INSTITUTE OF OCEANOLOGY
POLISH ACADEMY OF SCIENCES

Results and conclusions

05.02.20201, 09.06.2021- 09.09.2021, Jnr. 21/2183

REPORT
FROM THE RESEARCH CRUISE
AREX'2021
RV OCEANIA
9.06.2021 - 11.09.2021

Cruise leader, leg I-II-III:	prof. Waldemar Walczowski
Cruise leader, leg IVa:	dr Joanna Legeżyńska
Cruise leader, leg IVb:	dr Karol Kuliński
Cruise leader, leg V:	prof. Marek Zajączkowski
Coordination:	dr Agnieszka Beszczyńska-Möller

Powstańców Warszawy 55
81-712 Sopot, Poland
P.O. Box 148
tel. (+48 58) 551-72-81
fax (+48 58) 551-21-30
NIP PL 585 10 04 839
Regon 000632467
e-mail: office@iopan.gda.pl
home page: http://www.iopan.gda.pl
IO PAS
SOPOT

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 IOPAN during annual cruises on the research vessel Oceania for over 30 years in the Nordic Seas and the European Arctic. The AREX program is focused on multidisciplinary observations in areas such as physical oceanography, air-ocean interactions, ocean biogeochemistry 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, Isfjorden, Kongsfjorden) 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 changes of the Arctic environment.

Oceanographic measurements and collection of water samples during the AREX'2021 cruise contributed to several IO PAN statutory research areas, international and national research projects (EU H2020 INTAROS, EA-RISE, ACCESS, ADAMANT, CLIMB, PROSPECTOR, ANALOG, OPTYKA-BIS, ATAC-ICE, CoastDark, Alkenon and Polish-Norwegian projects under the GRIEG program: PHARMARINE, ArcticSGD, NEEDED) and PhD grants. The field work during the AREX'2021 cruise was focused on numerous research goals, subdivided into detailed tasks. A general overview is provided in the following sections.

2 Main scientific tasks carried out during the AREX cruise

2.1 Research tasks during the combined cruise leg I-II-III (Norwegian Sea, Greenland Sea, Barents Sea, Fram Strait and southern Nansen Basin)

2.1.1 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 the variability of intermediate and deep water masses in the eastern part of the Norwegian Sea, Greenland Sea and the Barents Sea Opening (DWINS project),
- Study of the impact of Atlantic Water variability and atmospheric circulation on the changing sea ice cover in the European Arctic (ATAC-ICE project).

2.1.2 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 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).

2.1.3 Marine ecology – plankton

- Describe the qualitative-quantitative composition and pattern distribution of zooplankton in the epipelagial of the West Spitsbergen Current, in the fjords and forefield of Hornsund and Kongsfjord in relation to environmental conditions (Task I.5),
- Identify the concentrations of selected pharmaceuticals used in human therapy in selected elements of the water column ecosystem (in sea water and in zooplankton organisms) in waters along the Norwegian coast and along the western coast of the Svalbard archipelago (Fram Strait) (PHARMARINE project, cooperation Task I.5),
- Describe of the diversity of meroplankton based on molecular methods and taxonomic analysis (PhD project, cooperation 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 (HIDEA project, cooperation Task I.5).

2.1.4 Marine chemistry

- Recognize the spatial variability of total mercury concentration in seawater from the eastern part of the Norwegian Sea, Greenland Sea, entrance to the Barents Sea, Fram Strait and north of Svalbard (Task II.8),

- Study the dependence 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 (Task I.3)

2.2 Research tasks during the cruise leg IVa (Hornsund and Kongsfjorden)

2.2.1 Marine ecology – plankton (PEP)

- Describe the qualitative-quantitative composition and pattern distribution of zooplankton in the fjords and foreground of the Hornsund and Kongsfjord 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 (PhD project, cooperation 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 (HIDEA project, cooperation Task I.5).

2.2.2 Marine ecology – plankton (PFBP)

- Estimate the abundance of feeding grounds of little auks nesting in Hornsund and Kongsfjord using optical methods (LOPC) (SEAPOP II project, Task I.7),
- Study the relationship between protozoa and zooplankton at the Hornsund forefield (Task 1.7, SEAPOP II),
- Genetic identification of two species of Calanus in the feeding grounds of little auks at the Hornsund forefield (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 Hornsund and Kongsfjorden (CoastDark project, Task I.7).

2.2.3 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),
- Determine the concentration of pharmaceuticals in the tissues of benthic organisms in the fjords of Hornsund and Kongsfjorden (PHARMARINE project),
- Determine the accumulation of pharmaceuticals in the Kongsfjorden benthic food network (PHARMARINE project).

2.2.4 Marine chemistry

- Identify places with increased concentrations of mercury and other metals in the inflow areas of materials from melting permafrost (Task II.8),
- Determine total mercury and methylmercury concentrations in selected benthic organisms (PhD project, E. Korejwo),
- Recognize the carbonate system structure in the salinity gradient in Kongsfjorden,
- Characterize the factors influencing the groundwater inflow (SGD) (ARCTIC SGD project),

- Identify SGD streams and accompanying chemical substances (ARCTIC SGD project),
- Study the SGD impact on meio- and macro-fauna (ARCTIC SGD project).

2.2.5 Marine optics

- 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),
- Continue studies aimed at the practical application of the trichromatic mechanism of water color perception in modern quantitative methods of studying marine environments (Task I.1 / Subtask I.1.1).

2.2.6 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).

2.2.7 Physical oceanography

- Study of 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).

2.3 Research tasks during the cruise leg IVb (Isfjorden)

2.3.1 Ecology – plankton (PFBP)

- 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),
- Describe characteristics of the 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).

2.3.2 Ecology – benthos

- Describe the impact of climate change on benthic ecosystems at the fjord shelf boundary and dependence on depth (CLIMB project),
- Study of the carbonates in the coastal zone and the impact of fluctuations on the skeletons of marine organisms (ANALOG project),
- Determine the succession and colonization in the coastal zone (ASCOMEA and Akvaplan NIVA project),
- Estimate the ice loss effects in the tidal zone (ADAMANT project) and coastal zone (ACCESS project).

2.3.3 Marine chemistry

- Determine the variability of the carbonate system in the surface layer and the water column (PROSPECTOR project),
- Determine the bioavailability of dissolved organic matter released from sediments (PROSPECTOR project),
- Characterize the factors influencing the groundwater inflow (SGD) (ARCTIC SGD project),
- Characterize the SGD discharge sites (ARCTIC SGD project),
- Identify SGD fluxes and accompanying chemical compounds (ARCTIC SGD project),
- Study of the SGD impact on meio- and macro-fauna (ARCTIC SGD project),
- Recognize the spatial variability of total mercury concentration in the West Spitsbergen fjords (Task II.8),
- Determine the total mercury and methylmercury concentrations in selected benthic organisms (PhD project, E. Korejwo),
- Identify locations with increased concentrations of mercury and other metals in the areas of increased discharge from melting permafrost (Task II.8).

2.3.4 Marine optics

- 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),
- Continue studies aimed at the practical application of the trichromatic mechanism of water color perception in modern quantitative methods of studying marine environments (Task I.1 / Subtask I.1.1).

2.3.5 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).

2.4 Research tasks during the cruise leg V (Isfjorden, Hornsund, northern Norway fjords and shelf)

2.4.1 Paleoceanography

- Reconstruct changes in the marine environment on the Spitsbergen shelf and northern Norway in the period after the last ice age, using foraminifera as the basic paleo-environmental indicator, supplemented by biogeochemical and genomic indicators (NEEDED and Alkenon project, Task III.2),
- Reconstruct changes in primary production and phytoplankton composition based on biogeochemical markers in sediments (Task II.4).

Organization of work during the COVID-19 pandemic

The AREX cruise took place in the planned period between June and September and has been divided in four parts (cruise legs) with two exchanges scientific teams between the subsequent legs. To reduce the risk of Covid-19, open ocean part of the AREX cruise was completed as one combined leg (leg I-II-III, lasting a total of 38 sailing days) and all participants carried an international Covid-19 vaccination passport. Additionally, participants of the first cruise leg were tested for the Covid-19 with negative results when embarking in Gdansk. The scientific team exchanges took place in the Norwegian port Longyearbyen and complied earlier quarantine requirements.

3 Implementation of the AREX 2021 cruise

The AREX cruise of the Institute of Oceanology Polish Academy of Sciences (IO PAN) research vessel Oceania, repeated every summer over the same period, in 2021 took place from June 15 to September 11. The AREX'2021 cruise lasted 88 days and was devoted to collection of oceanographic, meteorological, aerosol, chemical and ocean ecosystem observations in the open ocean regions including the eastern Norwegian and Greenland seas, Fram Strait and the southern Nansen Basin of the Arctic Ocean, and in the selected West Spitsbergen fjords (Hornsund, Isfjorden, Kongsfjorden). The scientific team was exchanged twice between the individual cruise legs during short stays in Longyearbyen which also served for loading and offloading of the scientific equipment.

The leaders of the hydrographic, ecological, meteorological, and chemical teams were responsible for coordinating the cruise activities for different teams. Work was performed in a three-shift system (three 4-hour shifts) during the open ocean part of the cruise. During the fjord part of the cruise, it was decided to adapt the work system to the weather conditions and sampling needs. The cruise was carried out in accordance with the AREX'2021 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 (albeit already including cuts due to the COVID-19 limitations) was fulfilled during the AREX 2021 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 AREX'2021 cruise itinerary

Cruise leg	Period	Ports of call and research areas	Cruise leader	Comments
I-II-III	**15.06-23.07.2021**	Gdansk - Longyearbyen (Norwegian Seas, Greenland Seas, Fram Strait)	Waldemar Walczowski	No team exchange during the combined leg I-II-III

IVa	**24.07-09.08.2021**	Longyearbyen – Longyearbyen (Hornsund and Kongsfjorden)	Joanna Legeżyńska	
IVb	**10.08-19.08.2021**	Longyearbyen – Longyearbyen (Isfjorden)	Karol Kuliński	Partial team exchange during the leg IVb
V	**20.08-11.09.2021**	Longyearbyen - Bergen - Gdansk (Isfjorden, Hornsund, northern Norway fjords and shelf)	Marek Zajączkowski	

4 Field measurements during the AREX'2021 cruise

4.1 Field measurements and sampling during the AREX'2021 leg I-II-III (open ocean part of the AREX cruise)

Oceanographic measurements carried on during the open ocean part of the AREX'2021 cruise included:

- Full-depth measurements of temperature, salinity, dissolved oxygen 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 nutrient analysis

During the AREX'2021 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 12 sections (H, K, 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. A total of 201 (194 standard program stations and 7 additional stations) conductivity-temperature-depth (CTD) full-depth stations were occupied within the geographical area 70°30'-81°15'N and 0-20°E. In addition, during the cruise leg I-II-III, measurements were carried out at six additional stations for the PHARMARINE project, located in the coastal zone of Norway. During this cruise leg, meteorological and aerosol measurements were carried out continuously, and plankton samples were collected to find out the qualitative-quantitative composition and the distribution pattern of zooplankton in the epipelagial of the West Spitsbergen Current. Location of oceanographic sections is shown on Figure 1.

4.1.1 Oceanographic measurements in open ocean

During of the cruise full-depth CTD stations were measured by SBE 9/11+ CTD (Sea-Bird Electronics) providing full depth profiles of temperature (sensor SBE3 SN4670 and SBE3 SN2937), salinity (conductivity sensor 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), and SBE19+ (SeaCat). The specifications of the individual sensors are provided in Table 2. 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 read from the device memory after each station. The CTD and LADCP system was mounted on the SeaBird bathymetric rosette equipped with 12 Niskin bottles (3x1.75 l. 9x12 l). Additionally, on 27 stations water samples were collected for nutrient analysis. The samples were frozen on board and analyzed after the cruise in the IOPAN laboratory. On selected stations, water samples were collected for post-cruise calibration of conductivity sensors (8 stations) and oxygen sensors (6 stations). During the entire cruise, sea currents were measured in the upper layer of approx. 200 m along the ship route using the RDI 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 stages I-II-III of the AREX'2021 cruise, seven Argo profiling floats (Argo-Poland, H2020 EA-RISE, BSH) were launched. One float was deployed during transit in the Baltic Sea and remaining six floats (two from IOPAN and four from BSH, Germany) were set out in the Nordic Seas during the regular station grid occupation.

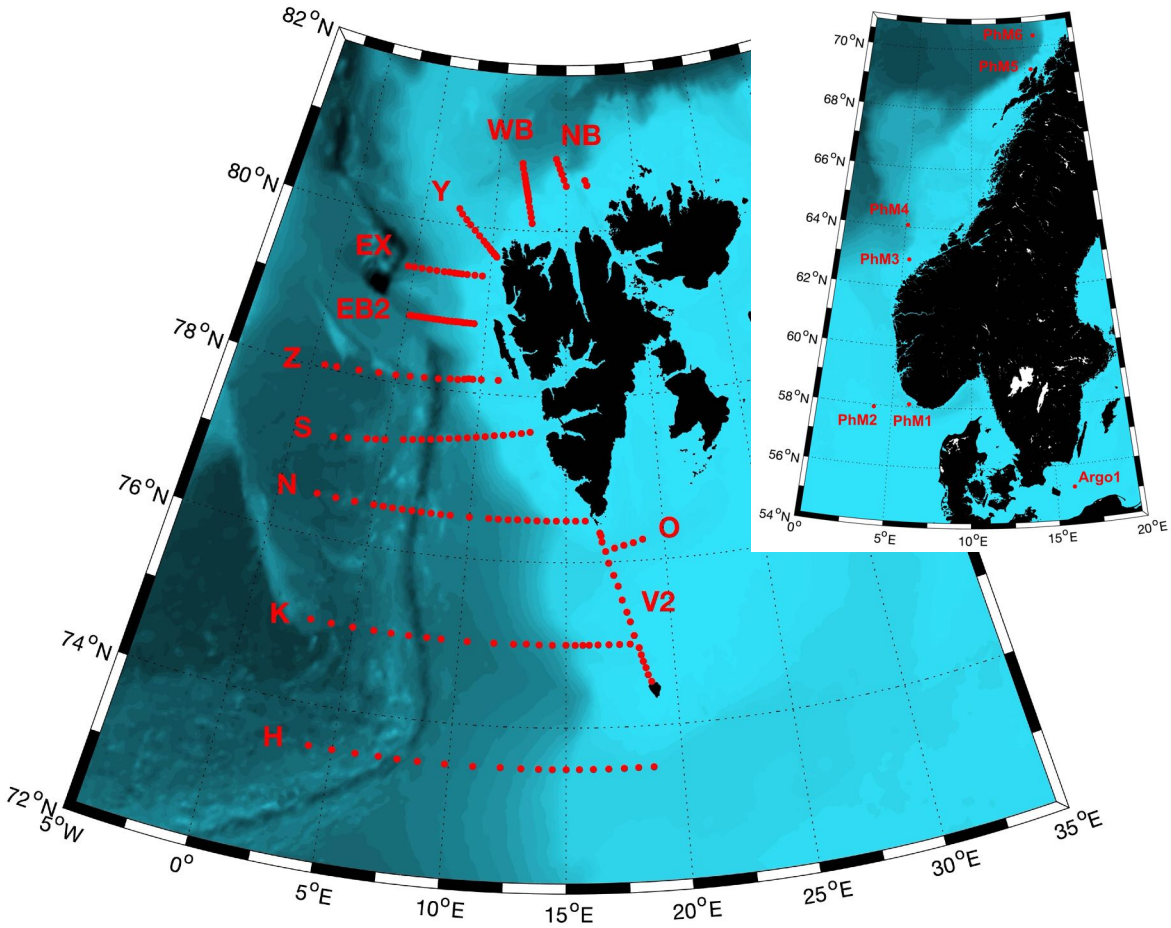

Figure 1. Distribution of CTD measuring stations and sections during stages I-II-III of the AREX 2021 cruise. The main map shows the positions of the standard AREX stations in 2021, the small map in the upper right corner shows the additional stations of the PHARMARINE project and the Argo station.

Table 2. Specifications of the individual sensors (9/11+ CTD and CTD SBE19+ SeaCat) used for CTD measurements during the AREX'2021 cruise.

SeaBird SBE9/11+ system			***SeaBird SBE19+ system***		
Sensor	***SN***	***Calibration date***	***Sensor***	***SN***	***Calibration date***
pressure	100967	2018-04-18	pressure	2096460	2020-01-15
conductivity 1 conductivity 2	2971 3342	2021-03-21 2021-03-02	conductivity	6922	2020-01-16
temperature 1 temperature 2	2937 4670	2021-03-26 2021-03-02	temperature	6922	2020-01-16
oxygen SBE43	1620	2021-04-17	oxygen optode	-	-

Table 3. List of CTD stations occupied during the open ocean part (leg I-II-III) of the AREX'2021 cruise.

File	Station	Lati-tude	Longi-tude	Water depth	Max Pres	Day	Month	Year	Hour	Min
AR21_001.awi	Argo1	55.251	16.035	9999	85	15	6	2021	21	34
AR21_002.awi	PhM1	58.088	6.078	375	340	17	6	2021	17	13
AR21_003.awi	PhM2	57.931	3.878	137	88	18	6	2021	3	21
AR21_004.awi	PhM3	62.924	5.448	167	97	19	6	2021	12	58
AR21_005.awi	PhM4	64.072	5.168	1031	206	19	6	2021	22	36
AR21_006.awi	PhM5	69.260	15.560	157	59	21	6	2021	22	54
AR21_007.awi	PhM6	70.370	16.038	299	203	22	6	2021	7	21
AR21_008.awi	H1	73.500	18.750	523	429	23	6	2021	6	52
AR21_009.awi	H2	73.502	18.094	508	414	23	6	2021	8	33
AR21_010.awi	H3	73.500	17.482	520	426	23	6	2021	10	11
AR21_011.awi	H5	73.499	16.821	540	447	23	6	2021	12	29
AR21_012.awi	H6	73.499	16.166	555	462	23	6	2021	14	5
AR21_013.awi	H7	73.499	15.572	525	481	23	6	2021	15	33
AR21_014.awi	H4	73.499	15.007	728	686	23	6	2021	17	1
AR21_015.awi	H8	73.498	14.421	1069	1032	23	6	2021	19	7
AR21_016.awi	H9	73.500	13.835	1358	1326	23	6	2021	20	58
AR21_017.awi	H10	73.500	13.083	1626	1599	24	6	2021	7	14
AR21_018.awi	H11	73.504	12.204	1856	1833	24	6	2021	9	48
AR21_019.awi	H12	73.499	11.037	2110	2092	24	6	2021	13	31
AR21_020.awi	H13	73.501	9.835	2330	2316	24	6	2021	17	33
AR21_021.awi	H14	73.501	8.671	2533	2524	24	6	2021	21	20
AR21_022.awi	H15	73.500	7.803	3134	3139	25	6	2021	0	52
AR21_023.awi	H16	73.505	6.998	2215	2199	25	6	2021	4	59
AR21_024.awi	H17	73.500	6.000	2182	2165	25	6	2021	8	54
AR21_025.awi	H18	73.499	5.004	2784	2781	25	6	2021	12	26
AR21_026.awi	H19	73.499	3.997	2829	2827	25	6	2021	17	10
AR21_027.awi	K7	75.007	13.151	2036	2016	26	6	2021	14	31
AR21_028.awi	K6	75.000	13.749	1845	1822	26	6	2021	18	9
AR21_029.awi	K5	74.999	14.365	1568	1540	26	6	2021	20	38
AR21_030.awi	K4	75.001	14.998	1160	1125	26	6	2021	23	9
AR21_031.awi	K3	74.999	15.428	869	829	27	6	2021	1	18
AR21_032.awi	V21	74.532	18.885	72	22	28	6	2021	13	0
AR21_033.awi	V22	74.614	18.748	116	67	28	6	2021	13	46
AR21_034.awi	V23	74.701	18.666	149	100	28	6	2021	14	47
AR21_035.awi	V24	74.780	18.561	279	232	28	6	2021	15	38
AR21_036.awi	V25	74.859	18.484	255	207	28	6	2021	16	33
AR21_037.awi	V26	74.947	18.409	121	72	28	6	2021	17	37
AR21_038.awi	K-3	74.996	17.997	202	154	28	6	2021	18	57
AR21_039.awi	K-2	74.997	17.503	164	115	28	6	2021	21	21
AR21_040.awi	K-1	74.999	17.009	178	129	28	6	2021	22	25

AR21_041.awi	K0	75.000	16.497	209	161	28	6	2021	23	34
AR21_042.awi	K1	74.999	16.086	268	220	29	6	2021	0	55
AR21_043.awi	K2	74.999	15.786	385	339	29	6	2021	1	52
AR21_044.awi	V27	75.097	18.209	122	73	29	6	2021	6	13
AR21_045.awi	V28	75.265	18.060	108	59	29	6	2021	7	41
AR21_046.awi	V29	75.383	17.919	152	103	29	6	2021	8	52
AR21_047.awi	V30	75.532	17.722	175	126	29	6	2021	10	57
AR21_048.awi	V31	75.701	17.555	262	214	29	6	2021	12	45
AR21_049.awi	V32	75.834	17.361	340	293	29	6	2021	14	58
AR21_050.awi	V33	75.984	17.134	367	321	29	6	2021	16	39
AR21_051.awi	V34	76.126	17.001	328	281	29	6	2021	18	10
AR21_052.awi	V35	76.242	16.833	265	217	29	6	2021	20	14
AR21_053.awi	V36	76.317	16.792	160	111	29	6	2021	21	5
AR21_054.awi	V37	76.351	16.736	100	51	29	6	2021	21	52
AR21_055.awi	O8	76.253	18.901	309	262	30	6	2021	1	11
AR21_056.awi	O7	76.218	18.421	298	251	30	6	2021	3	4
AR21_057.awi	O6	76.192	17.935	326	279	30	6	2021	4	15
AR21_058.awi	O5	76.163	17.459	357	310	30	6	2021	5	31
AR21_059.awi	N5	76.500	15.998	93	43	2	7	2021	20	48
AR21_060.awi	N4P	76.501	15.499	183	134	2	7	2021	21	56
AR21_061.awi	N4	76.502	15.010	200	152	2	7	2021	23	7
AR21_062.awi	N3P	76.501	14.501	259	211	3	7	2021	1	9
AR21_063.awi	N2P	76.500	13.499	1252	1254	3	7	2021	8	7
AR21_064.awi	N3	76.500	13.999	751	753	3	7	2021	11	25
AR21_065.awi	N2	76.503	13.000	1520	1539	3	7	2021	14	45
AR21_066.awi	N1P	76.505	12.491	1747	1758	3	7	2021	17	18
AR21_067.awi	N1	76.500	11.999	1884	1908	3	7	2021	19	56
AR21_068.awi	N0P	76.500	11.497	1996	2035	3	7	2021	22	30
AR21_069.awi	N0	76.501	10.999	2081	2112	4	7	2021	1	14
AR21_070.awi	N-1	76.500	9.992	2223	2219	4	7	2021	5	2
AR21_071.awi	N-2	76.500	9.000	2248	2192	4	7	2021	8	23
AR21_072.awi	N-3	76.499	8.499	2248	2277	4	7	2021	10	45
AR21_073.awi	N-4	76.500	7.999	1867	1714	4	7	2021	14	2
AR21_074.awi	N-5	76.499	7.490	2507	2498	4	7	2021	16	36
AR21_075.awi	N-6	76.500	6.998	2954	2955	4	7	2021	19	55
AR21_076.awi	N-7	76.500	6.497	2544	2551	4	7	2021	23	26
AR21_077.awi	N-8	76.499	5.989	2492	2482	5	7	2021	3	0
AR21_078.awi	N-9	76.501	5.499	1353	1321	5	7	2021	6	46
AR21_079.awi	N-10	76.502	4.998	2412	2401	5	7	2021	8	40
AR21_080.awi	N-11	76.500	3.996	214	166	5	7	2021	12	17
AR21_081.awi	N-11	76.501	4.001	2629	2622	5	7	2021	20	38
AR21_082.awi	N-12	76.501	2.998	1357	1325	6	7	2021	0	8
AR21_083.awi	N-13	76.504	2.011	3246	3256	6	7	2021	2	33
AR21_084.awi	K18	75.001	3.007	2490	2498	6	7	2021	14	30
AR21_085.awi	K17	75.000	3.981	1357	1325	6	7	2021	17	39
AR21_086.awi	K16	75.000	5.000	3128	3134	6	7	2021	20	9
AR21_087.awi	K15	75.000	6.000	1355	1323	6	7	2021	23	47
AR21_088.awi	K14	74.999	6.816	2090	2072	7	7	2021	2	1
AR21_089.awi	K13	74.999	7.641	1353	1321	7	7	2021	4	55
AR21_090.awi	K12	75.000	8.493	2878	2882	7	7	2021	7	26
AR21_091.awi	K11	75.000	9.164	2639	2636	7	7	2021	11	12
AR21_092.awi	K10	74.999	10.388	2539	2533	7	7	2021	15	19
AR21_093.awi	K9	75.000	11.634	2401	2389	7	7	2021	19	12
AR21_094.awi	K8	74.999	12.551	2184	2168	7	7	2021	22	23
AR21_095.awi	EB2-1	78.834	9.265	243	201	10	7	2021	23	17
AR21_096.awi	EB2-1P	78.835	9.019	246	204	11	7	2021	1	2
AR21_097.awi	EB2-2	78.835	8.790	261	212	11	7	2021	1	47
AR21_098.awi	EB2-2P	78.833	8.595	407	388	11	7	2021	2	34
AR21_099.awi	EB2-3	78.836	8.430	683	656	11	7	2021	3	18
AR21_100.awi	EB2-3P	78.836	8.253	870	830	11	7	2021	4	38

AR21_101.awi	EB2-4	78.836	8.098	974	951	11	7	2021	5	45
AR21_102.awi	EB2-4P	78.833	7.851	1081	1055	11	7	2021	7	7
AR21_103.awi	EB2-5	78.831	7.595	1110	1114	11	7	2021	8	19
AR21_104.awi	EB2-5P	78.833	7.347	1239	1205	11	7	2021	10	6
AR21_105.awi	EB2-6	78.834	7.095	1393	1357	11	7	2021	11	40
AR21_106.awi	EB2-6P	78.834	6.878	1580	1552	11	7	2021	13	18
AR21_107.awi	EB2-7	78.834	6.668	1745	1720	11	7	2021	15	41
AR21_108.awi	S1	77.568	12.986	182	133	12	7	2021	8	44
AR21_109.awi	S2	77.549	12.500	166	95	12	7	2021	10	8
AR21_110.awi	S3	77.533	12.002	217	169	12	7	2021	11	21
AR21_111.awi	S4	77.516	11.496	319	273	12	7	2021	13	51
AR21_112.awi	S5	77.505	10.992	702	664	12	7	2021	15	17
AR21_113.awi	S6	77.485	10.486	1279	1245	12	7	2021	17	10
AR21_114.awi	S7	77.469	9.996	1566	1538	12	7	2021	19	14
AR21_115.awi	S7P	77.452	9.500	1943	1922	12	7	2021	21	31
AR21_116.awi	S8	77.435	8.994	2105	2087	13	7	2021	0	6
AR21_117.awi	S8P	77.420	8.498	1441	1411	13	7	2021	3	2
AR21_118.awi	S9	77.405	8.001	2334	2326	13	7	2021	5	44
AR21_119.awi	S9P	77.385	7.500	3642	3668	13	7	2021	8	46
AR21_120.awi	S10	77.368	6.998	2712	2706	13	7	2021	12	48
AR21_121.awi	S11	77.354	6.511	2179	2168	13	7	2021	16	26
AR21_122.awi	S12	77.336	6.000	2609	2602	13	7	2021	19	19
AR21_123.awi	S13	77.300	4.998	2463	2456	13	7	2021	23	4
AR21_124.awi	S14	77.285	4.493	2428	2427	14	7	2021	1	56
AR21_125.awi	S15	77.273	4.019	2528	2519	14	7	2021	5	32
AR21_126.awi	S16	77.237	2.991	2933	2918	14	7	2021	9	20
AR21_127.awi	S17'	77.214	2.209	3238	3250	14	7	2021	13	24
AR21_128.awi	Z15'	78.039	0.810	3086	3099	14	7	2021	22	32
AR21_129.awi	Z14	78.049	1.500	1339	1321	15	7	2021	1	44
AR21_130.awi	Z13	78.067	2.812	3028	3048	15	7	2021	4	34
AR21_131.awi	Z12	78.084	3.984	1354	1322	15	7	2021	8	29
AR21_132.awi	Z11	78.092	4.986	2620	2613	15	7	2021	10	52
AR21_133.awi	Z10	78.105	5.829	2517	2515	15	7	2021	15	8
AR21_134.awi	Z9	78.116	6.659	2245	2230	15	7	2021	18	31
AR21_135.awi	Z8	78.124	7.487	3471	3486	15	7	2021	21	23
AR21_136.awi	Z7	78.140	8.167	2264	2229	16	7	2021	1	18
AR21_137.awi	Z6	78.142	8.628	1616	1589	16	7	2021	4	1
AR21_138.awi	Z5	78.154	9.005	1148	1113	16	7	2021	5	55
AR21_139.awi	Z4	78.165	9.260	731	692	16	7	2021	7	31
AR21_140.awi	Z3	78.163	9.502	307	262	16	7	2021	8	56
AR21_141.awi	Z2	78.168	10.004	286	264	16	7	2021	9	57
AR21_142.awi	Z1	78.175	11.005	301	254	16	7	2021	12	49
AR21_143.awi	EB-4	78.833	8.100	1004	970	16	7	2021	18	26
AR21_144.awi	EB-7P	78.834	6.421	2143	2127	16	7	2021	21	51
AR21_145.awi	EB-8	78.834	6.165	2397	2385	16	7	2021	23	55
AR21_146.awi	EB-8P	78.834	5.929	2511	2502	17	7	2021	1	59
AR21_147.awi	EB-9	78.834	5.698	2577	2568	17	7	2021	4	24
AR21_148.awi	EB-10`	78.832	5.223	2587	2580	17	7	2021	7	20
AR21_149.awi	EB-9P	78.832	5.408	2574	2566	17	7	2021	10	23
AR21_150.awi	EX9	79.415	4.584	2548	2549	17	7	2021	17	30
AR21_151.awi	EX8P	79.416	5.000	2506	2504	17	7	2021	20	12
AR21_152.awi	EX8	79.416	5.500	2285	2277	17	7	2021	22	33
AR21_153.awi	EX7P	79.416	5.998	1830	1807	18	7	2021	1	10
AR21_154.awi	EX7	79.416	6.480	1510	1471	18	7	2021	3	12
AR21_155.awi	EX6	79.416	6.979	1234	1199	18	7	2021	5	20
AR21_156.awi	EX5	79.419	7.333	1057	1020	18	7	2021	6	56
AR21_157.awi	EX4P	79.416	7.658	820	779	18	7	2021	8	19
AR21_158.awi	EX4	79.416	7.913	548	504	18	7	2021	9	17
AR21_159.awi	EX3P	79.416	8.166	323	276	18	7	2021	10	4
AR21_160.awi	EX3	79.416	8.502	185	186	18	7	2021	10	50

AR21_161.awi	EX2	79.417	8.999	160	124	18	7	2021	12	29
AR21_162.awi	EX1	79.417	9.497	127	121	18	7	2021	13	21
AR21_163.awi	NB1	80.552	16.537	109	45	19	7	2021	0	35
AR21_164.awi	NB2	80.613	16.395	157	113	19	7	2021	1	14
AR21_165.awi	HB1	80.545	15.024	168	119	19	7	2021	17	39
AR21_166.awi	HB2	80.621	14.855	181	132	19	7	2021	18	35
AR21_167.awi	HB3	80.690	14.699	851	813	19	7	2021	19	23
AR21_168.awi	HB5	80.752	14.560	741	707	19	7	2021	21	6
AR21_169.awi	HB7	80.814	14.418	867	854	19	7	2021	22	9
AR21_170.awi	HB8	80.872	14.285	1289	1258	19	7	2021	23	44
AR21_171.awi	WB18	80.808	11.761	1618	1625	20	7	2021	4	3
AR21_172.awi	WB17	80.747	11.811	1482	1452	20	7	2021	5	25
AR21_173.awi	WB16	80.676	11.925	1333	1301	20	7	2021	6	54
AR21_174.awi	WB15	80.629	11.986	1199	1169	20	7	2021	8	20
AR21_175.awi	WB14	80.580	12.048	1044	1029	20	7	2021	9	55
AR21_176.awi	WB13	80.547	12.087	964	926	20	7	2021	11	4
AR21_177.awi	WB12	80.516	12.133	837	797	20	7	2021	12	0
AR21_178.awi	WB11	80.483	12.172	688	651	20	7	2021	13	1
AR21_179.awi	WB10	80.469	12.195	608	570	20	7	2021	13	44
AR21_180.awi	WB9	80.453	12.216	513	469	20	7	2021	14	26
AR21_181.awi	WB8	80.436	12.239	388	342	20	7	2021	15	27
AR21_182.awi	WB7	80.418	12.258	266	229	20	7	2021	16	14
AR21_183.awi	WB6	80.383	12.312	234	178	20	7	2021	17	3
AR21_184.awi	WB5	80.353	12.316	198	170	20	7	2021	18	17
AR21_185.awi	WB4	80.286	12.402	238	190	20	7	2021	19	2
AR21_186.awi	WB3	80.224	12.483	233	190	20	7	2021	19	44
AR21_187.awi	WB2	80.161	12.555	209	177	20	7	2021	21	6
AR21_188.awi	WB1	80.090	12.635	228	184	20	7	2021	21	53
AR21_189.awi	Y13	80.195	7.456	602	559	21	7	2021	4	7
AR21_190.awi	Y12	80.134	7.696	580	536	21	7	2021	5	41
AR21_191.awi	Y11	80.073	8.040	550	509	21	7	2021	7	3
AR21_192.awi	Y10	80.017	8.353	539	497	21	7	2021	8	6
AR21_193.awi	Y9	79.956	8.710	522	480	21	7	2021	9	23
AR21_194.awi	Y8	79.896	9.049	502	457	21	7	2021	10	55
AR21_195.awi	Y7	79.838	9.377	502	457	21	7	2021	12	0
AR21_196.awi	Y6	79.796	9.610	465	425	21	7	2021	12	55
AR21_197.awi	Y5	79.754	9.843	419	370	21	7	2021	13	45
AR21_198.awi	Y4	79.731	9.948	342	307	21	7	2021	15	11
AR21_199.awi	Y3	79.706	10.108	177	138	21	7	2021	15	56
AR21_200.awi	Y2	79.681	10.245	136	88	21	7	2021	16	31
AR21_201.awi	Y1	79.659	10.348	74	29	21	7	2021	17	2

4.1.2 Aerosol and meteorological measurements

During the cruise leg I-II-III the vertical fluxes of CO_2 in the atmospheric boundary layer were measured by the Li-COR gas analyzer; measurements of marine aerosol characteristics and measurements of sensible and latent heat fluxes between the sea and the atmosphere were carried out with the OPC-N3 particle counter (optical particle counter), CPC (condensation particle counter) and LAS (laser aerosol spectrometer); with the use of two aethalometers AE31 and AE33, the concentration, absorption and dispersion of black carbon particles were measured. The vessel motion was recorded using the Ellipse-N-G4A2-B1 inertial motion detection system. The standard meteorological observations were carried out according to the SHIP standard and with the Vaisala WXT563 automatic weather station. The physical properties of the aerosol, such as aerosol optical thickness (AOD), were measured using the Microtops II solar photometer in favorable weather conditions (no clouds). At selected stations, water samples were collected from the surface microlayer (for surface active

substances - surfactants) using a Garrett net and bathometer (1 m below the surface). Samples from each station were filtered, preserved and then frozen. Sampling station list: PHM1, H6, H12, H18, K7, K4, V24, K-3, K0, K2, N-3, N-11, K18, K14, K10, EB2-6P, S11, S17, Z10, Z1, EX9, WB and Y5 (Fig. 2).

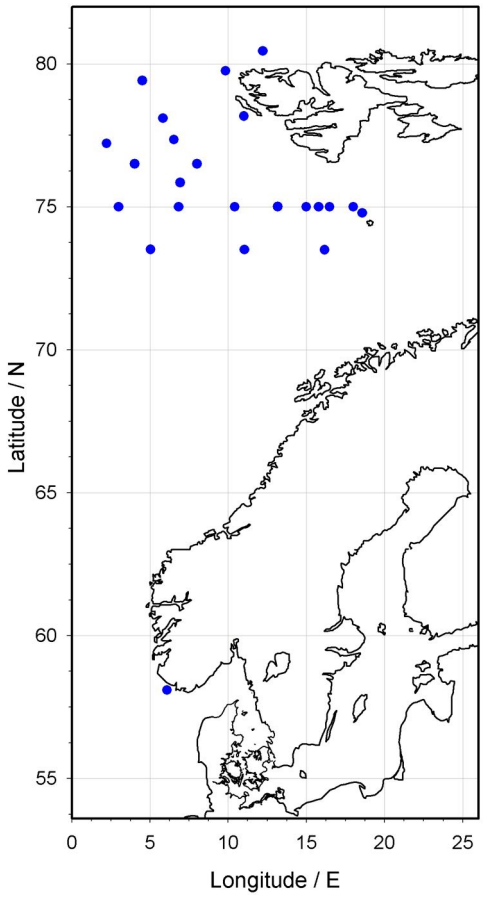

Figure 2. Stations with sampling of the surface microlayer during the AREX'2021 cruise.

4.1.3 Plankton measurements

During the leg I-II-III of the AREX expedition plankton samples were collected at the selected stations in the open ocean part (Norwegian, Barents and Greenland seas). For the collection of zooplankton samples, 40 standard stations and 20 supplementary stations were selected, located along 6 and 4 latitudinal measurement sections (transects). The extent of the layers was determined at each research station, based on the measurements of temperature and salinity profiles. On selected stations, plankton (zooplankton) samples were collected with sampling nets (WP2/180 and WP3/64). In total, 144 zooplankton samples were collected for the AREX long-term monitoring and 15 samples for the PHARMARINE project. Zooplankton samples for PHARMARINE research, zooplankton mass samples and samples of zooplankton biomass to measure the types and concentrations of selected pharmaceuticals used in human therapy in zooplankton organisms, were collected with the WP-2 (180) net in vertical hauls from the top layer of 50 m. A total of 20 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 a Juday net (64) in vertical

hauls, in the water layer from the bottom to the surface on shelf stations (maximum depth of 400 m). A total of 18 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) net in vertical hauls, in the 50-0 m water layer, at selected plankton stations. A total of 20 samples were collected of testing genetic diversity.

4.1.4 Marine chemistry measurements

- Water sampling for the IOPAN statuory Task II.8

During stages I-II-III, a total of 274 samples of seawater were collected for chemical analysis for the spatial variability of concentrations and bioavailability of mercury and other trace metals in the Western Spitsbergen region. Using a rosette and bathometers, samples were taken at 50 stations (Fig. 3) in the study area. At individual stations, samples were collected from different water layers at from 3 to 14 levels, depending on the ocean properties at individual stations (Table 4). Blank samples were also taken at three points. The results of the measurements will be statistically analyzed, considering the properties of sea water and the distribution of water masses.

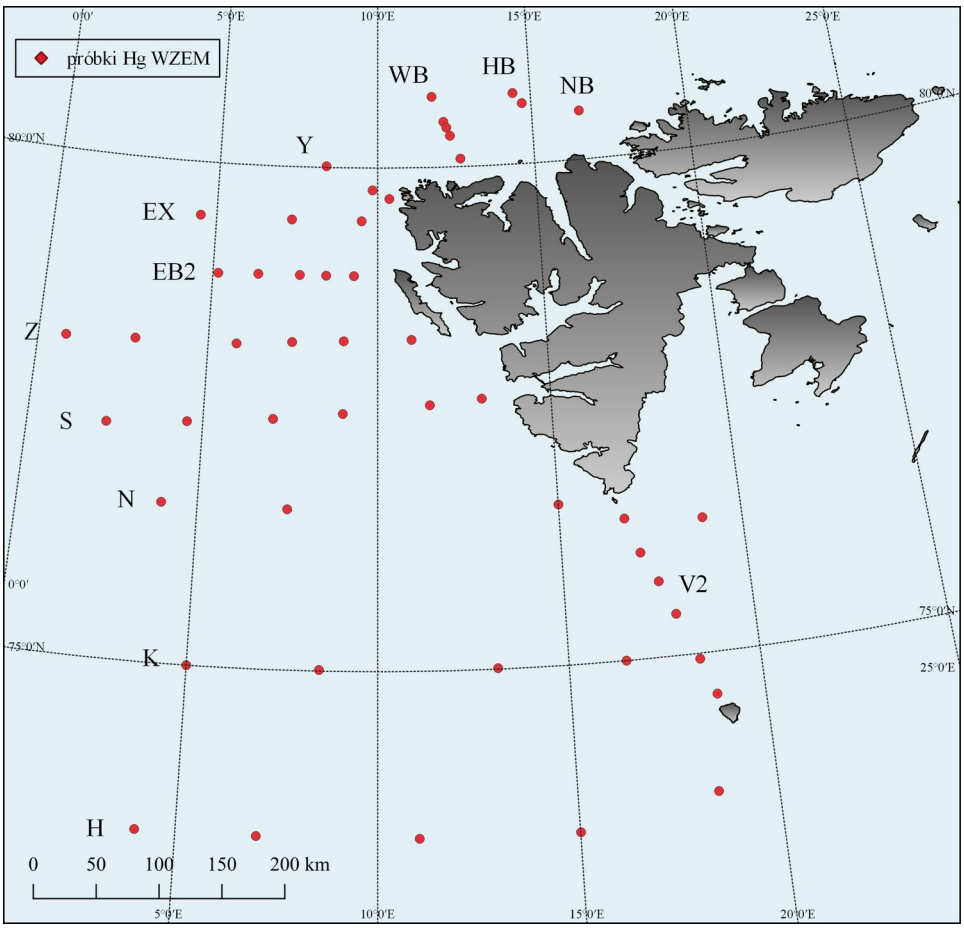

Figure 3. Stations with water sampling for mercury and trace metals concentration collected during the AREX'2021 cruise.

Table 4. List of stations with sampling for mercury concentration occupied during the open ocean part of the AREX'2021 cruise

ID	Station	File	Lon	Lat	Date	Time LT	Time UTC	H [m]	Number samples
1	**H1**	AR21_008	18.50005	73.75018333	23.06.2021	08:53	06:53	421	5
2	**H4**	AR21_014	15.00768	73.4996	23.06.2021	19:04	17:04	675	5
3	**H12**	AR21_019	11.03375	73.50073333	24.06.2021	15:35	13:35	2080	5
4	**H16**	AR21_023	6.9968	73.50546667	25.06.2021	07:02	05:02	2150	5
5	**H19**	AR21_026	3.99615	73.50145	25.06.2021	19:00	17:00	2763	5
6	**K7**	AR21_027	13.14143	75.00861667	26.06.2021	15:40	13:40	1976	5
7	**V22**	AR21_033	18.75062	74.61641667	28.06.2021	15:51	13:51	71	3
8	**V26**	AR21_037	18.41263	74.94935	28.06.2021	19:40	17:40	75	3
9	**K0**	AR21_041	16.49943	74.99985	29.06.2021	01:31	23:31	157	5
10	**V29**	AR21_046	17.91577	75.38283333	29.06.2021	10:55	08:55	101	3
11	**V31**	AR21_048	17.54598	75.69896667	29.06.2021	14:49	12:49	214	5
12	**V33**	AR21_050	17.13277	75.98283333	29.06.2021	18:49	16:49	320	5
13	**V36**	AR21_053	16.78348	76.31666667	29.06.2021	23:07	21:07	111	3
14	**O8**	AR21_055	18.91538	76.25011667	30.06.2021	03:18	01:18	255	5
15	**N4**	AR21_061	15.00218	76.50008333	03.07.2021	01:13	23:13	150	5
16	**N-5**	AR21_074	7.492833	76.4984	04.07.2021	18:39	16:39	2502	10
17	**N-11**	AR21_081	3.9994	76.50001667	05.07.2021	14:21	12:21	2481	11
18	**K16**	AR21_086	4.99945	74.99973333	06.07.2021	22:10	20:10	3047	14
19	**K12**	AR21_090	8.464783	75.00965	07.07.2021	09:33	07:33	2782	11
20	**EB2-1**	AR21_095	9.2774	78.83331667	11.07.2021	01:20	23:20	198	5
21	**EB2-3**	AR21_099	8.433083	78.83323333	11.07.2021	05:27	03:27	656	5
22	**EB2-5**	AR21_103	7.633683	78.83348333	11.07.2021	10:23	08:23	1099	4
23	**S1**	AR21_108	13.00287	77.56718333	12.07.2021	10:45	08:45	130	3
24	**S4**	AR21_111	11.50162	77.51708333	12.07.2021	15:55	13:55	277	5
25	**S8**	AR21_116	8.995967	77.43391667	13.07.2021	02:06	00:06	2050	5
26	**S10**	AR21_120	6.999217	77.36706667	13.07.2021	15:00	13:00	2660	5
27	**S14**	AR21_124	4.547333	77.29613333	14.07.2021	03:53	01:53	2427	5
28	**S17**	AR21_127	2.25275	77.22825	14.07.2021	15:32	13:32	3249	5
29	**Z15**	AR21_128	0.81015	78.04103333	15.07.2021	00:39	22:39	3089	5
30	**Z13**	AR21_130	2.848883	78.0804	15.07.2021	06:30	04:30	3046	5
31	**Z10**	AR21_133	5.833483	78.10083333	15.07.2021	16:20	14:20	2473	5
32	**Z8**	AR21_135	7.469233	78.14045	15.07.2021	23:31	21:31	3400	5
33	**Z5**	AR21_138	8.99435	78.16043333	16.07.2021	08:06	06:06	1097	5
34	**Z1**	AR21_142	10.99858	78.17496667	16.07.2021	14:55	12:55	252	5
35	**EB2-7P**	AR21_144	6.373117	78.82876667	17.07.2021	00:02	22:02	2084	5
36	**EB2-10**	AR21_148	5.157067	78.81455	17.07.2021	09:33	07:33	2536	5
37	**EX9**	AR21_150	4.500017	79.41671667	17.07.2021	19:48	17:48	2506	5
38	**EX5**	AR21_156	7.334817	79.42038333	18.07.2021	09:01	07:01	1011	5
39	**EX1**	AR21_162	9.49955	79.41681667	18.07.2021	15:24	13:24	127	3
40	**NB1**	AR21_163	16.53623	80.5532	19.07.2021	02:38	00:38	49	3

41	**HB3**	AR21_167	14.70152	80.68823333	19.07.2021	21:23	19:23	802	5
42	**HB7**	AR21_169	14.41785	80.81276667	20.07.2021	00:15	22:15	841	5
43	**WB18**	AR21_171	11.76133	80.80823333	20.07.2021	06:03	04:03	1615	6
44	**WB12**	AR21_177	12.1252	80.51376667	20.07.2021	12:10	10:10	793	5
45	**WB9**	AR21_180	12.21577	80.44605	20.07.2021	16:31	14:31	462	5
46	**WB5**	AR21_184	12.32425	80.35155	20.07.2021	20:22	18:22	168	5
47	**WB1**	AR21_188	12.6358	80.09003333	20.07.2021	23:59	21:59	190	3
48	**Y10**	AR21_192	8.370367	80.01466667	21.07.2021	10:14	08:14	501	5
49	**Y5**	AR21_197	9.836133	79.75356667	21.07.2021	15:48	13:48	364	21
50	**Y1**	AR21_201	10.3619	79.65898333	21.07.2021	19:09	17:09	28	3

- Water sampling for studying the carbonate system variability

To determine the variability of the carbonate system and its determinants in the surface layer and the water column at selected stations, samples of surface water were collected with the use of a water pump installed on the ship and samples from the water column with the use of a rosette. Measured parameters included salinity, temperature, pH, O_2, P_{atm}, pCO_2, DIC, alkalinity, DOC, nutrients, and metals.

Table 5. List of surface and water column sampling stations for carbonate system variables occupied during the open ocean part of the AREX'2021 cruise.

Station	File AR21_	Coordinates		Date	UTC	H [m]	Level column
K3	031	75 0.595' N	15 24.331' E	27.06.2021	01:47	818	0
K-3	038	75 0.036' N	18 0.012' E	28.06.2021	19:06	152	0
O8	055	78 14.990' N	18 55.295' E	30.06.2021	01:31	258	0
N4P	060	76 30.071' N	15 30.002' E	02.07.2021	22:03	132	0
N0P	068	76 30.038' N	11 30.097' E	03.07.2021	22:43	2000	0
N-10	079	76 30.061' N	05 0.097' E	05.07.2021	08:48	2373	0
N-12	082	76 30.044' N	03 0.004' E	06.07.2021	00:19	2749	0
K18	084	75 0.130' N	02 59.764' E	06.07.2021	16:48	2451	0
K10	092	74 59.999' N	10 25.066' E	07.07.2021	15:33	2480	0
EB2-1	095	78 50.006' N	09 16.298' E	10.07.2021	23:24	204	0
EB2-7	107	78 50.004' N	06 40.019' E	11.07.2021	15:39	1693	0
S1	108	77 34.012' N	12 59.916' E	12.07.2021	08:49	140	0
S7P	115	77 27.214' N	09 31.072' E	12.07.2021	22:04	1902	0
S12	122	77 20.029' N	06 00.110' E	13.07.2021	19:26	2500	0
S16	126	77 14.998' N	03.02.621' E	14.07.2021	11:07	2860	0
Z15'	128	78 02.448' N	00 48.595' E	14.07.2021	22:39	3025	0
Z10	132	78 06.032' N	05 50.064' E	15.07.2021	14:18	2464	0
Z1	142	78 10.486' N	10 59.926' E	16.07.2021	12:55	256	0
EB2-9P	149	78 49.974' N	05 24.904' E	17.07.2021	10:36	2550	0
EX7	154	79 24.994' N	06 29.845' E	18.07.2021	03:19	1440	0
EX1	162	79 25.030' N	09 30.028' E	18.07.2021	13:28	118	0

NB1	163	80 33.172' N	16 32.204' E	19.07.2021	00:40	45	0
HB7	169	80 48.856' N	14 24.934' E	19.07.2021	22:14	842	0
WB14	175	80 34.794' N	12 02.792' E	20.07.2021	10:00	1013	0
WB10	179	80 27.997' N	12 11.461' E	20.07.2021	13:51	570	0
WB1	188	80 05.401' N	12 38.173' E	21.07.2021	21:58	154	0
Y12	190	80 07.985' N	07 41.342' E	21.07.2021	05:45	540	0
Y8	194	79 52.794' N	09 02.572' E	21.07.2021	10:55	450	0
Y1	201	79 39.518' N	10 21.634' E	21.07.2021	17:02	36	0
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	2456
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	2300
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	2000
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	1500
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	1000
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	500
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	200
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	100
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	50
N-5	074	76 30.062' N	07 29.789' E	04.07.2021	16:50	2456	0
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	2832
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	2500
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	2000
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	1500
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	1000
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	500
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	200
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	100
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	50
K12	090	75 00.040' N	08 29.753' E	07.07.2021	07:34	2832	0
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	3418
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	2500
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	2000
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	1500
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	1000
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	500
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	200
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	100
Z8	135	78 08.209' N	07 29.006' E	15.07.2021	22:20	3418	0
EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	2506
EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	2000
EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	1500
EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	1000
EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	500
EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	200
EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	100
EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	50

EX9	150	79 24.994' N	04 31.130' E	17.07.2021	18:03	2506	0
WB14	175	80 34.794' N	12 02.792' E	20.07.2021	10:00	1013	1013
WB14	175	80 34.794' N	12 02.792' E	20.07.2021	10:00	1013	700
WB14	175	80 34.794' N	12 02.792' E	20.07.2021	10:00	1013	400
WB14	175	80 34.794' N	12 02.792' E	20.07.2021	10:00	1013	200
WB14	175	80 34.794' N	12 02.792' E	20.07.2021	10:00	1013	35
Y8	194	79 52.794' N	09 02.572' E	21.07.2021		450	450
Y8	194	79 52.794' N	09 02.572' E	21.07.2021		450	400
Y8	194	79 52.794' N	09 02.572' E	21.07.2021		450	200
Y8	194	79 52.794' N	09 02.572' E	21.07.2021		450	75
Y8	194	79 52.794' N	09 02.572' E	21.07.2021		450	50

- Water sampling for chlorophyll-a and for the HIDEA project

The samples were taken with the use of Niskin cylinders (10l). Meroplankton stations water samples from each station with 5 depth layers determined based on fluorescence measurements. Stations from the HIDEA project water samples collected from 3 depth layers (0, 25 and 50 m), with 0m samples taken with an oceanographic bucket. Physical measurements of temperature and salinity at sampling stations made it possible to access the environmental background.

The water samples were collected at the following stations:

- PhM1; PhM3; PhM5; H3; V22; V26; K-3; V29; V31; V34; N4; S3; EB2-1; Z2; EX3; HB3; WB3; Y5 (meroplankton stations, chlorophyll-a);
- H4; H18; K4; N2; N-11; K-16; EB2-5; S6; S16; EX5; HB3; WB6; Y9 (HIDEA project-bacterioplankton and protozoan plankton).

4.2 Field measurements and water sampling during the AREX'2021 leg IVa (Hornsund and Kongsfjorden)

During the leg IVa of the AREX'2021 cruise, measurements and water and sediment samples were collected in the West Spitsbergen fjords Hornsund and Kongsfjorden/Krossfjorden. The cruise leg lasted 16 days without calling Longyearbyen and crew exchange. The low or complete absence of ice cover in the inner parts of the fjords basins made it possible to perform additional optical measurements and to collect samples from the water column in the direct vicinity of the glaciers.

4.2.1 Ecological measurements - plankton (PEP, Plankton Ecology Lab)

- Long-term zooplankton monitoring under the AREX program and PHARMARINE

During the leg IVa, the collection of plankton samples (Hornsund - 4 stations; Kongsfjorden - 8 stations) was carried out using the WP2/180 net due to the failure of the mesh closing mechanism in the Multinet. The samples were collected from 3 layers of the water column.

In addition, individual zooplankton samples were collected on selected stations in the front of Hornsund and Kongsfjorden for the PHARMARINE project. In the foreground of Hornsund the WP2-500 net was used to collect samples on 12 stations.

- Meroplankton sampling for HIMERO

Meroplankton samples for genetic testing were collected in Hornsund and Kongsfjorden using a Juday/56 µm net from the entire water column (bottom-0m). Additionally, at 8 stations in Kongsfjorden and its forefront (V10-KB5 transect), 2 zooplankton samples (above and below the halocline) were collected. Sea water samples (1-2 l, from 5-8 depth levels) were collected at selected stations and then filtered on two filters with different porosity to verify chlorophyll concentrations.

- Zooplankton sampling for HIDEA

Eight zooplankton samples (WP2-180 net) and water samples (1 l of water from three depths: 0, 25, 50m) were collected for bacterioplankton and protozoal plankton for genetic testing. The water samples were filtered through a set of 2 filters with different porosity.

Table 6. Sampling stations and tools used by the PEP team during the AREX'2021 cruise leg IVa.

Station	Depth [m]	Date	Lon	Lat	Samples
HORNSUND					
H1	114	25.07.21	77 00.145	016 27.947	WP2/180µm; Juday/56µm, Niskin
H2	215	25.07.21	76 58.987	015 46.235	WP2/180µm; Juday/56µm, Niskin
H3	122	25.07.21	77 00.596	016 30.191	WP2/180µm; Juday/56µm, Niskin
H4	98	25.07.21	77 00.637	016 01.423	WP2/180µm; Juday/56µm, Niskin
AUK12	52	28.07.21	76 45.004	015 18.464	WP2/500µm; Juday/56µm
AUK11	216	28.07.21	76 41.111	014 48.487	WP2/500µm
AUK10	197	28.07.21	76 38.276	014 28.649	WP2/500µm
AUK9	194	29.07.21	76 34.860	014 06.553	WP2/500µm
AUK16	595	29.07.21	76 24.624	014 39.558	WP2/500µm
AUK15	176	29.07.21	76 28.339	015 03.918	WP2/500µm
AUK14	94	29.07.21	76 32.982	015 27.526	WP2/500µm
AUK13	34	29.07.21	76 35.516	015 47.050	WP2/500µm; Juday/56µm
AUK22	34	29.07.21	76 26.957	016 08.102	WP2/500µm; Juday/56µm
AUK21	86	29.07.21	76 25.692	015 48.253	WP2/500µm
AUK20	145	29.07.21	76 22.558	015 27.374	WP2/500µm
AUK19	312	29.07.21	76 18.876	014 58.206	WP2/500µm
KONGSFJORDEN/KROSSFJORDEN					
V10	298	31.07.21	78 55.974	008 32.497	WP2/180µm; Juday/56µm, Niskin
V12	217	31.07.21	78 58.799	009 30.925	WP2/180µm; Juday/56µm, Niskin
V14	263	31.07.21	79 00.386	010 28.963	WP2/180µm; Juday/56µm, Niskin
KB0	305	31.07.21	79 02.557	011 08.096	WP2/180µm; Juday/56µm, Niskin
KB1	364	31.07.21	79 00.607	011 24.337	WP2/180µm; Juday/56µm, Niskin
KB2	301	01.08.21	78 58.733	011 42.595	WP2/180µm; Juday/56µm, Niskin
KB3	350	02.08.21	78 57.060	011 53.677	WP2/180µm; Juday/56µm, Niskin
KB5	86	03.08.21	78 53.185	012 26.425	WP2/180µm; Juday/56µm, Niskin
KF1					Juday/56µm
SGD25					Juday/56µm
SGD30					Juday/56µm
KL1					Juday/56µm
KL2					Juday/56µm

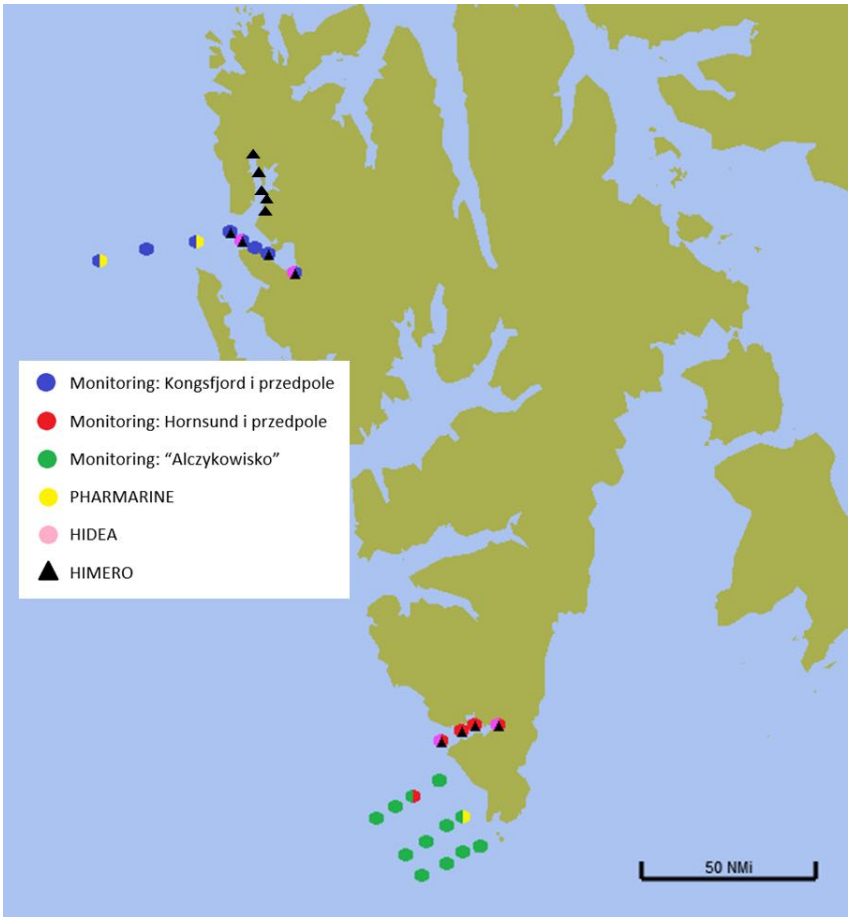

Figure 4. Location of the PEP sampling stations during the AREX'2021 cruise.

4.2.2 Ecological measurements - plankton (PFBP, Functioning of Pelagic Biocenosis Lab)

- Long-term zooplankton monitoring under the AREX program and PHARMARINE

During the cruise leg IVa, measurements and collection of samples were carried out for the IOPAN statuory Task I.7 and the projects SEAPOPIA, CoastDark and Calanetics. The measurements included vertical profiles of size and distribution of planktonic organisms measured in the 0-50m layer with laser optical particle counter (LOPC) during transects in Hornsund (section from station H1 to HB1) and along the hydrographic section in Kongsfjorden (from stations KB5 to KB0) and on the shelf next to the Hornsund entrance (two transects: AUK12-AUK9 and AUK16- AUK13). Additionally, samples were collected along vertical profiles (bottom-0m) at 3 long-term zooplankton monitoring stations on the shelf next to the Kongsfjorden inlet (V10, V12, V14). Plankton and particle distribution was measured using the LOPC-CTD-F-T at 34 vertical profiles (bottom-0m) in Hornsund, next to the at Torell glacier, Kongsfjorden and Krossfjorden. During the following part of the cruise, mesozooplankton samples (0-50m layer, WP2/180 µm net) were collected at 8 monitoring stations in Kongsfjorden (stations V10 to KB5). The same method was used at 13 stations at the front of Hornsund and the material collected at these stations was divided into samples for taxonomic analyzes and samples for genetic analysis of two Calanus species. Samples for distribution of protozoa (phytoplankton net, water from 5 levels: 0, 5, 15, 25, 40 m) and mesozooplankton (WP2 / 100 µm, layers 0-10-50-bottom) were collected at 11 stations in Hornsund, next to the Torell glacier, and in Kongsfjorden and Krossfjorden.

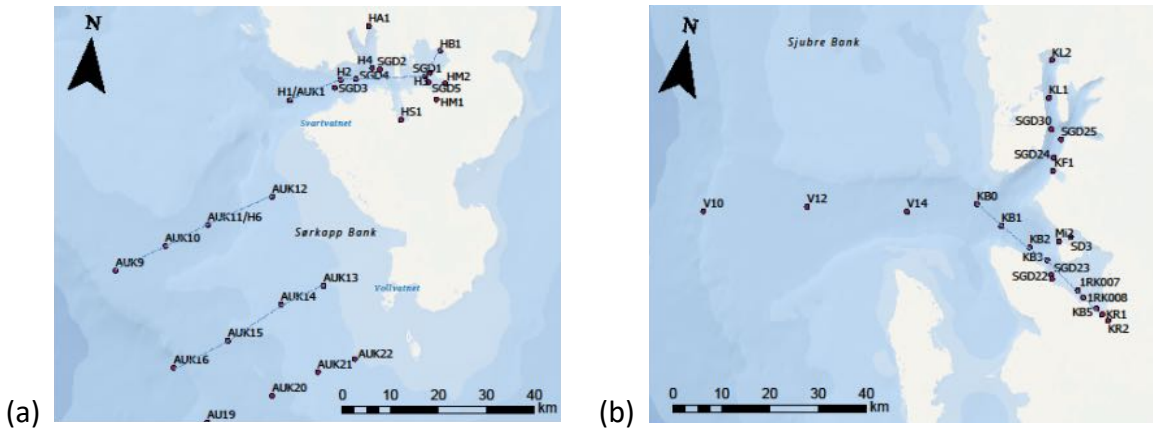

Figure 5. Location of the PFBP stations (a) in Horsund and its forefield and (b) in Kongsfjored and Krossfjorden occupied during the AREX 2021 cruise.

Table 7. Sampling stations and tools used by the PFBP team during the AREX'2021 cruise leg IVa.

Station	Depth [m]	Date	Lat	Lon	Samples
HORNSUND					
H1	114	25.07.21	77 00.145	016 27.947	WP2/180µm
H2	215	25.07.21	76 58.987	015 46.235	WP2/100µm; net fito; LOPC-CTD-F-T
H3	122	25.07.21	77 00.596	016 30.191	WP2/100µm; net fito; LOPC-CTD-F-T
H4	98	25.07.21	77 00.637	016 01.423	LOPC-CTD-F-T
HB1	50	25.07.2021	77 03.148	016 34.454	WP2/100µm; net fito; LOPC-CTD-F-T
HM1	66	27.07.2021	76 57.633	016 34.500	LOPC-CTD-F-T
HM2	53	27.07.2021	76 59.500	016 38.300	LOPC-CTD-F-T
HS1	76	27.07.2021	76 55.028	016 17.745	LOPC-CTD-F-T
HA1	80	28.07.2021	77 05.333	015 57.850	LOPC-CTD-F-T
SGD1	124	26.07.2021	77 00.130	016 27.840	LOPC-CTD-F-T
SGD2	83	26.07.2021	77 00.120	016 05.073	LOPC-CTD-F-T
SGD3	240	26.07.2021	76 57.973	015 43.474	LOPC-CTD-F-T
SGD4	167	25.07.2021	76 59.219	015 53.789	LOPC-CTD-F-T
SGD5	45	25.07.2021	76 59.506	016 29.772	LOPC-CTD-F-T
T1	38	30.07.2021	77 09.406	014 43.217	WP2/100µm; net fito; LOPC-CTD-F-T
T2	7	30.07.2021	77 09.353	014 35.419	WP2/100µm; net fito; LOPC-CTD-F-T
AUK12	52	28.07.21	76 45.004	015 18.464	WP2/180µm
AUK11	216	28.07.21	76 41.111	014 48.487	WP2/180µm
AUK10	197	28.07.21	76 38.276	014 28.649	WP2/180µm
AUK9	194	29.07.21	76 34.860	014 06.553	WP2/180µm
AUK16	595	29.07.21	76 24.624	014 39.558	WP2/180µm
AUK15	176	29.07.21	76 28.339	015 03.918	WP2/180µm
AUK14	94	29.07.21	76 32.982	015 27.526	WP2/180µm
AUK13	34	29.07.21	76 35.516	015 47.050	WP2/180µm
AUK22	34	29.07.21	76 26.957	016 08.102	WP2/180µm
AUK21	86	29.07.21	76 25.692	015 48.253	WP2/180µm
AUK20	145	29.07.21	76 22.558	015 27.374	WP2/180µm
AUK19	312	29.07.21	76 18.876	014 58.206	WP2/180µm
KONGSFJORDEN					
V10	298	31.07.21	78 55.974	008 32.497	WP2/180µm; LOPC

V12	217	31.07.21	78 58.799	009 30.925	WP2/180µm; LOPC
V14	263	31.07.21	79 00.386	010 28.963	WP2/180µm; LOPC
KB0	305	31.07.21	79 02.557	011 08.096	WP2/180µm; LOPC-CTD-F-T
KB1	364	31.07.21	79 00.607	011 24.337	WP2/100µm; net fito; LOPC-CTD-F-T
KB2	301	01.08.21	78 58.733	011 42.595	LOPC-CTD-F-T; WP2/180µm
KB3	350	02.08.21	78 57.060	011 53.677	LOPC-CTD-F-T; WP2/180µm
KB5	86	03.08.21	78 53.185	012 26.425	WP2/100µm; net fito; LOPC-CTD-F-T
KR1	59	03.08.21	78 52.603	012 29.948	WP2/100µm; net fito; LOPC-CTD-F-T
KR2	64	03.08.21	78 52.027	012 33.774	WP2/100µm; net fito; LOPC-CTD-F-T
Mi2	71	02.08.21	78 59.916	011 58.884	LOPC-CTD-F-T
SGD23		02.08.21	78 56.115	011 57.334	LOPC-CTD-F-T
SGD22		02.08.21			LOPC-CTD-F-T
SD3		05.08.21	79 00.606	016 05.300	LOPC-CTD-F-T
1RK008	42	03.08.21	78 54.178	012 17.689	LOPC-CTD-F-T
1RK007	102	03.08.21	78 54.856	012 14.077	LOPC-CTD-F-T
KF1	60	06.08.21	79 07.565	011 49.060	WP2/100µm; net fito; LOPC-CTD-F-T
KL1		07.08.21			LOPC-CTD-F-T
KL2	174	07.08.21	79 19.692	011 38.046	WP2/100µm; net fito; LOPC-CTD-F-T
SGD24	245	07.08.21	79 09.028	011 48.388	LOPC-CTD-F-T
SGD25	141	07.08.21	79 11.152	011 50.845	LOPC-CTD-F-T
SGD30	282	07.08.21	79 12.073	011 44.332	LOPC-CTD-F-T

4.2.3 Ecological measurements - benthos PEB (Benthos Ecology Lab)

- Long-term benthos monitoring under the AREX program

As part of the long-term monitoring of benthic fauna (infauna) samples were collected at monitoring stations in the Hornsund and Kongsfiorden. Macrofauna and meiofauna samples were collected at the monitoring stations in the fjords of Hornsund and Kongsfjorden to determine the taxonomic composition, biomass, abundance, and biodiversity of benthos determined by metagenomic methods. On each station benthos sampling included samples for the identification of macrofauna (with the van Veen's grab; 6-7 repetitions) with temperature and salinity background. Samples for the determination of environmental conditions (HCN, granulometry, chlorophyll concentration), and genetic samples from the surface layers of the sediment (samples from the sediment core collected with the box-corer). Additionally, a collection of 3 taxa of littoral fauna (Gammarus spp., Littorina spp., Semibalanus spp.) was carried out for genetic research under the Adamant project. Locations of the benthos sampling stations are shown on Fig.6.

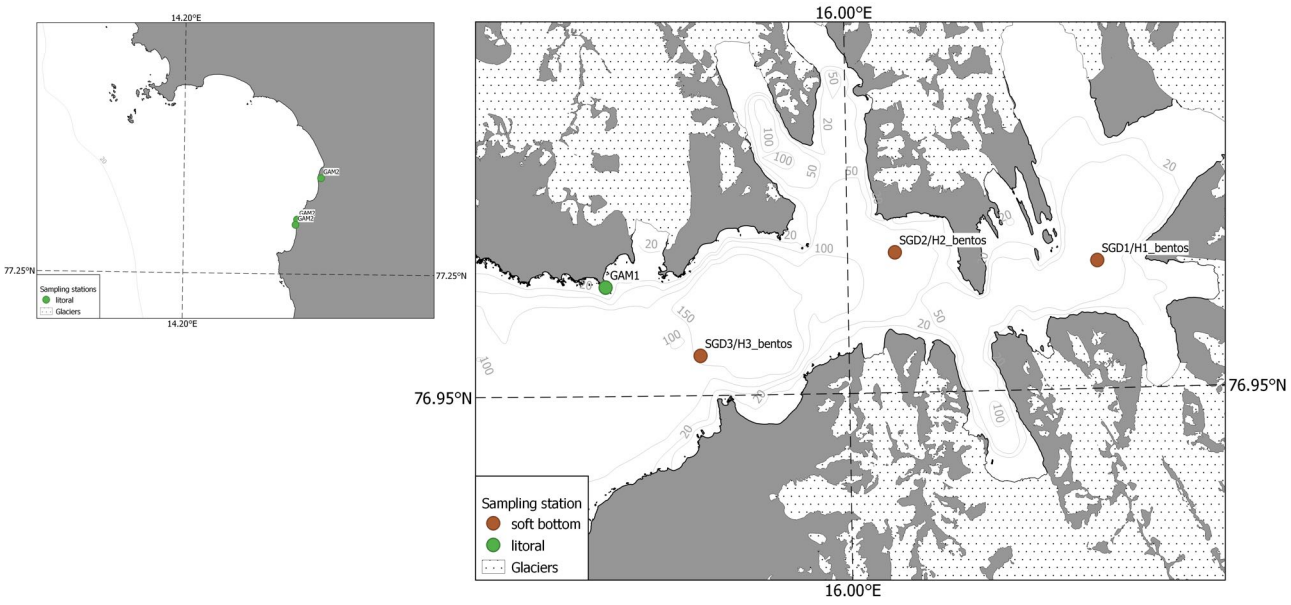

Figure 6. Locations of the benthic sampling station in the Hornsund region during the AREX 2021 cruise. The benthos monitoring stations are marked in brown, and the collection points of littoral fauna are marked in green.

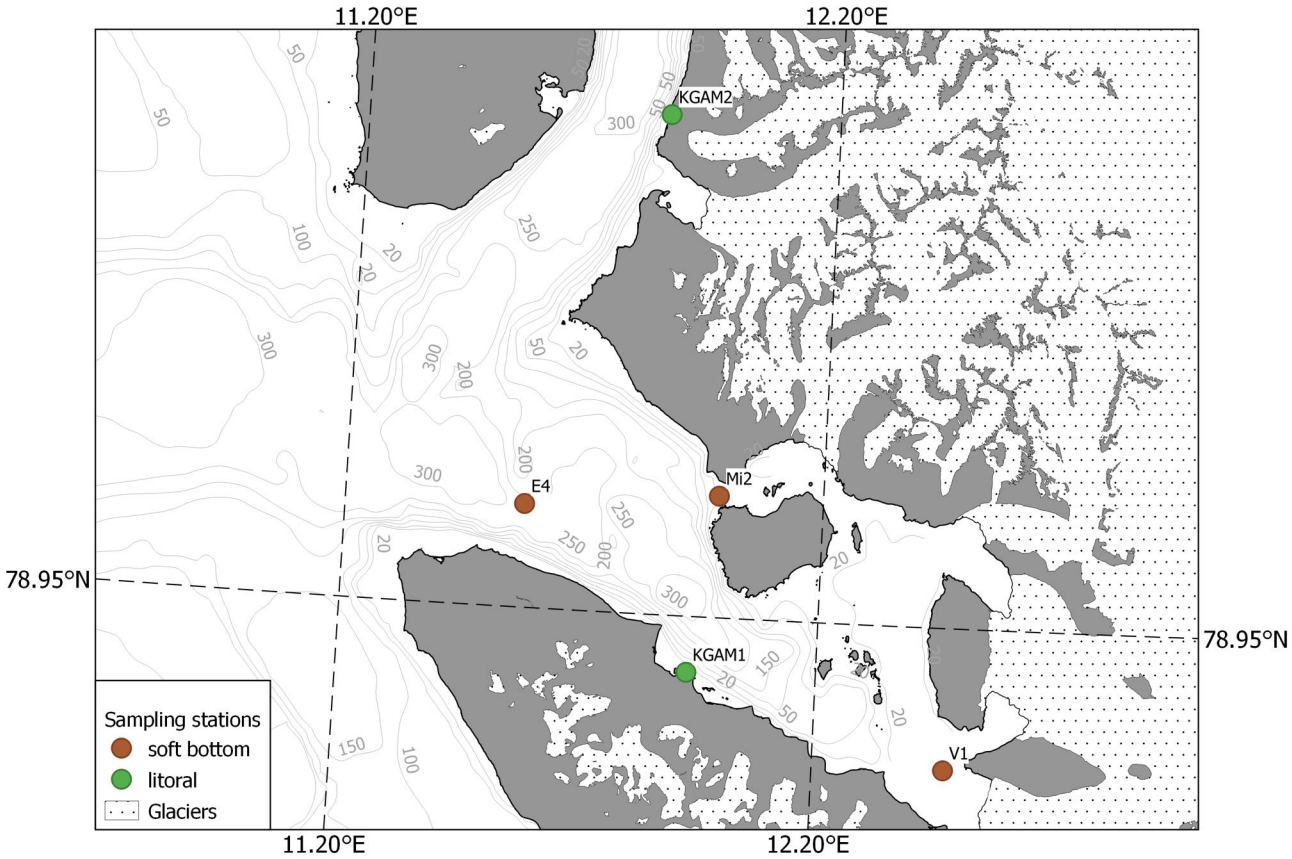

Figure 7. Locations of the benthic sampling station in the Kongsfjorden region during the AREX 2021 cruise. The benthos monitoring stations are marked in brown, and the collection points of littoral fauna are marked in green.

Table 8. Sampling stations and tools used by the PEB team during the AREX'2021 cruise leg IVa.

Station	Depth [m]	Date	Lat	Lon	Samples
HORNSUND					
SGD1/H1	124	26.07.21	77.00216667	16.464	vanVeen, box-corer
SGD2/H2	75	27.07.21	77.00713333	16.08813333	vanVeen, box-corer
SGD3/H3	240	26.07.21	76.96621667	15.72456667	vanVeen, box-corer
GAM1	0	28.07.21	76.99445	15.54971667	littoral fauna
GAM2	0	30.07.21	77.26081333	14.30479333	littoral fauna
GAM2	0	30.07.21	77.26908833	14.32661667	littoral fauna
GAM2	0	30.07.21	77.25977667	14.30344333	littoral fauna
KONGSFJORDEN					
E4	266	2.08.21	78.9914	11.57518333	vanVeen, box-corer
Mi2	71	2.08.21	78.9986	11.9814	vanVeen, box-corer
V1	74	3.08.21	78.89323333	12.47306667	vanVeen, box-corer
KGAM1	0	5.08.21	78.927645	11.930735	littoral fauna
KGAM2	0	6.08.21	79.14982167	11.83955667	littoral fauna

- Sampling for PHARMARINE project

In the Hornsund and Kongsfjorden fjords, a collection of selected macrofauna species was carried out with the epibenthic drug. Additionally, samples of *Gammarus oceanicus* were collected from the littoral zone. The material will be analyzed to determine the concentration of pharmaceuticals in the tissues of benthic organisms in the Hornsund and Kongsfjorden fjords.

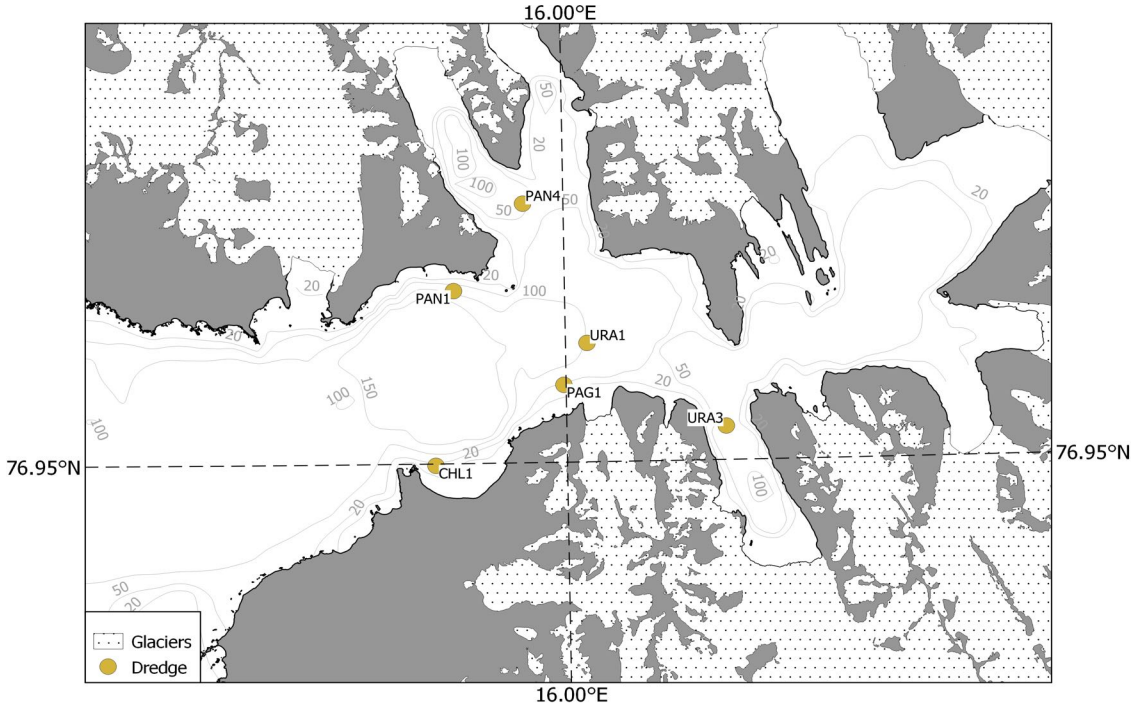

Figure 8. Location of PHARMARINE stations in the Hornsund region.

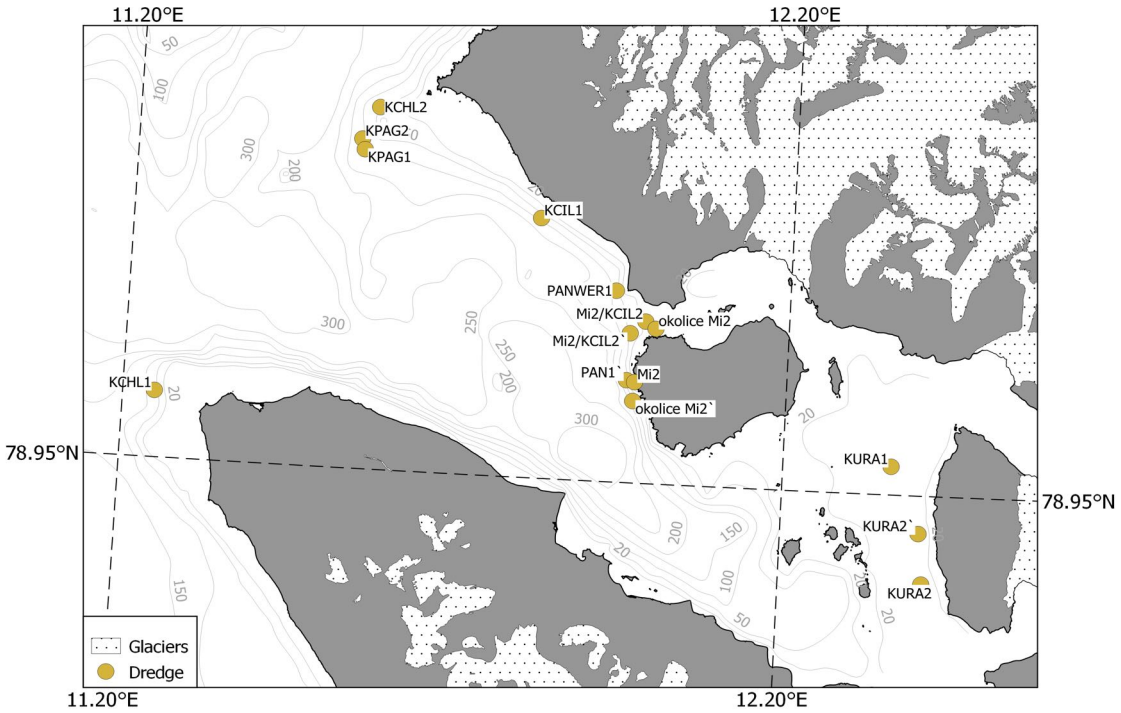

Figure 9. Location of PHARMARINE stations in the Kongsfjorden region.

Table 9. PHARMARINE stations (epibenthic drag or collection of littoral fauna) during the fjord part of the AREX'2021 cruise.

			Start		End	
Station	**Depth [m]**	**Date**	**Lat**	**Lon**	**Lat**	**Lon**
HORNSUND						
URA3	117	27.07.21	76.96165	16.22912	76.96623	16.21915
PAG1	49	27.07.21	76.97668	15.99672	76.97675	15.98525
CHL1	55	27.07.21	76.94938	15.81092	76.95018	15.82418
URA1	100	27.07.21	76.99102	16.03103	77.02070	15.99828
PAN1	55	28.07.21	77.00957	15.83987	77.00603	15.88002
PAN4		28.07.21	77.03938	15.94162	77.04508	15.93557
GAM1	0	28.07.21	76 59.667	015 32.983		
GAM2	0	30.08.21	77 15.6488	014 18.2876		
GAM2	0	30.08.21	77 16.1453	014 19.597		
GAM2	0	30.08.21	77 15.5866	014 18.2066		
KONGSFJORDEN						
PAN1`	180-200	2.08.21	78.98092	11.95795	78.97268	11.94865
PANWER1	57	2.08.21	79.00773	11.93543	79.01340	11.93573
KURA2	44	3.08.21	78.92340	12.41592	78.92707	12.41063
KURA2`	45	3.08.21	78.93860	12.40845	78.93312	12.41413
KURA1	61	3.08.21	78.95853	12.36317	78.95450	12.36927
KCHL1	150	4.08.21	78.97008	11.24777	78.96500	11.25163
KPAG2	85	4.08.21	79.04948	11.53793	79.05475	11.54267
KPAG1	70	4.08.21	79.04632	11.54272	79.04718	11.56817
KCHL2	50	4.08.21	79.05925	11.56212	79.06198	11.58515
KCIL1	100	4.08.21	79.02847	11.81600	79.02568	11.83882
Mi2/KCIL2	75	4.08.21	78.99887	11.98240	78.99675	11.95727

Mi2/KCIL2`	75	4.08.21	78.99512	11.95977	78.99737	11.99125
ok Mi2	57	5.08.21	78.99683	11.99828	78.99715	11.97127
ok Mi2`	130	5.08.21	78.97473	11.96892	78.97325	11.97273
Mi2		5.08.21	78.98045	11.97018	78.99667	12.01210
KGAM1	0	5.08.21	78.92765	11.93074		
KGAM2	0	6.08.21	79.14982	11.83956		

4.2.4 Marine chemistry measurements – PWZEM, PGM Labs

The aim of the AREX 2021 cruise was to collect samples for chemical analyses to study the spatial variability of mercury concentrations and bioavailability in the water and bottom sediments of the Spitsbergen fjords: Kongsfjorden, Krossfjorden, and Hornsund. The sea water and surface sediment samples (0-5cm) were collected at 13 measuring stations located at sea and from 3 points within watercourses located on land in the Ny-Alesund and Ny-London regions (Fig. 10). Additionally, sea ice samples were collected at stations located closest to the glacier front. A total of 105 seawater samples were collected from different levels of the water column, 6 ice samples and 11 bottom sediment samples (Table 1). During the leg IVa of the AREX 21 cruise, 5 samples of surface water were also collected for analysis for the presence of pharmaceutical residues, caffeine and other so-called "Emerging pollutants". The seawater samples were filtered and the filtrates and filters with the suspension were frozen.

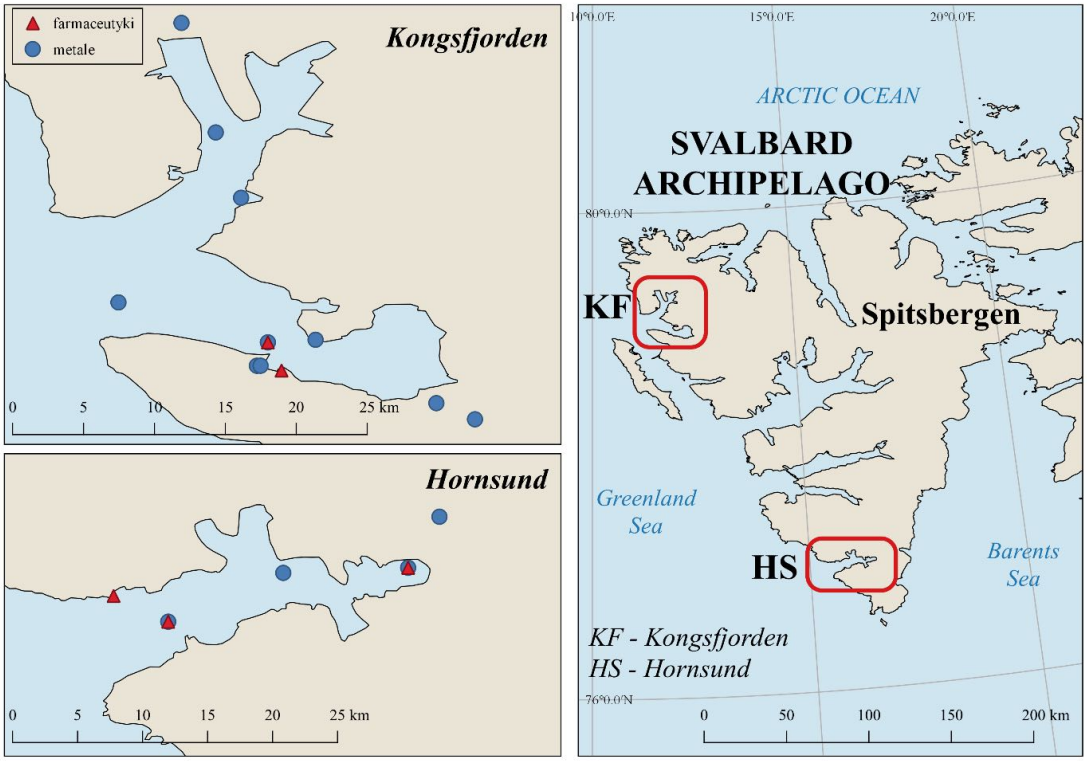

Figure 10. Location of measurement points where samples were collected for the IOPAN statuory Task II.8 and Task II.2. The points where the material for mercury analysis were collected are marked in blue; the red color marks the sampling sites for the analysis of pharmaceutical and other residues ("Emerging pollutants").

Table 10. Sampling stations for Task II.8 during the fjord part of the AREX'2021 cruise.

Station	Depth [m]	Date	Lat	Lon
HB1	50	25.07.21	77.05246667	16.57423
SGD1/H1	113	25.07.21	77.00241667	16.46578
SGD2/H2	74	25.07.21	77.00821667	16.08728
SGD3/H3	225	25.07.21	76.96723333	15.72792
KB1	366	31.07.21	79.01016667	11.4068
KB3	343	01.08.21	78.96113333	11.8938
KBX/1RK006A	106			
KB5	86	03.08.21	78.88686667	12.439
KR2 water / V1 sediment	64	03.08.21	78.86718333	12.56323
London	land	05.08.21	78.96259	12.05022
Ny-Alesund (river)	land	05.08.21	78.93499	11.85567
Ny-Alesund (river outlet)	land	05.08.21	78.93493	11.86789
KF1	60	06.08.21	79.1261	11.81767
SGD30	282	07.08.21	79.20146667	11.73947
KL2	174	07.08.21	79.3282	11.6341

Table 11. Sampling stations for Task II.2 during the fjord part of the AREX'2021 cruise.

Station	Depth [m]	Date	Lat	Lon
SGD1	113	25.07.21	77.0024167	16.46578
SGD3	225	25.07.21	76.9672333	15.72792
H-BAZA	14	29.07.21	76.99835	15.56907
KB3	343	01.08.21	78.9611333	11.8938
Ny-Alesund	16	05.08.21	78.9288333	11.93617

4.2.5 Marine chemistry measurements – PBM Lab.

- Measurements and sampling for ocean acidification studies

To analyze the carbonate system in the surface layer of sea water, continuous underway measurements were carried out:

a) Temperature (SST) (frequency 6/min),
b) Salinity (SSS) (frequency 6/min),
c) pH (frequency 3/h),
d) Carbon dioxide partial pressure (pCO_2) (frequency 1/s),
e) Water saturation with oxygen (O_2%) (frequency 1/min).

A total of ~ 36 GB of raw data was collected.

The analyzes were supplemented with discrete sampling of surface waters. Samples were taken for later analysis at IOPAN for:

a) Dissolved metal ions: Mg^{2+}, Ca^{2+}, 10 ml,
b) Dissolved inorganic carbon (DIC, 20 ml),
c) Total alkalinity (TA, 250 ml),
d) Chromophore dissolved organic matter (CDOM, 250 ml),
e) Nutrients (Nu, 10 ml).

A total of 40 samples were collected for each parameter.

A pore water incubation experiment was also carried out. For this purpose, 7 sediment cores were collected with a Gemax sampler. Additionally, sediment samples were taken and frozen.

- Marine chemistry sampling for the Arctic SGD project

As part of the Arctic SGD project, sediment samples (Niemisto probe, Gemax), pore water and sea water were collected. In addition, water samples were collected from land locations (beach, streams, tundra lakes).

*Table 12. Sampling stations for the Arctic SGD project during the fjord part of the AREX'2021 cruise, additional stations are marked ***

Station	Lat	Lon	Water samples	Sediment samples
HORNSUND				
SGD1	77 00.130	016 27.840	√	√
SGD2	77 00.120	016 05.073	√	√
SGD3	76 57.973	015 43.474	√	√
SGD4	76 59.250	015 52.861	√	√
SGD5	76 59.476	016 29.682	√	√
Beach**	77° 00.092°	15° 32.950°	√	
Beach**	77° 00.248°	15° 33.480°	√	
Pond**	77° 15.574°	14° 18.345°	√	
Pond**	77° 16.135°	14° 19.604°	√	
River**	77.2663°	14.326°	√	
Beach**	77° 15.696°	14° 18.438°	√	
KONGSFJORDEN/KROSSFJORDEN				
SGD31	78 57.060	011 53.677	√	√
SGD23	78 56.095	011 57.403	√	√
SGD22	78 55.694	011 58.238	√	√
SGD32	79° 00.12'	11° 28.25'	√	√
SGD36	78° 55.12'	07° 40.25'	√	√
SGD42**	78° 59.914'	11° 58.825'	√	√
SGD43**	78° 53.194'	12° 26.371'	√	
SGD45**	79° 19.680'	11° 37.994'	√	
River**	78.91377°	12.0403°	√	
Beach**	78.91431°	12.0421°	√	
Beach**	78.91460°	12.0306°	√	

River**	78.91963°	11.9574°	√	
Beach**	78° 57.737'	12° 02.951'	√	
River**	78° 57.745'	12° 02.350'	√	
River**	78° 57.745'	12° 02.350'	√	
Beach**	78° 56.074'	11° 52.087'	√	

4.2.6 Optical measurements

During the cruise leg IVa optical measurements were carried out at 33 stations in Hornsund, Kongsfjorden and Krossfjorden. The collected data include:

a) Secchi disk measurements (zSD), photos of the disk submerged to a depth of 1/2 zSD using the GoPro Hero8 black underwater camera.
b) Measurements of the backscattering coefficient (bb) using the "HYDROSCAT-4", near the surface and in the water column.
c) During the measurement with the Hydroscat-4 device, sea water samples were collected at the selected depth (about 20L for the "basic" program, and about 80L for the "extended" program).

At 29 stations, a 'standard sampling program' was carried out:

- samples for the analysis of concentrations of: SPM, POM, PIM, POC, CHla and other pigments,
- samples for measuring the light absorption coefficient spectra (ap, aph and ad),
- samples for measuring the particle size distributions of suspensions (PSD),
- filtered seawater (0.2 µm) to measure the absorption coefficient spectra by dissolved substances,
- measurements of the light attenuation coefficient spectra with the use of the VIPER device, on "fresh" seawater samples (measurement of the spectra of the attenuation factor (cn), the absorption coefficient (ag), and the reference spectra in MiliQ water).

Additionally, at 4 stations an 'extended sampling program' was carried out:

- fractionation of the seawater on board with high volume filtration kits through 20 [um] m and 5 [um] m grids,
- filtering with a filter kit through 2 um size filters,
- sample preparation for biogeochemical, morphological, and optical analyzes multiplied due to analyzes carried out on fractionated water samples.

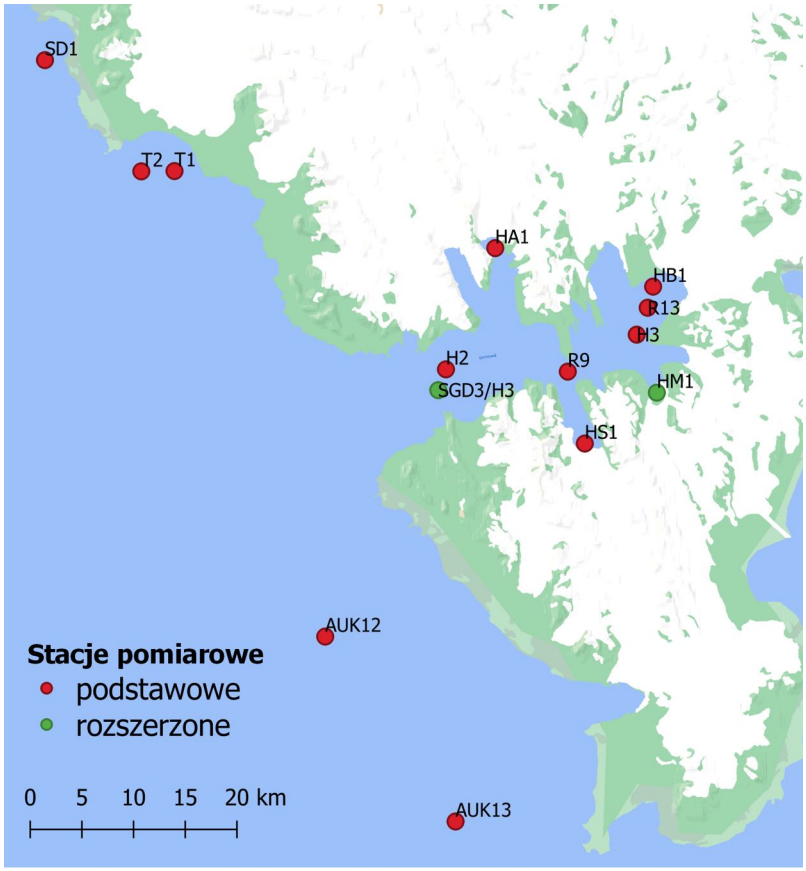

Figure 11. Location of the optical stations in the Hornsund region.

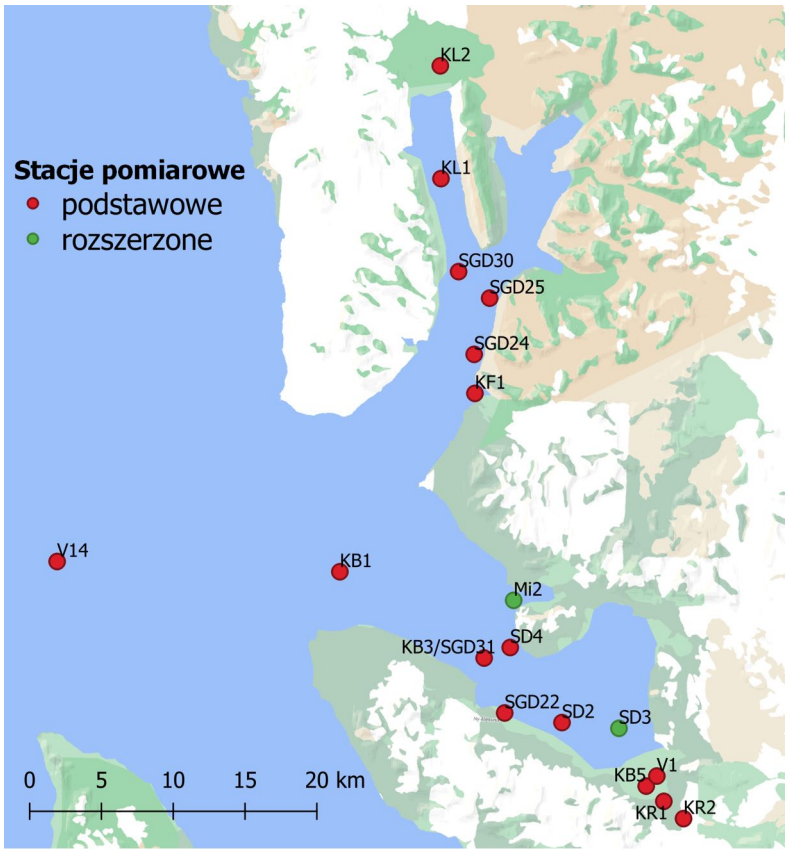

Figure 12. Location of the optical stations in the Kongsfjorden/Krossfjorden region.

*Table 13. Stations with optical measurements and water sampling during the fjord part of the AREX'2021 cruise, stations with an extended test program are marked **

Station	Depth [m]	Date	Lat	Lon	Samples
R9	96	24.07.21	76 58.825	016 14.150	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
HB1	50	25.07.21	77 03.148	016 34.454	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
H3	122	25.07.21	77 00.596	016 30.191	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
SGD3/H3*	240	26.07.21	76 57.973	015 43.474	Secchi disk, GoPro camera, HydroScat4, viper, water filtration, fractionation kit
HM1*	66	27.07.21	76 57.633	016 34.500	Secchi disk, GoPro camera, HydroScat4, viper, water filtration, fractionation kit
HS1	76	27.07.21	76 55.028	016 17.745	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
HA1	80	28.07.21	77 05.333	015 57.850	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
AUK12	52	28.07.21	76 45.004	015 18.464	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
AUK10	197	28.07.21	76 38.276	014 28.649	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
AUK - AUK9	0-50	28.07.21	76 38.190	014 29.605	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
AUK9	194	29.07.21	76 34.860	014 06.553	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
AUK13	34	29.07.21	76 35.516	015 47.050	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
AUK22	34	29.07.21	76 26.957	016 08.102	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
T1	38	30.07.21	77 09.406	014 43.217	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
T2	7	30.07.21	77 09.353	014 35.419	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
SD1	15	30.07.21	77 15.099	014 12.572	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
V14	263	31.07.21	79 00.386	010 28.963	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
KB0	305	31.07.21	79 02.557	011 08.096	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
KB1	364	31.07.21	79 00.607	011 24.337	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
KB3/SGD31	343	01.08.21	78 57.655	011 53.735	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
SGD22	11	01.08.21	78 55.694	011 58.238	Secchi disk, GoPro camera, HydroScat4, viper, water filtration

1RK006A	106	01.08.21	78 55.421	012 09.518	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
Mi2*	71	02.08.21	78 59.916	011 58.884	Secchi disk, GoPro camera, HydroScat4, viper, water filtration, fractionation kit
KB5/SGD80	86	03.08.21	78 53.185	012 26.425	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
KR1	59	03.08.21	78 52.603	012 29.948	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
KR2	64	03.08.21	78 52.027	012 33.774	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
V1	74	03.08.21	78 53.594	012 28.384	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
SD3*		05.08.21	79 00.606	016 05.300	Secchi disk, GoPro camera, HydroScat4, viper, water filtration, fractionation kit
SD4 (Ny London)		05.08.21	78 58.139	011 58.546	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
KF1	60	06.08.21	79 07.565	011 49.060	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
SGD24	245	07.08.21	79 09.028	011 48.388	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
SGD25	141	07.08.21	79 11.152	011 50.845	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
SGD30	282	07.08.21	79 12.073	011 44.332	Secchi disk, GoPro camera, HydroScat4, viper, water filtration
KL1		07.08.21			Secchi disk, GoPro camera, HydroScat4, viper, water filtration
KL2	174	07.08.21	79 19.692	011 38.046	Secchi disk, GoPro camera, HydroScat4, viper, water filtration

4.2.7 Aerosol and meteorological measurements

During the cruise leg IVa, measurements carried out to study the air-ocean interactions included:

- measurements of the droplet flux from the sea surface and their impact on ocean-atmosphere mass and energy exchanges,
- CO_2 fluxes in the atmospheric boundary layer were measured by the Li-COR gas analyzer,
- measurements of sea aerosol characteristics and measurements of air-ocean sensible and latent heat fluxes were carried out with the vessel motion was recorded using the Ellipse-N-G4A2-B1 inertial motion detection system,
- measurements of sea aerosol characteristics were collected with the OPC-N3 particle counters (optical particle counter), CPC (condensation particle counter) and LAS (laser aerosol spectrometer),
- physical properties of the aerosol, such as aerosol optical thickness (AOD), were measured using the Microtops II solar photometer in favorable weather conditions (no cloudiness), with the use of two aethalometers AE31 and AE33, and concentration of black carbon particles was also measured,
- standard meteorological observations were carried out according to the SHIP standard and with the Vaisala WXT563 automatic weather station; with the use of GILL anemometers, the flow of air masses was determined in three dimensions.

4.2.8 Physical oceanography measurements for the IOPAN statuory Task I.4

Oceanographic measurements carried out during the fjord part of the AREX 2021 cruise included measurements of vertical CTD profiles in Hornsund and Kongsfjorden and at their forefields. During the fjord part of the cruise hydrographic measurements were conducted in the main studied areas on 81 stations in total. The location of the stations is shown on Fig. 13. Measurements on all stations were collected using the Sea-Bird Electronics SBE9/11plus. During the fjord part of the cruise, water was also collected for the determination of nutrient content, a total of 33 samples at 5 stations.

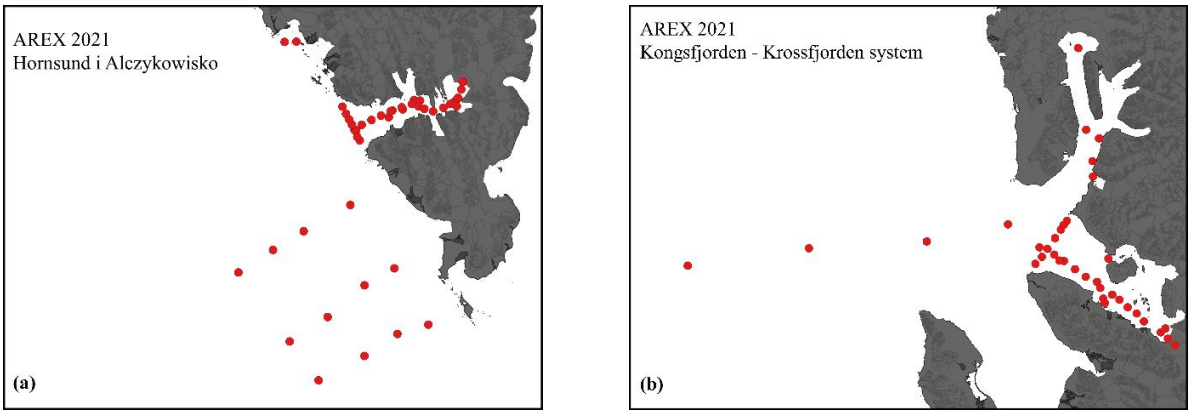

Figure 13. CTD stations occupied during the fjord part of the AREX 2021 cruise in (a) Horsund and at its forefield and (b) in Kongsfjorden and its forefield.

4.3 Field measurements and water sampling during the AREX'2021 leg IVb (Isfjorden)

During the cruise leg IVb physical and biogeochemical measurements and water sampling took place in Isfjorden. The very low or lack of sea ice in the inner fjord made it possible to collect measurements and collect samples in the immediate vicinity of tidal glaciers. The positions of stations and measurement/sampling type on each station are presented on Fig. 14 and in Table 14.

Table 14. List of stations and measurement/sampling type in Isfjorden during the leg IVb of the AREX'2021 cruise.

Station	Depth [m]	Date	Lat	Lon	Samples
SGD12	48	10.08.2021	78 13.996	15 39.961	rosette, camera, HydroScat4, viper, Secchi disk, phyto net, WP2 net, gemax, LOPC
SGD11	63	10.08.2021	78 14.229	15 38.143	rosette, camera, HydroScat4, viper, Secchi disk, phyto net, WP2 net, gemax, LOPC
N1	39	11.08.2021	78 22.488	14 47.701	rosette, HydroScat4, viper, LOPC, Secchi disk, taking colonization panels by divers
JSW23	45	11.08.2021	78 23.998	14 13.094	rosette, LOPC, HydroScat4, viper, camera, Secchi disk
SGD21	103	11.08.2021	78 14.996	13 58.550	rosette, camera, HydroScat4, viper, Secchi disk, gemax, LOPC
SGD20	100	11.08.2021	78 13.592	14 0.186	rozeta, LOPC, kamera, gemax
S2D	212	11.08.2021	78 11.910	15 4.302	rozeta, LOPC
Marc_deep	262	11.08.2021	78 6.289	13 42.725	rozeta, czerpacz vanVeen
SGD17	131	12.08.2021	78 4.133	14 5.863	rosette, camera, HydroScat4, viper, Secchi disk, gemax, LOPC

SGD18	128	12.08.2021	78 5.255	14 7.212	rozeta, LOPC, gemax, czerpacz vanVeen
SGD26	55	12.08.2021	77 58.014	14 16.984	rosette, camera, HydroScat4, viper, Secchi disk, gemax, LOPC
JMW12	48	12.08.2021	78 1.266	14 15.313	rosette, camera, HydroScat4, viper, Secchi disk, gemax, LOPC
DM	251	12.08.2021	78 12.746	14 10.030	rosette, vanVeen scoop
SGD21_SM	103	12.08.2021	78 14.959	13 58.730	rosette, vanVeen scoop
KL		13.08.2021	78 03.941	13 36.086	diving, collecting colonization panels
N2		13.08.2021	78 14.617	13 50.857	diving
SGD19	254	13.08.2021	78 11.683	13 47.453	rosette, Juday net, LOPC
JMW 25	33	13.08.2021	78 15.504	13 46.322	rosette, camera, HydroScat4, viper, Secchi disk, gemax, LOPC
S1D	212	13.08.2021	78 13.602	15 13.603	rosette
IT3	40	14.08.2021	78 26.746	17 19.078	rosette, camera, HydroScat4, viper, Secchi disk, phyto net, WP2 net, gemax, LOPC, Niemisto
IT3	40	14.08.2021	78 26.754	17 19.034	rosette
IT2	40	14.08.2021	78 26.408	17 20.712	rosette, LOPC, HydroScat4, viper, Secchi disk, camera
IT1	20	14.08.2021	78 26.272	17 22.570	rosette, LOPC, HydroScat4, viper, Secchi disk, camera
JMW15	71	14.08.2021	78 21.473	16 47.776	rosette, LOPC, HydroScat4, viper, Secchi disk, camera
SGD27	35	14.08.2021	78 24.010	16 22.526	rosette, LOPC, HydroScat4, viper, Secchi disk, camera, Nimesto, incubation experiment
WZEM1	206	14.08.2021	78 23.704	15 33.816	rosette, vanVeen scoop
WZEM2	144	14.08.2021	78 30.864	14 56.255	rosette, vanVeen scoop
SGD29	31	15.08.2021	78 33.896	1510.171	rosette, LOPC, HydroScat4, viper, Secchi disk, camera, Nimesto
B02	51	15.08.2021	78 34.296	15 3.042	rosette, LOPC, phyto mesh, WP2 net, camera
JMW4	81	15.08.2021	78 32.644	14 40.505	descent of the shore group
JMW4deep	71	15.08.2021	78 35.341	14 33.304	rosette, camera, LOPC, Niemisto
Yol2	67	15.08.2021	78 29.692	14 36.204	rosette, camera, LOPC, Niemisto
ID3	70	15.08.2021	78 40.406	15 16.267	LOPC, rosette, net
ID2	81	15.08.2021	78 43.501	15 16.193	rosette, net, camera, LOPC
SGD 14	16	15.08.2021	78 48.584	15 23.084	rosette, camera, LOPC, Niemisto
ISF3	99	16.08.2021	78 26.874	16 4.682	rosette, LOPC, camera, phyto mesh, WP2 net, Juday mesh, vanVeen scoop
ISF3	99	16.08.2021	78 26.884	16 4.709	rosette
SGD9	146	16.08.2021	78 36.542	16 28.837	rosette, LOPC, HydroScat4, viper, Secchi disk, WP2 net, Niemisto
SGD9	146	16.08.2021	78 36.552	16 28.849	rosette
JMW1		16.08.2021			descent of the coastal group (organisms, water, soil x 2 - tidal flat and slope), Pyramiden
BAB/SGD8	190	16.08.2021	78 39.688	16 44.383	rosette, LOPC, Niemisto, WP2 camera, net
IB1	94	17.08.2021	78 39.864	16 52.783	rosette, LOPC, net, camera
IB1 - ISA2					LOPC

ISA2	253	17.08.2021	78 15.966	15 7.598	rosette, LOPC, Juday net, WP2 netto, vanVeen scoop, pharmaceuticals
ISA2	253	17.08.2021	78 15.932	15 7.414	rosette,
DM2	274	17.08.2021	78 14.27	14 23.43	vanVeen scoop
SGD13	31	18.08.2021	78 15.455	15 27.788	rosette, Niemisto, LOPC, vanVeen scoop, HydroScat4, viper, Secchi disko
SGD15	18	18.08.2021	78 15.502	15 25.238	CTD, LOPC, Niemisto, vanVeen scoop
IA3		18.08.2021	78 16.002	15 30.215	CTD, LOPC, Niemisto, vanVeen scoop, water
IA2	69	19.08.2021	78 15.122	15 36.172	CTD, water, nets, camera
SGD11	61	19.08.2021	78 14.334	15 38.488	CTD, gemax, surface sediment for incubation experiment
JMW11		19.08.2021	78 11.299	15 8.685	descent of the shore group

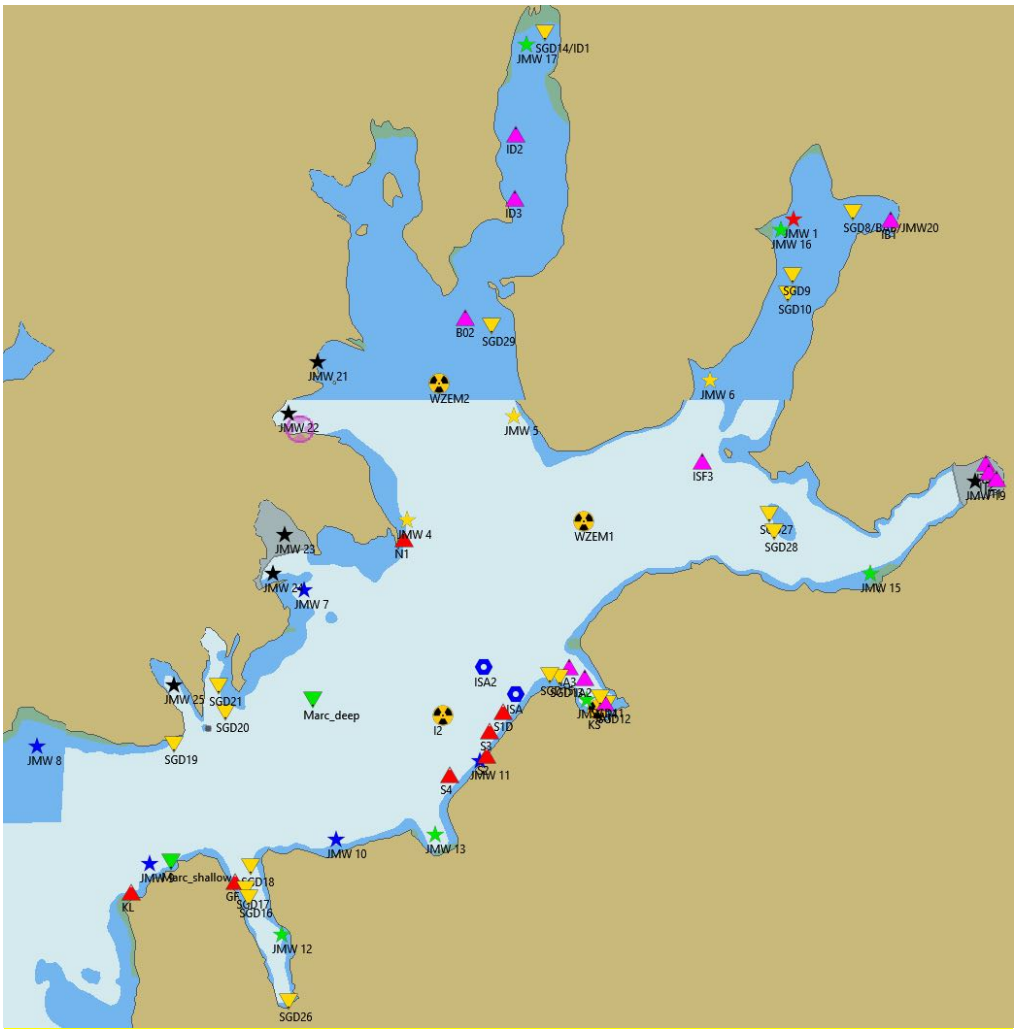

Figure 14. Positions of stations in Isfjorden during the leg IVb of the AREX 2021 cruise. The symbols show: yellow triangles - ArcticSGD stations, green triangles - CLIMB stations, red triangles - ANALOG stations, pink triangles - PFBP ecological stations, yellow and black circles - stations for statuory Tasks II.2. and II.8, and stars - stations for the ADAMANT project.

4.3.1 Ecological measurements - Plankton PFBP

During the cruise leg IVb, measurements and collection of samples were carried out for the IOPAN statuory Task I.7 and the CoastDark project. Samples included nano-, microplankton (bathometric bottle, Juday net) and zooplankton (WP2/100um net). The measurements included vertical profiles of size and distribution (in the 0-50m layer) of planktonic organisms measured with laser optical particle counter (LOPC) along transects from Billefjorden (from BAB station) to Adventfjorden (ISA). As part of the CoastDark project, at 33 stations vertical profiles of plankton and particles were measured in the entire water column using the LOPC-CTD-F-T augmented by a camera and collection of water samples (Fig. 14, Table 14).

4.3.2 Ecological measurements - benthos – PEB Lab.

The stations for the CLIMB project were merged with the SGD21 and Marc_deep stations. At each station, a CTD profile was measured and water was collected above the bottom and from the maximum fluorescence layer and then filtered in 3 replications for POM and chla. Additionally, 15 vanVeen grabs were collected at each station, 10 of them were sieved and the isolated benthos samples preserved in formalin for further studies. The next 5 grabs were used to collect samples for TOC, granulometry and chla, and the fauna samples were isolated from the residue for analysis of the isotope composition ($\delta^{13}C$, $\delta^{15}N$).

As part of the ANALOG project, aimed at studying carbonate chemistry in the coastal zone and its impact on the skeletons of marine organisms, 13 loggers were placed on the bottom near stations S1, S2, GF, SGD (HOBO MX2501 pH and Temperature Data Logger; HOBO U20L-02 water level (100 feet) Data Logger; HOBO U24-002-C salinity/conductivity in saltwater environments Data Logger; HOBO Pendant® Temperature/Light 64K Data Logger; HOBO Dissolved Oxygen Data Logger; Lowell Current meter; C3 Turner: Chlorophyl a and b, Turbidity; Turner C-sense in situ pCO_2 sensor). Additionally, colonization panels were collected at GF, KL and N1 stations (ASCOMEA and Akvaplan NIVA project). Additionally, a collection of 3 taxa of littoral fauna (Gammarus spp., Littorina spp., Semibalanus spp.) was carried out for genetic research under the ADAMANT project.

4.3.3 Marine chemistry measurements

Marine chemistry measurements and water sampling during the cruise leg IVb contributed to the PROSPECTOR and ArcticSGD projects and the IOPAN statuory Tasks II.8, II.2, and II.7.

- PROSPECTOR project

To analyze the carbonate system in the surface layer, continuous underway measurements were carried out:

a) Temperature (SST) (frequency 6/min),
b) Salinity (SSS) (frequency 6/min),
c) pH (frequency 3/h),
d) Carbon dioxide partial pressure (pCO_2) (frequency 1/s),
e) Oxygen saturation (O_2%) (frequency 1/min).

A total of 23 GB of raw data was collected.

Additionally, water damples from the surface layer were collected to analyze concentrations of:

a) Dissolved metal ions: Mg^{2+}, Ca^{2+}, 10 ml,
b) Dissolved inorganic carbon (DIC, 20 ml),
c) Total alkalinity (TA, 250 ml),
d) Chromophore dissolved organic matter (CDOM, 250 ml),
e) Nutrients (Nu, 10 ml).

A total of 72 samples were collected for each parameter.

A pore water incubation experiment was also carried out. For this purpose, 7 sediment cores were collected with a Gemax sampler. Additionally, sediment samples were collected and frozen.

- Arctic SGD project

As part of the Arctic SGD project, sediment samples (Niemisto probe, Gemax), pore water (Rhizon samplers) and water samples from the water column were collected. Measurements were made at 19 stations, including SGD and YOL2 stations. In addition, water samples were collected from land locations (beach, streams, tundra lakes). Collected water samples will be analyzed for concentrations of:

a) Dissolved metal ions: Mg^{2+}, Ca^{2+}, 10 ml,
b) Dissolved inorganic carbon (DIC, 20 ml),
c) Total alkalinity (TA, 250 ml),
d) Nutrients (Nu, 10 ml),
e) N_2/A_r,
f) dissolved ions Cl^-.

- IOPAN statuory Task II.8

The aim of the Tasks II.8 was to collect samples for chemical analysis to study the spatial variability of mercury concentrations and bioavailability in the water and bottom sediments in Isfjorden. The sea water and surface sediment samples (0-5cm) were collected at 9 stations. Additionally, sea ice samples were collected at stations located closest to the glacier front.

- IOPAN statuory Task II.2

During the AREX'2021 cruise leg IVb, 4 samples of surface water were also collected for analysis for the presence of pharmaceutical residues, caffeine and other so-called "Emerging pollutants". The seawater samples were filtered and the filtrates and filters with the suspension were frozen.

4.3.4 Optical measurements

During the cruise leg IVa optical measurements were carried out at 23 stations in Isfjorden. The collected data include:

a) Secchi disk measurements (zSD), photos of the disk submerged to a depth of 1/2 zSD using the GoPro Hero8 black underwater camera.
b) Measurements of the backscattering coefficient (bb) using the "HYDROSCAT-4", near the surface and in the water column.
c) During the measurement with the Hydroscat-4 device, sea water samples were collected at the selected depth (about 20L for the "basic" program, and about 80L for the "extended" program).

At 21 stations, a 'standard sampling program' was carried out:

- samples for the analysis of concentrations of: SPM, POM, PIM, POC, CHla and other pigments,
- samples for measuring the light absorption coefficient spectra (ap, aph and ad),
- samples for measuring the particle size distributions of suspensions (PSD),
- filtered seawater (0.2 µm) to measure the absorption coefficient spectra by dissolved substances,
- measurements of the light attenuation coefficient spectra with the use of the VIPER device, on "fresh" seawater samples (measurement of the spectra of the attenuation factor (cn), the absorption coefficient (ag), and the reference spectra in MiliQ water).

Additionally, at 2 stations an 'extended sampling program' was carried out:

- fractionation of the seawater on board with high volume filtration kits through 20 [um] m and 5 [um] m grids,
- filtering with a filter kit through 2 um size filters,

- sample preparation for biogeochemical, morphological, and optical analyzes multiplied due to analyzes carried out on fractionated water samples.

4.3.5 Aerosol and meteorological measurements

During the cruise leg IVb, measurements carried out to study the air-ocean interactions included:

- measurements of the droplet flux from the sea surface and their impact on ocean-atmosphere mass and energy exchanges,
- CO_2 fluxes in the atmospheric boundary layer were measured by the Li-COR gas analyzer,
- measurements of sea aerosol characteristics and measurements of air-ocean sensible and latent heat fluxes were carried out with the vessel motion was recorded using the Ellipse-N-G4A2-B1 inertial motion detection system,
- measurements of sea aerosol characteristics were collected with the OPC-N3 particle counters (optical particle counter), CPC (condensation particle counter) and LAS (laser aerosol spectrometer),
- physical properties of the aerosol, such as aerosol optical thickness (AOD), were measured using the Microtops II solar photometer in favorable weather conditions (no cloudiness), with two aethalometers AE31 and AE33, and concentration of black carbon particles was also measured,
- standard meteorological observations were carried out according to the SHIP standard and with the Vaisala WXT563 automatic weather station; with the use of GILL anemometers, the flow of air masses was determined in three dimensions.

4.4 Field measurements and water sampling during the AREX'2021 leg V (Isfjorden, Hornsund, Kveitehola, Nordkapp, western and southern Norwegian fjords)

The measurements and water samples were collected during the AREX'2021 leg V in Isfjorden, and Hornsund on Svalbard, in Kveitehola (Bjørnøya), at Nordcapp and three fjords in the Lofoten Islands and seven fjords in central, western and southern Norway. Measurements were collected for two Norwegian-Polish projects NEEDED and ActicSGD in Svalbard (Isfjorden, Hornsund and Kveitehola), and for the statutory Tasks II.4 and III.2 and the CLIMB project.

Table 15. List of sampling stations during the leg V of the AREX'2021 cruise.

Station	Date		Lat		Lon
Isfjorden Mouth	21.08.2021	N	78.03777833	E	12.49443833
Isfjorden Shelf	21.08.2021	N	77.67133	E	11.1118
Billefjorden	22.08.2021	N	78.61005333	E	16.48737667
Tempelfjorden	22.08.2021	N	78.40016667	E	16.37543333
Nordfjorden	22.08.2021	N	78.58901667	E	14.55506667
Trygghamna	22.08.2021	N	78.2584	E	13.77203333
Hornsund	23.08.2021	N	76.96689	E	15.72791667
Hornsund	23.08.2021	N	76.98698333	E	15.89648333
Hornsund	24.08.2021	N	76.89433333	E	14.68616667
Hornsund	24.08.2021	N	76.99176667	E	16.4962
Hornsund	24.08.2021	N	76.97247333	E	15.673145
Hornsund	24.08.2021	N	76.941965	E	14.90124833

Hornsund	24.08.2021	N	76.89433333	E	14.68616667
Kveithola	25.08.2021	N	74.87	E	16.48
Nord Capp	29.08.2021	N	70.85602333	E	20.34267833
Malangen 100	29.08.2021	N	69.53404167	E	18.50767
Malangen250	29.08.2021	N	69.47812333	E	18.37387667
Mistfjorden	30.08.2021	N	67.44931833	E	14.84084333
Holandfjorden	31.08.2021	N	66.70817	E	13.655555
Holandfjorden outer	31.08.2021	N	66.73219	E	13.48603667
Frohavet	01.08.2021	N	63.97555667	E	9.24457
Hellefjorden	02.01.1900	N	61.61372833	E	4.959333333
Bergen	03.04.2021	N	60.39921167	E	5.312893333
Selbjornfjorden	04.09.2021	N	59.98610667	E	5.246366667
Selbjornfjorden	04.09.2021	N	59.994335	E	5.234131667
Stavanger	05.09.2021	N	58.95977167	E	5.955021667
Stavanger	05.09.2021	N	58.98497	E	5.874133333
Oesterfjorden	06.05.2021	N	58.74047	E	9.255881667
Larvikfjorden	06.05.2021	N	59.00742167	E	10.07027667

4.4.1 Paleoceanography measurements

- NEEDED project

A CTDT profile and an acoustic Subbottom profiler were made at each station. Two long cores (4.5m), one Box Corer core, and water samples from three levels were collected. The measured parameters and samples included:

- CTDT profiles (salinity, temperature, depth, and water turbidity),
- water and surface sediment samples (for research on modern environmental DNA),
- sediment cores, apart from classic palaeoceanographic studies based on sedimentology, geochemistry and micropalaeontology, will be used for environmental fossil DNA in Holocene.

Table 15. List of paleooceanographic stations during the leg V of AREX'2021 (GC - gravity core box, BoxCor - box core box, Bt – batometer)

	Station	**Date**		**Lat**		**Lon**	**Samples**
1	Isfjorden Mouth	21.08.2021	N	78.03777833	E	12.49443833	GC, BoxCor, Bt
2	Isfjorden Shelf	21.08.2021	N	77.67133	E	11.1118	GC, BoxCor, Bt
3	Hornsund	24.08.2021	N	76.89433333	E	14.68616667	GC, BoxCor, Bt
4	Hornsund	24.08.2021	N	76.97247333	E	15.673145	GC
5	Hornsund	24.08.2021	N	76.941965	E	14.90124833	GC, BoxCor, Bt
6	Kveithola	25.08.2021	N	74.87	E	16.48	GC, BoxCor, Bt
7	Nordkapp	29.08.2021	N	70.85602333	E	20.34267833	Bt, Van Veen

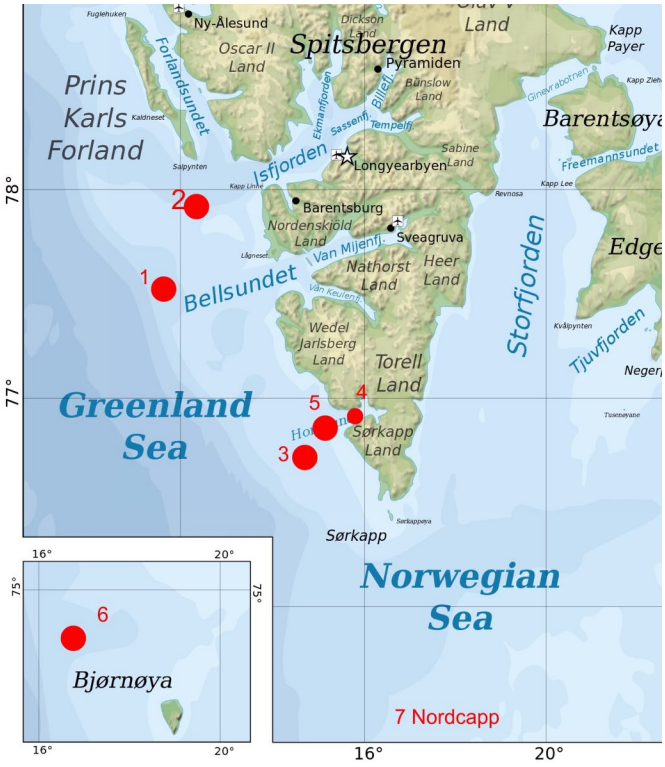

Figure 15. Paleooceanographic sampling stations occupied during the leg V of the AREX'2021 cruise.

- ArcticSGD project

During the leg V of the AREX'2021 cruise, two types of sediment samples were collected for the ArcticSGD project. Long cores were collected using a gravity corer at the stations in Isfjord and Hornsund (Table 16). Water samples taken from long cores will be analyzed for DIC, DOC, TA (Total Alkalinity), metals, nutrients, and chlorides. Bottom sediment samples were collected with Nemisto and Gemax scoops. At each station, 2 cores (usually with Nemisto) were obtained to collect pore water samples from the sediments. Additionally, at each station, a water sample was collected from the layer above the core to analyze the same parameters as for the pore water.

Table 16. List of long core sampling stations during the AREX'2021 leg V.

Fjord	Station	Lan	Lat	Date	Time (LT)	Segment	Length (cm)
Isfjorden	SGD9	78° 36.599'	16° 29.210'	22-Aug	8:15	Upper Segment*	120
						Lower Segment*	150
	SGD27	78° 23.982'	16° 22.386'	22-Aug	10:37	Upper Segment*	34
						Lower Segment*	150
	JMW4Deep	78° 35.347'	14° 33.444'	22-Aug	13:53	Upper Segment*	39
						Lower Segment*	150
	JMW25	78° 15.503'	13° 46.174'	22-Aug	17:45	Upper Segment*	-
						Lower Segment*	100**
Hornsund	SGD 3	76° 58.049'	15° 43.988'	23-Aug	10:05	Upper Segment*	148
						Lower Segment*	150***
	SGD 4	76° 59.174'	15° 53.644'	23-Aug	10:50	Upper Segment*	150+5****
						Lower Segment*	150
	SGD 5	76° 59.504'	15° 29.777'	24-Aug	13:19	Upper Segment*	-
						Lower Segment*	110**

Table 17. List of sediment and rainwater sampling stations during theAREX'2021 leg V.

Sediment sampling						
SGD51	69°28.677'	18° 22.320'	29-Aug-21	21:49	Fjord:	Malangard
SGD52	67°26.966'	14° 50.684'	30-Aug-21	22:09	Fjord:	MistFjorden
SGD53	66° 42.410'	13° 39.322'	31-Aug-21	8:27	Fjord:	HolandsFjorden
SGD54	63° 58.894'	9° 13.410'	1-Sep-21	9:52	Fjord:	Frohavet
SGD55	61° 36.767'	4° 57.569'	2-Sep-21	13:40	Fjord:	Arebretsfjord
SGD56	59° 59.148'	5° 14.735'	4-Sep-21	12:35	Fjord:	Selbjorndfjord
SGD57	59° 59.707'	5° 14.044'	4-Sep-21	17:30	Fjord:	
SGD58	58° 57.606'	5° 57.326'	5-Sep-21	8:30	Fjord:	Stavanger
SGD59	58° 59.090'	5° 52.413'	5-Sep-21	10:30	Fjord:	Stavanger
SGD60	58° 44.434'	9° 15.369'	6-Sep-21	9:15	Fjord:	Osterfjorden
SGD61	59° 00.469'	10° 04.194'	6-Sep-21	12:26	Fjord:	LarvikFjorden
Rainwater sampling						
SW207	77° 00.204°	15° 33.159'	23-Aug-21	20:30		
SW205	77° 00.014°	15° 34.347'	24-Aug-21	5:30		
RBI1	74° 29.370°	15° 11.939'	27-Aug-21	9:25		

4.4.2 Marine chemistry measurements - markers

During the leg V of the AREX'2021 cruise, sediment samples were collected at selected stations along the Norwegian coast (Fig. 16). Surface sediments (0.5 cm) were collected at 13 stations with a Van Veen grab. Additionally, at 10 stations, sediment cores (0-40 cm) were collected with the Niemistö sediment corer. At each of stations, three cores were collected (one core was sliced into 1 cm thick layers) and the samples were packed in plastic bags and frozen. Additionally, at each station, the parameters of the bottom water (temperature, salinity, dissolved oxygen) were measured with the Multi 197i multi-parameter meter (WTW). The collected bottom sediments will be used to determine selected lipid biomarkers, incuding pigments, hydrocarbons, steroids, and alkenones.

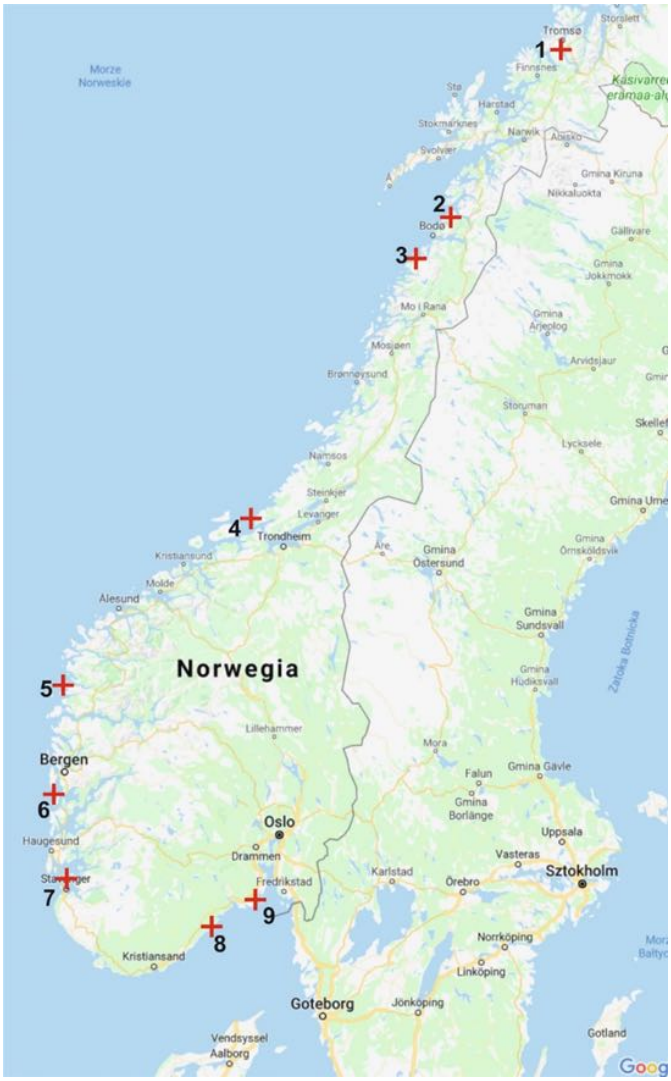

Figure 16. Sampling stations for chemical markers occupied during the leg V of the AREX'2021 cruise.

Table 18. List of sampling stations for chemical markers during the leg V of the AREX'2021 cruise.

	Station	Coordinates		Date	Samples
1	Malangen 1	69°32,060' N	18°30,644' E	29.08.21	surface sediment
	Malangen 2	69°28,656' N	18°22,291' E	29.08.21	surface sediment + 3 cores
2	Mistfjorden	67°26,979' N	14°50,622' E	30.08.21	surface sediment + 3 cores
3	Holandsfjorden 1	66°43,921' N	13°29,284' E	31.08.21	surface sediment
	Holandsfjorden 2	66°42,416' N	13°33,238' E	31.08.21	surface sediment + 3 cores
4	Frohavet	63°58,878' N	9°13,341' E	01.09.21	surface sediment + 3 cores
5	Årebrotsfjorden	61°36,757' N	4°57,593' E	02.09.21	surface sediment + 3 cores
6	Selbjørnfjorden 1	59°59,155' N	5°14,736' E	04.09.21	surface sediment + 3 cores
	Selbjørnfjorden 2	59°59,677' N	5°14,110' E	04.09.21	surface sediment
7	Høgsfjorden 1	58°57,599' N	5°57,324' E	05.09.21	surface sediment + 3 cores
	Høgsfjorden 2	58°59,081' N	5°52,415' E	05.09.21	surface sediment + 3 cores
8	Østerfjorden	58°44,454' N	9°15,284' E	06.09.21	surface sediment + 3 cores
9	Larviksfjorden	59°00,450' N	10°04,273' E	06.09.21	surface sediment + 3 cores

4.4.3 Ecological measurements - benthos

- CLIMB project

During the leg V of the AREX'2021 cruise, the bottom sediment and benthos samples were collected with a Van Veen grab in two fjords. In each fjord, samples were collected at shallow (100-150 m) and deep (depth>200 m) stations. Additionally, water samples were collected with a Niskin bottle, and the temperature and salinity profiles were measured with a CTD probe.

The following parameters were measured/sampled at each station:

- CTD profiles in the entire water column,
- Surface and bottom water samples were immediately filtered for phytopigment (5 repetitions) and POM (5 repetitions),
- 7 samples collected using a Van Veen grab were washed on a 0.5 mm sieve and preserved in formalin (community samples),
- 3 samples were collected from each Van Veen grab for the determination of phytopigments in the sediment, granulometry and chemical analyzes of the sediment; the residue of each grab was washed through a 0.5mm sieve and fauna samples were collected for stable isotope analysis.

Table 19. List of sampling stations for the CLIMB project during the leg V of the AREX'2021 cruise.

Station	Lon	Lat	Depth	Temperature bottom	Salinity bottom
Malangen - shallow	018°30.588 E	69°32.073 N	120 m	8.2°C	34.78
Malangen - deep	018°22.309 E	69°28.658 N	214 m	6.8°C	35.22
Selbjørnfjord - shallow	005°14.043 E	59°59.712 N	140 m	7.4°C	35.48
Selbjørnfjord - deep	005°14.734 E	59°59.142 N	220 m	7.2°C	35.23