

Report from the SMHI monitoring cruise with R/V Aranda



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Survey period: 2015-12-07 - 2015-12-15
Survey area: Skagerrak, Kattegat, the Sound, the Baltic Proper and the Gulf of Finland
Principal: SMHI and the Swedish Agency for Marine and Water Management

SUMMARY

The expedition was part of the Swedish regular marine monitoring programme and covered the Skagerrak, the Kattegat, the Sound, the Baltic Proper and the Gulf of Finland. Data presented in this report has been subject to preliminary quality control procedures only.

The water temperature was slightly above normal throughout the study area. The concentrations of nutrients in surface water were normal for the season in the Skagerrak and the Kattegat. In the Baltic proper, concentrations of inorganic nitrogen ($\text{NO}_2 + \text{NO}_3$) were at normal levels in the surface water. Phosphate and silicate showed levels above normal in the central and northern parts while the silicate was well below average for the season in the southern parts of the Baltic proper.

The effect of the inflow in December 2014 could not be detected farther north than the station BY20 in the Eastern Gotland Basin. In the Western and Northern Gotland Basins the oxygen situation remains very serious.

The next regular cruise is scheduled to start 7 January, 2016.

PRELIMINARY RESULTS

The expedition was conducted aboard the Finnish research vessel Aranda. It commenced in Helsinki on December 7 and ended in the same port on December 15. The winds during the expedition were predominantly western to northern, and varied in strength from brisk to gale force. Air temperatures ranged between 0.6 and 8.5 °C.

In the Gulf of Finland and the northern Baltic Proper four stations that are usually sampled by the Finnish Environment Institute (SYKE) were visited. This extended monitoring is part of a new collaboration between SYKE and SMHI with a view to, i.e., increasing the sampling frequency at Swedish and Finnish monitoring stations.

The Skagerrak

The temperature of the surface water varied between 8.9 and 10.0°C, which is above normal for the season. The salinity in the surface layer, also clearly higher than normal, varied between 33.1 and 34.2 psu. The stratification in both temperature and salinity was very weak, and the entire water column fairly homogeneous concerning these parameters.

Nutrient levels had risen since the previous survey in November and showed typical concentrations for the season. In the surface water, levels of phosphate ranged from 0.40 to 0.57 µmol/l, inorganic nitrogen (nitrite + nitrate) between 2.4 and 4.7 µmol/l, while silicate varied from 2.8 to 6.8 µmol/l. The lowest oxygen level in the bottom water was measured at Släggö, in the mouth of Gullmarsfjorden, 3.4 ml/l at 72 m depth. The lowest oxygen concentration, 5.3 ml/l, corresponding to a saturation of 80%, was measured at a depth of 300 metres in the outer parts of the area. Fluorescence measurements showed low biological activity in the surface layer 0-10 m. For more details on species composition see the separate algal report.

The Kattegat and the Sound

Also in the Kattegat, the temperature of the surface water was above normal, here between 8.2 and 8.5° C. The salinity of the surface layer varied between 29.4 and 31.3 psu, also higher than normal. In the Sound, temperature and salinity were 7.4°C and 19.1 psu, respectively. Similar to Skagerrak, the stratification was very weak and the water column almost homogeneous throughout.

Nutrient levels in the surface water were normal for the season while, due to the weak stratification, concentrations in the deep water were well below normal. Phosphate concentrations in the surface layer varied between 0.40 and 0.48 µmol/l, the sum of nitrite + nitrate was in the range of 2.7 - 3.7 µmol/l and silicate between 4.7 and 6.5 µmol/l. Even in the Sound the stratification was very weak. The nutrient concentrations were 0.62 µmol/l of phosphate, 4.73 µmol/l of nitrite + nitrate and 8.6 µmol/l of silicate.

Because of the weak stratification oxygen conditions in the deep water were good, especially in the Sound, where 6.6 ml/l was observed in the bottom water. The lowest value recorded in the Kattegat was found at station Anholt E, 4.4 ml/l at 61 metres depth.

The plankton activity was low throughout the water column.

The Baltic Proper

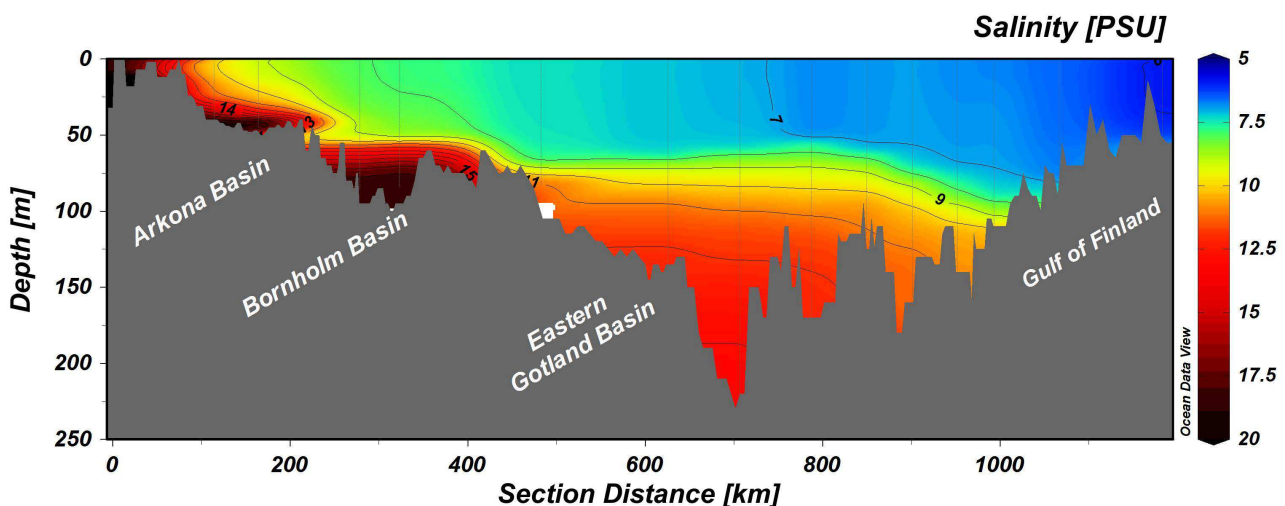
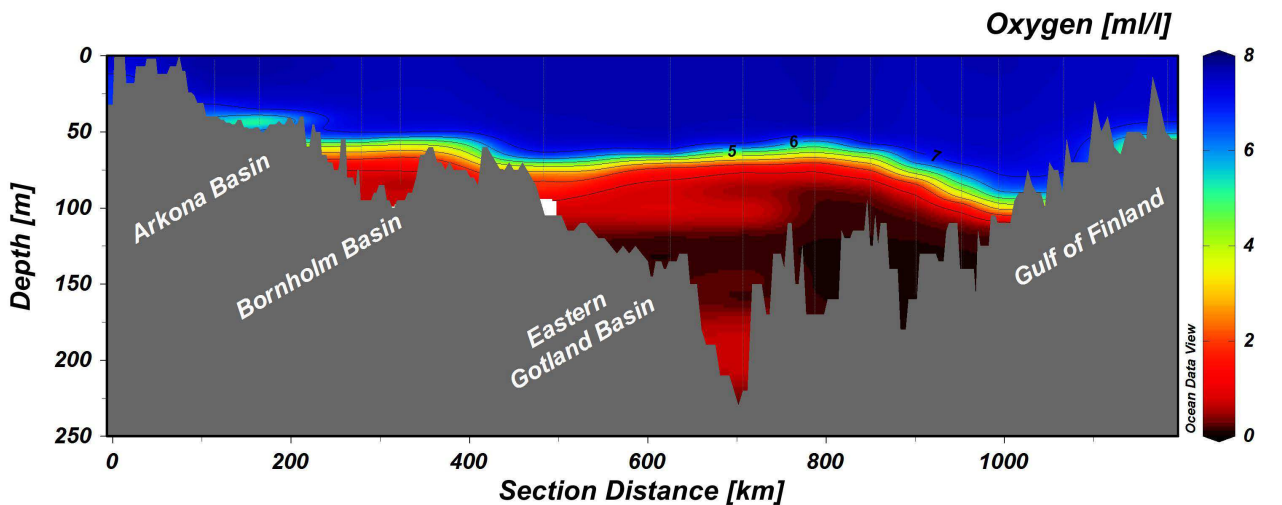
The temperature of the surface layer was slightly above normal for the season and varied from 6.7°C to 8.5°C. Surface salinity was elevated in the Arkona Basin, the Hanö Bay and parts of the Bornholm Basin, in other areas normal. The halocline and thermocline coincided and were found at 50-60 metres in the western Gotland Basin and at 50-80 metres depth in the eastern and northern Gotland Basin, while it was situated slightly shallower in the south.

Phosphate concentrations in the surface water had risen further since the previous survey and now lay between 0.5 and 0.6 $\mu\text{mol/l}$. The concentrations were above average for the season in northern, western and eastern Gotland Basins while they were normal in other areas. The concentrations of nitrite + nitrate were normal throughout the investigated area and ranged from 1.2 to 3.1 $\mu\text{mol/l}$. The concentrations of silicate were well below normal in the southern parts while they were normal or elevated in other areas. The concentrations ranged between 5 and 14 $\mu\text{mol/l}$.

In the Eastern Gotland Basin, acute hypoxia ($<2\text{ ml/l}$) occurred at depths exceeding 70-80 metres. Hydrogen sulphide was present, as during the previous survey, from 125 metres depth in the northern part (BY20). At BY15 and southwards the deep water was oxygenated and no hydrogen sulphide was measured. The concentration of oxygen in the bottom water was, however, very low, around 0.2 ml/l. Oxygen levels in the bottom water in the Bornholm Basin and Hanö Bight were still low and acute hypoxia prevailed.

In western and northern Gotland Basins the oxygen situation remains very serious. In the western Gotland Basin completely oxygen-free conditions were observed, with hydrogen sulphide from 70-80 m, while acute hypoxia, $<2\text{ ml/l}$, occurred from 60-70 meters. In the northern part completely oxygen-free conditions were observed from 100-125 metres and acute hypoxia from 70-90 metres.

Fluorescence measurements showed low biological activity.



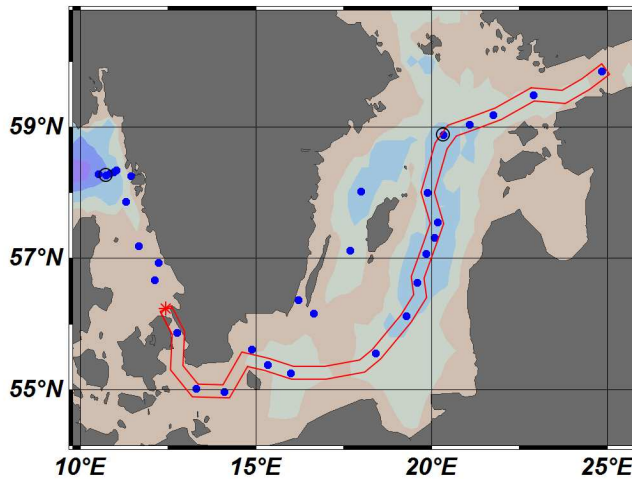


Figure 1. Transect showing the oxygen and salinity from the Sound to the Gulf of Finland.

PARTICIPANTS

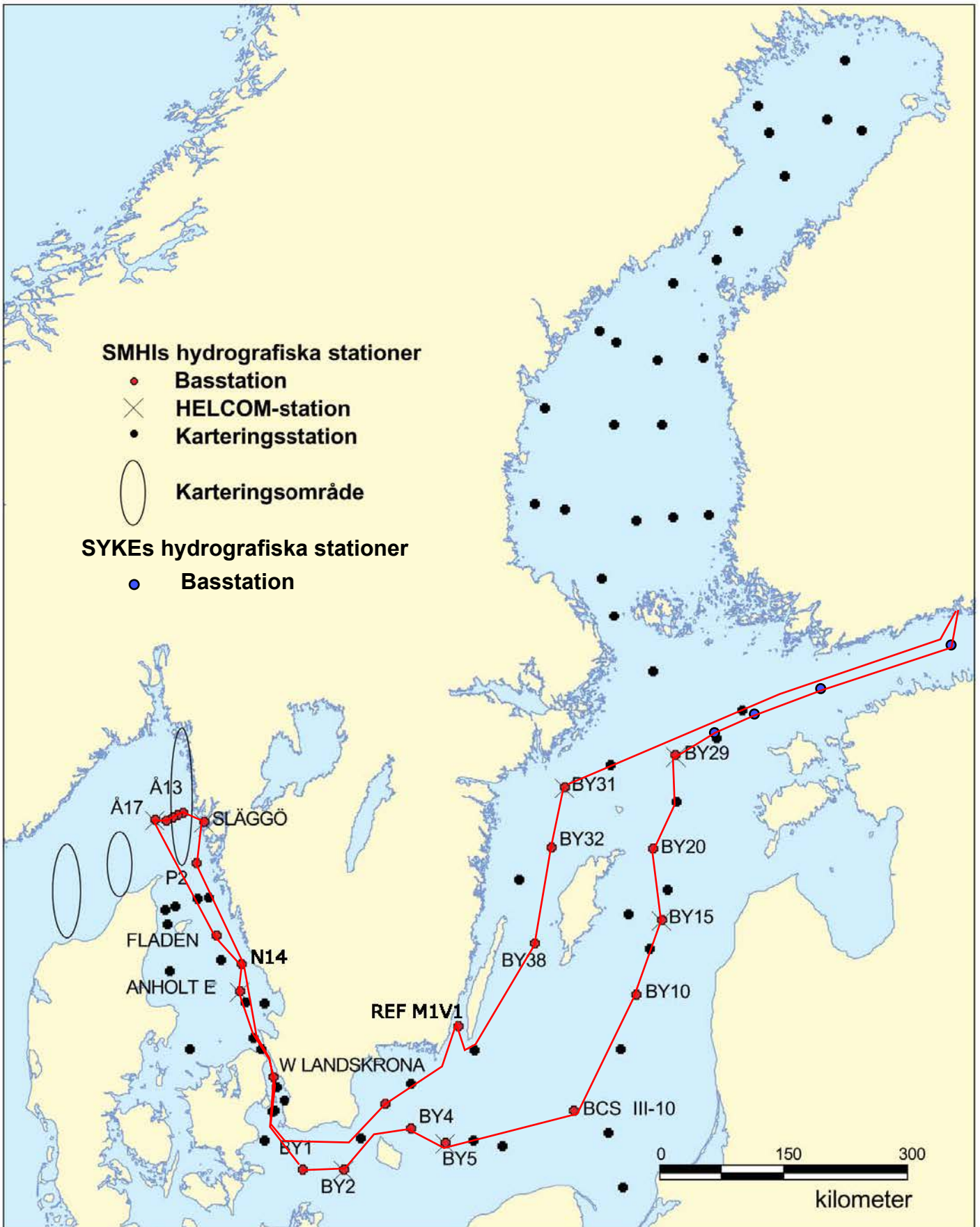
Name		Institute
Lars Andersson	Chief scientist	SMHI
Daniel Bergman-Sjöstrand	Helsinki-Lysekil	SMHI
Johan Håkansson		SMHI
Mikael Krysell	Lysekil-Helsinki	SMHI
Johan Kronsell		SMHI
Daniel Simonsson		SMHI
Jukka-Pekka Myllykangas		University of Helsinki

APPENDICES

- Track chart
- Table over stations, parameters and sampling depths
- Map showing bottom oxygen concentrations
- Monthly average surface water plots for selected stations
- Vertical profiles for selected stations

TRACKCHART

Country: Sweden
Ship: R/V ARANDA
Date: 20151207-201511214
Series: 0666-0697



SMHI
Ocean enh

***** Hydrographic series

Ship: 01-Aranda
Year: 2015

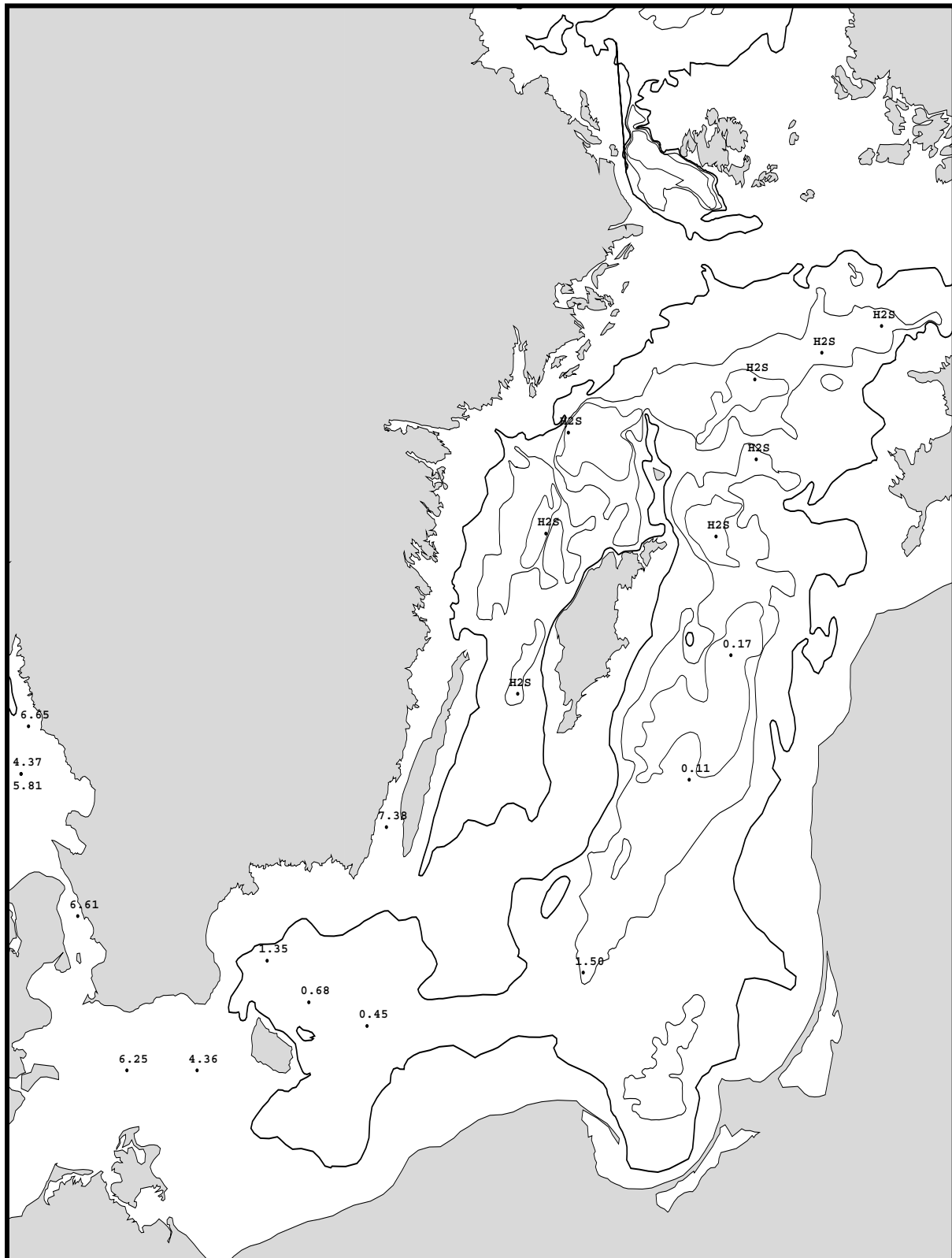
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Time: 13:09

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0693	BPSH05BAS		HANÖBUKTEN	N5537	E1452	20151212	1430	79		27 12	6.8	1011	1630	x	--x----	11	x	x	-	x	-	x	x	x	x	x	-	x	-	-	-	-
0694	BPWK01BAS		REF M1V1	N5622.25	E1612.1	20151212	2045	21		26 8	4.3	1010	9990	x	-xxxx--	5	x	x	x	-	x	x	x	x	x	x	-	-	-	-	-	
0695	BPWX45BAS		BY38 KARLSÖDJ	N5707	E1740	20151213	0530	111		34 3	3.5	1005	9990	x	--x----	14	x	x	-	x	x	x	x	x	x	-	-	-	-	-		
0696	BPWX38BAS		BY32 NORRKÖPINGSDJ	N5801	E1759	20151213	1045	202	9	36 8	1.7	1008	1230	x	-xx----	17	x	x	-	x	x	x	x	x	x	x	-	-	-	-	x	
0697	BPX37BAS		BY31 LANDSORTSDJ	N5835	E1814	20151213	1500	435		34 11	0.6	1009	1630	x	--xxx--	23	x	x	x	x	x	x	x	x	x	x	-	-	-	-	x	

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Bottom water oxygen concentration (ml/l)

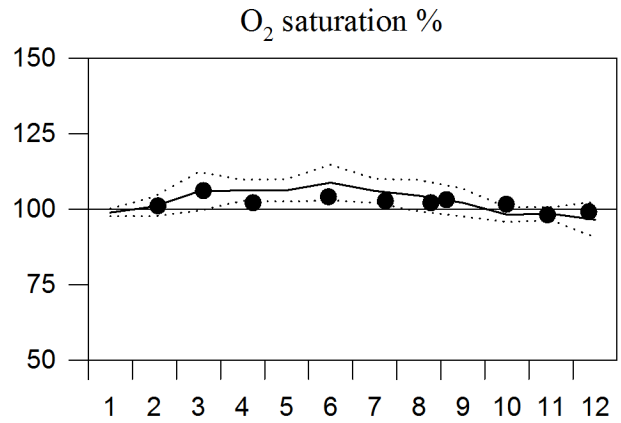
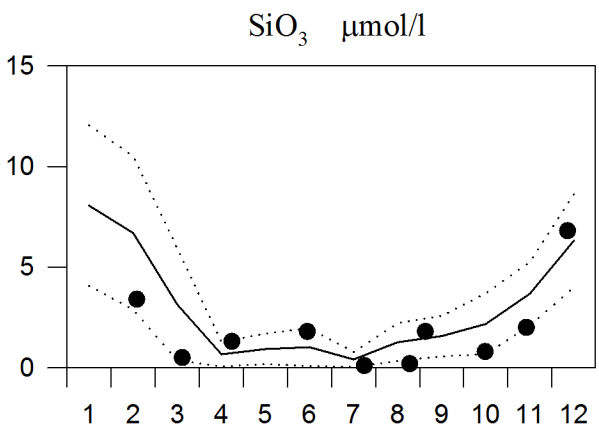
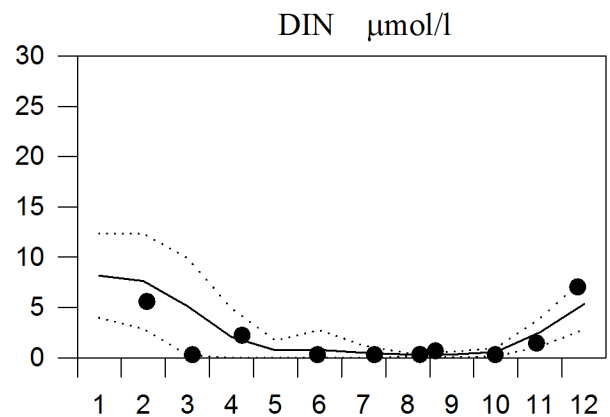
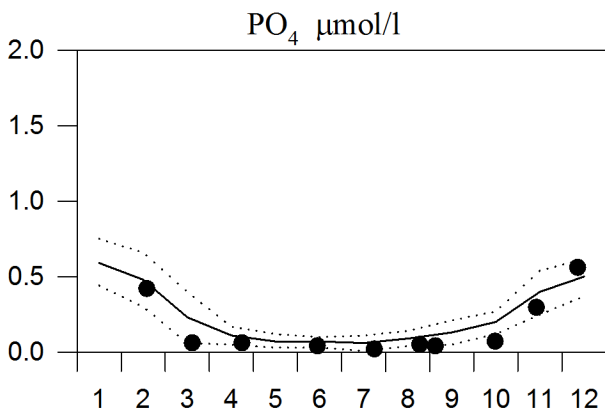
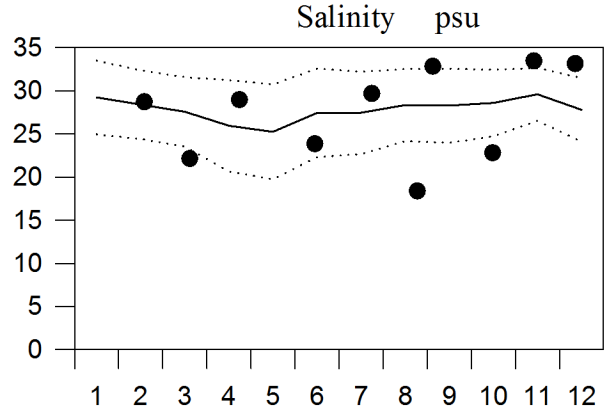
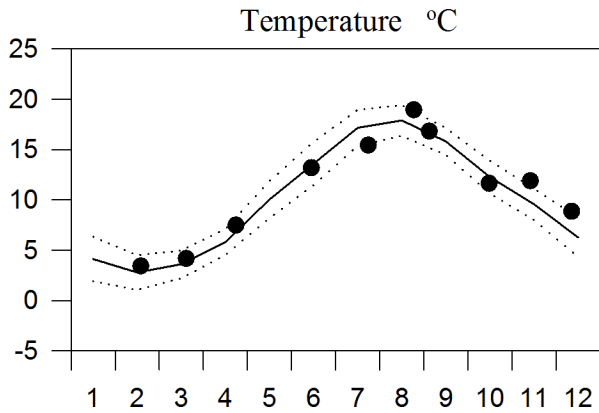
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Ship : Aranda
Date : 20151207-20151213
Series : 0666-0697



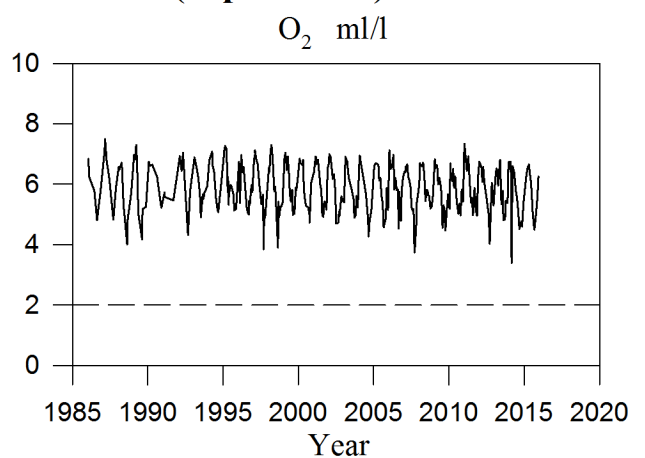
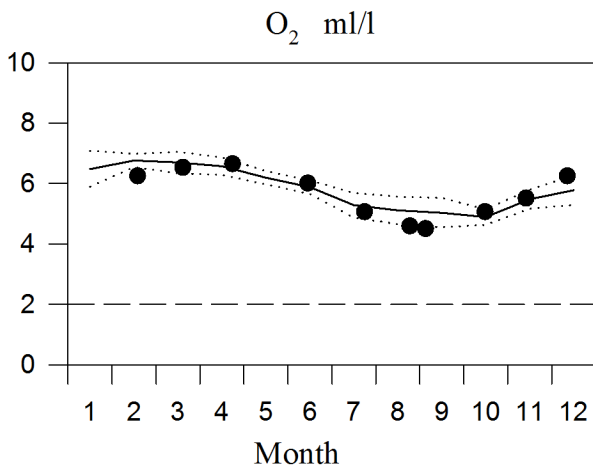
STATION P2 SURFACE WATER

Annual Cycles

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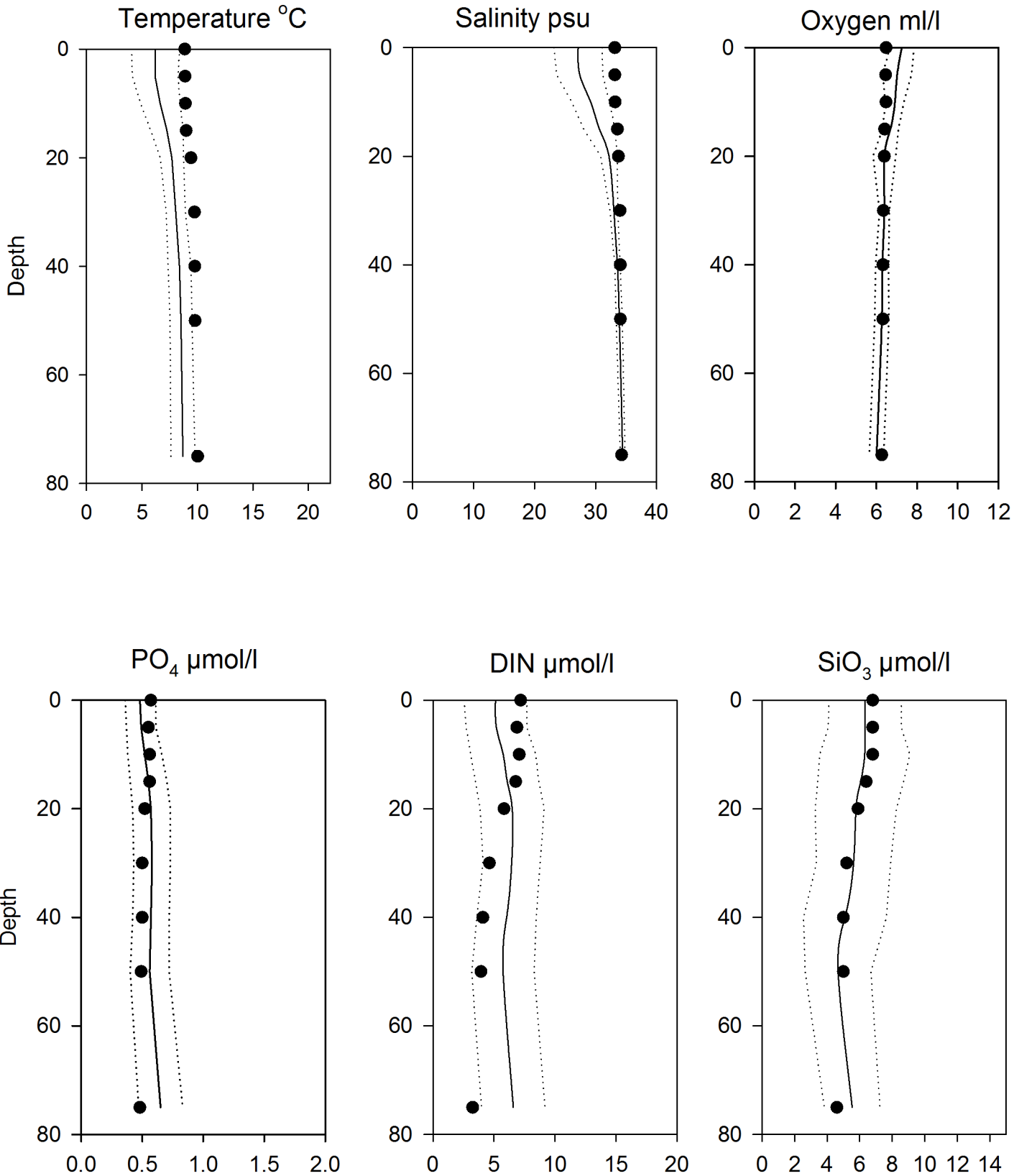


OXYGEN IN BOTTOM WATER (depth >75m)



Vertical profiles P2 December

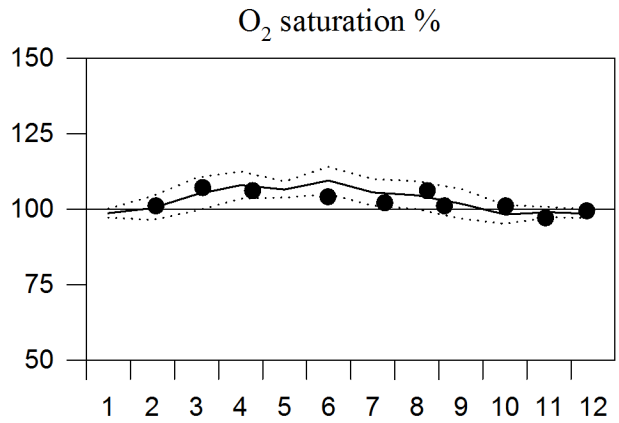
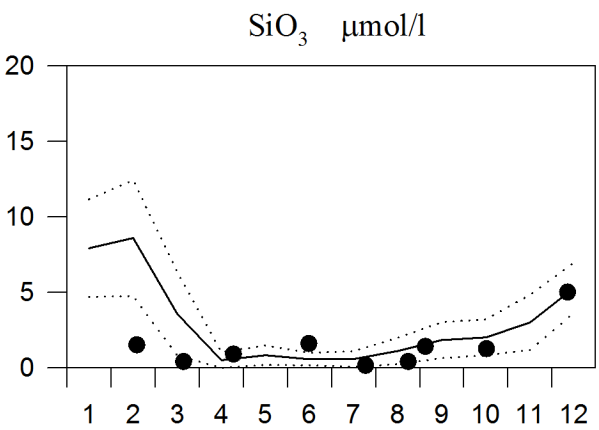
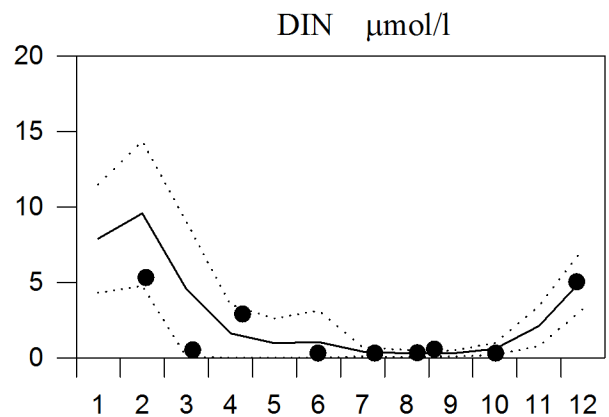
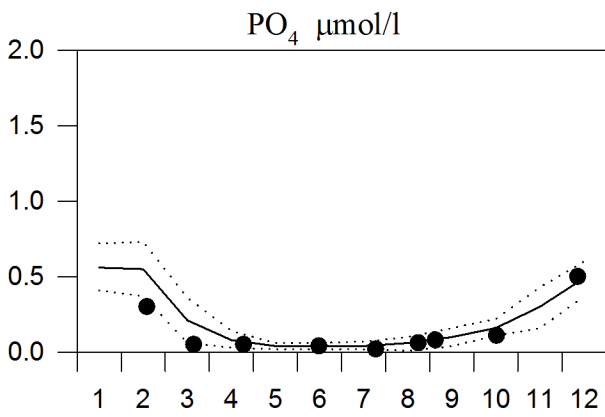
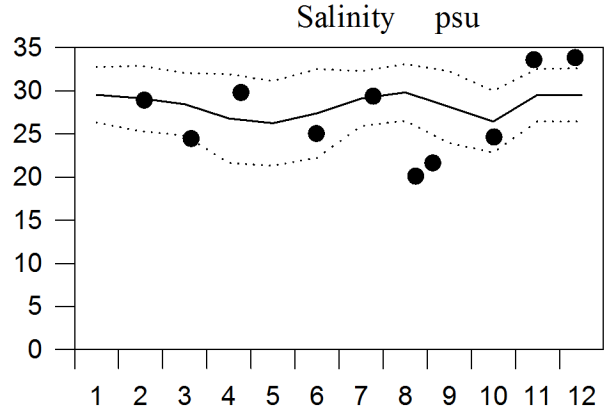
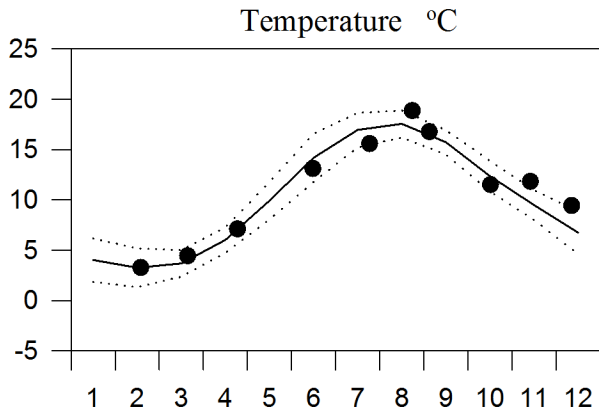
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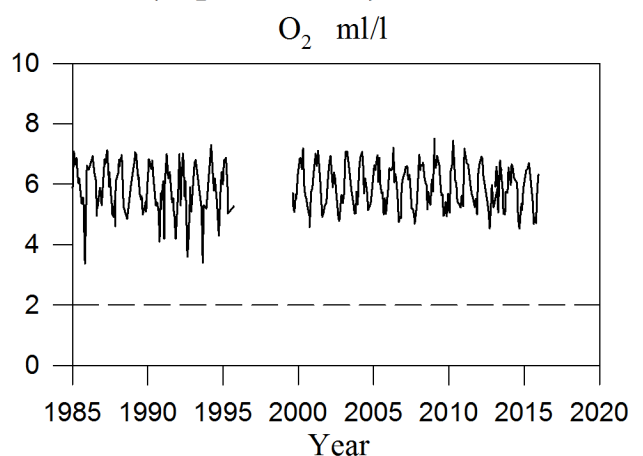
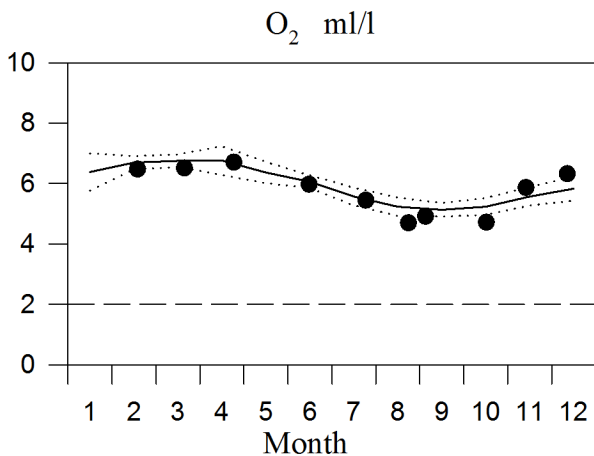
STATION Å13 SURFACE WATER

Annual Cycles

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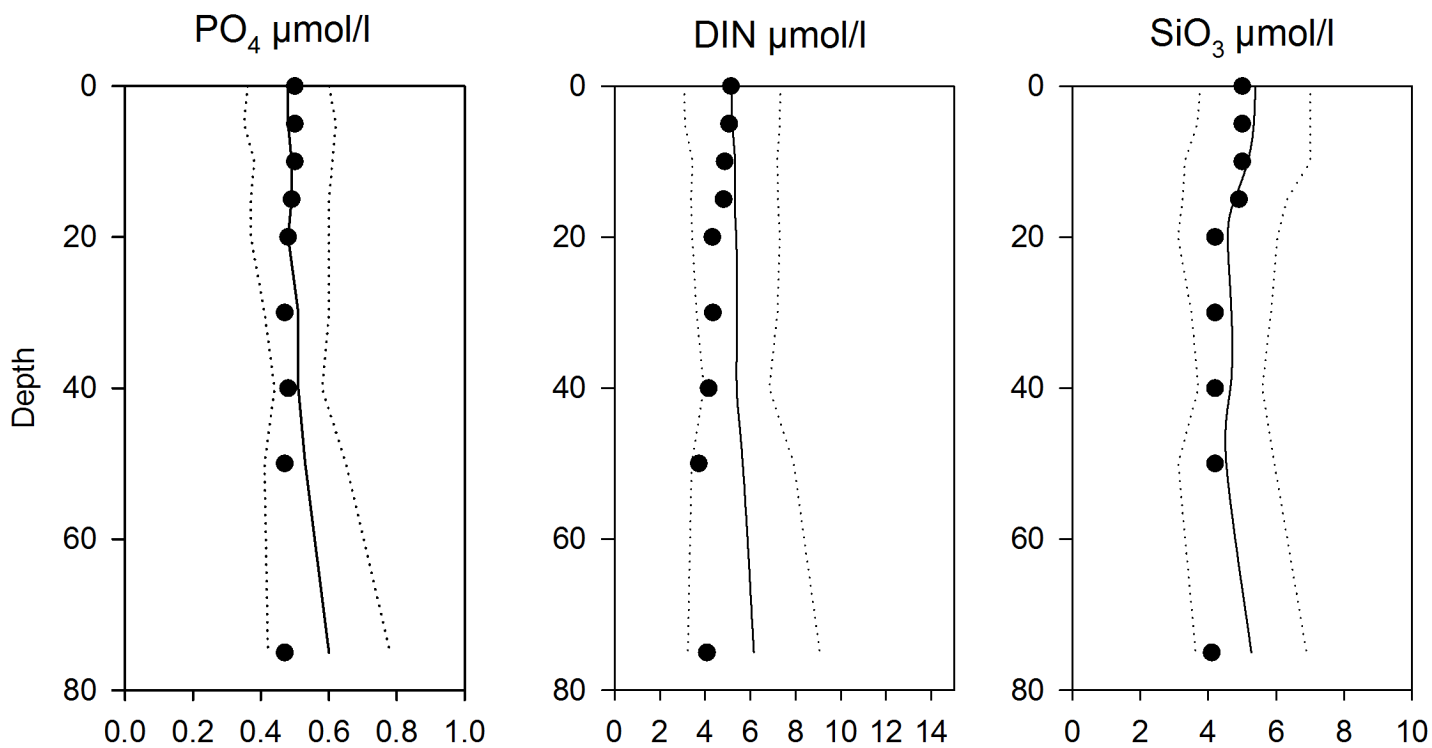
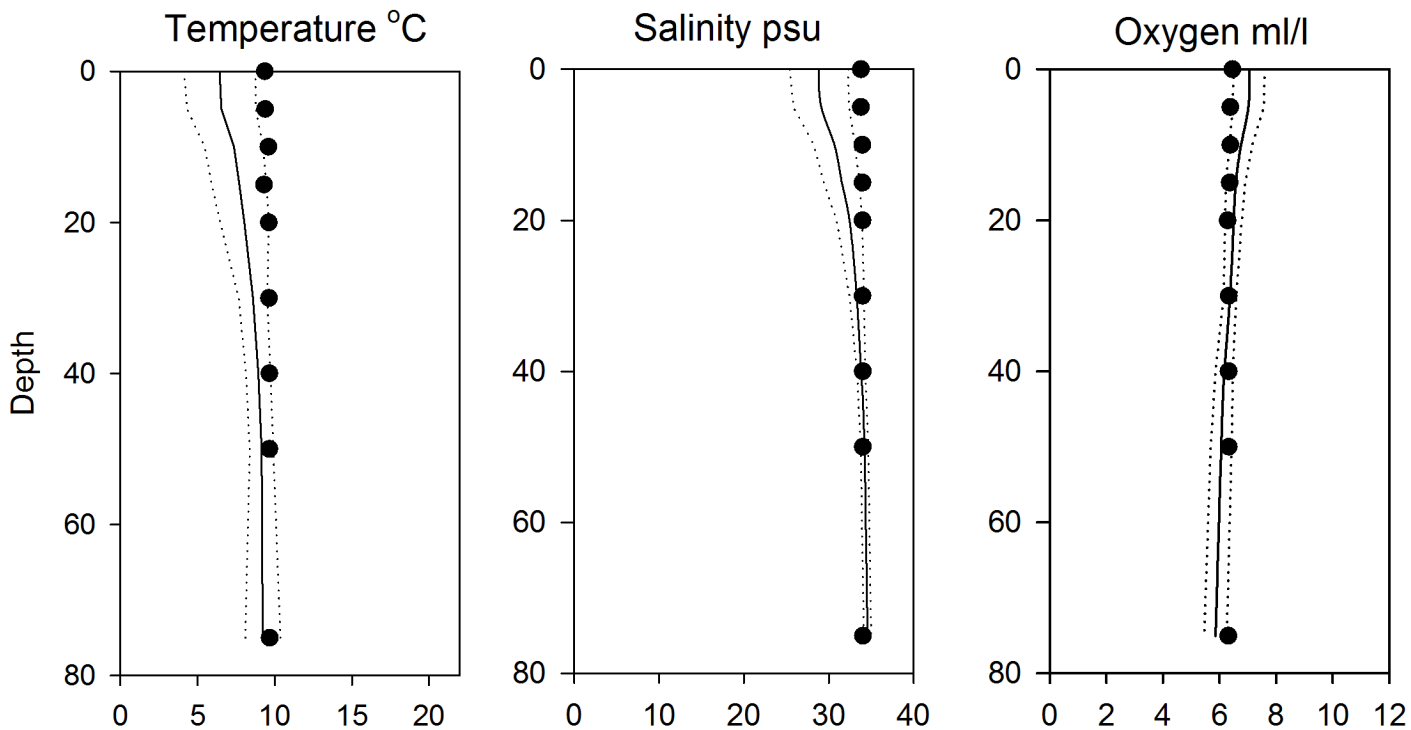


OXYGEN IN BOTTOM WATER (depth >=75m)



Vertical profiles Å13 December

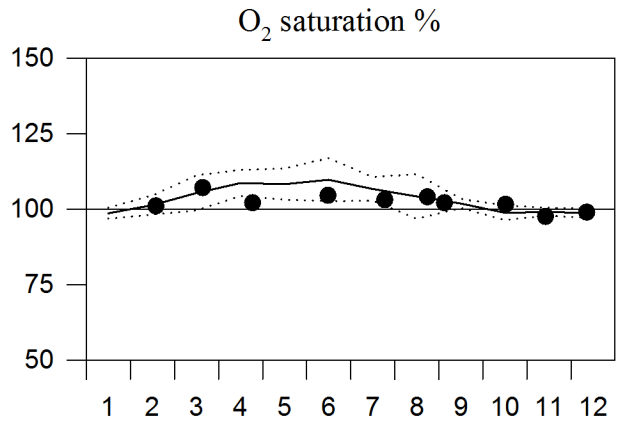
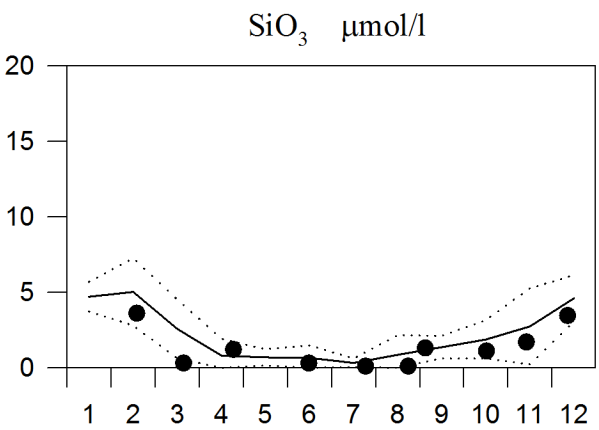
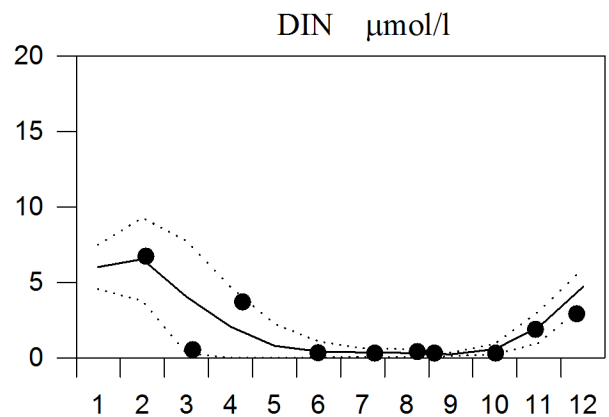
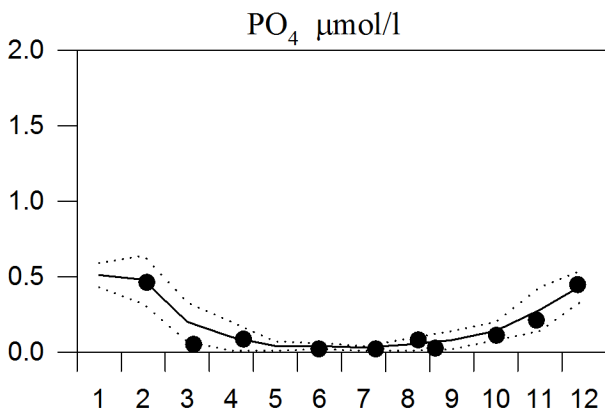
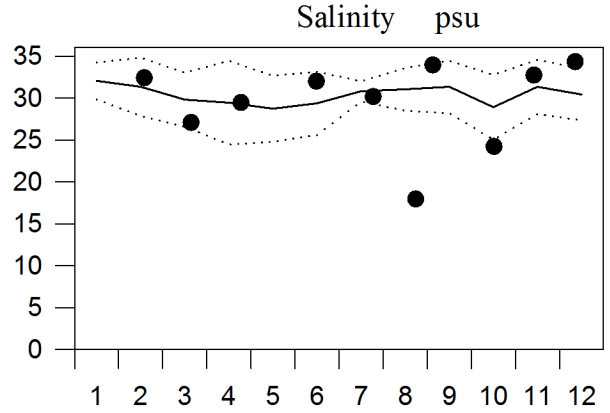
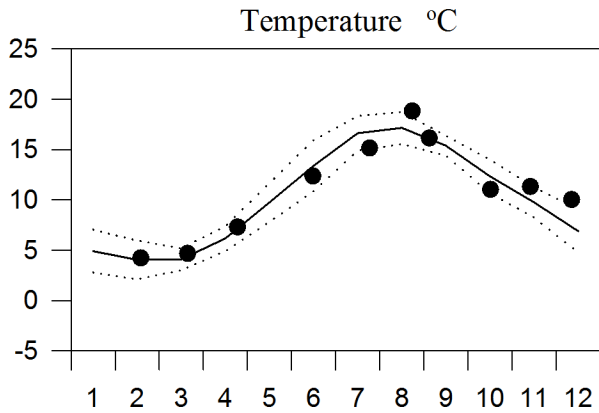
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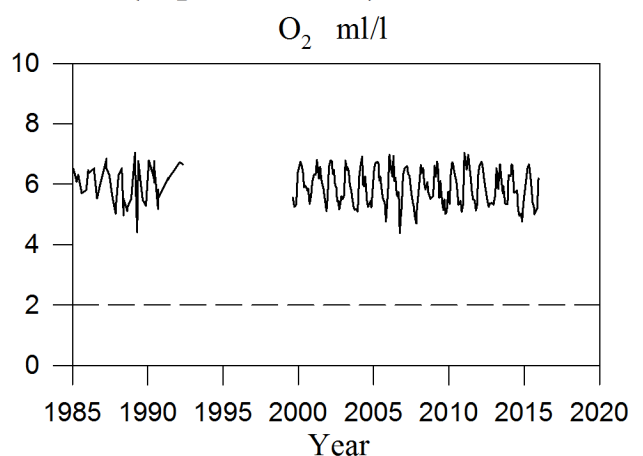
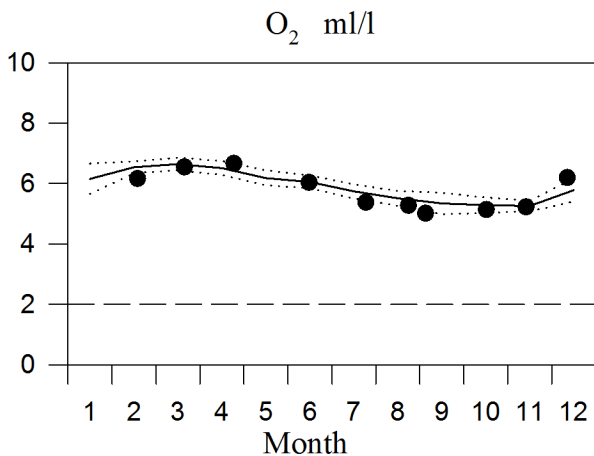
STATION Å15 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

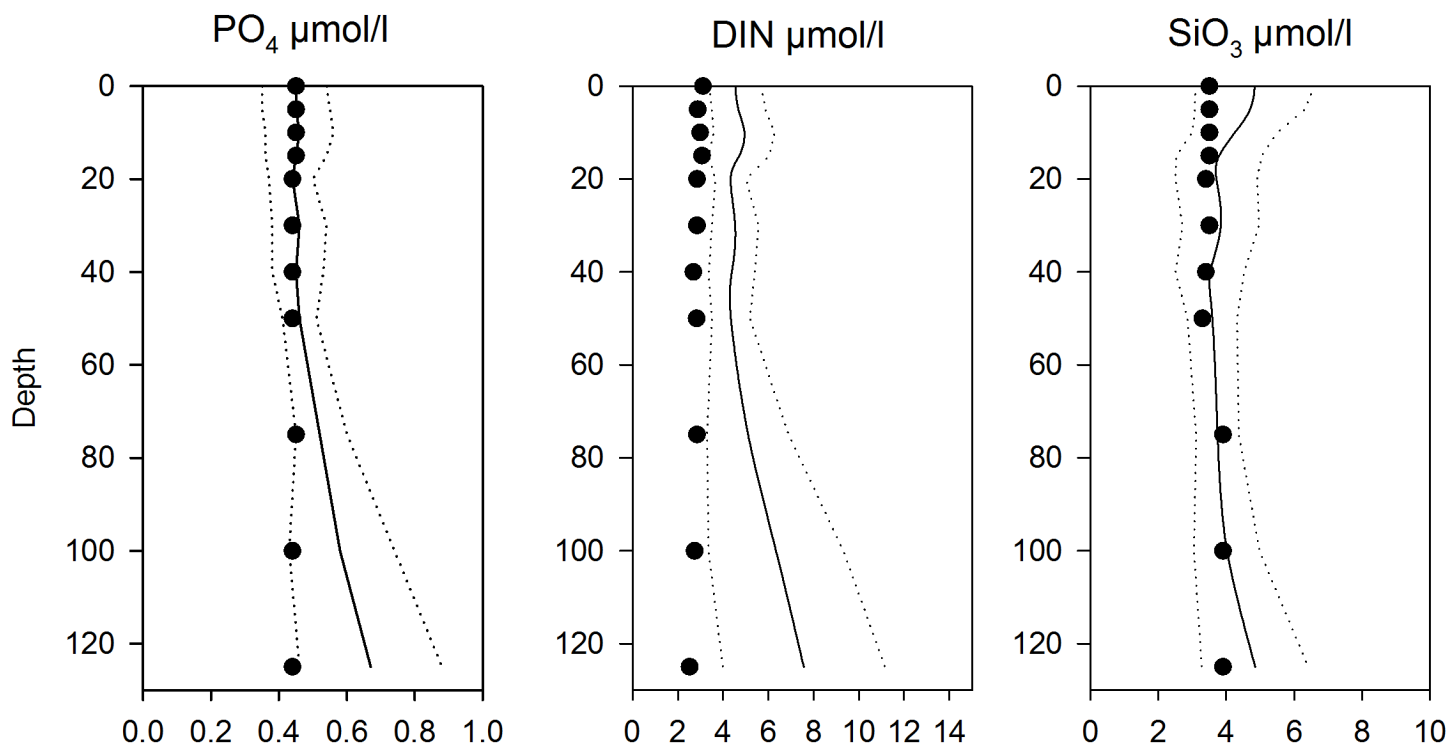
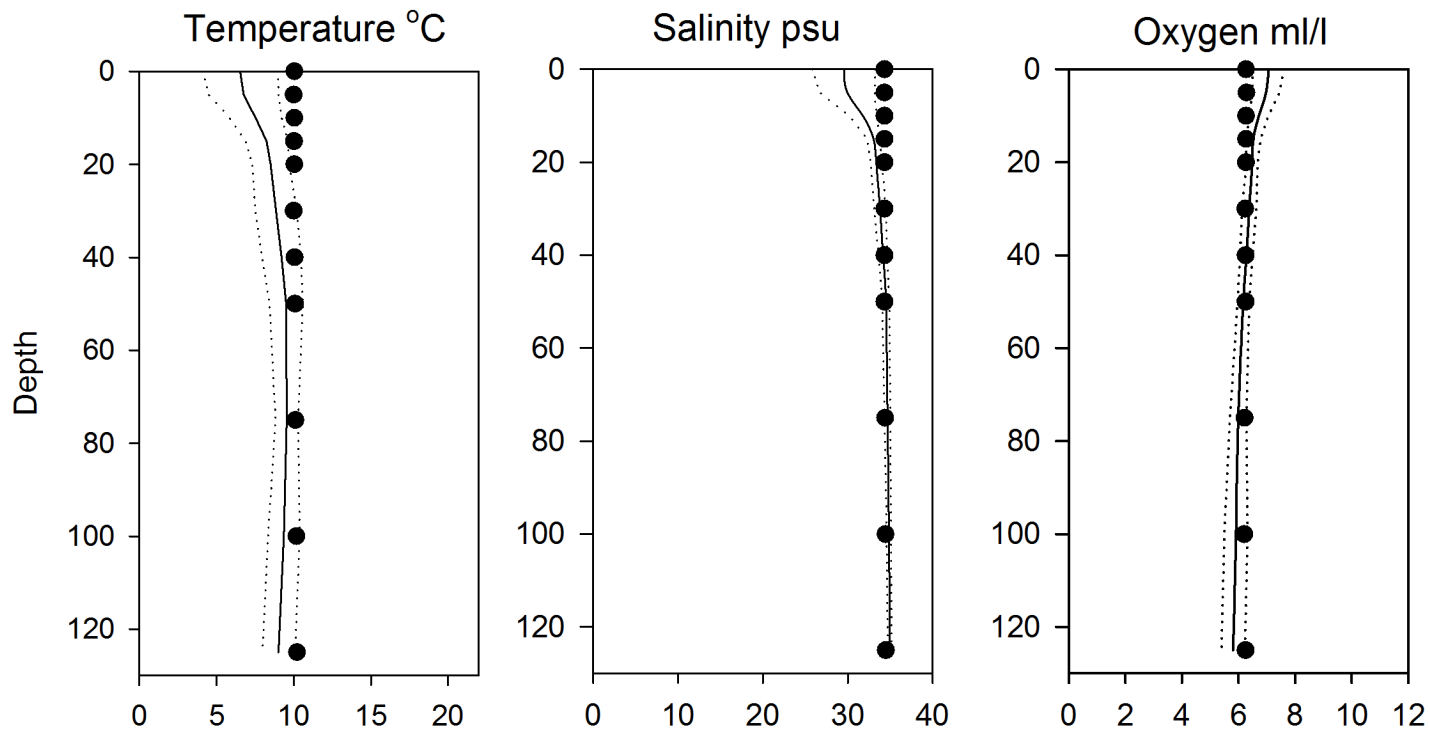


OXYGEN IN BOTTOM WATER (depth >=125m)



Vertical profiles Å15 December

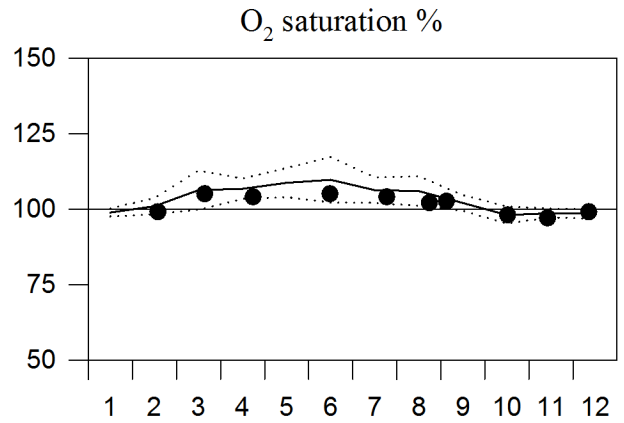
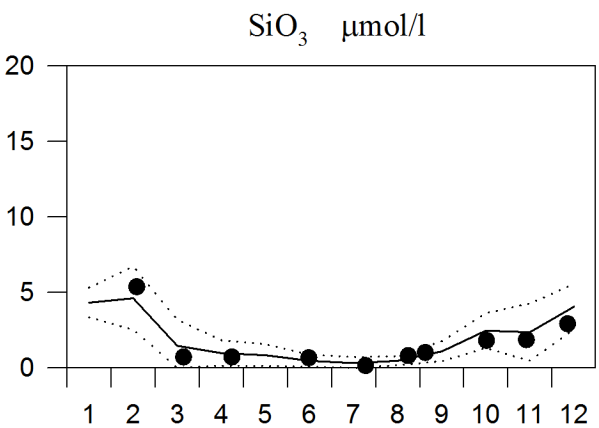
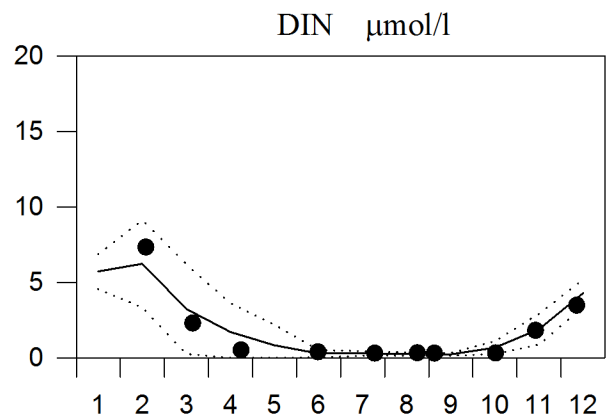
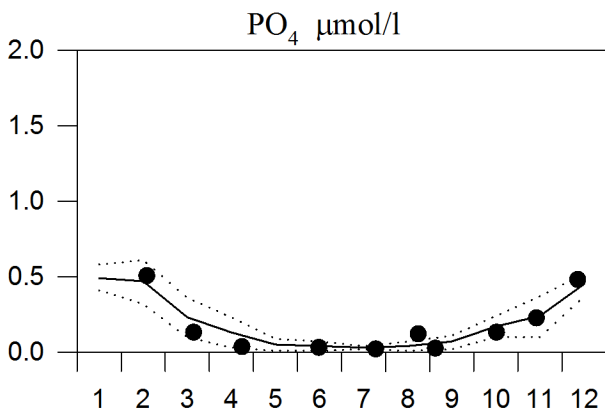
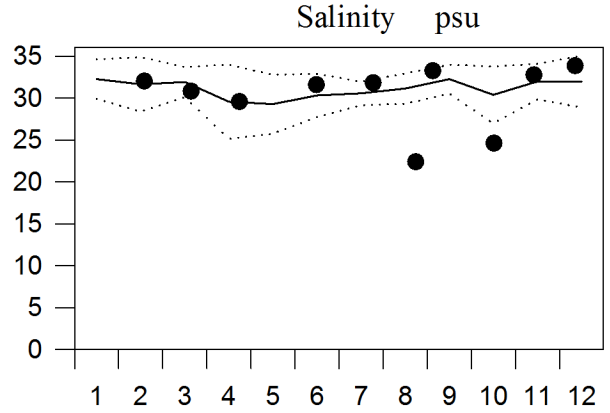
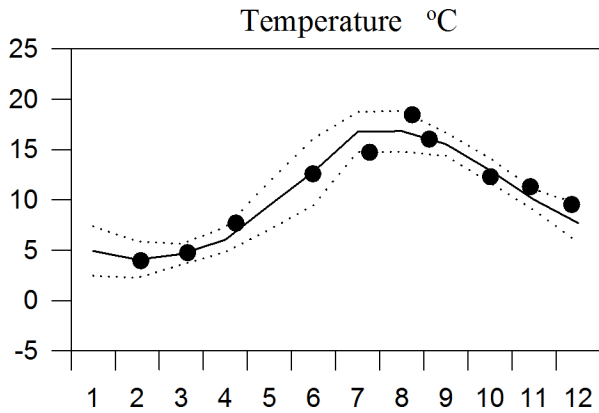
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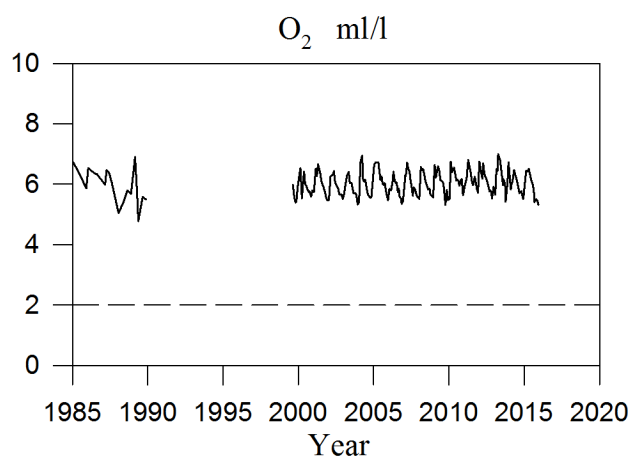
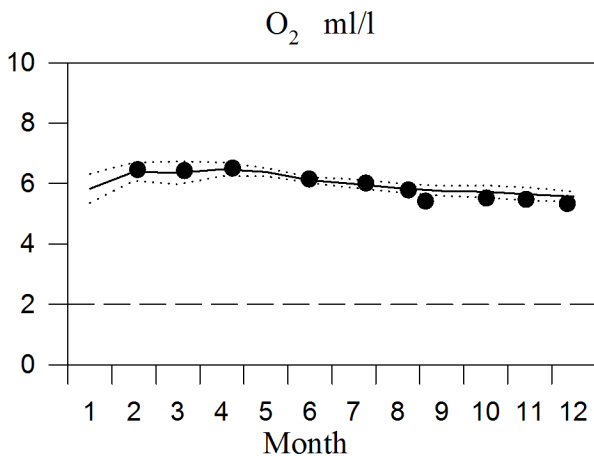
STATION Å17 SURFACE WATER

Annual Cycles

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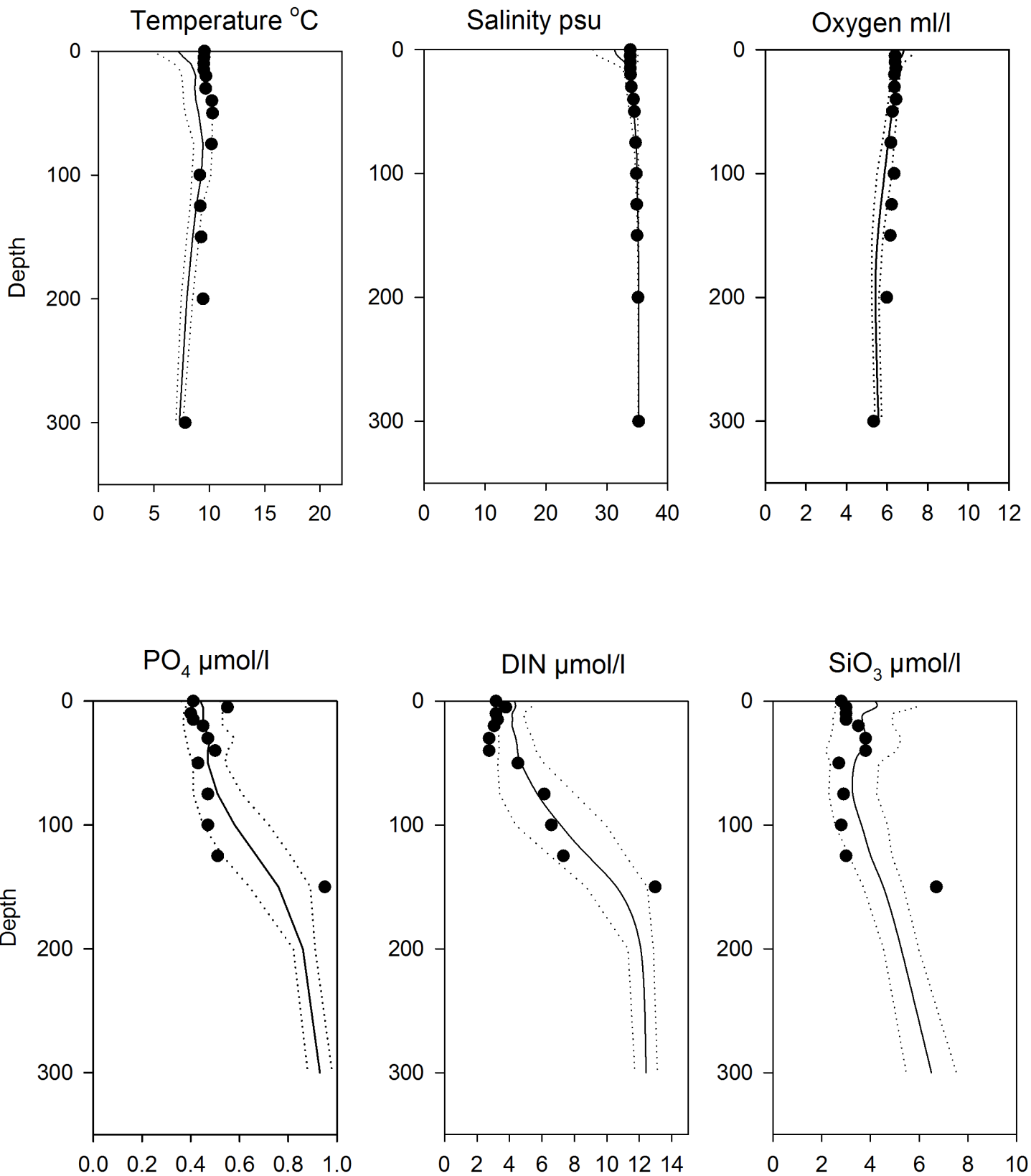


OXYGEN IN BOTTOM WATER (depth = 300m)



Vertical profiles Å17 December

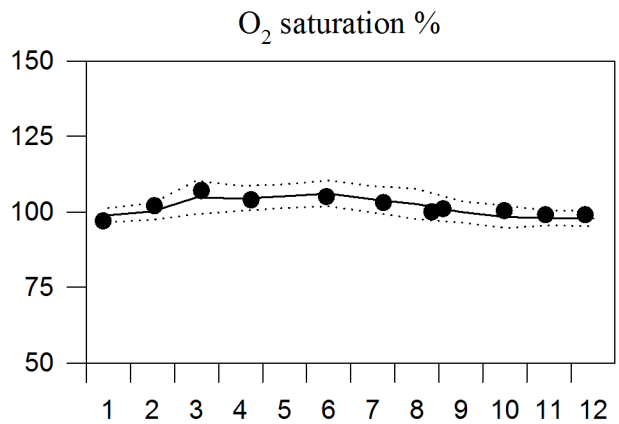
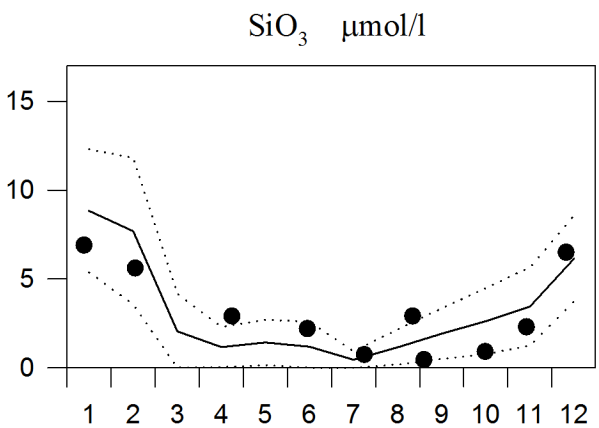
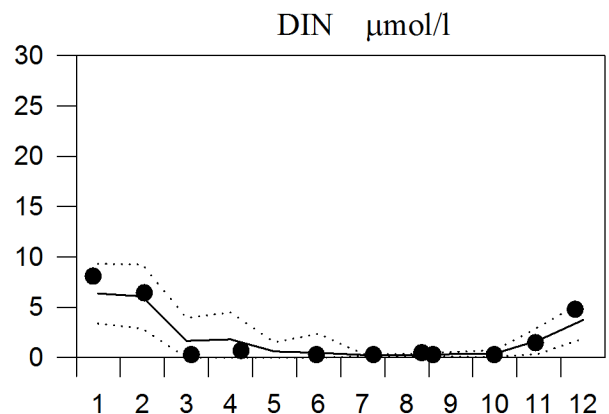
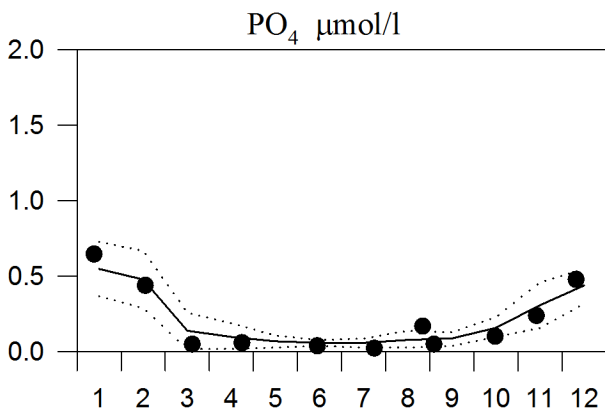
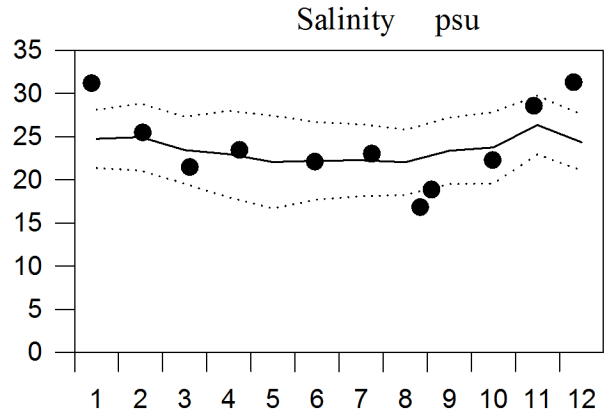
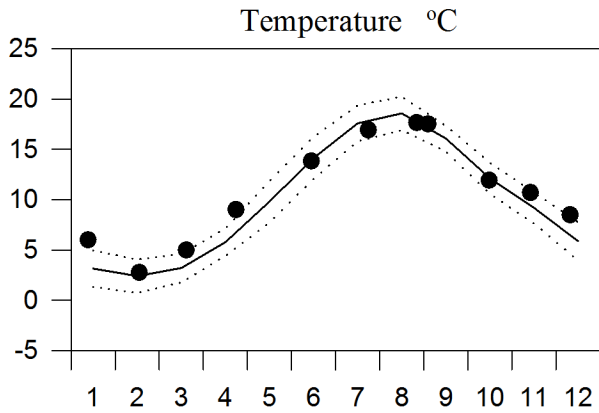
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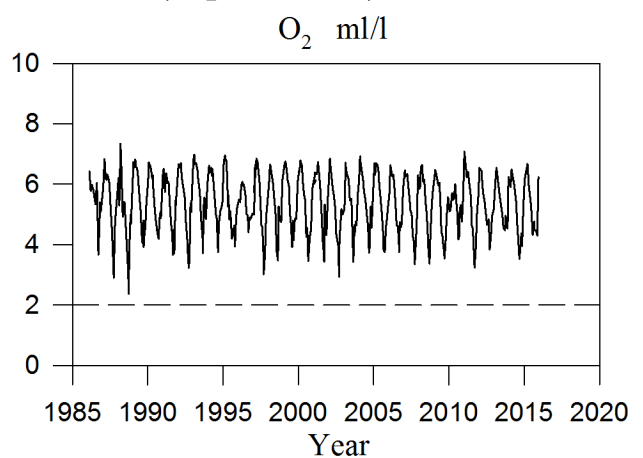
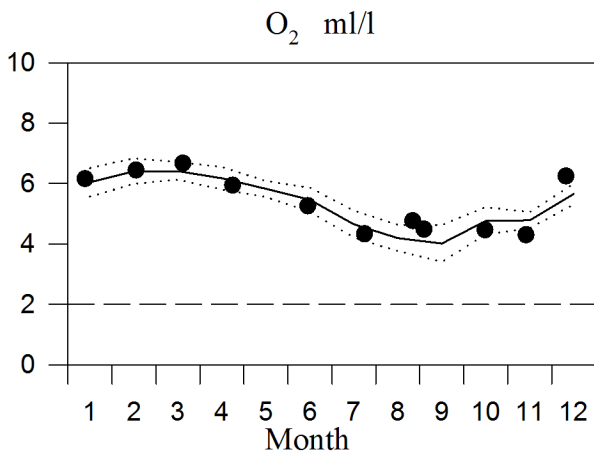
STATION FLADEN SURFACE WATER

Annual Cycles

— Mean 1996-2010 ····· St.Dev. ● 2015

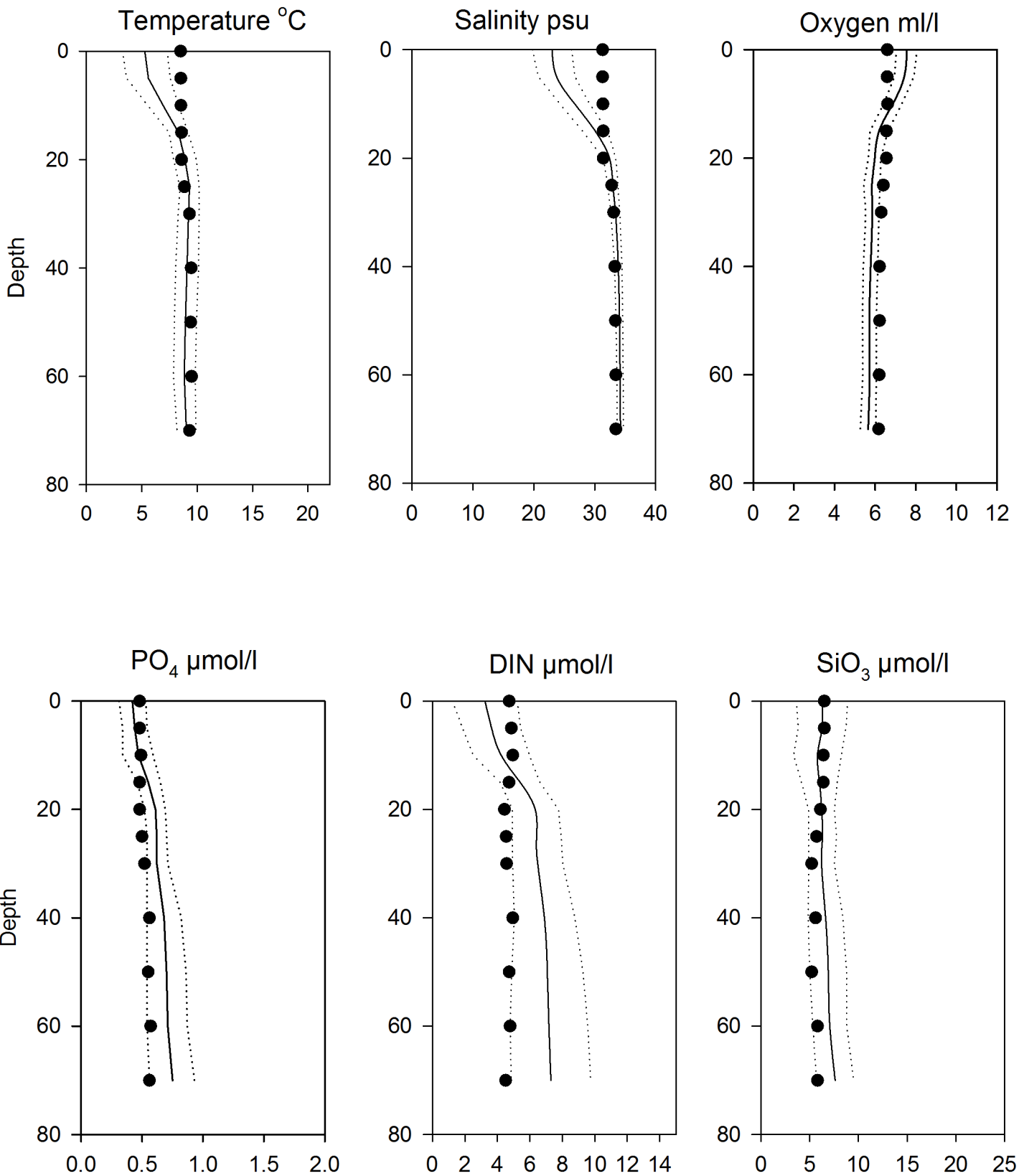


OXYGEN IN BOTTOM WATER (depth > 70m)



Vertical profiles Fladen December

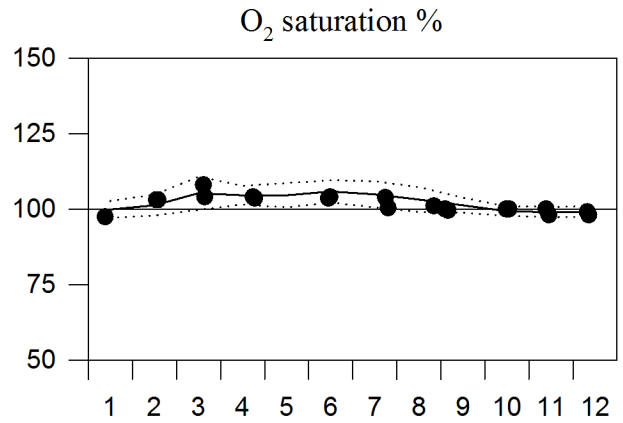
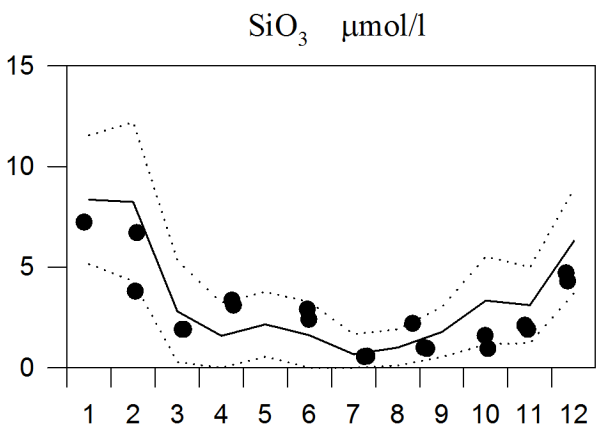
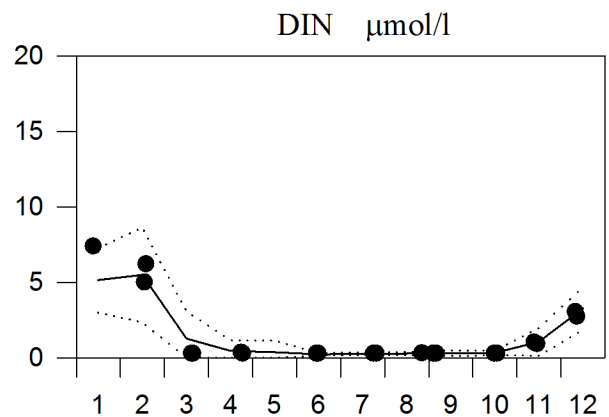
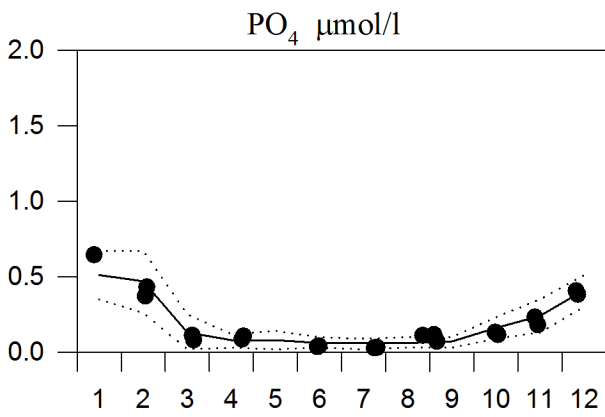
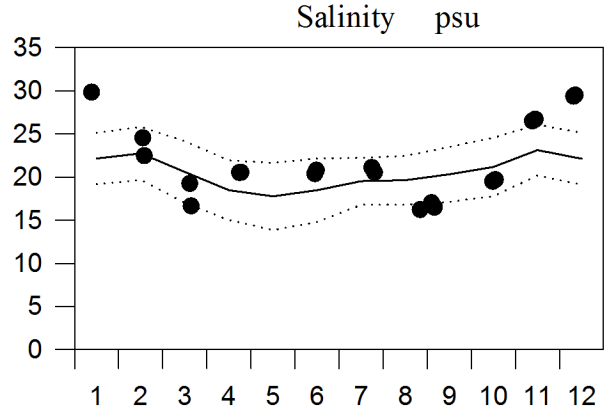
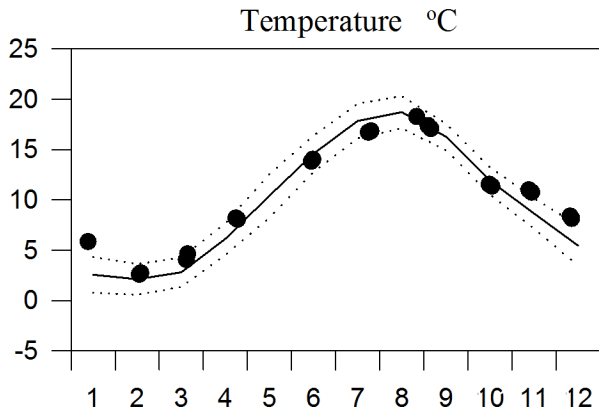
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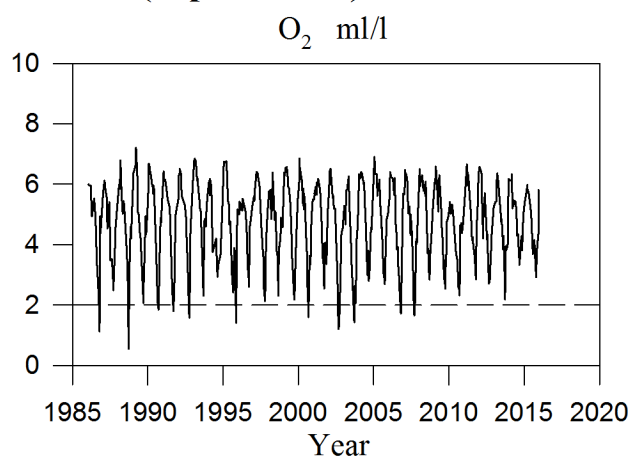
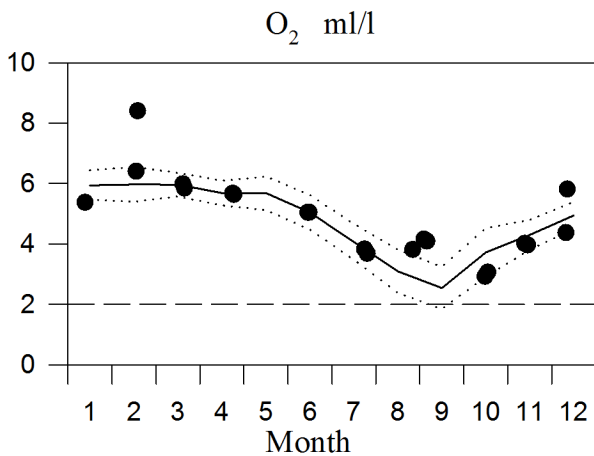
STATION ANHOLT E SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

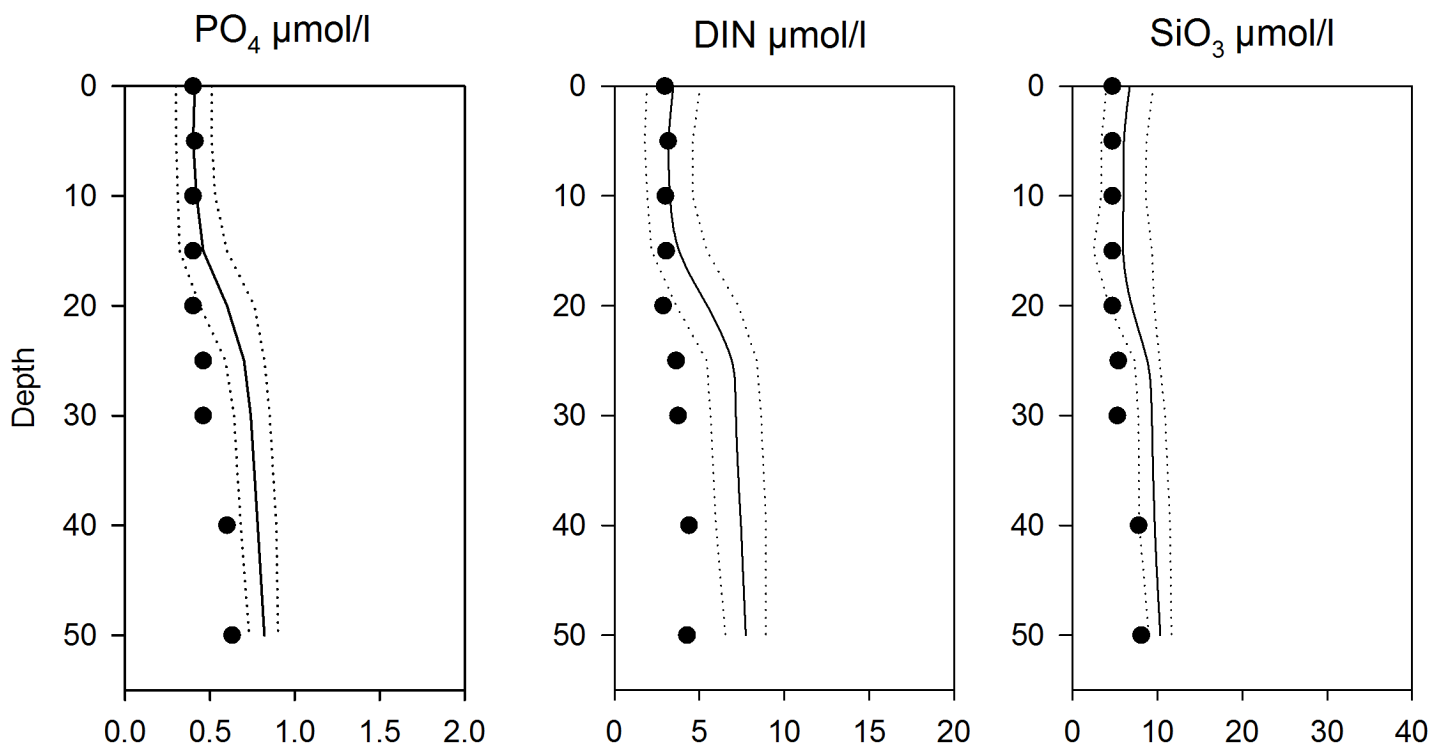
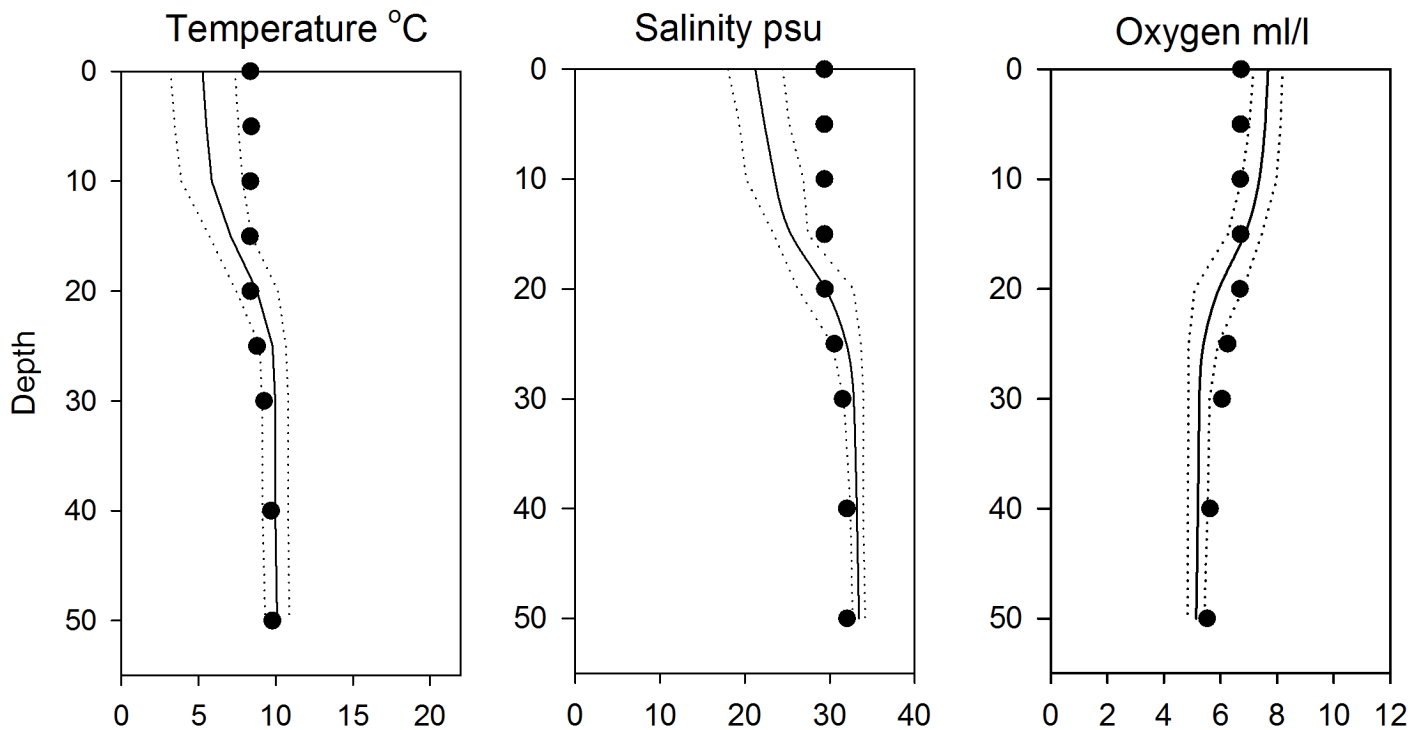


OXYGEN IN BOTTOM WATER (depth > 50m)



Vertical profiles Anholt E December

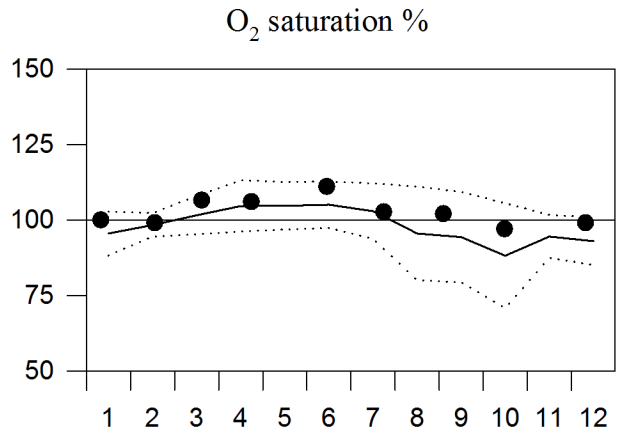
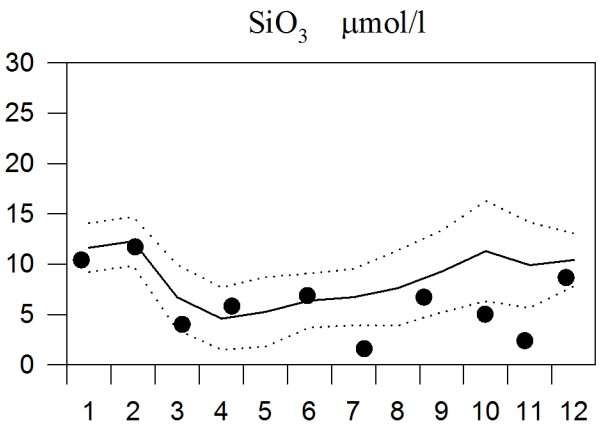
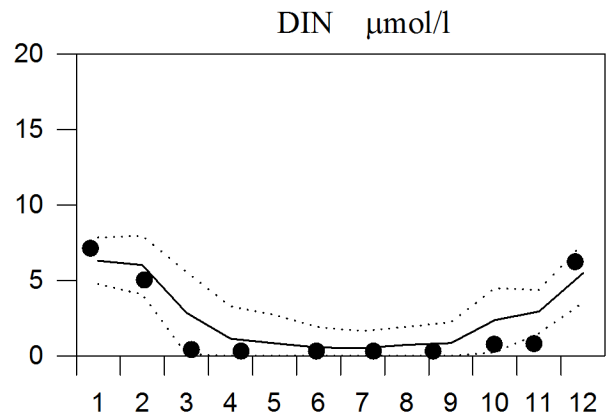
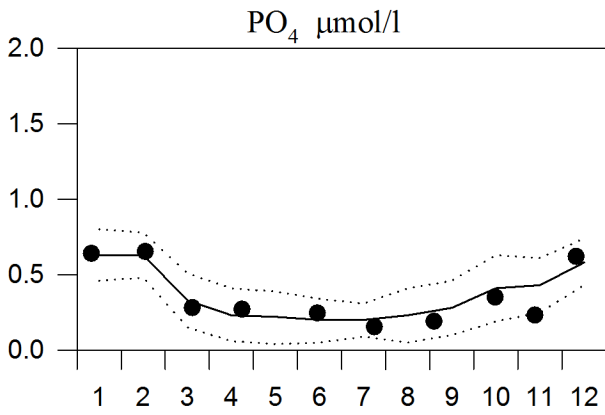
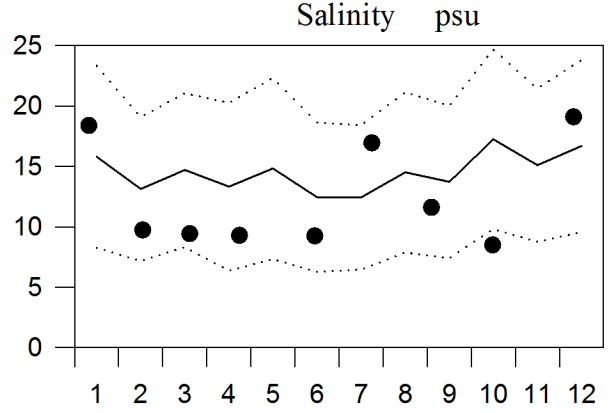
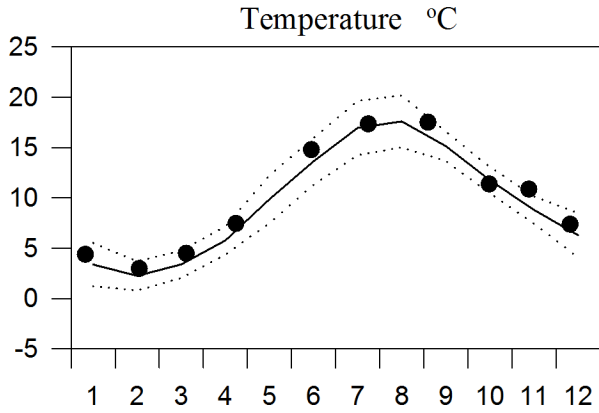
— Mean 1996-2010 St.Dev. ● 2015



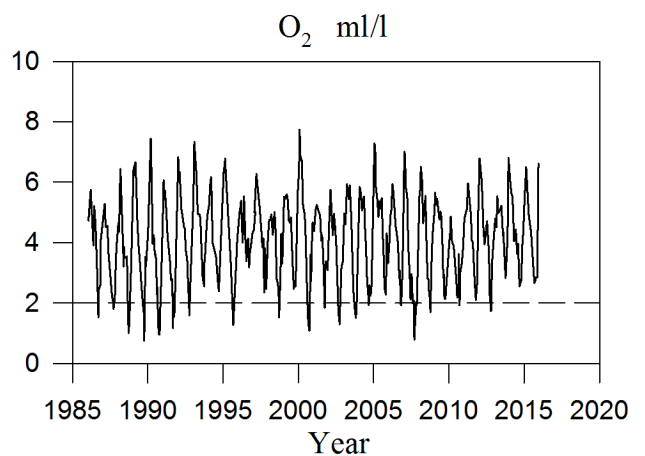
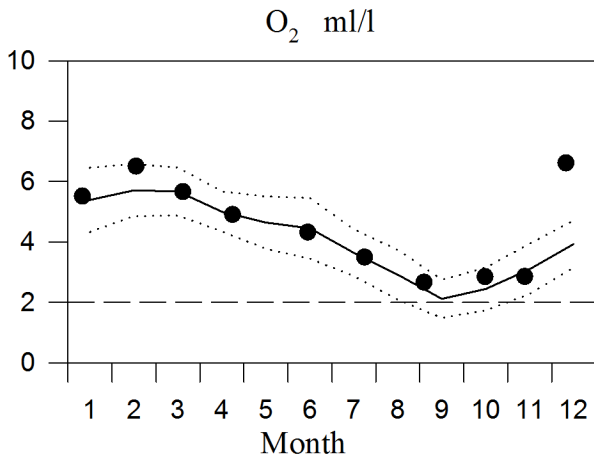
STATION W LANDSKRONA SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

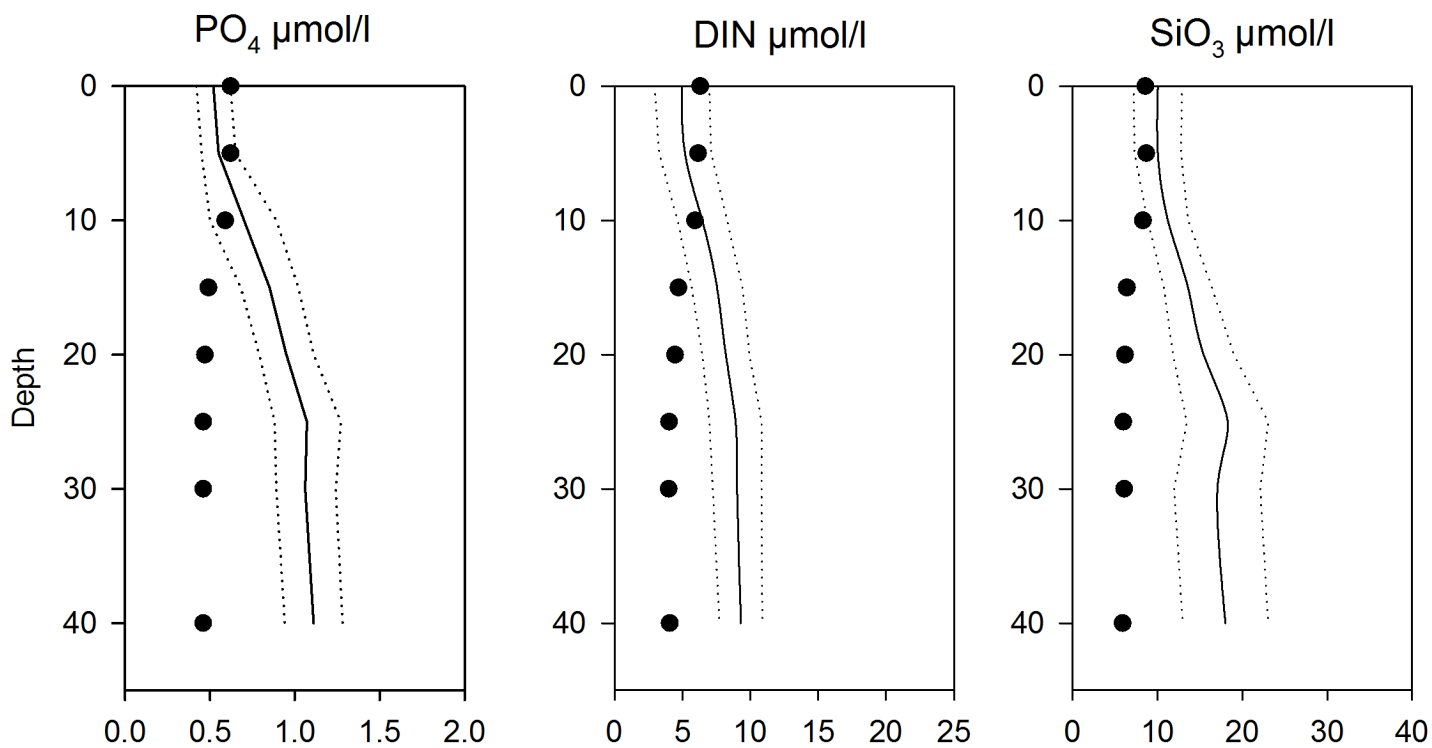
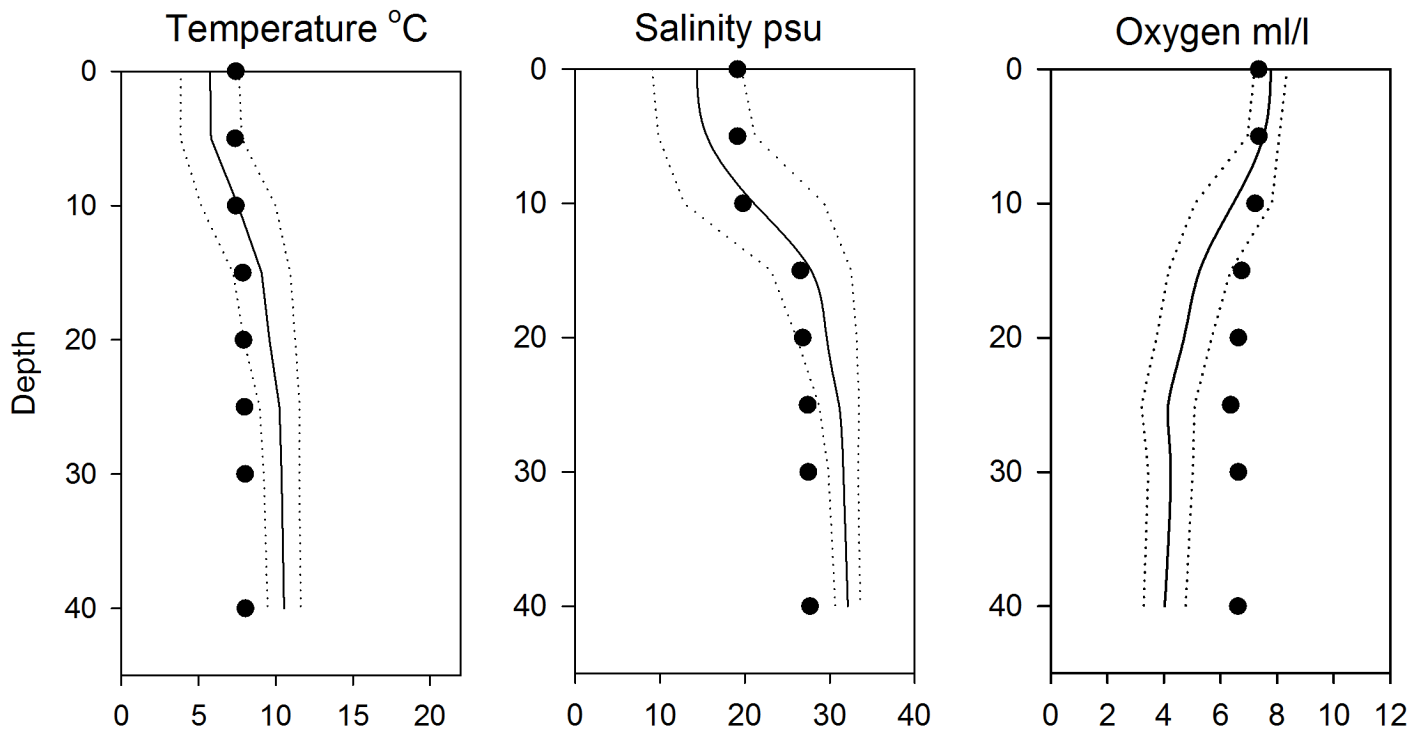


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles W Landskrona December

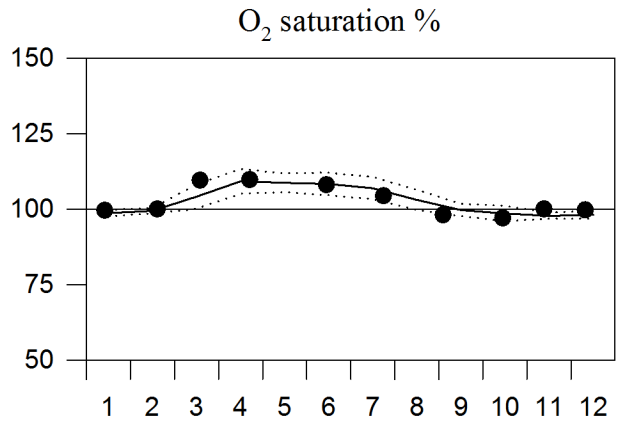
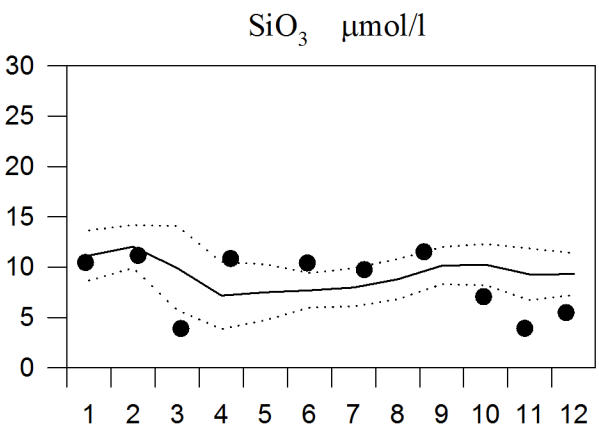
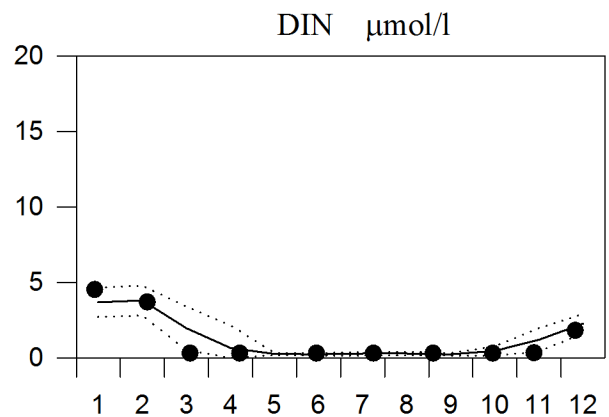
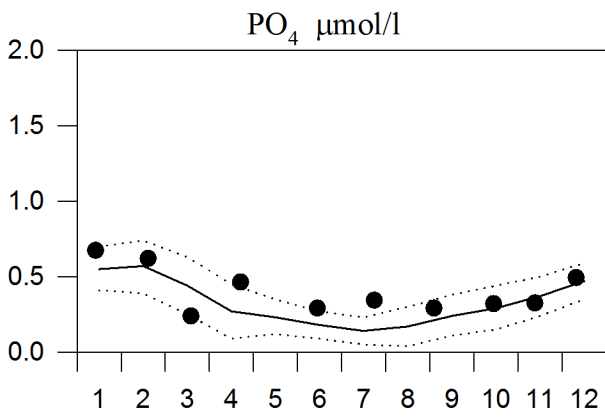
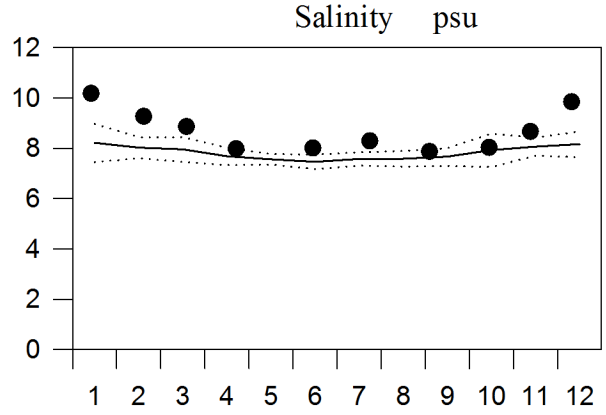
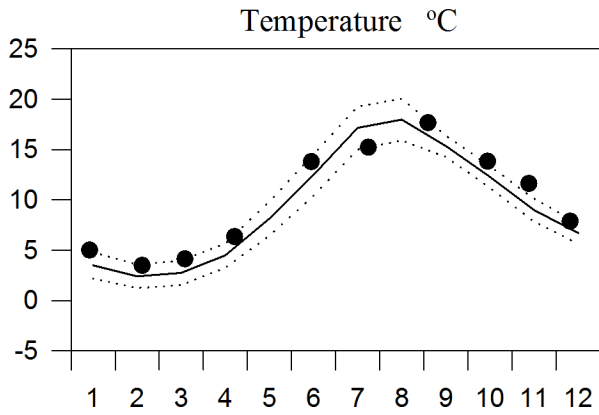
— Mean 1996-2010 St.Dev. ● 2015



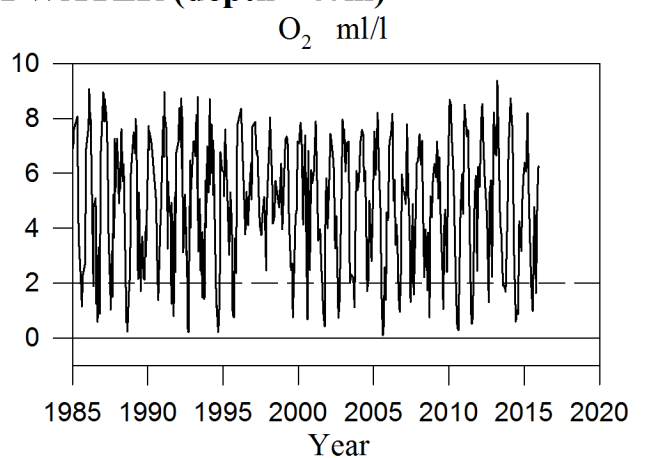
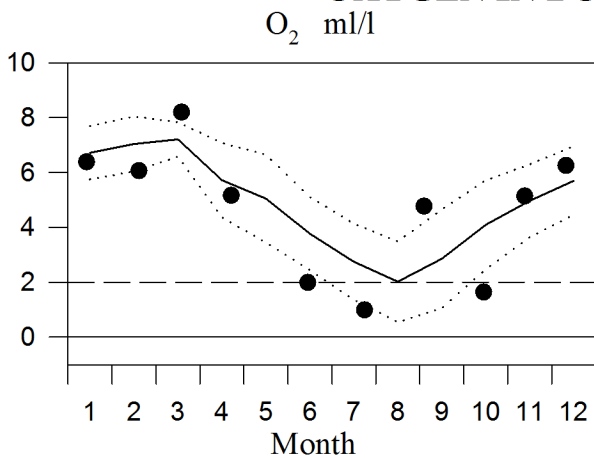
STATION BY1 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

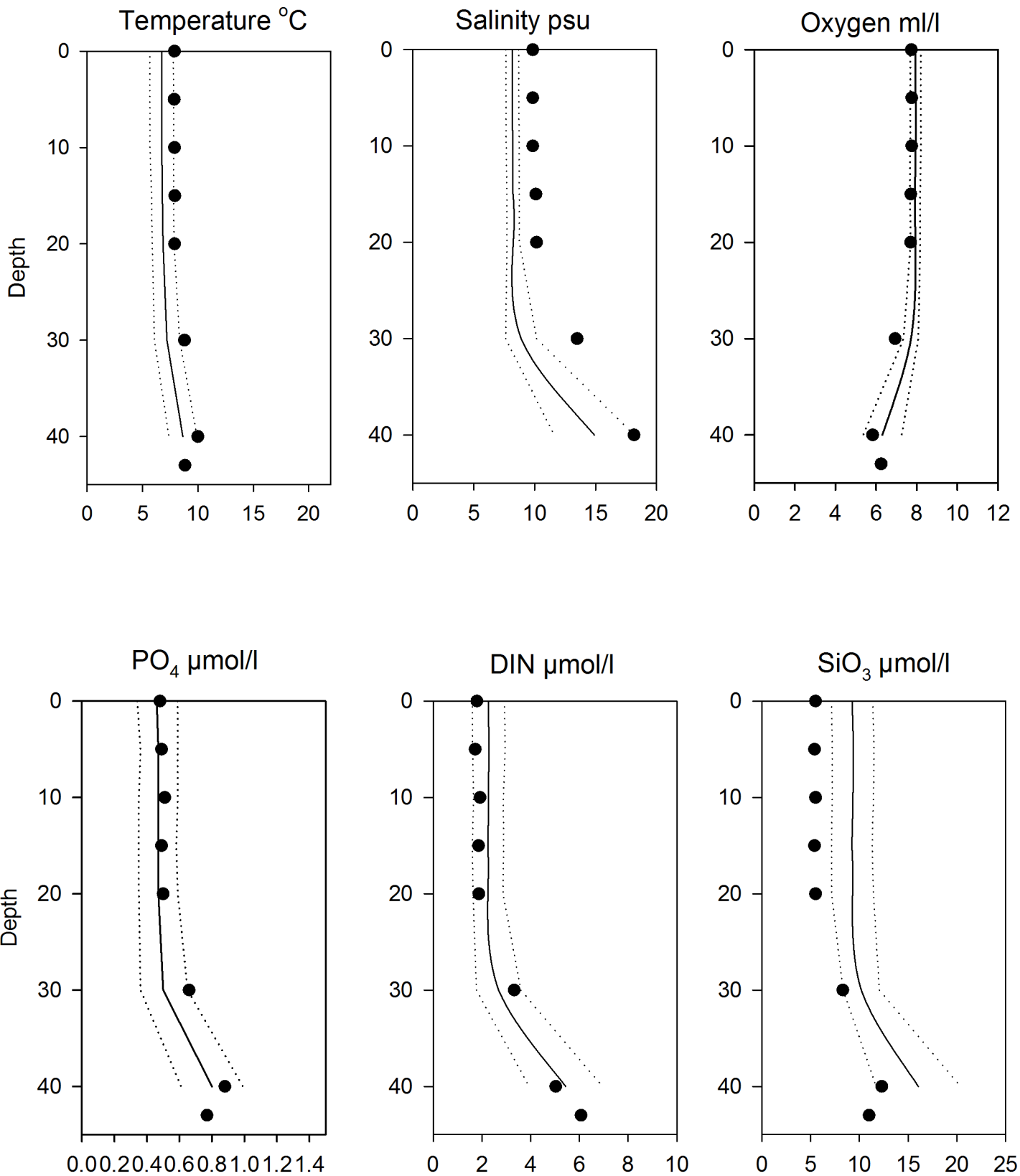


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles BY1 December

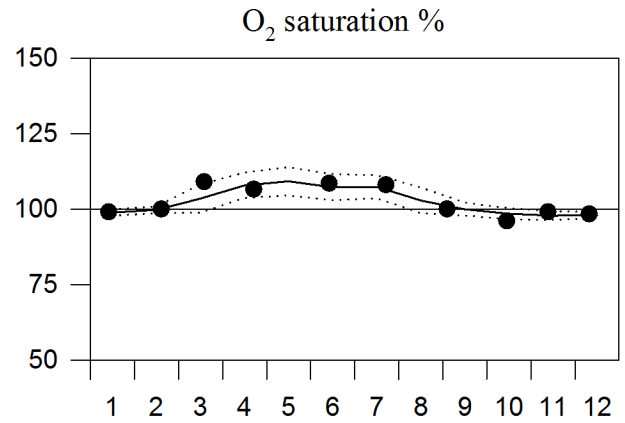
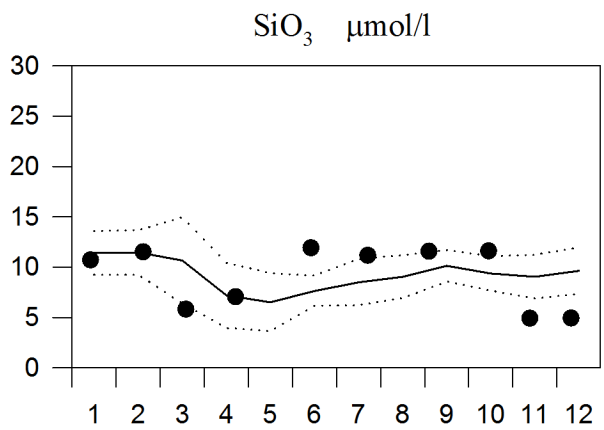
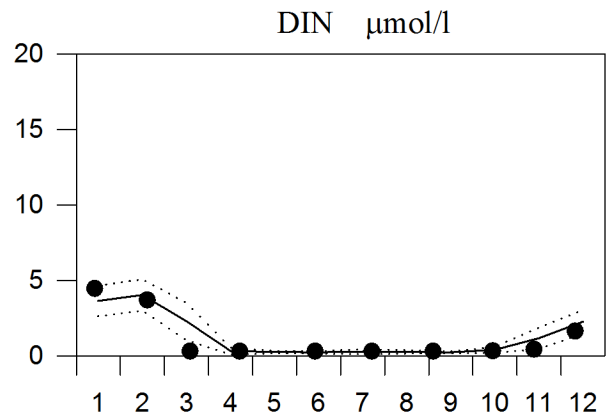
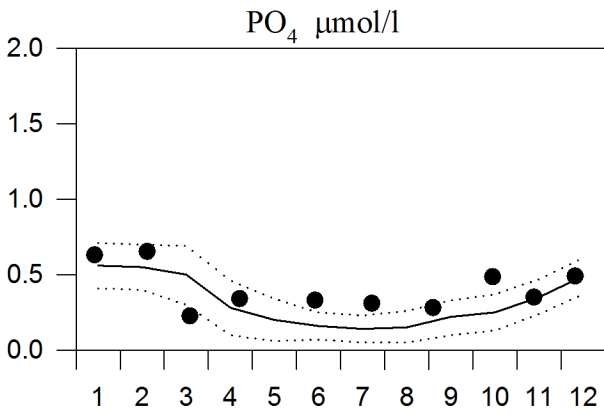
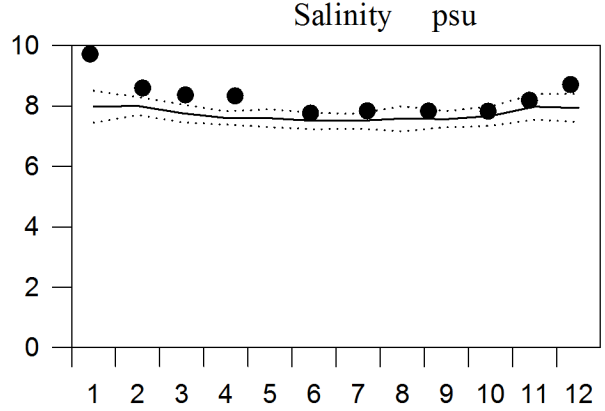
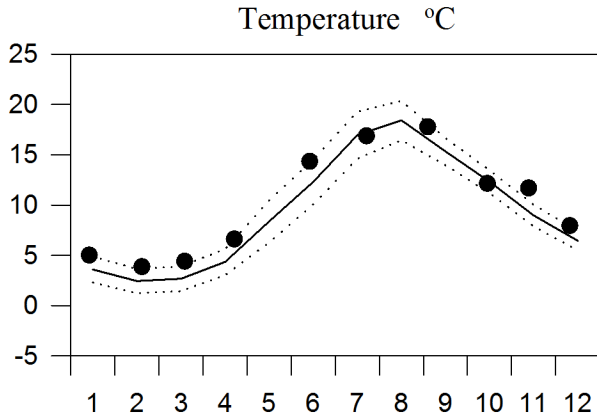
— Mean 1996-2010 ····· St.Dev. ● 2015



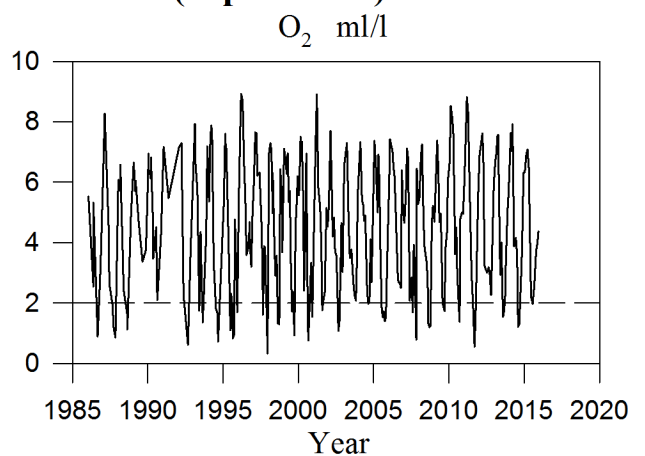
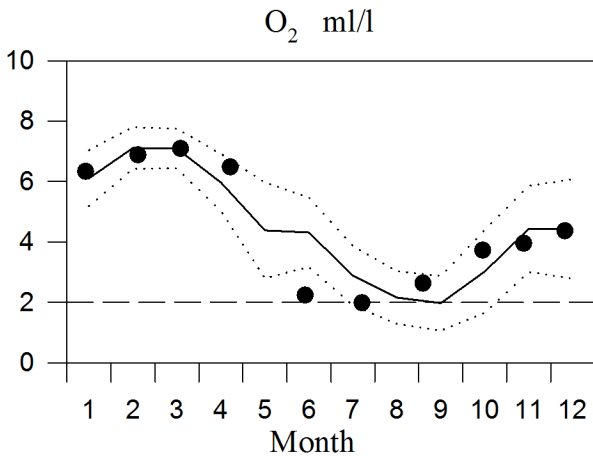
STATION BY2 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

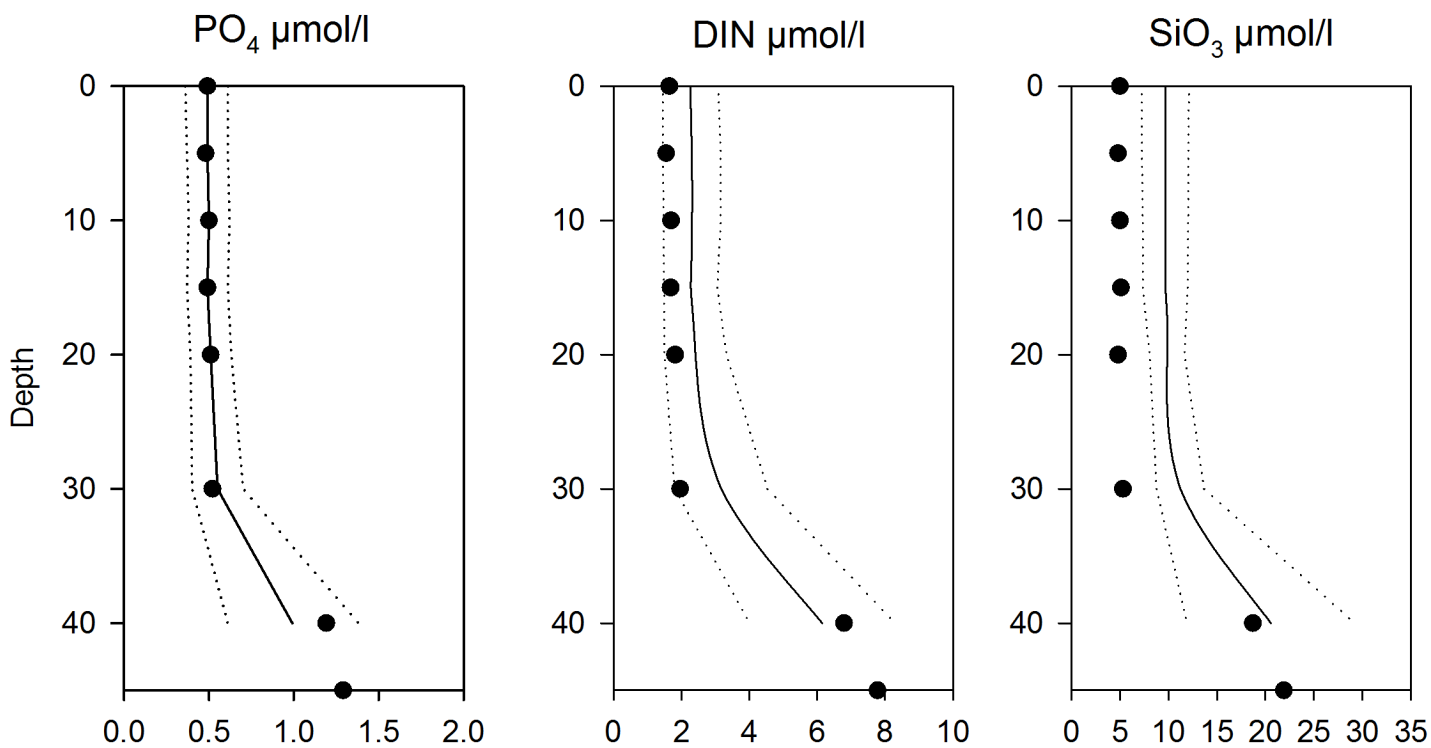
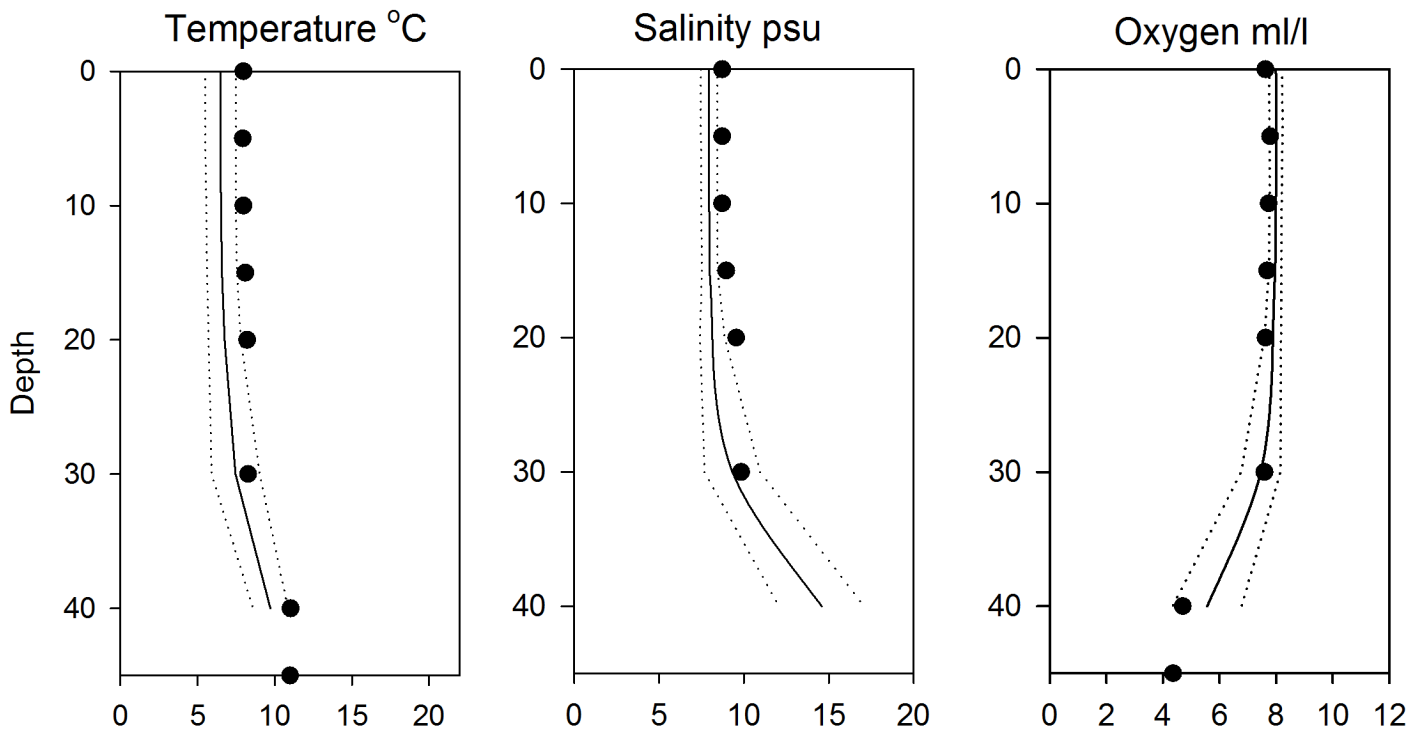


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles BY2 December

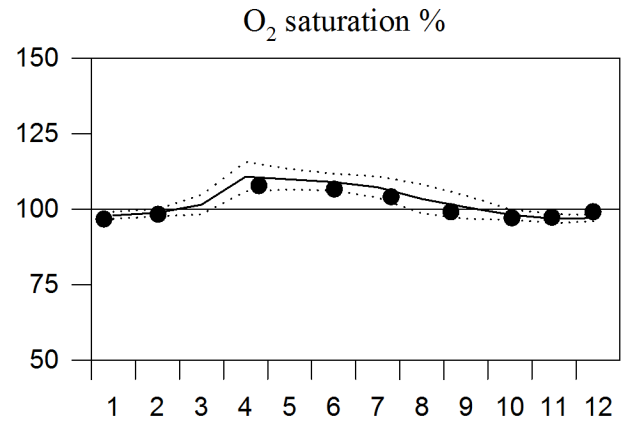
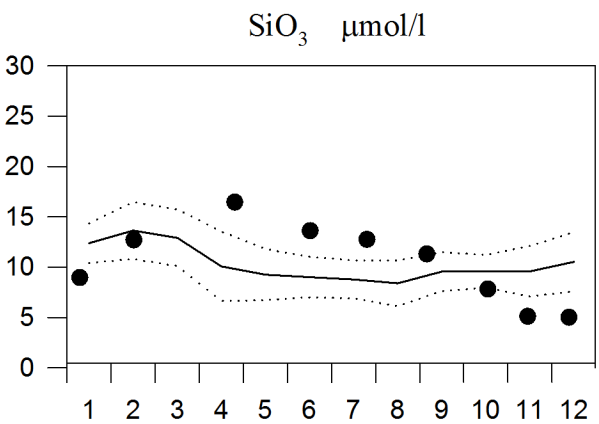
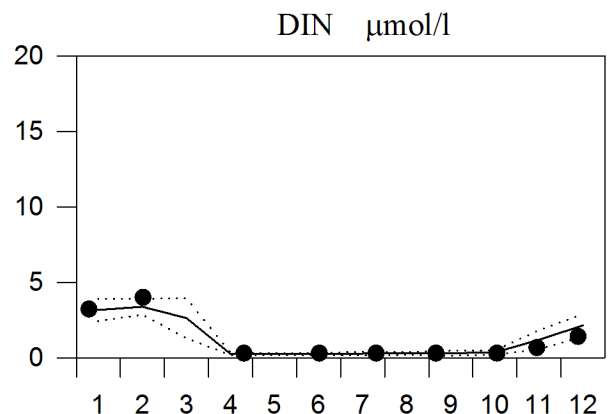
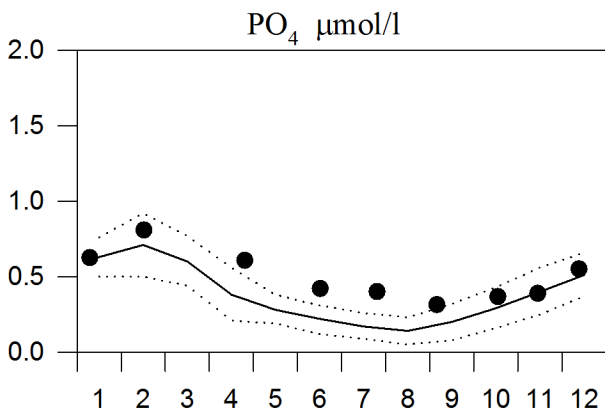
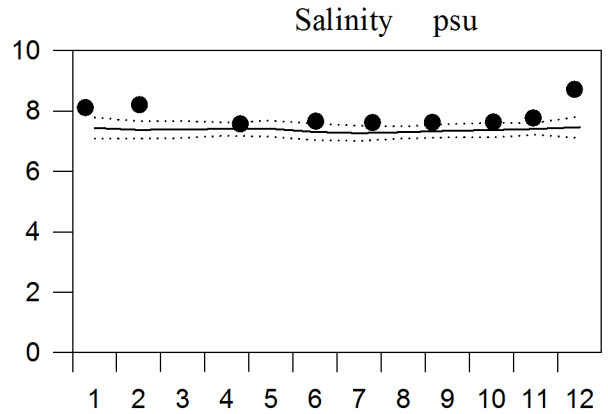
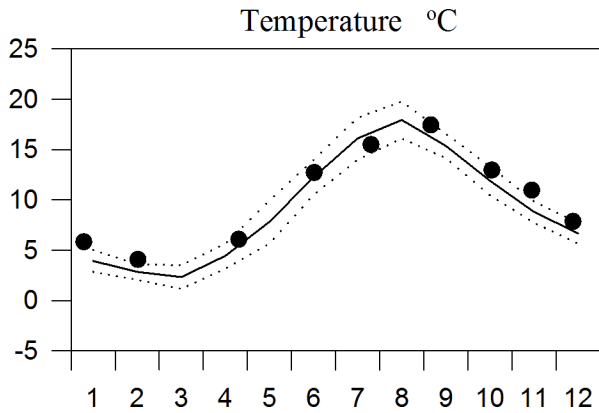
— Mean 1996-2010 ····· St.Dev. ● 2015



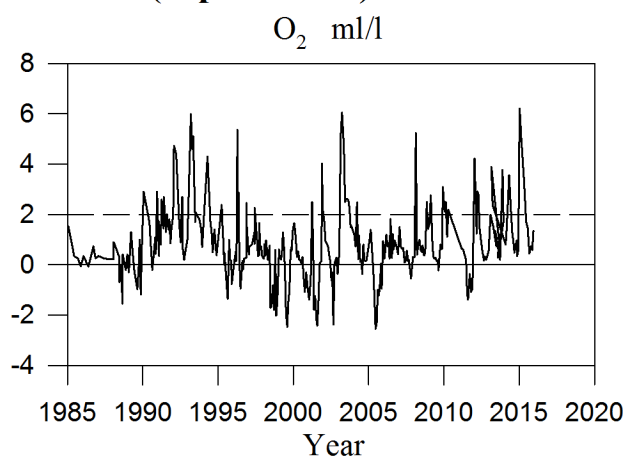
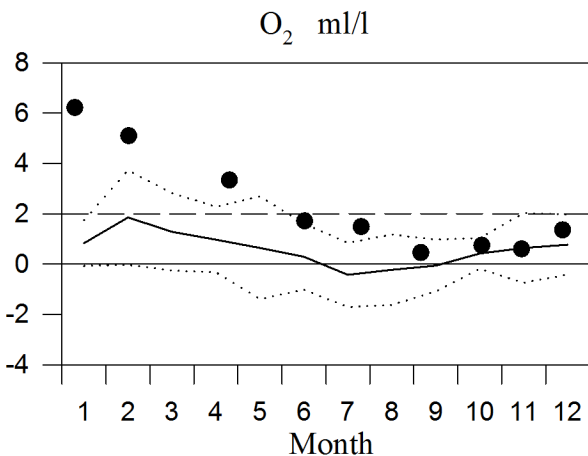
STATION HANÖBUKTEN SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

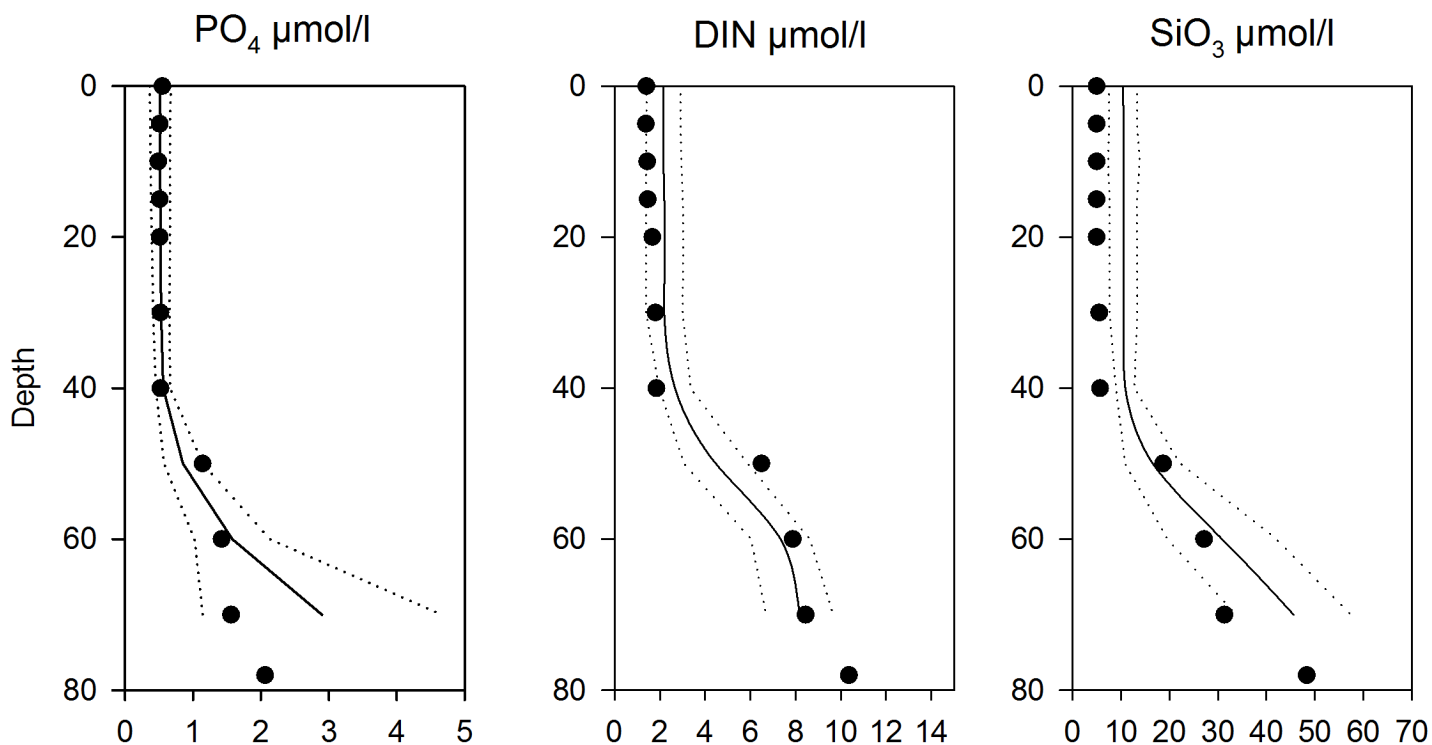
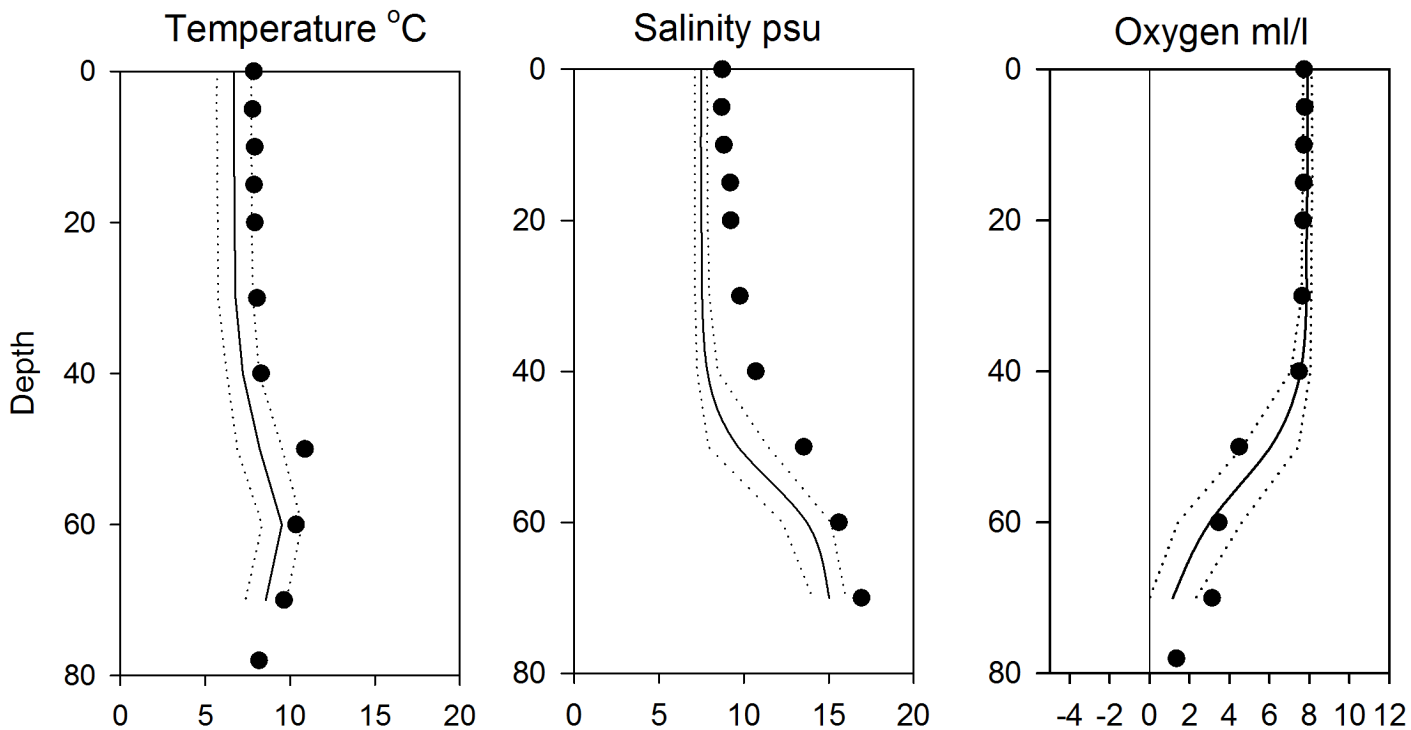


OXYGEN IN BOTTOM WATER (depth > 70m)



Vertical profiles Hanöbukten December

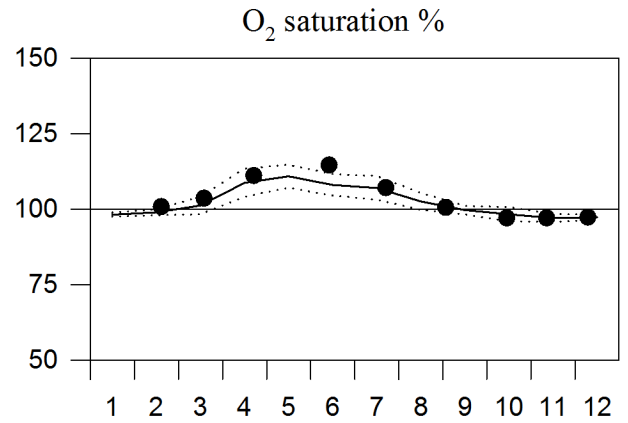
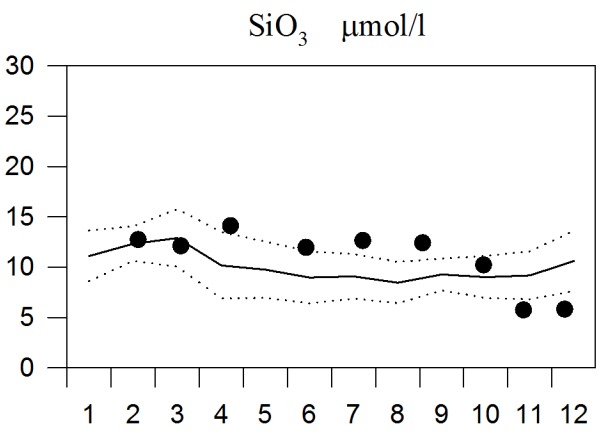
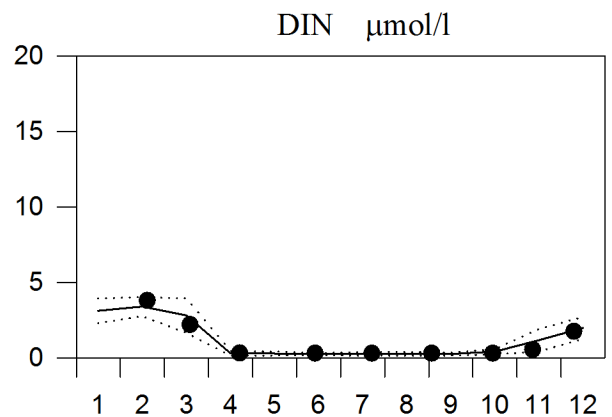
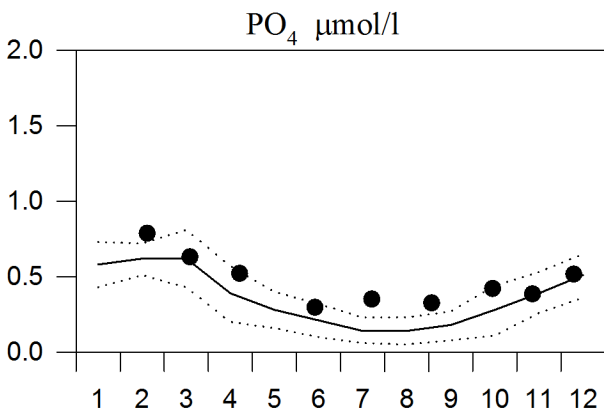
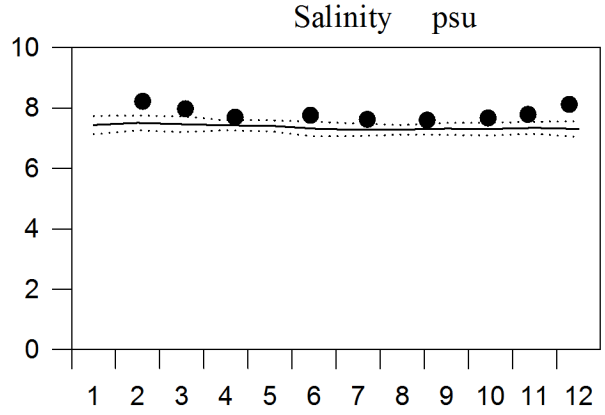
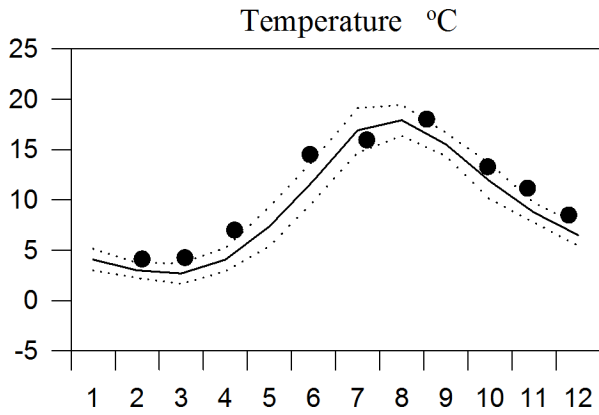
— Mean 1996-2010 ····· St.Dev. ● 2015



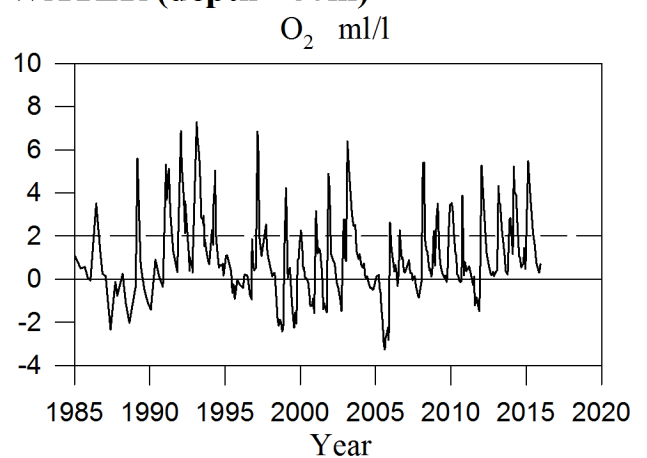
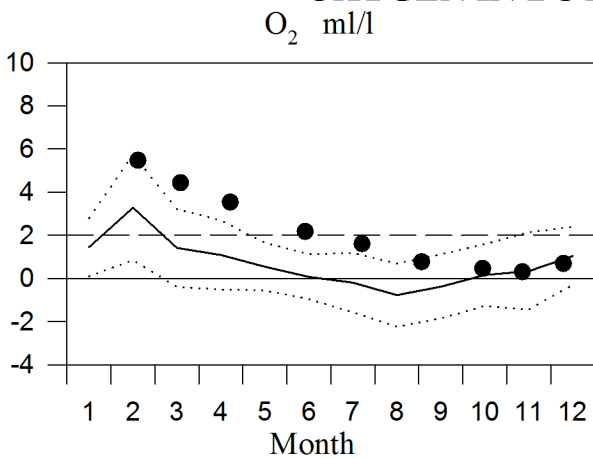
STATION BY4 SURFACE WATER

Annual Cycles

— Mean 1996-2010 ····· St.Dev. ● 2015

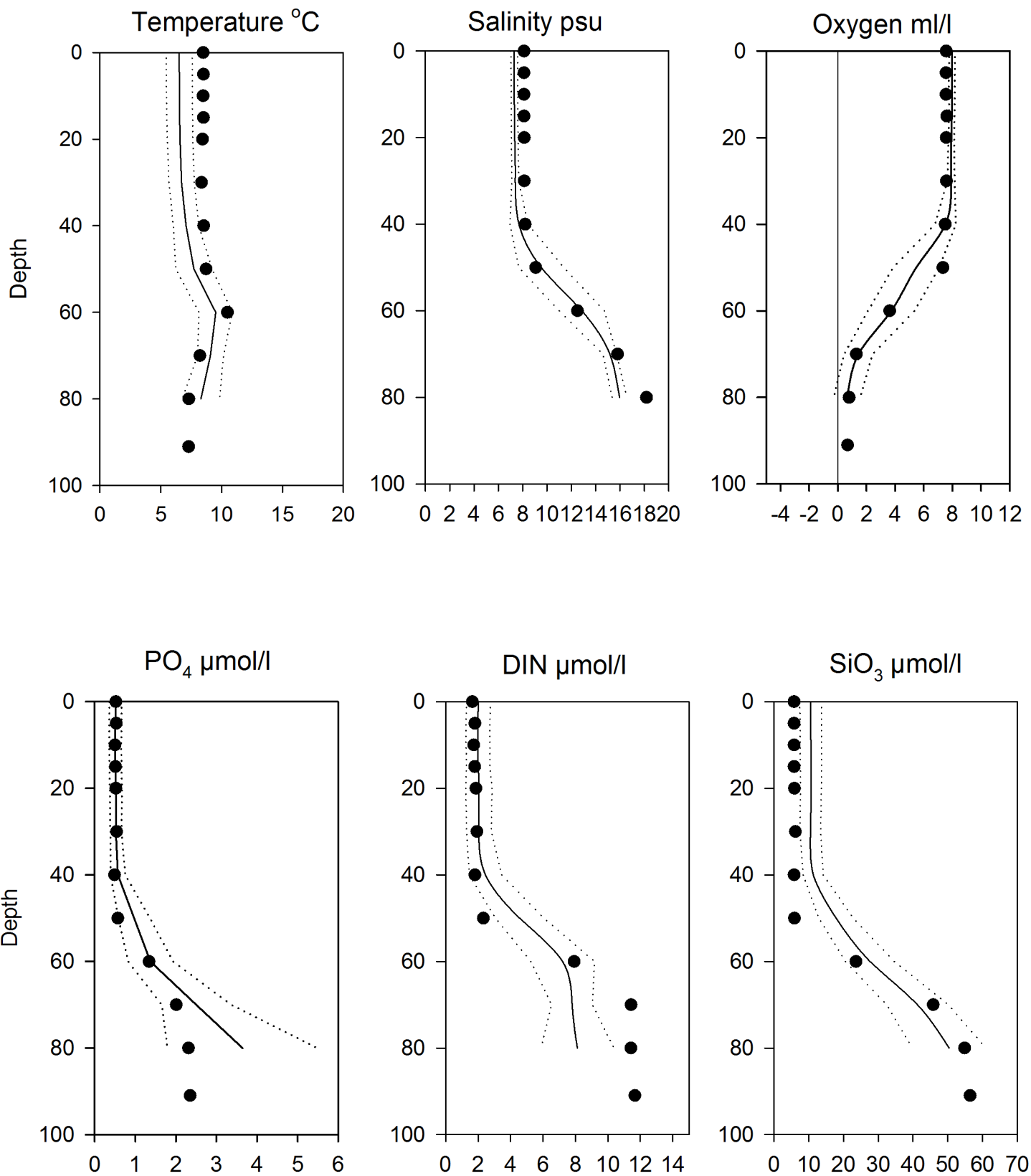


OXYGEN IN BOTTOM WATER (depth >80m)



Vertical profiles BY4 December

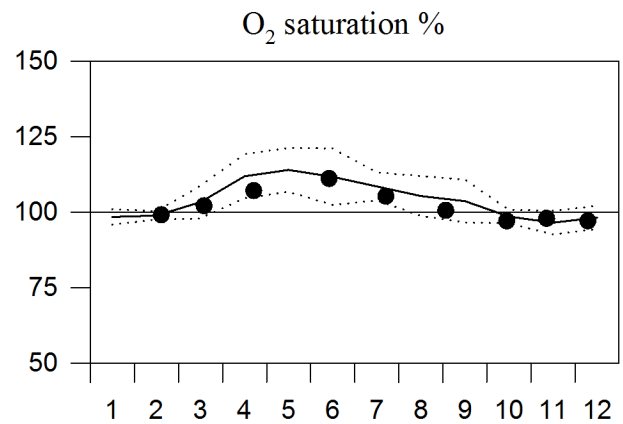
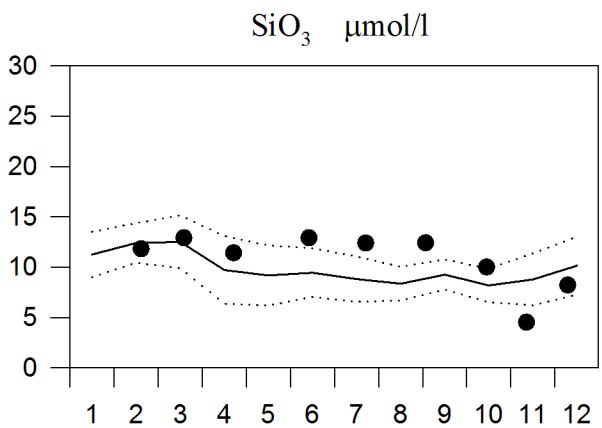
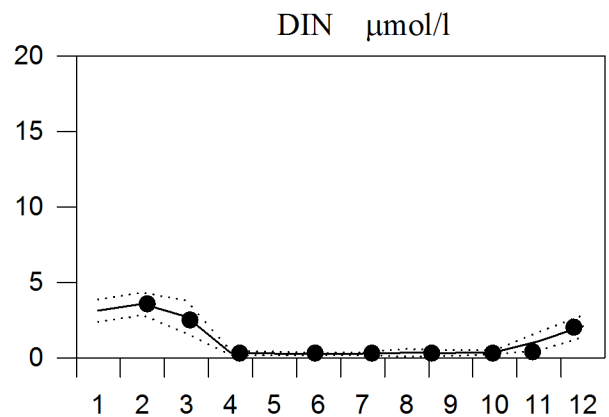
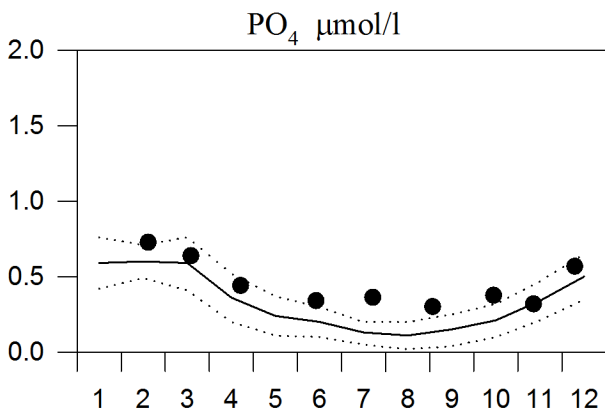
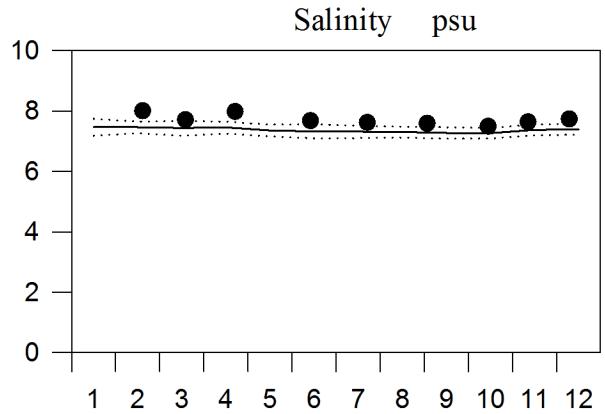
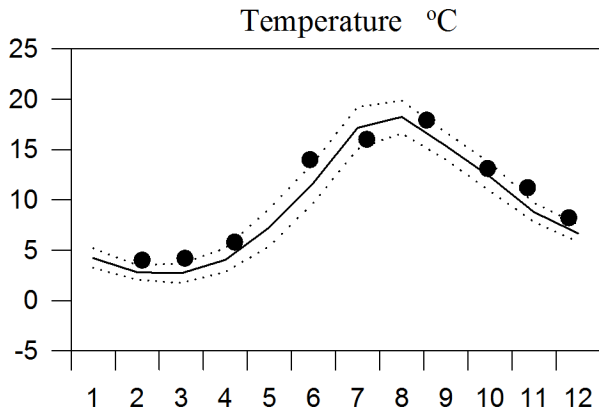
— Mean 1996-2010 ····· St.Dev. ● 2015



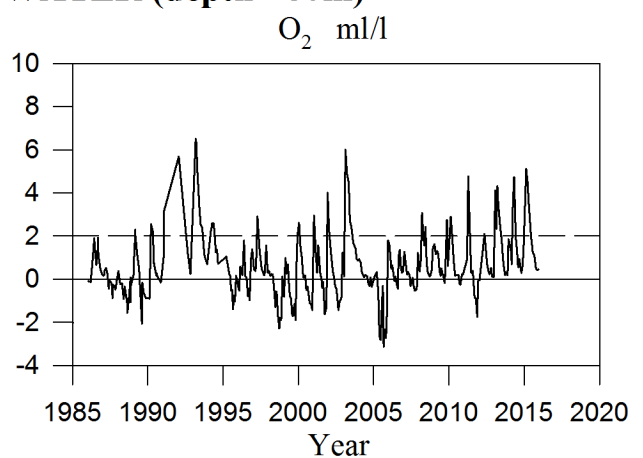
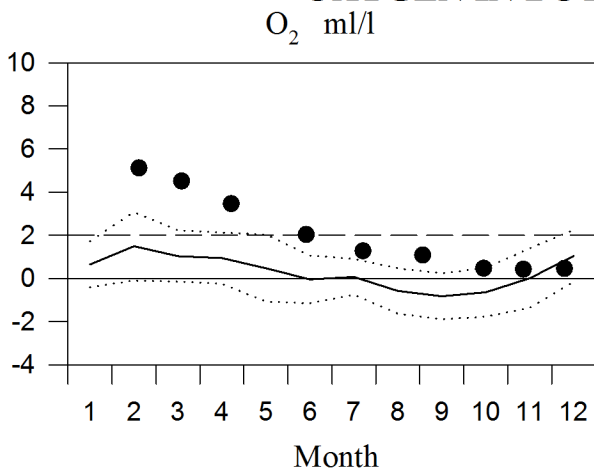
STATION BY5 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

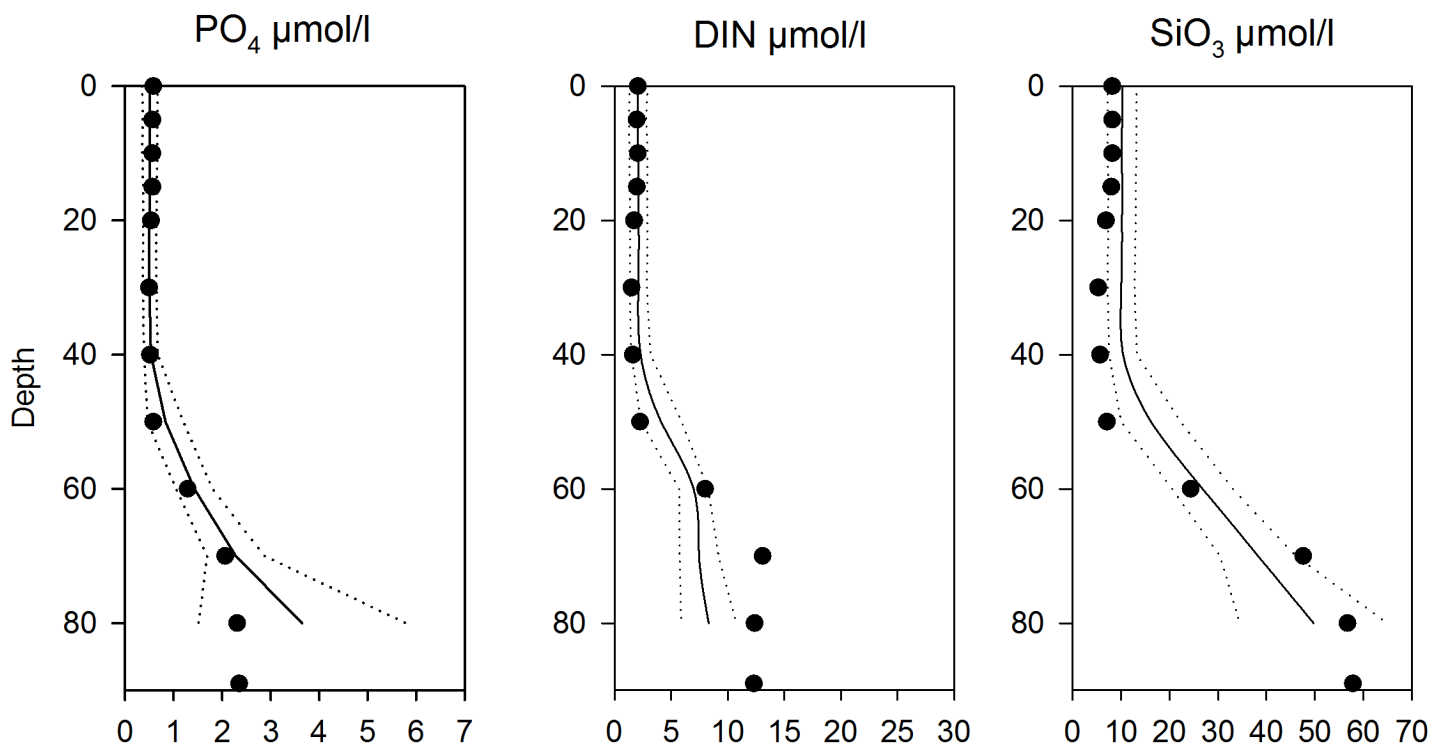
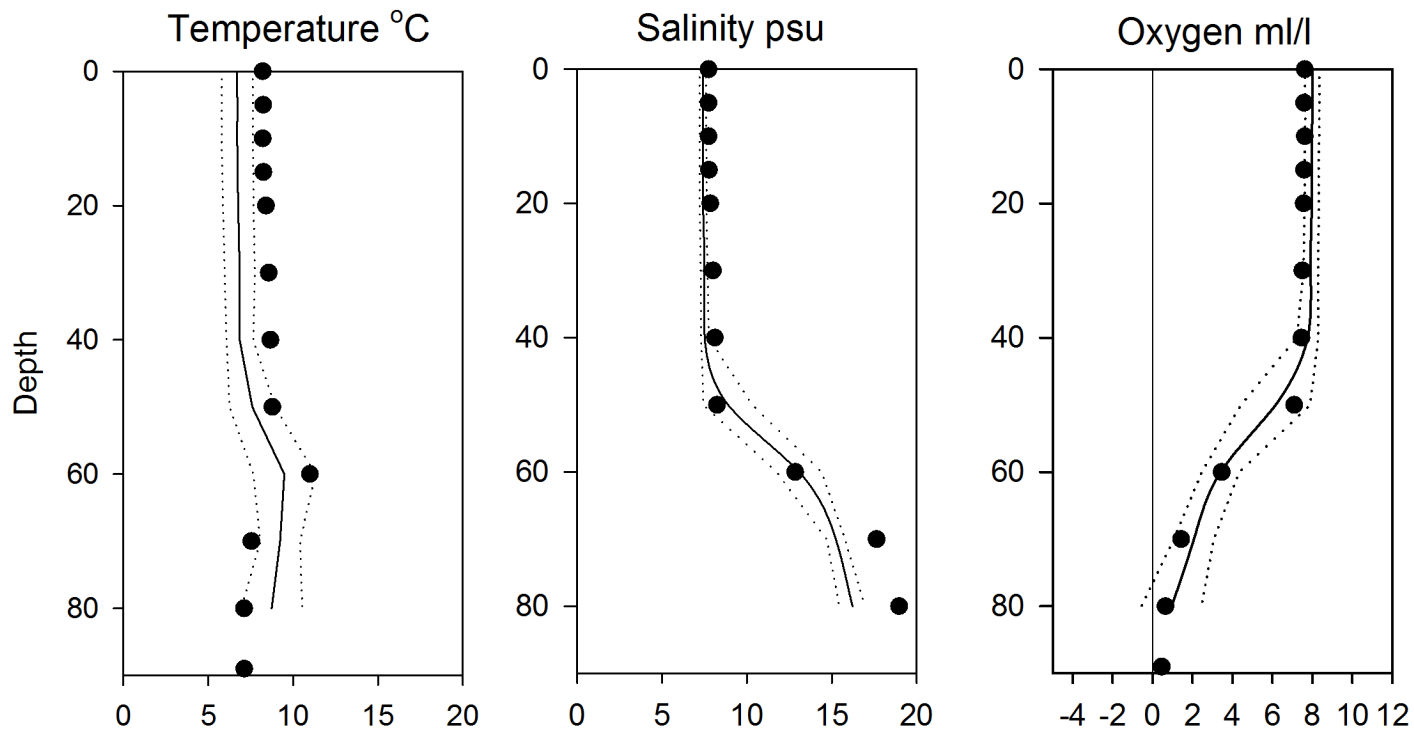


OXYGEN IN BOTTOM WATER (depth >80m)



Vertical profiles BY5 December

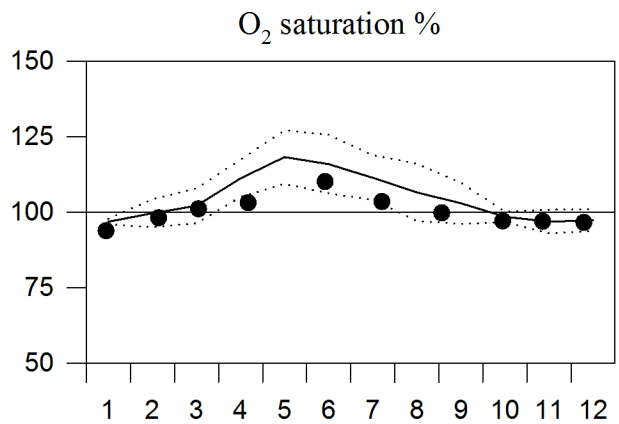
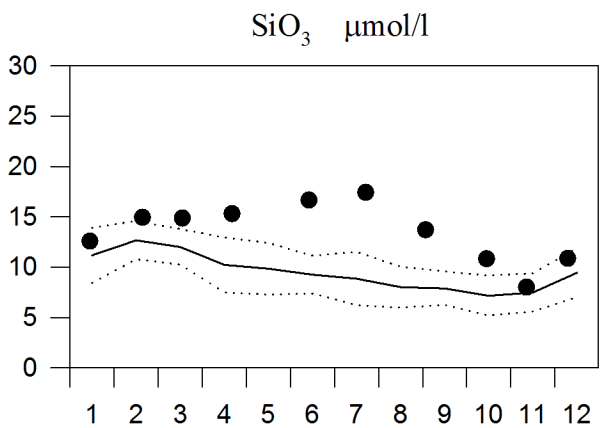
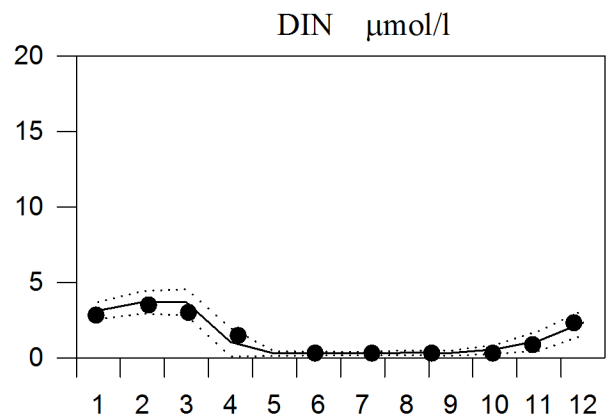
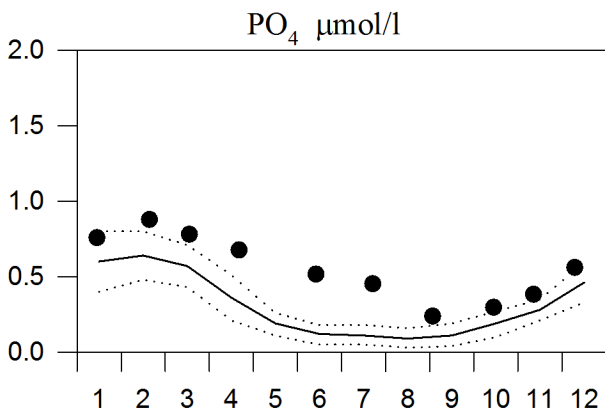
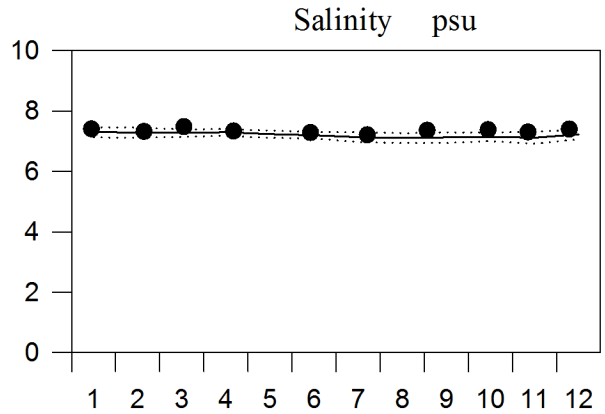
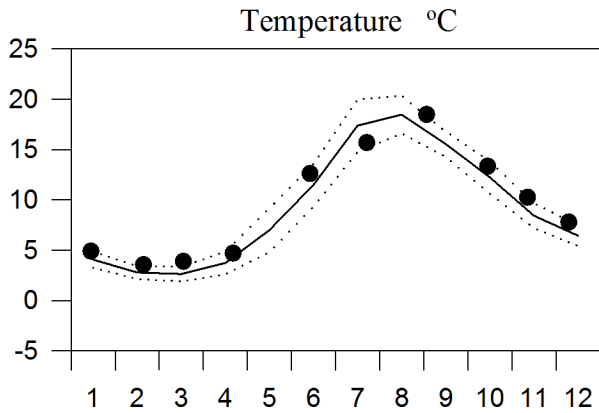
— Mean 1996-2010 ····· St.Dev. ● 2015



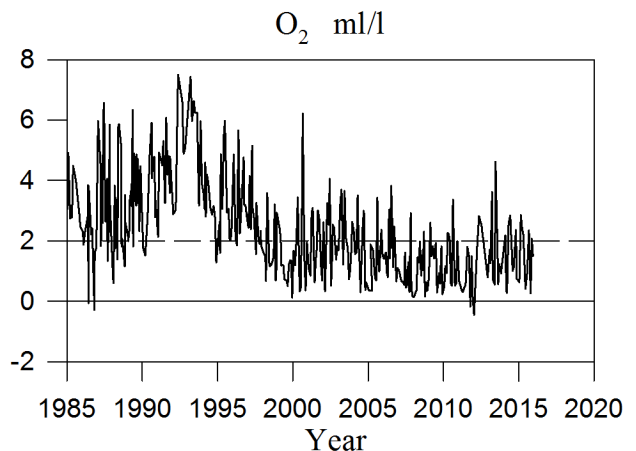
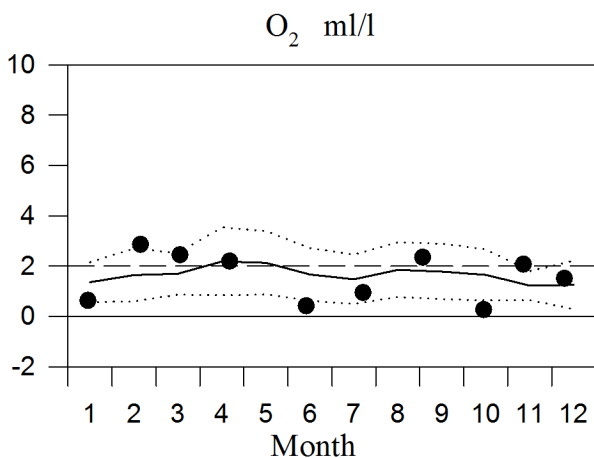
STATION BCS III-10 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

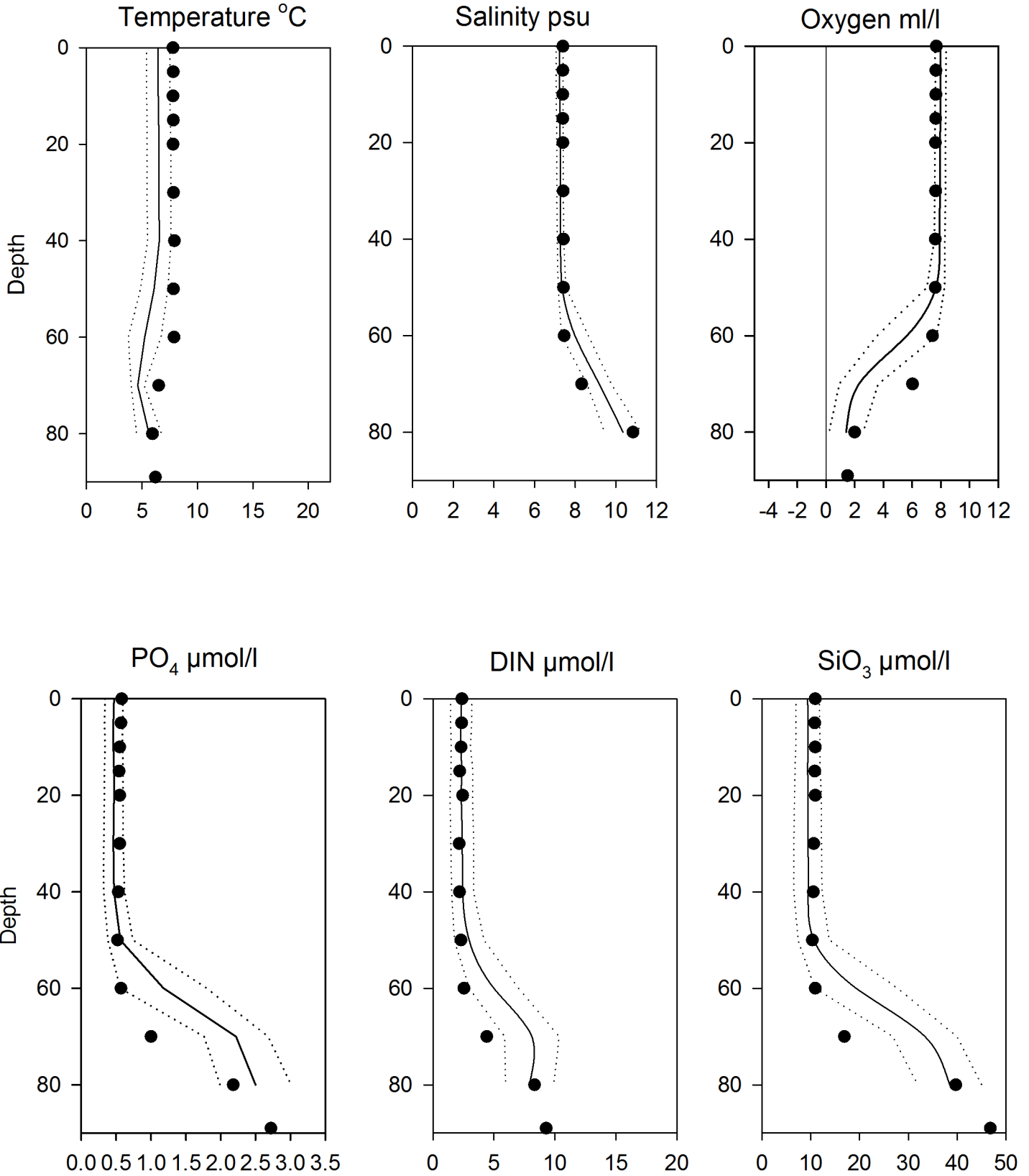


OXYGEN IN BOTTOM WATER (depth > 80m)



Vertical profiles BCS III-10 December

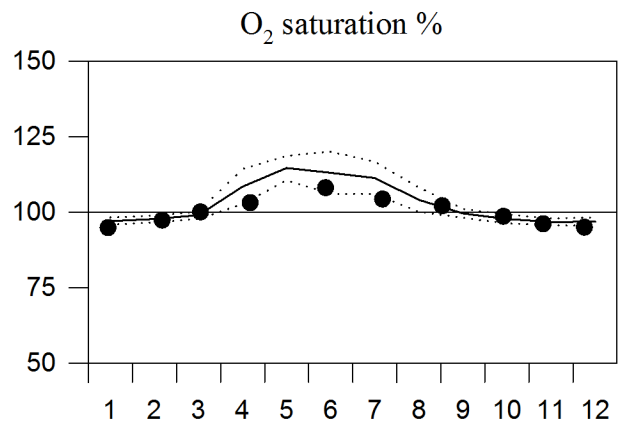
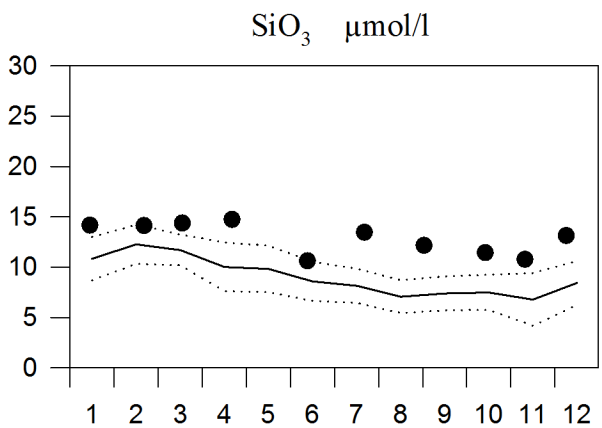
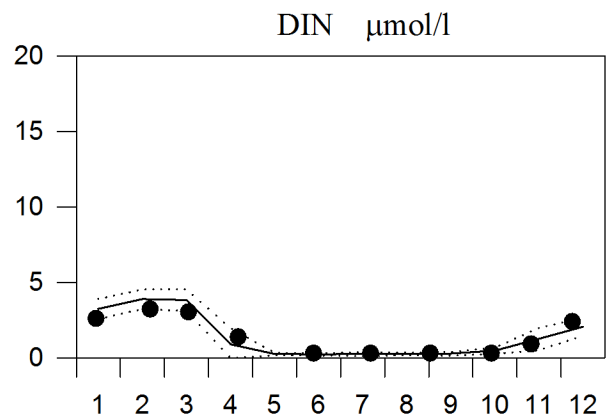
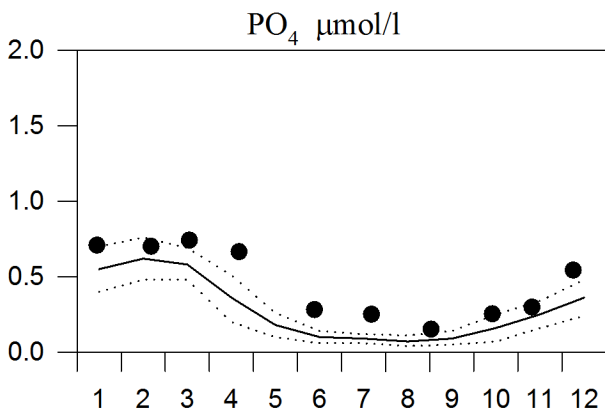
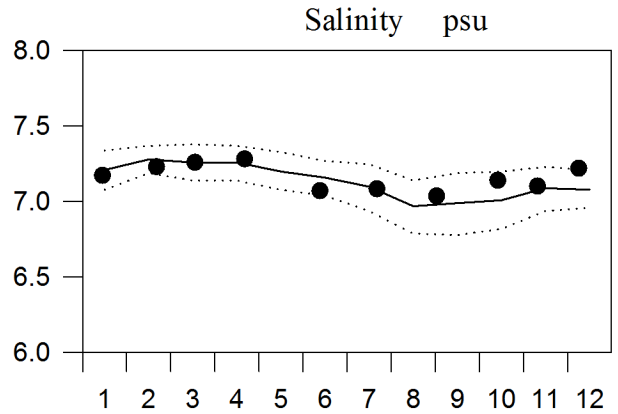
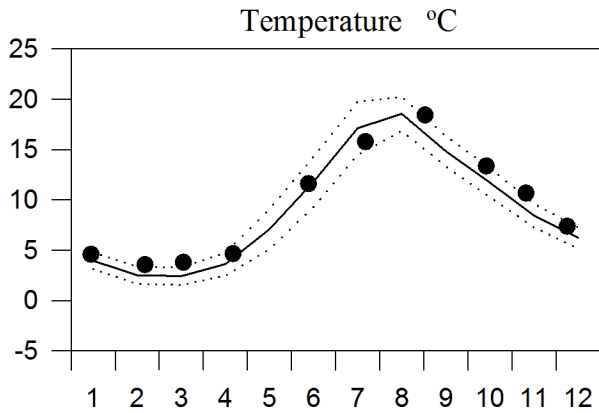
— Mean 1996-2010 ····· St.Dev. ● 2015



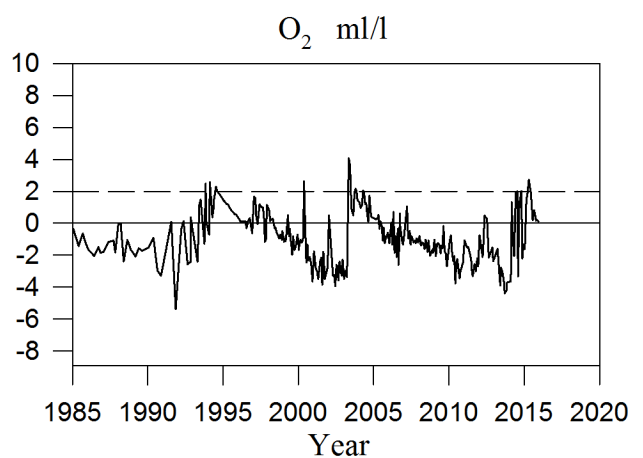
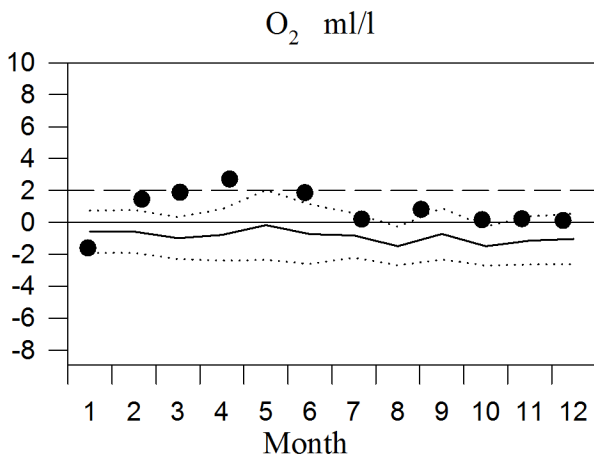
STATION BY10 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

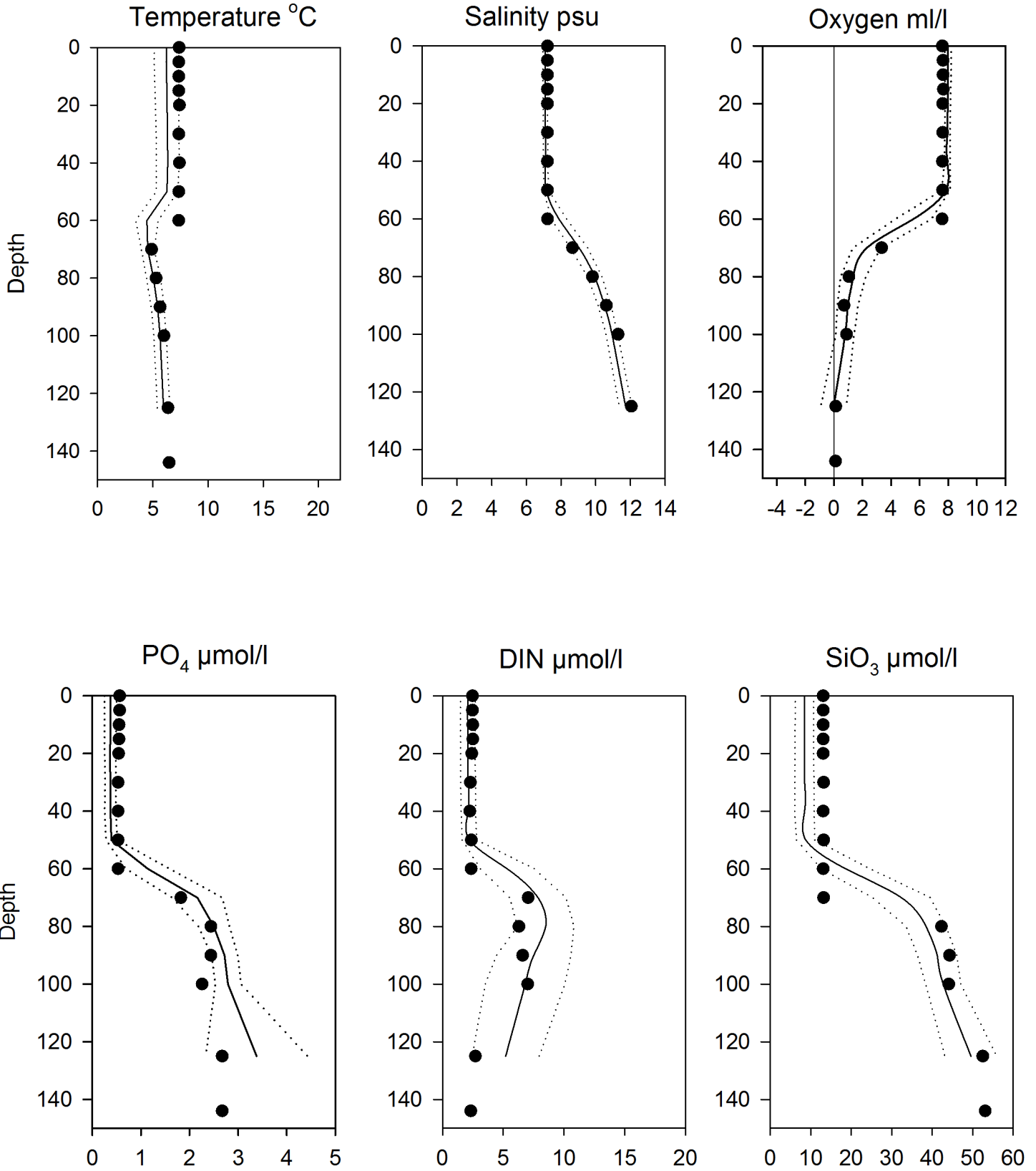


OXYGEN IN BOTTOM WATER (depth >125m)



Vertical profiles BY10 December

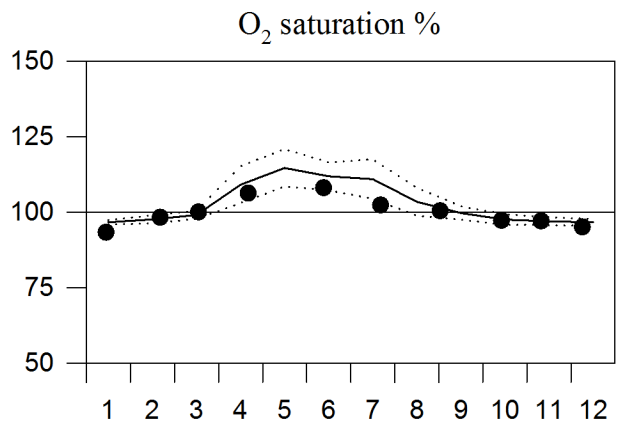
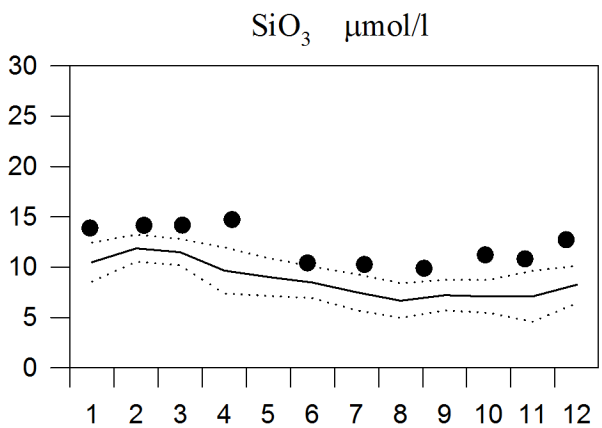
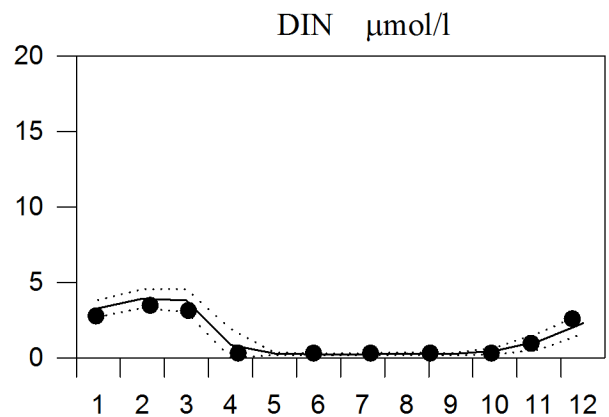
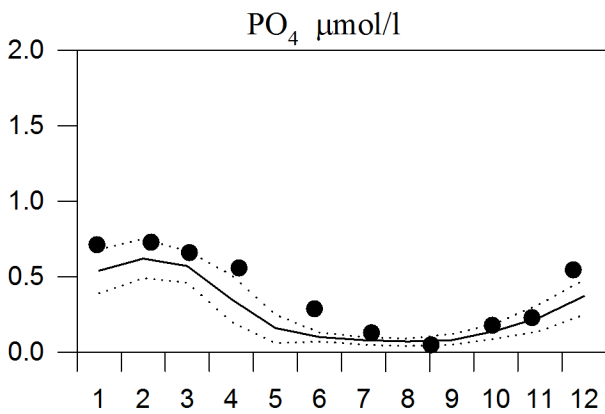
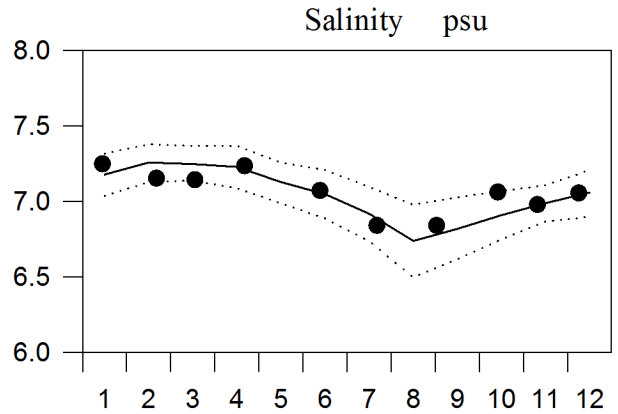
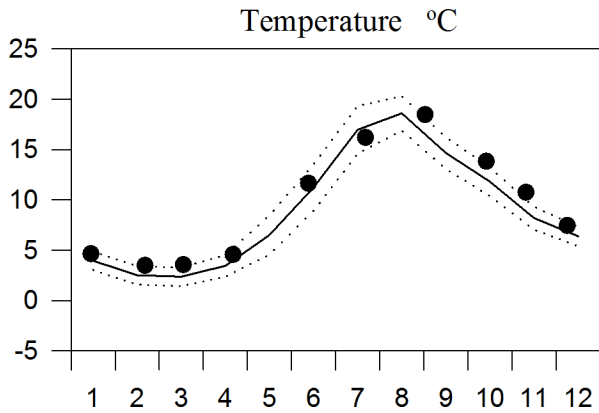
— Mean 1996-2010 ····· St.Dev. ● 2015



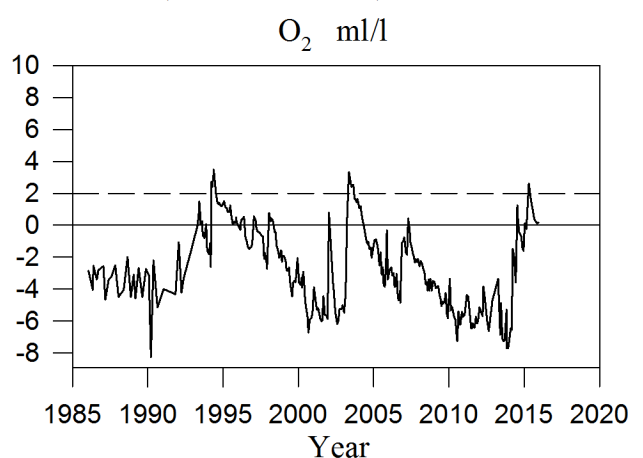
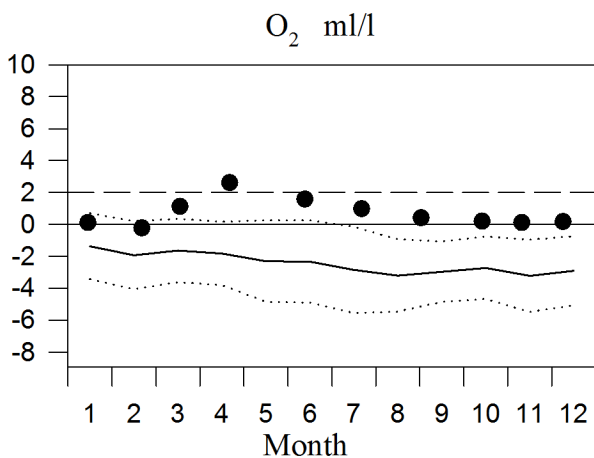
STATION BY15 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

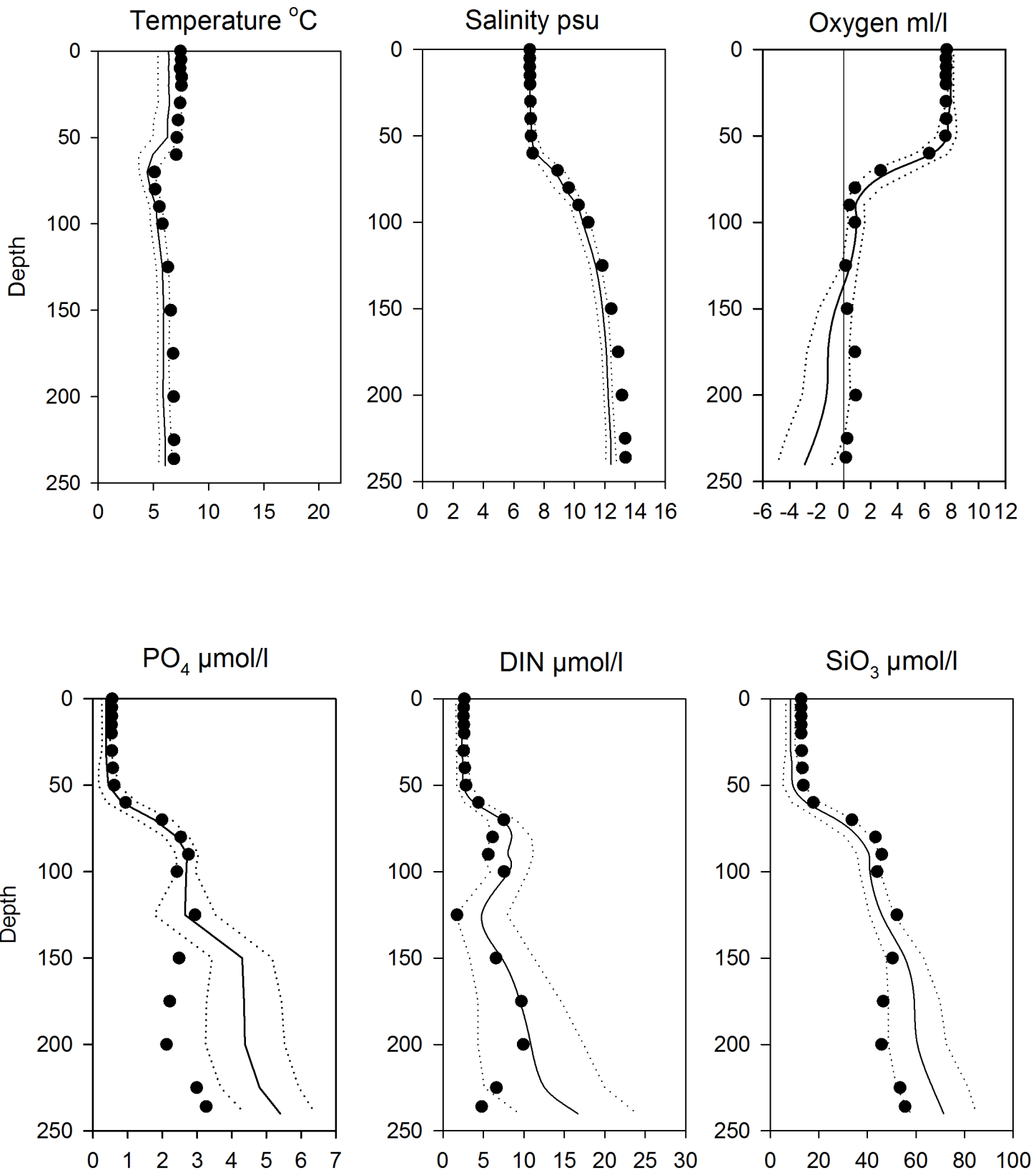


OXYGEN IN BOTTOM WATER (depth >225m)



Vertical profiles BY15 December

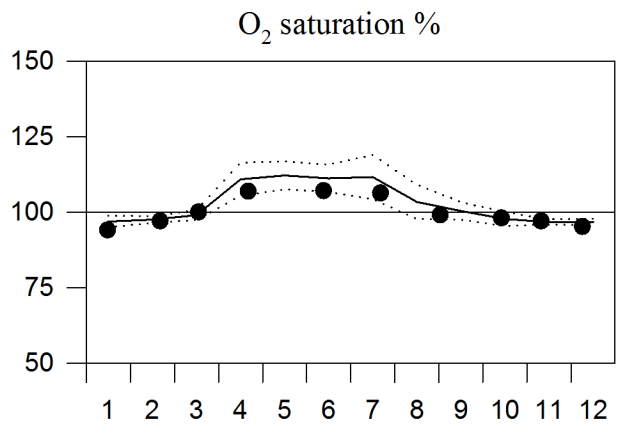
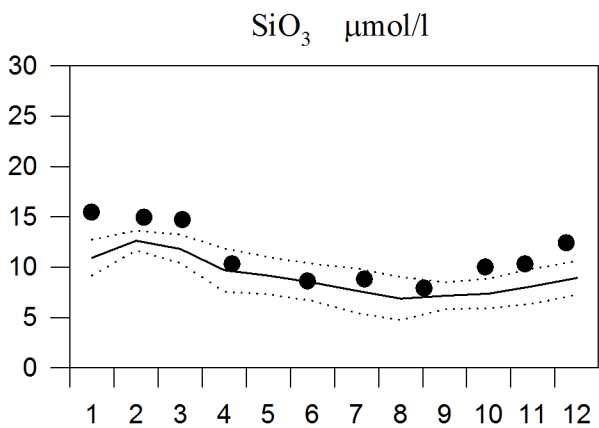
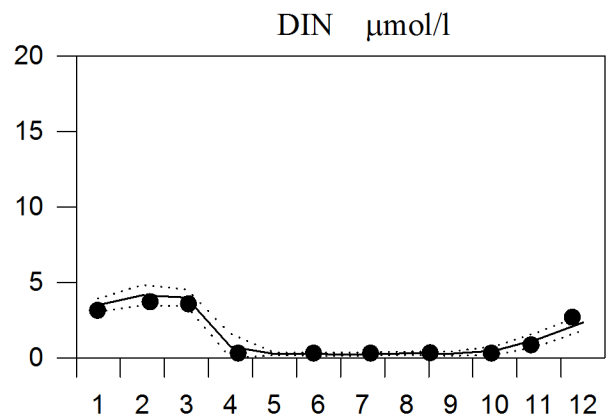
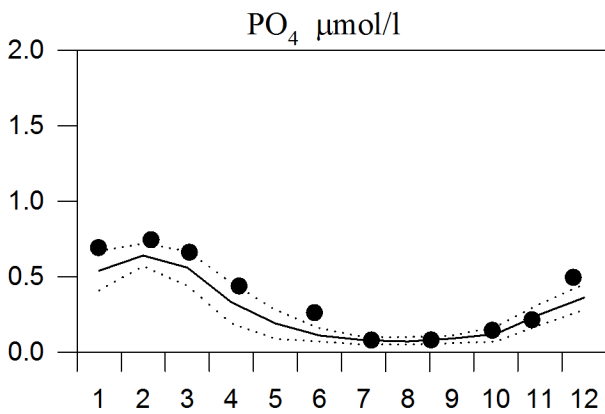
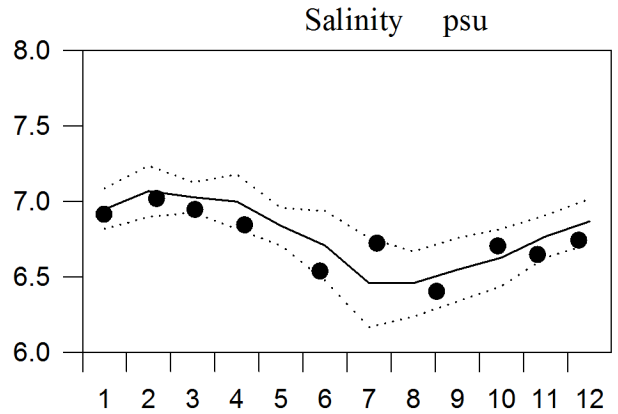
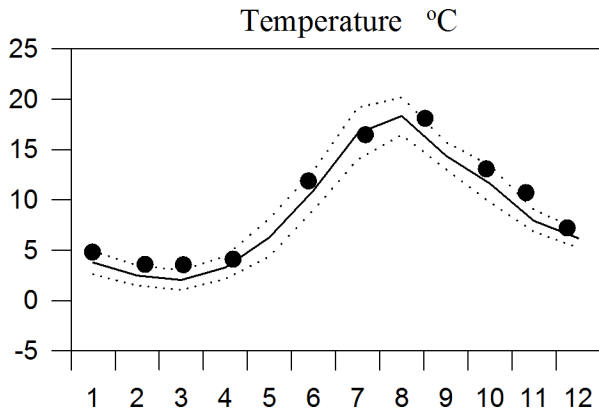
— Mean 1996-2010 St.Dev. ● 2015



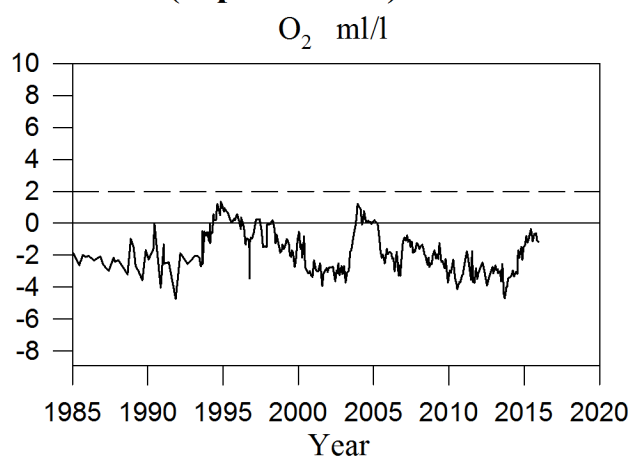
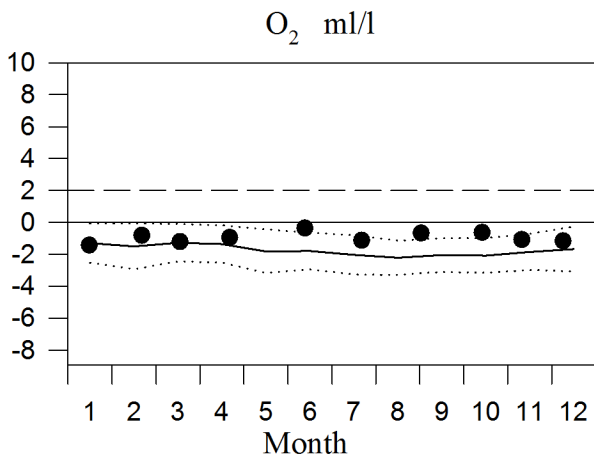
STATION BY20 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

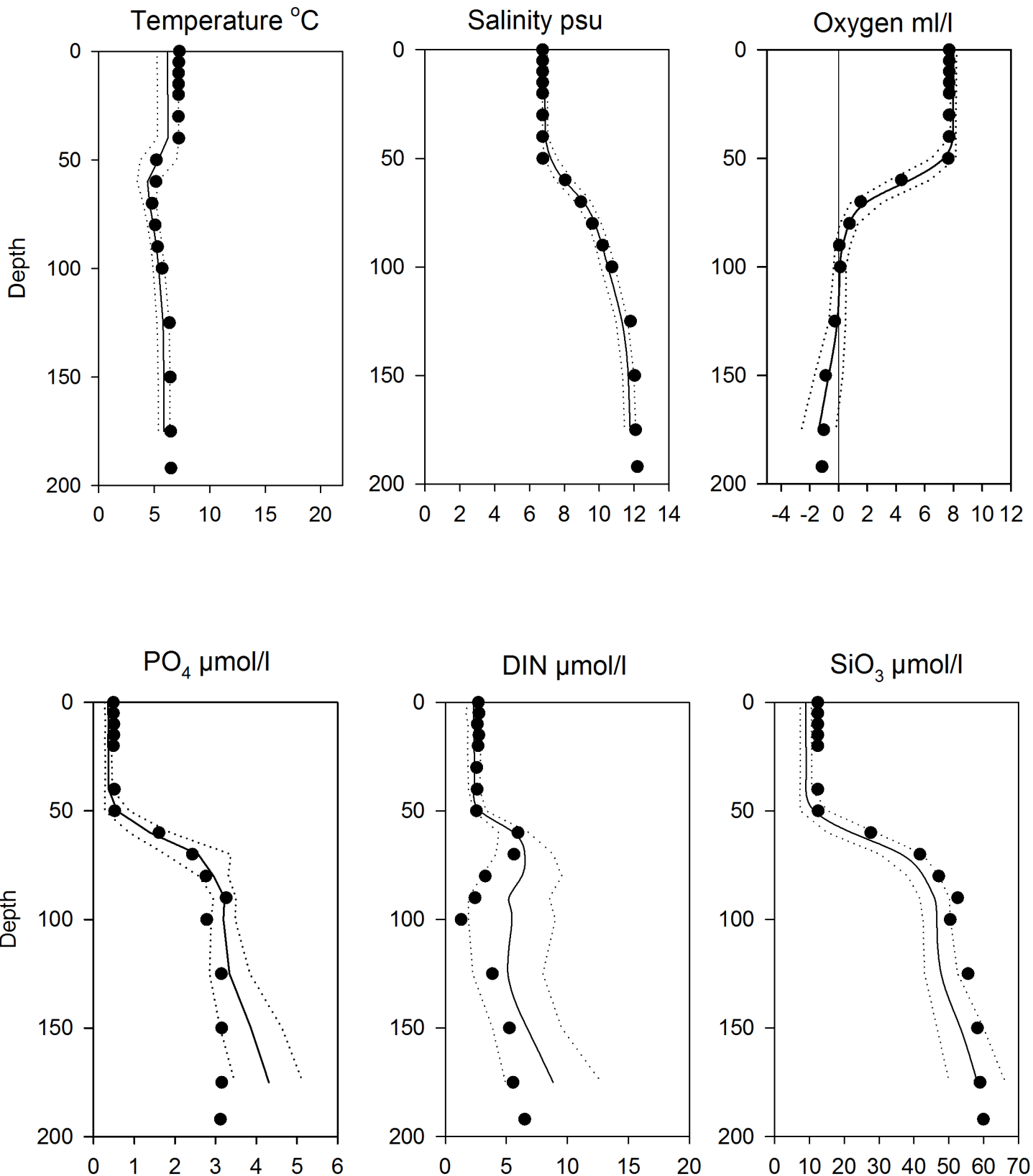


OXYGEN IN BOTTOM WATER (depth >175m)



Vertical profiles BY20 December

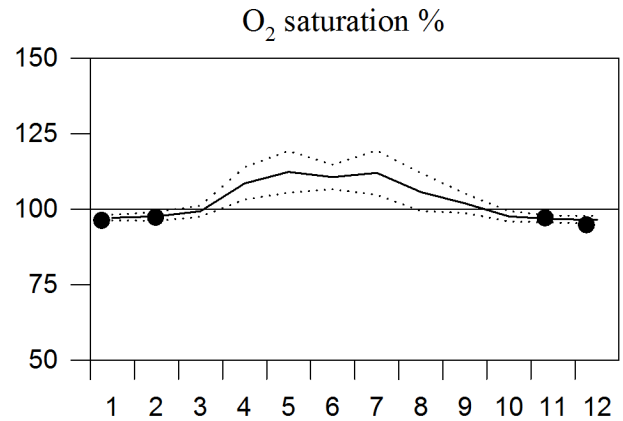
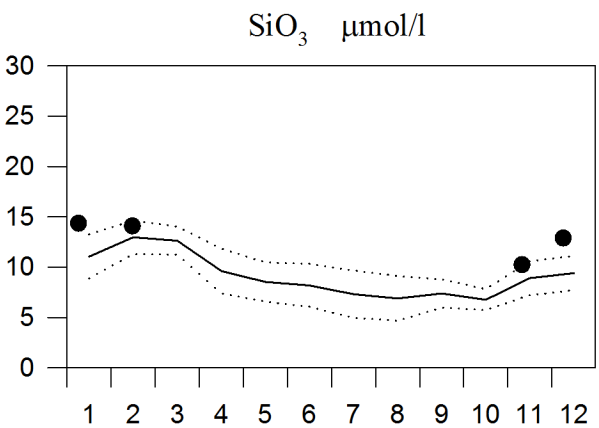
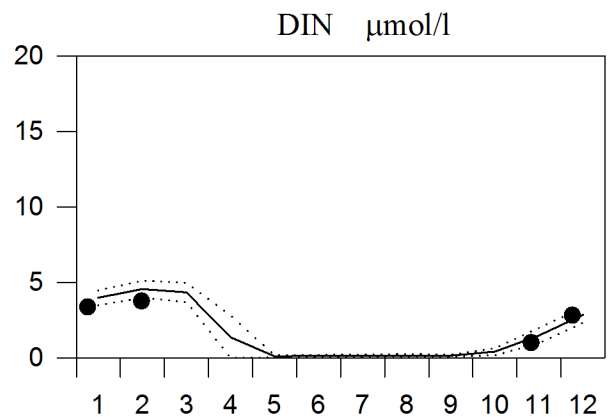
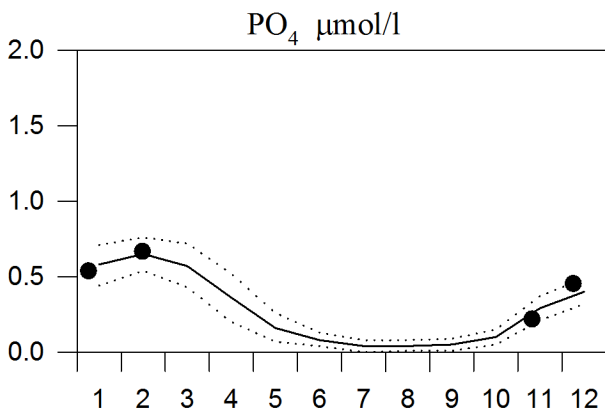
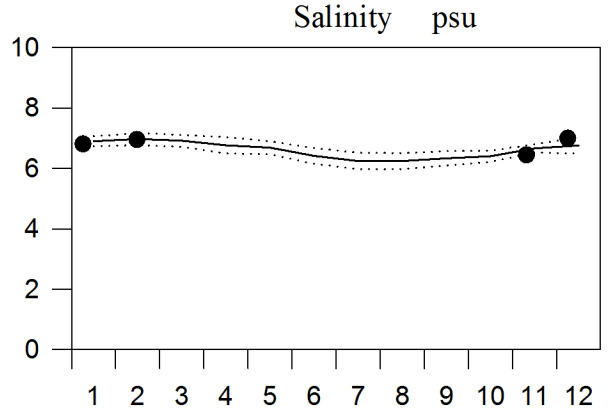
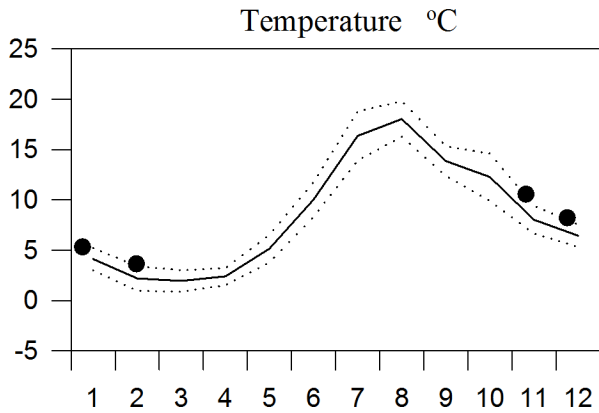
— Mean 1996-2010 ····· St.Dev. ● 2015



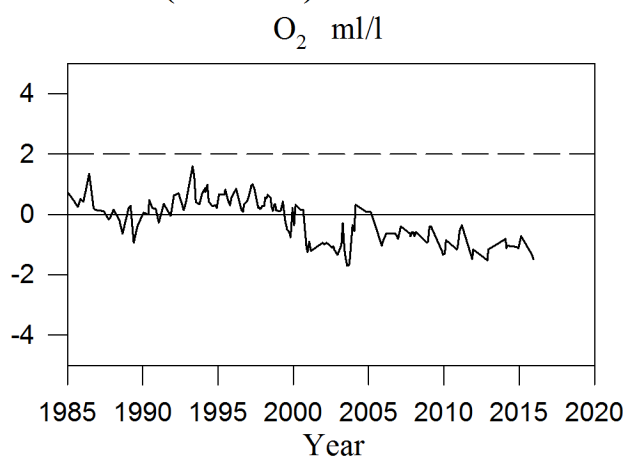
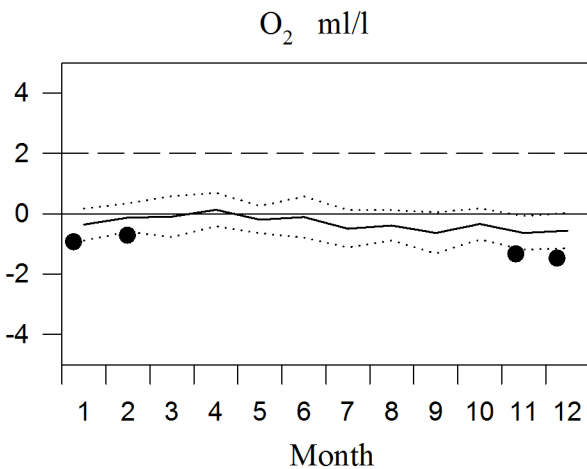
STATION BY29 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

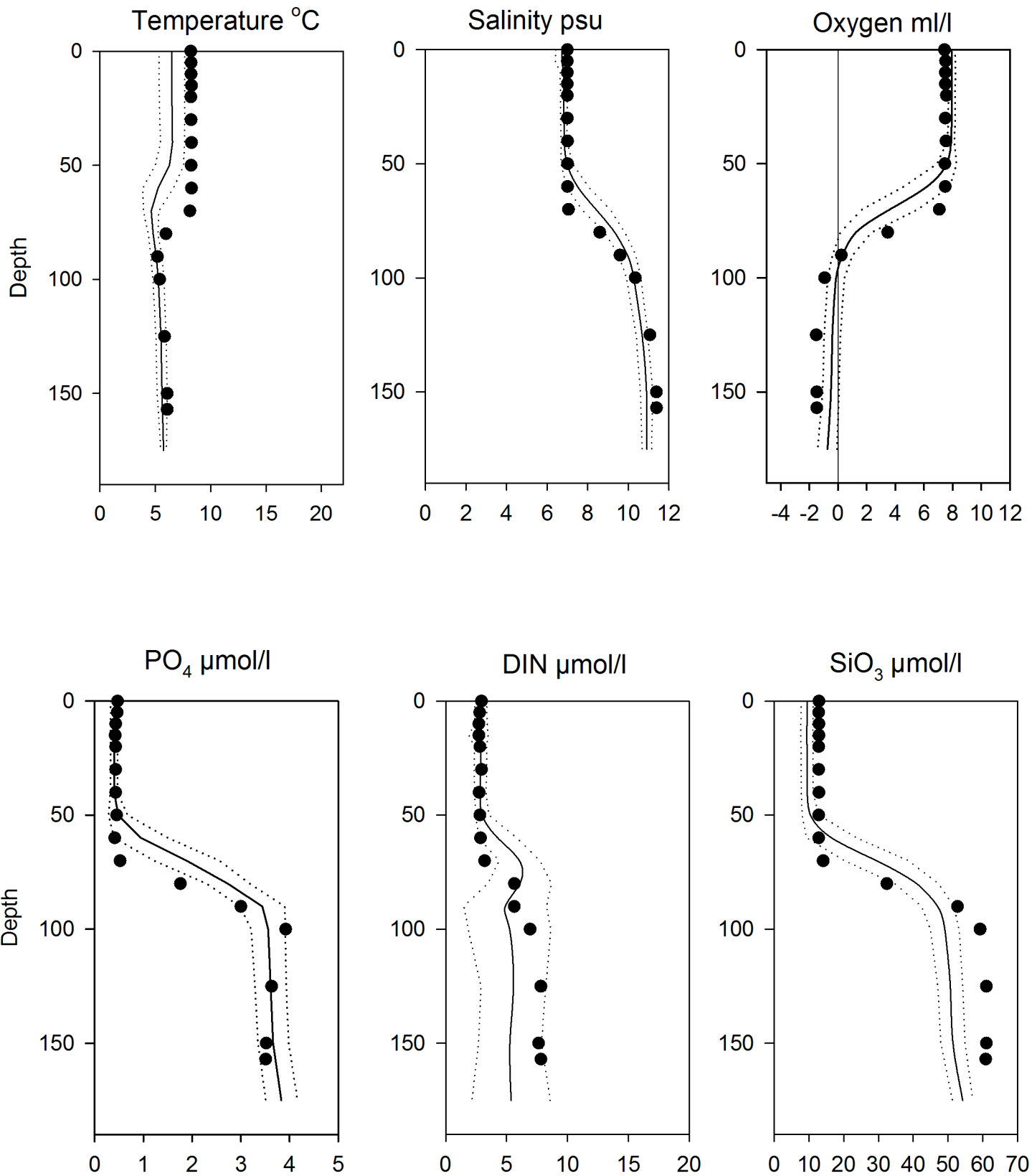


OXYGEN IN BOTTOM WATER (>=150m)



Vertical profiles BY29 December

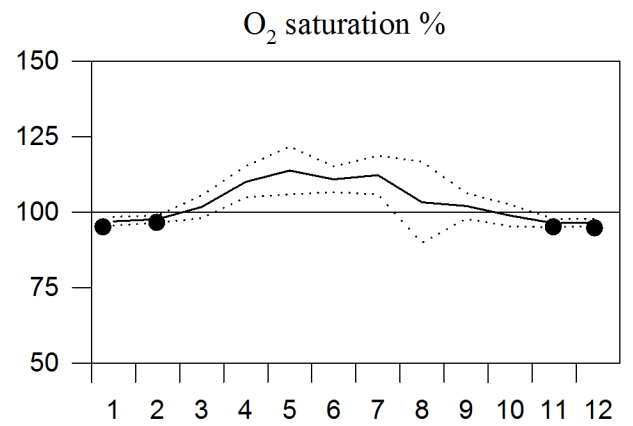
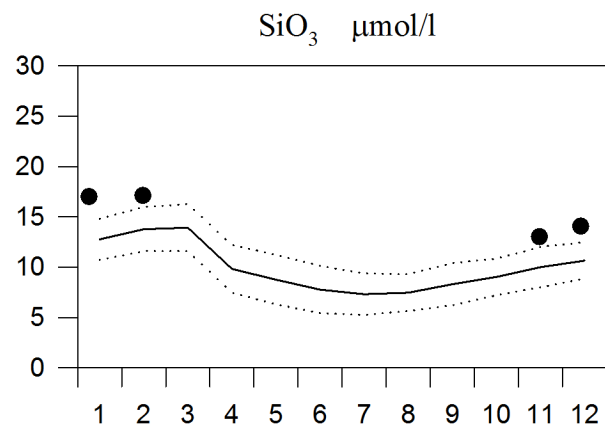
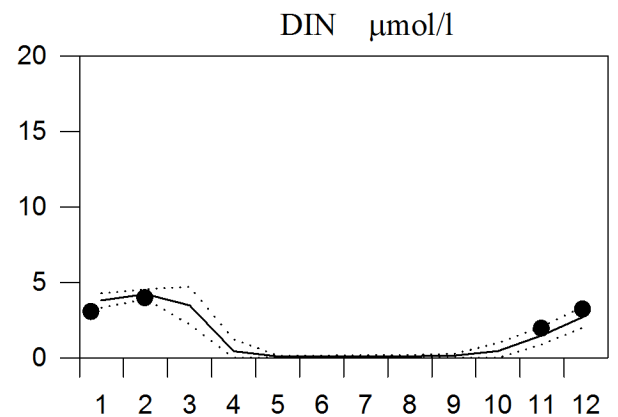
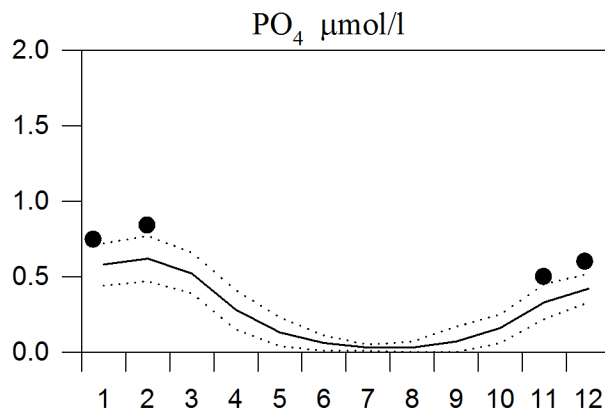
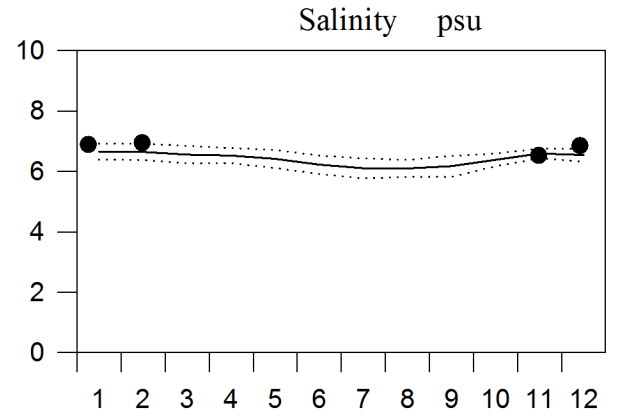
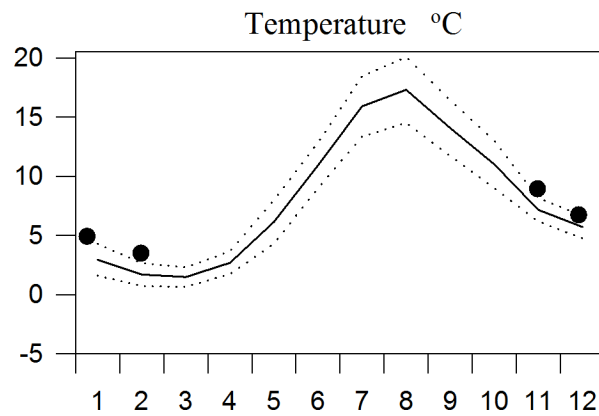
— Mean 1996-2010 ····· St.Dev. ● 2015



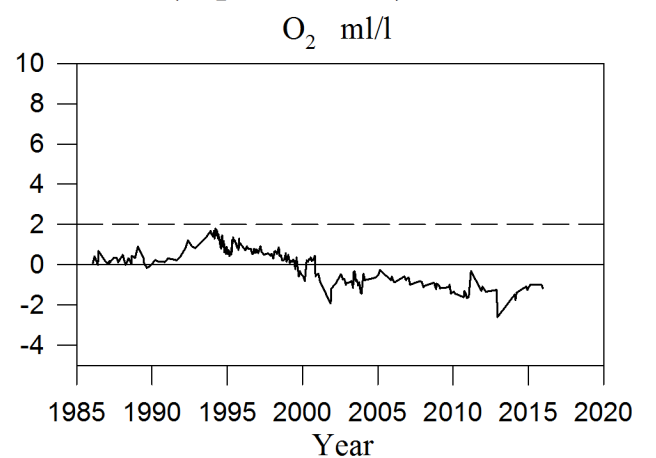
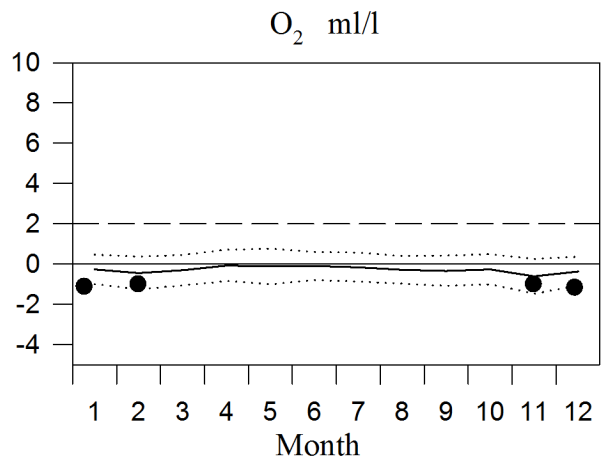
STATION BY31 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

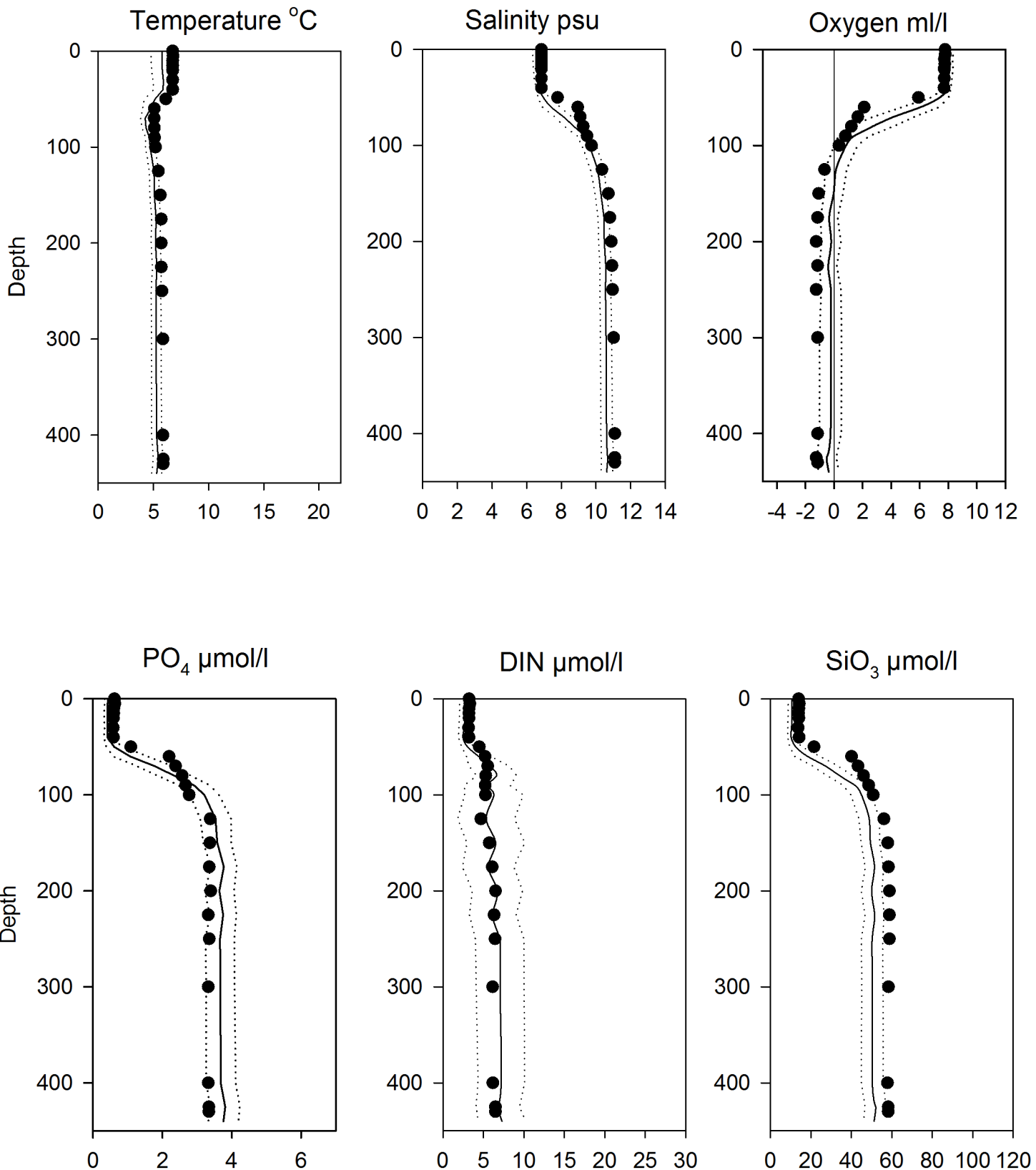


OXYGEN IN BOTTOM WATER (depth = 440m)



Vertical profiles BY31 December

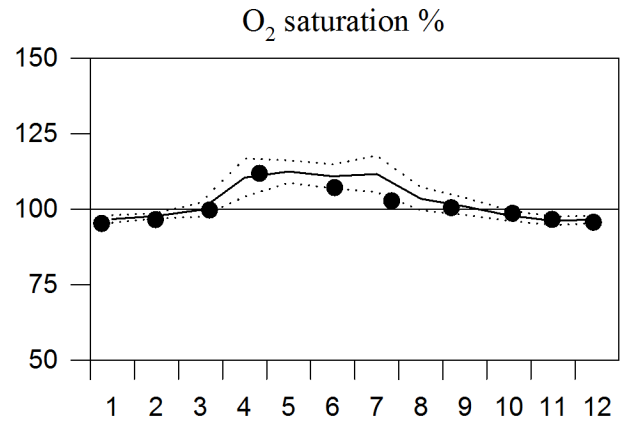
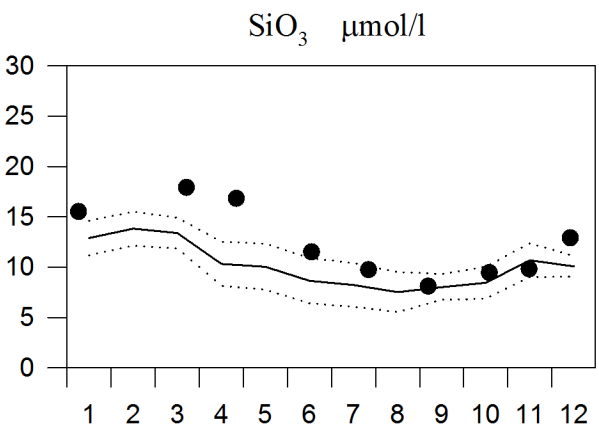
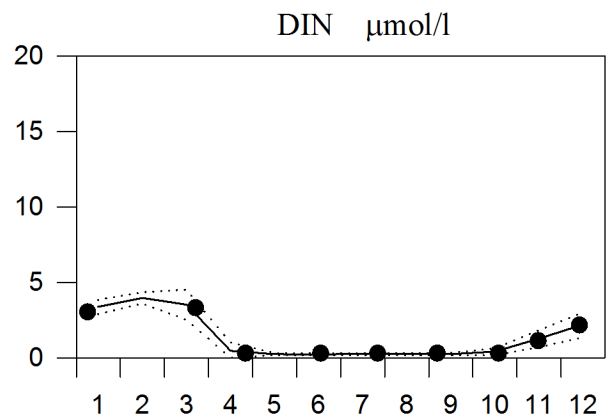
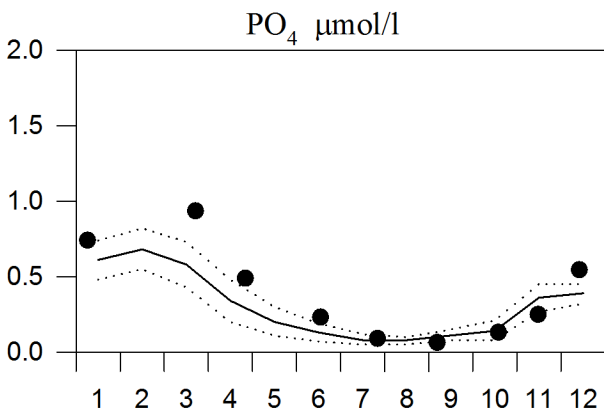
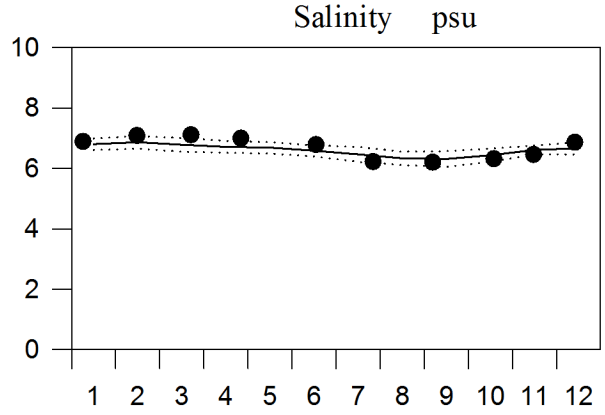
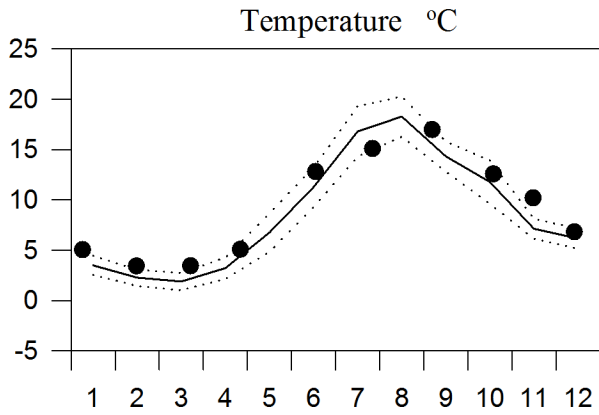
— Mean 1996-2010 ····· St.Dev. ● 2015



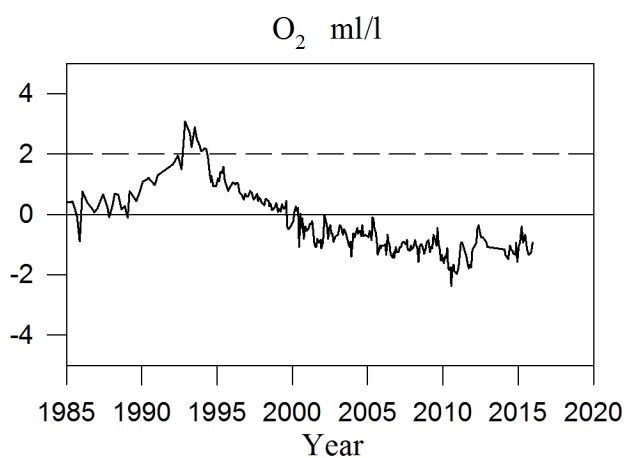
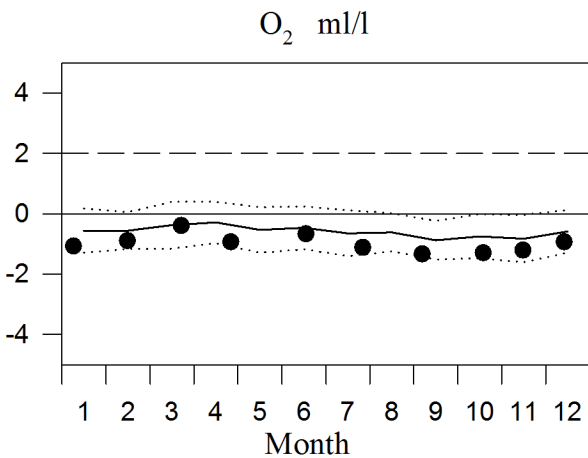
STATION BY32 SURFACE WATER

Annual Cycles

— Mean 1996-2010 ····· St.Dev. ● 2015

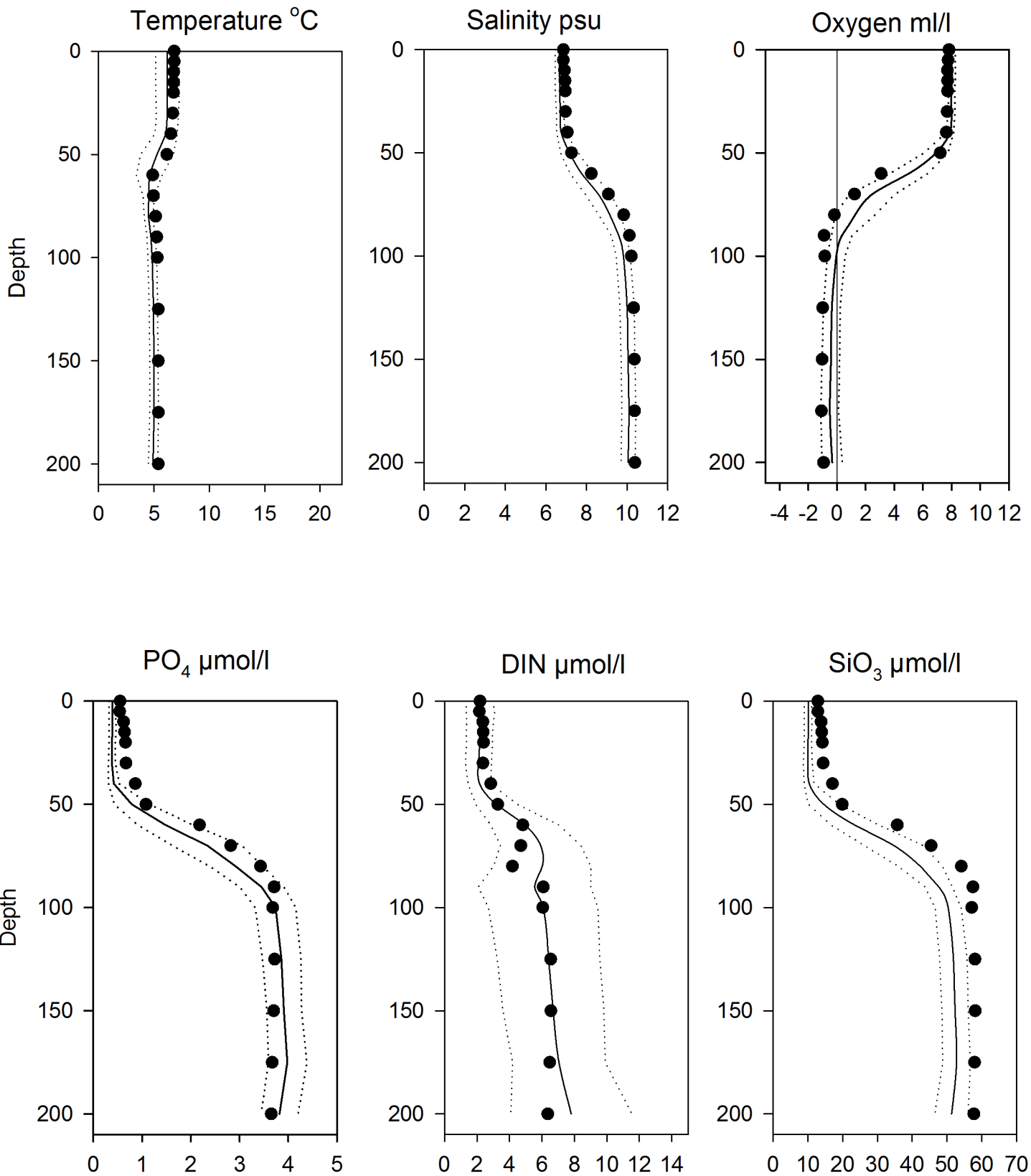


OXYGEN IN BOTTOM WATER (depth > 175m)



Vertical profiles BY32 December

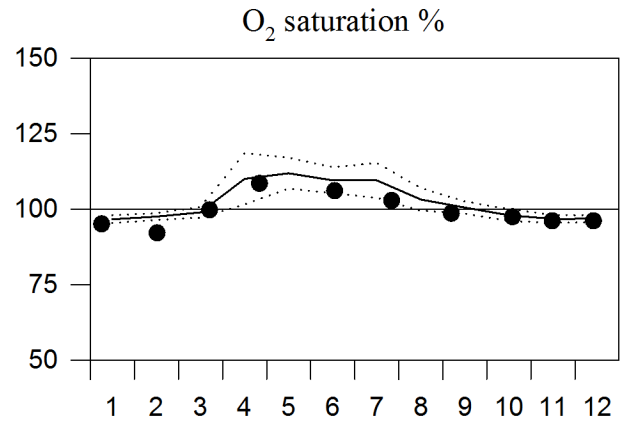
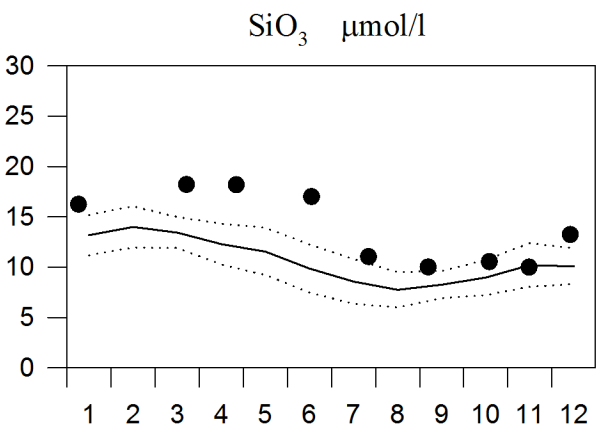
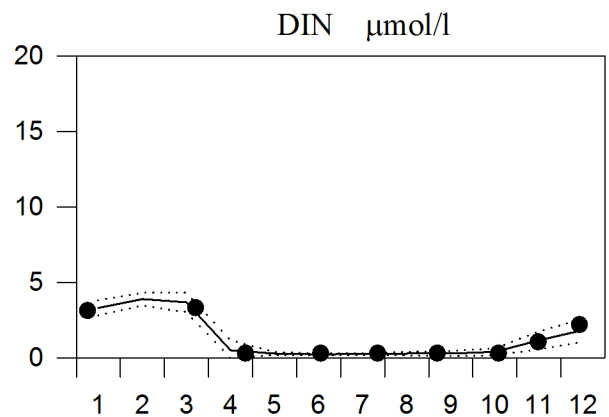
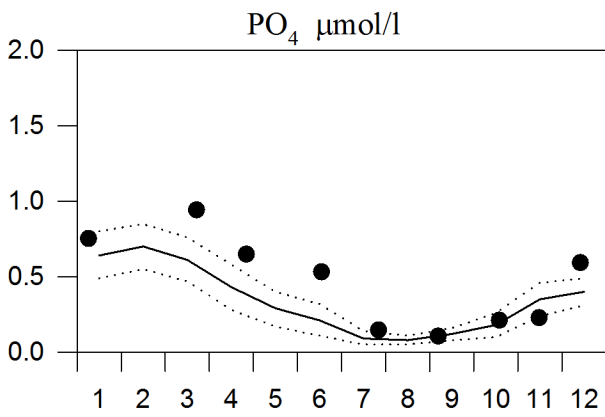
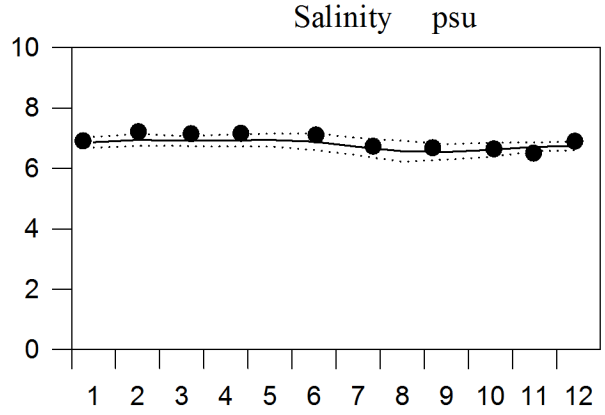
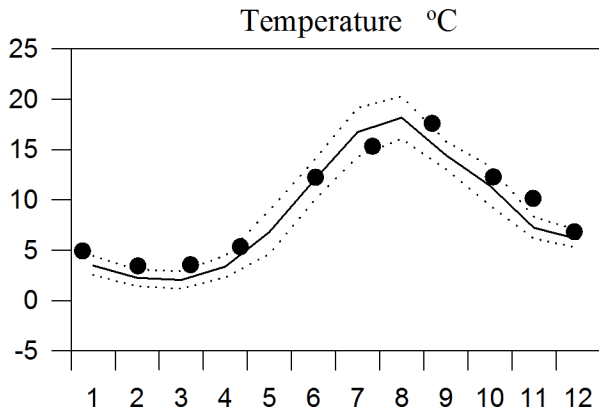
— Mean 1996-2010 ····· St.Dev. ● 2015



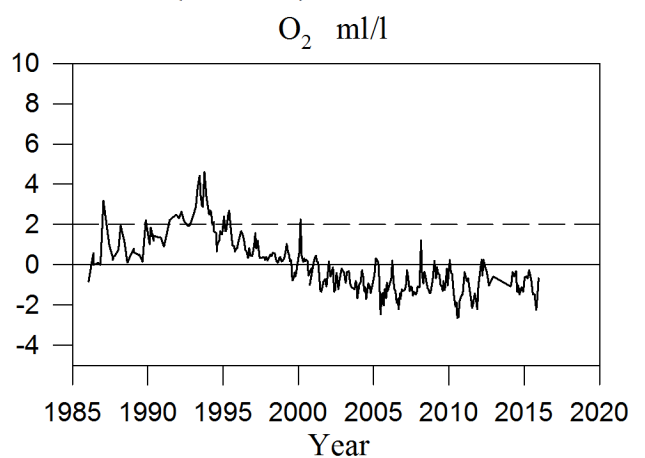
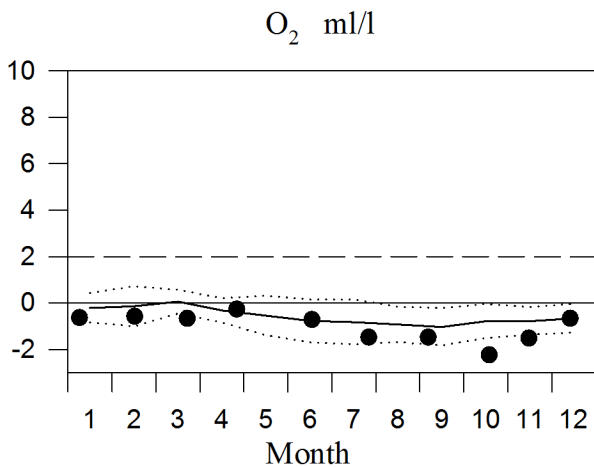
STATION BY38 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

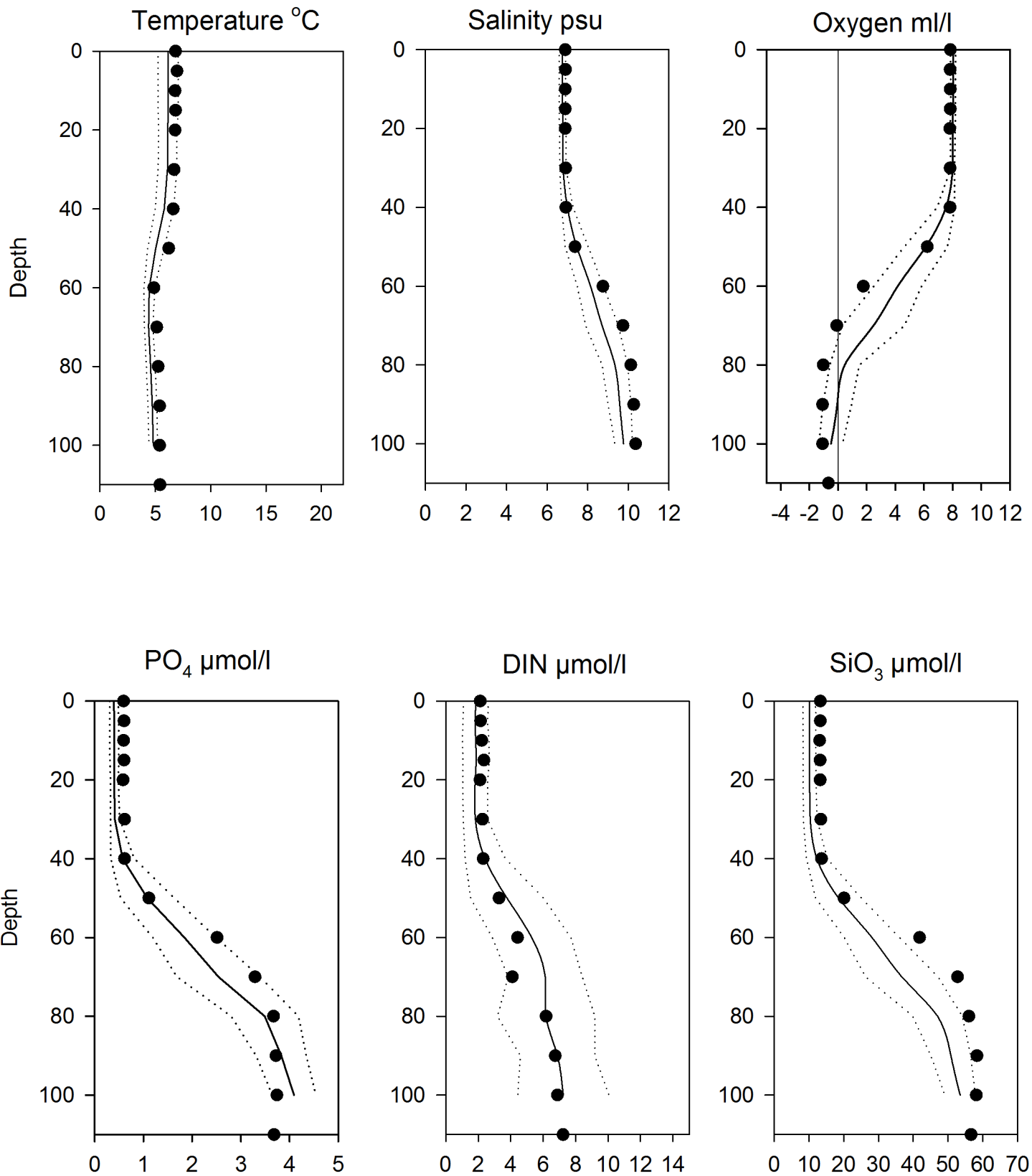


OXYGEN IN BOTTOM WATER (> 100m)



Vertical profiles BY38 December

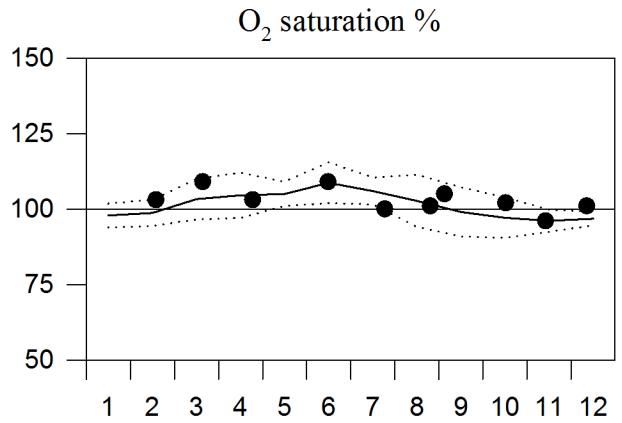
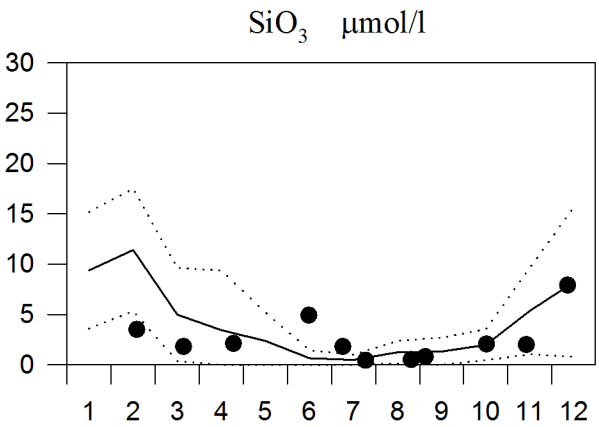
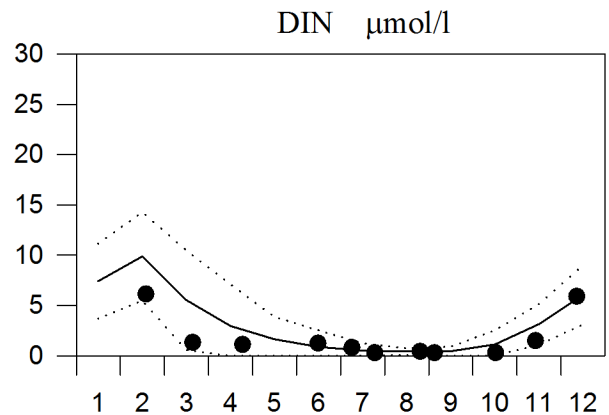
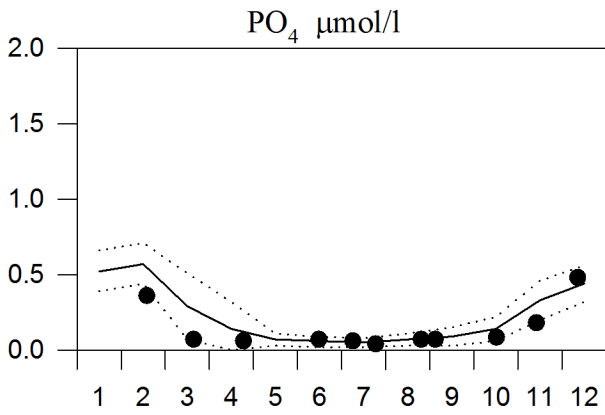
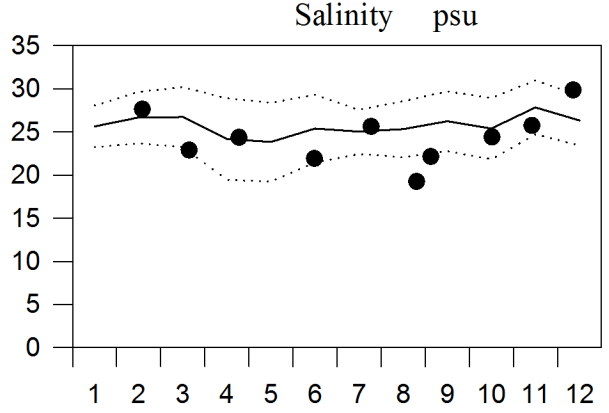
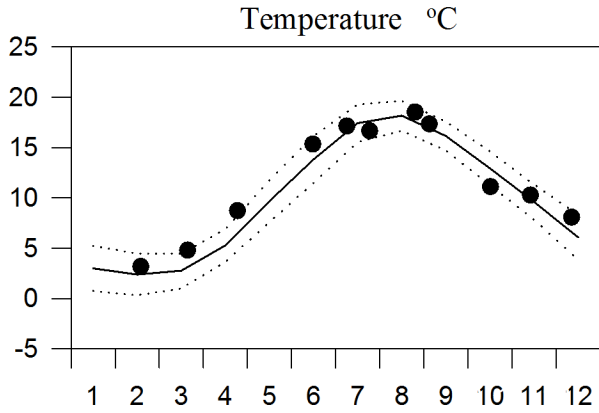
— Mean 1996-2010 ····· St.Dev. ● 2015



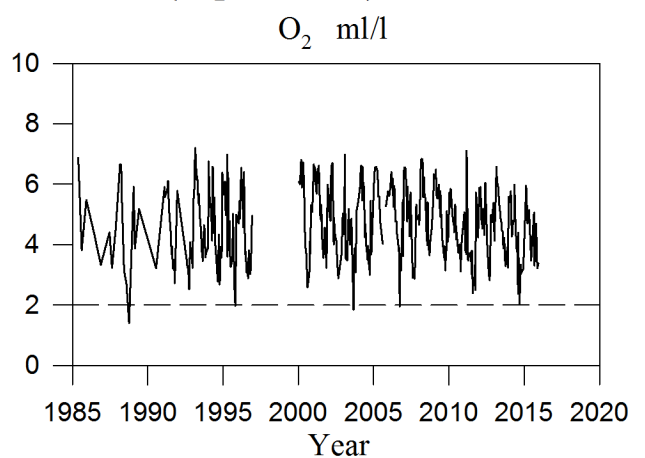
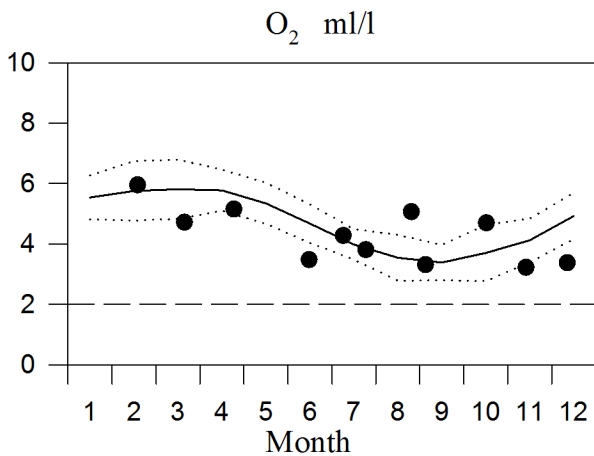
STATION SLÄGGÖ SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

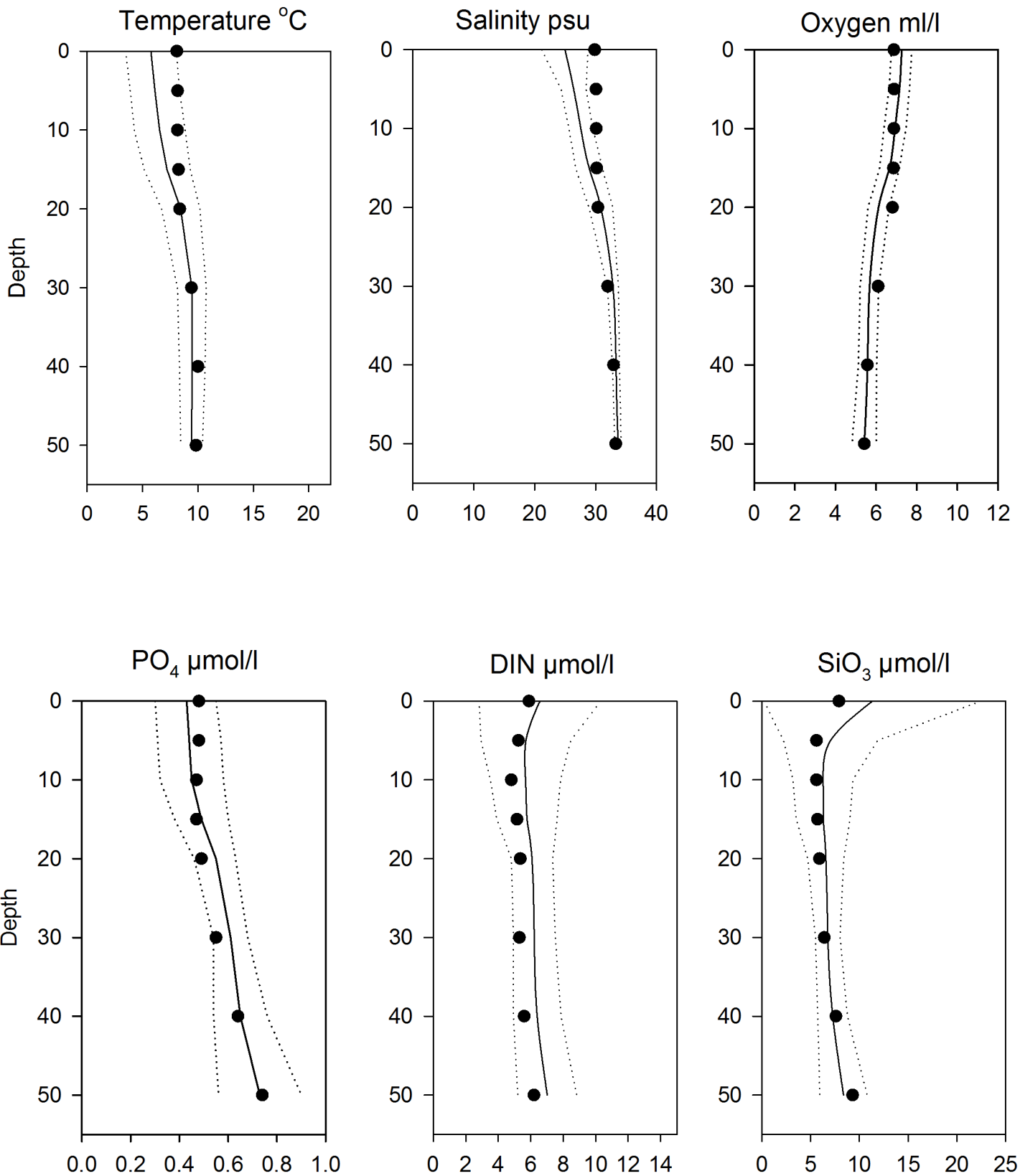


OXYGEN IN BOTTOM WATER (depth >50m)



Vertical profiles Släggö December

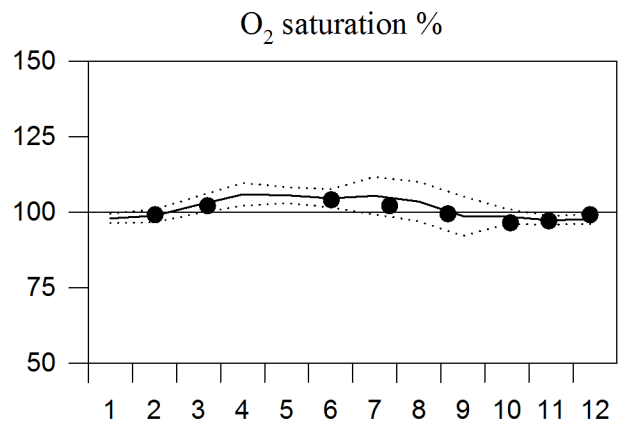
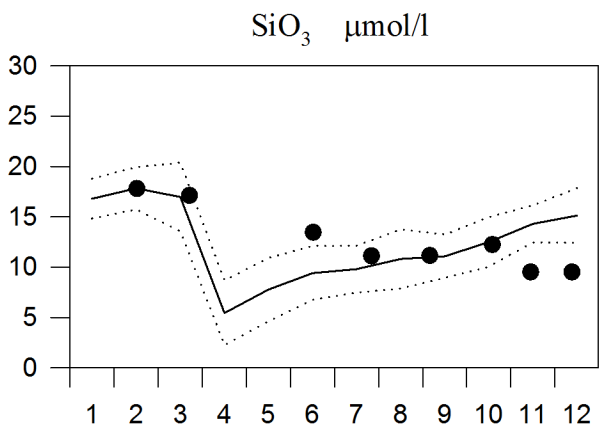
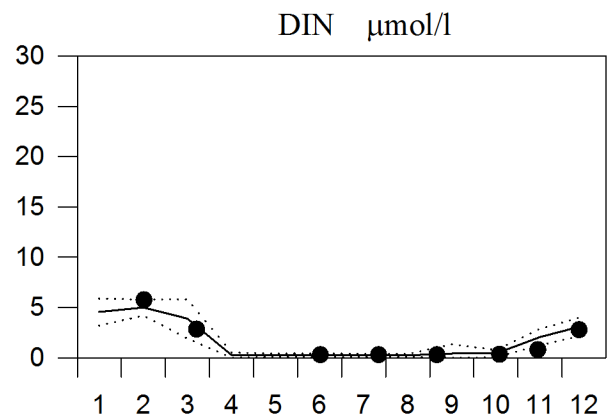
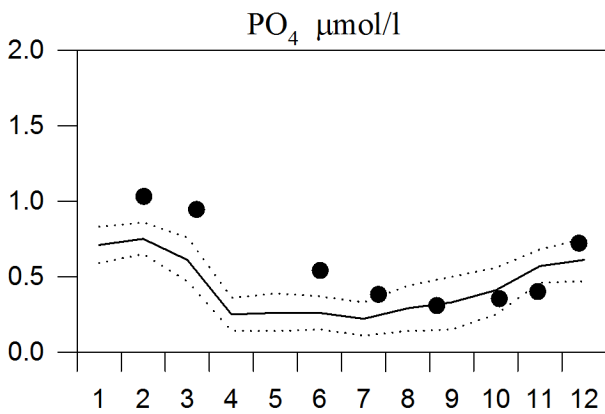
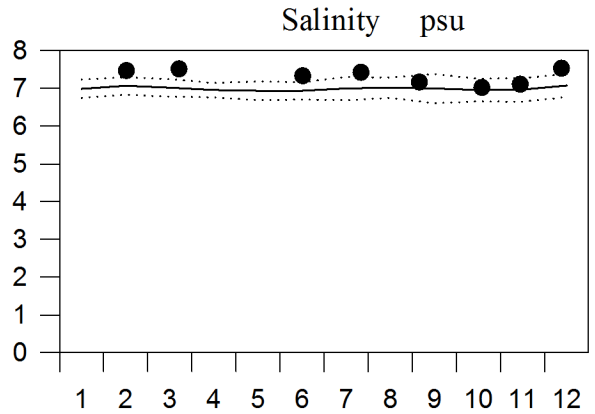
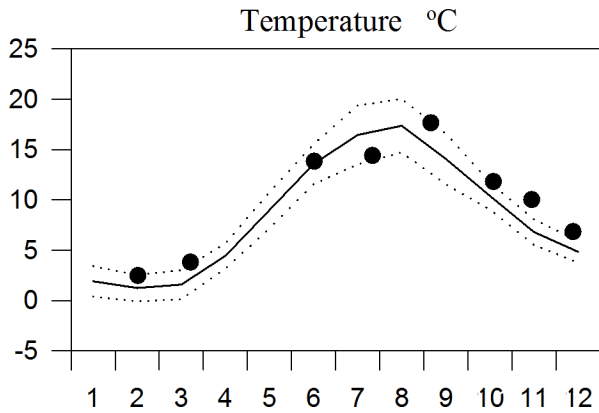
— Mean 1996-2010 St.Dev. ● 2015



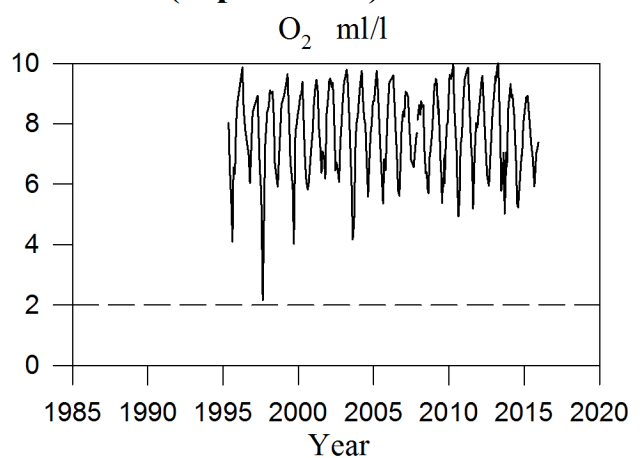
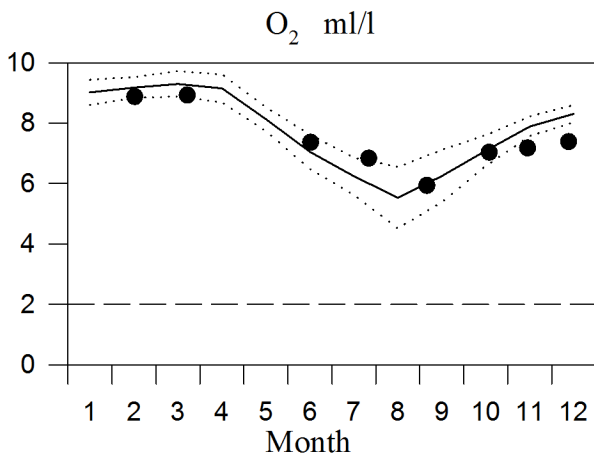
STATION REF M1V1 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015



OXYGEN IN BOTTOM WATER (depth >15m)



Vertical profiles Ref M1V1 December

— Mean 1996-2010 St.Dev. ● 2015

