

# CRUISE REPORT



*R/V Aranda*

Cruise 13/2019

COMBINE 3 leg 2  
5.8.2019 – 15.8.2019

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

**Objectives of the cruise**

The objectives of the cruise were:

- 1) Based on the HELCOM Monitoring Programme of the Baltic Sea, to conduct summer monitoring in the Northern Baltic Proper, Åland Sea, Bothnian Sea and Bothnian Bay. Measured parameters were water temperature, salinity, conductivity and oxygen / hydrogen sulfide, silicate and nutrient concentrations.
- 2) Phyto- and zooplankton sampling following the HELCOM monitoring programme;
- 3) Samples were also taken for PAH and oil for later analysis;
- 4) Special sampling for RNA studies of phytoplankton and population genomic analysis of zooplankton;
- 5) Maintenance of the instruments of the Finnish Meteorological Institute (FMI) and recovery of hydrophones of the Finnish Environment Institute (SYKE);
- 6) Intercalibration of hydrography, chemistry, phyto- and zooplankton with the University of Umeå, Sweden

Table 1. The scientific crew

Name	On board	Organization
Kotilainen Pekka	5.-13.8.2019	SYKE
Jalli Heini	5.-16.8.2019	IL
Lastumäki Ilkka	5.-16.8.2019	SYKE
Bruun Jan-Erik	5.-16.8.2019	SYKE
Hällfors Heidi	5.-16.8.2019	SYKE
Kinnunen Tanja	5.-16.8.2019	SYKE
Lehtinen Sirpa	5.-16.8.2019	SYKE
Riikonen Jere	5.-16.8.2019	SYKE
Roine Tuomo	5.-13.8.2019	SYKE
Rosendahl Kirsi	5.-16.8.2019	SYKE
Varmanen Piia	5.-16.8.2019	SYKE
Vuorio Kristiina	5.-13.8.2019	SYKE
Novikova Julia	5.-13.8.2019	Univ.St Petersburg.
Kuznetcova Daria	5.-13.8.2019	Univ.St Petersburg.
Diaz Juanita	5.-13.8.2019	Univ of Michigan

**Cruise Route**

Finnish Environment Institute  
 Agnes Sjöbergin katu 2  
 FI-00790 Helsinki  
 Finland  
<http://www.syke.fi/en>

Finnish Meteorological Institute  
 Erik Palménin aukio 1  
 P.O. Box 503  
 FI-00101 Helsinki  
 Finland  
<http://en.ilmatiiteenlaitos.fi/>

COMBINE 3 leg 1 12/2019 started from Turku on the 5<sup>th</sup> of August and headed to Loviisa – Landsort -transect LL15, LL17 and LL19. Some maintenance was done at the wave buoy of the Northern Baltic Proper, AALTO\_PI. After sampling of the stations TROSKAH, F69, F64, F33 and lifting of an ADCP current meter at MÄRKET\_WH. At the station SR3 an inter-calibration exercise together with the University of Umeå was conducted.

After the intercalibration Aranda headed along the Swedish coast towards the north, MS3, US3, F18, F16 and F13, and all the way to F2 via RR3.

Then CVI, CV, RR6 and RR7 were sampled on the 9<sup>th</sup> of August. BO3 and F15 were the following stations of the Finnish side of the Bothnian Bay. A hydrophone recording underwater noise were recovered outside of Vaasa and cruise continued towards the south via the stations US7, US6b, US5b, MS6, F26, MS9, SR5 and SR7. The transect of the Archipelago Sea were sampled at the stations IU1, IU3, IU5 and IU7. The last station of the 1<sup>st</sup> leg was LL12 south of Hanko. The 1<sup>st</sup> leg of the Cruise ended up to Hanko on the 13<sup>th</sup> of August 2019. The Route of the Cruise can is drawn in Figure 1.

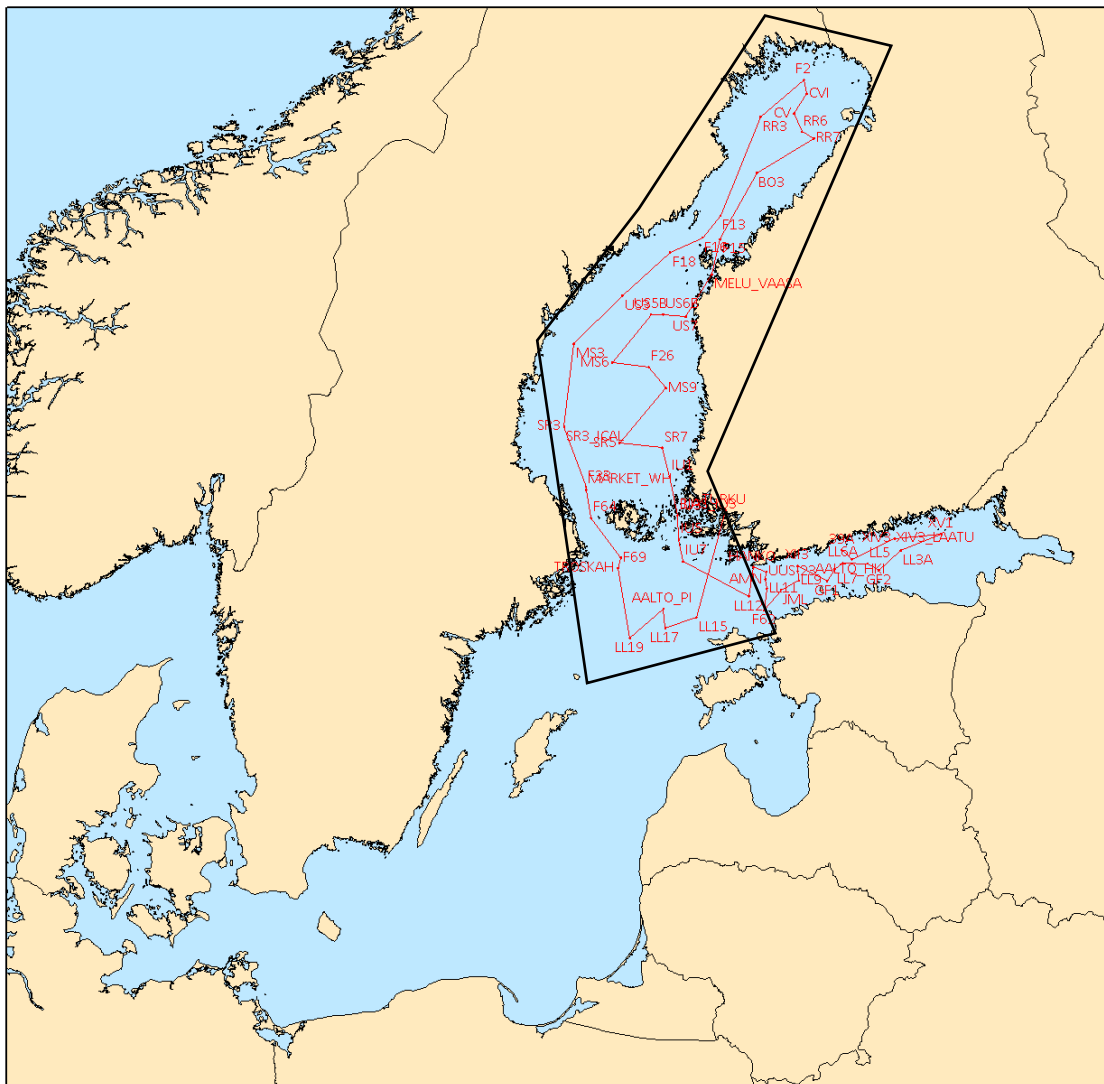


Figure 1. Cruise route of COMBINE 3 leg 2<sup>nd</sup> in August 2019 including the route of the 1<sup>st</sup> leg of the Cruise (framed).

Table 2. A list of stations

INDEX	STATION	latitude	longitude	depth	DATE	time	ctd	pH	ox	nu	ph	zo	be	chl	oil	tox	secchi
START	TURKU	60.44083	22.21908		2019-08-05	08:33											
2019010411	LL15	59.18332	21.74688	129	2019-08-05	19:20	x	x	x	x				x			
2019010412	LL17	59.03340	21.07957	173	2019-08-06	01:18	x	x	x	x	x	x		x	x	x	
2019010413	AALTO_PI	59.24978	20.99648	95	2019-08-06	04:54											
2019010414	LL19	58.88067	20.31068	165	2019-08-06	09:22	x	x	x	x	x	x		x	x	x	x
2019010415	TROSKAH	59.65995	19.88370	37	2019-08-06	16:54	x	x	x	x				x			x
2019010416	F69	59.78340	19.93005	189	2019-08-06	18:44	x	x	x	x				x			x
2019010417	F64	60.18903	19.14247	281	2019-08-07	00:06	x	x	x	x	x	x		x	x	x	
2019010418	MÄRKET_WH	60.49957	18.94862	128	2019-08-07	05:57											
2019010419	F33	60.53318	18.93785	131	2019-08-07	07:06	x	x	x	x				x			x
2019010420	SR3	61.18327	18.23013	71	2019-08-07	14:10	x	x	x	x	x	x		x			
2019010421	SR3_ICAL	61.18328	18.23013	71	2019-08-07	15:45		x	x	x	x			x			
2019010422	MS3	62.13438	18.16247	81	2019-08-07	22:04	x	x	x	x				x			
2019010423	US3	62.75888	19.19567	171	2019-08-08	03:52	x	x	x	x							x
2019010424	F18	63.31432	20.27267	99	2019-08-08	09:28	x	x	x	x				x			x
2019010425	F16	63.51678	21.06315	48	2019-08-08	13:23	x	x	x	x	x	x		x			x
2019010426	F13	63.78343	21.47938	62	2019-08-08	16:42	x	x	x	x				x			x
2019010427	RR3	64.93358	22.34577	91	2019-08-09	00:49	x	x	x	x		x					
2019010428	F2	65.38355	23.46248	82	2019-08-09	05:49	x	x	x	x	x	x			x	x	x
2019010429	CVI	65.23357	23.56255	67	2019-08-09	09:25	x	x	x	x				x			x
2019010430	CV	65.00028	23.24602	84	2019-08-09	12:05	x	x	x	x				x			x
2019010431	RR6	64.80022	23.47940	83	2019-08-09	15:04	x	x	x	x							x
2019010432	RR7	64.73360	23.81277	38	2019-08-09	17:15	x	x	x	x				x			x
2019010433	BO3	64.30188	22.34288	107	2019-08-09	22:44	x	x	x	x	x	x		x	x	x	
2019010434	F15	63.51687	21.51295	47	2019-08-10	06:05	x	x	x	x				x			x
2019010435	MELU_VAASA	63.11042	21.39182	14	2019-08-10	12:58											
2019010436	US7	62.60020	20.82958	26	2019-08-10	19:11	x	x	x	x				x			
2019010437	US6B	62.60023	20.26272	80	2019-08-10	21:32	x	x	x	x				x			
2019010438	US5B	62.58625	19.96837	217	2019-08-11	00:01	x	x	x	x	x	x			x	x	x
2019010439	MS6	61.98372	19.16342	71	2019-08-11	08:12	x	x	x	x							x
2019010440	F26	61.98360	20.06287	135	2019-08-11	11:43	x	x	x	x							x
2019010441	MS9	61.76700	20.53045	99	2019-08-11	15:33	x	x	x	x							x
2019010442	SR5	61.08298	19.58022	123	2019-08-11	21:43	x	x	x	x	x	x		x	x	x	
2019010443	SR7	61.08355	20.59650	76	2019-08-12	02:52	x	x	x	x				x			x
2019010444	IU1	60.76697	20.84683	31	2019-08-12	06:11	x	x	x	x				x			x
2019010445	BIAS_IU3	60.33528	21.11218	52	2019-08-12	11:25											
2019010446	IU3	60.33352	21.11353	50	2019-08-12	11:44	x	x	x	x							x
2019010447	IU5	60.05827	21.19833	87	2019-08-12	15:30	x	x	x	x				x			x
2019010448	IU7	59.81527	21.33663	90	2019-08-12	18:41	x	x	x	x	x	x		x			x
2019010449	LL12	59.48350	22.89690	80	2019-08-13	02:07	x	x	x	x	x	x		x	x	x	
END	HANKO	59.82100	22.95370		2019-08-13	09:55											

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

## **Conclusions**

### **Hydrography**

Hypoxia occurred in the Northern Baltic Proper below 60 meters depth (stations LL12-LL19, Figures 2-6).

Some flow of saline water from the Baltic Proper to the Bothnian Sea might have occurred.

### **Nutrients**

Higher phosphate concentrations were observed through the cruise in each basin (Northern Baltic Proper, Bay of Bothnia and in the Archipelago Sea) in August 2019 than in average in August 2010-2017 (Figures 34-66).

Dissolved nitrogen concentrations ( $\text{NH}_4$ ,  $\text{NO}_{2,3}$ ,  $\text{NO}_2$ ) were higher in August 2019 in the Northern Baltic Proper and in the Southern part of the Archipelago Sea (stations IU5 and IU7) than in average in August, indicating strong upwelling of the dissolved nutrients.

Observed concentrations of total nutrients ( $\text{N}_{\text{tot}}$  and  $\text{P}_{\text{tot}}$ ) were also higher in August 2019 than in average in summer (2000-2017).

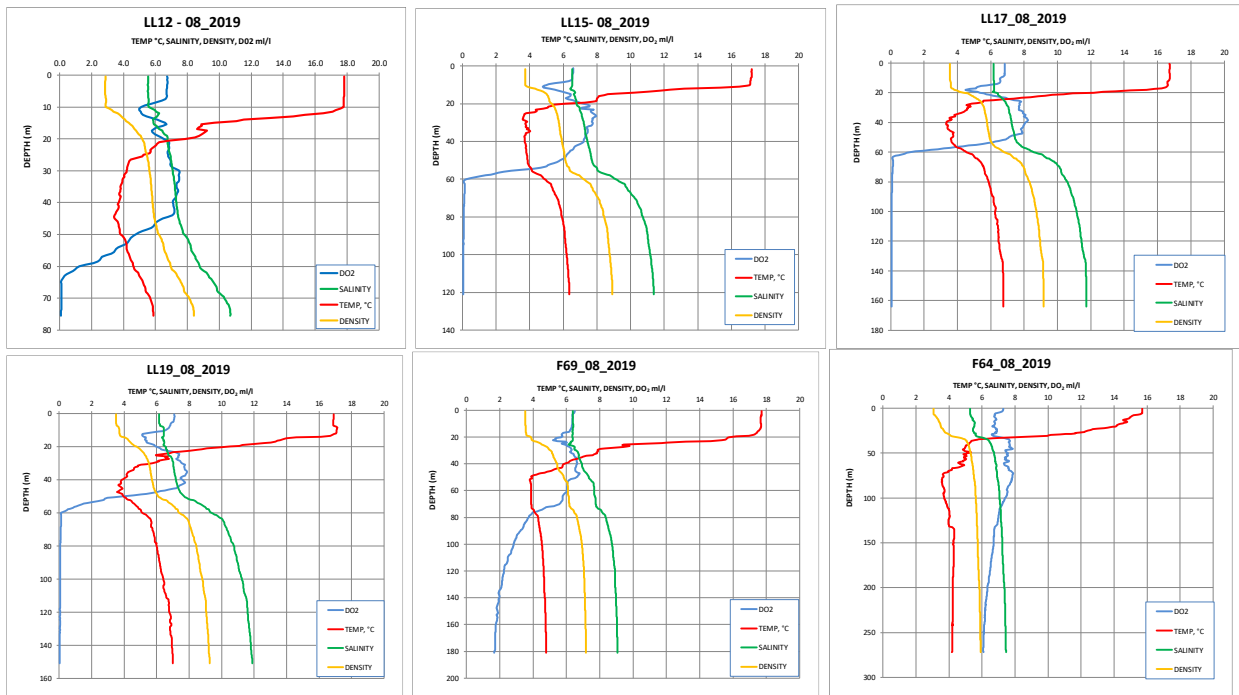
### **Chlorophyll a**

Fairly high chl a concentrations were observed in the Northern Baltic Proper compared with the previous years (Figures 221-241).

**Annex 1.** Observed DO<sub>2</sub>, temperature, salinity and density at the stations LL12, LL15, LL17, LL19, F69, F64, F33, SR7, SR5, SR3, SR3\_ICAL, F26, MS9, MS6, MS3, US7, US6B, US3, F18, F16, F13, F15, RR3, F2, CVI, CV, RR6, RR7, BO3, IU1, IU3, IU5 and IU7.

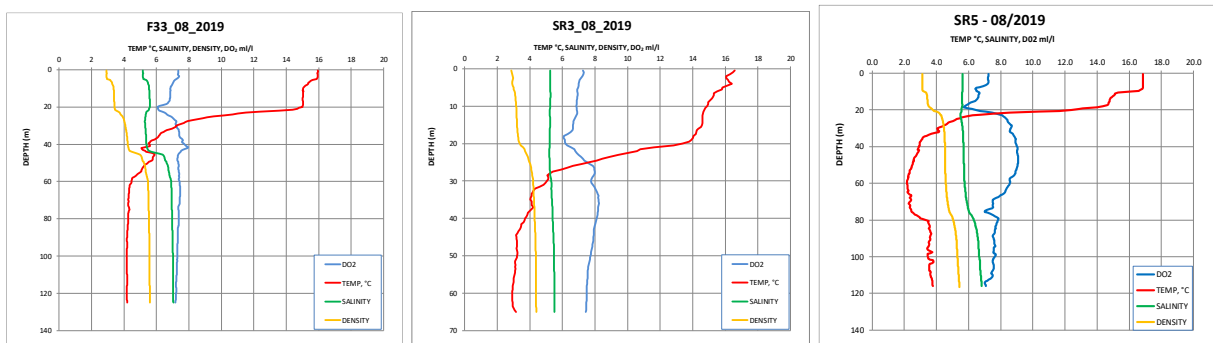
## Hydrography

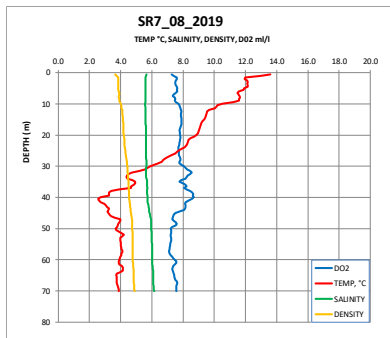
### The Northern Baltic Proper



Figures 2-6. Oxygen, temperature, salinity and density profiles at LL12, LL15, LL17, LL19, F69 and F64 In August 2019.

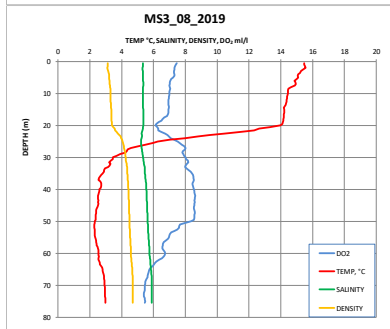
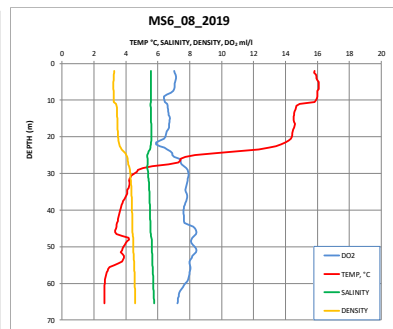
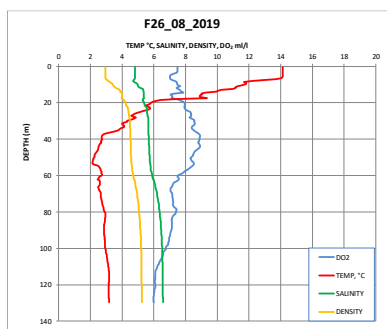
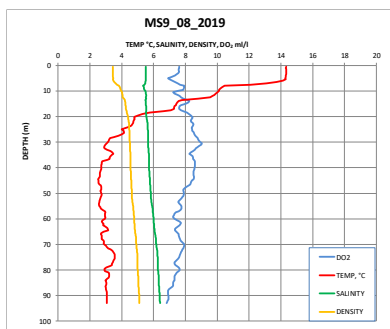
### Southern Bothnian Sea





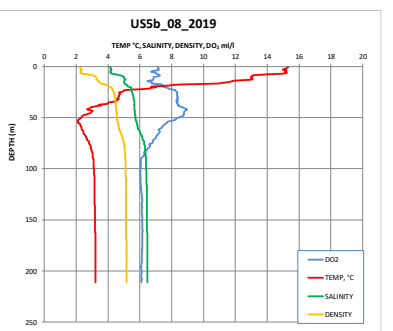
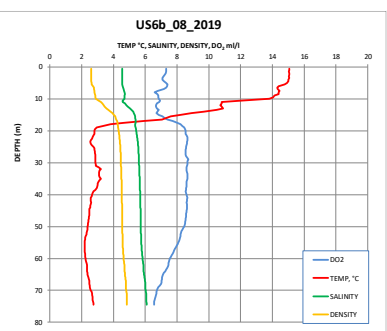
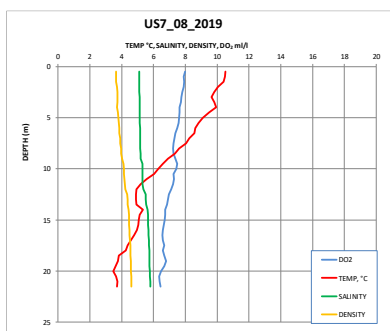
Figures 7-10. Oxygen, temperature, salinity and density profiles at F33, SR3, SR5 and SR7 in August 2019.

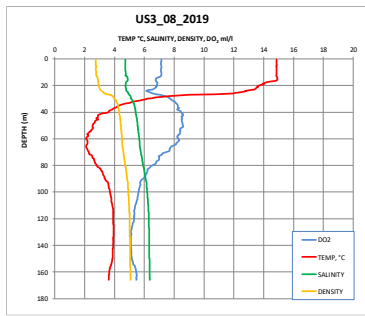
## Middle Bothnian Sea



Figures 11-14. Oxygen, temperature, salinity and density profiles at MS9, F26, MS6 and MS3 in August 2019.

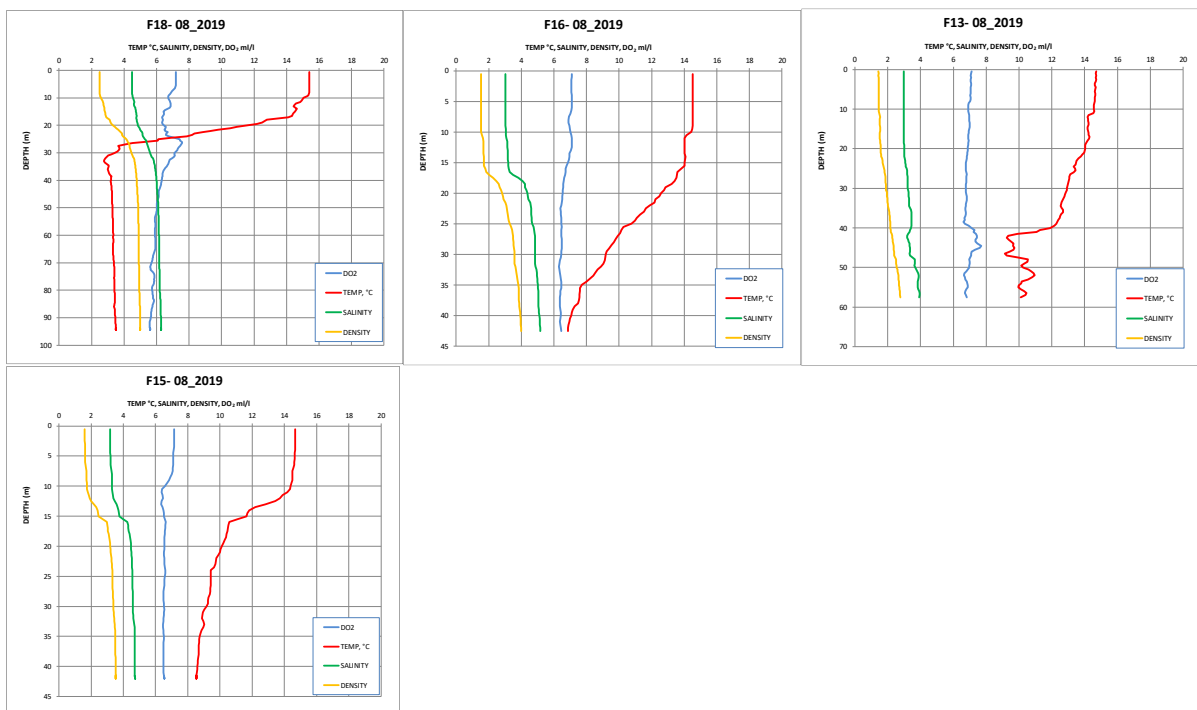
## Northern Bothnian Sea





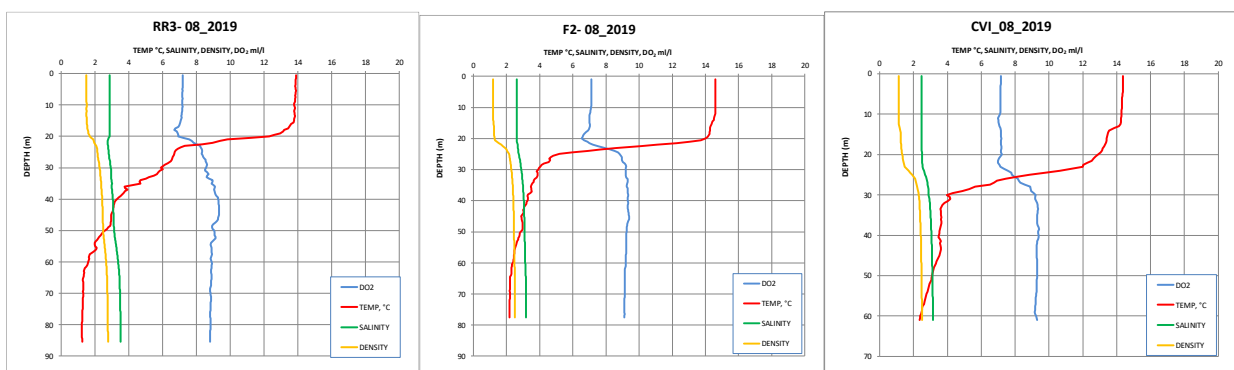
Figures 15-18. Oxygen, temperature, salinity and density profiles at US7, US6b, US5b and US3 in August 2019.

## Kvarken

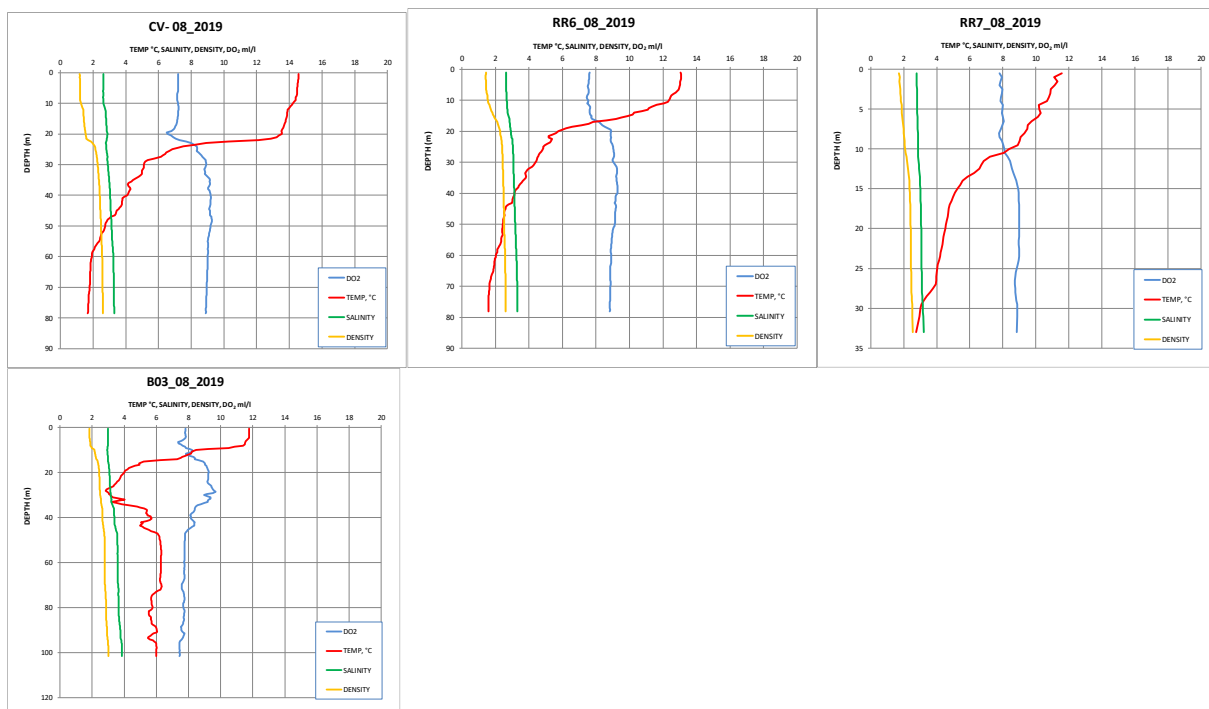


Figures 19-22. Oxygen, temperature, salinity and density profiles at F18, F16, F13 and F15 in August 2019.

## Bothnian Bay

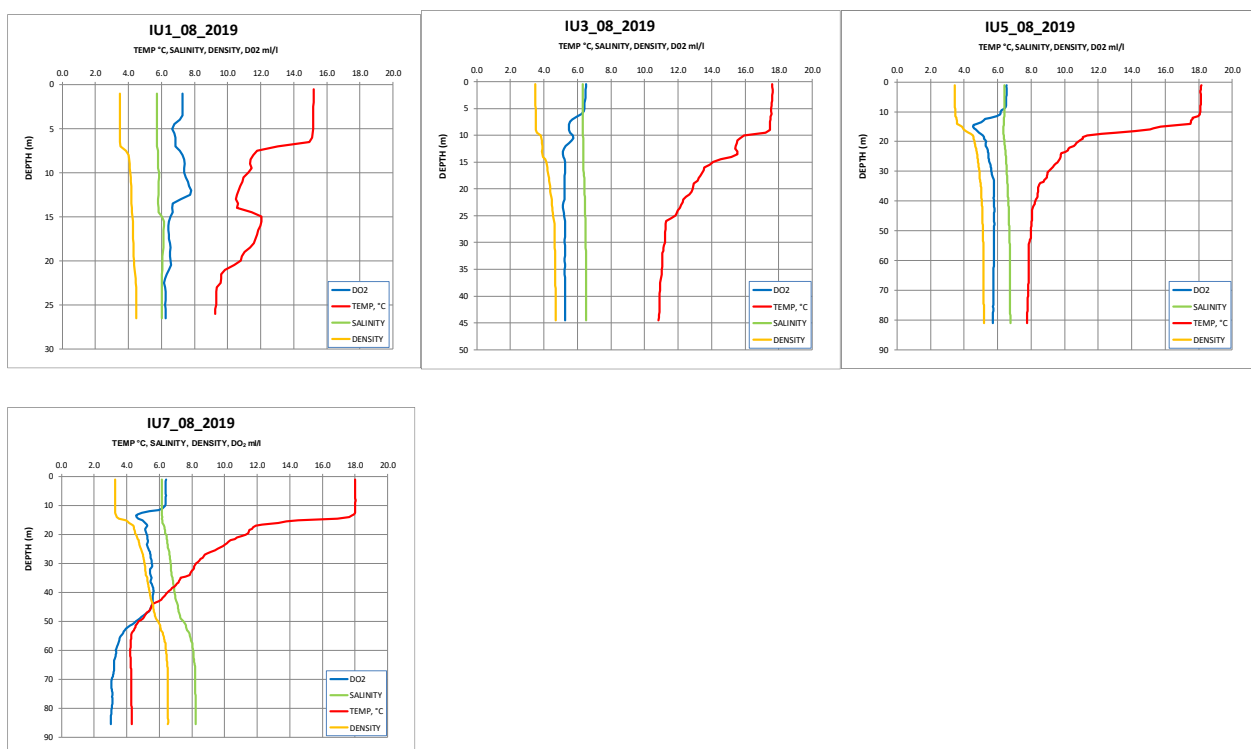






Figures 23-29. Oxygen, temperature, salinity and density profiles at RR3, F2, CVI, CV, RR6, RR7 and B03 in August 2019.

## The Archipelago Sea



Figures 30-33. Oxygen, temperature, salinity and density profiles at IU1, IU3, IU5 and IU7 in August 2019.

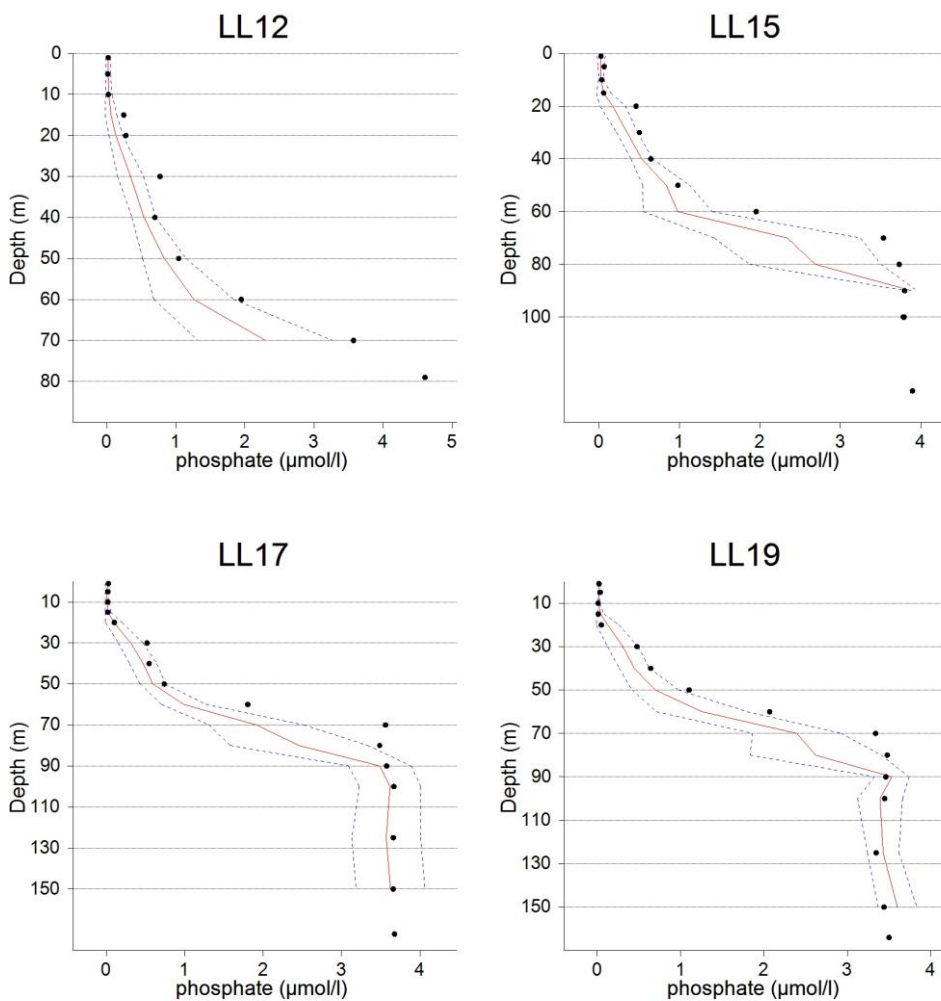
## Nutrients and Chlorophyll a

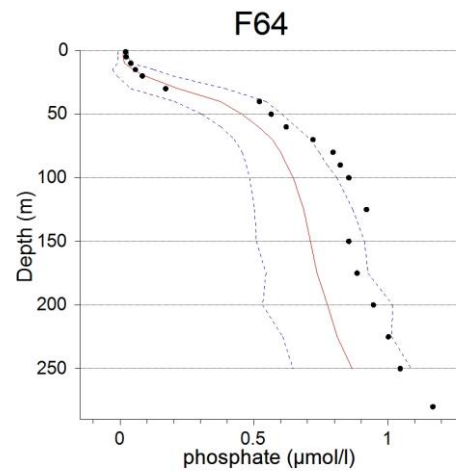
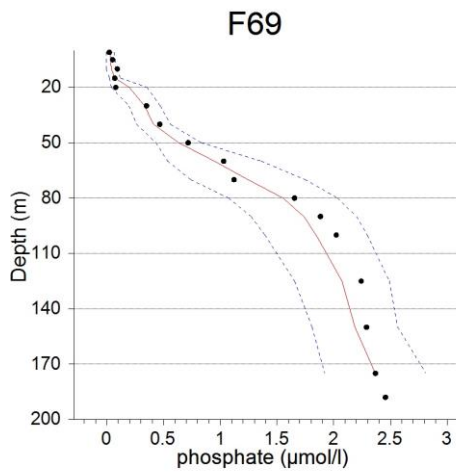
Dissolved nutrient concentrations ( $\text{PO}_4\text{-NH}_4\text{-N}$ ,  $\text{NO}_{2,3}\text{-N}$  and  $\text{NO}_2\text{-N}$ ), total nutrients ( $\text{P}_{\text{tot}}$ ,  $\text{N}_{\text{tot}}$ ) were measured at depths, 1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 125, 150, 175, 200, 225 and 250 meters depending on total depth at the following stations: LL12, LL15, LL17, LL19, F69, F64, F33, SR3, SR3\_ICAL, MS3, US3, F18, F16, F13, RR3, F2, CVI, CV, RR6, RR7, BO3, F15, US7, US6B, US5B, MS6, F26, MS9, SR5, SR7, IU1, IU3, IU5 and IU7. Black dots show observed data, red solid line represents summer average of 2000-2017 and blue dotted line stands for standard deviation of the data collected in August 2000-2017. Also chlorophyll a concentrations were measured in the productive layer (1, 5, 10, 15 and 20m) at some stations. Data have been presented in Figures 34-241.

### Nutrients

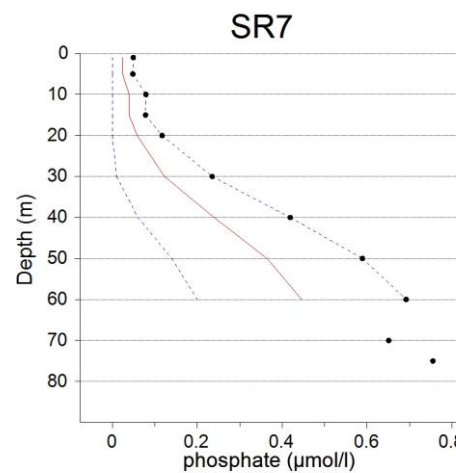
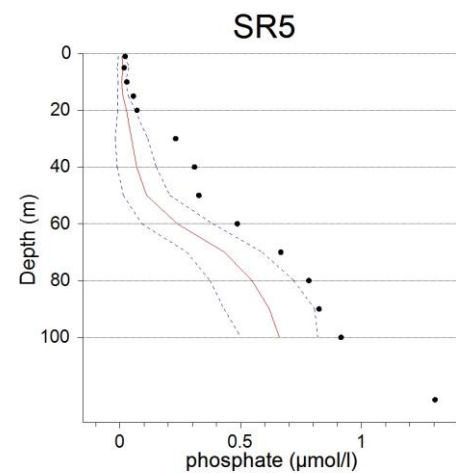
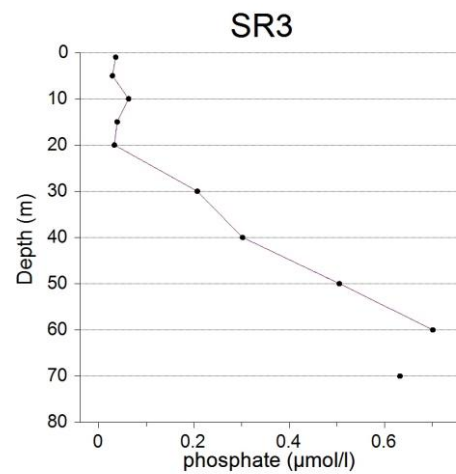
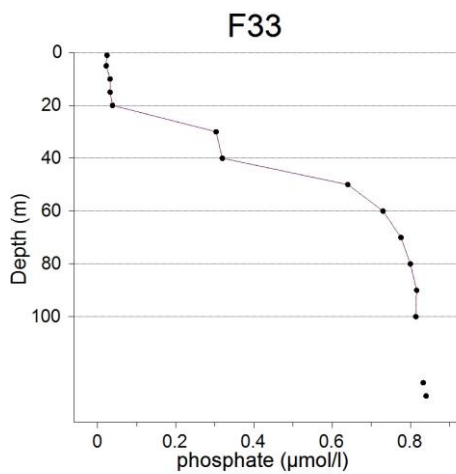
#### Phosphate, $\text{PO}_4$

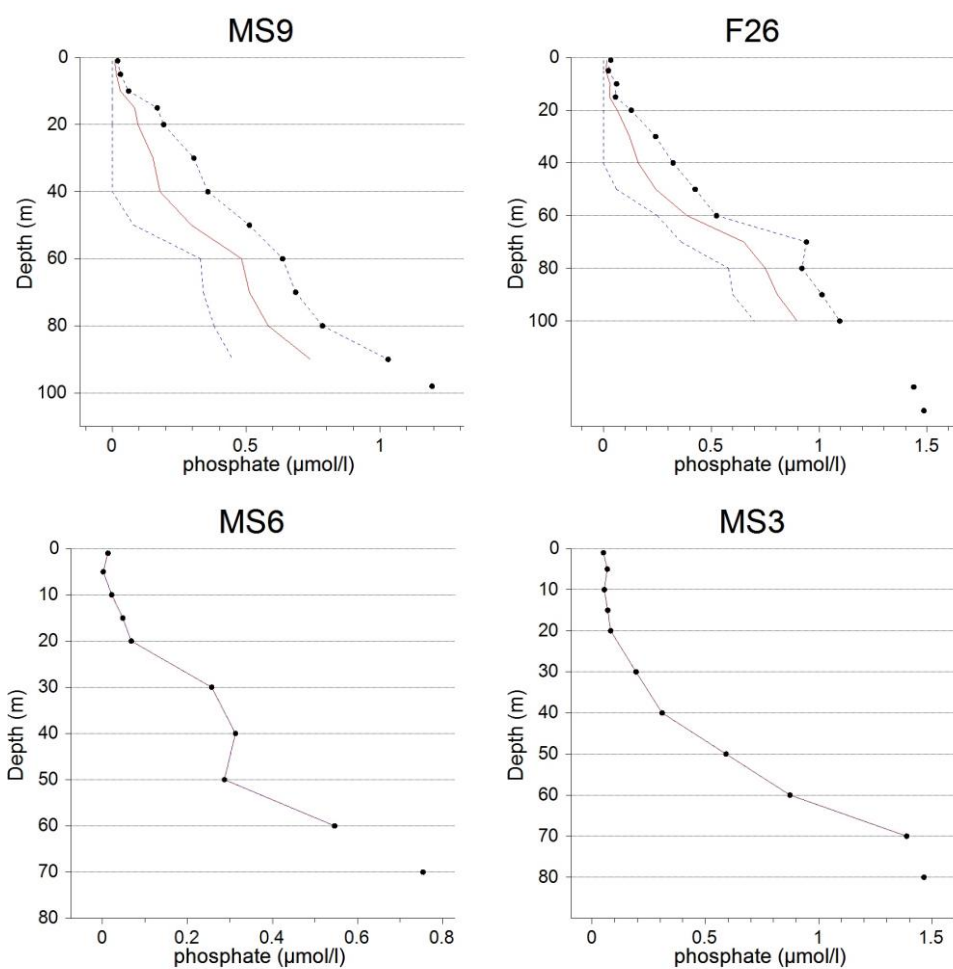
Higher  $\text{PO}_4$  -concentrations were observed in summer 2019 than the long-term averages in summer 2000-2017.



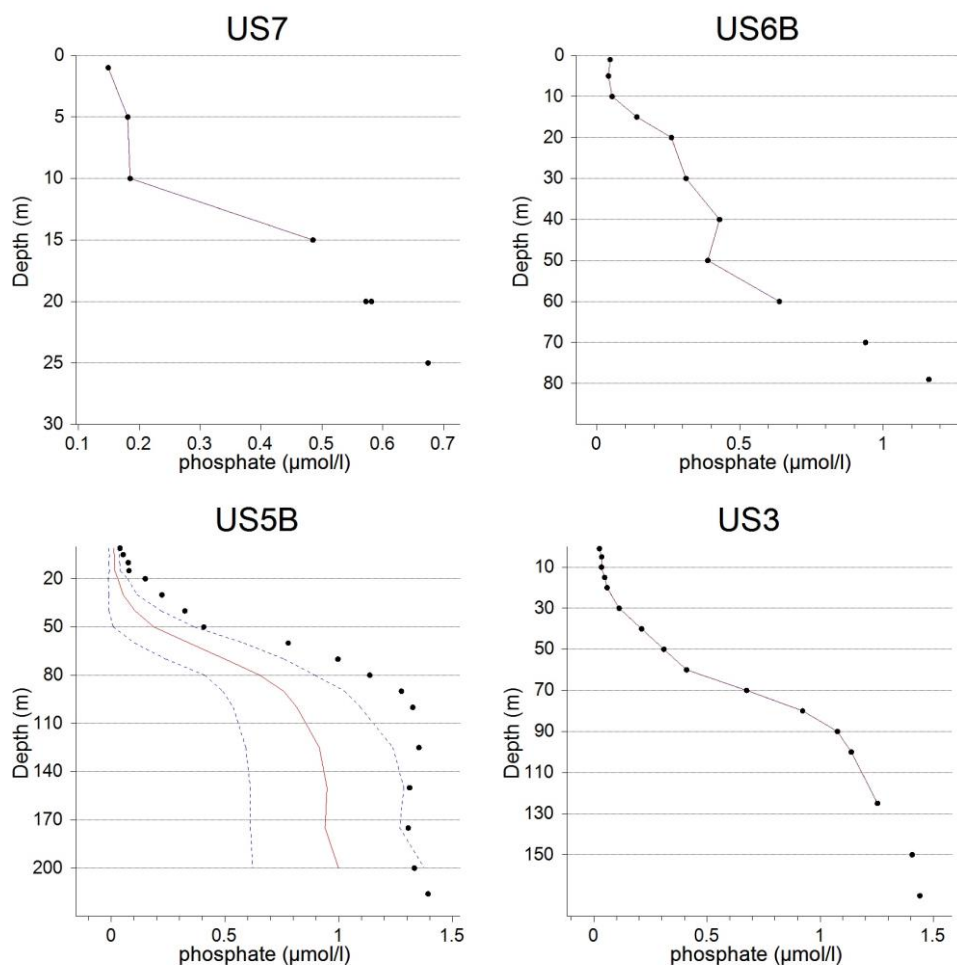


Figures 34-39. Observed  $\text{PO}_4$  -concentrations and average summer  $\text{PO}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in the Northern Baltic Proper at LL12, LL15, LL17, LL19, F69 and F64 in August 2019.

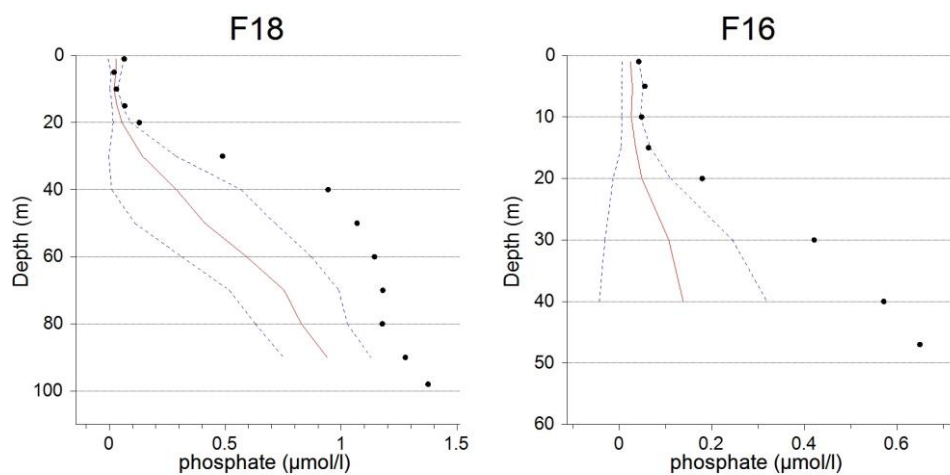


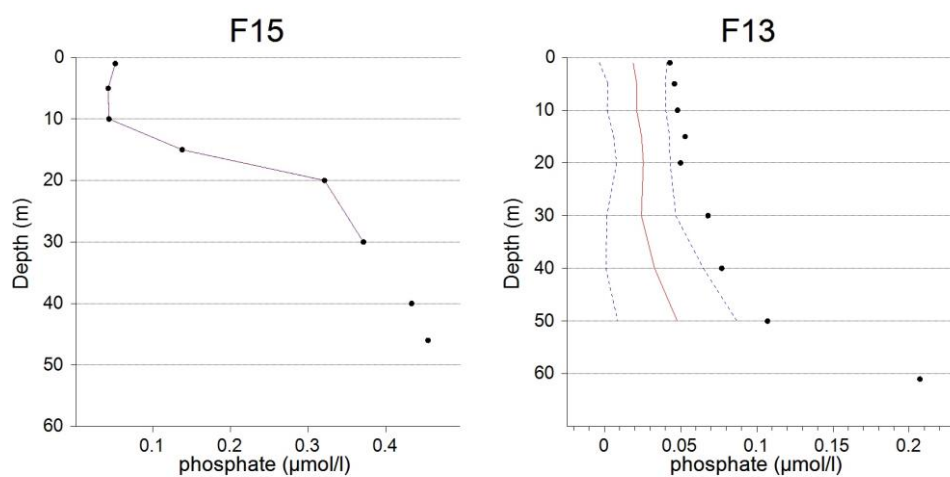


Figures 40-47. Observed  $\text{PO}_4$  -concentrations and average summer  $\text{PO}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in the Southern Part of the Bothnian Sea at F33, SR3, SR7, MS9, MS6, MS3 and F26 in August 2019.

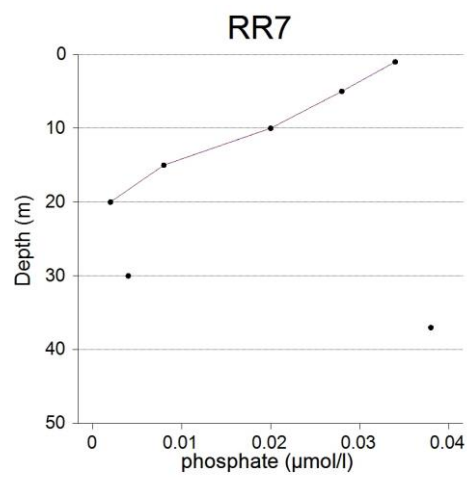
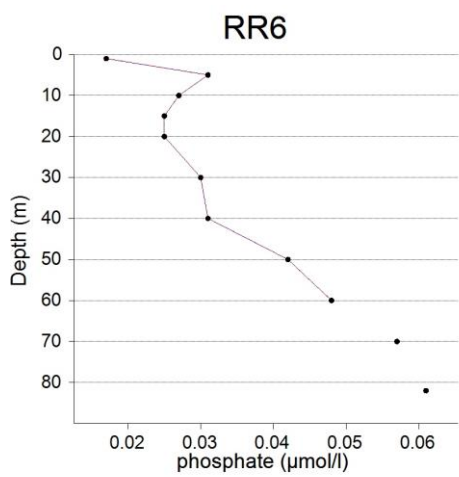
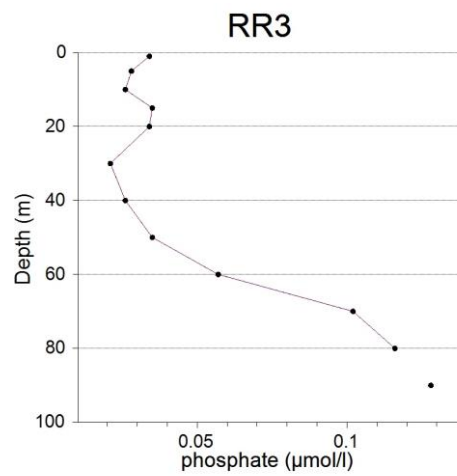
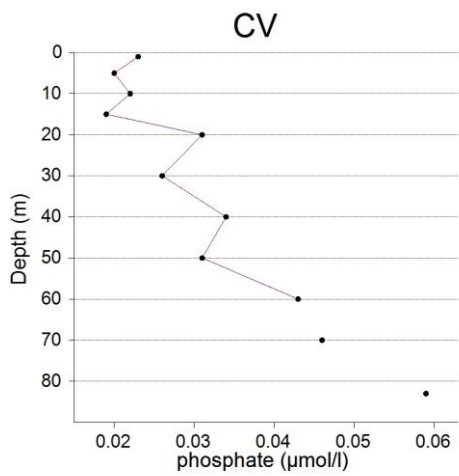
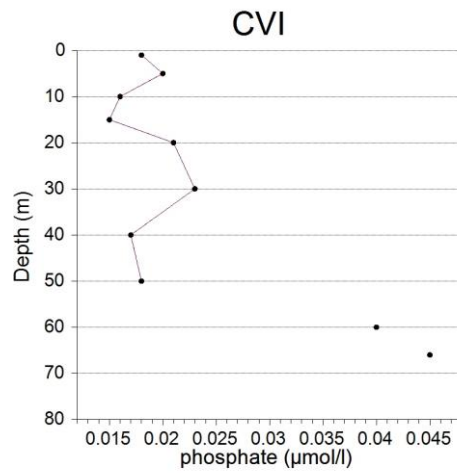
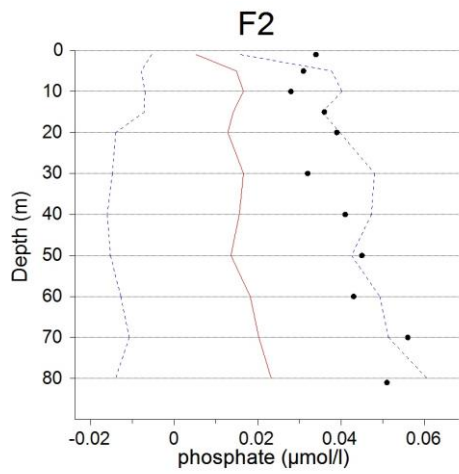


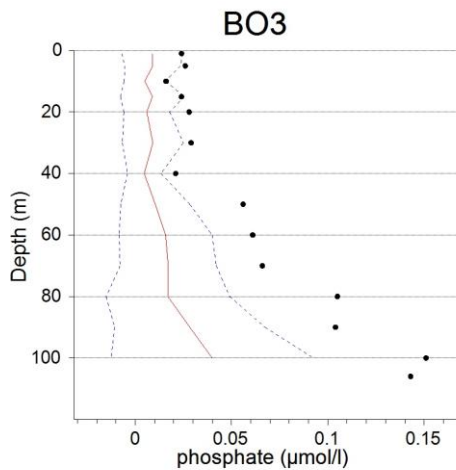
Figures 48-51. Observed PO<sub>4</sub> -concentrations and average summer PO<sub>4</sub> -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in the Northern Part of the Bothnian Sea at US7, US6, US5b and US3 in August 2019.



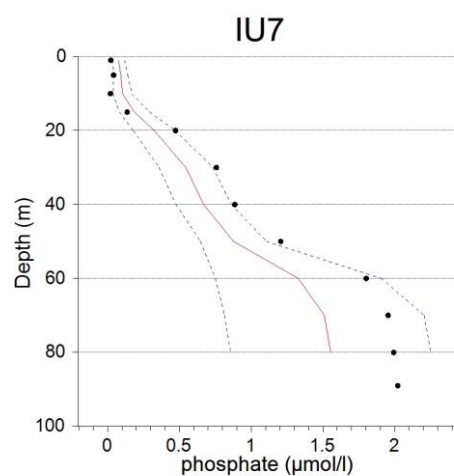
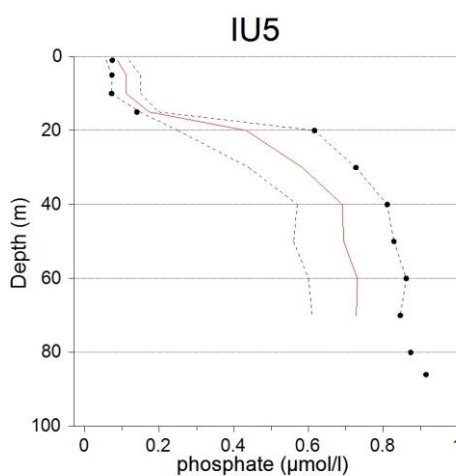
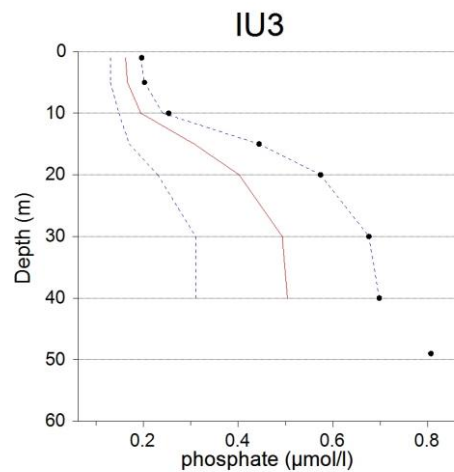
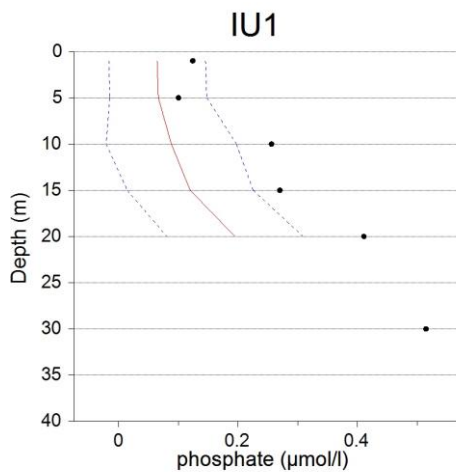


Figures 52-55. Observed  $\text{PO}_4$  -concentrations and average summer  $\text{PO}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in Kvarken at stations F18, F16, F15 and F13 in August 2019.





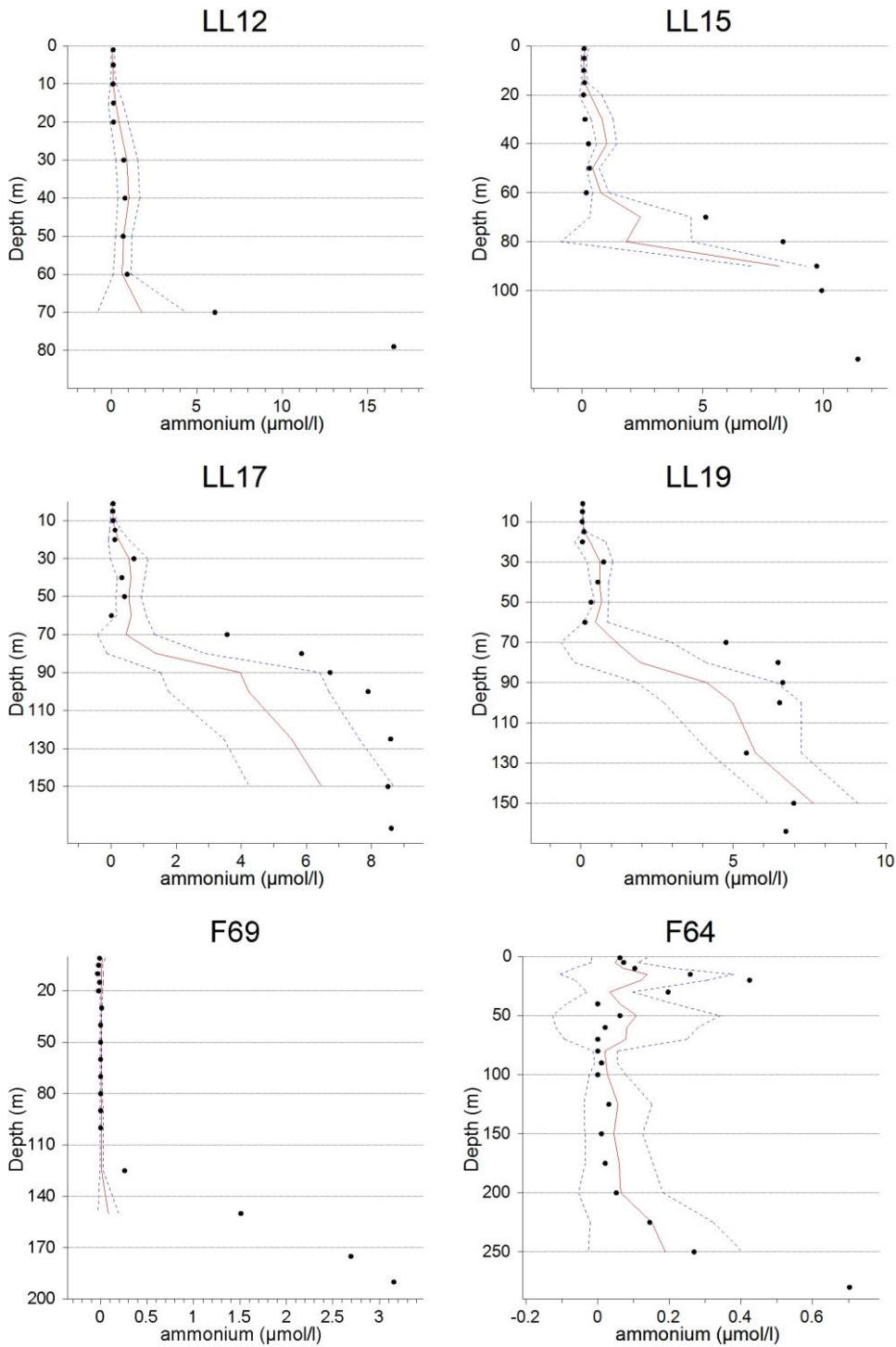
Figures 56-62. Observed  $\text{PO}_4$  -concentrations and average summer  $\text{PO}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Bay at stations F2, CV, CVI, RR3, RR6, RR7 and BO3 in August 2019.



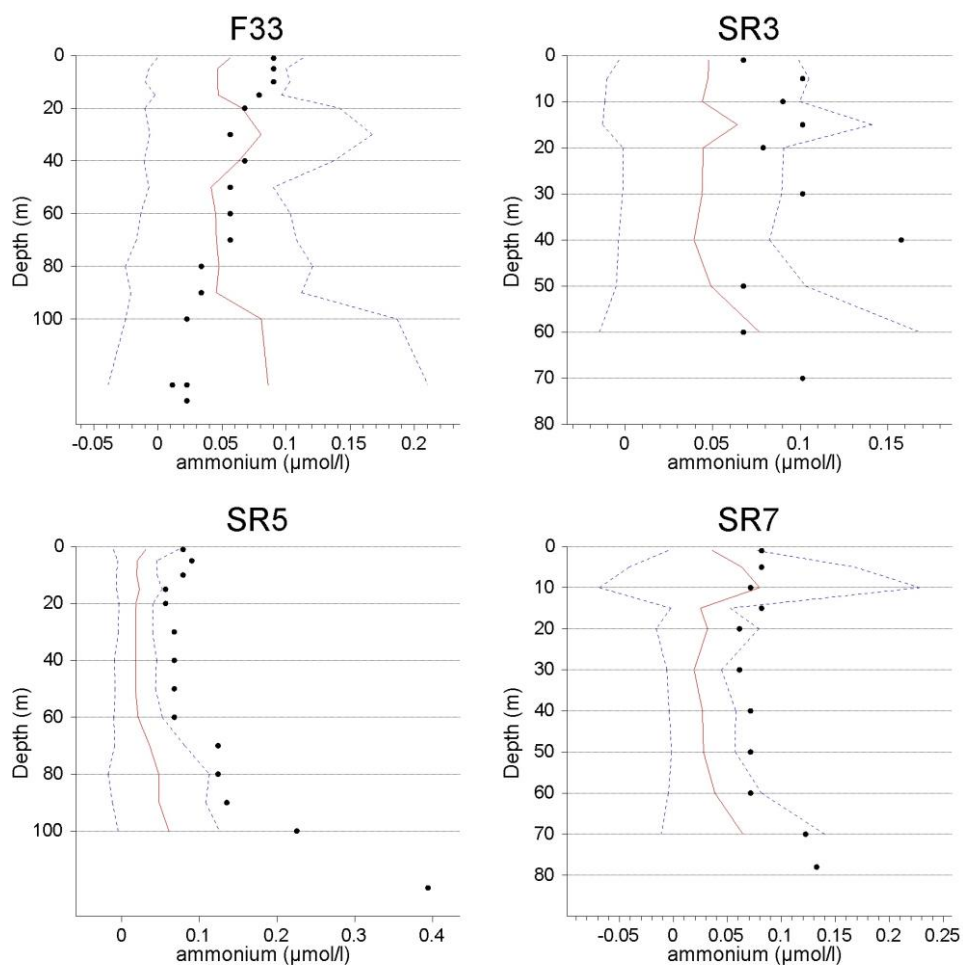
Figures 63-66. Observed  $\text{PO}_4$  -concentrations and average summer  $\text{PO}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in the Archipelago Sea at stations IU1, IU3, IU5 and IU7 in August 2019.



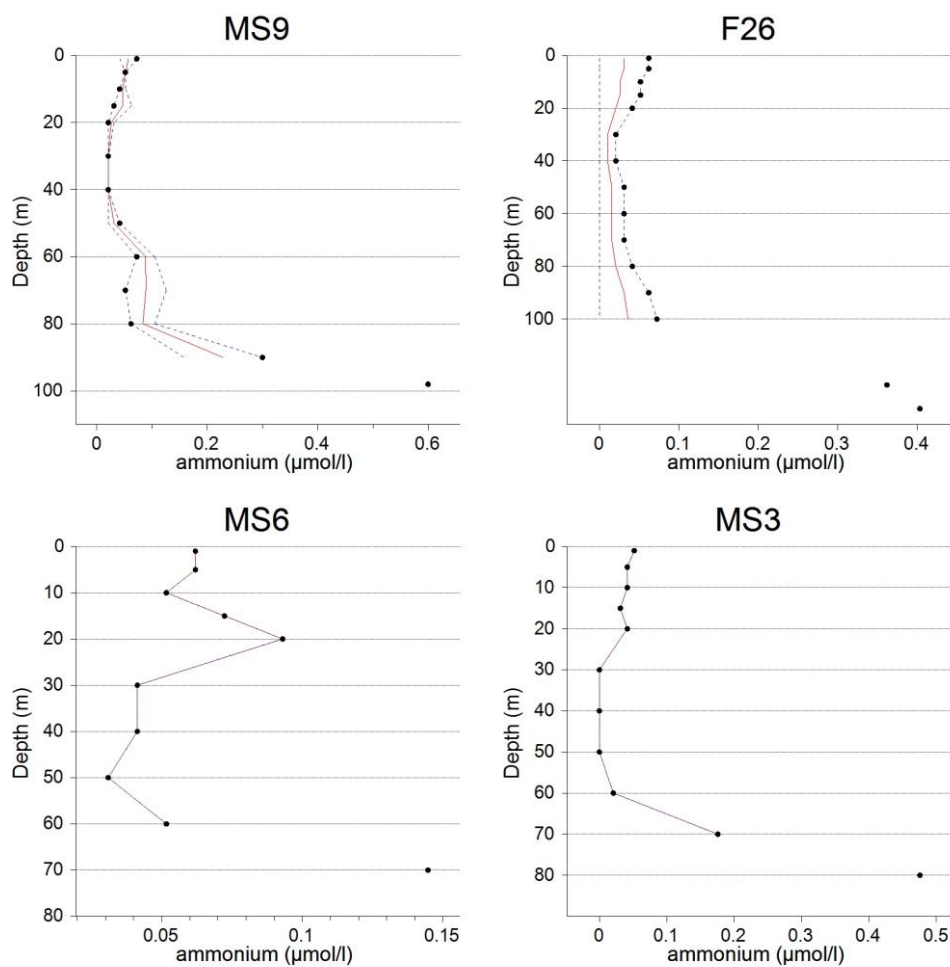
## Ammonium



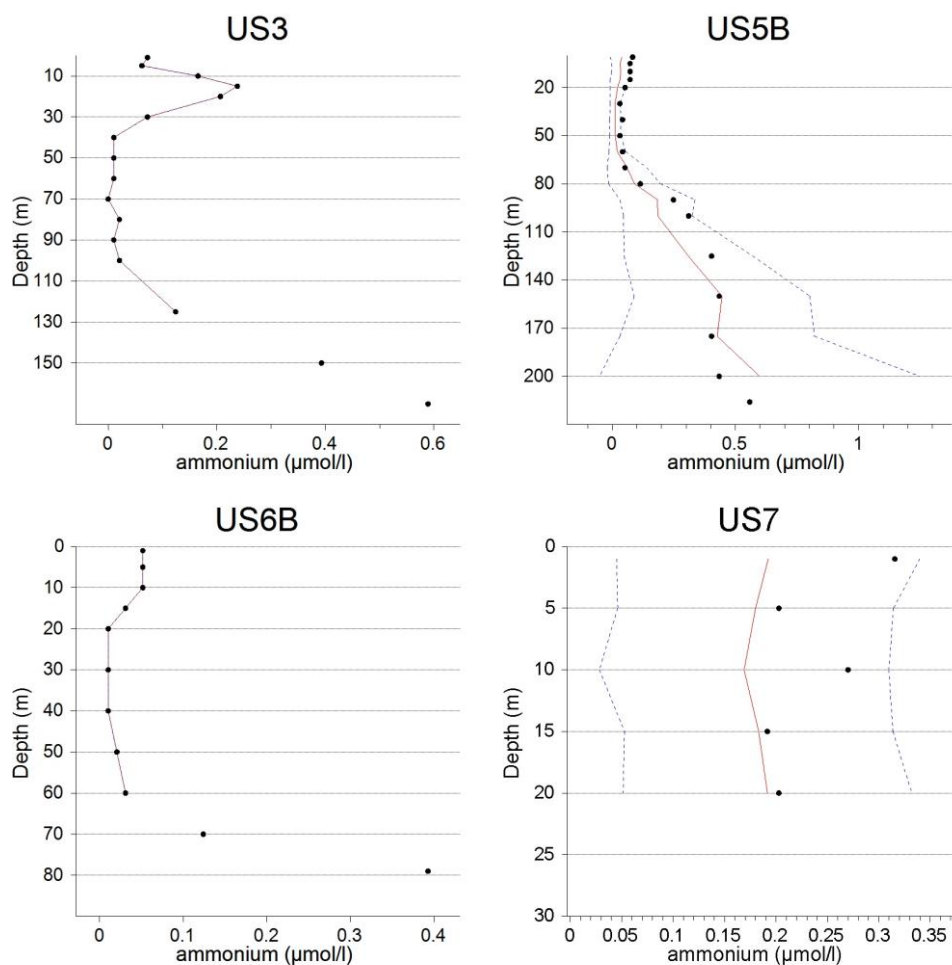
Figures 67-72. Observed  $\text{NH}_4$  -concentrations and average summer  $\text{NH}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in the Northern Baltic Proper at LL12, LL15, LL17, LL19, F69 and F64 in August 2019.



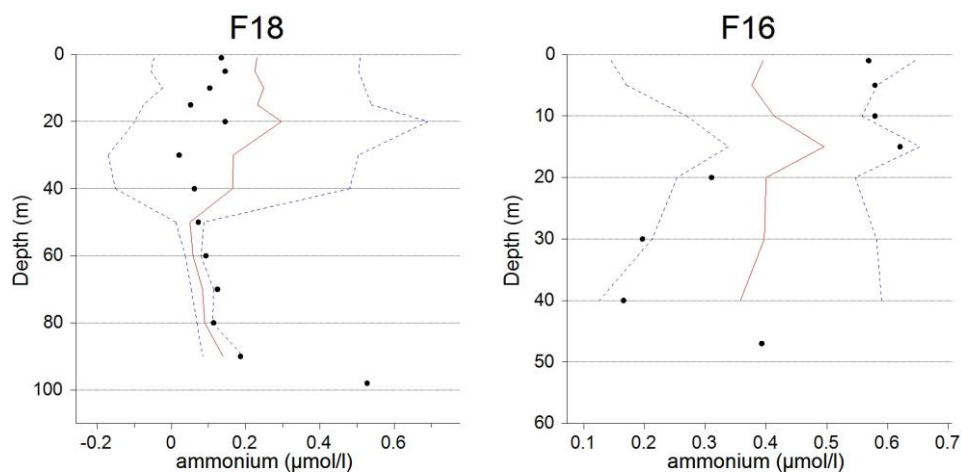
Figures 73-76. Observed  $\text{NH}_4$  -concentrations and average summer  $\text{NH}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in the Southern part of the Bothnian Sea at F33, SR3, SR5 and SR7 in August 2019.

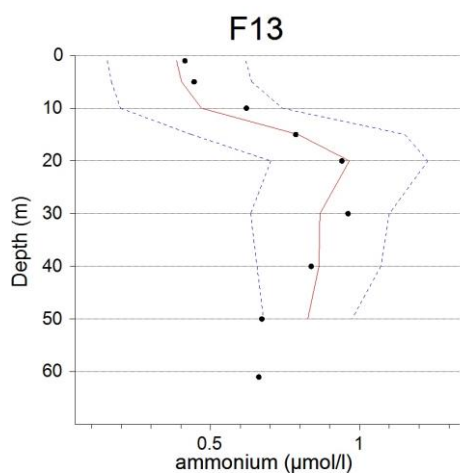
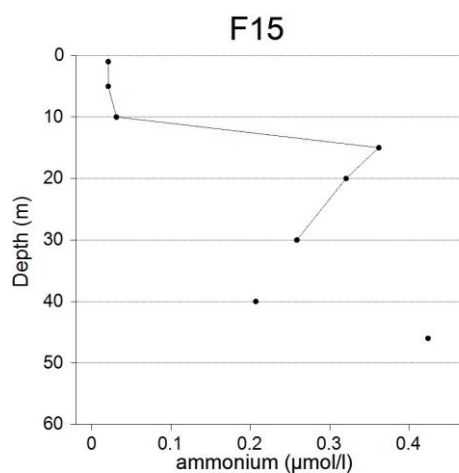


Figures 77-80. Observed  $\text{NH}_4$  -concentrations and average summer  $\text{NH}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Sea at MS9, F26, MS6 and MS3 in August 2019.

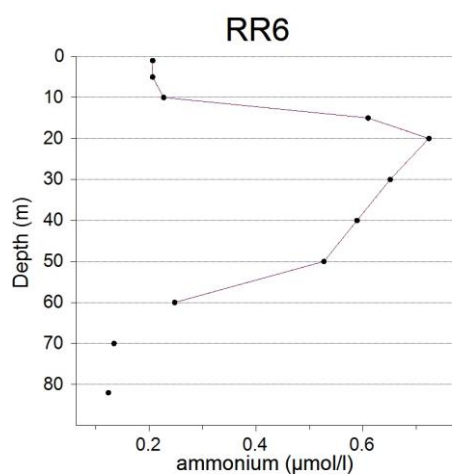
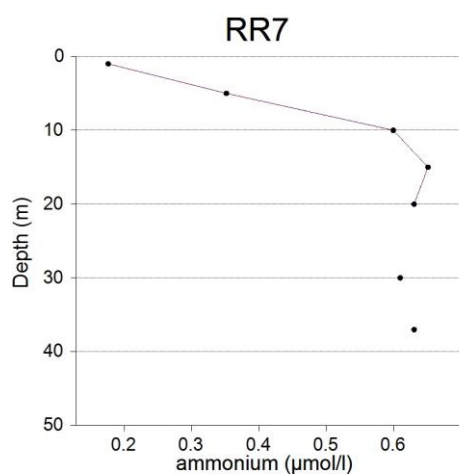
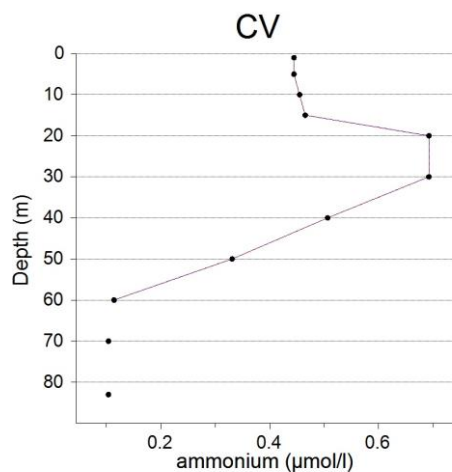
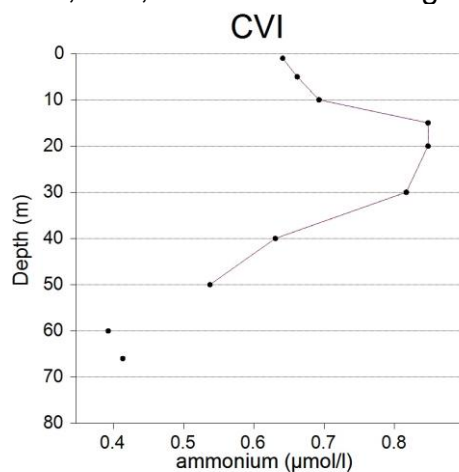


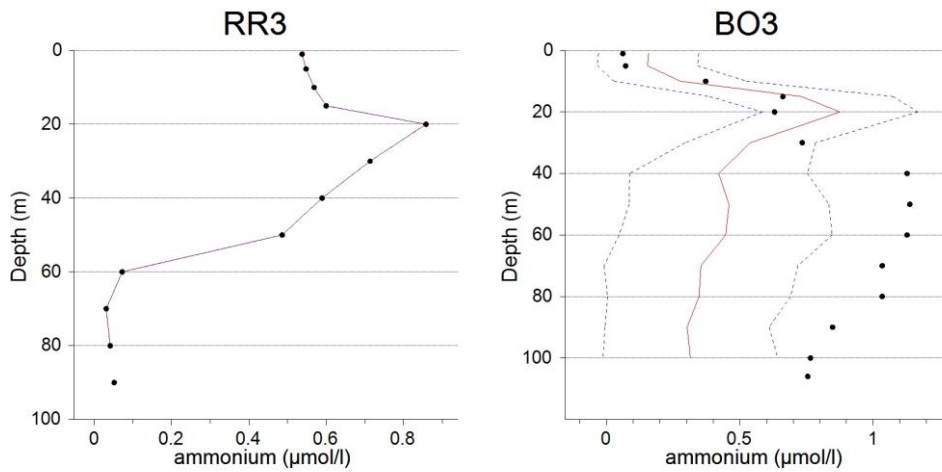
Figures 81-84. Observed  $\text{NH}_4$  -concentrations and average summer  $\text{NH}_4$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern part of the Bothnian Sea at US3, US5b, US6b and US7 in August 2019.



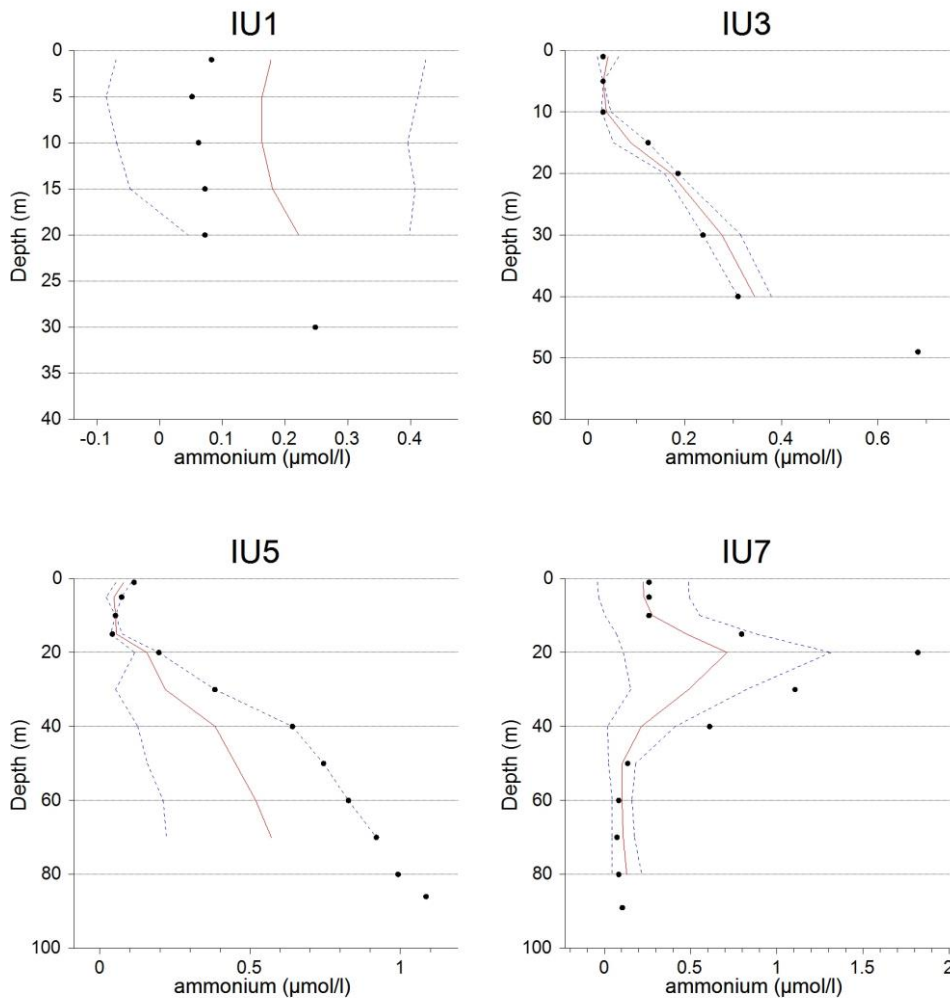


Figures 85-88. Observed  $\text{NH}_4$  -concentrations and average summer  $\text{NH}_4$  -concentrations since year 2000 (red line) and standard deviations (dotted blue line) in  $\text{NH}_4$  in Kvarken at F18, F16, F15 and F13 in August 2019.

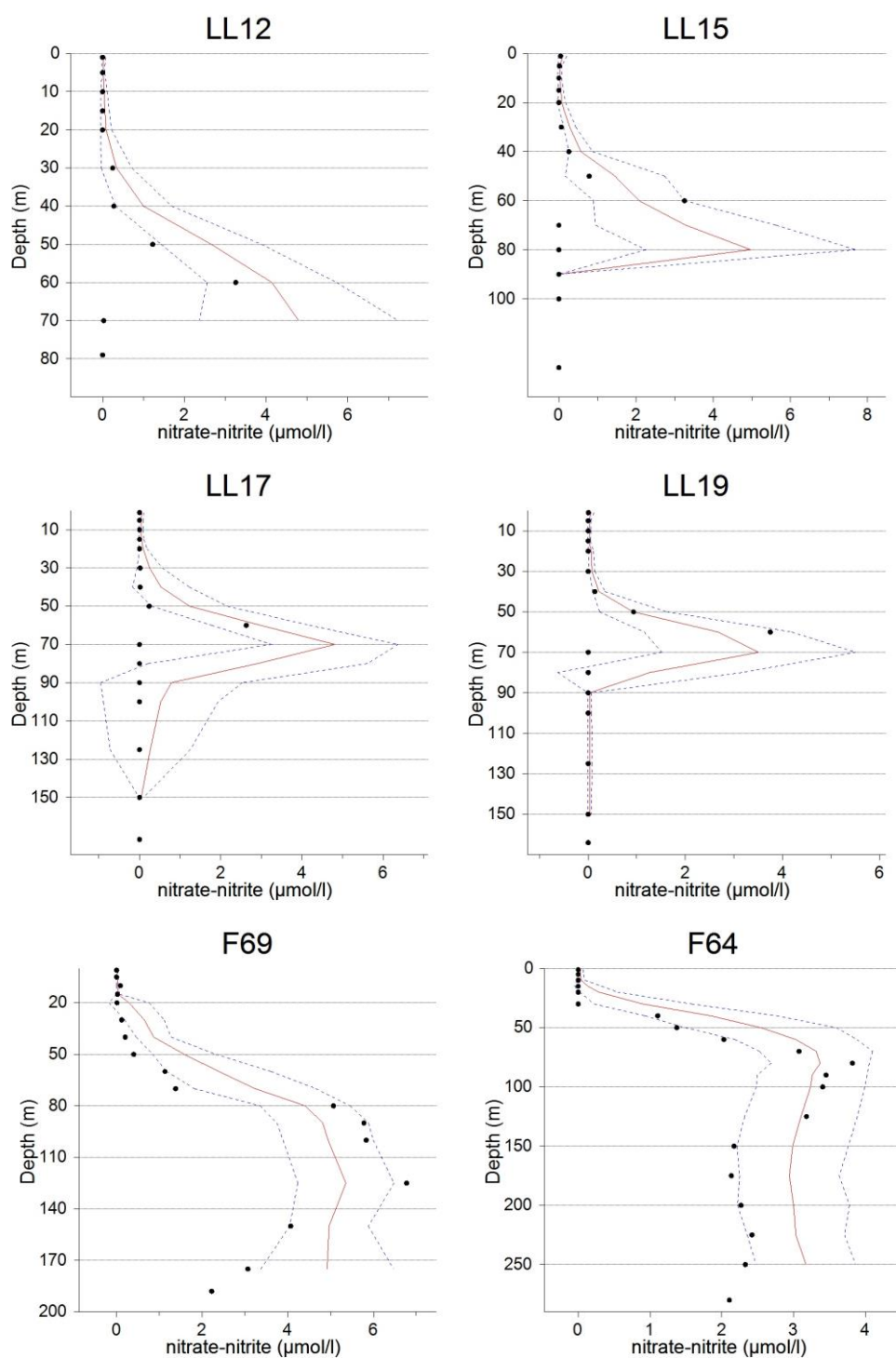




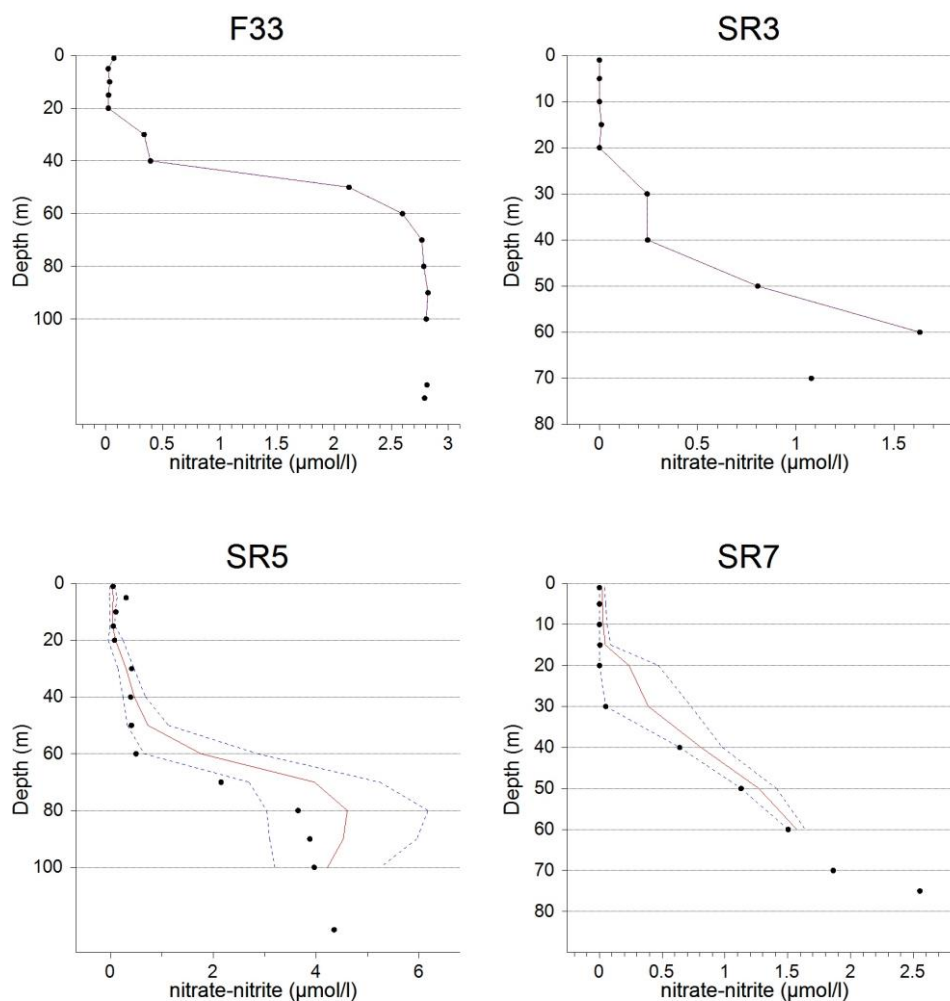
Figures 89-94. Observed  $\text{NH}_4$  -concentrations and average summer  $\text{NH}_4$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Bay at CVI, CV, RR7, RR6, RR3 and BO3 in August 2019.



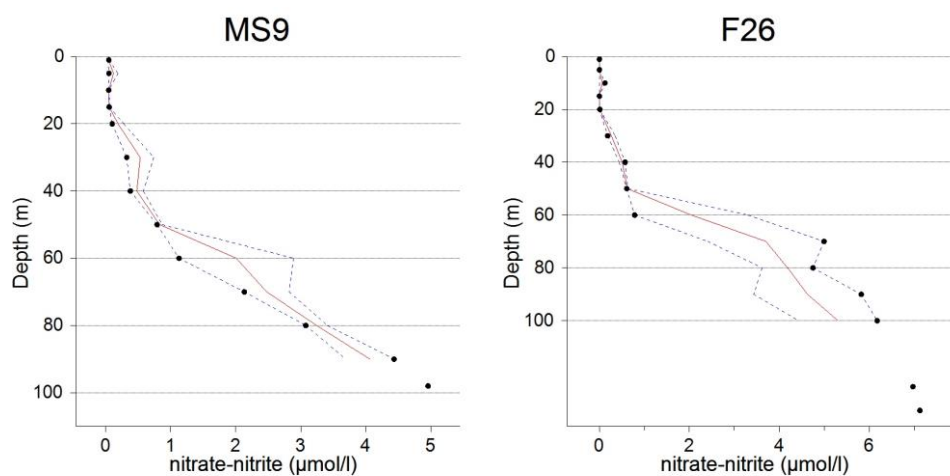
Figures 95-98. Observed  $\text{NH}_4$  -concentrations and average summer  $\text{NH}_4$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Archipelago Sea at IU1, IU3, IU5 and IU7 in August 2019.



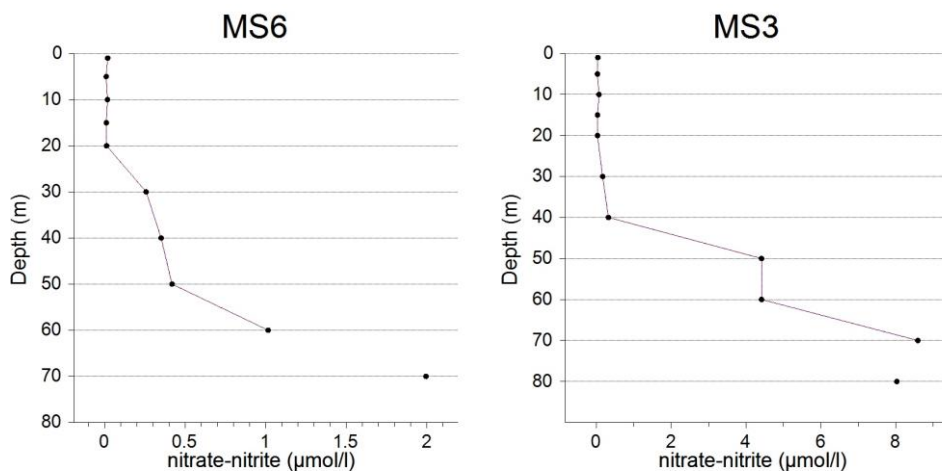
Figures 99-104. Observed  $\text{NO}_{2,3}$  -concentrations and average summer  $\text{NO}_{2,3}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern Baltic Proper at LL12, LL15, LL17 LL19, F69 and F64 in August 2019.



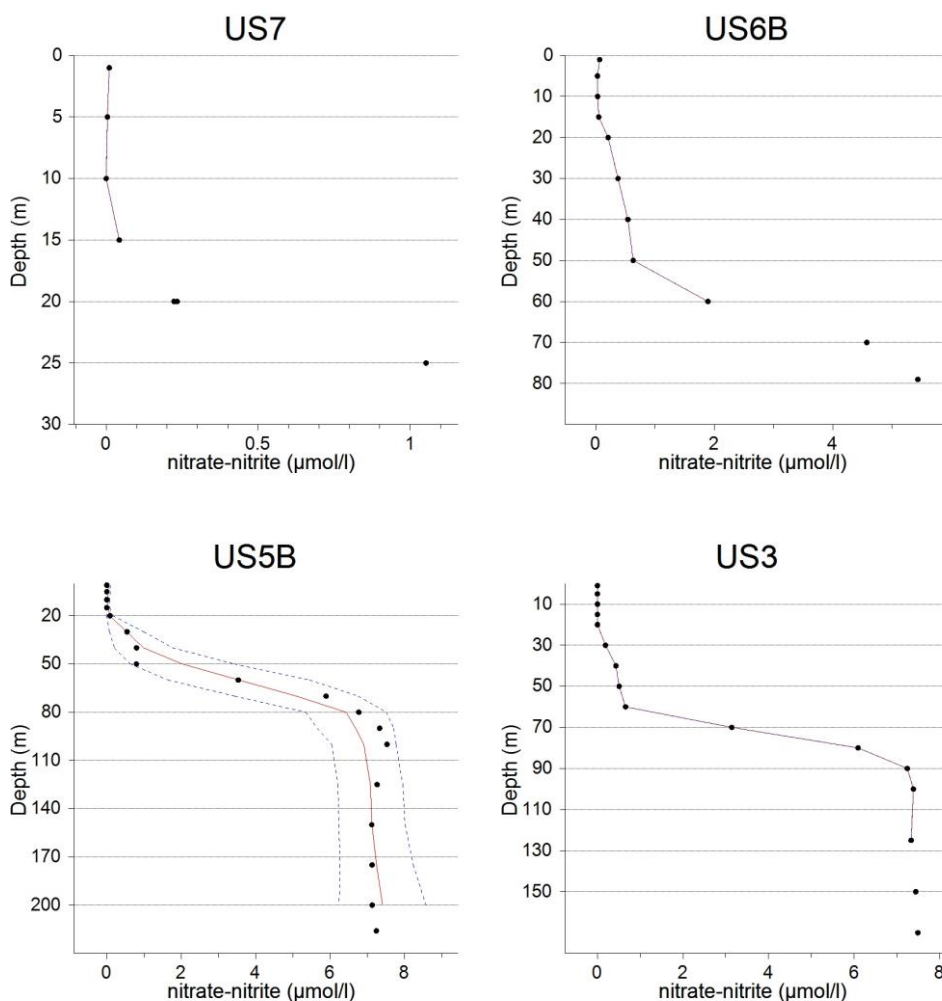
Figures 105-108. Observed  $\text{NO}_{2,3}$  -concentrations and average summer  $\text{NO}_{2,3}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Southern part of the Bothnian Sea at F33, SR3, SR5 and SR7 in August 2019.



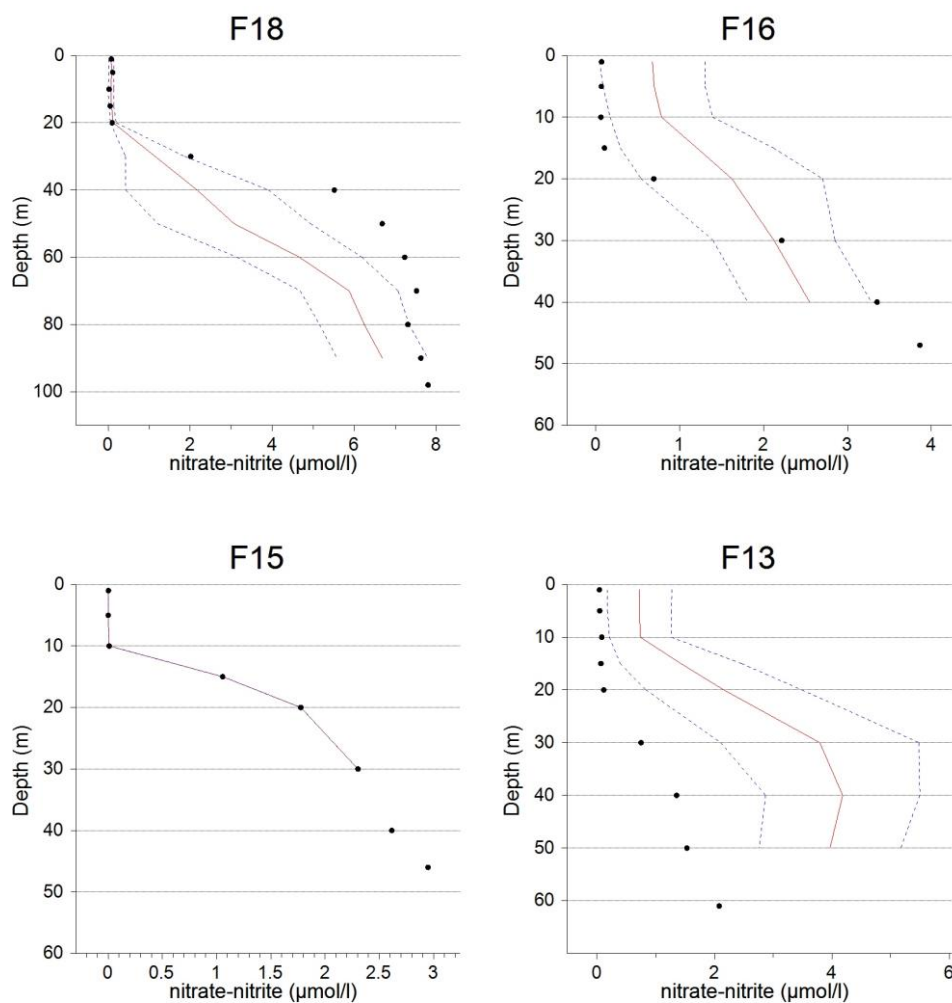




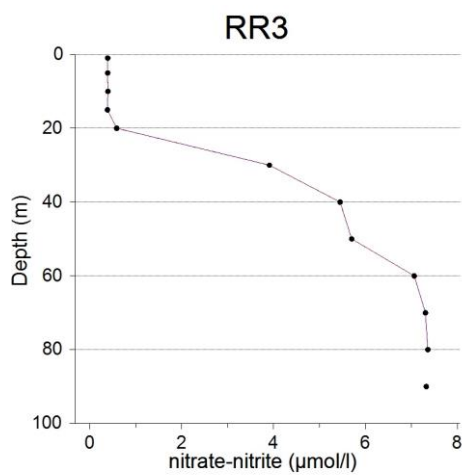
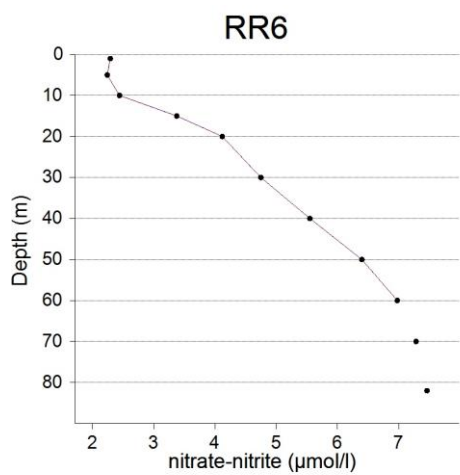
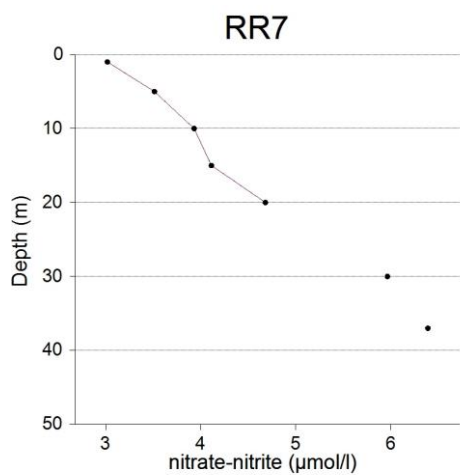
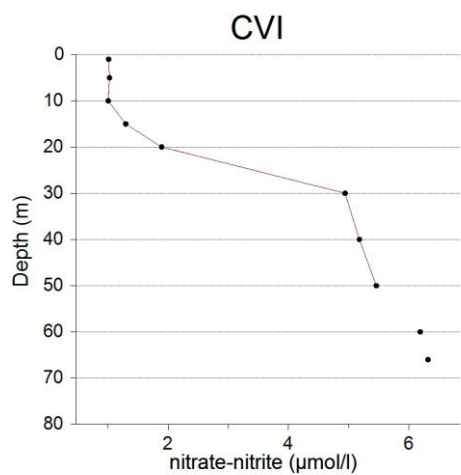
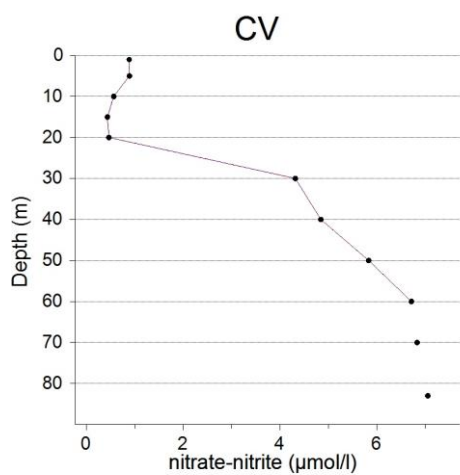
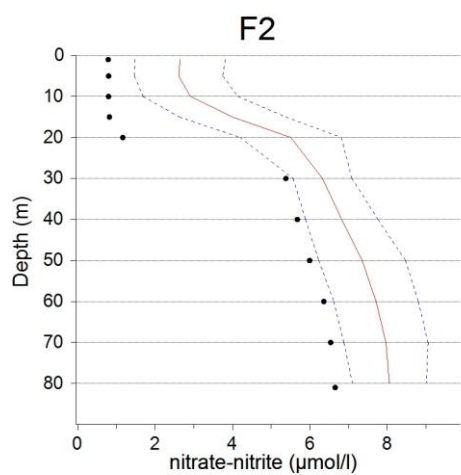
Figures 109-112. Observed NO<sub>2,3</sub> -concentrations and average summer NO<sub>2,3</sub> -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Sea at MS9, F26, MS6 and MS3 in August 2019.

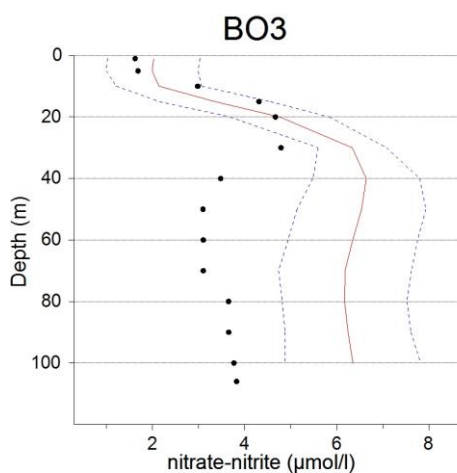


Figures 109-112. Observed NO<sub>2,3</sub> -concentrations and average summer NO<sub>2,3</sub> -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern part of the Bothnian Sea at US7, US6b, US5b and US3 in August 2019.

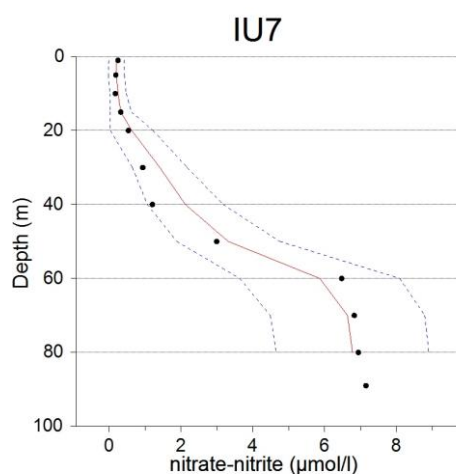
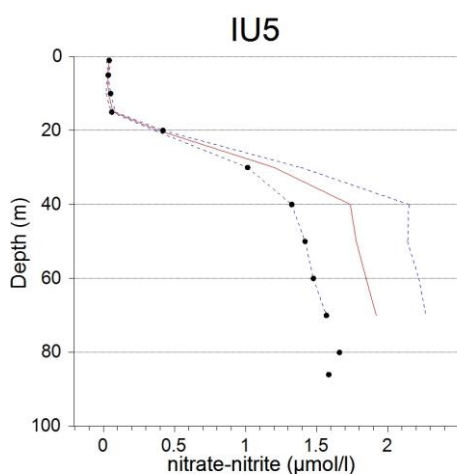
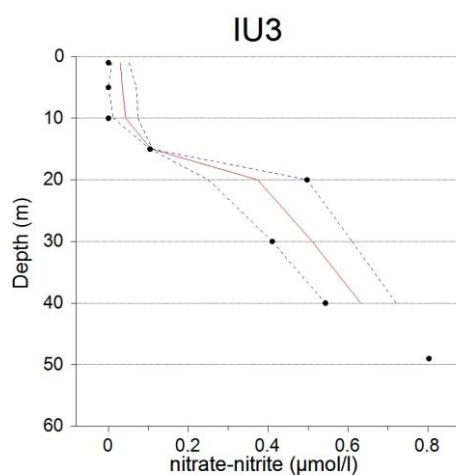
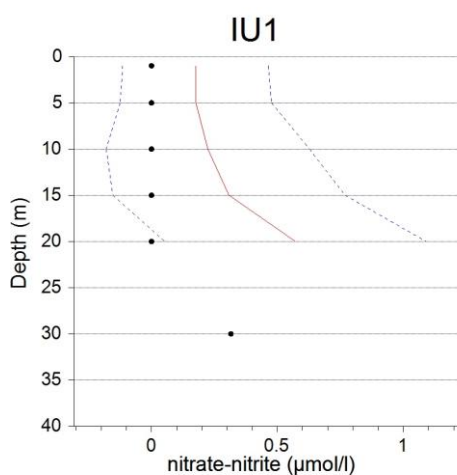


Figures 113-116. Observed  $\text{NO}_{2,3}$  -concentrations and average summer  $\text{NO}_{2,3}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Kvarken at F1, F16, F15 and F13 in August 2019.



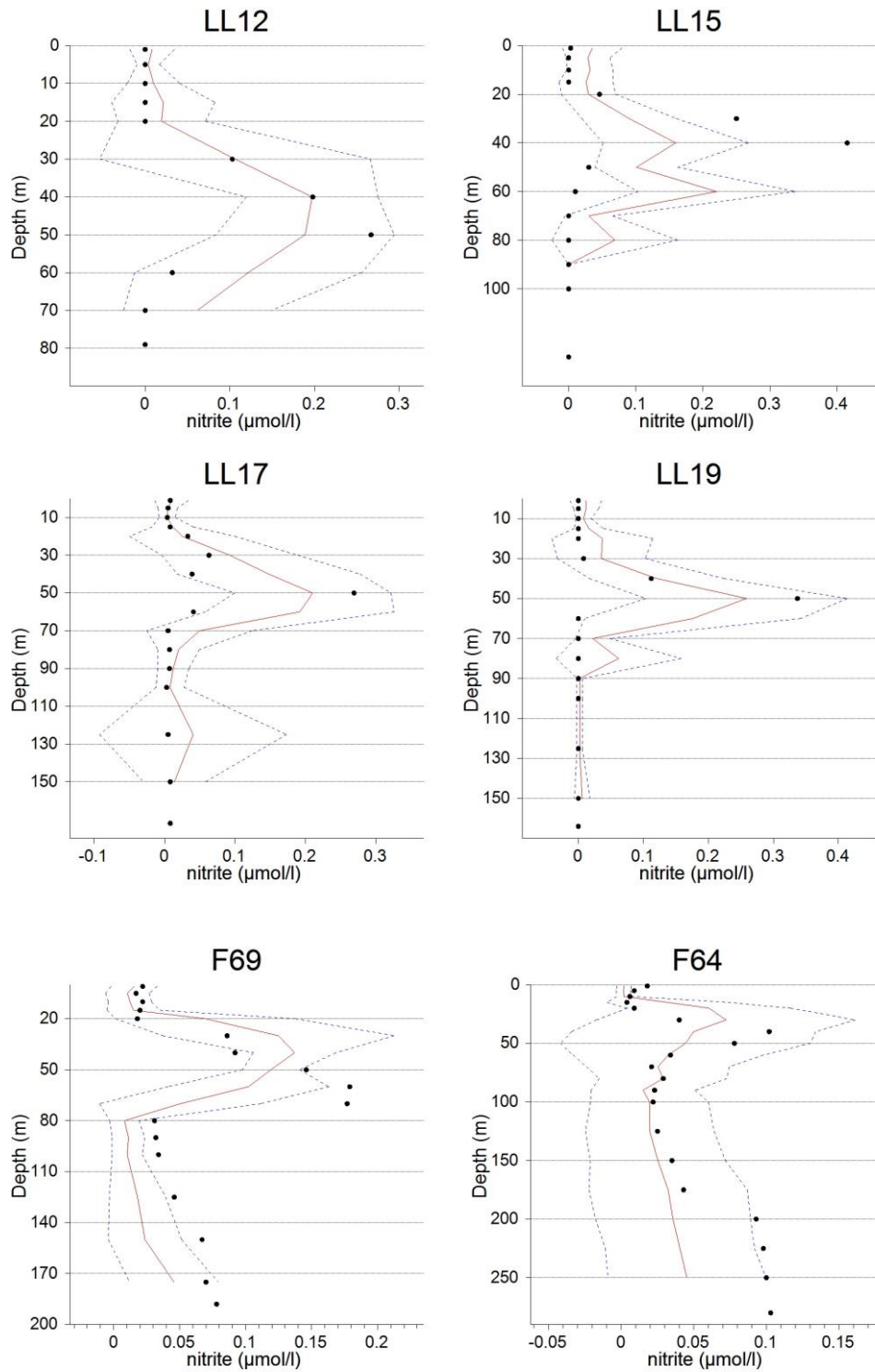


Figures 117-123. Observed  $\text{NO}_{2,3}$  -concentrations and average summer  $\text{NO}_{2,3}$  - concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Bay at F2, CV, CVI, RR7, RR6, RR3 and BO3 in August 2019.

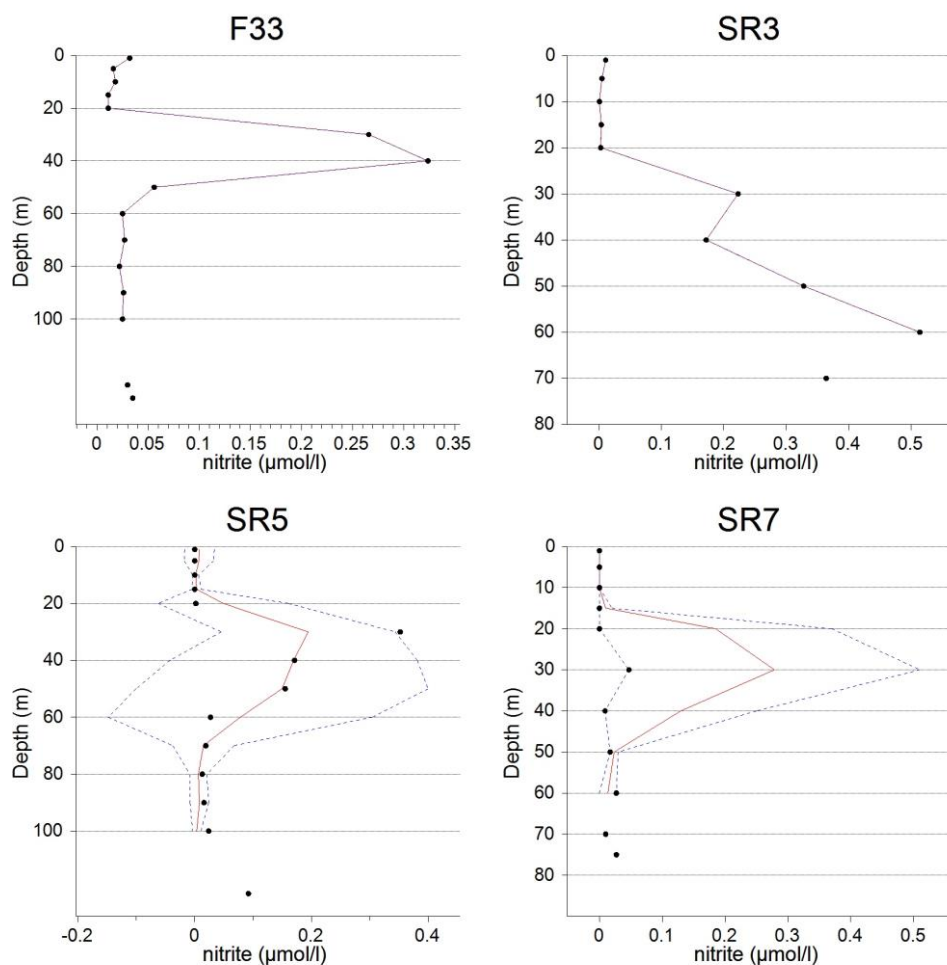


Figures 124-127. Observed  $\text{NO}_{2,3}$  -concentrations and average summer  $\text{NO}_{2,3}$  - concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Archipelago at IU1, IU3, IU5 and IU7 in August 2019.

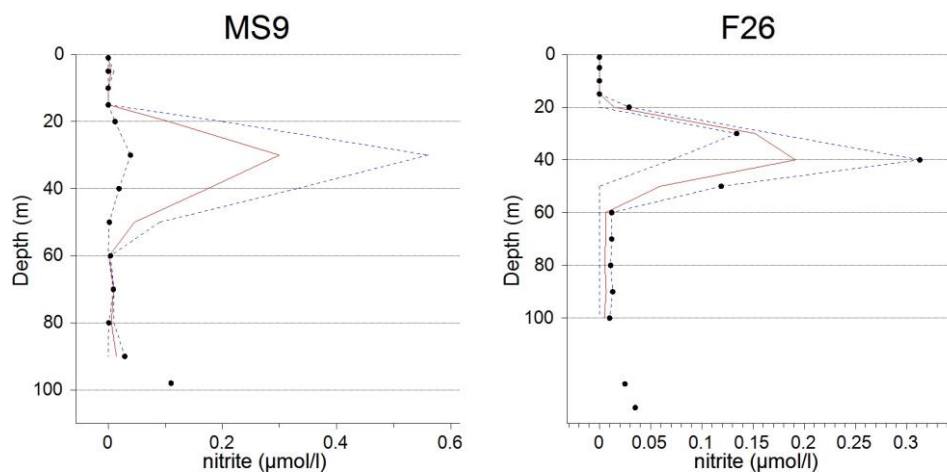
## Nitrate

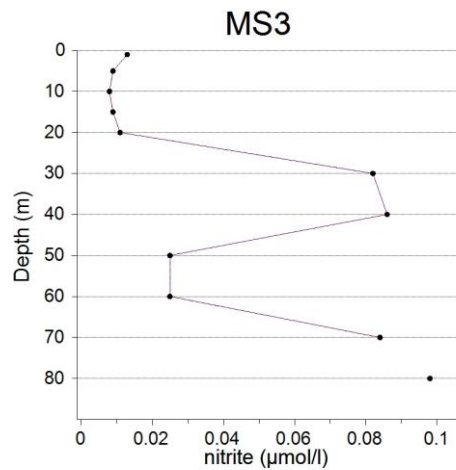
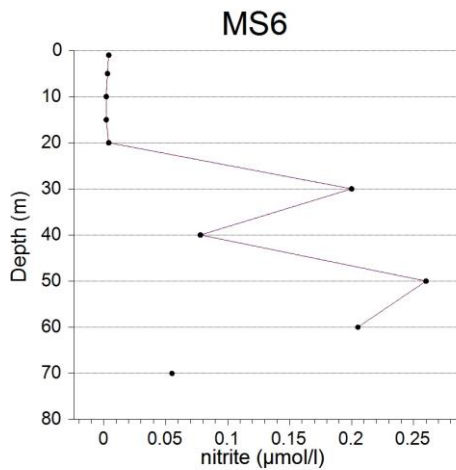


Figures 128-133. Observed  $\text{NO}_2$  -concentrations and average summer  $\text{NO}_2$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern Baltic Proper at LL12, LL15, LL17 LL19, F69 and F64 in August 2019.

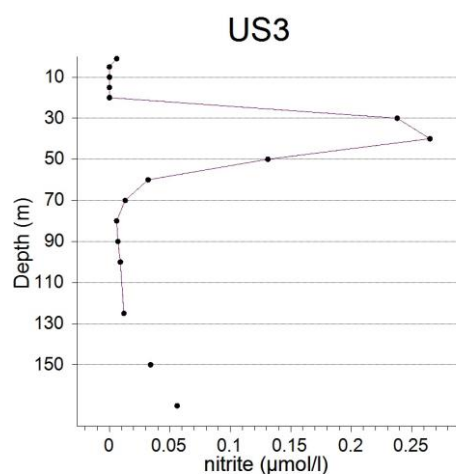
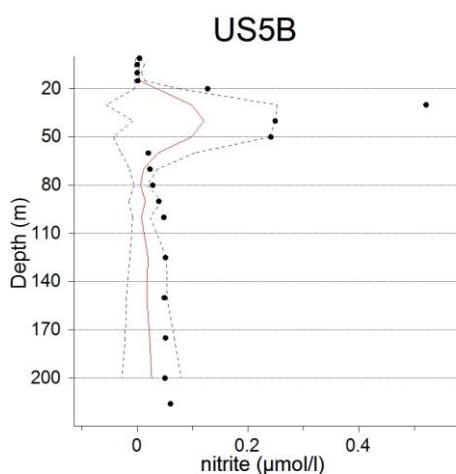
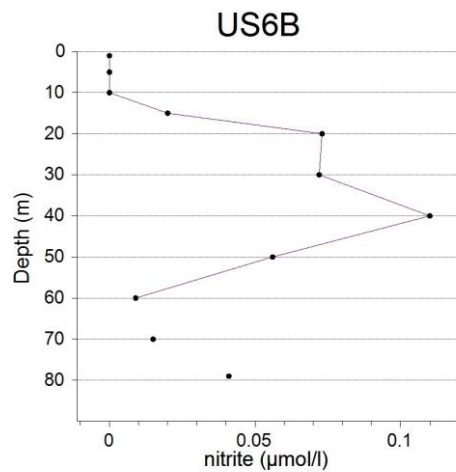
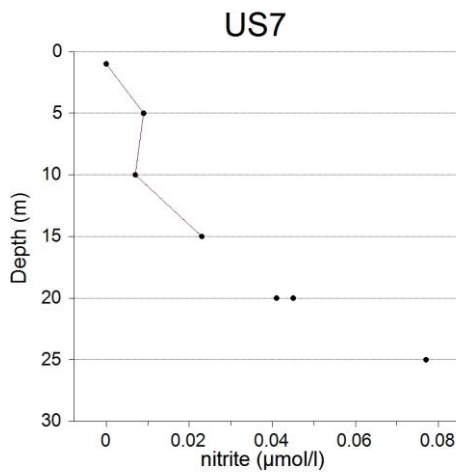


Figures 134-137. Observed  $\text{NO}_2$  -concentrations and average summer  $\text{NO}_2$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Southern Bothnian Sea at F33, SR3, SR5 and SR7 in August 2019.

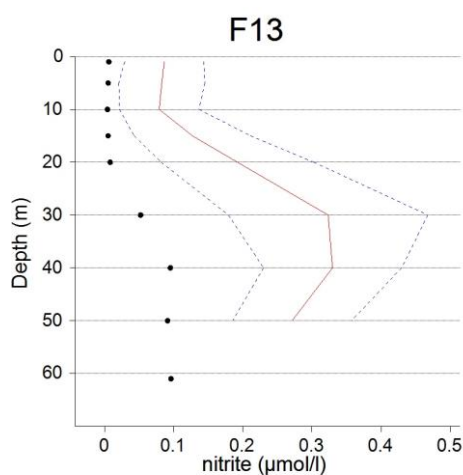
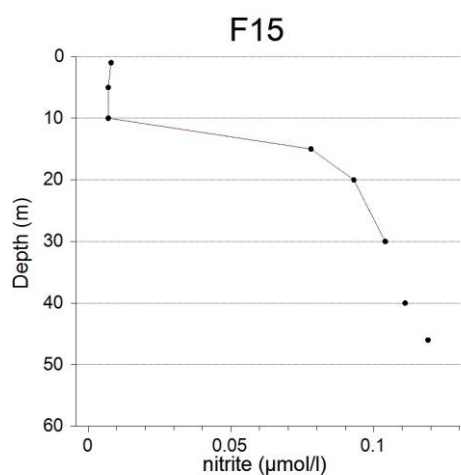
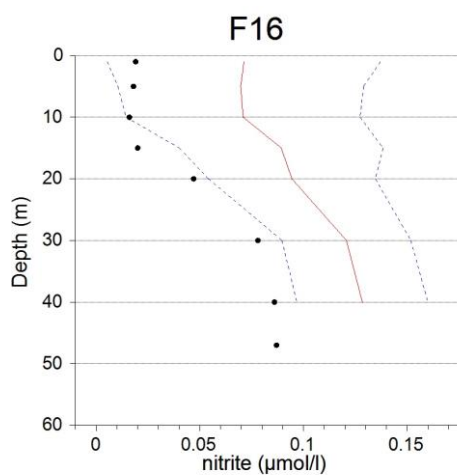
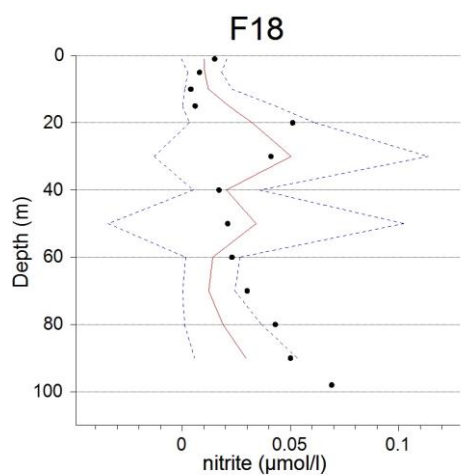




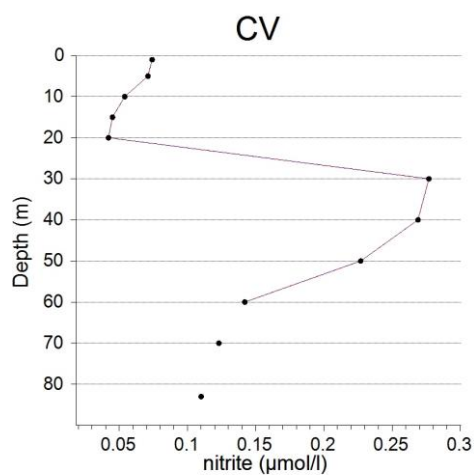
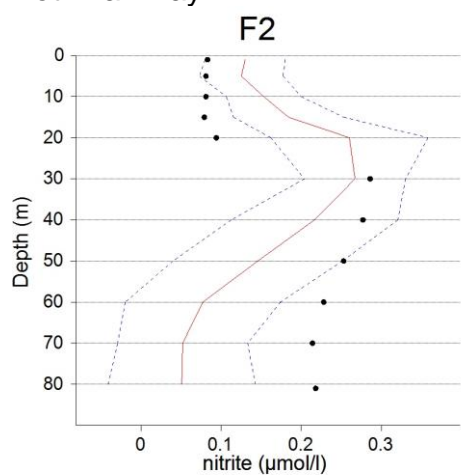
Figures 134-137. Observed  $\text{NO}_2$  -concentrations and average summer  $\text{NO}_2$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Sea at MS9, F26, MS6 and MS3 in August 2019.



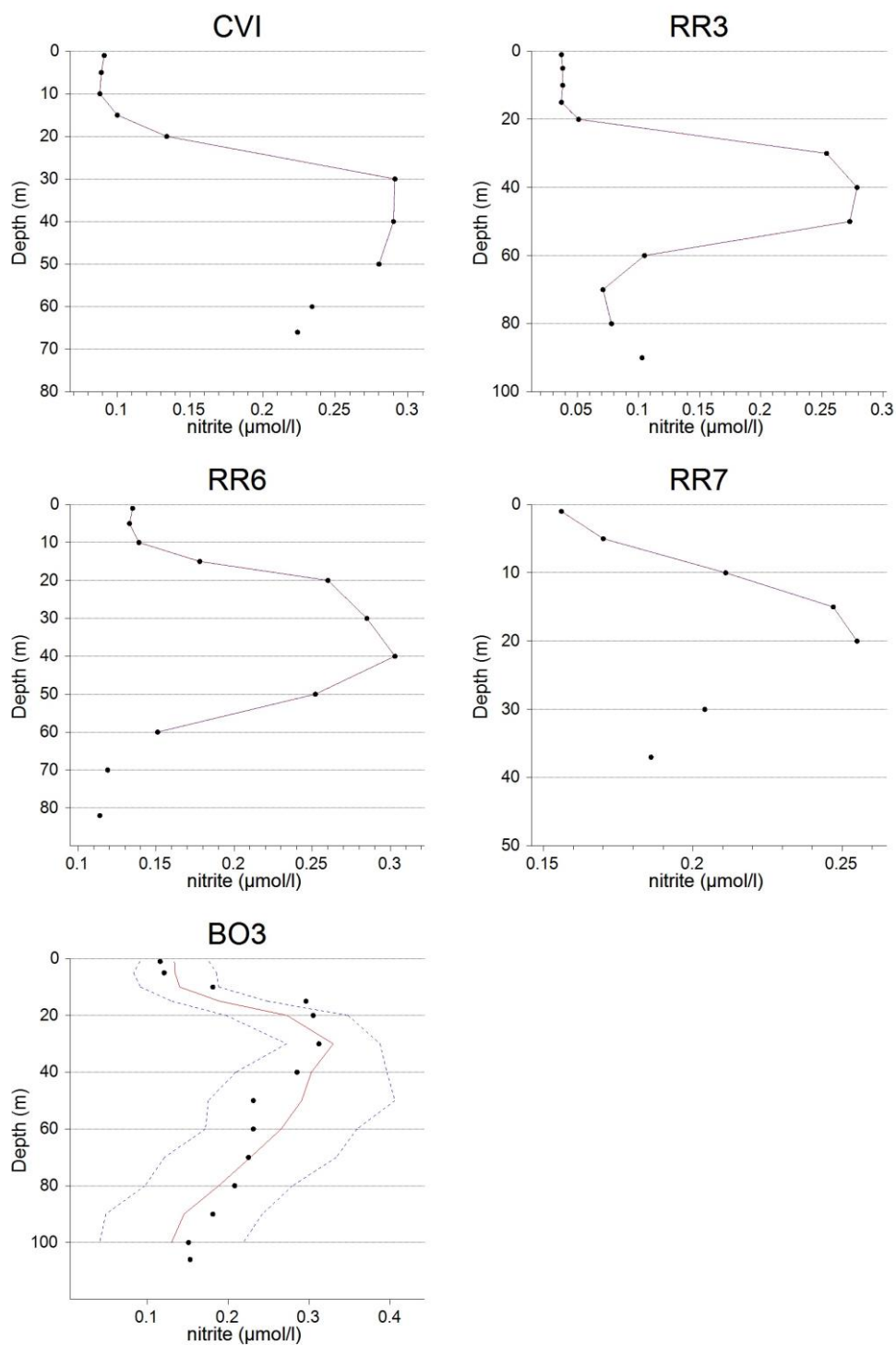
Figures 138-141. Observed  $\text{NO}_2$  -concentrations and average summer  $\text{NO}_2$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern Bothnian Sea at US7, US6b, US5b and US3 in August 2019.



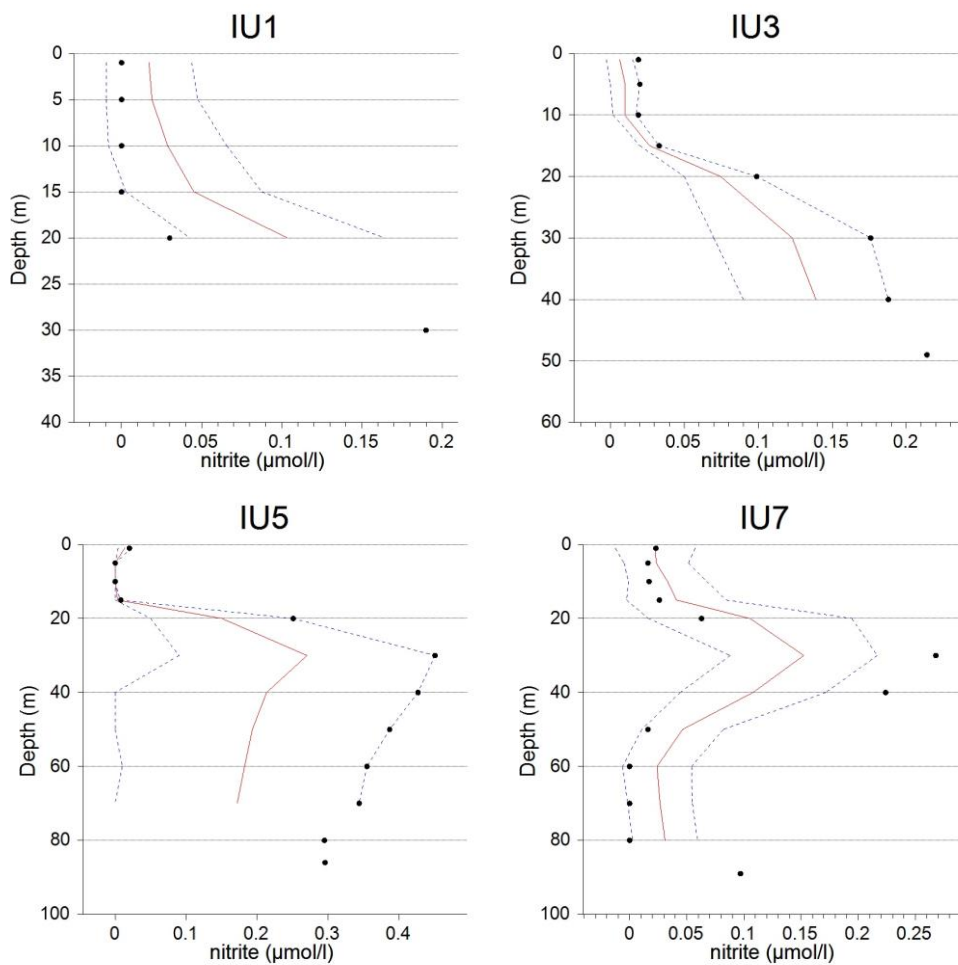
Figures 142-145. Observed  $\text{NO}_2$  -concentrations and average summer  $\text{NO}_2$  - concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Kvarken at F18, F16, F15 and F13 in August 2019. Bothnian Bay





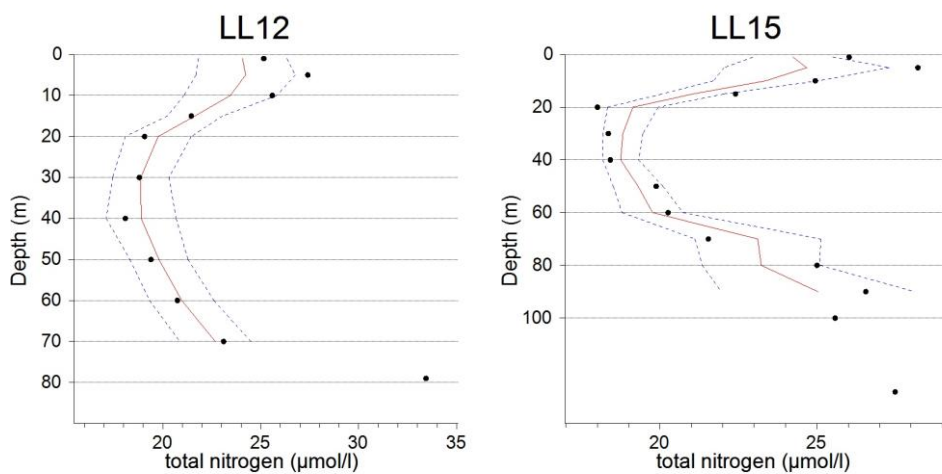


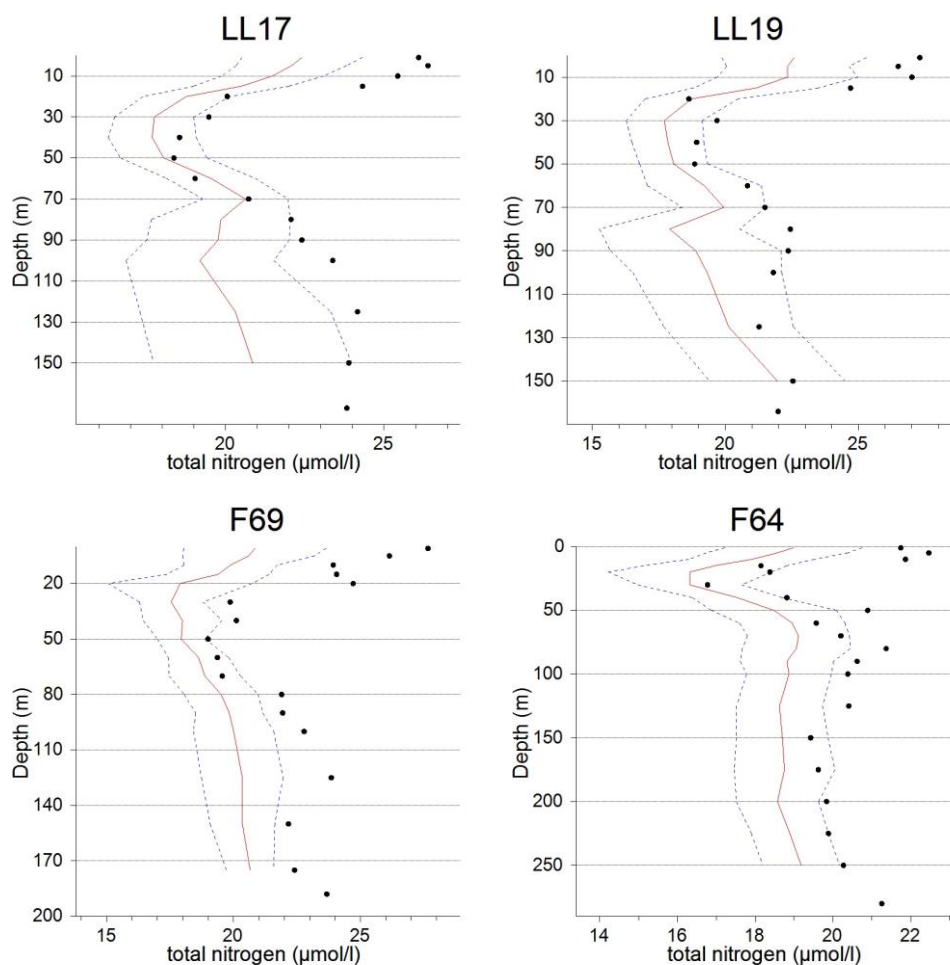
Figures 146-152. Observed  $\text{NO}_2$  -concentrations and average summer  $\text{NO}_2$  - concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Bay at F2, CV, CVI, RR3, RR6, RR7 and BO3 in August 2019.



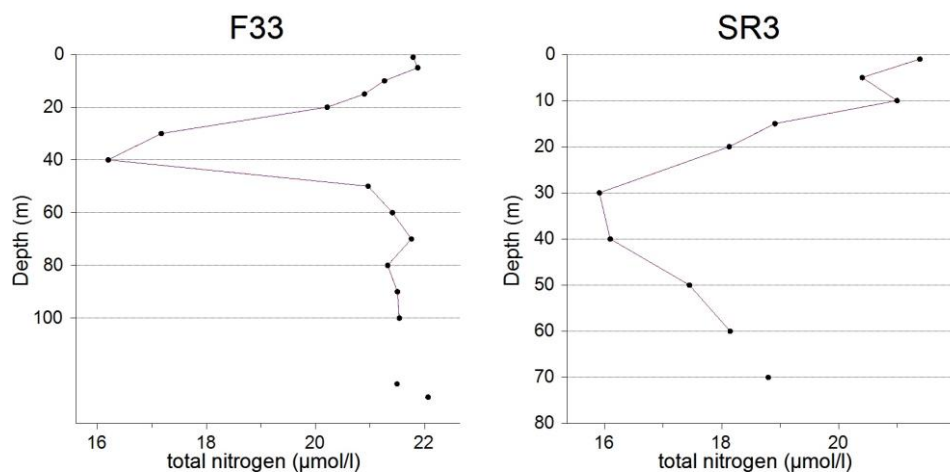
Figures 153-156. Observed  $\text{NO}_2$  -concentrations and average summer  $\text{NO}_2$  - concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Archipelago Sea at IU1, IU3, IU5 and IU7 In August 2019.

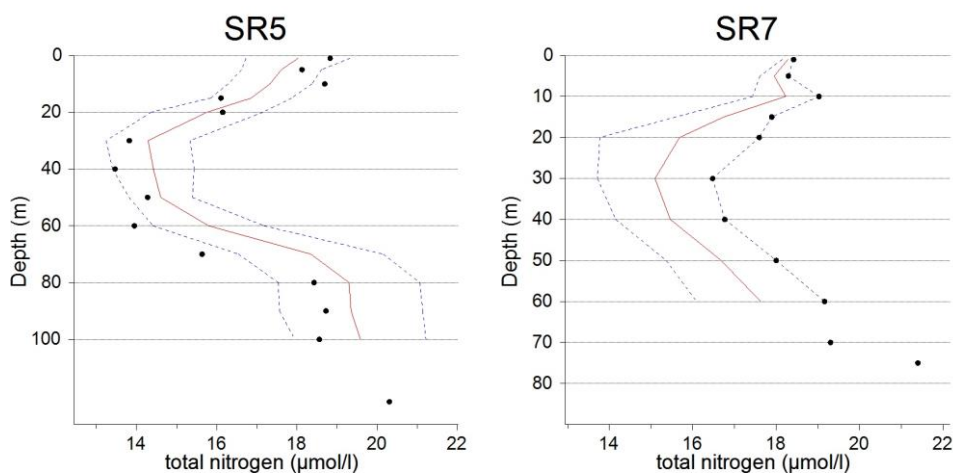
### Total Nitrogen



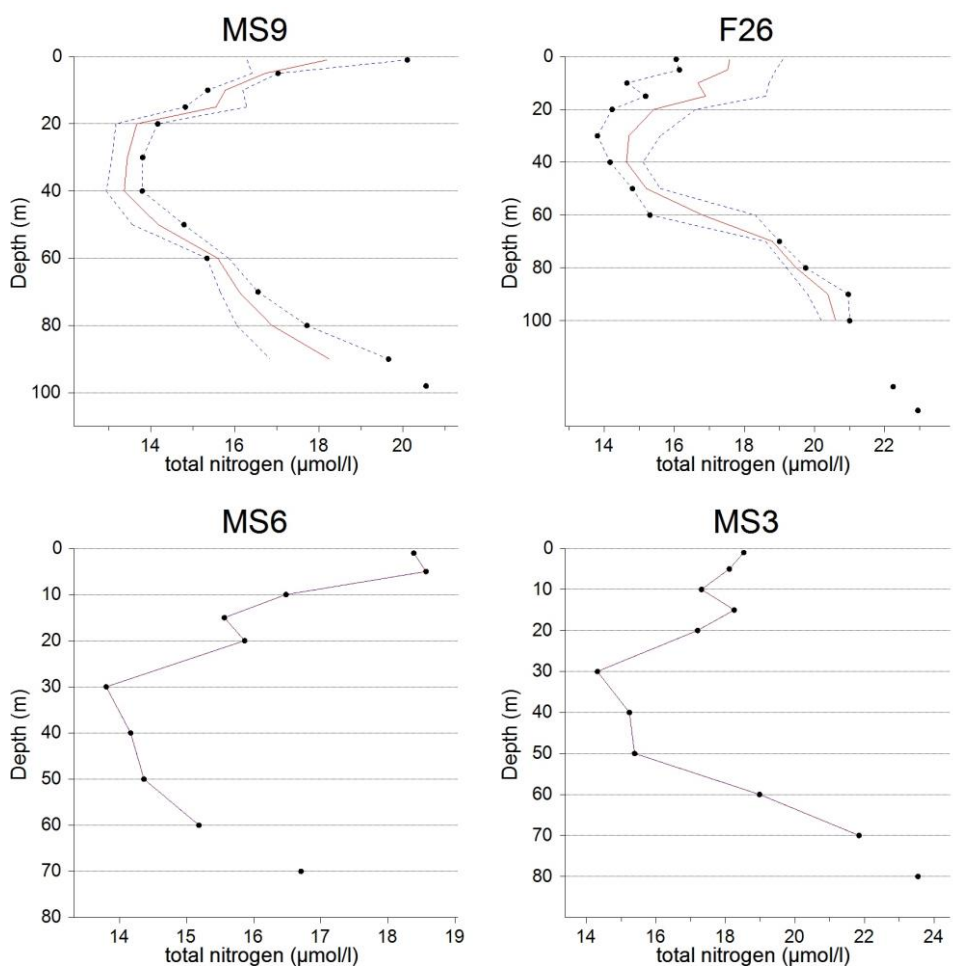


Figures 157-162. Observed  $N_{\text{tot}}$  -concentrations and average summer  $N_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern Baltic Proper at LL12, LL15, LL17, LL19, F69 and F64 In August 2019.

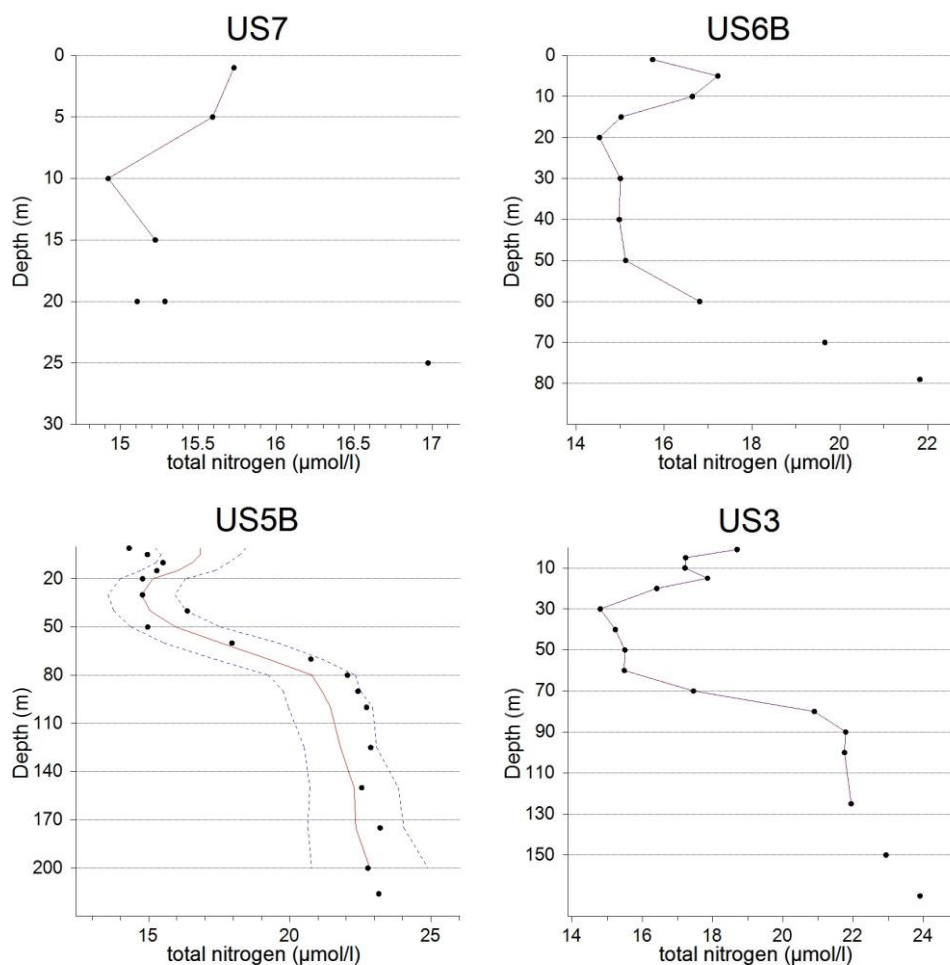




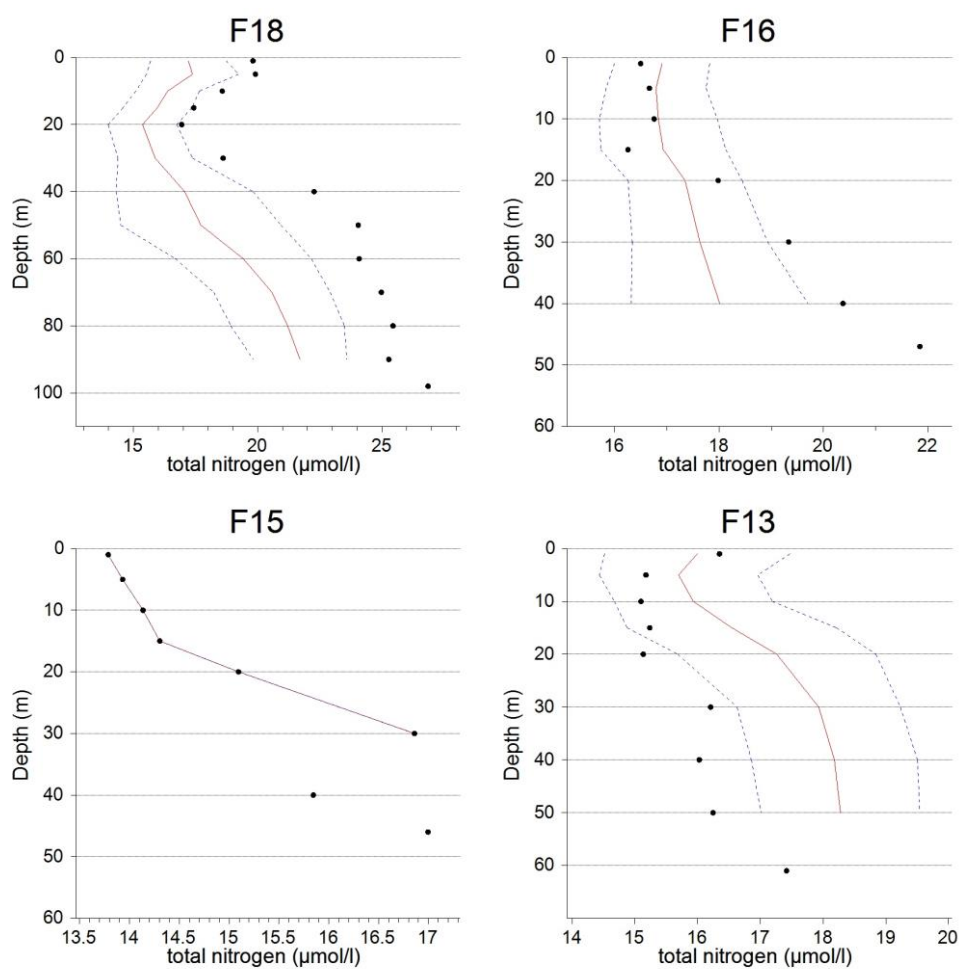
Figures 163-166. Observed N<sub>tot</sub> -concentrations and average summer N<sub>tot</sub> -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Southern Bothnian Sea at F33, SR3, SR5 and SR7 In August 2019.



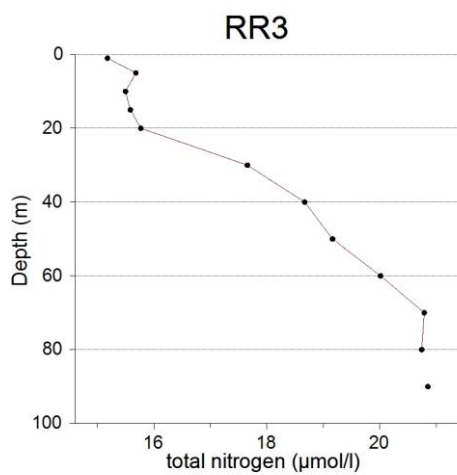
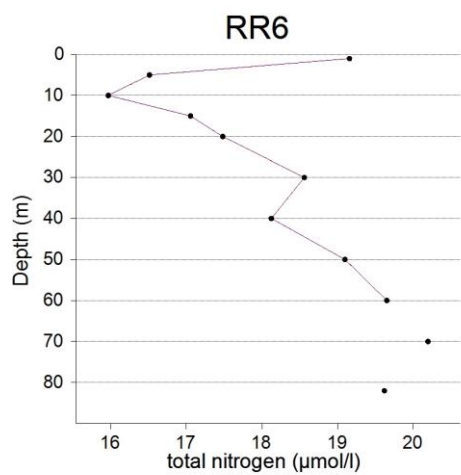
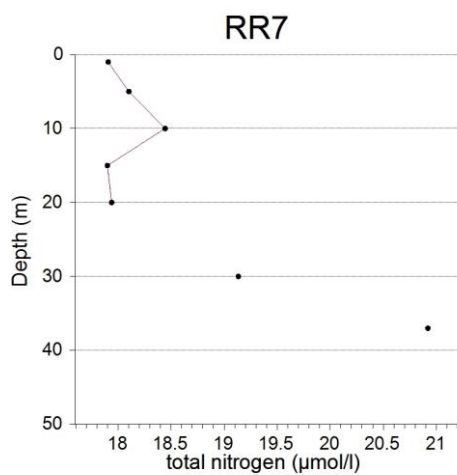
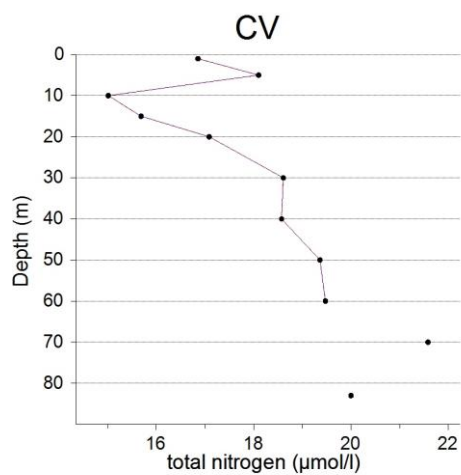
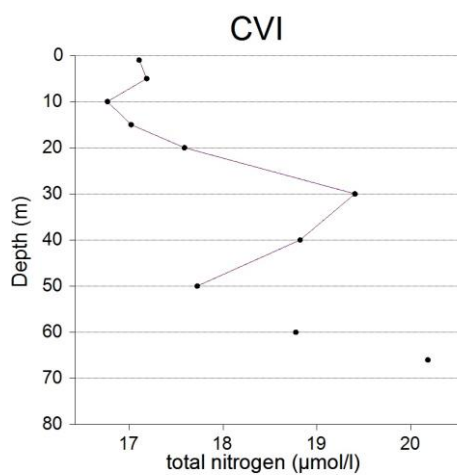
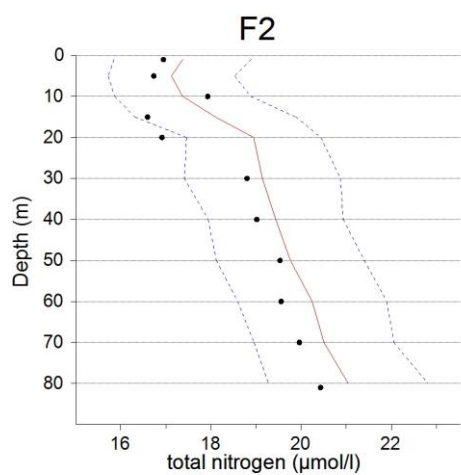
Figures 167-170. Observed N<sub>tot</sub> -concentrations and average summer N<sub>tot</sub> -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Sea at MS9, F26, MS6 and MS3 In August 2019.

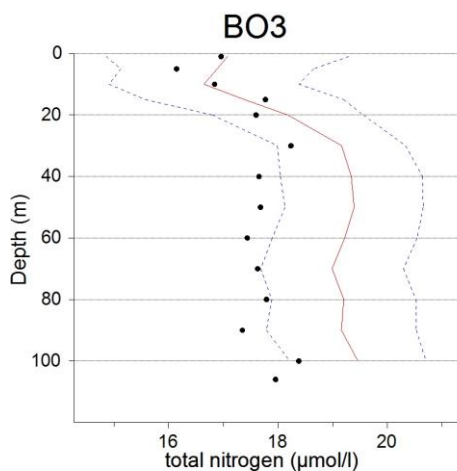


Figures 171-174. Observed  $N_{tot}$  -concentrations and average summer  $N_{tot}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the northern Bothnian Sea at US7, US6b, US5b and US3 In August 2019.



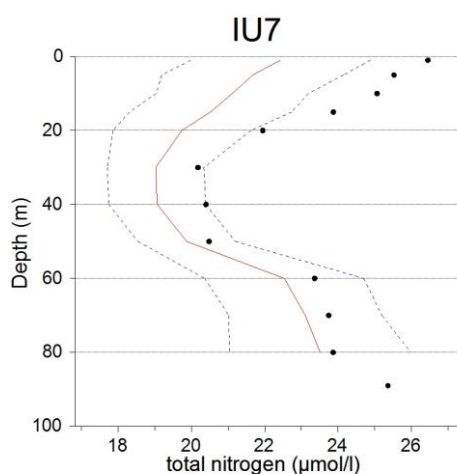
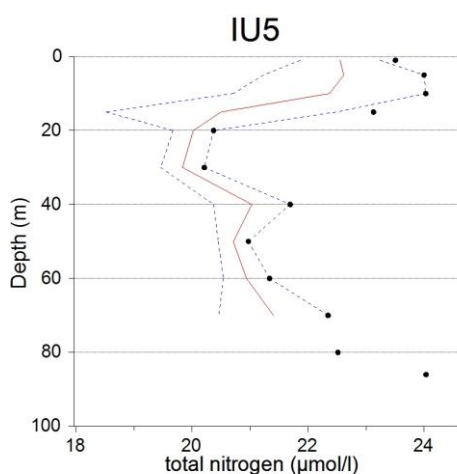
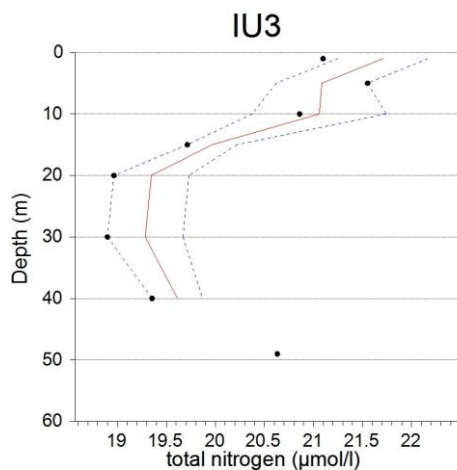
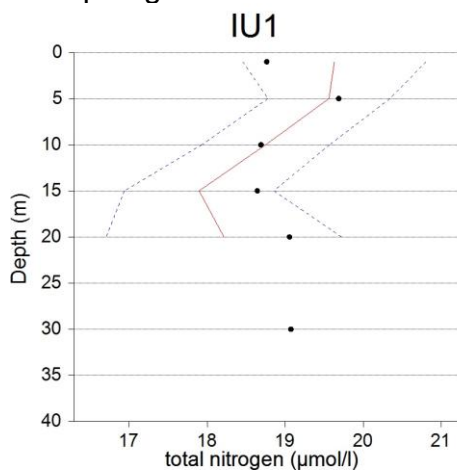
Figures 175-177. Observed  $N_{\text{tot}}$  -concentrations and average summer  $N_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in Kvarken at F18, F16, F15 and F13 In August 2019.





Figures 178-184. Observed  $N_{\text{tot}}$  -concentrations and average summer  $N_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Bay at F2, CVI, CV, RR7, RR6, RR3 and BO3 In August 2019.

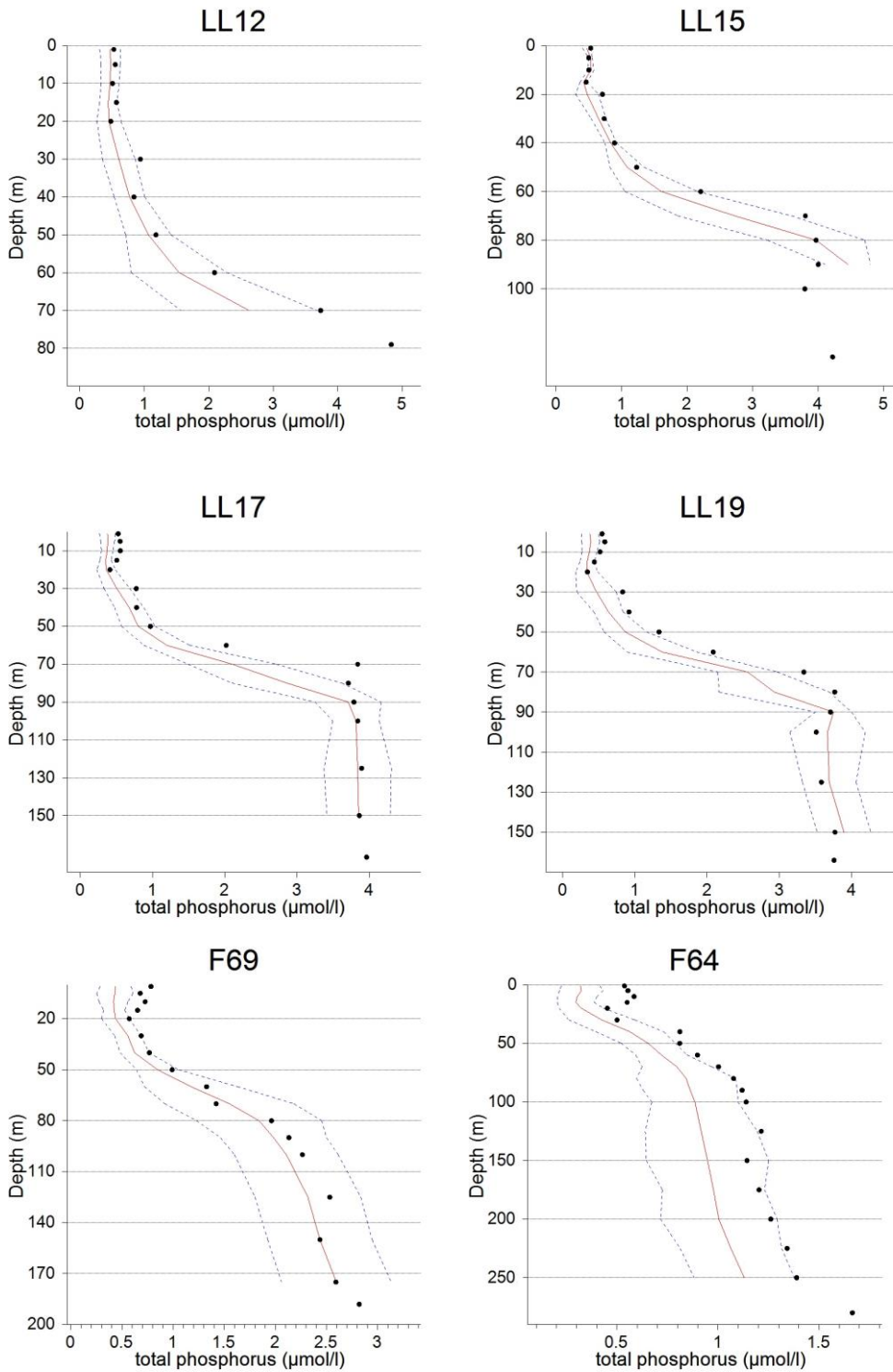
#### Archipelago Sea



Figures 185-188. Observed  $N_{\text{tot}}$  -concentrations and average summer  $N_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Archipelago at IU1, IU3, IU5 and IU7 In August 2019.

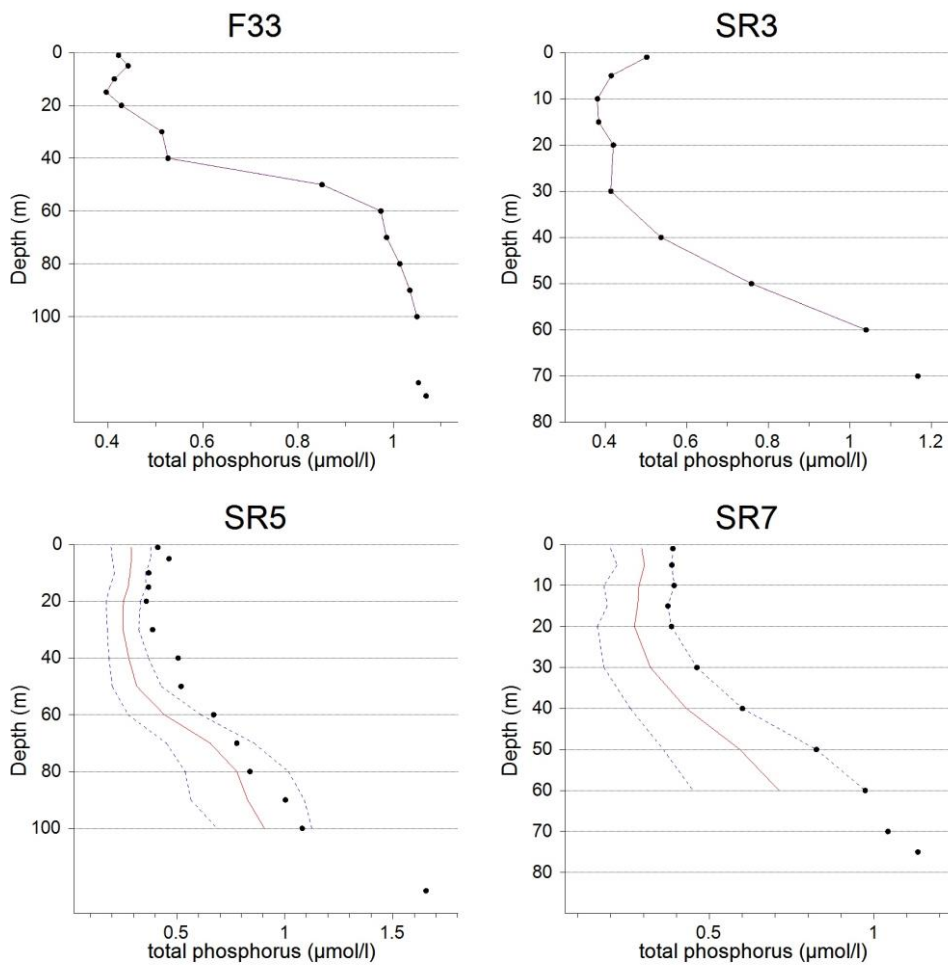


## Total phosphorus



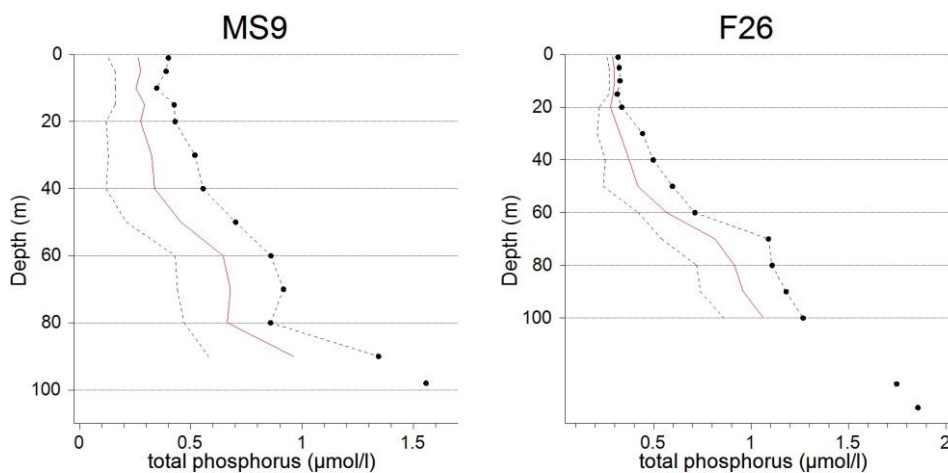
Figures 189-194. Observed  $P_{\text{tot}}$  -concentrations and average summer  $P_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Archipelago at LL12, LL15, LL17, LL19, F69 and F64 in August 2019.

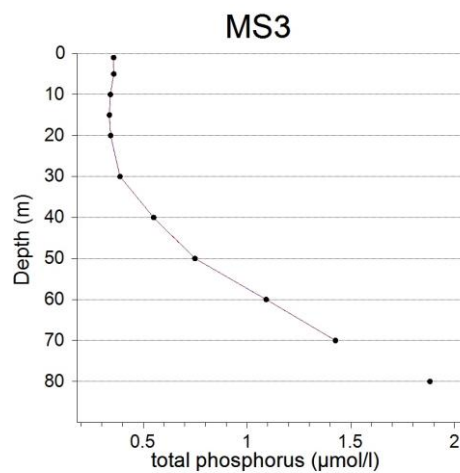
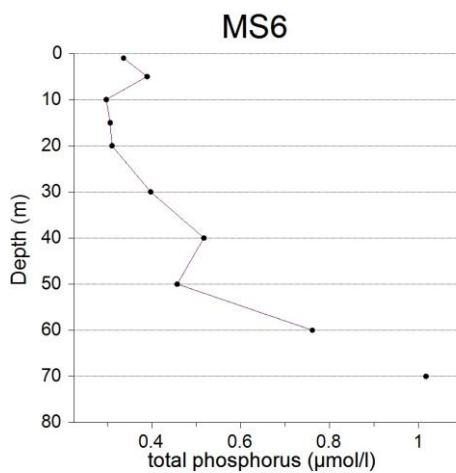
## Southern Baltic Sea



Figures 195-198. Observed P<sub>tot</sub> -concentrations and average summer P<sub>tot</sub> -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Southern Bothnian Sea at F33, SR3, SR5 and SR7 in August 2019.

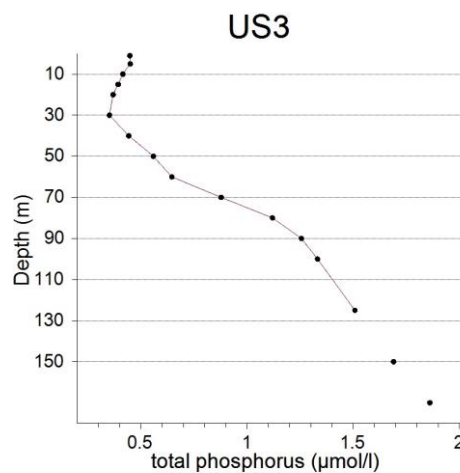
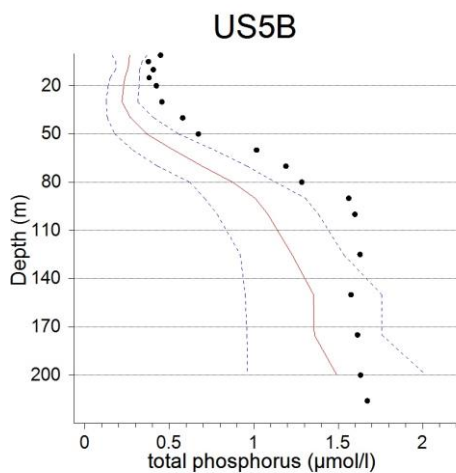
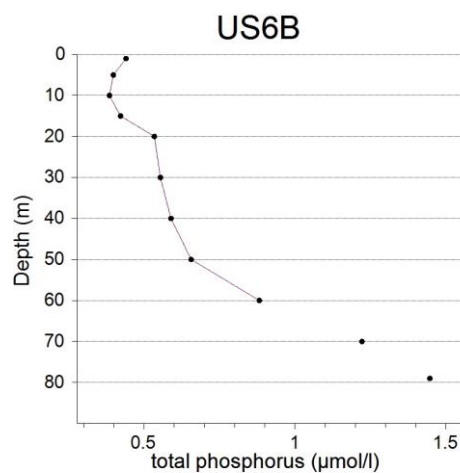
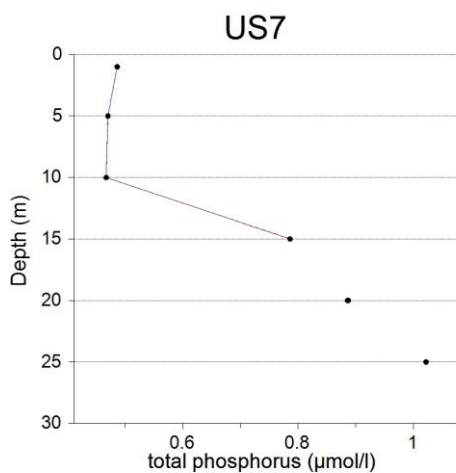
## Middle Bothnnian Sea



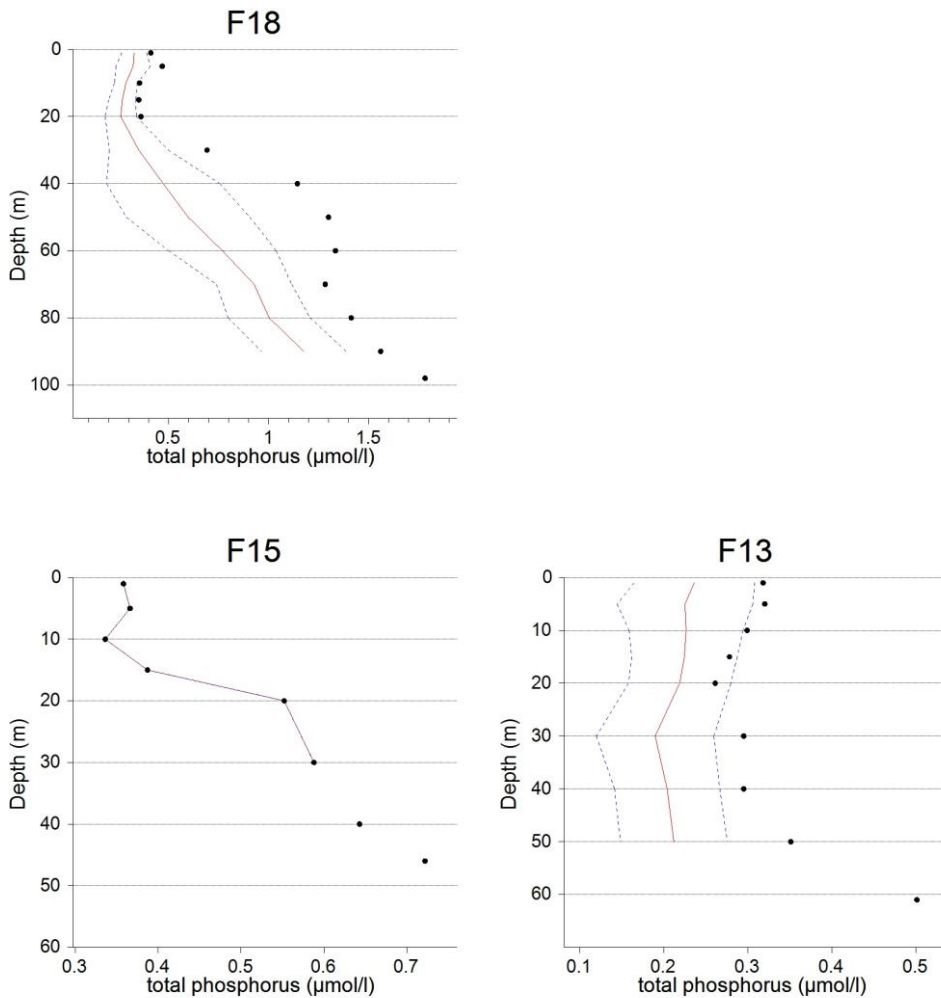


Figures 199-202. Observed  $P_{\text{tot}}$  -concentrations and average summer  $P_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Middle Bothnian Sea at MS9, F26, MS6 and MS3 in August 2019.

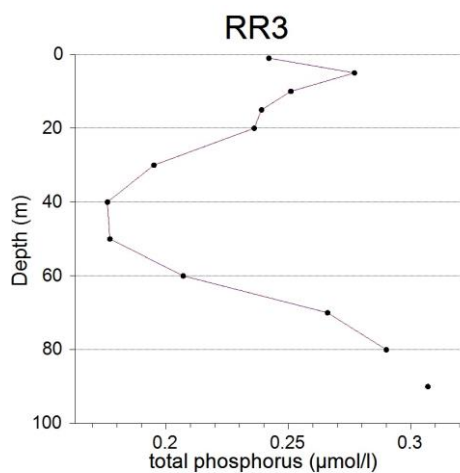
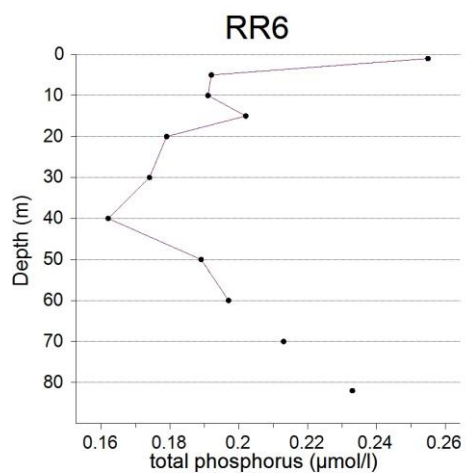
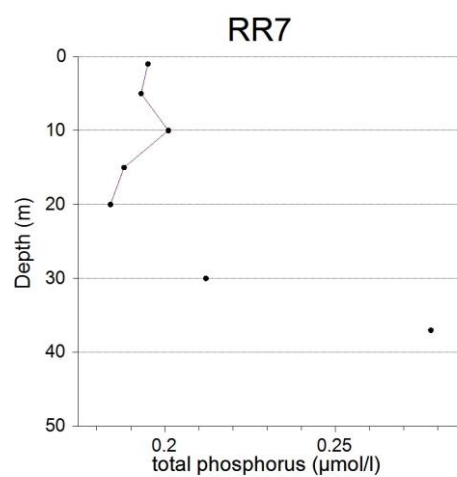
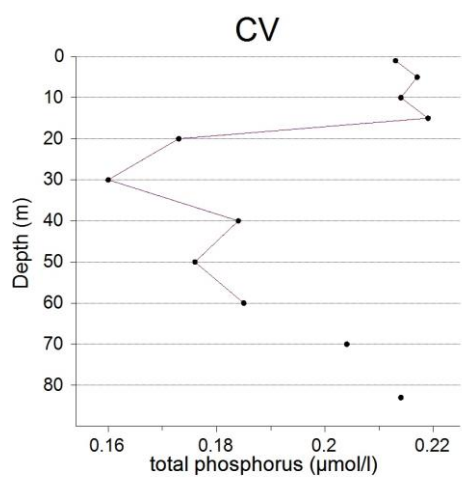
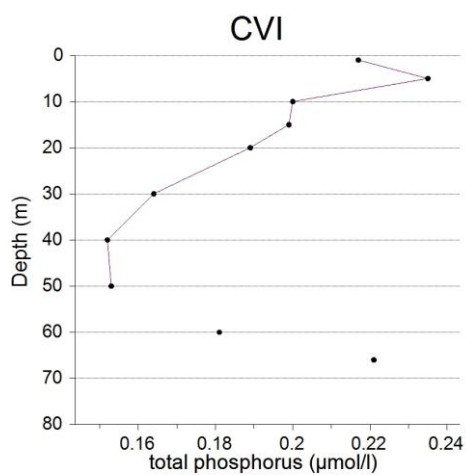
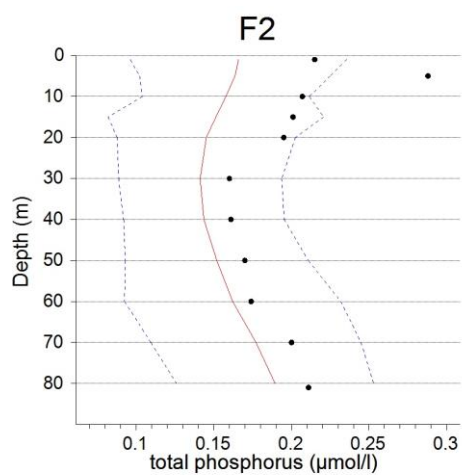
### Northern Bothnian Sea

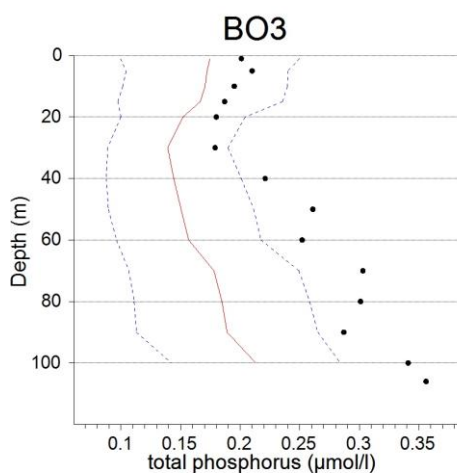


Figures 203-206. Observed  $P_{\text{tot}}$  -concentrations and average summer  $P_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern Bothnian Sea at US7, US6b, US5b and US3 in August 2019.



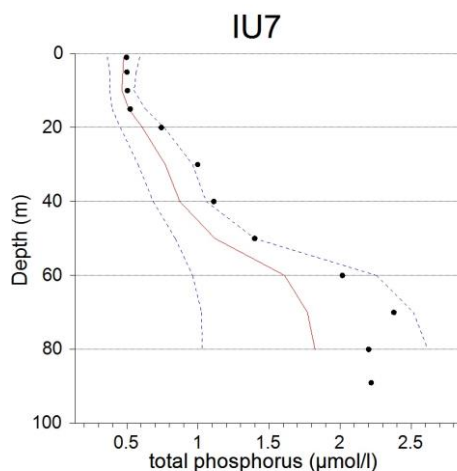
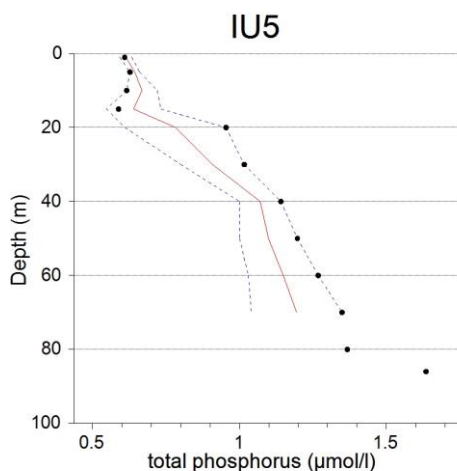
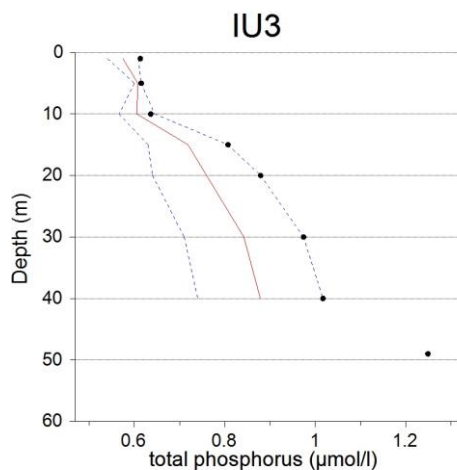
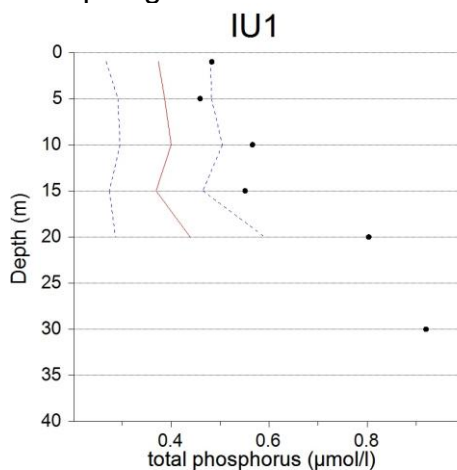
Figures 207-209. Observed  $P_{\text{tot}}$  -concentrations and average summer  $P_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern Bothnian Sea at F18, F15 and F13 in August 2019.





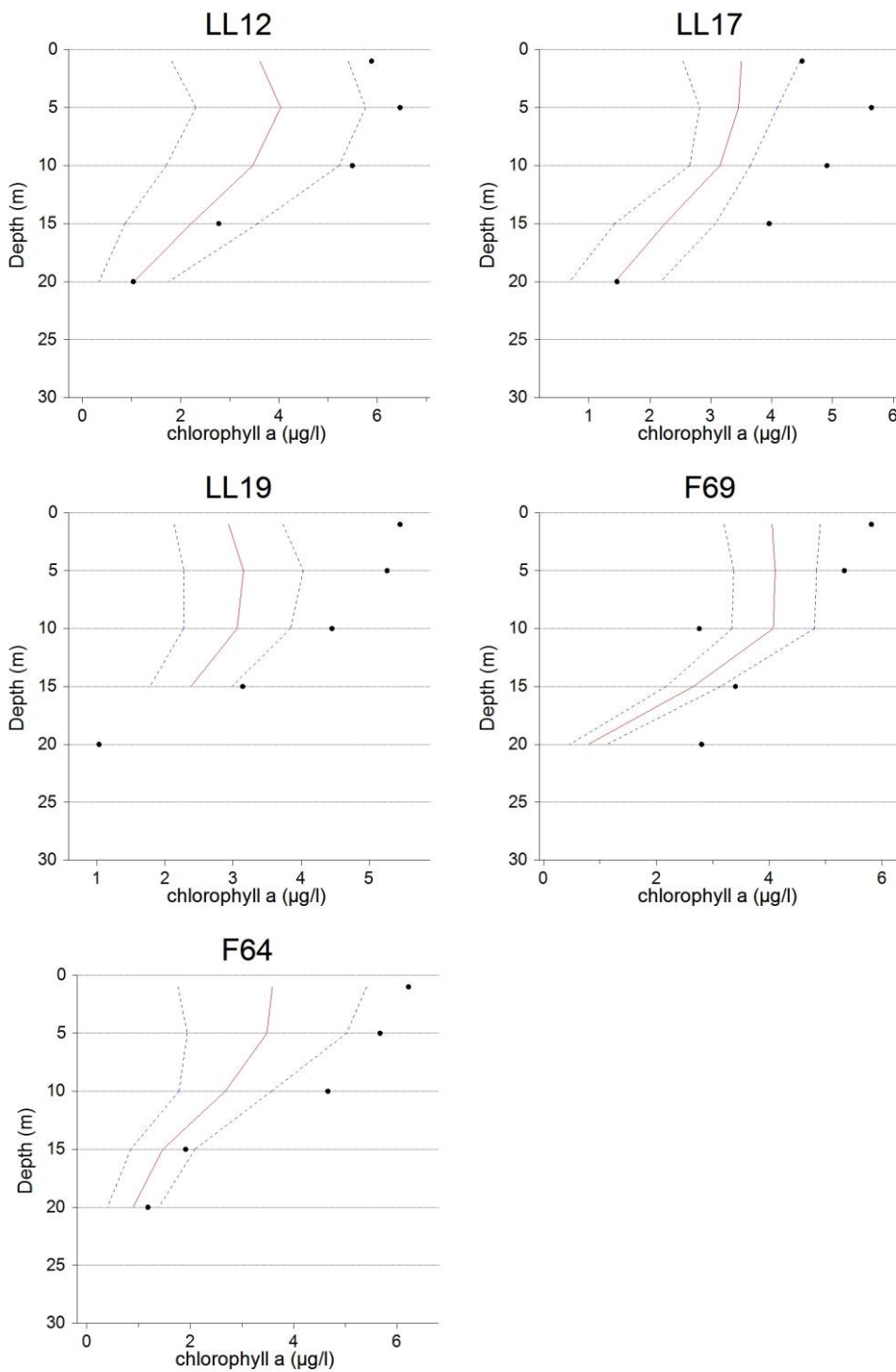
Figures 210-216. Observed  $P_{\text{tot}}$  -concentrations and average summer  $P_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Bothnian Bay at F2, CVI, CV, RR7, RR6, RR3 and BO3 in August 2019.

#### Archipelago Sea

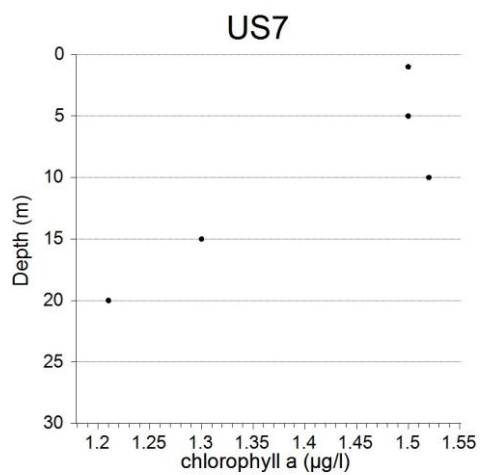
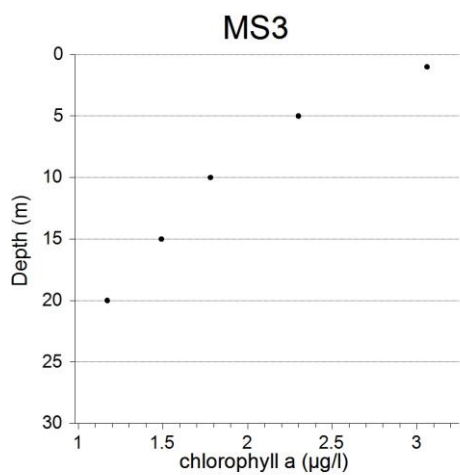
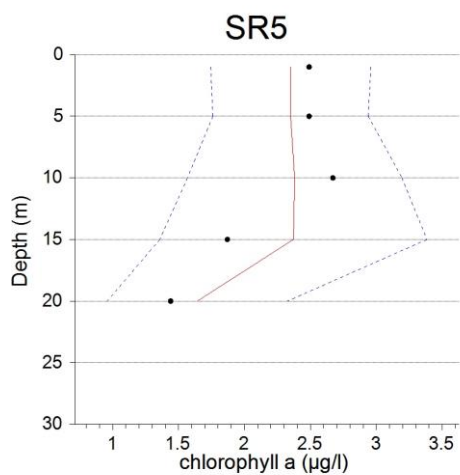
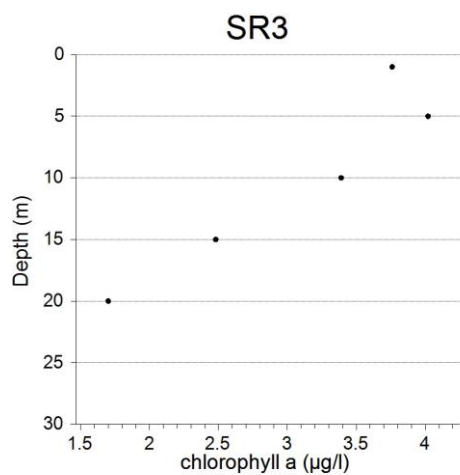
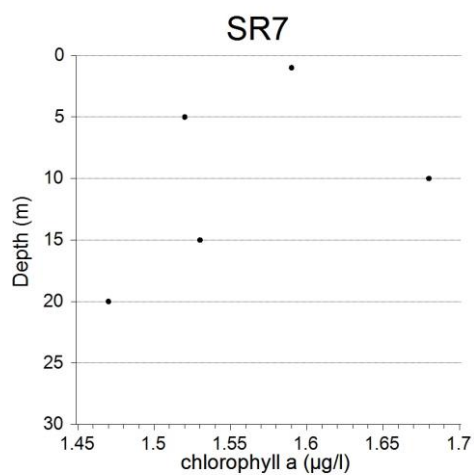
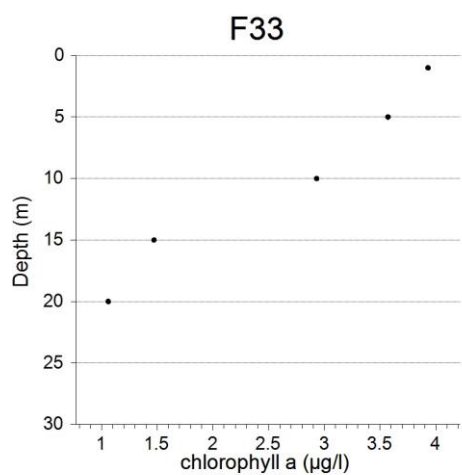


Figures 217-220. Observed  $P_{\text{tot}}$  -concentrations and average summer  $P_{\text{tot}}$  -concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Archipelago Sea at IU1, IU3, IU5 and IU7 in August 2019.

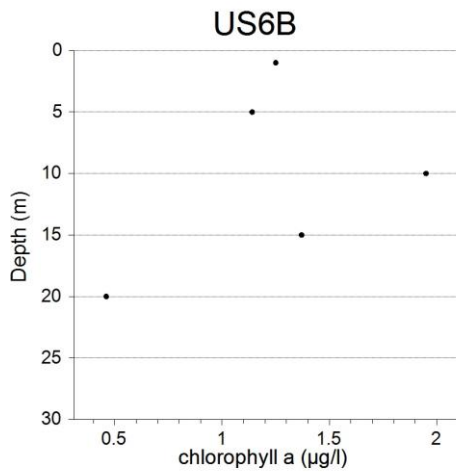
## Chlorophyll a



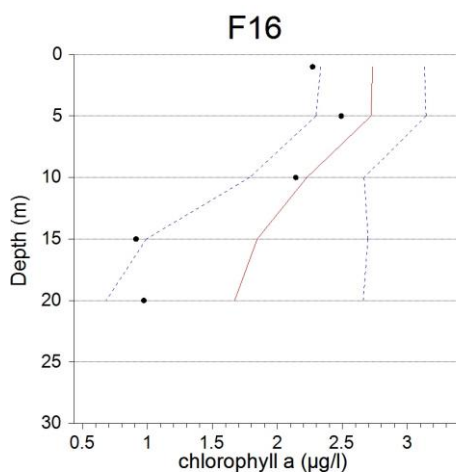
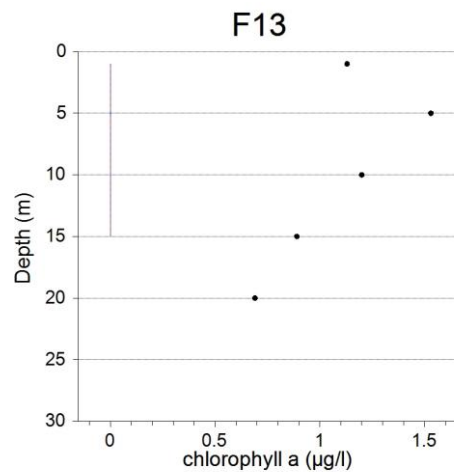
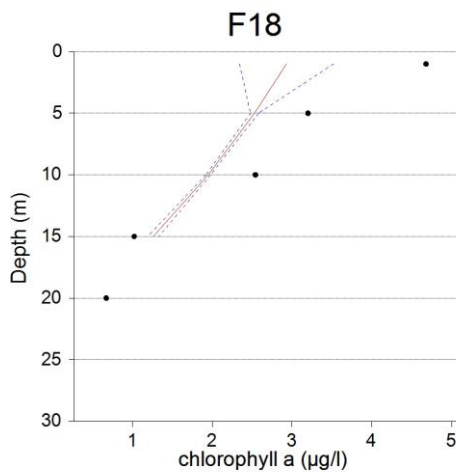
Figures 221-225. Observed chlorophyll a concentrations and average summer concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Northern Baltic Proper at LL12, LL17, LL19, F69 and F64 in August 2019.



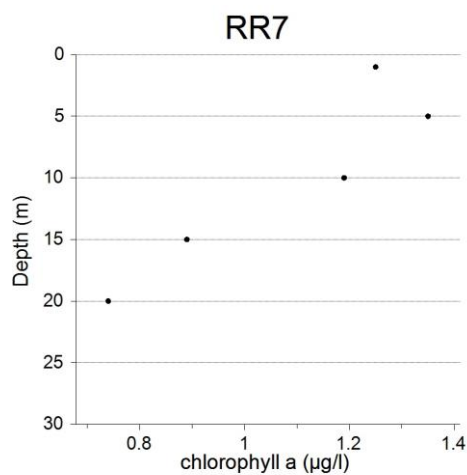
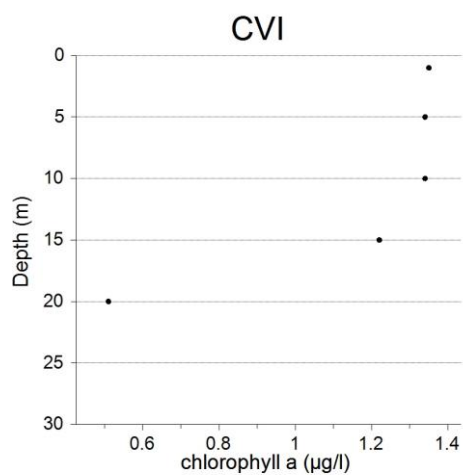
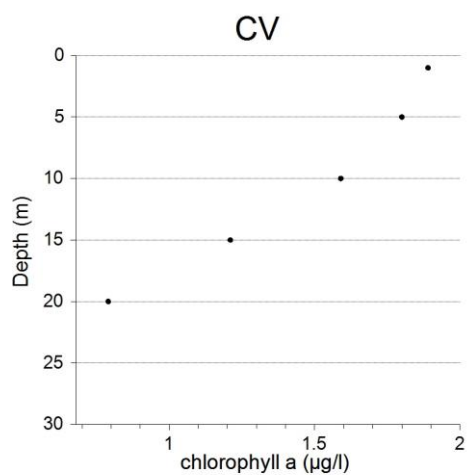




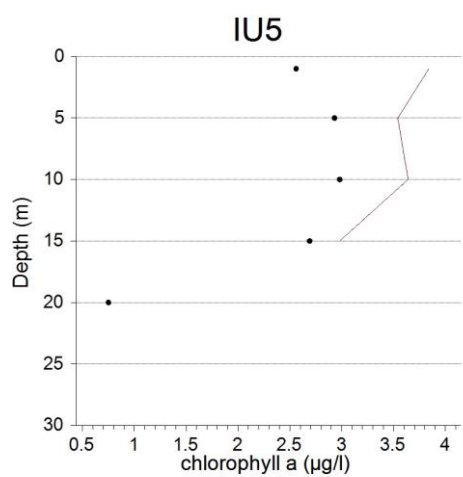
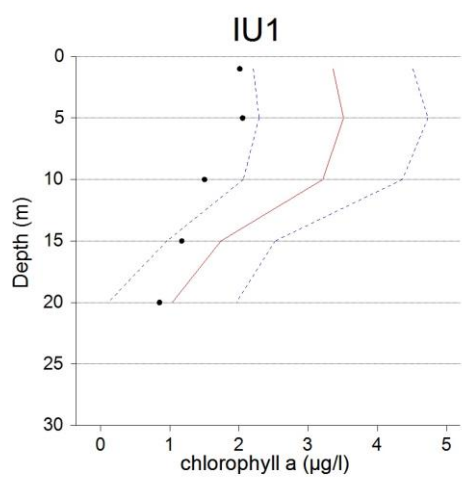
Figures 226-232. Observed chlorophyll a concentrations at F33, SR7, SR5, SR3, MS3, US6b and US7 and average summer concentration at SR5 since 2000 (red line) and standard deviations (dotted blue line) at in the Bothnian Sea in August 2019.

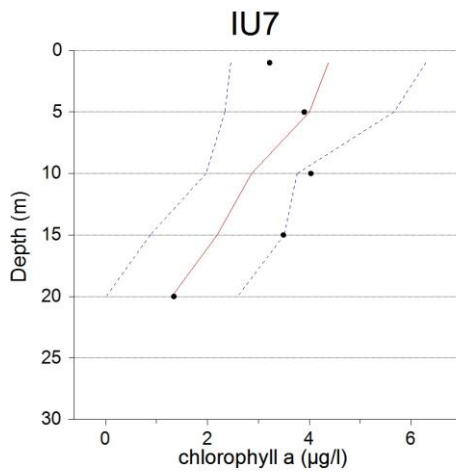


Figures 233-235. Observed chlorophyll a concentrations and average summer concentrations since 2000 (red line) and standard deviations (dotted blue line) in Kvarken at F18, F13 and F16 in August 2019.



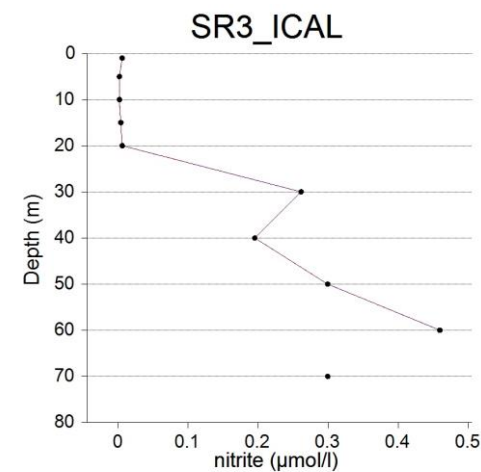
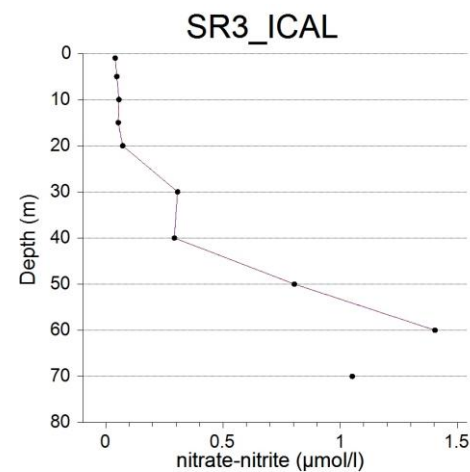
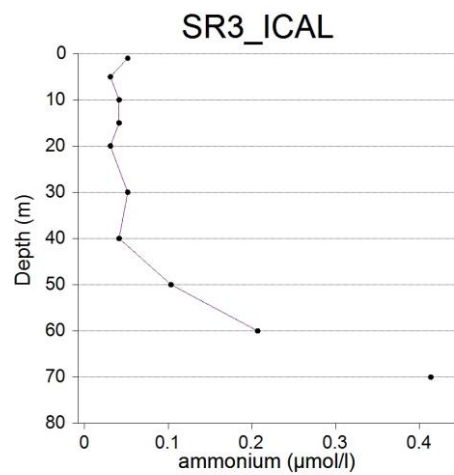
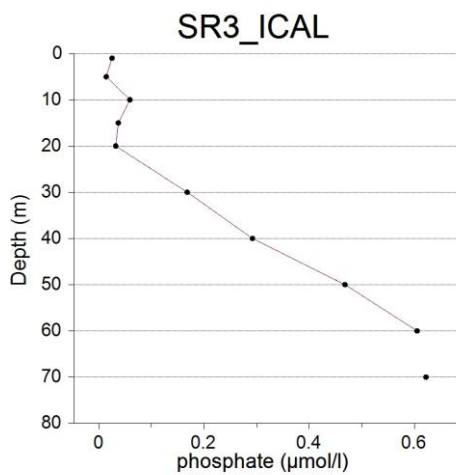
Figures 236-238. Observed chlorophyll a concentrations in the Bothnian Bay at CVI, CV and RR7 in August 2019.

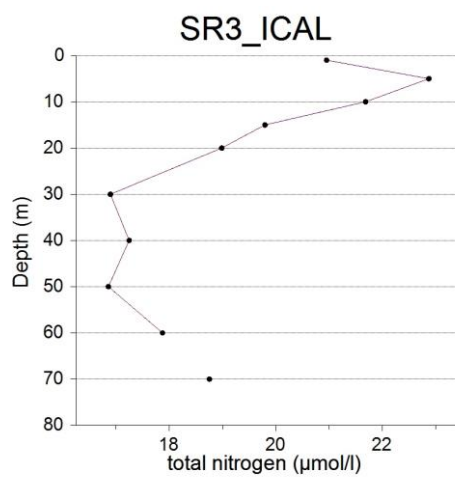
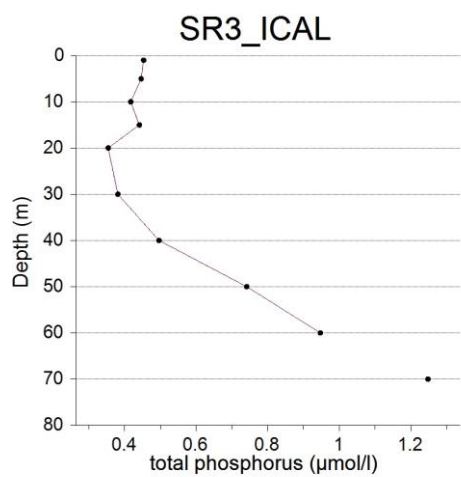




Figures 239-241. Observed chlorophyll a concentrations and average summer concentrations since 2000 (red line) and standard deviations (dotted blue line) in the Archipelago Sea at IU1, IU5 and IU7 in August 2019.

## Intercalibration





Figures 242-247. Observed  $\text{PO}_4$ ,  $\text{NH}_4$ ,  $\text{NO}_{2,3}$ ,  $\text{NO}_2$ ,  $\text{N}_{\text{tot}}$  and  $\text{P}_{\text{tot}}$  concentrations at the intercalibration station SR3\_ICAL in August 2019.