

Report from the SMHI monitoring cruise with R/V Aranda



Survey period: 2016-01-07 - 2016-01-15
Survey area: Skagerrak, Kattegat, the Sound and the Baltic Proper
Principal: SMHI and the Swedish Agency for Marine and Water Management

SUMMARY

The expedition was part of the Swedish marine monitoring programme and covered the Skagerrak, the Kattegat, the Sound and the Baltic Proper. In Kattegat the winter pool of nutrients were mapped. Data presented in this report has been subject to preliminary quality control procedures only.

The temperature in the surface water was above normal in the Baltic Proper. The concentrations of nutrients were generally normal for the season in Skagerrak and Kattegat. In the Baltic Proper the concentration of phosphate was elevated in the western parts while the silicate concentration was well below normal in the southern parts.

The effect of the inflow in December 2014 could not be detected further north than the station BY20 in the northern part of the Eastern Gotland Basin. At the station Gotland Deep BY15, hydrogen sulphide was again present in the bottom water. In the Western and Northern Gotland Basins the oxygen situation remains very serious as anoxic conditions occurred at depths exceeding 70-100 meters. Hypoxia in the bottom water was detected in the Hanö Bight, the Bornholm Basin and in the south eastern Baltic Proper.

The next monitoring cruise is scheduled to start on 15 February.

PRELIMINARY RESULTS

The cruise was operated aboard the Finnish research vessel Aranda. It commenced in Helsinki on January 7 and ended in the same port on January 15. The winds during the expedition were predominantly southeast to northern, and varied in strength from brisk to gale force. Air temperatures ranged between -14 and +4 °C. In the Kattegat and the Sound the winter pool of nutrients was mapped. Beyond the ordinary 4 stations, 12 extra mapping stations were visited.

The Skagerrak

The temperature of the surface water was normal for the season and varied between 2.6 and 4.6°C, lowest near the coast and high in the offshore areas. The salinity in the surface layer was also normal for the season and varied between 26.2 and 30.8 psu. The stratification, both the thermocline and the halocline, was weakly developed.

The nutrients in the surface showed typical values for the season, except for silicate which showed concentrations above normal in the central parts. In the surface water the concentration of phosphate ranged between 0.52 and 0.66 µmol/l, inorganic nitrogen (nitrite + nitrate) between 5.7 and 6.8 µmol/l, while silicate varied from 7.1 to 14.5 µmol/l.

The lowest oxygen concentrations, 4.5 ml/l, were found in the bottom water at Släggö in the mouth of the Gullmarn Fjord. Fluorescence measurements showed low biological activity in the surface layer. For more details on species composition see the separate algal report, AlgaAware.

The Kattegat and the Sound

The temperature in the surface water was normal for the season and varied between 2.7 and 4.6 °C. The surface salinity was generally lower than normal and ranged in the southern parts from 15.3 to 18.8 psu and in the northern parts from 20.2 to 23.2 psu. In the Sound the salinity was around 9 psu, which is lower than normal. A weak stratification was found at 10 – 20 meters depth.

The mapping of the winter pool of nutrients in Kattegat showed that the concentrations in the surface water were normal or lower than normal. The only exception was the station Fladen, which showed elevated concentrations of phosphate and silicate. Generally, the amount of all nutrients had increased since the last visit in December and the highest concentration were found in the western parts of Kattegat. The phosphate concentration now ranged from 0.6 – 0.8 µmol/l, inorganic nitrogen from 3.2 – 6.2 µmol/l and silicate varied between 7.8 to 12.7 µmol/l.

As a result of the weak stratification the oxygen situation in the deep water was good. The oxygen concentration in the bottom water was > 6 ml/l at all stations in Kattegat. The plankton activity was low in the whole investigated area.

The Baltic Proper

The temperature of the surface layer was above normal in the whole Baltic Proper and varied from 3.7°C to 6.1°C. Surface salinity was elevated in the Bornholm Basin, the Hanö Bight and in the Western Gotland Basin. The halocline and thermocline coincided and were found at 50 – 70 meters depth in the Western Gotland Basin, at 60 – 80 meters depth in the Eastern and Northern Gotland Basin, while found at shallower depth in the southern parts.

Phosphate concentrations in the surface water had risen even further since the previous cruise and in the Western Gotland Basin the concentration were high above normal, 0.8 -1.0 $\mu\text{mol/l}$. In the remaining parts the concentration ranged from 0.6-0.7 $\mu\text{mol/l}$. The concentrations of inorganic nitrogen (nitrite + nitrate) were normal and varied between 2.3 and 3.2 $\mu\text{mol/l}$. The silicate concentration was still below normal in the southern parts, while elevated above normal in the remaining parts of the Baltic Proper. The concentrations ranged from 7.4 to 16.8 $\mu\text{mol/l}$.

In the Eastern Gotland Basin, acute hypoxia (<2 ml/l) occurred at depths exceeding 70-80 metres. Similar to the previous cruise in December, completely oxygen-free conditions (anoxia) with hydrogen sulphide present were observed in the northern parts (BY20 and BY21) from 125 metres depth. At BY15, hydrogen sulphide was again present in the bottom water and from 150 – 225 meters depth the oxygen concentrations were low, < 0.7 ml/l. Hence, the effects of the inflow in December 2014 could not be detected further north than BY20 in the Eastern Gotland Basin. In the Western and Northern Gotland Basin the oxygen situation continues to be extremely bad. In the Western Gotland Basin anoxic conditions were found from depth exceeding 70 – 90 meters, while hypoxia was found from 50 – 70 meters depth. The Northern Gotland Basin had anoxic conditions from 100 meters depth and hypoxia from 80 – 90 meters depth. Oxygen levels in the bottom water in the Bornholm Basin, Hanö Bight and the south eastern Baltic Proper were still low and acute hypoxia prevailed.

Fluorescence measurements showed low biological activity.

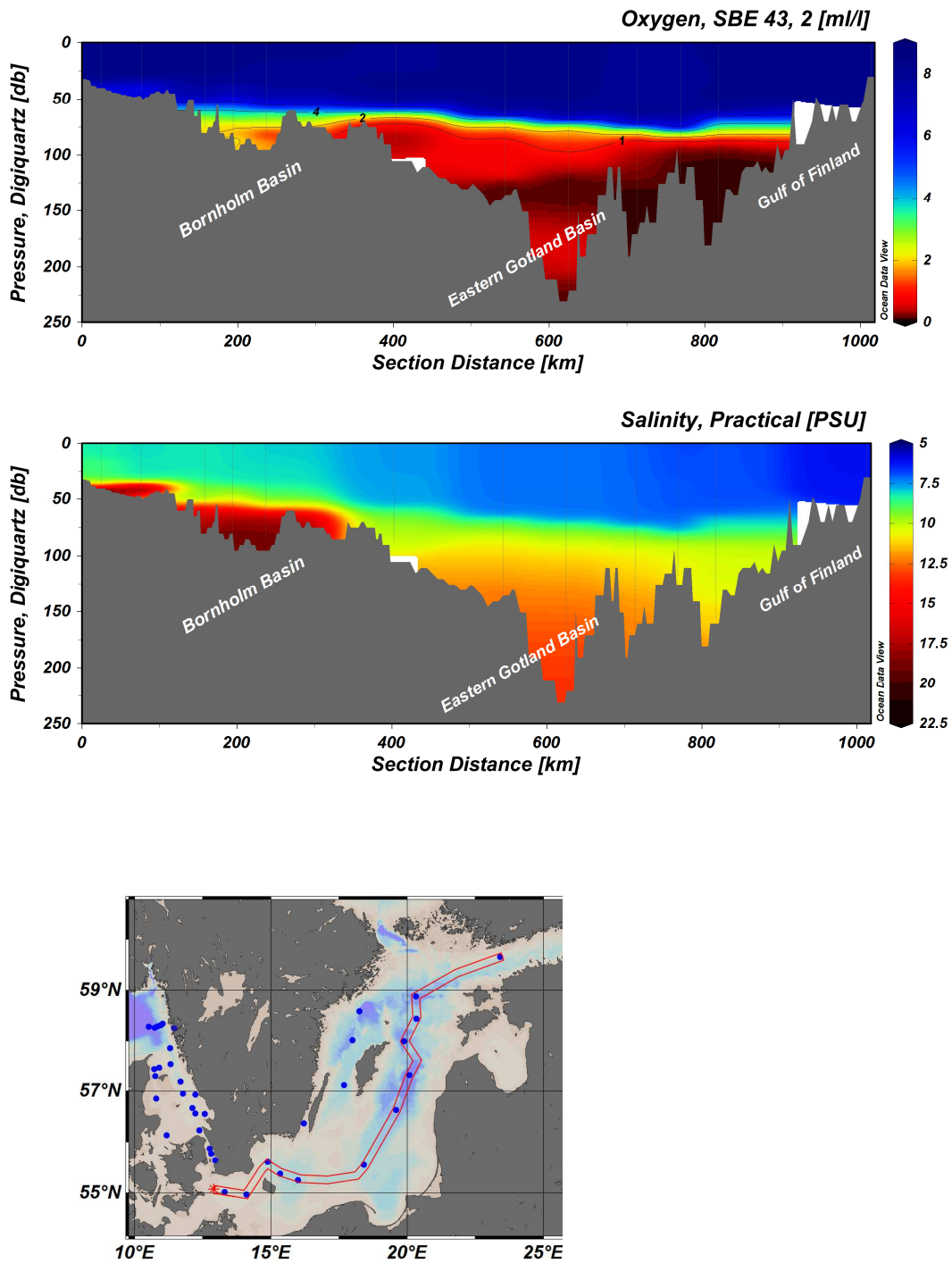


Figure 1. Transect showing the oxygen and salinity from the Sound to the Gulf of Finland.



PARTICIPANTS

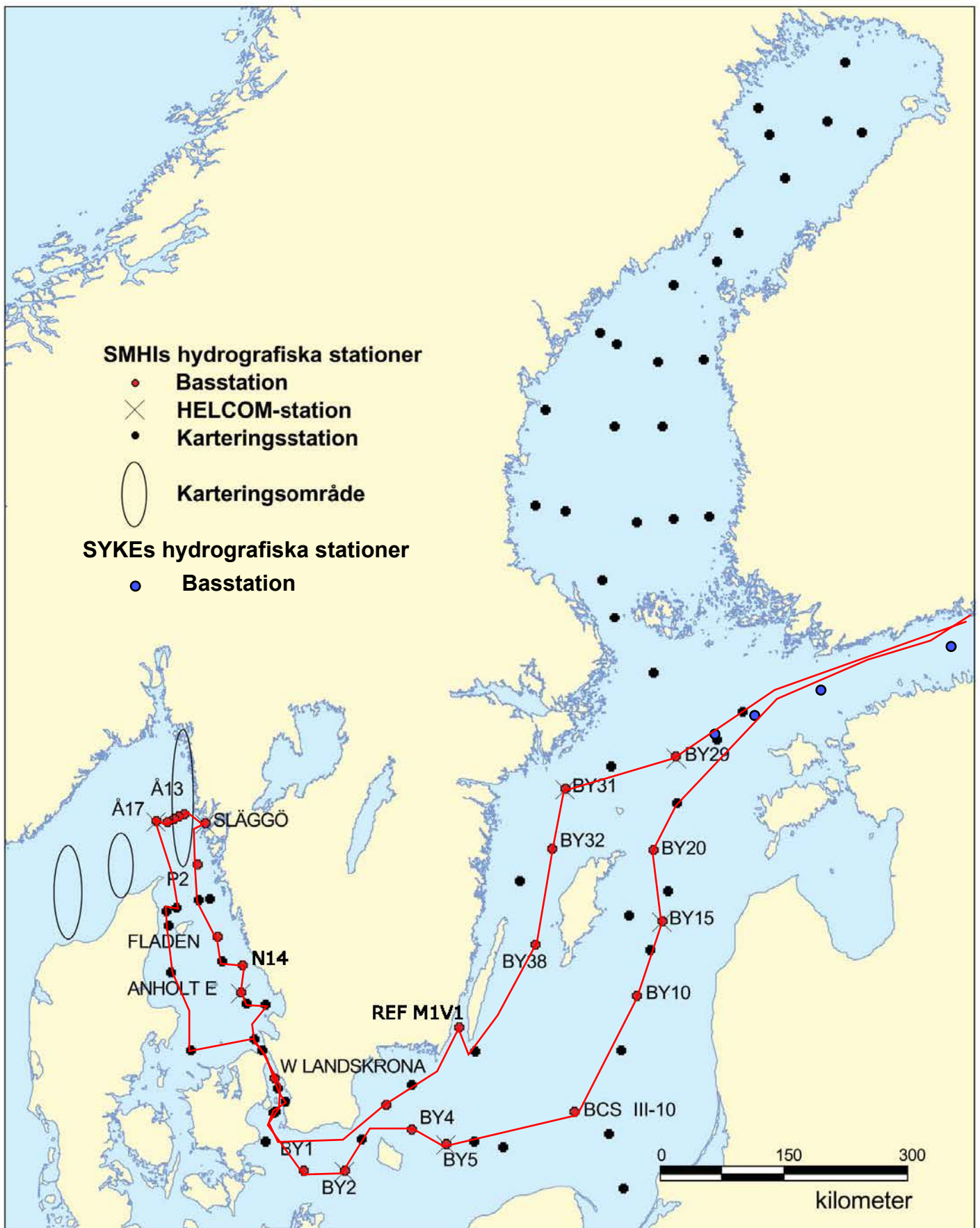
Name		Institute
Martin Hansson	Chief scientist	SMHI
Daniel Bergman-Sjöstrand		SMHI
Johan Håkansson		SMHI
Johan Kronsell		SMHI
Sari Sipilä		SMHI
Kristin Andreasson		SMHI

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: 20160107-20160115
 Series: 0001-0040



SMHI
Ocean enh

Hydrographic
series

Ship: 01-Aranda
Year: 2016

Date: 2016-01-20
Time: 22:09

Ser no	Stat code	P ro j	Station-----	Lat-----	Lon-----	Date yyyymmdd	Time hhmm utc	Bottom depth m	Secchi depth m	Wind di ve	Air temp C	Air pres hPa	WCSI elec aoae tu	C t	PPCPZZT Hrhhhoor Cilyooa motPBw PrP l	No de	T e m p l n	S e a h x y p i n	P o o l y g	H 2 o S P P	P t t P N	N o o 2 3 P N	N t 4 N N	N t 4 N N	A t k a 3 l s i	S h o l i u i o o o o	H o l i u i o o o o	L i u i o o o o	P t t P N	P t t P N	C m m			
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0002	BPX27EXT	BY21		N5826.5	E2020	20160108	0502	121		12 8	-6.6	1009	7990	x	-----	14	x	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
0003	BPEX26BAS	BY20	FÄRÖDJ	N5800	E1953	20160108	0822	195	8	13 11	-7.5	1007	2740	x	--x----	17	x	x	-	x	x	x	x	x	x	x	-	x	-	-	-	-	-	x
0004	BPEX21BAS	BY15	GOTLANDSDJ	N5720	E2003	20160108	1630	240		11 6	-6.1	1003	9990	x	--xxx--	19	x	x	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	x
0005	BPEX21EXT	BY15	GOTLANDSDJ	N5720	E2003	20160108	1800	240		12 9	-5.3	1002	9990	x	-----	5	x	x	-	x	x	x	x	x	x	x	-	x	-	-	-	-	-	-
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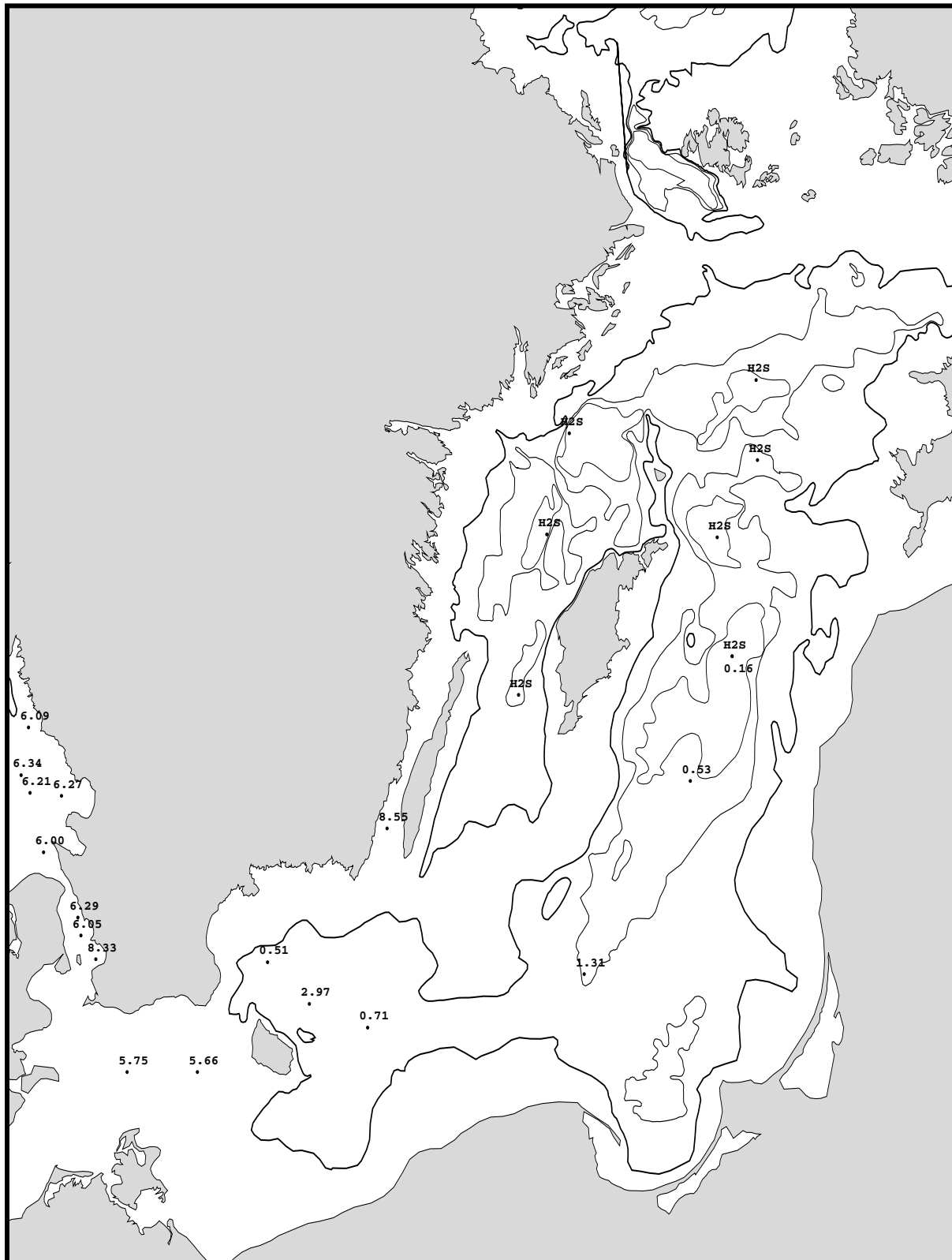
Bottom water oxygen concentration (ml/l)

Country: Finland

Ship : Aranda

Date : 20160107-20160114

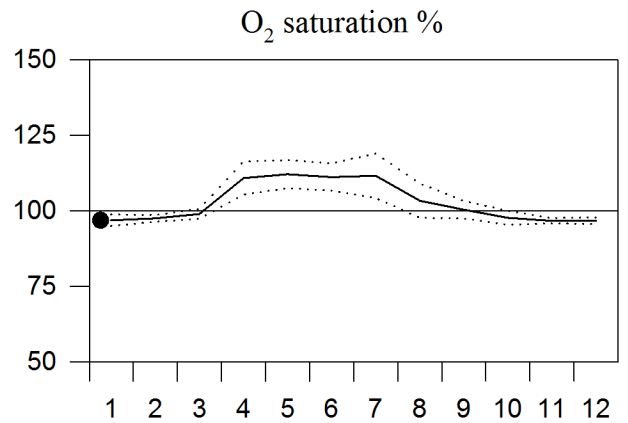
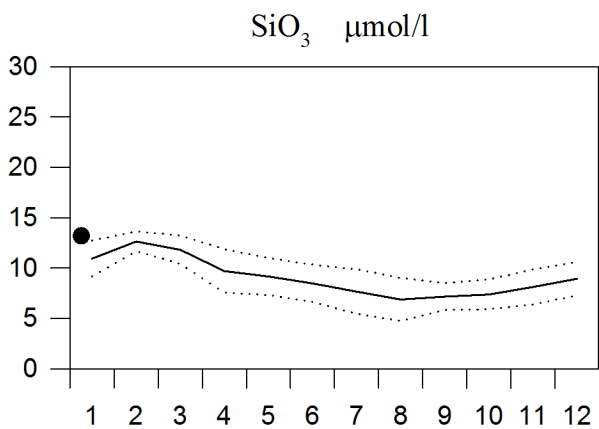
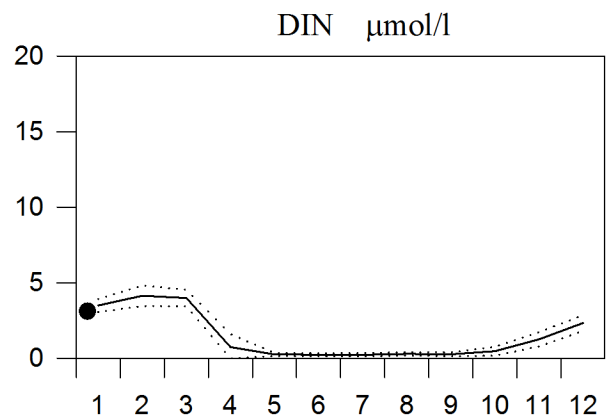
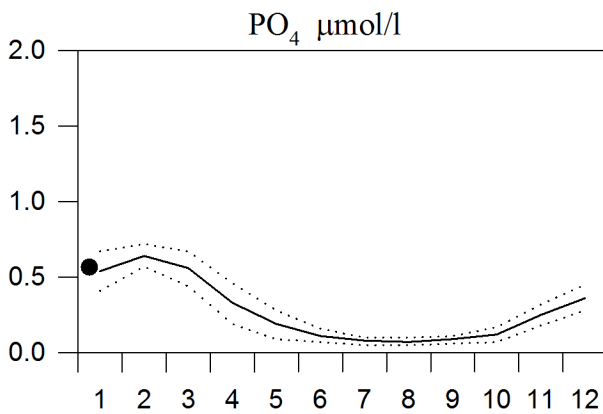
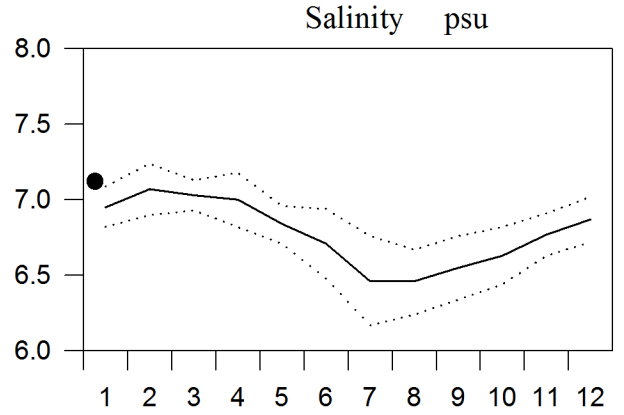
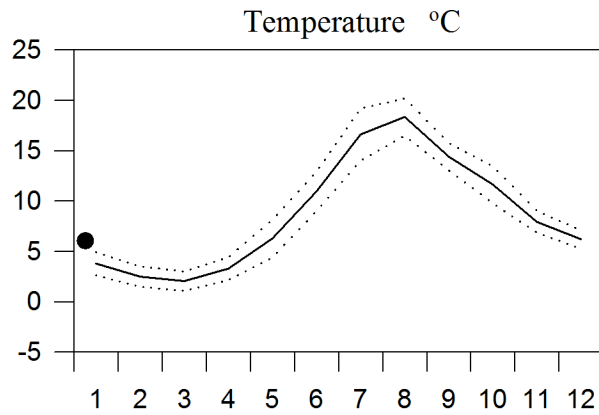
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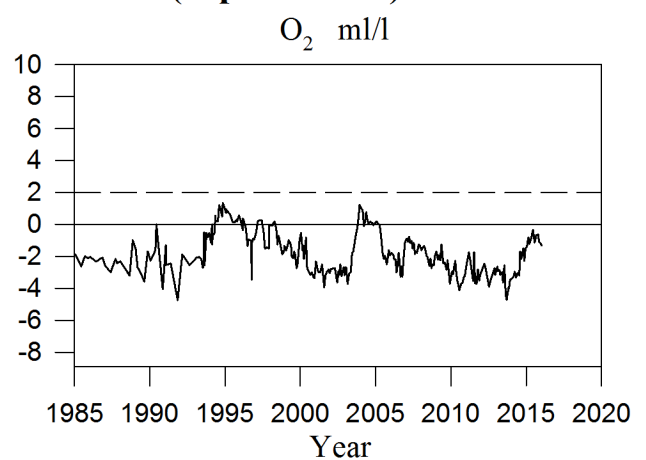
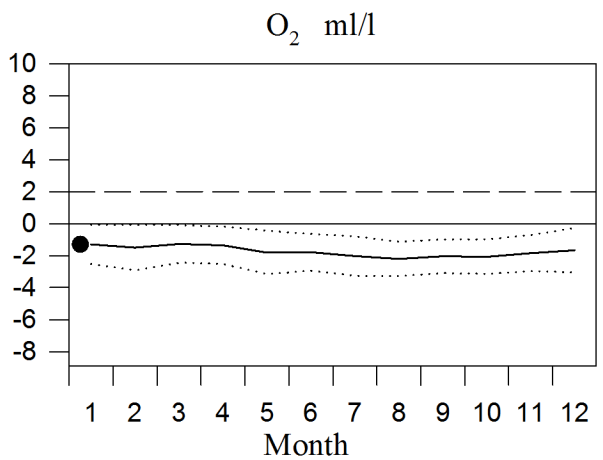
STATION BY20 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016



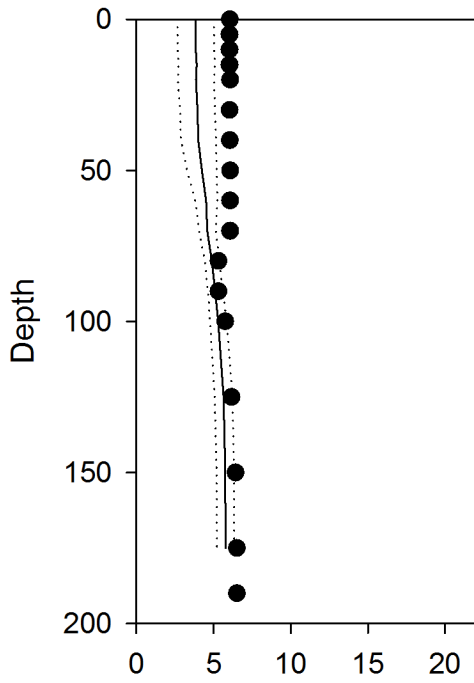
OXYGEN IN BOTTOM WATER (depth >175m)



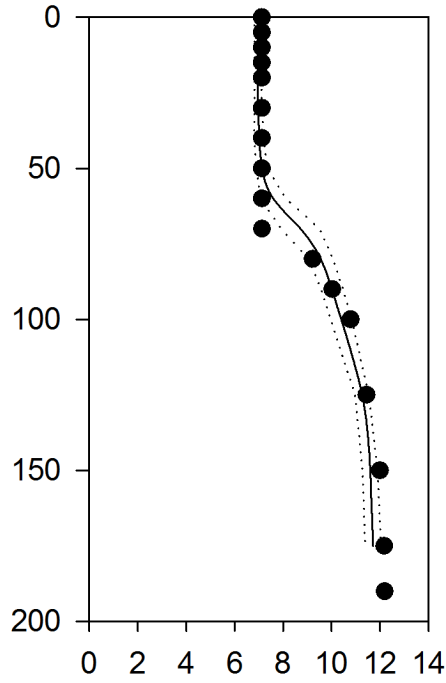
Vertical profiles BY20 January

— Mean 1996-2010 St.Dev. ● 2016

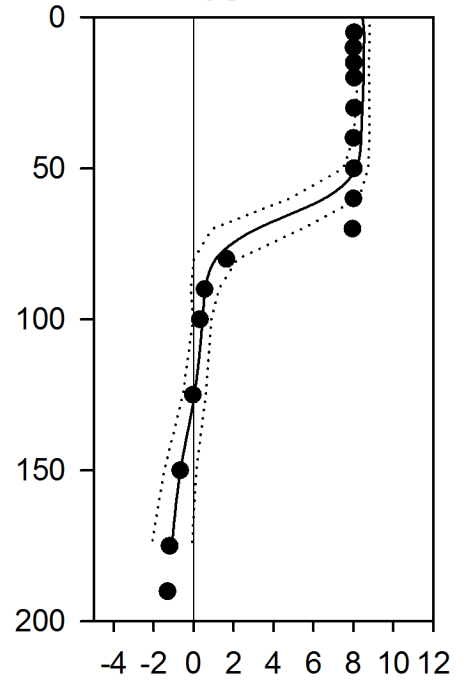
Temperature °C



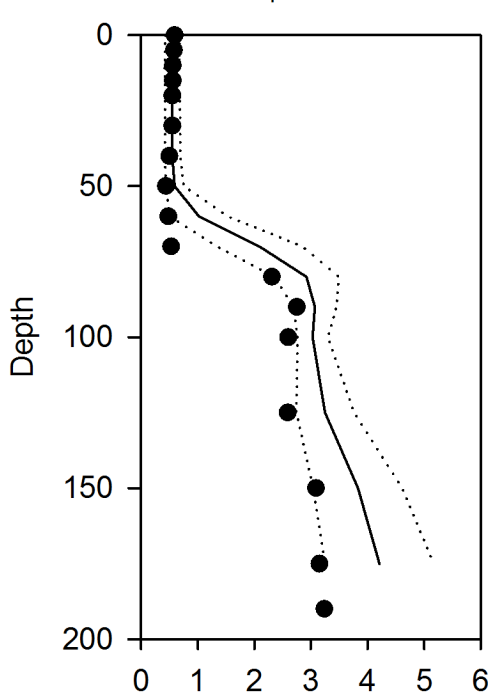
Salinity psu



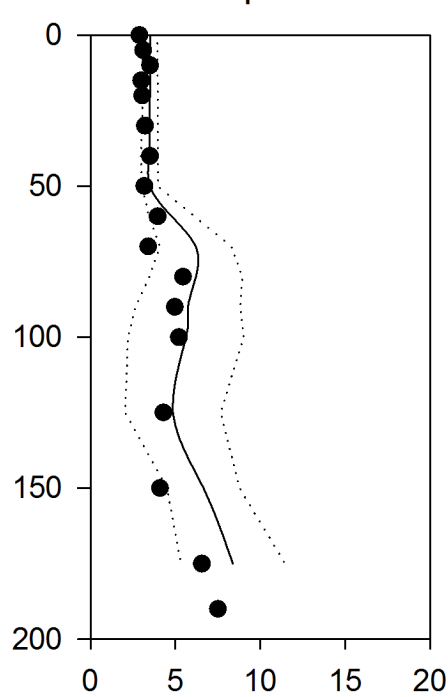
Oxygen ml/l



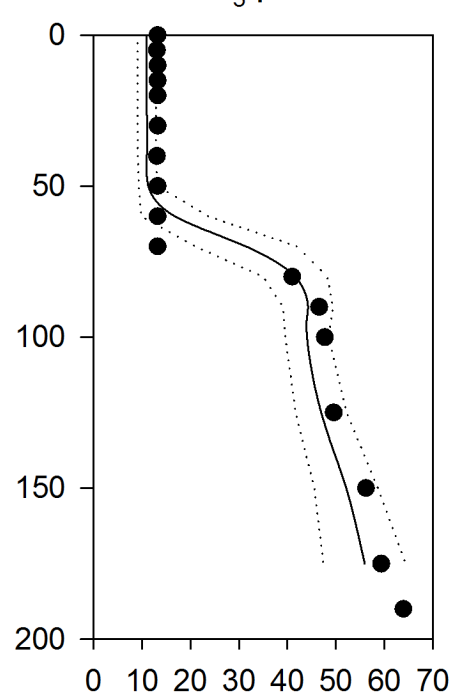
PO₄ μmol/l



DIN μmol/l



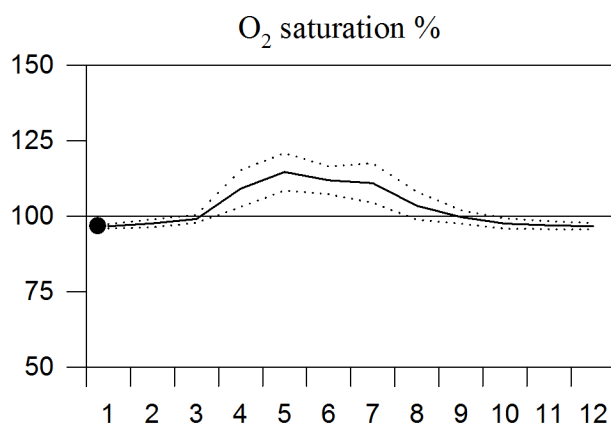
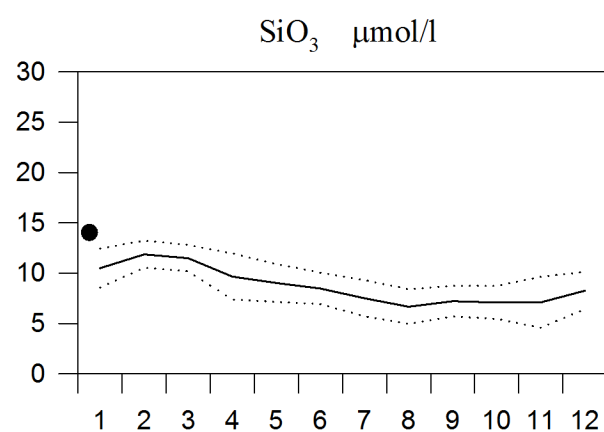
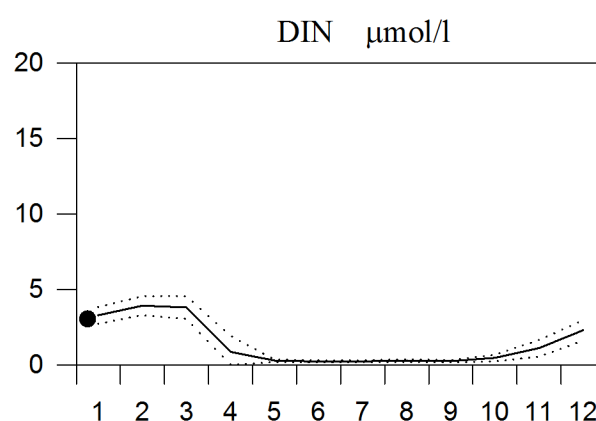
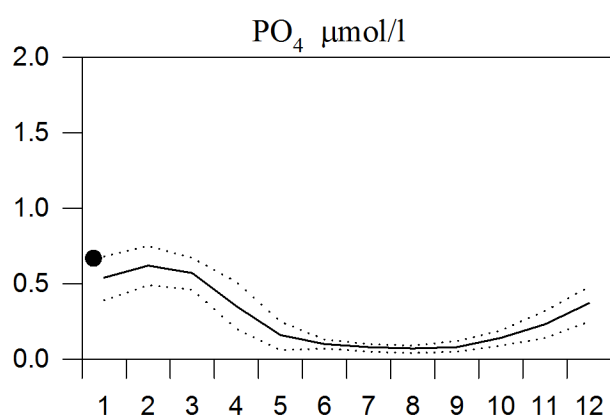
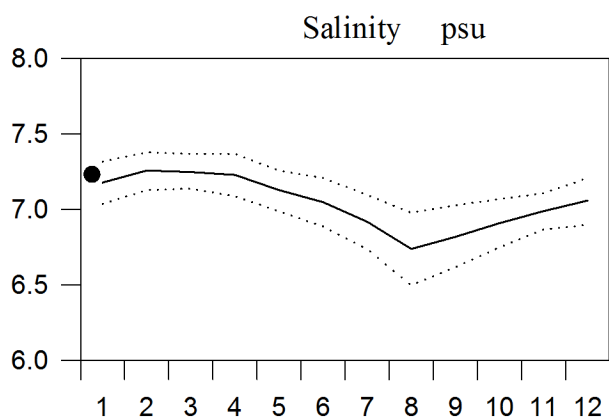
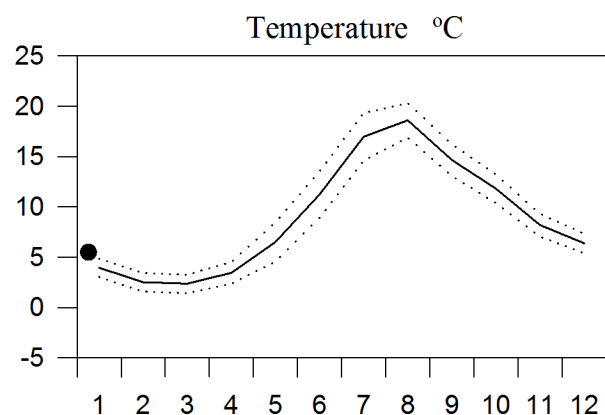
SiO₃ μmol/l



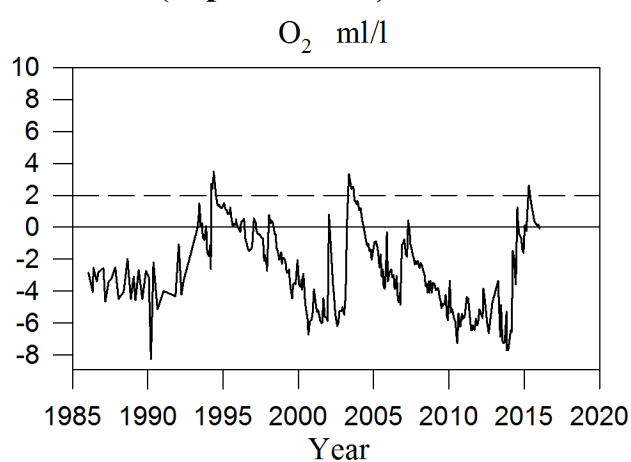
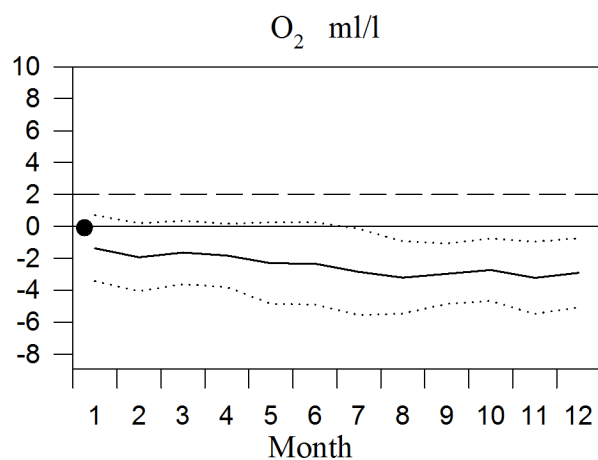
STATION BY15 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016



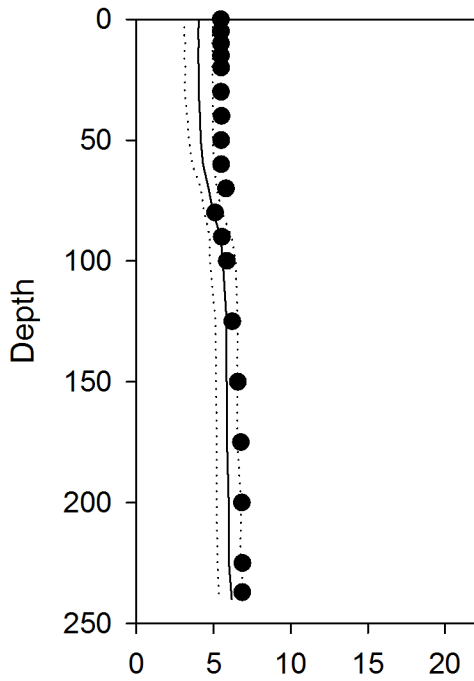
OXYGEN IN BOTTOM WATER (depth >225m)



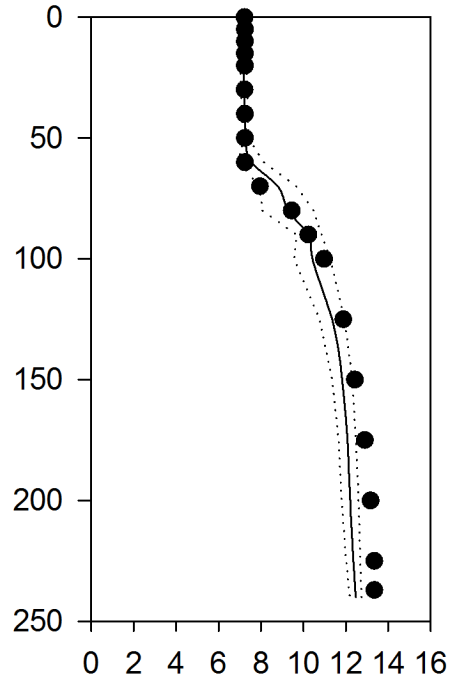
Vertical profiles BY15 January

— Mean 1996-2010 St.Dev. ● 2016

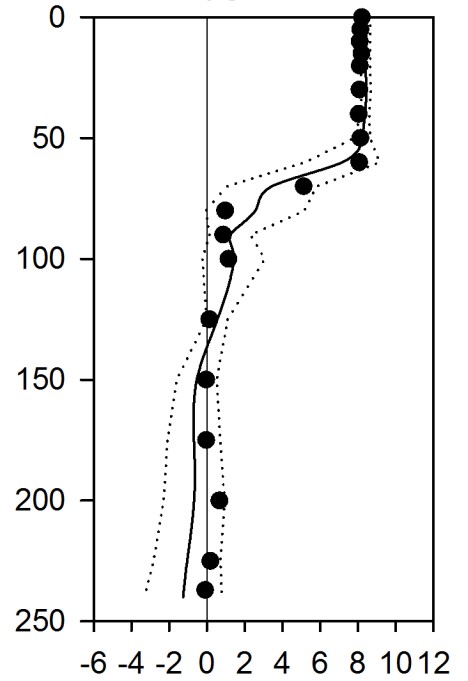
Temperature °C



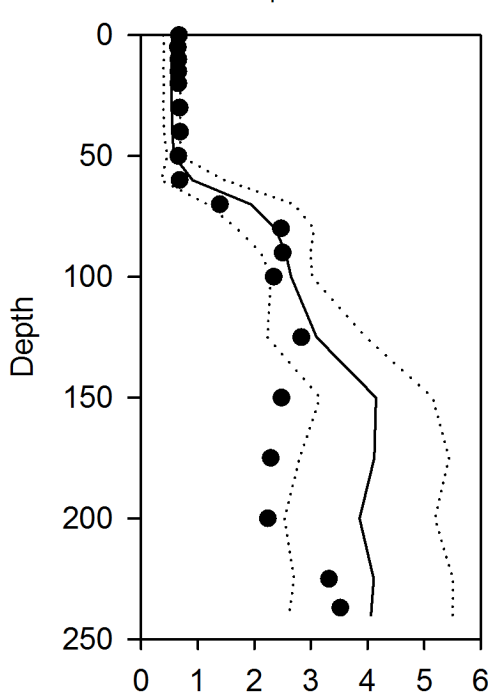
Salinity psu



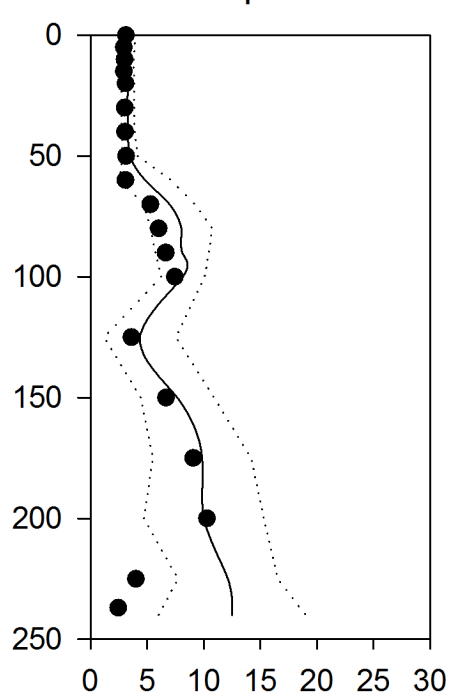
Oxygen ml/l



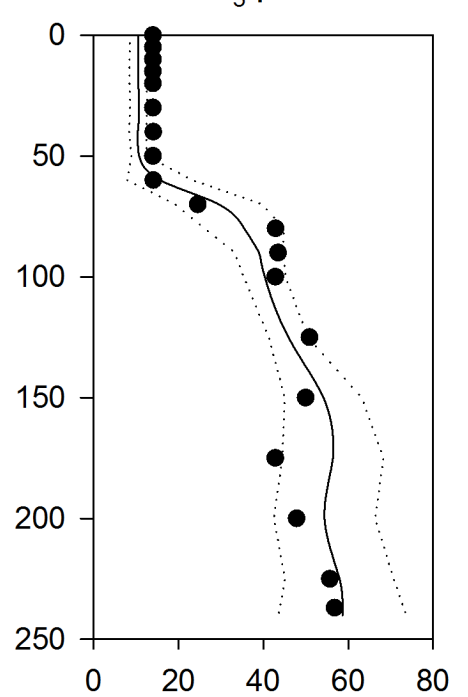
PO₄ μmol/l



DIN μmol/l



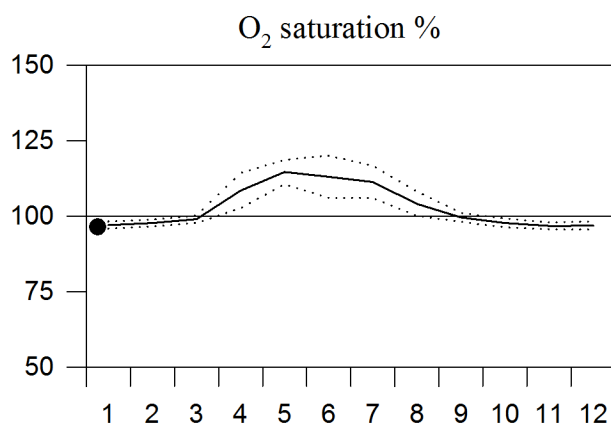
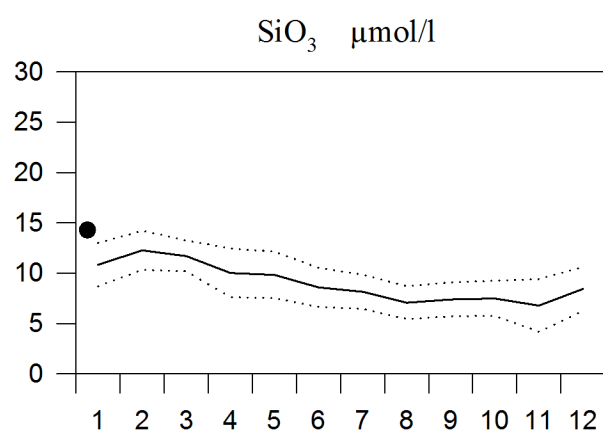
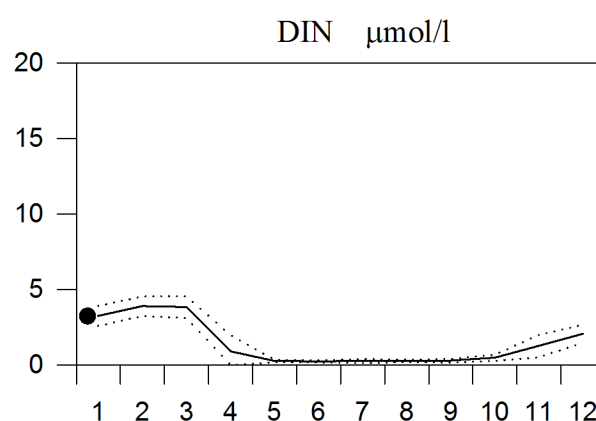
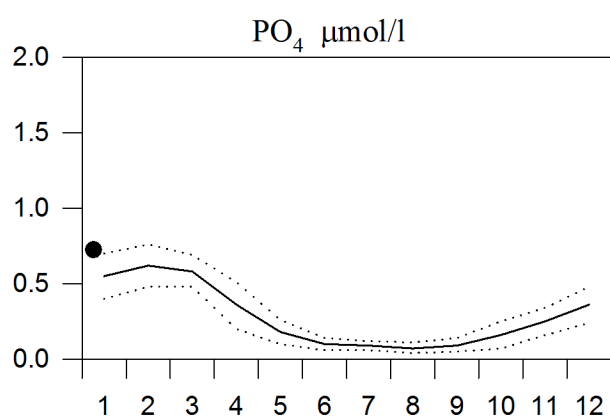
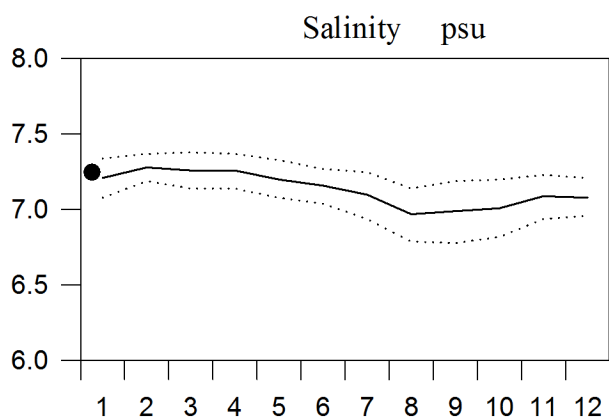
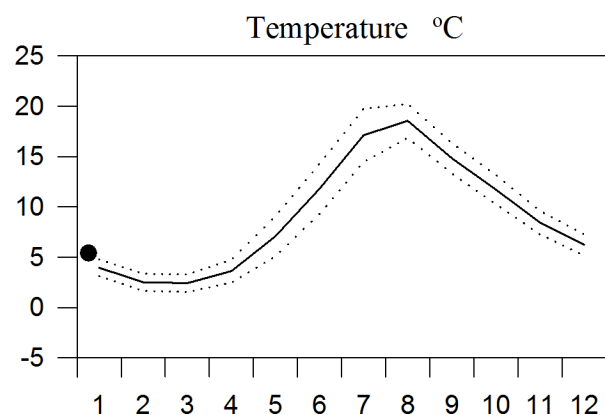
SiO₃ μmol/l



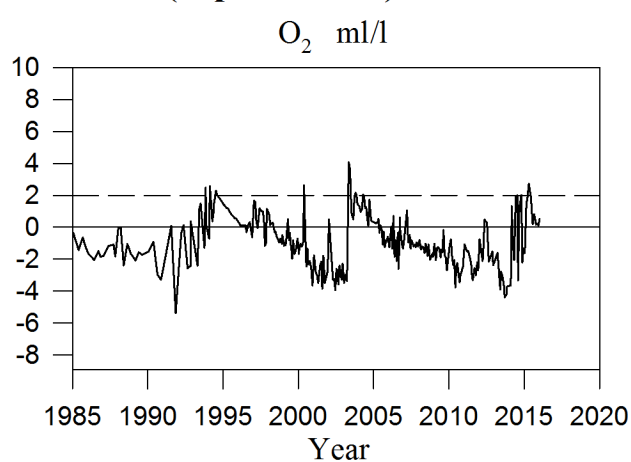
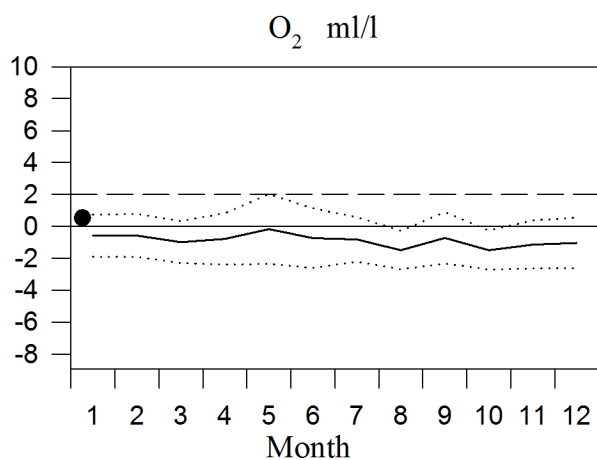
STATION BY10 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

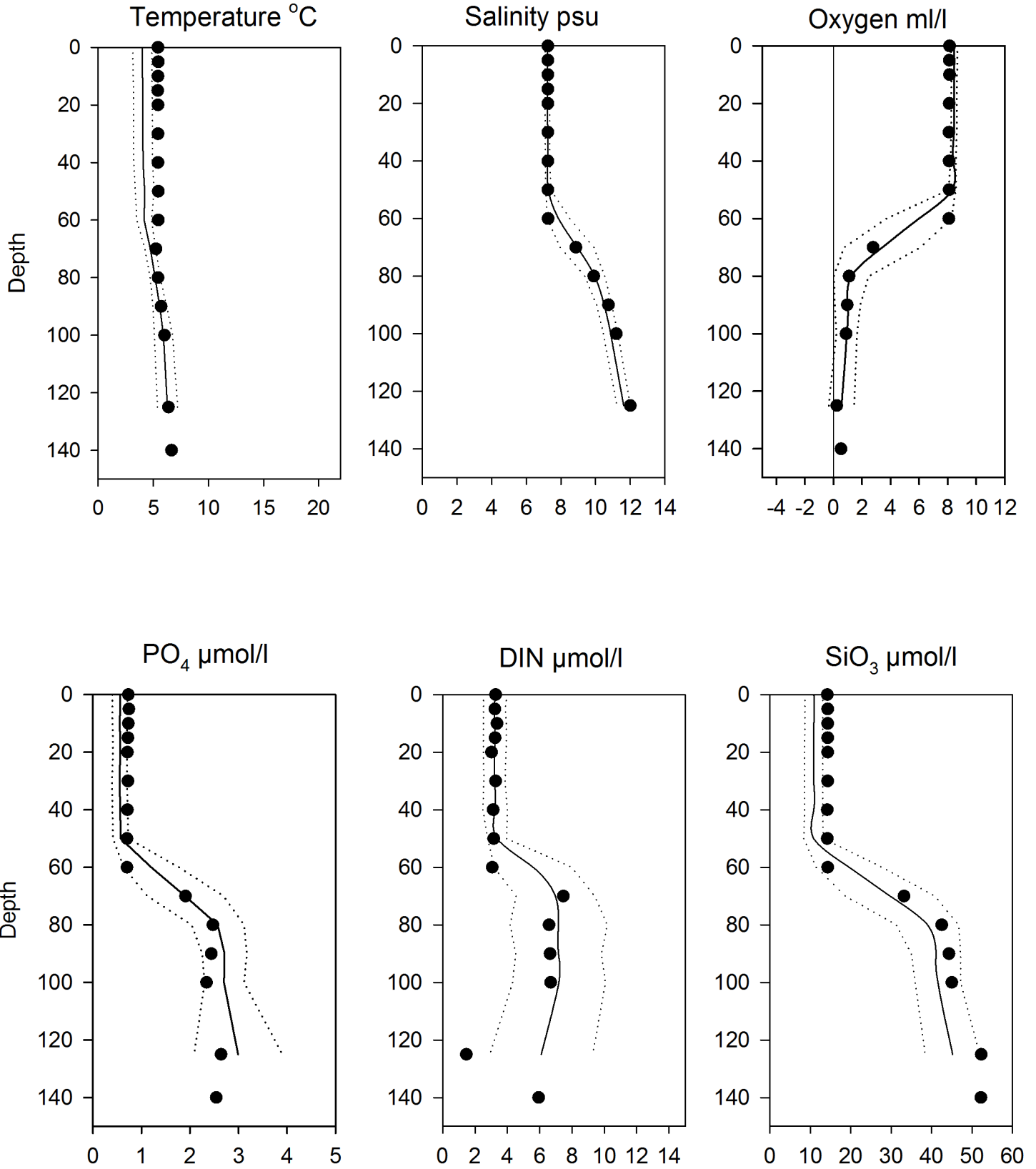


OXYGEN IN BOTTOM WATER (depth >125m)



Vertical profiles BY10 January

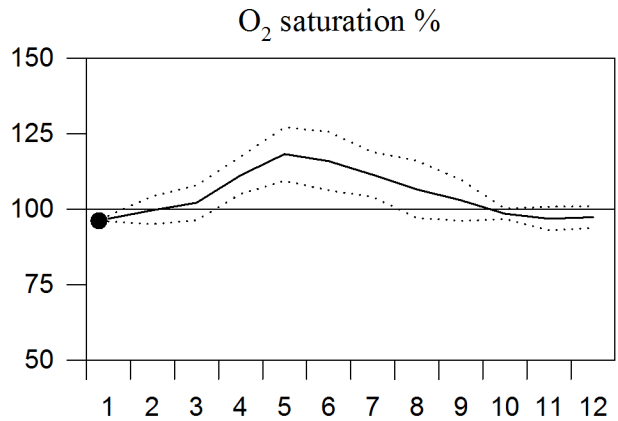
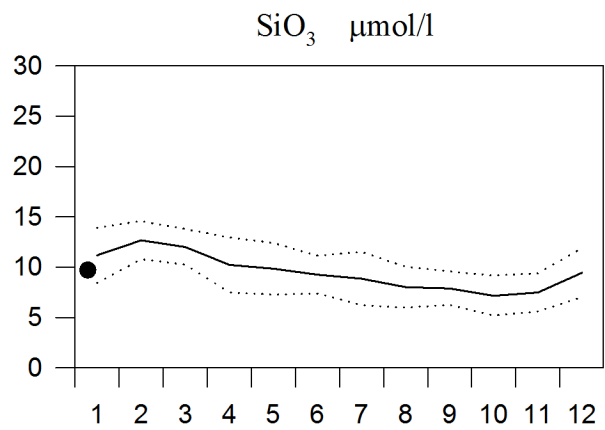
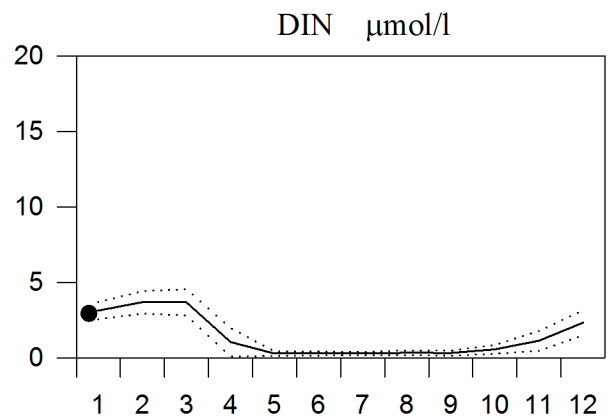
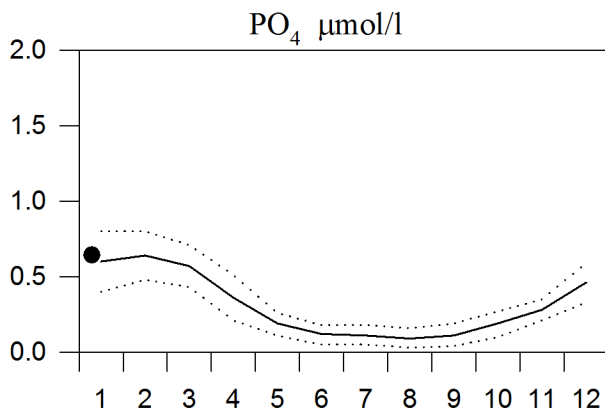
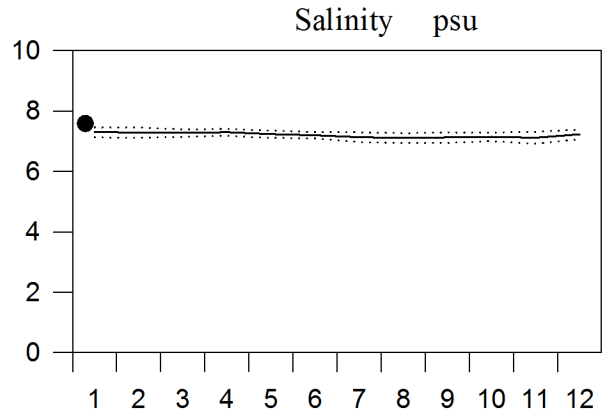
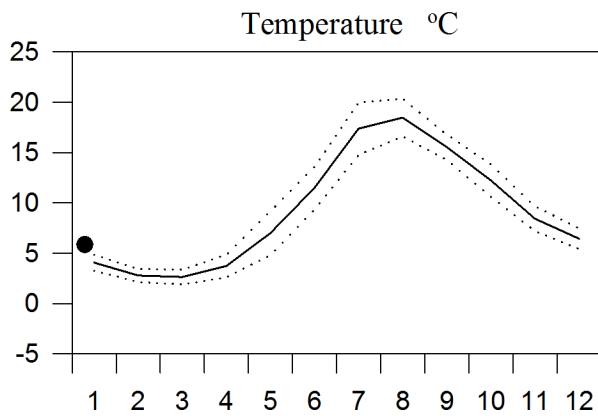
— Mean 1996-2010 St.Dev. ● 2016



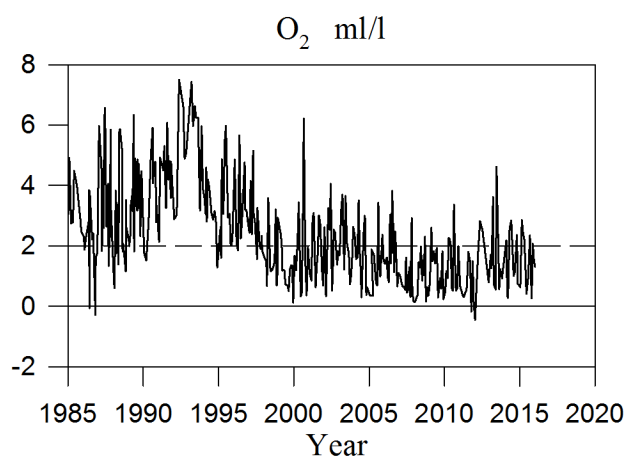
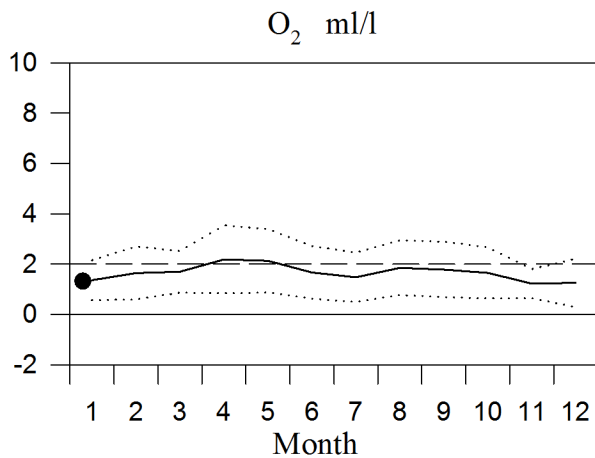
STATION BCS III-10 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

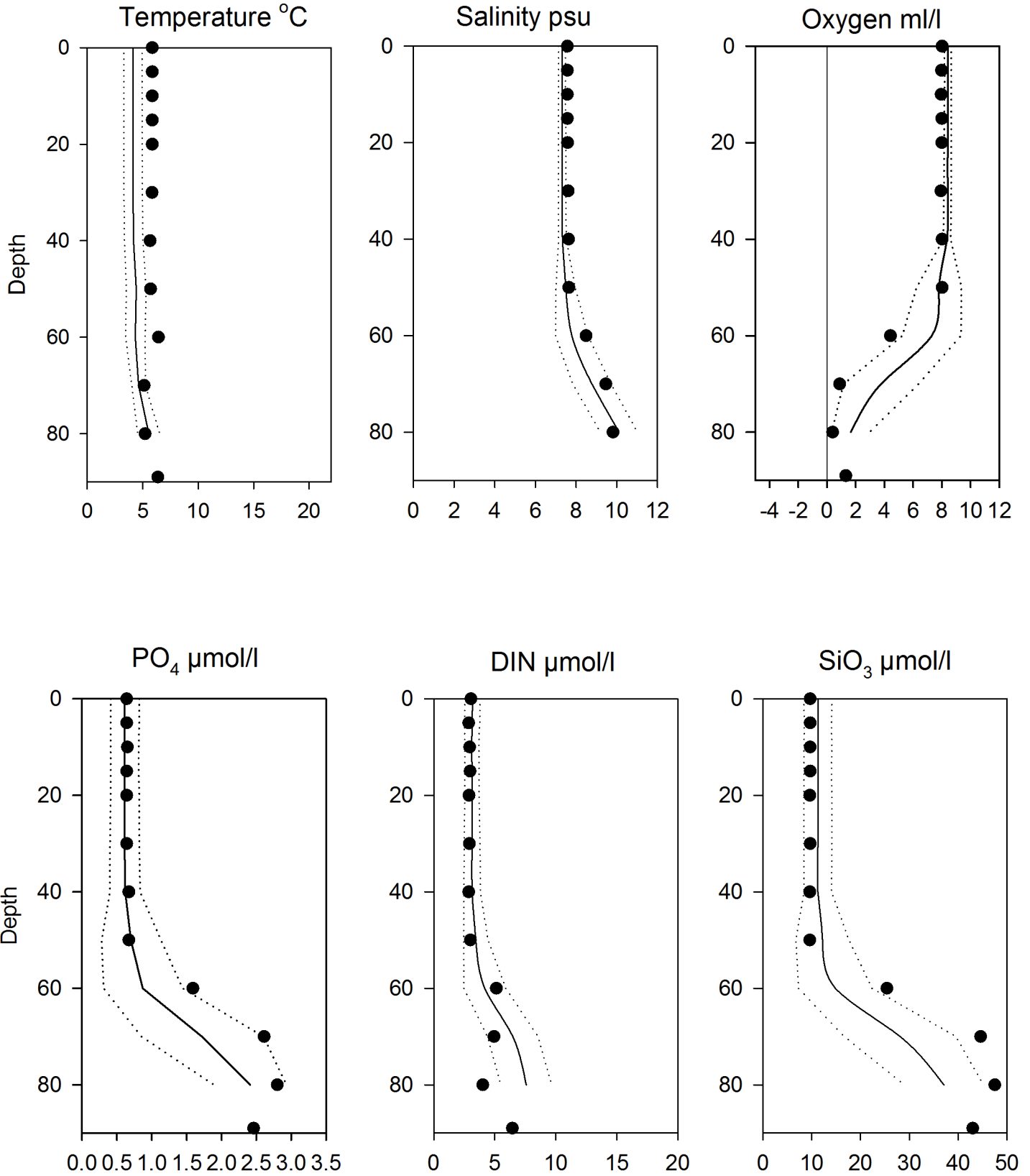


OXYGEN IN BOTTOM WATER (depth > 80m)



Vertical profiles BCS III-10 January

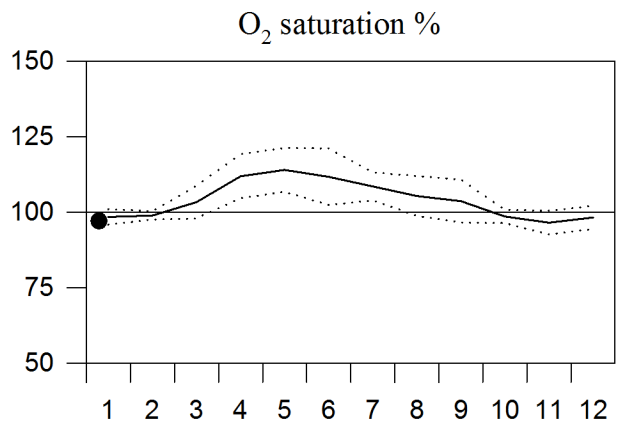
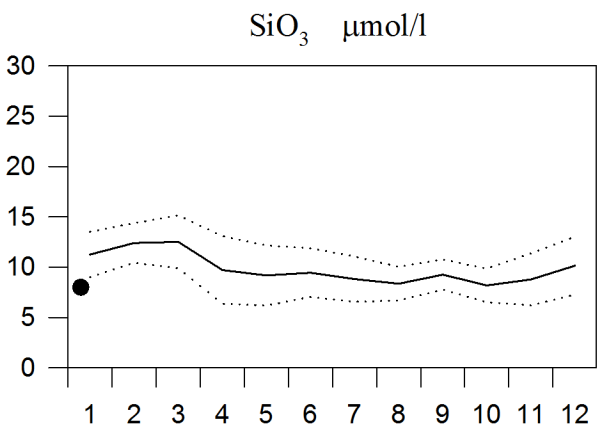
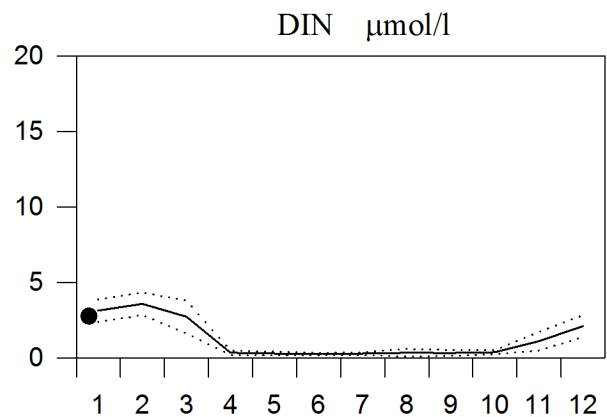
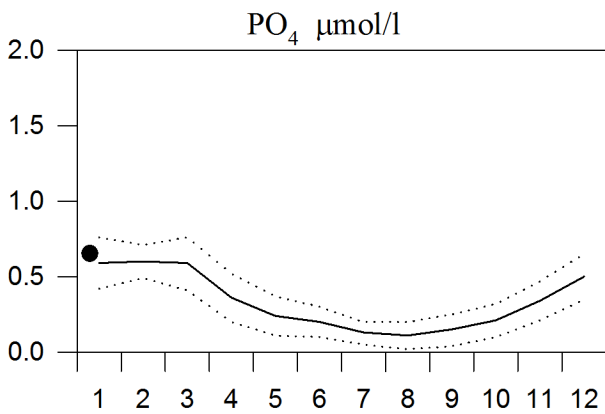
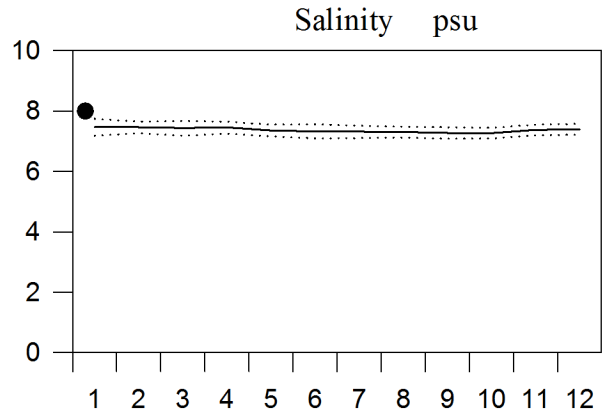
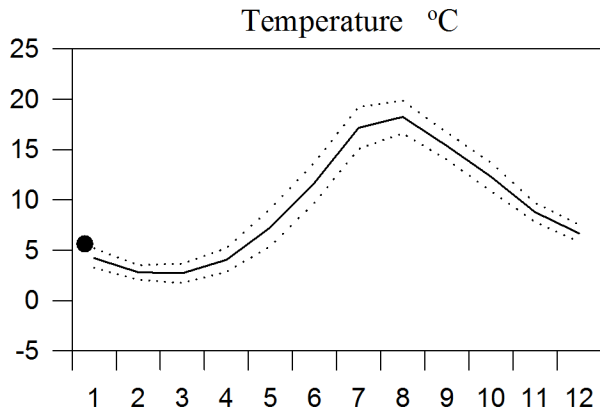
— Mean 1996-2010 St.Dev. ● 2016



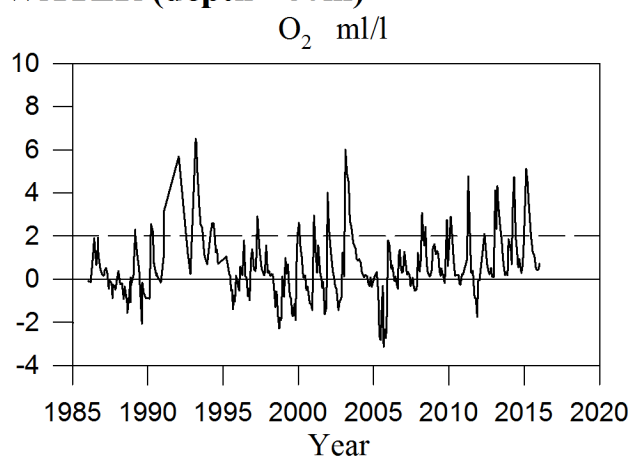
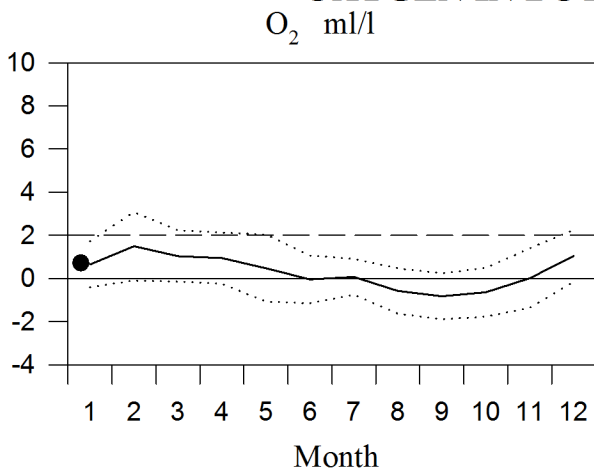
STATION BY5 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

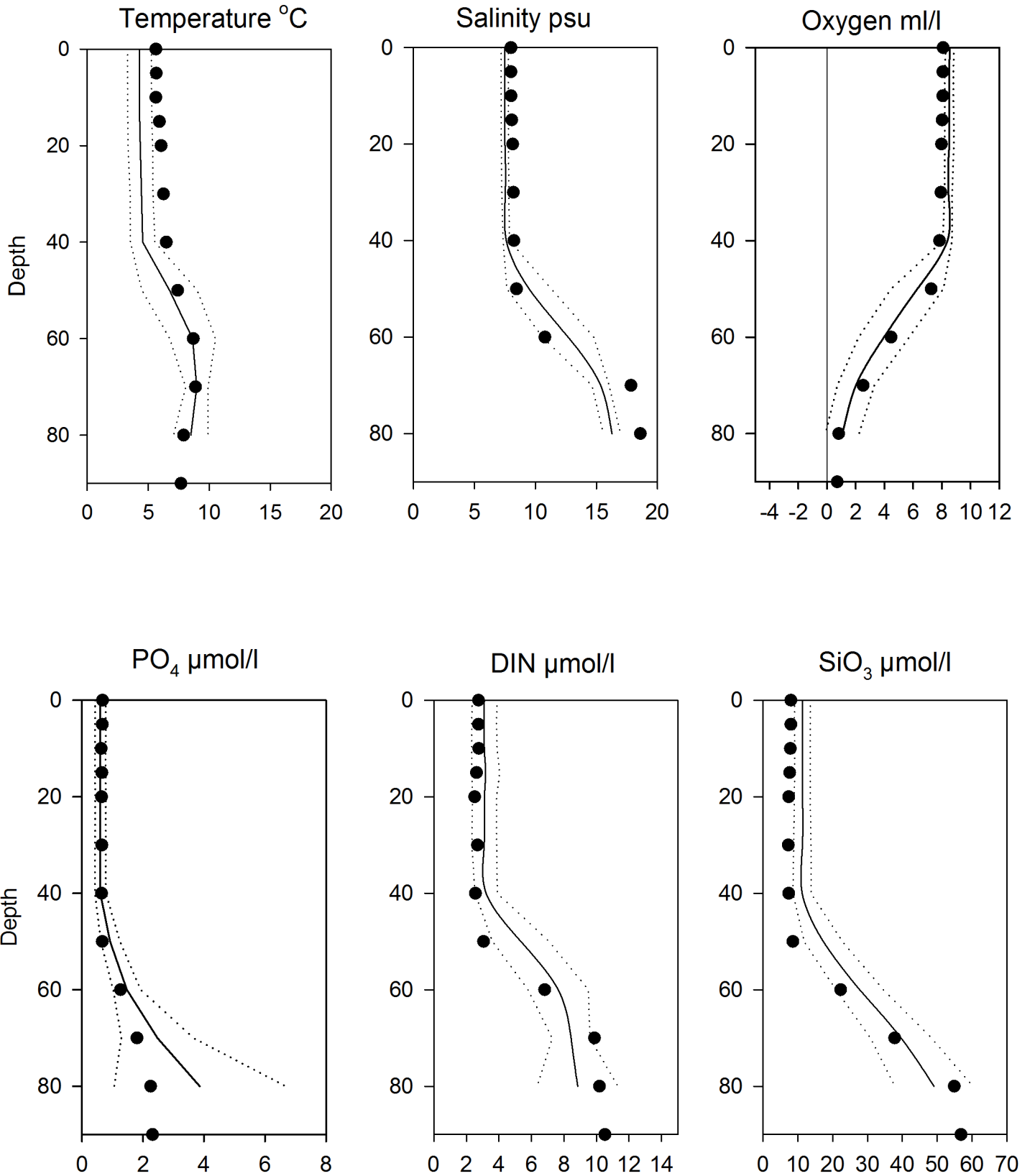


OXYGEN IN BOTTOM WATER (depth >80m)



Vertical profiles BY5 January

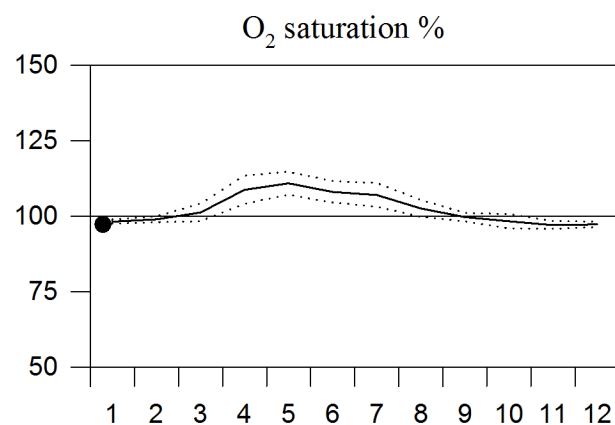
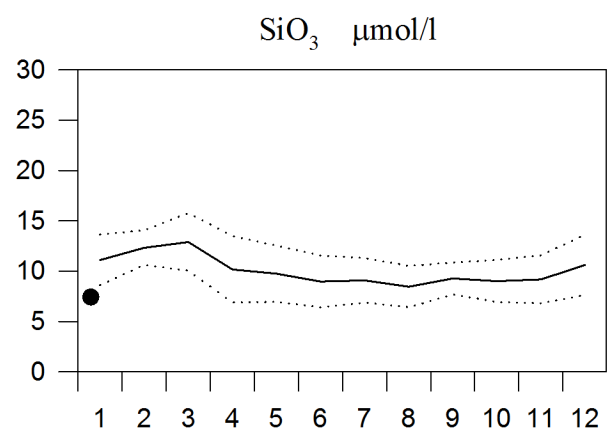
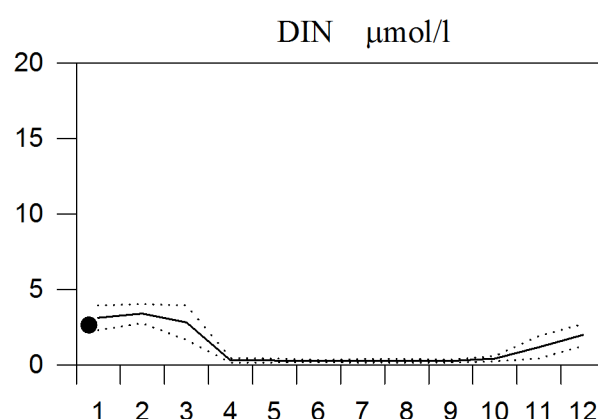
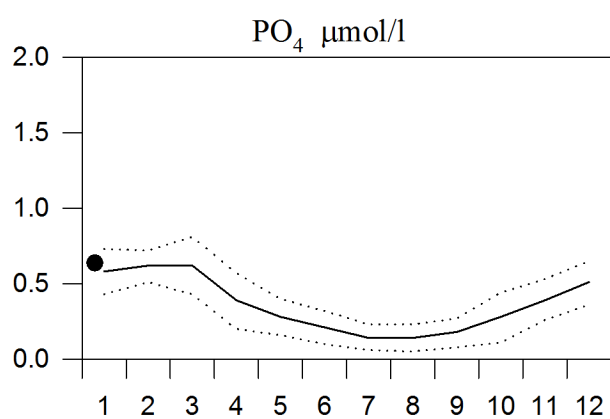
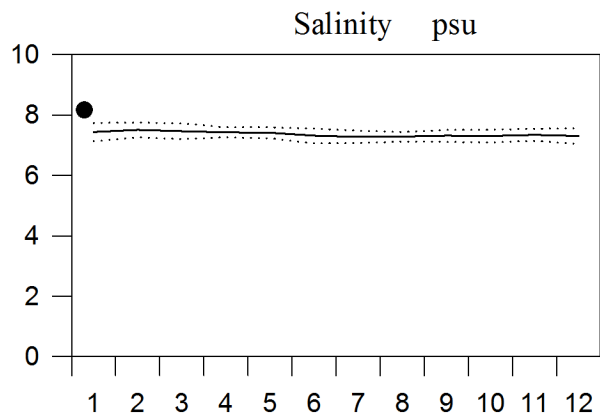
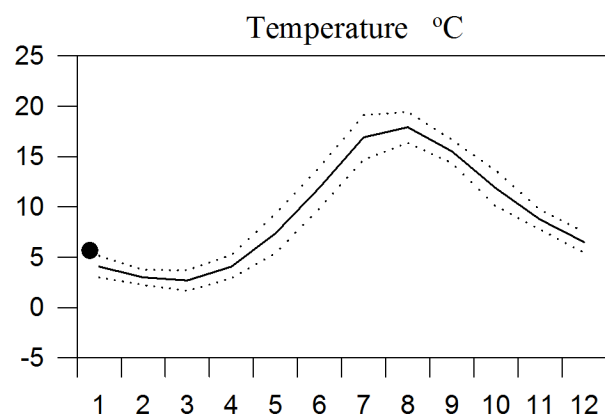
— Mean 1996-2010 St.Dev. ● 2016



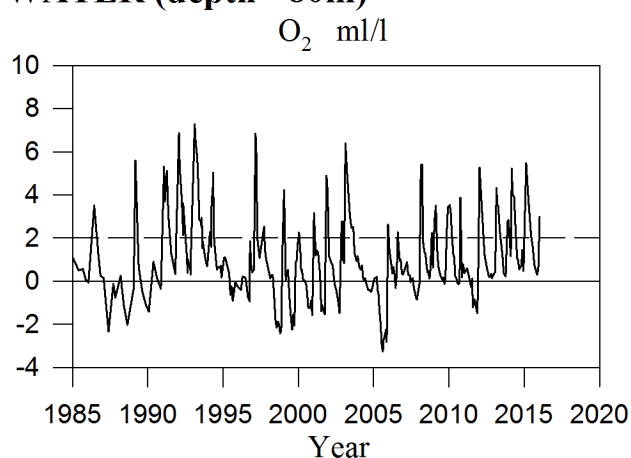
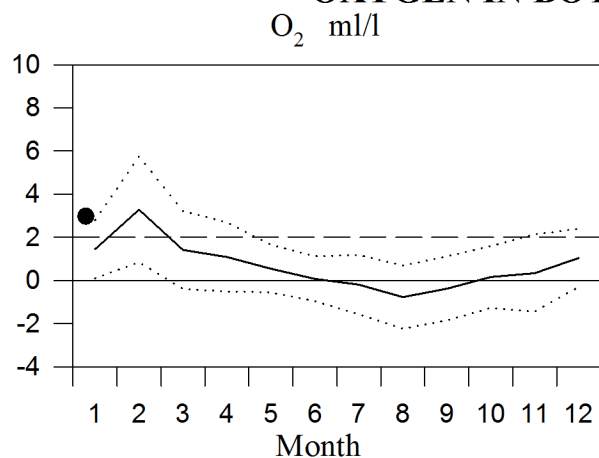
STATION BY4 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

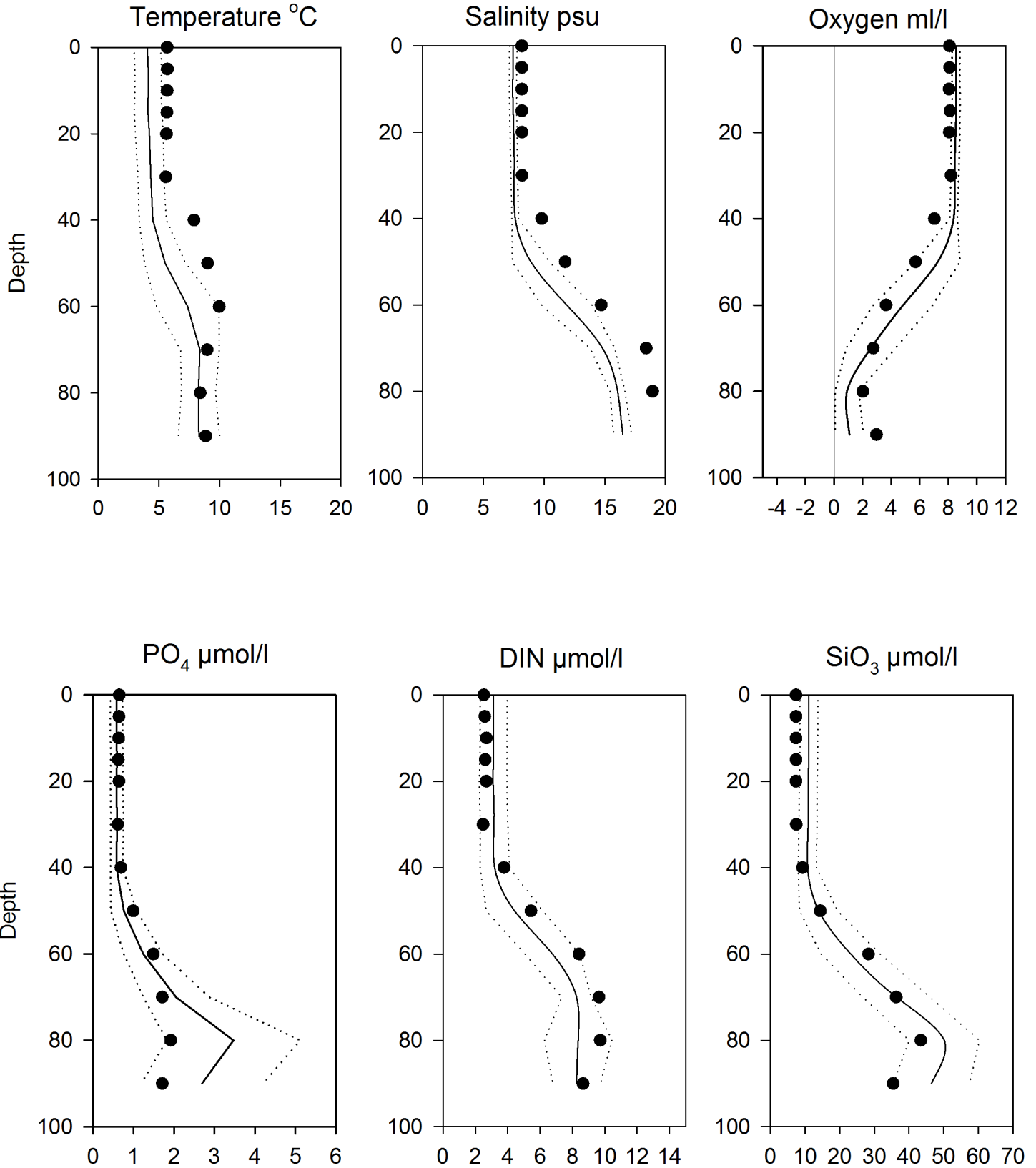


OXYGEN IN BOTTOM WATER (depth >80m)



Vertical profiles BY4 January

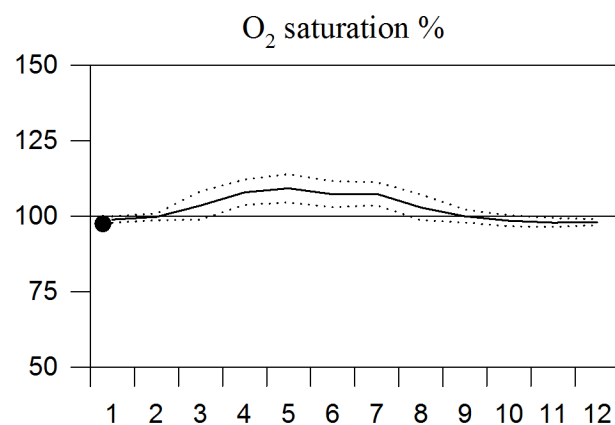
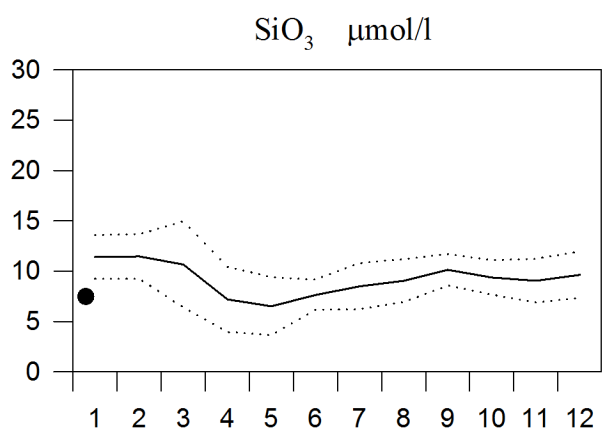
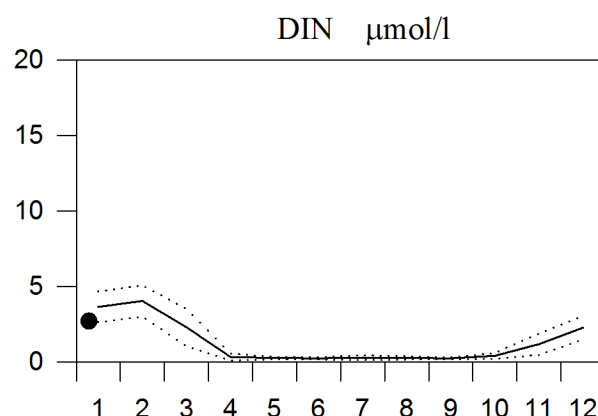
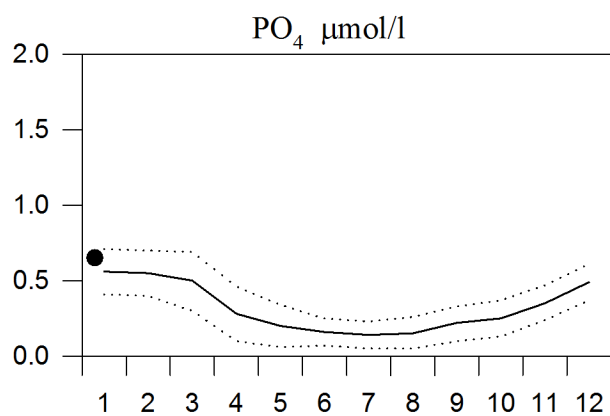
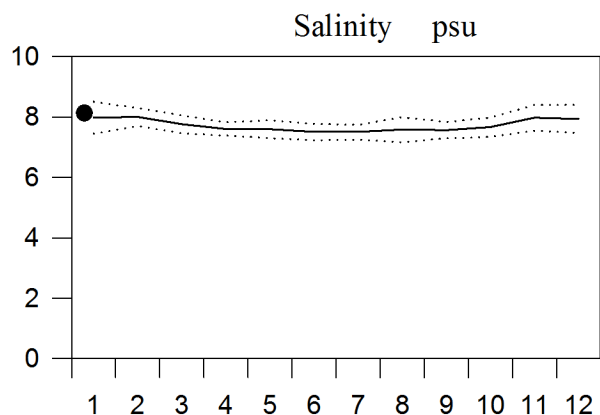
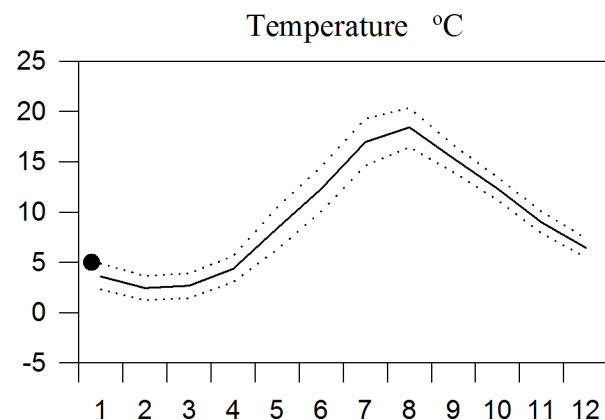
— Mean 1996-2010 St.Dev. ● 2016



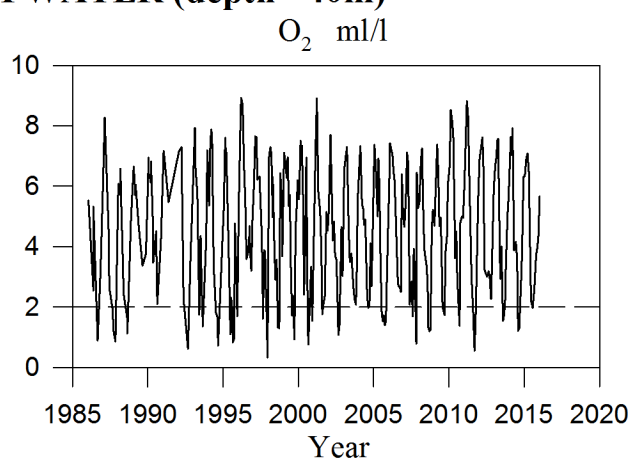
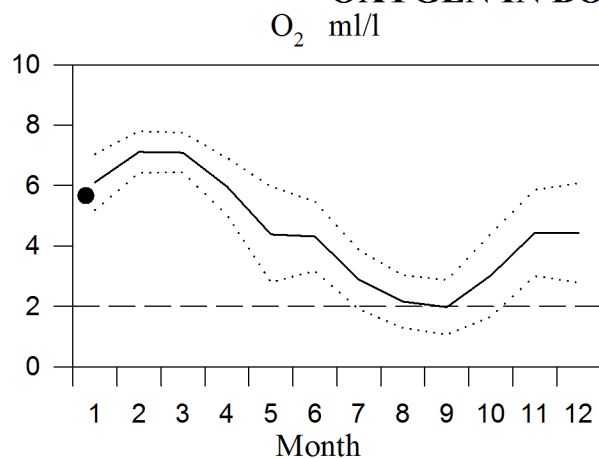
STATION BY2 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

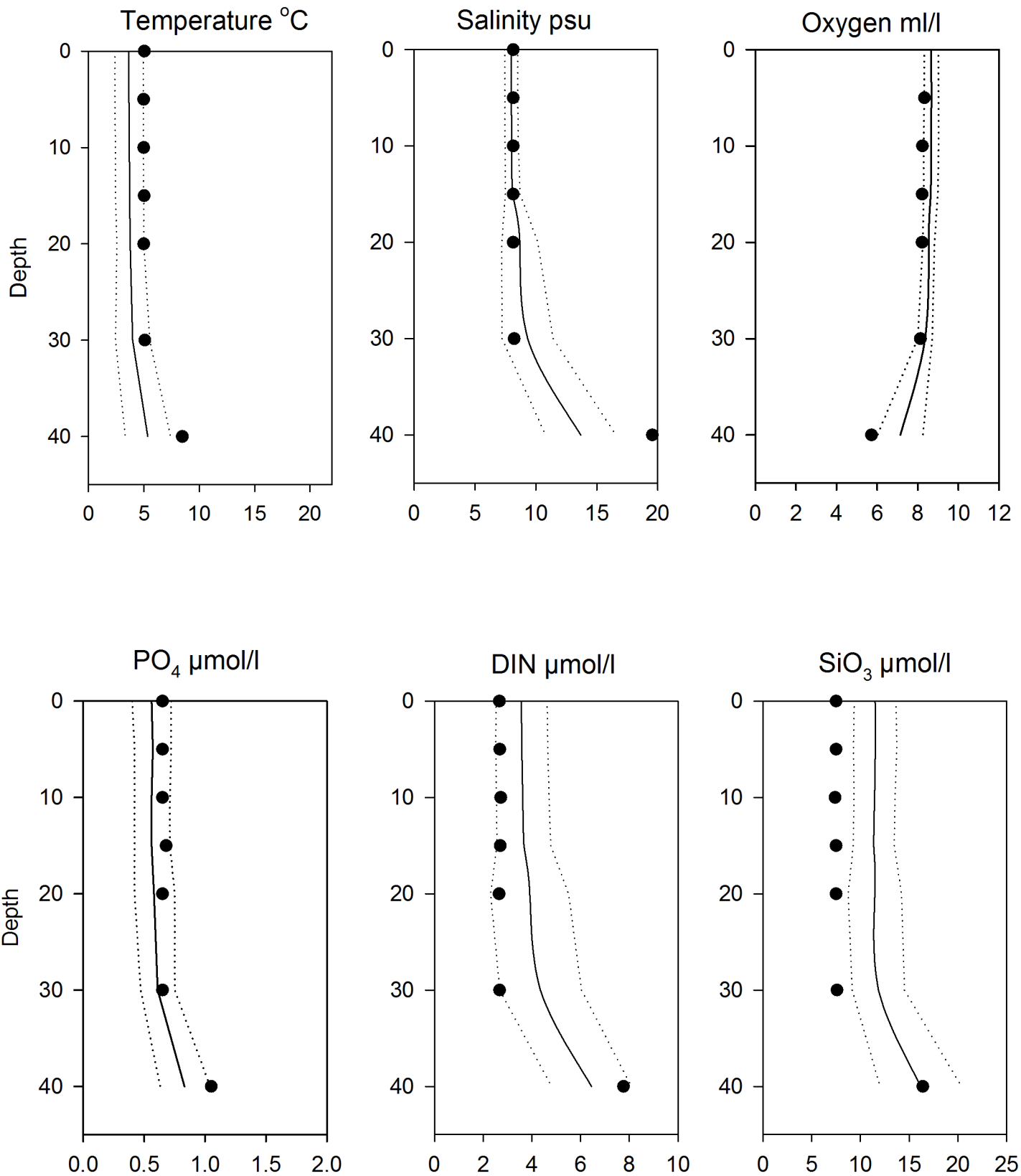


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles BY2 January

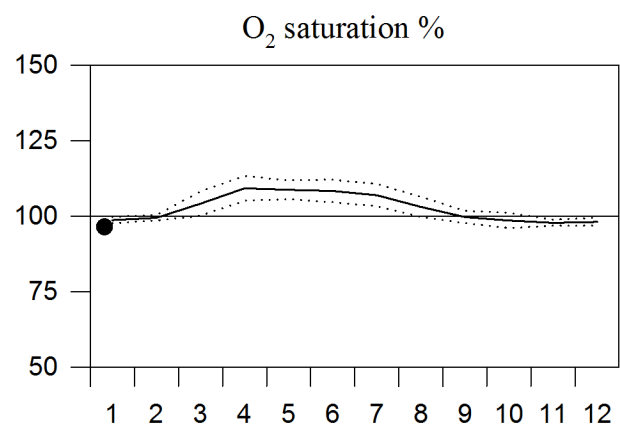
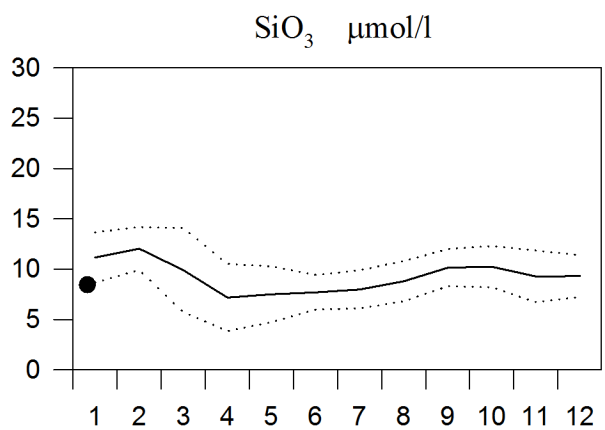
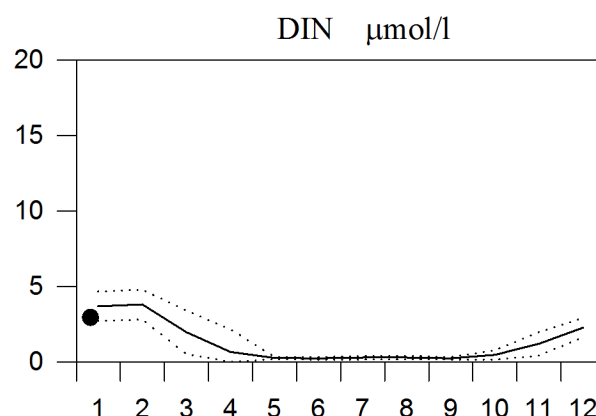
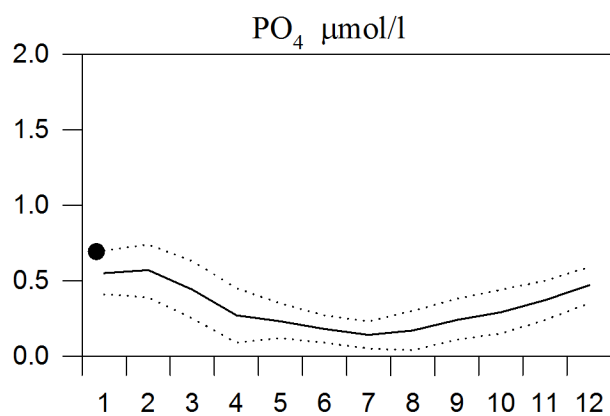
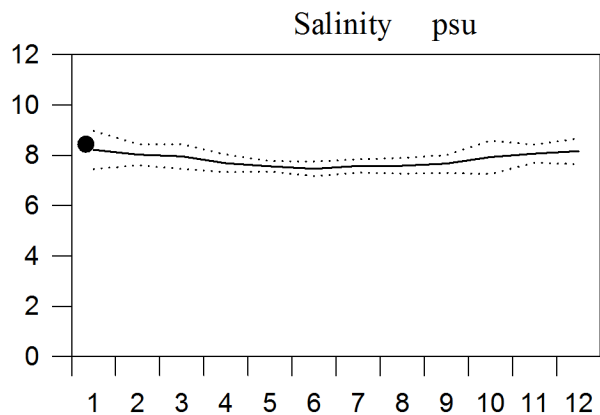
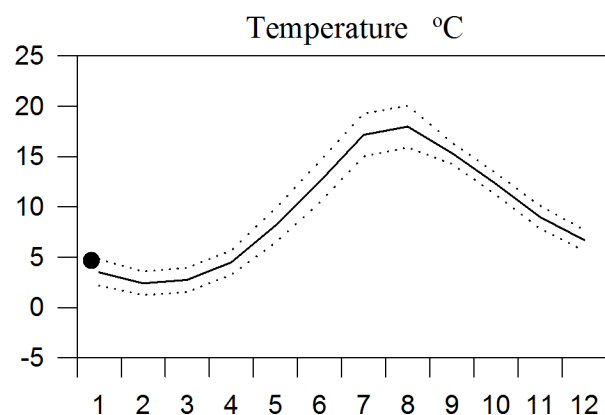
— Mean 1996-2010 St.Dev. ● 2016



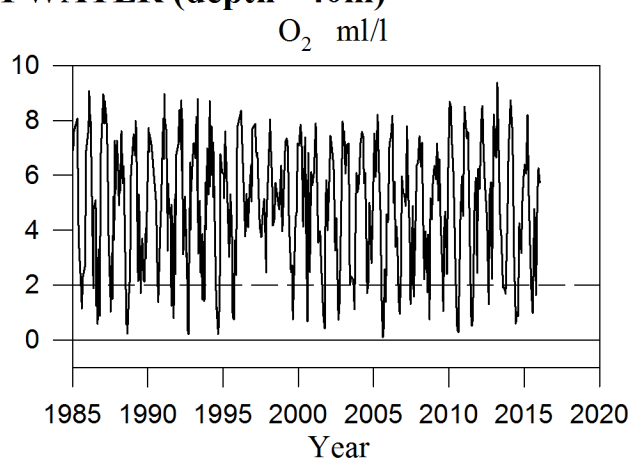
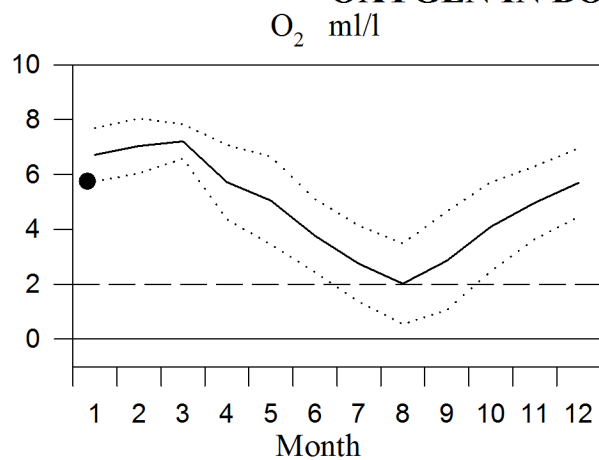
STATION BY1 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

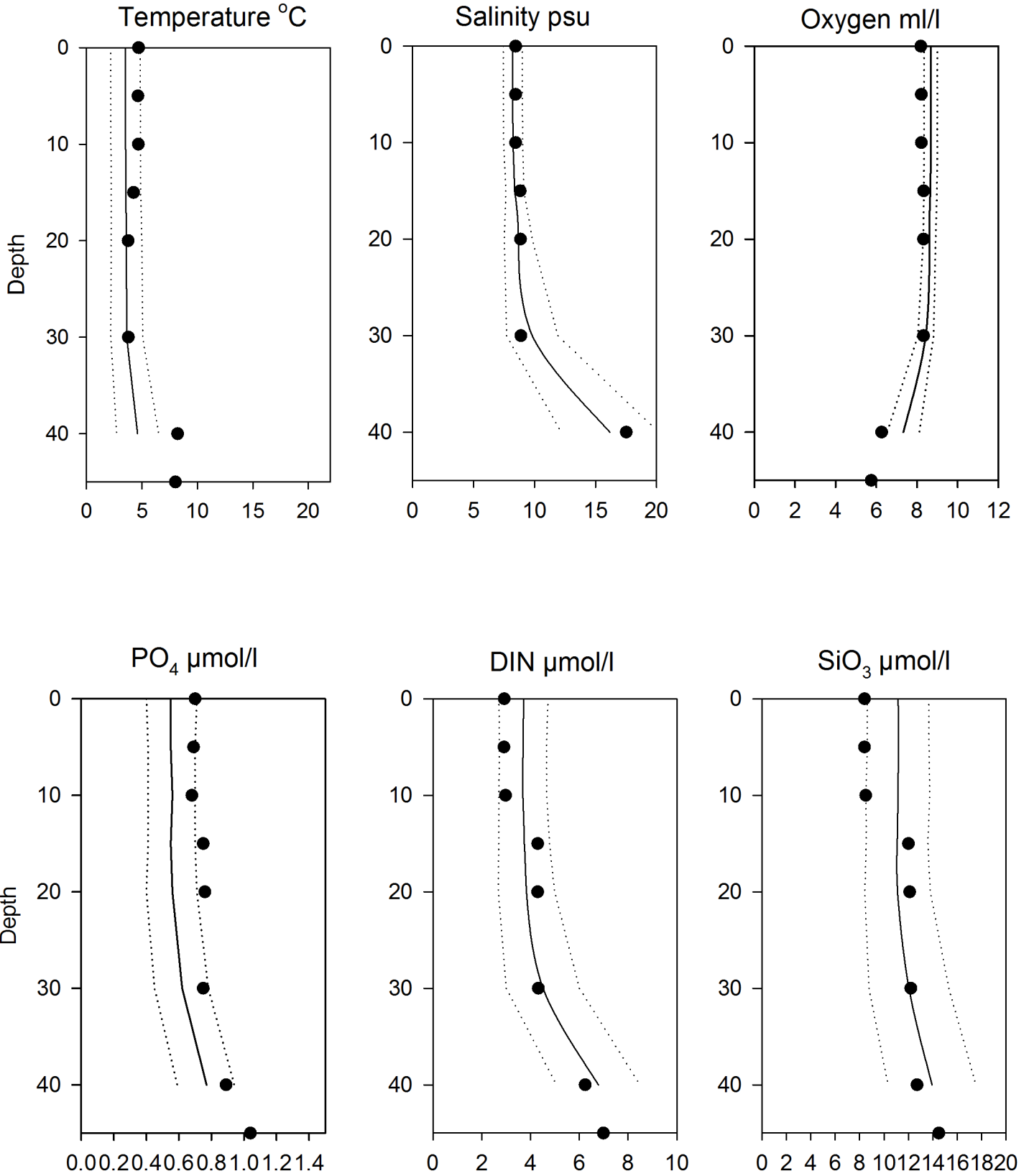


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles BY1 January

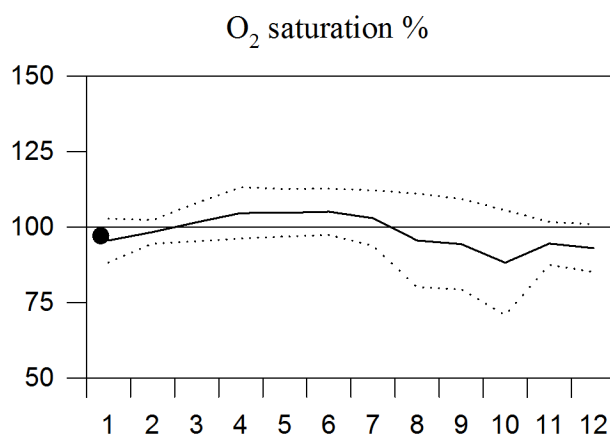
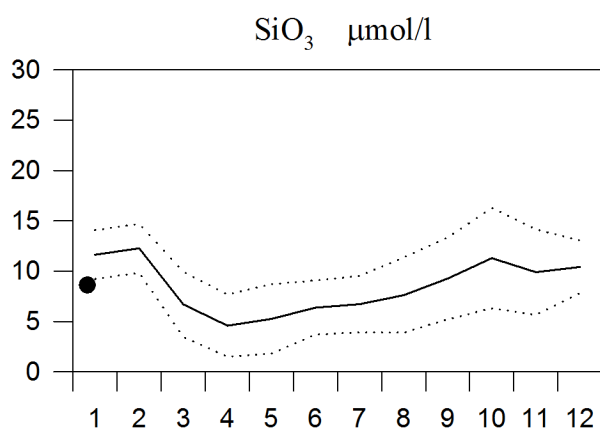
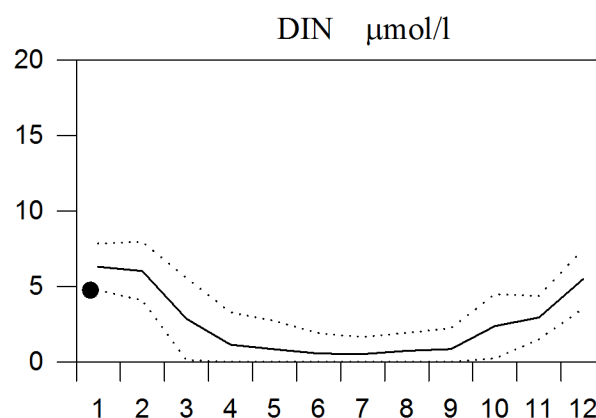
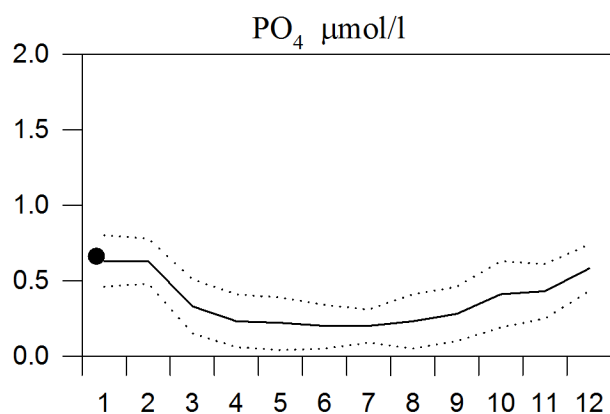
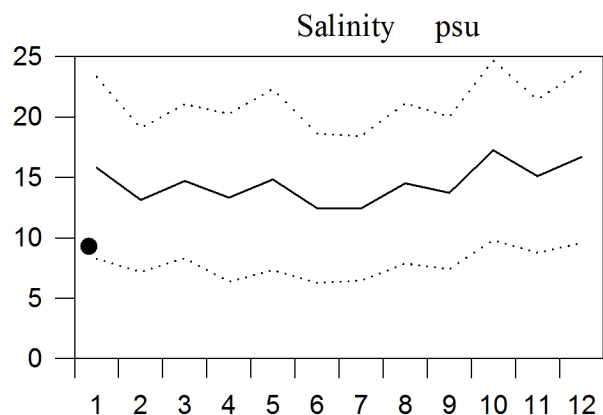
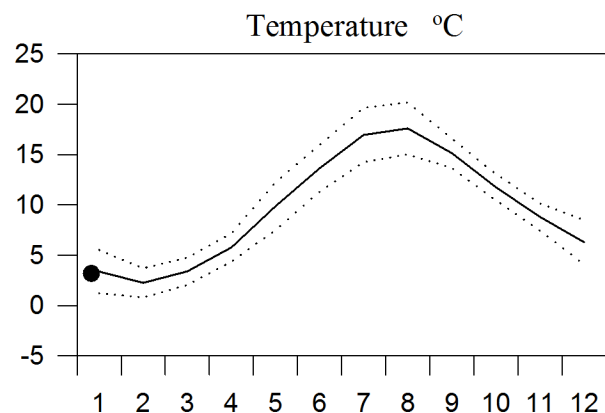
— Mean 1996-2010 St.Dev. ● 2016



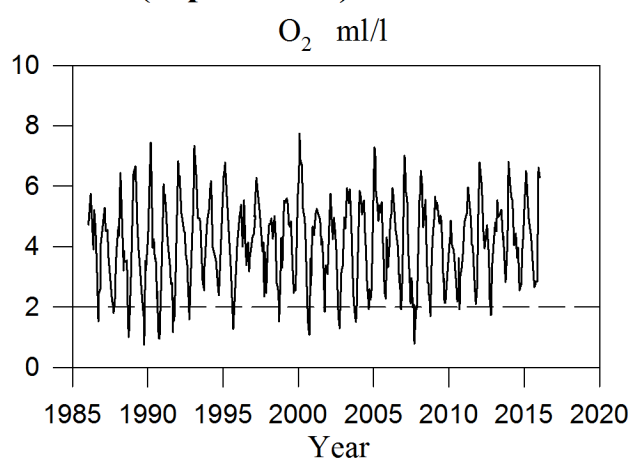
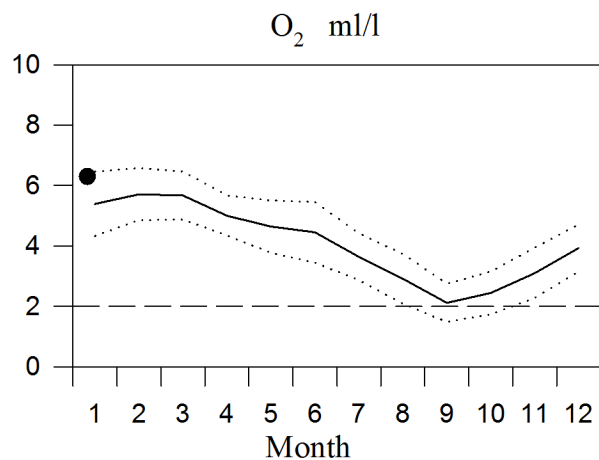
STATION W LANDSKRONA SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

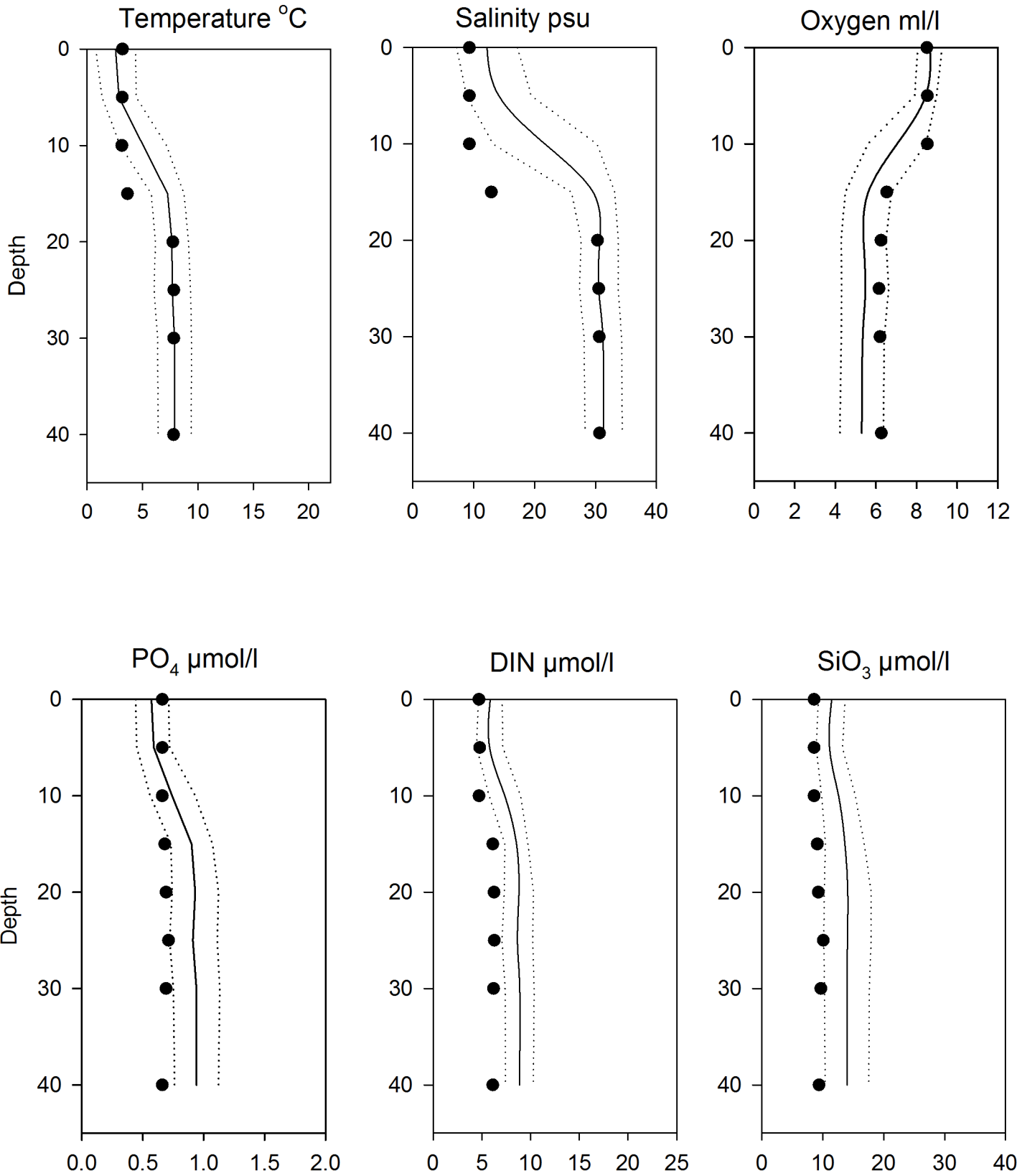


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles W Landskrona January

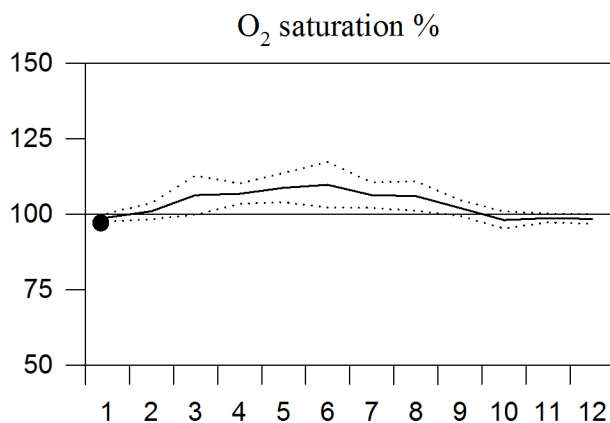
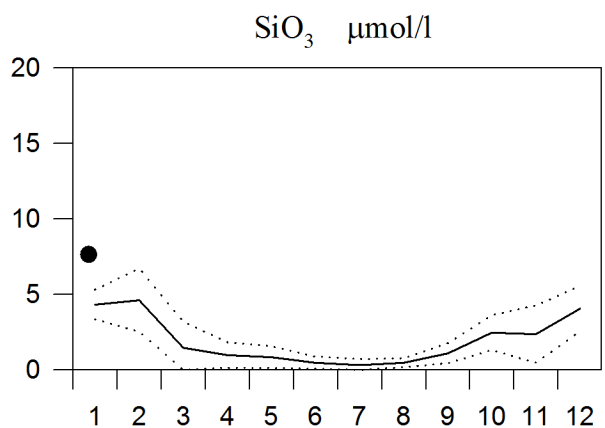
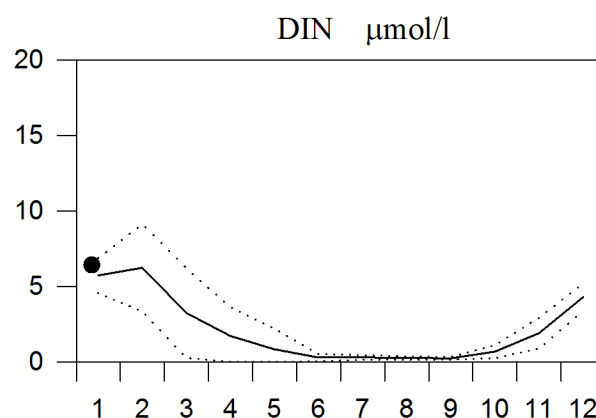
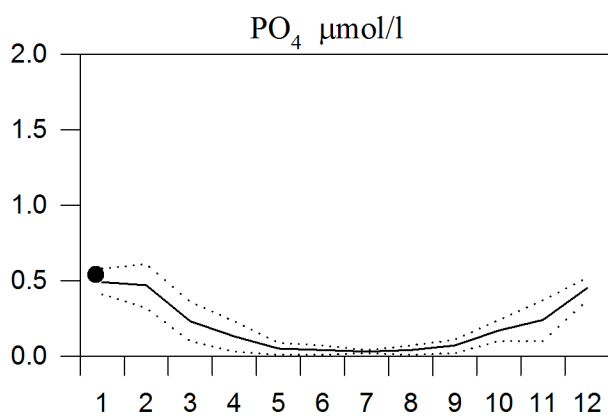
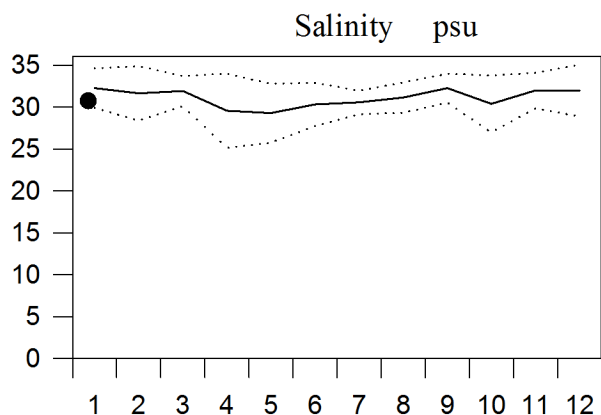
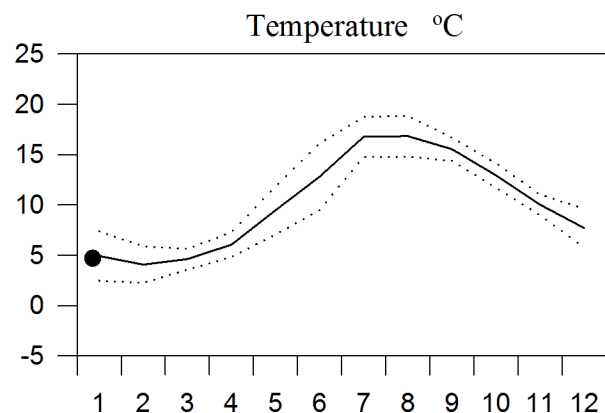
— Mean 1996-2010 St.Dev. ● 2016



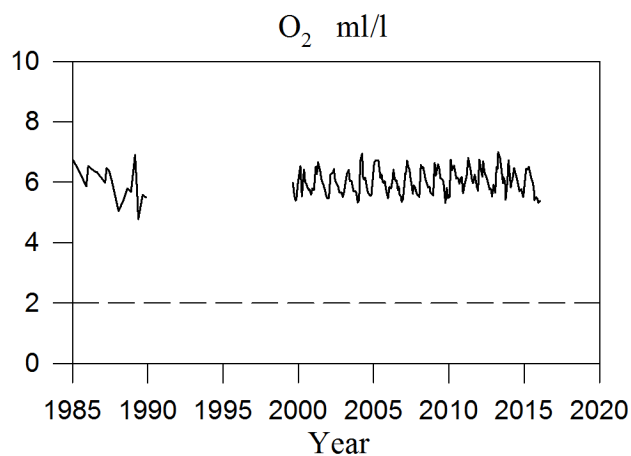
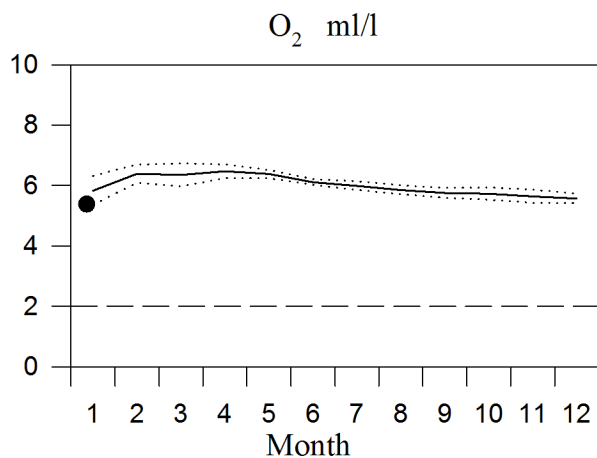
STATION Å17 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

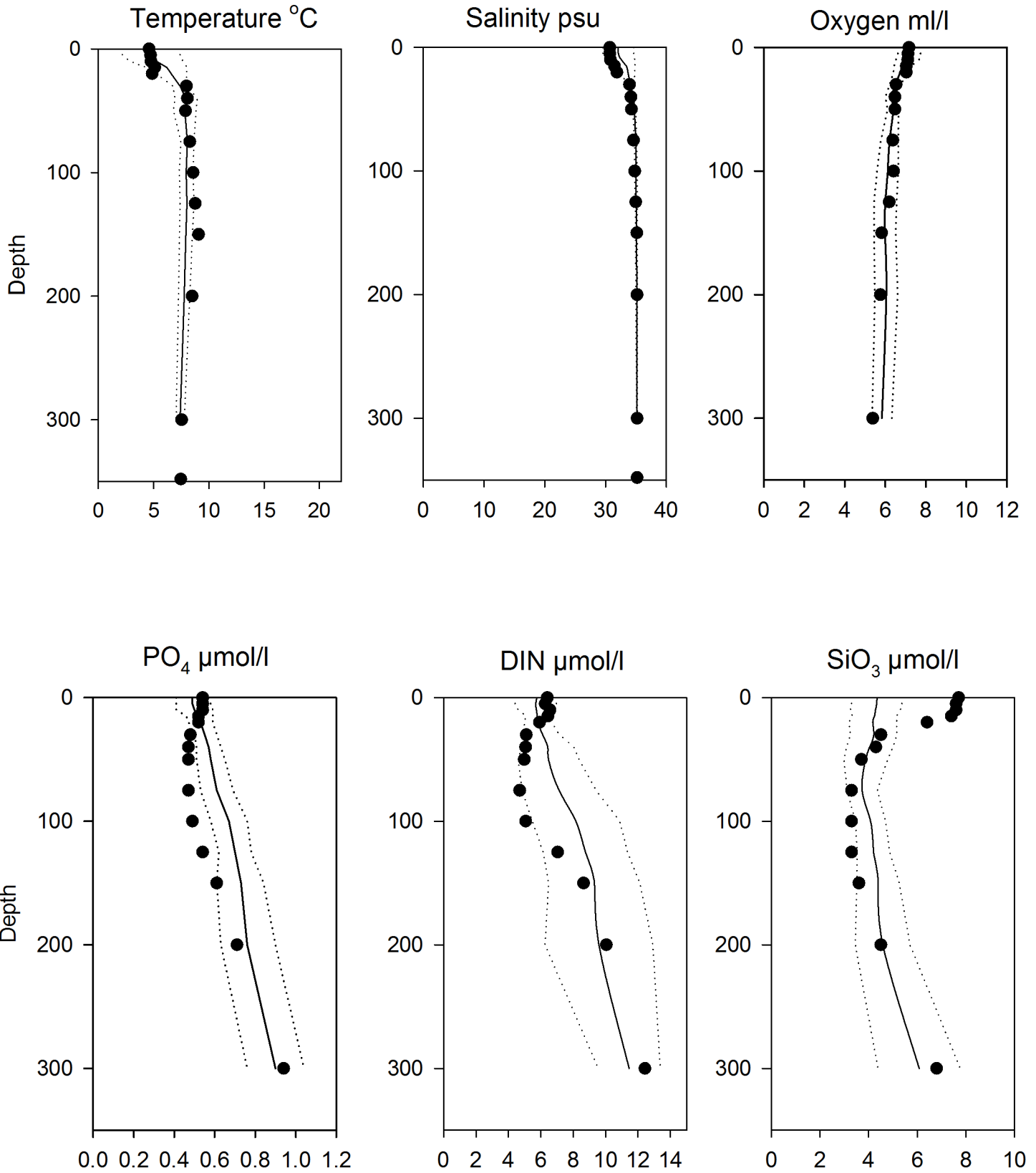


OXYGEN IN BOTTOM WATER (depth = 300m)



Vertical profiles Å17 January

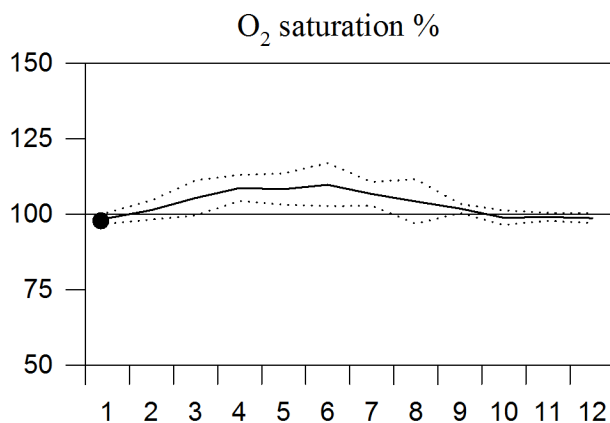
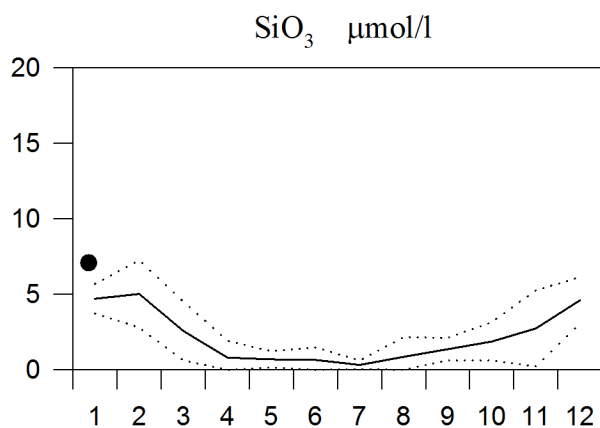
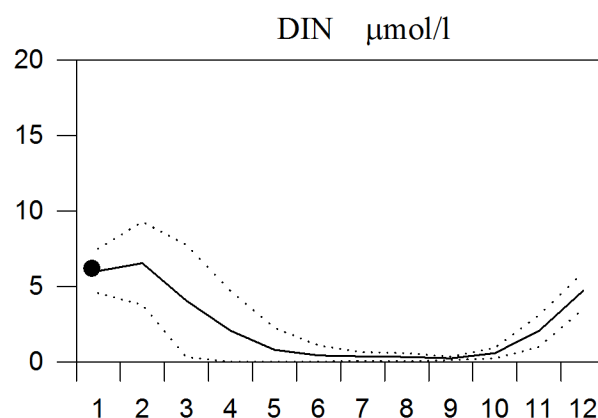
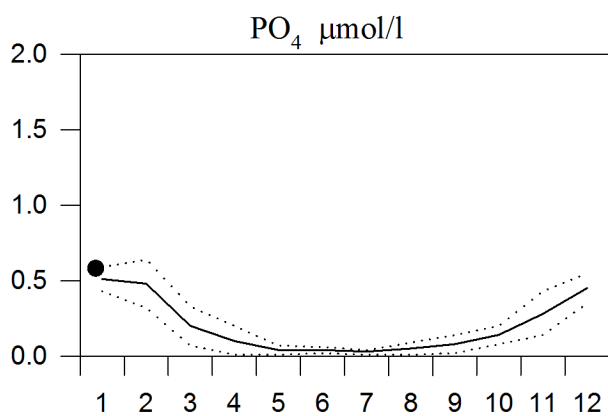
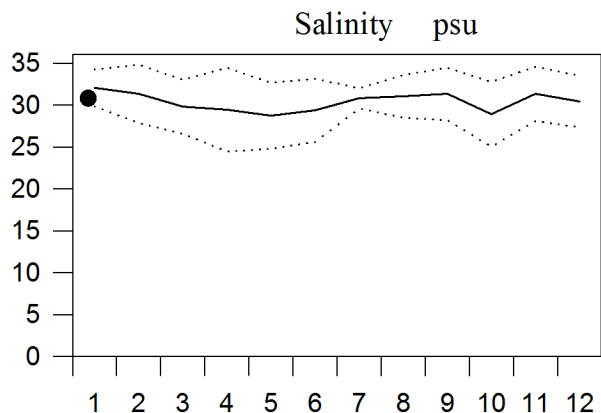
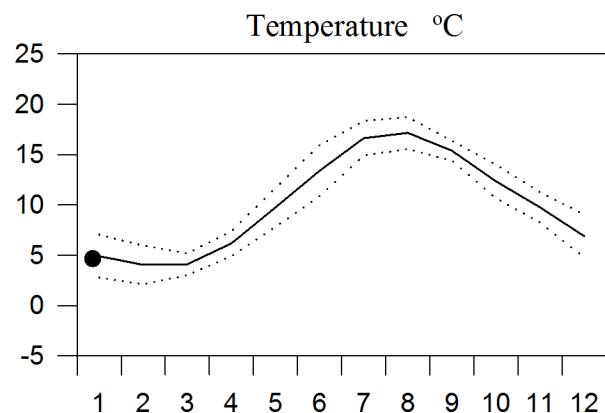
— Mean 1996-2010 St.Dev. ● 2016



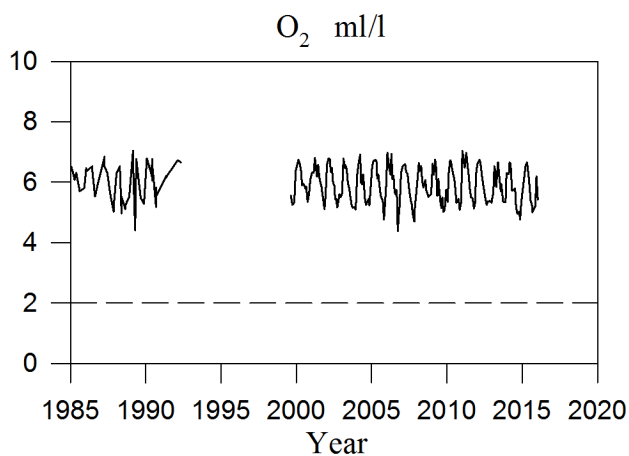
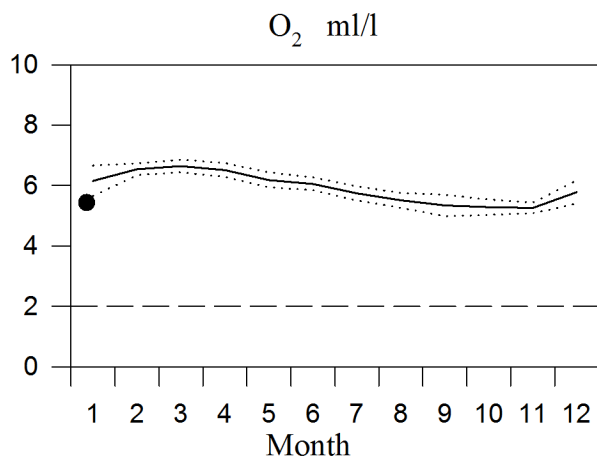
STATION Å15 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

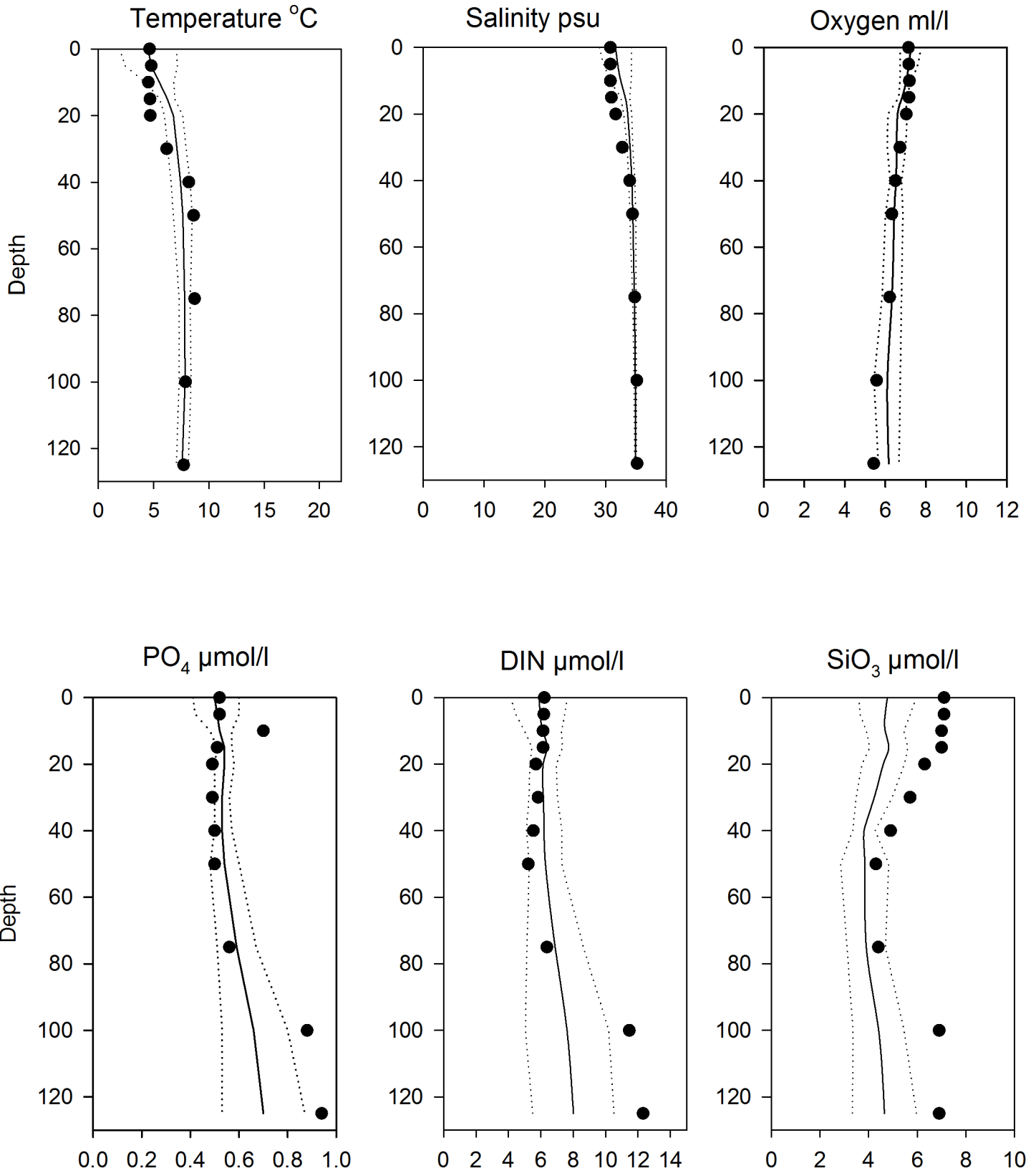


OXYGEN IN BOTTOM WATER (depth >=125m)



Vertical profiles Å15 January

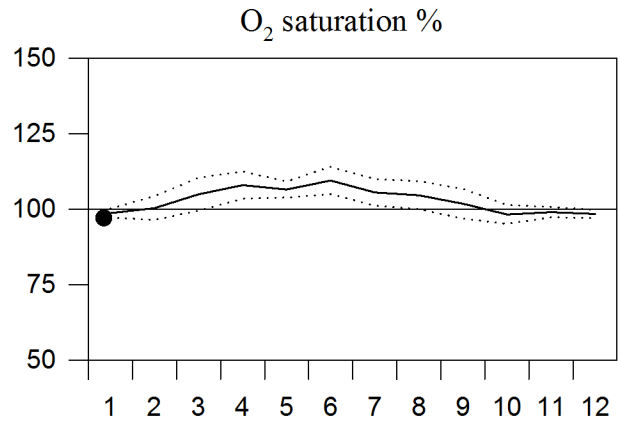
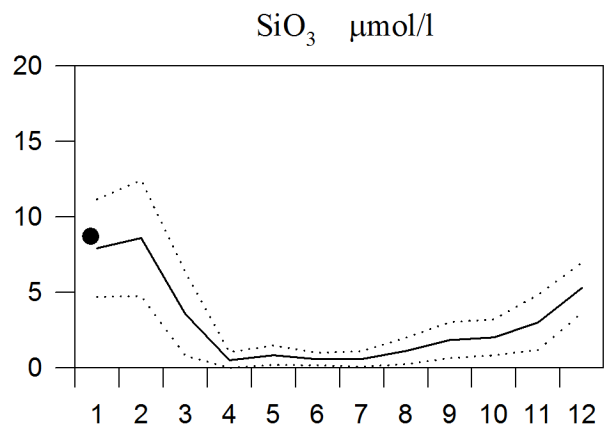
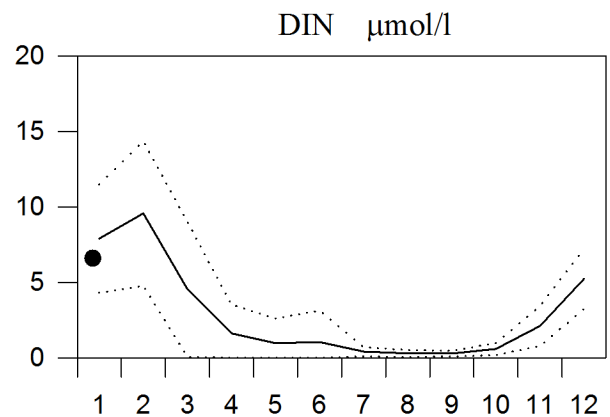
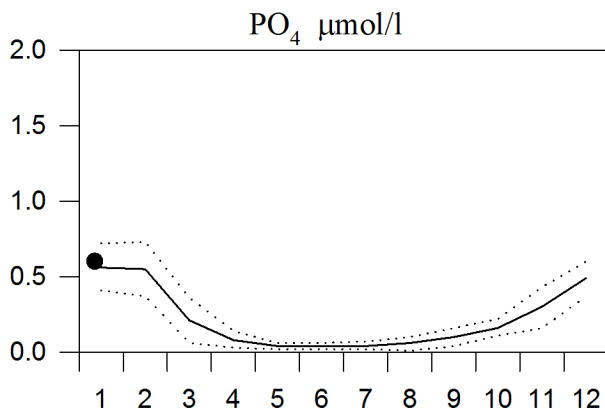
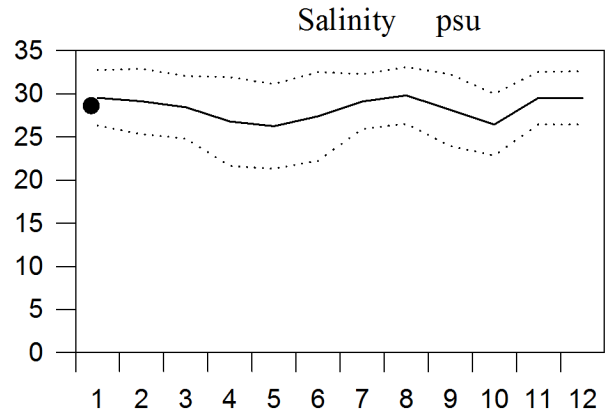
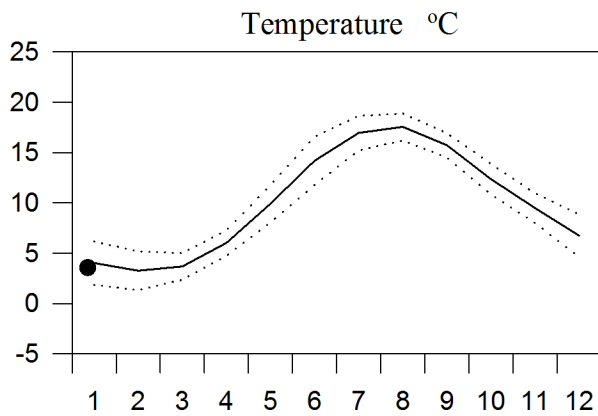
— Mean 1996-2010 St.Dev. ● 2016



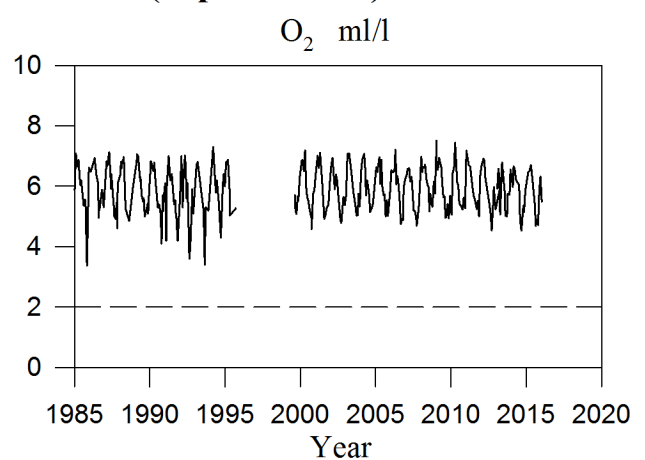
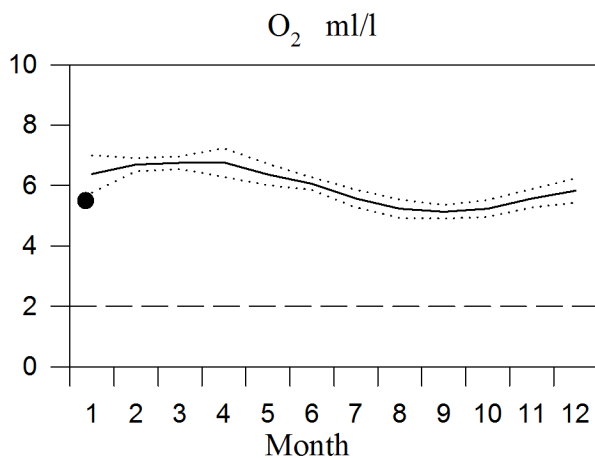
STATION Å13 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

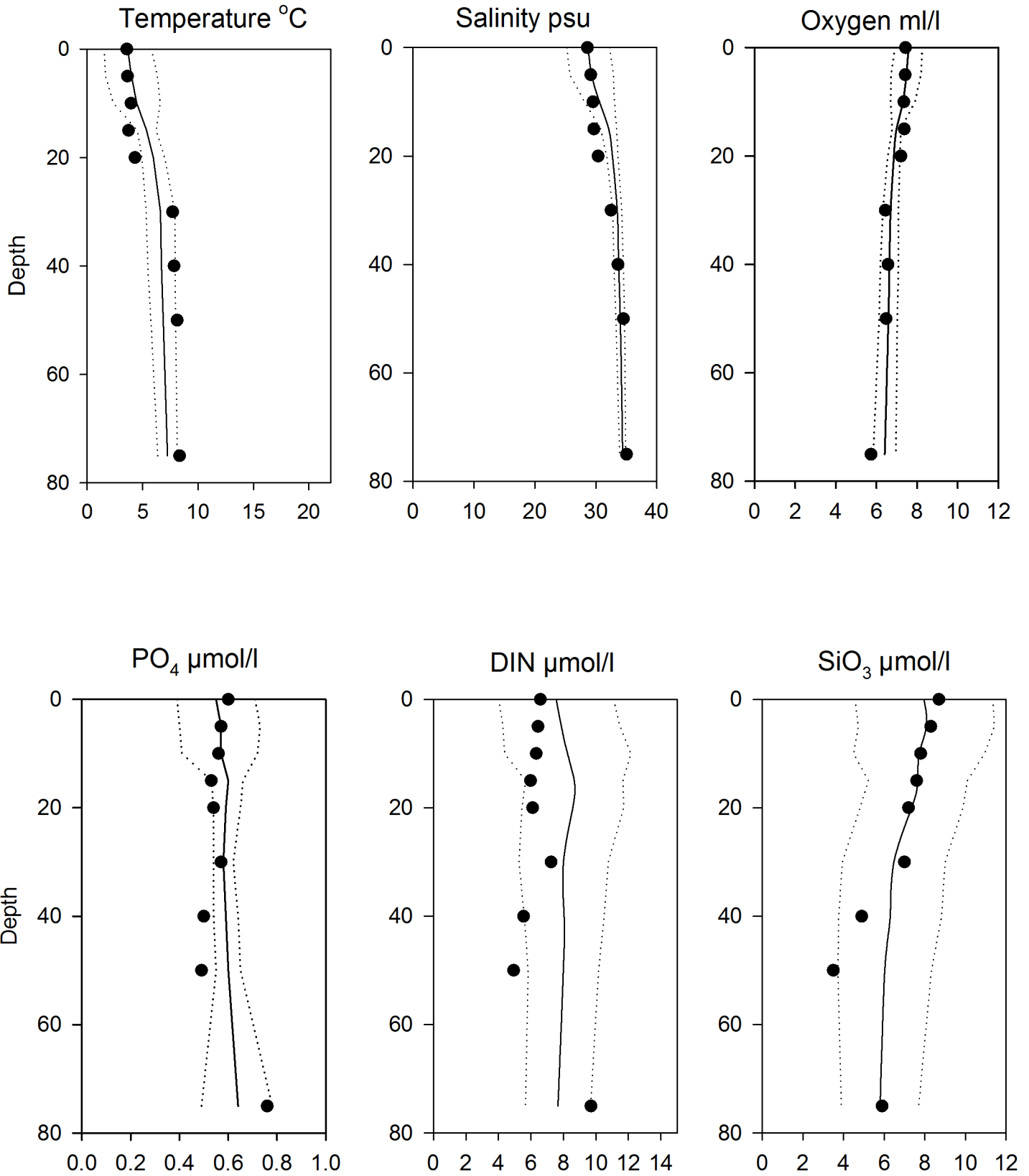


OXYGEN IN BOTTOM WATER (depth >=75m)



Vertical profiles Å13 January

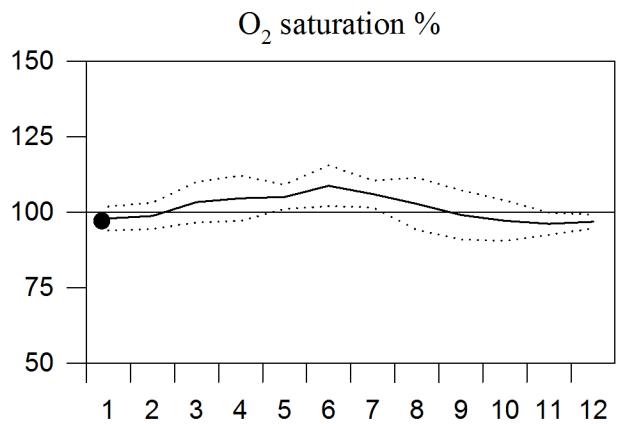
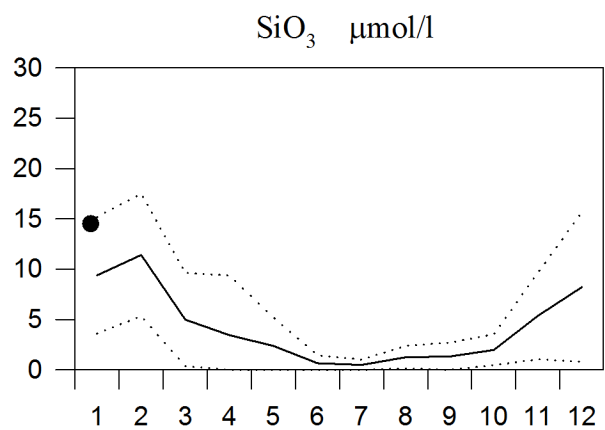
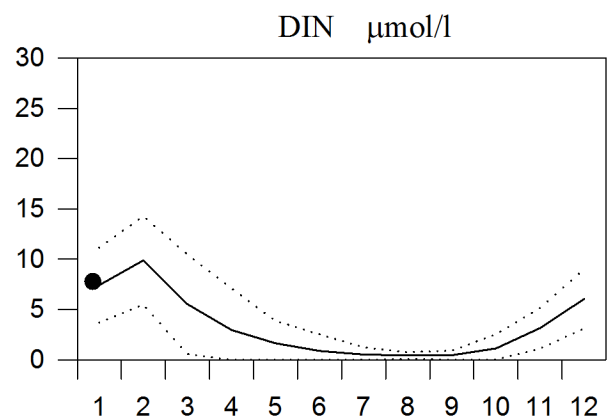
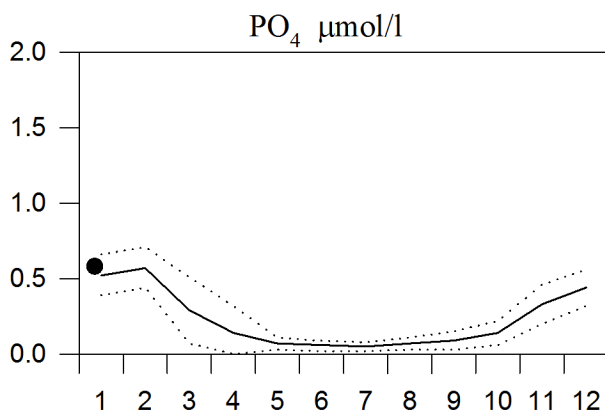
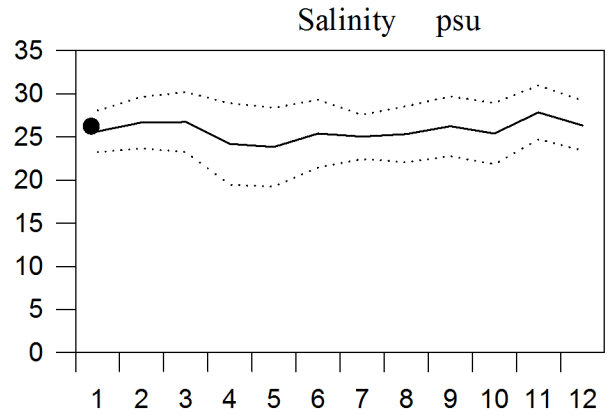
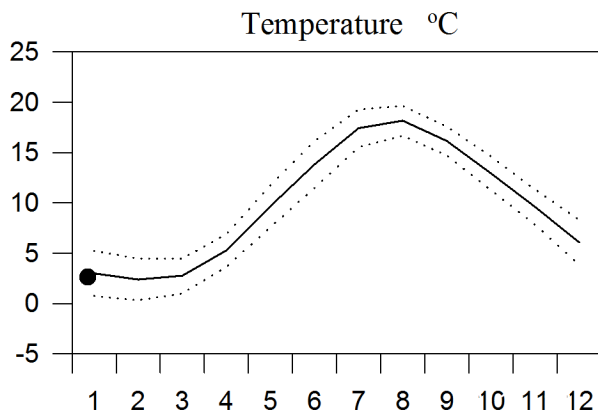
— Mean 1996-2010 St.Dev. ● 2016



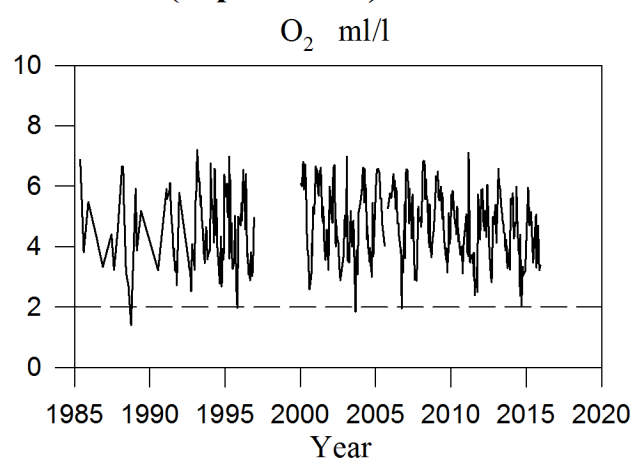
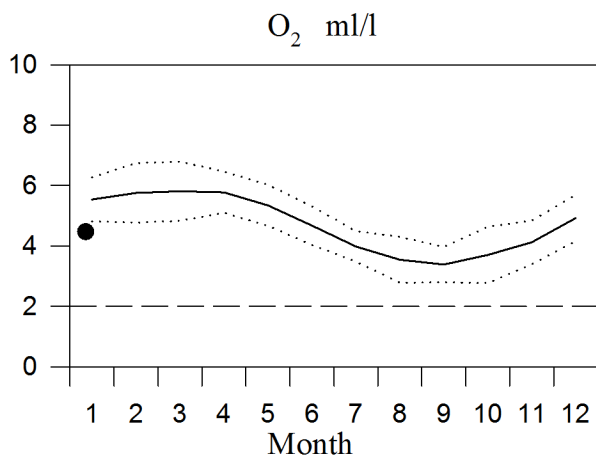
STATION SLÄGGÖ SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

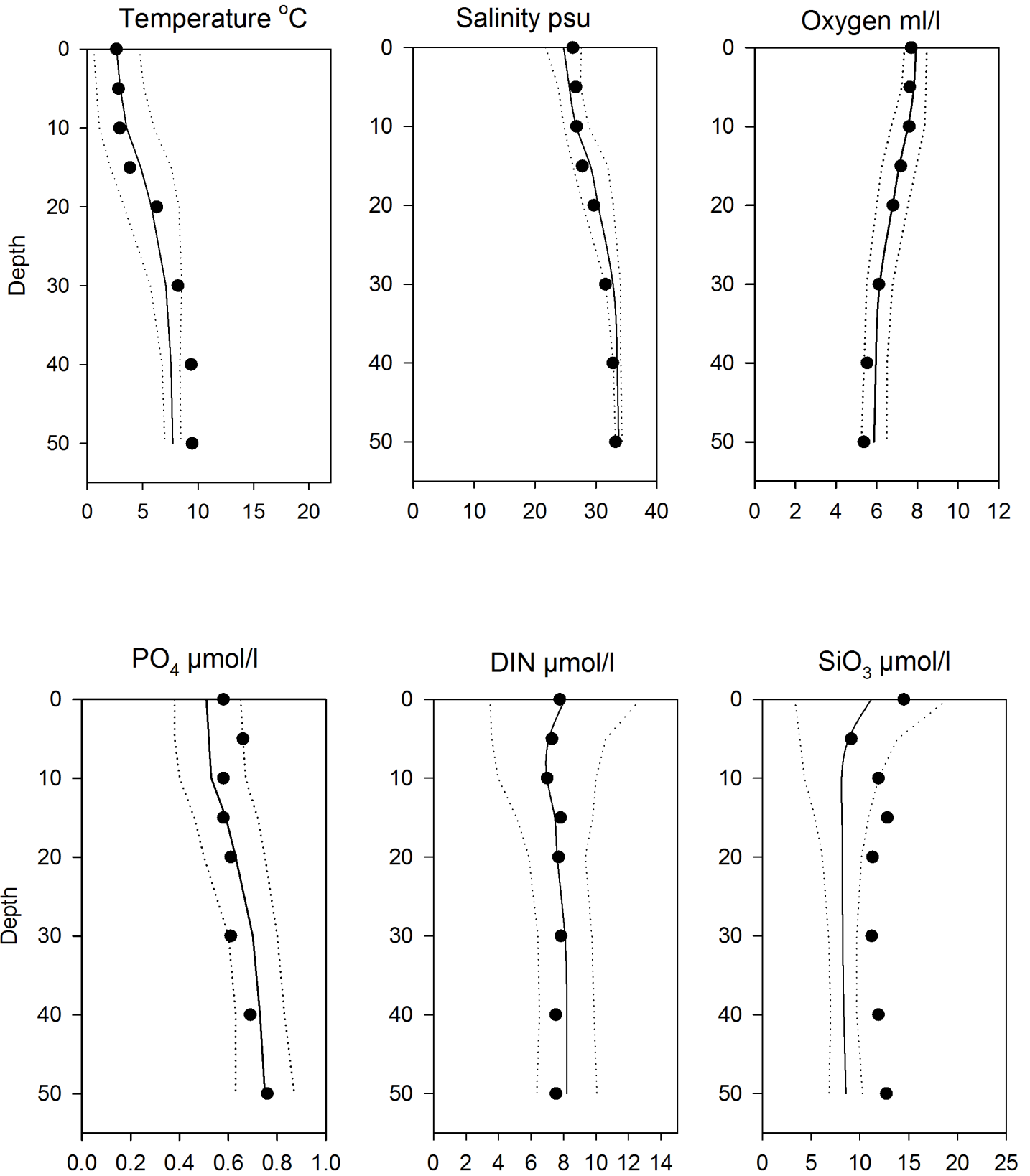


OXYGEN IN BOTTOM WATER (depth >50m)



Vertical profiles Släggö January

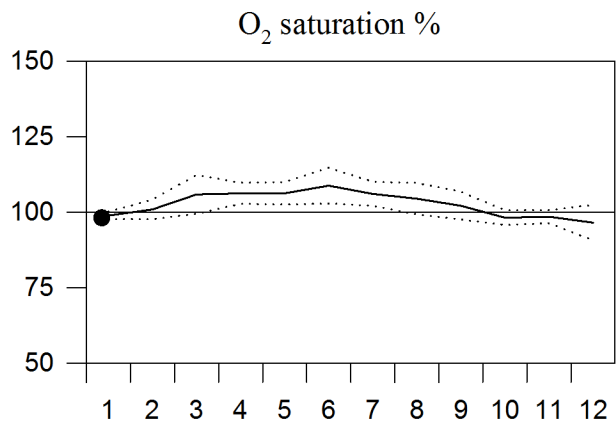
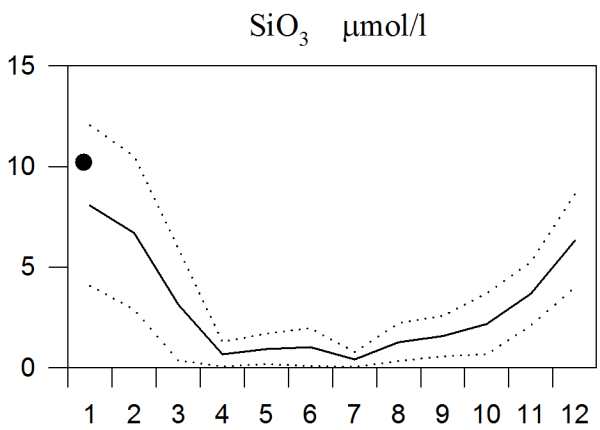
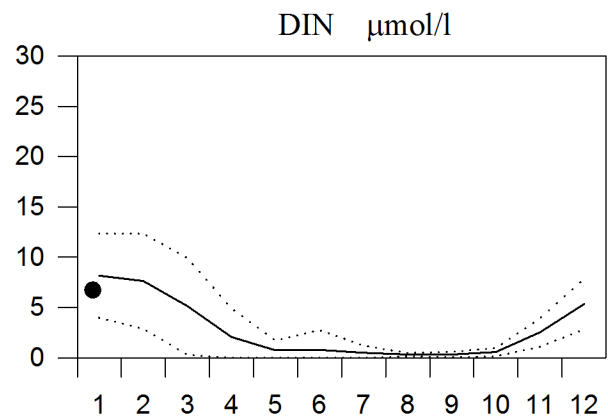
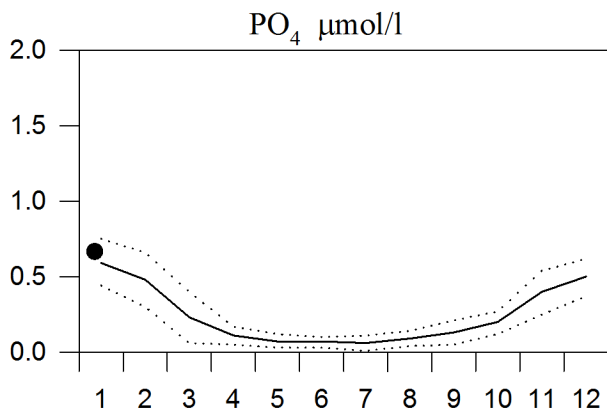
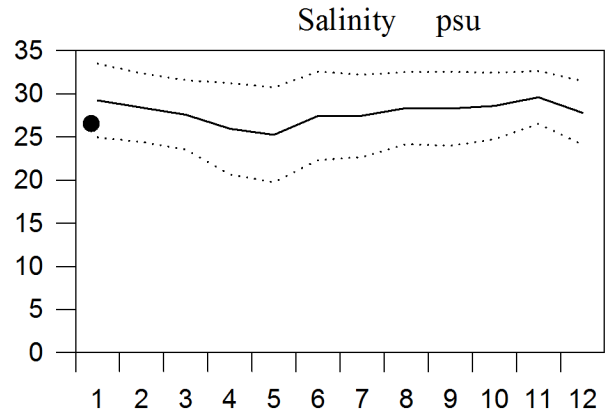
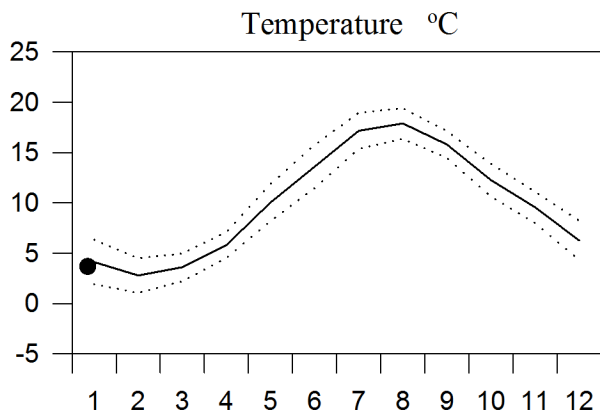
— Mean 1996-2010 St.Dev. ● 2016



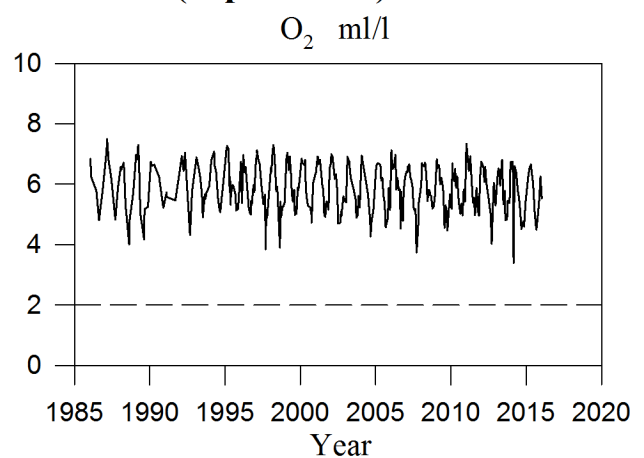
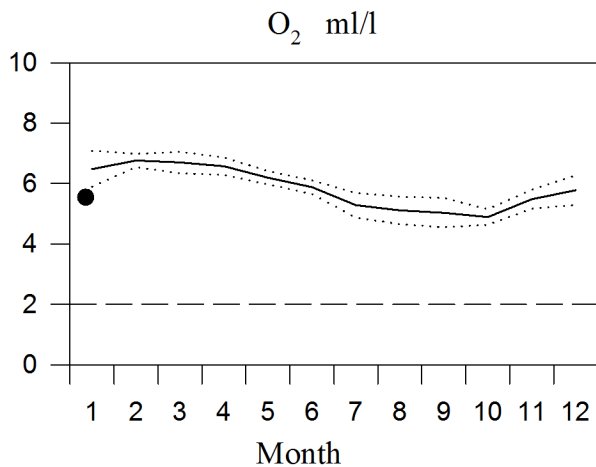
STATION P2 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

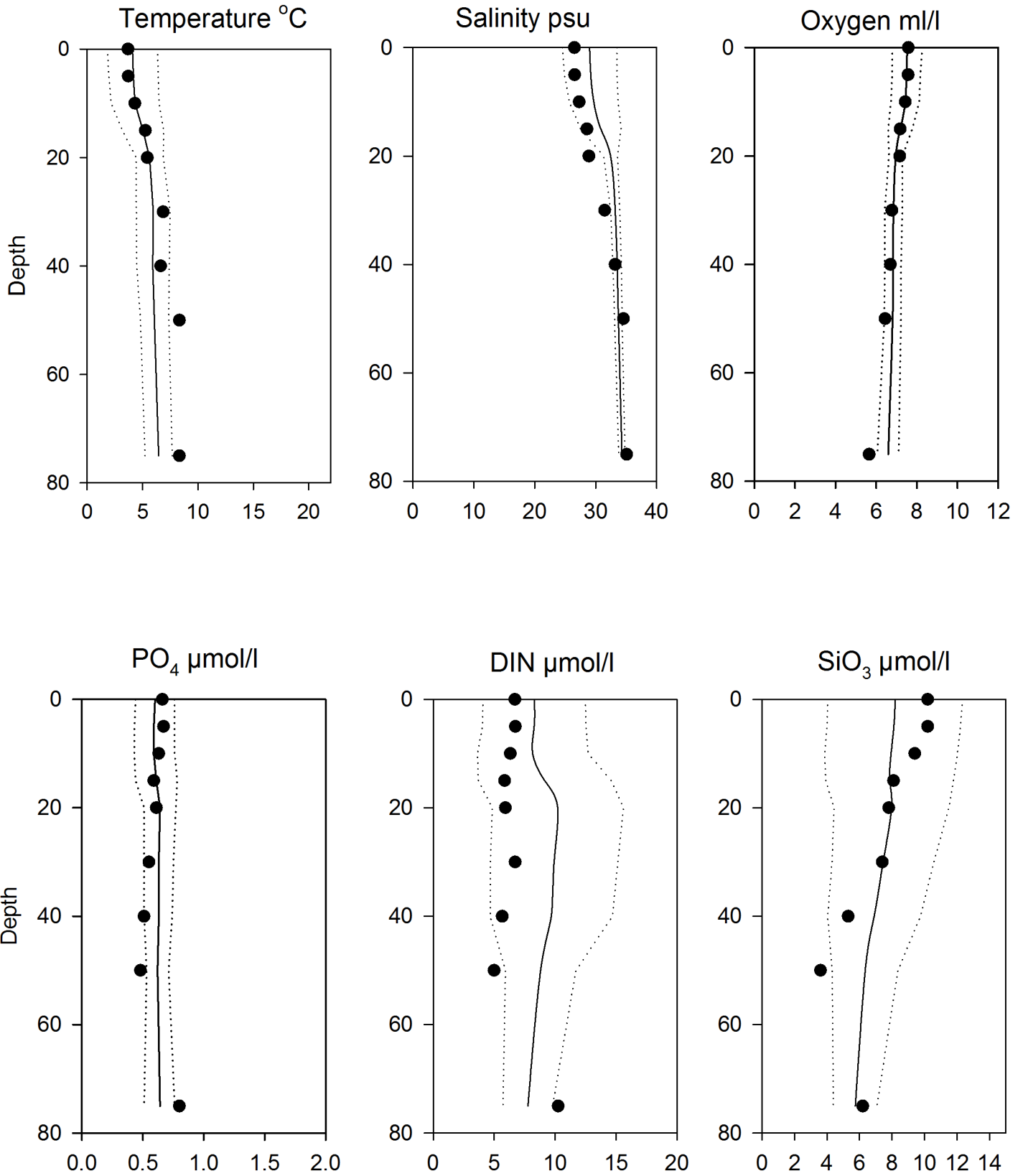


OXYGEN IN BOTTOM WATER (depth >75m)



Vertical profiles P2 January

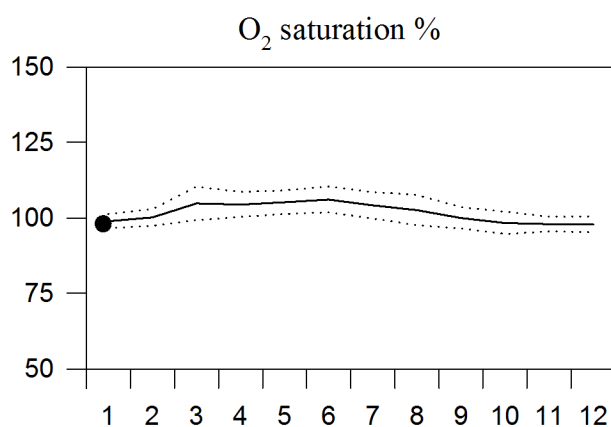
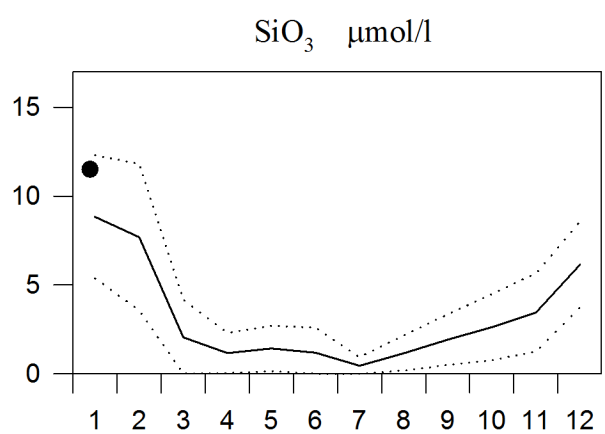
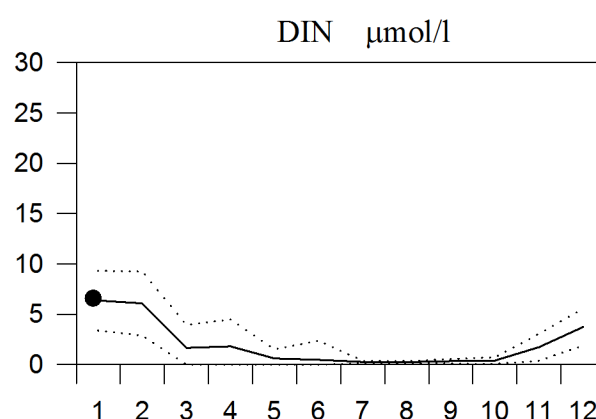
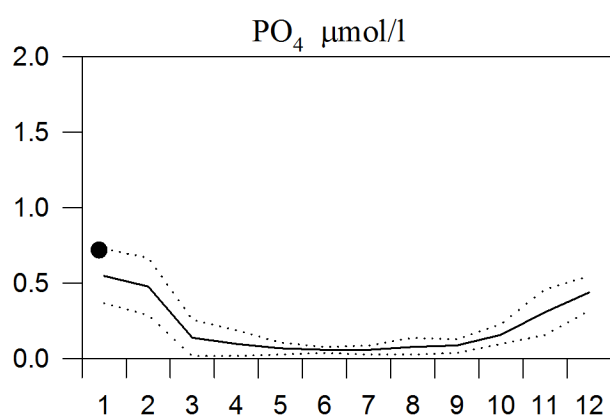
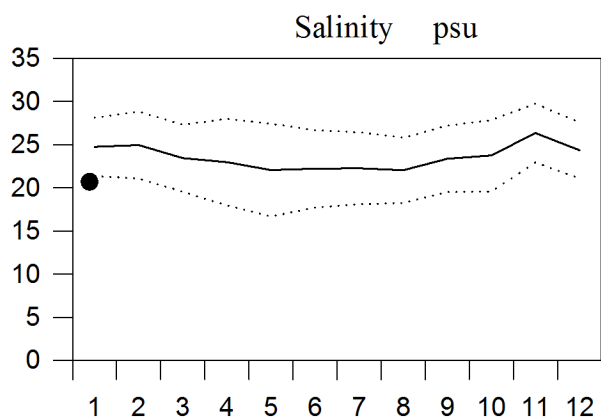
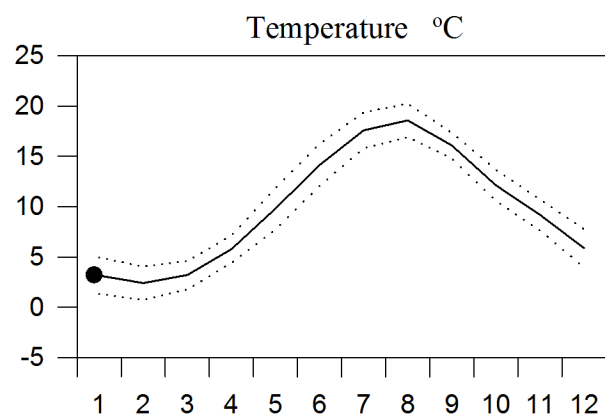
— Mean 1996-2010 St.Dev. ● 2016



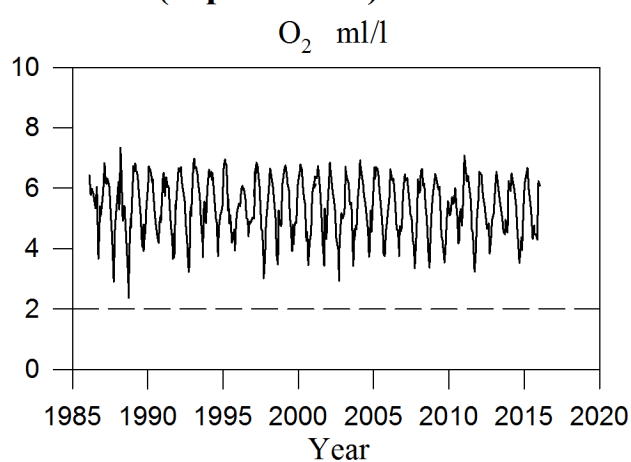
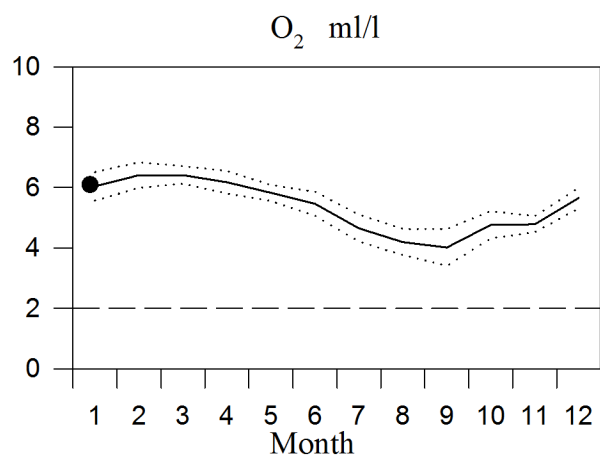
STATION FLADEN SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

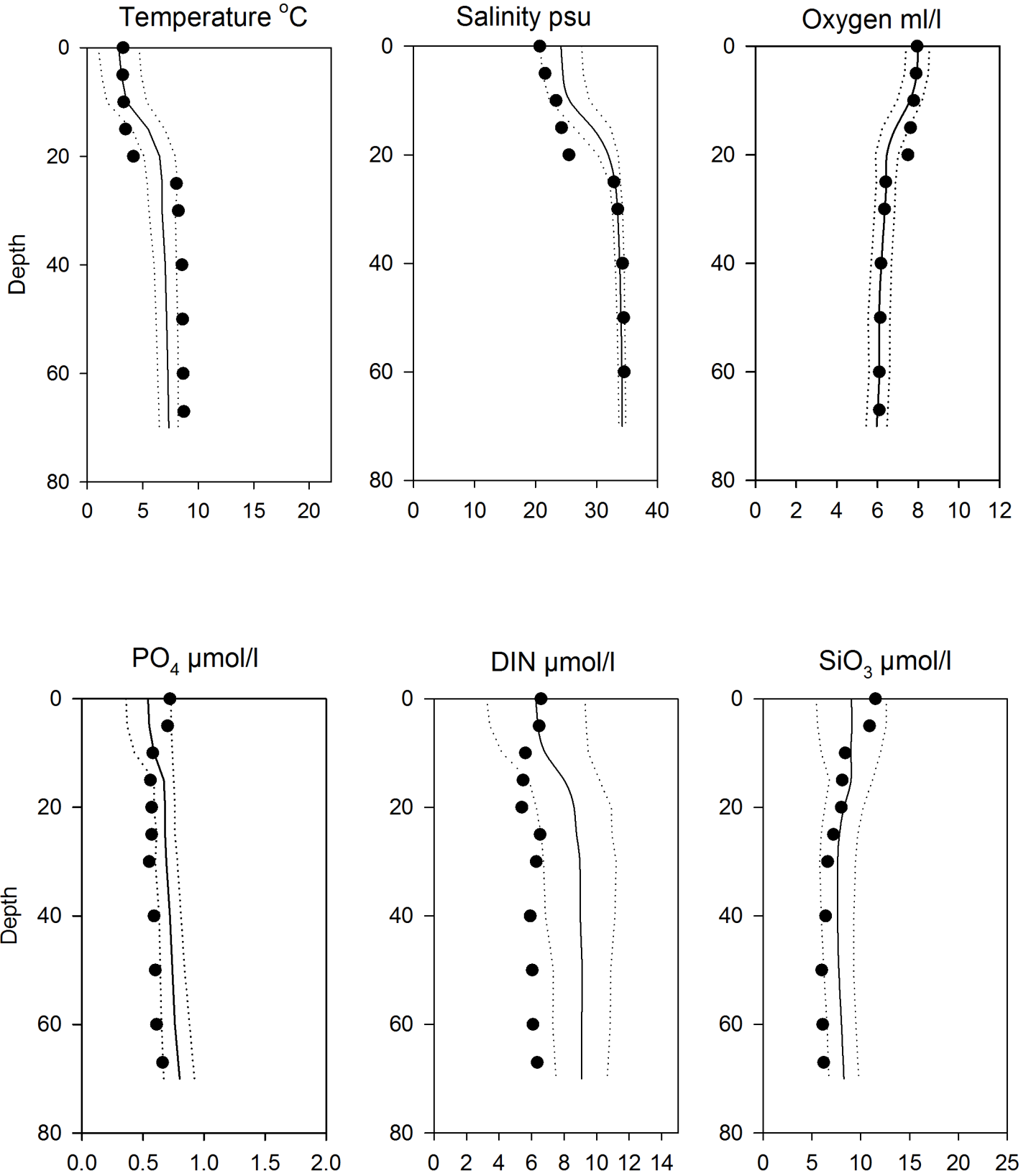


OXYGEN IN BOTTOM WATER (depth > 70m)



Vertical profiles Fladen January

— Mean 1996-2010 St.Dev. ● 2016



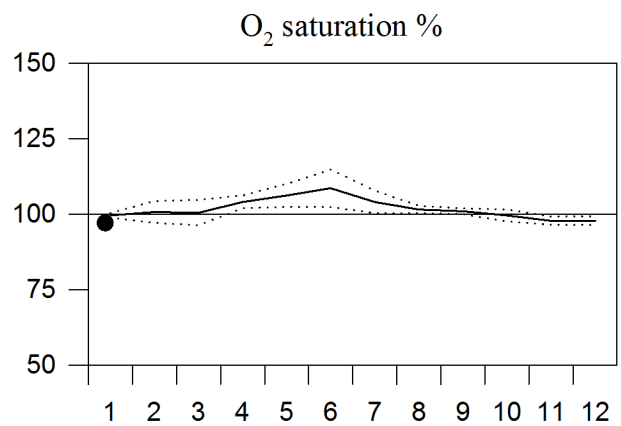
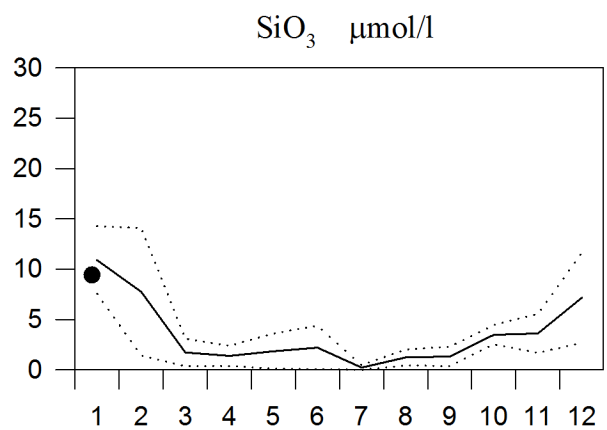
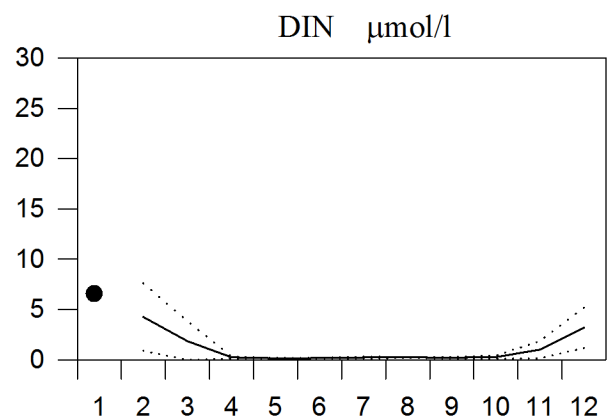
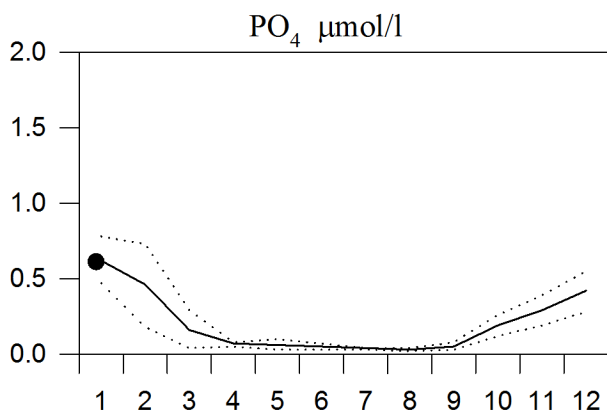
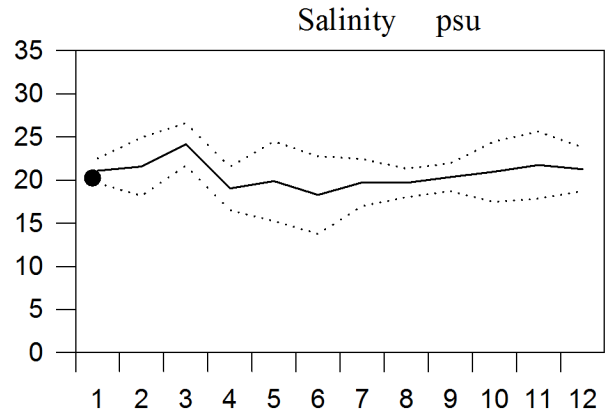
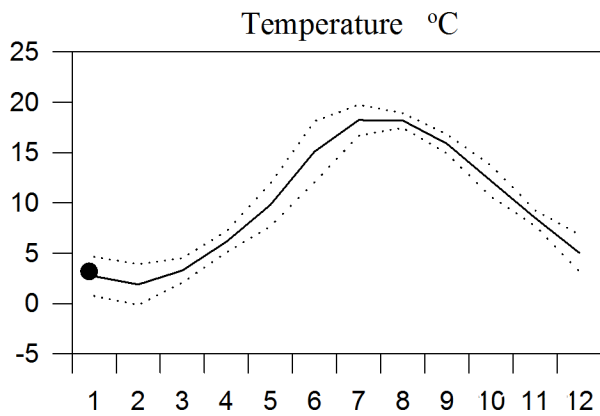
STATION N14 Falkenberg SURFACE WATER

Annual Cycles

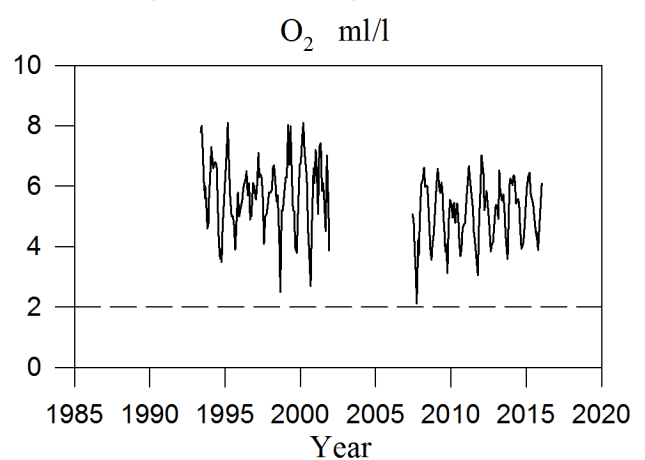
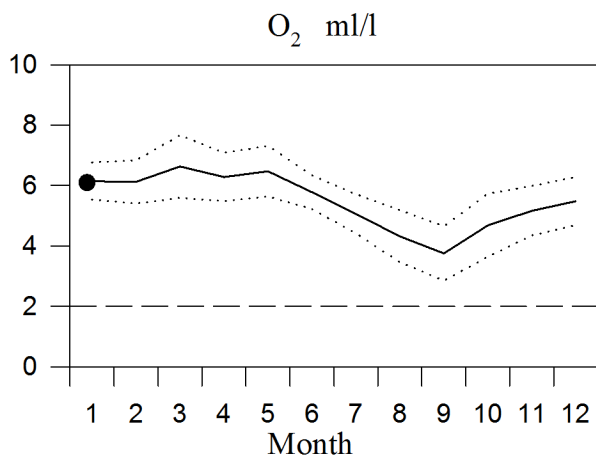
— Mean 2007-2010

..... St.Dev.

● 2016

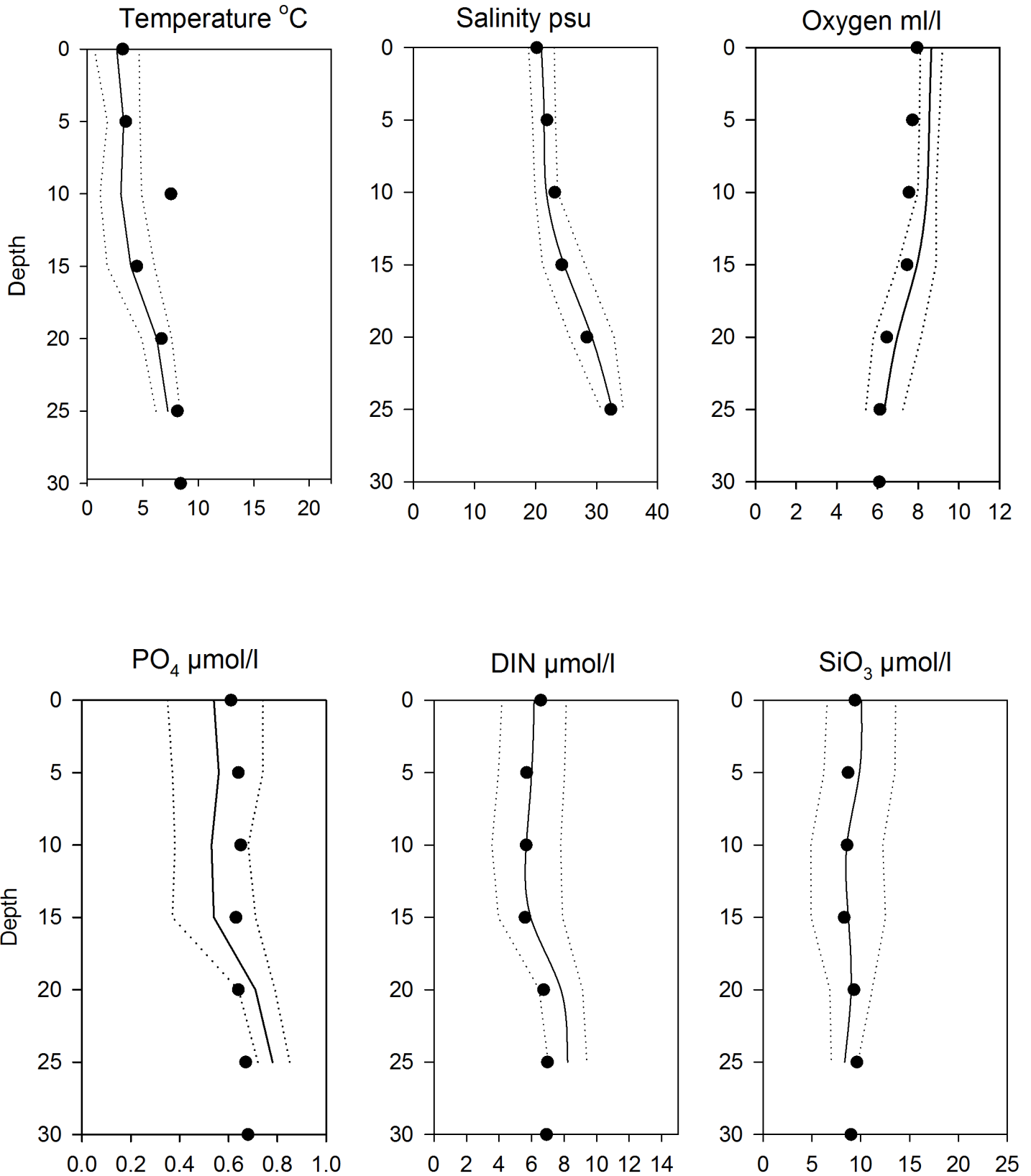


OXYGEN IN BOTTOM WATER (depth > 25m)



Vertical profiles N14 Falkenberg January

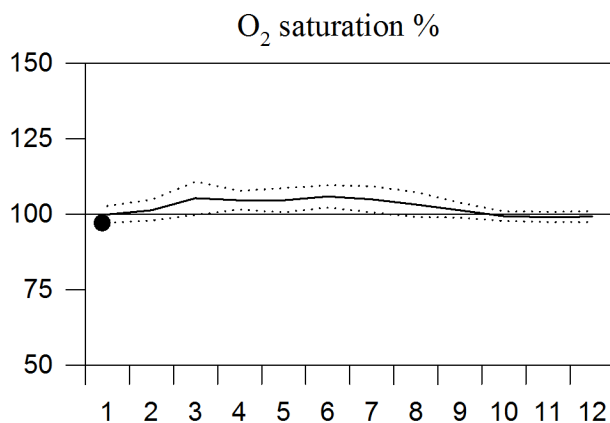
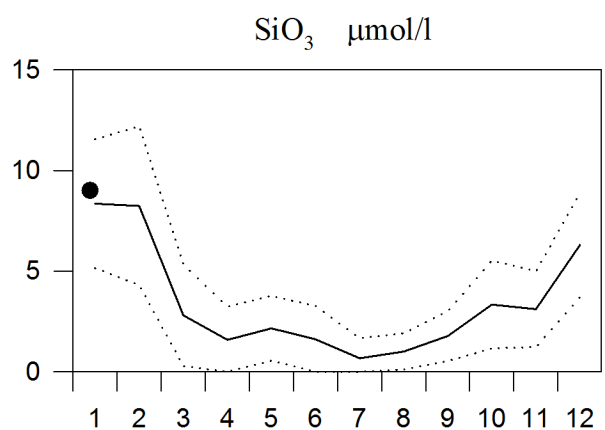
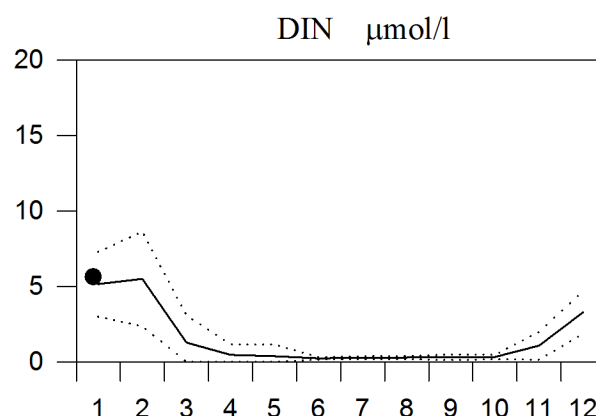
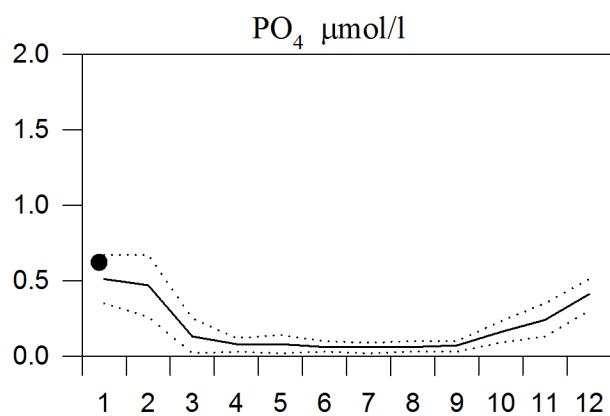
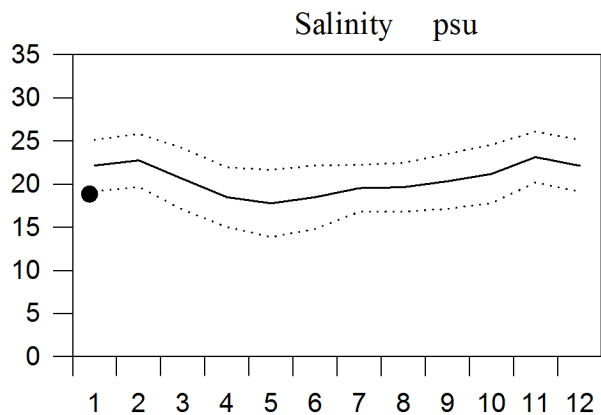
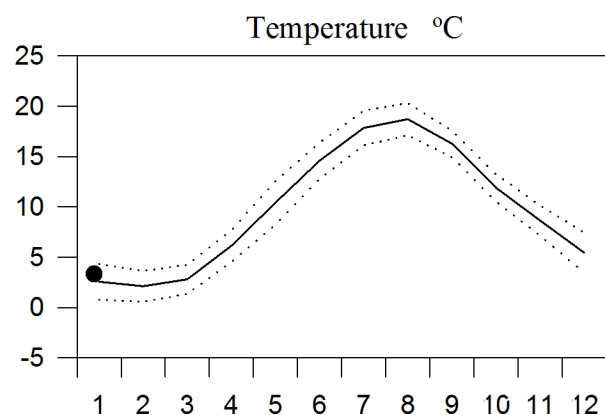
— Mean 1996-2010 St.Dev. ● 2016



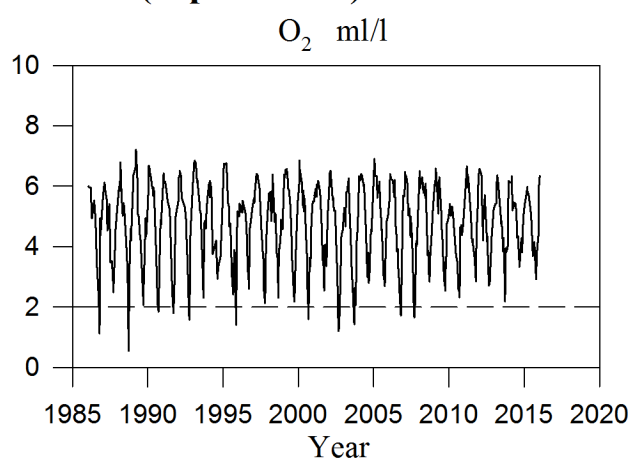
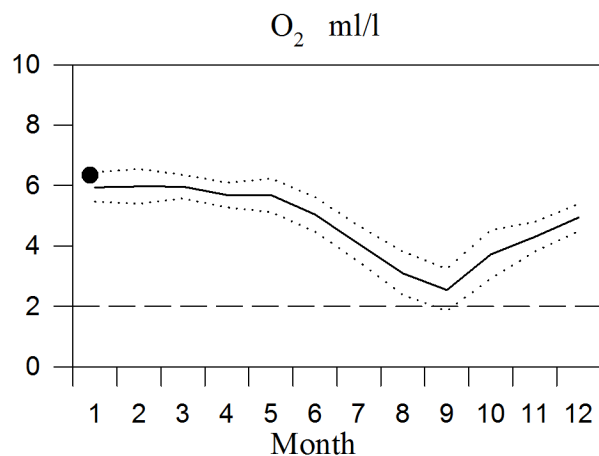
STATION ANHOLT E SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

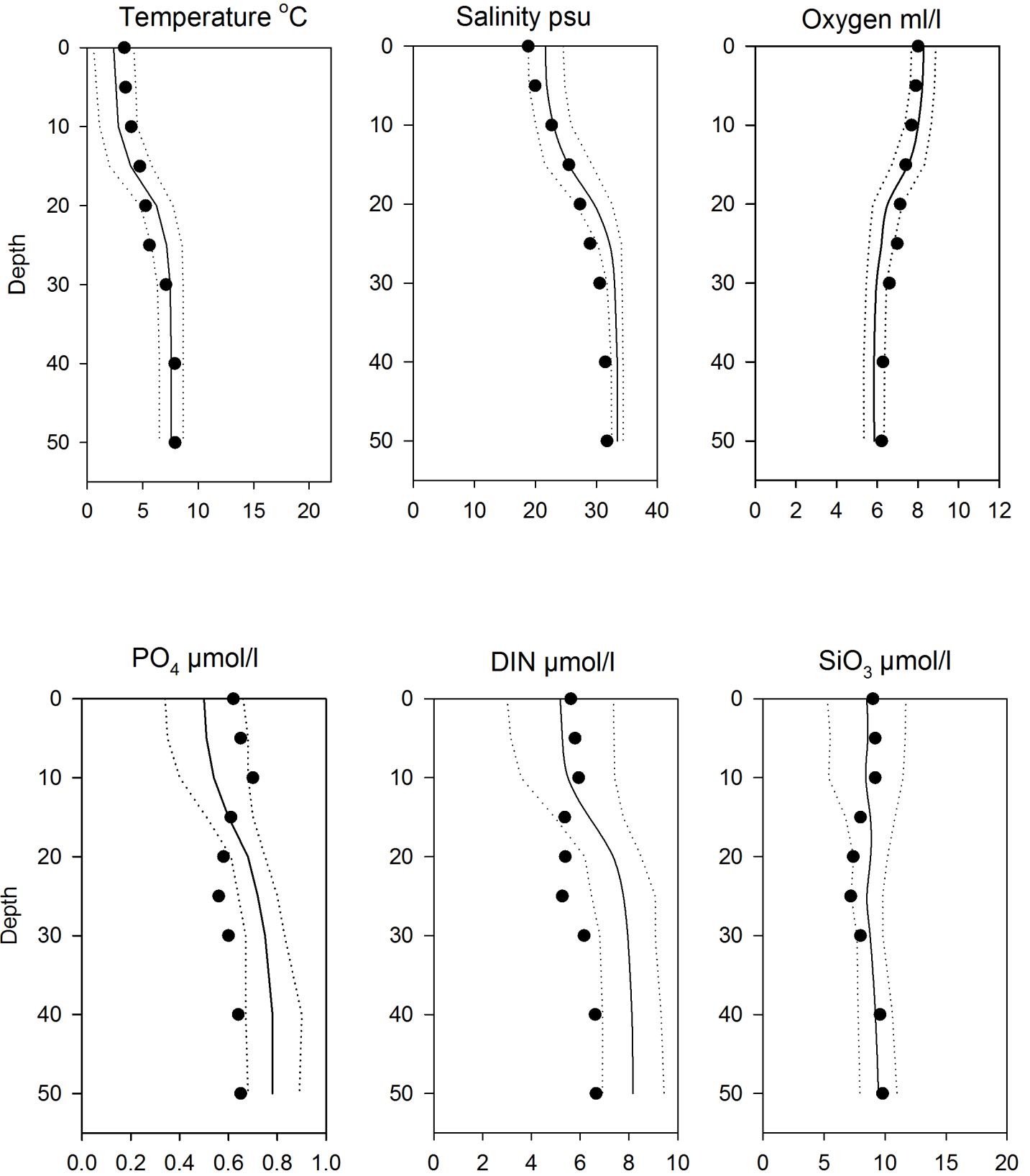


OXYGEN IN BOTTOM WATER (depth > 50m)



Vertical profiles Anholt E January

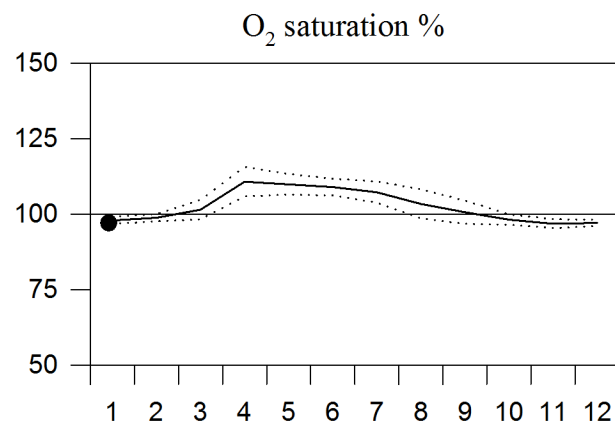
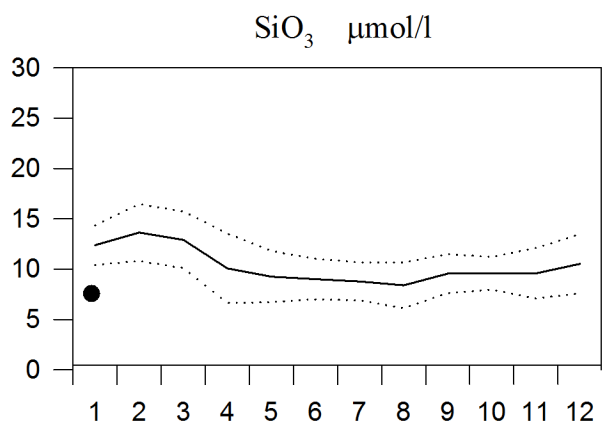
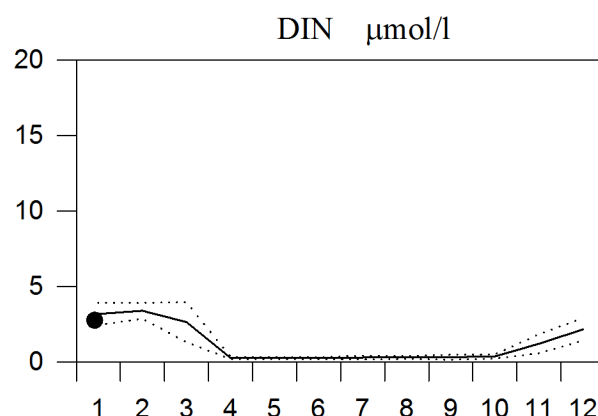
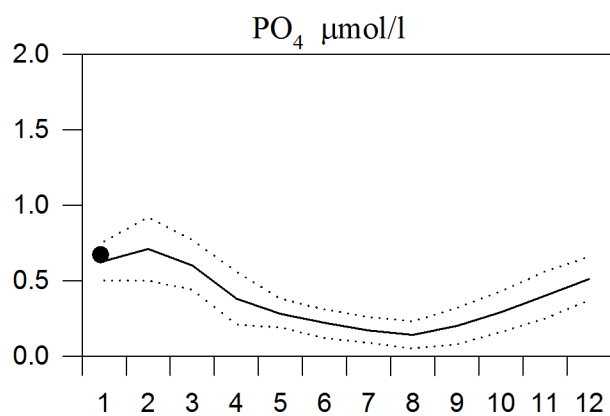
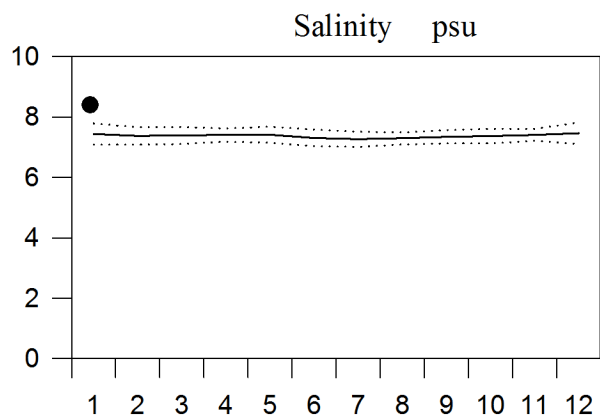
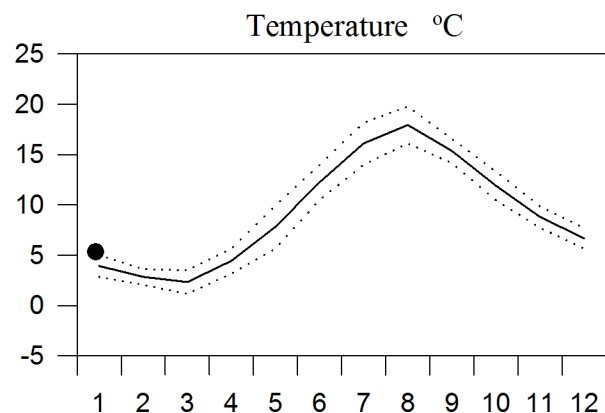
— Mean 1996-2010 St.Dev. ● 2016



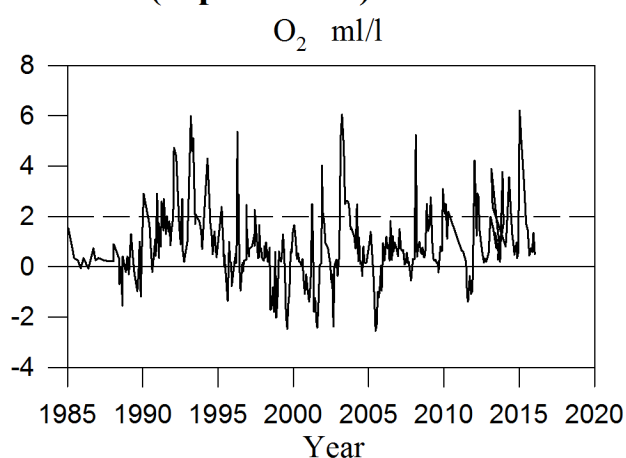
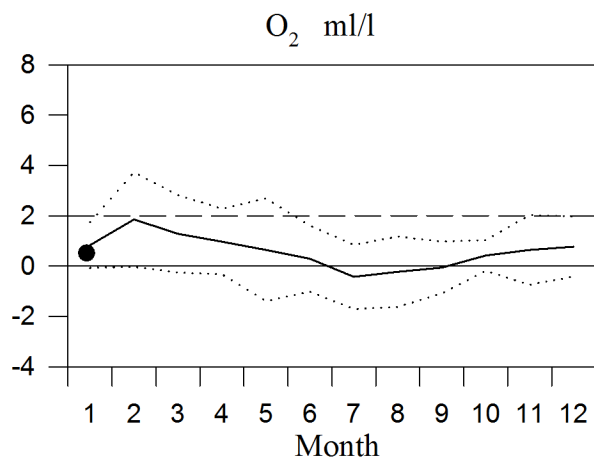
STATION HANÖBUKTEN SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

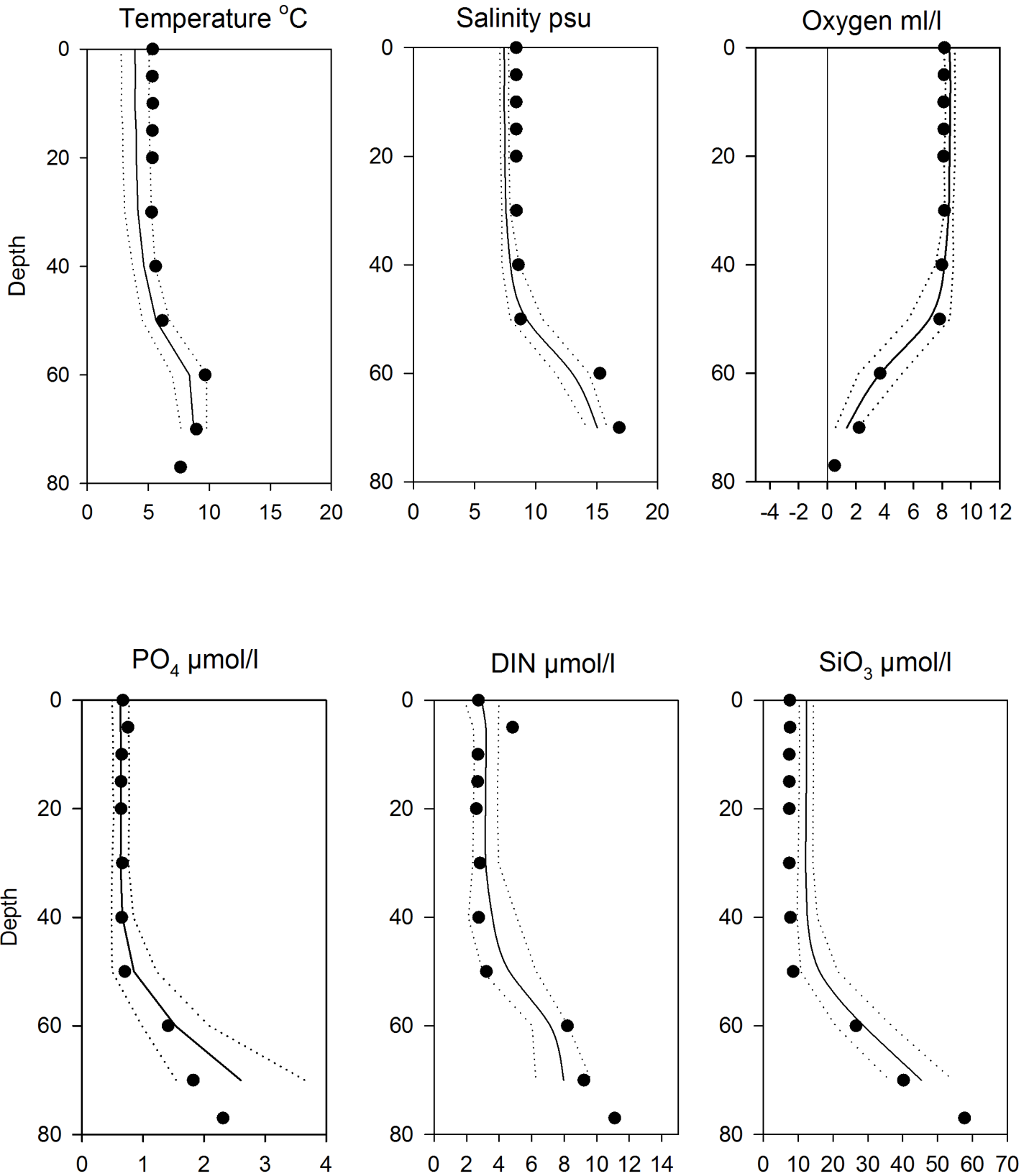


OXYGEN IN BOTTOM WATER (depth > 70m)



Vertical profiles Hanöbukten January

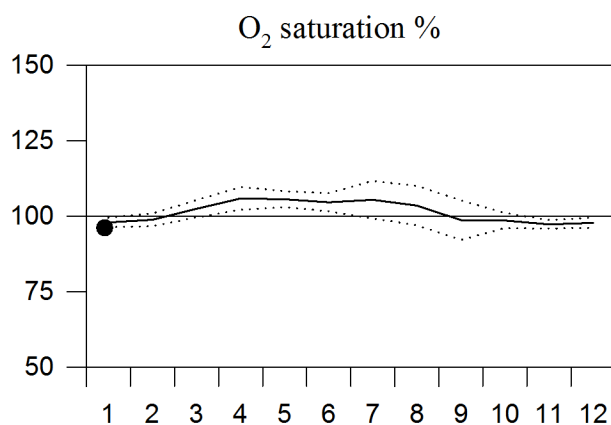
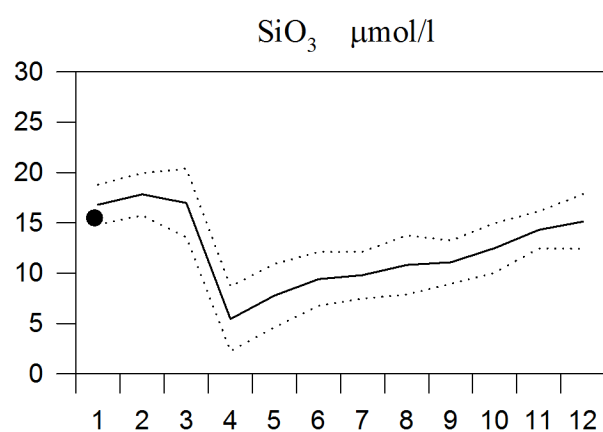
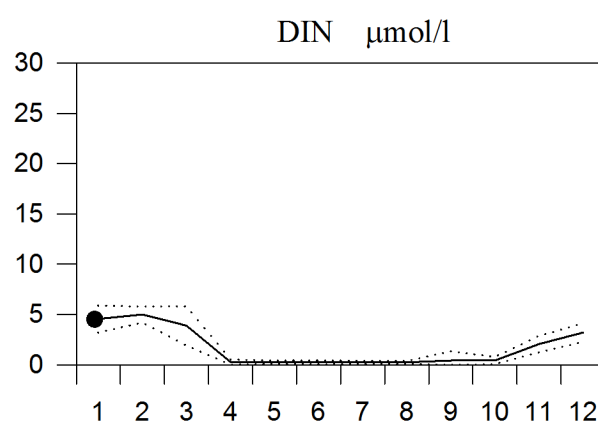
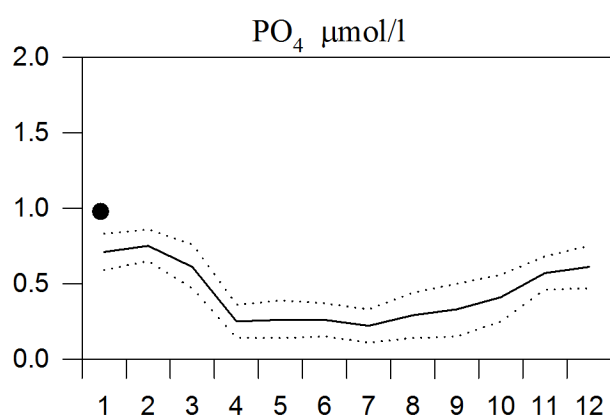
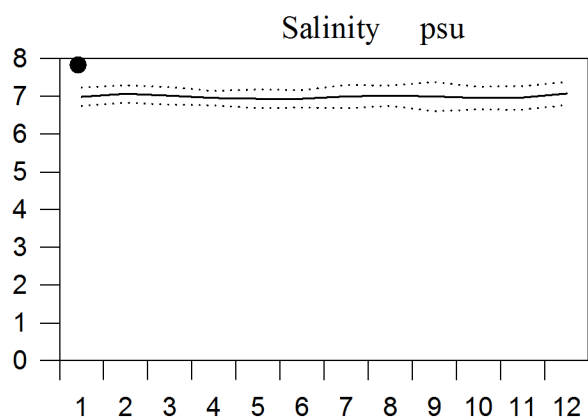
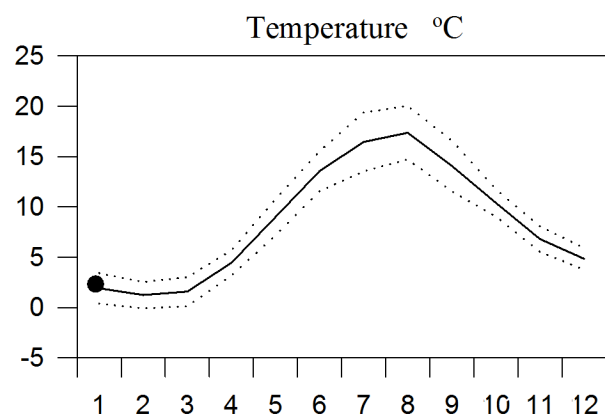
— Mean 1996-2010 St.Dev. ● 2016



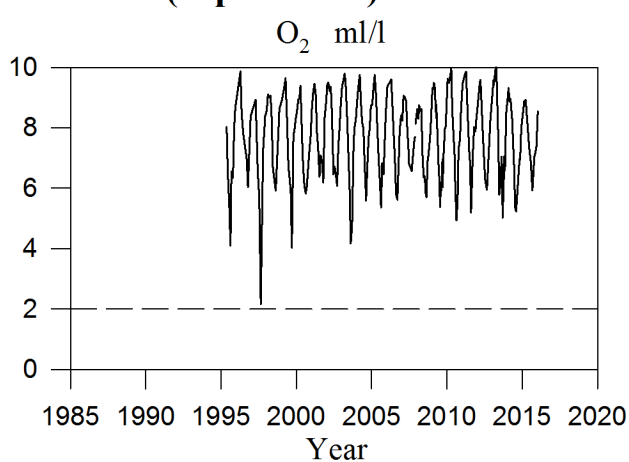
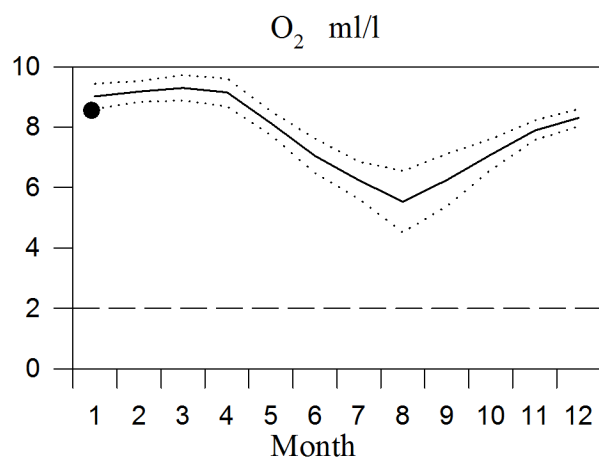
STATION REF M1V1 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016



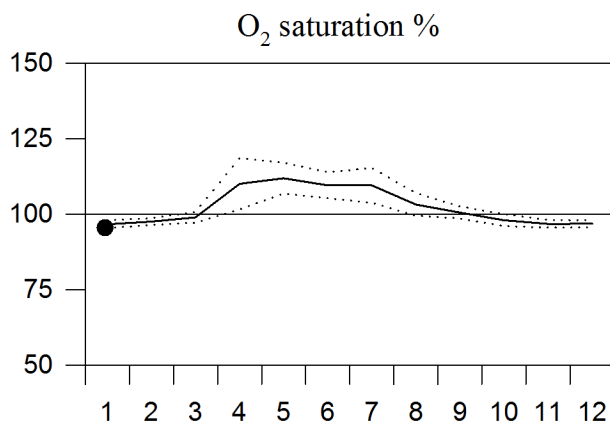
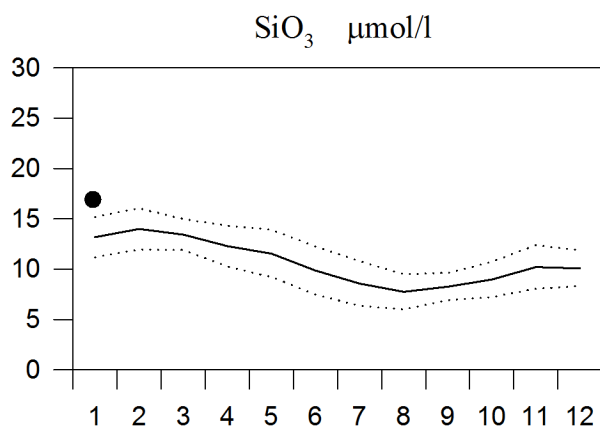
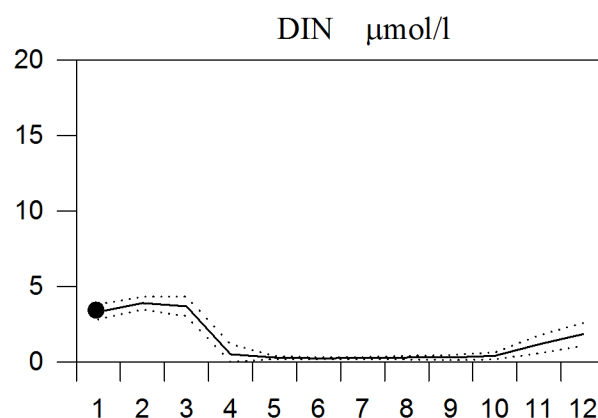
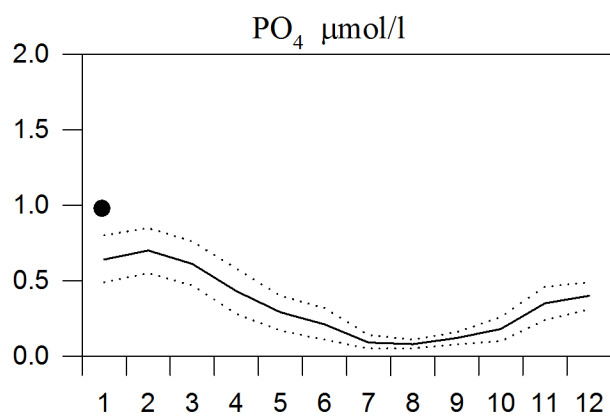
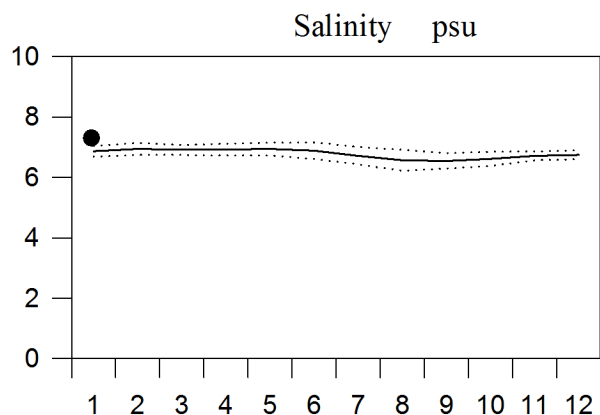
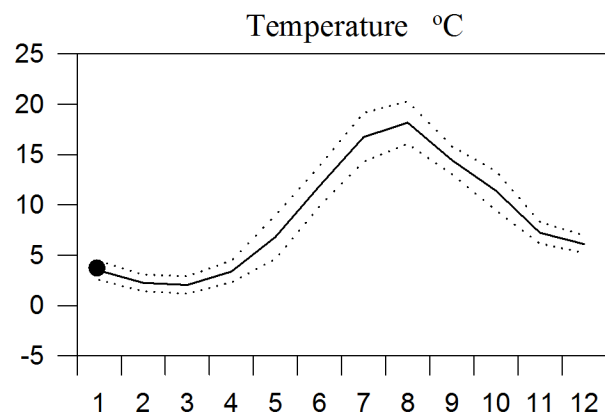
OXYGEN IN BOTTOM WATER (depth >15m)



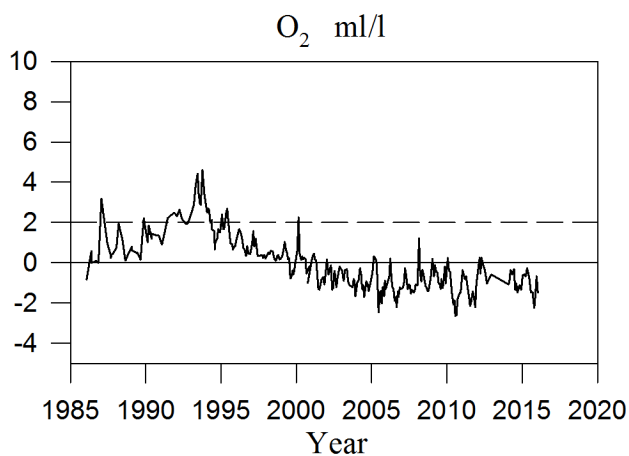
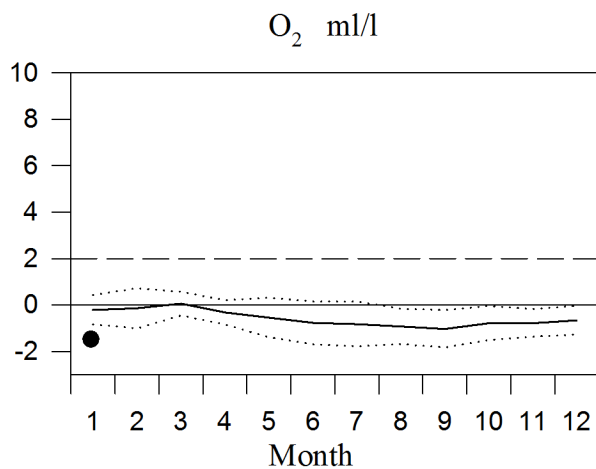
STATION BY38 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

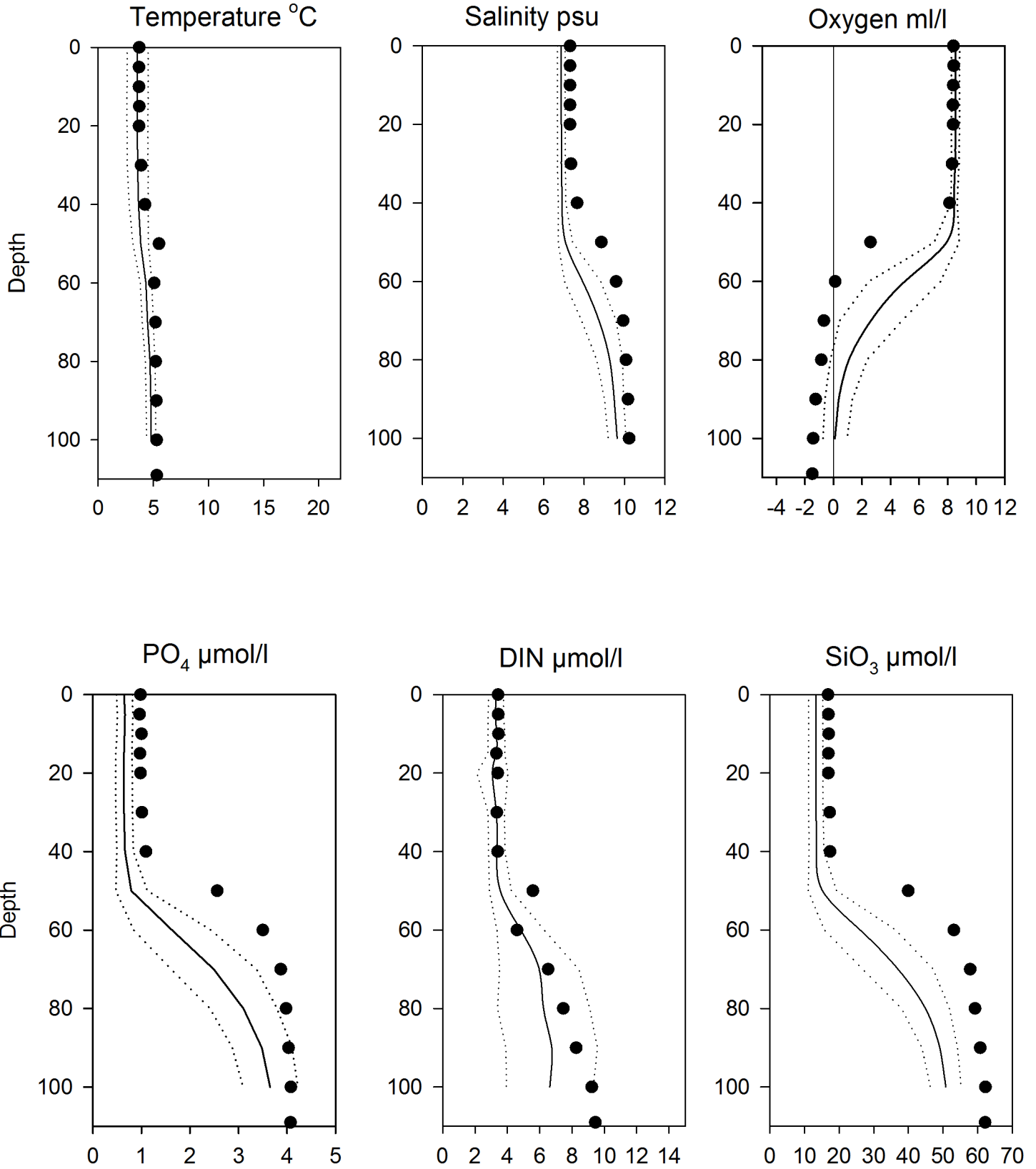


OXYGEN IN BOTTOM WATER (> 100m)



Vertical profiles BY38 January

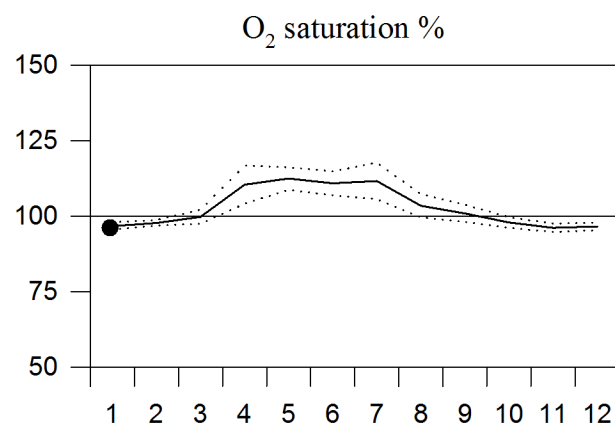
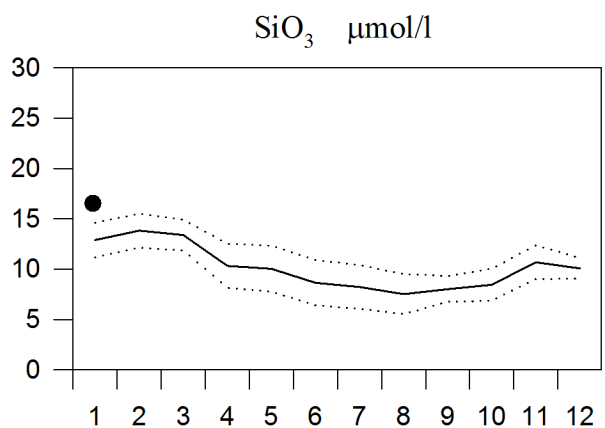
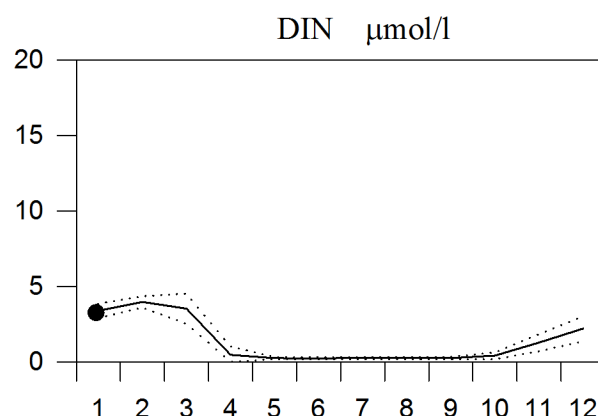
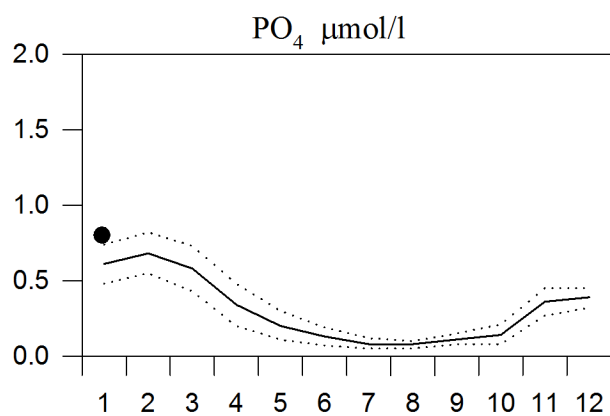
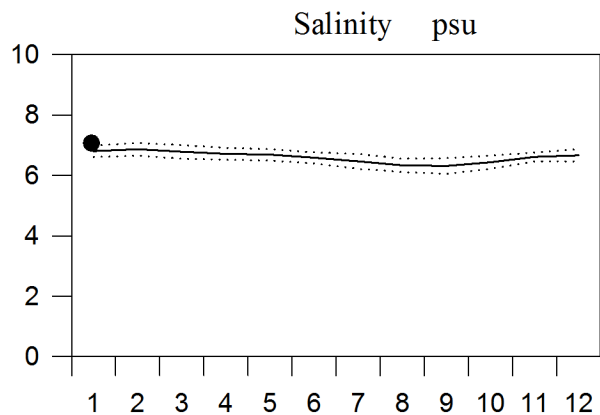
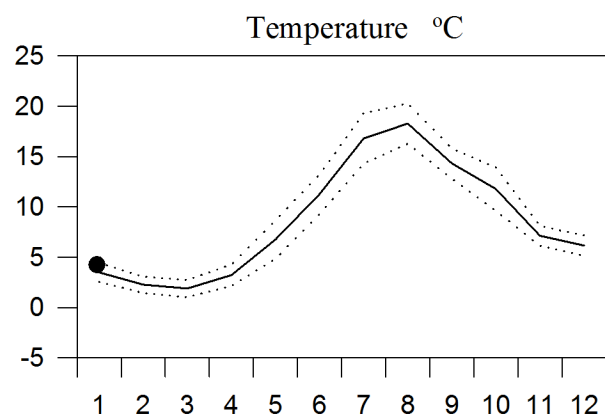
— Mean 1996-2010 St.Dev. ● 2016



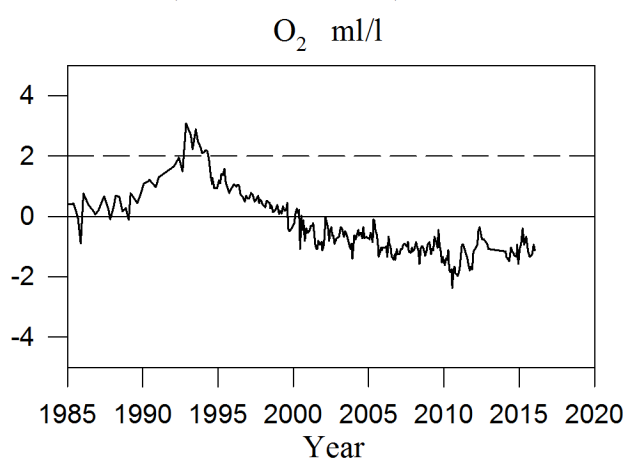
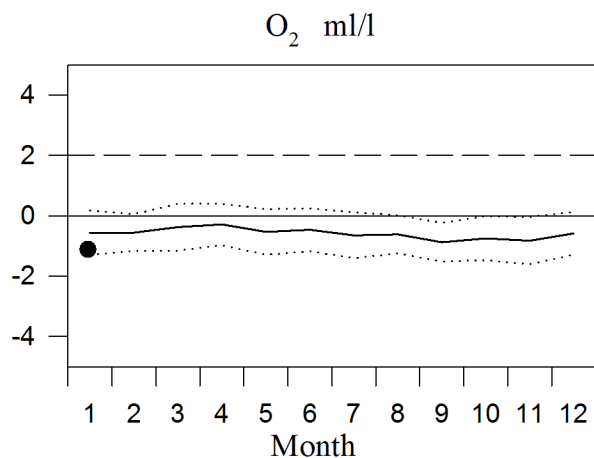
STATION BY32 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

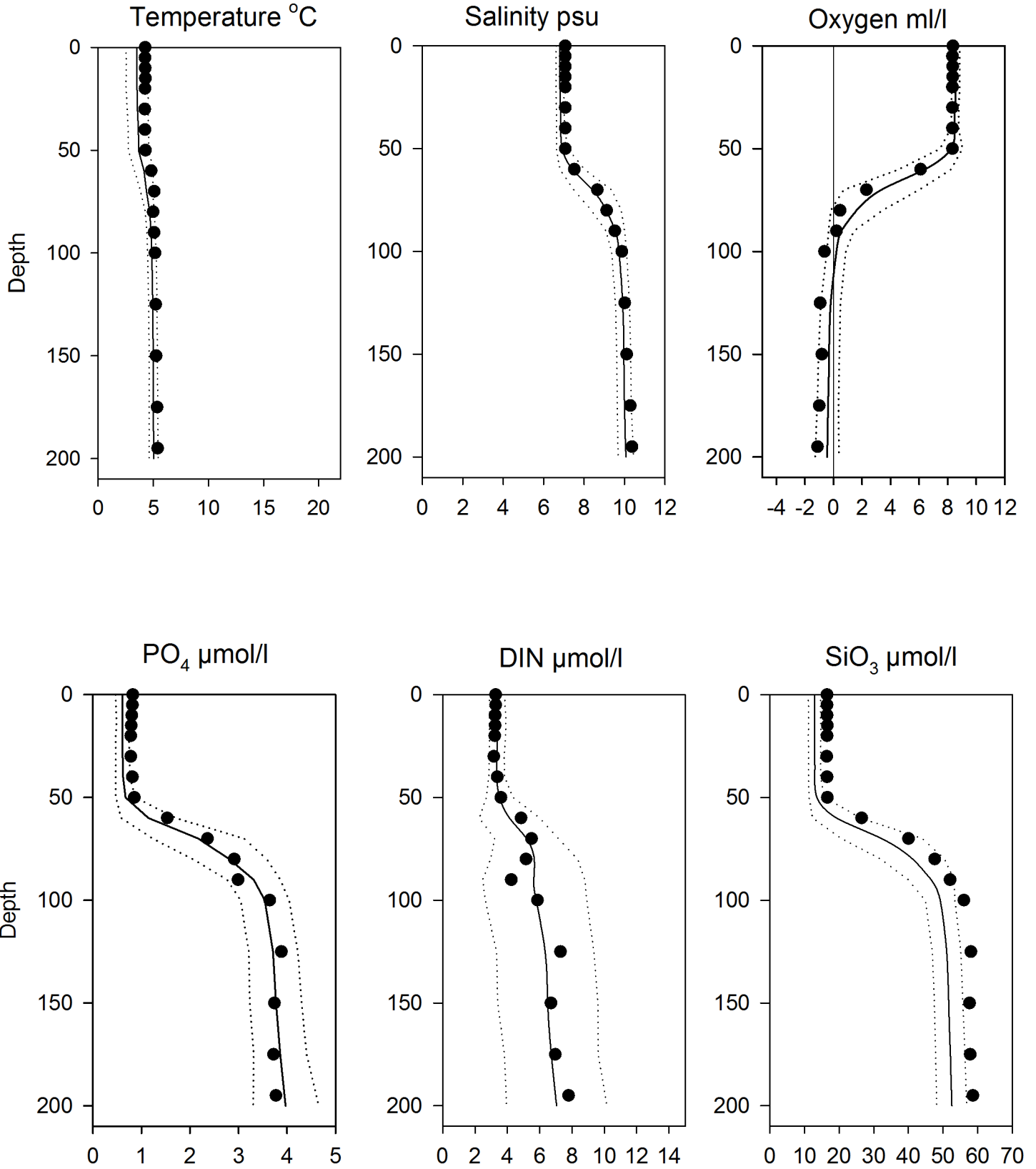


OXYGEN IN BOTTOM WATER (depth > 175m)



Vertical profiles BY32 January

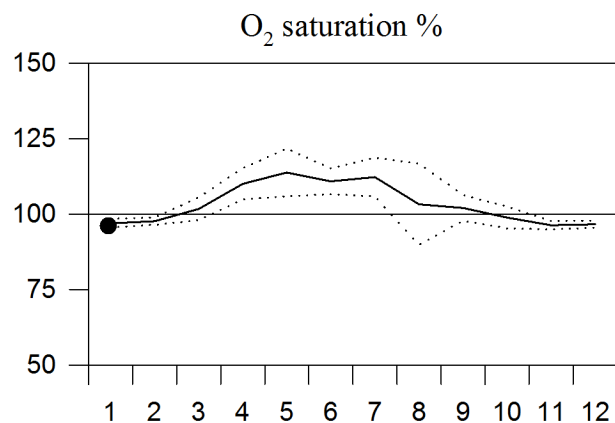
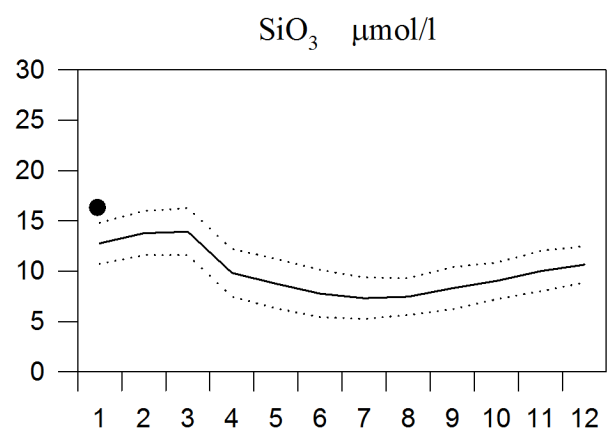
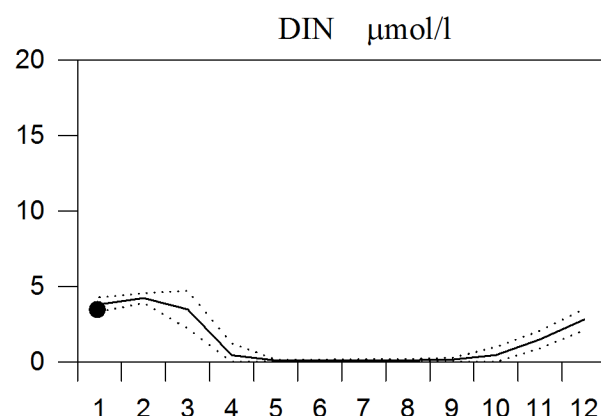
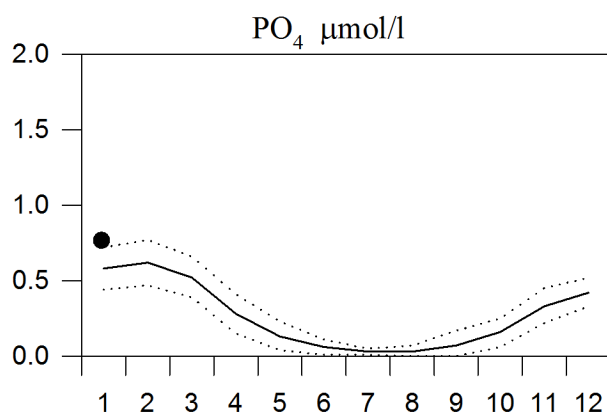
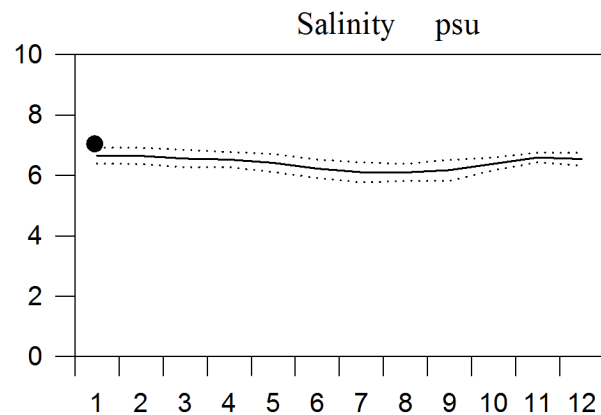
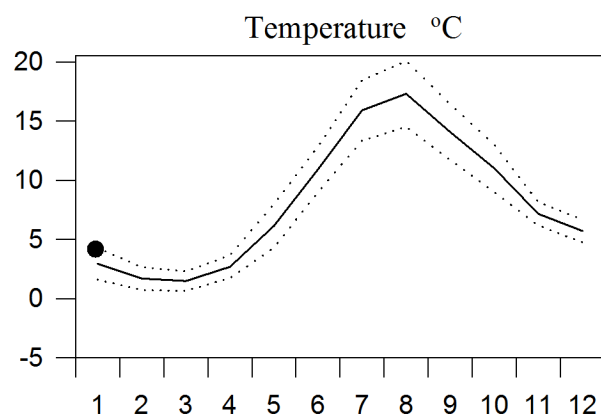
— Mean 1996-2010 St.Dev. ● 2016



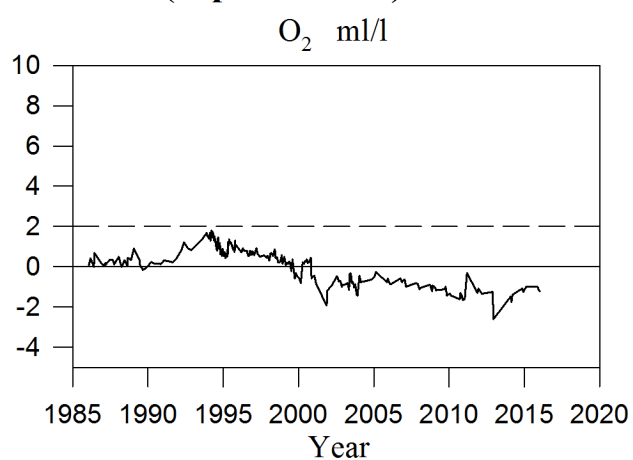
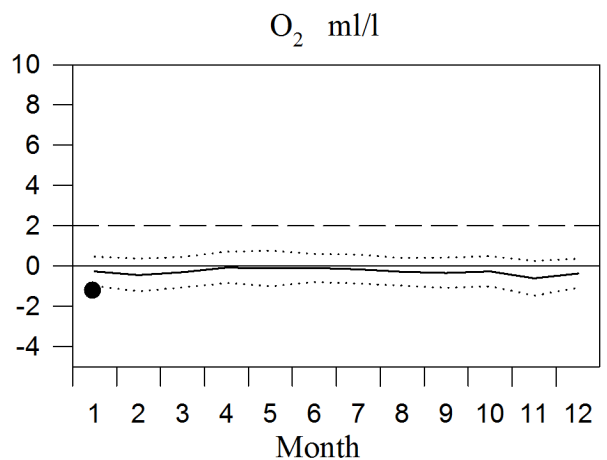
STATION BY31 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016

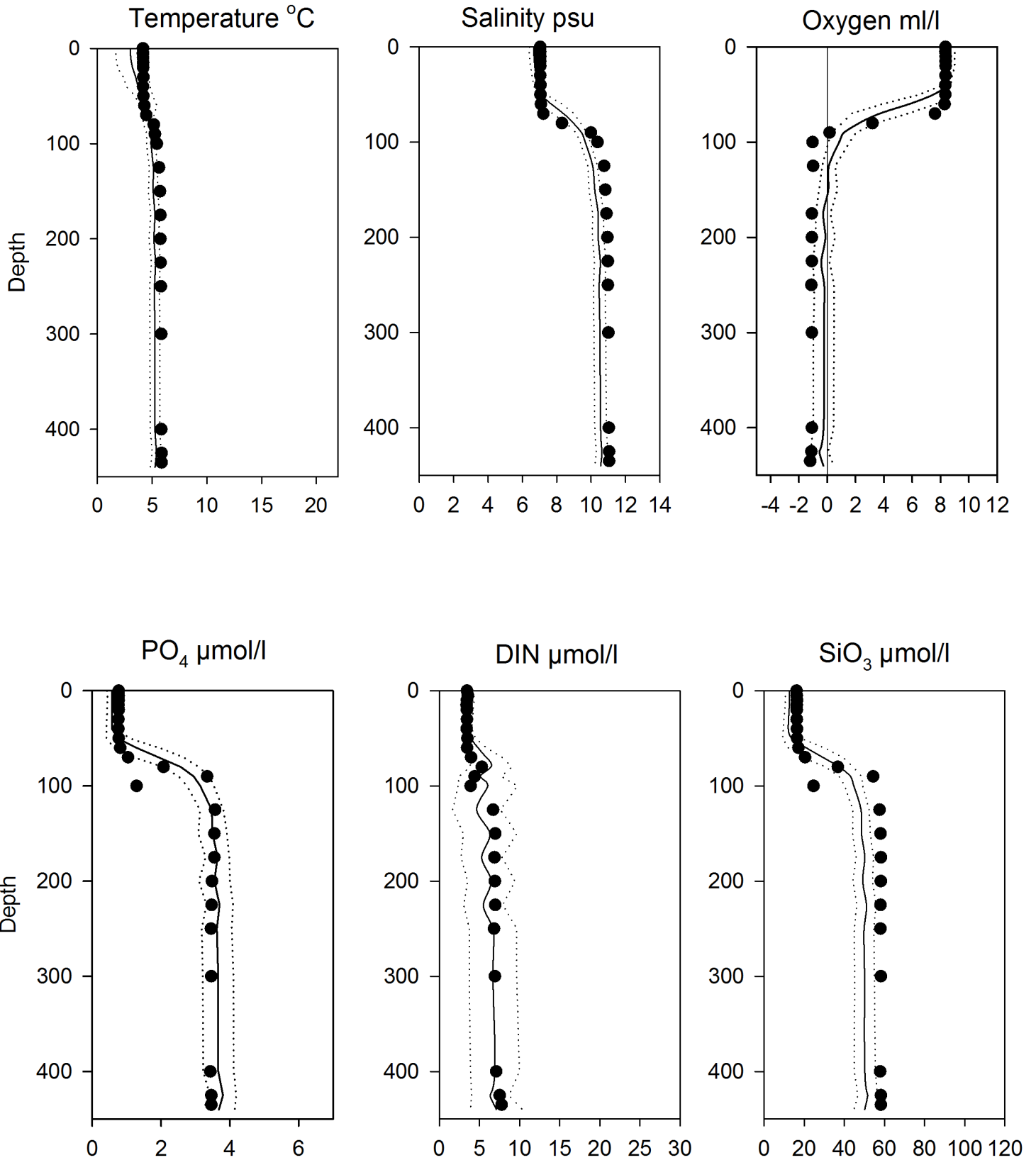


OXYGEN IN BOTTOM WATER (depth = 440m)



Vertical profiles BY31 January

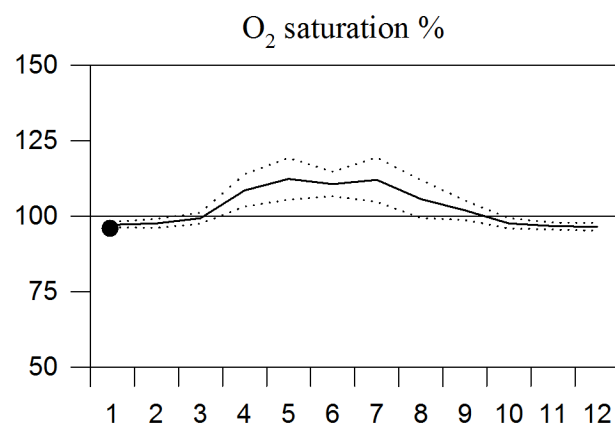
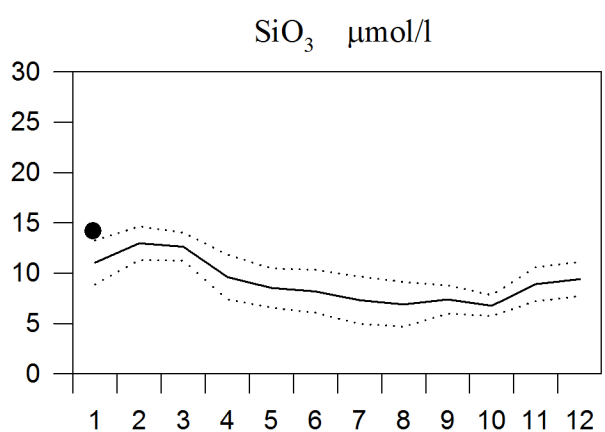
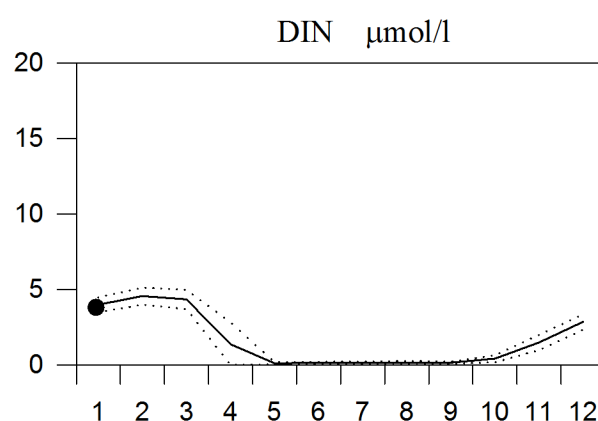
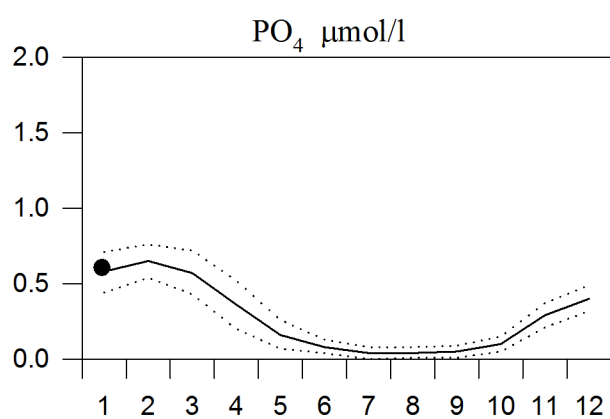
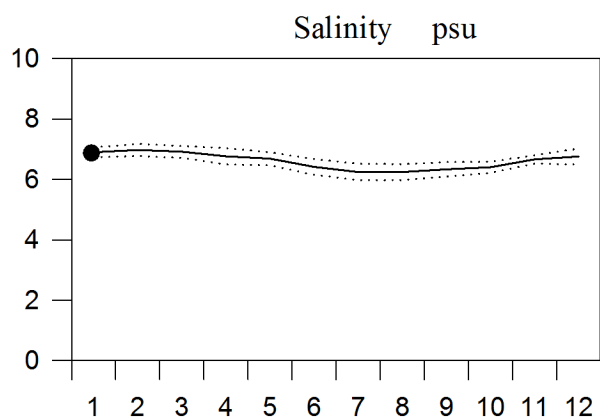
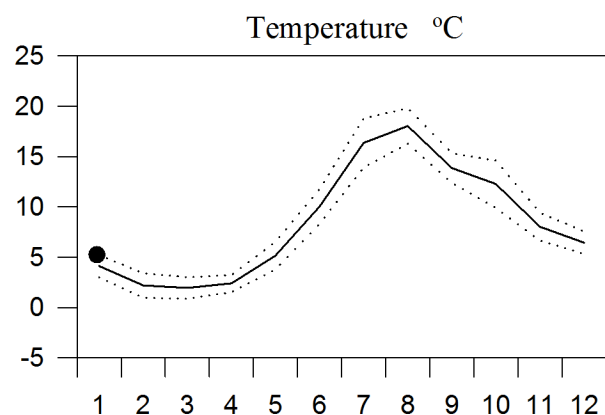
— Mean 1996-2010 St.Dev. ● 2016



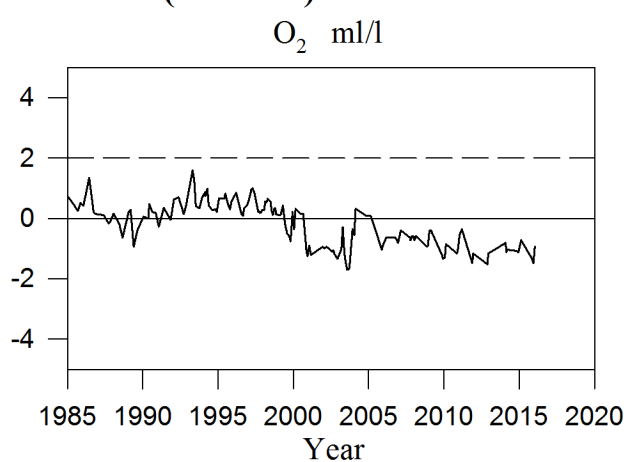
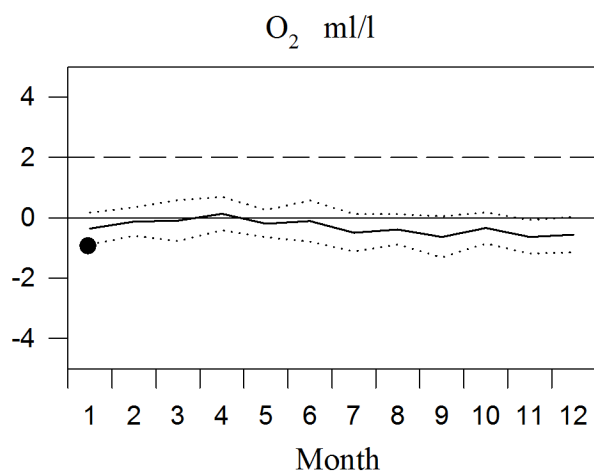
STATION BY29 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2016



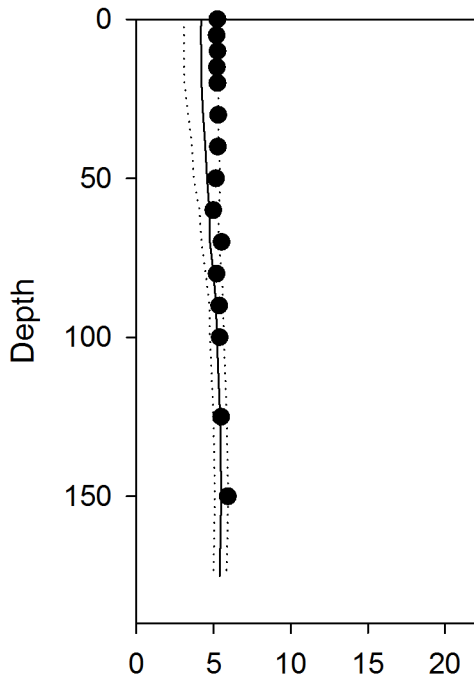
OXYGEN IN BOTTOM WATER (>=150m)



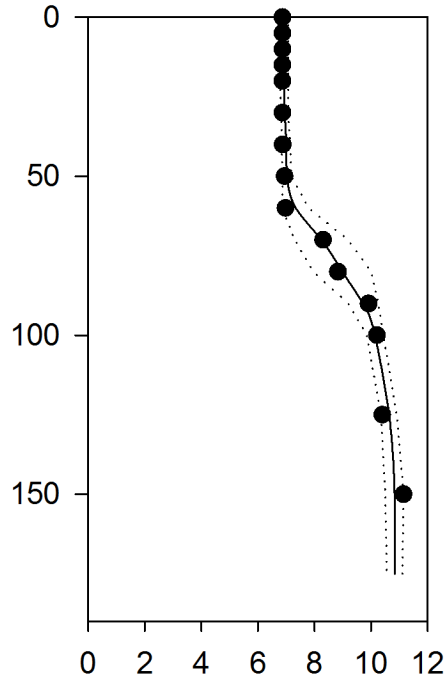
Vertical profiles BY29 January

— Mean 1996-2010 St.Dev. ● 2016

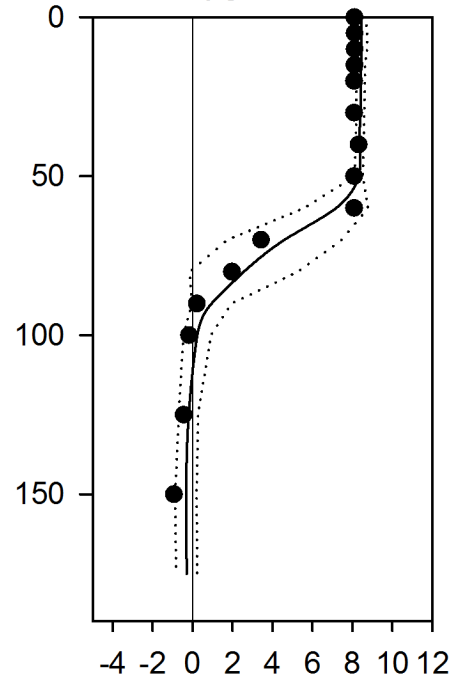
Temperature °C



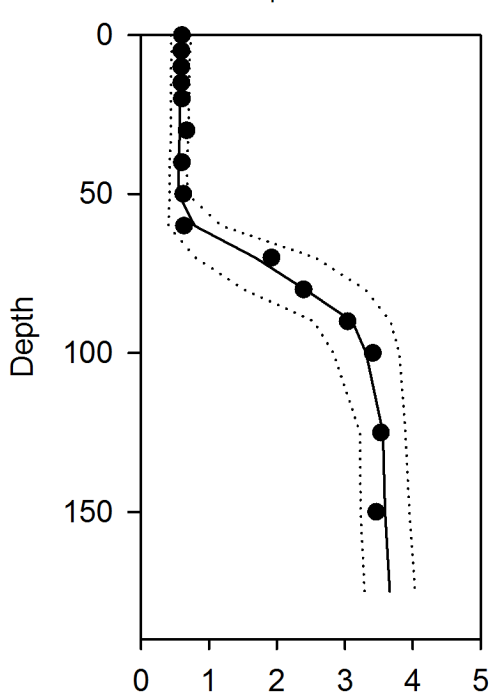
Salinity psu



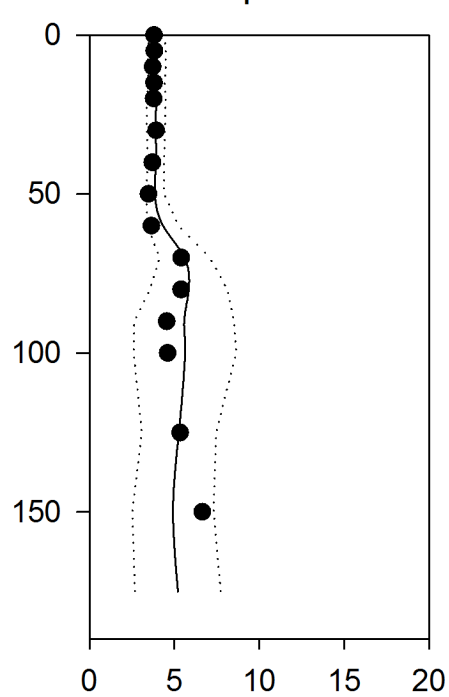
Oxygen ml/l



PO₄ μmol/l



DIN μmol/l



SiO₃ μmol/l

