Suomen ympäristökeskus
Finlands miljöcentral
Finnish Environment Institute

ILMATIETEEN LAITOS

CRUISE REPORT

R/V Aranda

Cruise 01/2024

COMBINE 1 leg 1
16.1.2024 – 19.1.2024
and
COMBINE 1 leg 2
19.1.2024 – 28.1.2024

This report is based on preliminary data and is subject to changes.

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The 1st leg

Objectives of the cruise

The objectives of the cruise were:

Monitoring of underwater sound pressure, harmful substances, hydrography (pH, oxygen, total sulfide, ammonia, nutrients), and physics (temperature and salinity) in compliance with HELCOM COMBINE and EU MSFD monitoring programs.

Additionally:
- servicing of FMI wave buoy
- large-volume water sampling

Table 1 The scientific crew

Name	On board	Organization
Tanja Kinnunen	16.-19.1.2024	SYKE
Noora Haavisto	16.-19.1.2024	SYKE
Ilkka Lastumäki	16.-19.1.2024	SYKE
Jere Riikonen	16.-19.1.2024	SYKE
Tuomo Roine	16.-19.1.2024	IL
Susanna Hyvärinen	16.-19.1.2024	SYKE
Mira Granlund	16.-19.1.2024	SYKE
Okko Outinen	16.-19.1.2024	SYKE
Sami Rantapusa	16.-19.1.2024	IL
Riikka Mattsson	16.-19.1.2024	SYKE
Meri Smedberg	16.-19.1.2024	SYKE
Viivi Pöyhönen	16.-19.1.2024	SYKE
Harri Kankaanpää	16.-19.1.2024	SYKE

Cruise Route of the 1st leg

Departure from Helsinki Tammasaari pier, January 16, 2024, at 1258 H.

Arrival to Hanko, January 19, 2024, at 0910 H.

The 2nd leg

The COMBINE 1 of the 2nd leg winter cruise objectives were to:

1) monitor hydrography and water chemistry.
2) sample oil, hazardous and drag substances in water and sediment.
3) carry out maintenance and to retrieve automated monitoring instruments (wave buoys and ADCPs).
4) install monitoring devices (hydrophones and an ice radar).
5) monitor and measure ice characteristics.
   in the Northern Baltic Proper, Archipelago Sea and in the Gulf of Bothnia.

Table 2 The scientific crew

Name	On board	Organization
Kotilainen Pekka	19. - 28. 1. 2024	SYKE
Mattsson Riikka	19. - 28. 1. 2024	SYKE
Lastumäki Ilkka	19. - 28. 1. 2024	SYKE
Kinnunen Tanja	19. - 28. 1. 2024	SYKE
Haavisto Noora	19. - 28. 1. 2024	SYKE
Smedberg Meri	19. - 28. 1. 2024	FMI
Riikonen Jere	19. - 28. 1. 2024	SYKE
Hyvärinen Susanna	19. - 28. 1. 2024	SYKE
Granlund Mira	19. - 28. 1. 2024	SYKE
Rantapusa Sami	19. - 28. 1. 2024	FMI
Lensu Mikko	19. - 28. 1. 2024	FMI
Seppänen Jaakko	19. - 28. 1. 2024	FMI
Petry Alice	19. - 28. 1. 2024	AALTO UNIV

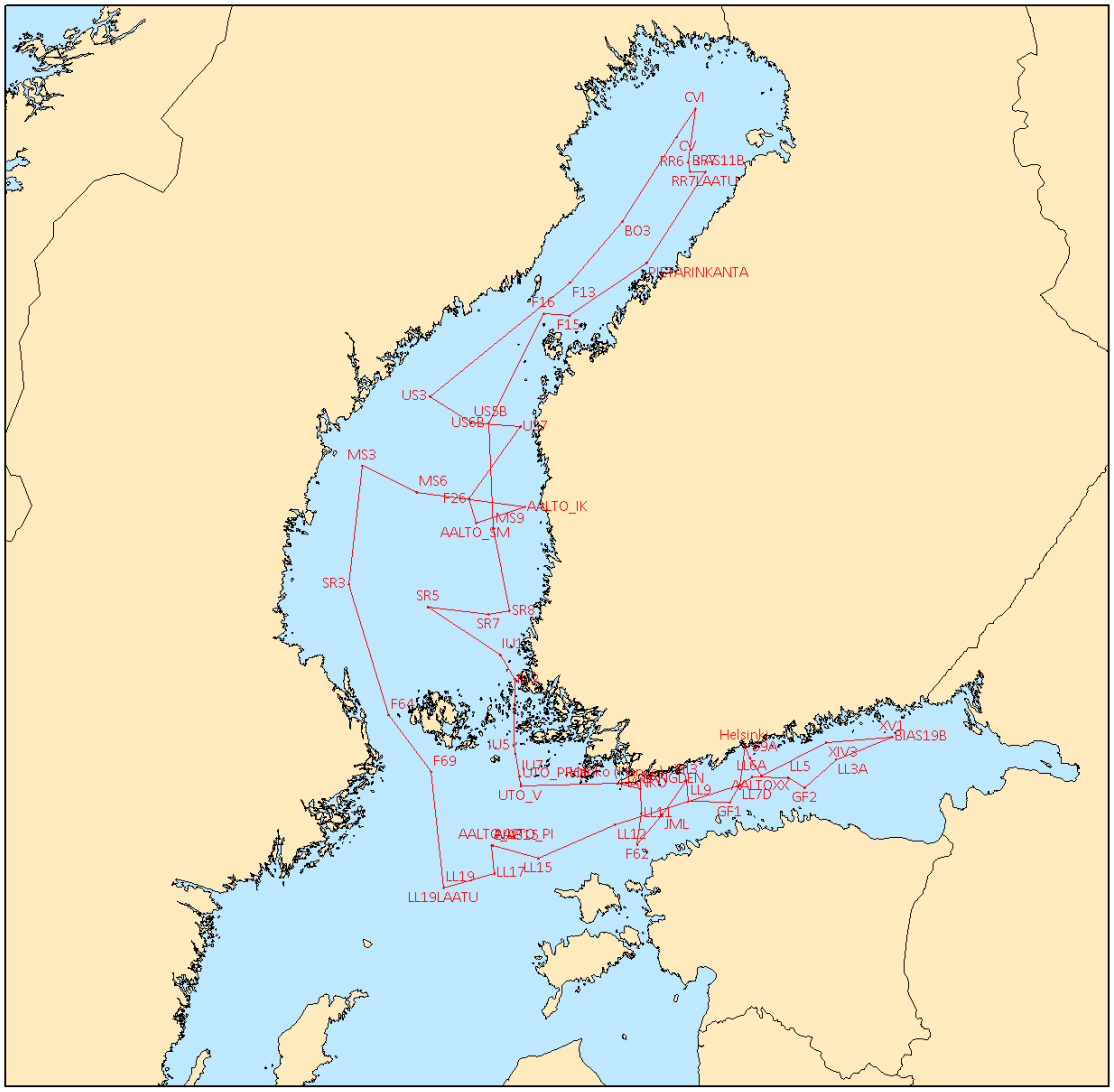
Cruise Route of the 2nd leg

The leg of the cruise left the outer port of Hanko at 16 hrs. (EET) on the 19th of January 2024.

At first the cruise headed to the Archipelago Sea near UTÖ, and automated instruments of the Finnish Meteorological Institute (FMI) were removed. Then cruise headed to IU7, IU5 and due to the ice conditions, a deeper, 10-meter fairway had to be taken in the inner Archipelago. Also, the station IU3 was replaced with IU2.The station IU1 was sampled and then ship continued to the Bothnian Sea. Further, the stations SR5, SR7, SR8, MS9, and US6b were sampled.
Then cruise headed to Quark and reached edge of the ice. The stations F16 and F15 were sampled.

An ice radar was installed near the fairway buoy of PIETARINKANTA. BO3 was sampled before the hydrophone installation at BIAS11 (RR7A). Despite the difficult ice conditions almost all stations in the Bothnian Bay were sampled, namely RR6, CVI, CV and BO3. Only the station RR3 had to be skipped.
F13 was the only station sampled in the Quark on the way back to south. Further, in the Bothnian Sea stations US3, US5b, US7, F26, SM6, MS3 and SR3 were sampled. Maintenance of one wave buoy and a rescue operation of another one by FMI were carried out (AALTO_SM and AALTO_IK).

On the way to the main basin, between the Swedish Coast and the Åland islands, F64 was sampled, and then F69, and LL stations (LL19, LL17, LL15, LL12) in the Northern Baltic Proper were sampled. In addition, some maintenance (wave buoy AALTO_PI) and an installation of a test wave buoy (AALTO_LP) and a hydrophone (BIAS15), respectively, were conducted.
Lastly on the way back to Helsinki an additional oil sample was taken at the station LL7 between Helsinki and Tallinn. R/V Aranda reached Helsinki, Tammasaari pier, on the 28th of January 2024 at 12 o'clock (EET).



Cruise route

Observations

The Gulf of Finland

Intrusion of higher-salinity surface water, probably from the Baltic Proper affecting the entire mixed layer.

Surface layer mixed typically between 0-10 or 0-20 m and at a few stations up to 0-50 m, depending on location. Stratified below the mixed layer.

Salinity in surface layer increased to highest levels in history at many pelagic stations, especially in the western survey region and in Estonian EEZ plus easternmost station. Elsewhere surface salinity was close to long-term average. A lens of higher salinity with record values within intermediate water layer at JML (30-40 m) and LL9 (40-50 m).

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Temperature of surface layer was lower than on the average due to prevailing ice coverage which was larger than during previous winters and closer to long-term average.

Temperature in near-bottom layer was either close to long-term average or higher, probably following the observed long-term trend.

Conditions were fully oxic throughout the water column from west to easternmost observation region.

Phosphorus concentrations as phosphate were record high in surface layer, between 0-10 m, 0-20 or 0-30 m depending on location at 12 out of 15 stations surveyed.

At three stations in central and western survey area surface-layer nitrate concentrations were close or at record levels.

Other nutrient concentrations were mostly close to earlier averages.

Instrument installations and retrievals were performed as planned. Sampling for harmful substances was completed.

The Archipelago Sea

Apart from the southernmost station, IU7, the entire water column was mixed in the Archipelago Sea. Observed nutrient concentrations were high, PO4 concentrations, > 1 µmol/l. N_{tot} 25-30 µmol/l and P_{tot} ~1.2 µmol/l, respectively.

Bothnian Sea

Water was stratified at deep stations (temperature, salinity) of the region.
Higher salinity values were measured than in long-term average (2000-2023).
Oxygen concentrations were partially lower than in earlier years and dissolved O_2 concentrations near bottom were ~5 ml/l and measured O_2 saturation was ~60 %, respectively.

Both PO_4 and $NO_{2,3}$ concentrations were higher than in average. The highest measured PO_4 concentrations were > 1.5 mol/l and NO_{23} > 8 mol/l.

Bothnian Bay

The entire Bothnian Bay and the Quark region was ice covered. Previously this had occurred in winter 2011. Ice conditions slightly slowed the cruise, but the original plan could be conducted.

In the northern part of the region higher salinity values at CV and CVI than in average were observed (Annex 2).

The Northern Baltic Proper

Water column was stratified in the Northern main basin. At the westernmost station (LL19), oxycline was observed at 65 meters depth. Further, a decline of the oxycline towards the east, 30 Nm away, oxycline was observed much deeper, at 90 meters depth (Annex 3). The observed nutrient concentrations were the highest at deep waters. The highest PO_4 concentrations measured were > 4µmol/l.

Conclusions

The Gulf of Finland

The environmental state of the Gulf of Finland has further deteriorated due to excessive phosphate in the water layer, especially in the surface layer. Physical forcing has again played a key role in hydrographic changes as exemplified by the changes in above-halocline layer at pelagic area.

Archipelago Sea

Wintertime nutrient concentrations were higher than usual. A slight intrusion of nutrient rich water, most probably from the Northern Baltic Proper to the Archipelago Sea, had occurred recently.

Bothnian Sea

An increasing trend of dissolved nutrient concentration continued, and the decline of oxygen concentration at deep waters in the region.

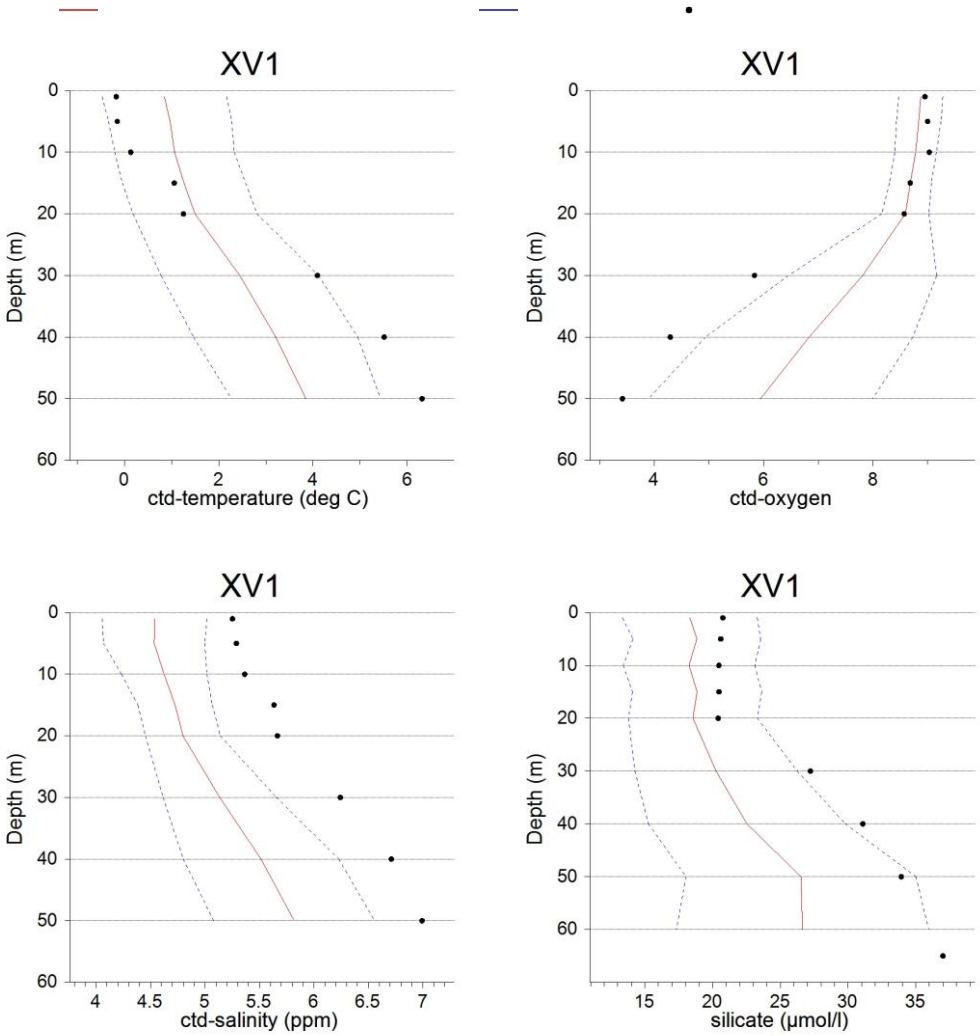
Bothnian Bay

Nutrient concentrations were also slightly above the long-term average (2000-2023). Concentrations are near the limit of detection, but measured nutrient concentrations seem to increase year by year.

The Northern Baltic Proper

The anoxic state of deep waters in the main basin remains the same as before and the observed nutrient concentrations were at the average level but high. The observed strong tilt in oxycline indicated a sort of west - east seiche in the region.

Annex 1. Selected variables at the stations XV1, LL7D, LL12, LL17, F64, SR5, US5B and BO3. Mean (red solid line) and standard deviation (blue dotted lines) represent the data collected at the same time of season since the year 1960.



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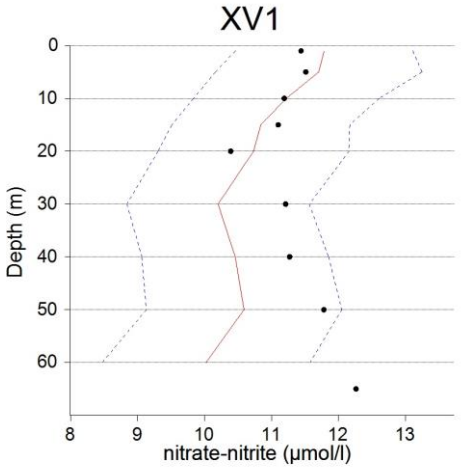

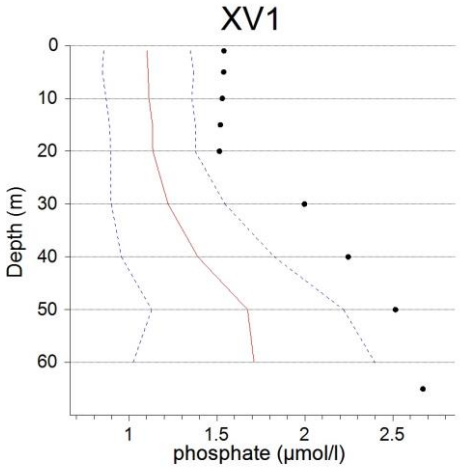

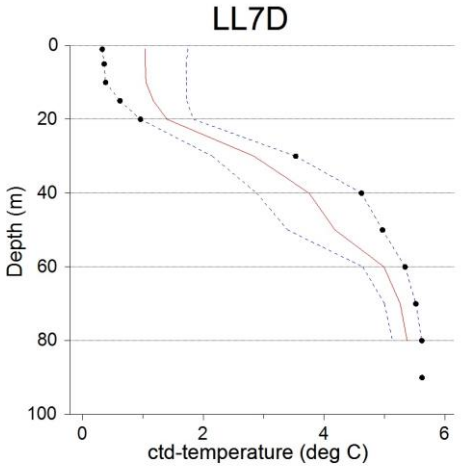

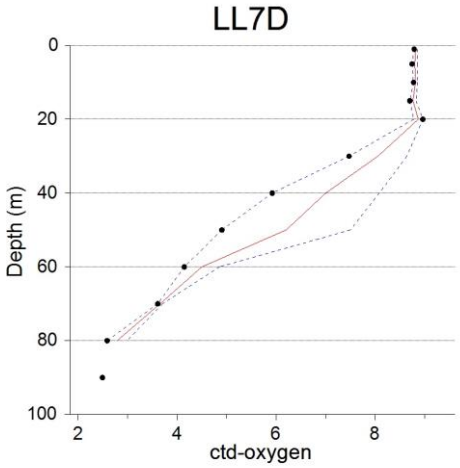

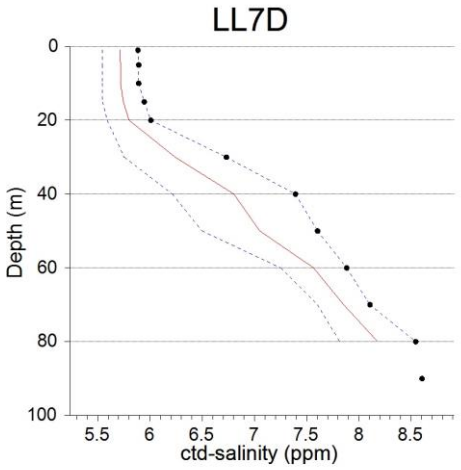

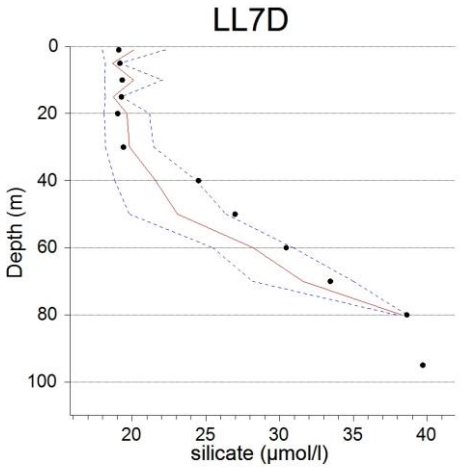

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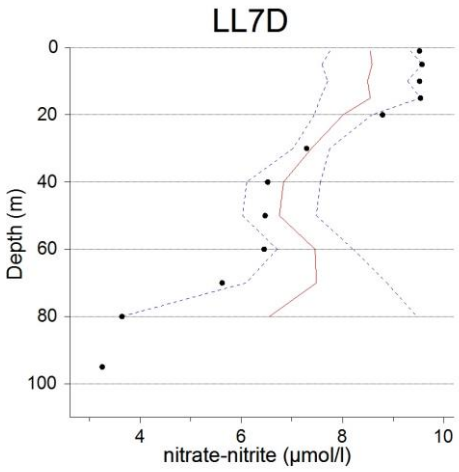

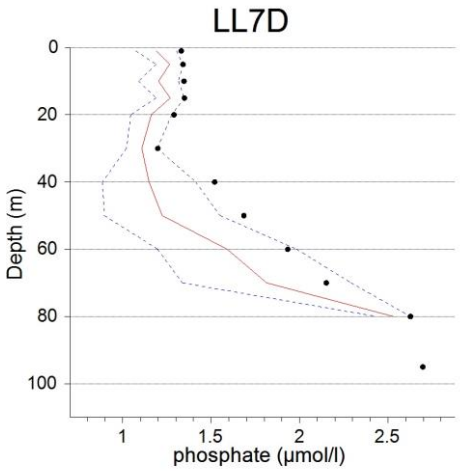

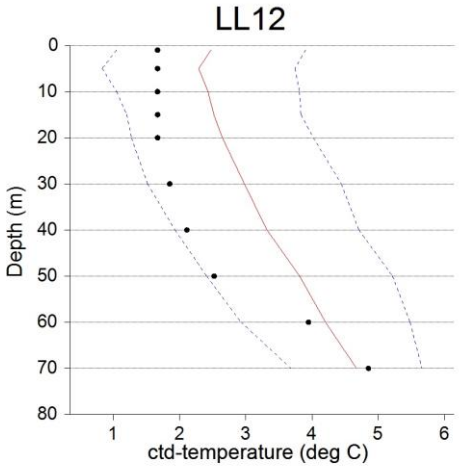

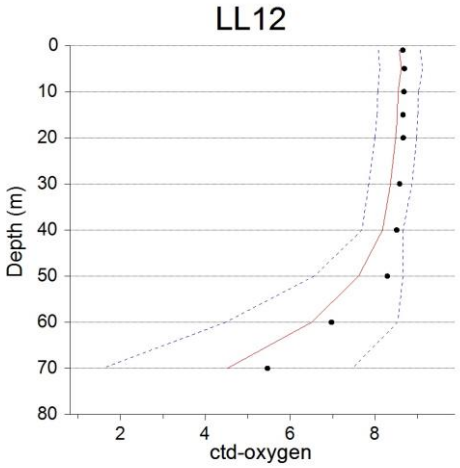

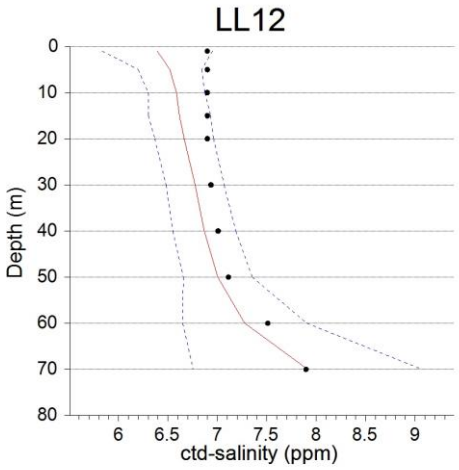

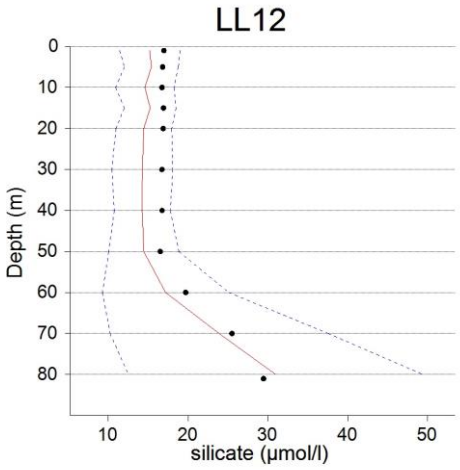

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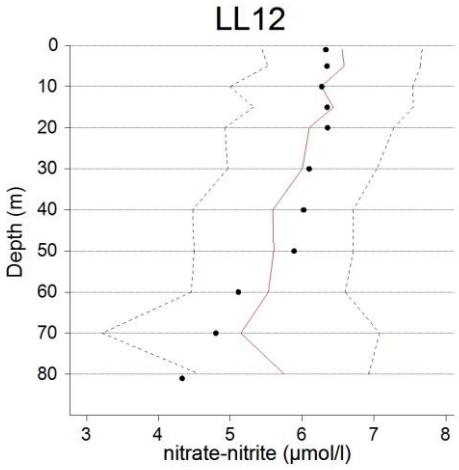

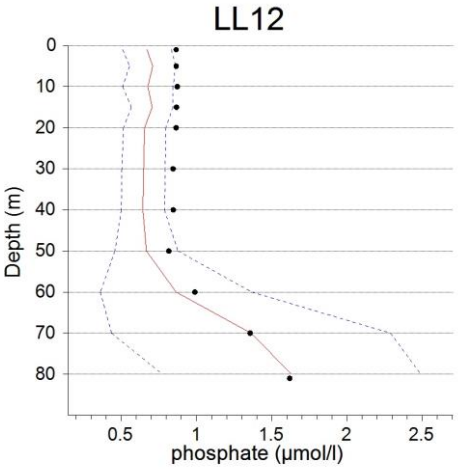

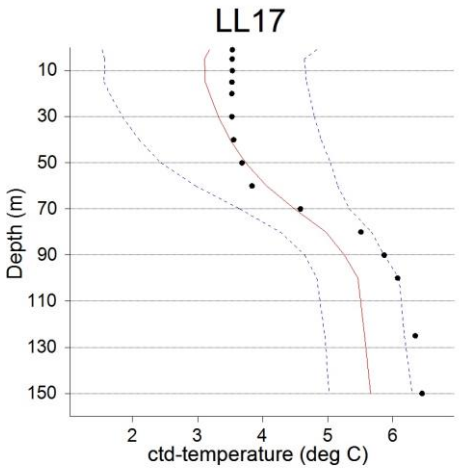

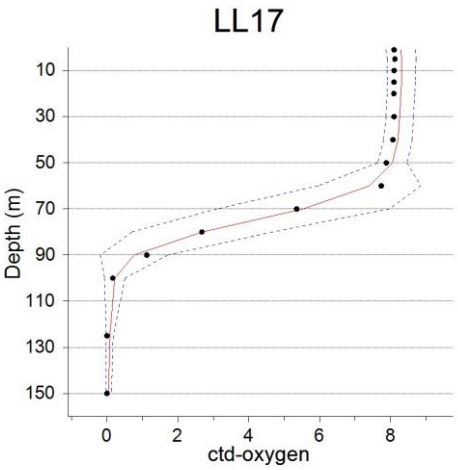

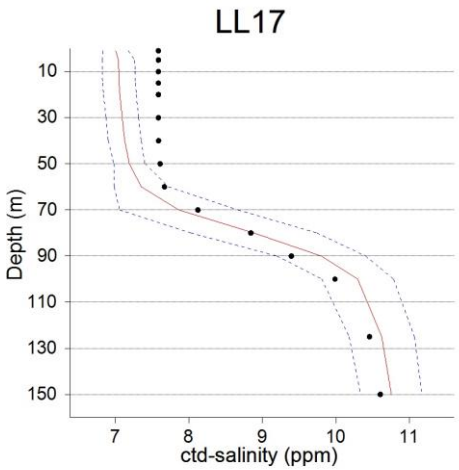

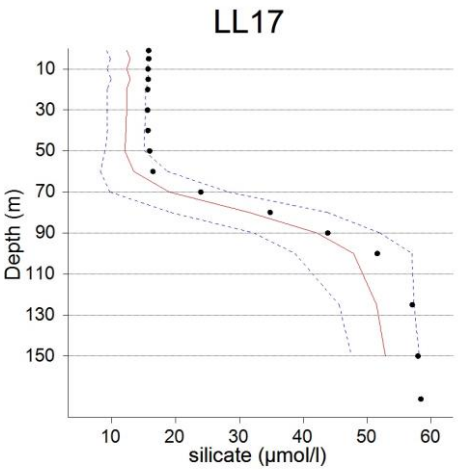

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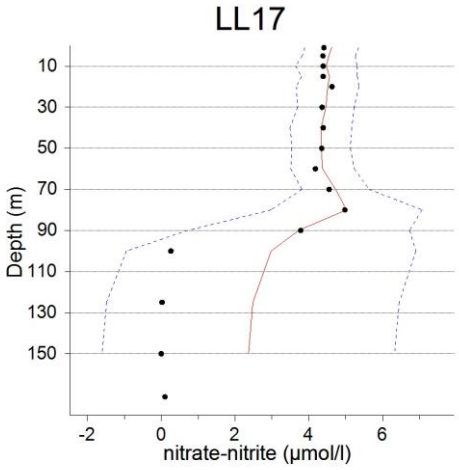

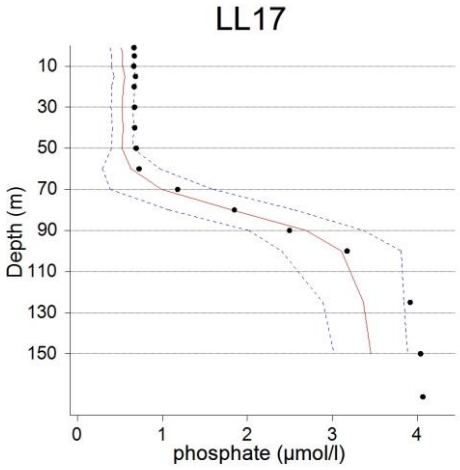

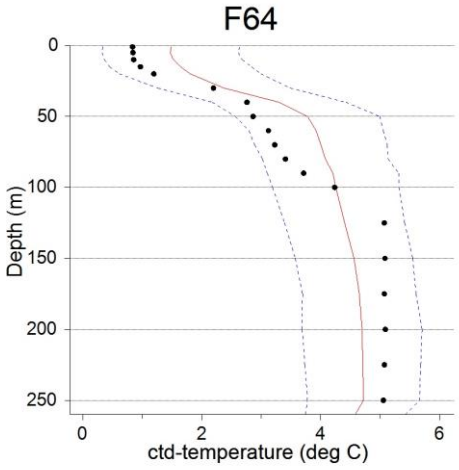

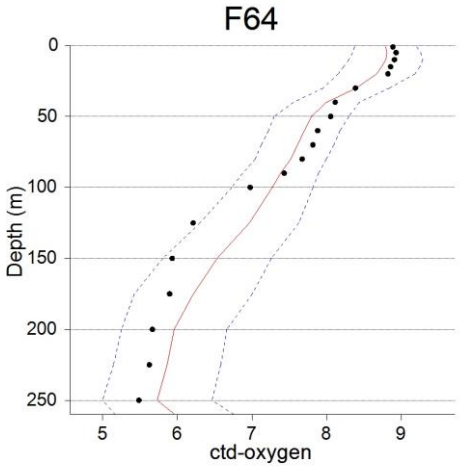

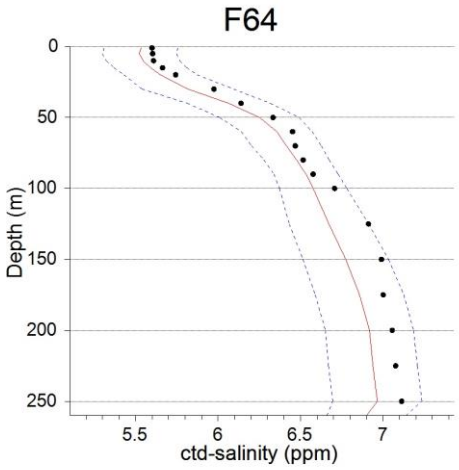

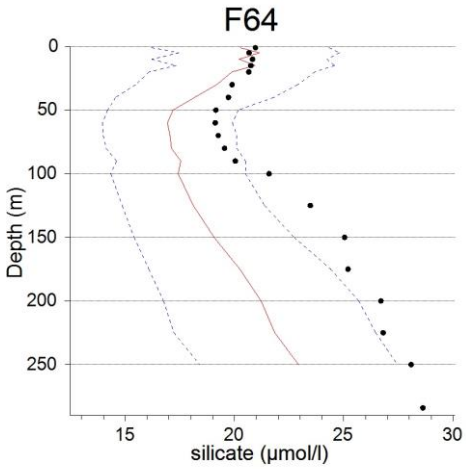

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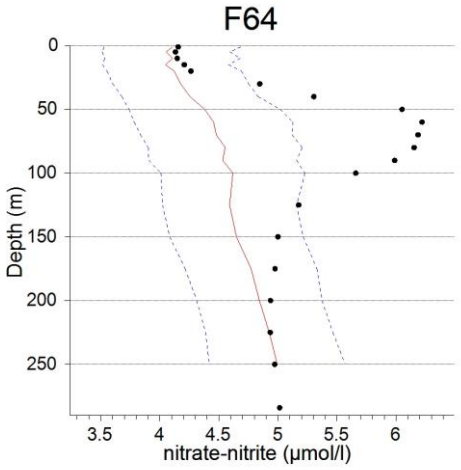

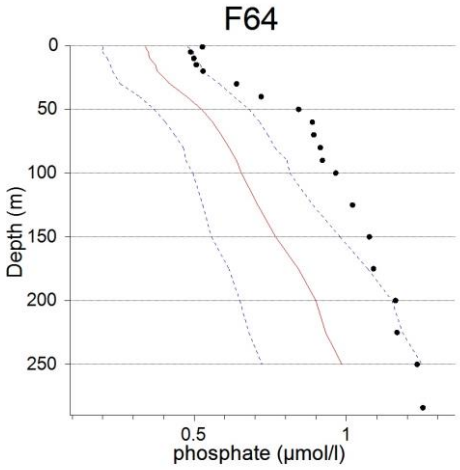

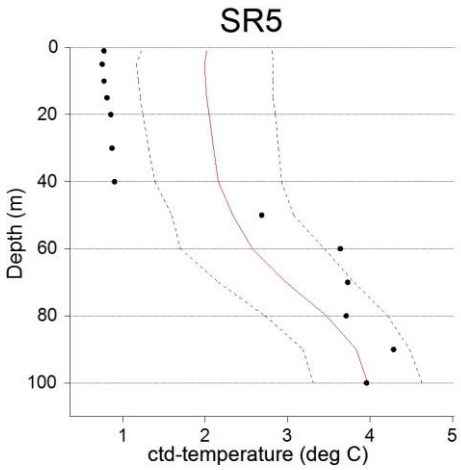

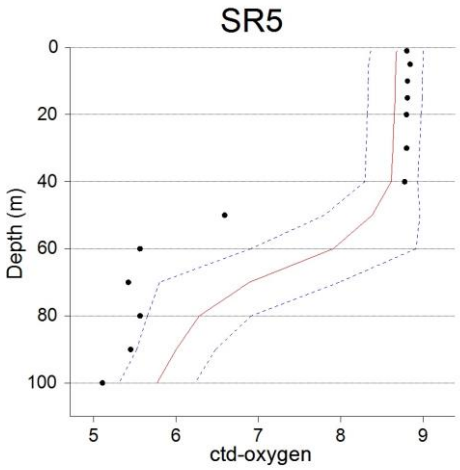

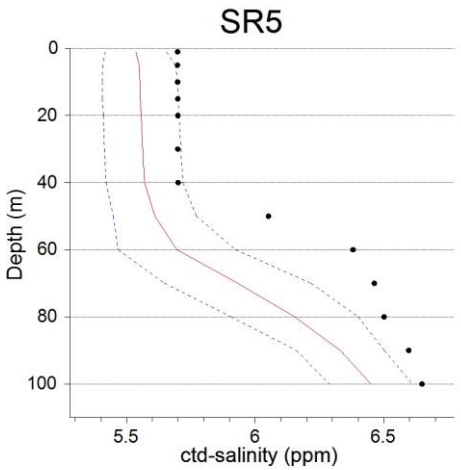

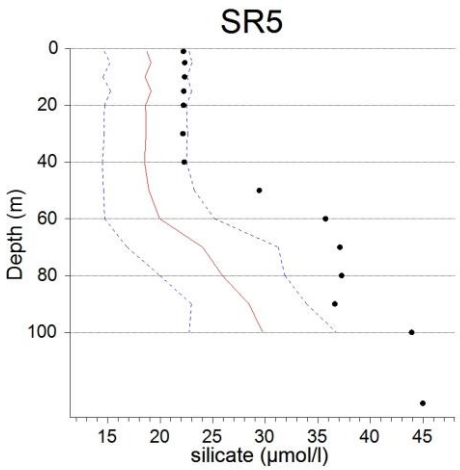

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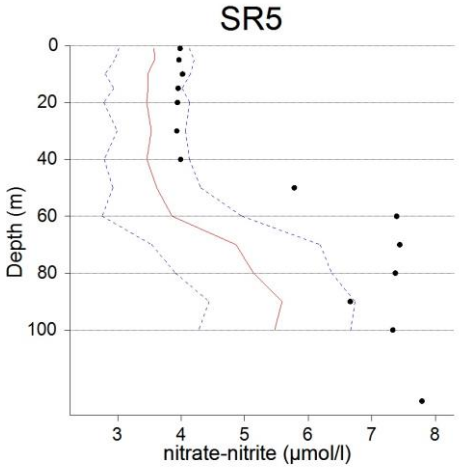

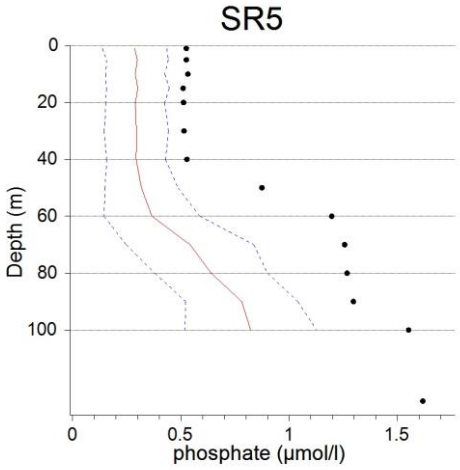

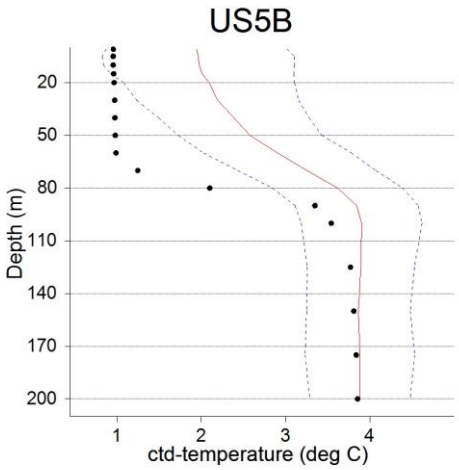

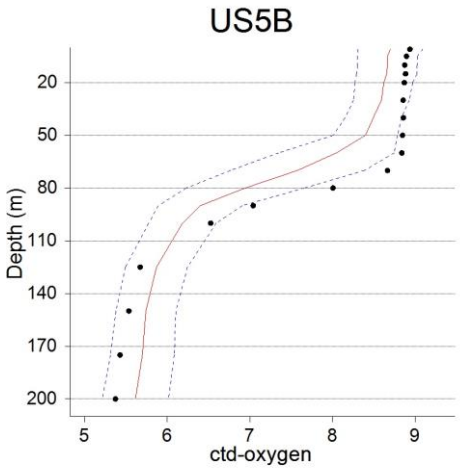

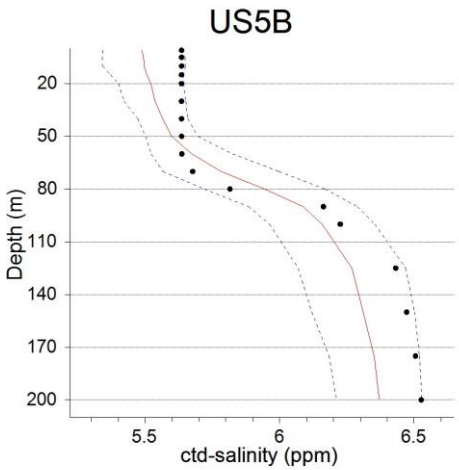

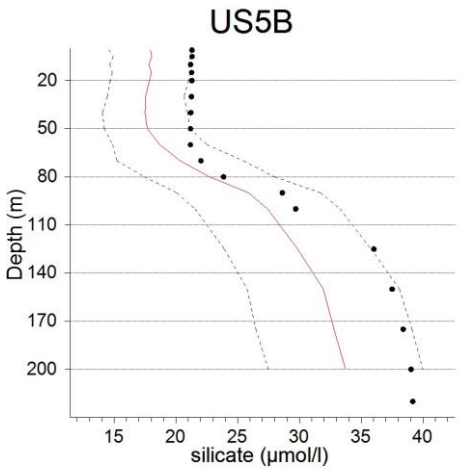

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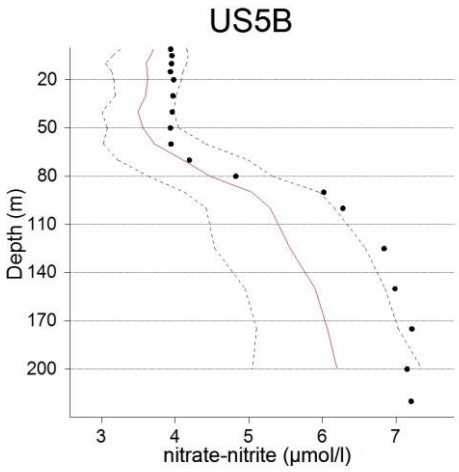

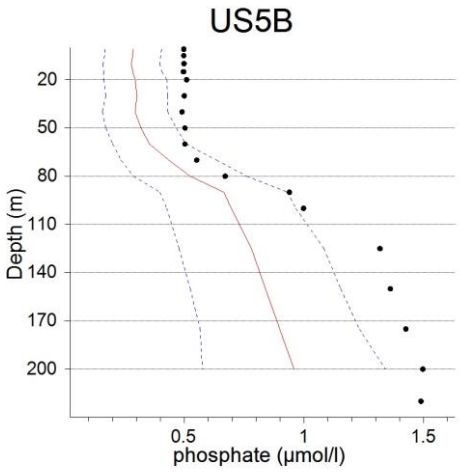

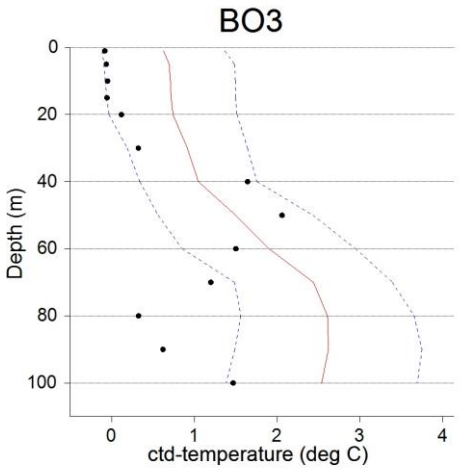

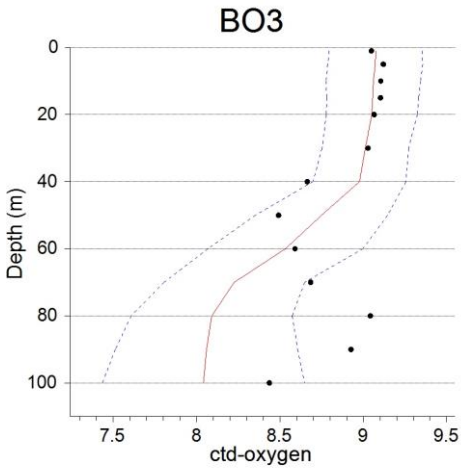

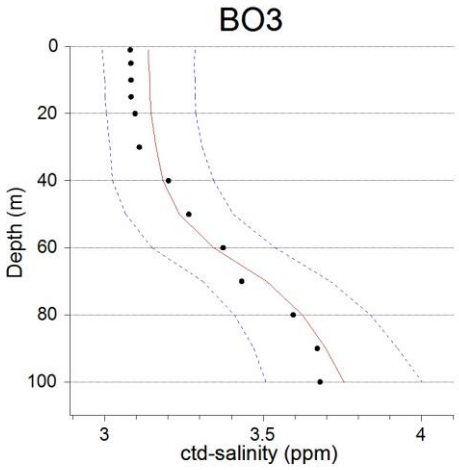

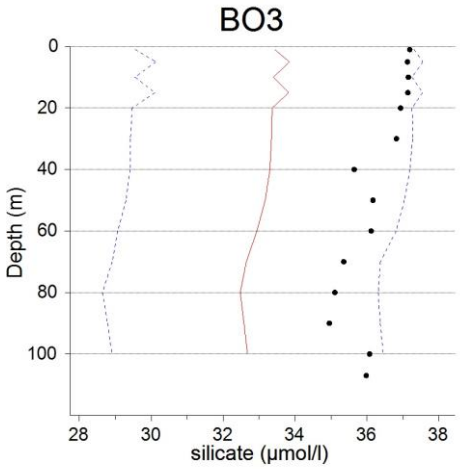

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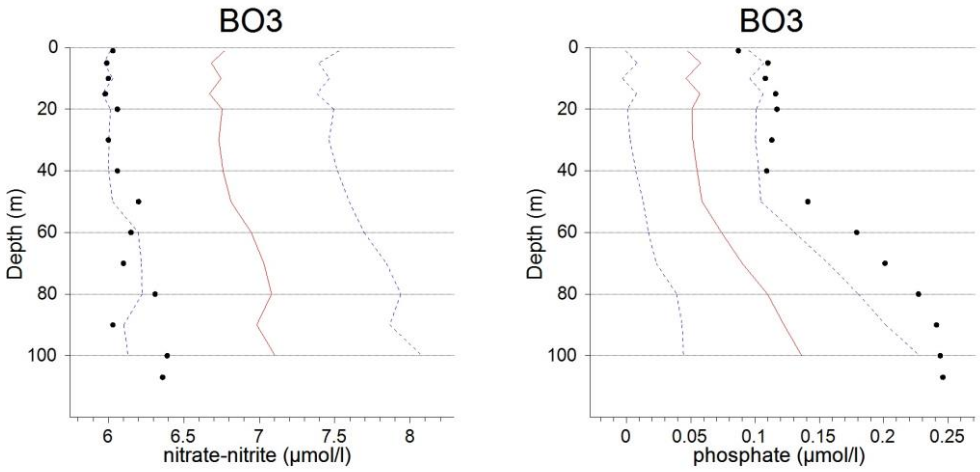
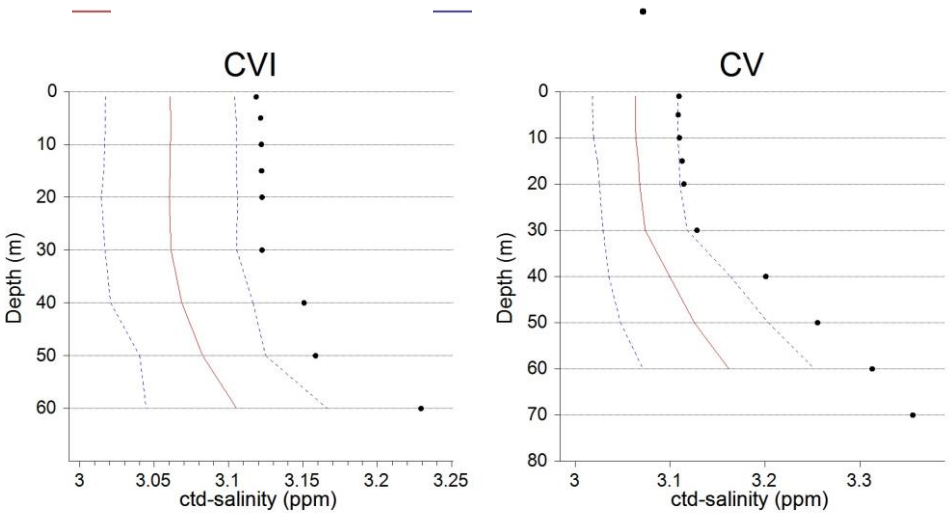


Annex 2. Salinity profiles at the stations CV and CVI. Mean (red solid line) and standard deviation (blue dotted lines) represent the data collected at the same time of season since the year 2000.



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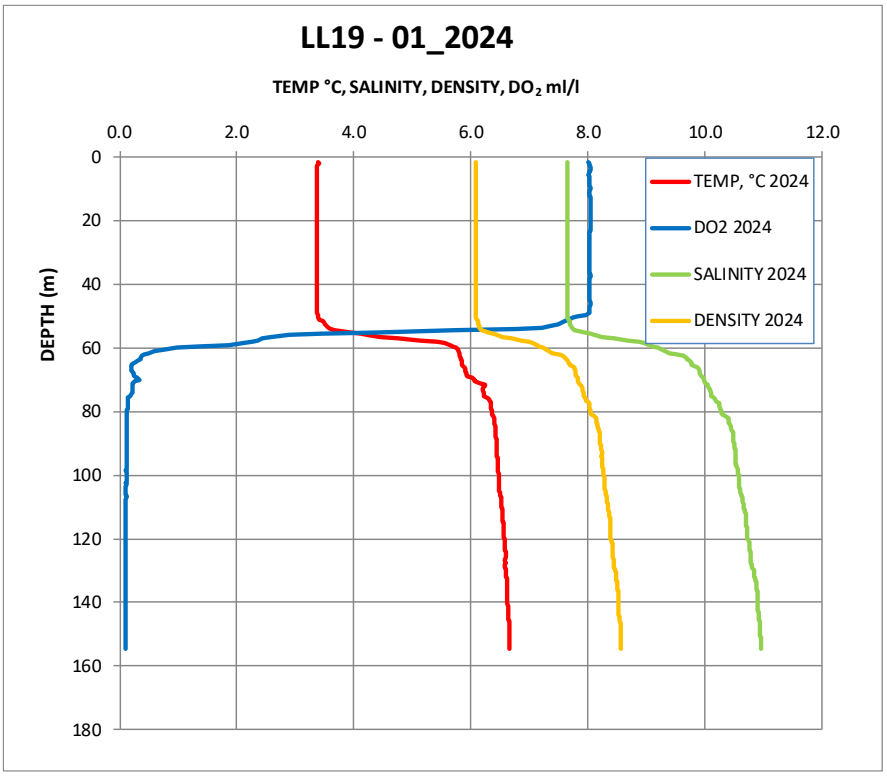
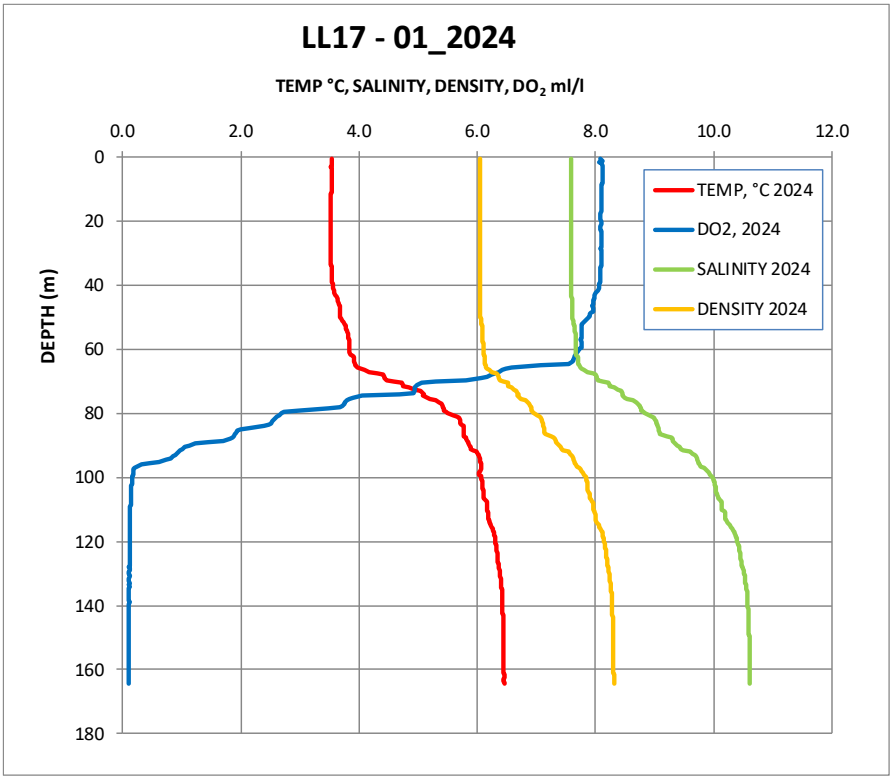
Annex 3. Observed temperature, oxygen, salinity and density profiles at the Northern Baltic Proper in January 2024.





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Annex 2. List of sampled stations of the cruise

INDEX	STATION	latitude	longitude	depth	DATE	time	ctd	pH	ox	nu	ph	zo	be	chl	oil	tox	secchi
Helsinki	Helsinki	60.16175	24.90163		2024-01-16	09.05											
2024010001	39A	60.06743	24.97933	43	2024-01-16	12.12	x	x	x	x							x
2024010002	AALTOXX	59.92253	25.17345	58	2024-01-16	15.48											
2024010003	XIV3	60.20262	26.19383	71	2024-01-16	21.32	x	x	x	x							
2024010004	XV1	60.24993	27.24712	66	2024-01-17	02.33	x	x	x	x							
2024010005	BIAS19B	60.24873	27.24723	68	2024-01-17	06.19											
2024010006	LL3A	60.06907	26.35293	70	2024-01-17	10.18	x	x	x	x					x		x
2024010007	GF2	59.83868	25.85917	85	2024-01-17	15.05	x	x	x	x							
2024010008	LL5	59.91698	25.59700	66	2024-01-17	18.28	x	x	x	x							
2024010009	LL6A	59.91692	25.02930	72	2024-01-17	21.22	x	x	x	x							
2024010010	LL7D	59.84705	24.83815	96	2024-01-18	00.56	x	x	x	x							
2024010011	GF1	59.70505	24.68207	84	2024-01-18	04.10	x	x	x	x							
2024010012	LL9	59.70008	24.03000	66	2024-01-18	07.20	x	x	x	x							
2024010013	XII3	59.86443	23.98562	33	2024-01-18	09.31	x	x	x	x							
2024010014	JML	59.58237	23.62575	80	2024-01-18	12.44	x	x	x	x							
2024010015	F62	59.33345	23.26358	97	2024-01-18	16.49	x	x	x	x							
2024010016	LL11	59.58337	23.29753	68	2024-01-18	20.39	x	x	x	x							
2024010017	LANGDEN	59.77677	23.26282	57	2024-01-19	04.19	x	x	x	x							
Hanko (Hango)	Hanko (Hango)	59.81017	22.90460		2024-01-19	07.26											
HANKO	HANKO	59.80867	22.90760		2024-01-19	14.11											
2024010018	UTO_V	59.73962	21.37085	65	2024-01-19	20.35											
2024010019	UTO_PROF	59.75662	21.36680	77	2024-01-19	21.39											
2024010020	IU7	59.81332	21.33607	94	2024-01-20	00.23	x	x	x	x							
2024010021	IU5	60.05820	21.19858	89	2024-01-20	03.43	x	x	x	x							
2024010022	IU2	60.58397	21.12973	46	2024-01-20	10.20	x	x	x	x							x
2024010023	IU1	60.76663	20.84665	33	2024-01-20	13.19	x	x	x	x							x
2024010024	SR5	61.08337	19.57980	126	2024-01-20	18.12	x	x	x	x		x			x		
2024010025	SR7	61.08315	20.59562	77	2024-01-21	00.14	x	x	x	x							
2024010026	SR8	61.12655	20.93000	48	2024-01-21	02.58	x	x	x	x							
2024010027	MS9	61.76683	20.53075	100	2024-01-21	08.36	x	x	x	x							
2024010028	US6B	62.60037	20.26257	82	2024-01-21	14.35	x	x	x	x							
2024010029	F16	63.51583	21.06363	45	2024-01-21	23.43	x	x	x	x							
2024010030	F15	63.51682	21.51317	49	2024-01-22	02.55	x	x	x	x							
2024010031	PIETARINKANTA	63.98355	22.83095	19	2024-01-22	11.59											
2024010032	RR7	64.73378	23.81295	40	2024-01-22	18.23	x	x	x	x							
2024010033	RR7LAATU	64.73377	23.81292	40	2024-01-22	19.29	x	x	x	x							
2024010034	BIAS11B	64.72980	23.52298	79	2024-01-22	21.44											
2024010035	RR6	64.80427	23.47700	85	2024-01-23	00.20	x	x	x	x							
2024010036	CVI	65.23385	23.56295	70	2024-01-23	07.47	x	x	x	x							
2024010037	CV	64.99870	23.24338	87	2024-01-23	11.57	x	x	x	x							x
2024010038	BO3	64.30133	22.34528	108	2024-01-23	17.49	x	x	x	x					x		
2024010039	F13	63.78278	21.47758	65	2024-01-24	02.07	x	x	x	x							
2024010040	US3	62.75897	19.19557	175	2024-01-24	11.16	x	x	x	x							x
2024010041	US5B	62.58620	19.96868	221	2024-01-24	18.27	x	x	x	x		x			x		
2024010042	US7	62.60033	20.82953	27	2024-01-24	22.55	x	x	x	x							
2024010043	F26	61.98355	20.06318	138	2024-01-25	04.17	x	x	x	x							
2024010044	AALTO_SM	61.79847	20.23343	108	2024-01-25	06.41											
2024010045	AALTO_IK	61.96568	21.03022	0	2024-01-25	13.44											
2024010046	MS6	61.98368	19.16353	72	2024-01-25	19.06	x	x	x	x							
2024010047	MS3	62.13443	18.16275	84	2024-01-25	23.22	x	x	x	x							
2024010048	SR3	61.18335	18.23002	72	2024-01-26	06.16	x	x	x	x							
2024010049	F64	60.18897	19.14240	285	2024-01-26	14.29	x	x	x	x					x		
2024010050	F69	59.78332	19.92965	194	2024-01-26	21.00	x	x	x	x							
2024010051	LL19	58.88070	20.31072	163	2024-01-27	06.15	x	x	x	x							
2024010052	LL19LAATU	58.88070	20.31073	163	2024-01-27	07.48	x										
2024010053	LL17	59.03330	21.07990	172	2024-01-27	12.05	x	x	x	x					x		x
2024010054	AALTO_PI	59.24968	20.99780	98	2024-01-27	14.44											
2024010055	AALTO_LP	59.25212	20.99693	98	2024-01-27	16.10											
2024010056	BIAS15	59.25015	21.01637	90	2024-01-27	17.04											

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2024010057	LL15	59.18328	21.74690	131	2024-01-27	19.41	x	x	x	x							
2024010058	LL12	59.48342	22.89642	82	2024-01-28	01.18	x	x	x	x							
2024010059	LL7	59.84518	24.83022		2024-01-28	08.15											
HELSINKI	HELSINKI	60.16182	24.90155		2024-01-28	10.43											

Parameters: ox = oxygen, nu = nutrients, ph = phytoplankton, zo = zooplankton, be = benthos, chl = chlorophyll a, oil = dissolved oil, tox = phytotoxins.

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