

## Report from the SMHI monitoring cruise with R/V Aranda



**Survey period:** 2016-03-15 - 2016-03-22  
**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. 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 spring bloom had started in the Skagerrak, Kattegat and in the south western parts of Baltic Proper. Inorganic nitrogen was completely exhausted down to 10 meters in the south western parts of Baltic Proper. The concentration of phosphate in the Baltic Proper surface water, that has previously been elevated, had now decreased to normal values for the season. Concentrations of silicate were however still elevated in the Western- and Eastern Gotland Basin.

At the Gotland Deep, no hydrogen sulphide was measured in the deep water but very low concentrations of oxygen were observed; only 1.02 ml/l was observed at 225 meters which is a decrease with 0.5 ml/l since February. In the Western Gotland Basin, anoxic conditions occurred at depths exceeding 90 meters. In the Hanö Bight, acute hypoxia was observed nearest the bottom. Bottom water with high oxygen levels was observed at the south western and southern parts of the Baltic Proper.

The next monitoring cruise is scheduled to start on the 18<sup>th</sup> of April.

## PRELIMINARY RESULTS

The cruise was operated aboard the Finnish research vessel Aranda. It commenced in Helsinki on February the 15<sup>th</sup> March and ended in the same port on 22<sup>nd</sup> March. The winds during the expedition were mainly weak and from south west. Air temperatures ranged between 0 and +5 ° C.

Scientists from Lund university participated the cruise to collect water samples for analyse of silicate isotopes. Also, scientists from SYKE were on board to intercalibrate, compare the analyse results, between SMHI and SYKE.

### The Skagerrak

The temperature of the surface water was normal for the season and varied between 4 and 5°C, lowest near the coast. The salinity in the open sea Skagerrak surface layer was normal for the season and below normal at the coast, the salinity ranged between 16.7 and 31.6. The stratification, both the thermocline and the halocline, was well developed and was observed at 10-20 meters in the open sea and more shallow near the coast.

The spring bloom was ongoing and all nutrients were almost exhausted down to 5 meters in the entire Skagerrak. In the surface water, the phosphate levels were in the interval from the detection limit (<0.02 µmol/l) – 0.06 µmol/l, inorganic nitrogen (nitrite + nitrate) at the detection limit (0.1µmol/l) while silicate varied from the detection limit (0.1 µmol/l) in the open sea to 0.8 µmol/l near the coast. The bottom water was well saturated with oxygen, also at Släggö in the mouth of the Gullmarn Fjord. Fluorescence measurements showed high biological activity in the surface water. 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 3.7 and 4.5 °C. The surface salinity was lower than normal and varied between 17.2 – 13.0. In the Sound, the salinity was around 9 which is also lower than normal. A strong stratification at 5-10 meters was observed in the northern part while it was observed deeper in the southern part, at 15 meters. A strong stratification was seen at 10-15 meters in the Sound.

The spring bloom was ongoing in the entire Kattegat and the Sound, which is normal for the season and all nutrients in the surface water had decreased since February. Levels of phosphate were between 0.08 and 0.12 µmol/l, the sum of nitrite+nitrate was below detection limit (<0.1 µmol/l), and silicate varied between 1.0 and 2.3 µmol/l. The levels of phosphate were a bit higher in the Sound, 0.29 µmol/l.

The oxygen condition in the deep water was good and the lowest concentration was observed in the Sound, 5.06 ml/l. Fluorescence measurements showed high biological activity especially at Anholt E.

### Baltic Proper

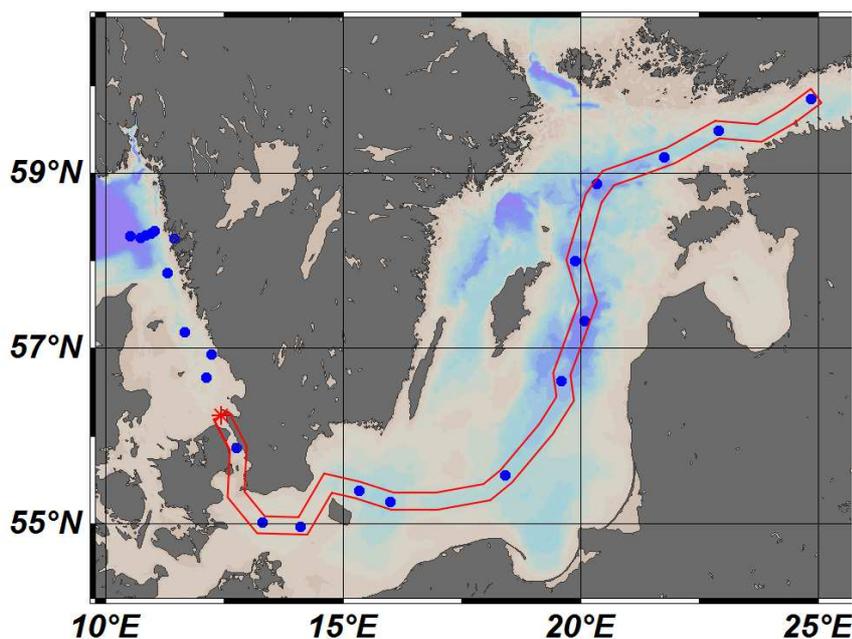
The temperature in the top layer was a bit higher than normal in the entire area and varied from 2.4°C till 4.2°C. Surface salinity was also generally elevated in the area and varied between 6.4 in the northern part to 8.4 in the south western part. The halocline and thermocline coincided and were found at 50–70 meters depth in the Western Gotland Basin and at 70-80 meters depth in the Eastern and Northern Gotland Basin and the southern parts. A weak and shallow stratification at 10-15 meters were observed in the northern and south western parts.

Close to the bottom in the southern Baltic proper at station BCSIII-10, a thin layer of warmer and saltier water was observed, which also included an increased oxygen content.

The nutrients, mainly phosphate and inorganic nitrogen, were generally lower compared with February. The spring bloom was ongoing in the Arkona- and Bornholm Basins and in the Hanö Bight where inorganic nitrogen were complete exhausted to 10 meters dept. The levels of phosphate in the surface layer, that previously were elevated, had now decreased to normal values for the season in the entire area and varied between 0.47 and 0.71  $\mu\text{mol/l}$ . The levels of nitrite+nitrate were normal in the Eastern- and Western Gotland Basins as well as in the southern parts and varied between 1.2 and 3.0  $\mu\text{mol/l}$ . On the other hand, the levels inorganic nitrogen were below normal in the south western Baltic Proper and below detection limit ( $<0.1 \mu\text{mol/l}$ ). The concentration of silicate was still elevated in the Western- and Eastern Gotland Basins while it was normal in the southern and south western parts. The levels varied between 6.8 and 17.4  $\mu\text{mol/l}$ .

Acute hypoxia ( $< 2 \text{ ml/l}$ ) was observed from 70 meters at the Fårö Deep and hydrogen sulphide was present from 150 meters depth. In the Eastern Gotland Basin, acute hypoxia was observed at depth below 70-80 meters. At the Gotland Deep (BY15), no hydrogen sulphide was measured in the bottom water but very low concentrations of oxygen were observed. The oxygen level at 225 meters had decreased with 0.5 ml/l to 1.02 ml/l since February. In the Western Gotland Basin complete anoxic condition was observed from 90 meters while acute hypoxia,  $<2 \text{ ml/l}$ , was present from 80 meters. In the Hanö bight acute hypoxia was only observed closest to the bottom. Oxygen rich deep water had reached the south western and southern parts of the Baltic Proper; oxygen levels in the Bornholm basin were 4.28 ml/l at 88 meters and the station BCSIII-10 had 3.14 ml/l at 89 meters. In February, it was acute hypoxia in the Bornholm Basin and lower oxygen levels at BCSIII-10.

Fluorescence measurements showed biological activity in the entire Baltic Proper. For more details on species composition see the separate algal report, AlgaAware.



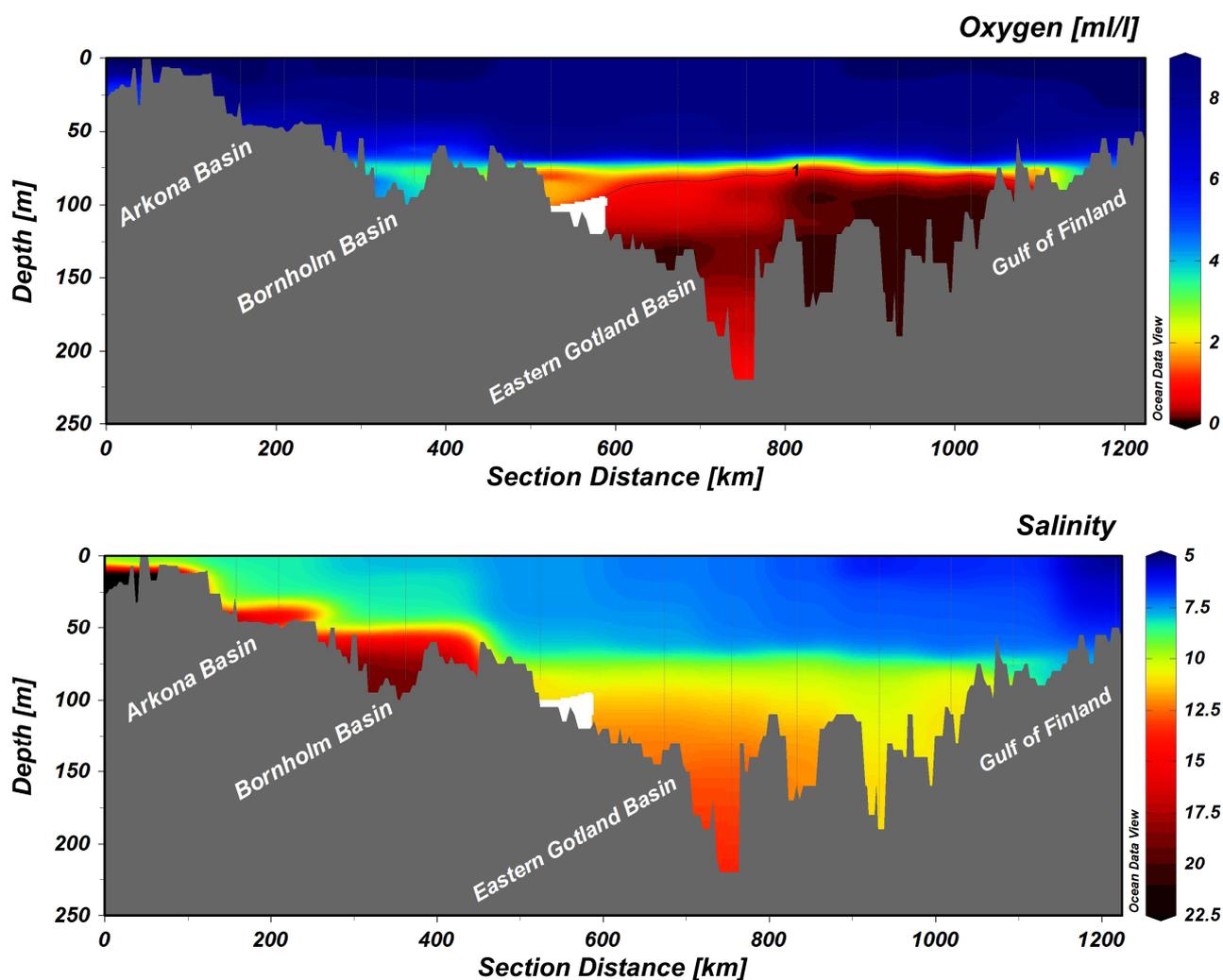


Figure 1. Transect showing the oxygen and salinity from the Sound to the Gulf of Finland.

## PARTICIPANTS

### Name

Örjan Bäck / Karin Wesslander Expeditionsledare  
 Jenny Lycken  
 Johan Kronsell  
 Sari Sipilä  
 Kristin Andreasson  
 Ilkka Lastumäki  
 Jere Riikonen  
 Carla Nantke  
 Zhouling Zhang

### Från

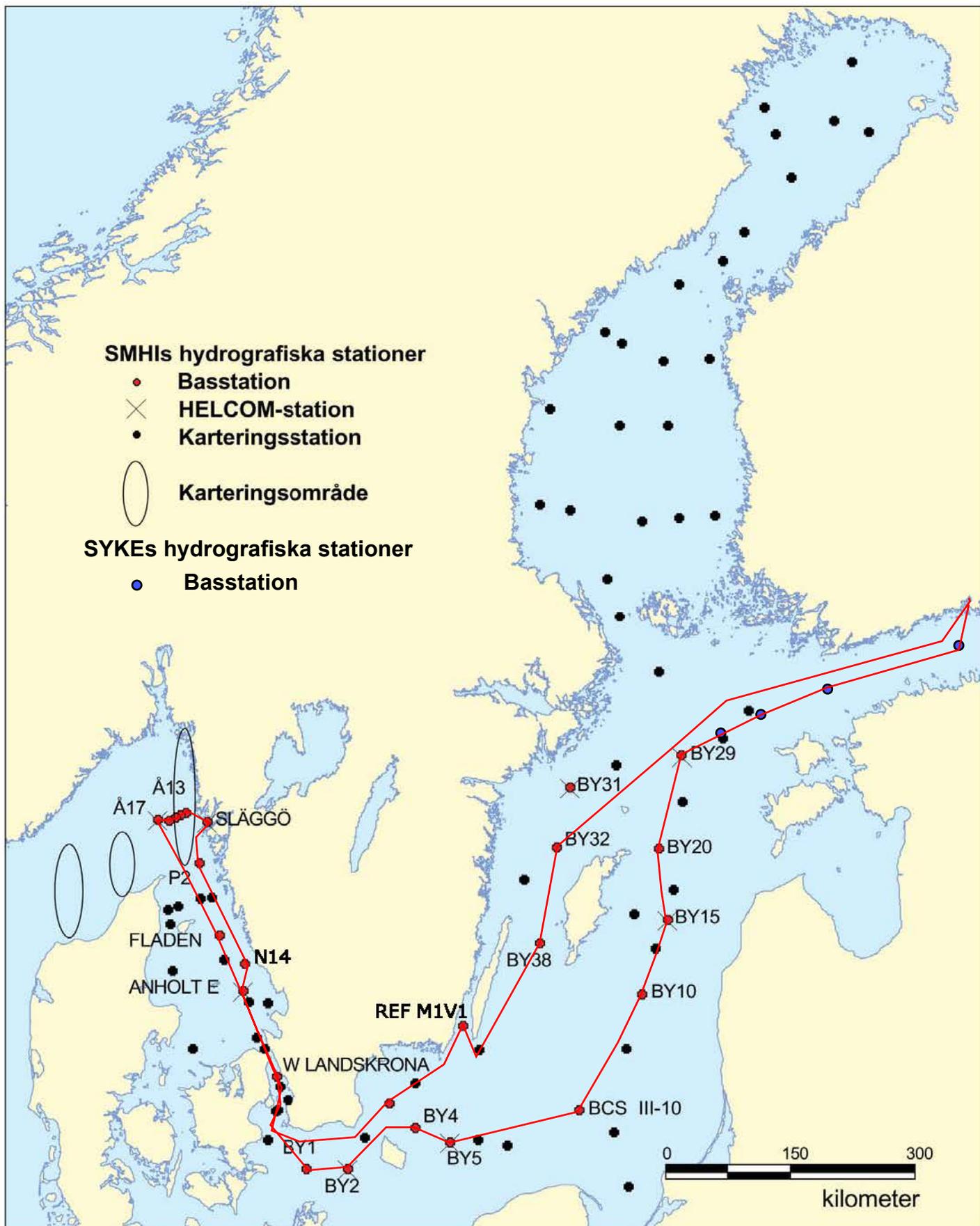
SMHI  
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 SYKE  
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 Lunds universitet  
 Lunds universitet

## 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

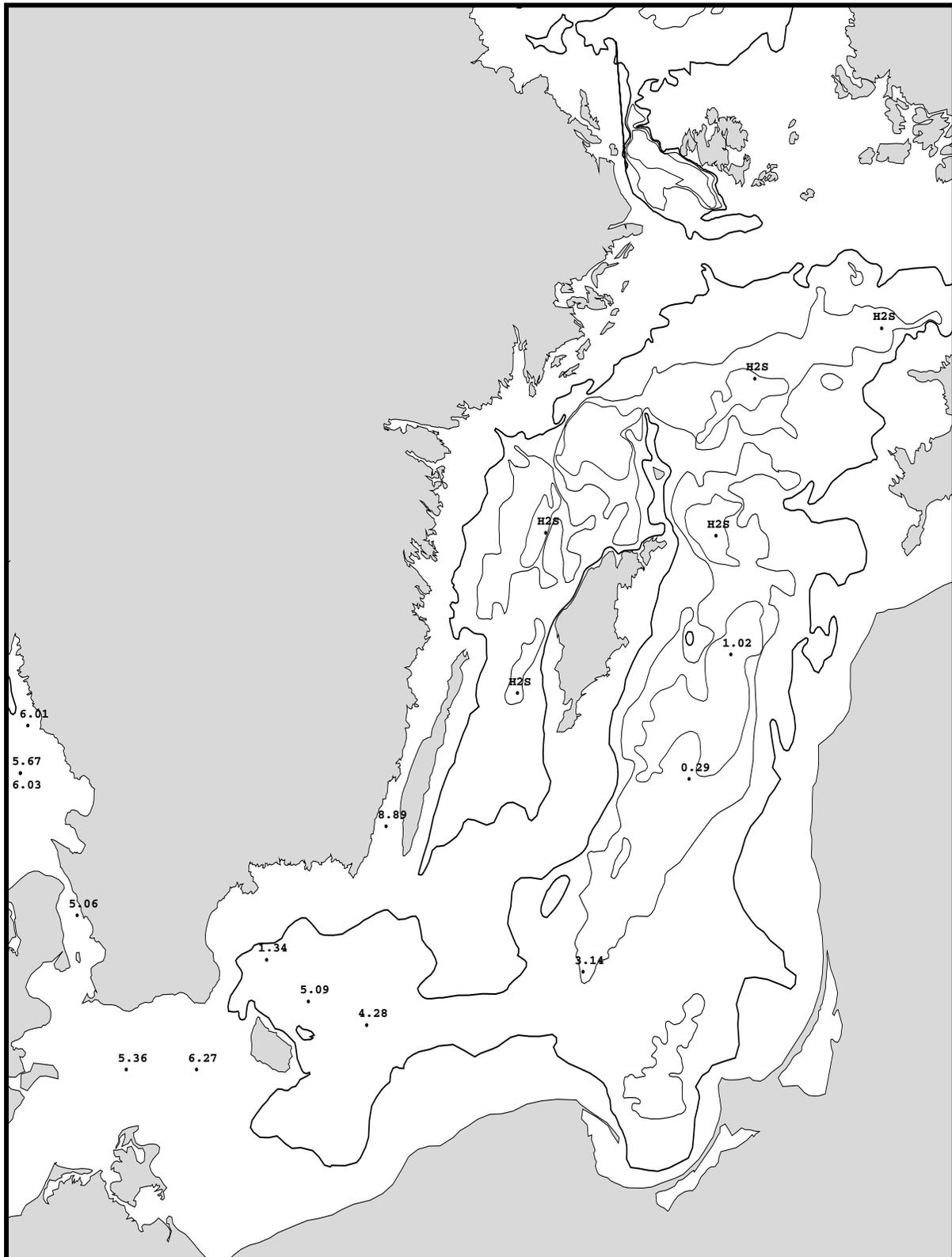
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# Bottom water oxygen concentration (ml/l)

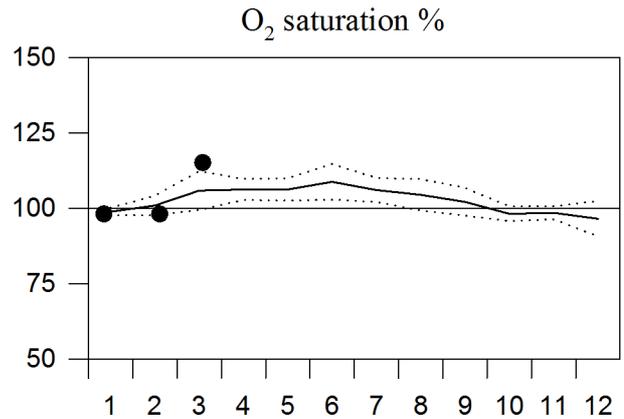
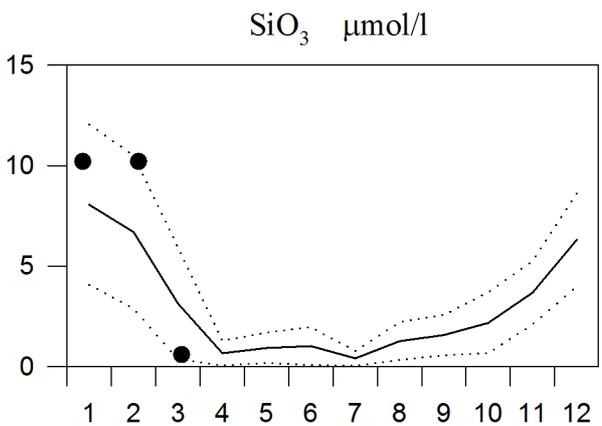
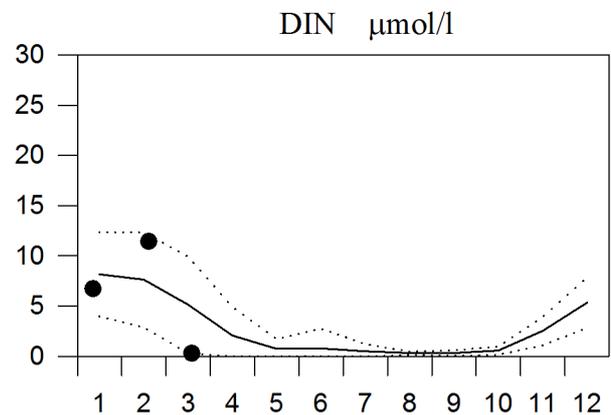
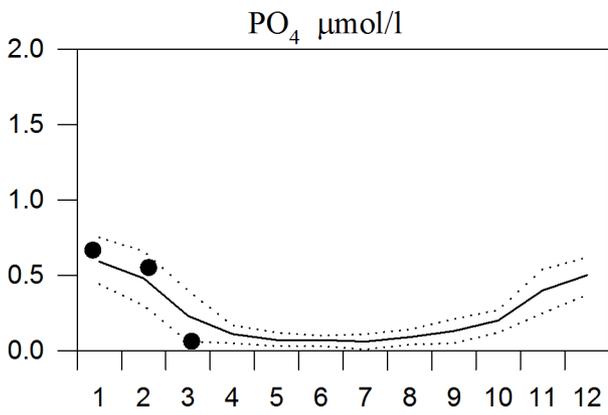
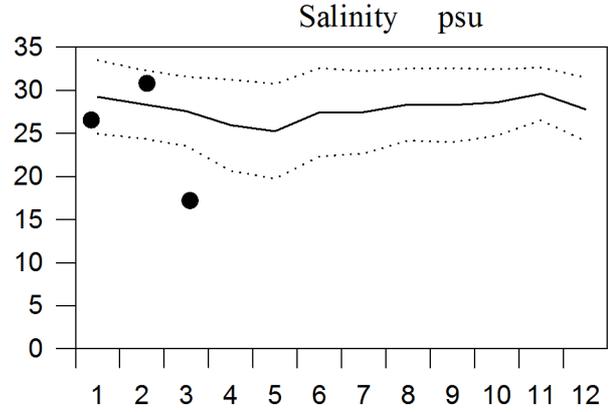
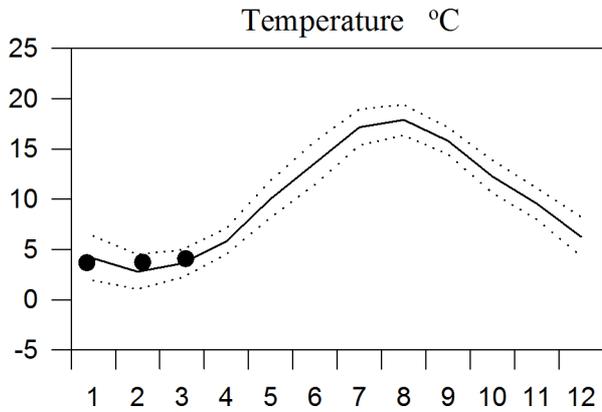
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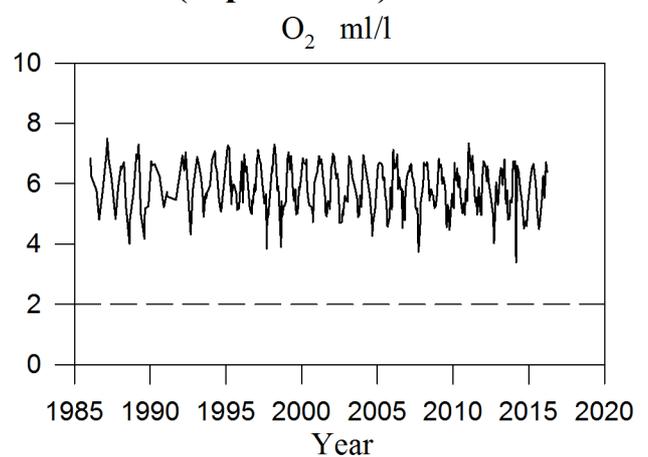
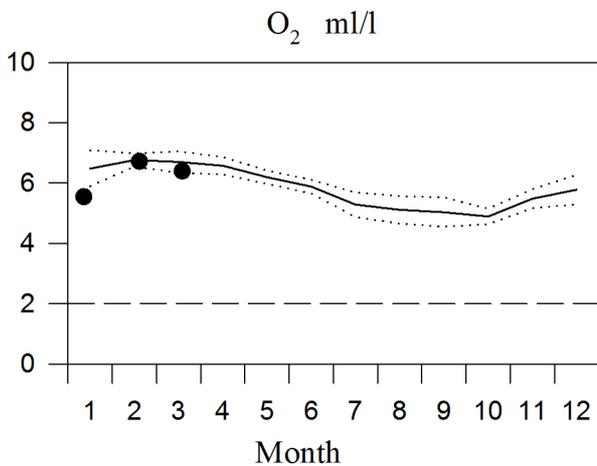
# STATION P2 SURFACE WATER

## Annual Cycles

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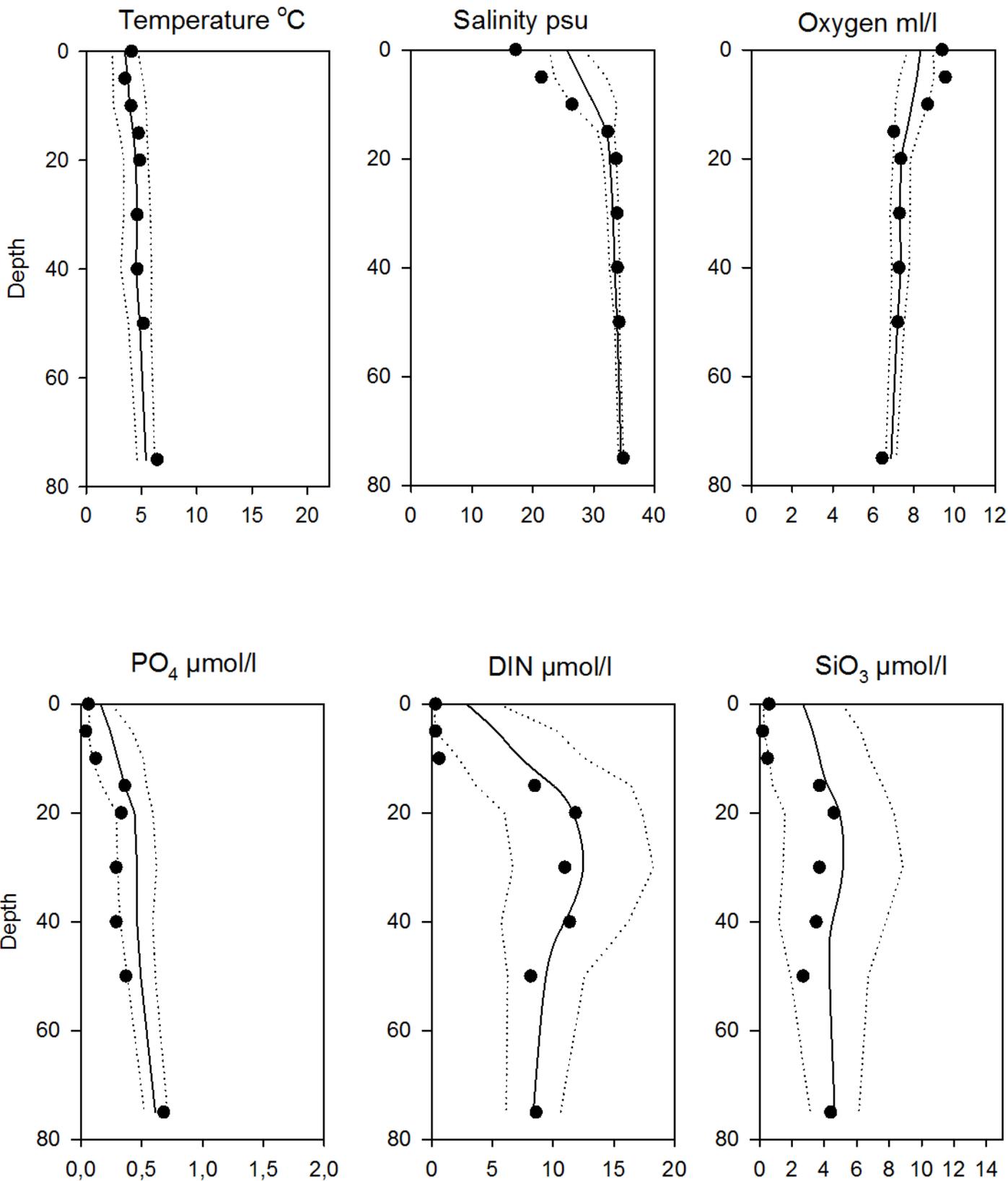


## OXYGEN IN BOTTOM WATER (depth >75m)



# Vertical profiles P2 March

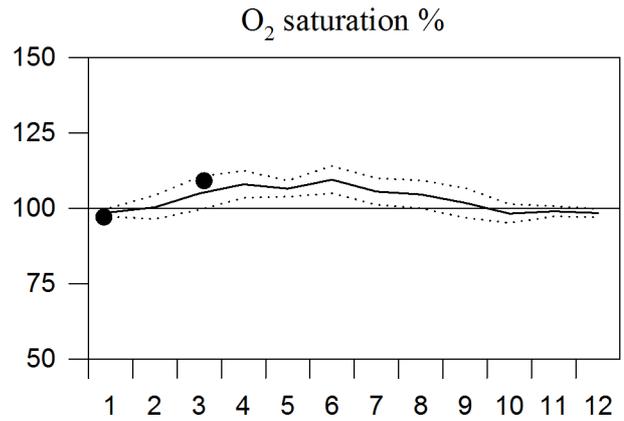
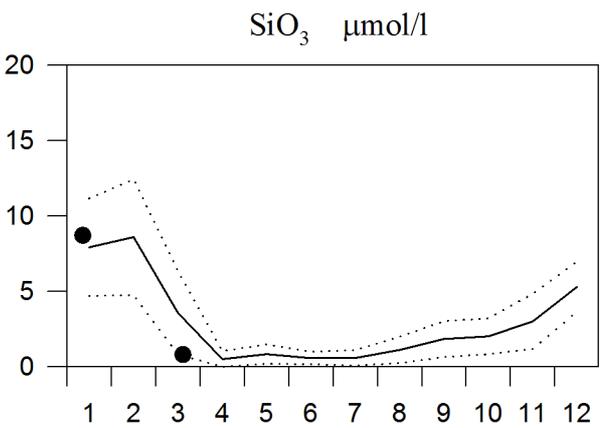
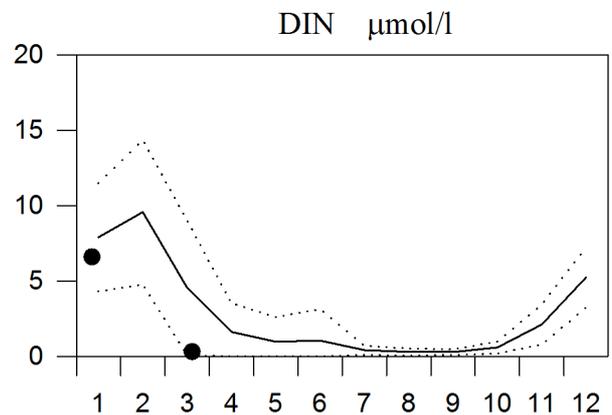
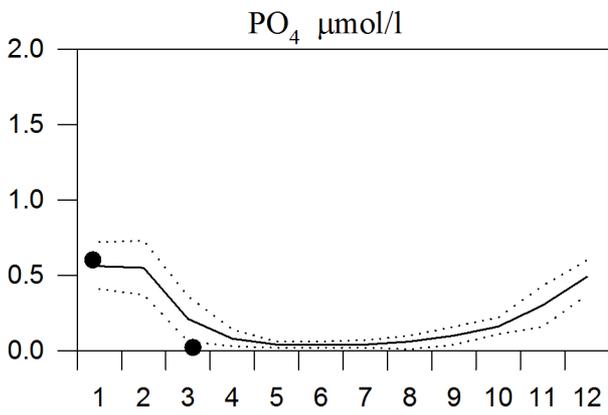
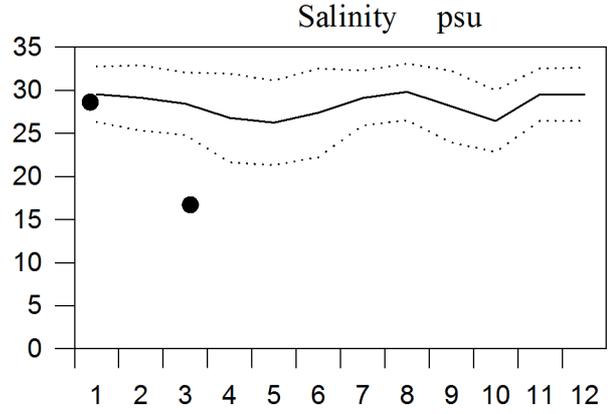
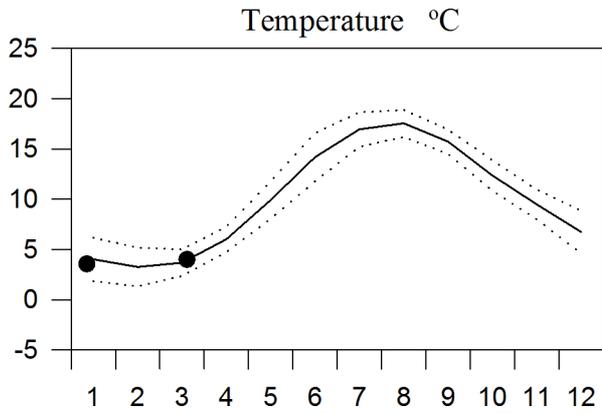
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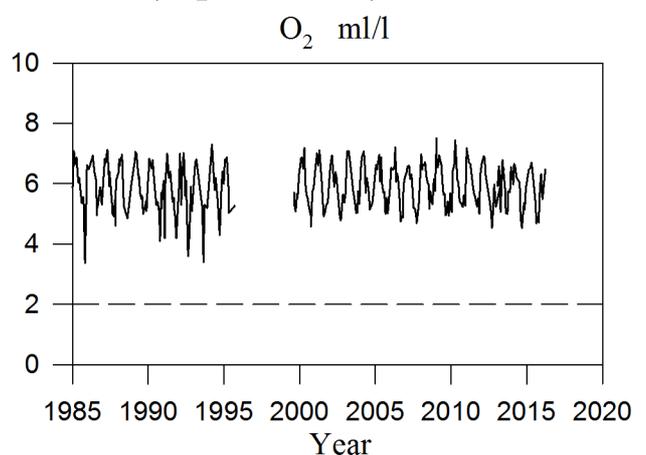
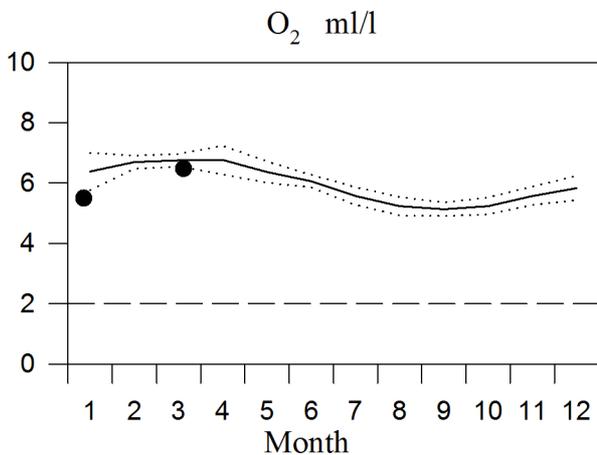
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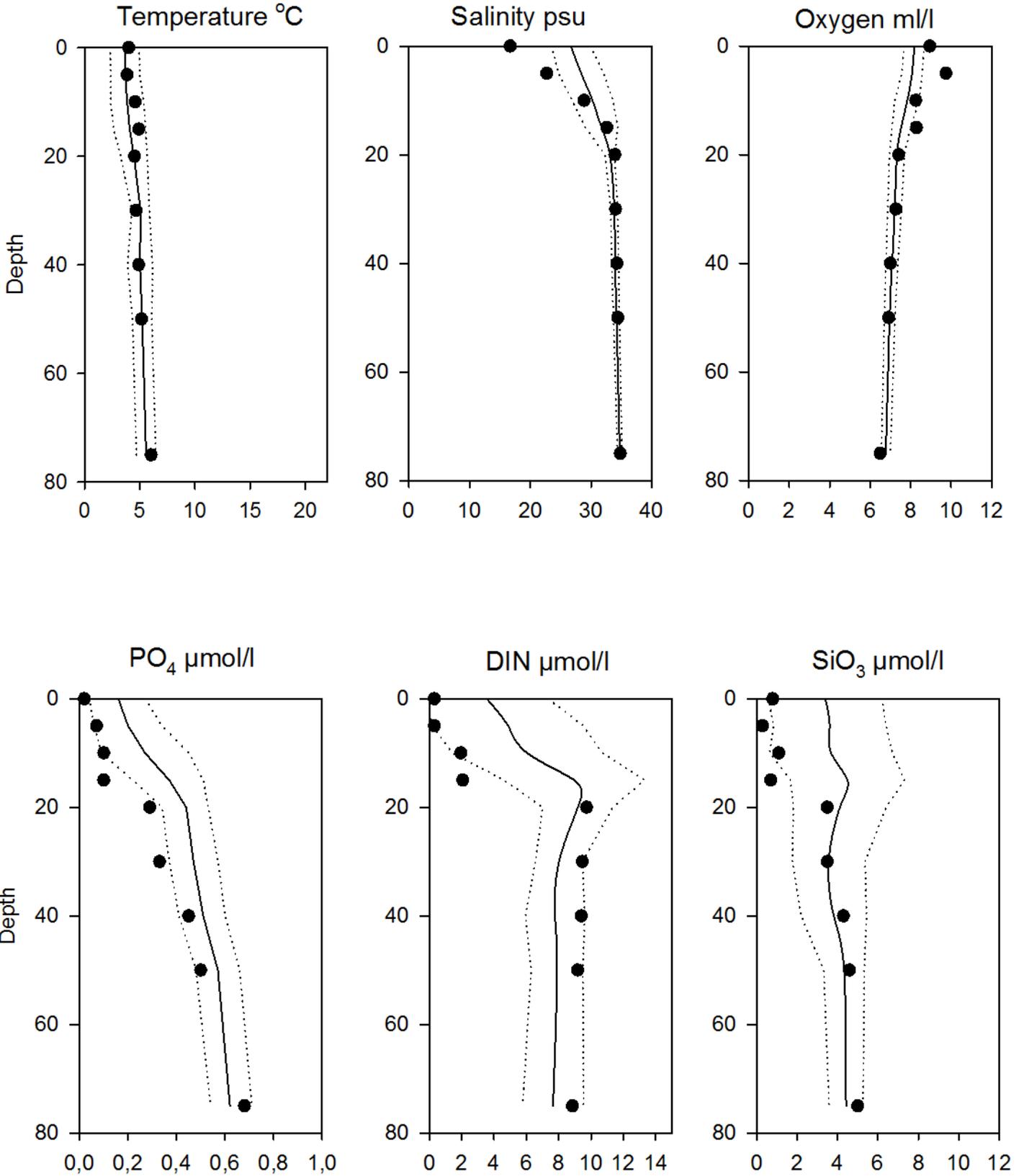


## OXYGEN IN BOTTOM WATER (depth >=75m)



# Vertical profiles Å13 March

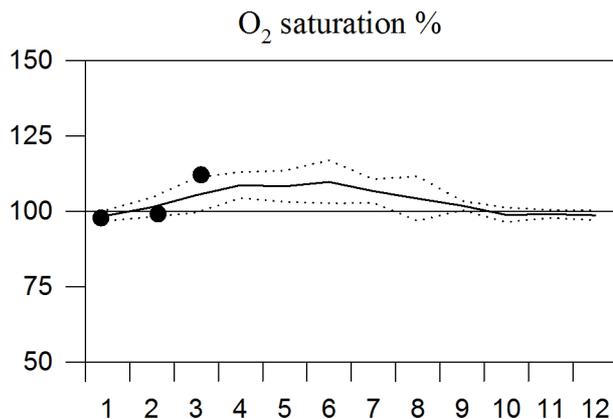
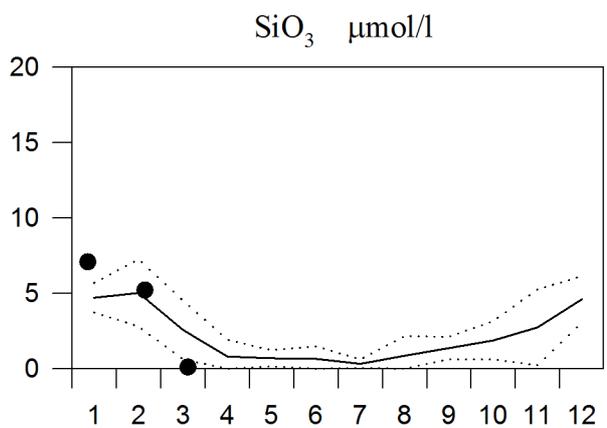
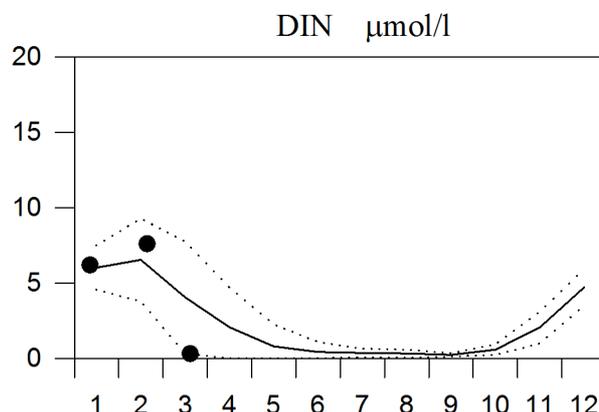
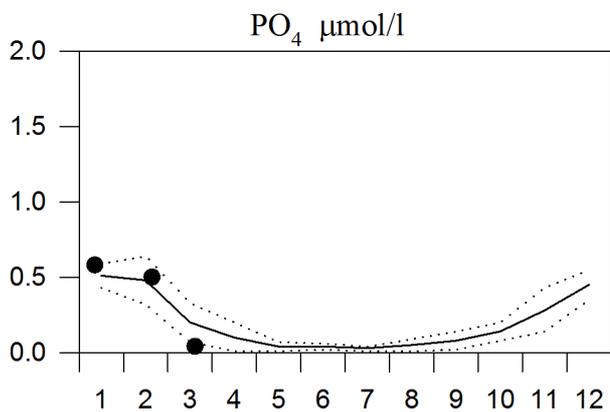
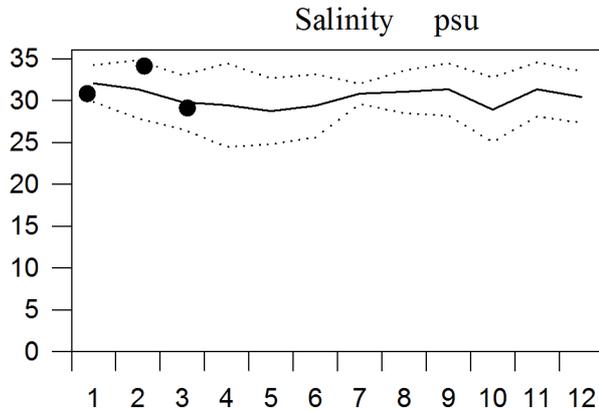
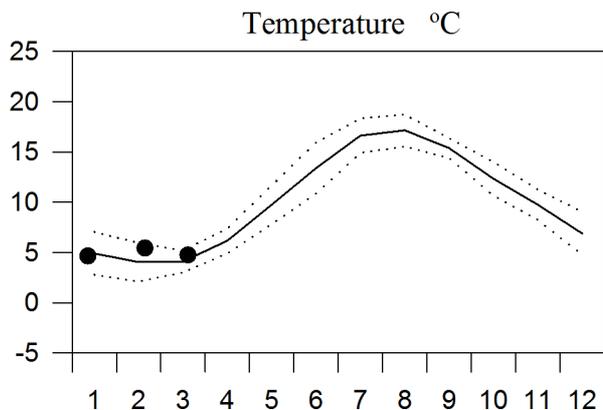
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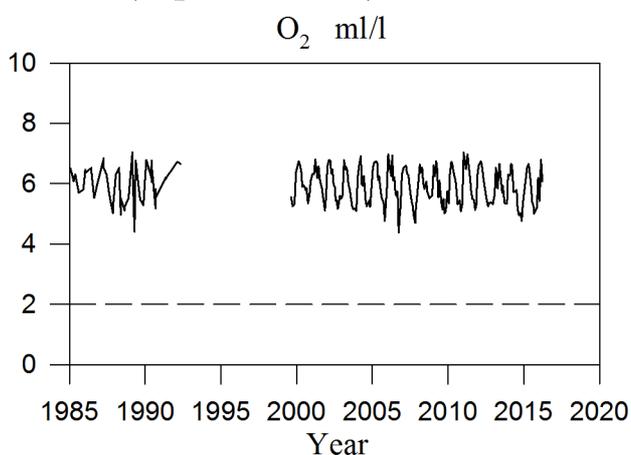
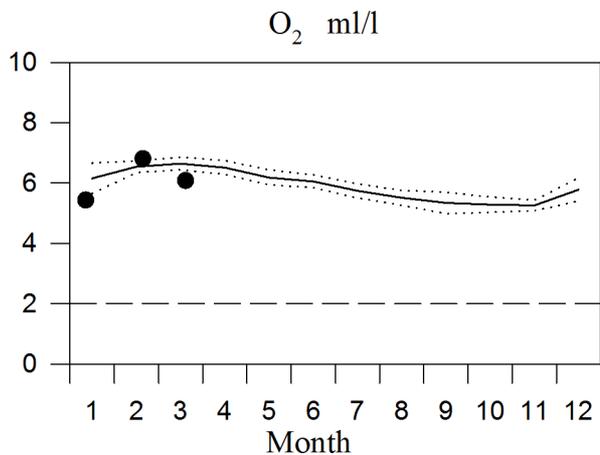
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## Annual Cycles

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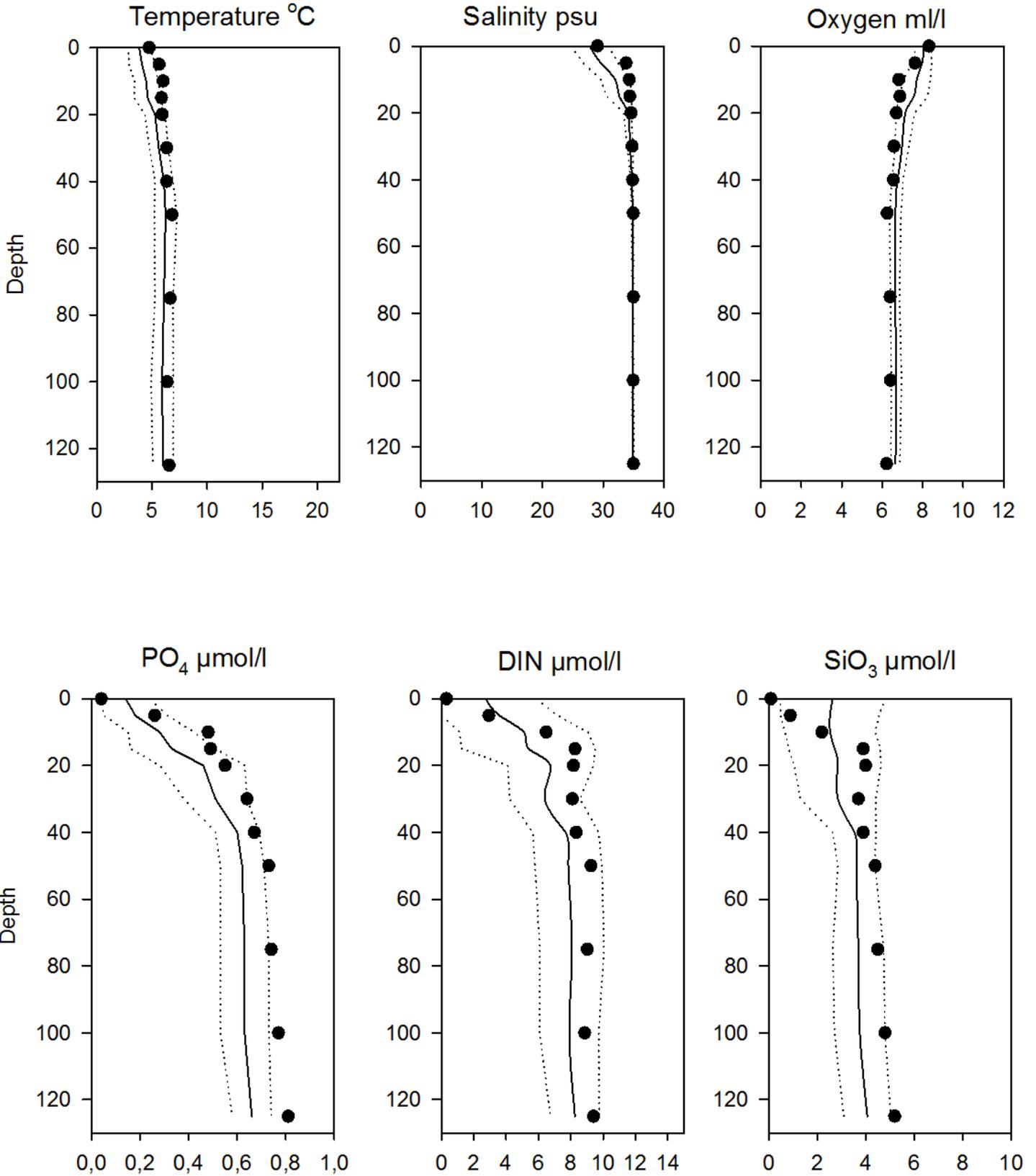


## OXYGEN IN BOTTOM WATER (depth >=125m)



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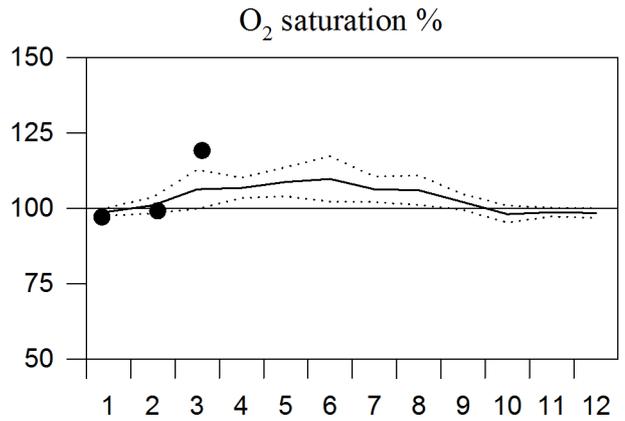
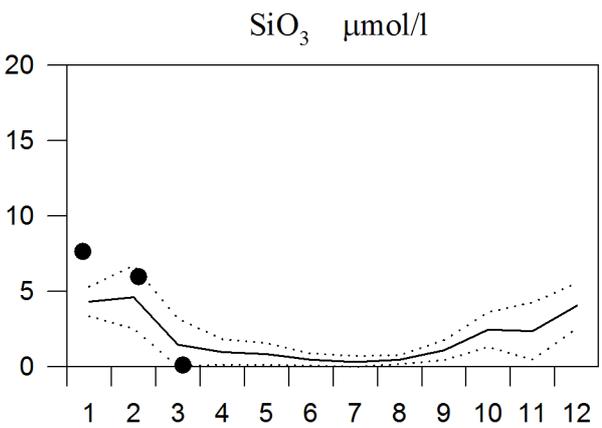
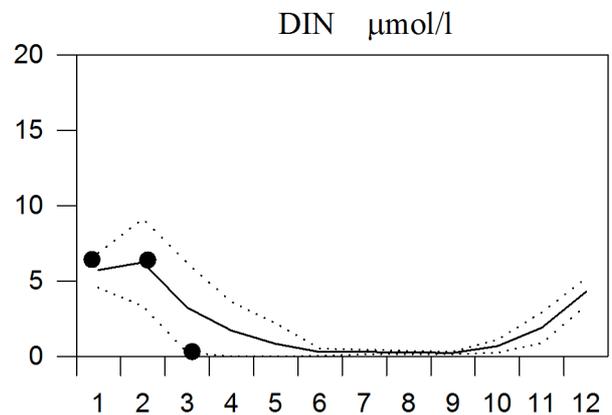
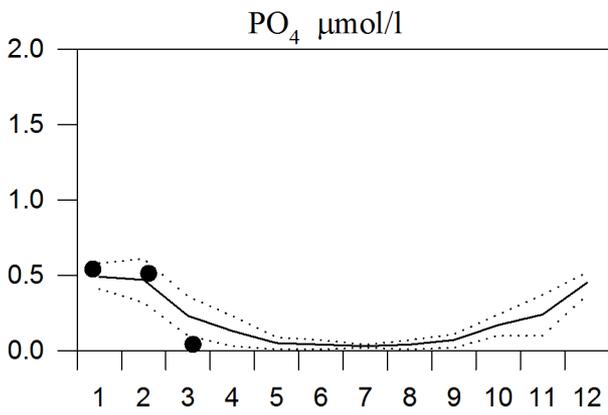
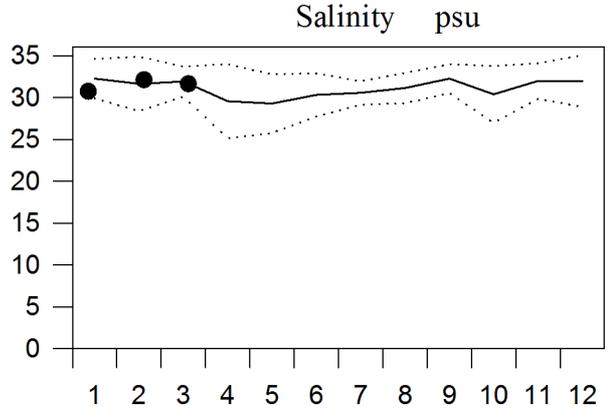
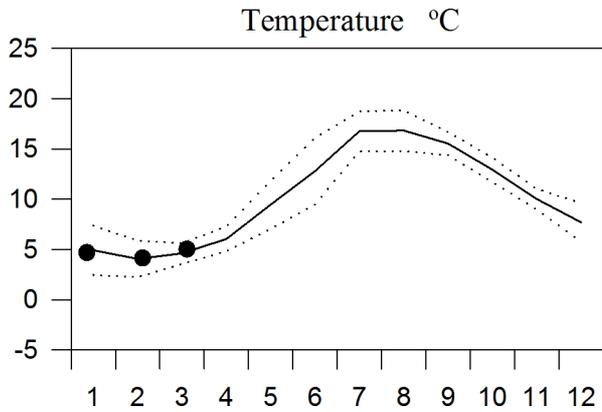
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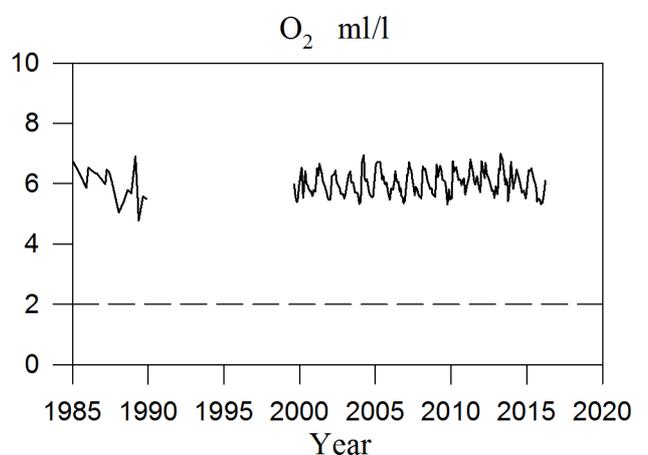
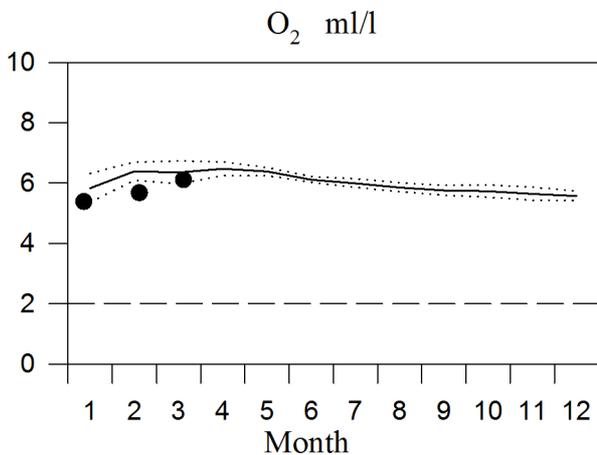
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## Annual Cycles

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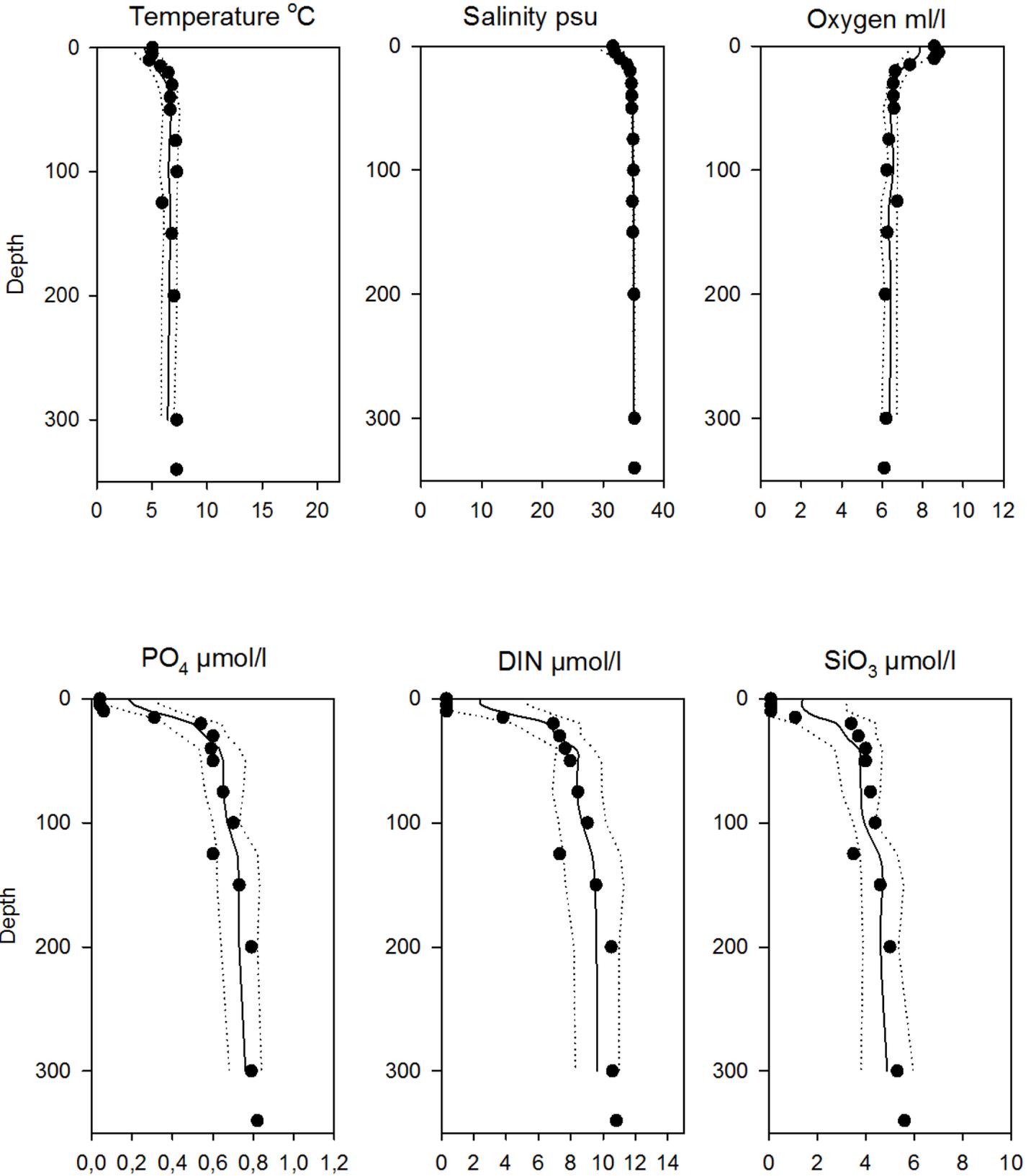


## OXYGEN IN BOTTOM WATER (depth = 300m)



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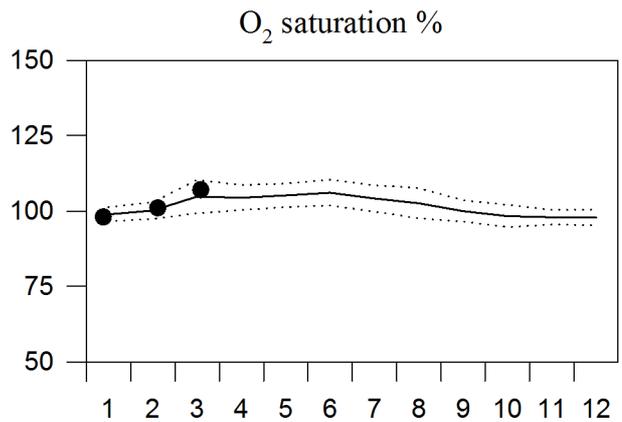
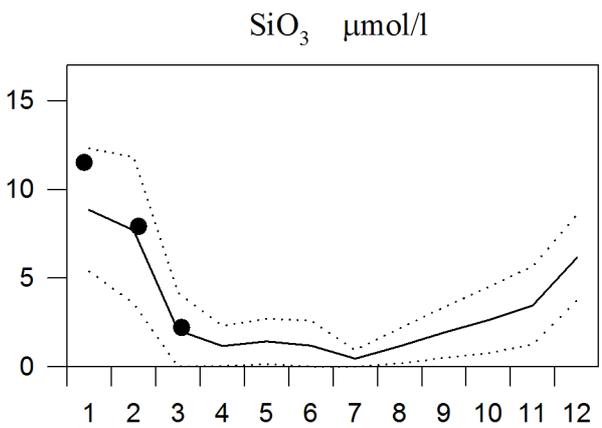
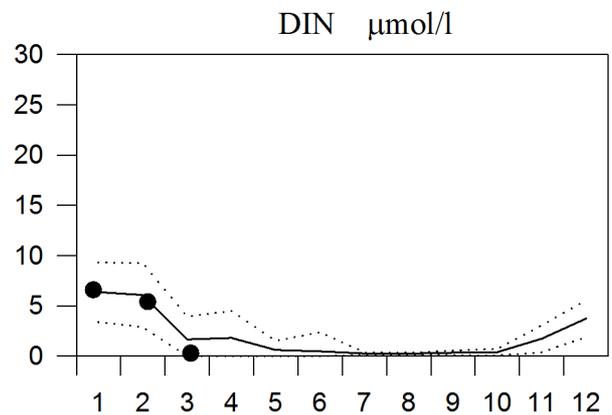
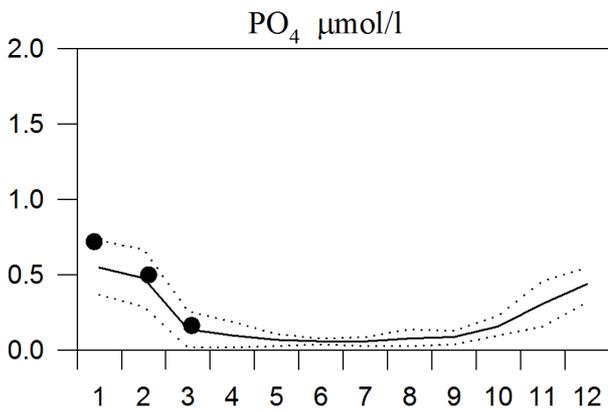
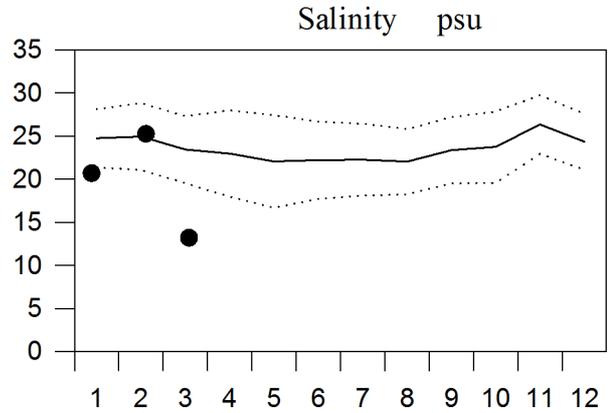
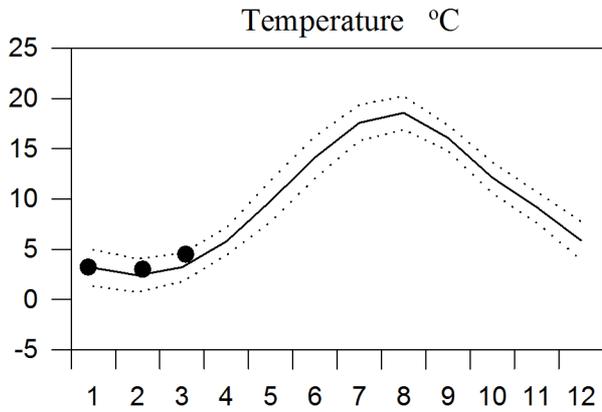
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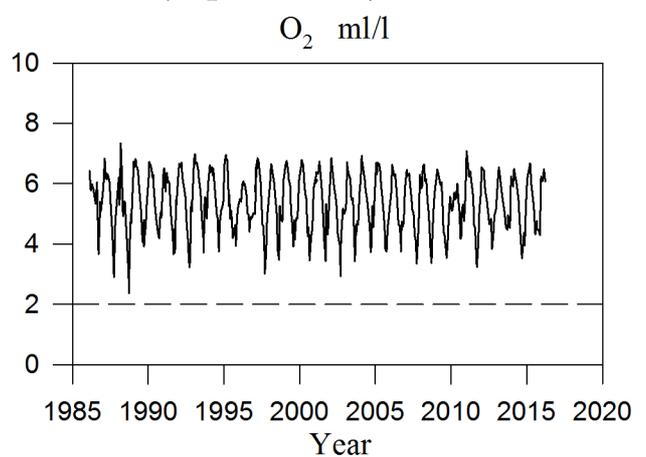
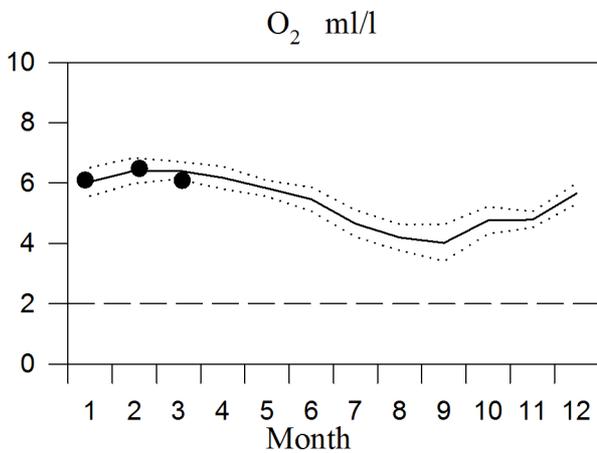
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## Annual Cycles

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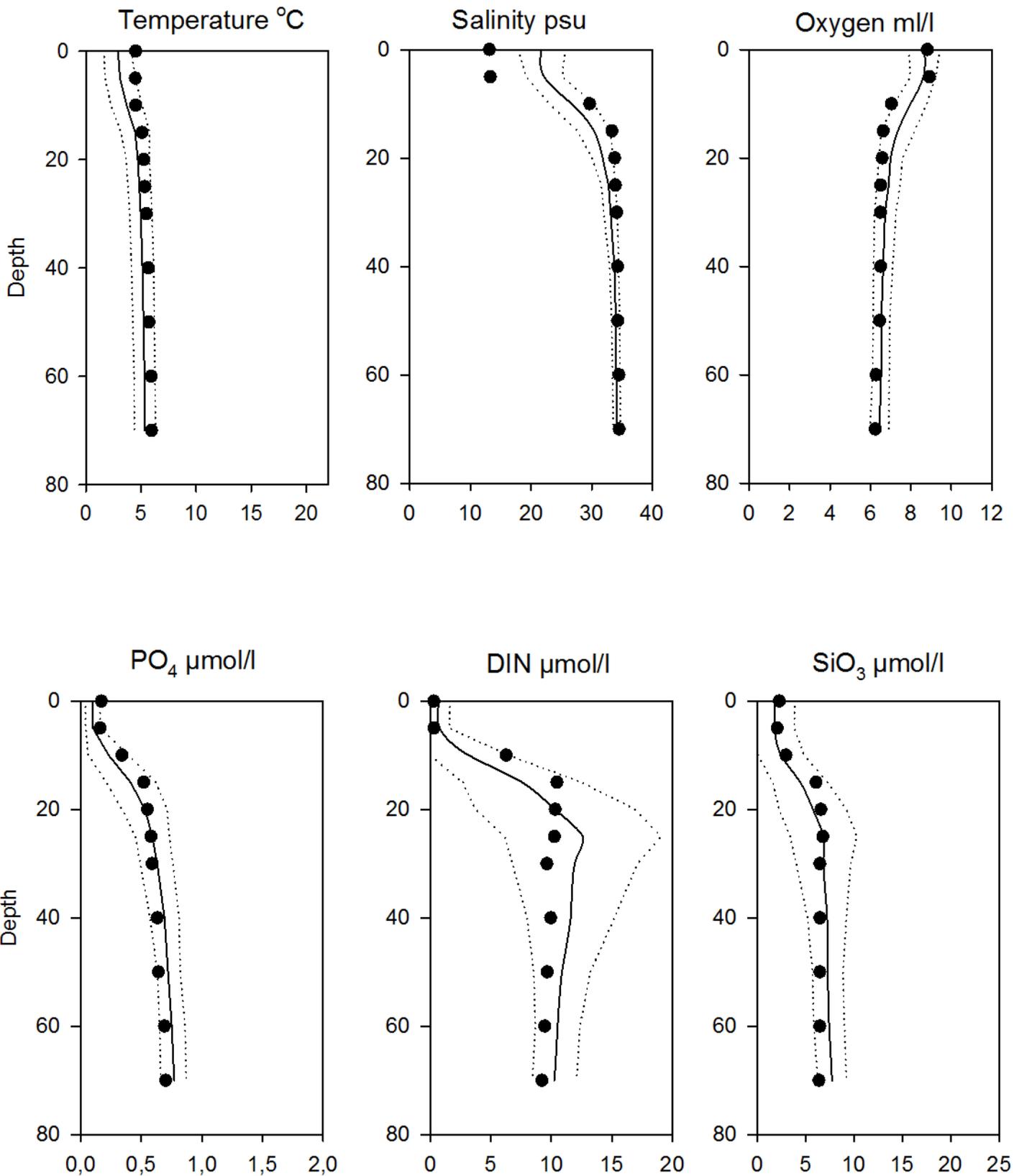


## OXYGEN IN BOTTOM WATER (depth > 70m)



# Vertical profiles Fladen March

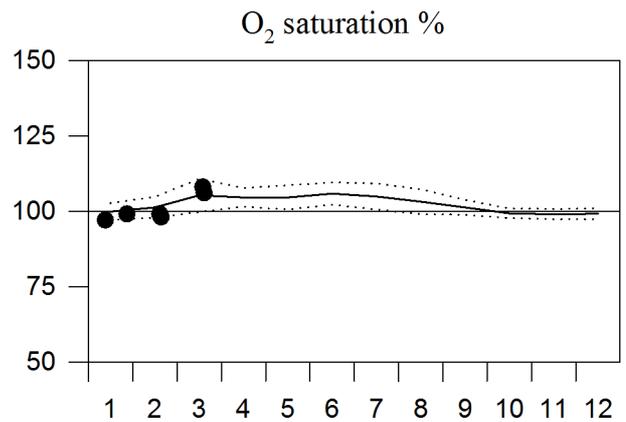
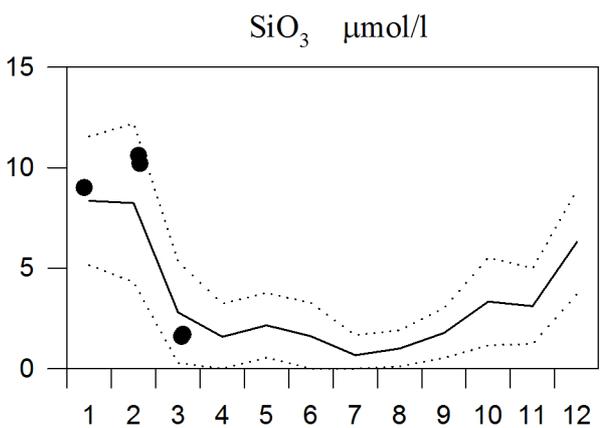
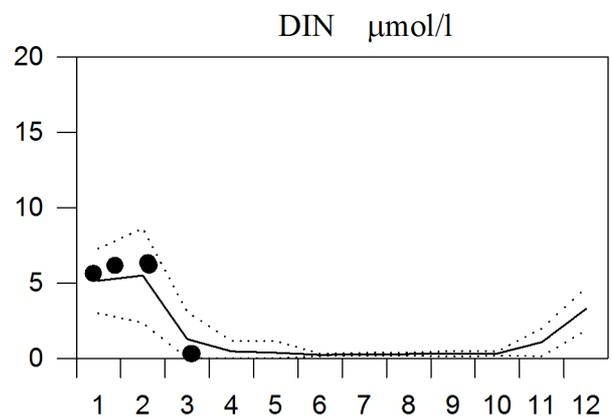
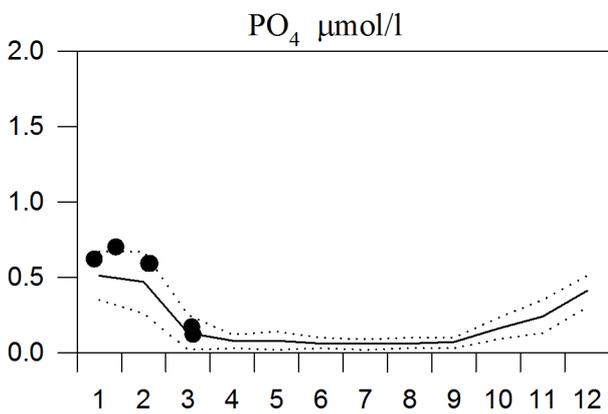
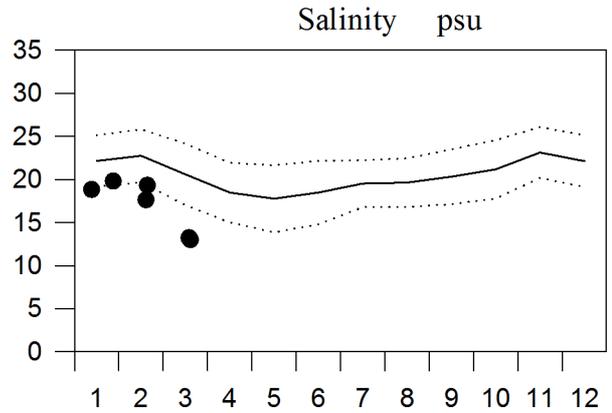
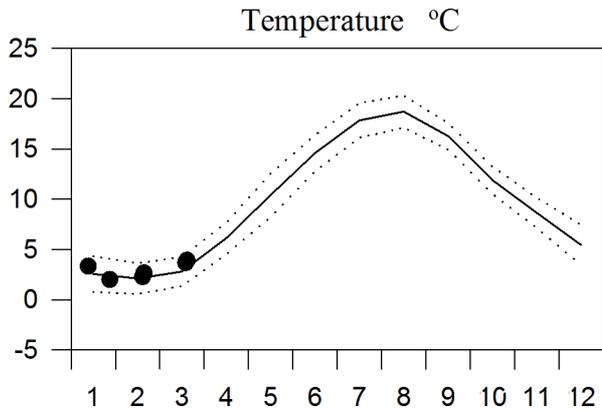
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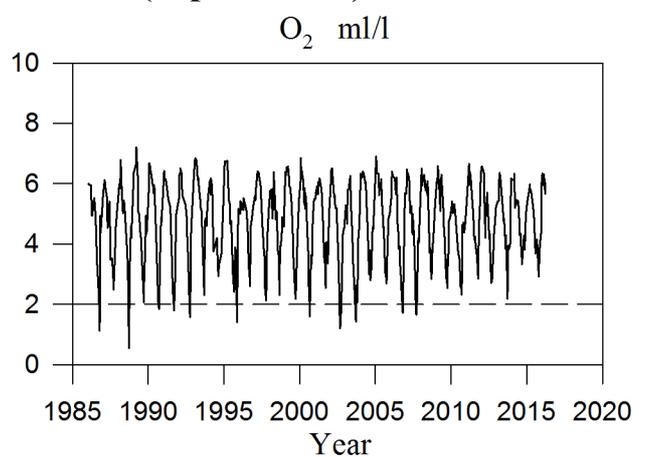
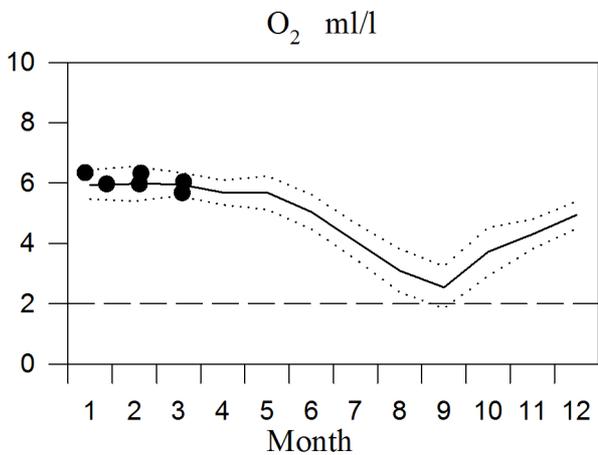
# STATION ANHOLT E SURFACE WATER

## Annual Cycles

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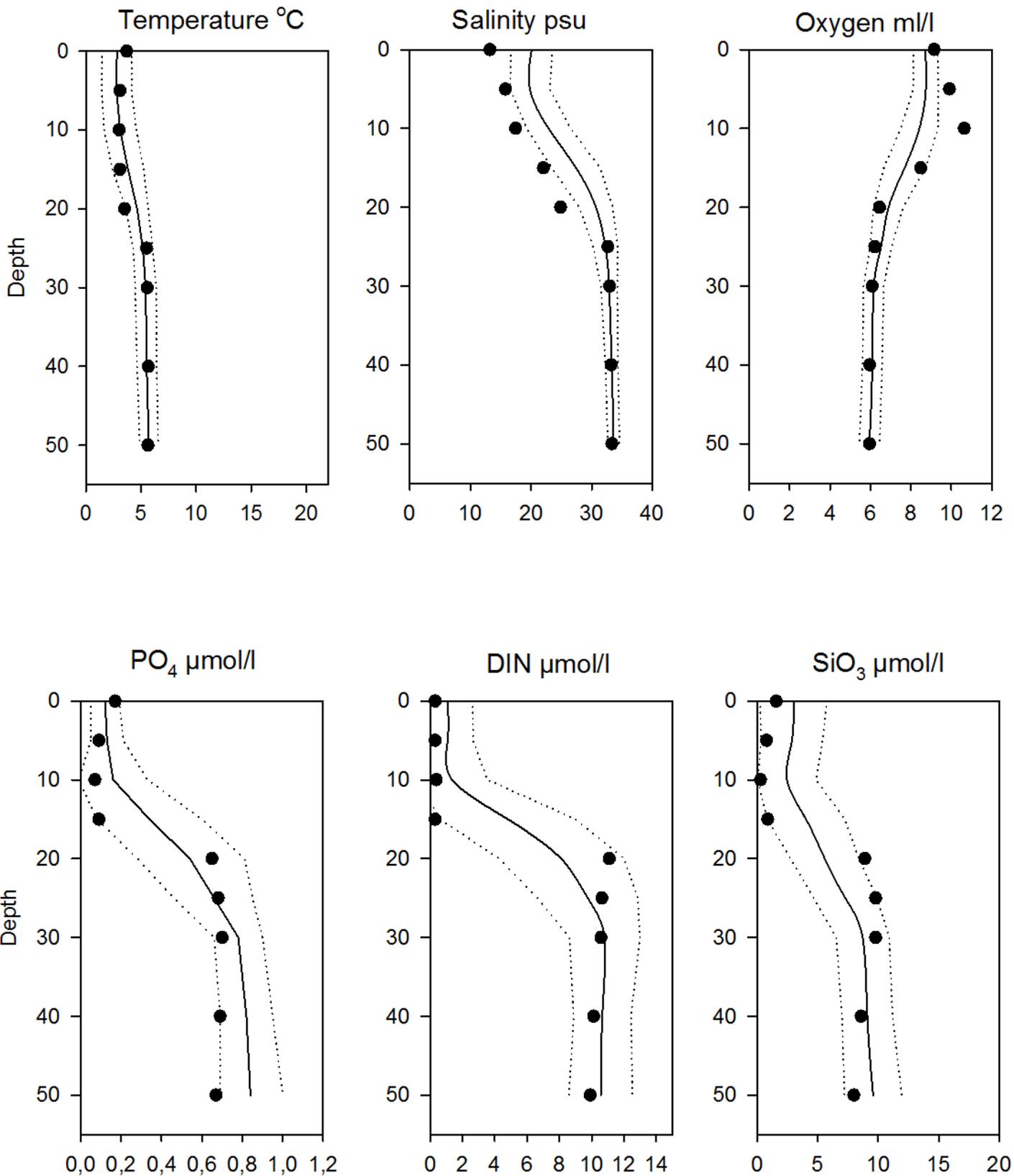


## OXYGEN IN BOTTOM WATER (depth > 50m)



# Vertical profiles Anholt E March

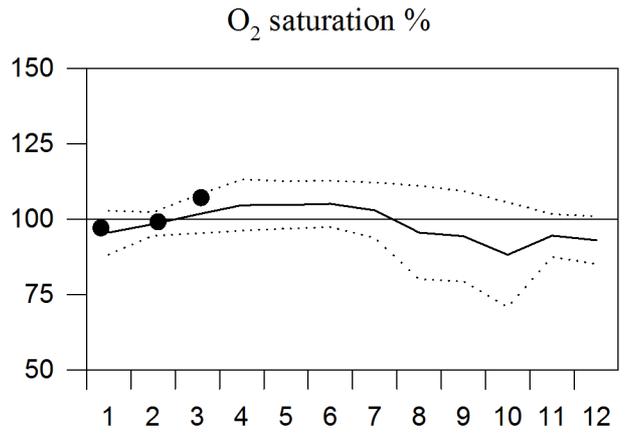
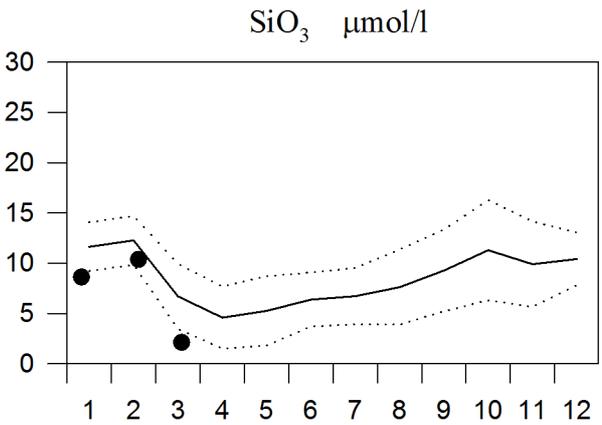
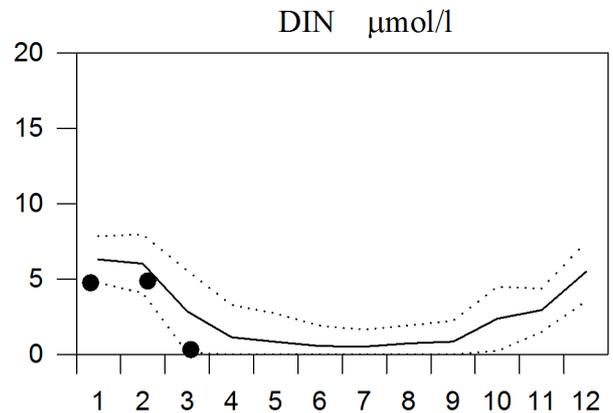
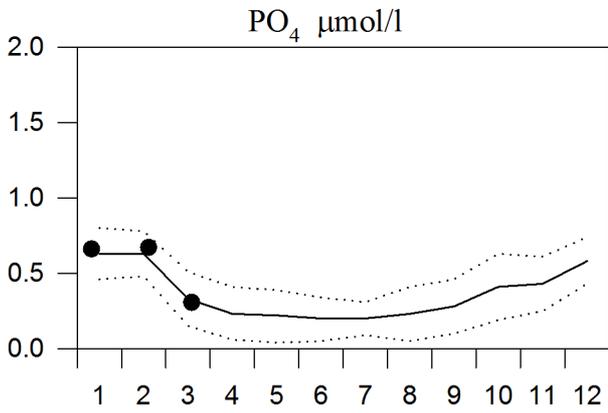
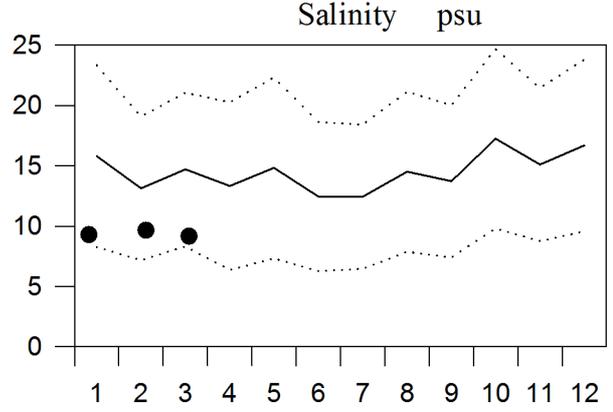
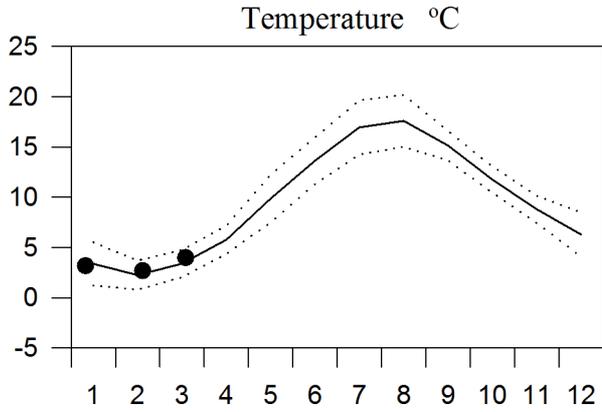
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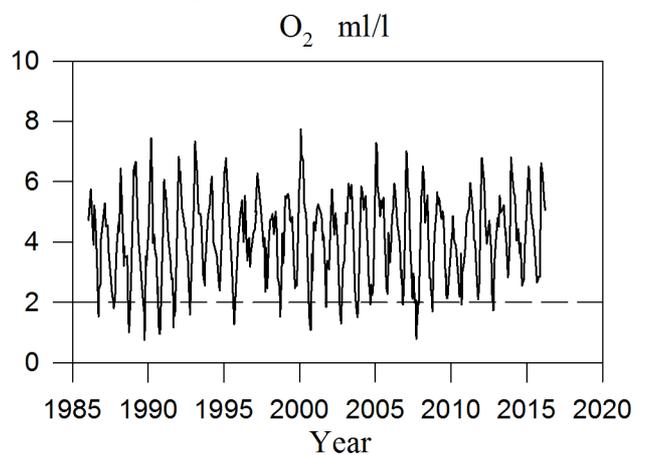
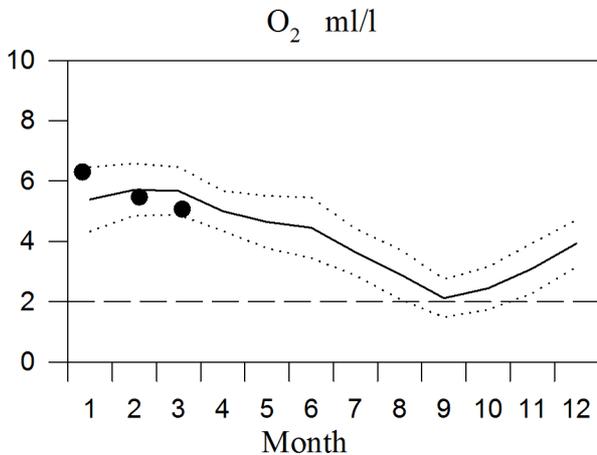
# STATION W LANDSKRONA SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

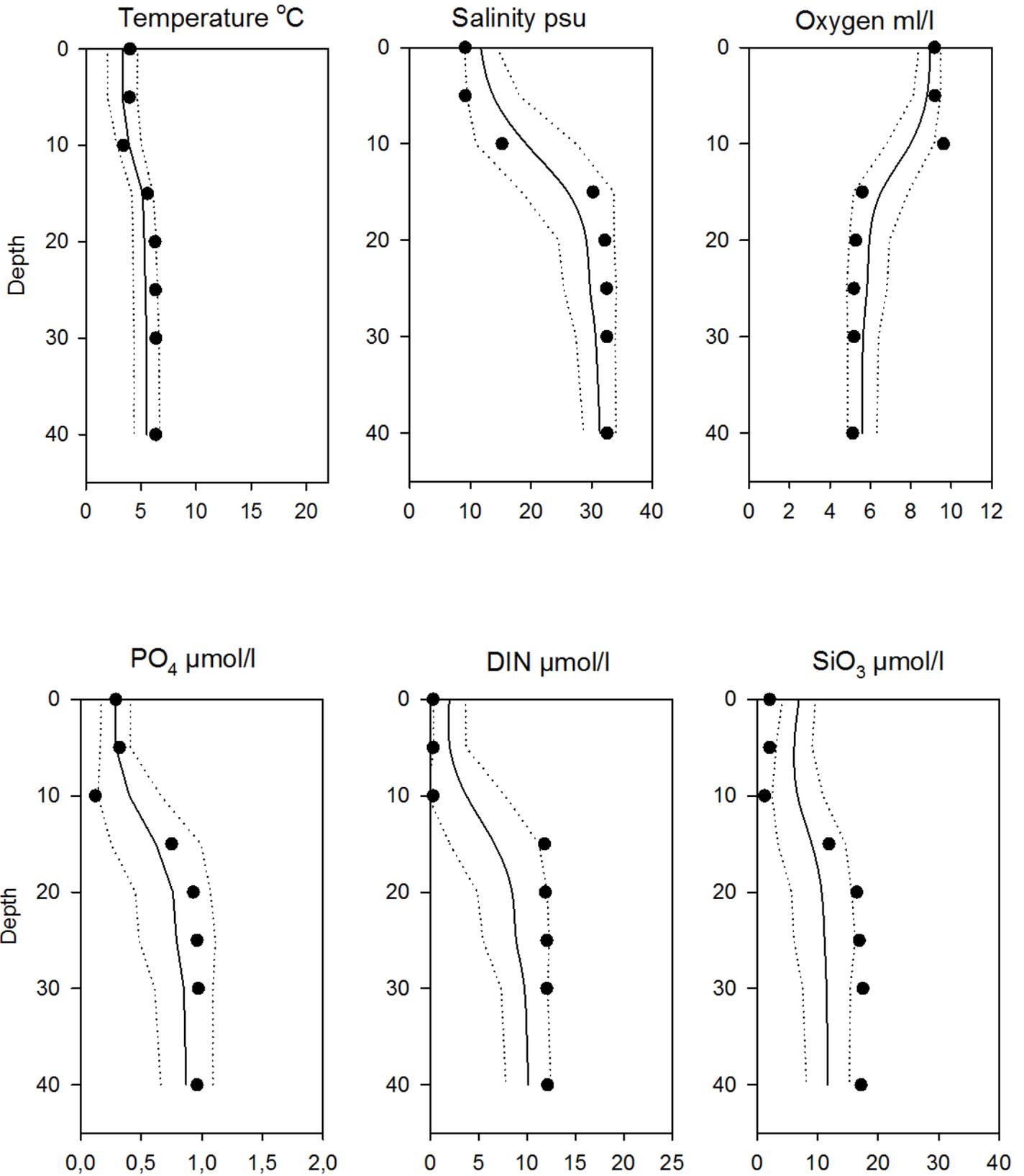


## OXYGEN IN BOTTOM WATER (depth >40m)



# Vertical profiles W Landskrona March

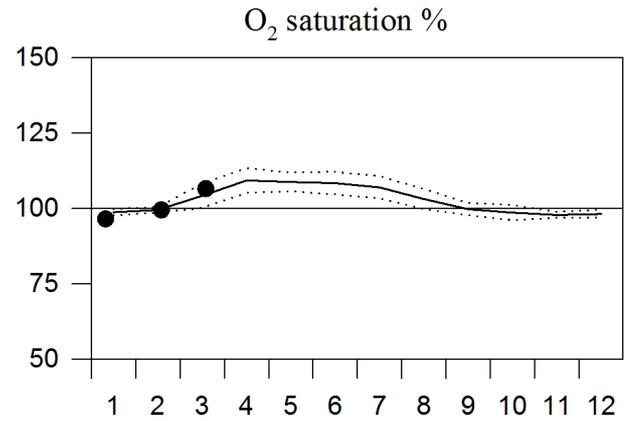
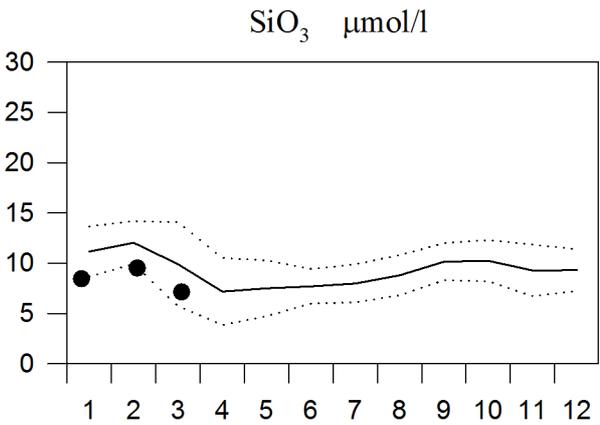
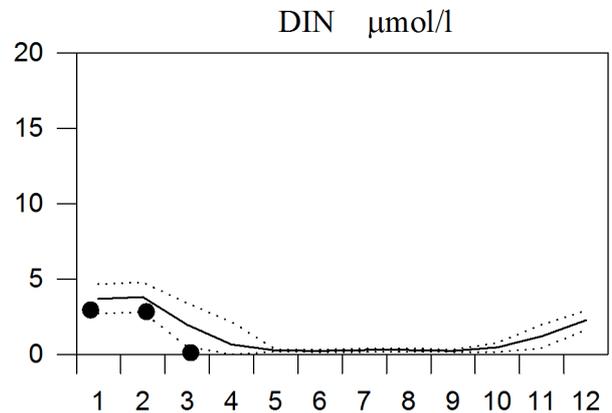
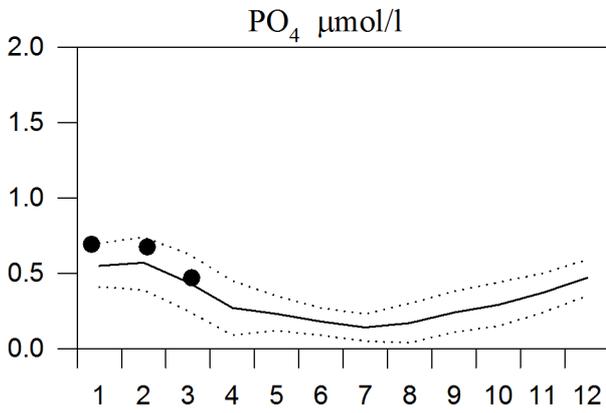
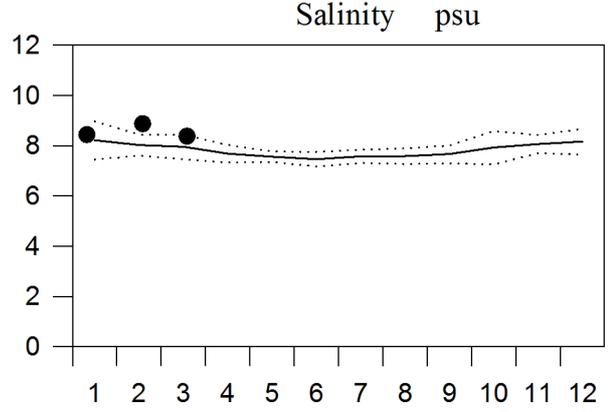
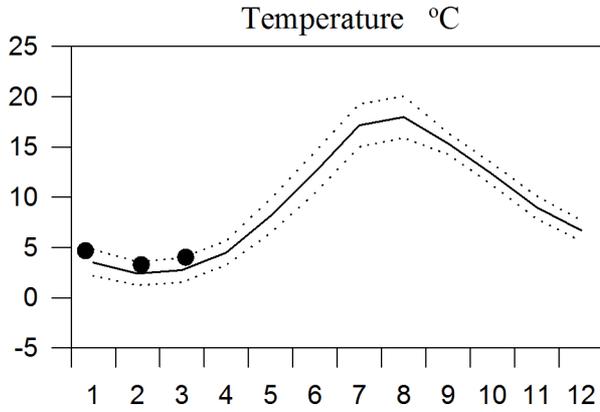
— Mean 1996-2010      ..... St.Dev.      ● 2016



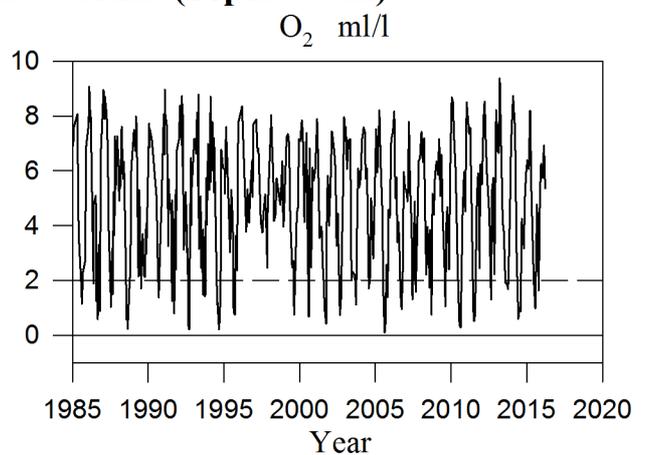
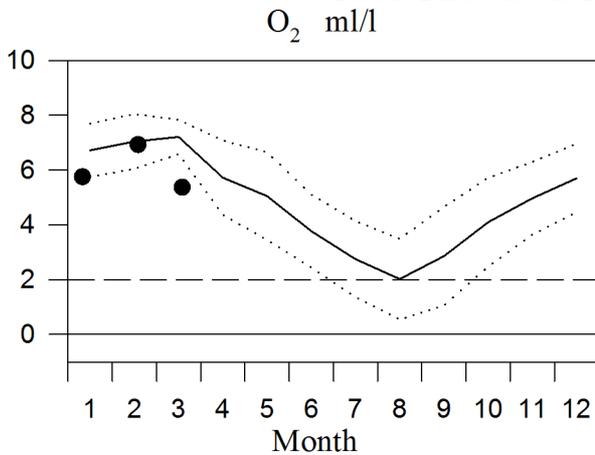
# STATION BY1 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

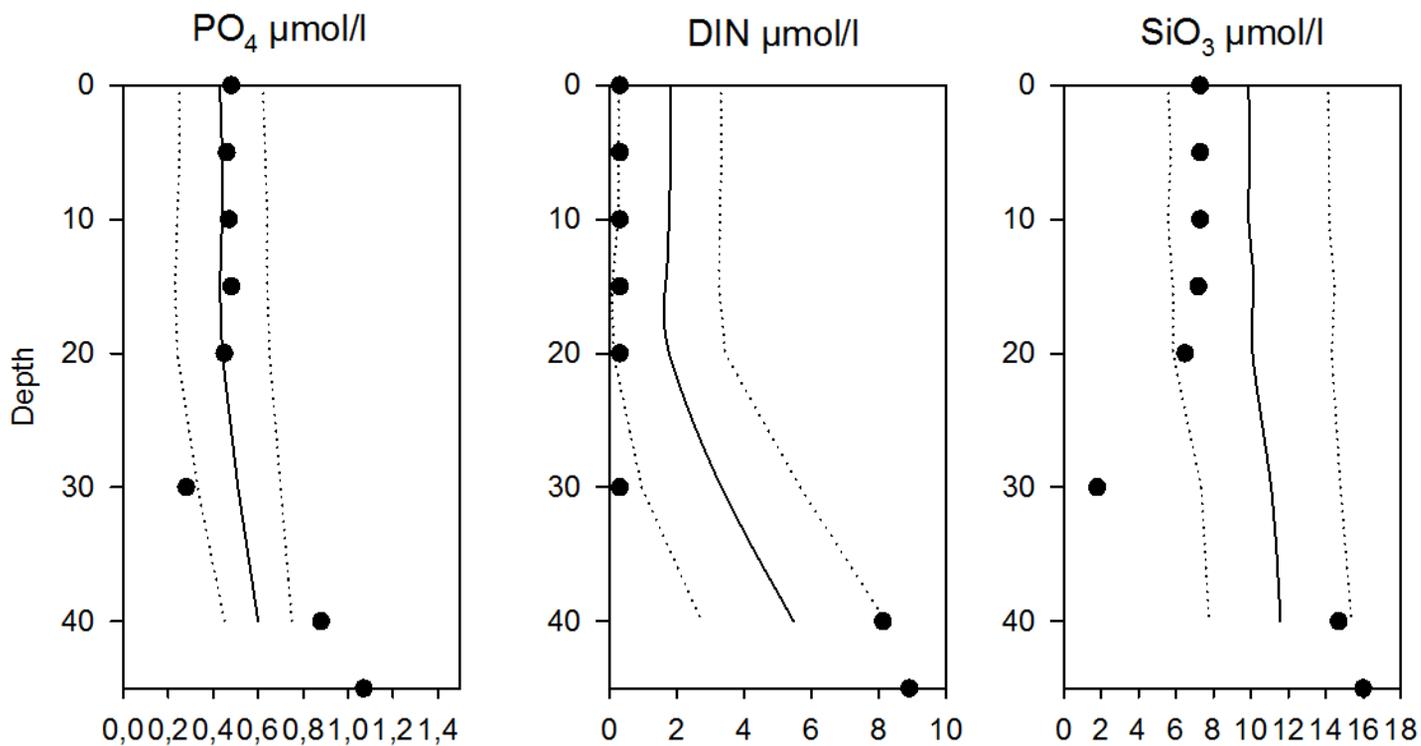
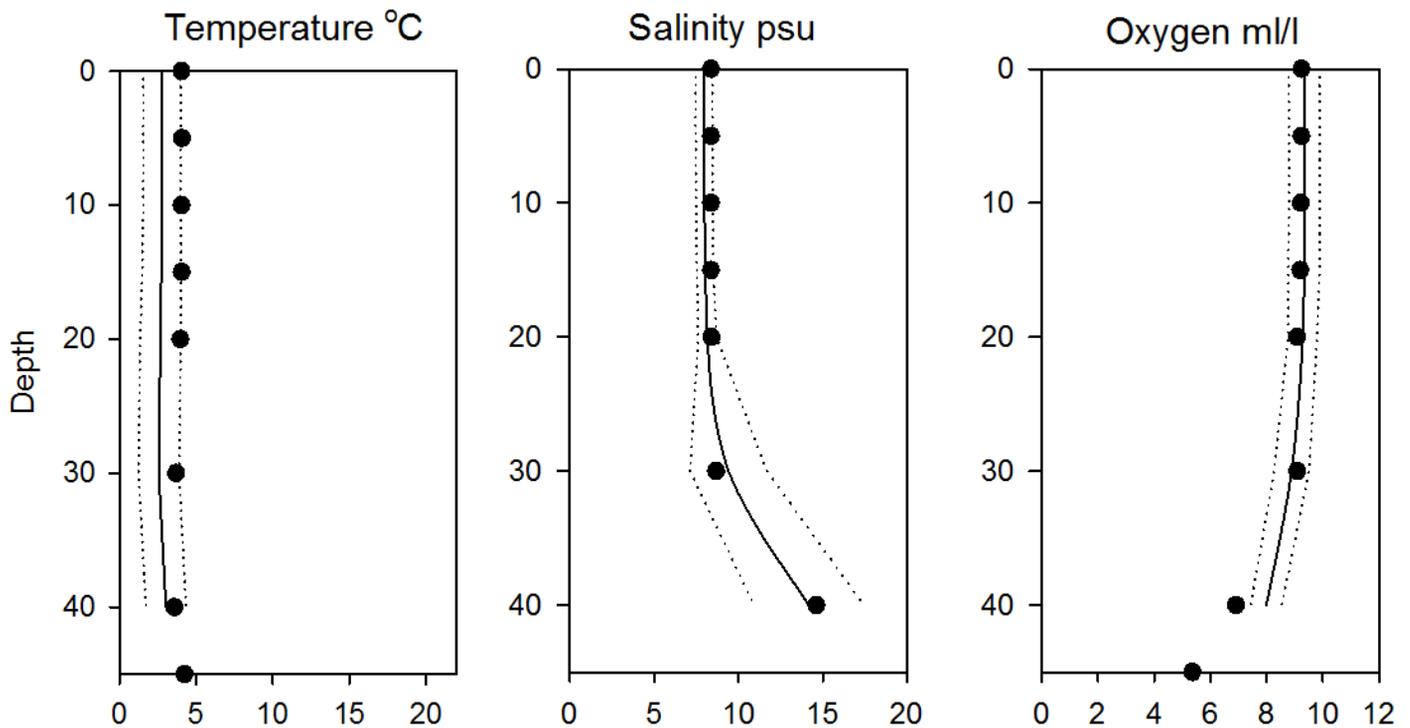


## OXYGEN IN BOTTOM WATER (depth >40m)



# Vertical profiles BY1 March

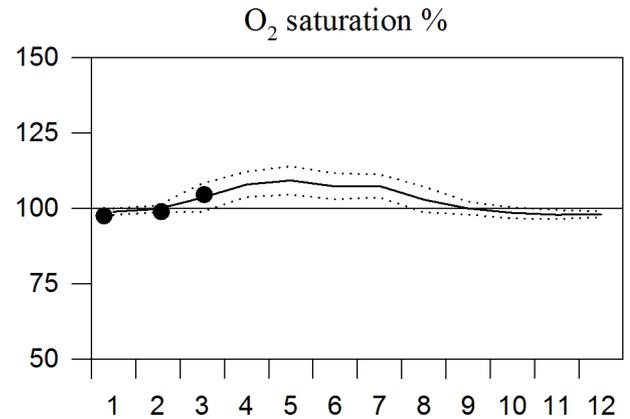
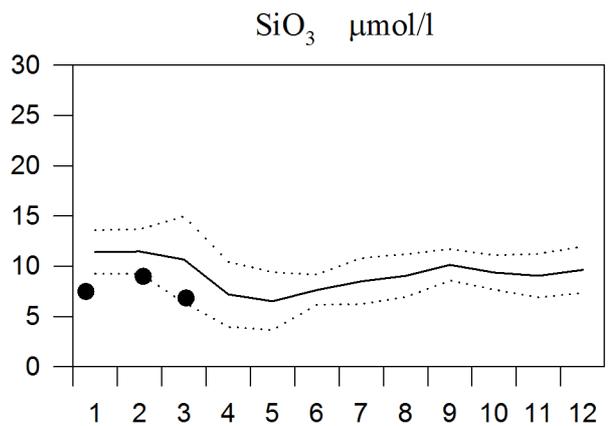
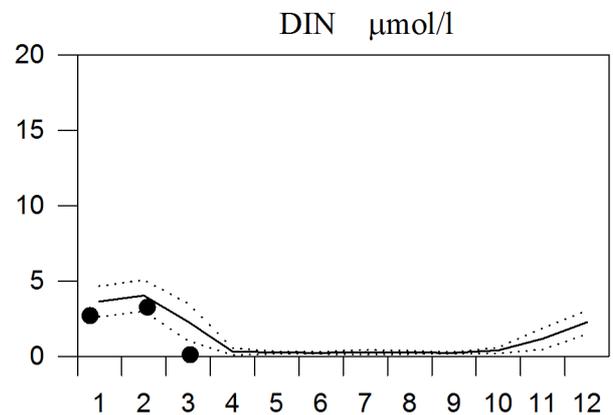
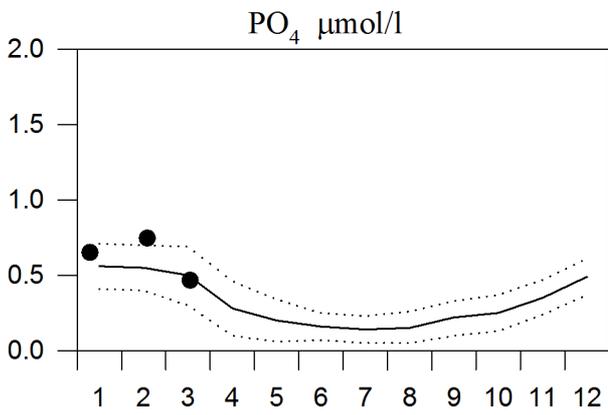
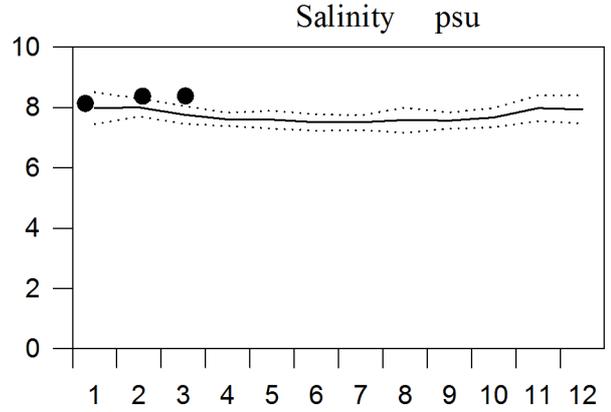
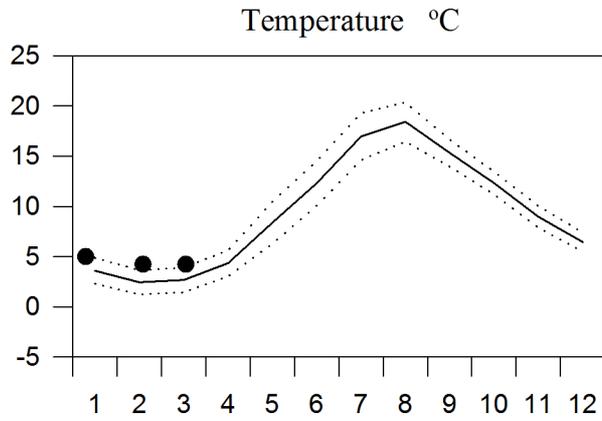
— Mean 1996-2010      ..... St.Dev.      ● 2016



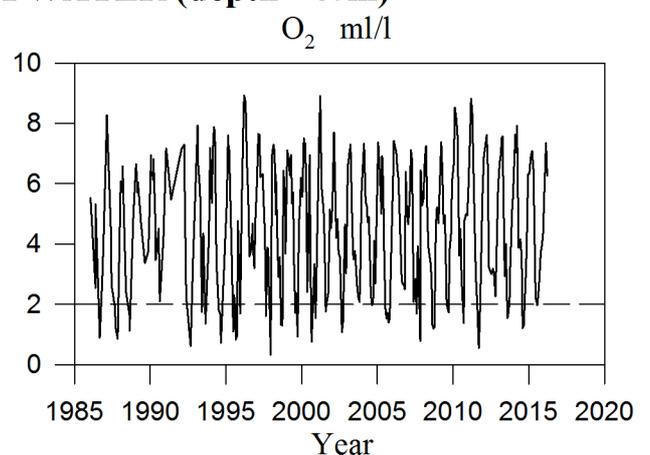
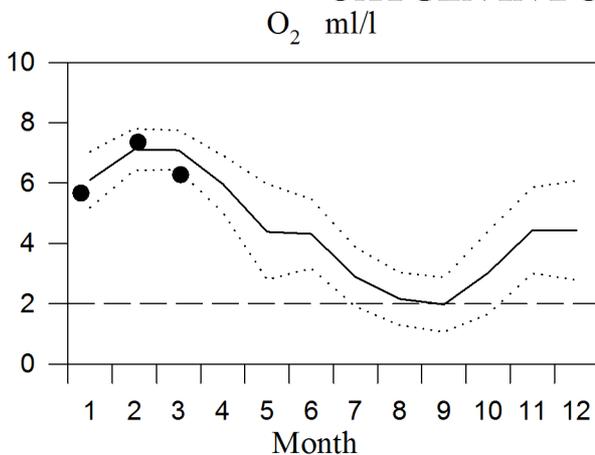
# STATION BY2 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

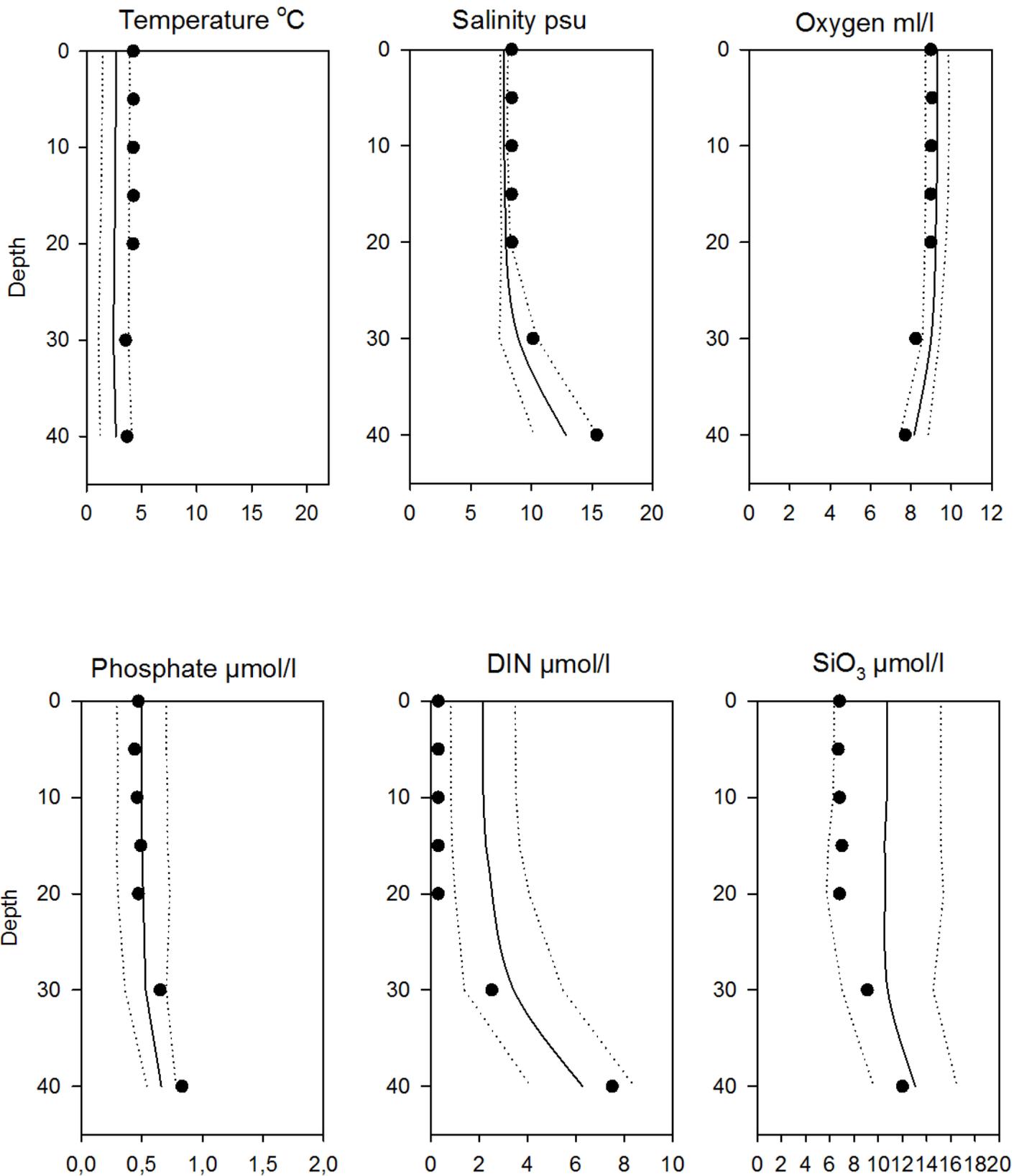


## OXYGEN IN BOTTOM WATER (depth >40m)



# Vertical profiles BY2 March

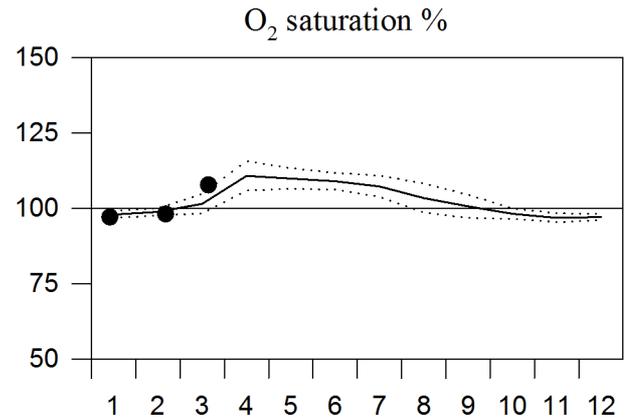
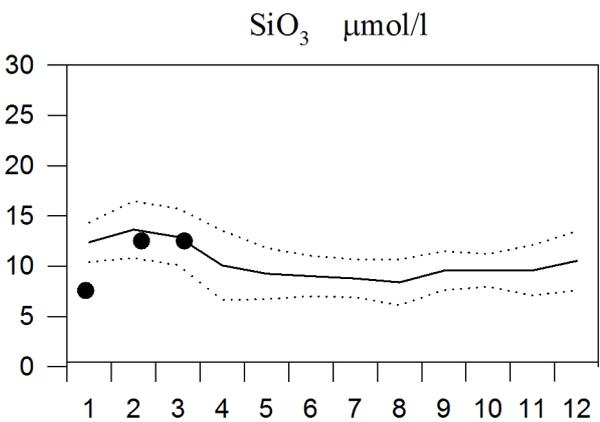
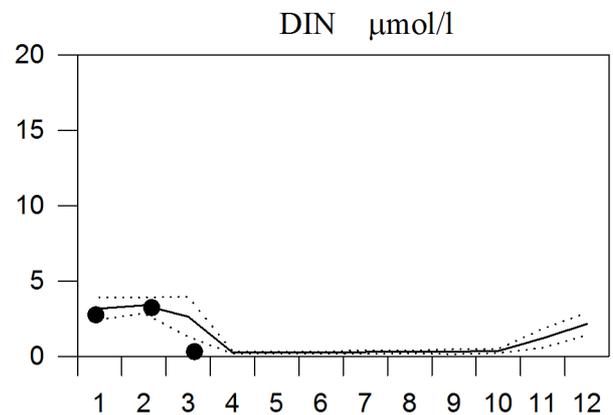
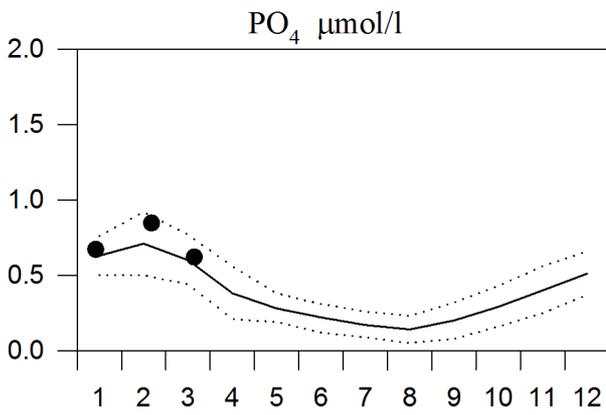
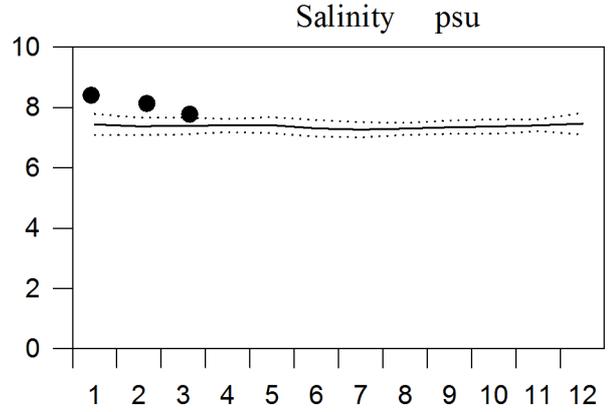
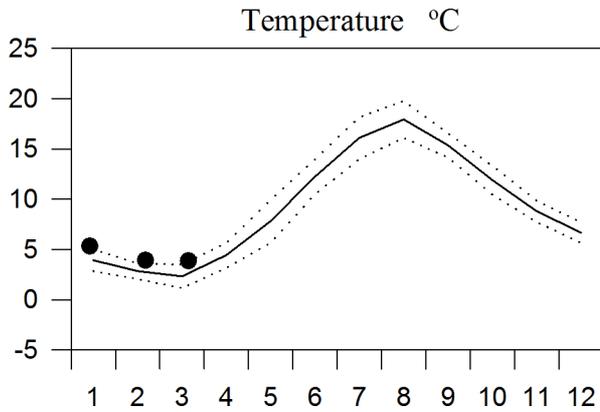
— Mean 1996-2010      ..... St.Dev.      ● 2016



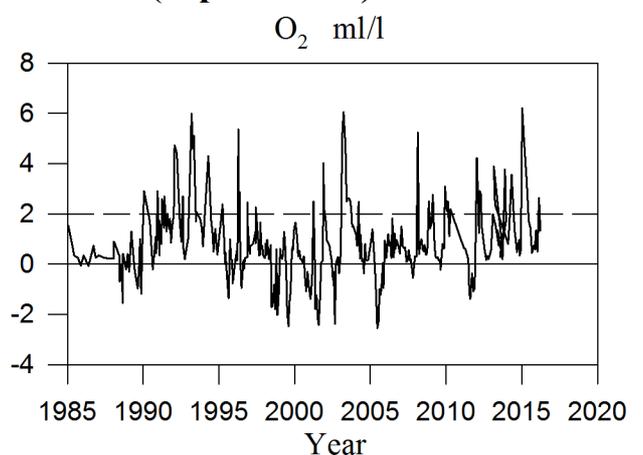
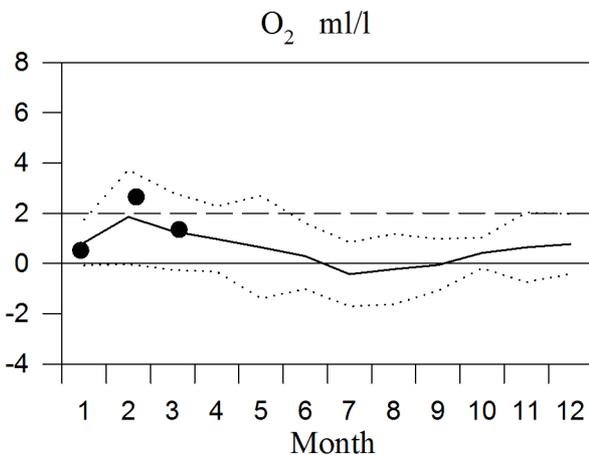
# STATION HANÖBUKTEN SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ····· St.Dev.      ● 2016

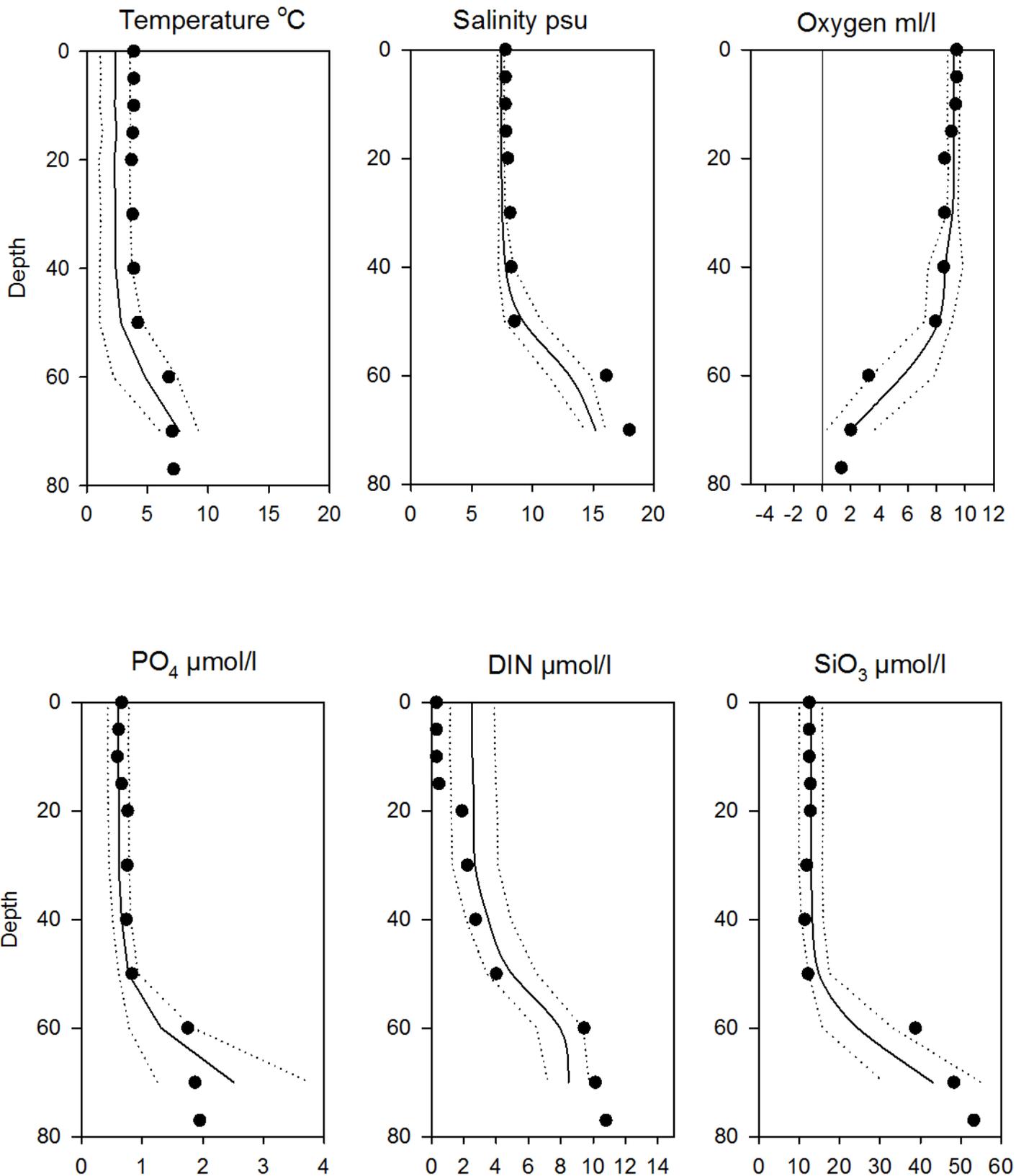


## OXYGEN IN BOTTOM WATER (depth > 70m)



# Vertical profiles Hanöbukten March

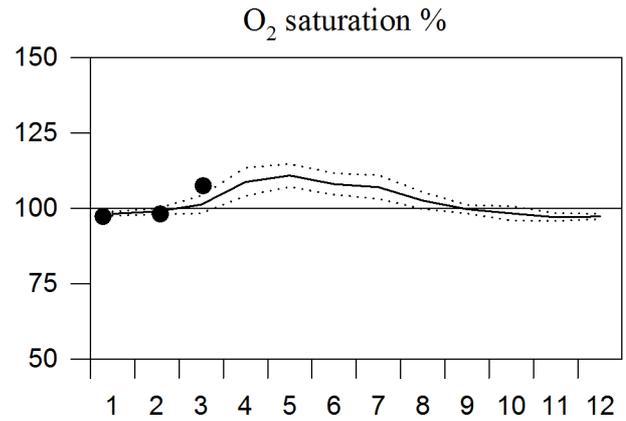
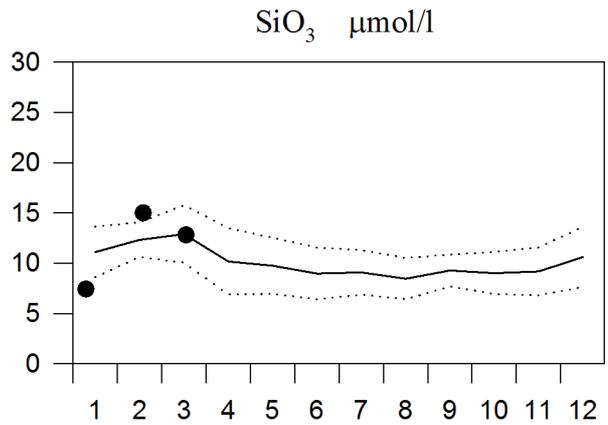
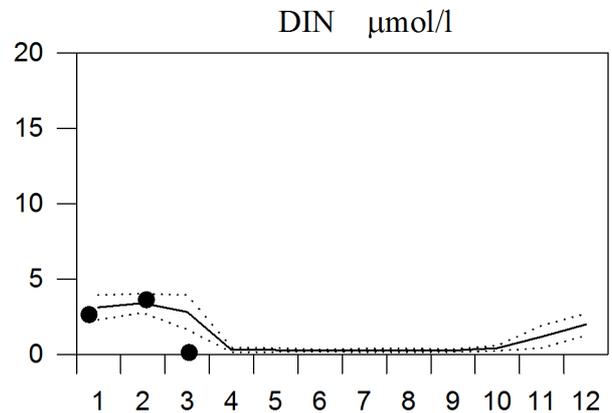
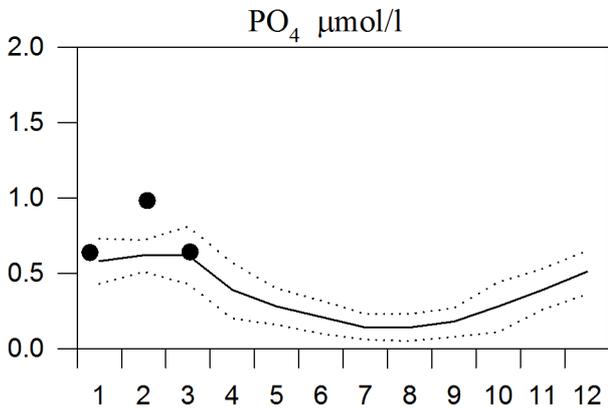
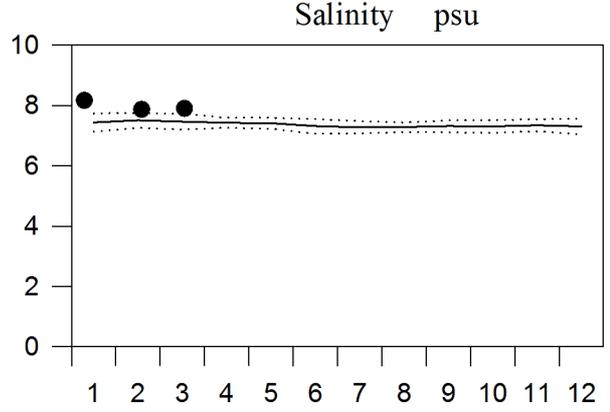
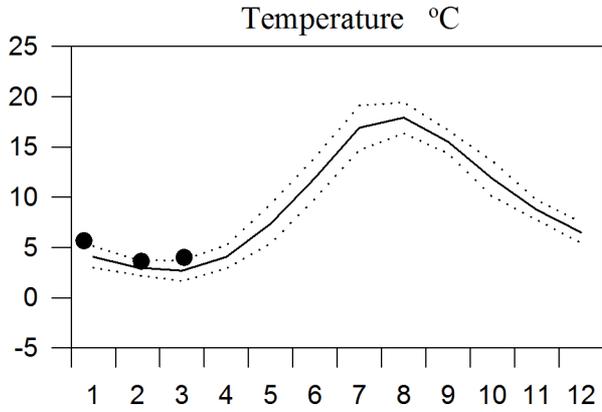
— Mean 1996-2010      ..... St.Dev.      ● 2016



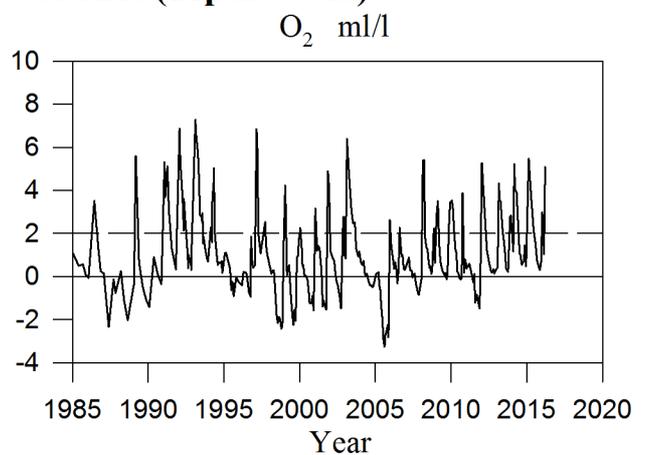
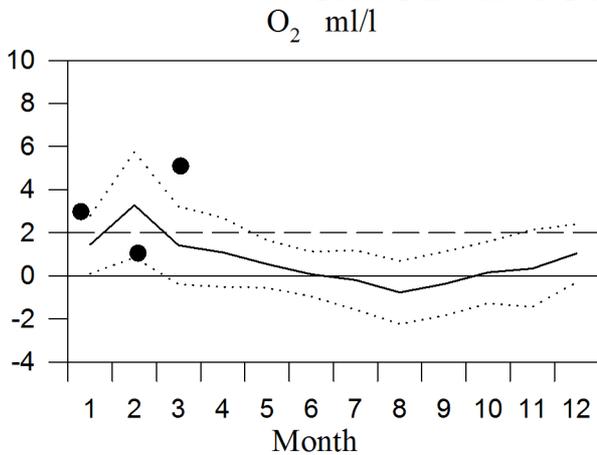
# STATION BY4 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

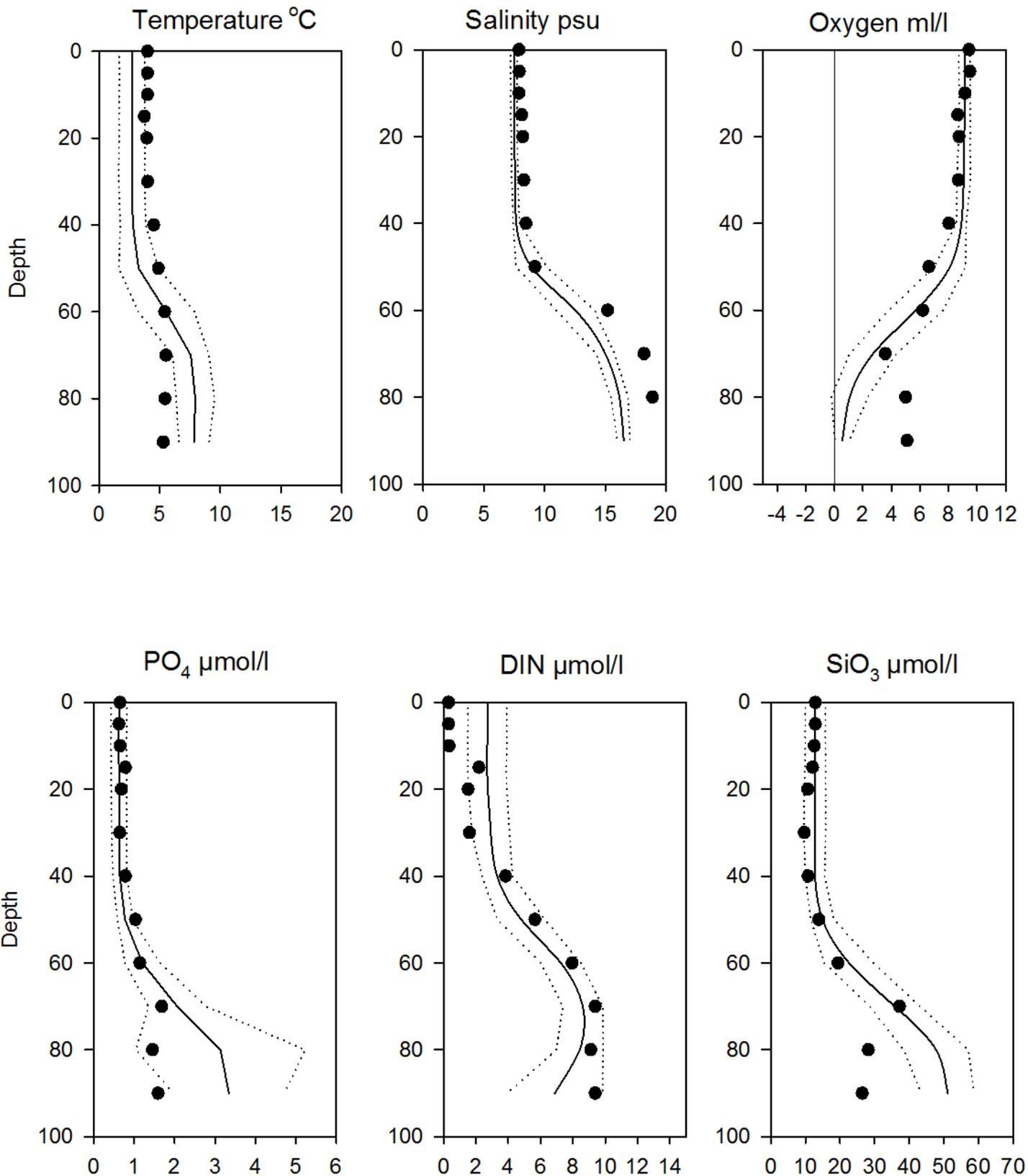


## OXYGEN IN BOTTOM WATER (depth >80m)



# Vertical profiles BY4 March

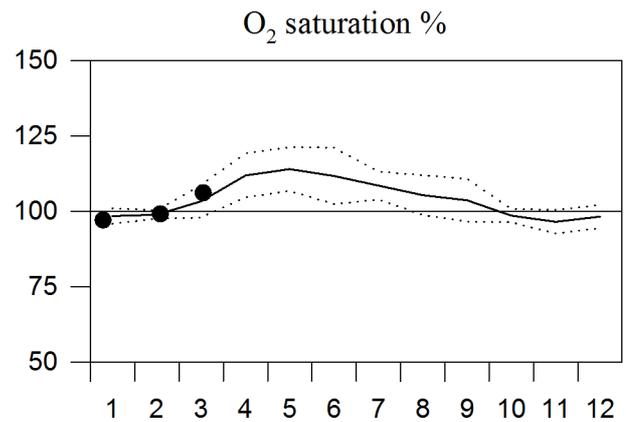
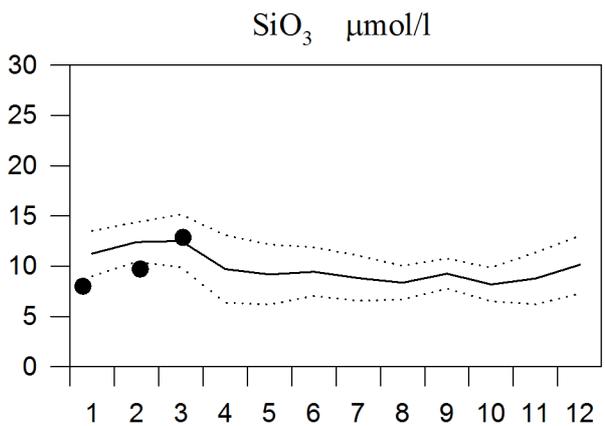
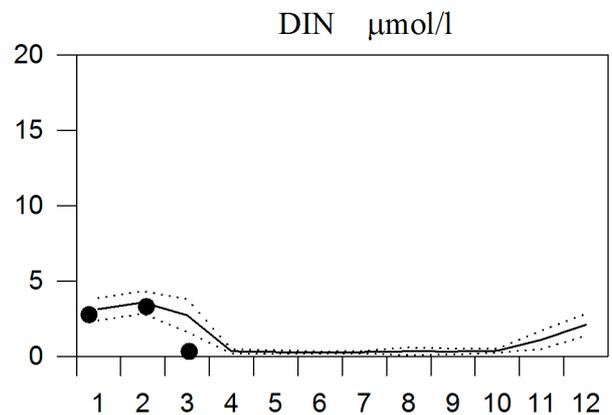
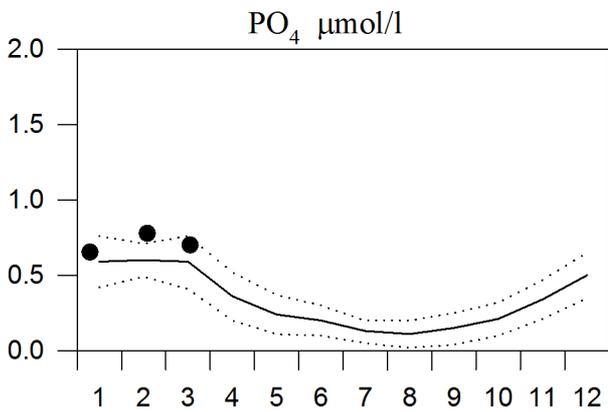
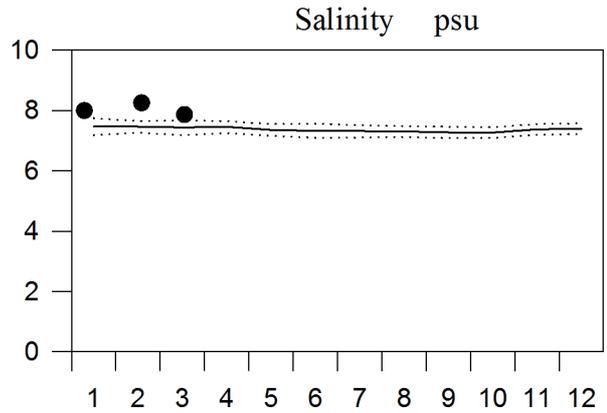
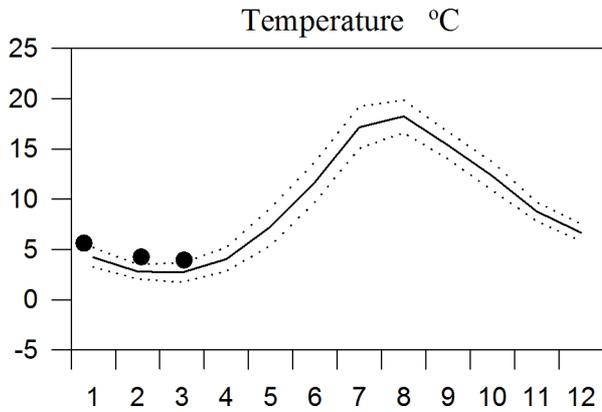
— Mean 1996-2010      ..... St.Dev.      ● 2016



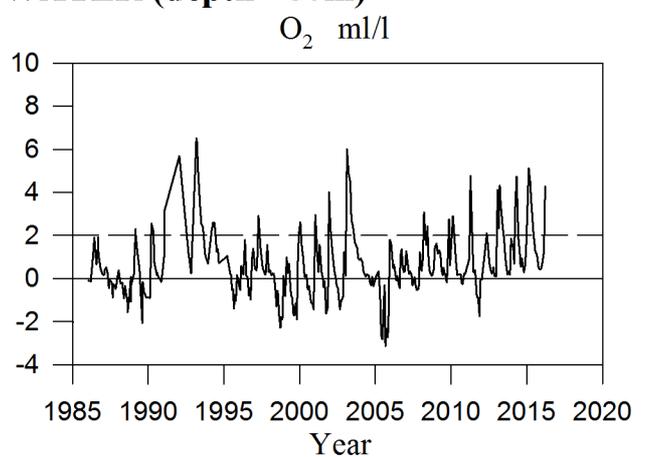
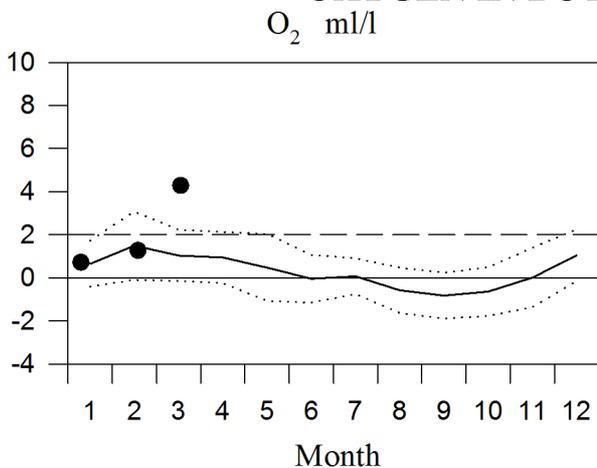
# STATION BY5 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

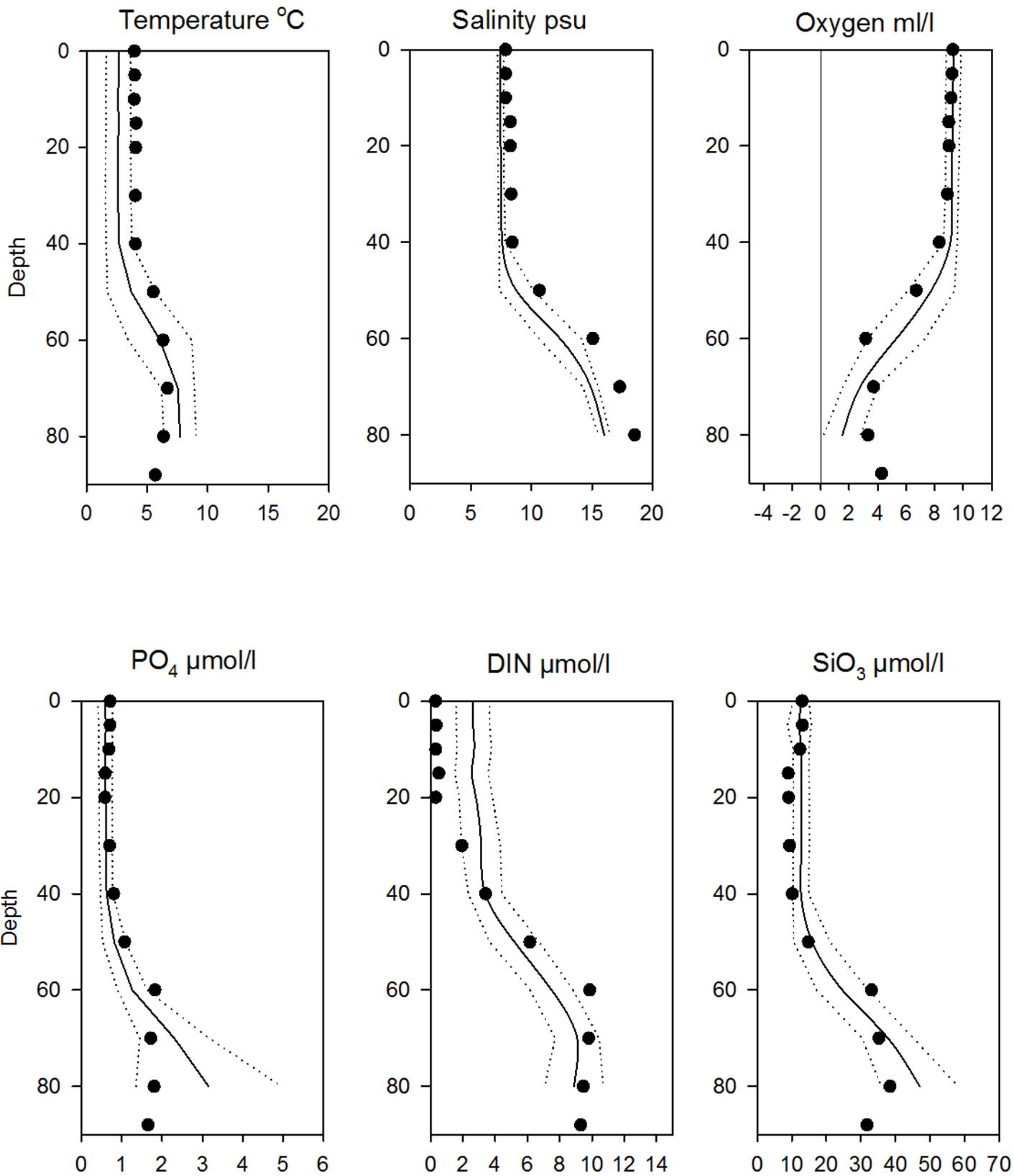


## OXYGEN IN BOTTOM WATER (depth >80m)



# Vertical profiles BY5 March

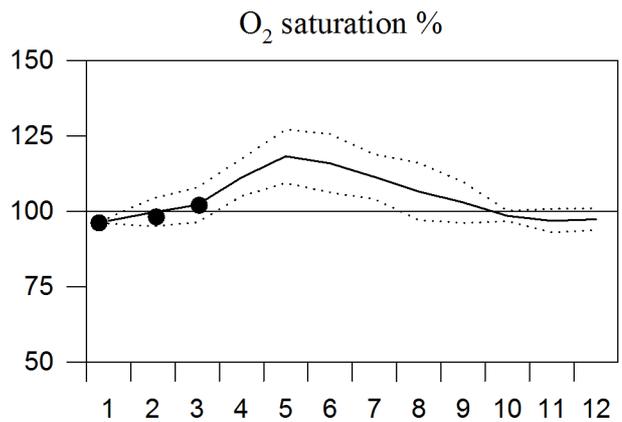
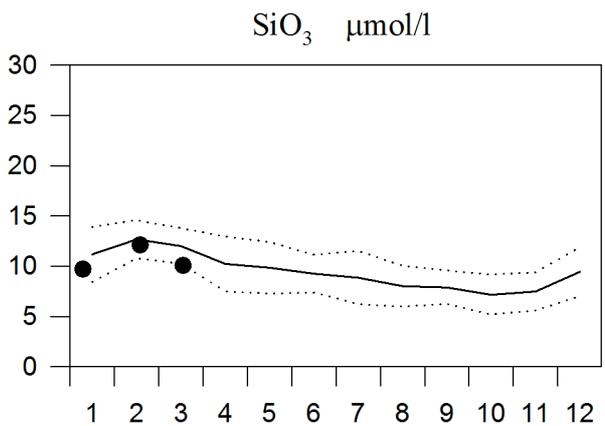
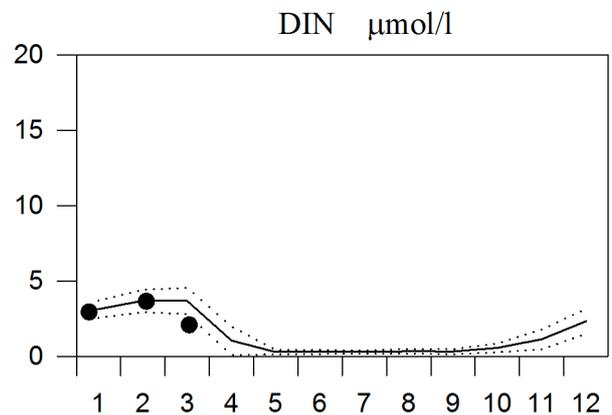
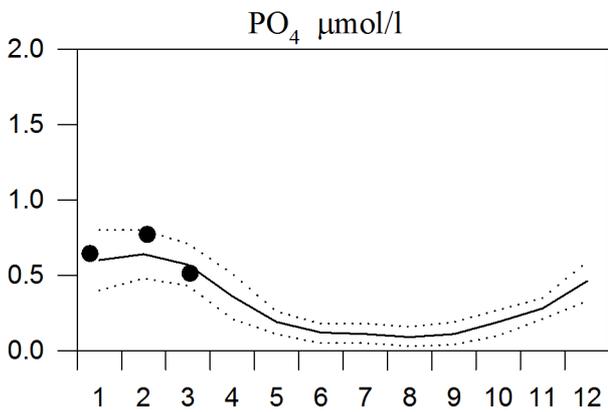
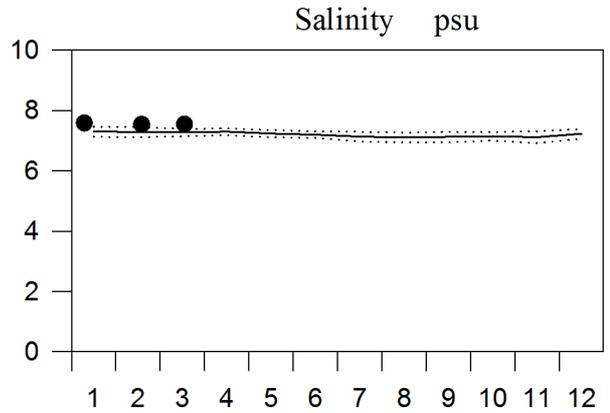
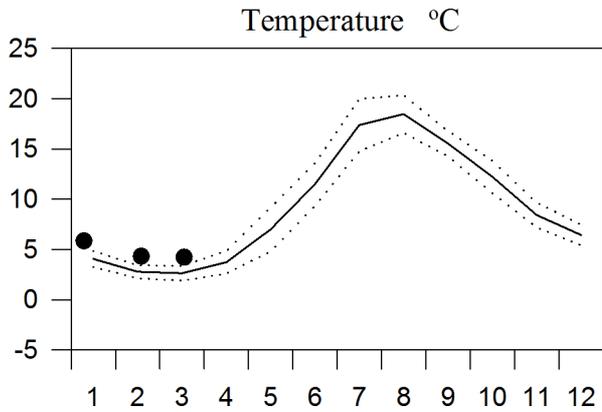
— Mean 1996-2010      ..... St.Dev.      ● 2016



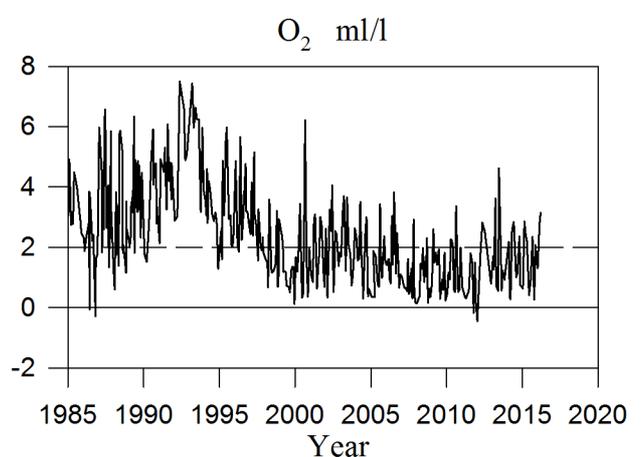
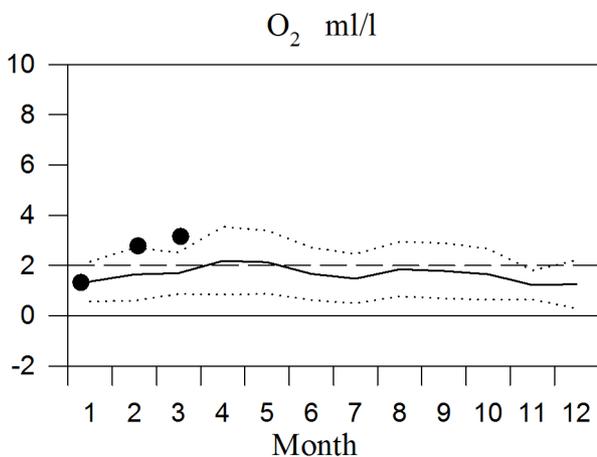
# STATION BCS III-10 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ····· St.Dev.      ● 2016

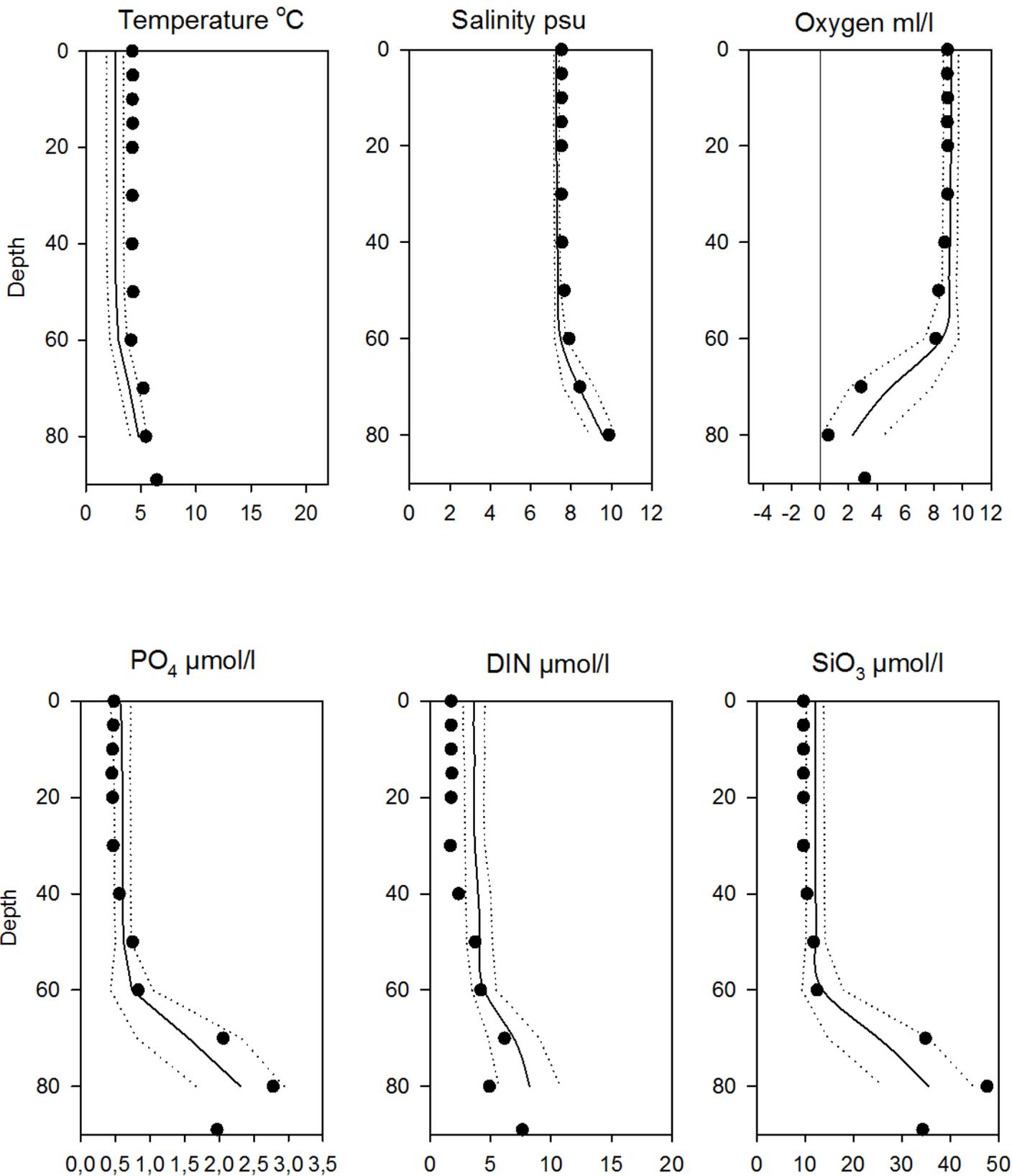


## OXYGEN IN BOTTOM WATER (depth > 80m)



# Vertical profiles BCS III-10 March

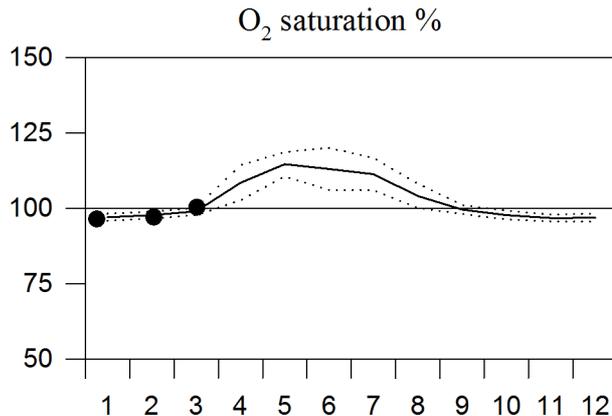
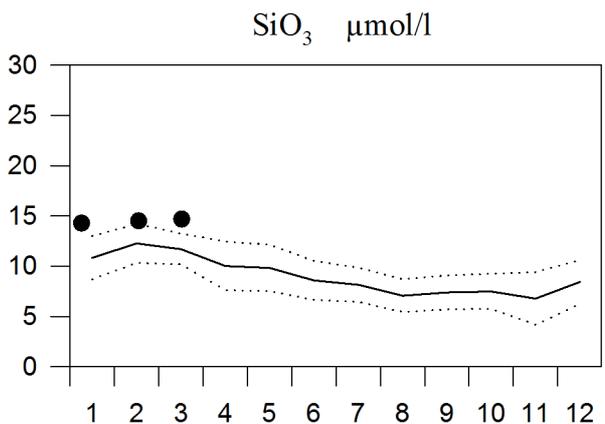
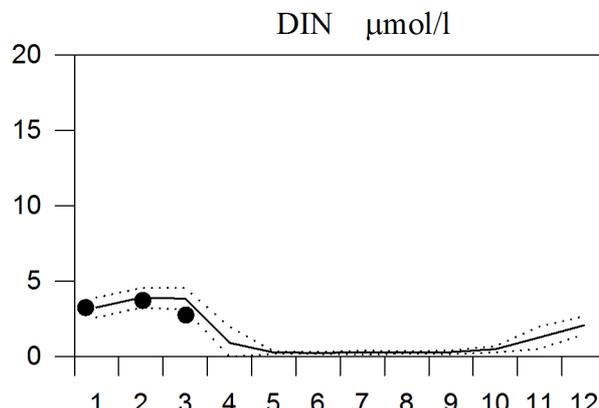
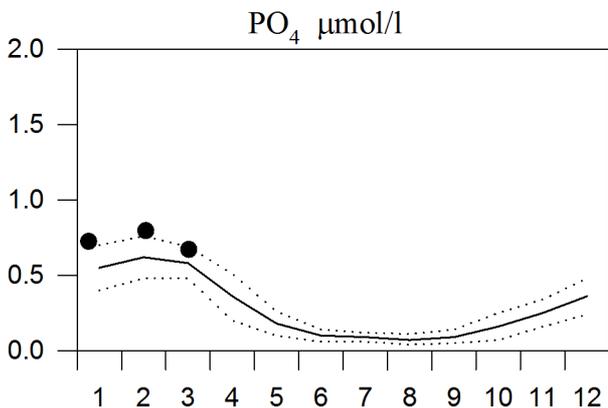
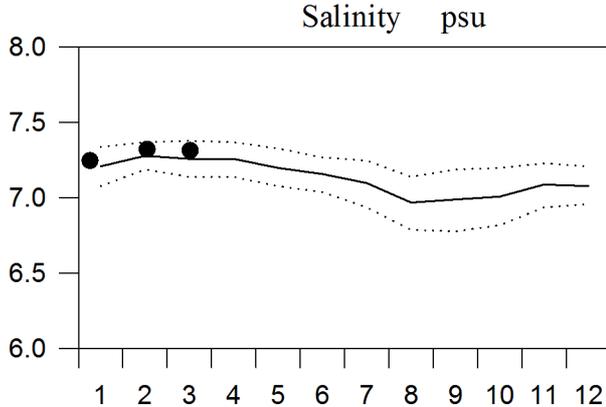
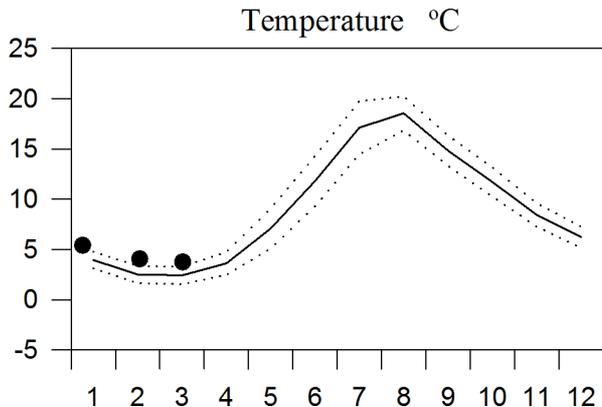
— Mean 1996-2010      ..... St.Dev.      ● 2016



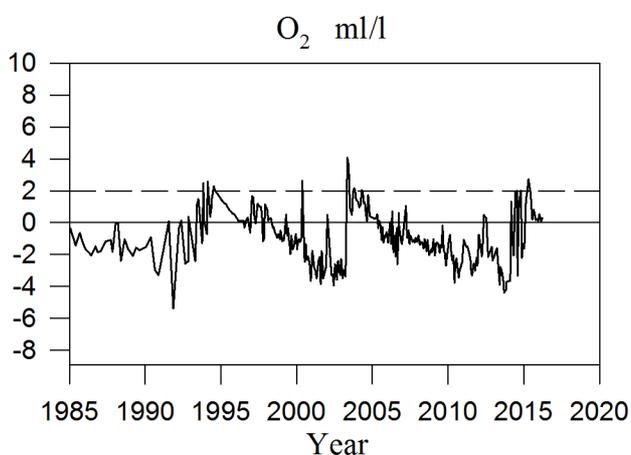
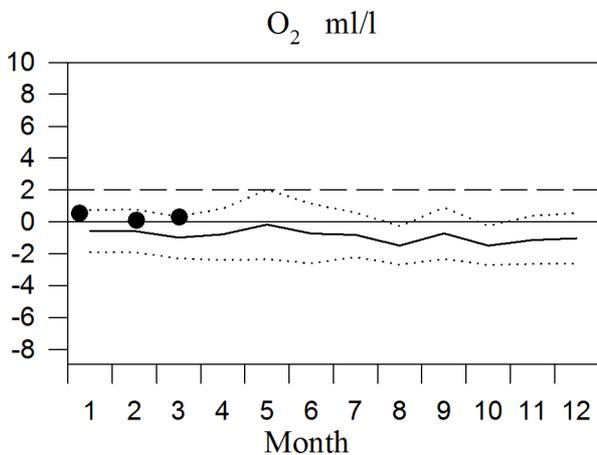
# STATION BY10 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

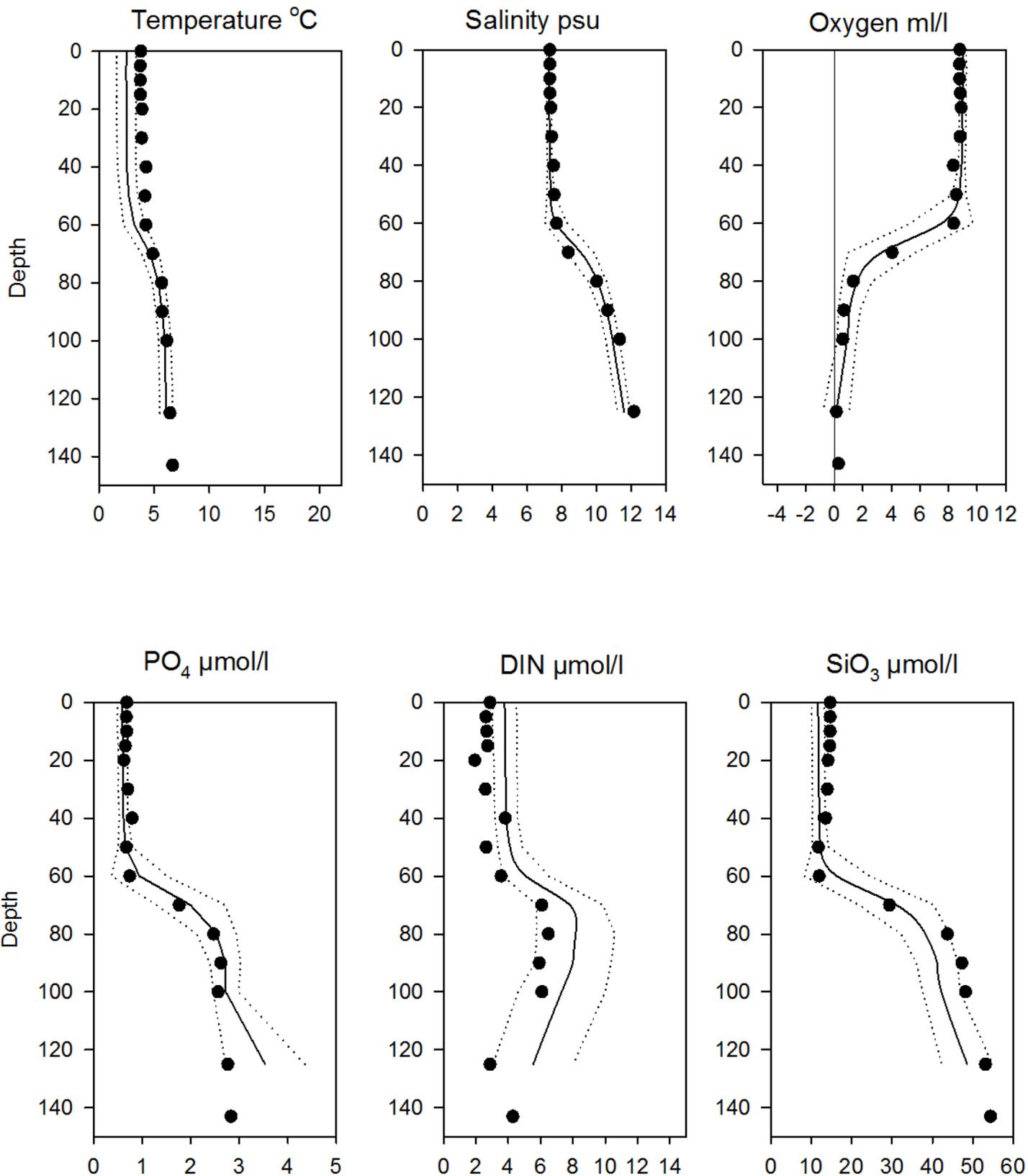


## OXYGEN IN BOTTOM WATER (depth >125m)



# Vertical profiles BY10 March

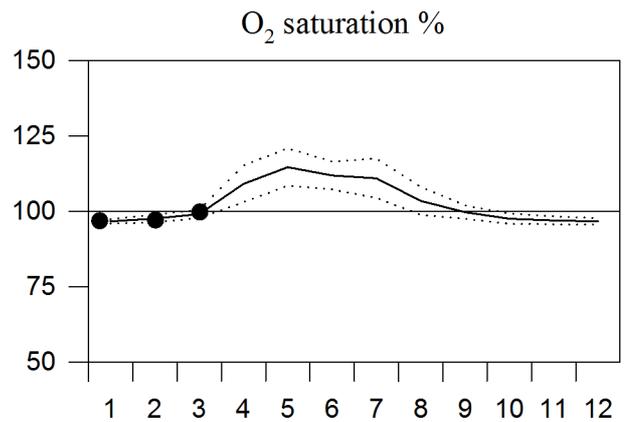
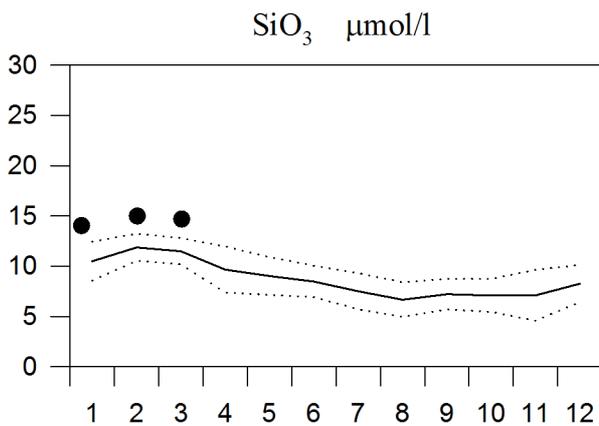
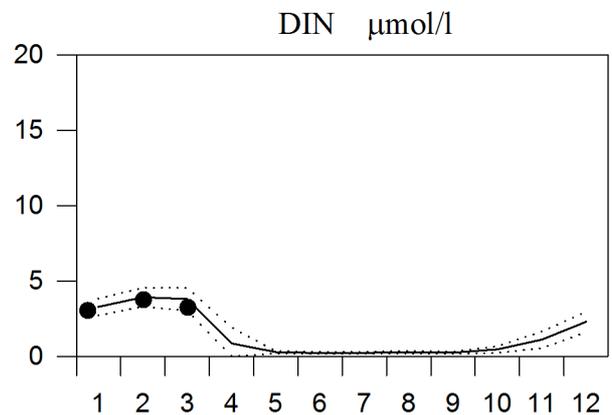
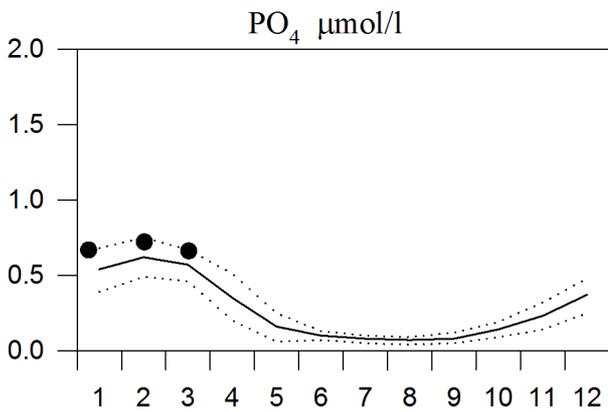
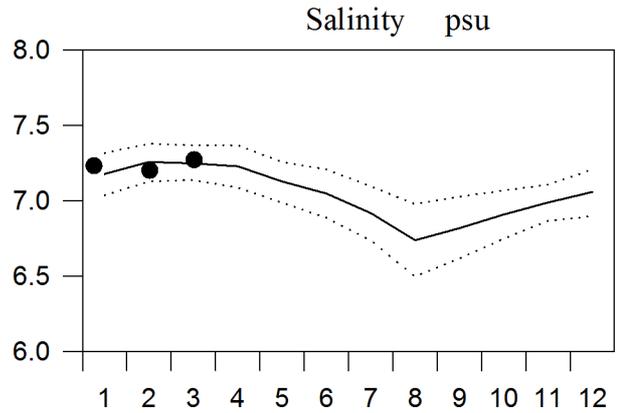
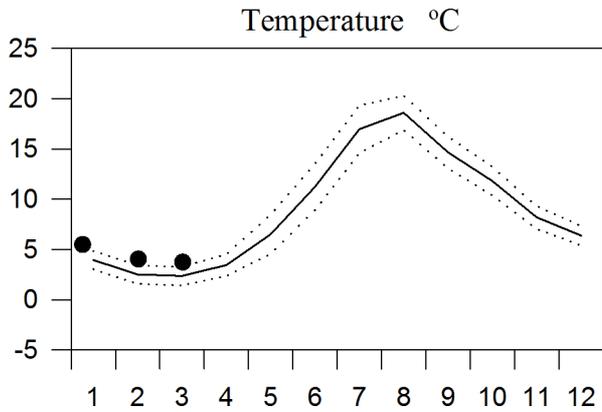
— Mean 1996-2010      ..... St.Dev.      ● 2016



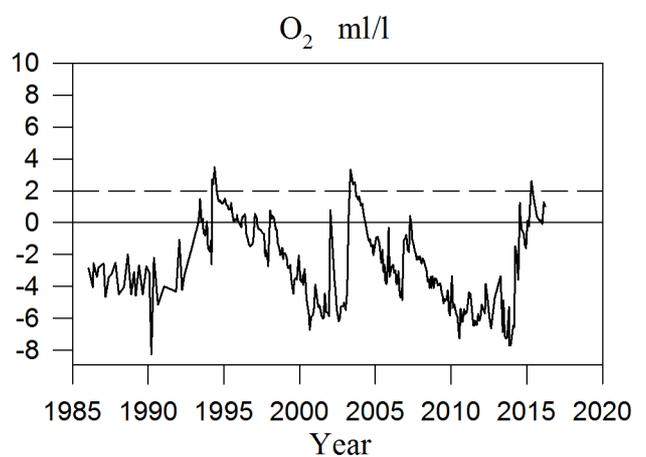
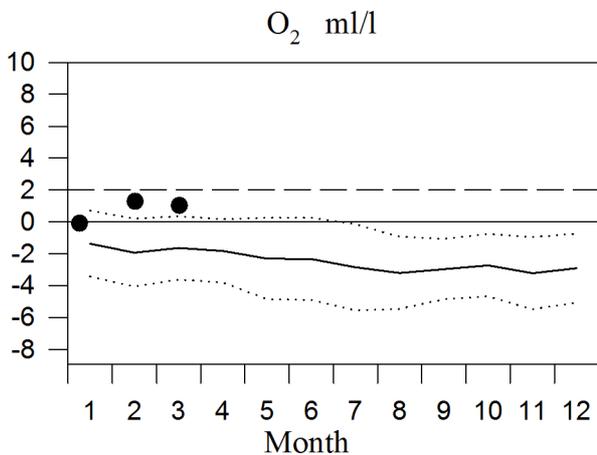
# STATION BY15 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

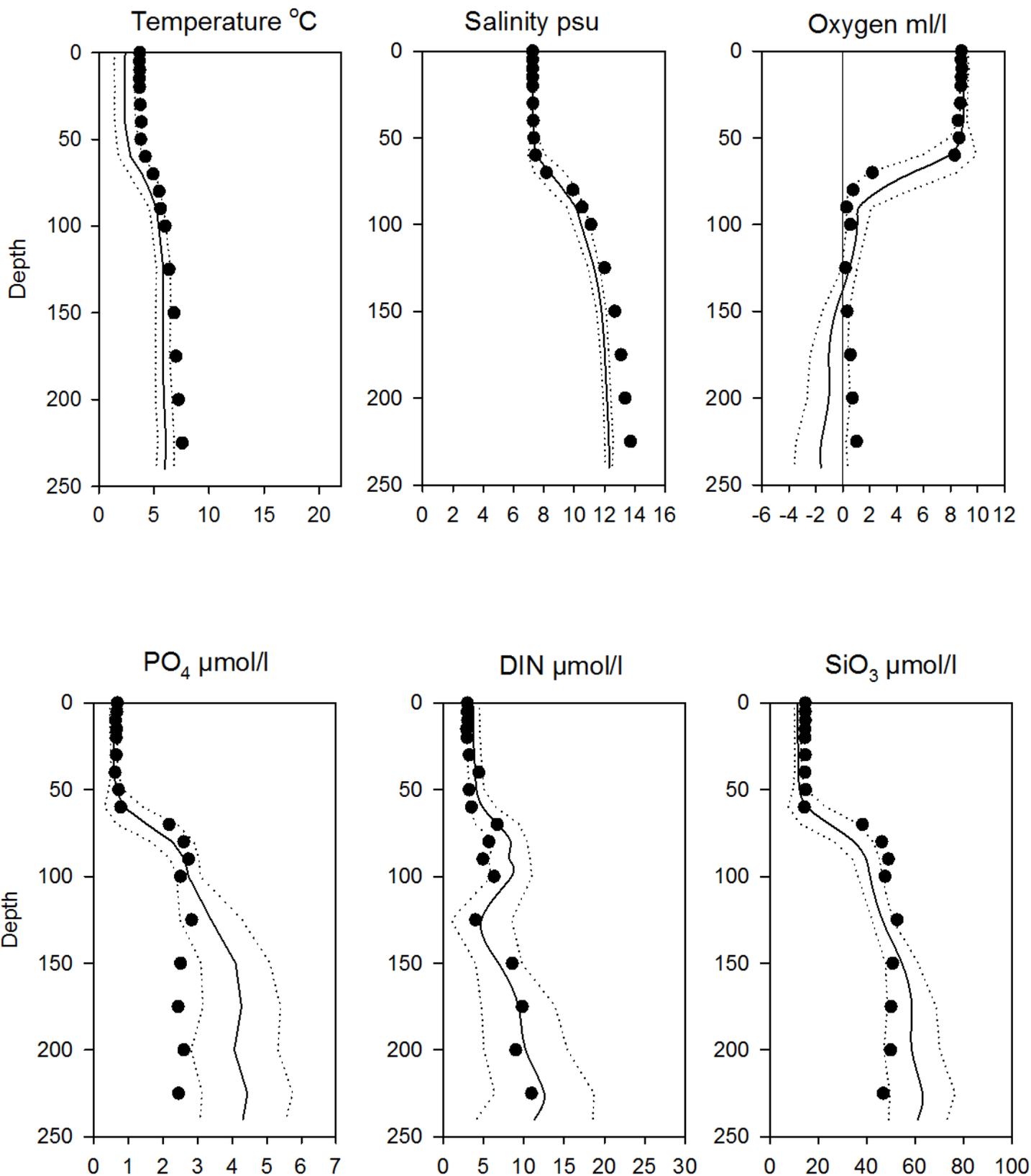


## OXYGEN IN BOTTOM WATER (depth >225m)



# Vertical profiles BY15 March

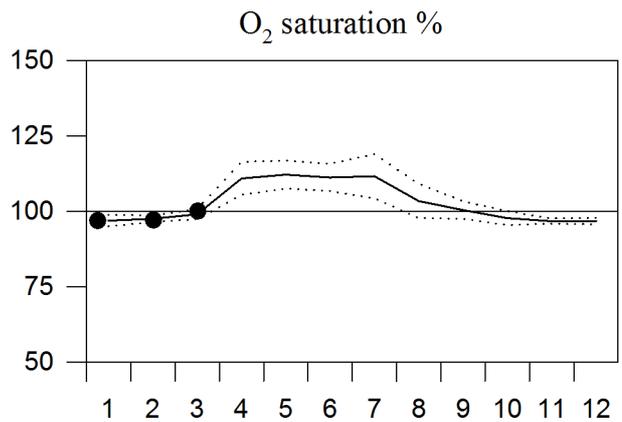
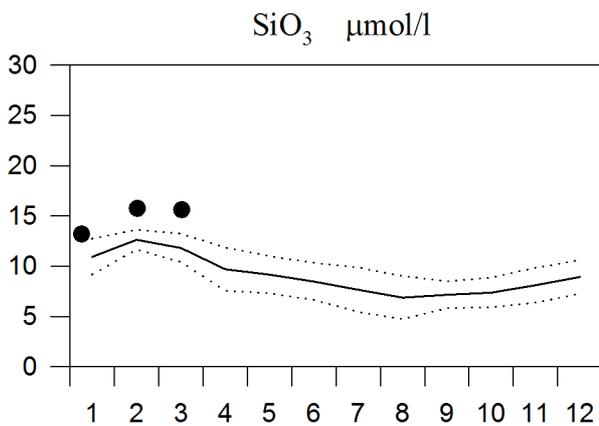
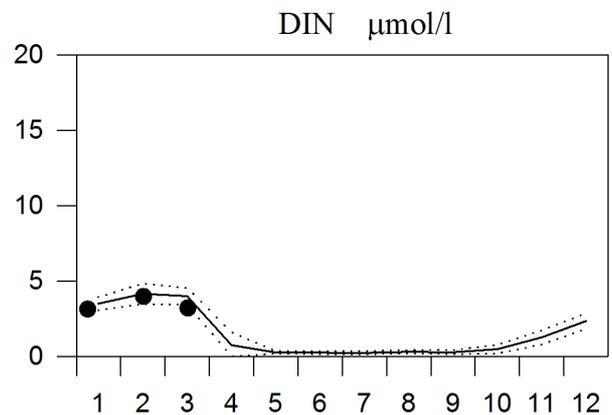
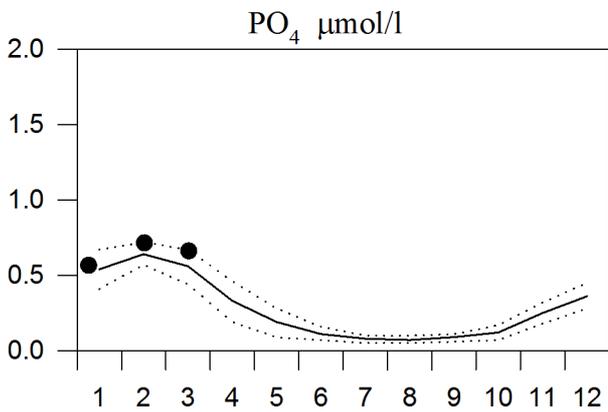
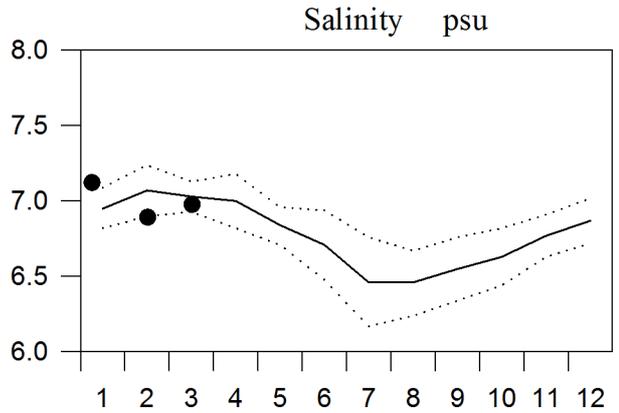
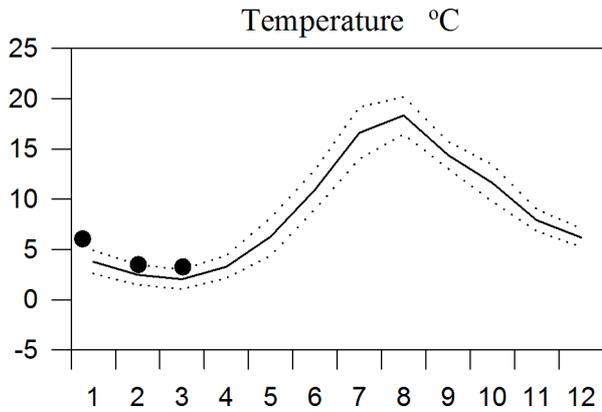
— Mean 1996-2010      ..... St.Dev.      ● 2015



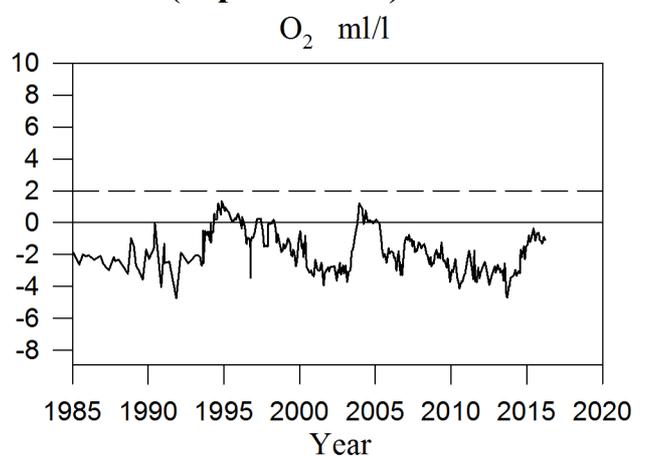
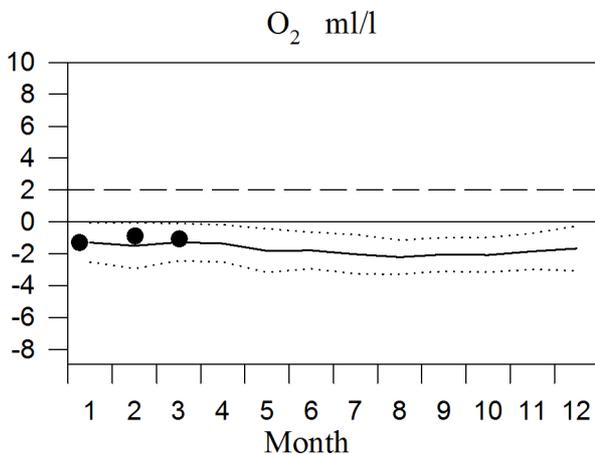
# STATION BY20 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

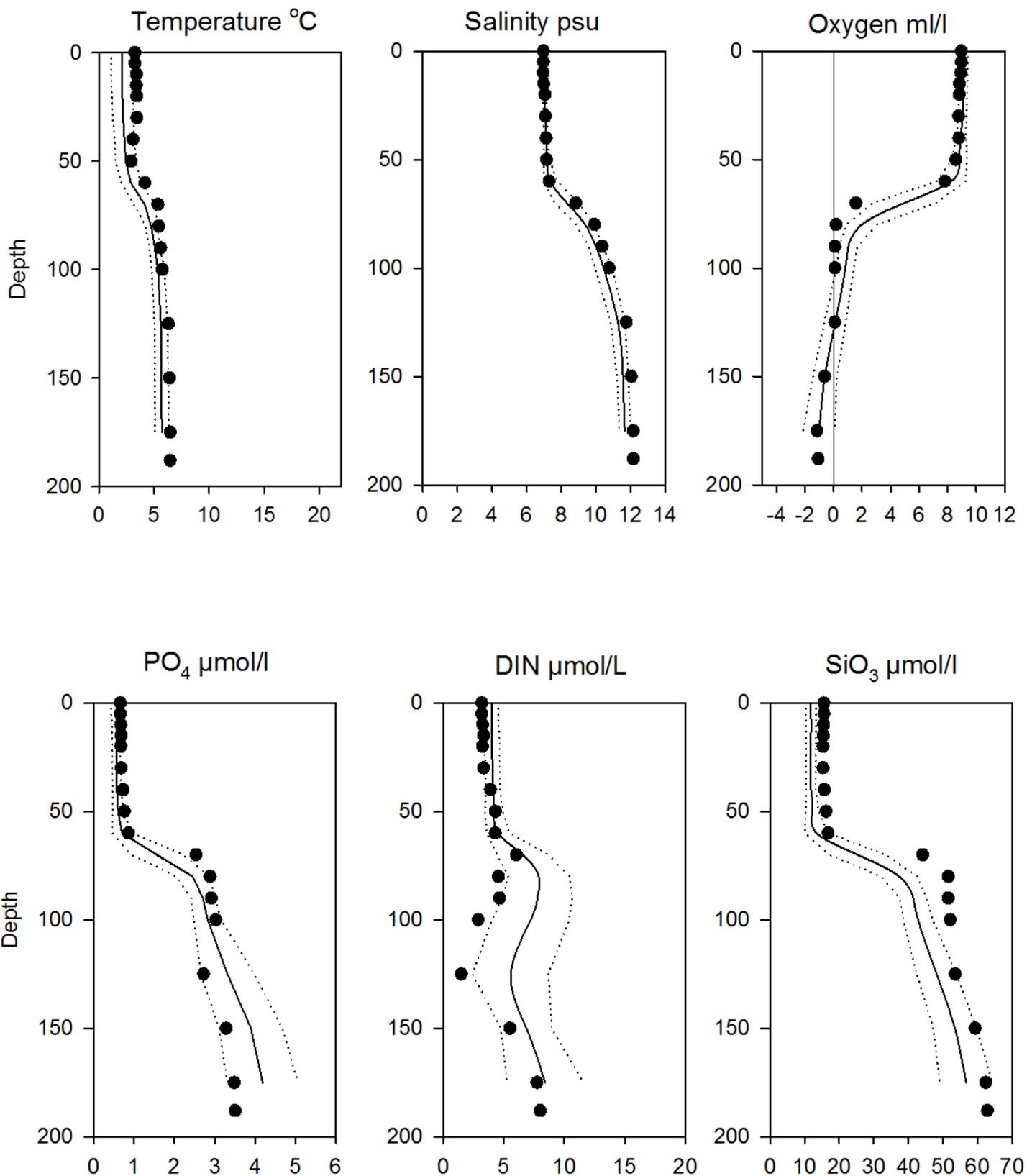


## OXYGEN IN BOTTOM WATER (depth >175m)



# Vertical profiles BY20 March

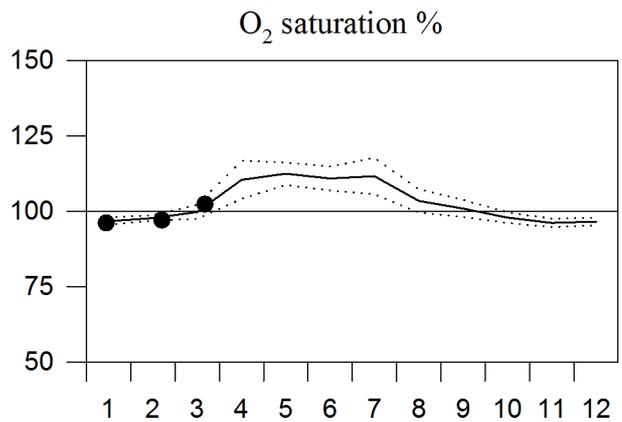
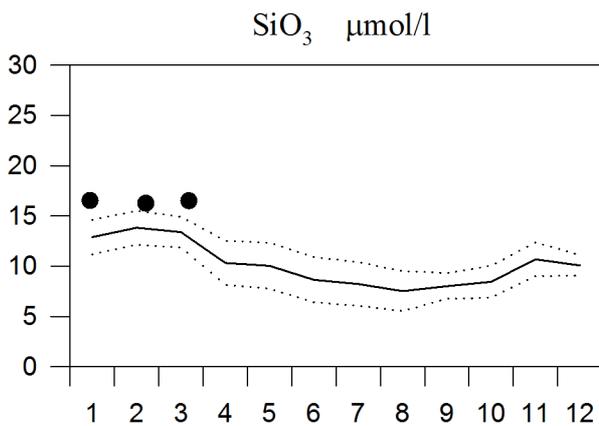
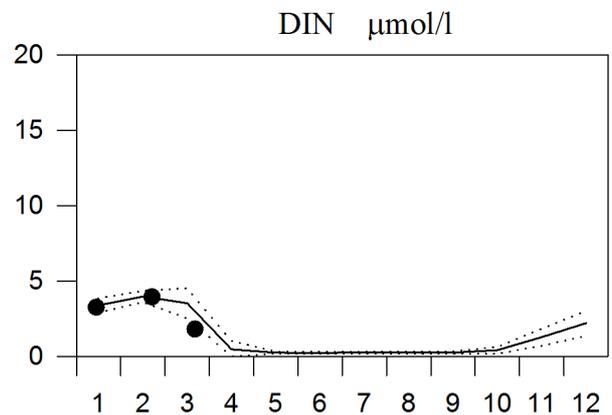
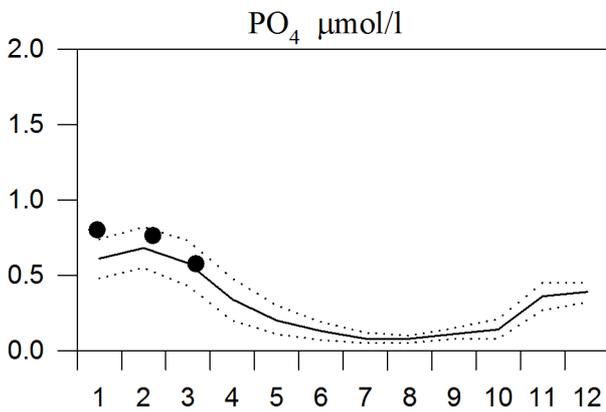
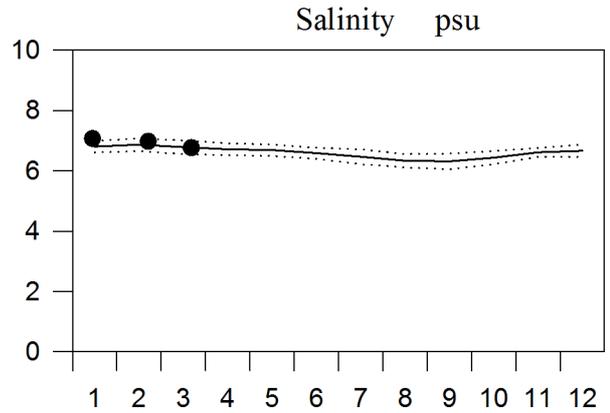
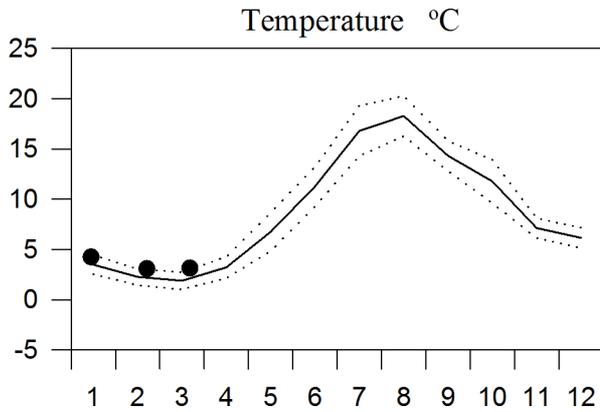
— Mean 1996-2010      ..... St.Dev.      ● 2016



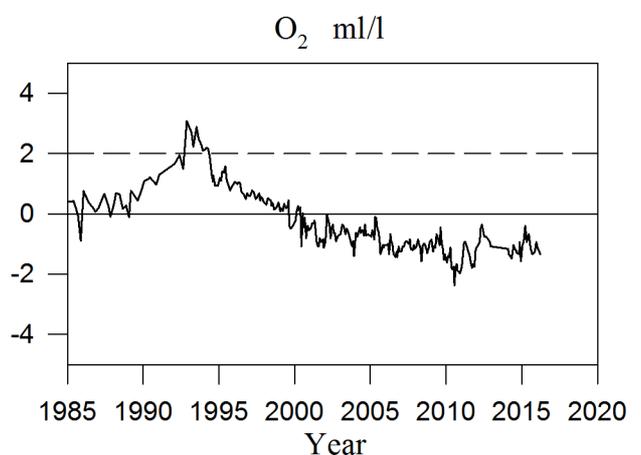
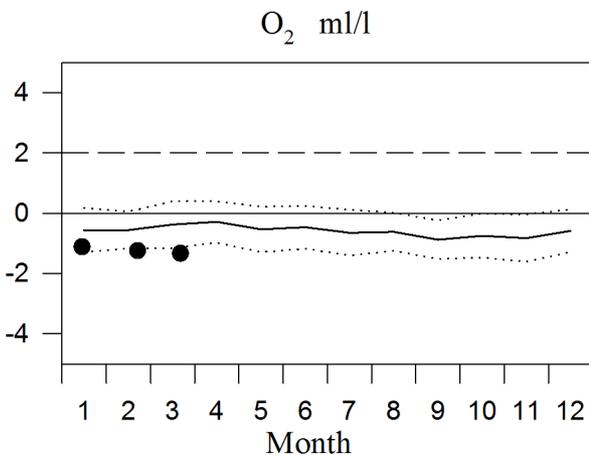
# STATION BY32 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

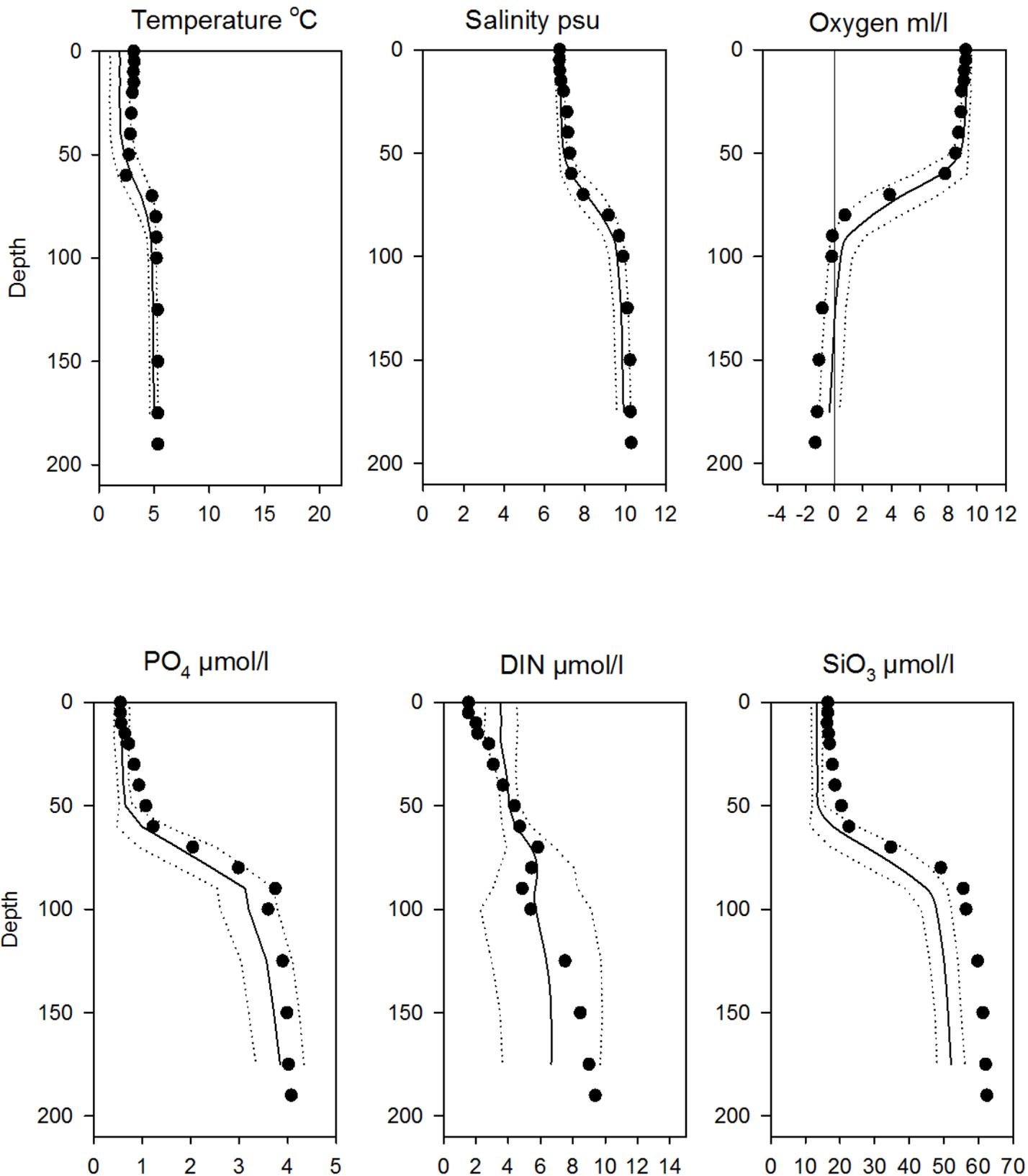


## OXYGEN IN BOTTOM WATER (depth > 175m)



# Vertical profiles BY32 March

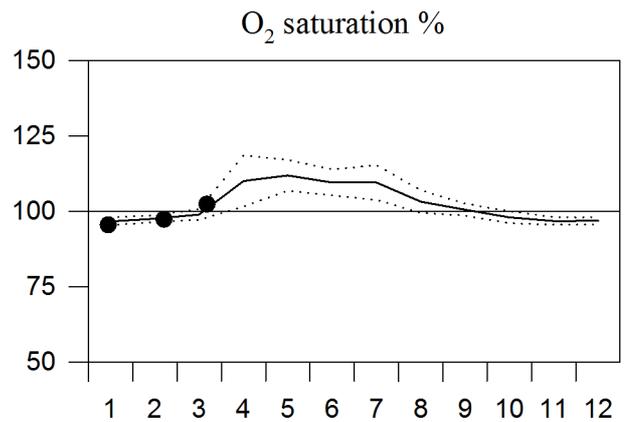
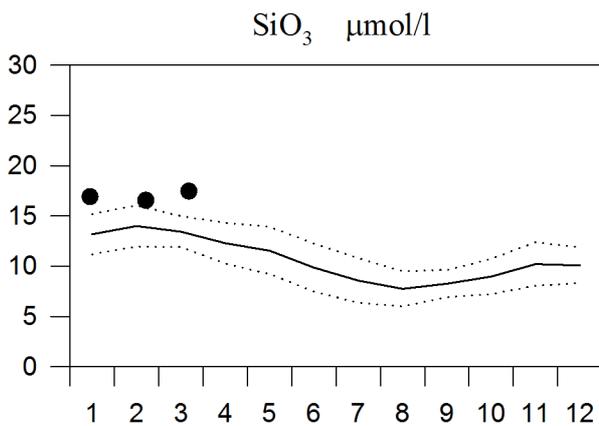
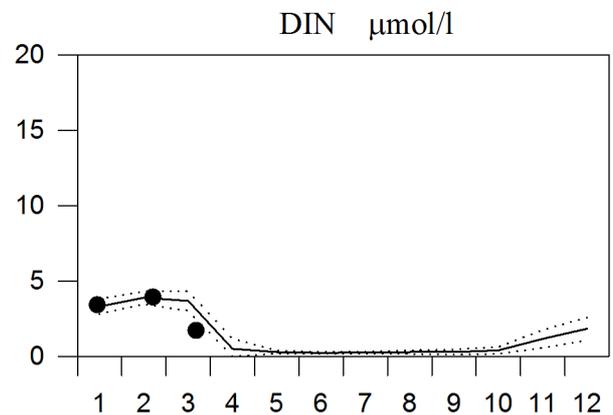
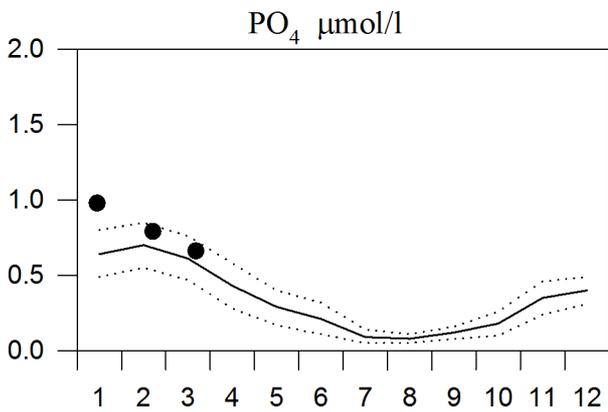
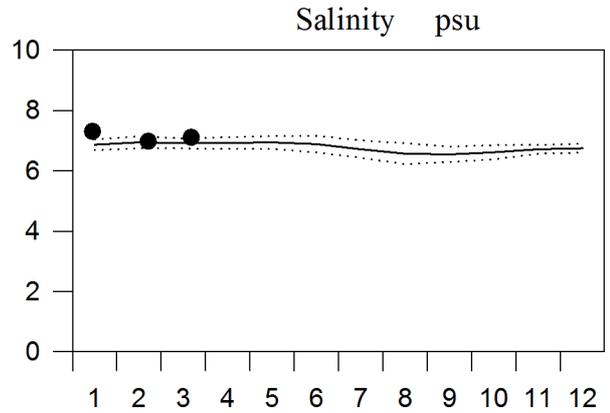
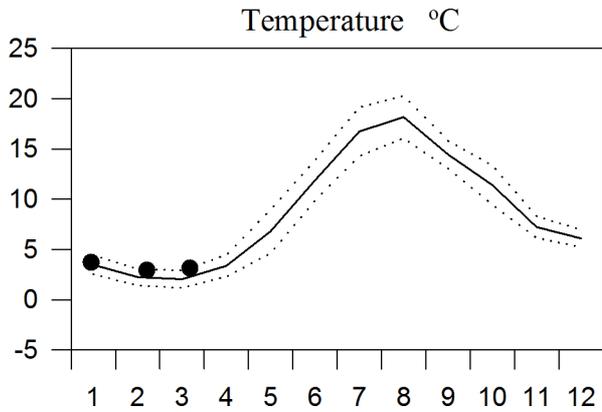
— Mean 1996-2010      ..... St.Dev.      ● 2016



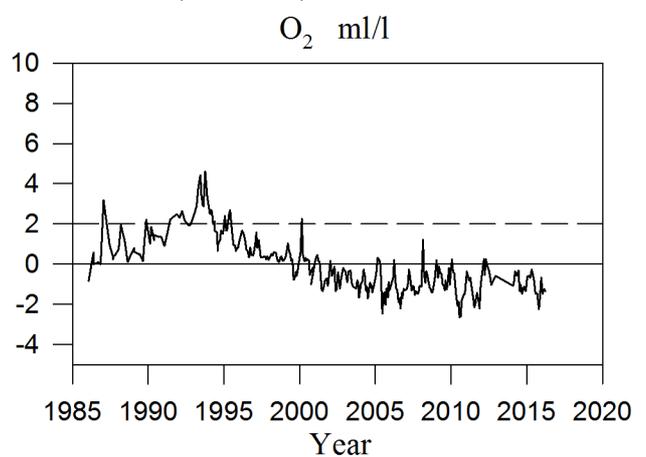
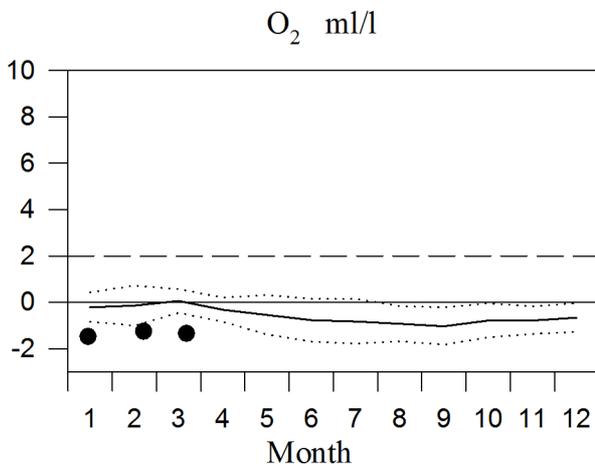
# STATION BY38 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

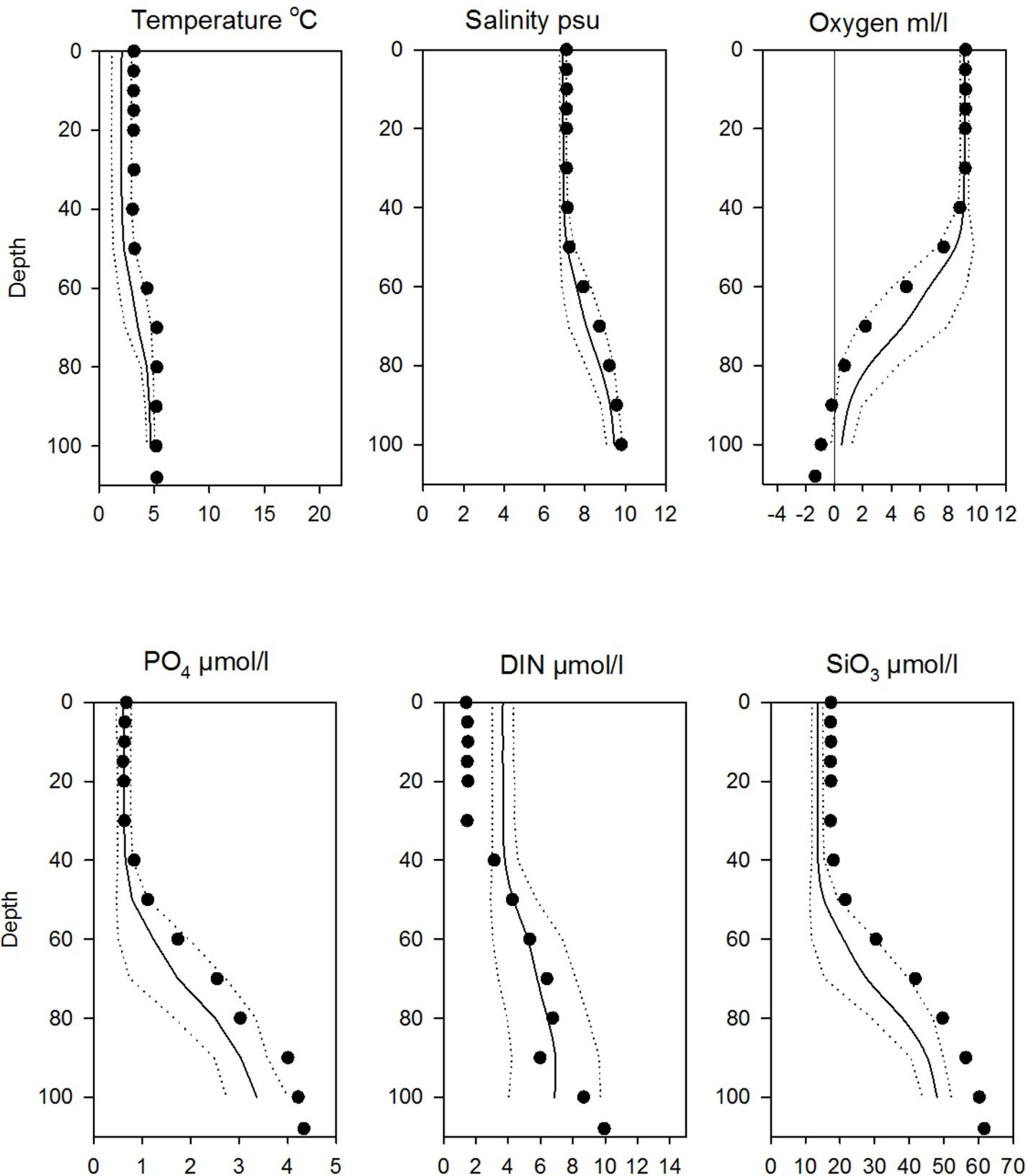


## OXYGEN IN BOTTOM WATER (> 100m)



# Vertical profiles BY38 March

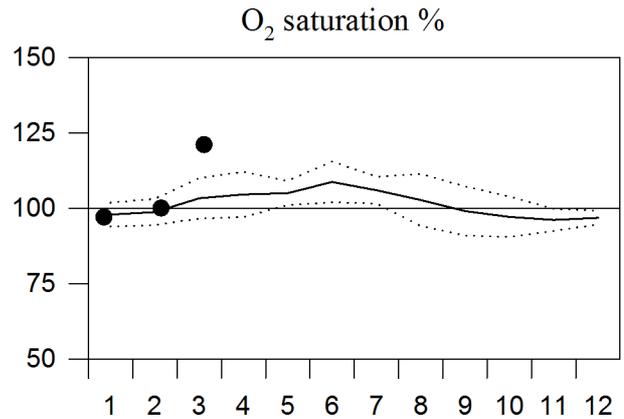
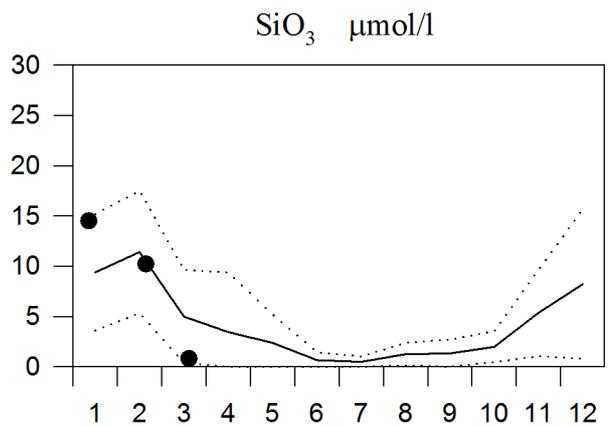
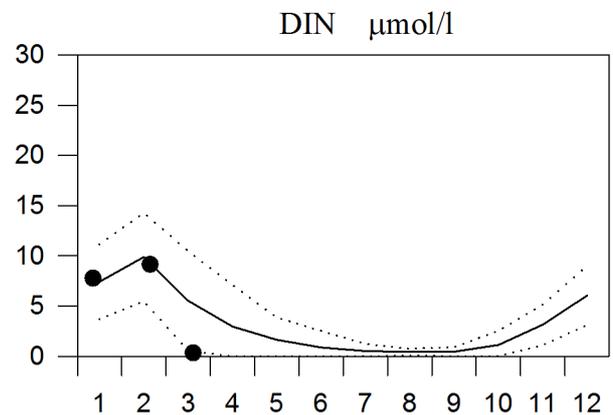
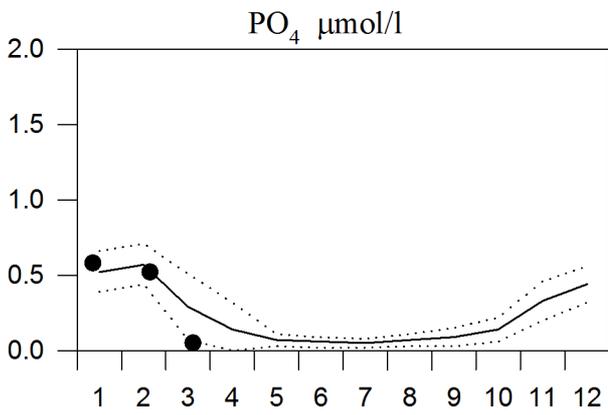
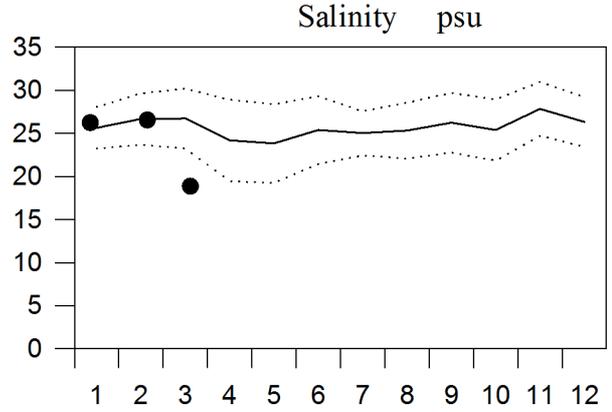
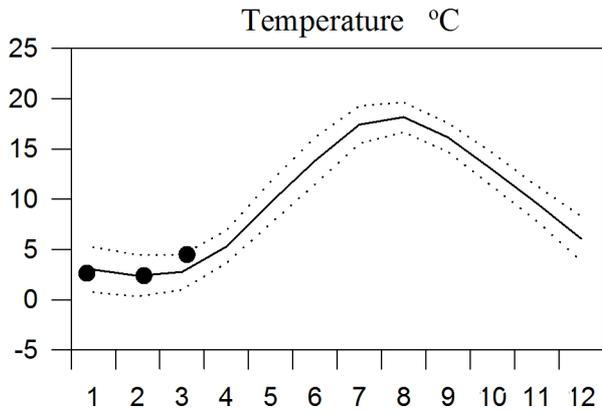
— Mean 1996-2010      ..... St.Dev.      ● 2016



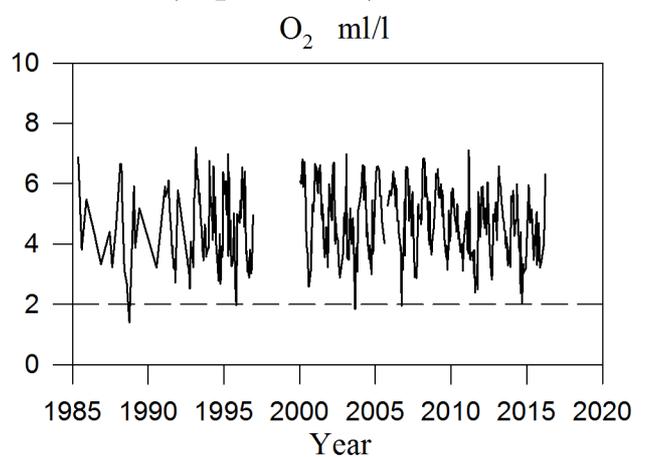
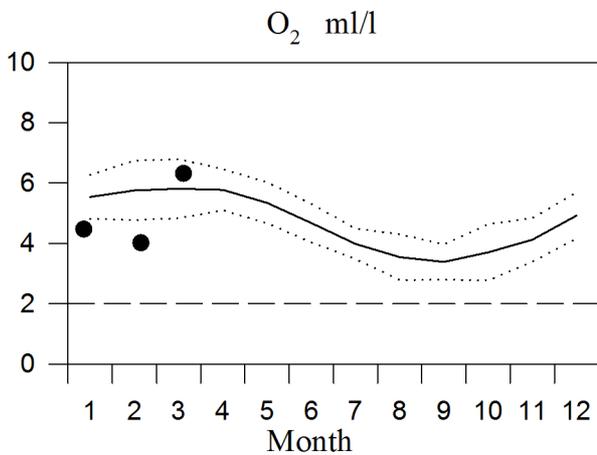
# STATION SLÄGGÖ SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ..... St.Dev.      ● 2016

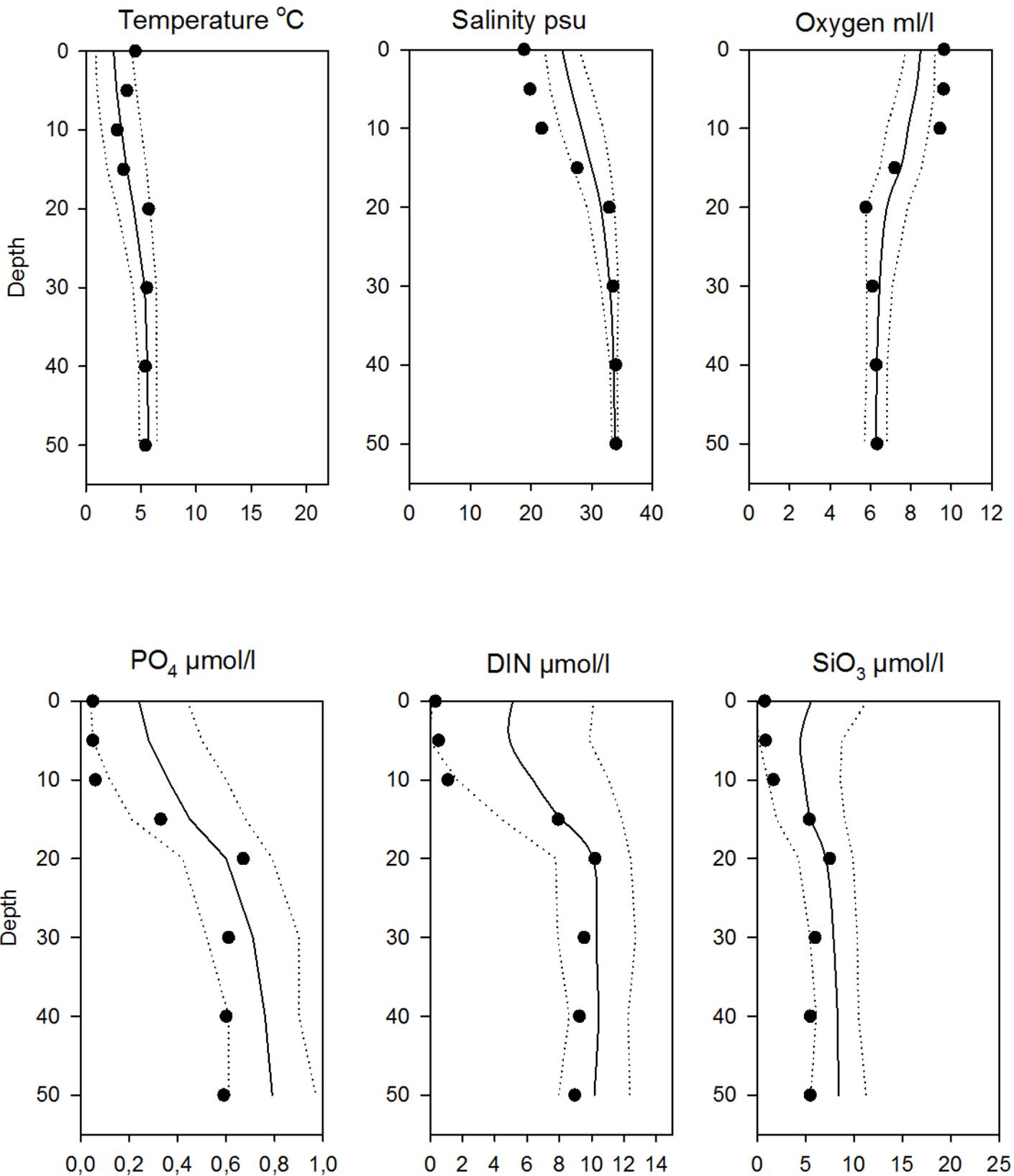


## OXYGEN IN BOTTOM WATER (depth >50m)



# Vertical profiles Släggö March

— Mean 1996-2010      ..... St.Dev.      ● 2016



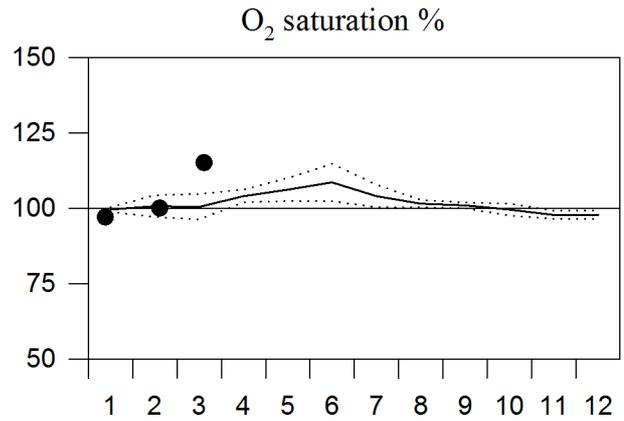
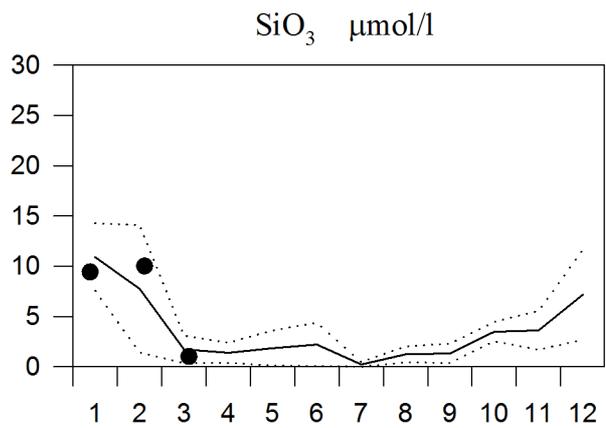
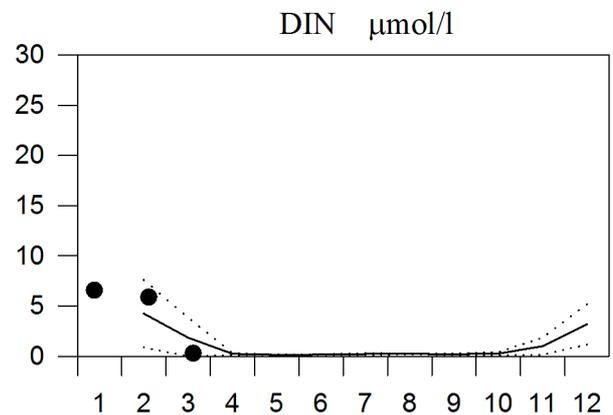
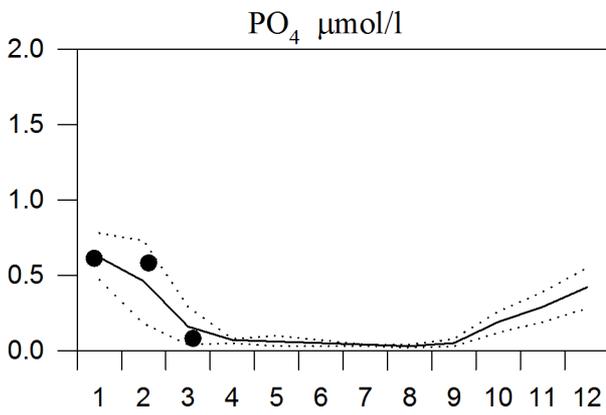
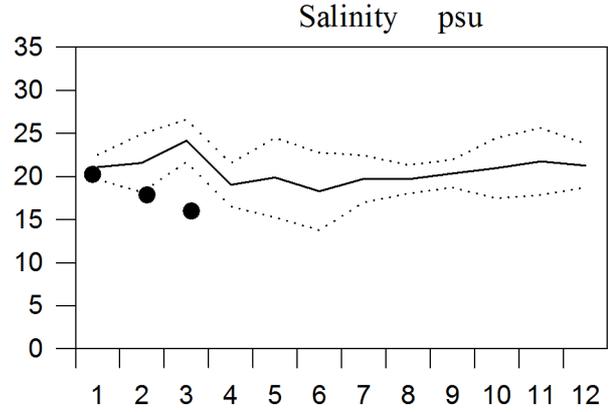
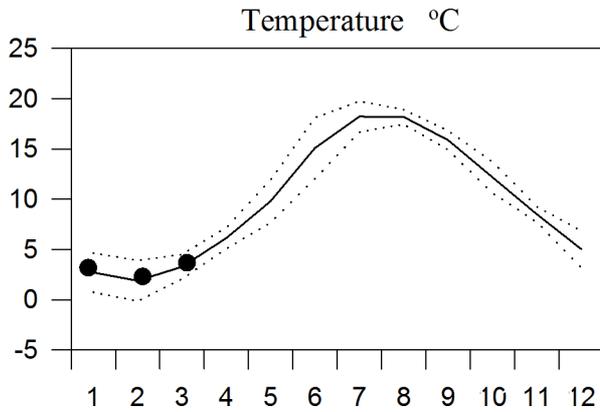
# STATION N14 Falkenberg SURFACE WATER

## Annual Cycles

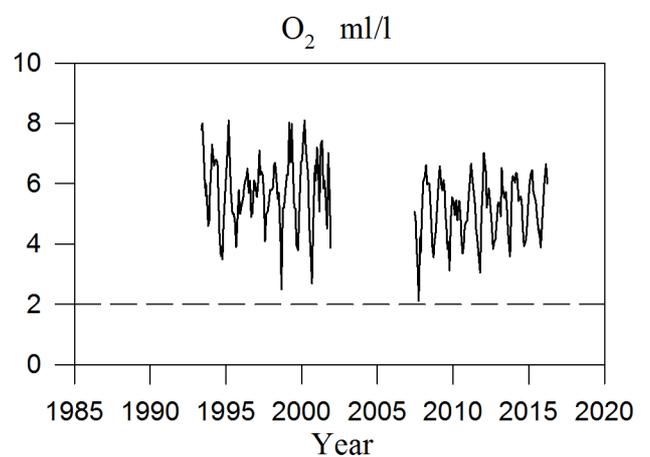
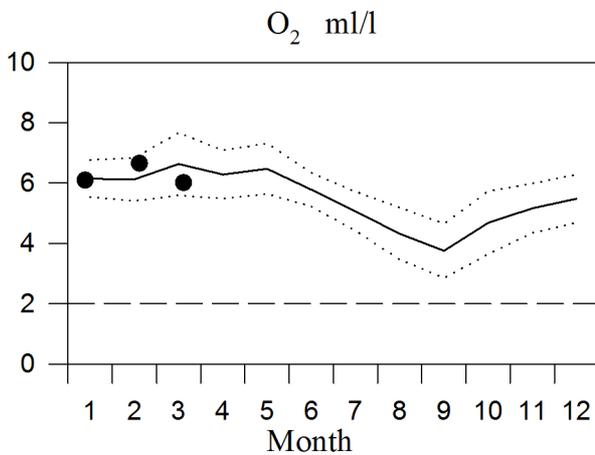
— Mean 2007-2010

..... St.Dev.

● 2016

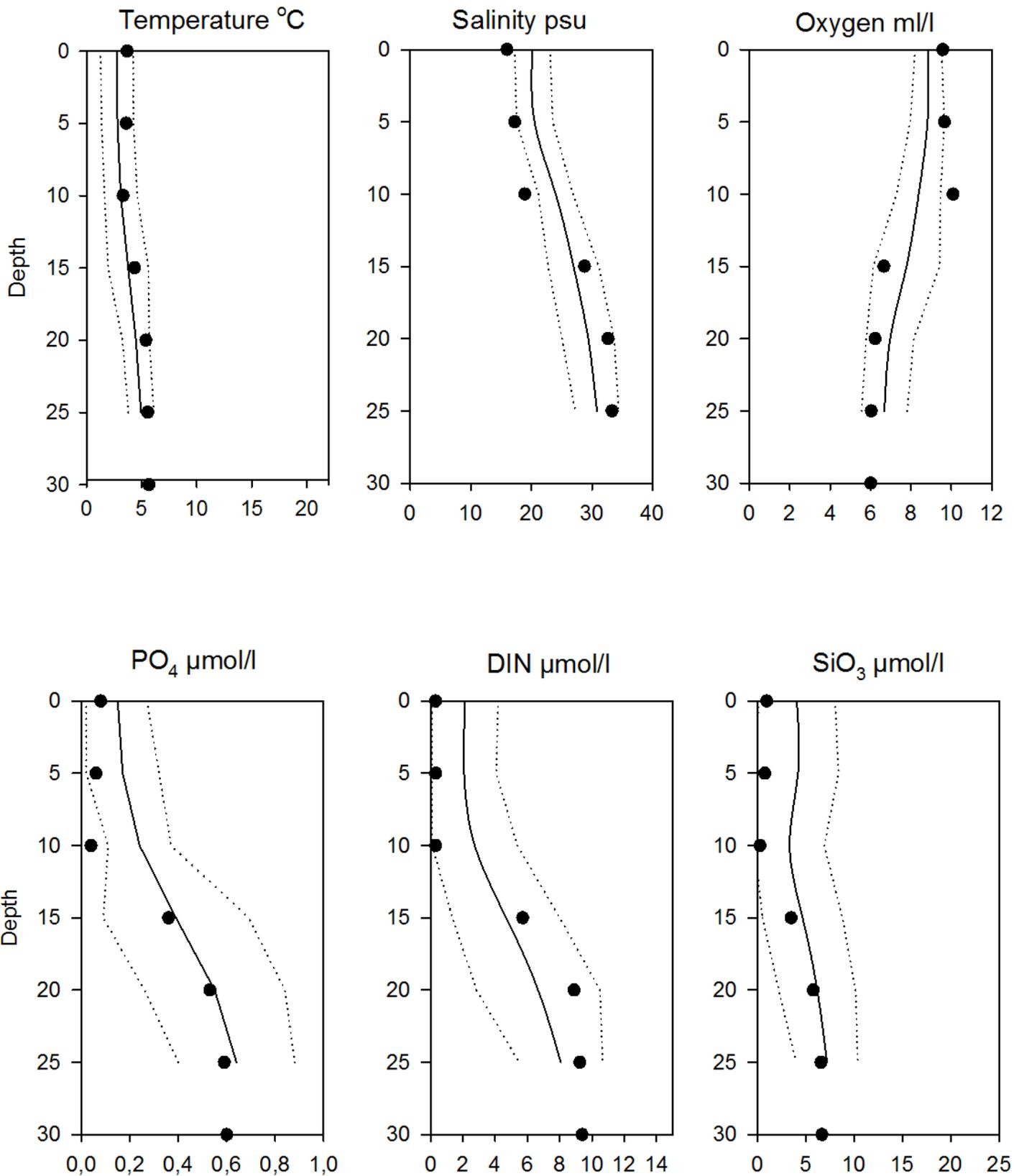


## OXYGEN IN BOTTOM WATER (depth > 25m)



# Vertical profiles N14 Falkenberg March

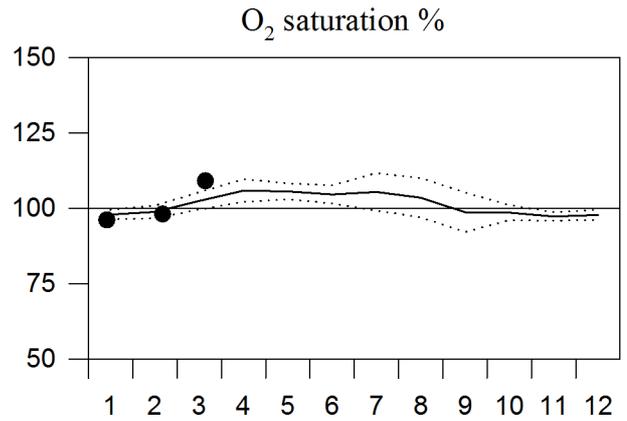
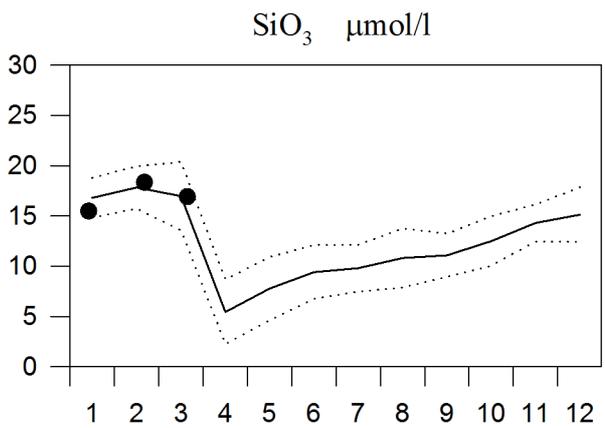
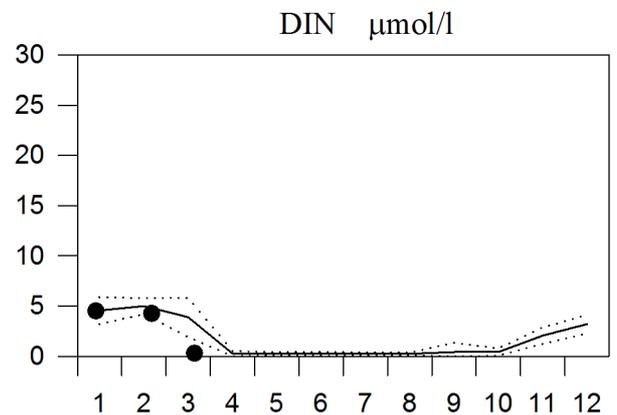
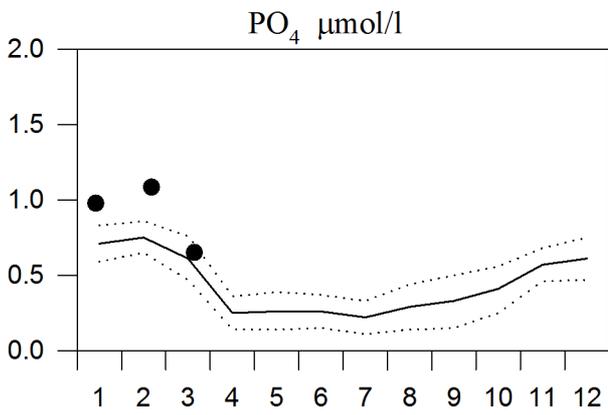
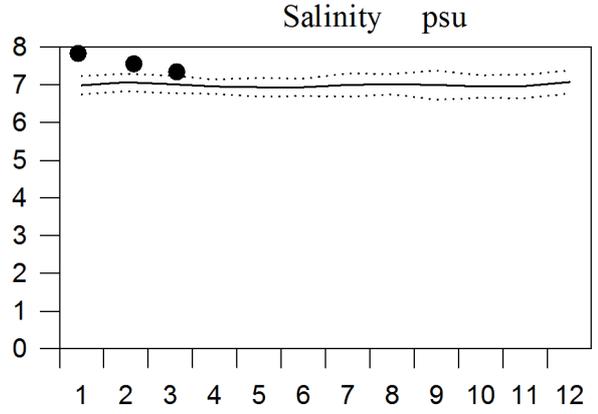
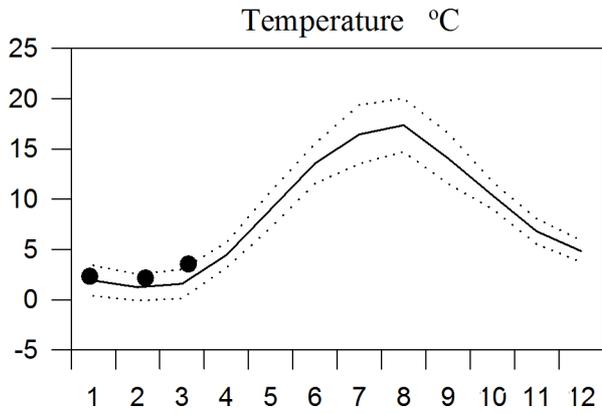
— Mean 1996-2010      ..... St.Dev.      ● 2016



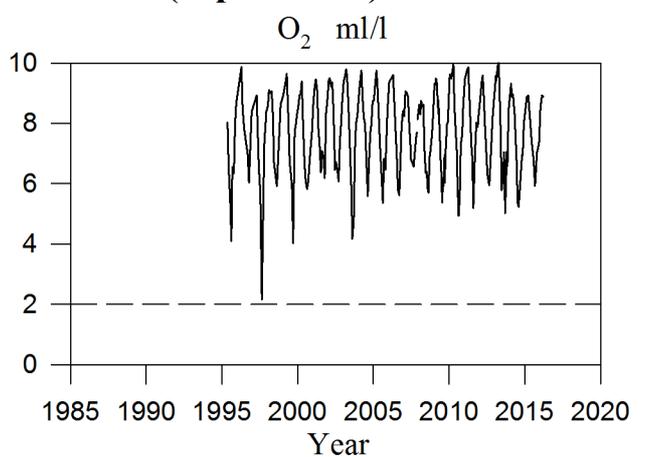
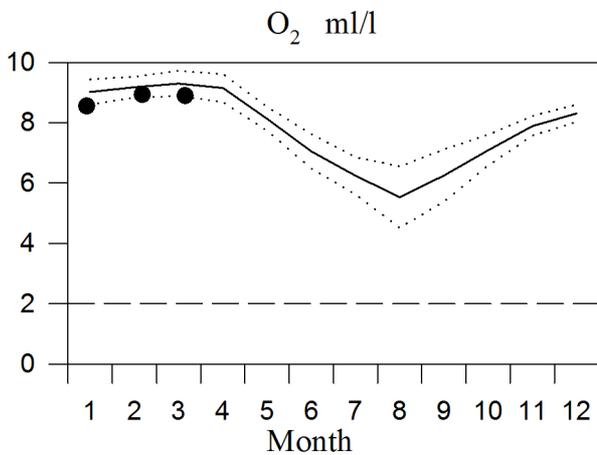
# STATION REF M1V1 SURFACE WATER

## Annual Cycles

— Mean 1996-2010      ····· St.Dev.      ● 2016



## OXYGEN IN BOTTOM WATER (depth >15m)



# Vertical profiles Ref M1V1 March

— Mean 1996-2010      ..... St.Dev.      ● 2016

