CRUISE REPORT

R/V Aranda

Cruise 02/2019

Combine1 2nd leg /2019

25. January - 2. February 2019

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

Objectives of the cruise

The objectives of the cruise were:

1) Winter monitoring of the Archipelago Sea, the Bothnian Sea, Åland Sea and the Northern Baltic Proper. Measured parameters were water temperature, salinity, conductivity and oxygen / hydrogen sulfide, silicate and nutrient concentrations;
2) Maintenance of the FMI (Finnish Meteorological Institute) and SMHI (Swedish Meteorological and Hydrographical Institute) instruments in the Bothnian Sea;
3) PAH sampling in the region;
4) Sampling of the benthic animals for micro plastics; and
5) Running QC of different sampling instruments.

Table 1. The scientific crew

Scientist	On board	Organization
Kotilainen Pekka	25.01 - 01.02.2019	SYKE/MRC
Jalli Heini	25.01 - 01.02.2019	FMI
Roine Tuomo	25.01 - 01.02.2019	FMI
Riikonen Jere	25.01 - 01.02.2019	SYKE/MRC
Hyvärinen Susanna	25.01 - 01.02.2019	SYKE/MRC
Flinkman Juha	25.01 - 01.02.2019	SYKE/MRC
Lastumäki Ilkka	25.01 - 01.02.2019	SYKE/MRC
Setälä Outi	25.01 - 01.02.2019	SYKE/MRC
Bruun Jan-Erik	25.01 - 01.02.2019	SYKE/MRC
Kinnunen Tanja	25.01 - 01.02.2019	SYKE/MRC

Cruise route

The 2nd leg of the Combine 1 cruise (Figure 1) started from Hanko on 25th of January 2019 and headed first to the Archipelago Sea (IU1, IU3, IU5 and IU7 stations) and then continued to the Bothnian Sea (SR8, SR7, SS29 and SR5). Cruise continued with sampling at station MS9 and maintenance of the wave buoy (AALTO_SM) and sampling at the stations F26 and MS6. After the stations US7, US6b and US5b cruise headed towards the north. Due to the ice conditions and a malfunction of one of the two main engines, sampling could be conducted further north than at the stations F16 and F18. After the return towards the south, the Swedish coast was sampled at US3, MS3, MS2, SR1A and SR3. Swedish wave buoy was lifted at FINNGRUNDET and cruise continued to the Aland Sea (F33, F64). After the stations F69 and TROSKELN ÅLANDS HAV, maintenance of the Finnish wave buoy (AALTO_PI) the last stations of the LANDSORT – LOVISA transect were sampled (LL17, LL15 and LL12). The cruise ended up to Helsinki.

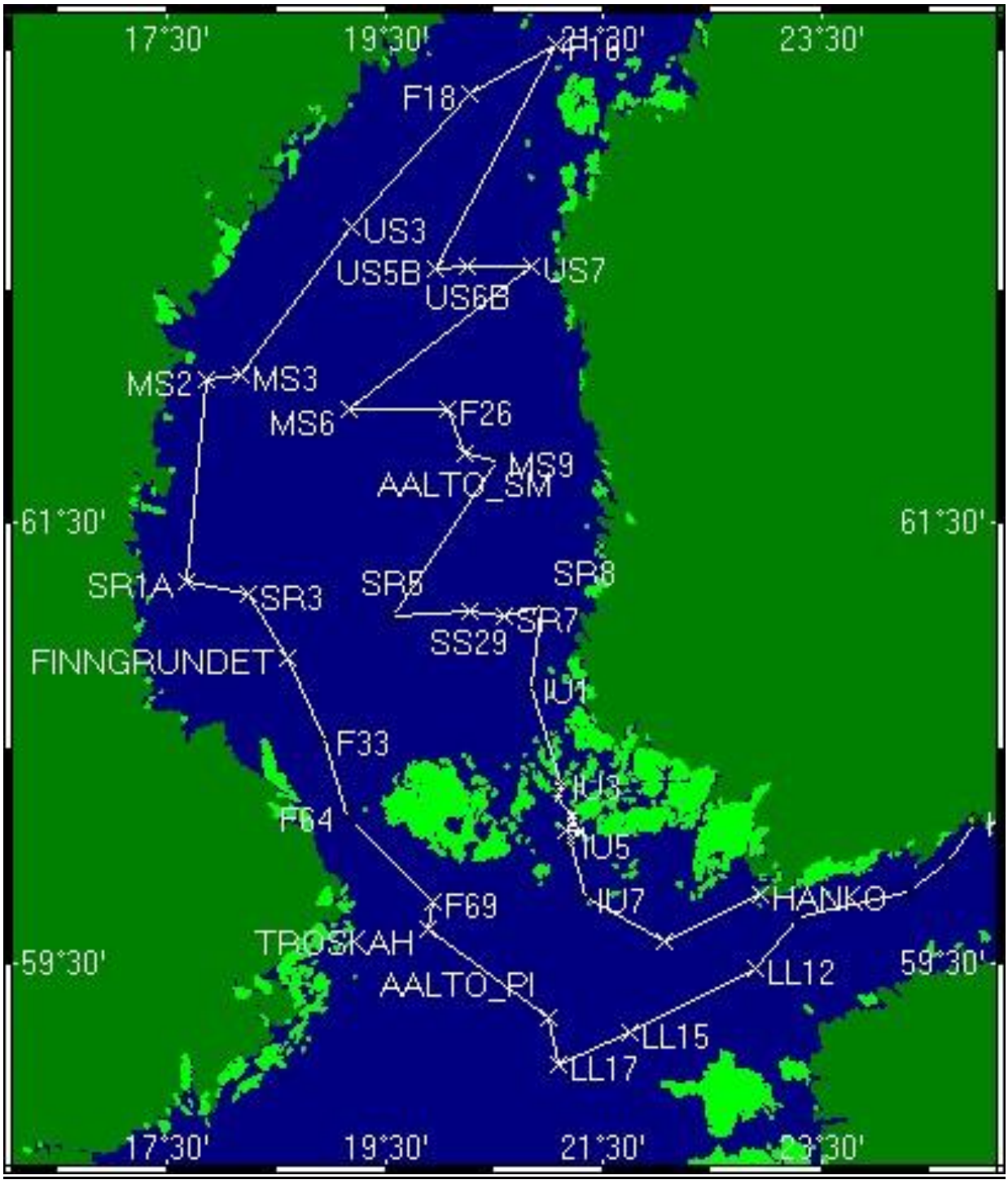

Figure 1. The 2nd leg of the Combine 1 cruise (25.01-01.02.2019) from Hanko to Helsinki.

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Table 2. List of sampled stations of the cruise.

INDEX	STATION	LAT (NORTH)	LON (EAST)	DEPTH (m)	DATE	TIME (UTC + 2)
	HANKO				2019-01-25	15:25
2019020057	IU7	60.0513	21.20171	92	2019-01-25	21:20
2019020058	IU5	60.03496	21.11893	89	2019-01-26	0:40
2019020059	IU3	60.19998	21.06815	49	2019-01-26	4:20
2019020060	IU1	60.46024	20.50788	34	2019-01-26	8:20
2019020061	SR8	61.07535	20.55961	46	2019-01-26	11:20
2019020062	SR7	61.05019	20.35774	79	2019-01-26	13:30
2019020063	SS29	61.06496	20.15984	113	2019-01-26	16:00
2019020064	SR5	61.04997	19.34773	121	2019-01-27	0:00
2019020065	MS9	61.46011	20.31821	98	2019-01-27	6:20
2019020066	AALTO_SM	61.4802	20.13849	110	2019-01-27	9:00
2019020067	F26	61.59014	20.03769	126	2019-01-27	12:20
2019020068	MS6	61.59027	19.09817	70	2019-01-27	16:15
2019020069	US7	62.36001	20.49745	21	2019-01-28	0:30
2019020070	US6b	62.36019	20.15781	79	2019-01-28	2:40
2019020071	US5b	62.2518	19.58201	216	2019-01-28	6:00
2019020072	US5bLAATU	62.2518	19.58201	216	2019-01-28	10:00
2019020073	F16	63.3094	21.0413	48	2019-01-28	21:40
2019020074	F18	63.18865	20.16332	99	2019-01-29	1:50
2019020075	US3	62.45528	19.11728	175	2019-01-29	8:00
2019020076	MS3	62.08019	18.0973	78	2019-01-29	15:40
2019020077	MS2	62.06997	17.50804	68	2019-01-29	17:40
2019020078	SR1A	61.13998	17.39797	59	2019-01-30	0:30
2019020079	SR3	61.11005	18.13818	71	2019-01-30	3:30
2019020080	FINNGR	60.5388	18.36065	69	2019-01-30	6:30
2019020081	F33	60.31965	18.56326	132	2019-01-30	11:10
2019020082	F64	60.11336	19.0852	287	2019-01-30	15:45
2019020083	F69	59.47006	19.55787	191	2019-01-30	21:40
2019020084	TROSKAH	59.39797	19.52991	56	2019-01-31	1:00
2019020085	AALTO_PI	59.15001	20.59943	99	2019-01-31	6:00
2019020086	LL17	59.02004	21.04762	172	2019-01-31	10:30
2019020087	LL17LAATU	59.02004	21.04762	172	2019-01-31	13:00
2019020088	LL15	59.11001	21.44805	131	2019-01-31	15:30
2019020089	LL12	59.2901	22.53795	83	2019-01-31	21:30
	HELSINKI				2019-02-01	9:00

Summary of the sampling

The cruise consisted of 33 stations (Table 2). CTD was deployed at all stations, and hydrography and nutrients were done at 15 monitoring stations. Quality control of sampling and analysis procedure were carried out at 2 stations (LL17LAATU and US5bLAATU). The wave buoy of the Finnish Meteorological Institute (FMI) was lifted, cleaned and put back. The entire sampling scheme of the cruise is shown in Table 3.

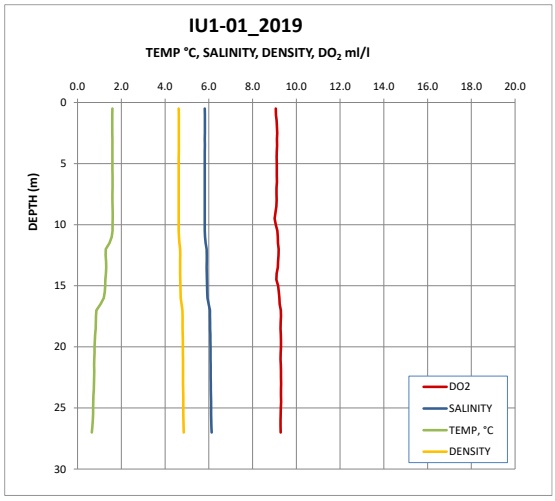
Table 3. The sampling scheme of the Cruise Combine 1 02/2019 (2nd leg).

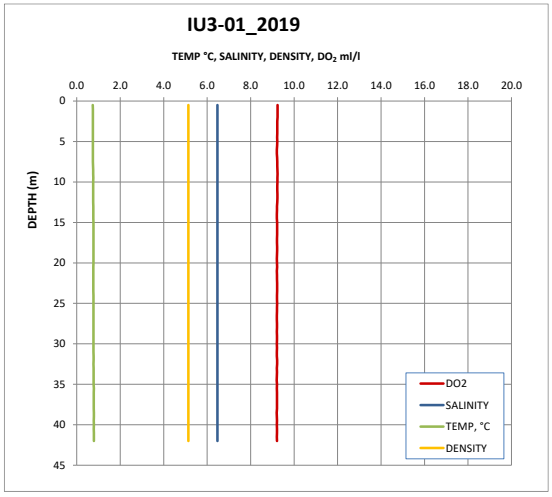
STATION	REGION	COUNTRY (EEZ)	LAT	LON	Secchi	Oil	CTD	Hydrography	Chemistry	Humus + pH	NIVA Benthos	PAH	Gemax
IU7	Archipelago Sea	FINLAND	59°48.91'	21°20.20'			x	x	x				
IU5	Archipelago Sea	FINLAND	60°03.49'	21°11.90'			x	x	x				
IU3	Bothnian Sea	FINLAND	60°20.00'	21°06.80'			x	x	x		x		
IU1	Bothnian Sea	FINLAND	60°46.02'	20°50.80'			x	x	x				
SR8	Bothnian Sea	FINLAND	61°07.54'	20°55.96'			x	x	x				
SR7	Bothnian Sea	FINLAND	61º05.02'	20°35.77'			x	x	x				
SS29	Bothnian Sea	FINLAND	61°06.50'	20°15.98'			x	x	x				
SR5	Bothnian Sea	FINLAND	61°05.00'	19°34.78'		x	x	x	x	x		x	x
MS9	Bothnian Sea	FINLAND	61°46.01'	20°31.82'			x	x	x		x		
AALTO_SM	Bothnian Sea	FINLAND	61°48.01'	20°13.85'			x						
F26	Bothnian Sea	FINLAND	61°59.01'	20°03.78'			x	x	x				
MS6	Bothnian Sea	SWEDEN	61°59.03'	19°09.82'			x	x	x		x		
US7	Bothnian Sea	FINLAND	62°36.00'	20°49.75'			x	x	x				
US6b	Bothnian Sea	FINLAND	62°36.02'	20°15.78'			x	x	x		x		
US5b	Bothnian Sea	FINLAND	62°35.18'	19°58.20'		x	x	x	x	x		x	
US5bLAATU	Bothnian Sea	FINLAND	62°35.18'	19°58.20'			x	x (200m)	x (200m)				
F16	Kvarken	FINLAND	63°30.94'	21°04.13'			x	x	x	x			
F18	Bothnian Sea	SWEDEN	63°18.86'	20°16.33'			x	x	x				
US3	Bothnian Sea	SWEDEN	62°45.53'	19°11.73'			x	x	x				
MS3	Bothnian Sea	SWEDEN	62°08.02'	18°09.73'			x	x	x				
MS2	Bothnian Sea	SWEDEN	62°06.99'	17°50.80'			x	x	x				
SR1A	Bothnian Sea	SWEDEN	61°13.99'	17°39.80'			x	x	x				
SR3	Bothnian Sea	SWEDEN	61°11.00'	18°13.82'			x	x	x				
FINNGRUNDET	Bothnian Sea	SWEDEN	60°53.88'	18°36.065'			x						
F33	Bothnian Sea	SWEDEN	60°31.96'	18°56.32'			x	x	x				
F64	ÅlandS	FINLAND	60°11.34'	19°08.52'	x	x	x	x	x			x	
F69	Northern Balitic	FINLAND	59°47.00'	19°55.78'			x	x	x		(x)		
TRÅSKELN ÅLANDS HAV	Northern Balitic	SWEDEN	59°39.60'	19°53.00'			x	x	x		x		
AALTO_PI	Northern Balitic	FINLAND	59°15.00'	20°59.81'			x						
LL17	Northern Balitic	ESTONIA	59°02.00'	21°04.77'	x	x	x	x	x			x	
LL17LAATU	Northern Balitic	ESTONIA	59°02.00'	21°04.77'			x (100m)	x (100m)	x (100m)				
LL15	Northern Balitic	ESTONIA	59°11.00'	21°44.80'			x	x	x				
LL12	Northern Balitic	FINLAND	59°29.01'	22°53.80'			x	x	x				

Results

Hydrography

In the Archipelago Sea the results showed that at stations IU1, IU3 and IU5 the entire water column was mixed down to the bottom. A clear startification was observed only at station IU7 as oxygen concentration diminished gradually (Figures 2-5). Close to the bottom oxygen saturation was ~65%. Salinity was higher in January 2019 than in September 2018 in the Archipelago Sea.





Figures 2-3. Temperature, salinity, density and oxygen profiles in January 2019 at IU1 and IU3.

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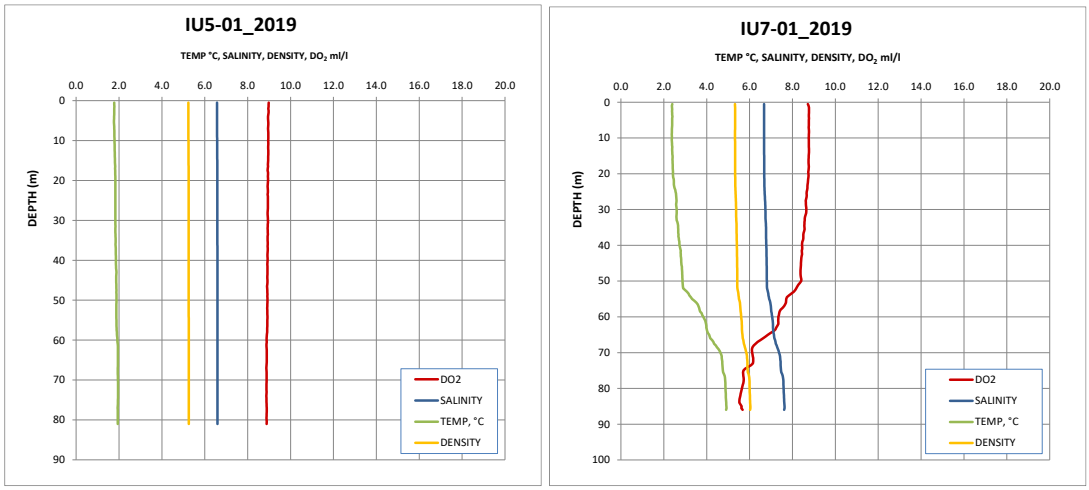
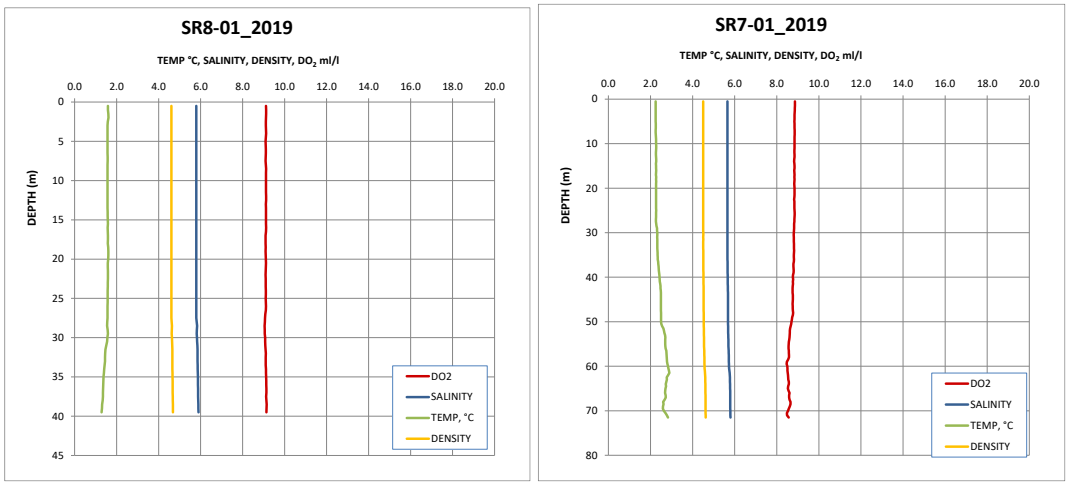


Figures 4-5. Temperature, salinity, density and oxygen profiles in January 2019 at IU5 and IU7.

In the Bothnian Sea the profiles of temperature, salinity, density and dissolved oxygen were straight and water column mixed down to 50m. Closer to the Finnish coast at shallow water homogeniousity was even clearer (at the stations SR7 and SR8). At MS9 oxygen concentration dropped drastically close to the bottom (Figure 8).



Figures 6-7. Temperature, salinity, density and oxygen profiles in the Bothnian Sea (at SR8 and SR7) in January 2019.

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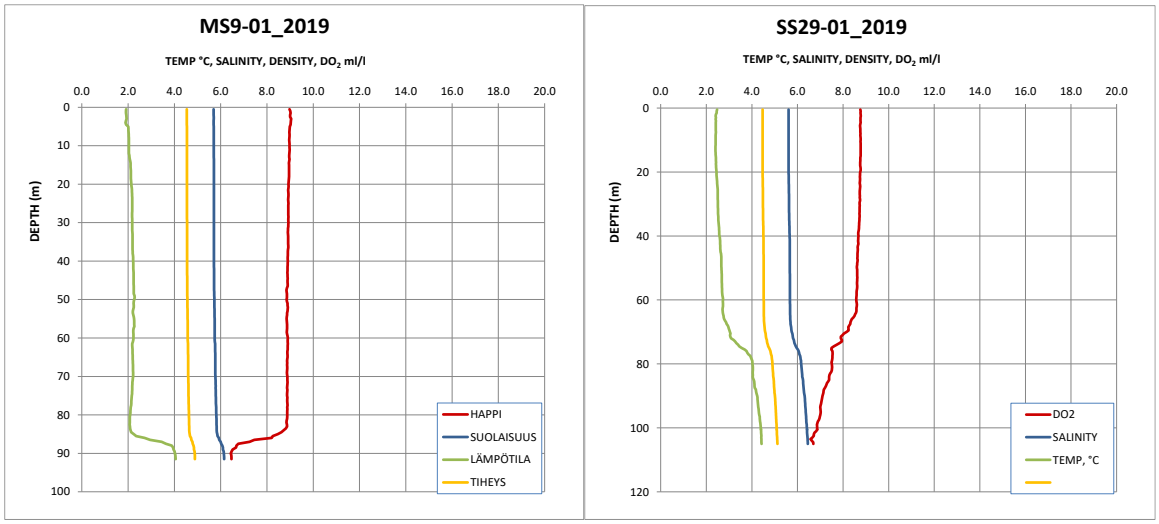
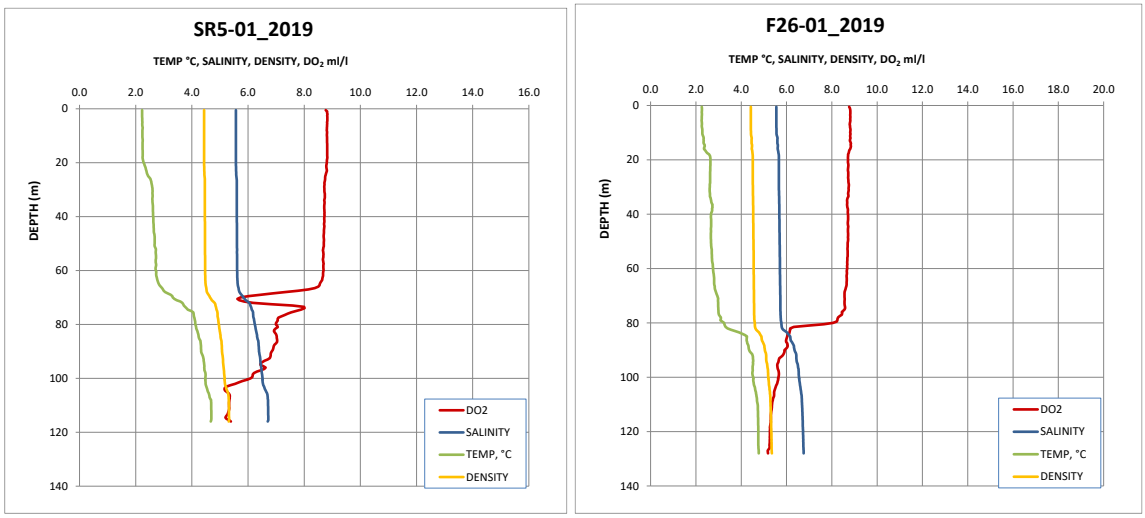


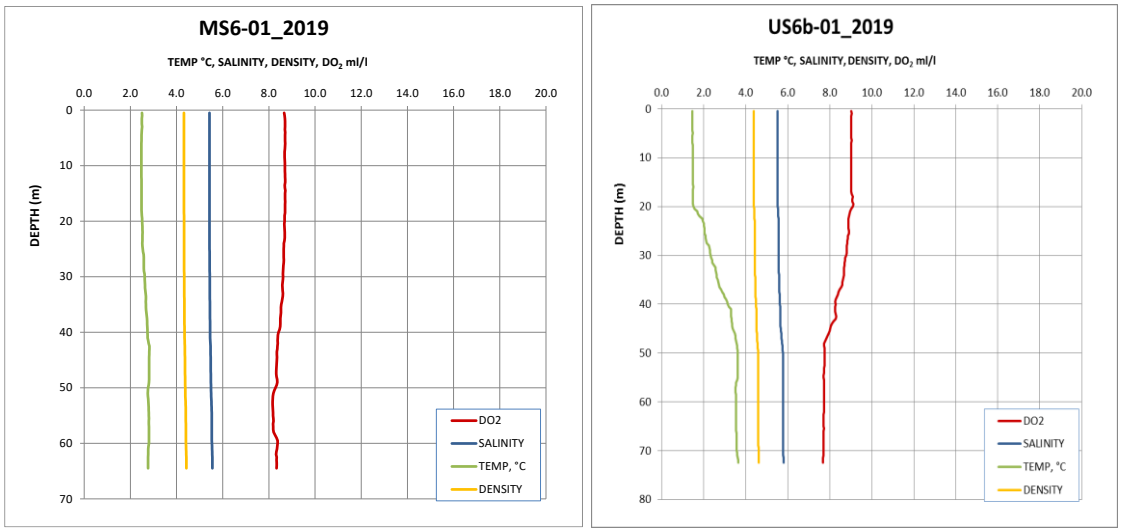
Figures 8-9. Temperature, salinity, density and oxygen profiles in the Bothnian Sea (at SR8, SR7, MS9 and SS29) in January 2019.

Stratified layers were observed below 60 meters depth at SR5 and at 80 meters at F26, respectively (Figures 10-11).

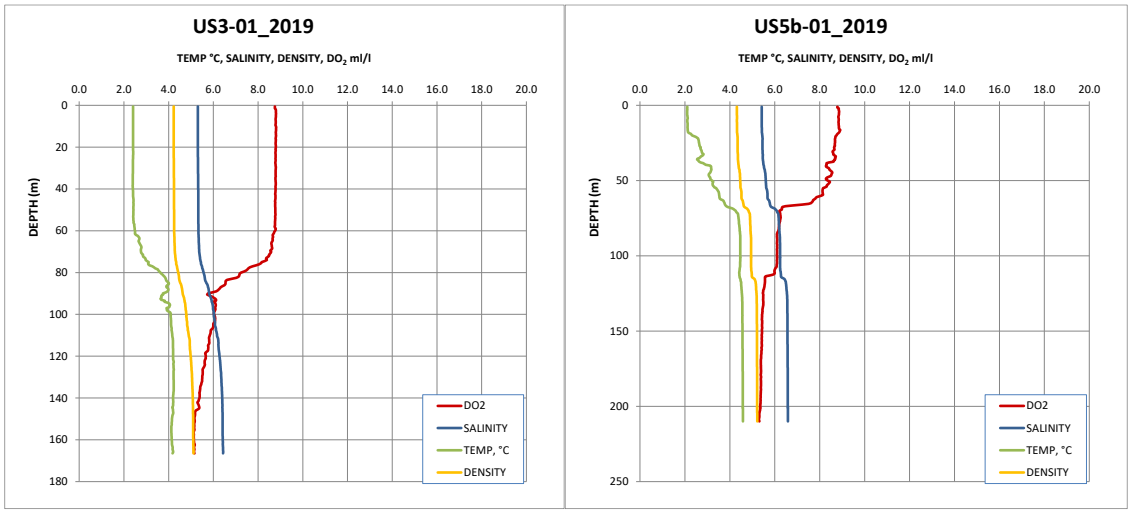


Figures 10-11. Temperature, salinity, density and oxygen profiles at SR5 and F26 in January 2019.

In the Northern part of the Bothinan Sea, salinity, oxygen, density and temperature profiles were less stratified at shallow stations than in the deeper layers. Oxygen concentrations were in general at high level.

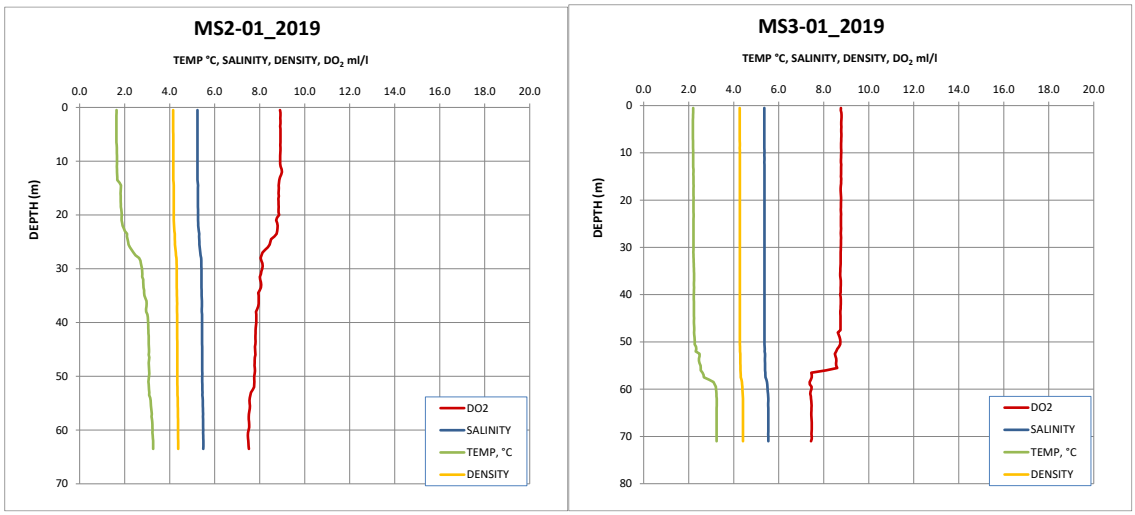


Figures 12-13. Temperature, salinity, density and oxygen profiles at shallow stations (MS6 and US6b) in January 2019.

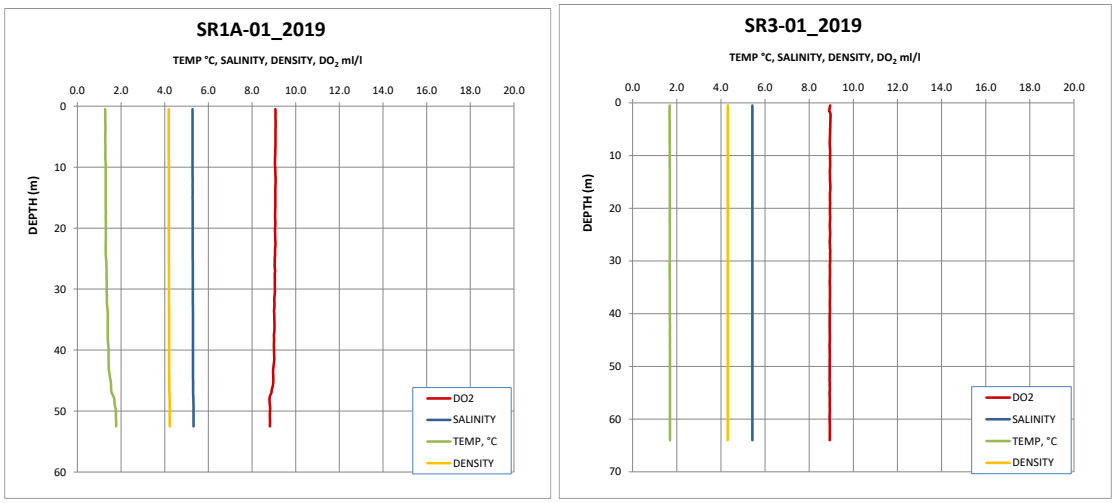


Figures 14-15. Temperature, salinity, density and oxygen profiles at deep stations (US3 and US5b) in January 2019.

On the Swedish coast of the Bothnian Sea oxygen concentrations were high and stratification almost non-existant (Figures 16-19).



Figures 16-17. Temperature, salinity, density and disolved oxygen profiles of MS2 and MS3 in January 2019.



Figures 18-19. Temperature, salinity, density and disolved oxygen profiles of SR1A and SR3 in January 2019.

In the Åland Sea the water in January was strongly stratified. Salinity was higher at F69 (the southern station of the two) than at F64. Oxygen saturation near bottom, at 180m, was near 30% at F69 (Figures 20-21).

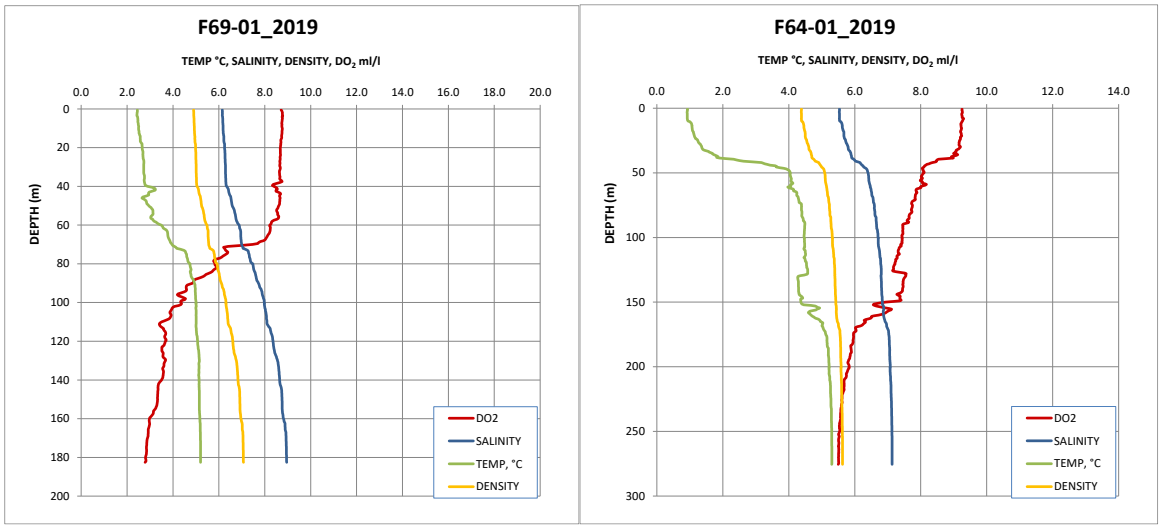


Figure 20-21. Temperature, salinity, density and dissolved oxygen profiles at the stations F69 and F64 in January 2019.

The profiles of LL17 and LL15 showed that in the Northern Baltic Proper deep layers were anoxic below 75m and at LL12 below 65m. In the western part of the Gulf of Finland (LL12) oxic condition can change rapidly due to occasional in and out flow of bottom water. In September 2018 oxygen was dedected even near bottom (Figures 22-24).

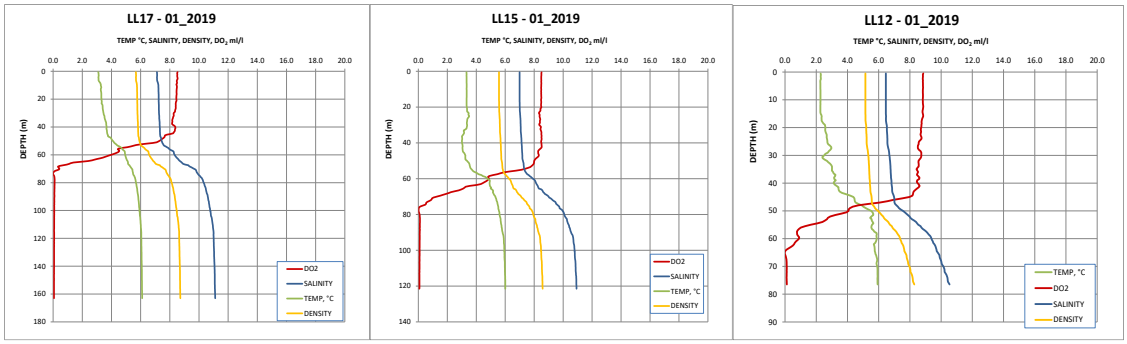
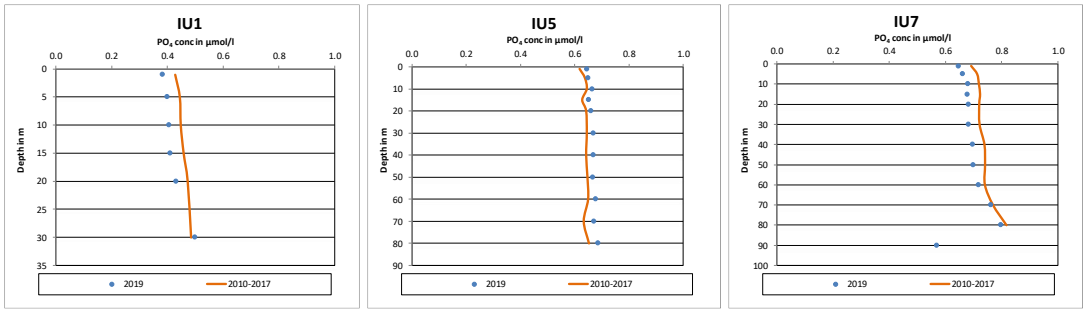


Figure 22-24. Temperature, salinity, density and dissolved oxygen profiles at the station LL17, LL15 and LL12 in January 2019.

Nutrients

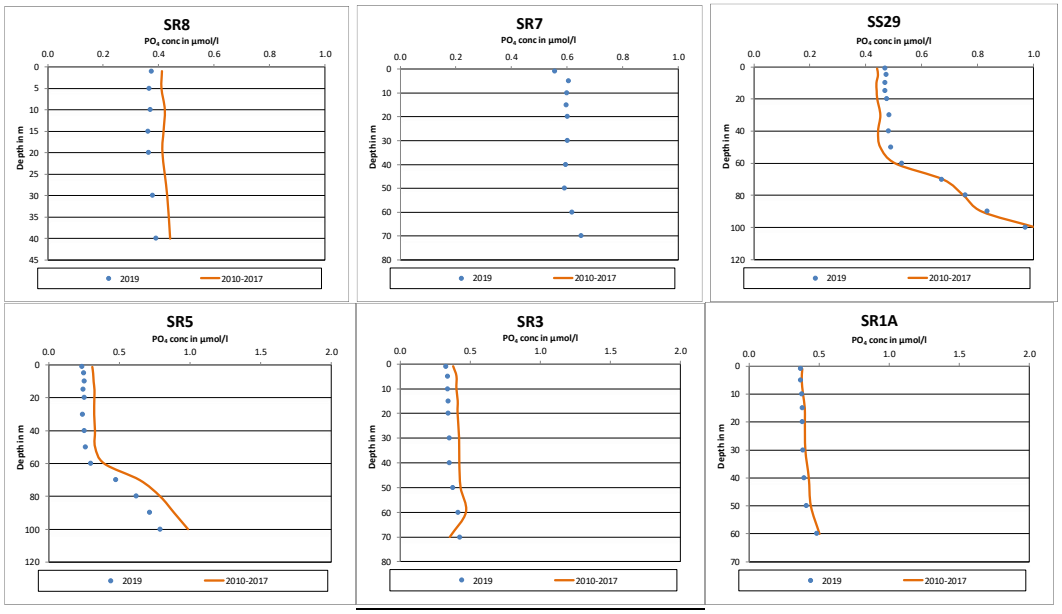
Dissolved phosphorus

In general, PO_4 concentrations were below the average observed in January 2010-2017. Only in the Northern part of the Baltic Proper high PO_4 concentrations were observed at the stations F69, LL12, LL15 and LL17 (figures 47-50).



Figures 25-27. PO_4 concentrations in January 2019 (blue dots) and in average (January 2010-2017, orange line) in the Archipelago at stations IU1, IU5 and IU7.

In the northern part of the Archipelago Sea, at IU1, PO_4 concentrations were between 0.4-0.5 µmol/l) and in the southern part of the Archipelago and on the edge of the Northern Baltic Proper (IU5 and IU7) concentrations were clearly higher, from 0.65 to 0.80 µmol/l, and they were close to the average level of 2010-2018 (Figures 25-27).



Figures 28-33. PO_4 concentrations in January 2019 (blue dots) and in average (January 2010-2017, orange line) in the southern Bothnian Sea at stations SR8, SR7, SS29, SR5, SR3 and SR1A.

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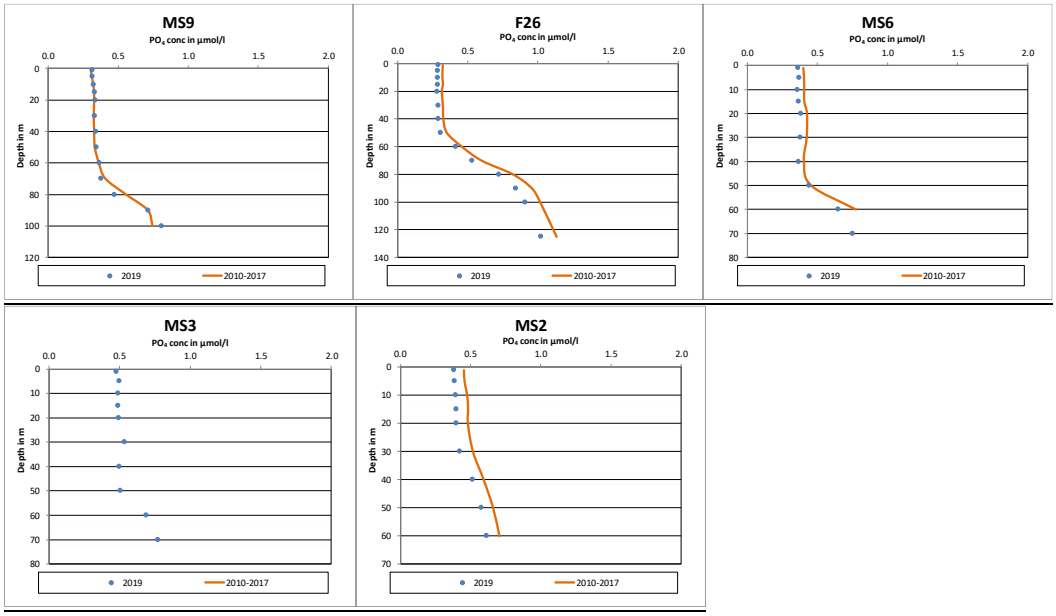
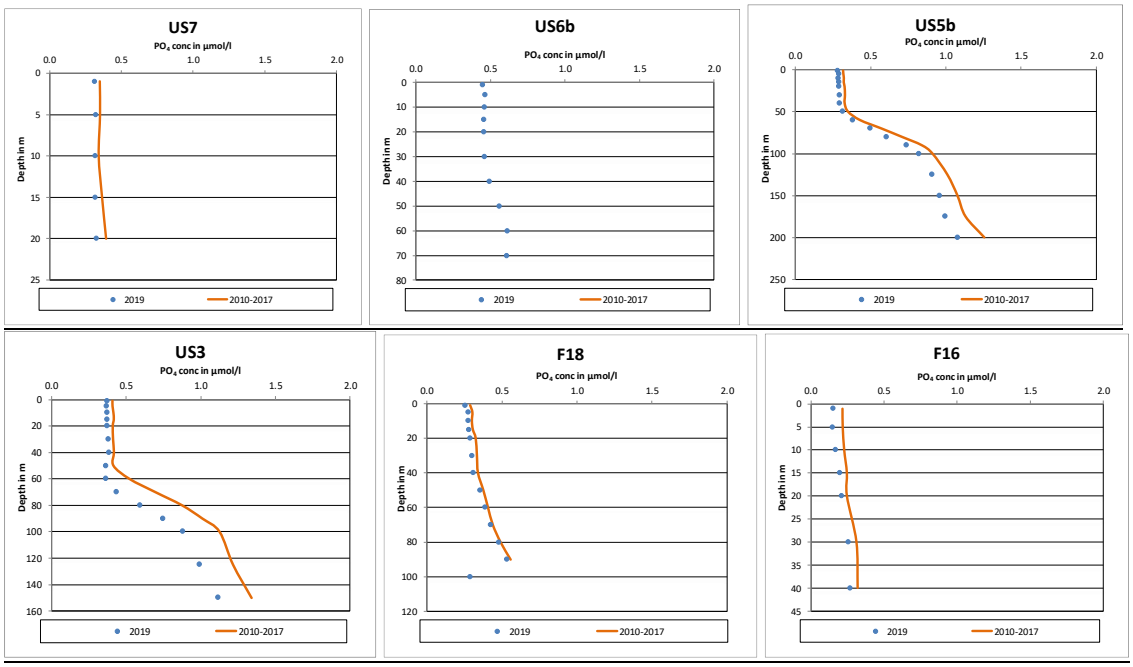


Figures 34-38. PO_4 concentrations in January 2019 (blue dots) and in average (January 2010-2017, orange line) in the central Bothnian Sea at stations MS9, F26, MS6, MS3 and MS2.



Figures 39-44. PO_4 concentrations in January 2019 (blue dots) and in average (January 2010-2017, orange line) in the northern Bothnian Sea at stations US7, US6b, US5b, US3, F18 and F16.

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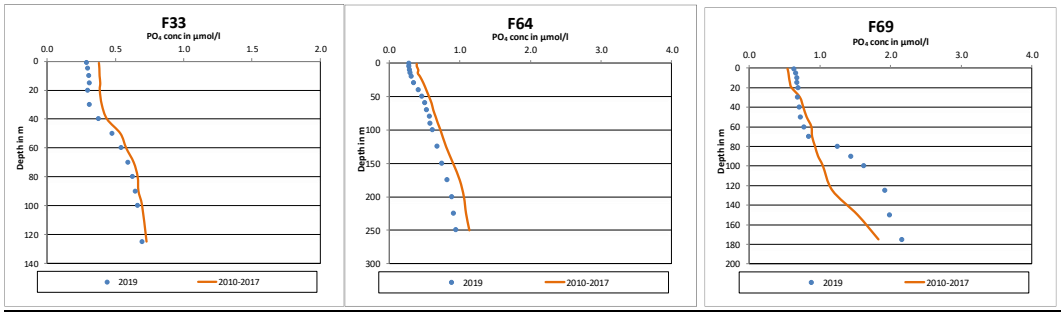
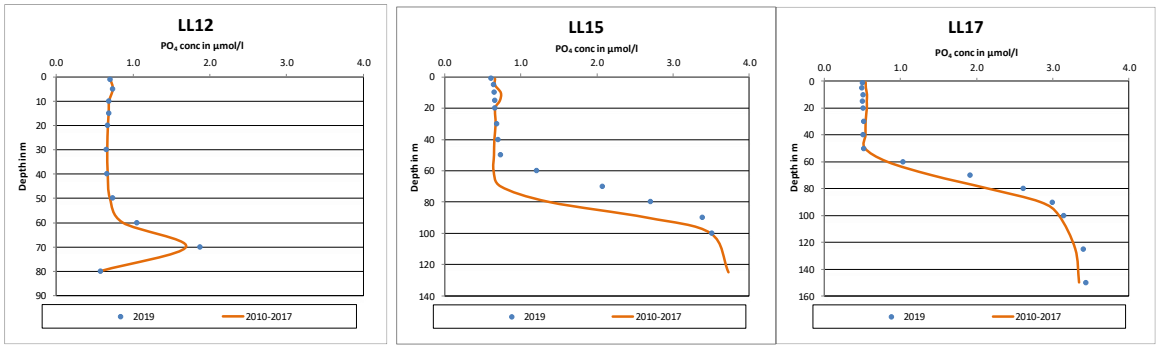


Figures 45-47. PO_4 concentrations in January 2019 (blue dots) and in average (January 2010-2017, orange line) in the Åland Sea at stations F33, F64 and F69.

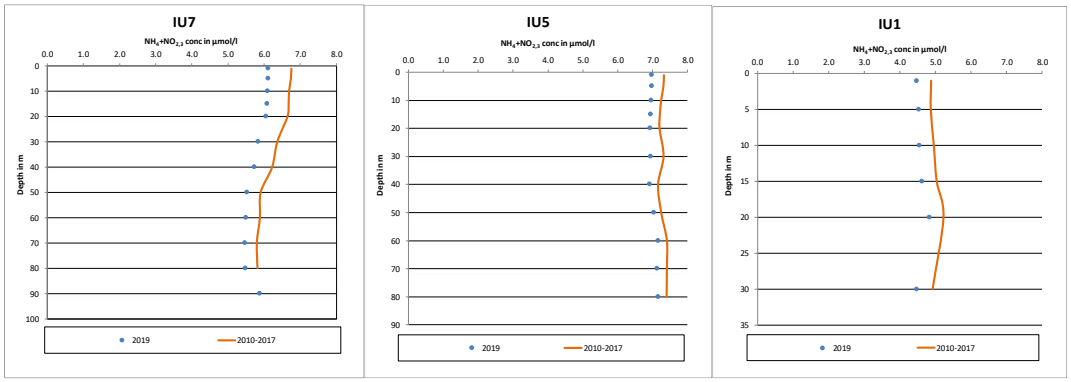


Figures 48-50. PO_4 concentrations in January 2019 (blue dots) and in average (August 2010-2017 orange line) at stations LL12, LL15 and LL17.

PO_4 concentrations below 60 m in January 2019 were higher than in average (in January 2010-2017) at LL15 and LL17 (Figures 49-50).

Dissolved Nitrogen

Observed $NH_4 + NO_{2,3}$ concentrations were close to average winter concentrations (average of 2010-2017) or even below the average. Only in the Northern part of the Baltic Proper the concentrations were clearly higher than in average (Stations F69 and LL12 figures 75-76) and in deeper layers, below 80 meters (Figures 78-79) at the stations LL15 and LL17.



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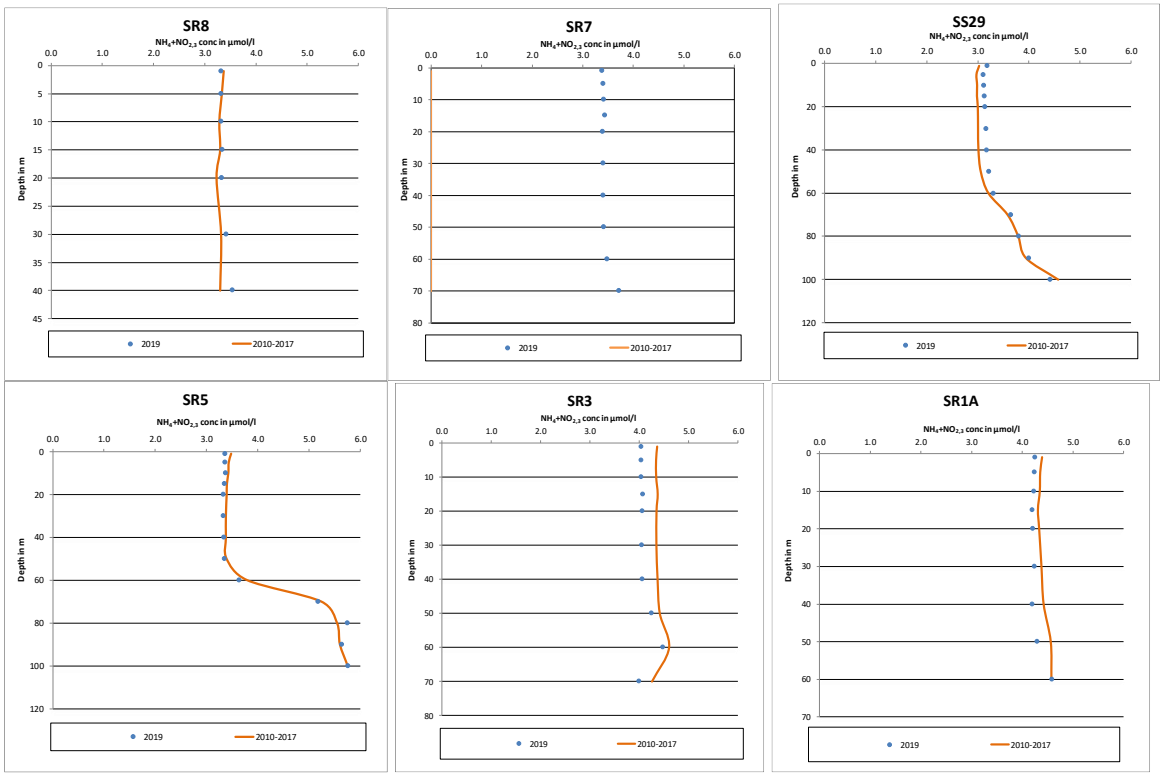
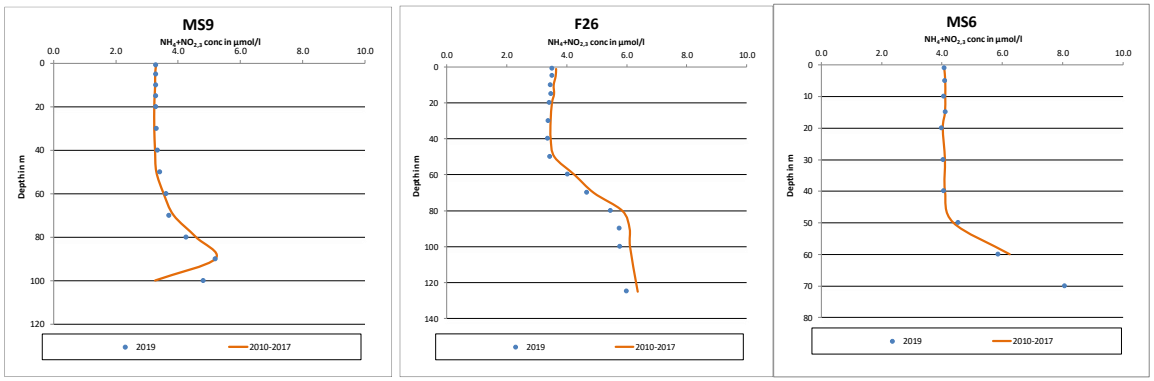
Figures 51-53. $NH_4 + NO_{2,3}$ concentrations in the Archipelago Sea IU7, IU5 and IU1 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line).

Due to the shallow character of the station IU1, concentrations of dissolved nitrogen ($NH_4 + NO_{2,3}$) were very much the same from surface to bottom. At IU5 observed concentrations were the highest concentrations, but in general the observed concentrations were lower than in average in January 2010-2017. (Figures 51-53).



Figures 54-59. $NH_4 + NO_{2,3}$ concentrations in the Bothnian Sea SR8, SR7, SS29, SR5, SR3 and SR1A in January 2019 (blue dots) and averages of January in 2010-2017 (orange line).

In the southern part of the Bothnian Sea observed concentrations were highest at stations SS29 and SR5 in deeper layers. In general, in January 2019 observed concentrations were at average level or even below the average of 2010-2017 (Figures 54-59).



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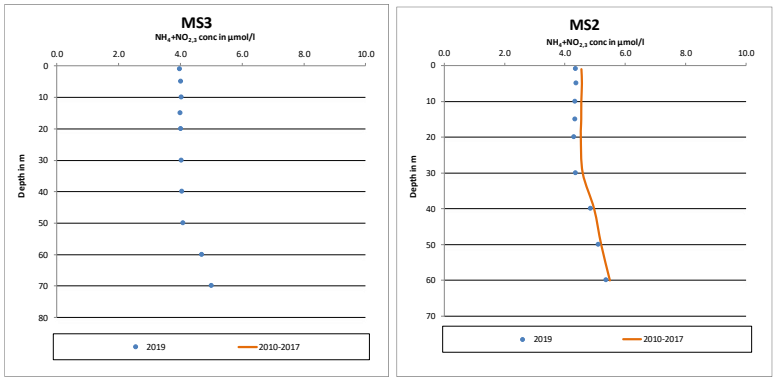
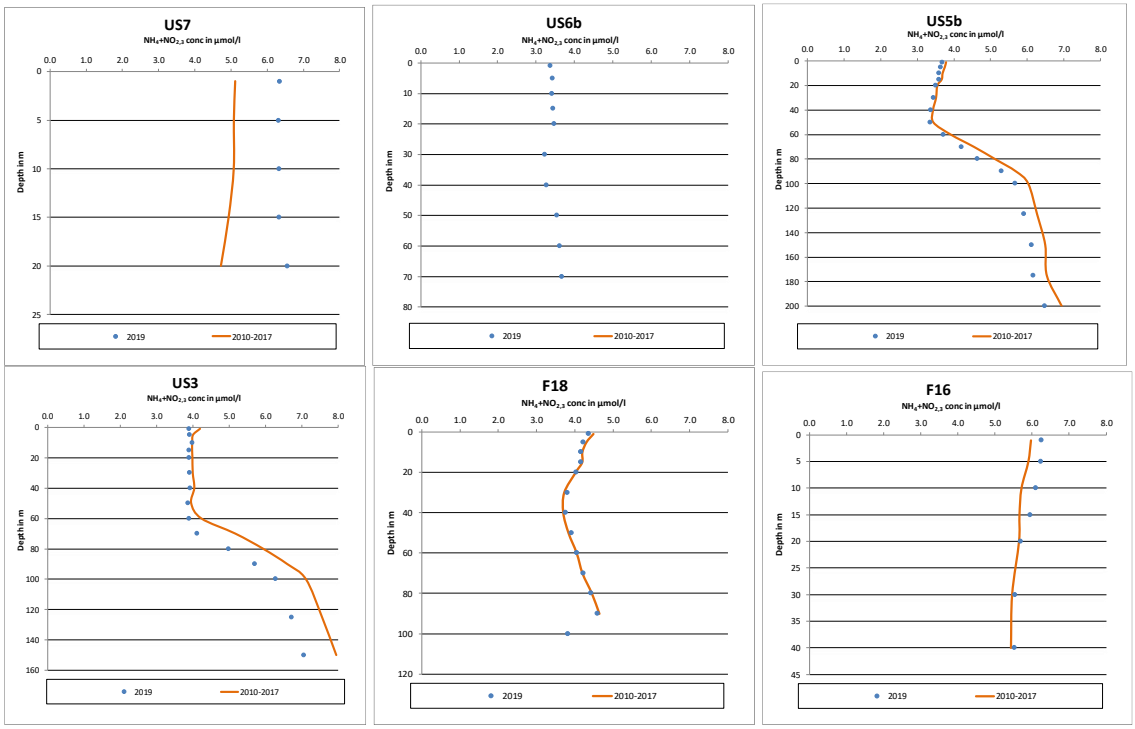


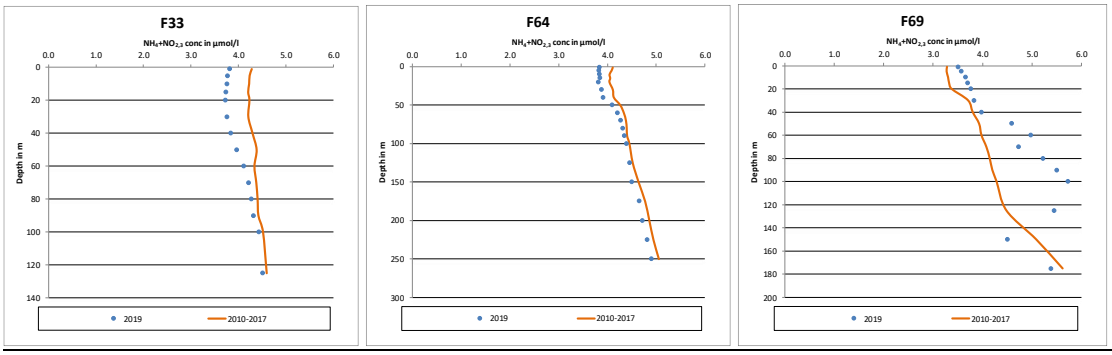
Figures 60-64. $NH_4 + NO_{2,3}$ concentrations in the Bothnian Sea MS9, F26, MS6, MS3 and MS2 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line, except MS3 no data in 2010-2017).

$NH_4 + NO_{2,3}$ concentrations in the Bothnian Sea were observed to be very close to the average of 2010-2017 or slightly lower than the average.



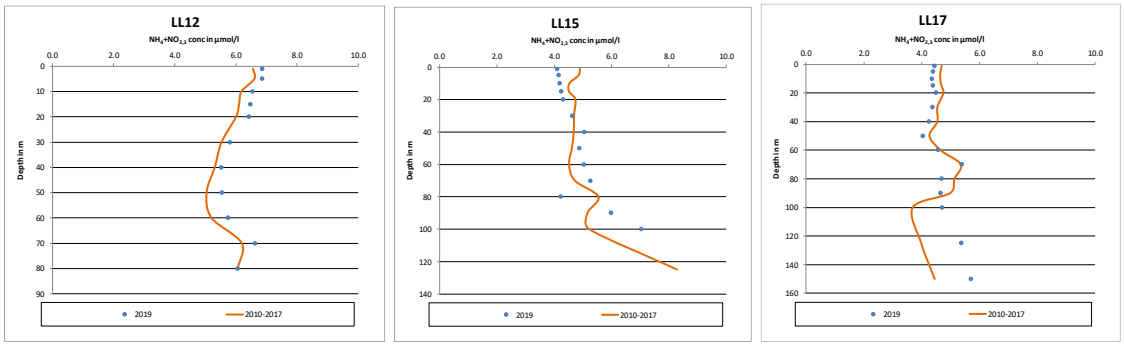
Figures 67-72. $NH_4 + NO_{2,3}$ concentrations in the Bothnian Sea at US7, US6b, US5b, US3, F16 and F18 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line, except US6b no data in 2010-2017).

$NH_4 + NO_{2,3}$ concentrations in the Bothnian Sea at US7, US6b, US5b, US3, F16 and F18 in January 2019 were highest at shallow stations and close to the coast. At deep stations, and below 60m, concentrations were lower than in average in January 2010-2017 (Figures 67-72).



Figures 73-75. $NH_4 + NO_{2,3}$ concentrations in January 2019 (blue dots) and in average (January 2010-2017, orange line) in the Åland Sea at stations F33, F64 and F69.

The observations of the Aland Sea (stations F33, F64 and F69) showed that the $NH_4 + NO_{2,3}$ concentrations in January 2019 were much higher than in average, indicating an upwelling in the region. $NH_4 + NO_{2,3}$ concentrations at F33 and F64 were below the average in 2010-2017 in January (Figures 73-75).

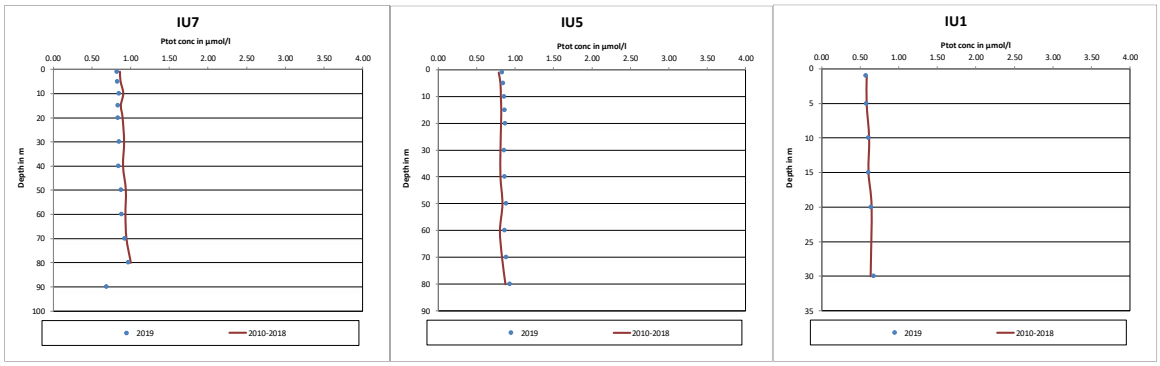


Figures 76-79. $NH_4 + NO_{2,3}$ concentrations at LL12, LL15 and LL17 stations in January 2019 (blue dots) and in average 2010-2017 in January (orange line).

$NH_4 + NO_{2,3}$ concentrations in the Northern part of the Baltic Proper in January 2019 were below the average of 2010-2017 in January, down to 30 meters depth, but higher below 80 meters, respectively. $NH_4 + NO_{2,3}$ concentrations at LL12 were higher at surface than at LL15 and LL17. The highest concentrations of dissolved nitrogen were observed at deeper layers, below 60 meters.

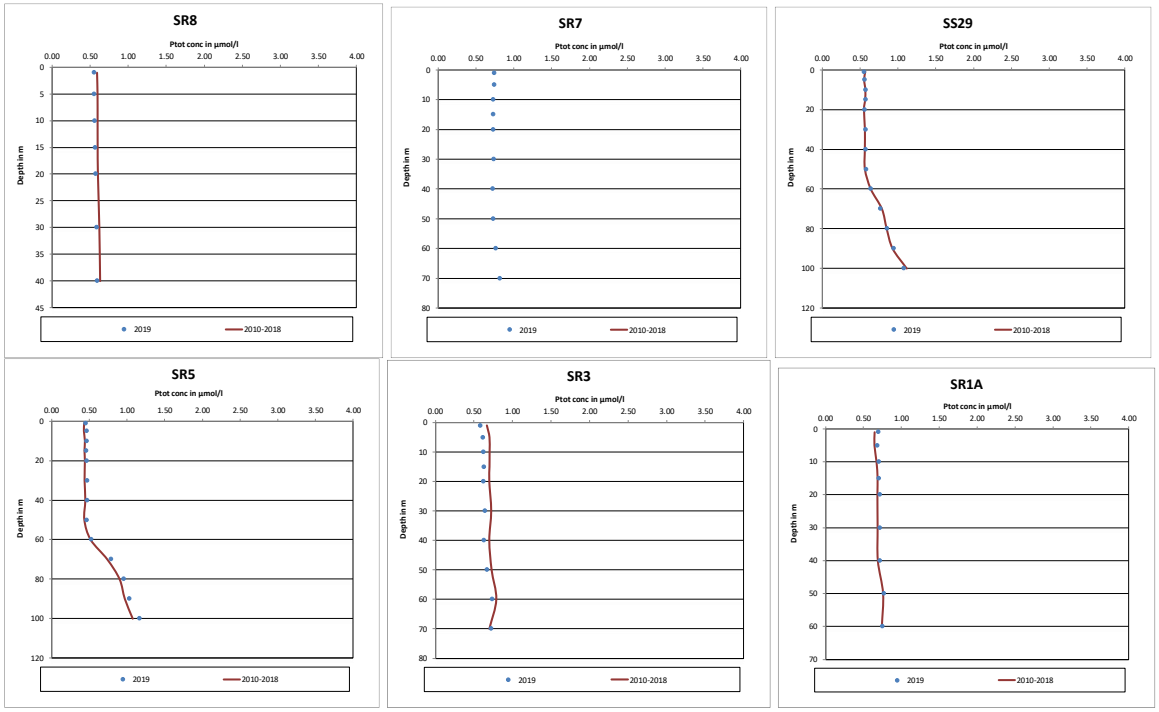
Total phosphorus

Observed P_{tot} concentrations were close to the average or below the average concentrations of January 2010-2017.Only in the Northern main basin, water column was strongly stratified from 70 meters on. Further, the concentrations in January 2019 were higher than in average (2010-2017) from the 60m on indicating a slight upwelling (Figures 101, 103-105).



Figures 80-82. P_{tot} concentrations at IU7, IU5 and IU1 stations in January 2019 (blue dots) and in average 2010-2017 in January (orange line).

P_{tot} concentrations in January 2019 were the very similar to average concentrations in January of 2010-2017.



Figures 83-88. P_{tot} concentrations at SR8, SR7, SS29, SR5 SR3 and SR1A stations in January 2019 (blue dots) and in average 2010-2017 in January (orange line).

P_{tot} concentrations in January 2019 were the very similar to average concentrations in January of 2010-2017. Some stratification was observed at deeper stations below 70m (SR5 and SS29), Pot concentrations were higher than in the upper part of the profile.

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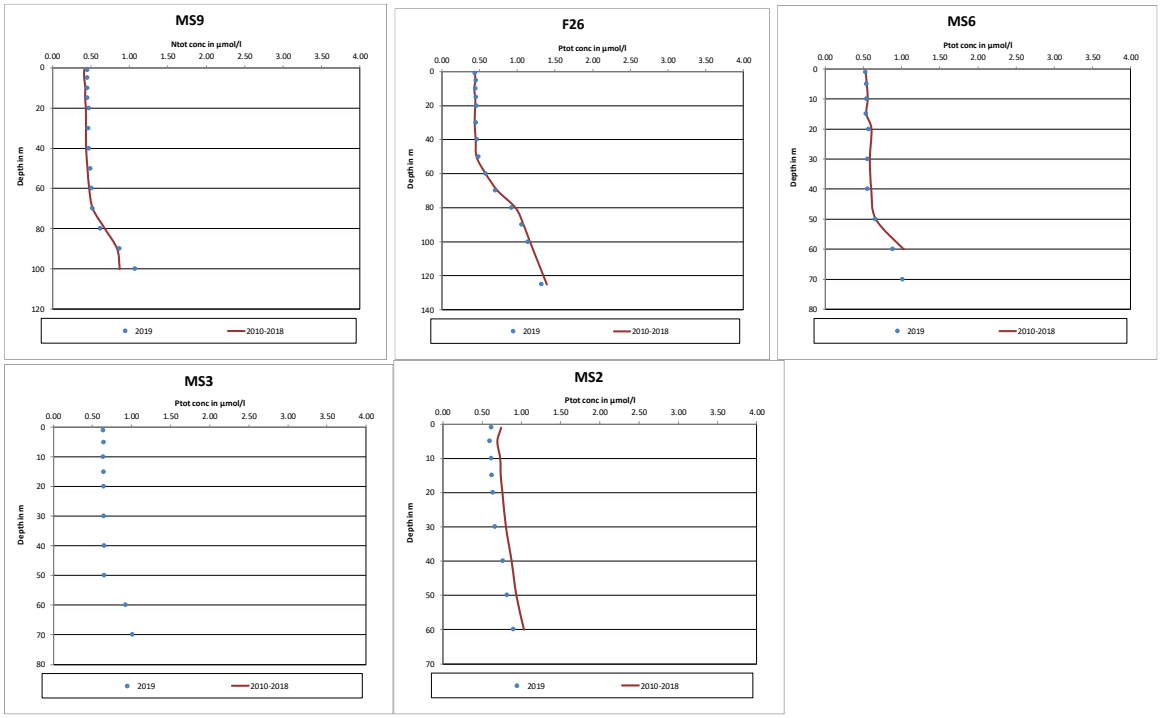
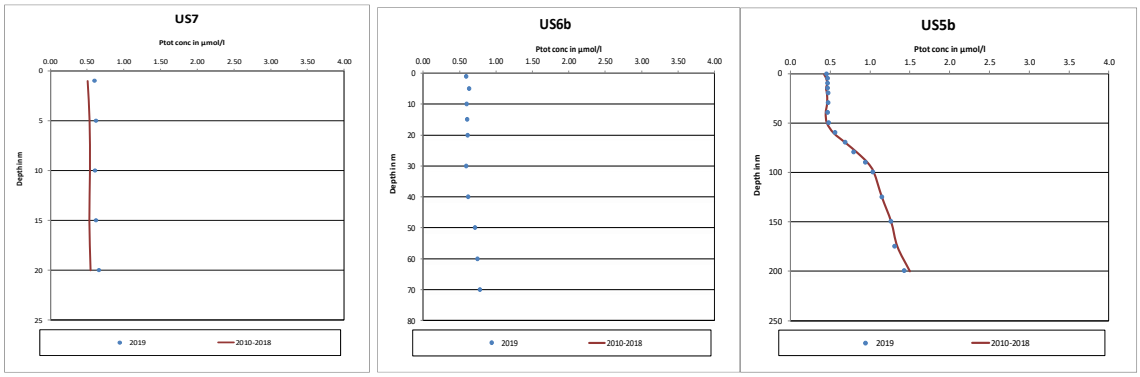


Figures 89-93. P_{tot} concentrations in the Bothnian Sea MS9, F26, MS6, MS3 and MS2 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line, except MS3 no data in 2010-2017).

P_{tot} concentrations in the Bothnian Sea MS9, F26, MS6, MS3 and MS2 in January 2019 were lower or around the average concentrations of January in 2010-2017.



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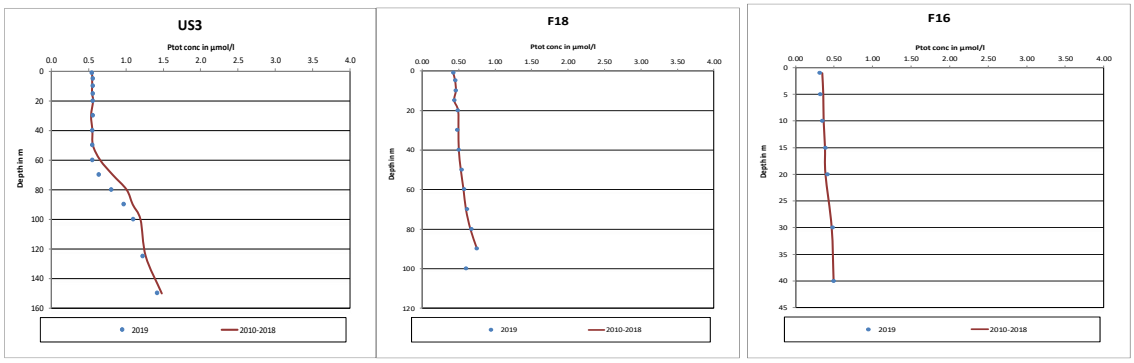
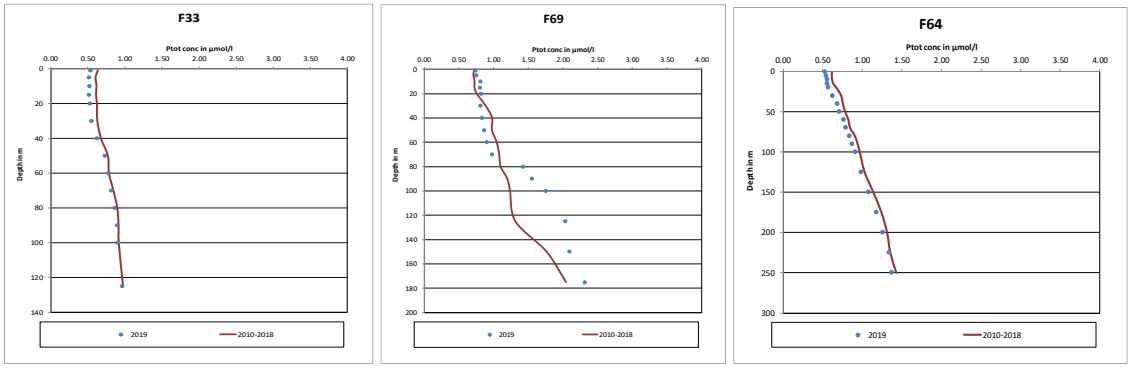


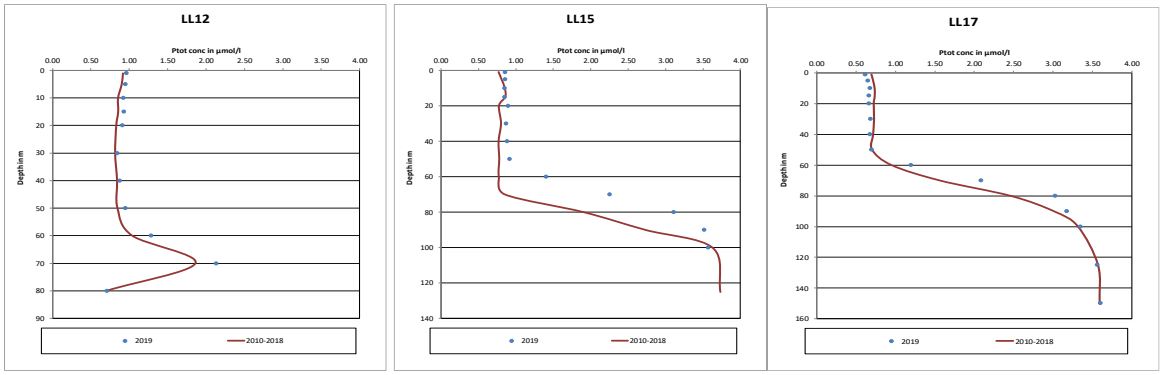
Figures 94-99. P_{tot} concentrations in the Bothnian Sea US7, US6b, US5b, MS3 and MS2 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line, except MS3 no data in 2010-2017).



Figures 100-102. P_{tot} concentrations in the Bothnian Sea US7, US6b, US5b, MS3 and MS2 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line, except MS3 no data in 2010-2017).

P_{tot} concentrations were clearly higher at F69 in January 2019 than in average in January 2010-2017 indicating some upwelling at the station.

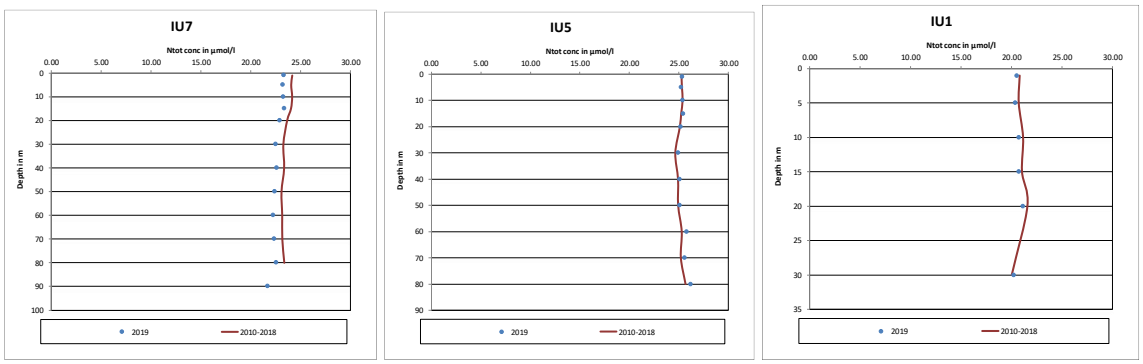
Water column in the Northern main basin was strongly stratified from 70 meters on. P_{tot} concentrations in January 2019 were higher than in average in January from the 60m on, which indicated a slight upwelling (Figures 101, 103-105).



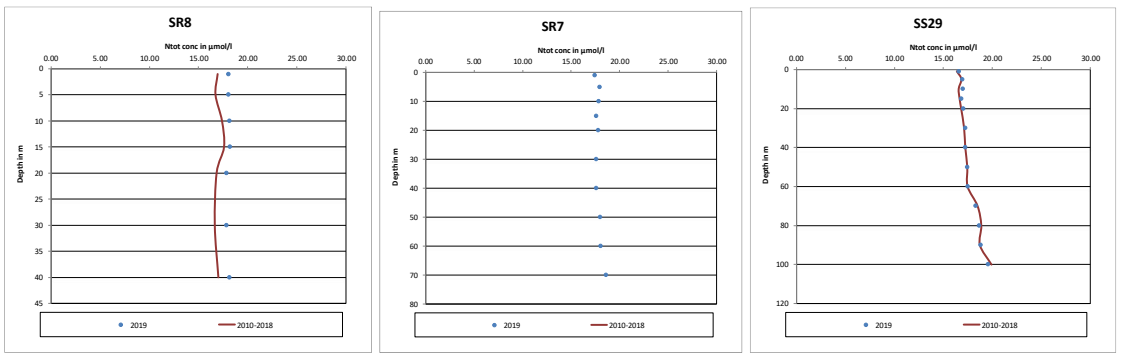
Figures 103-105. P_{tot} concentrations at LL12, LL15 and LL17 stations in January 2019 (blue dots) and in average 2010-2017 in January (orange line).

Total Nitrogen

Winter concentrations of N_{tot} in January 2019 followed mainly the average of January 2010-2017. Higher N_{tot} concentrations were observed in the Northern part of the Baltic Proper (Figures 127-131). In January 2019 higher N_{tot} concentrations were observed than in average in January (2010-2017). Higher concentrations were observed especially in the upper part of the water column.



Figures 106-108. N_{tot} concentrations in the Archipelago Sea IU7, IU5 and IU1 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line).



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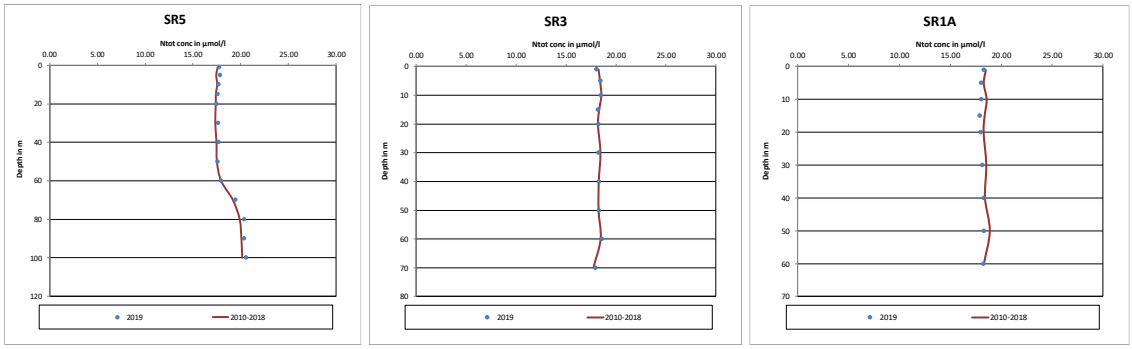
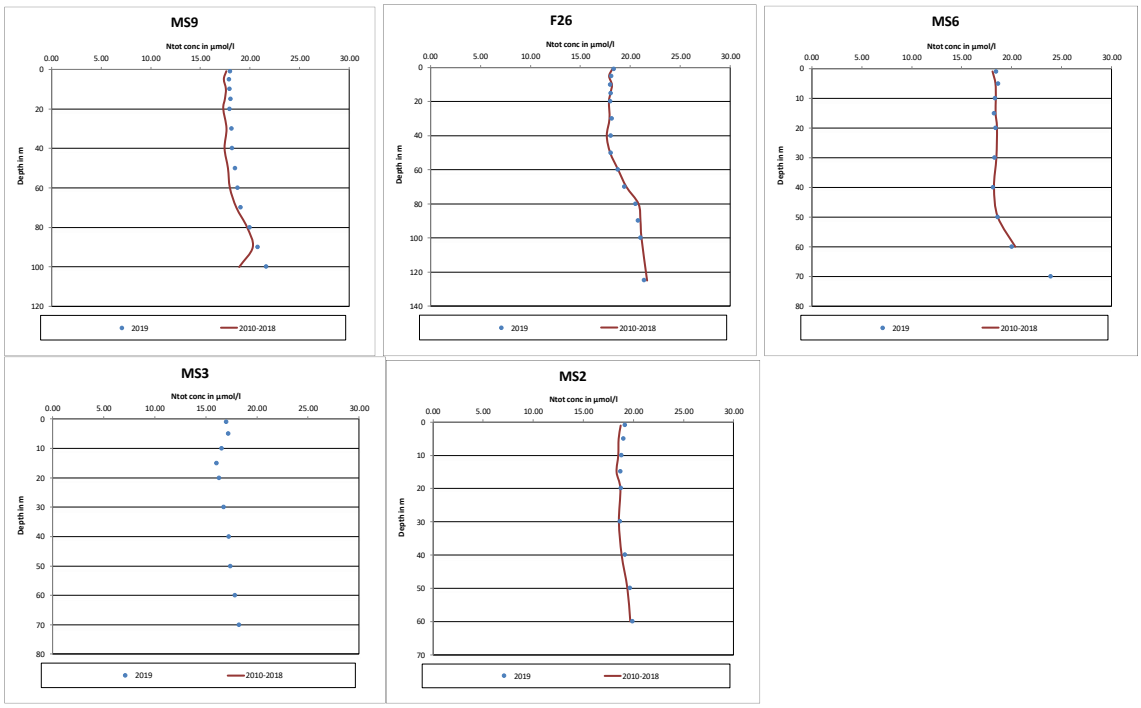


Figures 109-114. N_{tot} concentrations in the Archipelago Sea SR8, SR7, SS29, SR5, SR3 and SR1A in January 2019 (blue dots) and averages of January in 2010-2017 (orange line).



Figures 115-119. N_{tot} concentrations in the Archipelago Sea MS9, F26, MS6, MS3 and MS2 in January 2019 (blue dots) and averages in January in 2010-2017 (orange line).

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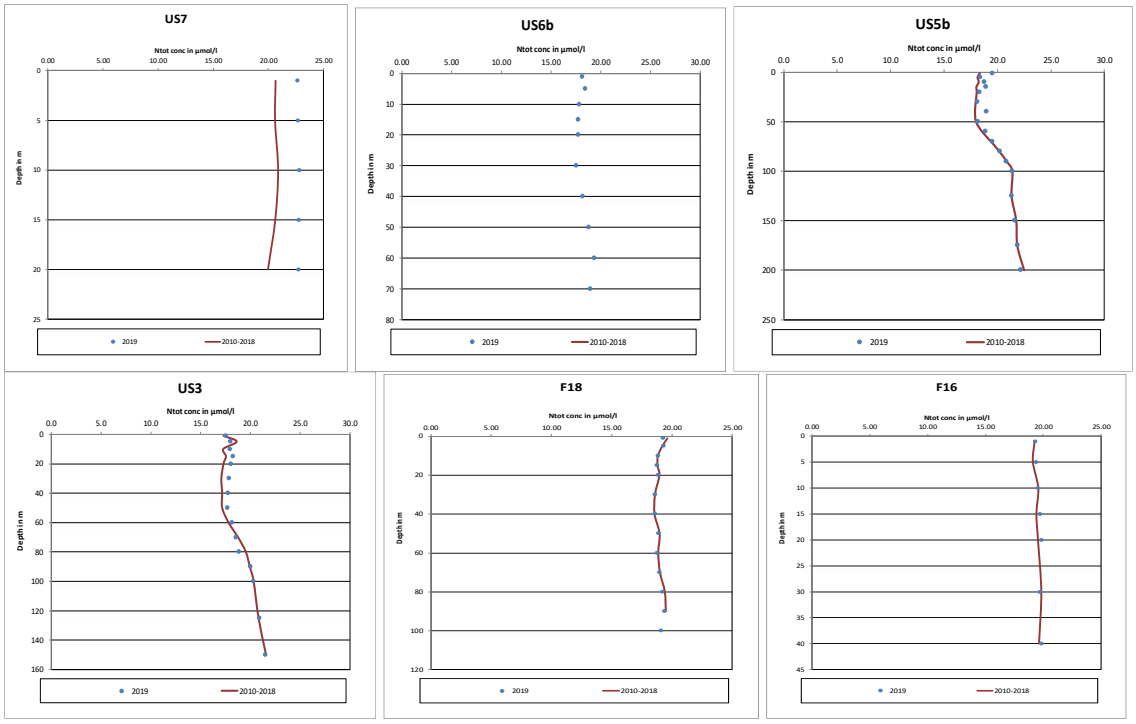
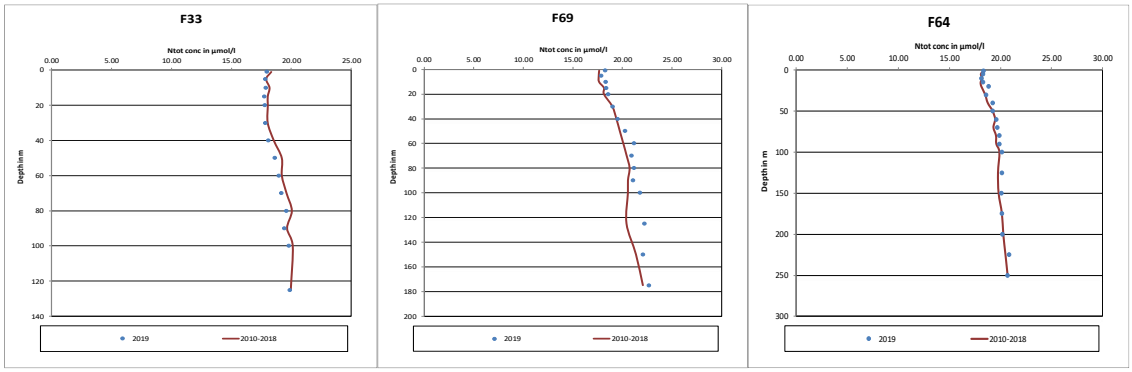


Figures 120-125. N_{tot} concentrations in the Archipelago Sea US7, US6b, US5b, US3, F18 and F16 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line).

Higher N_{tot} concentrations in January 2019 were observed in the upper part of the water column (<50m) than in average in January 2010-2017 in the Northern part of the Bothnian Sea.



Figures 126-128. N_{tot} concentrations in the Archipelago Sea F33, F69 and F64 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line).

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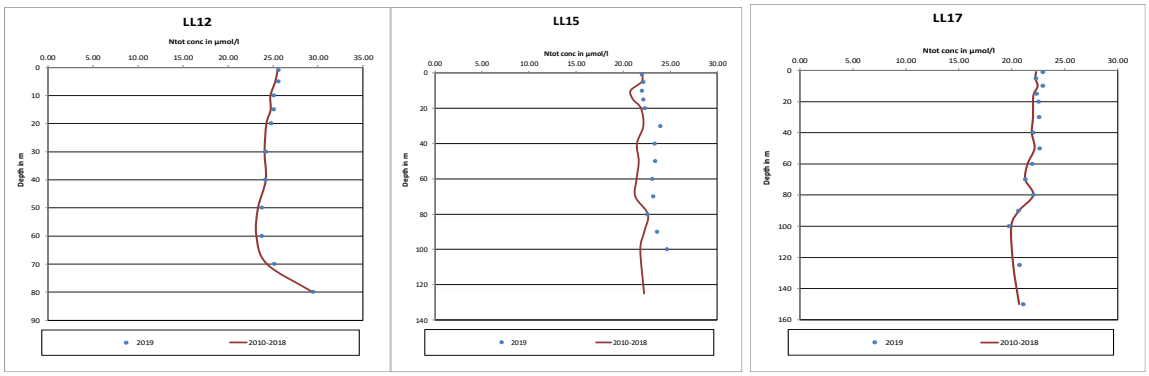

Figures 129-131. N_{tot} concentrations in the Archipelago Sea LL12, LL15 and LL17 in January 2019 (blue dots) and averages of January in 2010-2017 (orange line).

N_{tot} concentrations in January 2019 were higher than in average in January (2010-2017). The higher concentrations were possibly due to upwelling from the Gotland deep (Figures 127-131).

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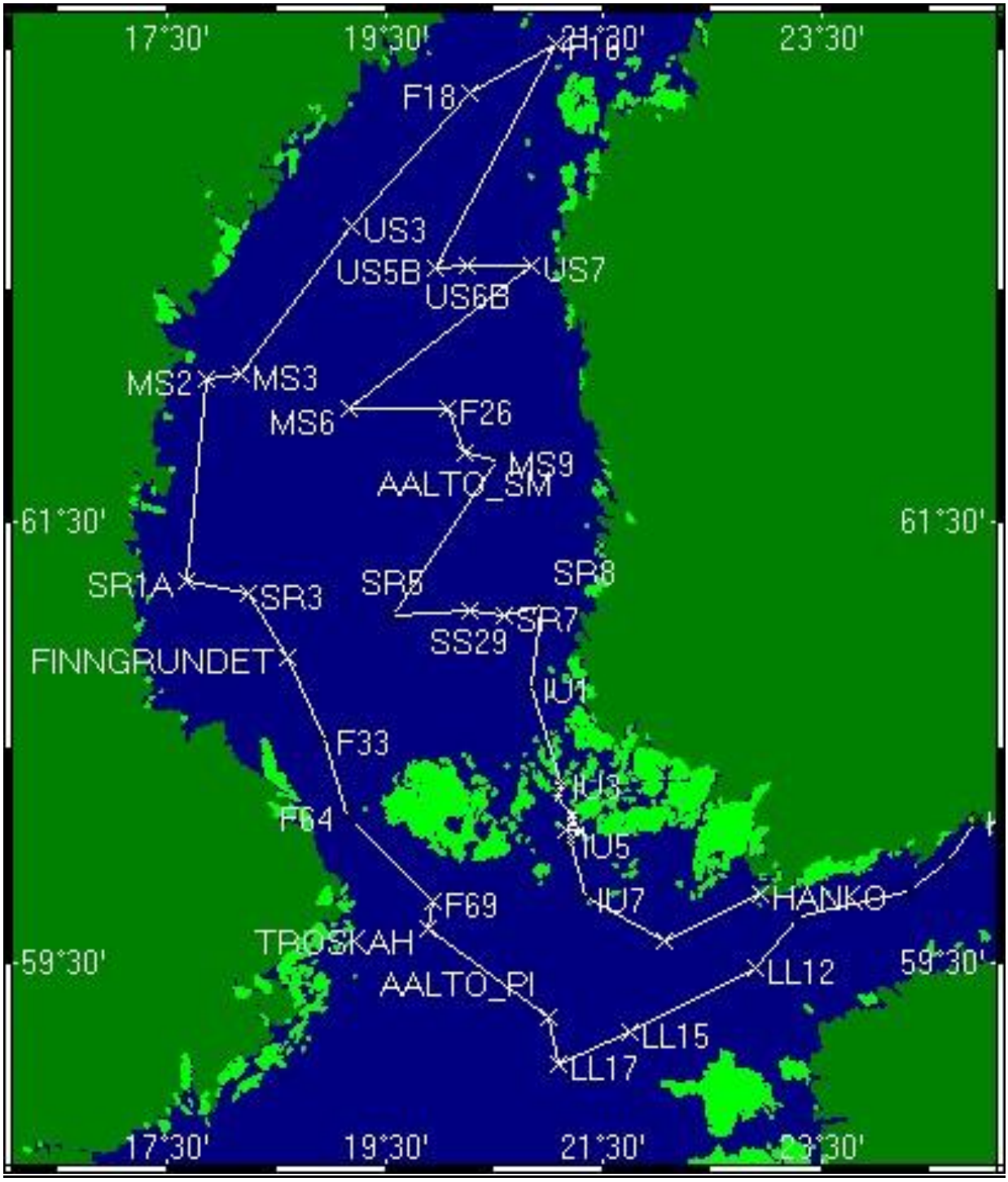

Other results

Validation

Validation of the quality of analysis was carried out at US5bLAATU (200m) on parameters N_{tot}, NH_4-N, NO_{23}-N, P_{tot}, PO_4, SiO_2, O_2. H_2S was validated at L17_LAATU at 100 meters depth.

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