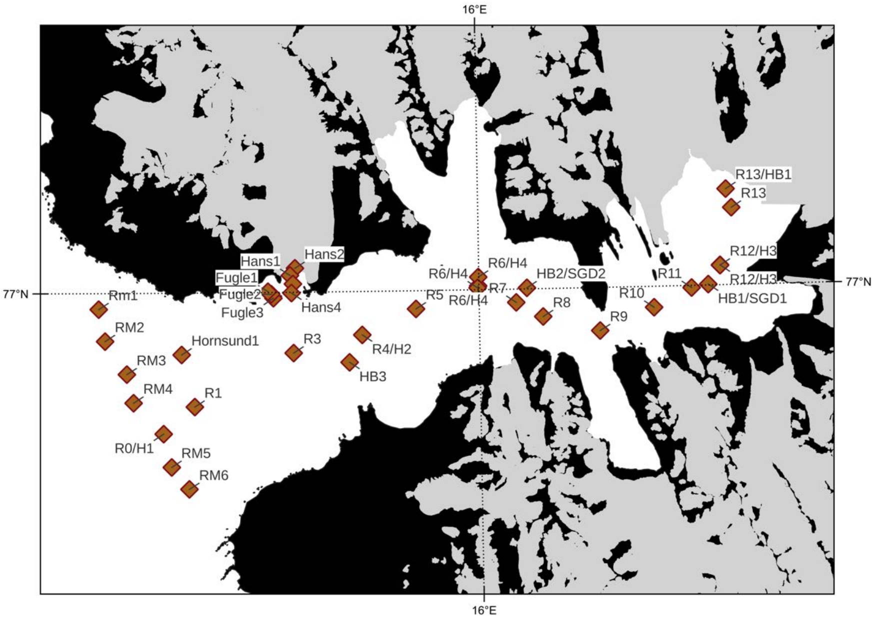

Figure 4. Map of stations occupied in Hornsund during the leg IVa of the AREX 2022 cruise.

Figure 5. Map of the stations in the Hans Glacier area occupied during the AREX2022 leg IVa.

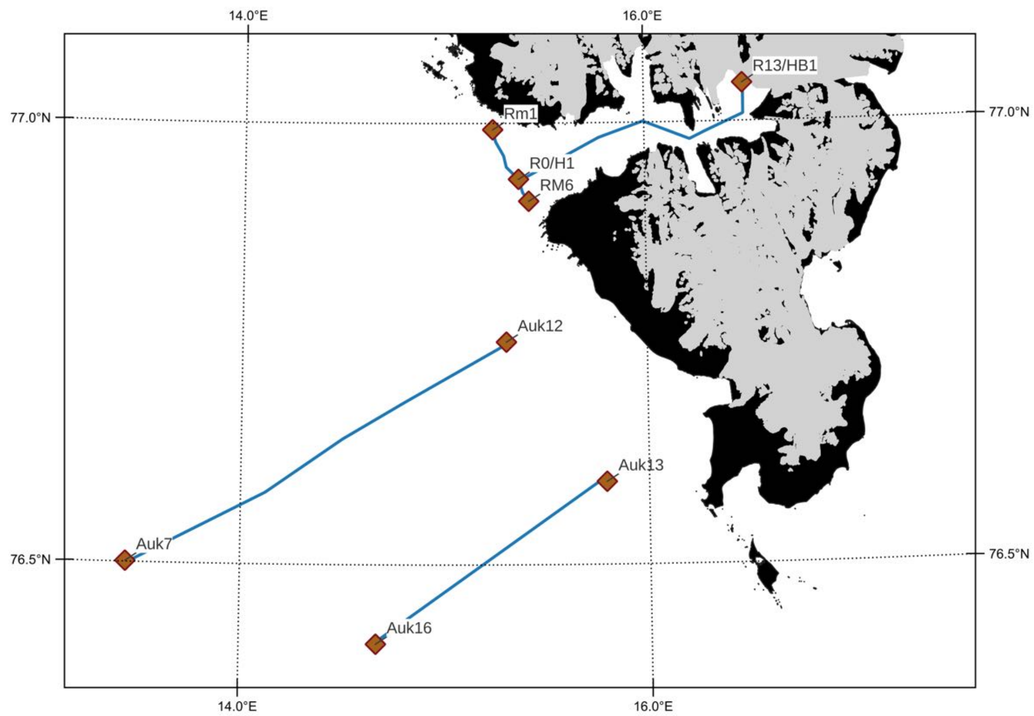

Figure 6. Map of the LOPC sections during the AREX 2022 leg IVa (start and end points indicated).

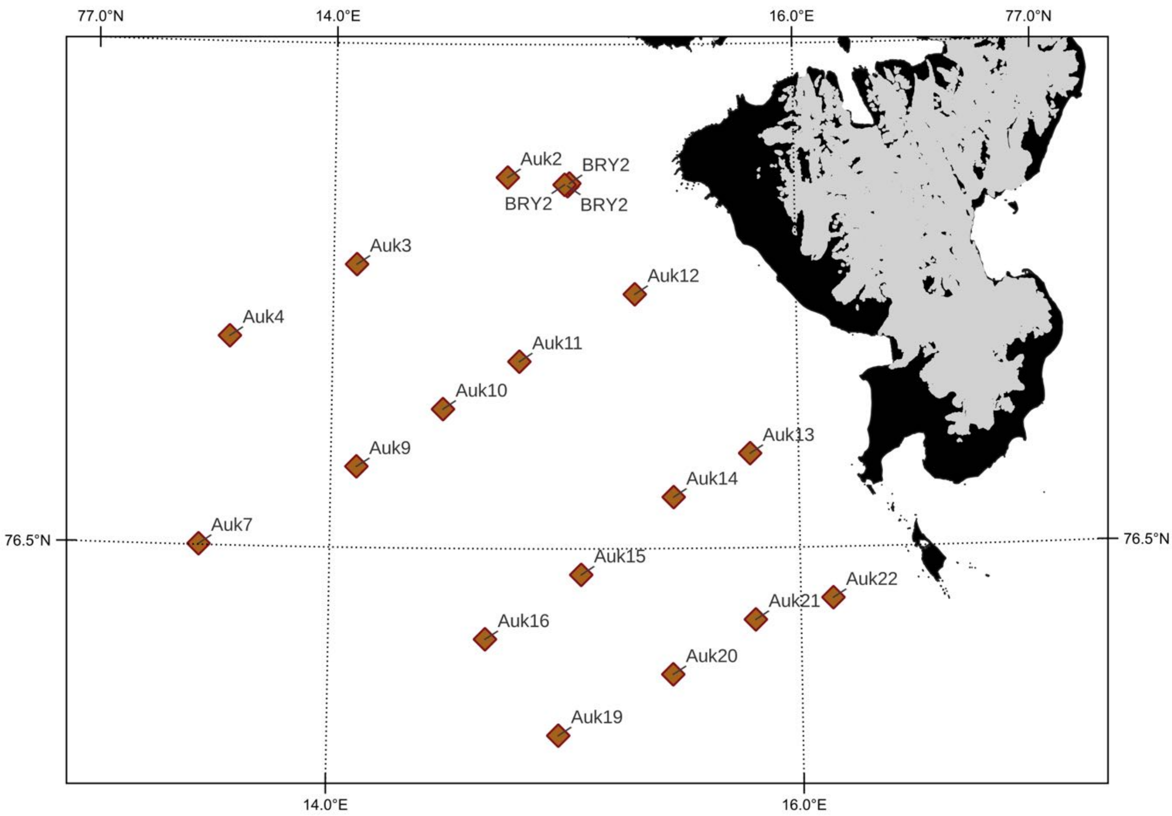

Figure 7. Map of stations occupied at the Hornsund forefield during the AREX2022 leg IVa.

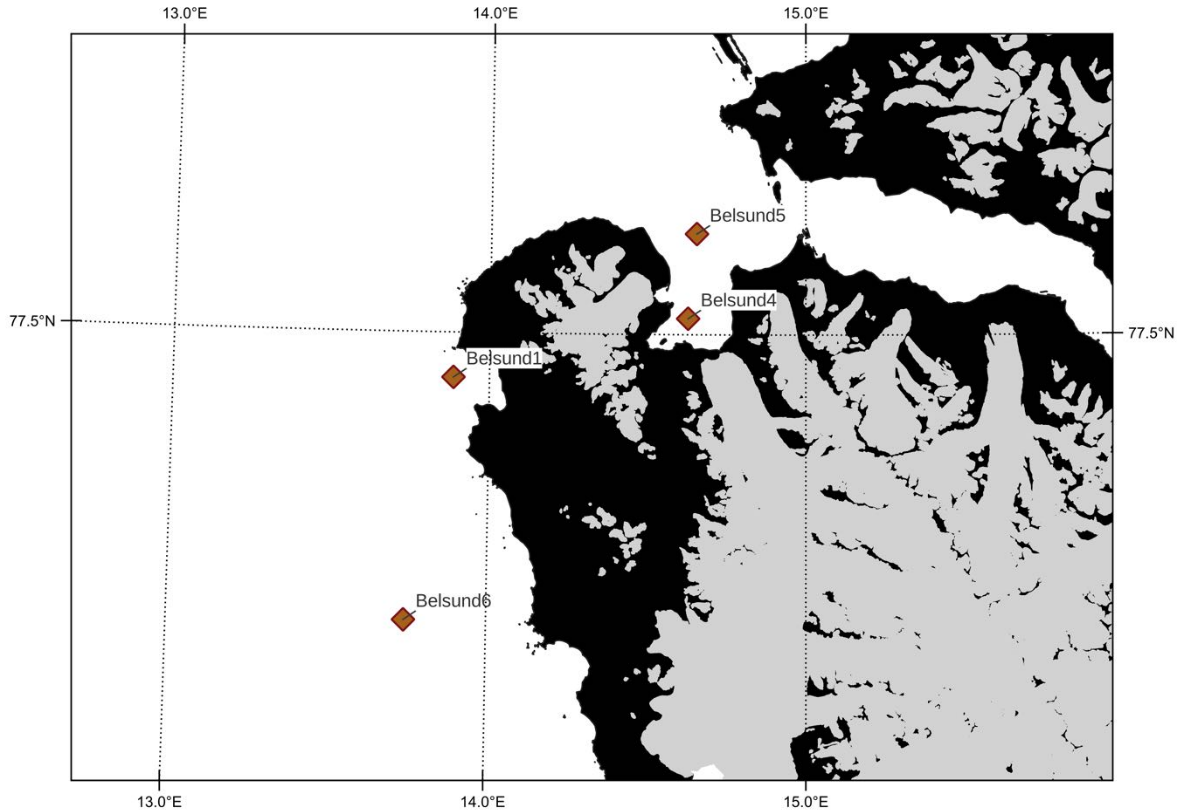

Figure 8. Map of stations near and in Belsund occupied during the AREX 2022 leg IVa.

4.3.2 Marine ecology sampling and measurements - plankton (PEP)

- Long-term zooplankton monitoring under the AREX program (Task I.5)

Zooplankton samples were collected using the MultiNet_180/WP2_180 network in vertical hauls and measurements of environmental factors in the entire water column and water transparency were made using the Secchi disk method at 4 stations of long-term zooplankton monitoring in Hornsund and its foreland.

Zooplankton samples were collected using the WP-2_500/MultiNet_180 network in a layer of 50-0 m in the entire water column, and hydrographic and water transparency measurements were made using the Secchi disc method at 16 stations at the auk's feeding ground in the Hornsund forefield.

- Meroplankton sampling for HIMERO

Meroplankton samples for genetic testing were collected using a Juday/56 µm net from the entire water column (bottom-0m) at selected 4 hydrographic stations in the Hornsund fjord and measurements of environmental factors in the entire water column and water transparency were carried out using the Secchi disc method. Sea water samples (2-3 l, from 5-7 depth levels) were collected at selected stations and then filtered on two filters with different porosity to verify chlorophyll concentrations.

- Zooplankton sampling for HIDEA

Zooplankton samples were collected using the WP-2_180 net from a layer of 0-50 m (optimally: two repetition) and measurements of environmental factors in the entire water column and water transparency were performed using the Secchi disc method and seawater samples were collected for the analysis of bacterioplankton and protozoan plankton (1L) from three depths (50 m, 25 m, 0 m), at the station in the inner basin and at the station by the estuary of the Hornsund fjord, then 1 L was filtered on each of the 2 filters of different thickness.

- Protista sampling for TWINS

Water samples were collected with a rosette with bathometers/single bathometer to determine the concentration POC, chlorophyll and qualitative-quantitative composition of Protista at 2 research stations located in different regions of the Polar Front (from 5-7 depths in water column).

MultiNet_60/Juday_56 zooplankton samples were collected to study the habitat preferences of selected zooplankton species at 2 research stations located in different regions of the Polar Front and measurements of environmental factors in the entire water column and water transparency using the Secchi disk method.

Zooplankton samples were collected using the WP3_1000 network to study the food preferences of selected zooplankton species at 2 research stations located in different regions of the Polar Front - mass selection of selected twin zooplankton species for further genetic, lipid and stable isotope analysis)

- Zooplankton sampling for PHARMARINE

One additional sample was collected with the WP2-500 net in the feeding area of the little auk in the foreground of the Hornsund Fjord, which was then placed in a ziplock bag and frozen at -80°C for further analysis for the content of pharmaceuticals in zooplankton.

Table 5. List of research stations for zooplankton monitoring in Hornsund, project HIMERO, project HIDEA, project TWINS carried by the PEP team during the AREX'2022 cruise leg IVa.

Station	**Measurement**	**Sampling**
H1/AUK1	CTD, Zooplankton (monitoring), meroplankton, water samples chla (HIMERO), water samples (protista, bacteria); zooplankton (HIDEA), water transparency	MultiNet_180, Juday_56, WP2_180 water carousel or bathometer, Secchi disk
H2	CTD, Zooplankton (monitoring), meroplankton, water samples chla (HIMERO), water samples (protista, POC, chla), zooplankton (TWINS), water transparency	MultiNet_180, MultiNet_60, WP3_1000, Juday_56 water carousel or bathometer, Secchi disk
H4	CTD, Zooplankton (monitoring), meroplankton, water samples chla (HIMERO), water transparency	WP2_180, Juday_56, water carousel or bathometer, Secchi disk
H3 /Brepollen	CTD, Zooplankton (monitoring), meroplankton (HIMERO), water samples (protista, bacteria); zooplankton (HIDEA), water transparency	WP2_180, Juday_56, water carousel or bathometer, Secchi disk

Table 6. List of research stations for zooplankton monitoring at the Horsund forefield for projects HIMERO, HIDEA, TWINS, and Pharmarine carried by the PEP team during the AREX'2022 leg IVa.

Station	Measurement	Samples
AUK2	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK3	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK4	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK7	CTD, Zooplankton (monitoring), zooplankton (Pharmarine), water transparency	WP2_500, Secchi disk
AUK9	CTD, Zooplankton (monitoring)	WP2_500, Secchi disk
AUK10	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK11/H6	CTD, Zooplankton (monitoring), water samples (protista, POC, chla), zooplankton (TWINS)	MultiNet_180, MultiNet_60, WP3_1000x 13, Juday_56, WP2_500, water carousel or bathometer, Secchi disk
AUK12	CTD, Zooplankton (monitoring), meroplankton (HIMERO), water transparency	WP2_500, Juday_56, Secchi disk
AUK13	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK14	CTD, Zooplankton (monitoring), meroplankton (HIMERO), water transparency	WP2_500, Juday_56, Secchi disk
AUK15	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK16	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK19	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK20	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK21	CTD, Zooplankton (monitoring), water transparency	WP2_500, Secchi disk
AUK22	CTD, Zooplankton (monitoring), meroplankton (HIMERO), water transparency	WP2_500, Juday_56, Secchi disk

4.3.3 Marine ecology measurements - plankton (PFBP)

The measurements included collection of water samples for the analysis of chlorophyll *a*, SPM, carotenoids, nano-, microplankton (bathometric bottle: 0, 5, 15, 25, 40 m, CoastDark; 5, 15, 25, 35, 50 m, Orange), nano- and microplankton (small planktonic net, approx. 25 m) and mesozooplankton (WP2/100um net, layers: bottom-50m-10m-0m, CoastDark; WP2/180um net 0-50m Orange, SEAPOP2). Plankton and particle distribution was measured using the LOPC-CTD-F-T (transect and vertical profile).

SPM – sea water filtered through Whatman glass fiber filters (GF/F, nominal pore size 0.7 µm). Material remaining on the filter was dried (24 h, 60°C) and then placed in a freezer (-80°C).

Chlorophyll a and carotenoids - sea water filtered through Whatman glass fiber filters (GF/F, nominal pore size 0.7 µm). Material remaining on the filter was placed in a freezer (-80°C).

Zooplankton – samples preserved with a solution of 4% formalin in sea water with the addition of borax (CoastDark, Orange, SeaPop2) and in ethanol (replacement after approx. 24h, Orange, SeaPop2), part frozen for carotenoid analysis (Orange).

Research stations: R12/H3, R13/HB1, R13, R11, R10, R9, R8, R7, R5, R3, R2, Hb2/H3, R6/H4, R4/H2, Rm1, Rm2, Rm3, Rm4, Rm5, Rm6, R1, , R0/H1, Auk7, Auk9, Auk10, Auk11, Auk12, Auk13, Auk14, Auk15, Auk16, Auk19, Auk20, Auk21, Belsund6, Belsund5, Belsund2 (Table 4, Figs 4, 7 and 8).

LOPC sections: between R13/HB1 and R0/H1, between Rm1 and Rm6, between Auk7 and Auk12, and between Auk13 and Auk16 (Table 4, Fig. 6).

4.3.4 Marine ecology measurements - benthos

As part of the long-term monitoring of benthic fauna (infauna) samples were collected at monitoring stations in the Hornsund. Macrofauna and meiofauna samples were collected at the monitoring stations in the fjords of Hornsund to determine the taxonomic composition, biomass, abundance, and biodiversity of benthos. On each station benthos sampling included samples for the: soft bottom sediments were collected using a van Veen's grab and a box-corer and hard bottom sediments using a bottom dredge. To select the macrofauna from the sediment collected with the van Veen grab, they were sieved on a 500 µm sieve.

In order to extract Kinorhynch from the sediments collected with the van Veen dredge, they were subjected to the 'bubble and blot' method on board. Cores were taken from the sediments collected with a box-corer for granulometric analysis, carbon and nitrogen content, concentration of dyes and meiofauna. In addition, surface sediments were collected with a sterile spatula for eDNA analysis. Hydrozoa samples were taken with a bottom dredge.

Samples were collected at stations H1, HB1, HB2, HB3 (soft bottom sediments) and BRY2 (hard bottom sediments) (Tab. 4, Fig. 4 and 7).

4.3.5 Marine chemistry measurements – ZChiBM WZEM/PBM

As part of the ArcticSGD project and statutory tasks, samples of bottom sediments were collected using the GEMAX core probe and the Van Veen scoop as well as the gravitational core (to identify freshwater sepage from bottom sediments). Sea water samples were collected using a rosette or a bathometer from specific depths. The basic parameters of sea water (temperature and salinity) were measured using the CTD probe. Seawater samples will be analyzed for the presence of total mercury. Bottom sediment samples will be analyzed for total mercury concentration, methylmercury concentration, concentration of individual labile and stable mercury fractions.

Samples were collected at stations Hans1, Hans2, Hans3, HB1, HB2, Bellsund1, Bellsund5, Bellsund6, SGD1, SGD2 (Tab. 4, Figs 4, 5 and 8).

4.3.6 Optical measurements

During the cruise leg IVa of the AREX2022 cruise the measurements were collected for Task II.5 and the DOMinEA project at selected stations using the following instruments:

- Optical-hydrological probe for measuring the inherent optical properties of seawater:

- CTD (Conductivity-Temperature-Depth) probe, Seabird SBE 49 FastCAT
- Light absorption and attenuation meter - AC9, (WetStar)
- WetStar 3-channel fluorimeter for measuring light fluorescence via CDOM
- DH4 data integrator, (WetLabs Inc.)

Figure 9. Optical-hydrological probe for measuring the inherent optical properties of sea water.

Using the optical-hydrological probe, the vertical profiles were made from the surface to a depth of approx. 180m or to the bottom at selected stations. The depth of the profile depended on the depth of a given location, the length of the measuring rope and weather conditions.

- Optical profiling system - COPs (Compact Optical Profiling system), (Biospherical Instruments Inc.) – a system of two radiometers for determining the apparent properties of sea water; one of them measures the bottom-up radiation, the other the radiation intensity. COPs are equipped with 19 spectral channels (340, 380, 395, 412, 443, 465, 490, 510, 520, 532, 555, 565, 589, 625, 665, 683, 710, 765 nm and the PAR channel).

Figure 10. The pictures show the compact optical profiling system COPs.

The COPs was lowered from the ship side in the free-fall mode, away from the ship shadow, to the depth of the lower border of the euphotic zone or to the bottom (depending on the location depth) or shallower (due to weather conditions). Underwater measurements were supplemented with simultaneous overwater measurements of Es(λ) radiation intensity using a sensor mounted on board the ship. These measurements were used to calculate the PAR level in the profiles and the color of the water ("ocean color").

- Surface platform for measuring upward radiation - RAMSES, TRIOS - a radiometer placed on a specially constructed frame, enabling measurement just below the water surface, regardless of weather conditions. Underwater measurements were supplemented by simultaneous above-water measurements of radiation intensity using a sensor on board the ship.

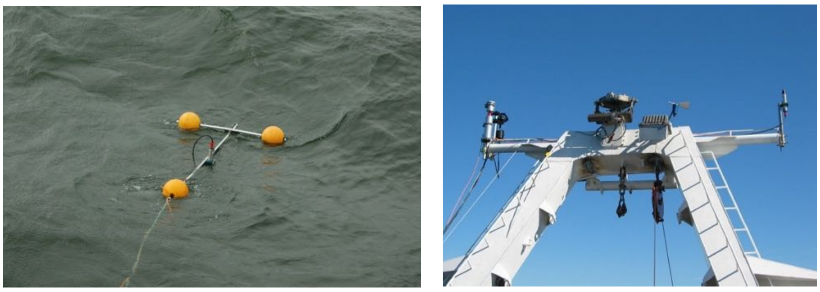

Figure 11. Surface platform for measuring upward radiation - RAMSES, TRIOS.

- Additionally, water was also collected for the determination of parameters:
  - $a_{CDOM}(\lambda)$ – light absorption by the CDOM,
  - a_{pl} – absorption of light by particles suspended in water,
  - EEM – DOM excitation and emission fluorescence matrices,
  - DOC – concentration of dissolved organic carbon,
  - Chla – chlorophyll *a* concentration,
  - HPLC – concentration of chlorophyll and accessoty pigments,
  - Lignin phenols – lignin concentration,
  - SPM – concentration of suspended organic matter,
  - Fractions - for some of the above parameters, water samples were taken from additionally separated fractions with the sizes of suspended particles of 20 µm, 5 µm, 2 µm.

Sea water samples were taken with a 30l bathometer or a rosette equipped with a set of 10l water bottles. Sampling depths were selected based on temperature, salinity, and chlorophyll a concentration profiles made just before water sampling. Water samples were always taken from the surface, chl *a* maximum, deep water chl *a* maximum, above the bottom.

Stations with optical measurements: Fugle 2, R12/H3, R13/HB1, HB3, HB2/H3, R6/H4, R4/H2, R0/H1/AUK1, AUK2, AUK3, AUK4, AUK11/H6 (Table 4).

4.3.7 Aerosol and meteorological measurements

The measurements were carried out using the following measurement equipment: OPC3N - Optical Particle Counter, Li-COR 7200, AE-31 eathalometer, Vaisala WXT563 autonomous weather station, Microtops II solar photometer, Ellipse-N-G4A2-B1. The measured parameters included the distribution of aerosol particle sizes in the surface layer of the atmosphere, concentration of marigenic aerosol, CO_2 and H_2O concentration in the atmosphere, concentration of Black Carbon particles in the surface layer of the atmosphere, wind speed and direction, air temperature and humidity, and ship motion was recorded using the inertial motion detection system. The measurements were carried out continuously. All data collected during the cruise leg IVa were stored in the IOPAN data base.

4.3.8 Physical oceanography measurements for the IOPAN Task I.4

Oceanographic measurements carried out during the fjord part of the AREX2022 cruise included measurements of vertical CTD profiles in Hornsund. Additionally, CTD measurements were made at all ecological stations in the Hornsund and Bellsund fjords and at the Hornsund forefield and water samples were collected using a hydrographic rosette. In total, 56 CTD profiles were recorded (Tab. 4, Figs 4, 7 and 8).

CTD measurements covered the whole water colum from the surface to the bottom. Depending on sampling needs, the SBE9/11+ measuring system with a rosette by Sea-Bird Electronics or the old system based also on the Sea-Bird Electronics SBE9/11+ probe, mounted in a protective cage, was used. The set with a bathymetric rosette, standardly used in ocean measurements, is equipped with a pressure sensor, a double set of seawater temperature and electroconductivity sensors, a water dissolved oxygen sensor, a fluorescence sensor, and an altimeter. The CTD system was mounted on the SeaBird bathymetric rosette equipped with 12 Niskin bottles (3x1.75 l. 9x12 l). Information about the individual sensors of both CTD measurement systems is given in Table 2 (same systems as used during the cruise legs II and III).

4.4 Measurements and sampling during the AREX2022 leg IVb (Kongsfjorden)

4.4.1 General information

The cruise was started and ended in Longyearbyen. During this leg, field work was carried out in Kongsfjorden, Krossfjorden and their forefields, with additional terrestrial sampling on the Prins Karls Forland. The positions of stations and measurement/sampling type on each station are presented on Fig. 12 and in Table 7.

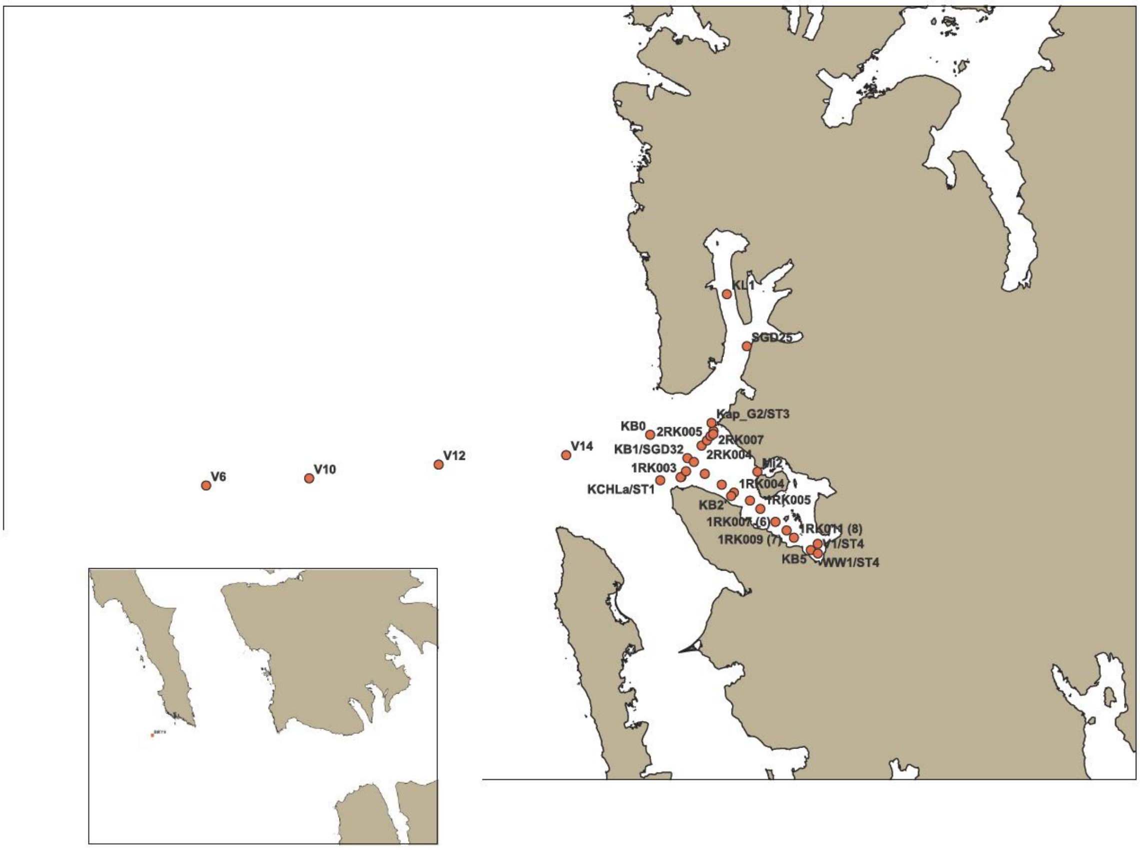

Figure 12. Map of measurements and sampling stations during the leg IVb of the AREX2022 cruise.

Table 7. The station list and details of the measurements with responsible IOPAN labs during the leg IVb of the AREX2022 cruise.

Station name	Depth water (m)	Data	Time UTC	Lat	Lon	Measurement	IOPAN labs responsible					
							ZDM OOLab	ZEM Bentos	ZChiBM WZEM/PBM	ZFM Optics	ZEM PEP	ZEM PFBP
V6	1135	07.08.22	7:40	78 54.430	07 45.31	CTD DO F; CTD, zooplankton (monitoring); net (phyto), WP2_180 (2x), caretonoids; water column (Radon, CTD, alkalinity (AT), dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), chlorines, nutrients (Nu), isotopes, macroions (Me));	x		x		x	x
V10	328	07.08.22	11:30	78 56.130	08 32.088	CTD DO F; CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency; mezozooplankton (WP2/180 µm, 0-50m)	x				x	x
V12	219	07.08.22	15:10	78 58.513	09 30.988	CTD DO F; CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency; mezozooplankton (WP2/180 µm, 0-50m)	x				x	x
V14	265	07.08.22	18:00	79 0.312	10 29.536	CTD DO F; SPM, apl, Chla, HPLC, fik, CDOM, fractions, PSD, POC, DOC, EEM, lignins, Secchi disk, C-Ops, ac9plus, radiation, Viper, Hydroscat-4; CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency; LOPC vert., net (phyto), WP2_180, caretonoids	x			x	x	x
KB0	312	08.08.22	8:30	79 02.648	11 07.842	CTD DO F; SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation; CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency; chlorofilu a, SPM, pierwotniaków CoastDark; LOPC vert., net (phyto), WP2_100, SPM, Chl, caretonoids	x			x	x	x
KB1 /SGD32	327	08.08.22	10:30	79 00.794	11 25.829	CTD DO F; SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation; CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water samples (protista; bacteria); zooplankton (HIDEA), water transparency; LOPC vert., net (phyto), WP2_180, caretonoids; Kioryncha; water column (CTD, Rn, AT, DIC, DOC, Nu, Me, isotopes); surface sediment (porosity, macro- meio-fauna); pore water samples (AT, DIC, DOC, Nu, Me, isotopes, Cl-)	x		x	x	x	x
KB3	344	08.08.22	14:50	78 57.348	11 55.896	CTD DO F; SPM, apl, Chla,HPLC, fik, POC, CDOM, fractions, PSD, DOC, EEM, lignins, Secchi disk, C-Ops, ac9plus, radiation, Viper, Hydroscat-4; SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation; CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency; chl a, SPM, prostista samples CoastDark; Kinoryncha; water column (CTD, Rn, AT, DIC, DOC, Nu, Me, Water isotopes);	x		x	x	x	x
1RK004	285	08.08.22	19:21	78 57.976	11 48.286	CTD, LOPC vert.	x					x
KB2	315	08.08.22	20:03	78 58.621	11 42.439	CTD, LOPC vert.	x					x

1RK003	220	08.08.22	20:30	78 57.348	11 55.896	CTD, LOPC vert.	x					x
2RK001	180	08.08.22	21:16	78 59.066	11 23.218	CTD, LOPC vert.	x					x
2RK002	320	08.08.22	21:50	78 59.625	11 55.577	CTD, LOPC vert.	x					x
2RK003	385	09.08.22	6:22	79 00.488	11 28.927	CTD, LOPC vert.	x					x
2RK004	226	09.08.22	6:55	79 01.973	11 32.047	CTD, LOPC vert.	x					x
2RK005	128	09.08.22	7:19	79 02.458	11 34.424	CTD, LOPC vert.	x					x
2RK006	66	09.08.22	7:35	78 57.348	11 55.896	CTD, LOPC vert.	x					x
2RK007	24	09.08.22	7:53	79 03.326	11 37.186	CTD, LOPC vert.	x					x
Mi2	67	09.08.22	8:55	78 59.940	11 58.646	CTD; SPM, apl, Chla, HPLC, fik, POC, PSD, Secchi disk, fractions, PSD, Viper, Hydroscat-4; osad, bentos vanVeen, box-corer; water column (CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes); surface sediment (porosity, macro- and meio-fauna); pore water samples (AT, DIC, DOC, Nu, Me, Water isotopes, Cl-), LOPC vert.	x	x	x	x		x
SGD23	138	09.08.22	13:04	78 56.058	11 57.396	CTD; water column (CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes); surface sediment (porosity, macro- and meio-fauna); pore water samples (AT, DIC, DOC, Nu, Me, Water isotopes, Cl-)	x		x			
E4/KG1	270	09.08.22	16:28	78 59.492	11 34.316	CTD; osad, bentos vanVeen, 3box-corer; Kinoryncha; LOPC vert.	x	x				x
KB2'	183	10.08.22	15:58	78 57.668	11 47.087	CTD; SPM, apl, Chla, HPLC, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation; CTD, water samples (protista, POC, chla), zooplankton (TWINS), water transparency; LOPC vert.	x			x	x	x
KB5	76	11.08.22	10:54	78 53.232	12 25.010	CTD DO F; SPM, apl, Chla, HPLC, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation; CTD, zooplankton (monitoring and HIDEA), water samples (protista; bacteria); zooplankton (HIDEA), meroplankton, water samples Chla (HIMERO), water transparency; LOPC vert., net (phyto), WP2_100, WP2_180, SPM, Chl, caretonoids	x			x	x	x
WW1/ST4	71	11.08.22	13:44	78 52.956	12 28.318	CTD DO F; dredges, nets WP2, WP3 (mammal food); LOPC vert.	x					x
V1/ST4	86	11.08.22	14:44	78 53.807	12 28.080	CTD DO F; vanVeen, box-corer; Kinoryncha; water column (CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes); surface sediment (porosity, macro- and meio-fauna); pore water samples (AT, DIC, DOC, Nu, Me, Water isotopes, Cl-); LOPC vert.	x	x	x			x
1RK011 (8)	43	11.08.22	18:54	78 54.259	12 16.993	CTD, LOPC vert.	x					x
1RK009 (7)	84	11.08.22	19:20	78 54.871	12 13.471	CTD, LOPC vert.	x					x
1RK007 (6)	97	11.08.22	19:53	78 55.582	12 08.143	CTD, LOPC vert.	x					x
1RK005	230	11.08.22	20:44	78 56.661	12 00.880	CTD, LOPC vert.	x					x
SGD25	140	12.08.22	9:00	79 10.996	11 50.580	CTD; SPM, apl, Chla, HPLC, fik, POC, PSD, Secchi disk, Viper, Hydroscat-4; Water column (CTD, Rn, AT, DIC, DOC, Nu, Me, Water isotopes); surface sediment (porosity, macro- meio-fauna); pore water samples (AT, DIC, DOC, Nu, Me, water isotopes, Cl-);	x		x	x		
KL1	259	12.08.22	16:57	79 15.502	11 39.780	CTD; SPM, apl, Chla, HPLC, fik, POC, PSD, Secchi disk, Viper, Hydroscat-4; Water column (CTD, Rn, AT, DIC, DOC, Nu, Me, Water isotopes); surface sediment (porosity, macro- and meio-fauna); pore water samples (AT, DIC, DOC, Nu, Me, water isotopes, Cl-)	x		x	x		
BRY9	80	13.08.22	13:59	78 10.960	11 43.655	CTD; dredge (Hydrozoa)	x	x				

KCHLa /ST1	100	10.08.22	08:25	78 58.679	11 13.881	dredge (Chlamys islandica); dredge, nets WP2, WP3 (mammal food)		x				
Kap_G1 /ST2	40-110	10.08.22	10:50	79 03.057	11 37.153	dredge (Hydrozoa); dredge and nets WP2, WP3 (mammal food)		x				
Kap_G2 /ST3	100	10.08.22	11:19	79 04.036	11 36.050	dredge and nets WP2, WP3 (mammal food)		x				
ST5	248	11.08.22	22:34	78 56.604	12 01.378	dredge and nets WP2, WP3 (mammal food)		x				

4.4.2 Marine ecology measurements - plankton (PEP)

- Long-term zooplankton monitoring under the AREX program (Task I.5)

Zooplankton samples were collected using the MultiNet_180/WP2_180 net in vertical hauls and measurements of environmental factors in the entire water column and water transparency were made using the Secchi disk method at 8 stations of long-term zooplankton monitoring in Kongsfjord and its foreground.

- Zooplankton sampling for HIMERO

Zooplankton samples were collected using the Juday_56 net in bottom-to-surface vertical hauls at selected 4 hydrographic stations in Kongsfjord and its foreground, and environmental factors were measured the water column and water transparency using the Secchi disc method.

Samples of zooplankton above and below the halocline were collected using the Juday56 net at selected 7 hydrographic stations in Kongsfjord and its foreground.

Water samples for chlorophyll measurements were collected with a rosette with bathometers/single bathometer at each of the selected stations (approx. 2-3l of water from each station) from 5-7 depths in the water column (depths determined based on the fluorescence measurement), then filtered in duplicate, for each of the 2 filters of different thickness.

- Zooplankton sampling for HIDEA

Zooplankton samples were collected using the WP-2_180 net from a layer of 0-50 m (optimally: two repetition) and measurements of environmental factors in the entire water column and water transparency were performed using the Secchi disc method and seawater samples were collected for the analysis of bacterioplankton and protozoan plankton (1L) from three depths (50 m, 25 m, 0 m), at the station in the inner basin and at the station by the estuary of the Kongsfjorden fjord, then 1 L was filtered on each of the 2 filters of different thickness.

- Zooplankton sampling for TWINS

MultiNet_60/Juday_56 zooplankton samples were collected to study the habitat preferences of selected zooplankton species at 1 research stations and measurements of environmental factors in the entire water column and water transparency using the Secchi disk method.

Zooplankton samples were collected using the WP3_1000 network to study the food preferences of selected zooplankton species at one research station - mass selection of selected twin zooplankton species for further genetic, lipid and stable isotope analysis.

Table 8. List of stations for zooplankton monitoring in Kongsfjorden for the projects HIMERO, HIDEA, and TWINS during the AREX'2022 cruise leg IVb.

Station name	Latitude	Longitude	Measurement	Samples
V6	78°54.401	7°45.804	CTD, zooplankton (monitoring)	MultiNet_180, Secchi disk
V10	78°56.133	8°32.119	CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency	MultiNet_180, Juday-56, water carousel or bathometers, Secchi disk
V12	78°58.513	9°30.988	CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency	MultiNet_180, Juday-56, water carousel or bathometers, Secchi disk
V14	79°0.404	10°28.493	CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency	MultiNet_180, Juday-56, water carousel or bathometers, Secchi disk
KB0	79°2.569	11°7.981	CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency	WP2-180x2, Juday-56, water carousel or bathometers, Secchi disk
KB1	79°0.809	11°25.638	CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water samples (protista, bacteria); zoopl. (HIDEA), water transparency	MultiNet_180, Juday-56, WP2_180x2, water carousel or bathometers, Secchi disk
KB3	78°57.327	11°56.018	CTD, zooplankton (monitoring), meroplankton, water samples Chla (HIMERO), water transparency	MultiNet_180, Juday-56 x3, water carousel or bathometers, Secchi disk
KB2'	78°57.692	11°47.073	CTD, water samples (protista, POC, chla), zooplankton (TWINS), water transparency	MultiNet_60x2, Juday-56 x1, WP3-1000 x14, water carousel or bathometers, Secchi disk
KB5	78°53.235	12°25.009	CTD, zooplankton (monitoring and HIDEA), water samples (protista, bacteria); zooplankton (HIDEA), meroplankton, water samples Chla (HIMERO), water transparency	MultiNet_180, WP2-180, Juday-56, water carousel or bathometers, Secchi disk

Collected zooplankton samples were preserved with a solution of 4% formalin in sea water or in ethanol. Protozoan samples were preserved with Lugol's solution, and filters with chlorophyll and suspension were frozen at -80°C. After being transported to the country, the planktonic samples will be subjected to a qualitative and quantitative analysis.

4.4.3 Marine ecology measurements - plankton (PFBP)

The measurements included collection of water samples for the analysis of chlorophyll *a*, SPM, carotenoids, nano-, microplankton (bathometric bottle: 0, 5, 15, 25, 40 m, CoastDark; 5, 15, 25, 35, 50 m, Orange), nano- and microplankton (small planktonic net, approx. 25 m) and mesozooplankton (WP2/100um net, layers: bottom-50m-10m-0m, CoastDark; WP2/180um net 0-50m Orange, SEAPOP2). Plankton and particle distribution was measured using the LOPC-CTD-F-T (sections - Task I.7 and vertical profiles - CoastDark).

Table 9. List of stations for zooplankton monitoring at the Kongsfjorden forefield for the projects CoastDark, Orange, and SEAPOP2 during the AREX'2022 cruise leg IVb.

Name station	Depth water (m)	Latitude	Longitude	Measurements/sampling
V6	1122	78.907	7.763	net (phyto), WP2_180 (2x), caretonoids
V10	528	78.936	8.534	WP2_180
V12	219	78.975	9.516	WP2_180
V14	275	79.006	10.509	LOPC vert., net (phyto), WP2_180 (2x), caretonoids
KB0	328	79.046	11.131	LOPC vert., net (phyto), WP2_100, SPM, Chl, caretonoids
KB1	330	79.013	11.433	LOPC vert., net (phyto), WP2_180 (2x), caretonoids
KB3	349	78.955	11.933	LOPC vert., net (phyto), WP2_100, SPM, Chl, caretonoids
1RK004	287	78.968	11.802	LOPC vert.
KB2	312	78.978	11.706	LOPC vert.
1RK003	220	78.996	11.565	LOPC vert.
2RK001	197-223	78.985	11.393	LOPC vert.

2Rk002	313	78.996	11.433	LOPC vert.
2RK003	390	79.008	11.473	LOPC vert.
2RK004	237	79.026	11.533	LOPC vert.
2RK005	135	79.041	11.574	LOPC vert.
2RK006	68	79.048	11.599	LOPC vert.
2RK007	23-27	79.055	11.620	LOPC vert.
Mi2	70	78.999	11.976	LOPC vert.
E4	275	78.991	11.573	LOPC vert.
KB2’	186	78.962	11.786	LOPC vert.
KB5	79	78.887	12.417	LOPC vert., fito, WP2_100, WP2_180 (2x), SPM, Chl, caretonoids
WW1	78	78.883	12.473	LOPC vert.
V1	76	78.897	12.467	LOPC vert.
1RK008	41	78.904	12.287	LOPC vert.
1RK007	89	78.914	12.230	LOPC vert.
1RK006	101	78.926	12.141	LOPC vert.
1RK005	239	78.944	12.023	LOPC vert.

SPM – sea water filtered through Whatman glass fiber filters (GF/F, nominal pore size 0.7 µm). The material that remained on the filter was dried (24 h, 60 degrees C) and then placed in a freezer (-80st C). Chlorophyll a and carotenoids - sea water filtered through Whatman glass fiber filters (GF/F, nominal pore size 0.7 µm). The material that remained on the filter was placed in a freezer (-80st C). Protists (nano- and microplankton) – samples preserved with Lugol's liquid. Zooplankton – samples preserved with a solution of 4% formalin in sea water with the addition of borax (CoastDark, Orange, SeaPop2) and in ethanol (replacement after approx. 24h, Orange, SeaPop2), part frozen for carotenoid analysis (Orange).

4.4.4 Marine ecology measurements - benthos

As part of the long-term monitoring of benthic fauna samples of macrofauna (van Veen grab) and meiofauna (box-corer) were collected at 3 stations in Kongsfjorden. At the same stations, sediment samples were taken for grain size analysis, concentration of photosynthetic pigments, content of organic carbon and total nitrogen and their isotopes. Macrofauna samples were washed on a sieve with a diameter of 0.5mm net and preserved with 4% formalin solution. Meiofauna samples were preserved with 4% formalin. In addition, a large number of *Chlamys islandica* mussels were collected using the dredge for the Pharmarine project and *Hydrozoa* for the Ascomea project. Meiofauna samples for taxonomic purposes (Kinorhyncha) were collected at four stations. At five stations, planktonic and benthic species (dredges, WP2 and WP3 net) were collected for research on the composition of marine mammals' food (NPI project). In addition, the bottom was filmed in 4 locations under the bird cliff in Krossfjorden.

Table 10. List of stations for benthos monitoring in Kongsfjorden during the AREX’2022 cruise leg IVb.

Station name	Latitude	Longitude	Sample type	Analyzes
E4	78° 59.492	11° 34.316	sediment, benthos, Kinoryncha (vanVeen, box corer)	POC, TOC_{org}, N_{tot}, isotopes C i N, granulometry, photosynthetic pigments, macro- and meiofauna, taxonomy
Mi2 /SGD42	78°59.958	11°58.616	sediment, benthos, vanVeen, box corer	POC, TOC_{org}, N_{tot}, isotopes C i N, granulometry, photosynthetic pigments, macro- and meiofauna, taxonomy

V1 /ST4	78°53.816	12°28.101	sediment, benthos, Kinoryncha (vanVeen, box corer); marine mammals' food (nets WP3, WP2, dredge)	POC, TOC_{org}, N_{tot}, isotopes C i N, granulometry, photosynthetic pigments, macro- and meiofauna, taxonomy; stable isotopes of carbone and nitrogen
KChla /ST1	78°53.679	11°13.881	*Ch. Islandica* (dredge); marine mammals' food (nets WP3, WP2, dredge)	experiments focused on pharmaceutics impacts on fauna (UG); stable isotopes of carbone and nitrogen
Kb1	79°0.809	11°25.638	Kinoryncha (box corer)	taxonomy
Kb3	78°57.331	11°56.027	Kinoryncha (box corer)	taxonomy
KAP_G1/ ST2	78°03.057	11°37.153	Hydrozoa (dredge); marine mammals food (nets WP3, WP2, dredge)	taxonomy; stable isotopes of carbone and nitrogen
KAP_G2/ ST3	79 04.036	11 36.050	Hydrozoa (dredge); marine mammals food (nets WP3, WP2, dredge)	taxonomy; stable isotopes of carbone and nitrogen
BRY9	78°11.422	11°39.636	Hydrozoa (dredge)	taxonomy
ST5	78° 56.604	12° 01.378	marine mammals food (nets WP3, WP2, dredge)	stable isotopes of carbone and nitrogen
Kam1	79 13.247	11 52.198	Underwater camera	
Kam2	79 13.024	11 50.748	Underwater camera	
Kam3	79 12.956	11 50.092	Underwater camera	
Kam4	79 12.961	11 50.335	Underwater camera	

Macro- and meiobenthos samples preserved in a 4% formalin solution in sea water will be subjected to qualitative and quantitative analysis. Sediments frozen at -20°C (samples for grain size analysis, eDNA, and the amount and quality of organic carbon) or at -80°C (samples for photosynthetic dye analysis). Hydrozoa samples were preserved in 96% ethanol. Kinorhynch organisms extracted from the collected bottom sediments after collection on board the ship, and initially identified using a binocular, were preserved in 10% formalin in seawater and some in ethyl alcohol.

4.4.5 Marine chemistry measurements

As part of the ArcticSGD project, CTD measurements were carried out (using a rosette equipped with a CTD probe or a CTD probe launched from the side crane), seawater samples were taken (using a rosette or bathometer) and bottom sediments (using Gemax and gravity corer) for identification of freshwater sepage from bottom sediments. The research plan was fully implemented, and samples were taken from additional stations.

Table 11. List of stations with chemical measurements and sampling in Kongsfjorden during the AREX2022 cruise leg IVb.

Station name	Latitude	Longitude	Sample type	Chemical analyses
V6	78°54.438	7°45.840	Water column	Radon, CTD, alkalinity (AT), dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), chlorines, nutrients (Nu), water isotopes, macroions (Me)
KB1 /SGD32	79°00.808	11°25.648	Water column	CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes
			Surface sediment	Porosity, marco- and meiofauna
			Pore water samples	AT, DIC, DOC, Nu, Me, water isotopes, Cl^-
KB3	78°57.331	11°56.027	Water column	CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes
Mi2 /SGD42	78°59.958	11°58.616	Water column	CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes
			Surface sediment	Porosity, marco- and meiofauna
			Pore water samples	AT, DIC, DOC, Nu, Me, water isotopes, Cl^-
SGD23	78°56.066	11°57.509	Water column	CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes
			Surface sediment	Porosity
			Pore water samples	AT, DIC, DOC, Nu, Me, water isotopes, Cl^-
V1	78°53.806	12°28.031	Water column	CTD, Rn, AT, DIC, DOC, Nu, Me, Water isotopes
			Surface sediment	Porosity, marco- and meiofauna

			Pore water samples	AT, DIC, DOC, Nu, Me, water isotopes, Cl^-
SGD25	79°10.99	11°50.547	Water column	CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes
			Surface sediment	Porosity
			Pore water samples	AT, DIC, DOC, Nu, Me, water isotopes, Cl^-
KL1	79°15.500	11°39.806	Water column	CTD, Rn, AT, DIC, DOC, Nu, Me, water isotopes
			Surface sediment	Porosity, marco- and meiofauna
			Pore water samples	AT, DIC, DOC, Nu, Me, Water isotopes, Cl^-

As part of the sampling on the island of Prins Karls Forland, approximately 10 kg of soil was collected from above and below the permafrost layer. The samples were frozen and transported to the laboratory. The samples will be used in incubation experiments during which the following parameters will be measured: DIC, DOC, alkalinity, nutrients, and oxygen concentration. At the same time, surface water samples were collected from the water reservoir located in the immediate vicinity of the permafrost for the following parameters: DIC, DOC, alkalinity, nutrients, metals. Seawater samples collected in bottles were preserved for transport. Bottom sediment samples were frozen at -20°C.

4.4.6 Optical measurements

Surface water was collected and filtered for further analysis: Chla, HPLC, apl; CDOM, DOC, EEM, lignins, SPM, Chla, HPLC, fic, POC, apl, PSD. Secchi depth was measured, backscatter in the water column was measured with HydroScat-4, light attenuation by particles and CDOM absorption with Viper, collected and filtered for analysis. Measurements of light absorption and attenuation in the vertical profile (ac9plus), top-down radiation on the sea surface (trios) and top-down and bottom-up radiation in the vertical profile (C-OPs) were performed.

Table 11. List of stations with optical measurements during the AREX2022 cruise leg IVb.

Station name	Depth [m]	fr	Secchi dysk	Latitude	Longitude	Parameters and measurements
V14	15			79,007	10,474	SPM, apl, Chla, HPLC, fik, CDOM, fractions, PSD, POC, DOC, EEM, lignins, Secchi disk, C-Ops, ac9plus, radiation, Viper, Hydroscat-4
	25					
	50					
KB0	0-wiadro	all	6,5	79,043	11,133	SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation
	0-wiadro	all				
	0-wiadro	all				
	0-wiadro	A				
	0-wiadro	A				
	0-wiadro	A				
	0-wiadro	B				
	0-wiadro	B				
	0-wiadro	B				
	0-wiadro	C				
	0-wiadro	C				
	0-wiadro	C				
	0					
	15					
	30					
	80					
KB1	0-wiadro	all	3,0	78,696	11,811	SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation
	0-wiadro	all				
	0-wiadro	all				
	0-wiadro	A				

	0-wiadro	A				
	0-wiadro	A				
	0-wiadro	B				
	0-wiadro	B				
	0-wiadro	B				
	0-wiadro	C				
	0-wiadro	C				
	0-wiadro	C				
	0					
	25					
	60					
	100					
Mi2	0			78,999	11,977	SPM, apl, Chla, HPLC, fik, POC, PSD, Secchi disk, fractions, PSD, Viper, Hydroscat-4
	0					
	0					
KB3	0		2,0	78,955	11,933	SPM, apl, Chla, HPLC, fik, POC, CDOM, fractions, PSD, DOC, EEM, lignins, Secchi disk, C-Ops, ac9plus, radiation, Viper, Hydroscat-4
	15					
	25					
	60					
KB3	0-wiadro	all	3,0	78,956	11,935	SPM, apl, Chla, HPLC, fractions, PSD, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation
	0-wiadro	A				
	0-wiadro	B				
	0-wiadro	C				
KB2'	0		4,0	78,962	11,784	SPM, apl, Chla, HPLC, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation
	20					
	60					
KB5	0		1,0	78,971	12,416	SPM, apl, Chla, HPLC, CDOM, DOC, EEM, lignins, C-Ops, ac9plus, radiation
	25					
	50					
	75					
SGD25	0-wiadro		3,0	79,183	11,845	SPM, apl, Chla, HPLC, fik, POC, PSD, Secchi disk, Viper, Hydroscat-4
KL1	0-wiadro		2,0	79,258	11,663	SPM, apl, Chla, HPLC, fik, POC, PSD, Secchi disk, Viper, Hydroscat-4

4.4.7 Aerosol and meteorological measurements

The measurements were carried out using the following measurement equipment: OPC3N - Optical Particle Counter, Li-COR 7200, AE-31 eathalometer, Vaisala WXT563 autonomous weather station, Microtops II solar photometer, Ellipse-N-G4A2-B1. The measured parameters included the distribution of aerosol particle sizes in the surface layer of the atmosphere, concentration of marigenic aerosol, CO_2 and H_2O concentration in the atmosphere, concentration of Black Carbon particles in the surface layer of the atmosphere, wind speed and direction, air temperature and humidity, and the recording of the ship motion using an inertial motion detection system was also introduced. The measurements were carried out continuously. All data collected during stage IVb were deposited on a network drive at the Institute of Oceanology PAN.

4.4.8 Physical oceanography measurements for the IOPAN Task I.4

Oceanographic measurements carried out during the fjord part of the AREX 2022 cruise included measurements of vertical CTD profiles in Kongsfjord. Additionally, CTD measurements were made at all ecological stations in Kongsfjorden, on the shelf and at the fjord forefield. In total, 30 CTD profiles were recorded.

Table 12. List of CTD stations in Kongsfjorden, Krossfjorden and their forefield during the AREX2022 cruise leg IVb.

Station name	Water depth (m)	Data	Time UTC	Lat	Lon	Measurement
V6	1135	07 08 2022	07:40	78 54.430	07 45.31	CTD DO F
V10	328	07 08 2022	11:30	78 56.130	08 32.088	CTD DO F
V12	219	07 08 2022	15:10	78 58.513	09 30.988	CTD DO F
V14	265	07 08 2022	18:00	79 0.312	10 29.536	CTD DO F
KB0	312	08 08 2022	08:30	79 02.648	11 07.842	CTD DO F
KB1/SGD32	327	08 08 2022	10:30	79 00.794	11 25.829	CTD DO F
KB3	344	08 08 2022	14:50	78 57.348	11 55.896	CTD DO F
1RK004	285	08 08 2022	19:21	78 57.976	11 48.286	CTD
KB2	315	08 08 2022	20:03	78 58.621	11 42.439	CTD
1RK003	220	08 08 2022	20:30	78 05.772	11 33.896	CTD
2RK001	180	08 08 2022	21:16	78 59.066	11 23.218	CTD
2RK002	320	08 08 2022	21:50	78 59.625	11 55.577	CTD
2RK003	385	09 08 2022	06:22	79 00.488	11 28.927	CTD
2RK004	226	09 08 2022	06:55	79 01.973	11 32.047	CTD
2RK005	128	09 08 2022	07:19	79 02.458	11 34.424	CTD
2RK006	66	09 08 2022	07:35	79 02.873	11 95.914	CTD
2RK007	24	09 08 2022	07:53	79 03.326	11 37.186	CTD
Mi2	67	09 08 2022	08:55	78 59.940	11 58.646	CTD
SGD23	138	09 08 2022	13:04	78 56.058	11 57.396	CTD
E4/KG1	270	09 08 2022	16:28	78 59.492	11 34.316	CTD
KB2'	183	10 08 2022	15:58	78 57.668	11 47.087	CTD
KB5	76	11 08 2022	10:54	78 53:232	12 25.010	CTD DO F
WW1/ST4	71	11 08 2022	13:44	78 52.956	12 28.318	CTD DO F
V1	86	11 08 2022	14:44	78 53.807	12 28.080	CTD DO F
1RK011 (8)	43	11 08 2022	18:54	78 54.259	12 16.993	CTD
1RK009 (7)	84	11 08 2022	19:20	78 54.871	12 13.471	CTD
1RK007 (6)	97	11 08 2022	19:53	78 55.582	12 08.143	CTD
1RK005	230	11 08 2022	20:44	78 56.661	12 00.880	CTD
SGD25	140	12 08 2022	09:00	79 10.996	11 50.580	CTD
KL1	259	12 08 2022	16:57	79 15.502	11 39.780	CTD
BRY9	80	13 08 2022	13:59	78 10.960	11 43.655	CTD

4.4.9 Marine acoustic measurements

On August 10-11 acoustic profiling of the water column was carried out in Kongsfjorden to detect ichtiofauna occurring in this area. A triple frequency echo sounder SIMRAD EK60 was used to perform this task, generating acoustic pulses at frequencies of 70 kHz, 120 kHz, and 200 kHz. Before starting the data recording, sea water parameters were measured using a CTD probe, and then a partial calibration of the echo sounder was carried out at the position of 78°57.591'N and 11°47.439'E. Due to the strong currents (>=0.5 knots) generated by the tides that occurred during the calibration process, it was only successfully for the 70 kHz transducer. After completing the calibration of the SIMRAD EK60 sonar, hydroacoustic data were collected along four previously planned profiles.

Table 13. Hydroacoustic sections in Kongsfiord measurred during the AREX'2022 cruise leg IVb.

Profile ID	Start		End	
	Lat	Lon	Lat	Lon
1a (profile along the fjord)	78° 53,120 N	12° 27,589 E	78° 56,714 N	11° 59,200 E

1b (profile along the fjord)	78° 56,714 N	11° 59,200 E	79° 00,475 N	11° 28,420 E
1c (profile along the fjord)	79° 00,475 N	11° 28,420 E	79° 02,955 N	11° 01,691 E
2 (cross profile)	79° 02,993 N	11° 36,473 E	78° 58,932 N	11° 23,228 E
3 (cross profile)	79° 01,547 N	11° 49,984 E	78° 58,242 N	11° 38,298 E
4 (cross profile)	78° 57,520 N	12° 01,009 E	78° 55,871 N	11° 56,266 E

4.5 Measurements and sampling during the AREX'2022 leg IVc (Isfjorden)

4.5.1 General information

Fig. 13 and Table 14 present the station list where measurements were carried out and samples collected during the cruise leg IVc.

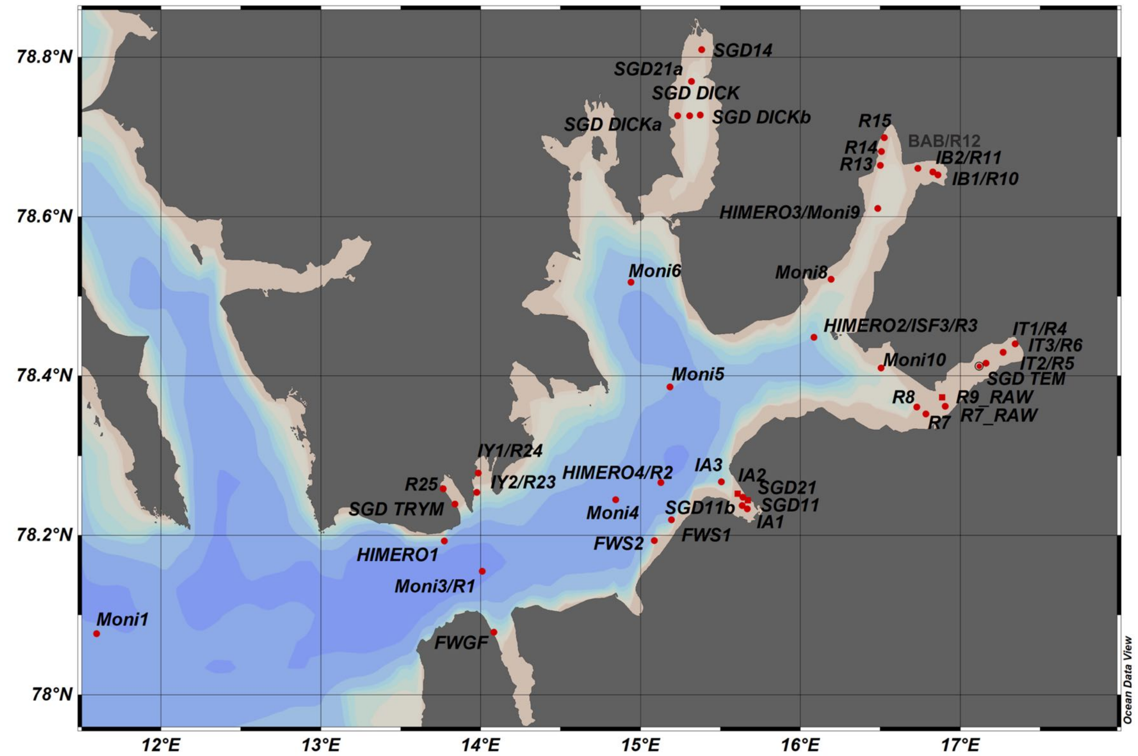

Figure 13. Map of measurement and sampling stations during the leg IVc of the AREX2022 cruise.

Table 14. List of stations completed during the AREX 2022 leg IVc.

Lp.	Location	Station name	Latitude and longitude	
1	Fjord axis	Moni5	78 23.142	15 11.110
2	Grumant	Himero4/R2	78 15.950	15 07.658
3	Fjord axis	MONI4	78 14.672	14 50.790
4	Adventfjorden	IA1	78 13.979	15 40.073
5	Adventfjorden	SGD11	78 14.219	15 38.221
6	Adventfjorden	SGD21	78 14.870	15 38.438
7	Adventfjorden	SGD11b	78 14.633	15 40.294
8	Adventfjorden	IA2	78 15.139	15 36.404
9	Adventfjorden	IA3	78 16.002	15 30.385
10	Billefjorden	MONI8	78 31.260	16 11.538
11	Billefjorden	HIMERO3/MONI9	78 36.601	16 29.090
12	Billefjorden	IB1/R10	78 39.109	16 51.755
13	Billefjorden	IB2/R11	78 39.333	16 49.825
14	Billefjorden	BAB/R12	78 39.606	16 44.164

15	Sassenfjorden	R7	78 21.132	16 47.168
16	Tempelfjorden	SGD TEM	78 24.712	17 07.229
17	Tempelfjorden	IT1/R4	78 26.401	17 20.698
18	Tempelfjorden	IT2/R5	78 25.775	17 16.214
19	Tempelfjorden	IT3/R6	78 24.956	17 09.697
20	Sassenfjorden	R8	78 21.634	16 43.722
21	Sassenfjorden	MONI10	78 24.585	16 30.289
22	Sassenfjorden	R7_RAW	78 21.708	16 54.436
23	Sassenfjorden	R9_RAW	78 22.386	16 53.242
24	Nordfjorden	MONI6	78 31.040	14 56.425
25	Dicksonfjorden	SGD DICK	78 43.573	15 18.498
26	Dicksonfjorden	SGD DICKa	78 43.564	15 13.978
27	Dicksonfjorden	SGD DICKb	78 43.640	15 22.524
28	Dicksonfjorden	SGD21a	78 46.144	15 19.150
29	Dicksonfjorden	SGD14	78 48.538	15 23.076
30	Billefjorden	R15	78 41.928	16 31.625
31	Billefjorden	R14	78 40.868	16 30.518
32	Billefjorden	R13	78 39.834	16 30.129
33	Billefjorden	HIMERO2/ISF3/R3	78 26.881	16 05.183
34	Ymerbukta	IY1/R24	78 16.674	13 59.124
35	Ymerbukta	IY2/R23	78 15.221	13 58.595
36	Trygghamna	R25	78 15.493	13 46.079
37	Trygghamna	SGD TRYM	78 14.345	13 50.435
38	Oś fiordu	HIMERO1	78 11.546	13 46.448
39	Oś fiordu	MONI3/R1	78 09.288	14 00.666
40	Oś fiordu	MONI1	78 04.567	11 35.892
41	Trygghamna	SGD TRYM	78 14.346	13 50.241
42	Trygghamna	R25	78 15.533	13 47.730
43	Tempelfjorden	SGD TEM	78 24.806	17 06.748
44	Groenfjorden	FWGF	78 04.681	14 05.074
45	Grumant	FWS2	78 11.594	15 05.258
46	Grumant	FWS1	78 13.146	15 11.743
47	Adventfjorden	SGD21	78 14.938	15 38.614
48	Adventfjorden	SGD11	78 14.198	15 38.009

4.5.2 Marine ecology measurements - plankton (PEP)

- Zooplankton sampling for HIMERO

Zooplankton samples were collected using the Juday_56 net in bottom-to-surface vertical hauls at selected 4 hydrographic stations in Isfjorden and environmental factors were measured the water column and water transparency using the Secchi disc method.

Water samples for chlorophyll measurements were collected with a rosette with bathometers/single bathometer at each of the selected stations (approx. 2-3l of water from each station) from 5-7 depths in the water column (depths determined based on the fluorescence measurement), then filtered in duplicate, for each of the 2 filters of different thickness.

Table 15. List of stations in Isfjorden occupied by the PEP team during the AREX'2022 cruise leg IVc.

LP	Station name or section	Depth	Coordinates		Measurement	Equipment
			Lat	Lon		
1	SGD19/HIMERO1	301 270 240	78° 11.650'N 78° 11.522'N 78° 11.490'N	13° 48.744'E 13° 46.984'E 13° 44.770'E	CTD, meroplankton, water samples chla (HIMERO)	Juday_56, water carousel or bathometers

2	ISF3/HIMERO2	83	78° 26.860'N	16° 5.248'E	CTD, meroplankton, water samples chla (HIMERO)	Juday_56, water carousel or bathometers
3	SGD9/HIMERO3	137	78° 36.581'N	16° 29.033'E	CTD, meroplankton, water samples chla (HIMERO)	Juday_56, water carousel or bathometers
4	ISA2/HIMERO4	245	78° 15.953'N	15° 7.726'E	CTD, meroplankton, water samples chla (HIMERO)	Juday_56, water carousel or bathometers

4.5.3 Marine ecology measurements - plankton (PFBP)

The measurements included collection of water samples for the analysis of chlorophyll *a*, SPM, carotenoids, nano-, microplankton (bathometric bottle: 0, 5, 15, 25, 40 m), nano- and microplankton (small planktonic net, approx. 25 m) and mesozooplankton (WP2/100um net, layers: bottom-50m-10m-0m) Task I.7, CoastDark, RAW.

Plankton and particle distribution was measured using the LOPC-CTD-F-T (transect and vertical profile).

SPM – sea water filtered through Whatman glass fiber filters (GF/F, nominal pore size 0.7 µm). The material that remained on the filter was dried (24 h, 60st C) and then placed in a freezer (-80st C).

Chlorophyll *a* - sea water filtered through Whatman glass fiber filters (GF/F, nominal pore size 0.7 µm). The material that remained on the filter was placed in a freezer (-80st C).

Protists (nano- and microplankton) – samples preserved with Lugol's solution.

Zooplankton – samples preserved with a solution of 4% formalin in sea water with the addition of borax.

4.5.4 Marine chemistry measurements

As part of the ArcticSGD project, CTD measurements were carried out (using a rosette equipped with a CTD probe or a side CTD probe), seawater samples were taken (using a rosette or a side bathometer) and bottom sediments (using a Gemax core barrel and a gravity core barrel) for identification freshwater seepage from bottom sediments. The research plan was fully implemented, and samples were taken from additional stations.

Measurements of pCO_2, pO_2, SST and SSS were also carried out. These parameters were measured using a measurement set consisting of a thermosalinograph SeaBird, Fibox detector for measuring oxygen concentration and Piccaro analyzer for measuring pCO_2 concentration in the surface water layer. Discrete samples for DOC, DIC, AT, pH, metals, and nutrients were also taken.

As part of the RAW project, water and suspended solids samples were collected at stations located in a gradient of distance from the fronts of glaciers and river mouths. These included: DIC, DOC, AT, pH, Nutrients, Iron, Metals, POC, $d^{13}C$ and samples for biological research. At the same time, in selected locations in Dicksonfjorden and Tempelfjorden, online measurements of pCO2, pO2, T and S as well as pH in the water column were carried out using a submersible pump.

4.5.5 Optical measurements

During the cruise leg IVa of the AREX2022 cruise the measurements were collected for Task II.5 and the DOMinEA project at selected stations using the following instruments:

- Optical-hydrological probe for measuring the real optical properties of sea water, which includes:
  - CTD (Conductivity-Temperature-Depth) probe, Seabird SBE 49 FastCAT

- Light absorption and attenuation meter - AC9, (WetStar)
- WetStar 3-channel fluorimeter for measuring light fluorescence via CDOM
- DH4 data integrator, (WetLabs Inc.)

Using an optical-hydrological probe (at selected stations), vertical profiles were made from the surface to a depth of approx. 180m or to the bottom -2m. The depth of the profile depended on the depth of a given location, the length of the measuring rope and weather conditions.

- Optical profiling system - COPs (Compact Optical Profiling system), (Biospherical Instruments Inc.). – a system of two radiometers for determining the apparent properties of sea water; one of them measures the bottom-up radiation, the other the radiation intensity. COPs are equipped with 19 spectral channels (340, 380, 395, 412, 443, 465, 490, 510, 520, 532, 555, 565, 589, 625, 665, 683, 710, 765 nm and the PAR channel).

The COPs were lowered from the ship side in the free-fall mode, away from the ship shadow, to the depth of the lower border of the euphotic zone or to the bottom (depending on the location depth) or shallower (due to weather conditions). Underwater measurements were supplemented with simultaneous overwater measurements of Es(λ) radiation intensity using a sensor mounted on board the ship. These measurements were used to calculate the PAR level in the profiles and the color of the water ("ocean color").

- Surface platform for measuring upward radiation - RAMSES, TRIOS - a radiometer placed on a specially constructed frame, enabling measurement just below the water surface, regardless of weather conditions. Underwater measurements were supplemented by simultaneous above-water measurements of radiation intensity using a sensor on board the ship.
- Additionally, water was also collected for the determination of parameters:
  - $a_{CDOM}(\lambda)$ – light absorption by the CDOM,
  - a_{pl} – absorption of light by particles suspended in water,
  - EEM – DOM excitation and emission fluorescence matrices,
  - DOC – concentration of dissolved organic carbon,
  - Chla – chlorophyll *a* concentration,
  - HPLC – concentration of chlorophyll and accessoty pigments,
  - Lignin phenols – lignin concentration,
  - SPM – concentration of suspended organic matter,
  - Fractions - for some of the above parameters, water samples were taken from additionally separated fractions with the sizes of suspended particles of 20 µm, 5 µm, 2 µm.

Sea water samples were taken with a 30l bathometer or a rosette equipped with a set of 10l water bottles. Sampling depths were selected based on temperature, salinity, and chlorophyll a concentration profiles made just before water sampling. Water samples were always taken from the surface, chl *a* maximum, deep water chl *a* maximum, above the bottom.

During the cruise leg IVc of the AREX 2022 expedition, as part of the IOPAN Task I.1 and the OPTYKA-BIS project, the following equipment was used at selected stations:

- In situ measurements of the backscattering coefficient in sea water; HydroScat-4 (Hobi Labs) measurements just below the water surface and in profiles in the water column,

- Determination of the Secchi disk's viewing range by the operator, and taking digital photographs documenting the color of the disk submerged at a depth of half the viewing range, as well as the background color of the water column recorded with digital camera,
- Collection of discrete sea water samples (Niskin bottle) for further analyzes on board the ship and subsequent laboratory analyses,
- Fractionation of sea water samples using a system of cascade filtration of large volumes of sea water (using a set of net and filters with nominal mesh sizes: 20, 5 and 2 µm),
- Measurements in the lab on board the spectra of the light attenuation coefficient in discrete samples of sea water, and in prepared fractions or filtrates of water (Viper photometer (TriOS)),
- Measurements in the labon board of the angular characteristics of light scattering in sea water samples and in their fractions, taking into account the polarization of light; LISST-VSF meter (Sequoia Sci.),
- Preparation of samples for subsequent analyzes of spectra of light absorption coefficient by suspension particles (particle samples collected on GF/F filters and frozen, "filter pad technique"),
- Preparation of samples for subsequent analyzes of various characteristics of concentration, composition, and size distribution of marine suspensions (particle samples collected on filters, dried and/or frozen, gravity analysis, calcination and high-temperature combustion, high-performance liquid chromatography (HPLC); discrete samples of water with suspension preserved Lugol's solution, analyzes using a Coulter Multisizer IV counter (Beckaman Coulter)).

Measurements of the inherent optical properties of seawater were also collected:

- spectral values of the backscattering coefficient of suspension particles $b_{bp}(\lambda_i)$,
- spectra of light attenuation coefficients by all particles and their size fractions in sea water $c_p(\lambda)$,
- spectra of light absorption coefficients for all suspension particles and their size fractions $a_p(\lambda)$, as well as in the division into phytoplankton and non-algal particles/detritus, $a_{ph}(\lambda)$ and $a_d(\lambda)$,
- spectra of the light scattering coefficient by all particles and their size fractions $b_p(\lambda)$,
- spectra of light absorption coefficients by chromophoric substances dissolved in sea water $a_g(\lambda)$,
- selected characteristics of the volumetric light scattering function (VSF) taking polarization into account.

Characteristics of the concentration, composition, and size distribution of the suspended matter were measured as following:

- mass concentrations of all suspensions and their size fractions in sea water (SPM),
- mass concentrations of organic and inorganic suspension fractions and their size fractions in sea water (POM and PIM),
- mass concentration of suspended organic carbon (POC),
- concentrations of various phytoplankton pigments, including chlorophyll *a* (Chla),
- particle size distribution of suspensions (PSD).

Measurements and sampling were carried out at 5 stations: Moni4, Moni10, SGDtrym, SGDtem, and FWS2. On the last three, measurements were carried out in cooperation with colleagues from the Scripps Institution of Oceanography, using LISST-VSF measuring device.

4.5.6 Aerosol and meteorological measurements

The measurements were carried out using the following measurement equipment: OPC3N - Optical Particle Counter, Li-COR 7200, AE-31 eathalometer, Vaisala WXT563 autonomous weather station, Microtops II solar photometer, Ellipse-N-G4A2-B1. The measured parameters included the distribution of aerosol particle sizes in the surface layer of the atmosphere, concentration of marigenic aerosol, CO_2 and H_2O concentration in the atmosphere, concentration of Black Carbon particles in the surface layer of the atmosphere, wind speed and direction, air temperature and humidity. Ship motion was recorded using an inertial motion detection system. The measurements were carried out continuously. All data collected during the leg IVc were stored on a network drive at IOPAN.

4.6 Measurements and sampling during the AREX'2022 leg IVd (Isfjorden)

4.6.1 Work at sea during the AREX2022 leg IVd

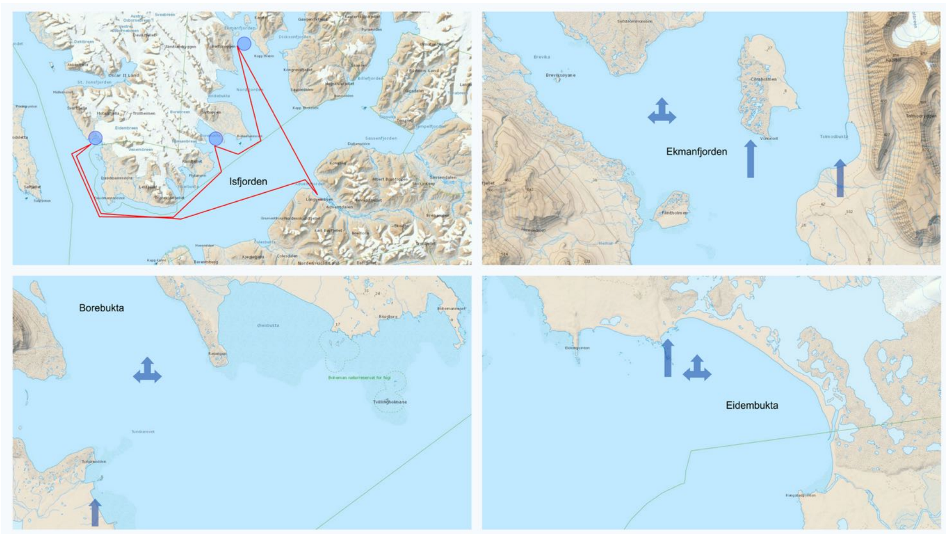

Figure 14. The cruise track of the leg IVd (August 24-26, 2022) and measuring stations in specific regions.

Table 16. List of stations sampling and measurements in coastal freshwater ponds.

date	time	place name	latitude	longitude
2022-08-24	14.15-11.00	Coraholmen/Ekmanfjorden	78°40.015'	14°42.661'

number	salinity	temperature	pH	nutrients	macrofauna	plankton	diatoms	photo
pond 1	6.9	5.5 °C	8.2		x	x	x	
pond 2	6.3	5.5 °C	8.4		x	x	x	
pond 3	9.2	5.5 °C	8.4		x	x	x	
pond 4	4.6	5.5 °C	8.5	x	x	x	x	
pond 5	16	5.5 °C	8.4		x	x	x	

date	time	place name	latitude	longitude
2022-08-25	14.00-11.00	Tundraodden/Borebukta	78°20.190'	14°13.405'

number	salinity	temperature	pH	nutrients	macrofauna	plankton	diatoms	photo
pond 1	0	6.8 °C	8.4		x	x	x	
pond 2	0	6.8 °C	8.7		x	x	x	
pond 3	1.4	6.8 °C	8.73		x	x	x	
pond 4	1.33	6.8 °C	8.67	x	x	x	x	
pond 5	10.6	6.8 °C	8.47		x	x	x	

date	time	place name	latitude	longitude
2022-08-26	14.30-24.00	Eidembukta/Eidembukta	78°22.434'	12°45.105'

number	salinity	temperature	pH	nutrients	macrofauna	plankton	diatoms	photo
pond 1	0.13	7.0 °C	9.13		x	x	x	
pond 2	0.52	7.0 °C	8.62		x	x	x	
pond 3	0.42	7.0 °C	8.64		x	x	x	
pond 4	0.14	7.0 °C	8.85	x	x	x	x	
pond 5	0.26	7.0 °C	8.64		x	x	x	

Table 17. Measurements and collection of samples at the tidal flat.

date	time	place name	latitude	longitude	activities	activities	activities	activities	activities coastal	photo
2022-08-24	14.15-11.00	Ekmanfjorden	78°40.016	14°34.400	lander/bait/camera 30 m	plastic count	tidal flat sampling	seabed photo-profile 5.15, 30 m	coastal ponds	
2022-08-25	14.00-11.00	Borebukta	78°22.445	14°17.839	lander/bait/camera 50 m	plastic count	tidal flat sampling	seabed photo-profile 5.15, 30 m	coastal ponds	
2022-08-26	14.30-24.00	Eidembukta	78°21.680	12°47.404	lander/bait/camera 27 m	plastic count	tidal flat sampling	seabed photo-profile 5.15, 30 m	coastal ponds	

Table 18. Measurements and collection of samples for counting plastic.

date	time	place name	latitude	longitude	100 m unit nr of items	100 m unit nr of items	100 m unit nr of items	photo
2022-08-24	14.15-11.00	Ekmanfjorden/Tolmodbukta	78°39,799'	14°50,948'	2	2	3	
2022-08-25	14.00-11.00	Borebukta/Tundraodden	78°20,130'	14°13,732'	50	30	23	
2022-08-26	14.30-24.00	Eidembukta	78°22,151'	12°45,534'	15	15	30	

The CTD and turbidity measurements were made with the Bergen Sensor Data probe. Photographic documentation of the sea bottom was performend with the camera on a drone and a time lapse camera on a lander with a baited trap. Bio-optical measurements were carried out between the stations, lasting about 45 minutes during the ship move.

4.7 Measurements and sampling during the AREX'2022 leg V

4.7.1 General information

Transit to Horsund and field work in the fjord were complerted under good weather conditions. The weather worsened during the following days and the ship had to wait in shelter for 24 h in the Kveithola-Bjornoya region. Due to the rough sea state, the planned cores in the Jan Mayen area could not be acquired. Alternative loction on the Vøring Plateau at the eastern end of the Jan Mayen Fracture Zone was selected with the water depth of 1200 m. Two sediment cores, each 1.5 m long were collected there but very loose surface sediment could not be retrieved. Samples for environmental DNA were also collected in the same location and CTD cast was measured.

Work was continued north of the Faroe Islands where two attemps to collect sediment cores were not successful. At the first location at the water depth of 500 m, there was no soft sediment layer on the stony bottom. At the depth of 1200m surface sediments consisted of the clay sand which prevented the corer from entering the sediment layer. Only the surface sediment sample of about 1 kg was collected by the top of the corer (stuck to it) and used for the foraminifera analysis.

4.7.2 Paleoceanographic measurements

Description of measuring methods and equipment:

- Gravity core 1.5 m long
- Box Core
- Van Ven Drainer
- 30 l bathometer
- CTD probe

Description of the measured parameters and the samples taken:

- Sediment cores, apart from classic palaeoceanographic studies based on sedimentology, geochemistry, and micropalaeontology, will be used for environmental fossil DNA in Holocene,

- Water and surface sediment samples (for research on modern environmental DNA),
- CTD profiles (salinity, temperature, depth).

Table 19. List of paleooceanographic stations during the leg V of AREX'2022

Station name	Date	Time	Lat			Long			Water depth
OCE2022_HR6	28.08.2022	16:50	N	76	58.3634	E	15	40.3699	65
OCE2022_HR7	28.08.2022	22:30	N	76	56.5135	E	14	54.0726	135
OCE2022_KV1	30.08.2022	14:50	N	74	52.1092	E	16	29.0195	354
OCE2022_KV2	30.08.2022	17:00	N	74	50.296	E	16	1.3403	374
OCE2022 Echo KV	30.08.2022	18:25	N	74	50.1676	E	15	56.5342	366
End of Echo KV	30.08.2022	19:30	N	74	52.3473	E	16	30.9929	
OCE2022_ATL1	31.08.2022	12:30	N	72	30.1151	E	10	26.9705	2100
OCE2022_ATL2	01.09.2022	8:30	N	69	34.298	E	6	44.9523	3000
OCE2022_ATL3	02.09.2022	2:50	N	67	7.7642	E	3	14.2078	1235
OCE2022_FIC	03.09.2022	15:00	N	62	45.0673	W	8	13.5096	568
OCE2022_FIC01	04.09.2022	14:30	N	62	55.6223	W	6	19.5708	990

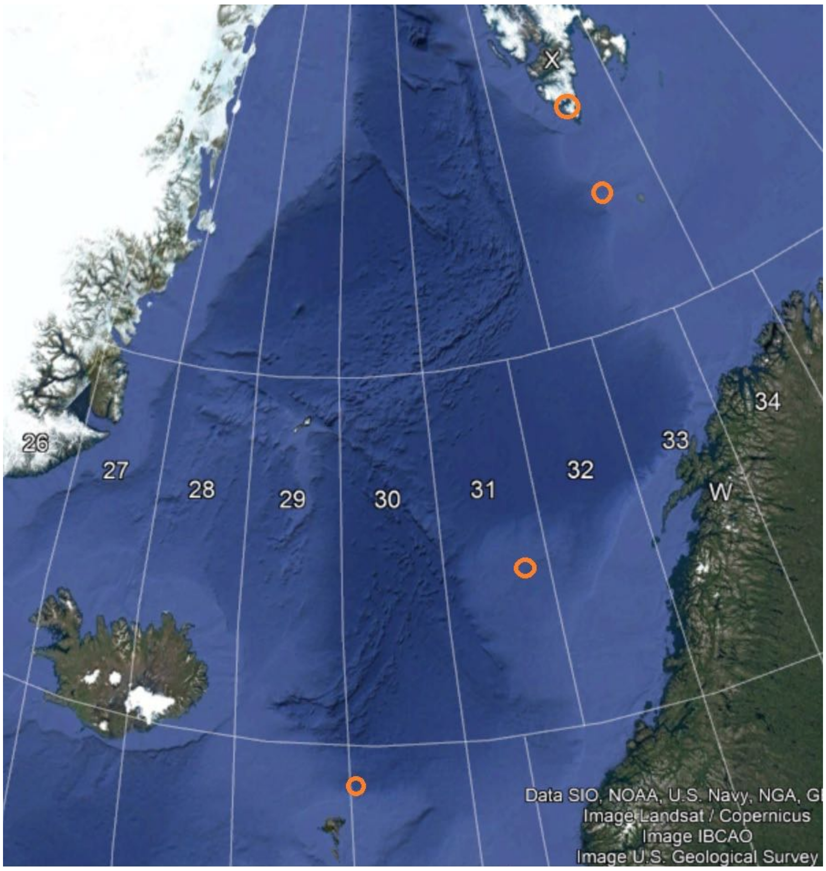

Figure 15. Paleooceanographic sampling stations occupied during the leg V of the AREX'2022 cruise.