CRUISE REPORT

R/V Aranda

Cruise 01/2022

Combine 1

17.1.2022 – 29.1.2022

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

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Objectives of the cruise

The COMBINE 1 1st leg of the winter cruise

The objectives of the cruise were:

1) Monitoring of the Gulf of Finland, Northern Baltic Proper, Åland sea and the Southern part of the Bothnian Sea. Measured parameters were total oil, nutrients, ammonia/ammonium, oxygen, hydrogen sulfide (total sulfides), pH, salinity, and temperature.

2) Collection of surface water and surficial sediment samples for monitoring of harmful substances

3) Installation of a sediment trap

The COMBINE 1 2nd leg winter cruise was based on the HELCOM COMBINE monitoring programme.
The objectives of the cruise were:

4) to monitor hydrography and chemistry of water in the Archipelago Sea, the Gulf of Bothnia and the Northern Baltic Proper. The parameters were secchi disk visibility, temperature, salinity, conductivity, dissolved oxygen, hydrogen sulphide, pH, fluorescence, nutrients (Ntot, Ptot, NH4, NO2,3, PO4) and silicate;

5) to analyze concentrations of oils and to collect samples of harmful substances and drugs;

6) to maintain automated wave buoys in the Bothnian Sea and the Northern Baltic Proper; and

7) to study coverage, thickness and quality of ice in the Bothnian Bay and where ice was observed during the cruise

Table 1. The scientific crew

Name	On board	Organization
Harri Kankaanpää	**17.-21.01.2022**	**SYKE**
Maiju Lehtiniemi	**17.-21.01.2022**	**SYKE**
Outi Setälä	**17.-21.01.2022**	**SYKE**
Ilkka Lastumäki	**17.-29.01.2022**	**SYKE**
Jere Riikonen	**17.-29.01.2022**	**SYKE**
Panu Hänninen	**17.-29.01.2022**	**SYKE**
Pia Varmanen	**17.-29.01.2022**	**SYKE**
Mira Granlund	**17.-29.01.2022**	**SYKE**
Noora Haavisto	**17.-29.01.2022**	**SYKE**
Heini Jalli	**17.-29.01.2022**	**FMI**
Pekka Kosloff	**17.-29.01.2022**	**FMI**
Mikko Lensu	**21.-29.01.2022**	**FMI**
Jaakko Seppänen	**21.-29.01.2022**	**FMI**
Andrei Sandru	**21.-29.01.2022**	**FMI**
Pekka Kotilainen	**21.-29.01.2022**	**SYKE**

Cruise Route

The 1st leg of the cruise started in Helsinki on January 17, 2022. Leg one ended in Hanko on January 21, 2022 (Figure 1).

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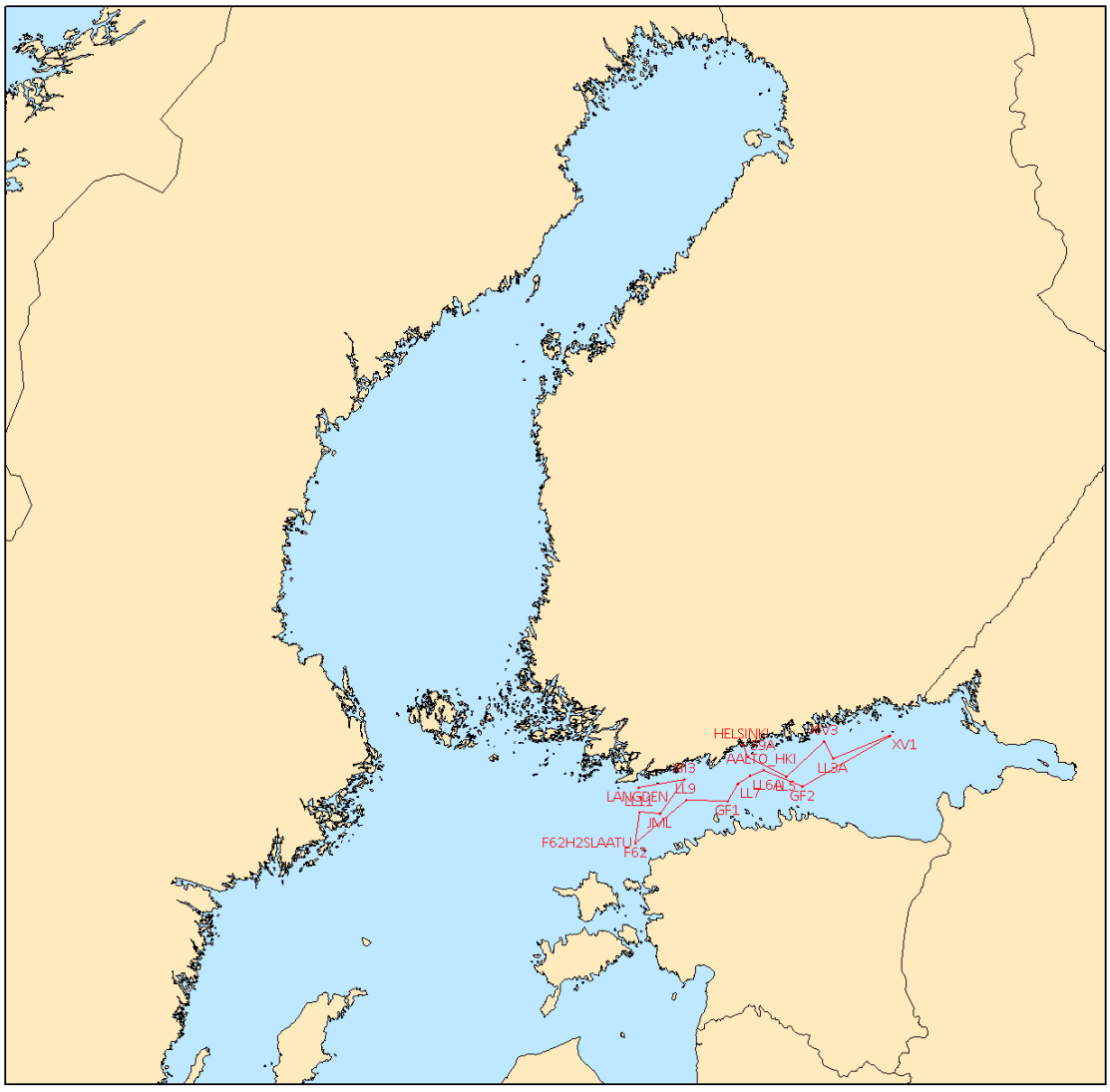


Figure 1. The 1st leg of the COMBINE 1 winter cruise (17.-21.1.2022)

The 2nd leg of the COMBINE 1 winter cruise started from the port of Hanko. R/V Aranda headed to the Archipelago Sea starting at the station IU7. Then followed the stations IU5, IU3 and IU1. Aranda sailed in the Finnish waters of the Bothnian Sea sampling stations SR8 and SR7, and then headed to SR5, in the middle of the southern Bothnian Sea. Station MS9 followed by F26 and only after that the wave buoy at AALTOSM of the Bothnian Sea was maintained. Maintenance of the wave buoy was conducted during the day light and in the afternoon, on the 23rd of January, station MS6 were sampled and stations of the US -transect followed as US7, US6b, US5b.
In the Kvarken, station F15 was sampled, and the cruise headed to BO3. In the Bothnian Bay the stations RR7, RR6, CV, CVI, F2, RR3 were monitored. Just after the stations RR3 first signs of ice were observed. On the way towards the south followed three stations in the Kvarken, F13, F16 and

F18, were sampled. In the Bothnian Sea stations US3, MS3, SR and F33 were sampled and the station F64 between the Åland Islands and Sweden.
After F64 followed F69 and due to heavy weather cruise took a break of a couple of hours in order to wait for better wind conditions but also for timing the sampling between the upcoming storm and wind fronts.
However, station LL19 had to be skipped and LL17 was tried to be sampled but only bottom sample could be sampled as the water pushed to the stern deck. Thus, LL17 was decided to be skipped, too. Finally, the wind cheesed and the stations LL15 and LL12 were able to be sampled.
The cruise headed to its last stations. The wave buoy outside Helsinki was lifted just in time as the wind again increased rapidly. The last station was LL7D in order to sample hazardous substances and samples for analysis of drugs in water. The station LL7D was not suitable for sediment sample the sediments were finally taken at LL7S. The 2nd leg and the entire winter cruise COMBINE 1 ended up to Tammasaari, Helsinki in a snowstorm at 19.00 hrs. on the 29th of January 2022.

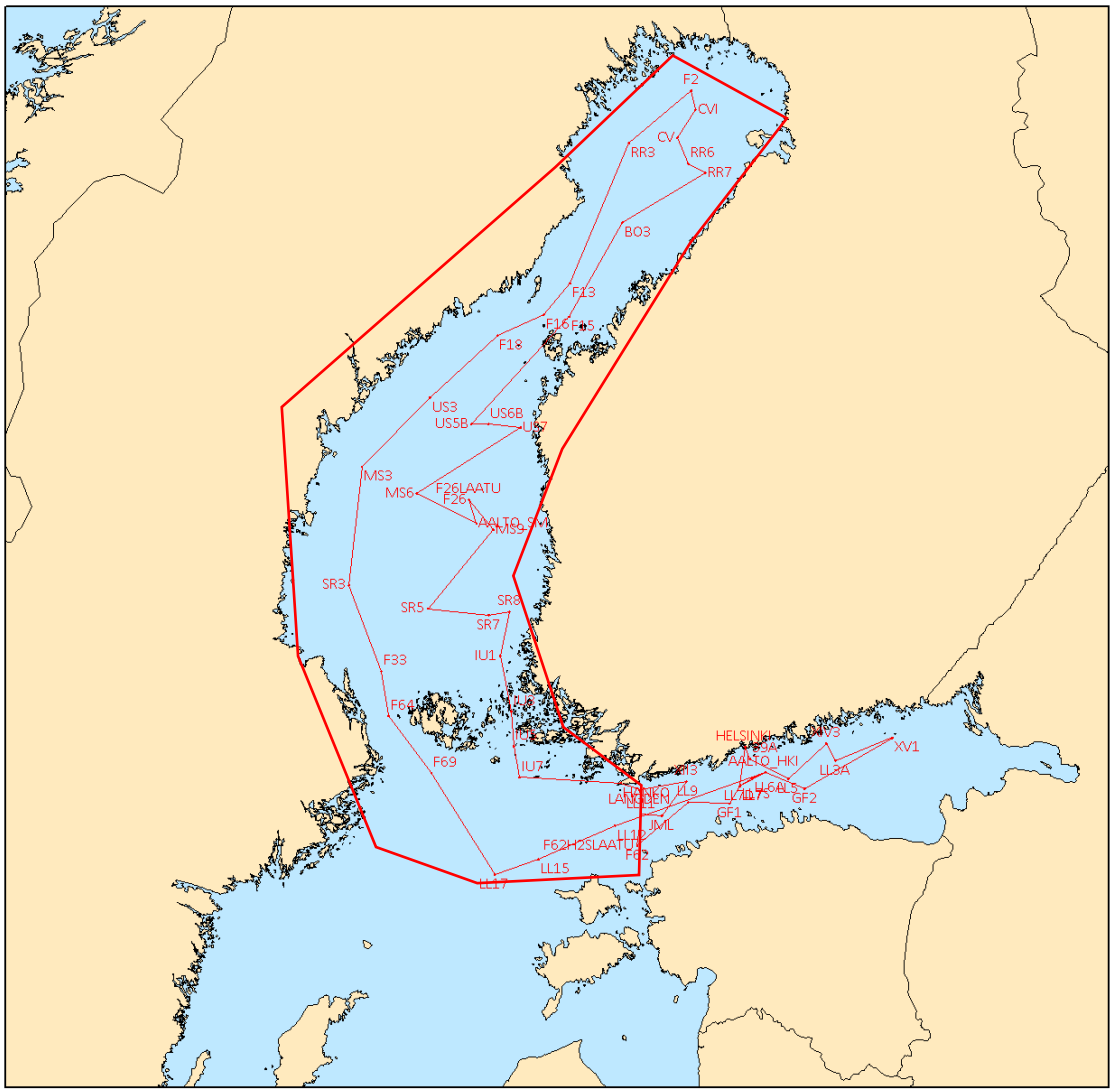


Figure 2. Cruise route of the 2nd leg 21-29.1.2022 framed in red.

Conclusions

The development regarding dissolved oil in Baltic Sea surface water is an example of improving chemical pressure to the ecosystem. This development stems from various measures including improved legislation, international treaties, effective operative air surveillance of sea areas for oil spills, and improved attitudes.

The situation regarding hydrographic chemical results in the water column underline that the measures taken to protect the Baltic Sea remain inadequate. The Gulf of Finland is so much affected by the constant influxes of water from the Baltic Proper that this natural circulation keeps phosphate concentrations high. Therefore, achieved cuts in nutrient inputs from land (runoff) alone cannot improve the situation. Also, the effective vertical circulation of water in the shallow Gulf of Finland generates a yet another internal feed mechanism to support high phosphate concentrations in surface water. As one result, hypoxia and anoxia remain common in the area.

Archipelago Sea

Oxygen concentrations were high in the region and apart from the southmost station, IU7, the entire water column was completely mixed from surface to bottom.

Phosphorus and phosphate winter concentrations were higher than in average (concentrations in 2000-2021). Total phosphorus and phosphate concentrations > 1µmol/l.

Bothnian Sea

Oxygen concentrations in deep layer were higher than in the last years (2020-2021) but lower than the long-term averages.
High nutrient concentrations, both total and dissolved, were observed.

Kvarken
High salinity values were observed indicating some intrusion or upwelling of saline water in the region.
Nutrient concentrations were occasionally very high, indicating some upwelling in the region.
Ptot > 1µM at deep layers (>40 m). Also, Ntot concentrations were high in the southern Kvarken.

Bothnian Bay

Record high phosphorus concentrations were observed. However, they were low compared with other parts of the Baltic Sea and close to the limit of detection, respectively.

Northern Baltic Proper

Water temperatures below 60m depth were above the long-term average. > +6 °C and anoxic.
High nutrient concentrations were also observed > 4 µmol/l.

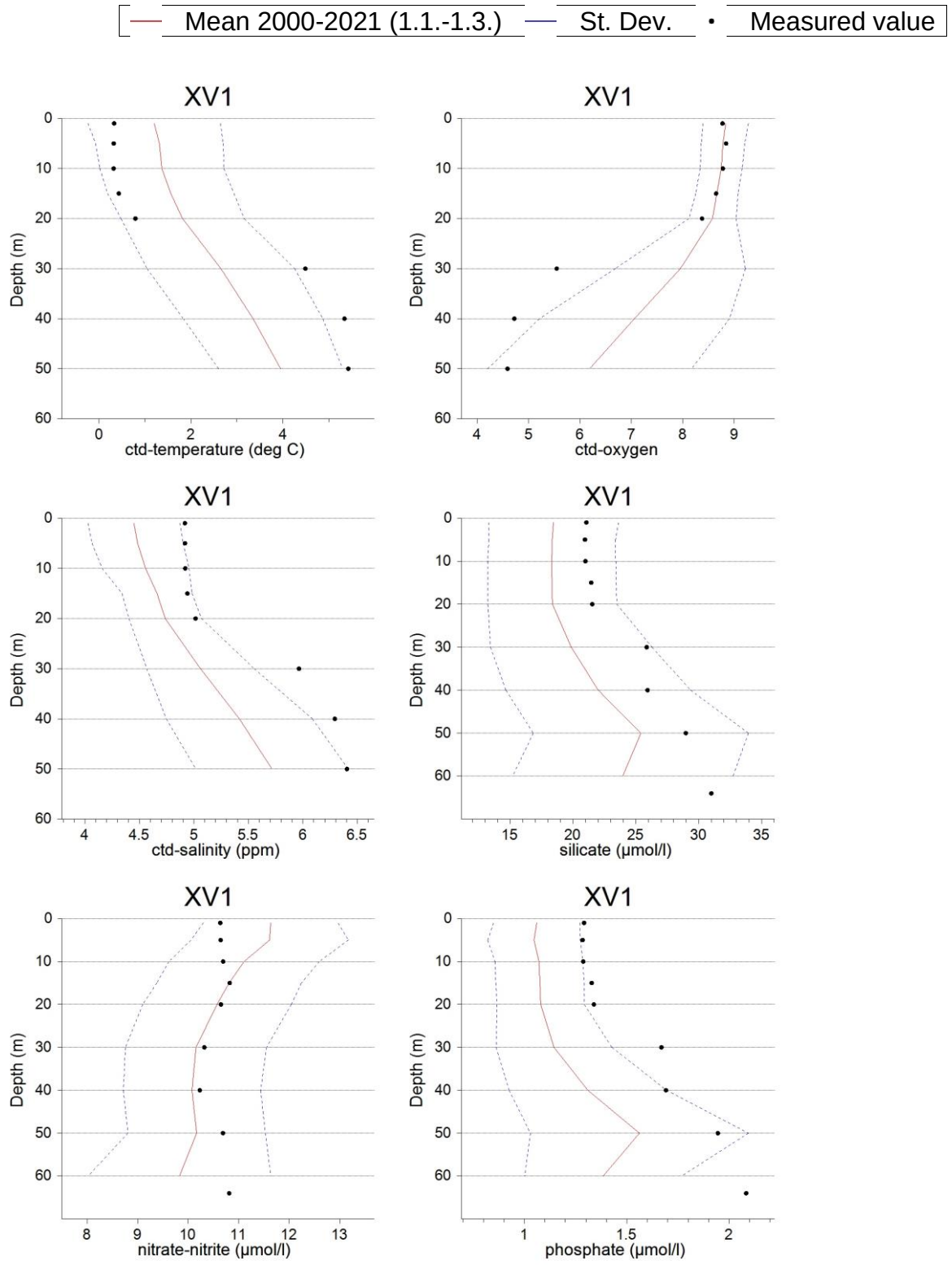
Observations

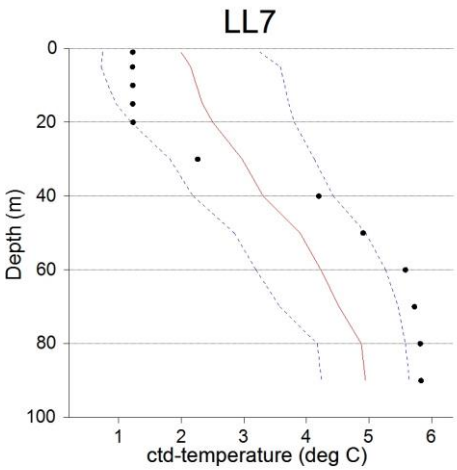
Observations

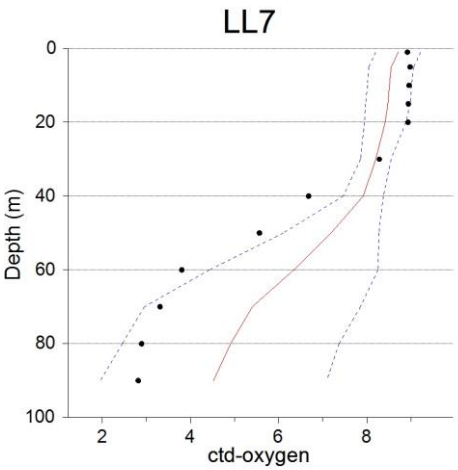
All planned measurements and installations were accomplished. Hydrographic profiles of priority stations XV1 and LL7 are illustrated in Annex 1. A complete list of the leg 1 stations is in Annex 2. In the Gulf of Finland, surface water contained only low concentrations (0.1 – 0.2 µg l^{-1}) of oil products, i.e. at levels typical for winter season over the past few years. The area was characterized by low oxygen concentrations in the west, lower than in 2021. These anoxic locations exhibited dissolved, toxic hydrogen sulfide. Concentrations of dissolved phosphates in surface water were high than in 2021 and also in comparison with long-term phosphate concentrations and seem to have reached a new higher regime since approximately 2005. Similarly, phosphate concentrations remained high in near-bottom layer in comparison to earlier years' observations.

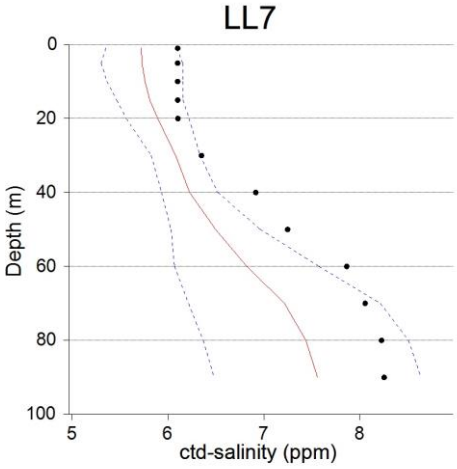
Annex 1. Selected variables at the stations XV1, LL7, LL12, LL17, F64, SR5, US5B, BO3 and F2. Mean (red solid line) and standard deviation (blue dotted lines) represent the data collected at the same time of season since the year 2000.

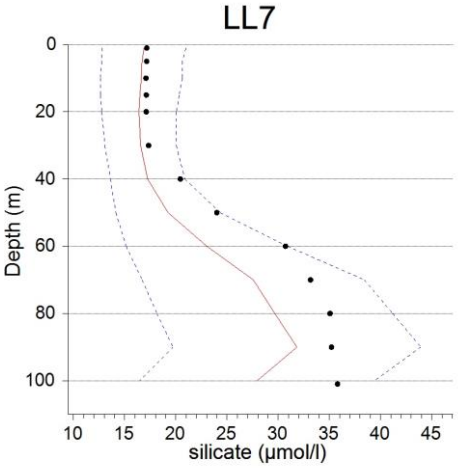
Observations of the 1st leg 17.-21.1.2022

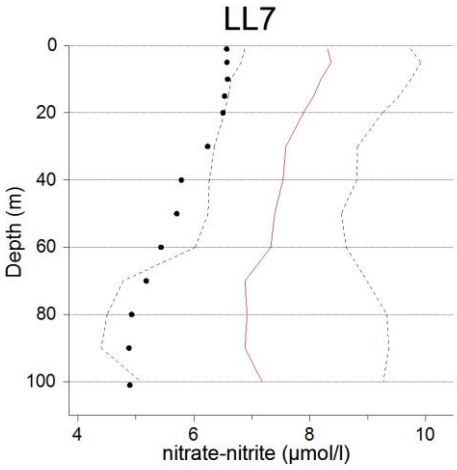


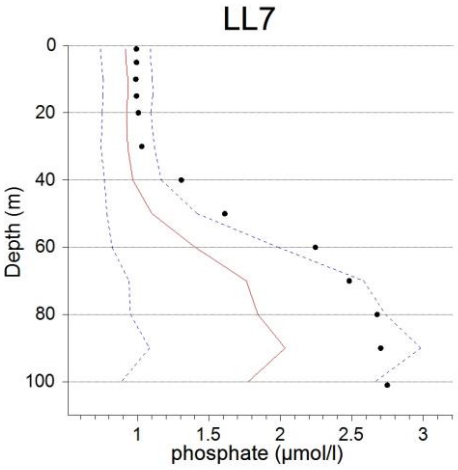

LL7
Depth (m)
0
20
40
60
80
100
1
2
3
4
5
6
ctd-temperature (deg C)


LL7
Depth (m)
0
20
40
60
80
100
2
4
6
8
ctd-oxygen


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


LL7
Depth (m)
0
20
40
60
80
100
10
15
20
25
30
35
40
45
silicate (µmol/l)

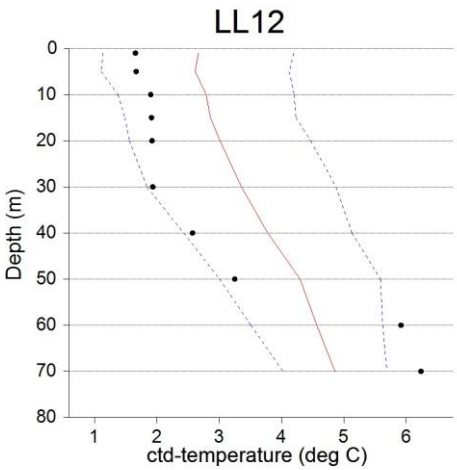

LL7
Depth (m)
0
20
40
60
80
100
4
6
8
10
nitrate-nitrite (µmol/l)

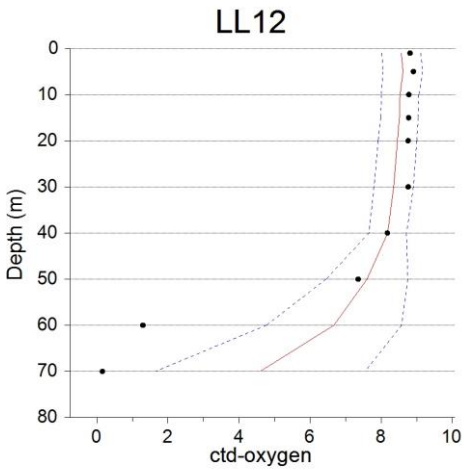

LL7
Depth (m)
0
20
40
60
80
100
1
1.5
2
2.5
3
phosphate (µmol/l)

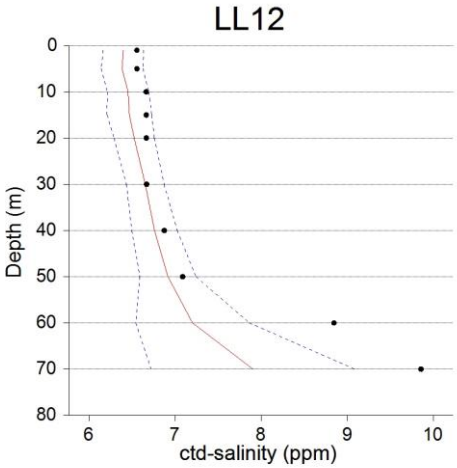
Observations of the 2nd leg 21-29.1.2022

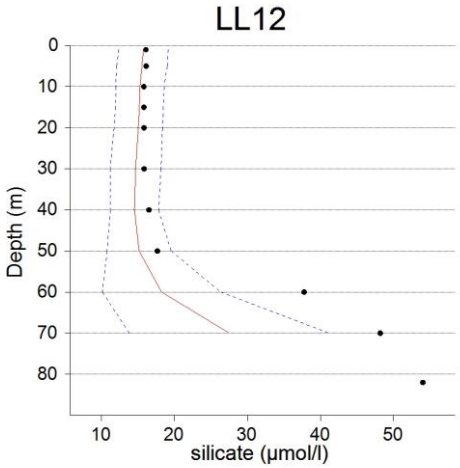
Northern Baltic Proper

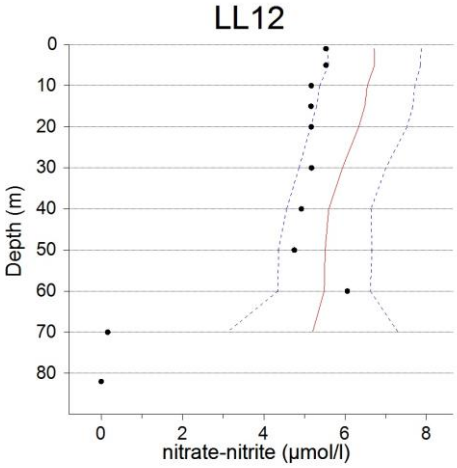
Mean 2000-2021 (1.1.-1.3.) — St. Dev. • Measured value

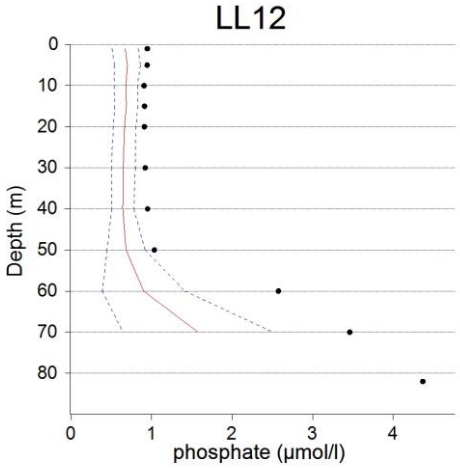


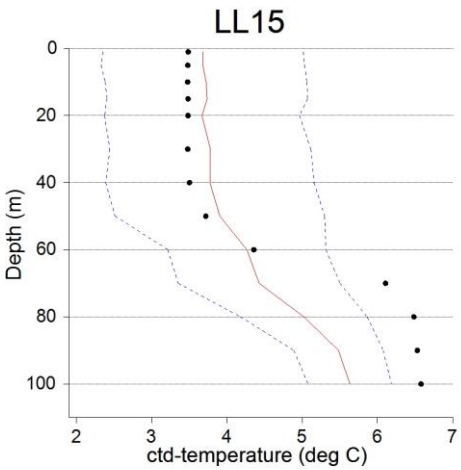


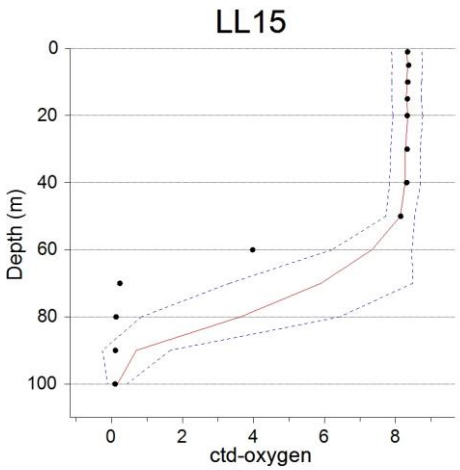


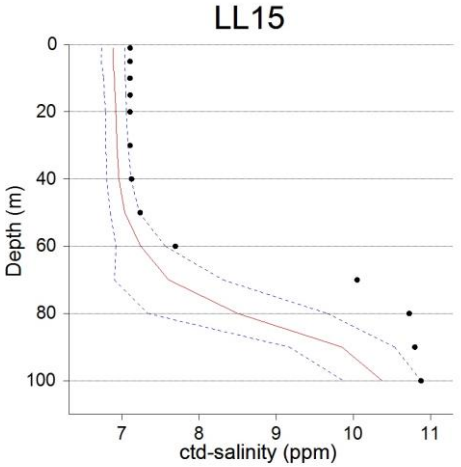


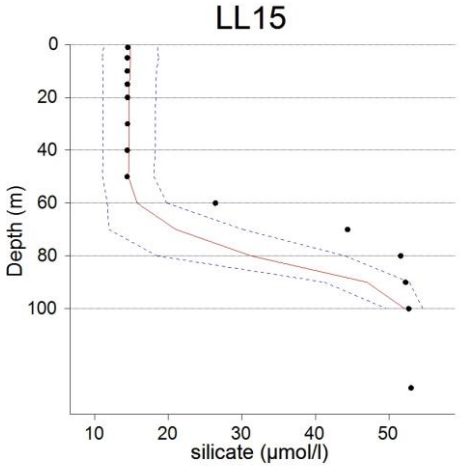


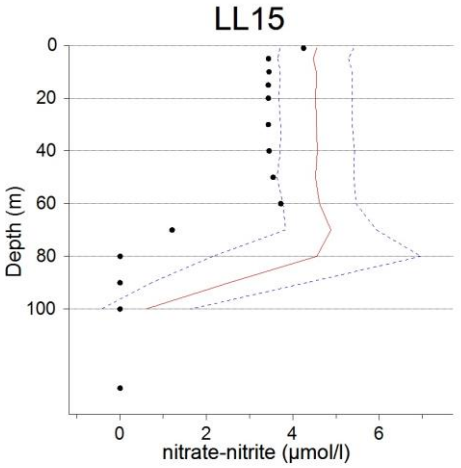


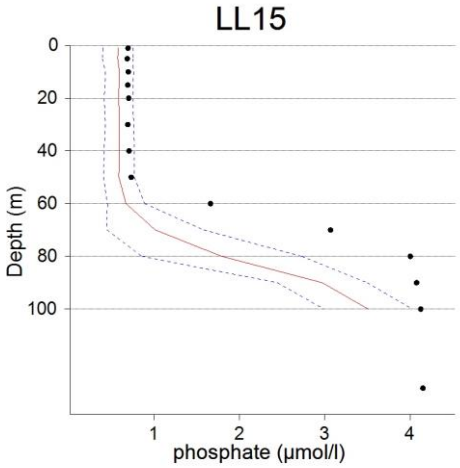

LL15
Depth (m)
0
20
40
60
80
100
2
3
4
5
6
7
ctd-temperature (deg C)


LL15
Depth (m)
0
20
40
60
80
100
0
2
4
6
8
ctd-oxygen

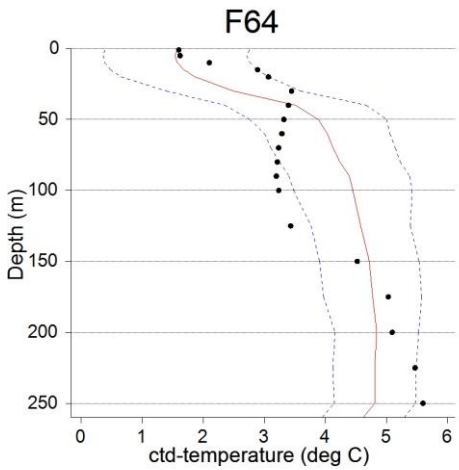

LL15
Depth (m)
0
20
40
60
80
100
7
8
9
10
11
ctd-salinity (ppm)

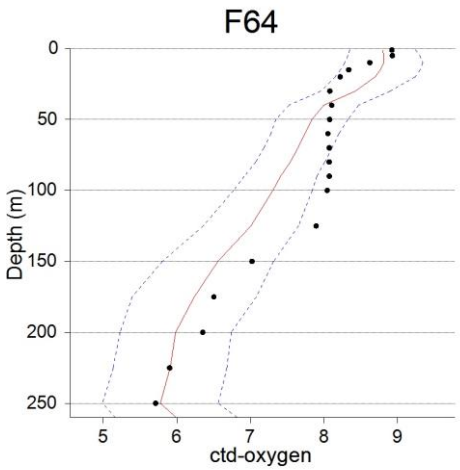

LL15
Depth (m)
0
20
40
60
80
100
10
20
30
40
50
silicate (µmol/l)

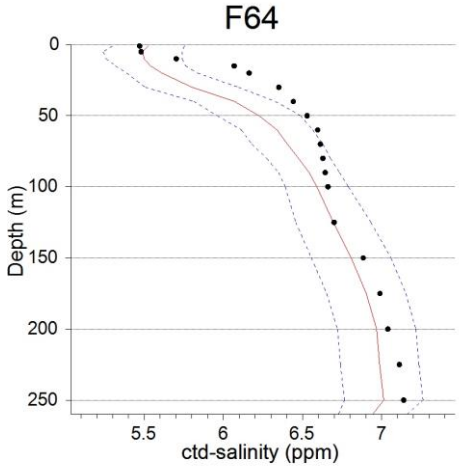

LL15
Depth (m)
0
20
40
60
80
100
0
2
4
6
nitrate-nitrite (µmol/l)

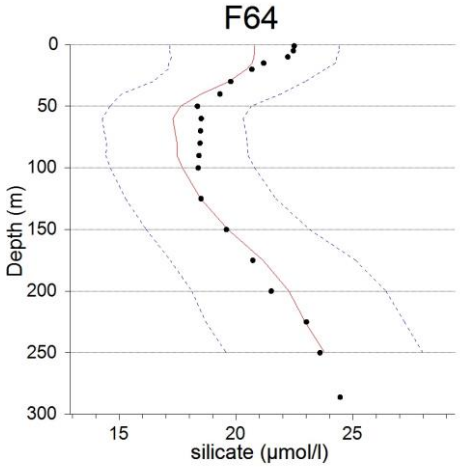

LL15
Depth (m)
0
20
40
60
80
100
1
2
3
4
phosphate (µmol/l)

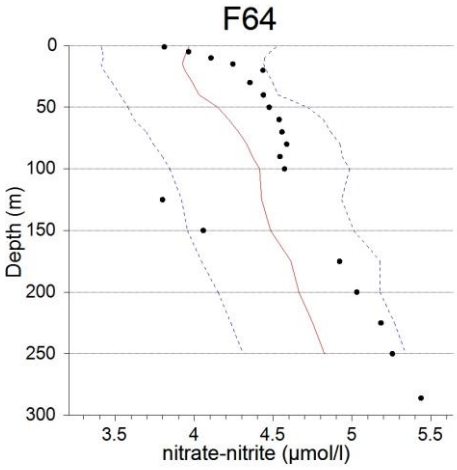
Åland Sea

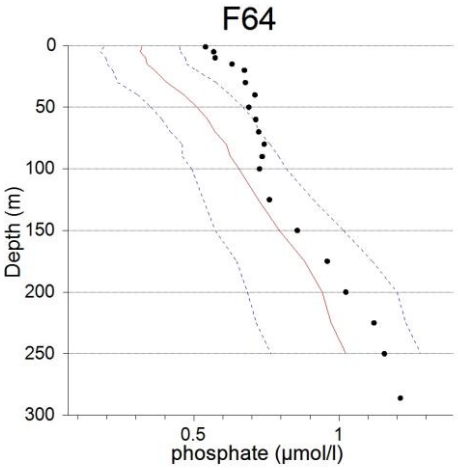

F64
Depth (m)
0
50
100
150
200
250
0
1
2
3
4
5
6
ctd-temperature (deg C)


F64
Depth (m)
0
50
100
150
200
250
5
6
7
8
9
ctd-oxygen

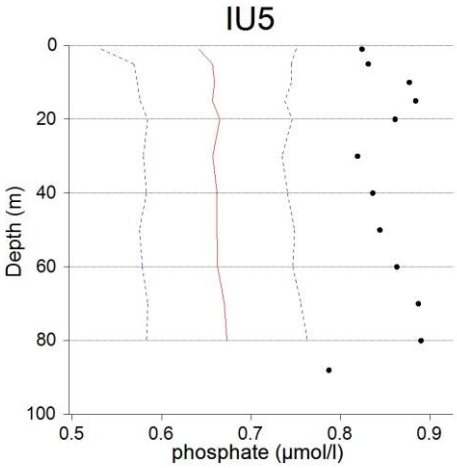

F64
Depth (m)
0
50
100
150
200
250
5.5
6
6.5
7
ctd-salinity (ppm)

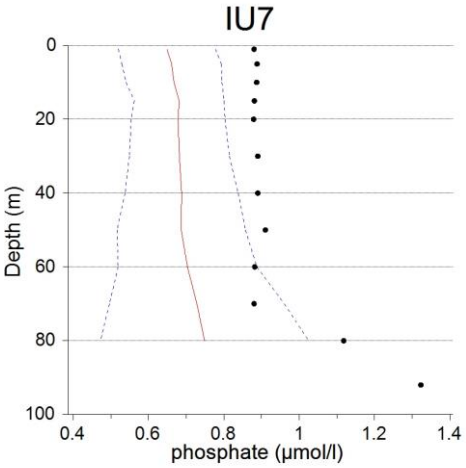

F64
Depth (m)
0
50
100
150
200
250
300
15
20
25
silicate (µmol/l)

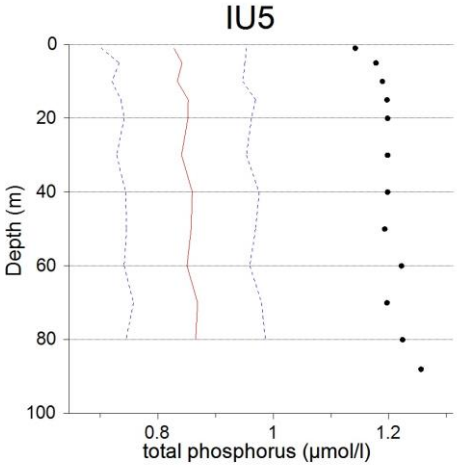


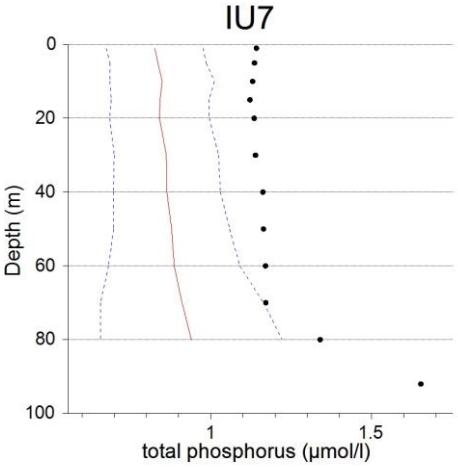


Archipelago Sea

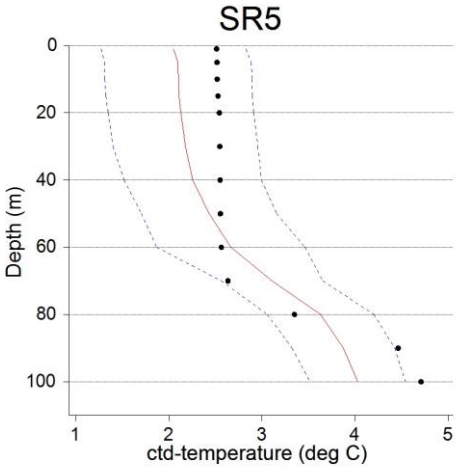


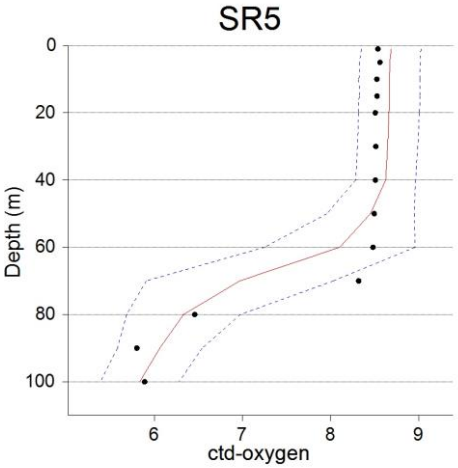


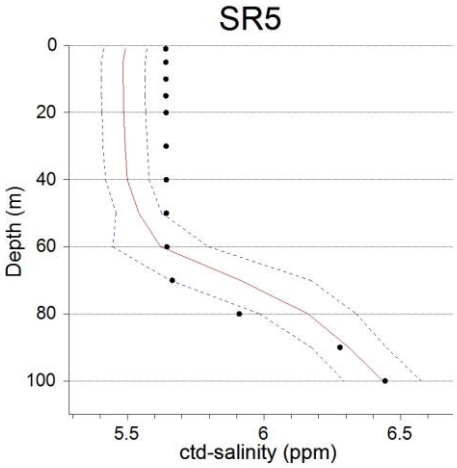


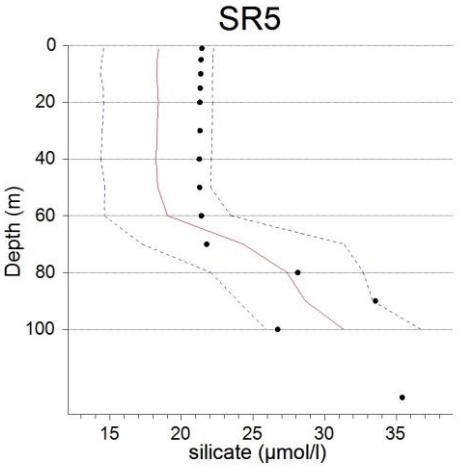


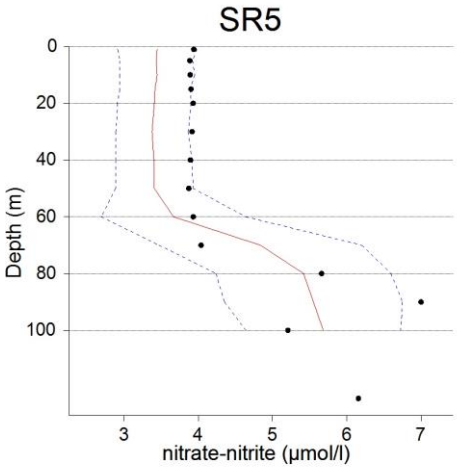
Bothnian Sea

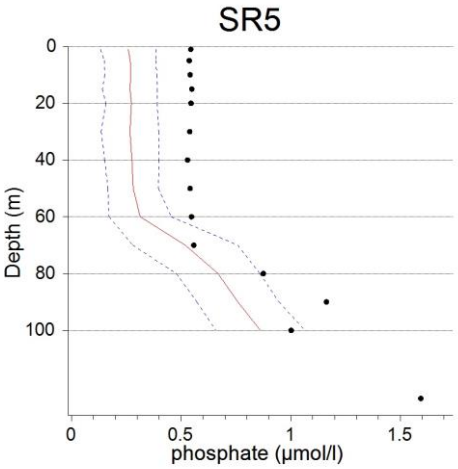


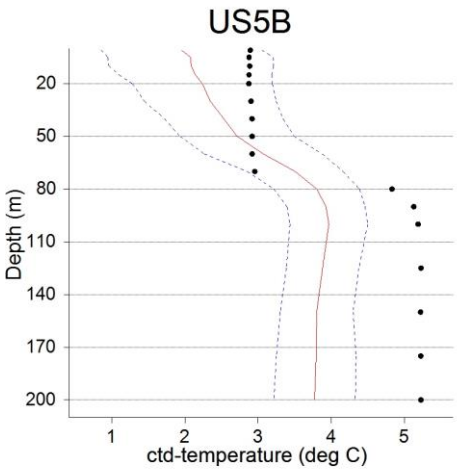


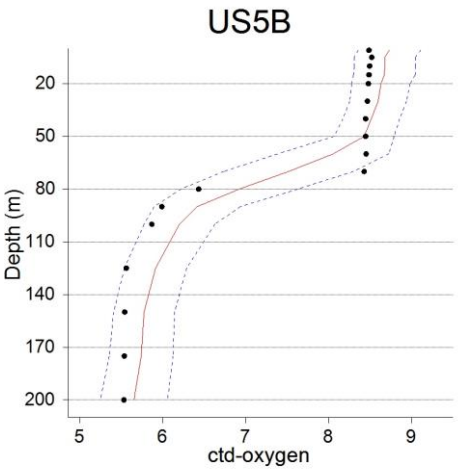


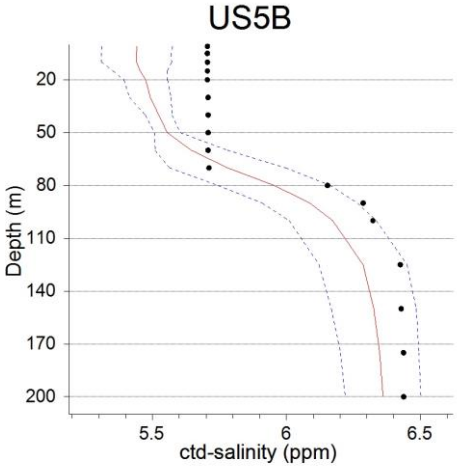


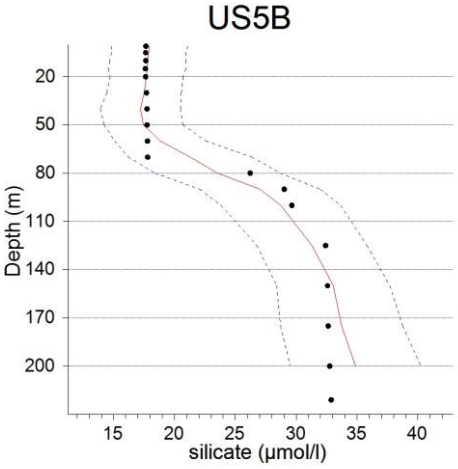


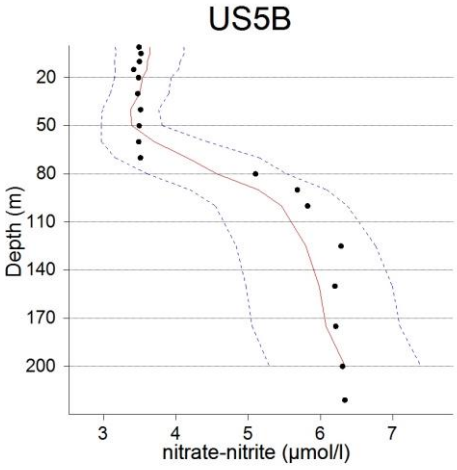


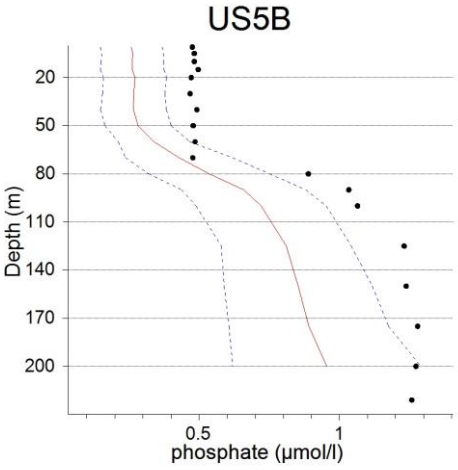

US5B
Depth (m)
20
50
80
110
140
170
200
1
2
3
4
5
ctd-temperature (deg C)


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

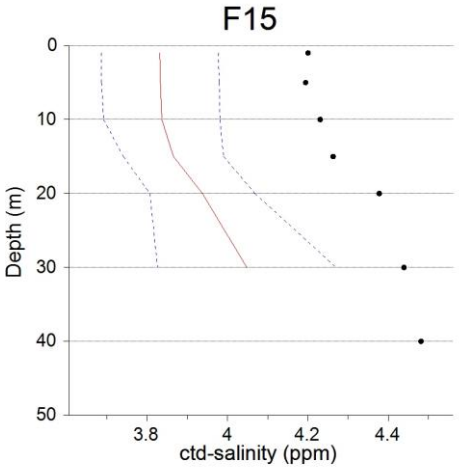

US5B
Depth (m)
20
50
80
110
140
170
200
5.5
6
6.5
ctd-salinity (ppm)

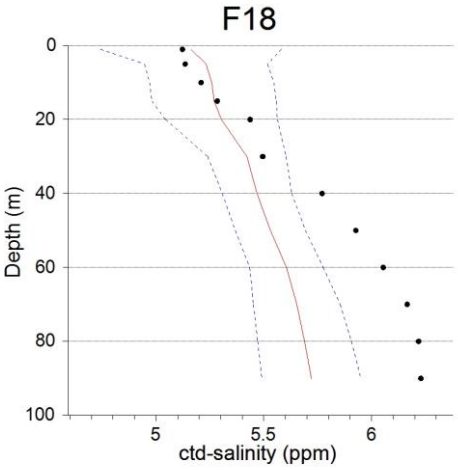

US5B
Depth (m)
20
50
80
110
140
170
200
15
20
25
30
35
40
silicate (µmol/l)

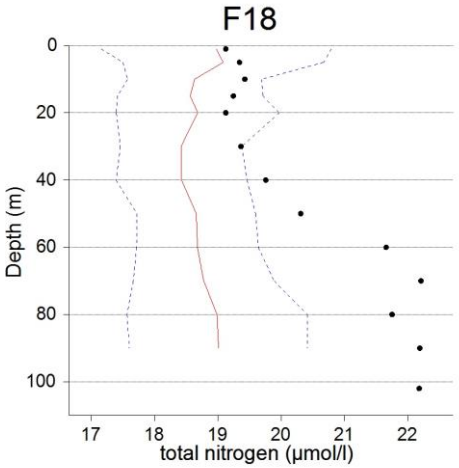

US5B
Depth (m)
20
50
80
110
140
170
200
3
4
5
6
7
nitrate-nitrite (µmol/l)

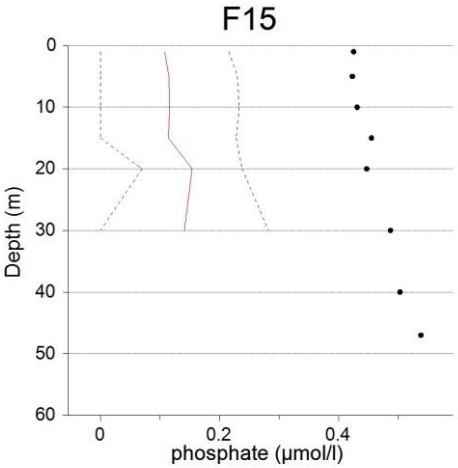

US5B
Depth (m)
20
50
80
110
140
170
200
0.5
1
phosphate (µmol/l)

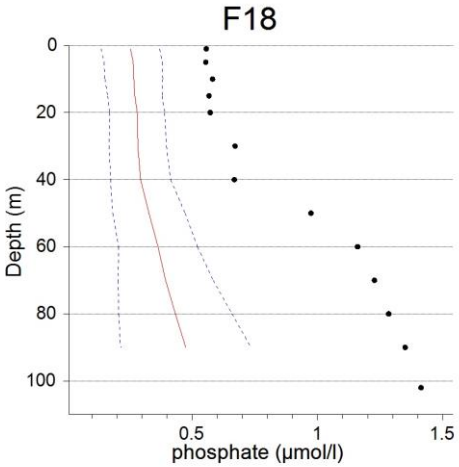
Kvarken

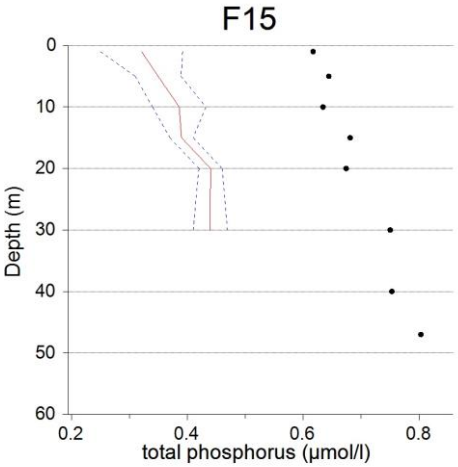

F15
Depth (m)
0
10
20
30
40
50
3.8
4
4.2
4.4
ctd-salinity (ppm)

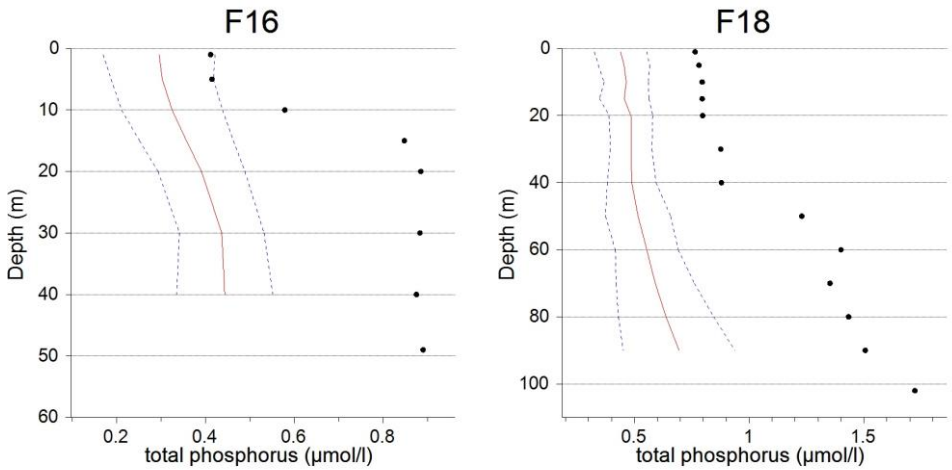

F18
Depth (m)
0
20
40
60
80
100
5
5.5
6
ctd-salinity (ppm)


F18
Depth (m)
0
20
40
60
80
100
17
18
19
20
21
22
total nitrogen (µmol/l)

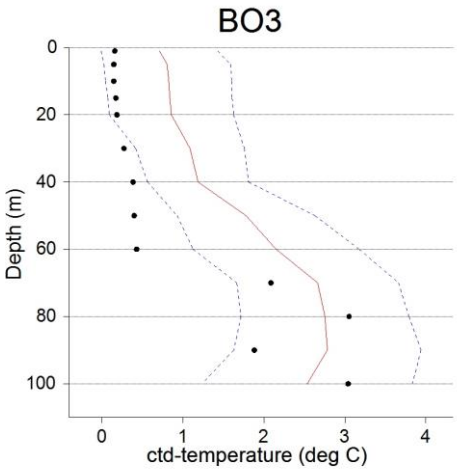

F15
Depth (m)
0
10
20
30
40
50
60
0
0.2
0.4
phosphate (µmol/l)

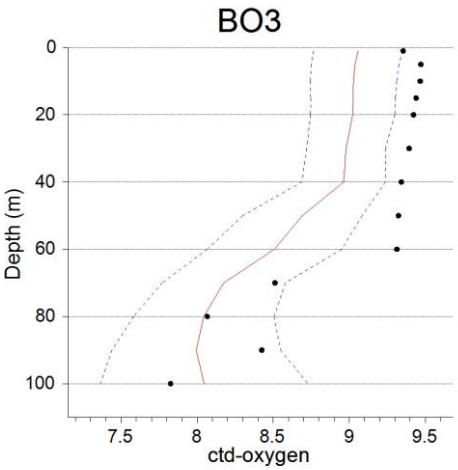

F18
Depth (m)
0
20
40
60
80
100
0.5
1
1.5
phosphate (µmol/l)

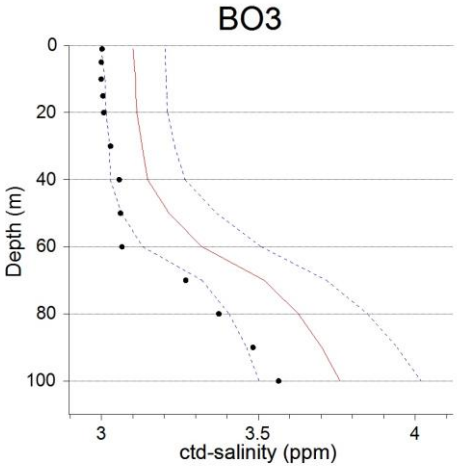

F15
Depth (m)
0
10
20
30
40
50
60
0.2
0.4
0.6
0.8
total phosphorus (µmol/l)

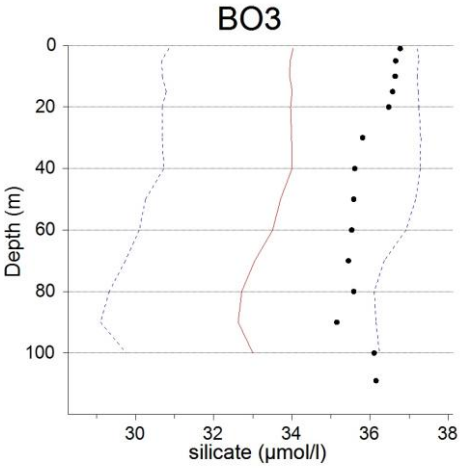

F16
Depth (m)
0
10
20
30
40
50
60
0.2
0.4
0.6
0.8
total phosphorus (µmol/l)
F18
Depth (m)
0
20
40
60
80
100
0.5
1
1.5
total phosphorus (µmol/l)

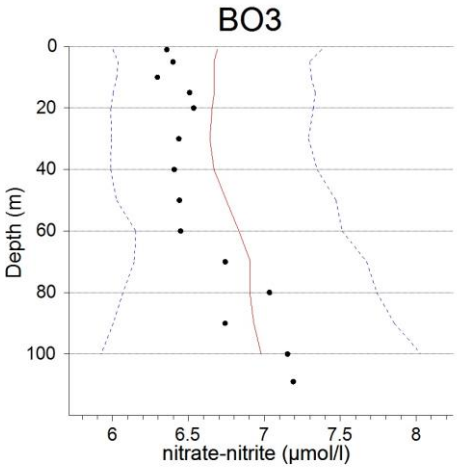
Bothnian Bay

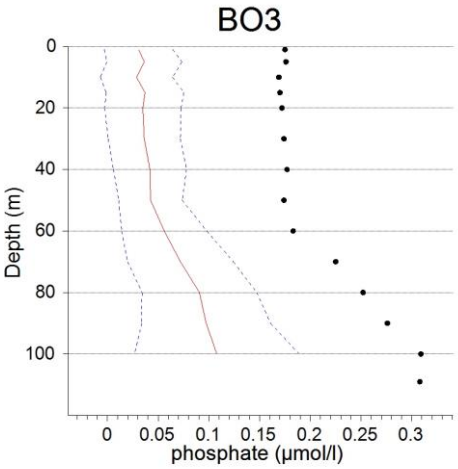


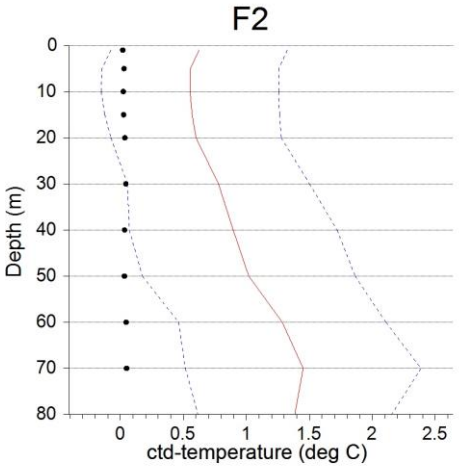


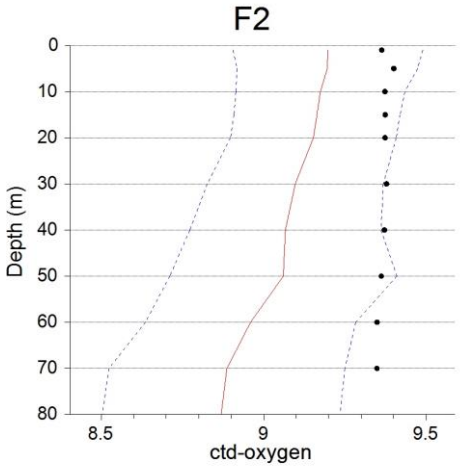


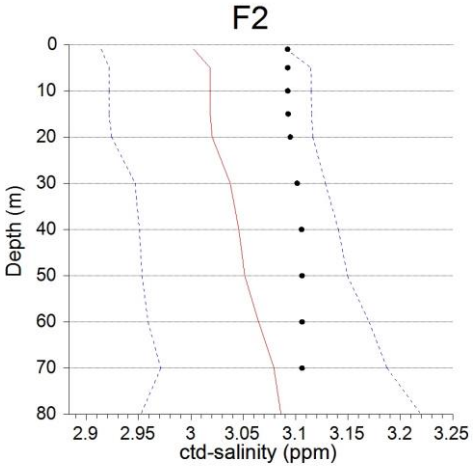


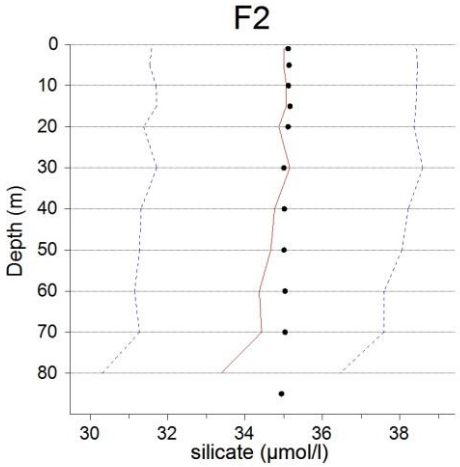


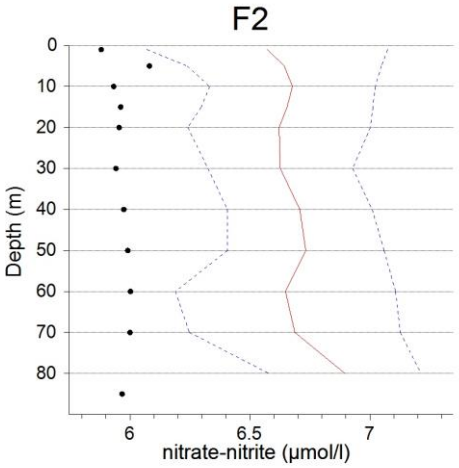


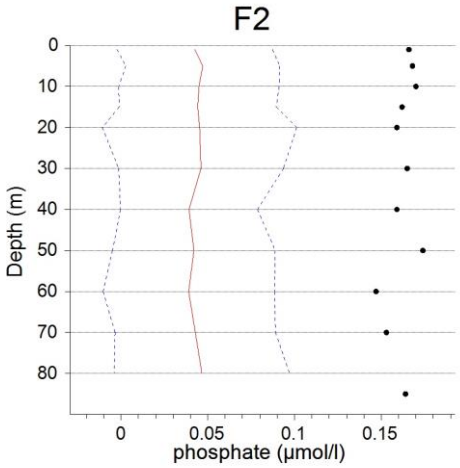

F2
Depth (m)
0
10
20
30
40
50
60
70
80
0
0.5
1
1.5
2
2.5
ctd-temperature (deg C)


F2
Depth (m)
0
10
20
30
40
50
60
70
80
8.5
9
9.5
ctd-oxygen


F2
Depth (m)
0
10
20
30
40
50
60
70
80
2.9
2.95
3
3.05
3.1
3.15
3.2
3.25
ctd-salinity (ppm)


F2
Depth (m)
0
10
20
30
40
50
60
70
80
30
32
34
36
38
silicate (µmol/l)


F2
Depth (m)
0
10
20
30
40
50
60
70
80
6
6.5
7
nitrate-nitrite (µmol/l)


F2
Depth (m)
0
10
20
30
40
50
60
70
80
0
0.05
0.1
0.15
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	60.16157	24.90105		2022-01-17	09:13											
2022010001	39A	60.06678	24.98015	42	2022-01-17	18:28	x	x	x	x							
2022010002	LL5	59.91663	25.59852	71	2022-01-17	22:13	x	x	x	x							
2022010003	XIV3	60.20320	26.19283	78	2022-01-18	02:35	x	x	x	x							
2022010004	LL3A	60.06727	26.34658	69	2022-01-18	05:12	x	x	x	x					x		
2022010005	XV1	60.25153	27.24863	59	2022-01-18	13:16											
2022010006	XV1	60.24988	27.24680	65	2022-01-18	17:04	x	x	x	x							
2022010007	GF2	59.83852	25.85693	86	2022-01-19	03:06	x	x	x	x							
2022010008	AALTO_HKI	59.96423	25.23662	62	2022-01-19	06:40	x										
2022010009	LL6A	59.91677	25.03023	73	2022-01-19	08:03	x	x	x	x							
2022010010	LL7	59.84662	24.83763	102	2022-01-19	11:39	x	x	x	x					x		
2022010011	GF1	59.70503	24.68228	84	2022-01-19	13:56	x	x	x	x							
2022010012	LL9	59.70013	24.03087	65	2022-01-19	18:12	x	x	x	x							
2022010013	F62	59.33345	23.26347	97	2022-01-19	23:53	x	x	x	x							
2022010014	F62H2SLAATU	59.33348	23.26343	97	2022-01-20	01:20											
2022010015	LL11	59.58352	23.29650	65	2022-01-20	04:19	x	x	x	x							
2022010016	JML	59.58192	23.62687	78	2022-01-20	08:09	x	x	x	x							
2022010017	XII3	59.86418	23.98563	37	2022-01-20	14:41	x	x	x	x							
2022010018	LANGDEN	59.77688	23.26283	57	2022-01-20	18:41	x	x	x	x							
HANKO	HANKO	59.82272	22.94778		2022-01-20	21:26											
HANKO	HANKO	59.82273	22.94778		2022-01-21	08:45											
2022010019	IU7	59.81507	21.33643	93	2022-01-21	16:55	x	x	x	x							
2022010020	IU5	60.05813	21.19828	89	2022-01-21	20:44	x	x	x	x							
2022010021	IU3	60.33330	21.11323	50	2022-01-22	00:58	x	x	x	x							
2022010022	IU1	60.76682	20.84665	32	2022-01-22	06:45	x	x	x	x							
2022010023	SR8	61.12652	20.93000	48	2022-01-22	10:08	x	x	x	x							x
2022010024	SR7	61.08350	20.59650	78	2022-01-22	12:17	x	x	x	x							x
2022010025	SR5	61.08017	19.57750	125	2022-01-22	16:09	x	x	x	x					x		
2022010026	MS9	61.76688	20.53060	102	2022-01-23	00:36	x	x	x	x							
2022010027	F26	61.98348	20.06297	138	2022-01-23	04:05	x	x	x	x							
2022010028	F26LAATU	61.98350	20.06297	138	2022-01-23	06:05	x	x	x	x							
2022010029	AALTO_SM	61.80073	20.23457	109	2022-01-23	08:58	x										
2022010030	MS6	61.98363	19.16367	72	2022-01-23	15:53	x	x	x	x							
2022010031	US7	62.60027	20.82970	27	2022-01-23	22:51	x	x	x	x							
2022010032	US6B	62.60025	20.26297	82	2022-01-24	01:18	x	x	x	x							
2022010033	US5B	62.58622	19.96883	222	2022-01-24	04:00	x	x	x	x					x		
2022010034	F15	63.51687	21.51323	48	2022-01-24	16:22	x	x	x	x							
2022010035	BO3	64.30205	22.34343	110	2022-01-24	22:43	x	x	x	x					x		
2022010036	RR7	64.73370	23.81293	39	2022-01-25	06:58	x	x	x	x							
2022010037	RR6	64.80028	23.47960	86	2022-01-25	09:15	x	x	x	x							x
2022010038	CV	65.00028	23.24625	87	2022-01-25	11:59	x	x	x	x							x
2022010039	CVI	65.23368	23.56272	71	2022-01-25	14:34	x	x	x	x							
2022010040	F2	65.38367	23.46272	86	2022-01-25	17:05	x	x	x	x					x		
2022010041	RR3	64.93373	22.34610	95	2022-01-25	22:20	x	x	x	x							
2022010042	F13	63.78417	21.48038	64	2022-01-26	07:15	x	x	x	x							x
2022010043	F16	63.51680	21.06277	50	2022-01-26	10:52	x	x	x	x							x
2022010044	F18	63.31428	20.27265	103	2022-01-26	14:29	x	x	x	x							
2022010045	US3	62.75880	19.19570	177	2022-01-26	20:20	x	x	x	x							
2022010046	MS3	62.13453	18.16312	85	2022-01-27	02:35	x	x	x	x							
2022010047	SR3	61.18322	18.23007	73	2022-01-27	09:31	x	x	x	x							x
2022010048	F33	60.53327	18.93755	135	2022-01-27	14:34	x	x	x	x							
2022010049	F64	60.18902	19.14253	287	2022-01-27	18:19	x	x	x	x					x		
2022010050	F69	59.78328	19.92988	190	2022-01-28	00:02	x	x	x	x							
2022010051	LL17	59.03277	21.08297	169	2022-01-28	16:08				x							
2022010052	LL15	59.18318	21.74740	131	2022-01-28	20:07	x	x	x	x							
2022010053	LL12	59.48358	22.89720	83	2022-01-29	02:10	x	x	x	x					x		
2022010054	AALTO_HKI	59.96442	25.23472	61	2022-01-29	10:31	x										
2022010055	LL7D	59.84660	24.83758	101	2022-01-29	12:56											
2022010056	LL7S	59.85845	24.83850	77	2022-01-29	13:46											
HELSINKI	HELSINKI	60.16182	24.90157		2022-01-29	17:09											

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