Suomen ympäristökeskus
Finlands miljöcentral
Finnish Environment Institute

ILMATIETEEN LAITOS

CRUISE REPORT

R/V Aranda

Cruise 05/2023

COMBINE 3

8.8.2023 – 19.8.2023

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

Objectives of the cruise

The objectives of the cruise were:

1) Monitoring of the Northern Baltic Proper, Archipelago Sea, Bothnian Sea, Quarken, the Bothnian Bay and the Gulf of Finland.
2) Measured parameters were temperature, salinity, conductivity, oxygen, silicate, nutrients (NH_4, NO_{23}, N_{tot}, PO_4, P_{tot}) and oil compounds. Some sediment samples were also taken and benthic animals sieved during the 2nd leg.
3) Samples of Chlorophyll a, phytoplankton and zooplankton were taken to be analyzed later.
4) Samples of hazardous substances and phycotoxins were taken.
5) Maintenance of the automated instruments were also carried out during the cruise (wave buoys and hydrophones).
6) Additionally, some specific samples of zooplankton (eDNA and *Acartia* spp.) were taken.

   It should be noted that one of the two pumps of the nutrient analyzer was out of order, and thus NO_2 concentrations weren't obtained.

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Table 1 The scientific crew

Name	On board	Organization
Pekka Kotilainen	**8-16.8.2023**	**Syke**
Eilsa Lindgren	**8-16.8.2023**	**FMI**
Alexandra Hahn	**8-16.8.2023**	**GEOMAR**
Ilkka Lastumäki	**8-19.8.2023**	**Syke**
Pia Varmanen	**8-19.8.2023**	**Syke**
Antti Räike	**8-19.8.2023**	**Syke**
Riikka Mattsson	**8-19.8.2023**	**Syke**
Tanja Kinnunen	**8-19.8.2023**	**Syke**
Mira Granlund	**8-19.8.2023**	**Syke**
Sami Rantapusa	**8-19.8.2023**	**FMI**
Maiju Lehtiniemi	**16-19.8.2023**	**Syke**
Smedberg Meri	**16-19.8.2023**	**FMI**
Skyttä Annaliina	**16-19.8.2023**	**Syke**
Lehto Anne-Mari	**16-19.8.2023**	**Syke**
Eklin Tero	**16-19.8.2023**	**Syke**
Luhtanen Anne-Mari	**16-19.8.2023**	**Syke**
Kulmala Airi	**16-19.8.2023**	**MTK**
Eriksson Fredrik	**16-19.8.2023**	**Reporter**
Hagelberg Eija	**16-19.8.2023**	**BSAG**

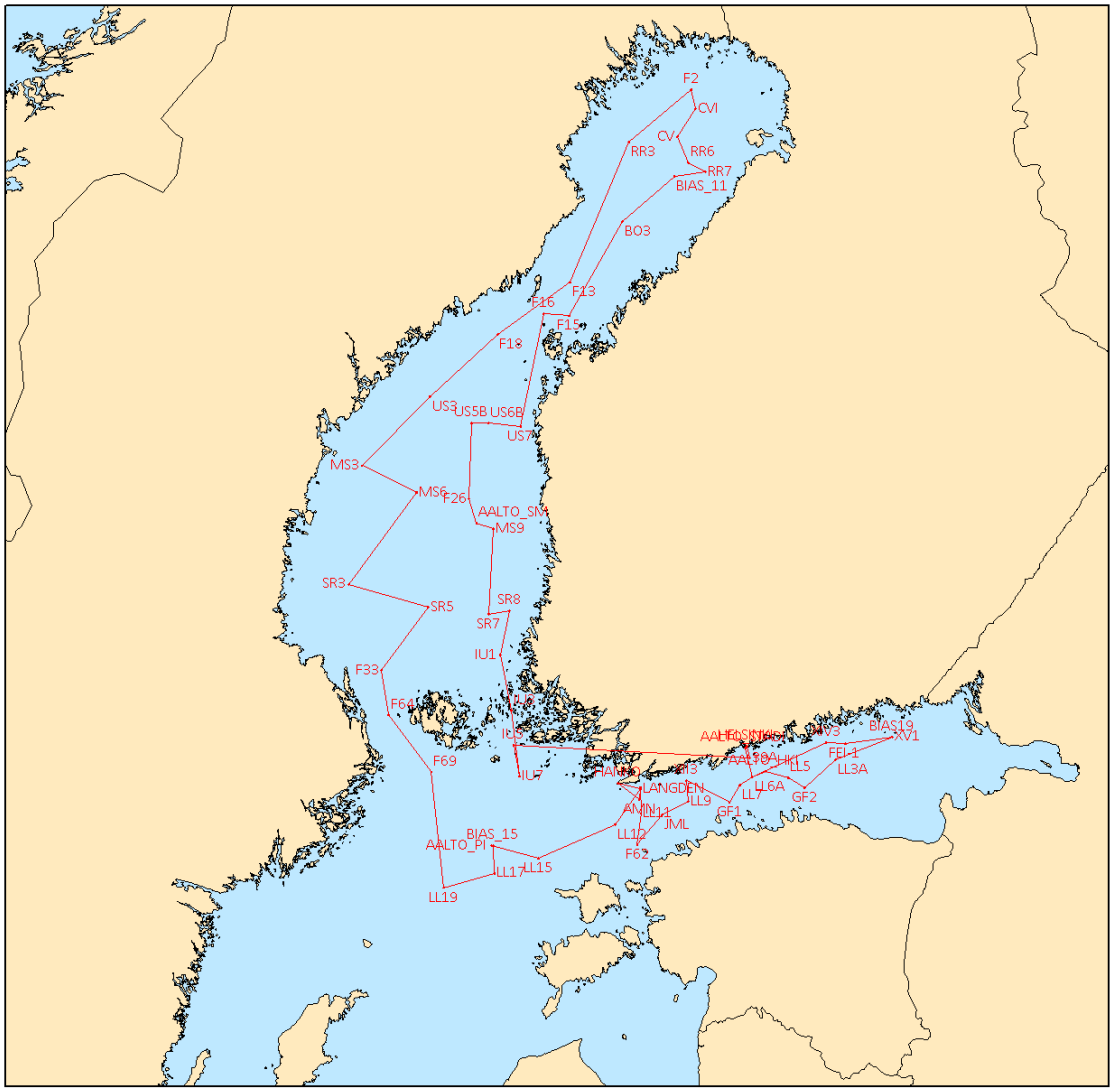
Cruise Route

1st leg

R/V Aranda departed from Helsinki at 10.00 hrs. Due to strong wind cruise plan had to be changed pre the departure. Planned maintenance of the wave buoy had to be postponed and the first sampled station was 39A off Helsinki. Then Aranda headed to the west to Hanko and further to the Archipelago Sea, which gave some shelter compared with south wind > 20-25 m/s in the Northern Baltic Proper. First station in the Archipelago Sea was IU5, and only after that IU7 off Utö due to the passed storm. IU3 and IU1 were the last sampled stations of the Archipelago transect.
On the Finnish side of the Bothnian Sea sampled stations were: SR8, SR7, MS9, F26, US5b, US6b and US7. Wave buoy of FMI was lifted for the maintenance carried out. After that the cruise headed to Quarken F16 and F15. In the Bothnian Bay the stations BO3, RR7, RR6, CV, CVI, F2 and RR3 were sampled. On the way back towards the south, F13 and F18 were also sampled in the Quarken. On the Swedish side of the Bothnian Sea US3, MS3, MS6, SR3 SR5 and F33 were sampled. Before entering the Northern Baltic Proper F64 between the Sweden and Åland islands were visited. Finally in the Northern Baltic Proper LL19, LL17, LL15 and LL12 were sampled. In between the LL17 and the Ll15 a wave buoy was lifted, cleaned and its's maintenance carried out. The 1st leg of the cruise ended up to Hanko on 16 August 2023.

2nd leg

The second leg of the cruise started from Hanko the same day and continued sampling on the stations in the westernmost Gulf of Finland: LANGDEN, AMN, LL11, F62, JML, LL9and XII3. Then stations in the middle of the GoF were sampled: GF1, LL7 and LL6A. Wave buoy of FMI was lifted for the maintenance in the middle of the GoF. After that the cruise headed towards eastern sampling stations: LL5, GF2, LL3A, XV1, FEI-1 and XVI3. In the eastern GoF also a hydrofone BIAS19 was take up. After all sampling stations were completed, the cruise headed back to LL6A to pump 4 m3 of water to be brought to the Institute for mesocosm experiments. The final stop was for lifting the wave buoy of the FMI for the maintenance near Suomenlinna in Helsinki waters. The second leg of the cruise ended up to Helsinki on Saturday morning 19 August 2023 at 08:30 hours.



Cruise route

Observations

Archipelago Sea

The entire water column was mixed from surface to bottom at shallow stations (IU1 and IU3) and at deeper stations of the region some stratification was observed. Due to heavy winds or a storm, thermocline was found at the depth of 20m (IU7) and at the depth of 35 m at IU5.
For the same reason (= storm) nutrients were mixed in the entire water column at shallow stations (IU1 and IU3) and at the deeper stations and for the same reason high nutrient concentrations were observed at surface and lower than the average in deep waters.

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Bothnian Sea

Hydrography
Lower surface temperature and higher salinity than in average in August were observed especially in the productive layer on the Swedish coast.

Nutrients
Observed nutrient concentrations, especially P_{tot}, N_{tot} and PO_4 concentrations, were above the long-term averages of August.

Bothnian Bay

Hydrography
Observed surface temperatures were 2 -3 °C higher than usually in August.

Nutrients
P_{tot} and PO_4 concentrations were higher than ever before and above the limit of detection. The highest measured P_{tot} concentrations were > 0.6 µmol/l and PO_4 concentrations even > 0.3 µmol/l at deep layers, respectively.

Quarken

Hydrography
Salinity at surface was above the average. The storm just before the cruise might have caused some local upwelling.

Nutrients
Temporal upwelling could also be seen as high nutrients concentrations in the productive layer.

Northern Baltic Proper

Hydrography
Deep water is anoxic layer at 80-90 meters depth as before and observed H_2S concentrations were as high as 50 µmol/l near bottom.

Nutrients
Observed N_{tot} and P_{tot} and PO_4 concentrations were above the long-term averages at the anoxic water column.

Gulf of Finland

Hydrography
Deep water is anoxic at 80-90 meters depth as before in the western GoF. Better situation is observed near the bottom in the eastern parts of the Gulf although oxygen is depleted there as well.

Nutrients
Observed N_{tot} and P_{tot} and PO_4 concentrations were close to the average concentrations of the past ten years but high concentrations were also observed e.g., at XV1 in the eastern GoF.

Conclusions

It seems that, some upwelling in the Archipelago Sea and in the Bothnian Sea had occurred due to the storm in the beginning of the cruise.

P_{tot} and PO_4 summer concentrations have increased for years in deep waters in the Bothnian Sea. Oxygen concentrations seem to decrease in deep layers, but still the O_2 saturation is as high as 50-70%.

P_{tot} and PO_4 concentrations continue to increase in the Bothnian Bay.

The anoxic layer in the Northern Baltic Proper remains the same, no oxygen > 80-90 meters, but H_2S concentrations even higher than before.

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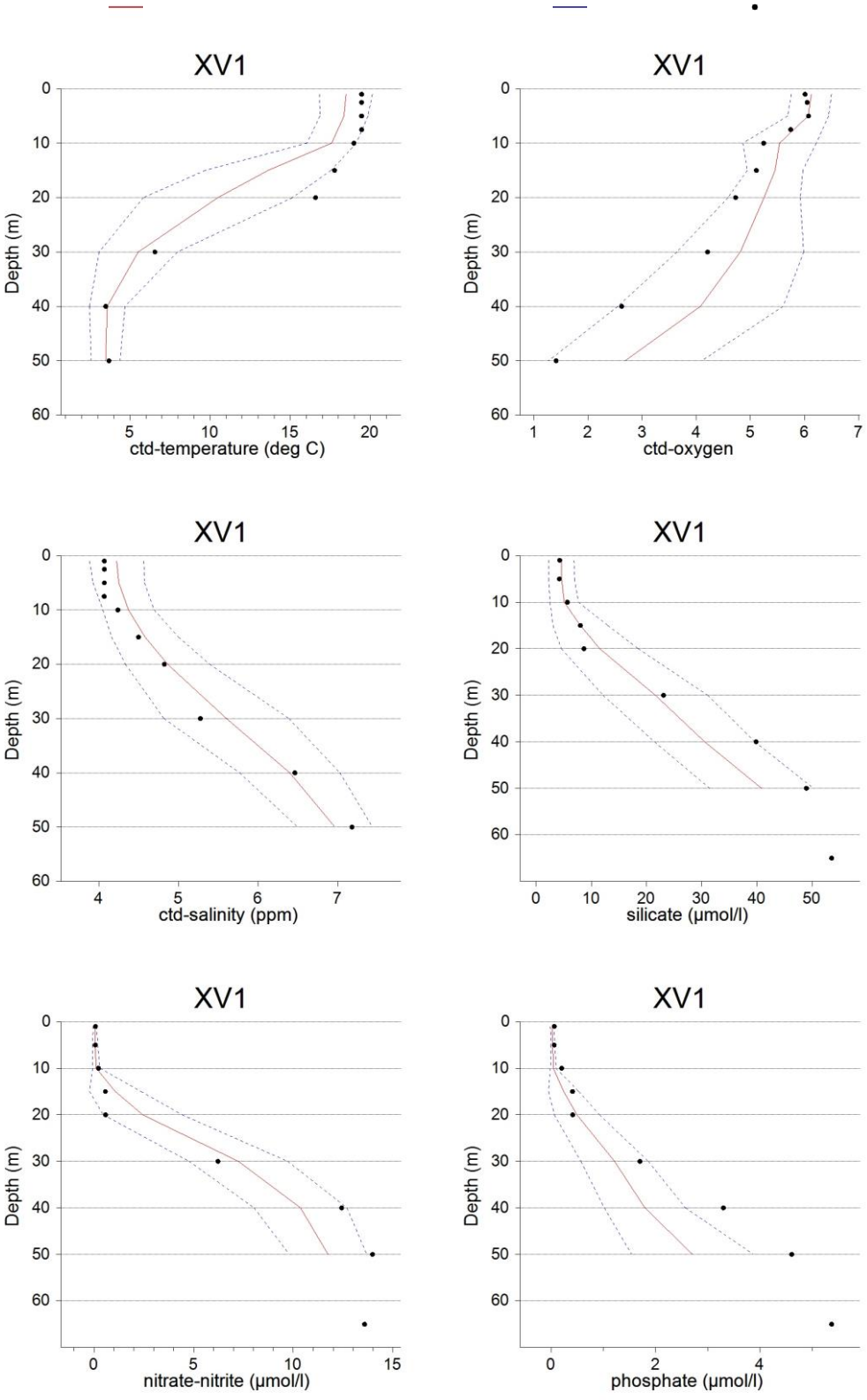
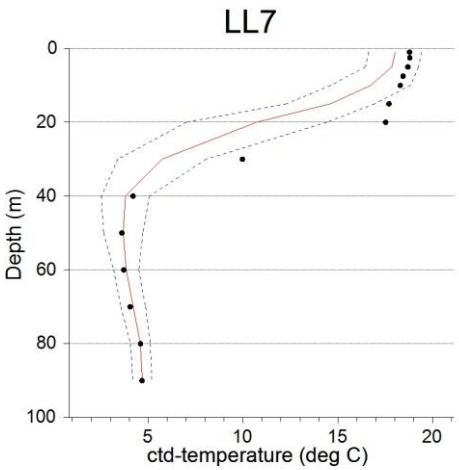
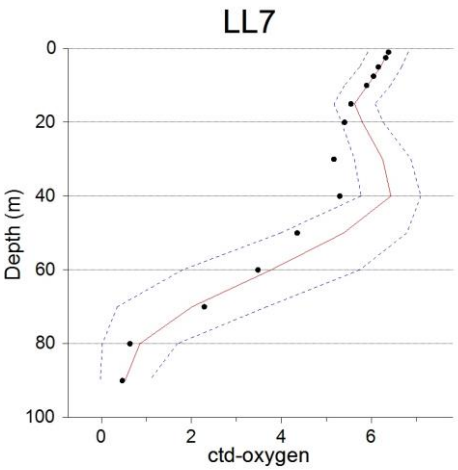
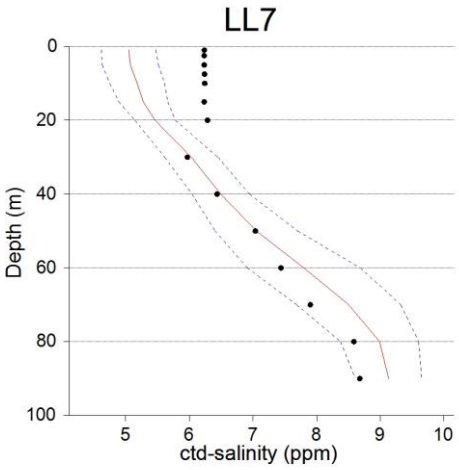
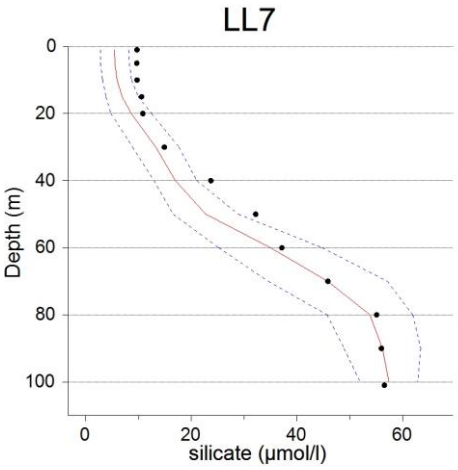
Annex 1. Selected variables at the stations XV1, LL7, LL12, LL17, F64, SR5, US5B, BO3 and F2. Mean (red solid line) and standard deviation (blue dotted lines) represent the data collected at the same time of season since the year 2000.

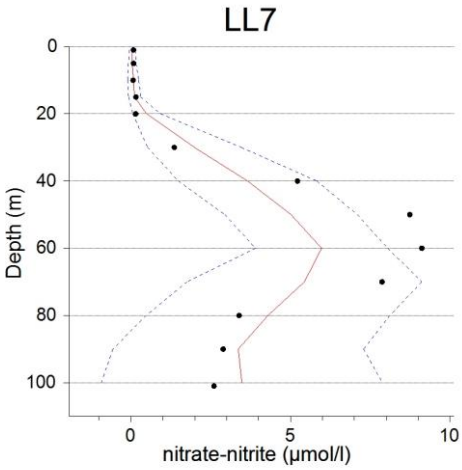


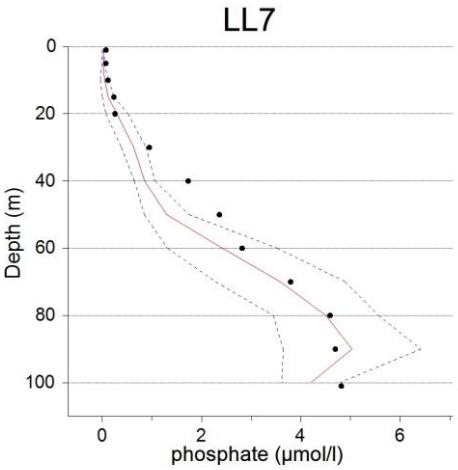

LL7
Depth (m)
0
20
40
60
80
100
5
10
15
20
ctd-temperature (deg C)

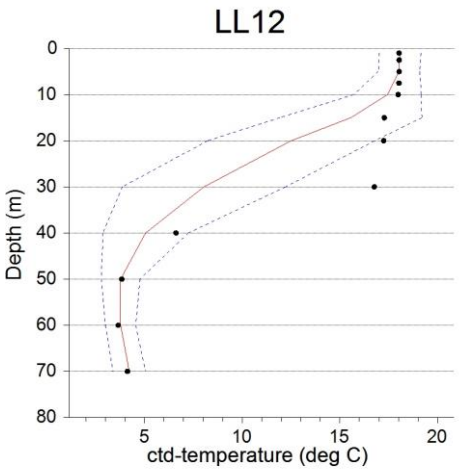

LL7
Depth (m)
0
20
40
60
80
100
0
2
4
6
ctd-oxygen

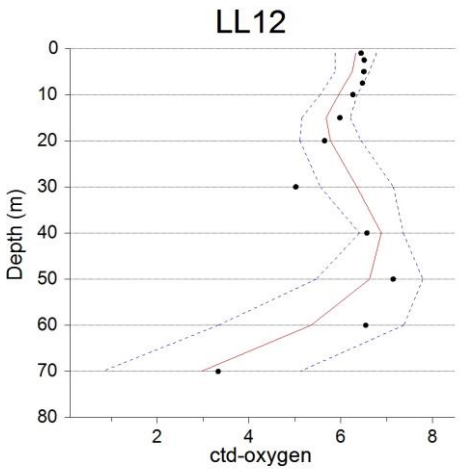

LL7
Depth (m)
0
20
40
60
80
100
5
6
7
8
9
10
ctd-salinity (ppm)

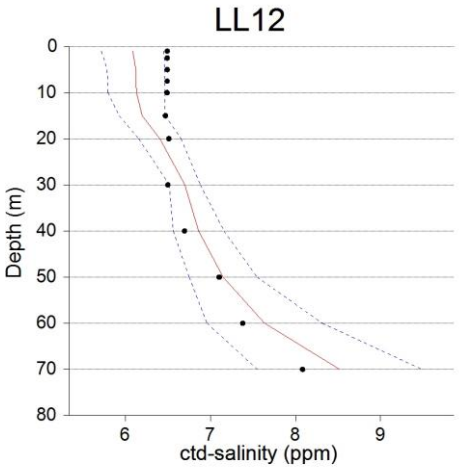

LL7
Depth (m)
0
20
40
60
80
100
0
20
40
60
silicate (µmol/l)

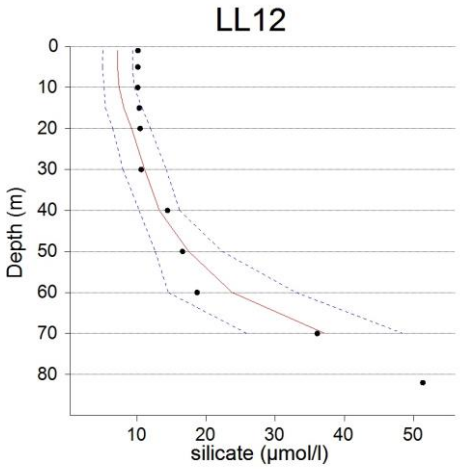

LL7
Depth (m)
0
20
40
60
80
100
0
5
10
nitrate-nitrite (µmol/l)

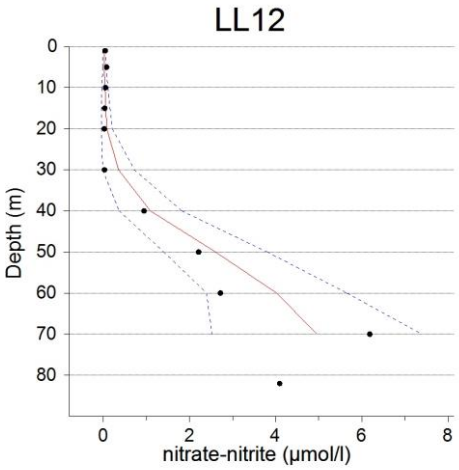

LL7
Depth (m)
0
20
40
60
80
100
0
2
4
6
phosphate (µmol/l)

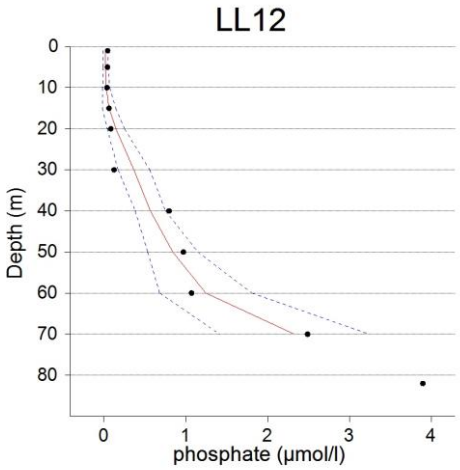

LL12
Depth (m)
0
10
20
30
40
50
60
70
80
5
10
15
20
ctd-temperature (deg C)

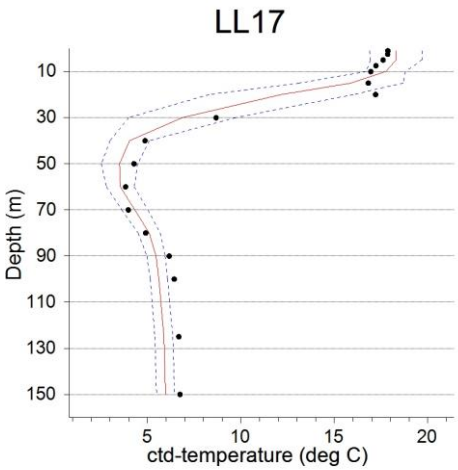

LL12
Depth (m)
0
10
20
30
40
50
60
70
80
2
4
6
8
ctd-oxygen

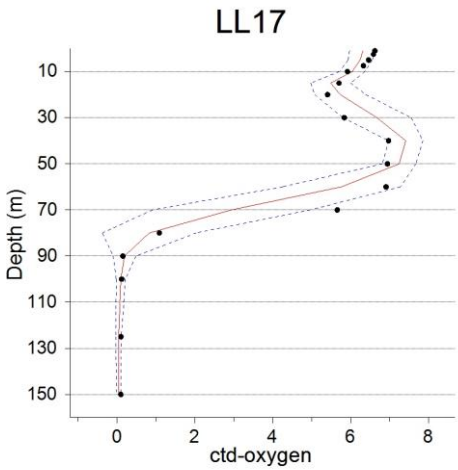

LL12
Depth (m)
0
10
20
30
40
50
60
70
80
6
7
8
9
ctd-salinity (ppm)

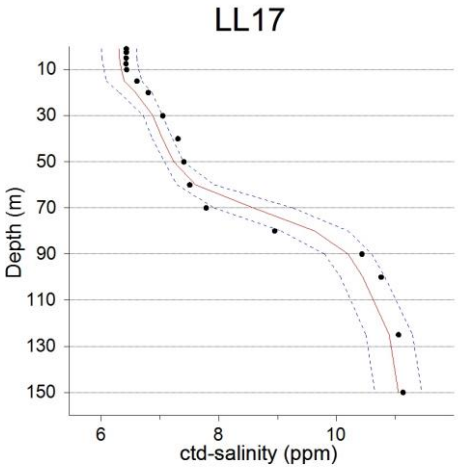

LL12
Depth (m)
0
10
20
30
40
50
60
70
80
10
20
30
40
50
silicate (µmol/l)

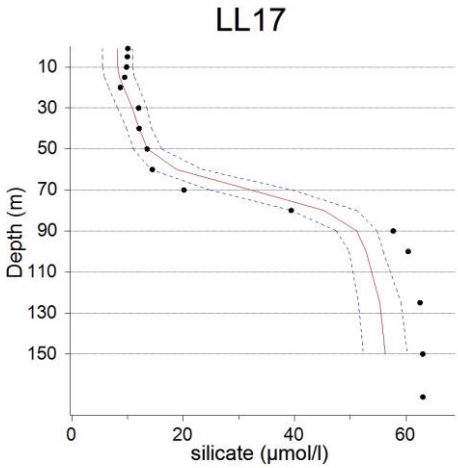

LL12
Depth (m)
0
10
20
30
40
50
60
70
80
0
2
4
6
8
nitrate-nitrite (µmol/l)

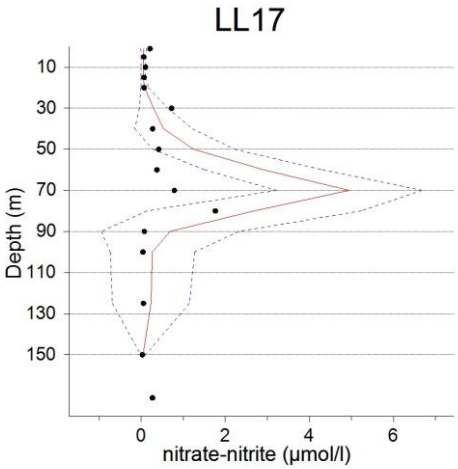

LL12
Depth (m)
0
10
20
30
40
50
60
70
80
0
1
2
3
4
phosphate (µmol/l)

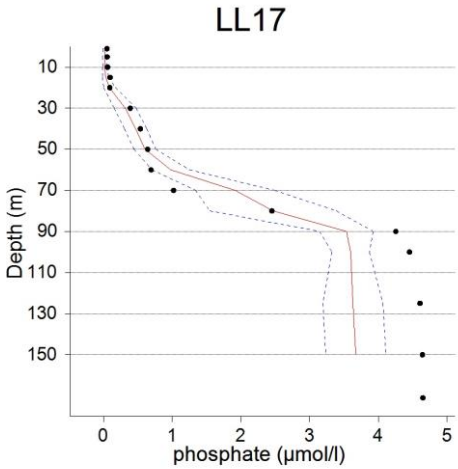

LL17
Depth (m)
10
30
50
70
90
110
130
150
5
10
15
20
ctd-temperature (deg C)

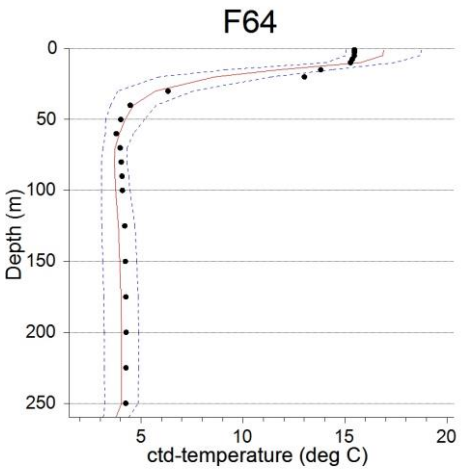

LL17
Depth (m)
10
30
50
70
90
110
130
150
0
2
4
6
8
ctd-oxygen

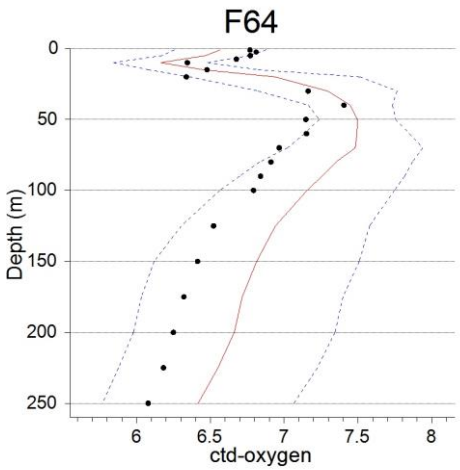

LL17
Depth (m)
10
30
50
70
90
110
130
150
6
8
10
ctd-salinity (ppm)

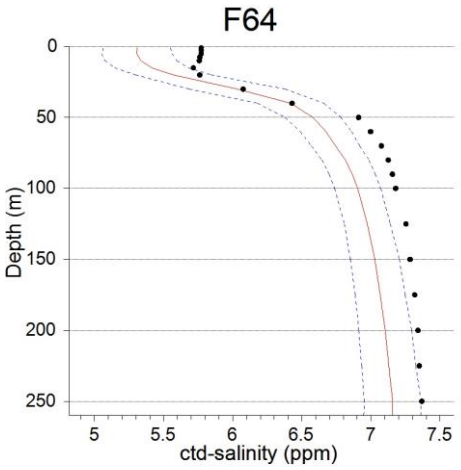

LL17
Depth (m)
10
30
50
70
90
110
130
150
0
20
40
60
silicate (µmol/l)

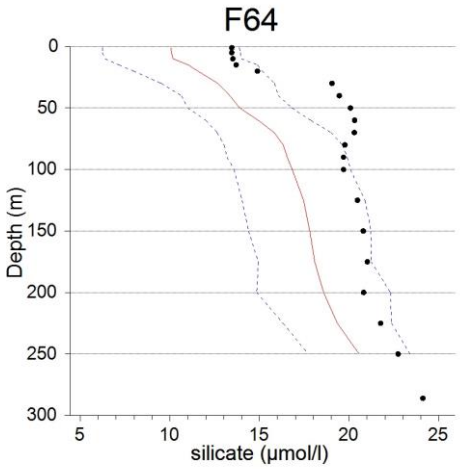

LL17
Depth (m)
10
30
50
70
90
110
130
150
0
2
4
6
nitrate-nitrite (µmol/l)

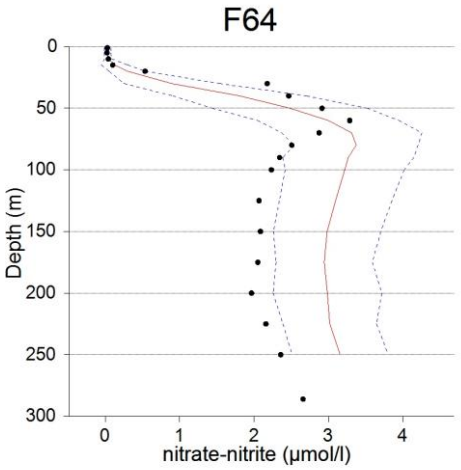

LL17
Depth (m)
10
30
50
70
90
110
130
150
0
1
2
3
4
5
phosphate (µmol/l)

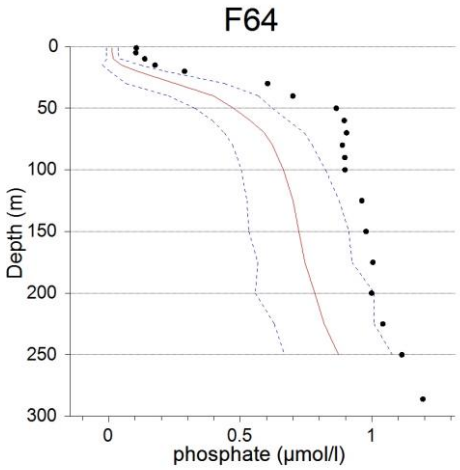

F64
Depth (m)
0
50
100
150
200
250
5
10
15
20
ctd-temperature (deg C)

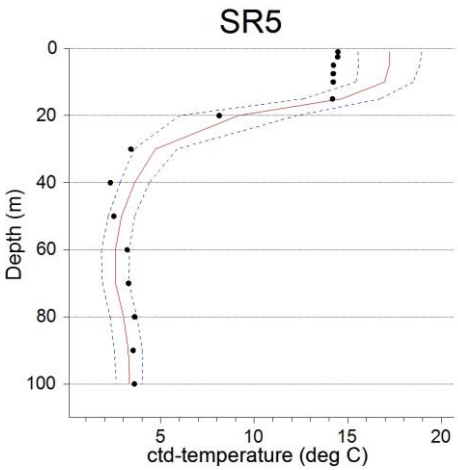

F64
Depth (m)
0
50
100
150
200
250
6
6.5
7
7.5
8
ctd-oxygen

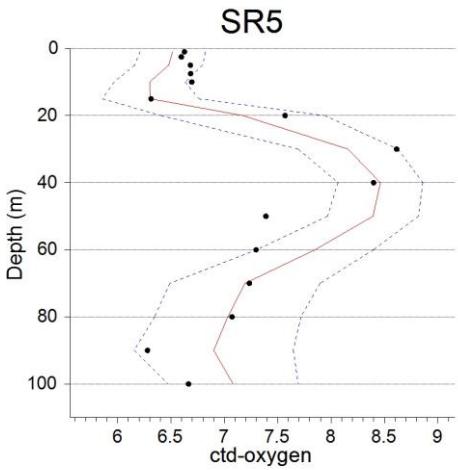

F64
Depth (m)
0
50
100
150
200
250
5
5.5
6
6.5
7
7.5
ctd-salinity (ppm)

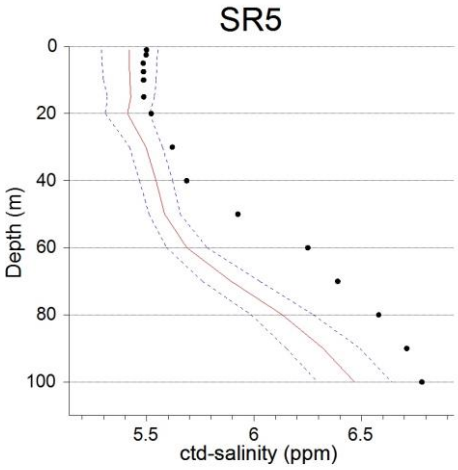

F64
Depth (m)
0
50
100
150
200
250
300
5
10
15
20
25
silicate (µmol/l)

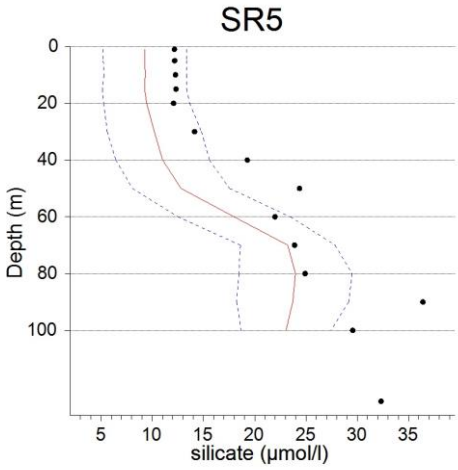

F64
Depth (m)
0
50
100
150
200
250
300
0
1
2
3
4
nitrate-nitrite (µmol/l)

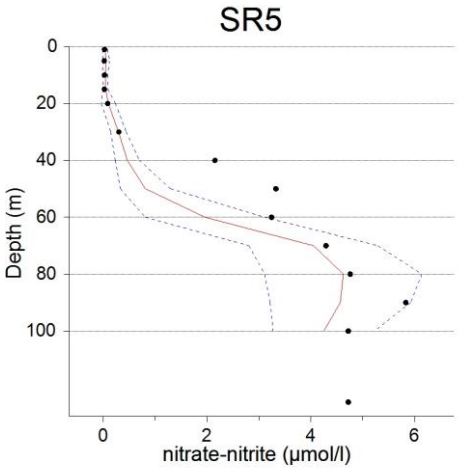

F64
Depth (m)
0
50
100
150
200
250
300
0
0.5
1
phosphate (µmol/l)

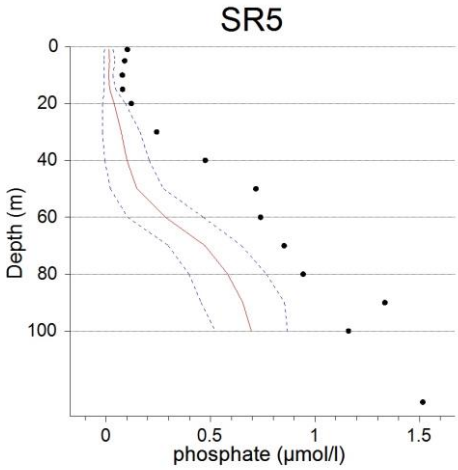

SR5
Depth (m)
0
20
40
60
80
100
5
10
15
20
ctd-temperature (deg C)

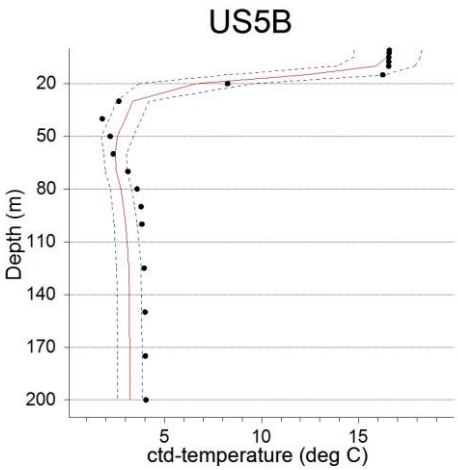

SR5
Depth (m)
0
20
40
60
80
100
6
6.5
7
7.5
8
8.5
9
ctd-oxygen

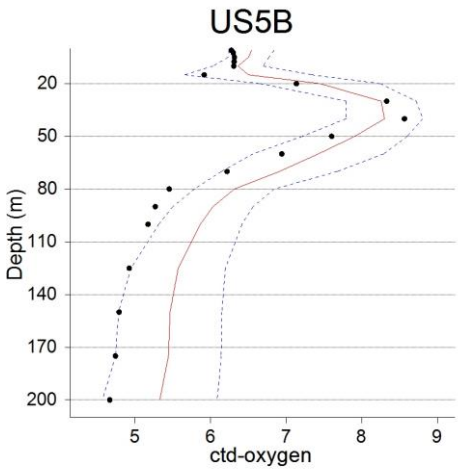

SR5
Depth (m)
0
20
40
60
80
100
5.5
6
6.5
ctd-salinity (ppm)

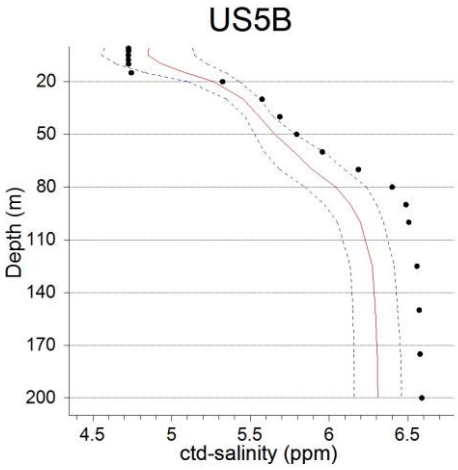

SR5
Depth (m)
0
20
40
60
80
100
5
10
15
20
25
30
35
silicate (µmol/l)

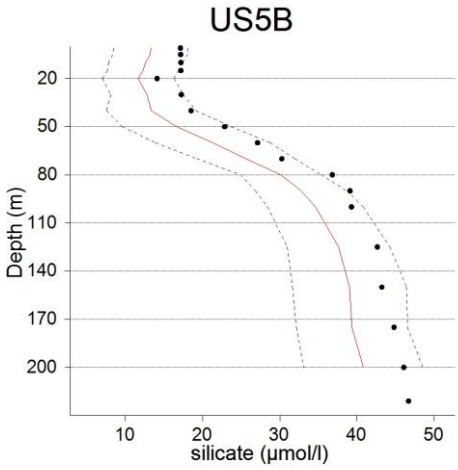

SR5
Depth (m)
0
20
40
60
80
100
0
2
4
6
nitrate-nitrite (µmol/l)

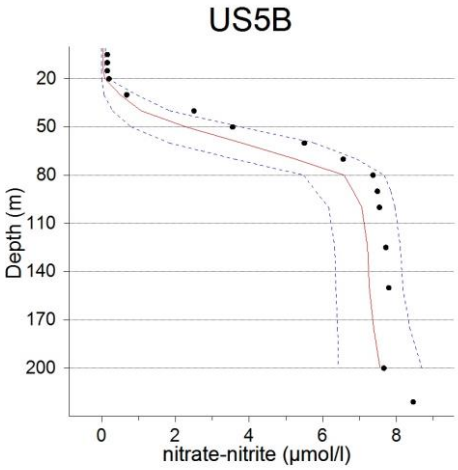

SR5
Depth (m)
0
20
40
60
80
100
0
0.5
1
1.5
phosphate (µmol/l)

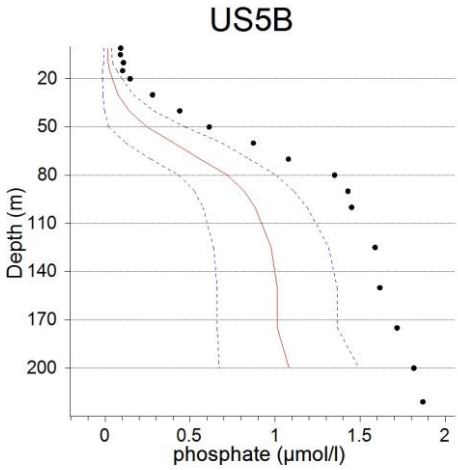

US5B
Depth (m)
20
50
80
110
140
170
200
5
10
15
ctd-temperature (deg C)

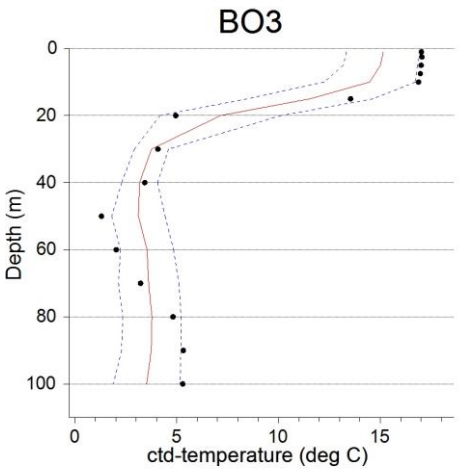

US5B
Depth (m)
20
50
80
110
140
170
200
5
6
7
8
9
ctd-oxygen

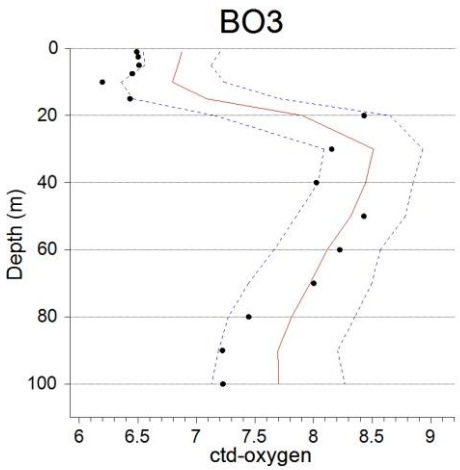

US5B
Depth (m)
20
50
80
110
140
170
200
4.5
5
5.5
6
6.5
ctd-salinity (ppm)

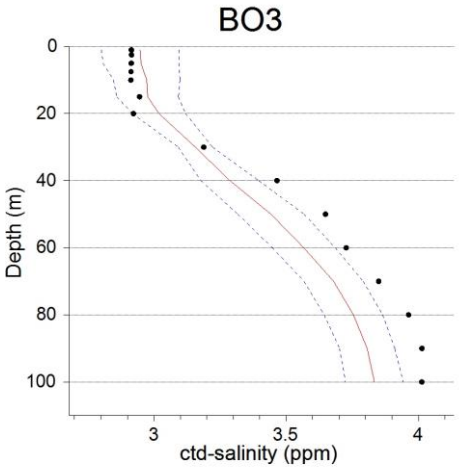

US5B
Depth (m)
20
50
80
110
140
170
200
10
20
30
40
50
silicate (µmol/l)

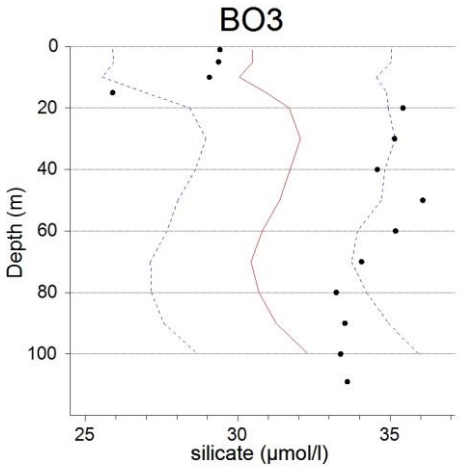

US5B
Depth (m)
20
50
80
110
140
170
200
0
2
4
6
8
nitrate-nitrite (µmol/l)

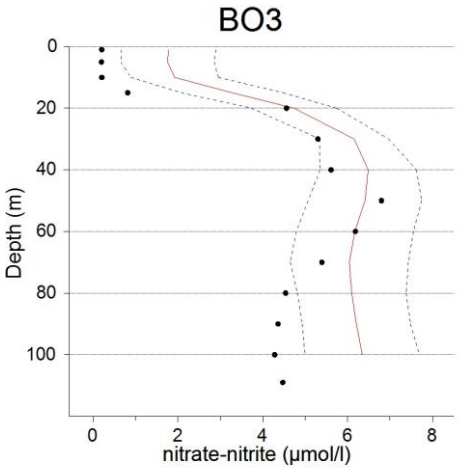

US5B
Depth (m)
20
50
80
110
140
170
200
0
0.5
1
1.5
2
phosphate (µmol/l)

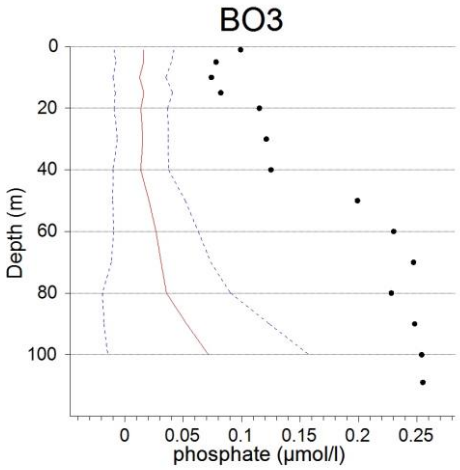

BO3
Depth (m)
0
20
40
60
80
100
0
5
10
15
ctd-temperature (deg C)

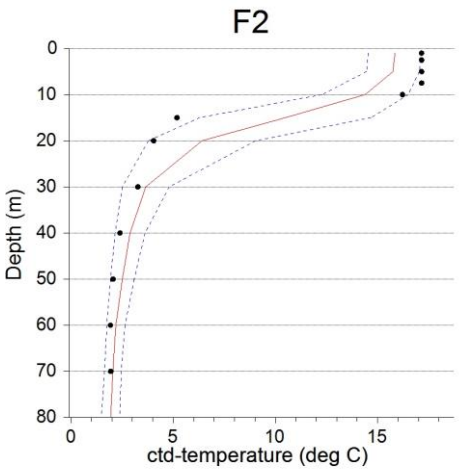

BO3
Depth (m)
0
20
40
60
80
100
6
6.5
7
7.5
8
8.5
9
ctd-oxygen

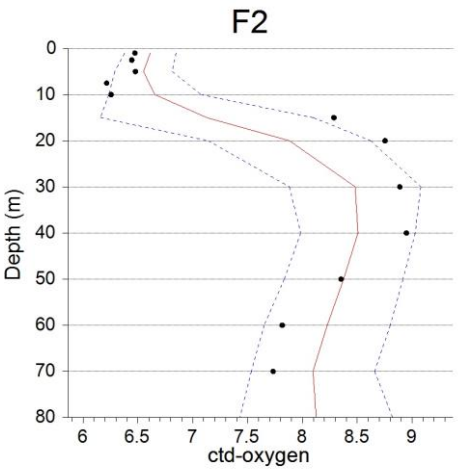

BO3
Depth (m)
0
20
40
60
80
100
3
3.5
4
ctd-salinity (ppm)

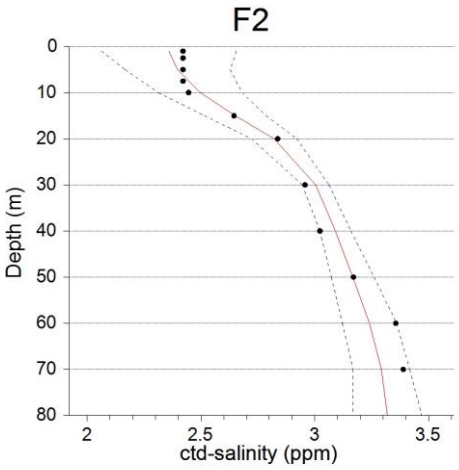

BO3
Depth (m)
0
20
40
60
80
100
25
30
35
silicate (µmol/l)

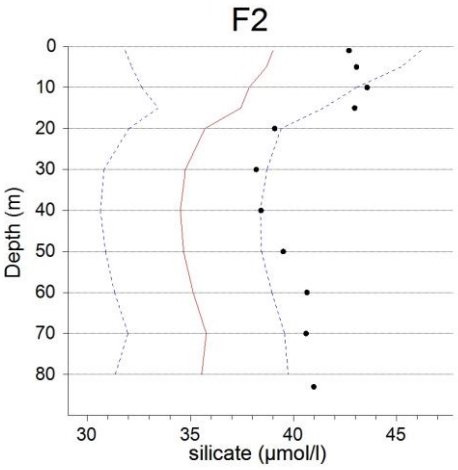

BO3
Depth (m)
0
20
40
60
80
100
0
2
4
6
8
nitrate-nitrite (µmol/l)

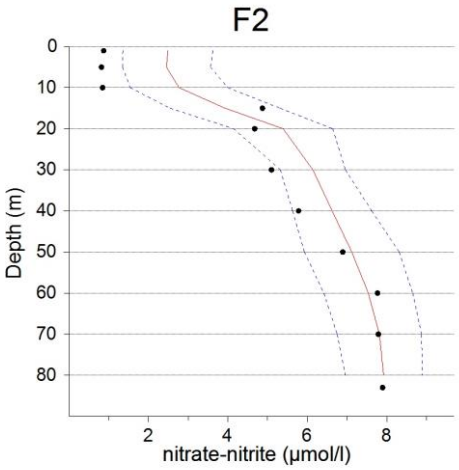

BO3
Depth (m)
0
20
40
60
80
100
0
0.05
0.1
0.15
0.2
0.25
phosphate (µmol/l)

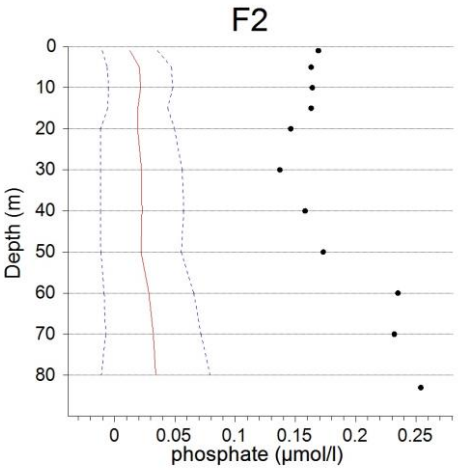

F2
Depth (m)
0
10
20
30
40
50
60
70
80
0
5
10
15
ctd-temperature (deg C)


F2
Depth (m)
0
10
20
30
40
50
60
70
80
6
6.5
7
7.5
8
8.5
9
ctd-oxygen


F2
Depth (m)
0
10
20
30
40
50
60
70
80
2
2.5
3
3.5
ctd-salinity (ppm)


F2
Depth (m)
0
10
20
30
40
50
60
70
80
30
35
40
45
silicate (µmol/l)


F2
Depth (m)
0
10
20
30
40
50
60
70
80
2
4
6
8
nitrate-nitrite (µmol/l)


F2
Depth (m)
0
10
20
30
40
50
60
70
80
0
0.05
0.1
0.15
0.2
0.25
phosphate (µmol/l)

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	60.15917	24.92283		2023-08-08	07:23											
2023010183	39A	60.06648	24.98002	42	2023-08-08	08:32	x	x	x	x				x			x
2023010184	IU5	60.05808	21.19855	90	2023-08-09	00:08	x	x	x	x				x			
2023010185	IU7	59.81503	21.33683	92	2023-08-09	03:27	x	x	x	x	x	x		x			x
2023010186	IU3	60.33325	21.11358	50	2023-08-09	10:23	x	x	x	x	x	x		x			x
2023010187	IU1	60.76672	20.84682	34	2023-08-09	14:40	x	x	x	x				x			x
2023010188	SR8	61.12645	20.93023	48	2023-08-09	17:53	x	x	x	x				x			
2023010189	SR7	61.08343	20.59677	79	2023-08-09	19:55	x	x	x	x				x			
2023010190	MS9	61.76670	20.53078	101	2023-08-10	01:21	x	x	x	x				x			
2023010191	AALTO_SM	61.79877	20.23677	100	2023-08-10	05:09	x										
2023010192	F26	61.98357	20.06335	138	2023-08-10	07:37	x	x	x	x				x			x
2023010193	US5B	62.58608	19.96910	222	2023-08-10	12:56	x	x	x	x	x	x		x			x
2023010194	US6B	62.60017	20.26325	82	2023-08-10	17:21	x	x	x	x				x			
2023010195	US7	62.60008	20.82995	28	2023-08-10	20:04	x	x	x	x				x			
2023010196	F16	63.51678	21.06322	49	2023-08-11	03:38	x	x	x	x	x	x		x			x
2023010197	F15	63.51683	21.51308	48	2023-08-11	06:31	x	x	x	x				x			x
2023010198	BO3	64.30190	22.34348	110	2023-08-11	12:48	x	x	x	x	x	x		x	x		x
2023010199	BIAS_11	64.68545	23.24037	82	2023-08-11	18:27											
2023010200	RR7	64.73350	23.81290	40	2023-08-11	20:41	x	x	x	x				x			
2023010201	RR6	64.80018	23.47965	87	2023-08-11	22:29	x	x	x	x				x			
2023010202	CV	65.00018	23.24625	87	2023-08-12	00:55	x	x	x	x				x			
2023010203	CVI	65.23350	23.56298	70	2023-08-12	03:43	x	x	x	x				x			x
2023010204	F2	65.38350	23.46280	84	2023-08-12	06:20	x	x	x	x	x	x		x			x
2023010205	RR3	64.93357	22.34615	94	2023-08-12	12:49	x	x	x	x				x			
2023010206	F13	63.78333	21.47960	64	2023-08-12	21:49	x	x	x	x				x			
2023010207	F18	63.31423	20.27278	103	2023-08-13	03:18	x	x	x	x				x			
2023010208	US3	62.75867	19.19590	177	2023-08-13	09:02	x	x	x	x				x			x
2023010209	MS3	62.13455	18.16323	84	2023-08-13	14:58	x	x	x	x				x			x
2023010210	MS6	61.98355	19.16360	73	2023-08-13	18:54	x	x	x	x				x			
2023010211	SR3	61.18318	18.22995	73	2023-08-14	01:06	x	x	x	x				x			
2023010212	SR5	61.08332	19.57955	126	2023-08-14	06:27	x	x	x	x	x	x		x			x
2023010213	F33	60.53308	18.93790	134	2023-08-14	12:53	x	x	x	x				x			x
2023010214	F64	60.18892	19.14258	287	2023-08-14	18:23	x	x	x	x	x	x		x			x
2023010215	F69	59.78318	19.93013	192	2023-08-15	01:25	x	x	x	x				x			
2023010216	LL19	58.88075	20.31100	165	2023-08-15	08:42	x	x	x	x				x			x
2023010217	LL17	59.03337	21.07970	172	2023-08-15	13:06	x	x	x	x	x	x		x	x		x
2023010218	BIAS_15	59.25025	21.01782	92	2023-08-15	16:58											
2023010219	AALTO_PI	59.24915	20.99810	108	2023-08-15	17:39											
2023010220	LL15	59.18322	21.74710	130	2023-08-15	22:22	x	x	x	x				x			
2023010221	LL12	59.48338	22.89675	83	2023-08-16	07:10	x	x	x	x	x	x		x			
HANKO	HANKO	59.79027	23.26657		2023-08-16	11:07											
2023010222	LANGDEN	59.77682	23.26293	57	2023-08-16	11:34	x	x	x	x	x	x		x			x
2023010223	AMN	59.69038	23.25702	55	2023-08-16	13:43	x	x	x	x				x			x
2023010224	LL11	59.58335	23.29673	68	2023-08-16	15:42	x	x	x	x				x			x
2023010225	F62	59.33333	23.26332	97	2023-08-16	18:16	x	x	x	x				x			
2023010226	JML	59.58177	23.62665	80	2023-08-16	21:20	x	x	x	x				x			
2023010227	LL9	59.70007	24.02998	66	2023-08-16	23:51	x	x	x	x	x	x		x			
2023010228	XII3	59.86393	23.98537	37	2023-08-17	02:38	x	x	x	x				x			
2023010229	GF1	59.70495	24.68212	84	2023-08-17	06:11	x	x	x	x	x	x		x			x
2023010230	LL7	59.84640	24.83758	102	2023-08-17	09:13	x	x	x	x	x	x		x	x	x	x
2023010231	LL6A	59.91672	25.03008	73	2023-08-17	12:09	x	x	x	x				x			x
2023010232	AALTO_HKI	59.96408	25.23685	62	2023-08-17	13:50											
2023010233	LL5	59.91673	25.59672	70	2023-08-17	16:34	x	x	x	x				x			x
2023010234	GF2	59.83840	25.85662	87	2023-08-17	18:50	x	x	x	x				x			
2023010235	LL3A	60.06728	26.34660	68	2023-08-17	22:28	x	x	x	x	x	x	x	x		x	
2023010236	BIAS19	60.25032	27.24688	67	2023-08-18	03:57											
2023010237	XV1	60.25012	27.24703	66	2023-08-18	05:11	x	x	x	x	x	x	x	x		x	x
2023010238	FEI-1	60.19377	26.49777	49	2023-08-18	10:28	x	x	x	x			x	x			x
2023010239	XIV3	60.20322	26.19310	78	2023-08-18	12:58	x	x	x	x				x			x
2023010240	LL6A	59.91690	25.03038	73	2023-08-18	18:17	x										
2023010241	AALTO_STADI	60.14392	24.90387	21	2023-08-19	02:00											

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