

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



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**Survey period:** 2015-10-12 - 2015-10-19  
**Survey area:** Skagerrak, Kattegat, the Sound, the Baltic Proper and the Gulf of Finland  
**Principal:** SMHI and the Swedish Agency for Marine and Water Management

### SUMMARY

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

The surface water in Skagerrak and Kattegat was somewhat cooler, around 11°C, than the surface water in the Baltic Proper where there was about 13°C. Inorganic nitrogen (NO<sub>2</sub>+NO<sub>3</sub>) in surface waters were close to the detection limit in all regions. The concentrations of phosphate were low throughout the region except in the Southern Baltic, where they were somewhat higher than normal. The effect of the large inflow event in December 2014 could not be seen farther north than the station BY20 in the Eastern Gotland Basin. The inflow event contributed to more oxygen in the Baltic Proper deep water but oxygen levels are now declining and the oxygen concentration in the Gotland Deep had now been reduced to 0.5 ml/l. The concentration of hydrogen sulphide has decreased which probably is an effect of the inflow. In Western- and Northern Gotland Basins the oxygen situation remains severe. In the Western Gotland Basin, completely oxygen-free conditions were found from 80-90 meters while acute hypoxia occurred from 80 meters. The northern part was completely oxygen-free from 70-80 meters and acute hypoxia occurred from 70 meters. Oxygen levels in the bottom water in the Bornholm Basin and Hanö Bight had decreased by a further 0.5 ml/l since the previous survey in September and acute hypoxia was also noted. During the entire expedition an outflow from the Baltic to the Kattegat was ongoing and there was a strong two-layer stratification in the Sound.

The next regular cruise is scheduled to start November 9, 2015.

**Address:**  
Sven Källfelts gata 15  
SE-426 71 Vastra Frolunda  
SWEDEN

**Telephone:**  
+46 11 4958000

**E-mail:**  
karin.wesslander@smhi.se  
**WWW:**  
<http://www.smhi.se/>

## **PRELIMINARY RESULTS**

The expedition was conducted aboard the Finnish research vessel Aranda and started in Helsinki on October 12 and ended in the same port on October 19. The winds during the expedition were mainly easterly and weak. Air temperatures ranged between 5.6 and 11.3 °C. During the entire expedition an outflow from the Baltic to the Kattegat was ongoing.

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

During the expedition a bottom-mounted measuring rig was taken up at the southern Öland. The system was deployed April 25, 2015 and has since then measured the temperature, salinity and oxygen at 58 meters depth with a measurement frequency of 10 minutes. The purpose of this operation is to follow the oxygen development in the Western Gotland Basin.

### **The Skagerrak**

The temperature of the surface water had begun to drop and was about normal or slightly below, in the range between 11.07 and 12.29 °C. Below the cooled surface water a layer of warmer summer water was found and there below a thermocline at 40-60 meters. The salinity of the surface layer varied between 22.81 and 24.67 psu, lowest at the coast. In off-shore Skagerrak, the halocline ranged over a large depth range, 10-40 m, and surface salinity was slightly lower than normal. Closest to the coast the halocline was more developed, 10-20 m, and surface salinity around normal.

All nutrients in the surface waters showed low concentrations both at the coast and in the outer parts which is normal for the season. The concentrations in surface waters for phosphate was in the range 0.07-0.13 µmol/l, inorganic nitrogen (NO<sub>2</sub> + NO<sub>3</sub>) around the detection limit <0.1 µmol/l and silicate 0.8-2.1 µmol/l. The lowest oxygen levels in the bottom water was measured at Släggö in Gullmarsfjorden estuary, 4.69 ml/l at 69 m, which is slightly higher than normal. Slightly lower oxygen concentration, 4.27 ml/l were found at the same station at 20-30 m depth is probably due the warmer water layer there.

Fluorescence measurements showed low biological activity in the surface layer 0-10 m. For more details on species composition see separate report on the algae situation.

### **The Kattegat and the Sound**

In the Kattegat, the temperature of the surface water was in the range of 10.89 to 11.92 °C, which is normal to slightly below normal for the season. The salinity of the surface layer varied between 19.48 and 22.7 psu in the Kattegat, which is typical. In the Sound the salinity was low, 8.49 psu, depending on the outflowing surface water from the Baltic Sea. The stratification, where the halocline and thermocline coincided, were found in 10 to 20 meters depth.

The concentrations of nutrients in surface waters were normal for the season in Kattegat. The phosphate content ranged from 0.10 to 0.13 µmol/l and thus continues to rise, which is the normal case in the fall. Silicate showed lower levels than normal, 0.9-1.6 µmol/l, and inorganic nitrogen (NO<sub>3</sub> + NO<sub>2</sub>) were below the reporting limit. In the Sound surface water where the phosphate concentration (0.35 µmol/l) and the content of inorganic nitrogen (0.28 µmol/l) normal and the content of silicate (5.0 µmol/l) low. However, ammonium was present (0.47 µmol/l) indicating degradation of organic material in the surface layer. In the Sound, there was also a very strong

stratification at 10 m, where the surface water had 8.49 psu in salinity and bottom water was 33.89 psu. In the stratification an oxygen-minima was observed of 2.30 ml/l, as well as elevated levels of all nutrients. The lowest oxygen levels in the bottom water were measured at Anholt E in the Kattegat (2.92 ml/l) and at W Landskrona in the Sound (2.84 ml/l).

Plankton activity was low in the surface layer 0-10 m. For details about the species composition see separate report on the algae situation.

## **The Baltic Proper**

The temperature in the surface layer were normal or slightly above normal for the season and varied from 12.14 °C to 13.88 °C, eastern and northern parts were slightly warmer than the western part. Surface salinity was normal for the time of year with slightly higher levels in the eastern part and ranged from 5.54 psu in the central Gulf of Finland to 8.03 psu in the south western Baltic. The halocline was found at 40-70 meters depth in the western and 60-80 meters depth in the eastern Gotland Basin, while it was slightly shallower in the south. In the Bornholm Basin the halocline was found at 55-65 m depth. Thermocline was at 30 meters depth and was well developed.

The concentrations of phosphate in surface waters were now higher than in September throughout the Baltic Sea. The concentrations ranged between 0.12 µmol/l in the northern Baltic Proper to 0.49 µmol/l in the south western Baltic Proper where levels were somewhat higher than normal. There was still somewhat elevated levels of silicate which varied between 7.1 and 12.2 µmol/l. The highest phosphate levels were noted in the Arkona Basin and the highest silicate at the coastal station REFM1V1. Inorganic nitrogen (NO<sub>2</sub> + NO<sub>3</sub>) was still completely exhausted in the whole area except at the coastal station RefM1V1 where it could be measured inorganic nitrogen in surface waters.

In order to follow the progress of the major inflow to the Baltic Sea, which occurred in December 2014, was also during this expedition an additional sampling carried out at station BY21 in Northern Gotland Basin. It appeared, however, no effects of the inflow event at this station. Just like the last sampling in September, an effect of the inflow at BY20 was still visible. Hydrogen sulphide was still present from 80 meters depth, but with slightly lower concentrations than during the previous survey.

In Western- and Northern Gotland Basins the oxygen situation remains very severe. In the Western Gotland Basin completely oxygen-free conditions, when hydrogen sulphide is formed, were found from 80-90 m while acute hypoxia, <2 ml/l, were found from 80 meters. The northern part was completely oxygen-free from 70-80 meters and had acute hypoxia from 70 meters.

In the Gotland Deep in the Eastern Gotland Basin, acute hypoxia occurred at depths exceeding 80 meters. The entire water column was now oxygenated, and no hydrogen sulphide was measured. Concentration of oxygen, however, had further declined slightly since the previous expedition in September and was now around 0.5 ml/l. Oxygen levels in the bottom water in the Bornholm Basin and Hanö Bight had decreased by 0.5 ml/l since the previous survey in September and acute hypoxia thus remained.

Fluorescence measurements showed low biological activity of the thermocline. For more details on species composition see separate report on the algae situation.

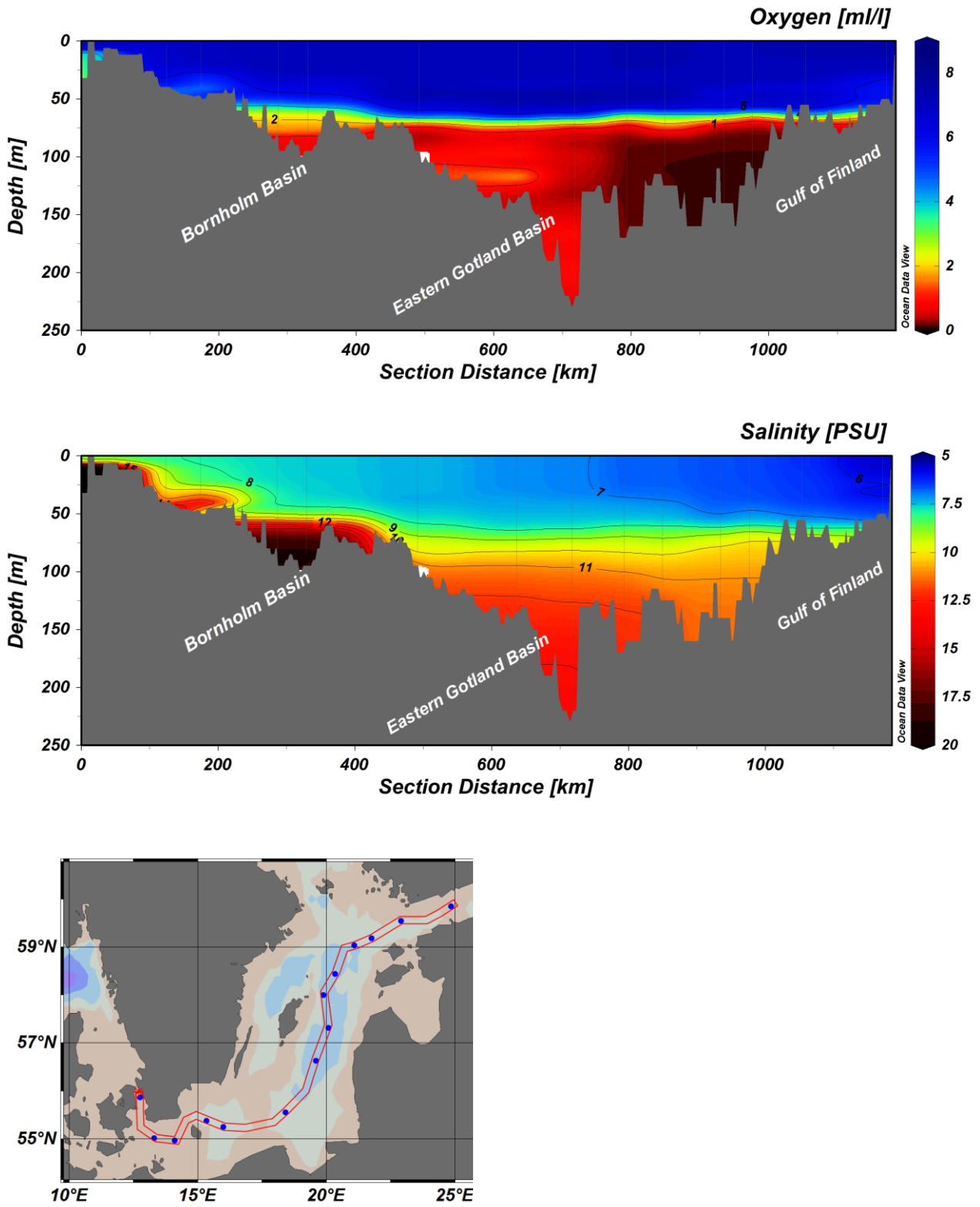


Figure 1. Transect showing the oxygen and salinity from the Sound to the Gulf of Finland.

## PARTICIPANTS

<b>Name</b>		<b>Institute</b>
Karin Wesslander	Chief scientist	SMHI
Kristin Andreasson		SMHI
Lars Andersson		SMHI
Johan Kronsell	Lysekil-Helsinki	SMHI
Daniel Simonsson	Helsinki-Lysekil	SMHI
Sari Sipilä		SMHI

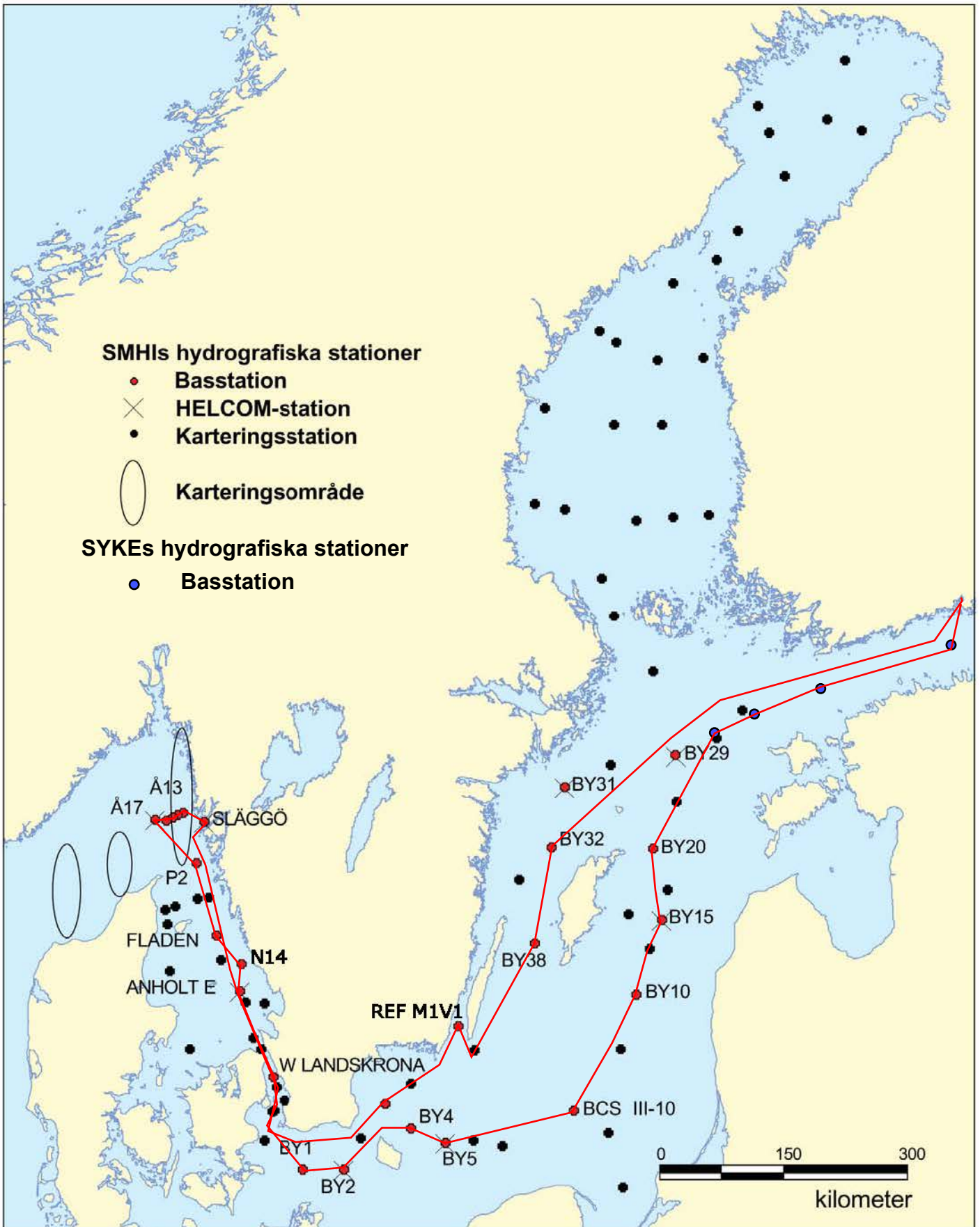
## APPENDICES

- 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



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Ship: R/V ARANDA  
Date: 20151012-20151019  
Series: 0606-0636





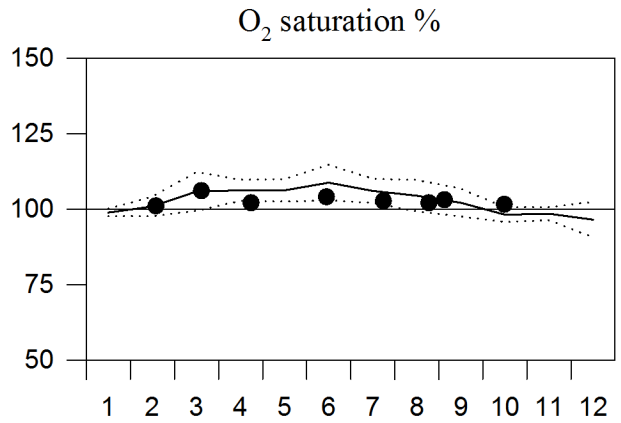
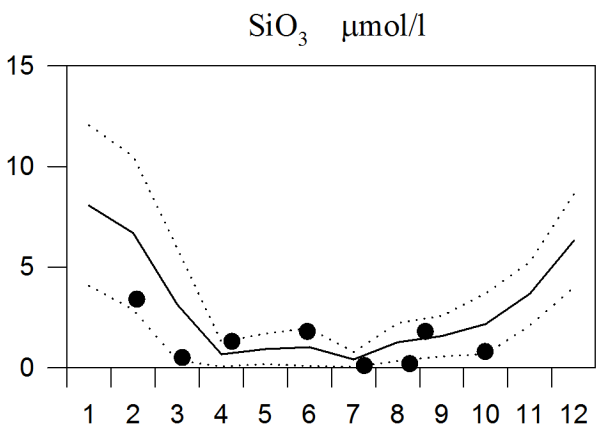
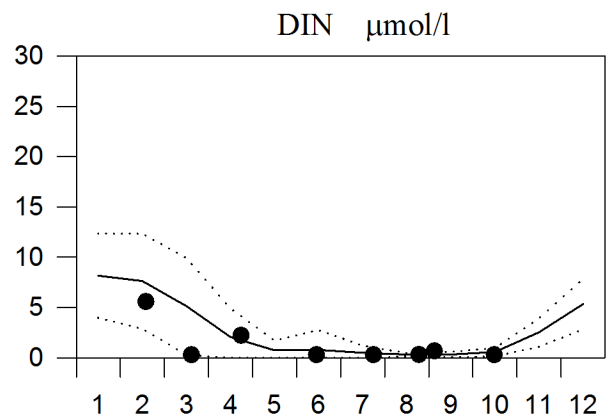
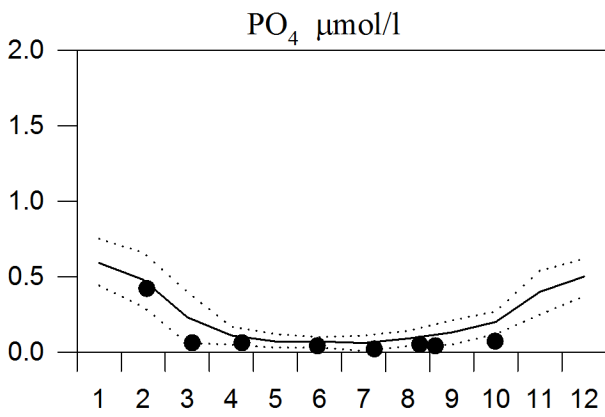
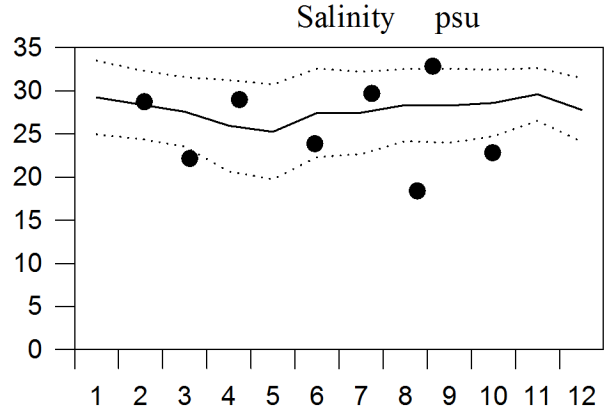
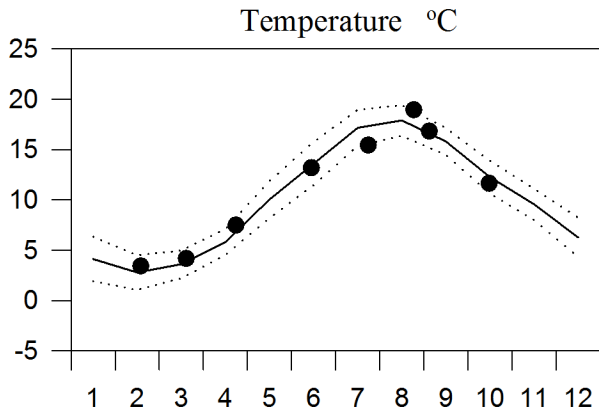




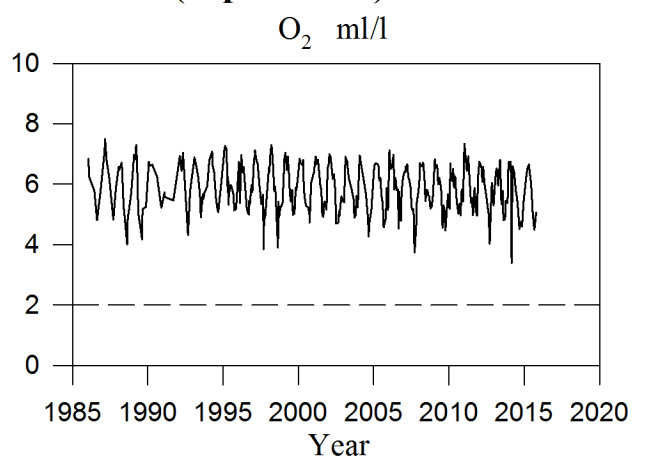
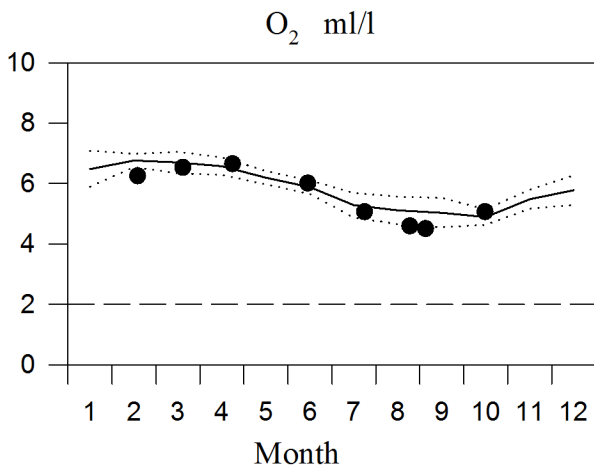
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## Annual Cycles

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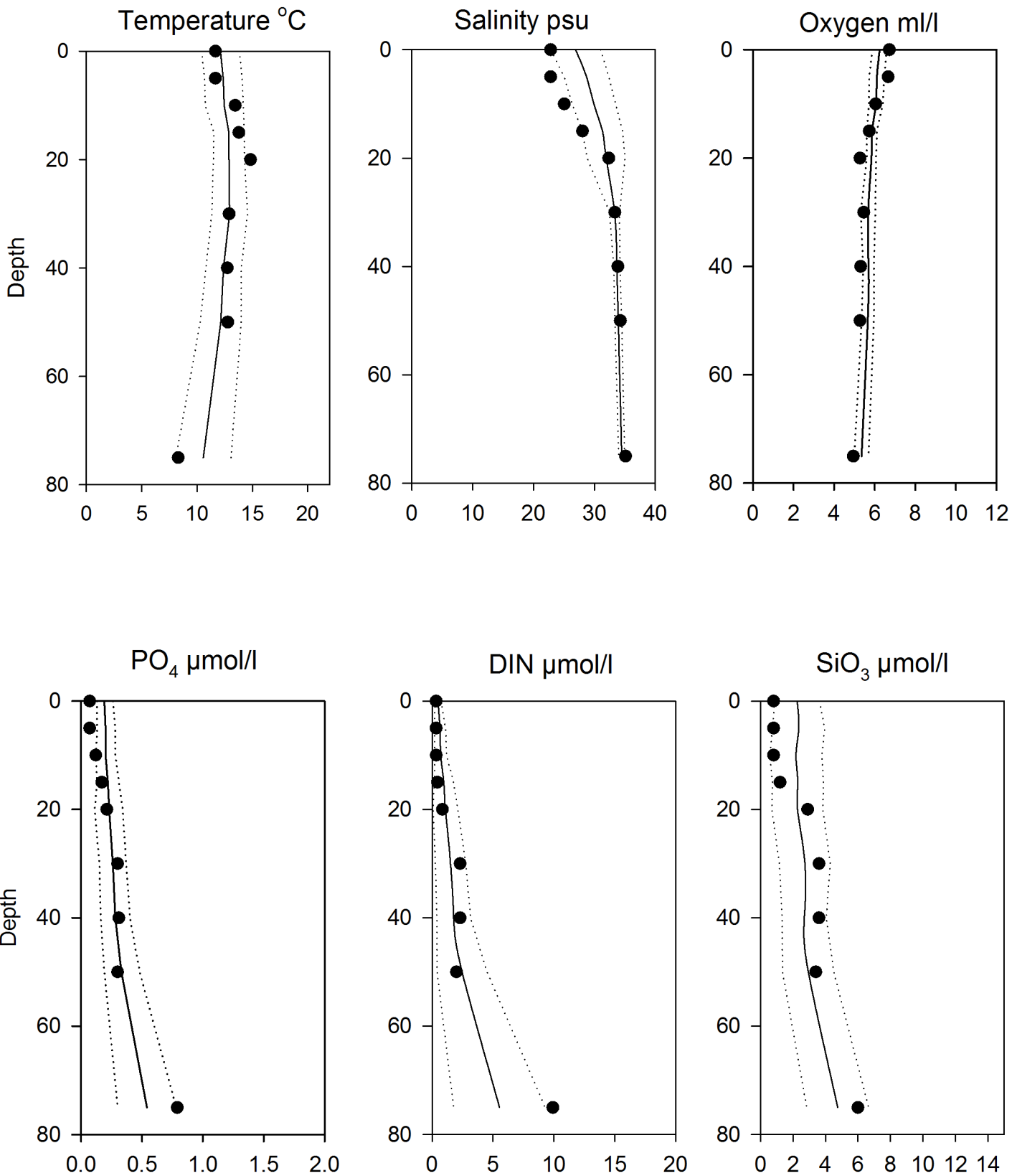


## OXYGEN IN BOTTOM WATER (depth >75m)



# Vertical profiles P2 October

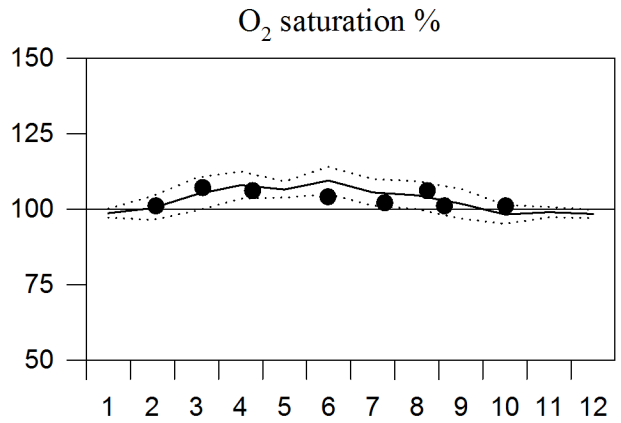
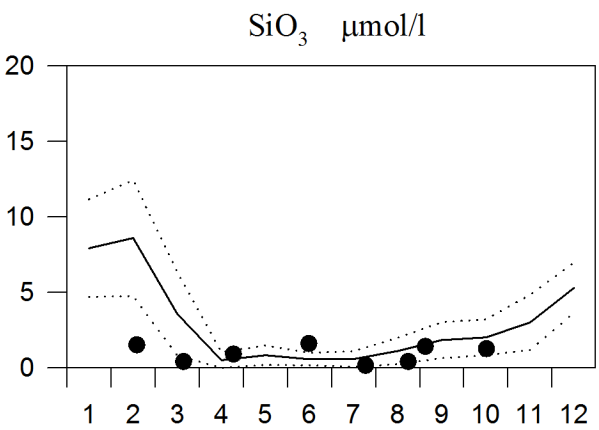
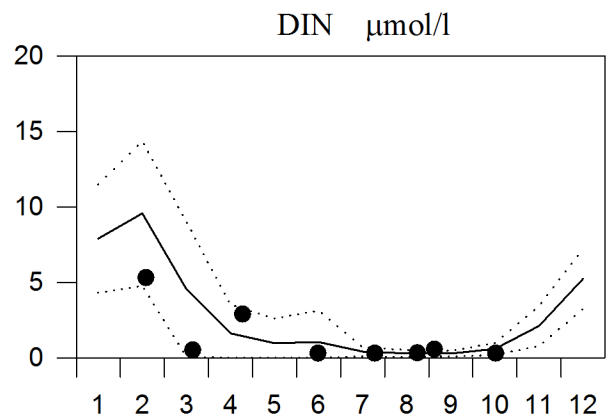
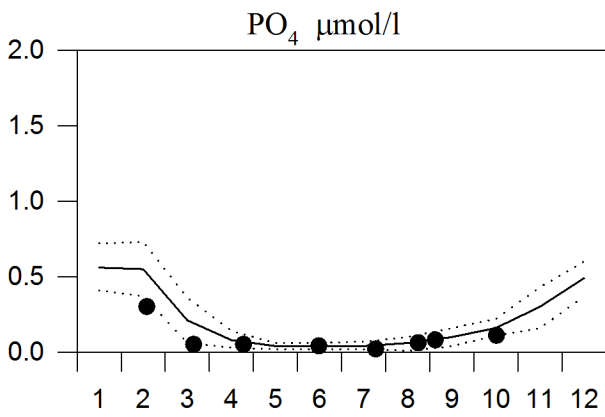
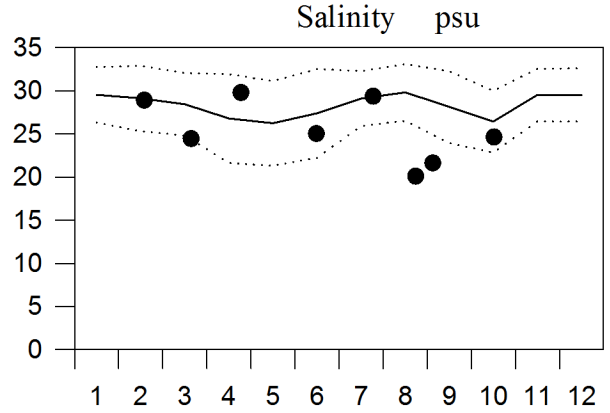
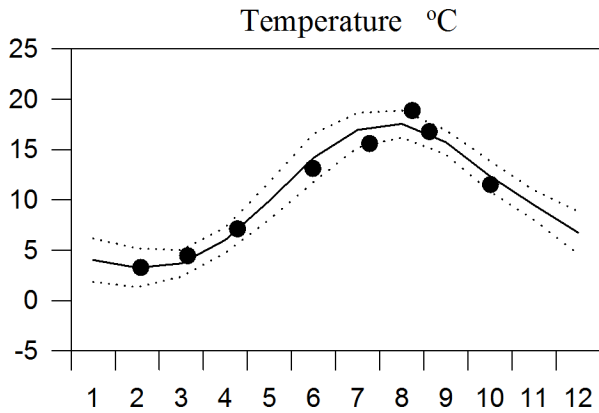
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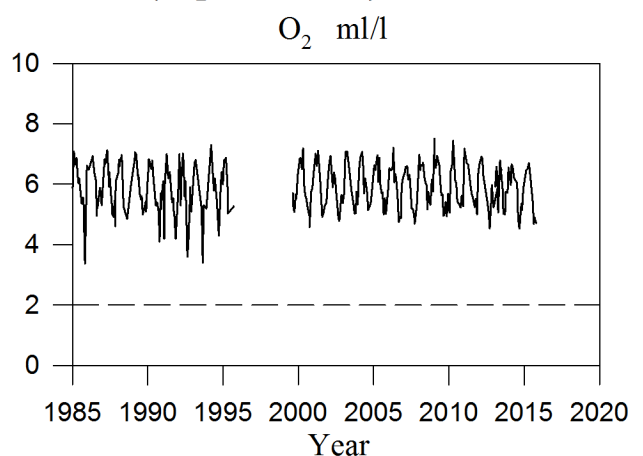
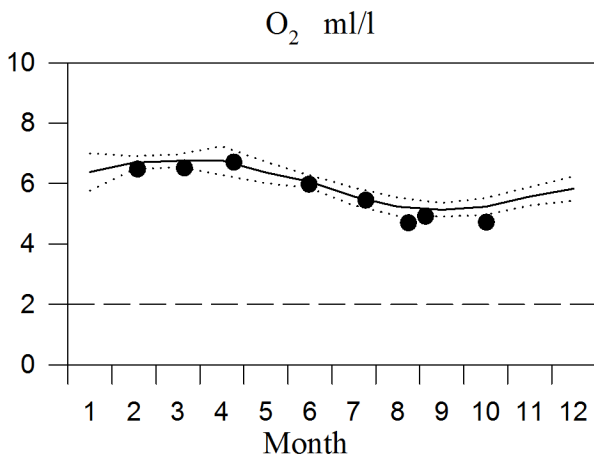
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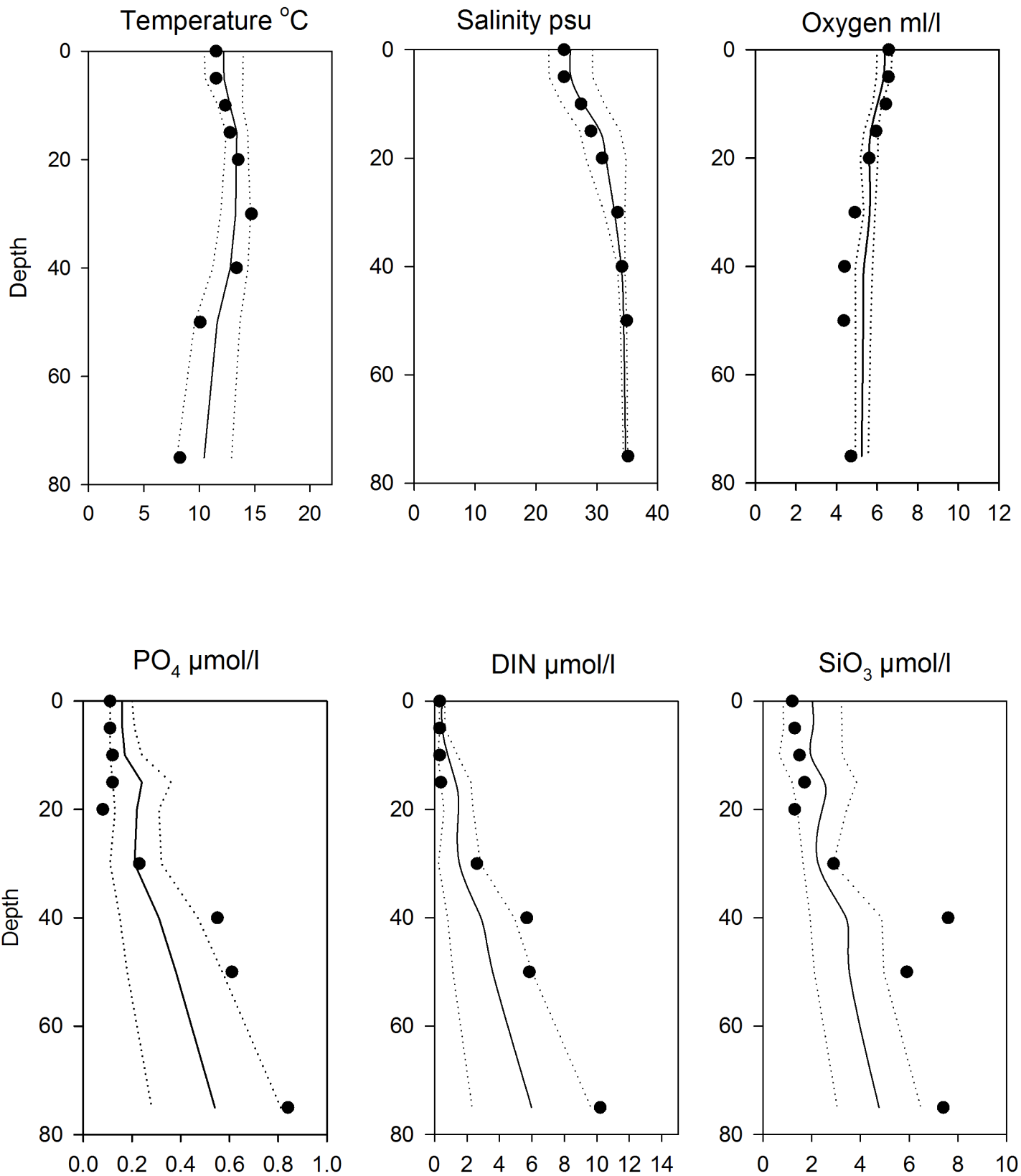


## OXYGEN IN BOTTOM WATER (depth >=75m)



# Vertical profiles Å13 October

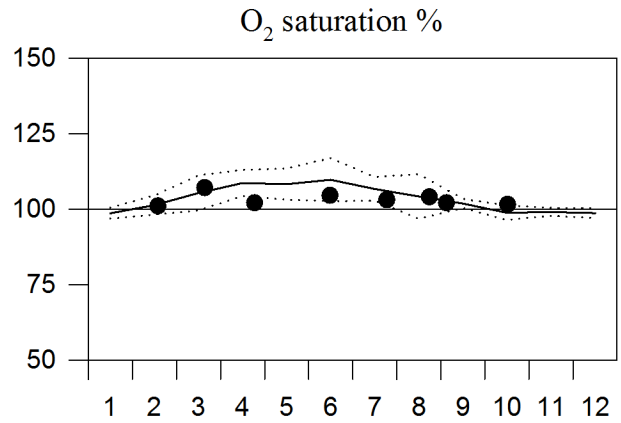
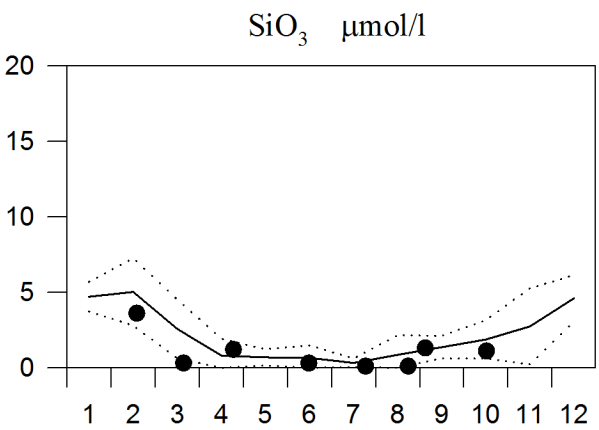
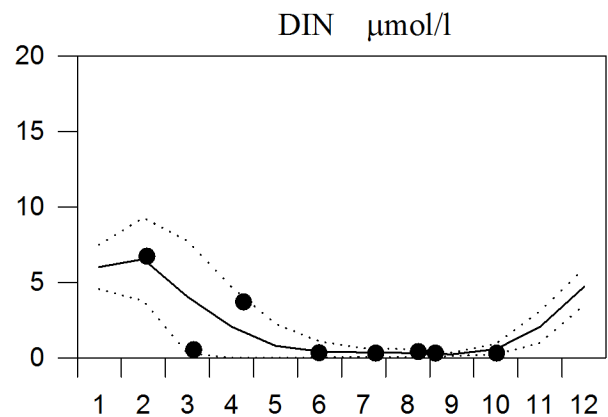
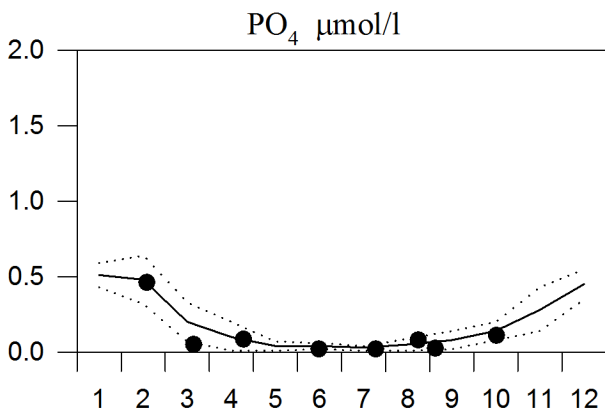
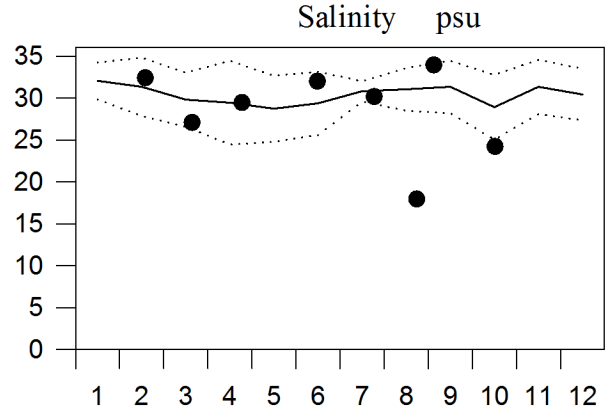
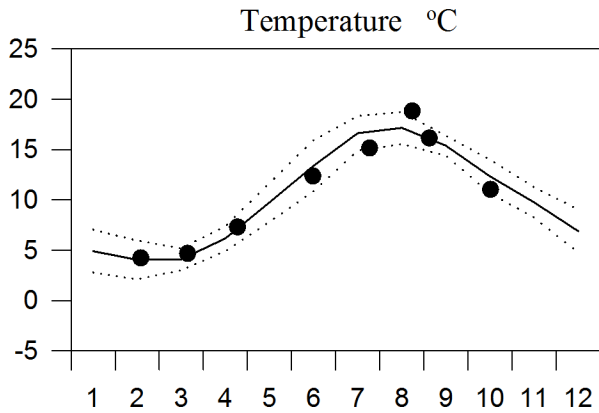
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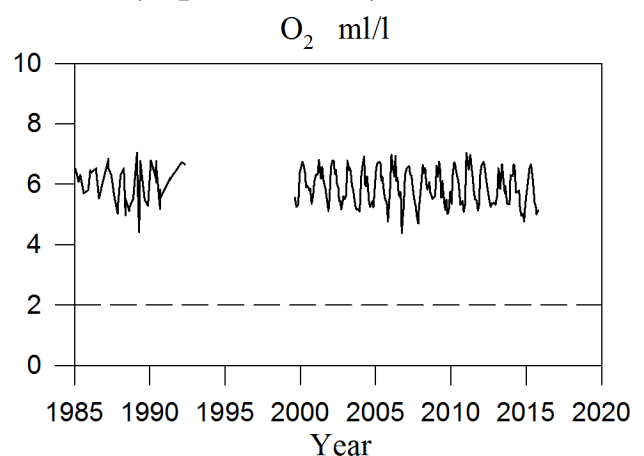
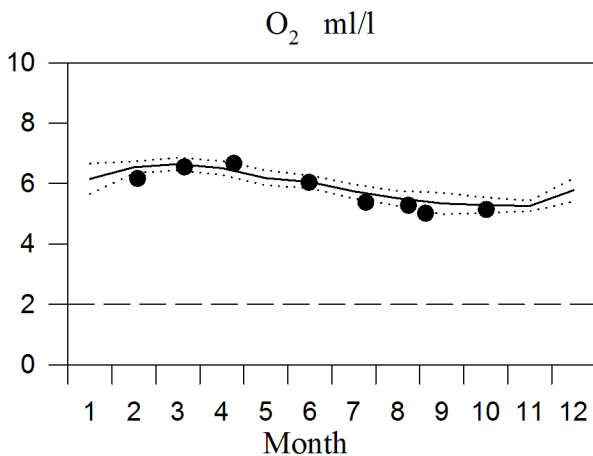
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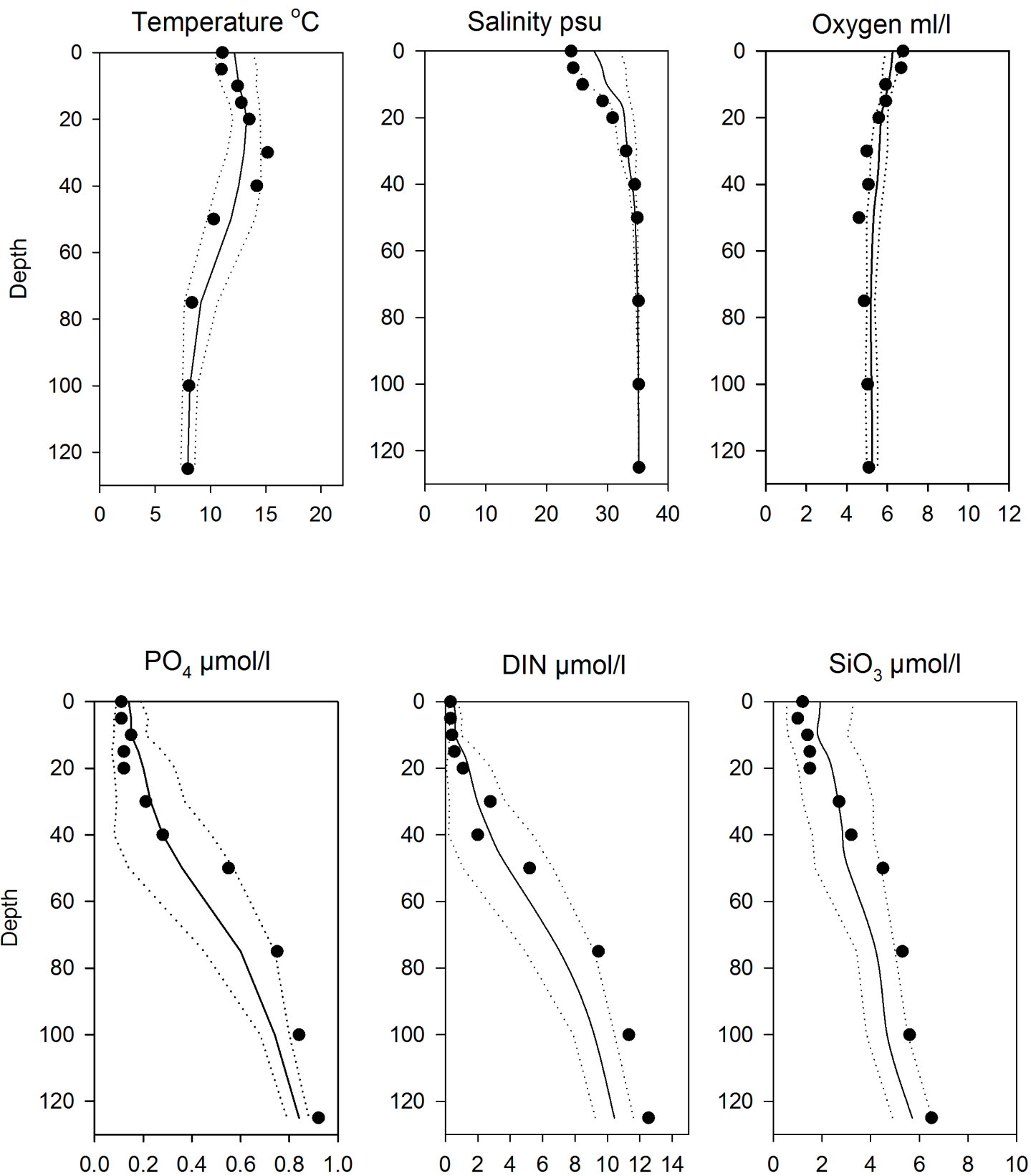


## OXYGEN IN BOTTOM WATER (depth >=125m)



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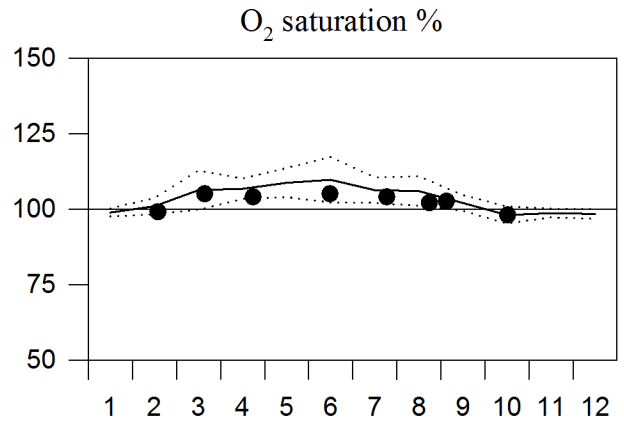
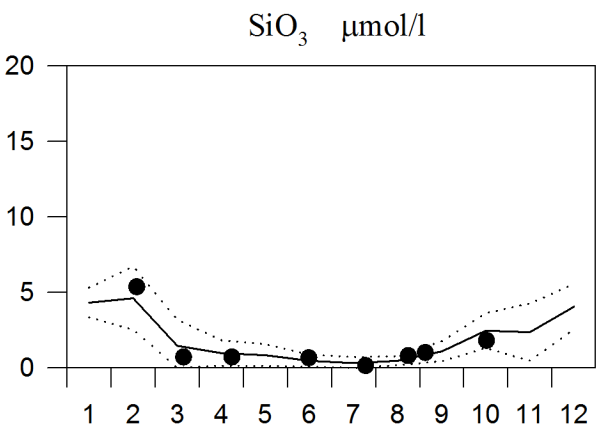
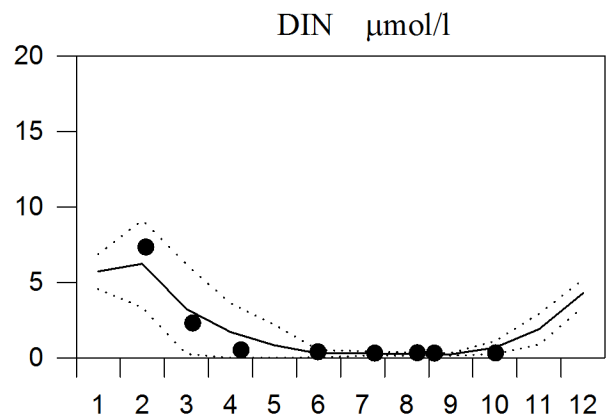
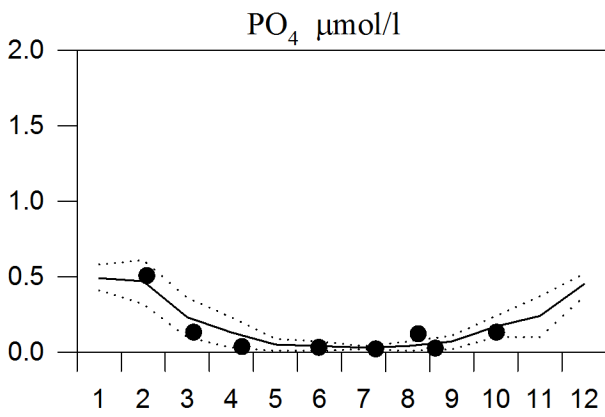
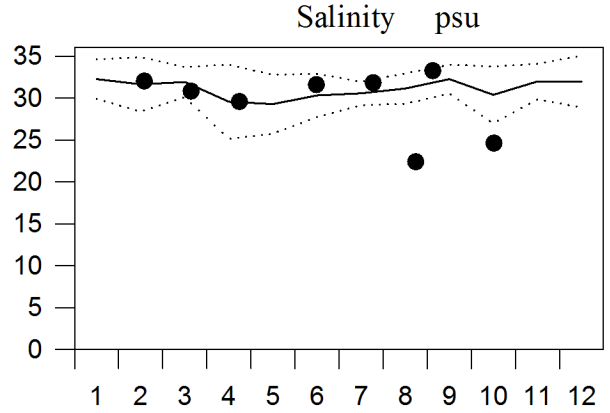
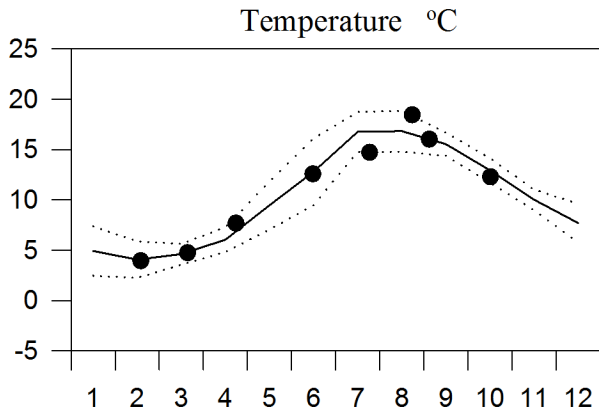




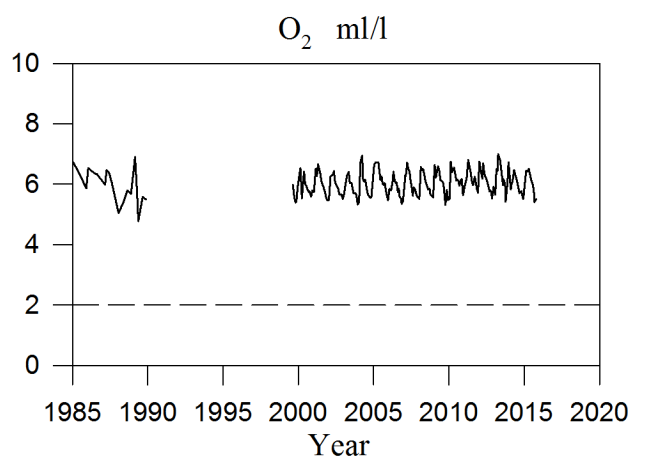
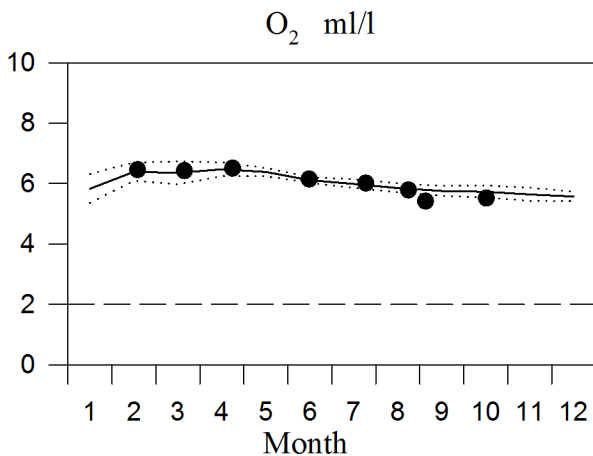
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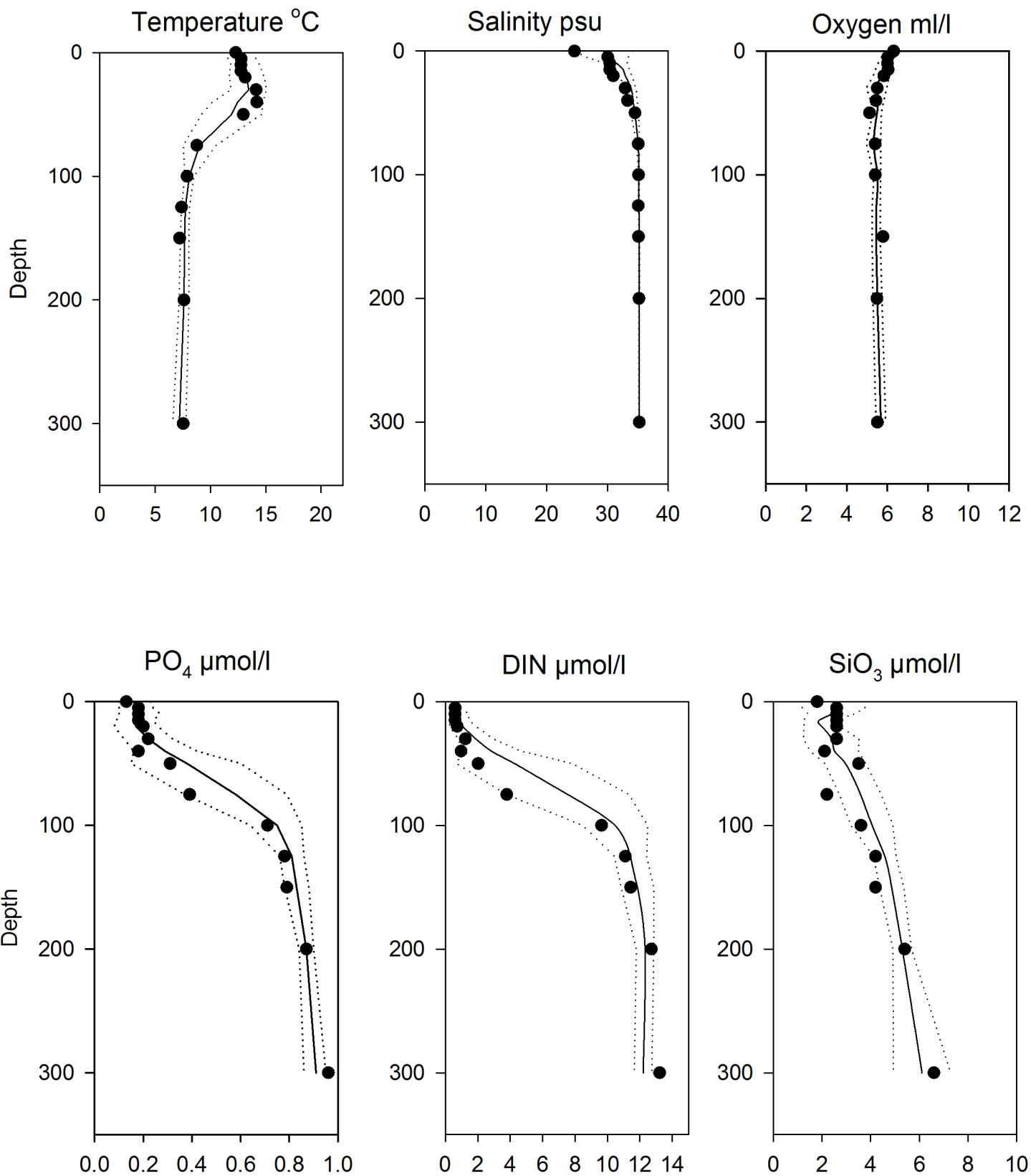


## OXYGEN IN BOTTOM WATER (depth = 300m)



# Vertical profiles Å17 October

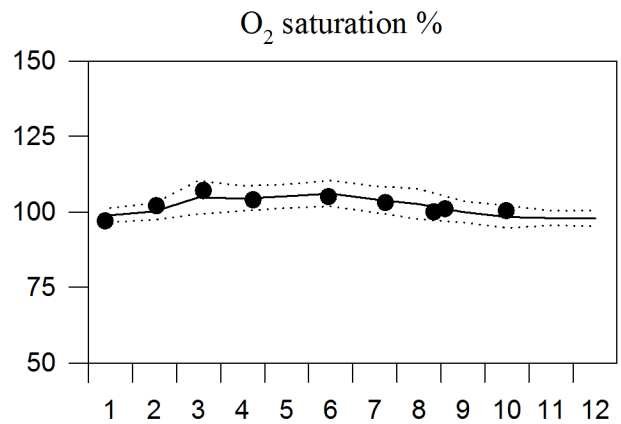
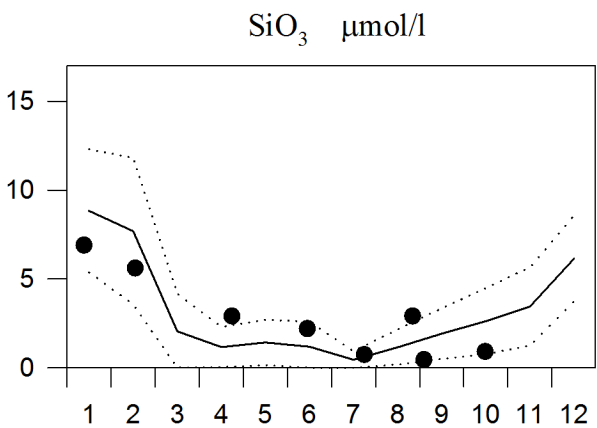
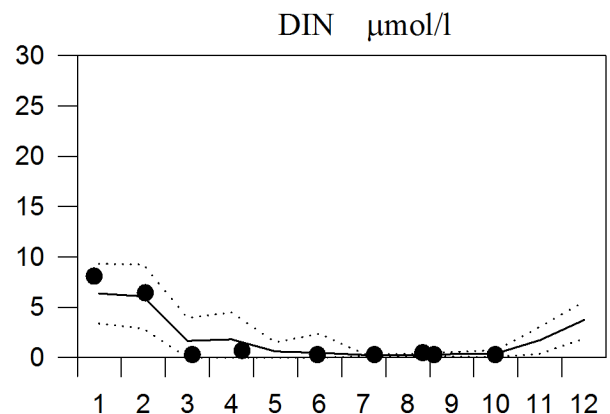
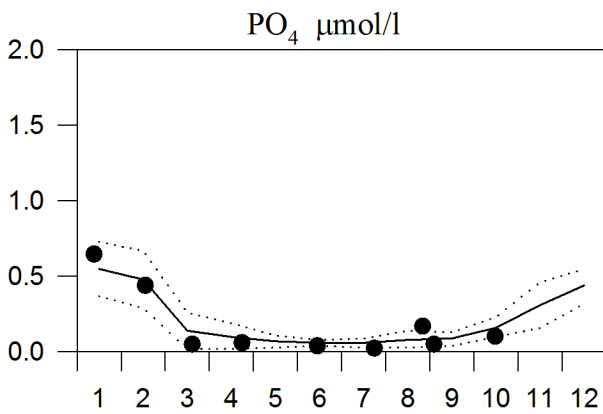
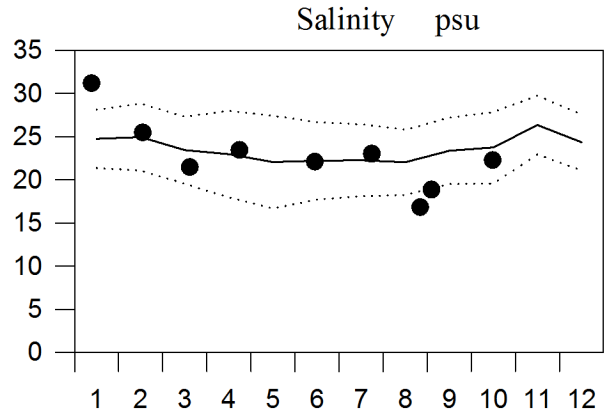
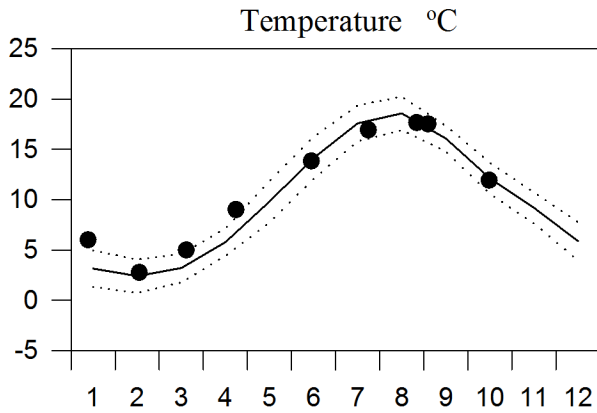
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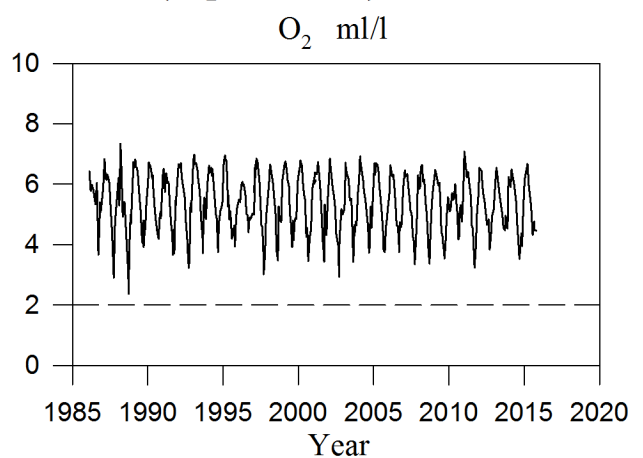
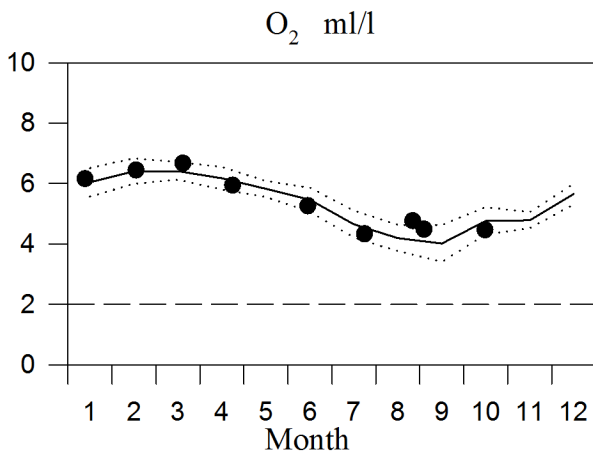
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## Annual Cycles

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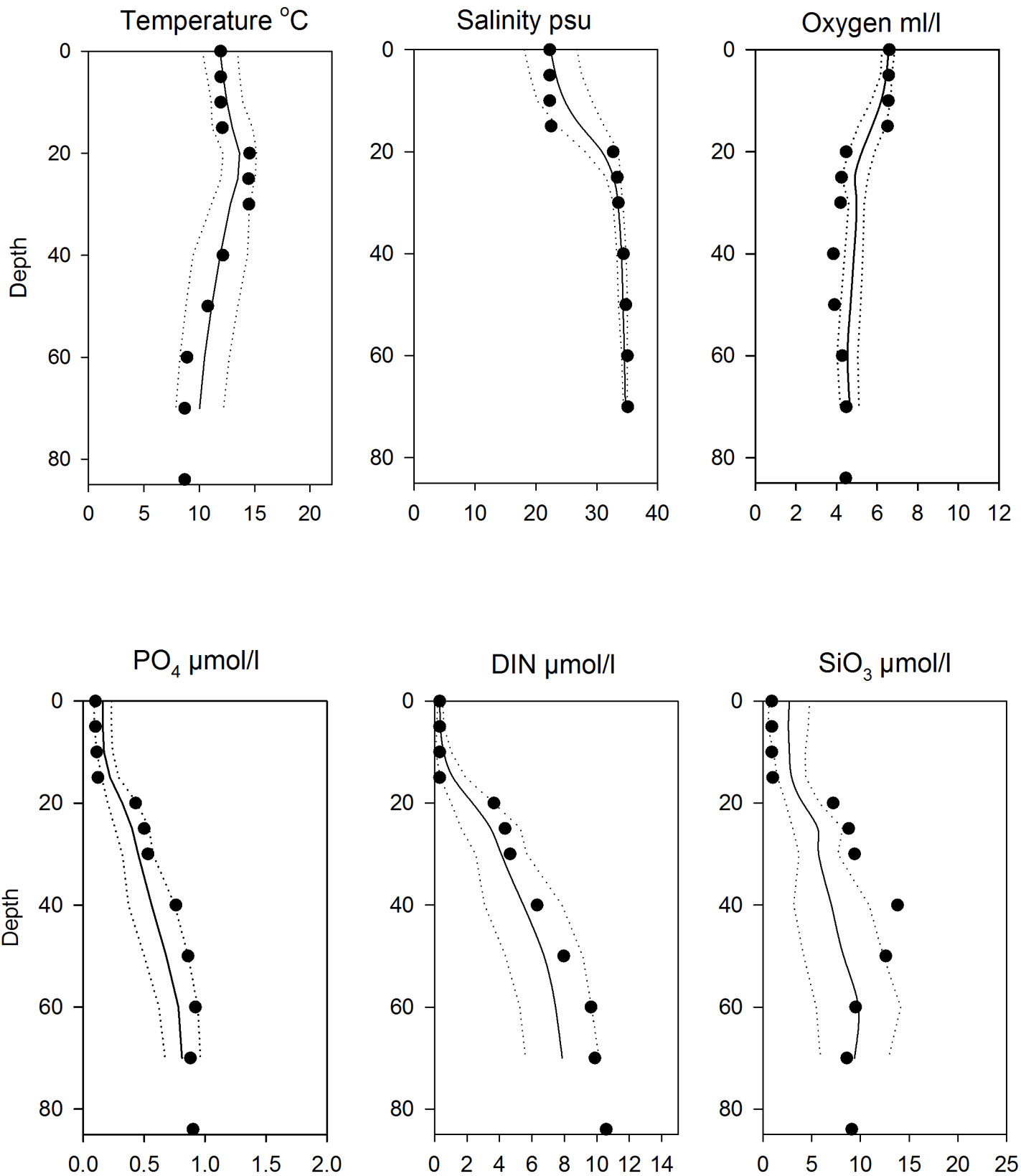


## OXYGEN IN BOTTOM WATER (depth > 70m)



# Vertical profiles Fladen October

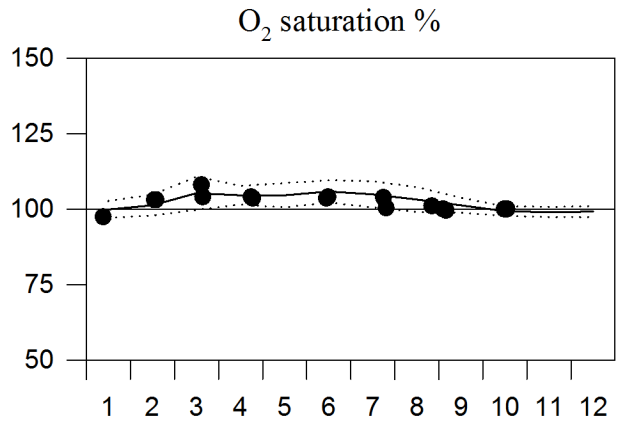
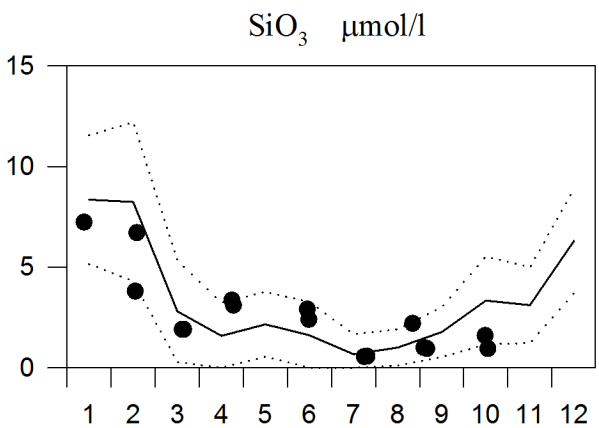
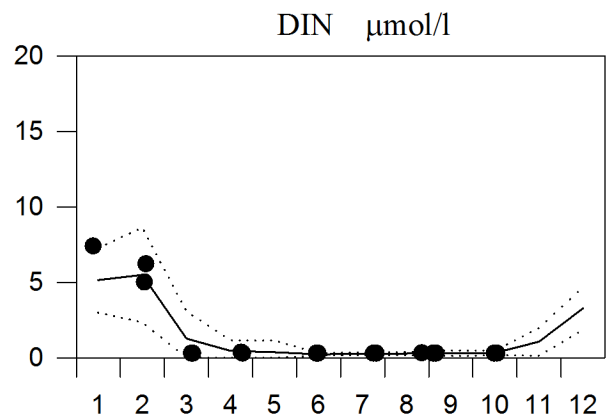
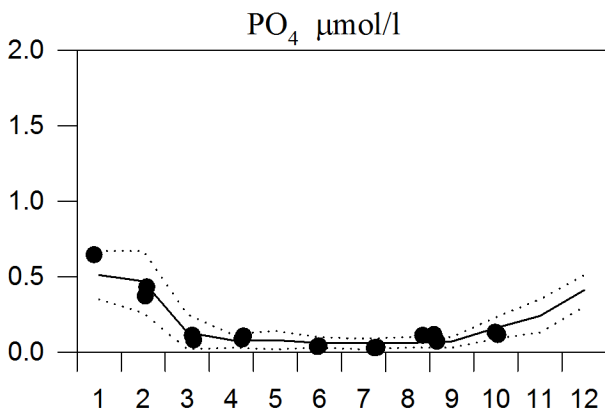
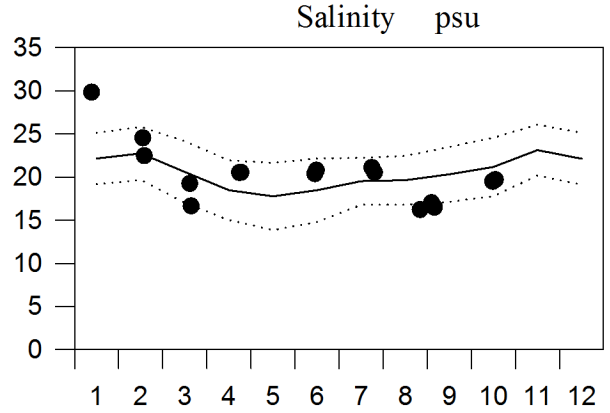
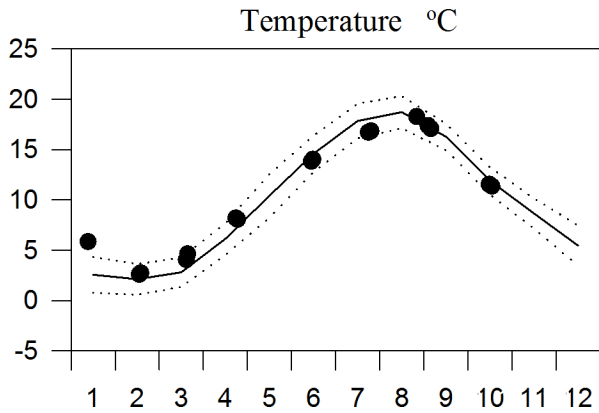
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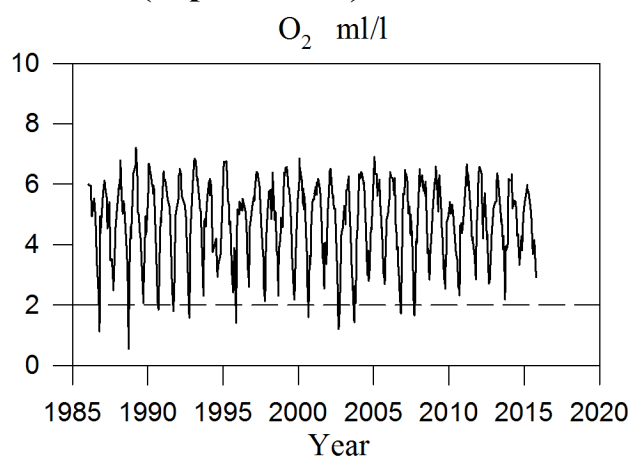
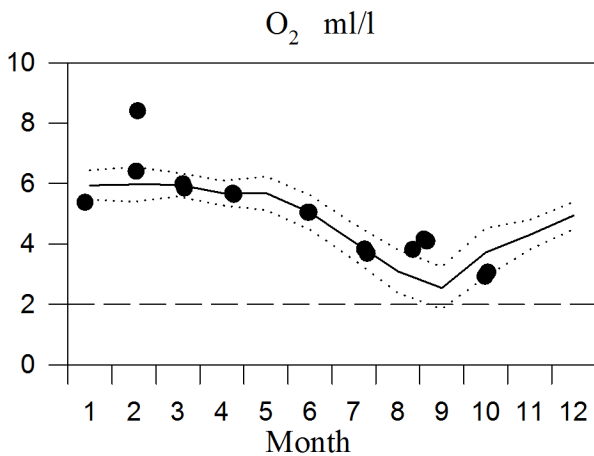
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## Annual Cycles

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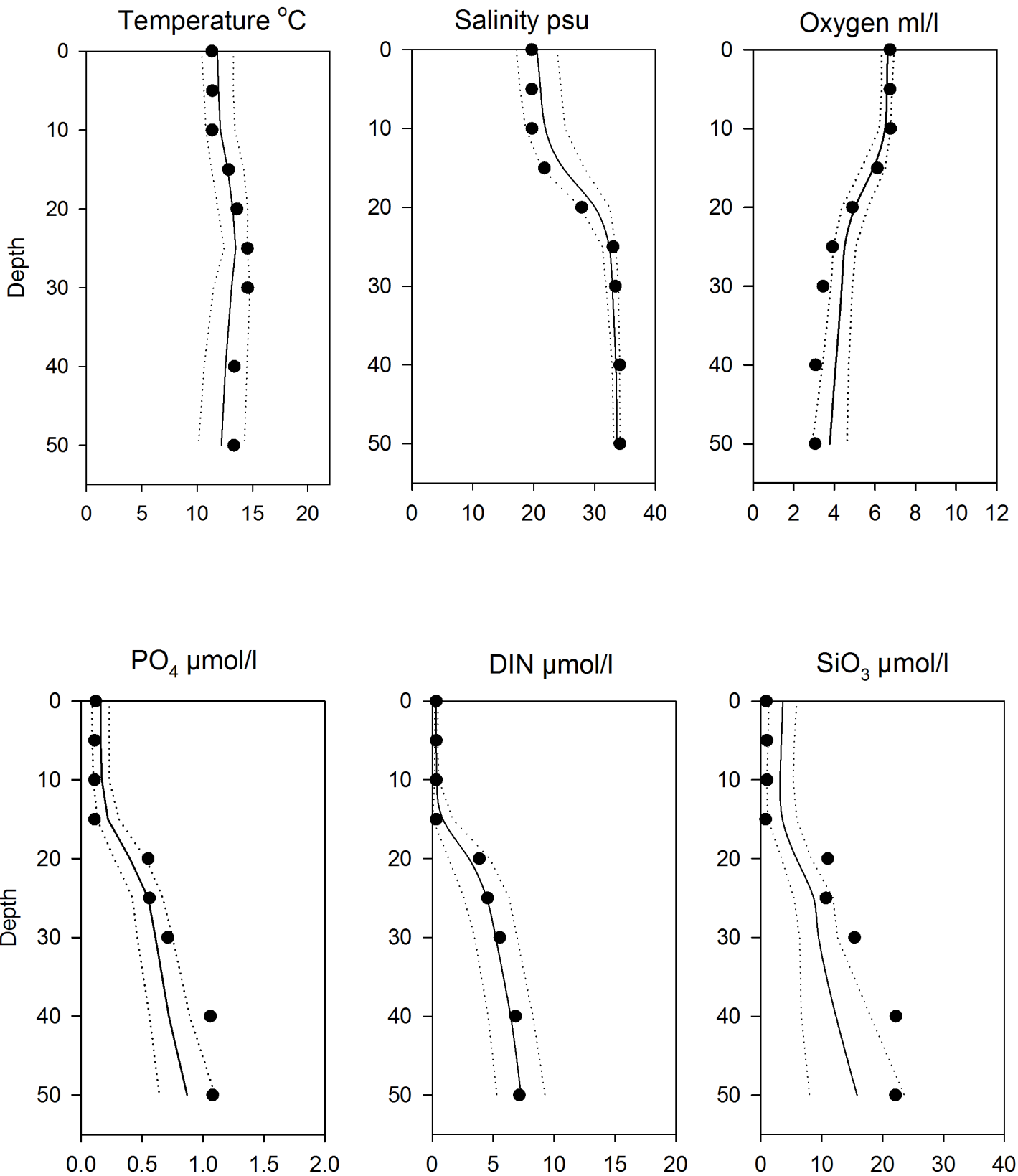


## OXYGEN IN BOTTOM WATER (depth > 50m)



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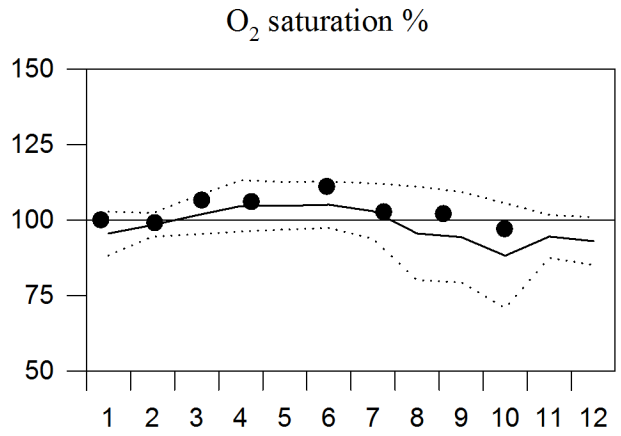
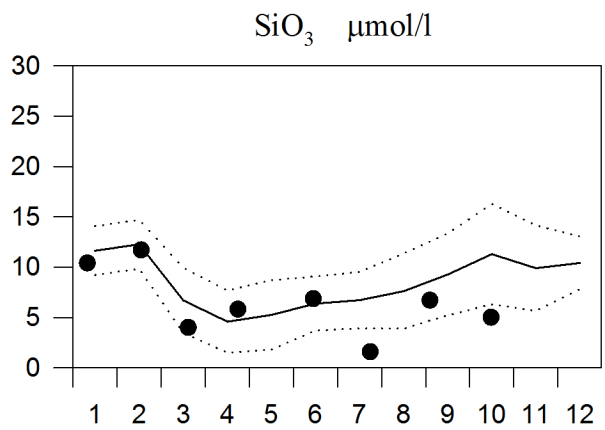
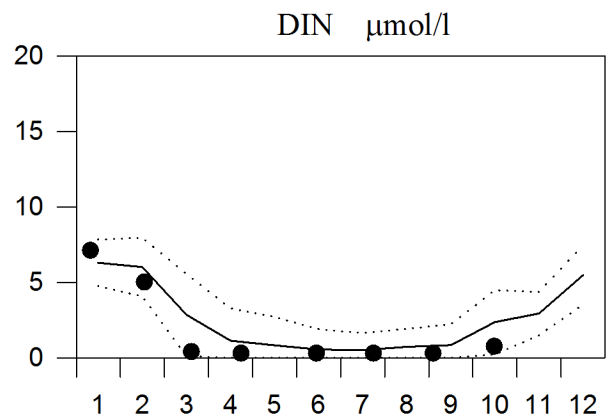
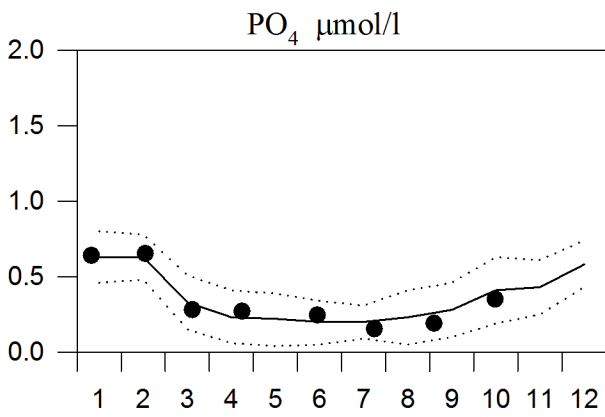
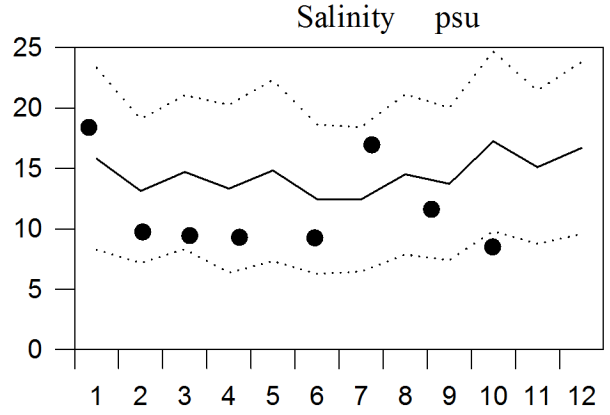
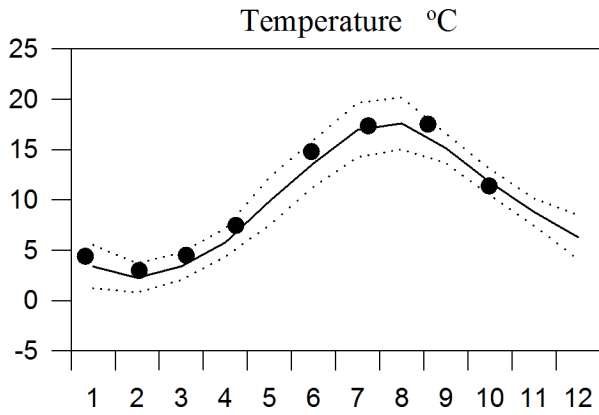




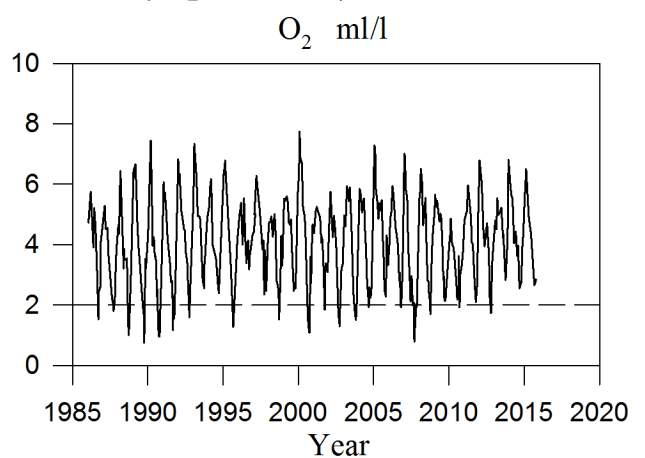
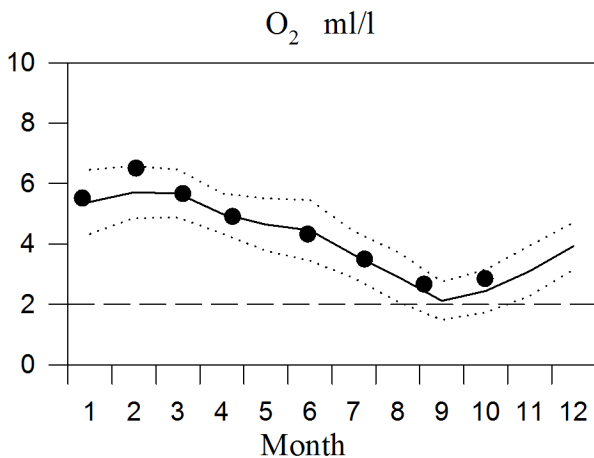
# STATION W LANDSKRONA SURFACE WATER

## Annual Cycles

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

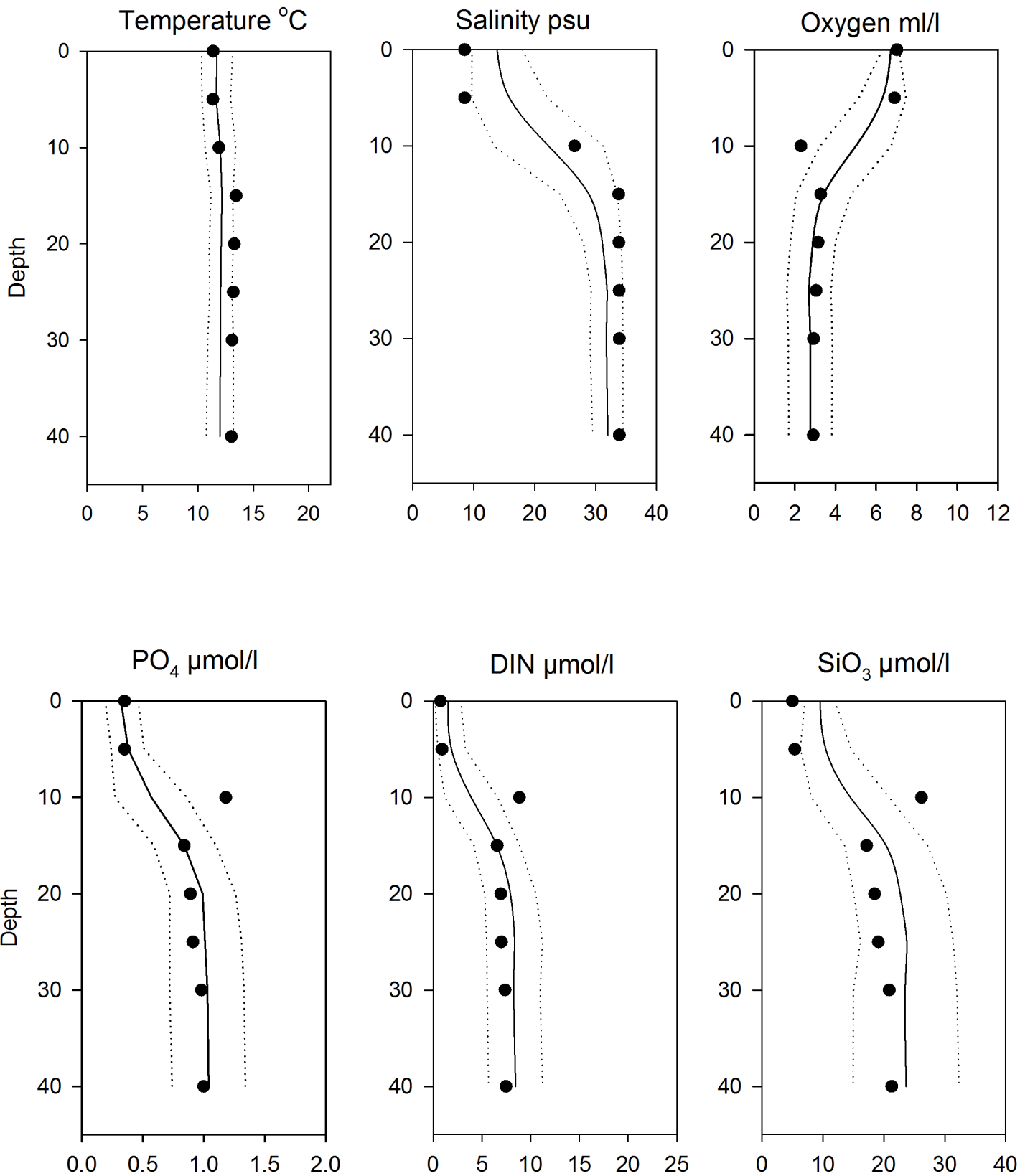


## OXYGEN IN BOTTOM WATER (depth >40m)



# Vertical profiles W Landskrona October

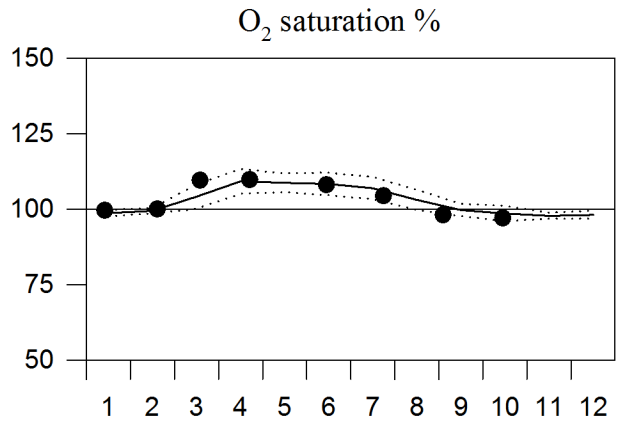
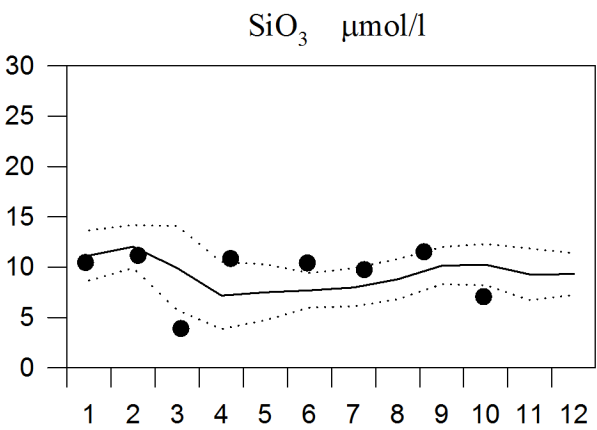
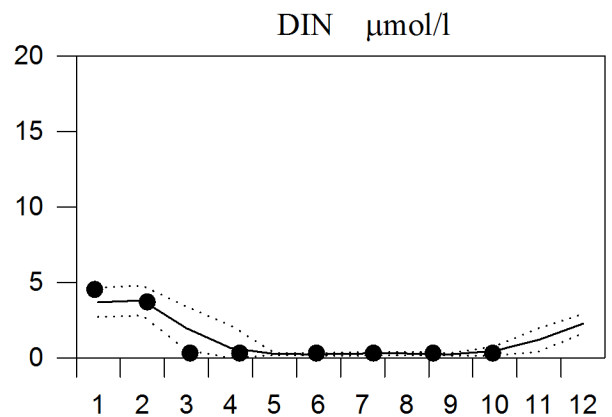
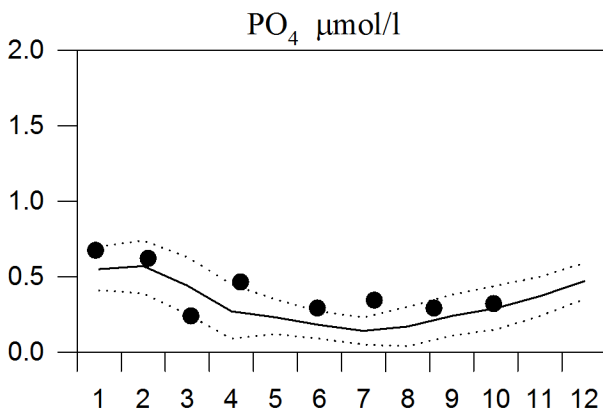
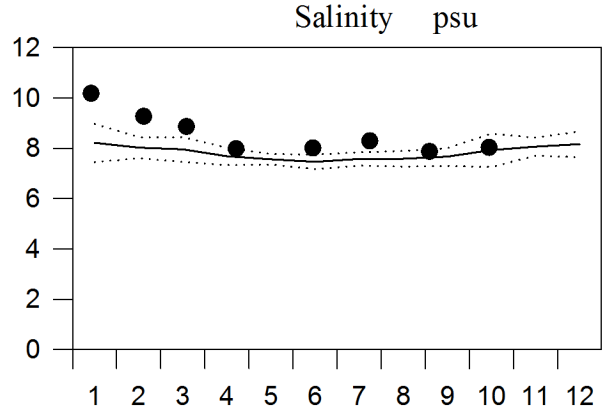
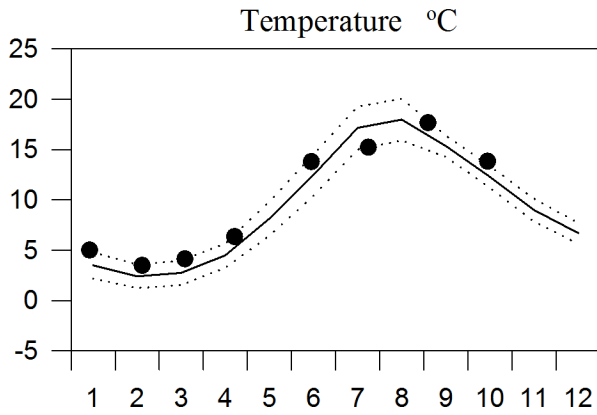
— Mean 1996-2010      ..... St.Dev.      ● 2015



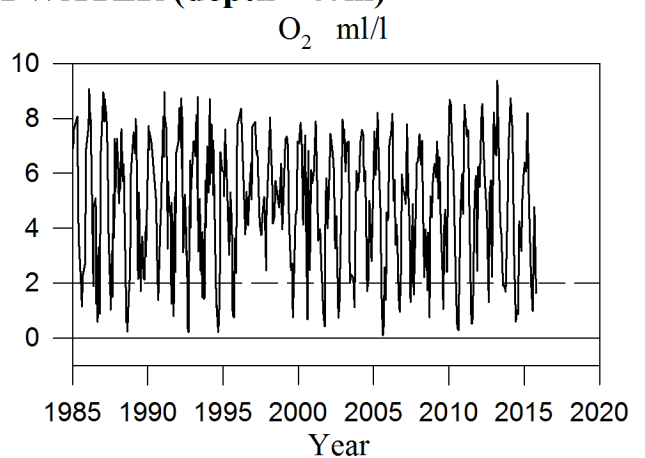
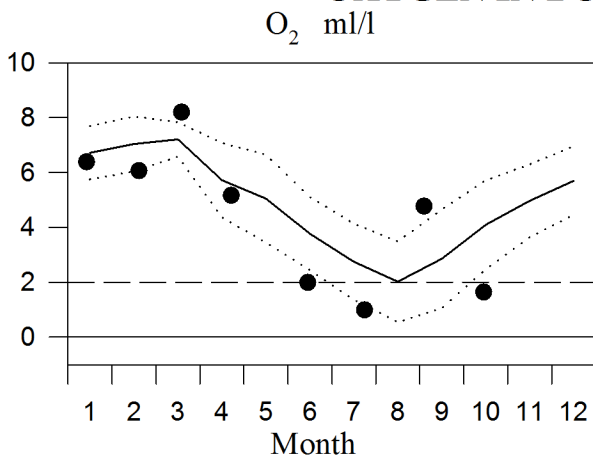
# STATION BY1 SURFACE WATER

## Annual Cycles

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

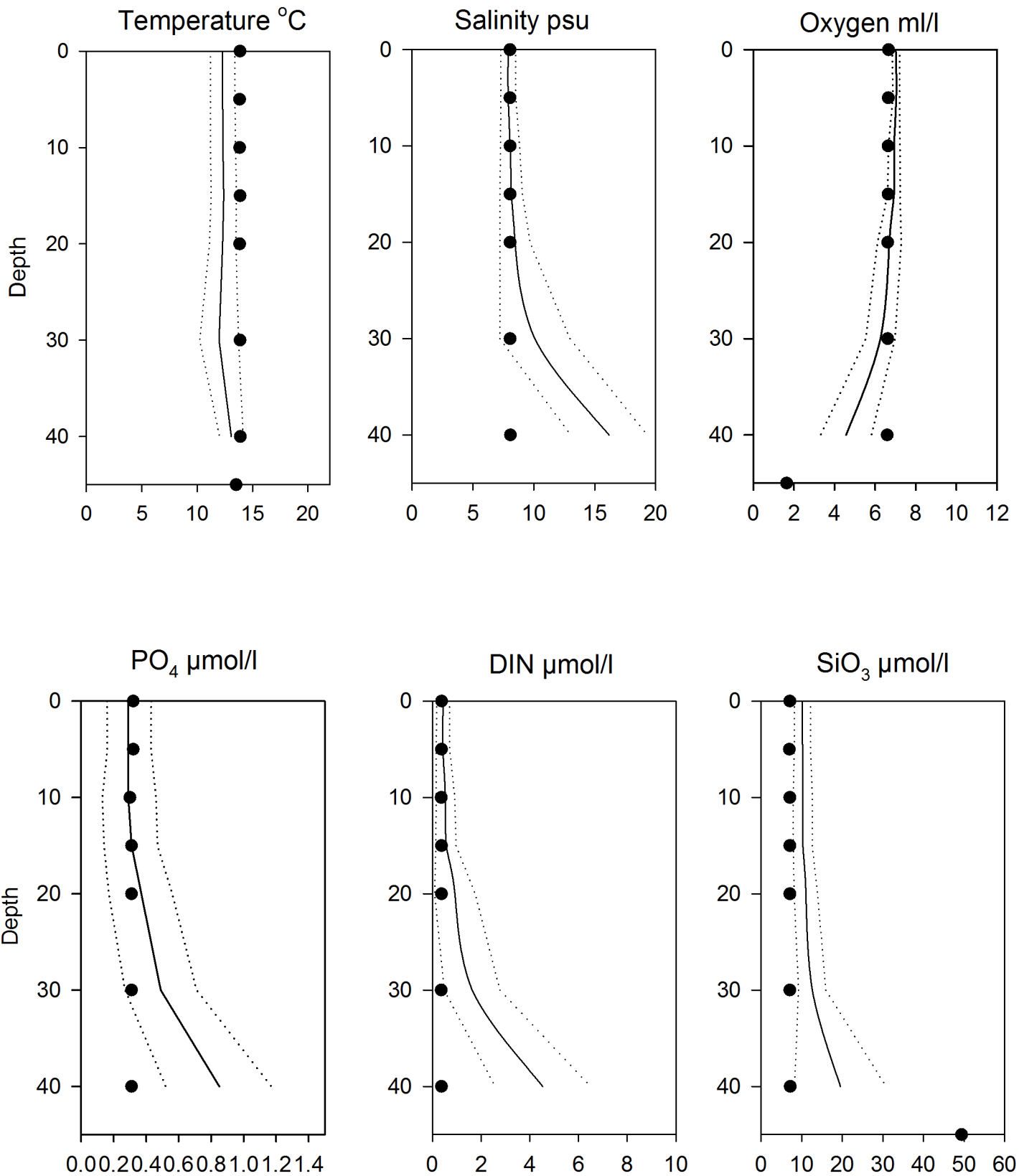


## OXYGEN IN BOTTOM WATER (depth >40m)



# Vertical profiles BY1 October

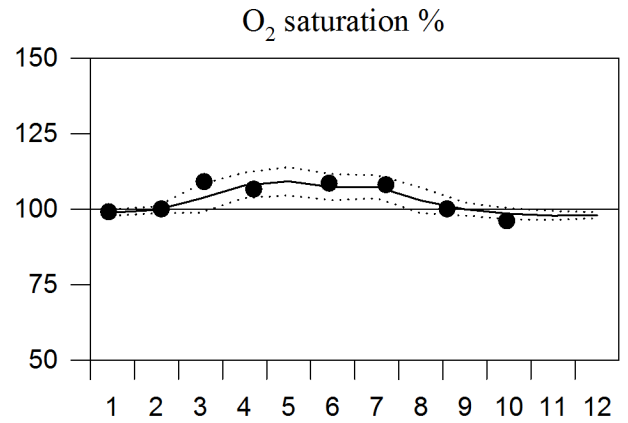
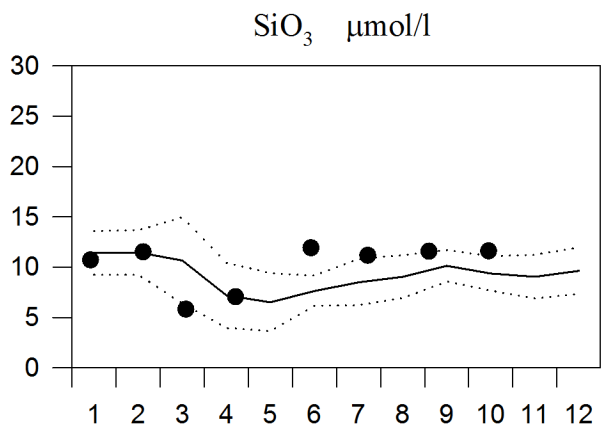
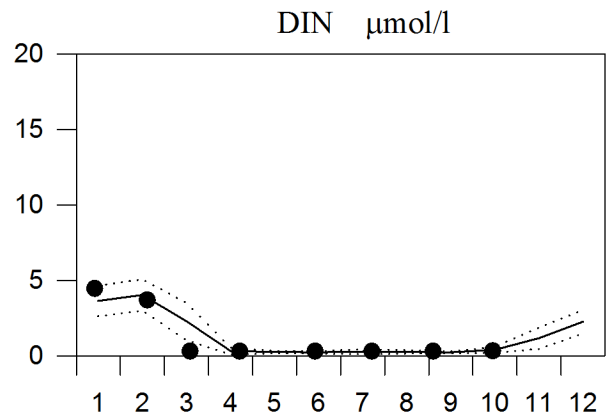
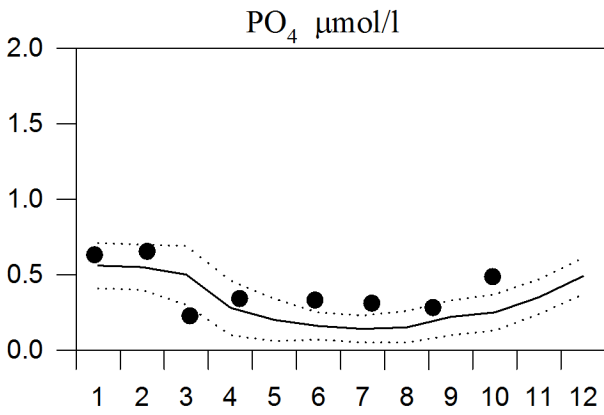
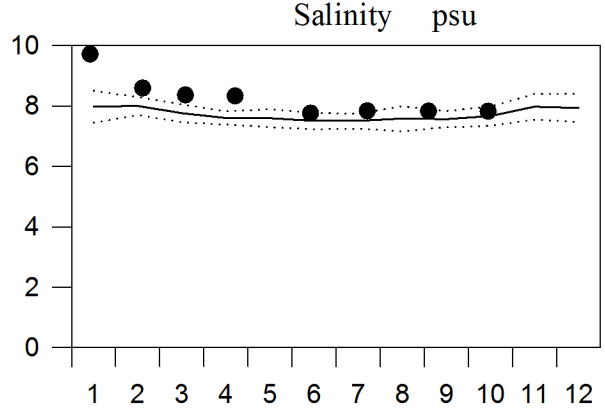
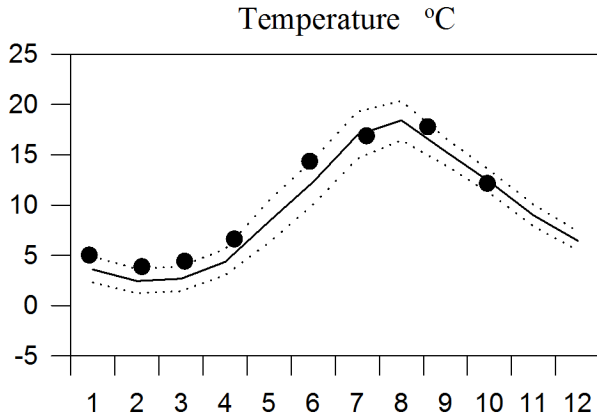
— Mean 1996-2010      ····· St.Dev.      ● 2015



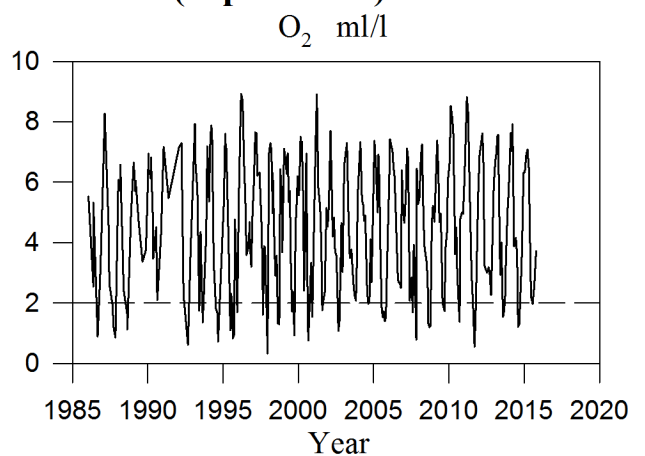
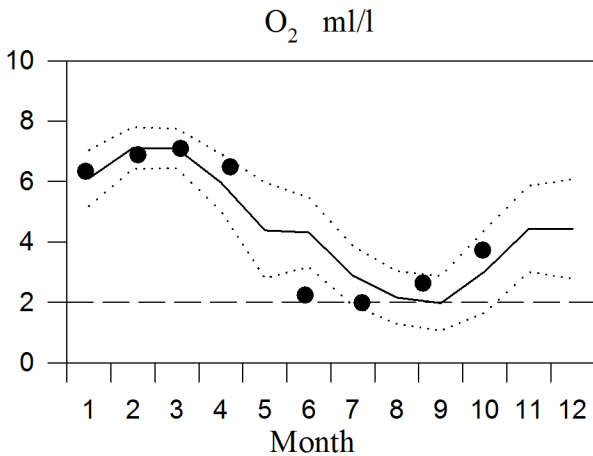
# STATION BY2 SURFACE WATER

## Annual Cycles

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

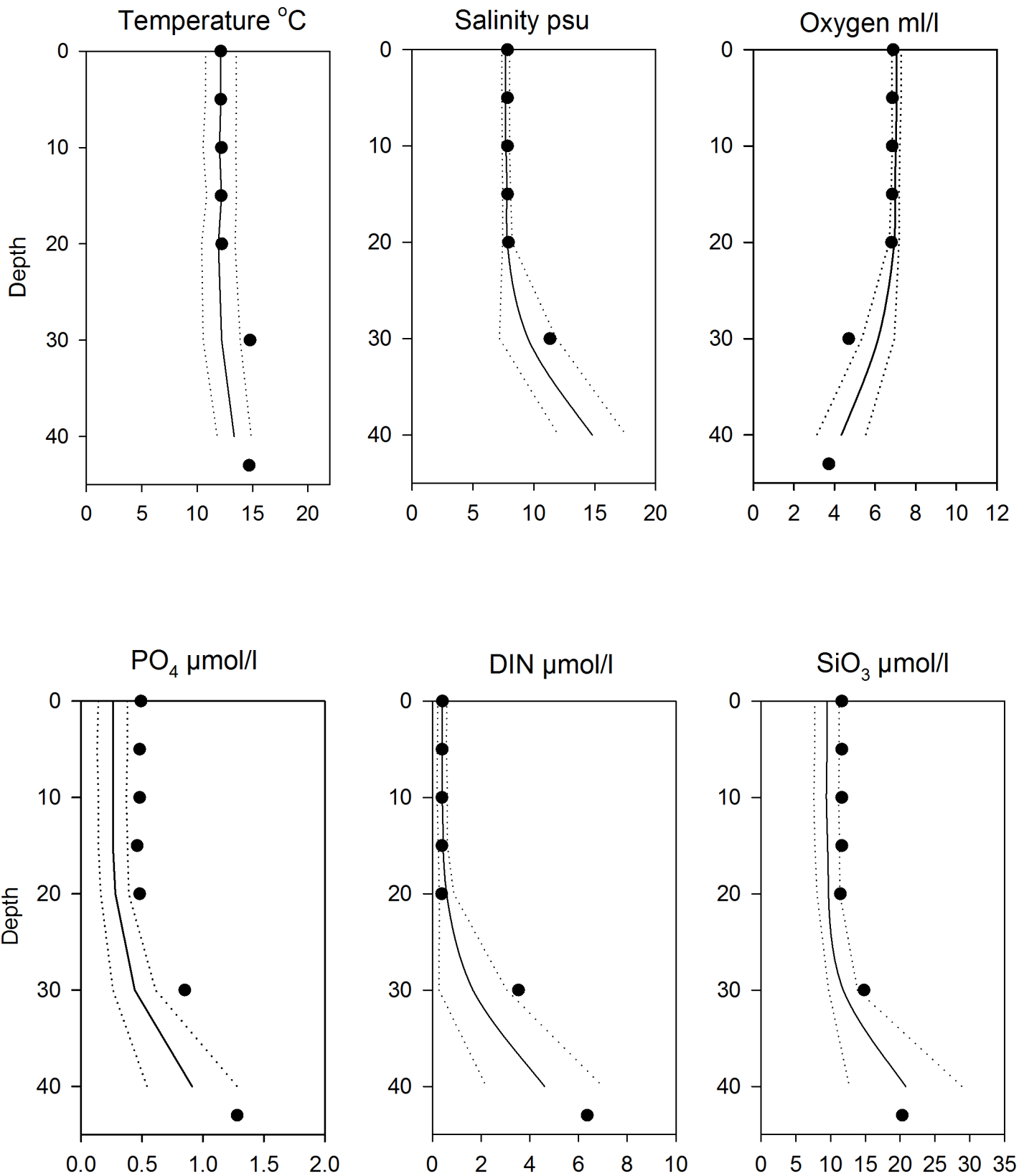


## OXYGEN IN BOTTOM WATER (depth >40m)



# Vertical profiles BY2 October

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

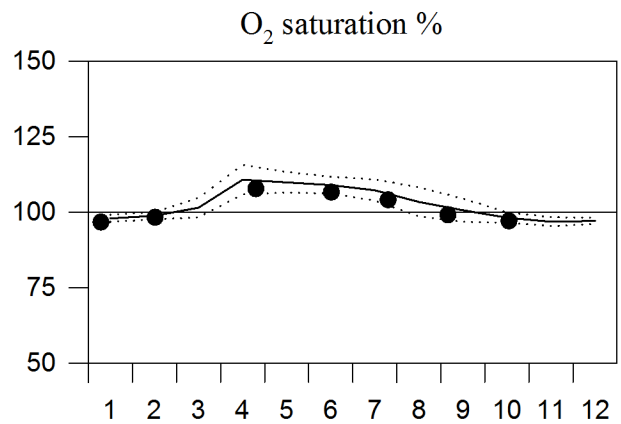
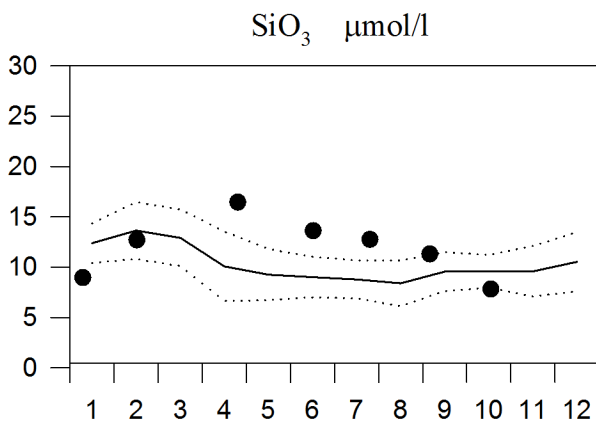
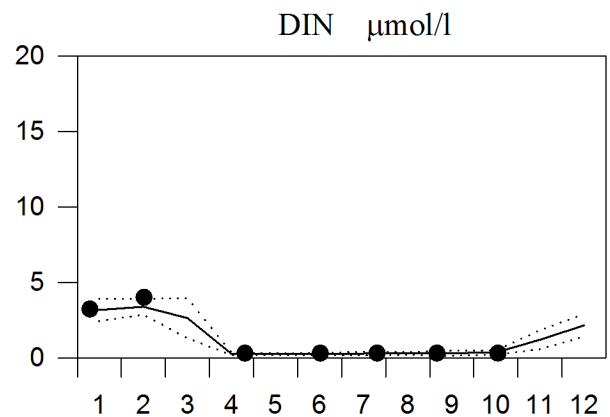
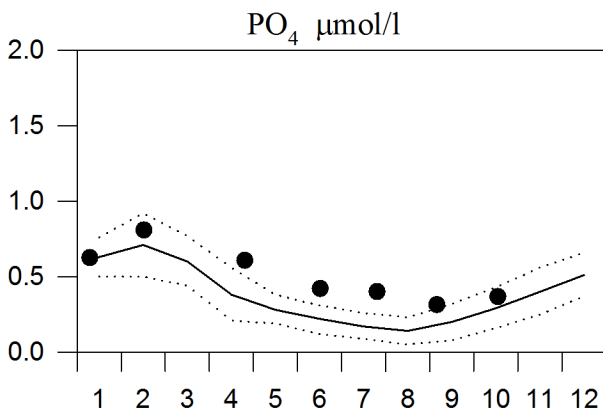
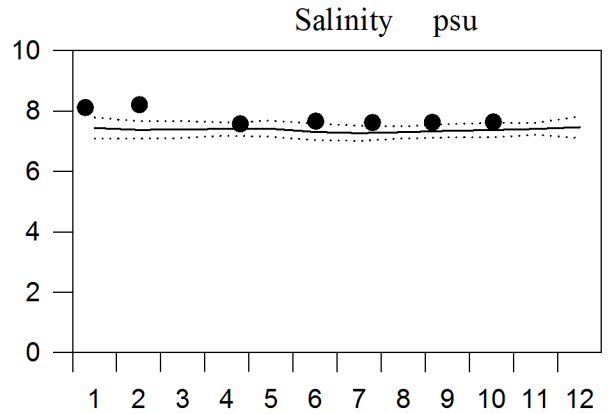
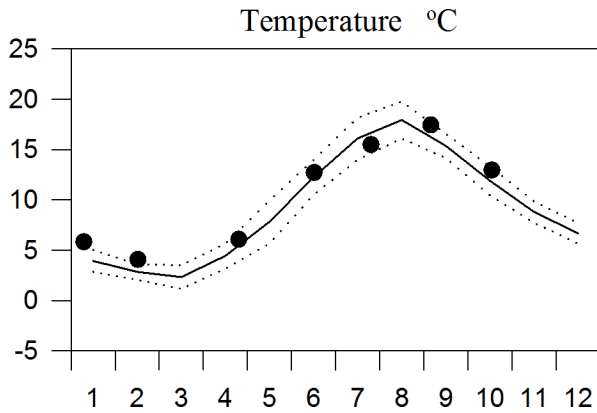




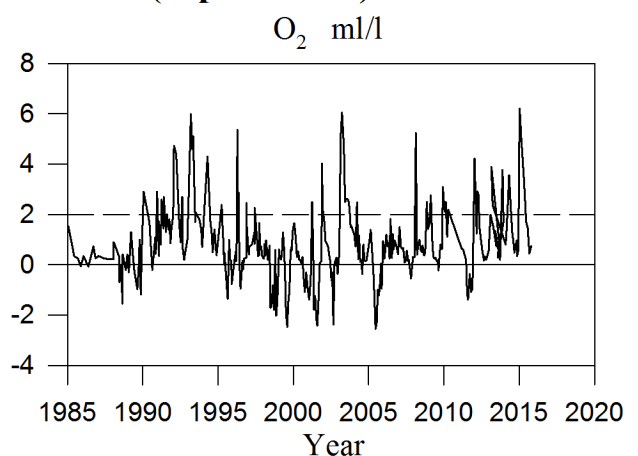
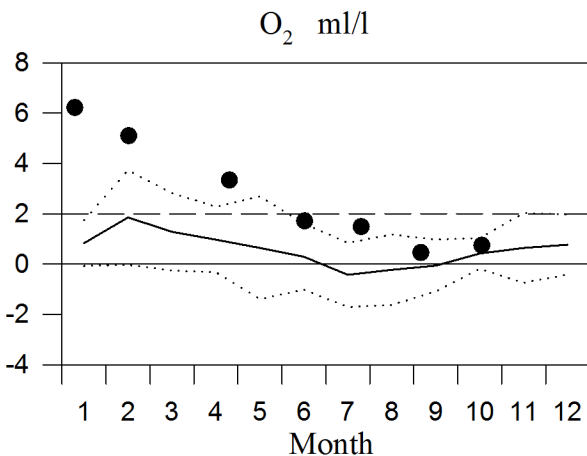
# STATION HANÖBUKTEN SURFACE WATER

## Annual Cycles

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

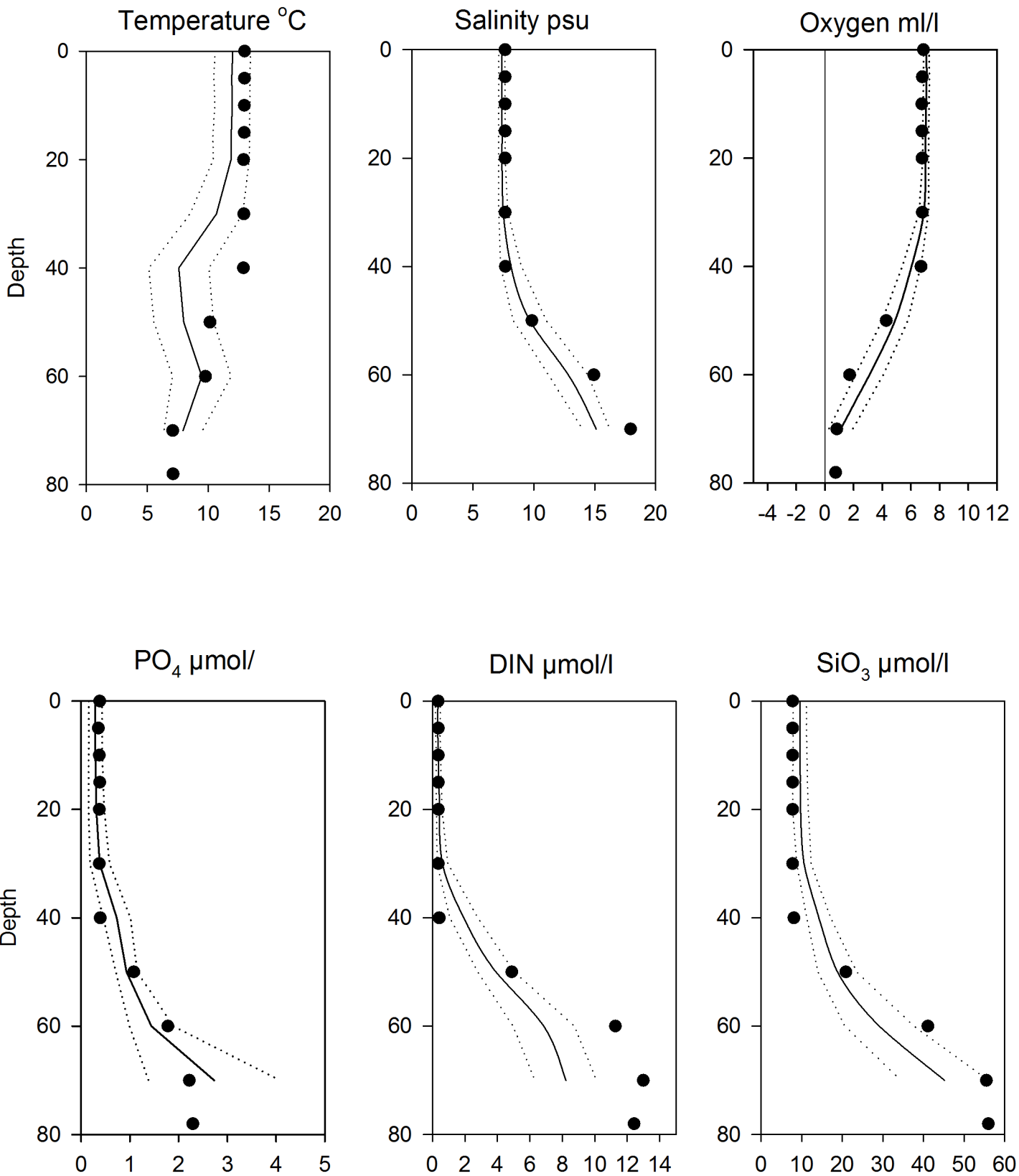


## OXYGEN IN BOTTOM WATER (depth > 70m)



# Vertical profiles Hanöbukten October

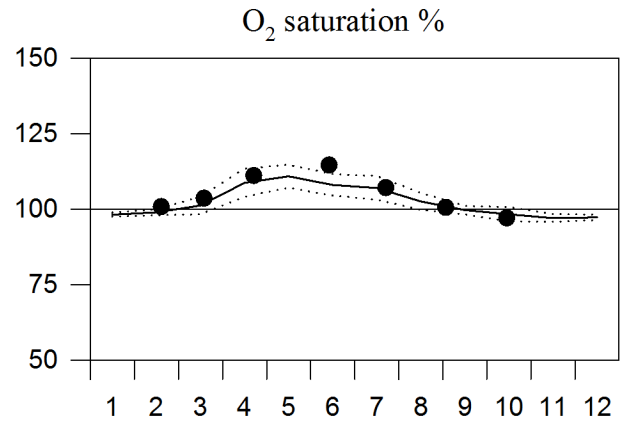
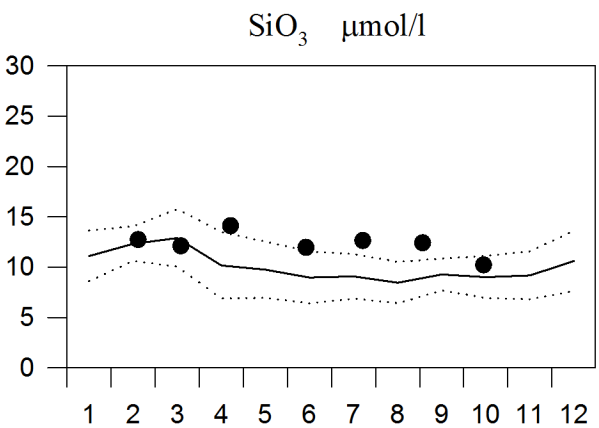
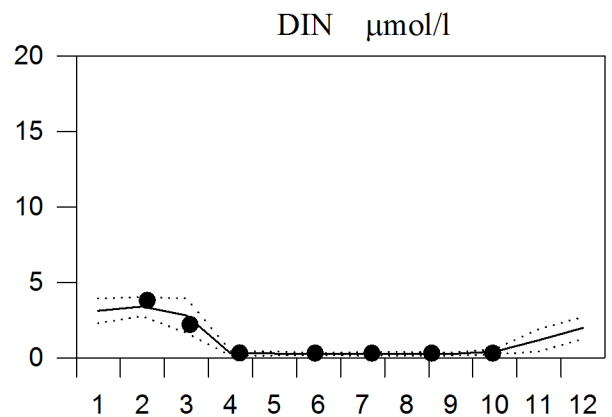
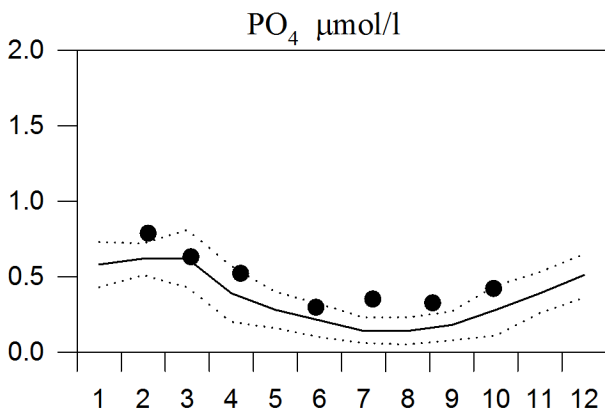
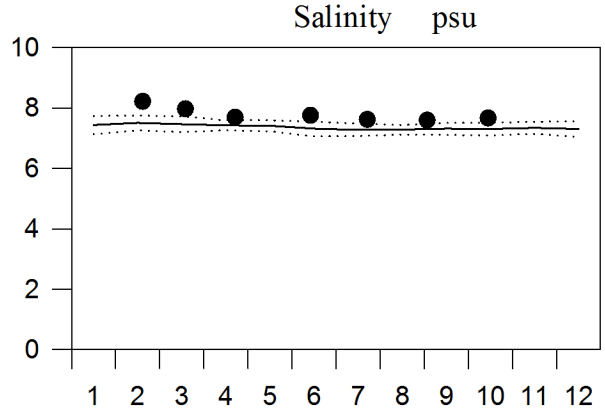
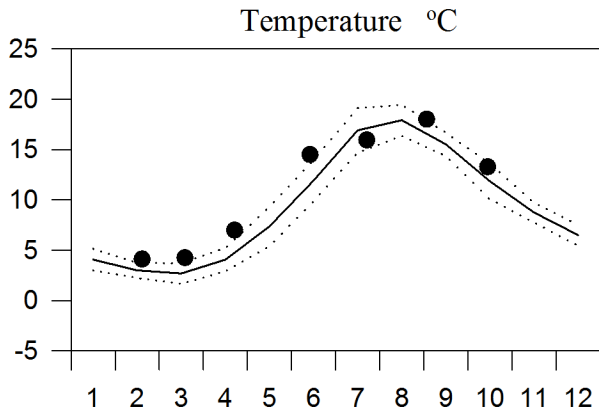
— Mean 1996-2010      ····· St.Dev.      ● 2015



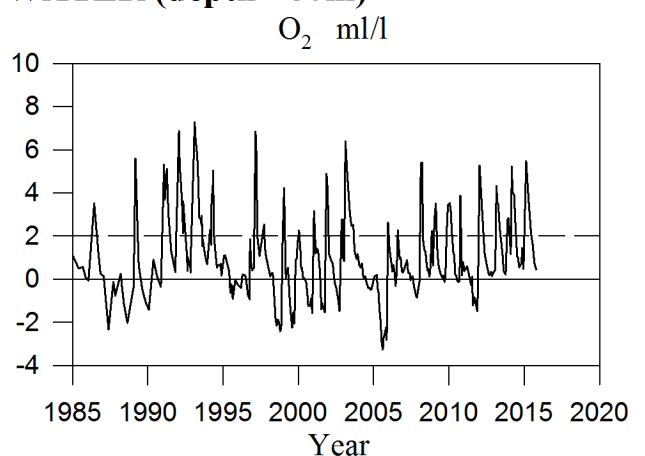
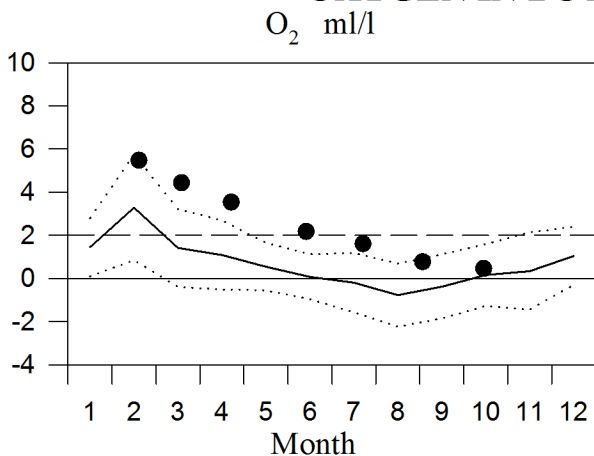
# STATION BY4 SURFACE WATER

## Annual Cycles

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

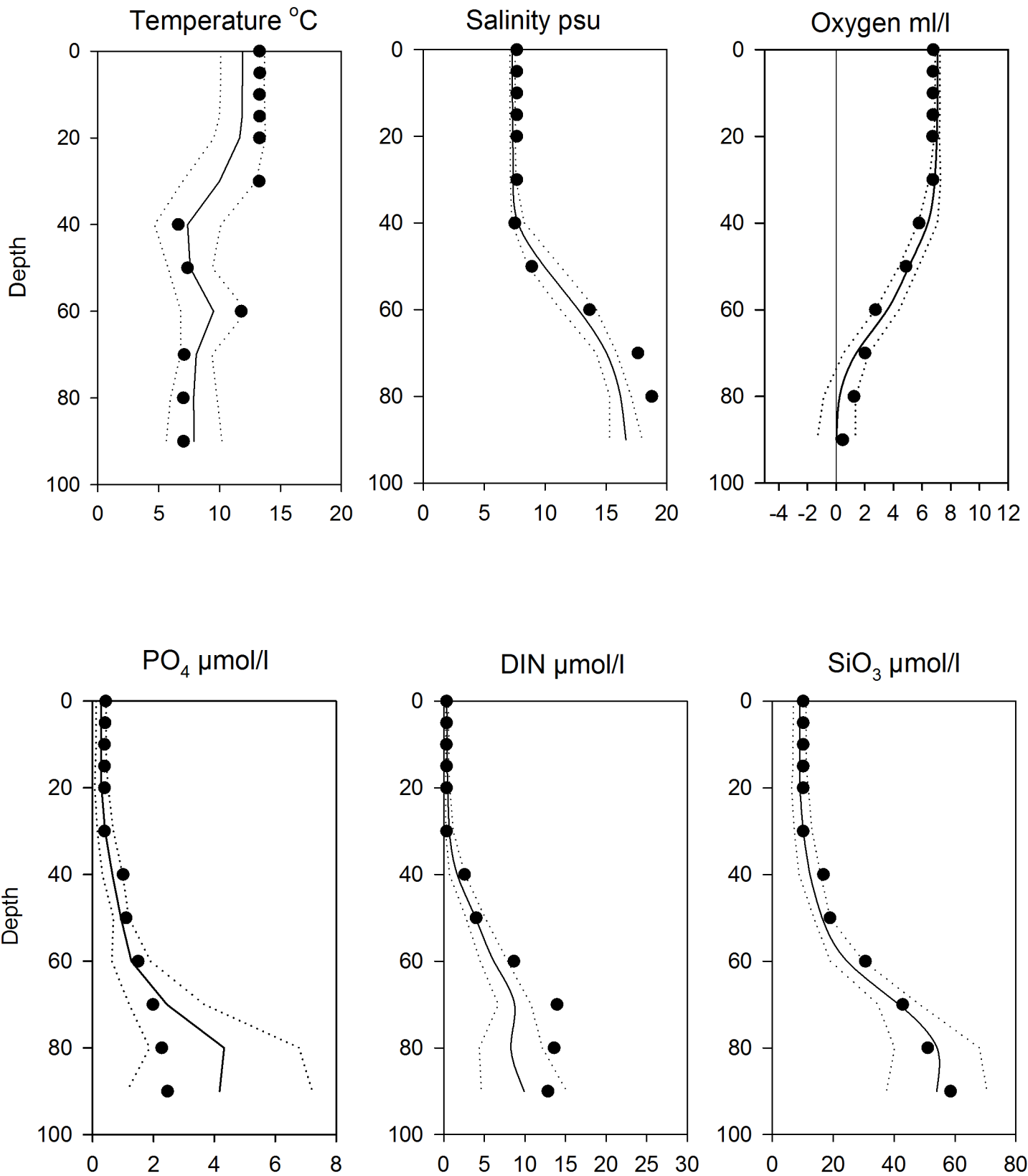


## OXYGEN IN BOTTOM WATER (depth >80m)



# Vertical profiles BY4 October

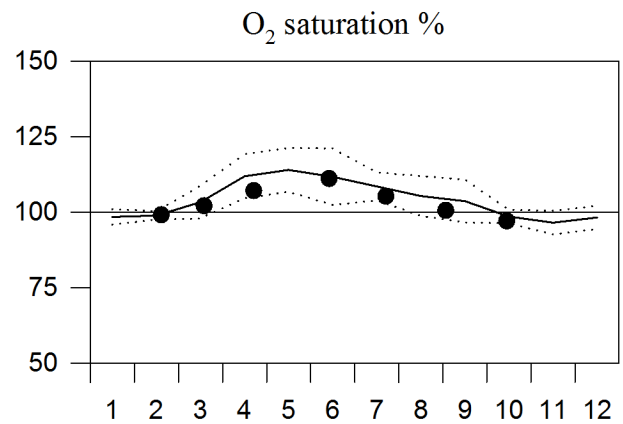
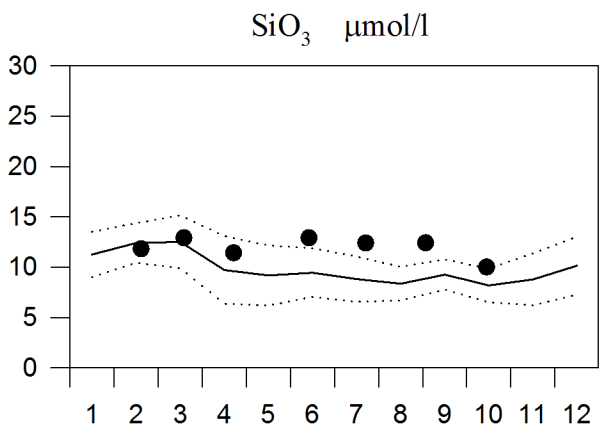
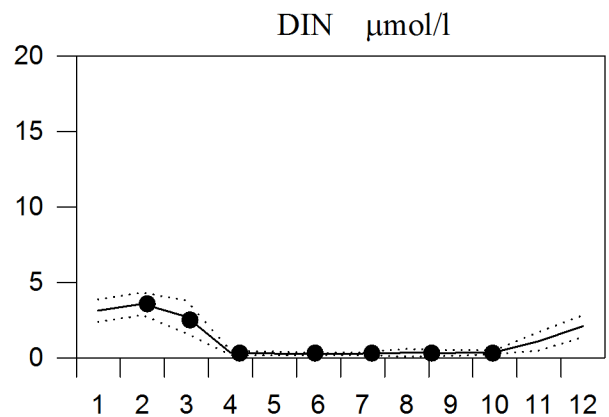
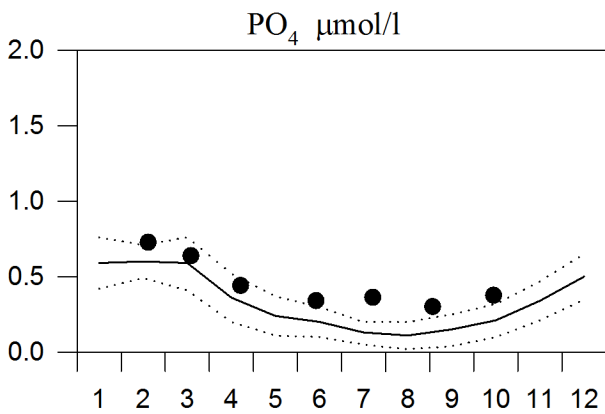
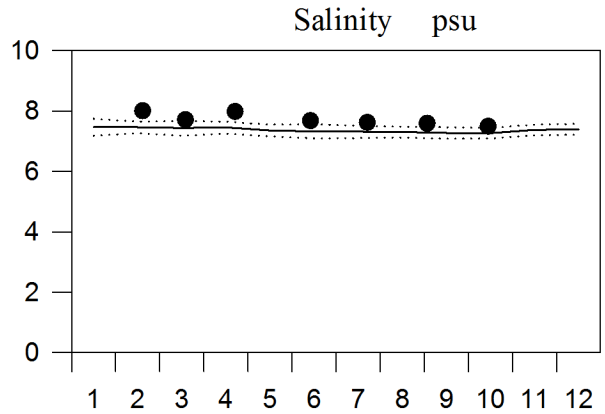
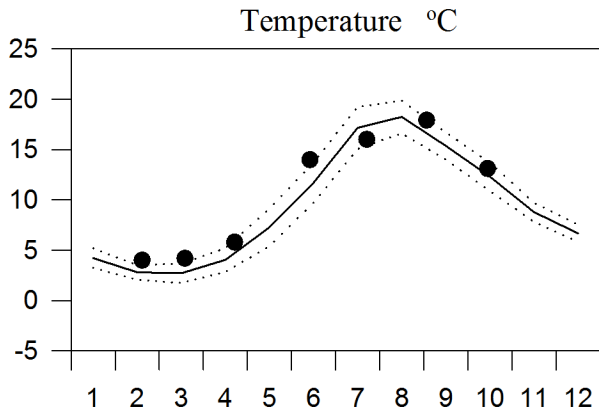
— Mean 1996-2010      ····· St.Dev.      ● 2015



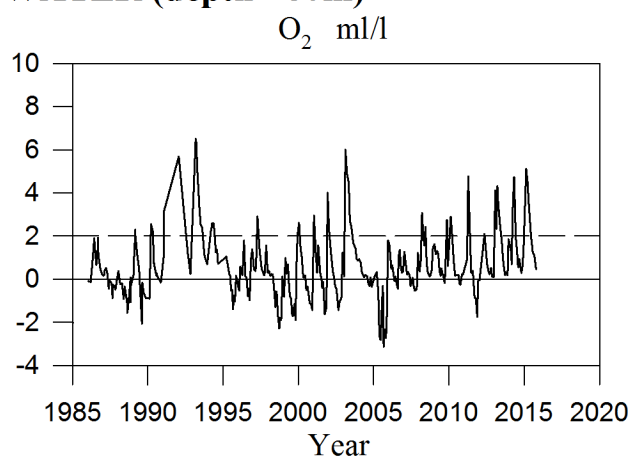
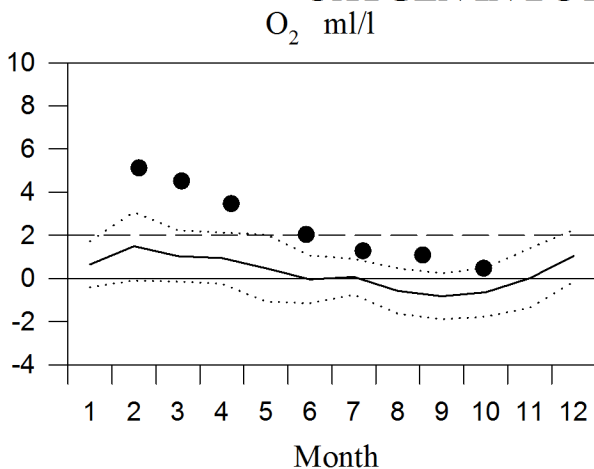
# STATION BY5 SURFACE WATER

## Annual Cycles

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

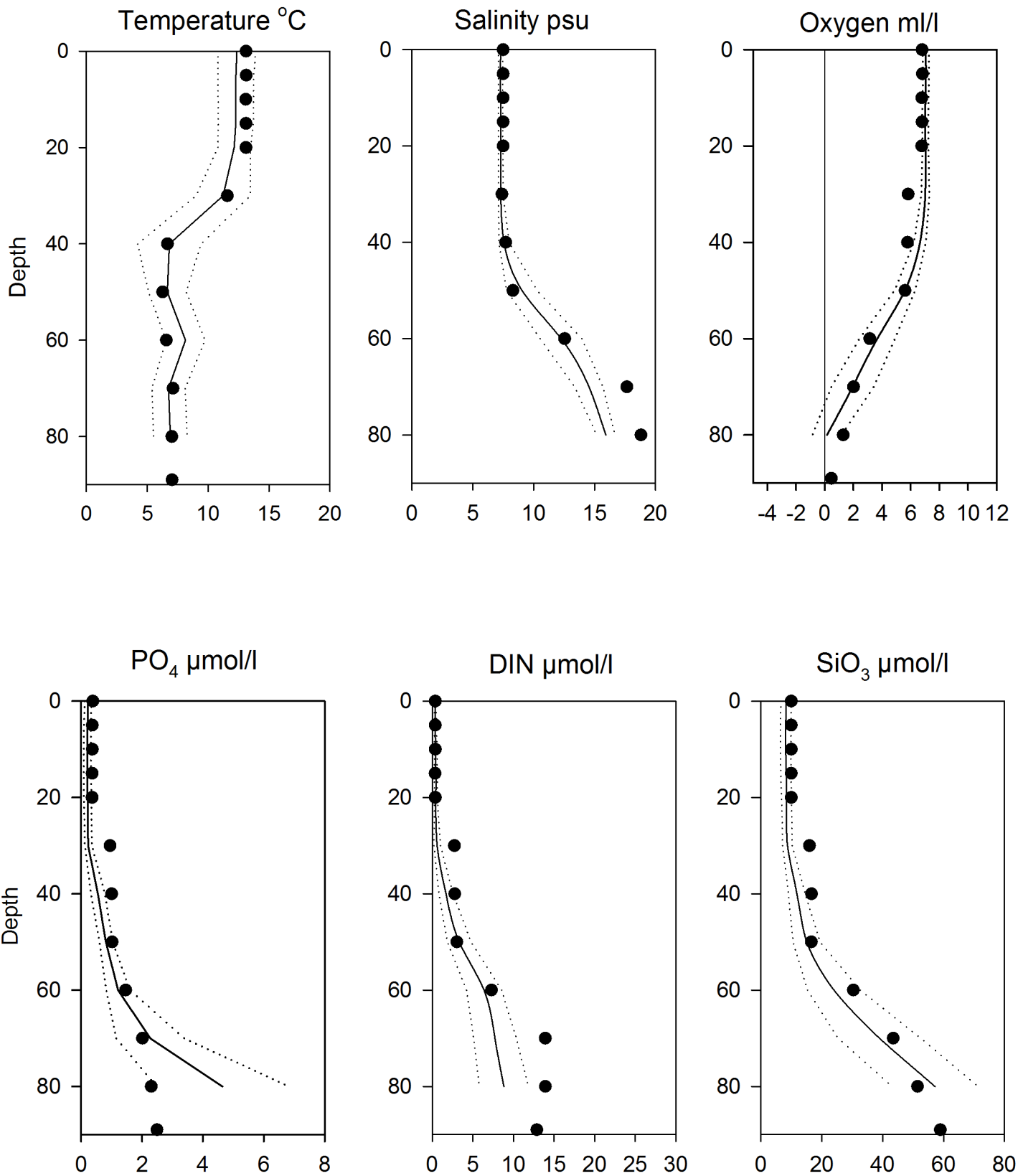


## OXYGEN IN BOTTOM WATER (depth >80m)



# Vertical profiles BY5 October

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

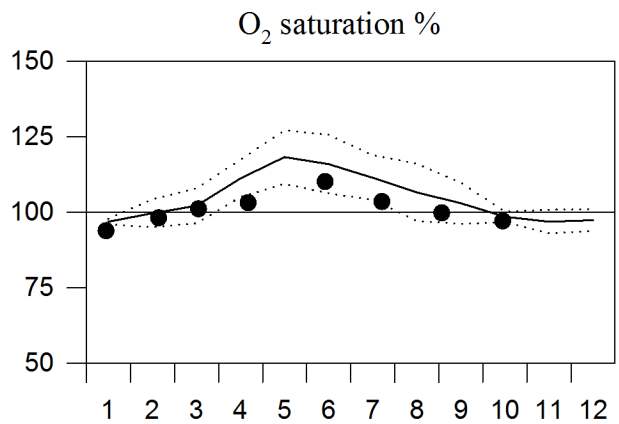
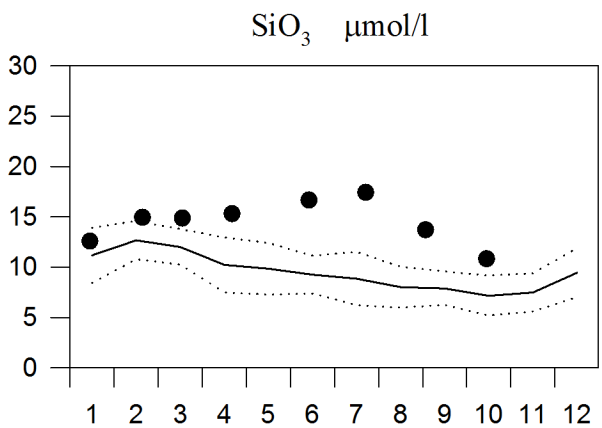
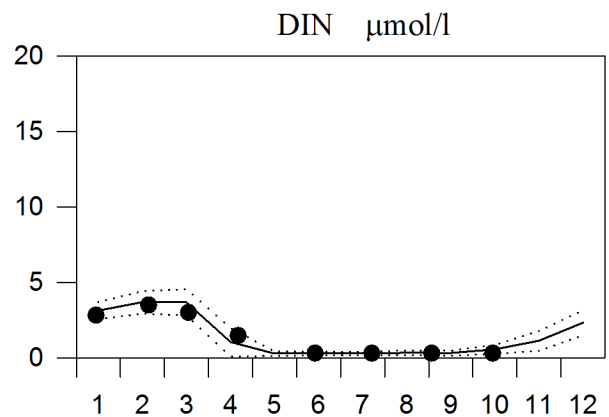
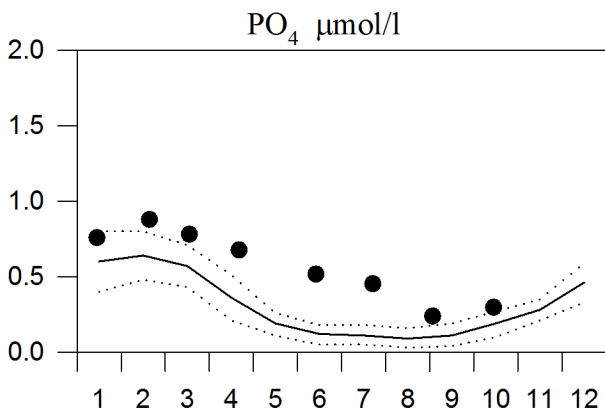
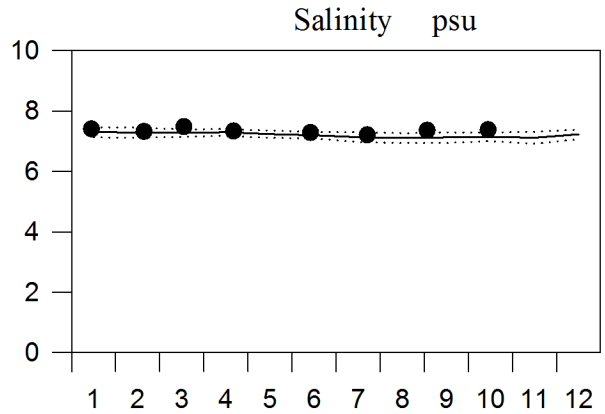
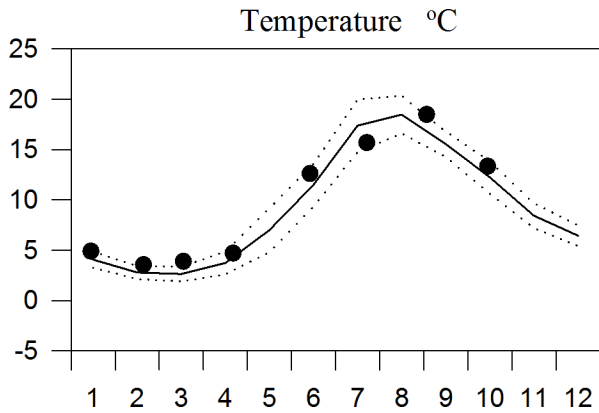




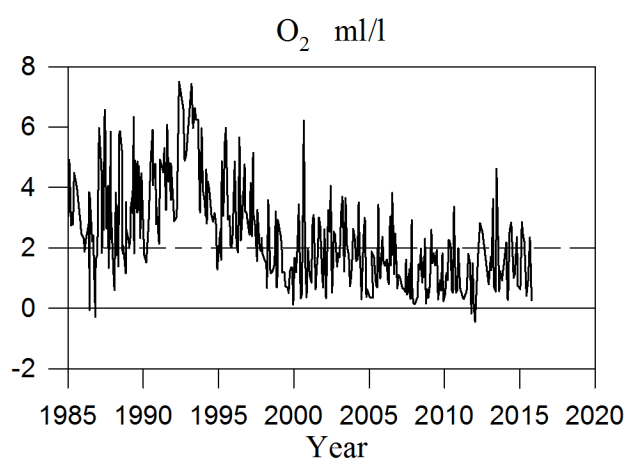
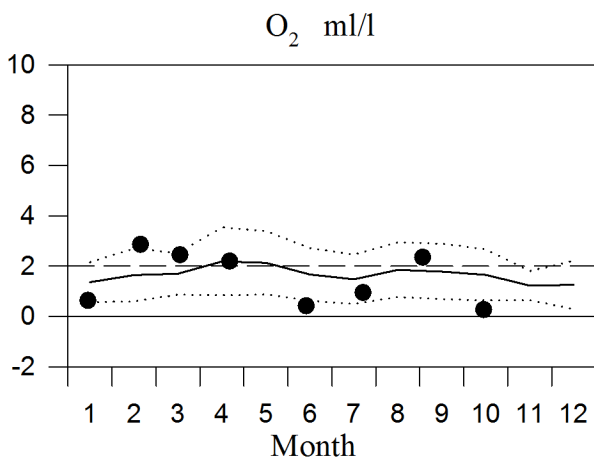
# STATION BCS III-10 SURFACE WATER

## Annual Cycles

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

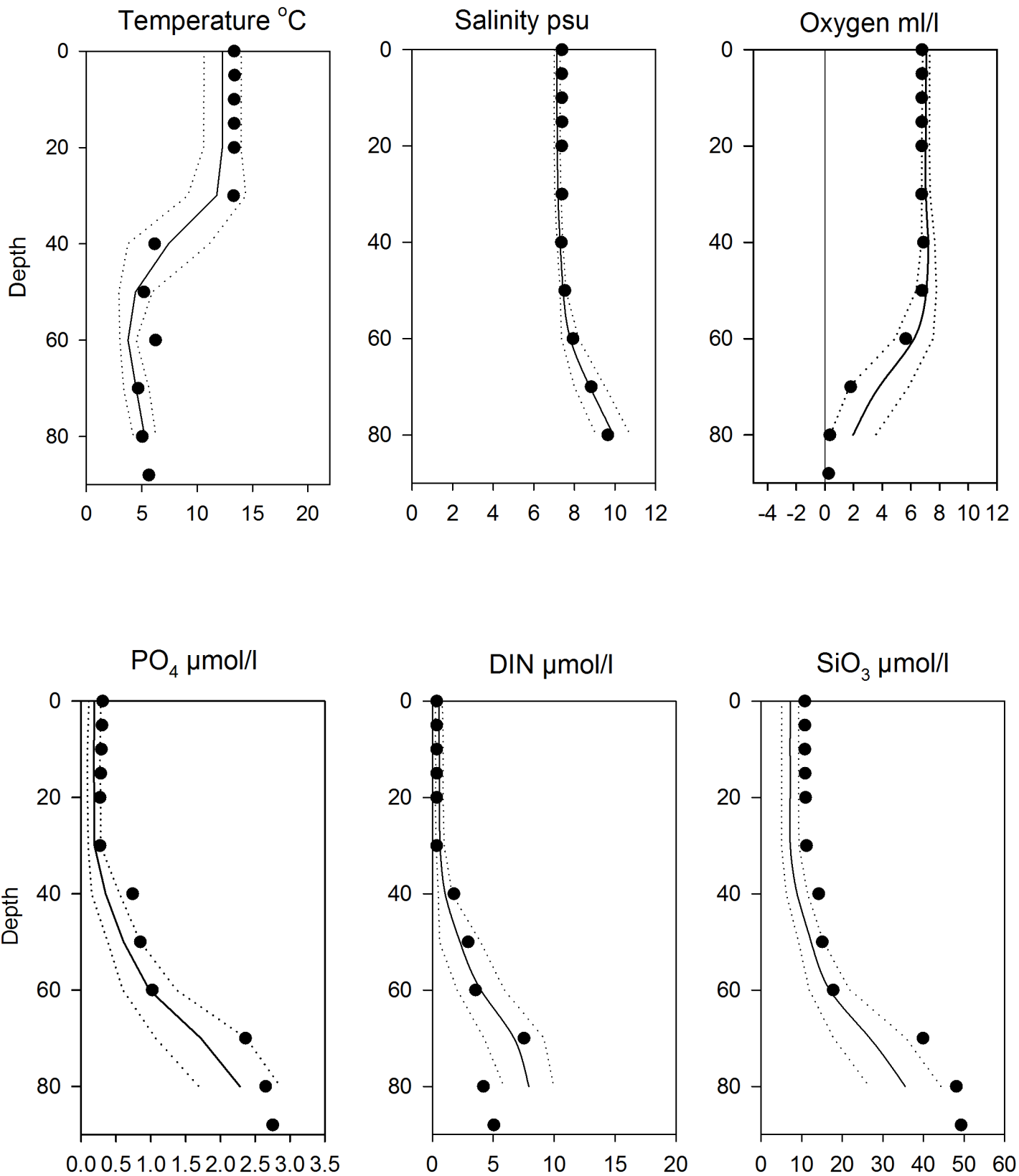


## OXYGEN IN BOTTOM WATER (depth > 80m)



# Vertical profiles BCS III-10 October

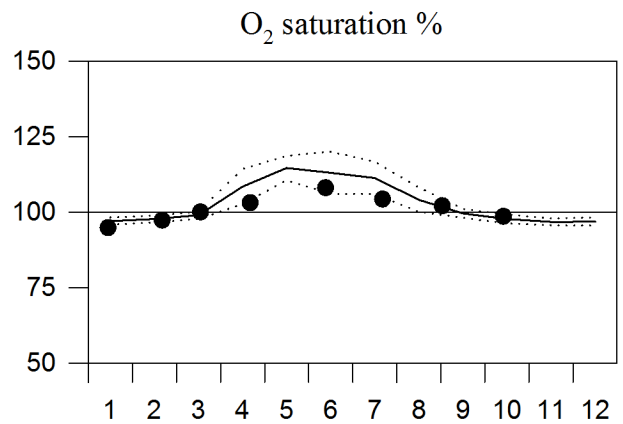
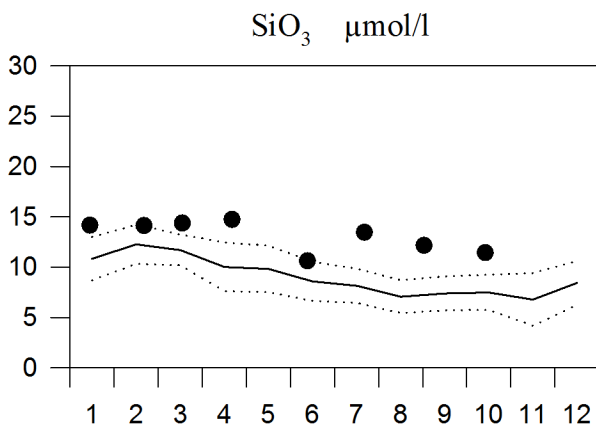
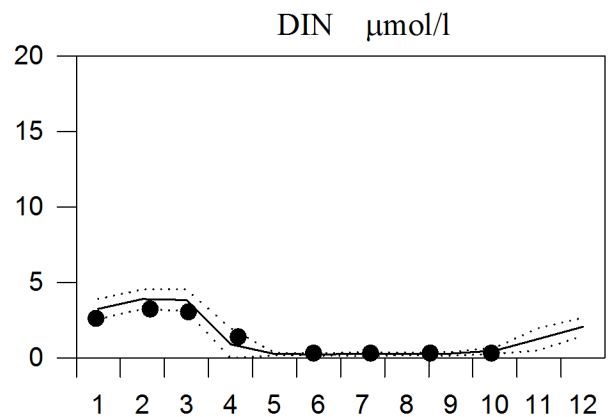
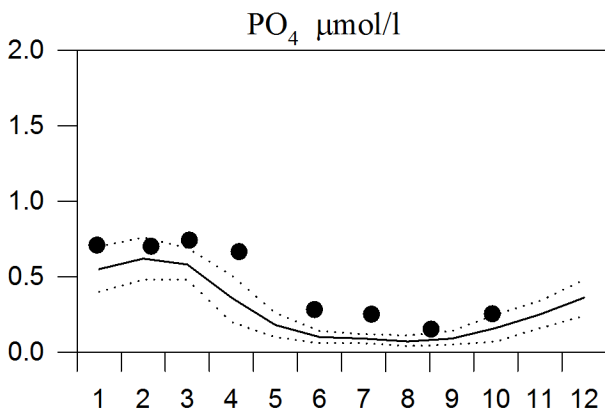
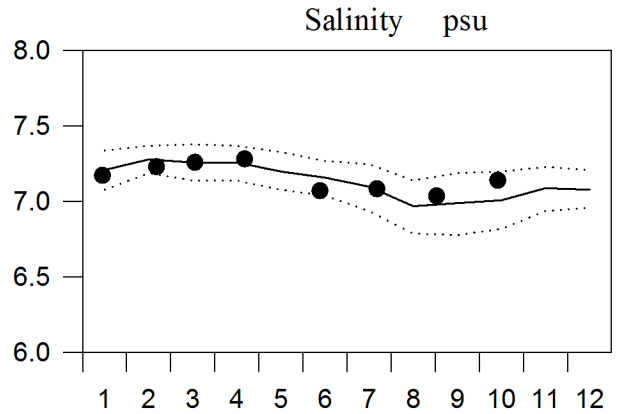
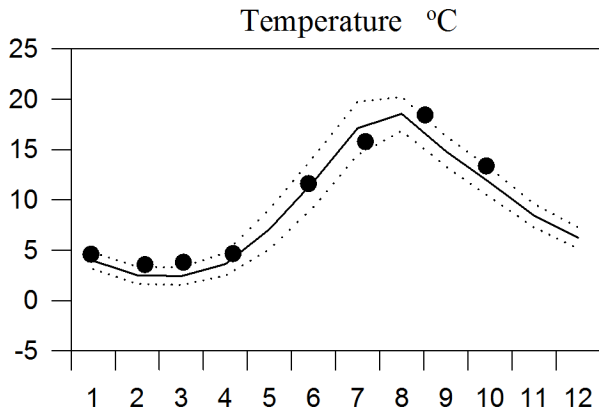
— Mean 1996-2010      ····· St.Dev.      ● 2015



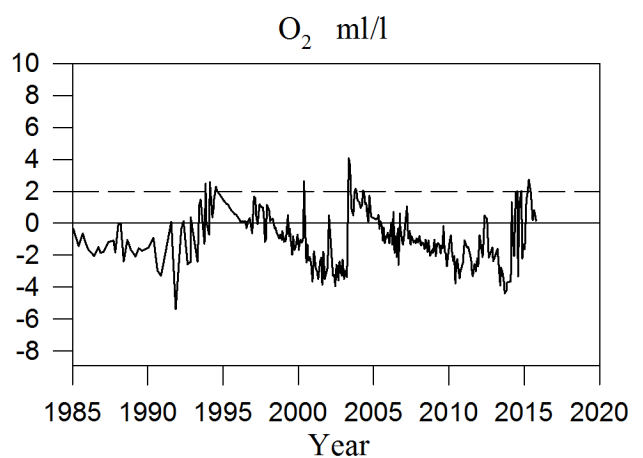
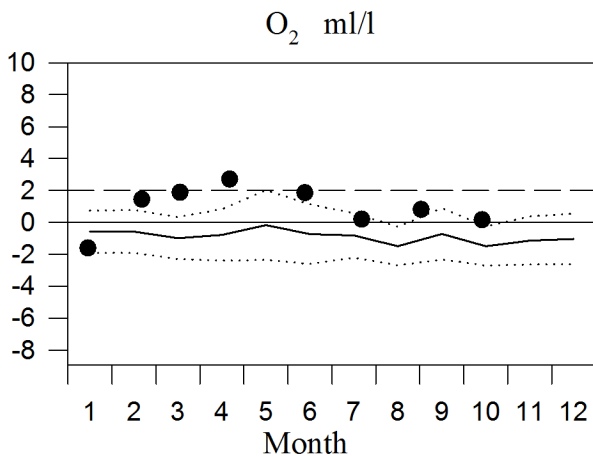
# STATION BY10 SURFACE WATER

## Annual Cycles

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

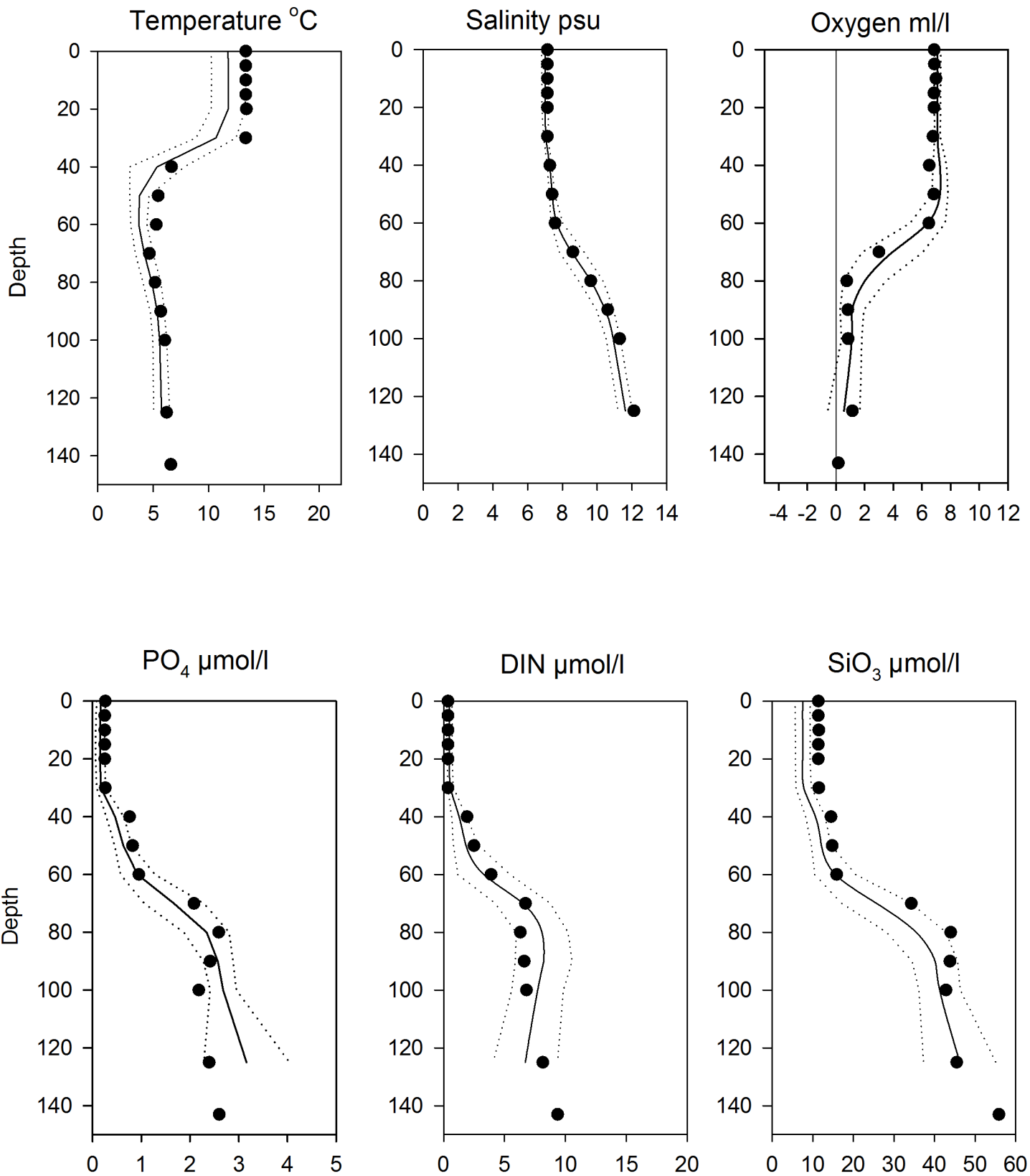


## OXYGEN IN BOTTOM WATER (depth >125m)



# Vertical profiles BY10 October

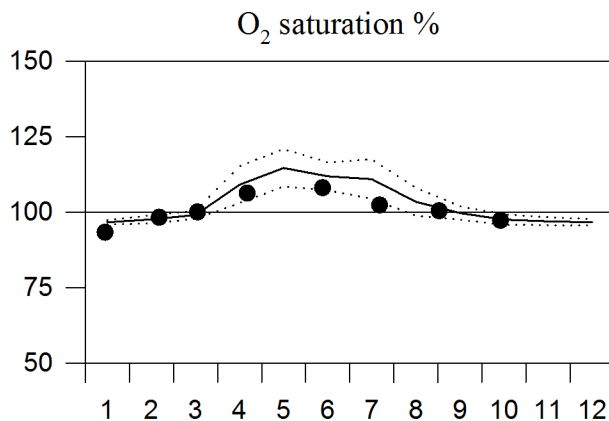
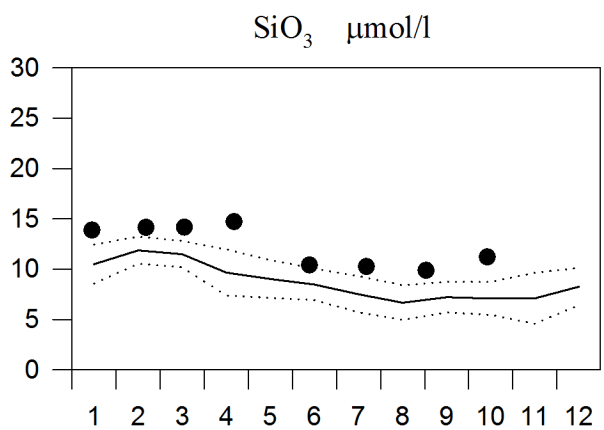
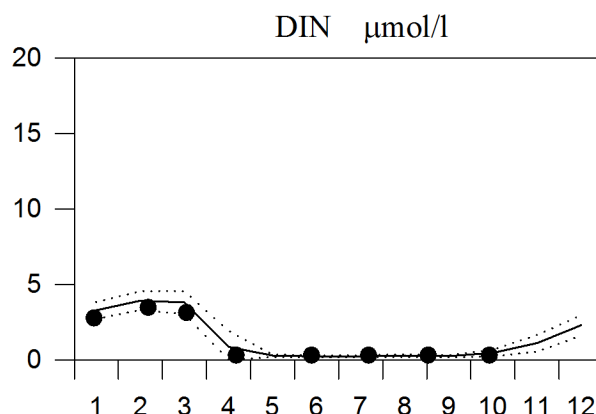
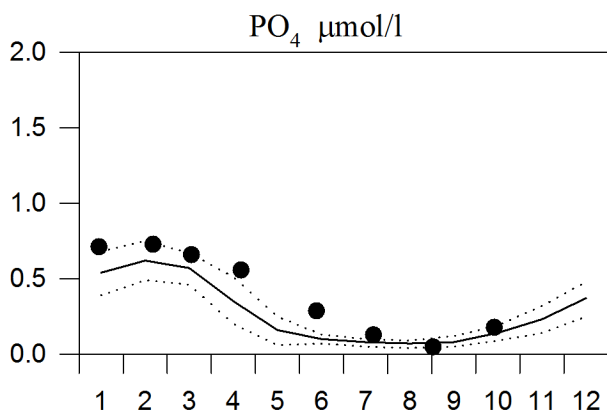
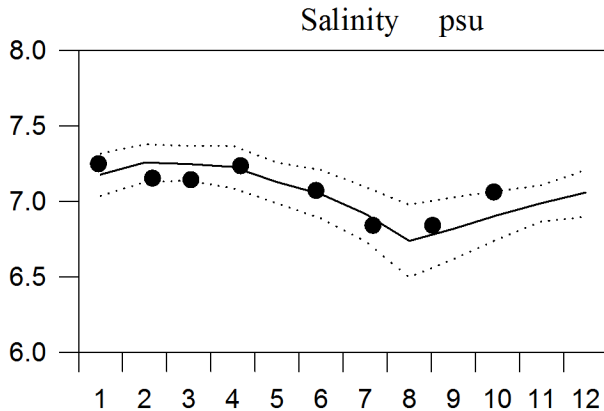
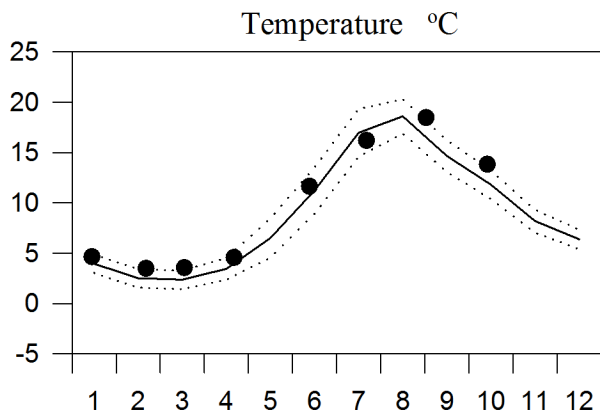
— Mean 1996-2010      ····· St.Dev.      ● 2015



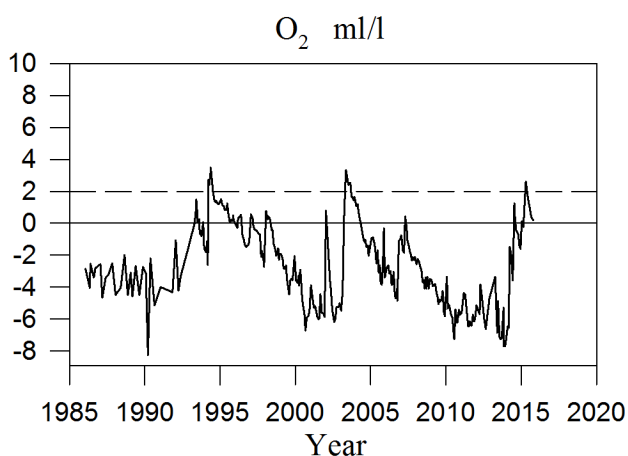
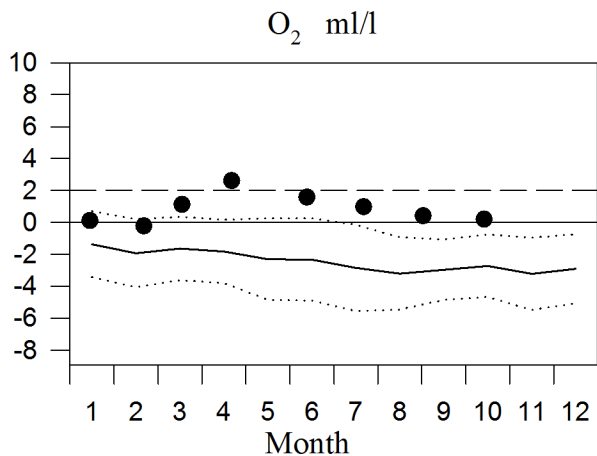
# STATION BY15 SURFACE WATER

## Annual Cycles

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

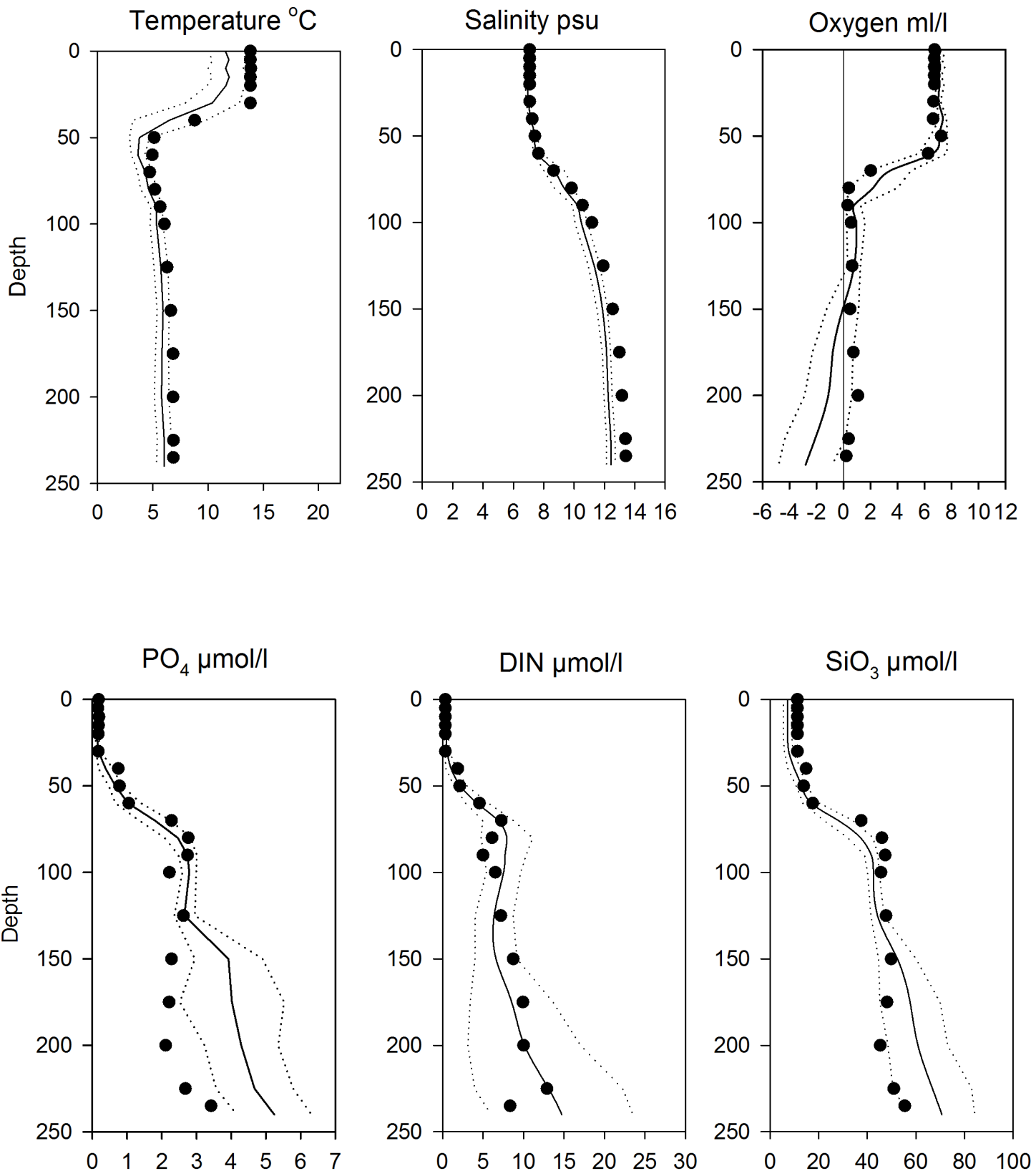


## OXYGEN IN BOTTOM WATER (depth >225m)



# Vertical profiles BY15 October

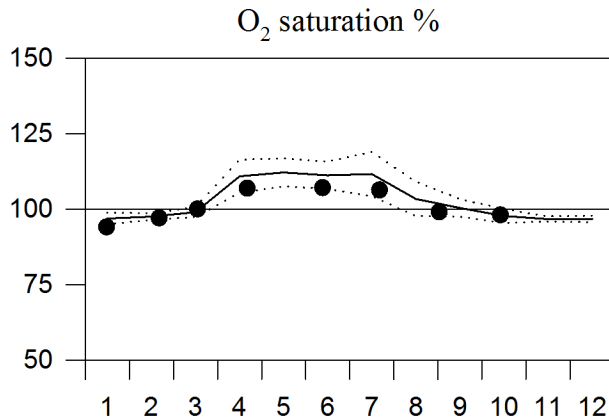
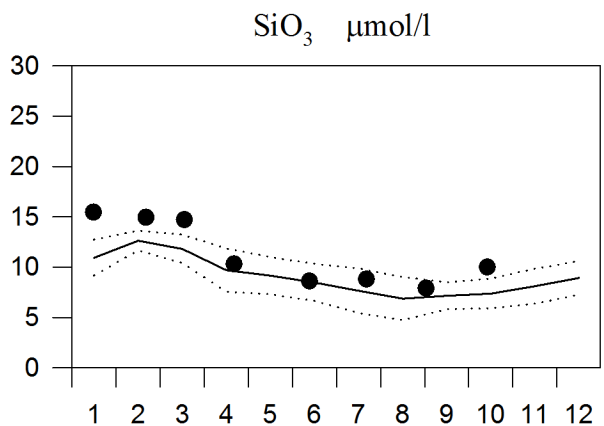
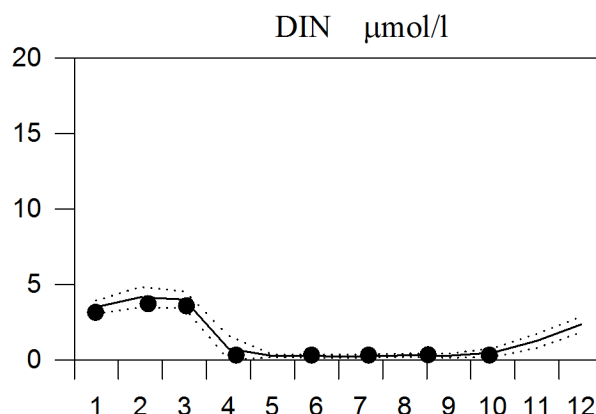
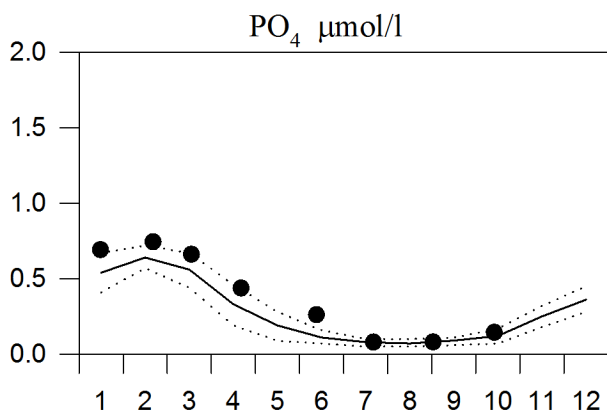
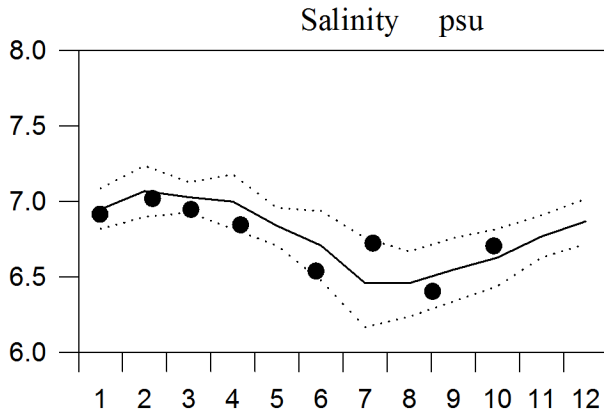
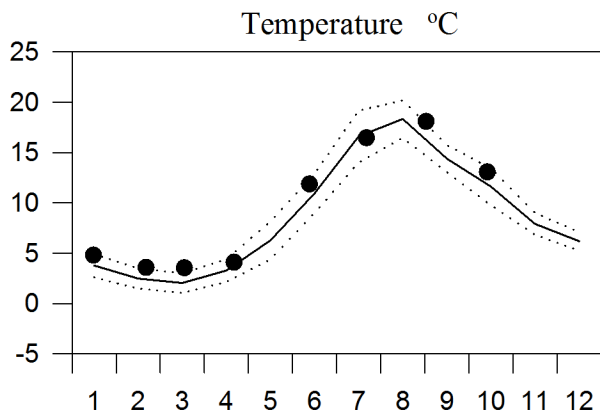
— Mean 1996-2010      ..... St.Dev.      ● 2015



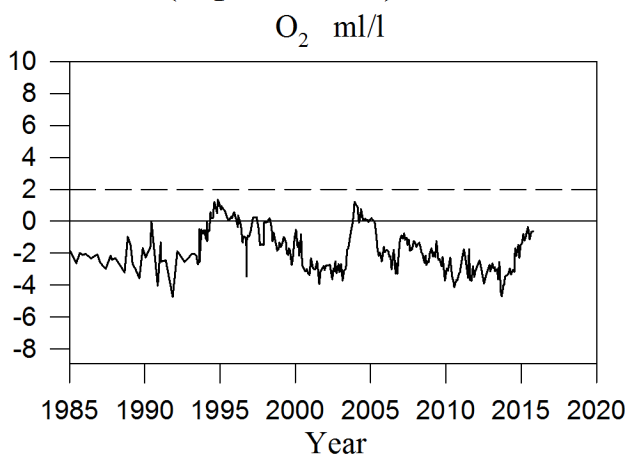
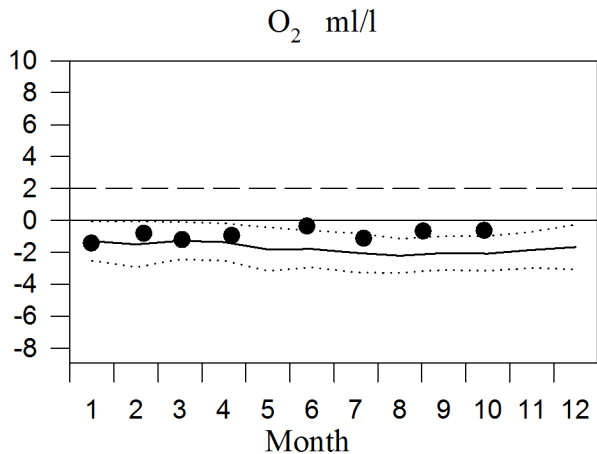
# STATION BY20 SURFACE WATER

## Annual Cycles

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

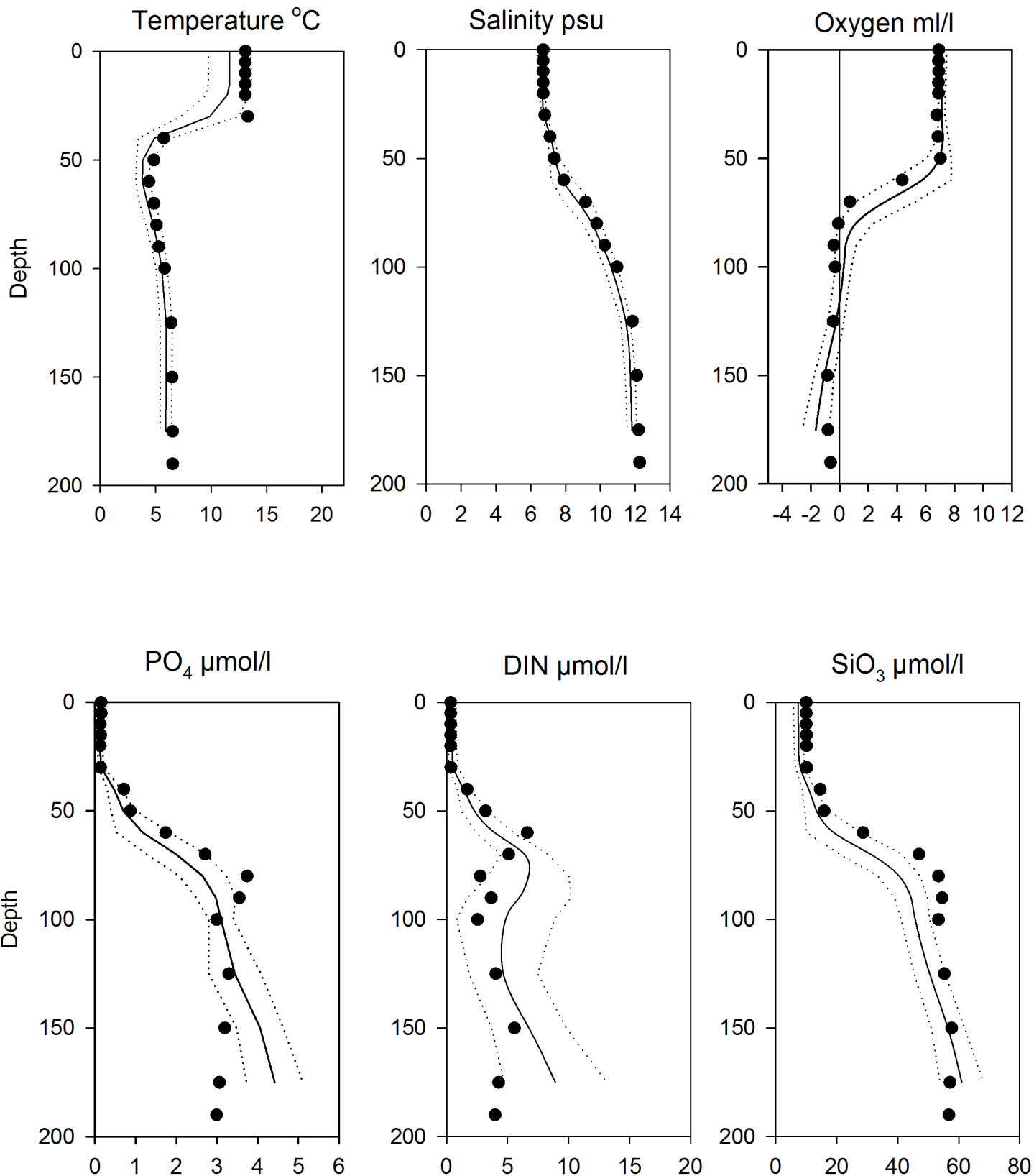


## OXYGEN IN BOTTOM WATER (depth >175m)



# Vertical profiles BY20 October

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

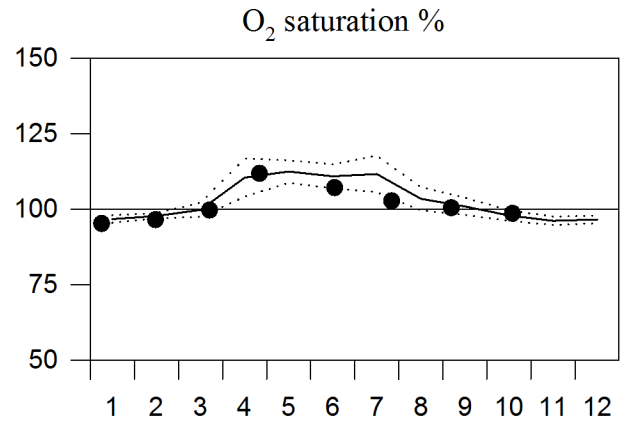
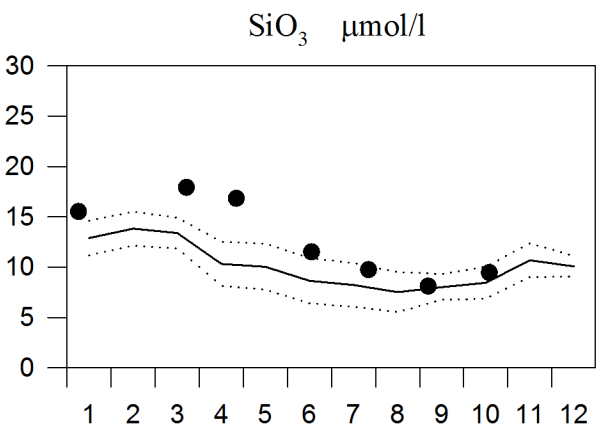
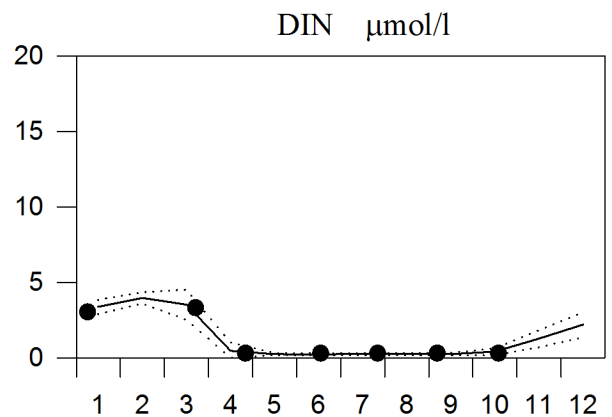
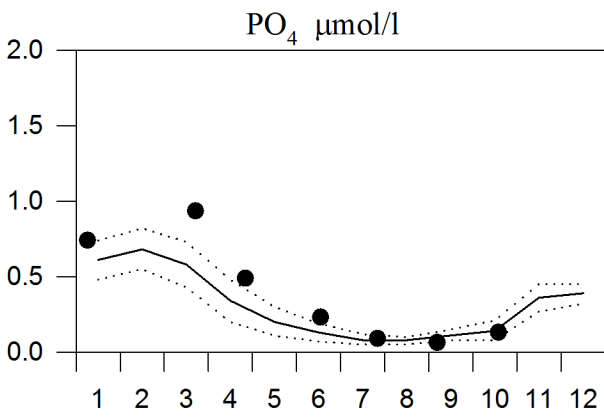
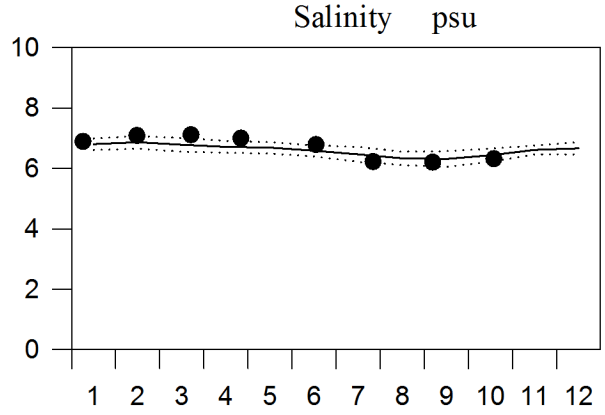
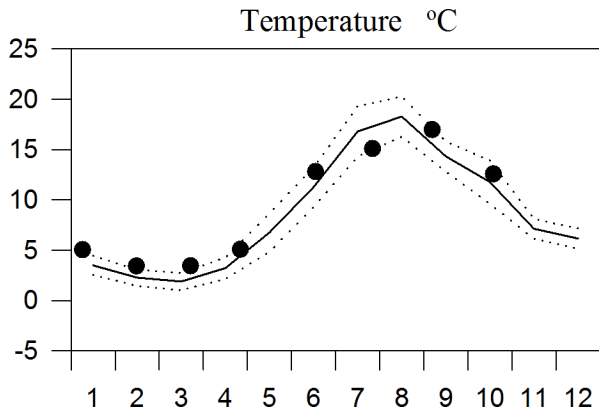




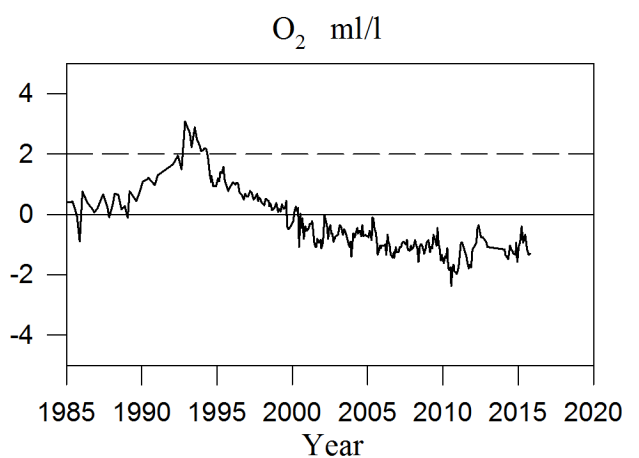
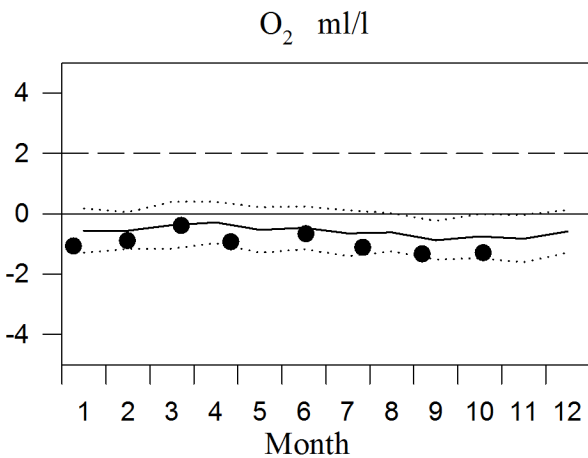
# STATION BY32 SURFACE WATER

## Annual Cycles

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

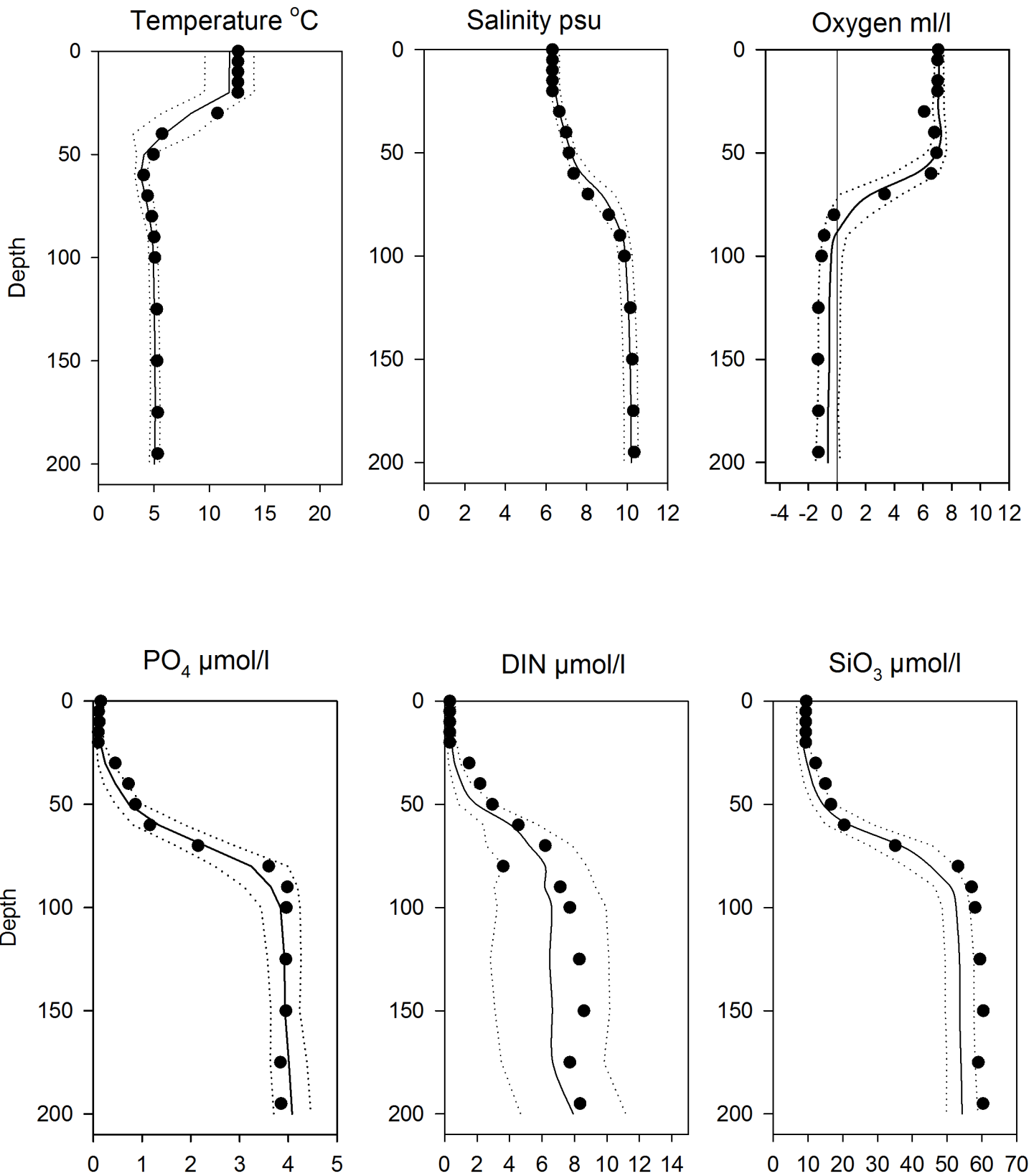


## OXYGEN IN BOTTOM WATER (depth > 175m)



# Vertical profiles BY32 October

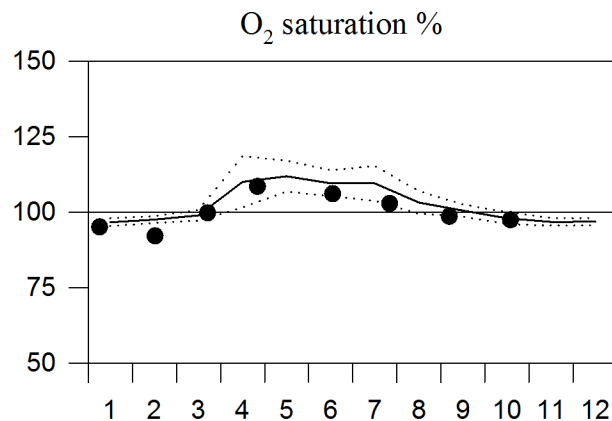
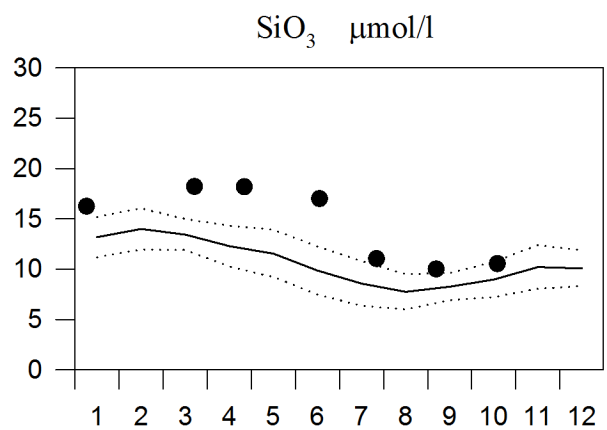
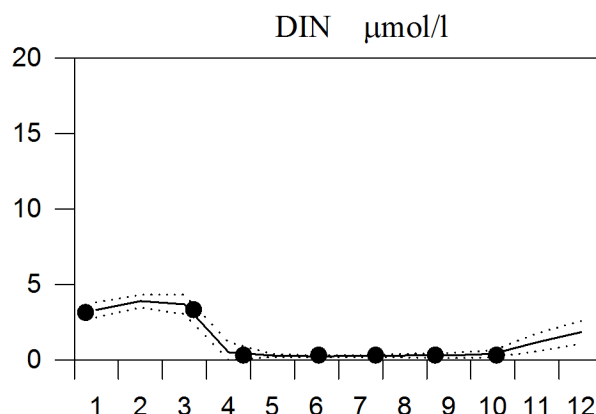
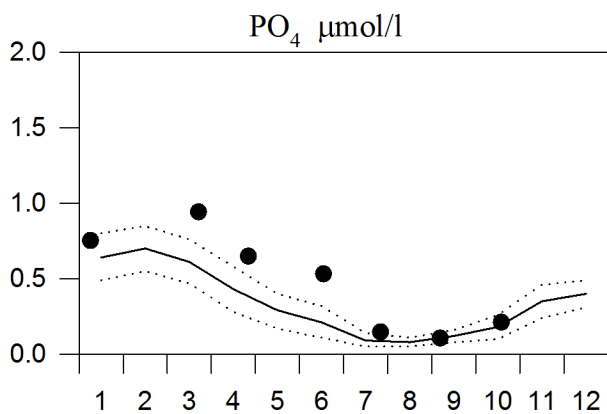
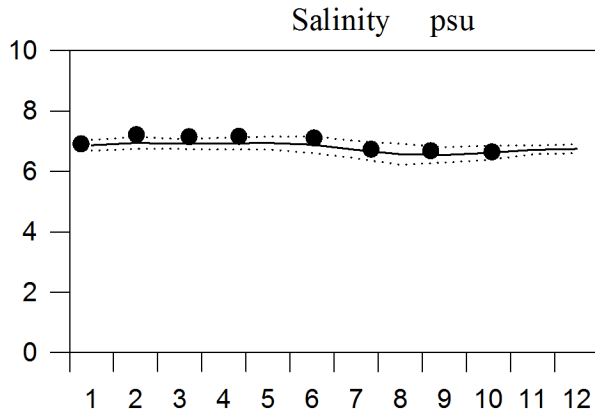
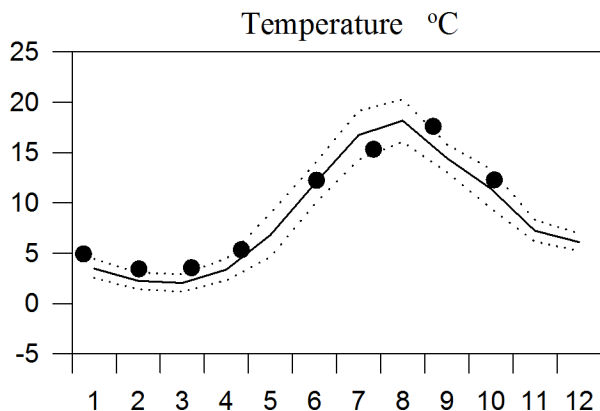
— Mean 1996-2010      ····· St.Dev.      ● 2015



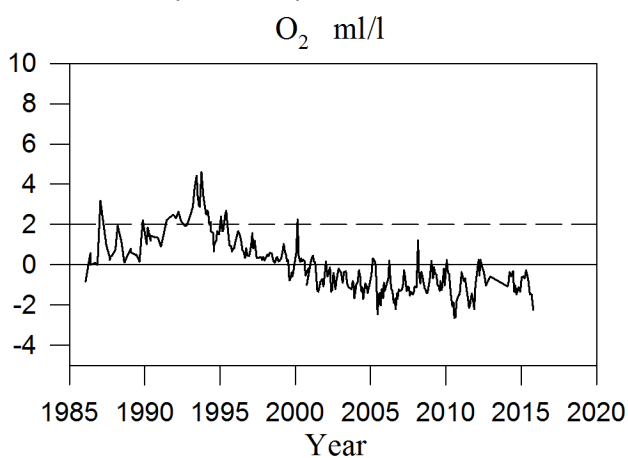
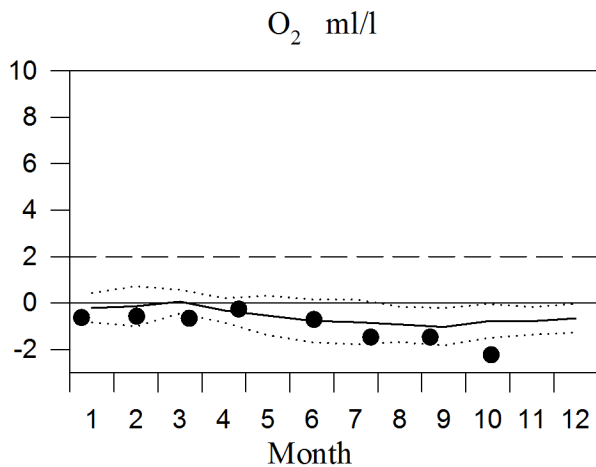
# STATION BY38 SURFACE WATER

## Annual Cycles

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

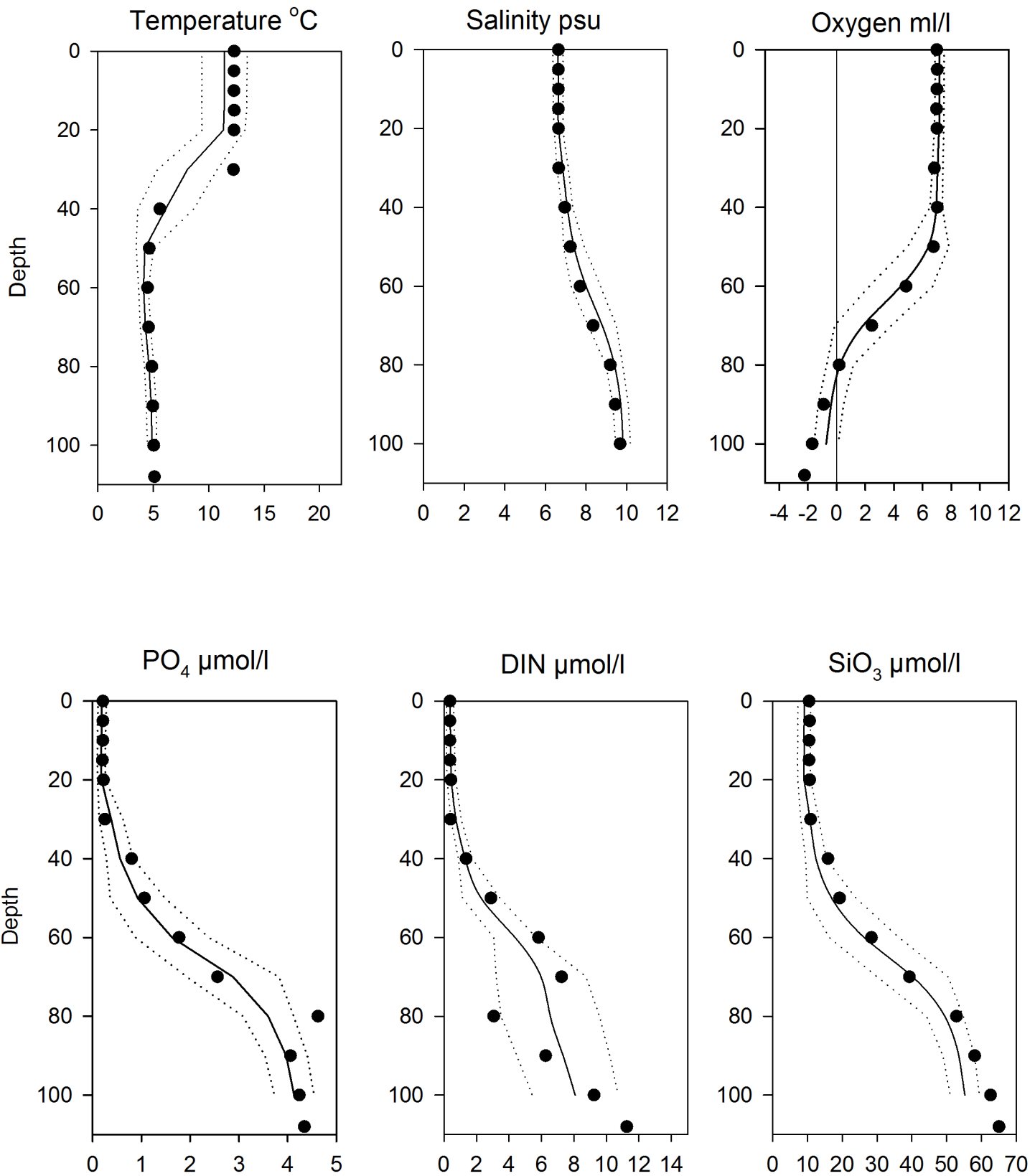


## OXYGEN IN BOTTOM WATER (> 100m)



# Vertical profiles BY38 October

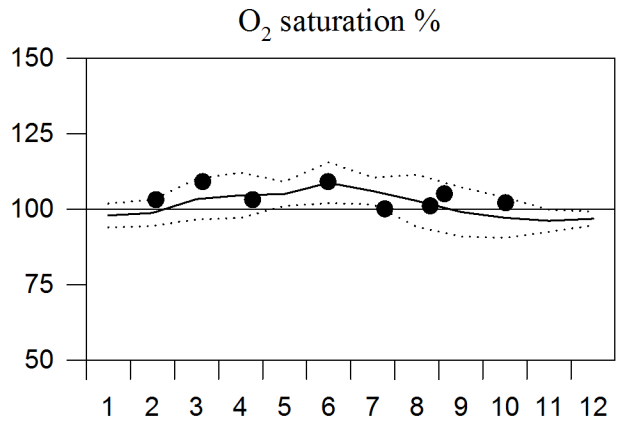
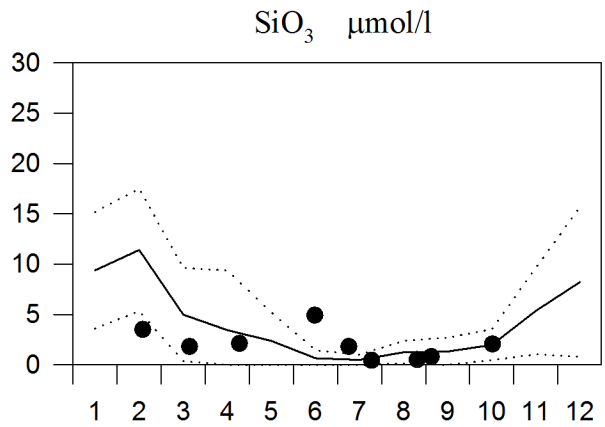
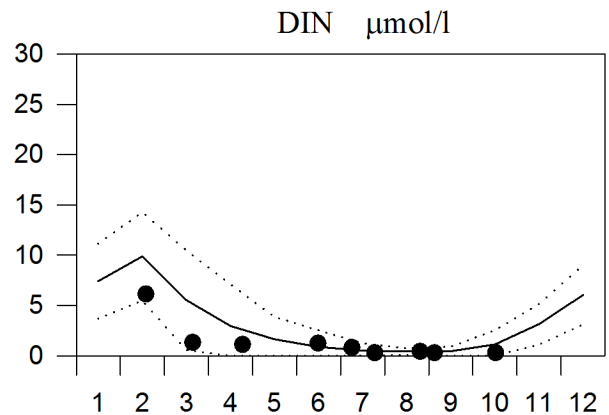
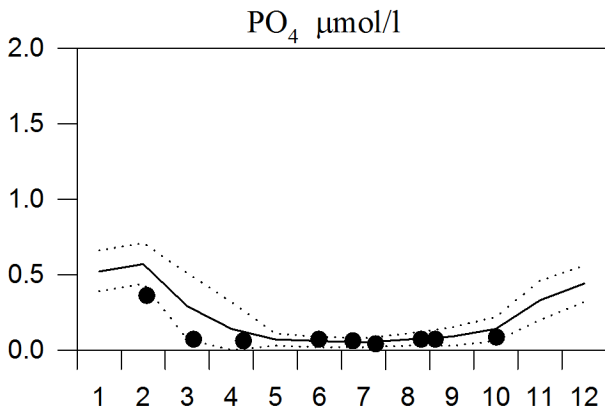
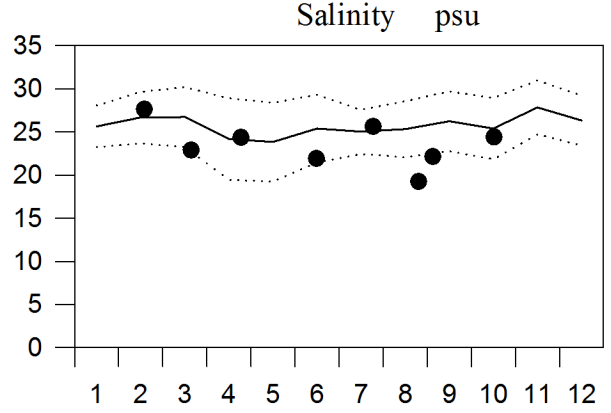
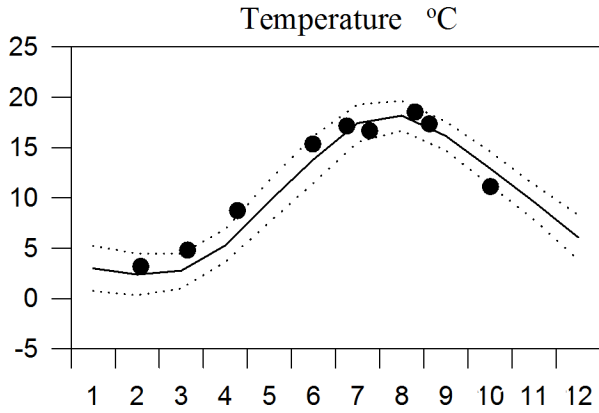
— Mean 1996-2010      ····· St.Dev.      ● 2015



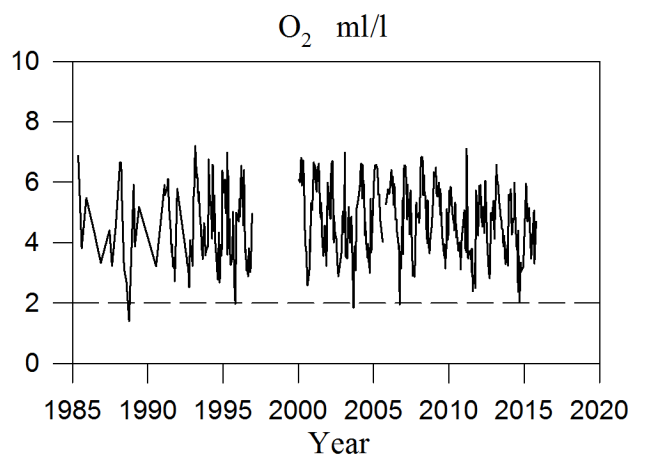
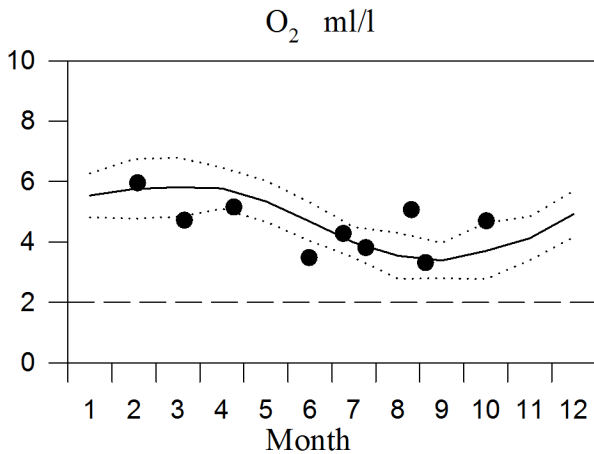
# STATION SLÄGGÖ SURFACE WATER

## Annual Cycles

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

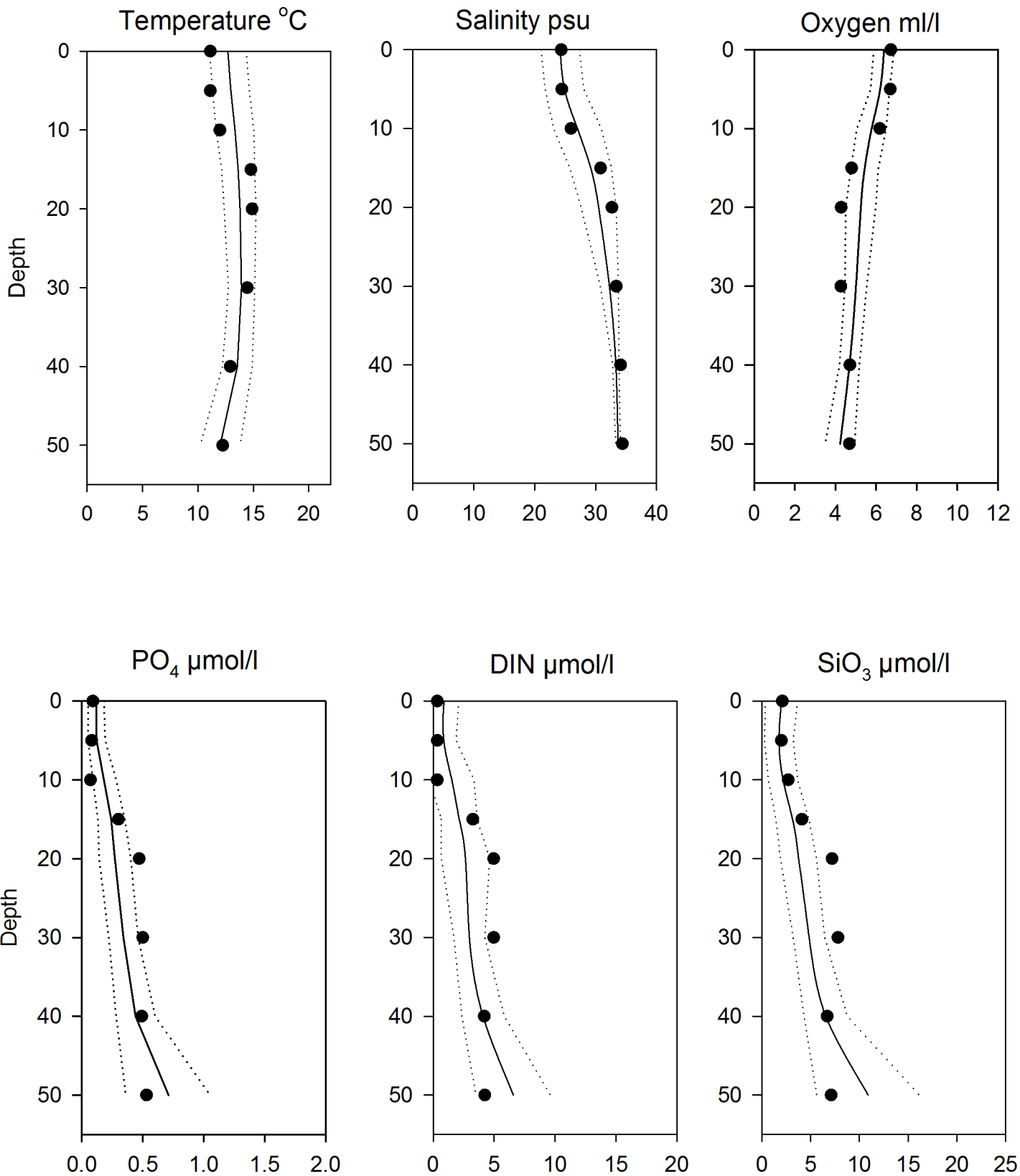


## OXYGEN IN BOTTOM WATER (depth >50m)



# Vertical profiles Släggö October

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



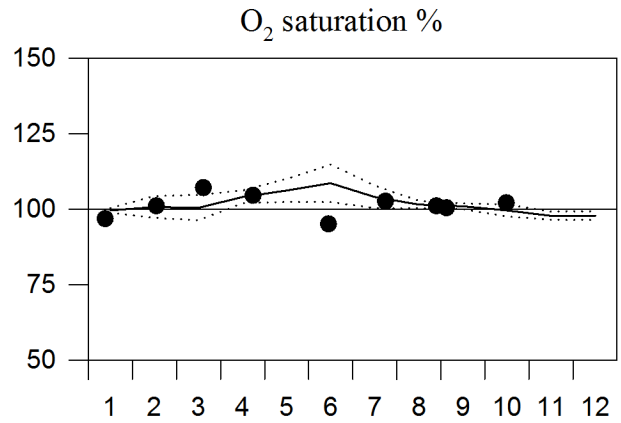
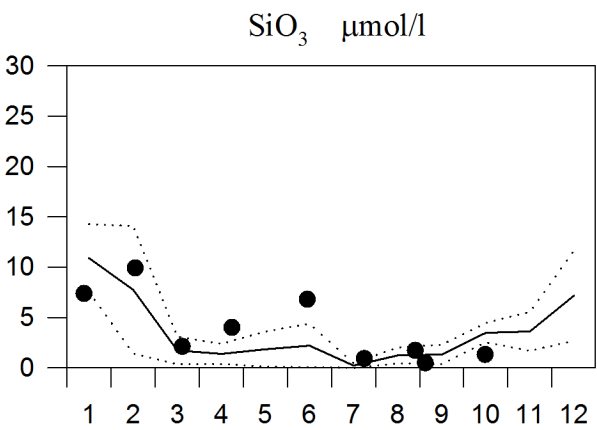
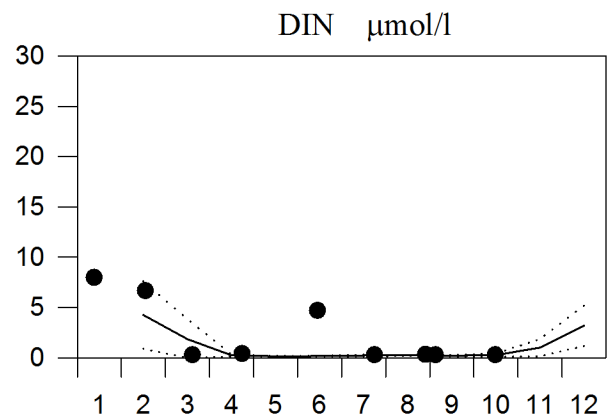
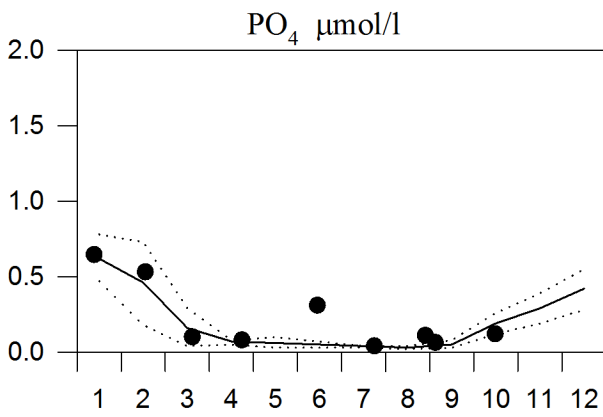
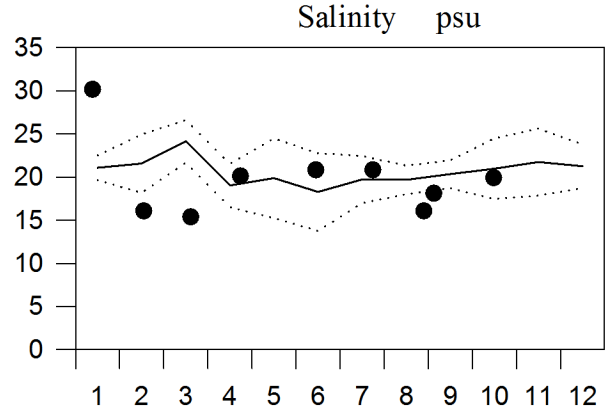
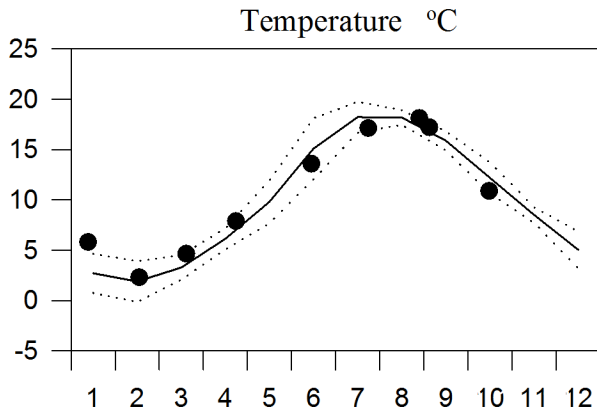
# STATION N14 Falkenberg SURFACE WATER

## Annual Cycles

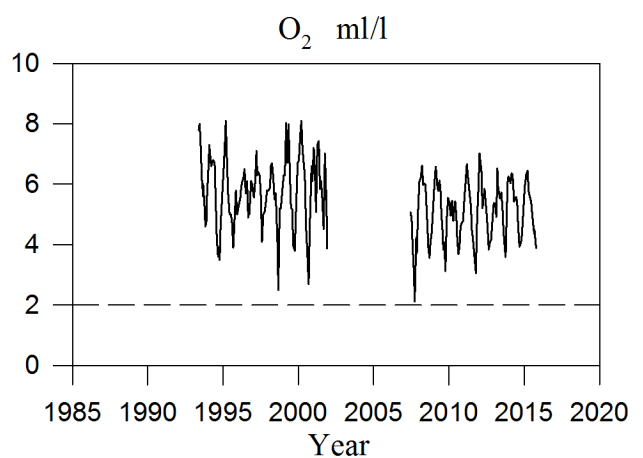
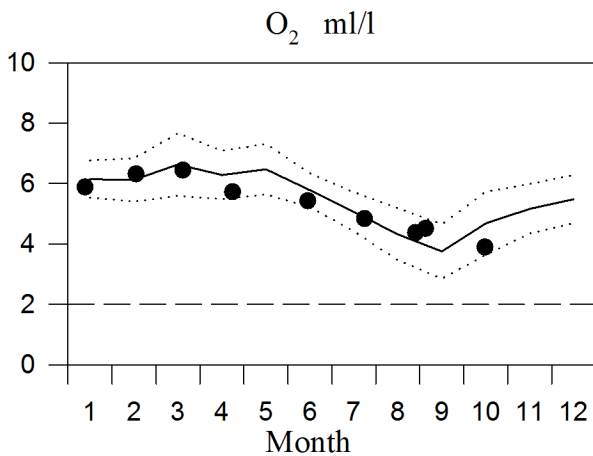
— Mean 2007-2010

..... St.Dev.

● 2015

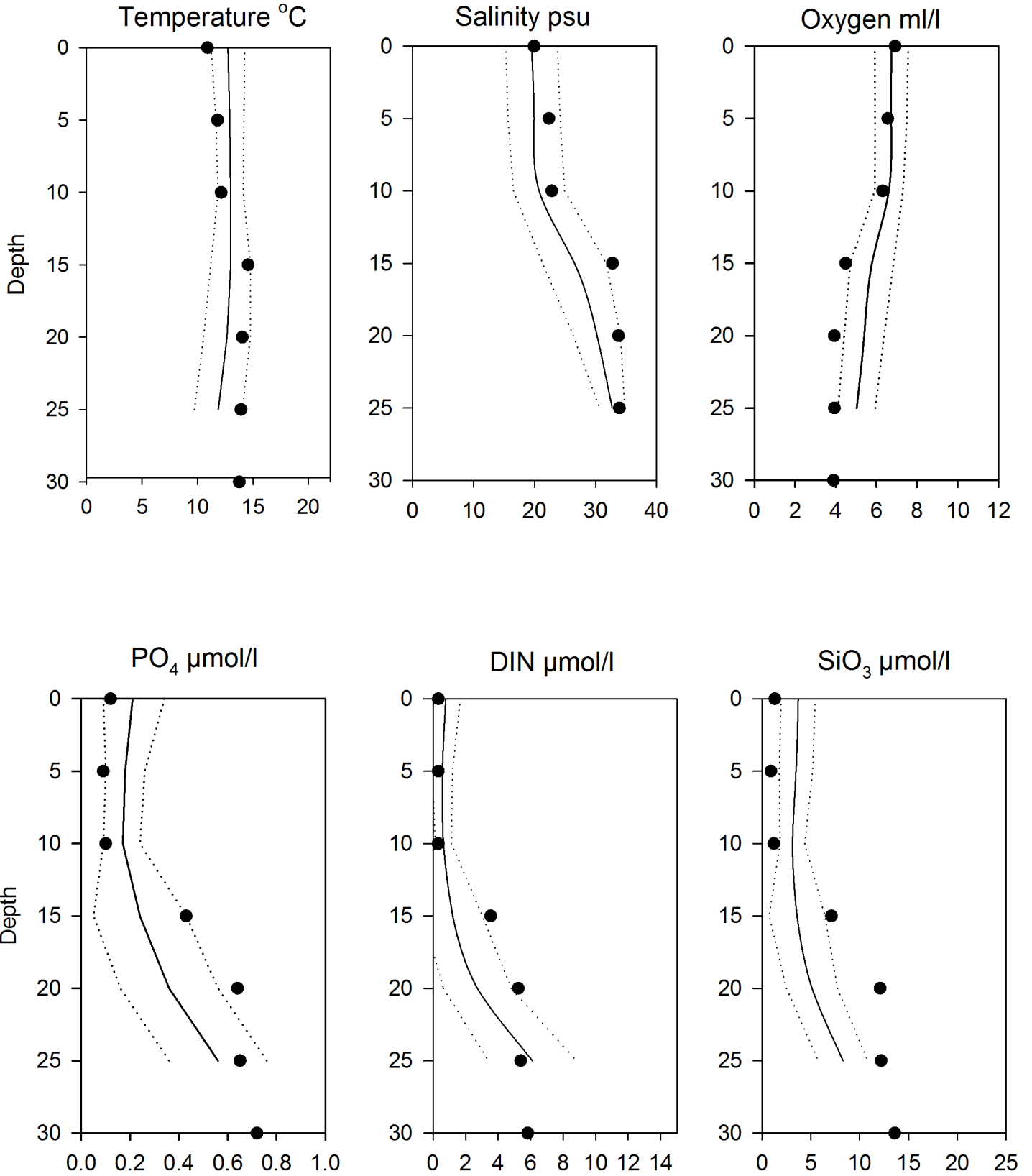


## OXYGEN IN BOTTOM WATER (depth > 25m)



# Vertical profiles N14 Falkenberg October

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

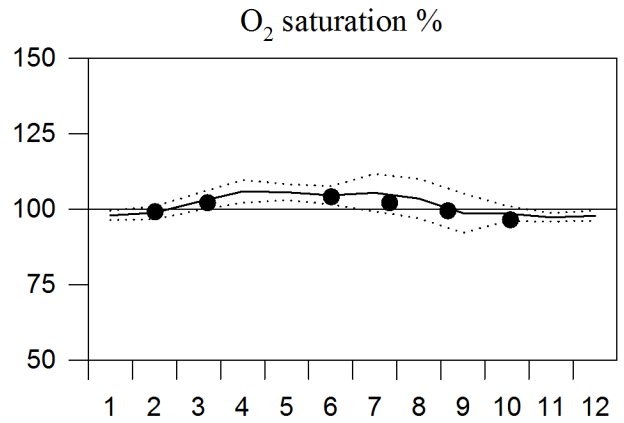
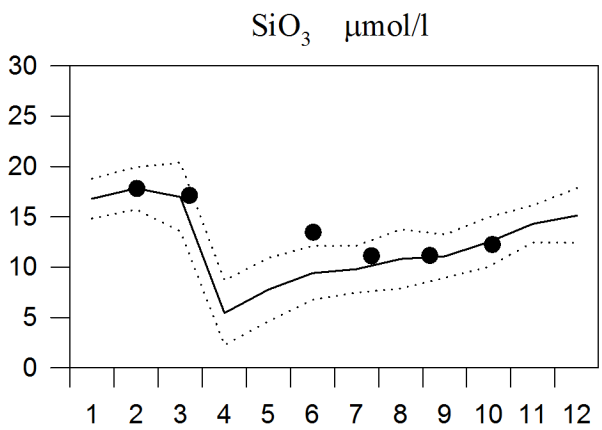
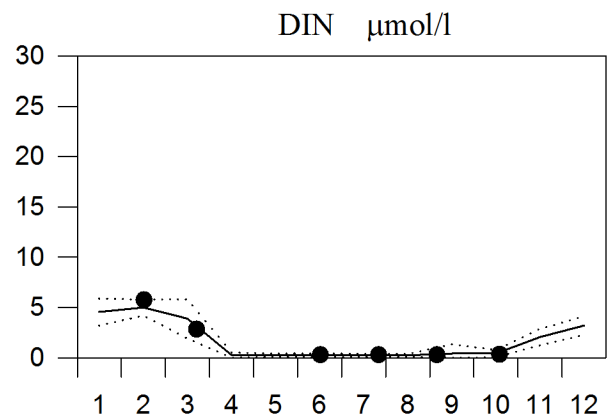
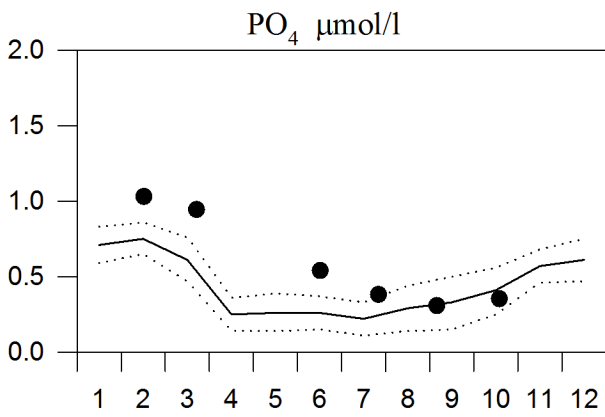
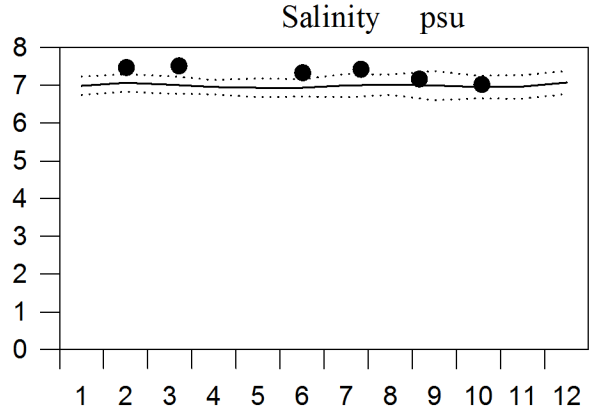
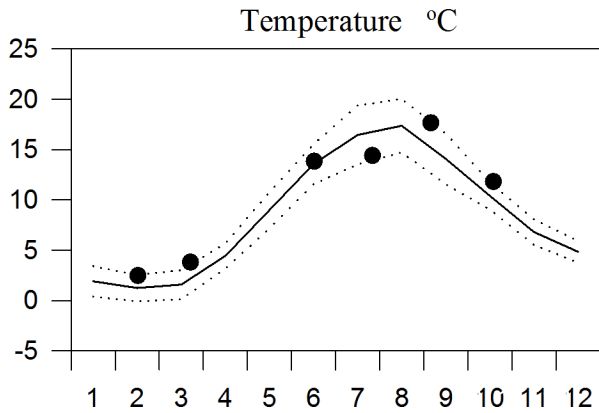




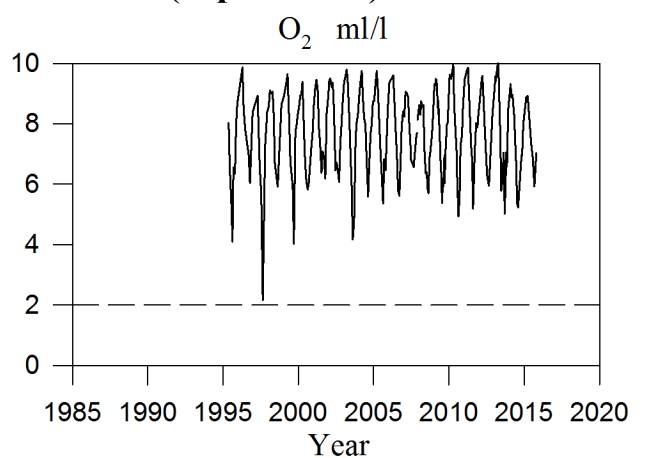
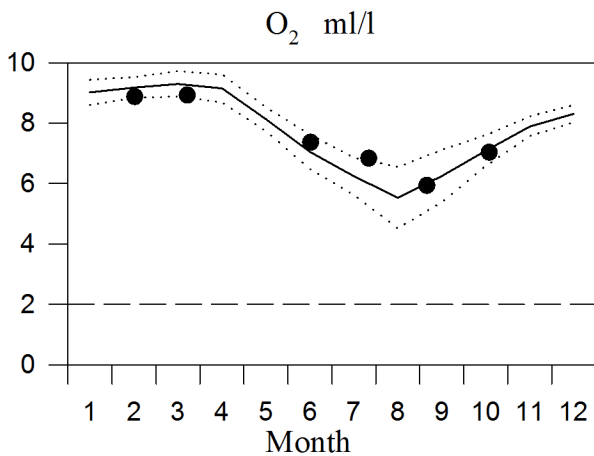
# STATION REF M1V1 SURFACE WATER

## Annual Cycles

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



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



# Vertical profiles Ref M1V1 October

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

