

Report from the SMHI monitoring cruise with R/V Aranda



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Survey period: 2015-08-31 - 2015-09-07
Survey area: Skagerrak, Kattegat, the Sound, the Baltic Proper and the Gulf of Finland
Principal: SMHI and the Swedish Agency for Marine and Water Management

SUMMARY

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

The water temperature in the surface layer had now increased and was substantially normal for the season. In the southern and southeastern Baltic Proper relatively high concentrations of phosphate and silicate were measured. The large inflow that occurred in December 2014 could not be seen further north than at the last expedition and the oxygen levels in the inflowing water had also declined even more. In the northern and western Gotland basin and in the western part of the Gulf of Finland the oxygen situation remains severe as completely oxygen free conditions are found at depths exceeding 70-80 metres. Acute hypoxia was found from 60 metres in the western Gotland basin. In the bottom water in the Bornholm basin and in the Hanö Bight, oxygen levels had declined compared to the previous sampling in July and acute hypoxia was experienced. Oxygen levels in the Arkona basin had increased to $>2\text{ml/l}$ and acute hypoxia did no longer prevail.

The next cruise is planned to start October 12, 2015.

PRELIMINARY RESULTS

The cruise, performed on board the Finnish research vessel Aranda, began in Helsinki on August 31 and ended in the same port on the 7th September. Winds during the expedition were mainly weak to moderate. In parts of the Baltic Proper however, the wind increased to gale force on a few occasions. Air temperatures ranged from 11-18°C.

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

During the cruise, a scientist from the Danish Technological University collected water samples for iodine isotope analyses. Aim of this project is to investigate how discharge water from nuclear power plants spreads in the Baltic Sea. Also, two scientists from SYKE joined the cruise and made multi net sampling from different layers in the water column to investigate how the salt water intrusion December 2014 affected the zoo plankton community.

The Skagerrak

The temperature in the surface water had increased since last expedition and was now about the normal for the season and varied between 16.03 and 17.34°C, highest near the coast. The surface salinity varied between 22.14 and 33.87 psu, lowest along the coast. The salinity was higher than normal off shore and near the coast it was lower than normal. The stratification was found around 35 meter off shore and the coast it was found shallower at 10-20 metres depth.

The nutrients in the surface waters were still very low both at the coast and offshore, and had started to increase at some stations which is normal for the season. Phosphate concentrations in the surface waters were in the interval 0.03 – 0.08 µmol/l, inorganic nitrogen (nitrite+nitrate and ammonia) <0.1-0.37 and <0.20-0.67 µmol/l respectively, while silicate varied between 0.8-1.8 µmol/l.

The lowest oxygen concentration in the bottom water was found at Släggö in the mouth of the Gullmar fjord, 3.31 ml/l.

Fluorescence measurements showed biological activity with higher intensity just above the pycnocline. For more details see the separate phytoplankton report.

The Kattegat and the Sound

In Kattegat, the temperature in the surface water was around 17°C which is normal for the time of year. The salinity in the surface layer was a bit lower than normal for the season and varied between 16.45 and 11.46 psu with the lowest salinity in the Sound. The halocline and the thermocline were found at 10-20 metres depth.

The concentration of nutrients in the surface water was low or almost exhausted, which is normal for the season. The phosphate concentration varied between 0.05-0.11 µmol/l and had increased some since the last visit in July. Silicate also showed low concentrations around 0.4-1.0 µmol/l. In the Sound, the concentrations of nutrients were also normal; phosphate was 0.19 µmol/l and silica was 6.7 µmol/l. Inorganic nitrogen was below the reporting limit in both Kattegat and the Sound.

The lowest oxygen concentrations in the bottom water were measured at Anholt E in Kattegat, 4.09 ml/l and 2.66 ml/l at W Landskrona in the Sound.

The plankton activity was low in the surface water, but some higher around the pycnocline. For more details see the separate phytoplankton report.

The Baltic Proper

The temperature in the surface water had increased since last expedition and was normal or somewhat above normal for the season and varied between 17.0 and 18.5°C. The eastern parts were somewhat warmer than the western parts. The surface salinity was around the normal for the season and varied between 5.51 psu in the central Gulf of Finland to 7.87 psu in the Arkona basin. The halocline was found at 60-80 metres depth in the western and eastern Gotland basin, while it was shallower in the southern parts. In the Arkona basin it was found at 30-40 metres depth. The thermocline was found at 20-30 metres depth and was well developed.

The concentration of phosphate and silicate in the surface water was now lower than at the last visit but still above normal in the southern and in the south eastern Baltic Proper. The high concentrations of phosphate and silicate in the surface waters could be attributed to the inflow, and nutrient rich bottom water consequently reaching the surface water. In the remaining parts the concentrations were normal for the season. Phosphate concentrations varied between 0.05-0.34 µmol/l and silicate between 7.9-13.7. The high phosphate concentration was observed at Hanö Bight in the south western Baltic Proper and the highest silicate concentration at BCSIII-10 in the south eastern Baltic Proper. The inorganic nitrogen was completely consumed down to 20 metres depth except at the coastal station RefM1V1 where inorganic nitrogen increased from 15 meters depth.

To monitor the inflow to the Baltic Sea that occurred during December 2014 extra sampling points were visited in the northern Gotland basin north of Fårö Deep (BY20). No markable signs of the inflow were to be seen north of BY20 but just as last visit in July weak signs of the inflow were found intermediary at BY20.

In the western and northern Baltic Proper, and in the western Gulf of Finland, the oxygen situation was still severe. Completely oxygen free conditions were found at depths exceeding 70-80 metres. In the Gotland Deep, in the eastern Gotland basin, acute hypoxia was found at depths exceeding 70 metres. Hydrogen sulphide was now found at two intermediate thin layers; 80-95 metres and around 125 metres. Below the oxygen free layer, the deep water was still oxygenated, but the concentrations had declined even more since last expedition in July.

Acute hypoxia was found in the western Gotland basin from 60 metres depth. In the northern and eastern Gotland basin and in the western Gulf of Finland hypoxia was found from 70-80 metres depth. The oxygen content in the bottom water in the Bornholm basin and the Hanö bight had declined further compared to the last measurements in July, and also here acute hypoxia was observed. The oxygen concentration in the Arkona basin had increased since the last visit to >2 ml/l and it were no longer acute hypoxia.

Fluorescence measurements showed biological activity with higher intensity just above the pycnocline. For more details see the separate phytoplankton report.

For more information about the algal situation, please see the separate phytoplankton report.

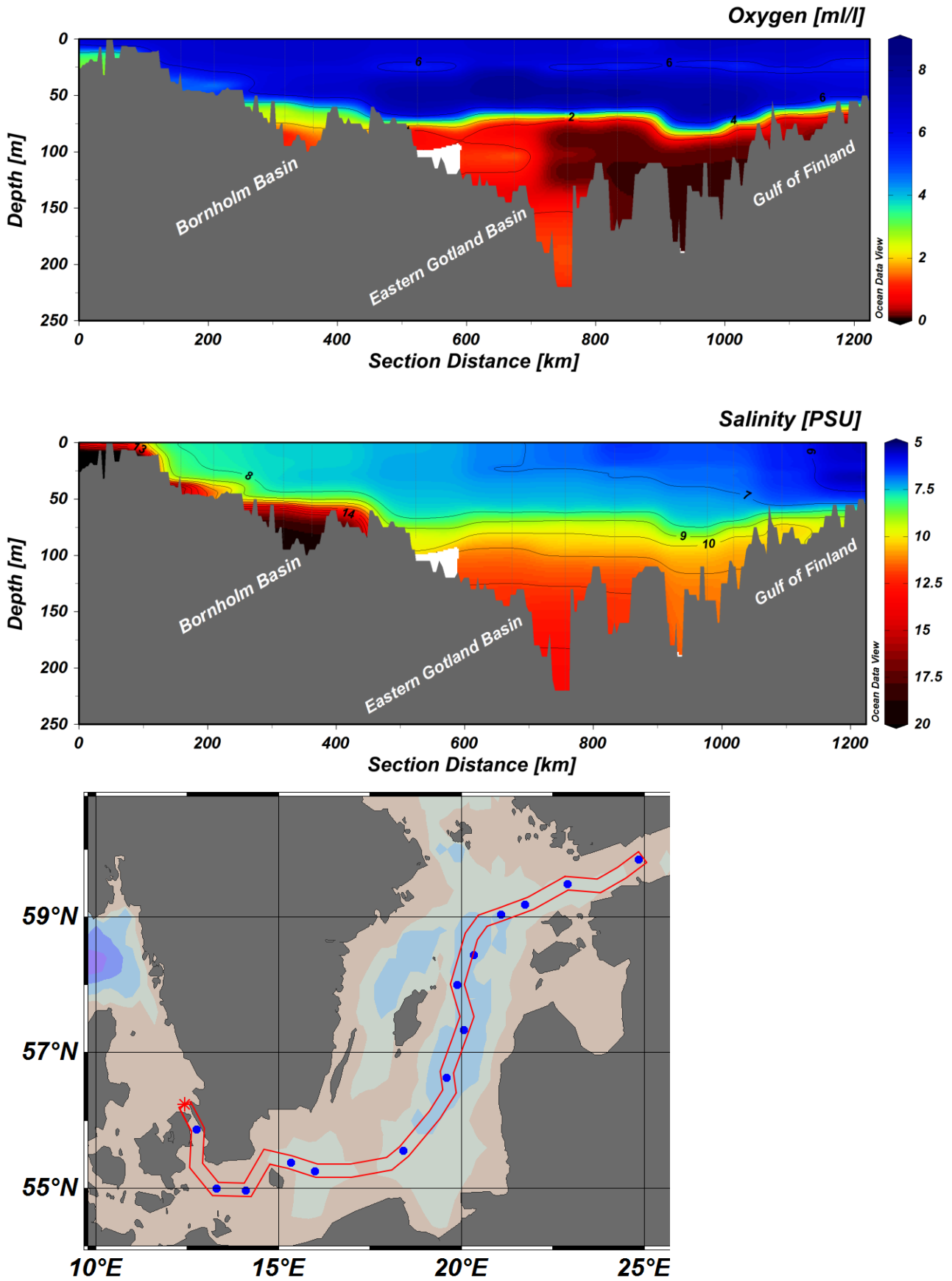


Figure 1. Transect showing the oxygen and salinity from the Sound to the Gulf of Finland.



PARTICIPANTS

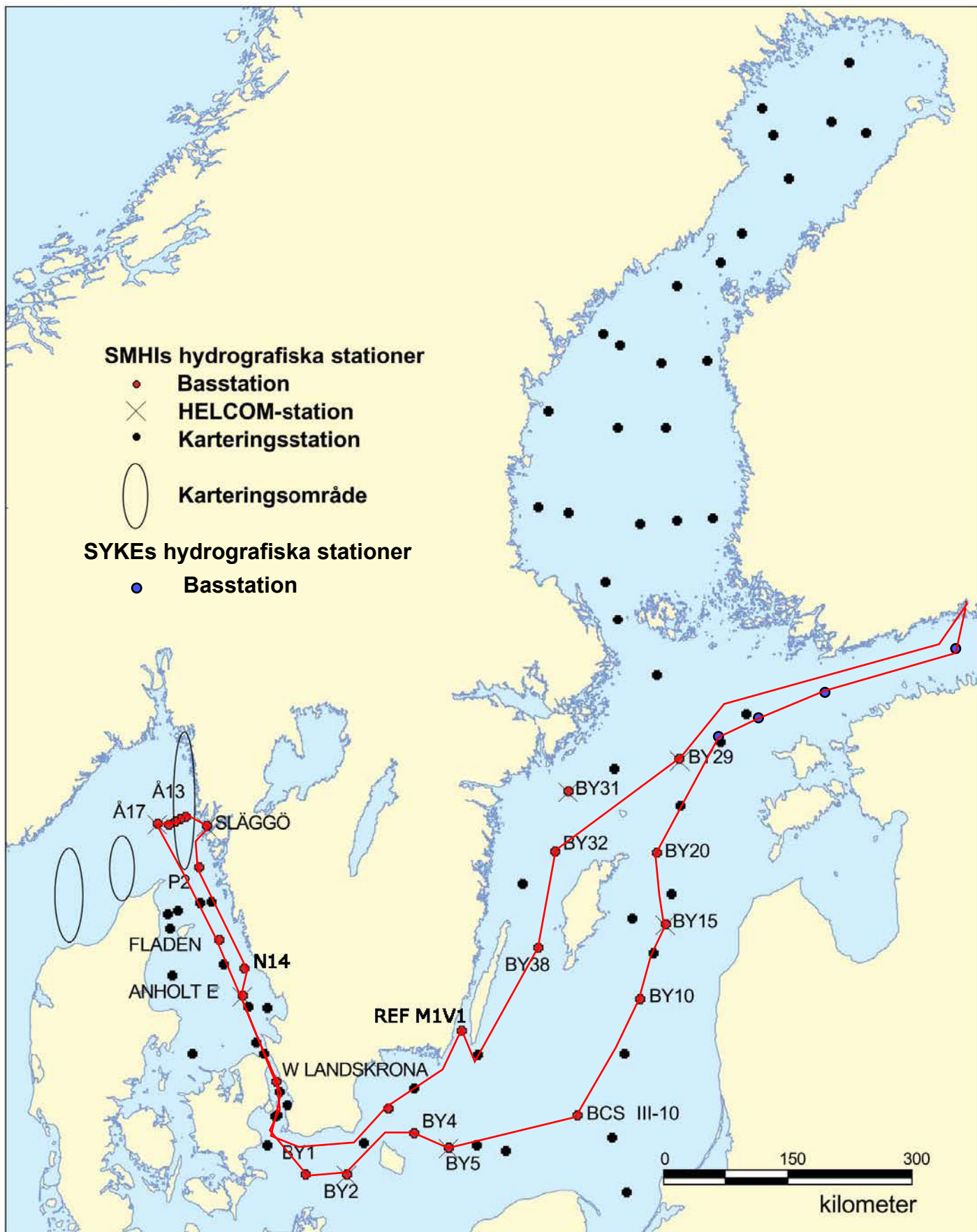
Name		Institute
Karin Wesslander	Chief Scientist	SMHI
Sara Johansson		SMHI
Johan Kronsell		SMHI
Daniel Simonsson		SMHI
Sari Sipilä		SMHI
Juha Flinkman		SYKE
Maiju Lehtiniemi		SYKE
Haitao Zhang		DTU

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

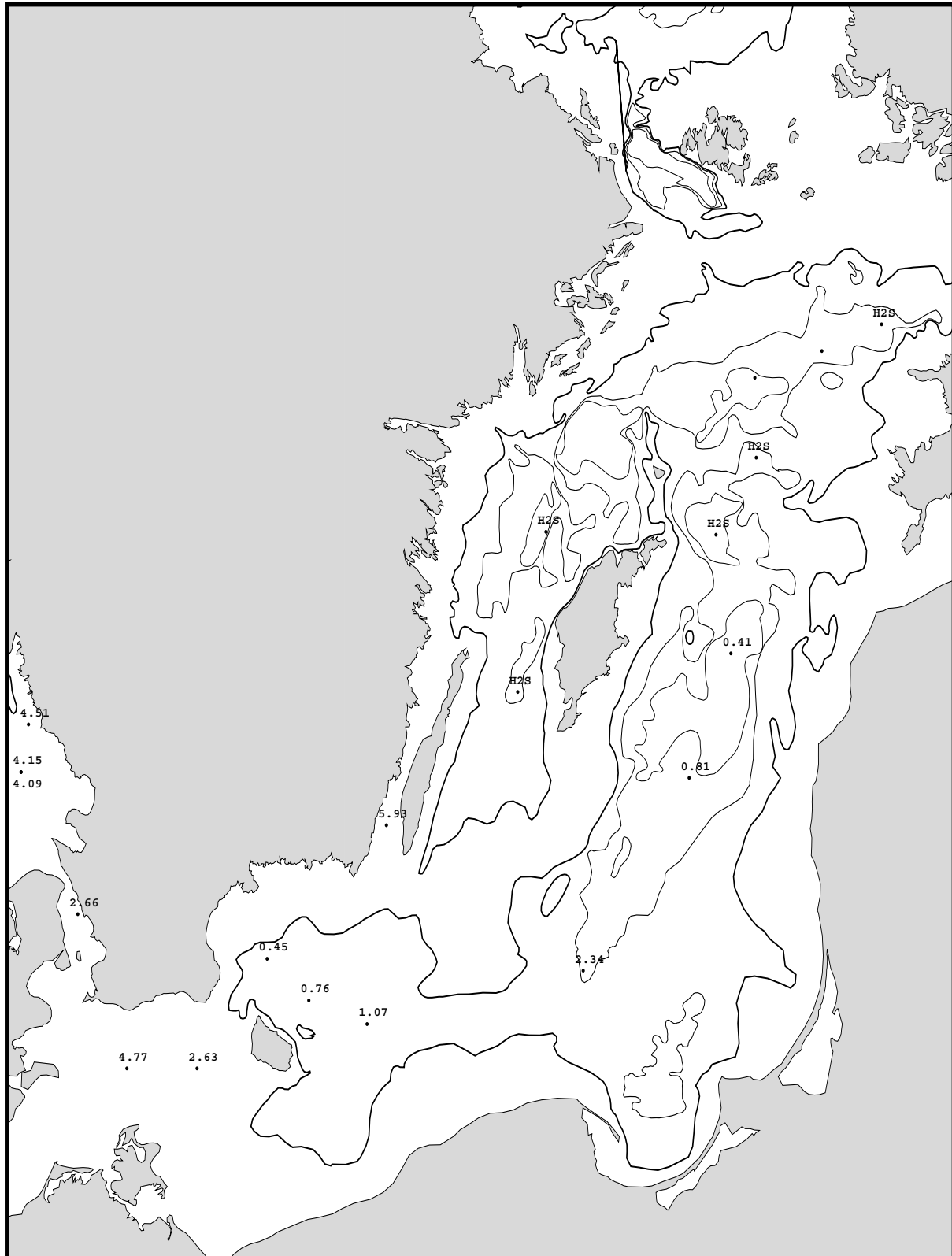
TRACKCHART

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Ship: R/V ARANDA
Date: 20150831-20150907
Series: 0544-0575



Bottom water oxygen concentration (ml/l)

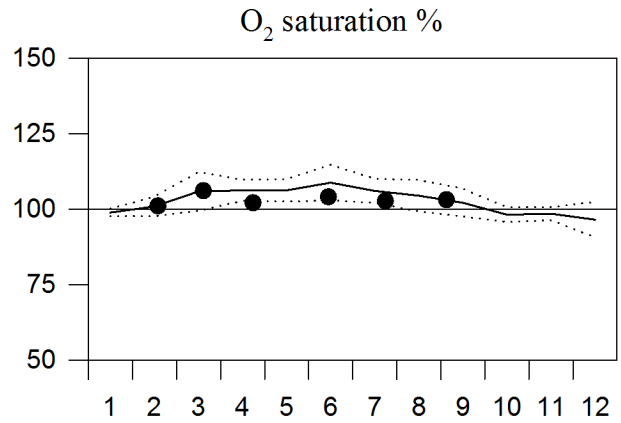
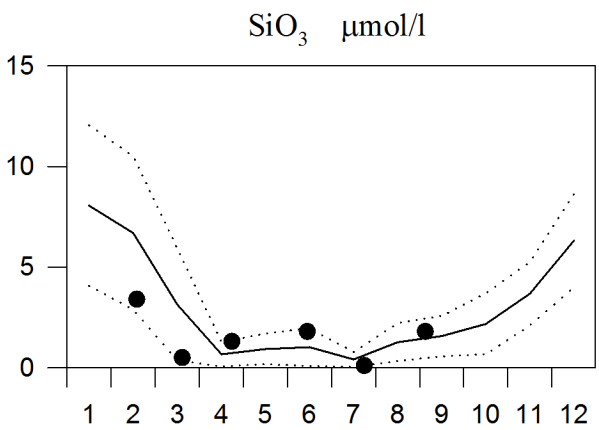
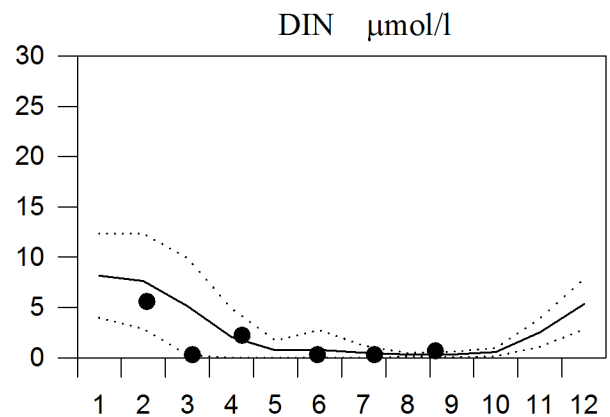
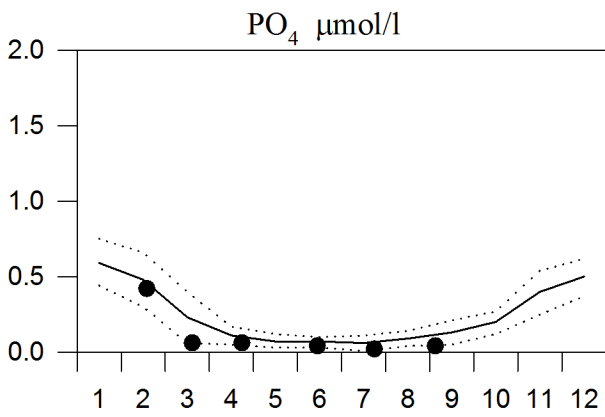
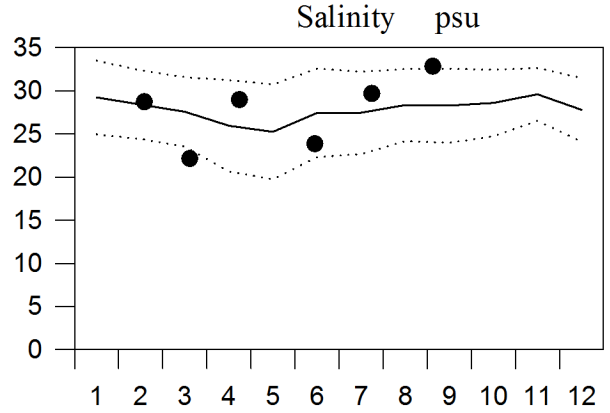
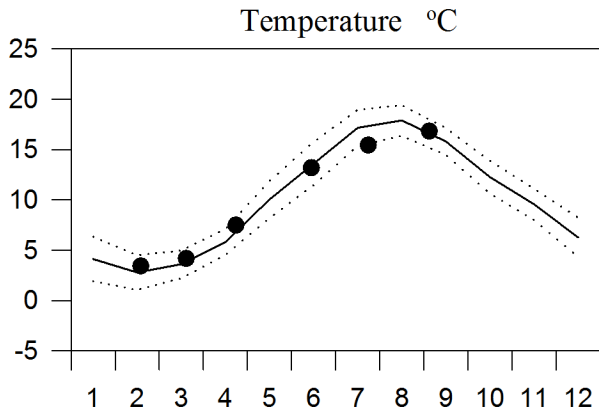
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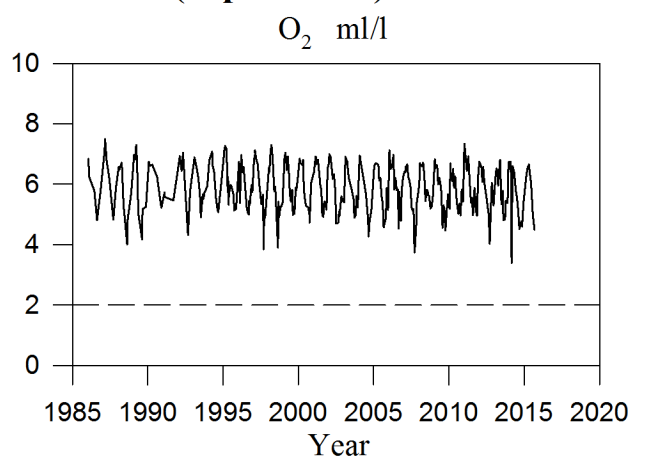
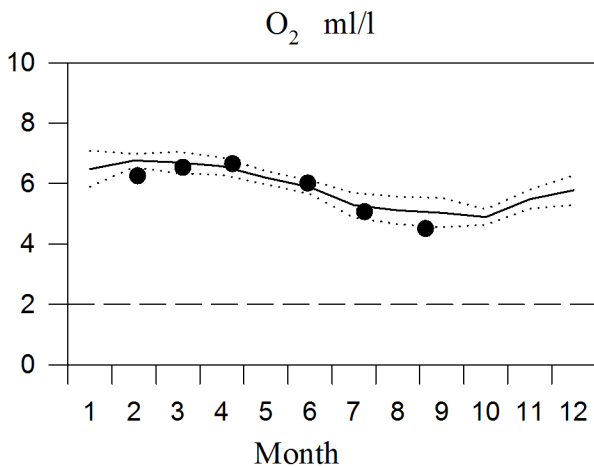
STATION P2 SURFACE WATER

Annual Cycles

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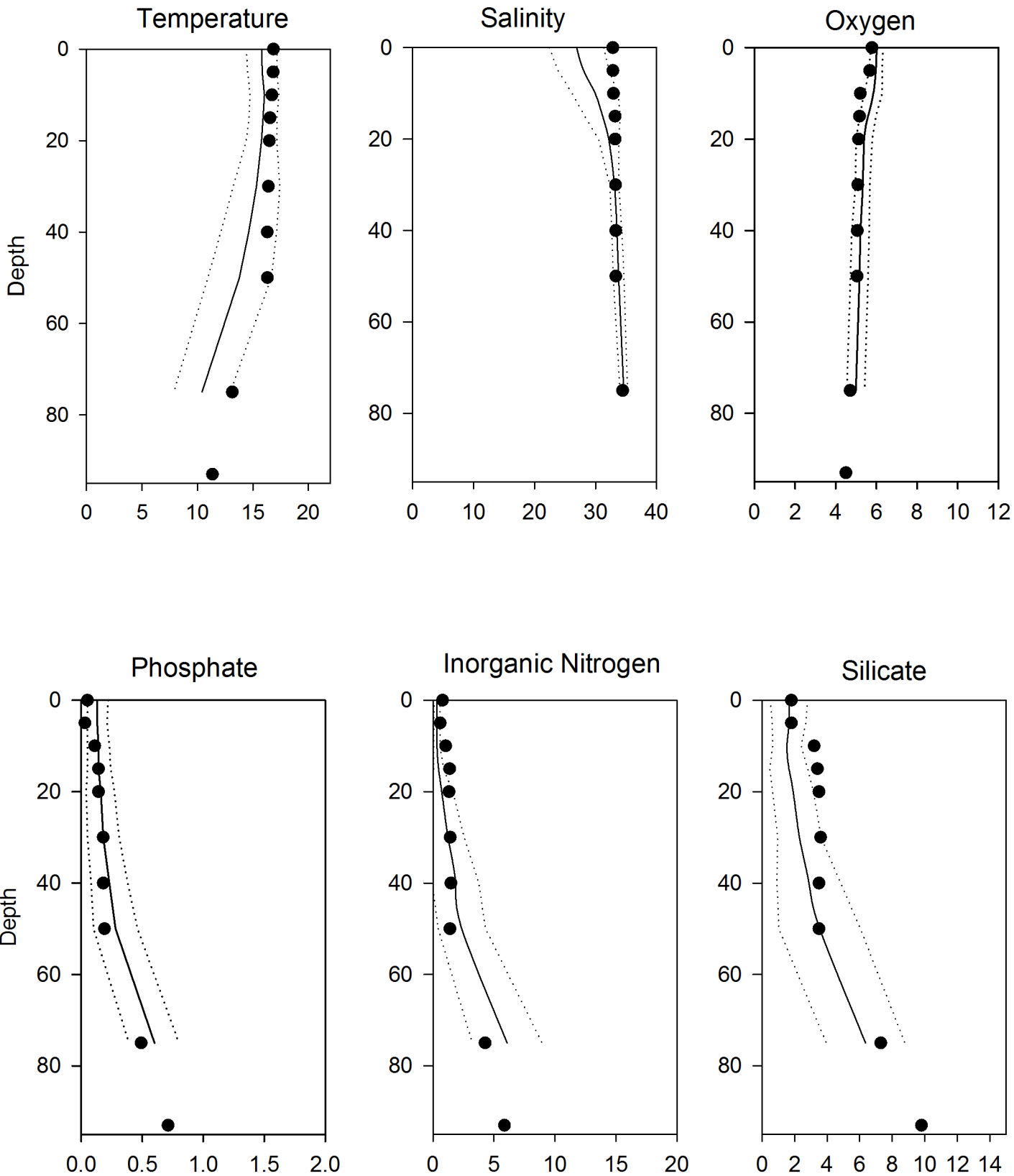


OXYGEN IN BOTTOM WATER (depth >75m)



Vertical profiles P2 September

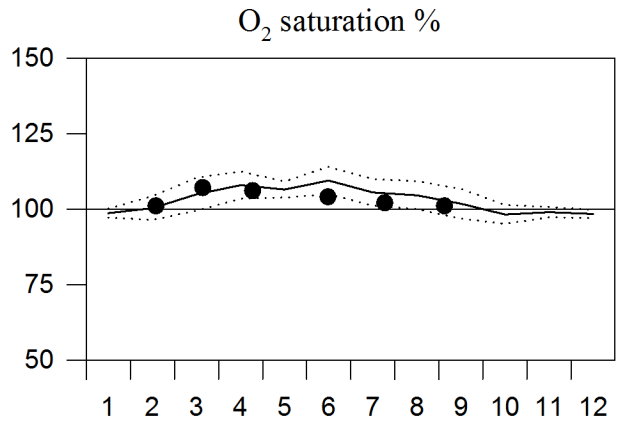
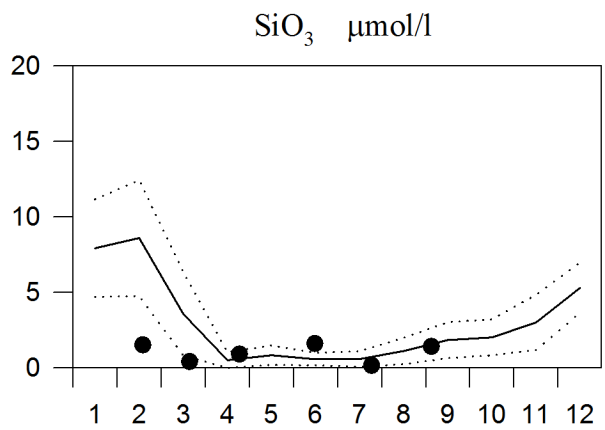
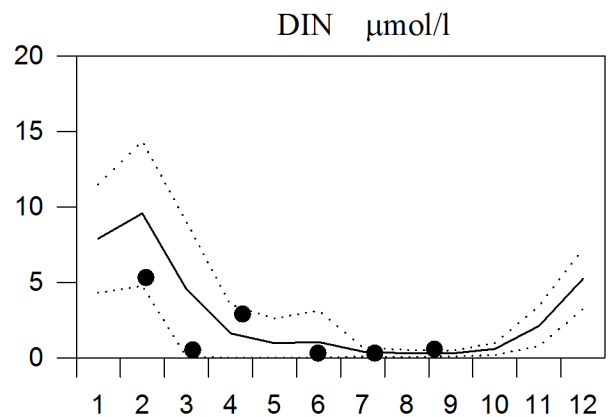
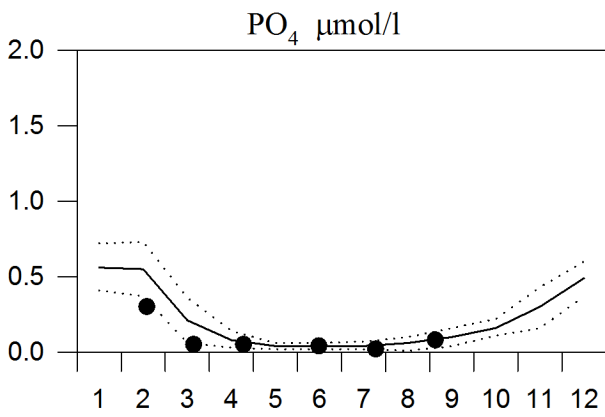
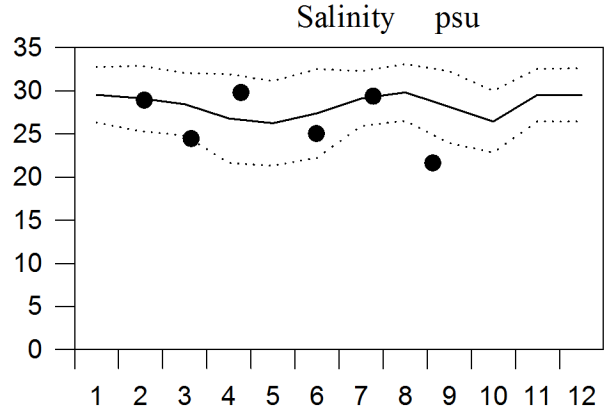
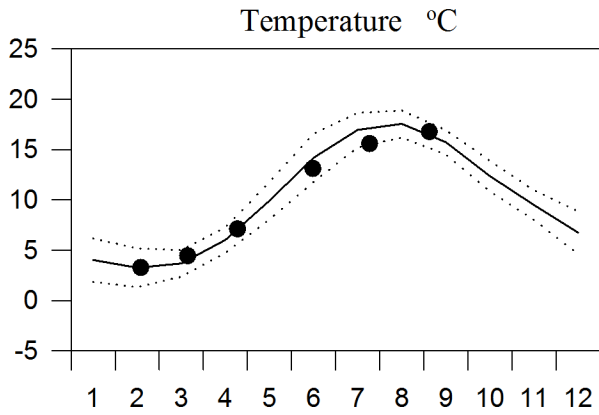
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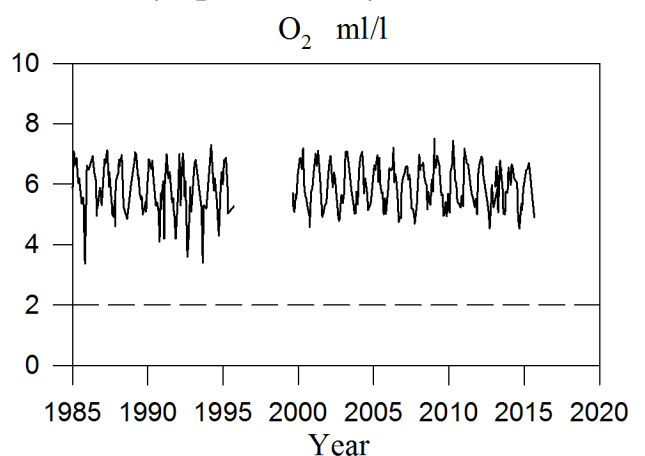
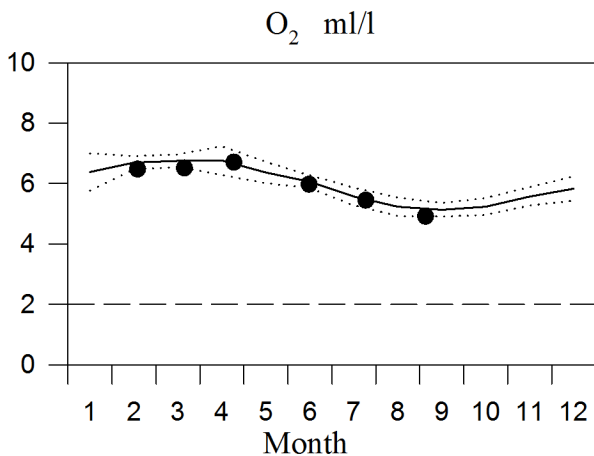
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Annual Cycles

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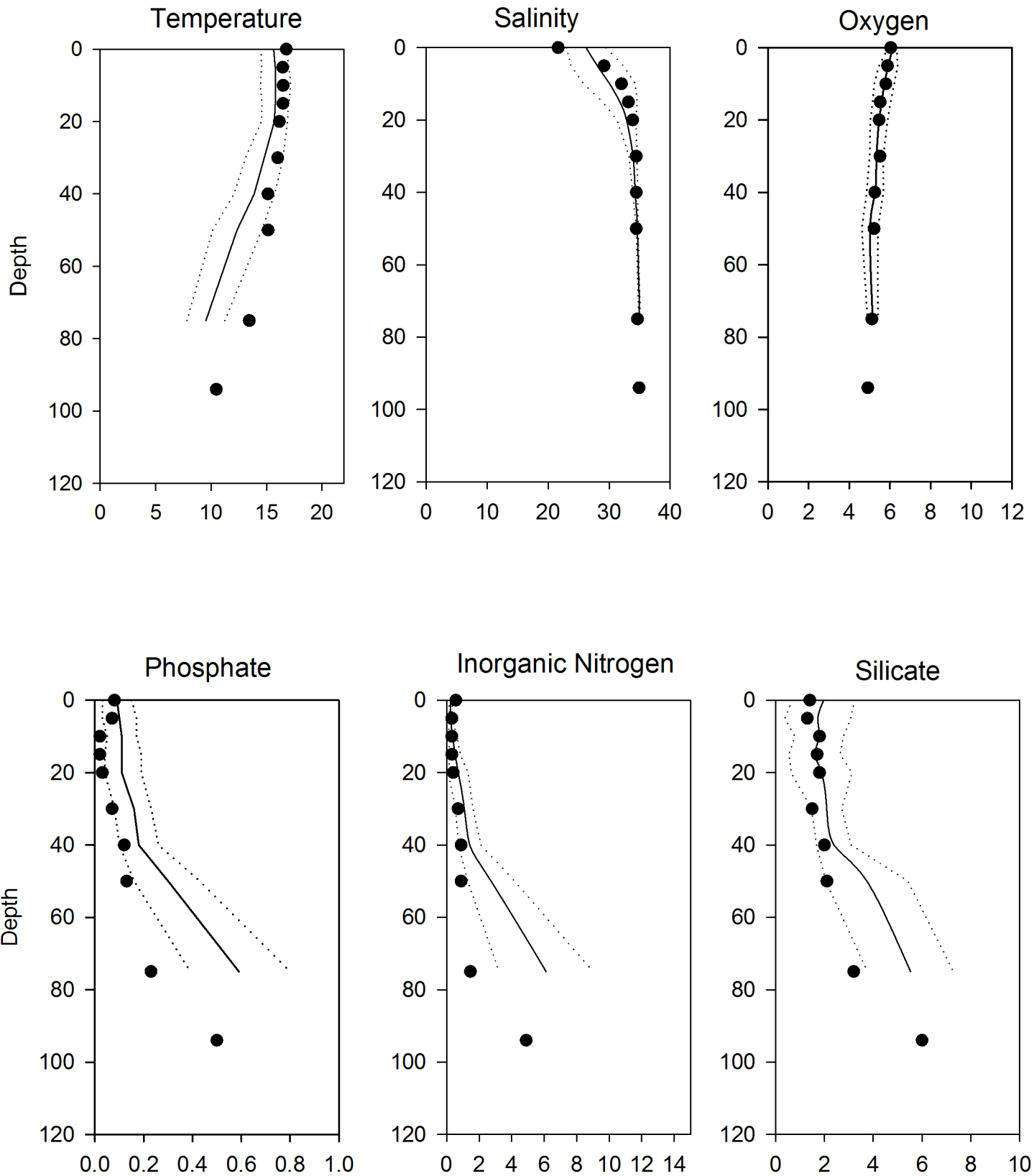


OXYGEN IN BOTTOM WATER (depth >=75m)



Vertical profiles Å13 September

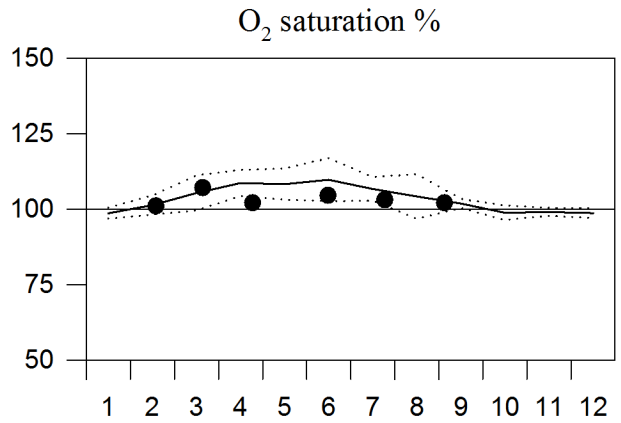
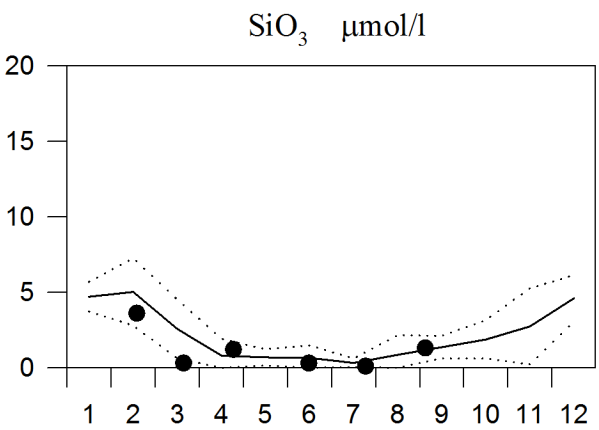
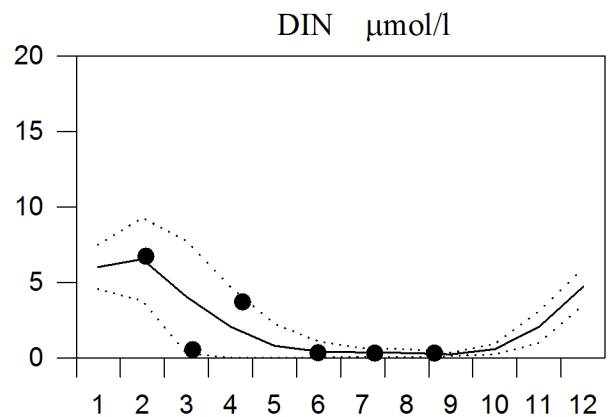
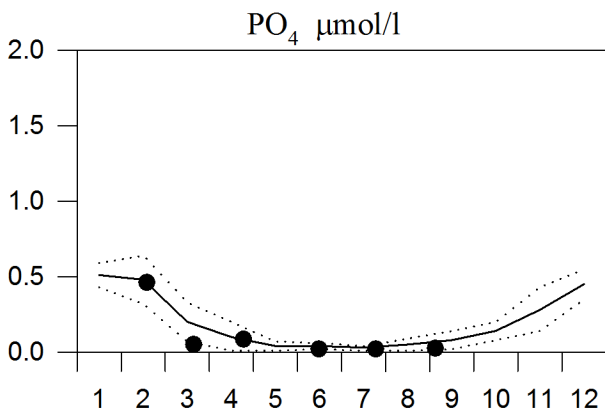
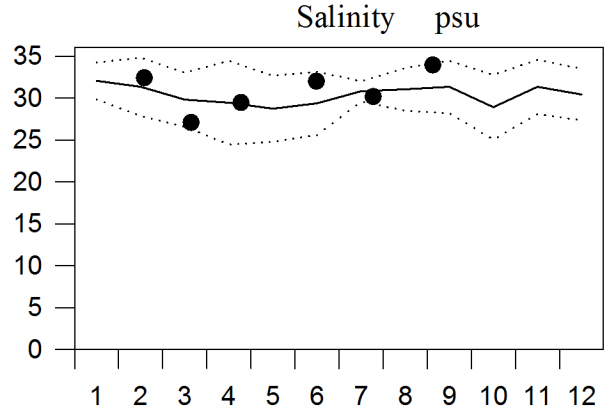
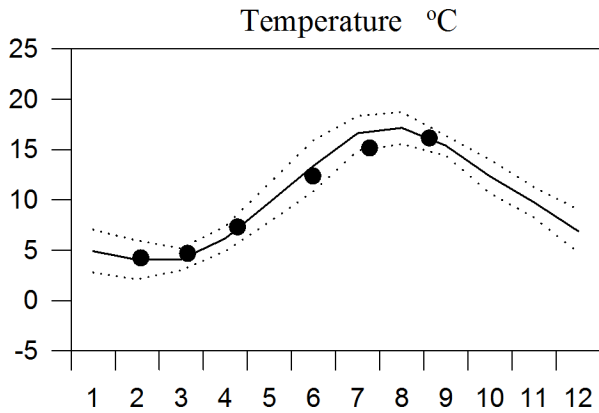
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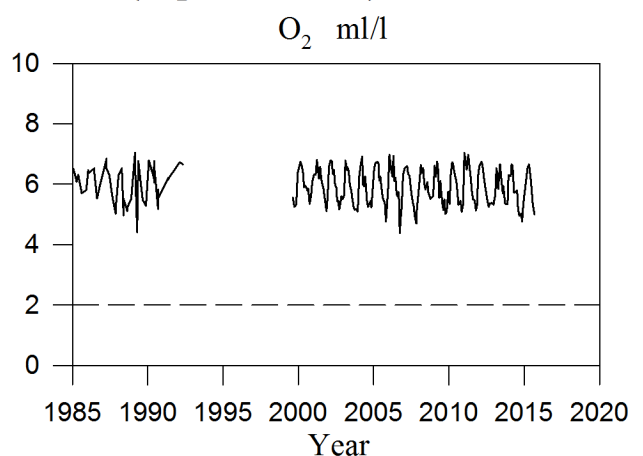
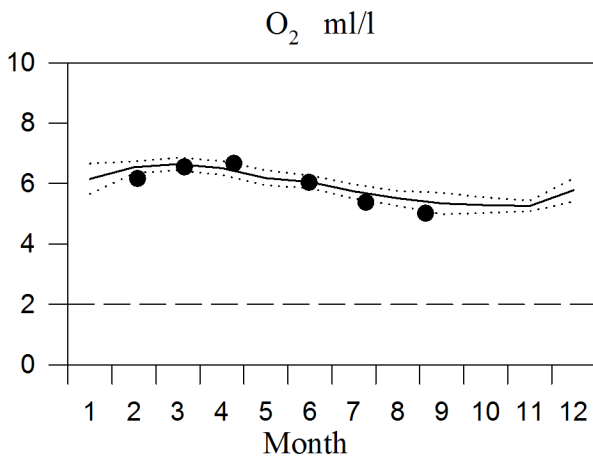
STATION Å15 SURFACE WATER

Annual Cycles

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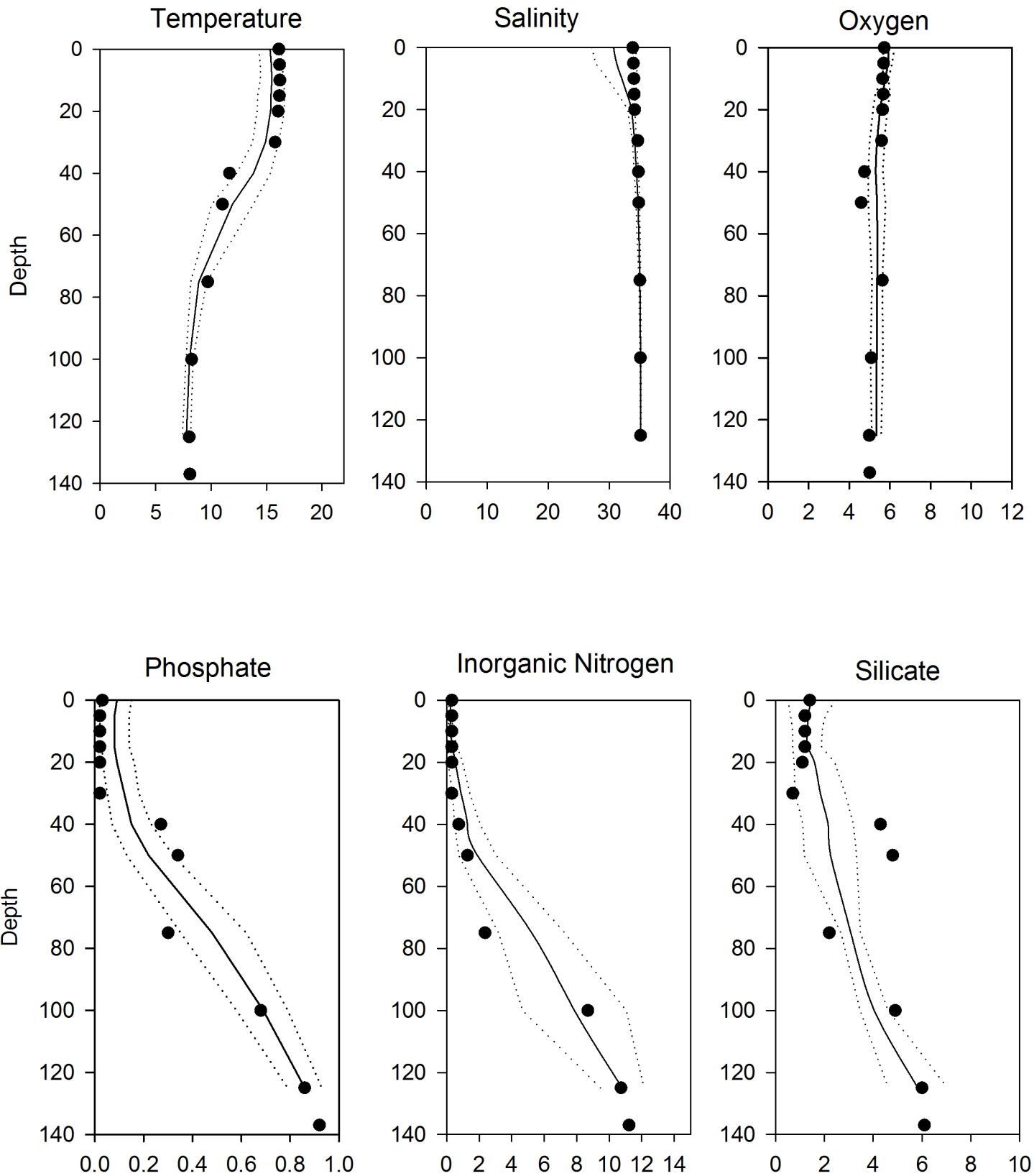


OXYGEN IN BOTTOM WATER (depth >=125m)



Vertical profiles Å15 September

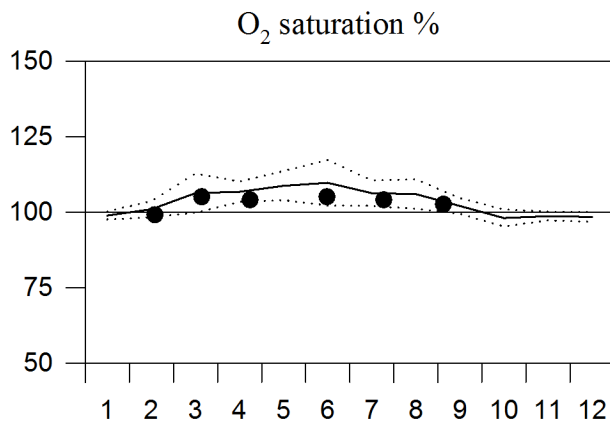
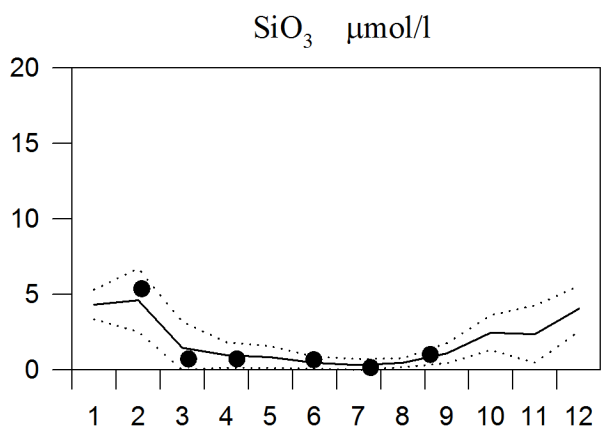
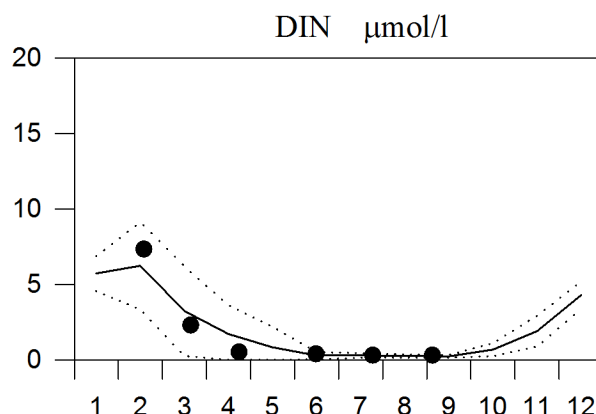
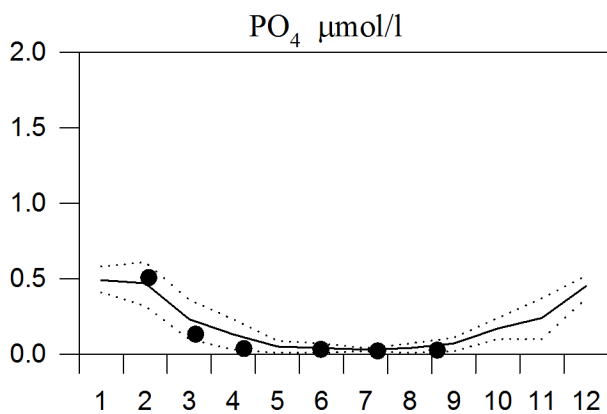
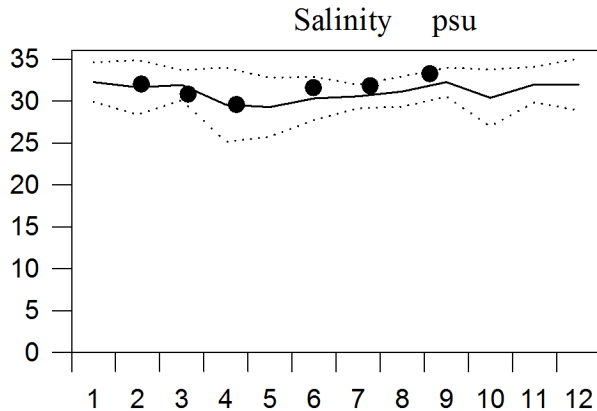
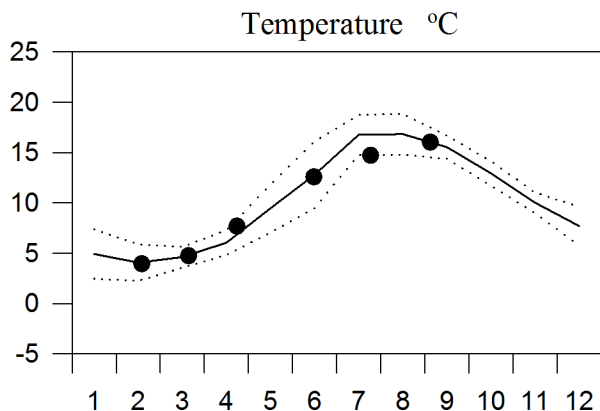
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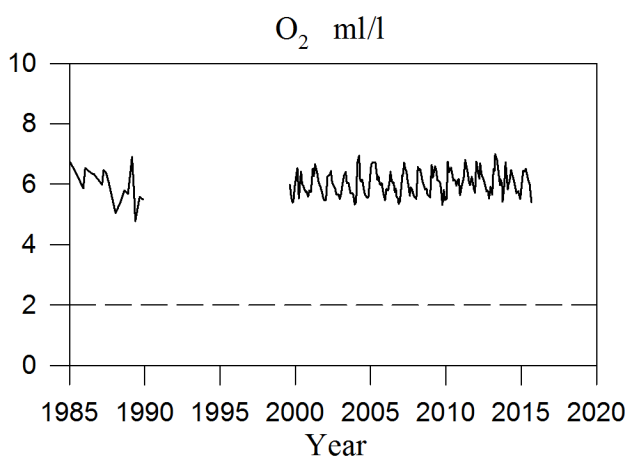
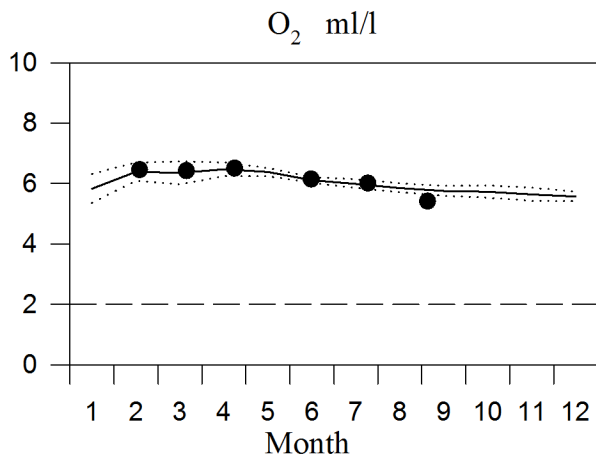
STATION Å17 SURFACE WATER

Annual Cycles

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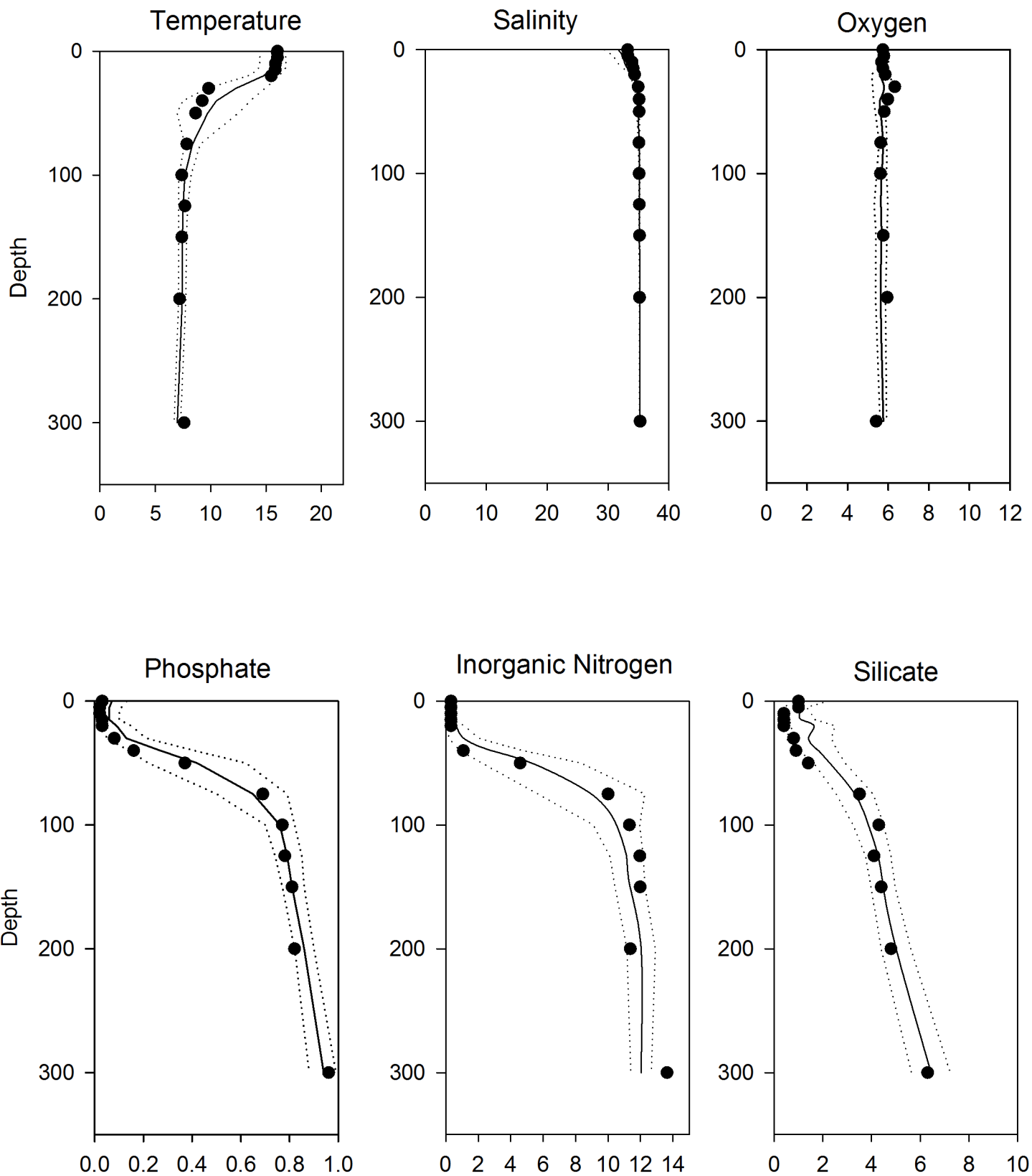


OXYGEN IN BOTTOM WATER (depth = 300m)



Vertical profiles Å17 September

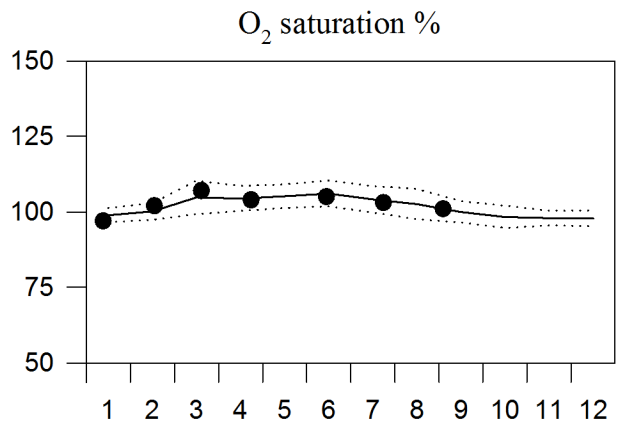
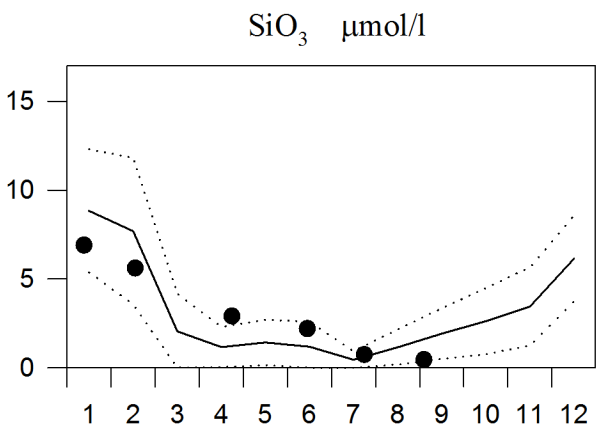
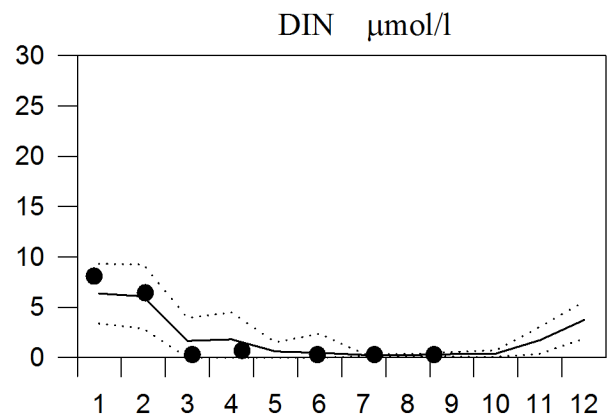
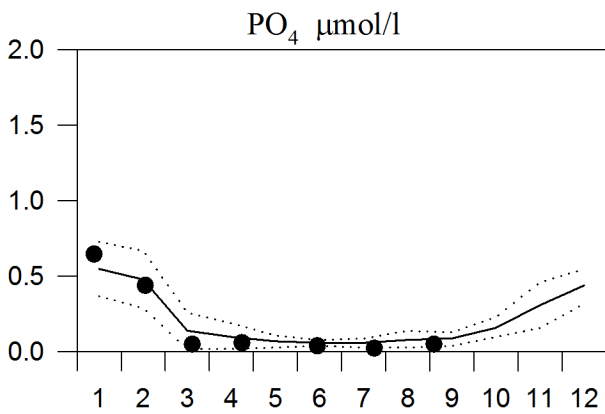
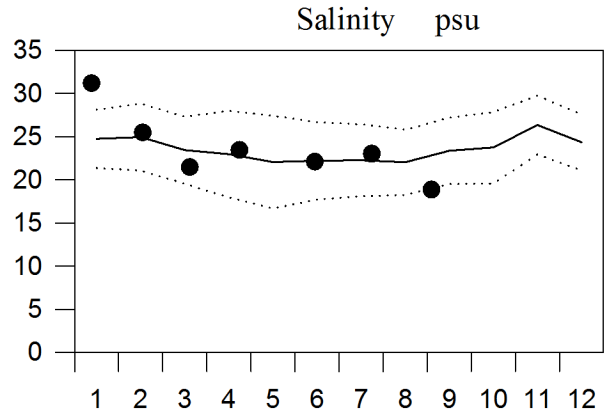
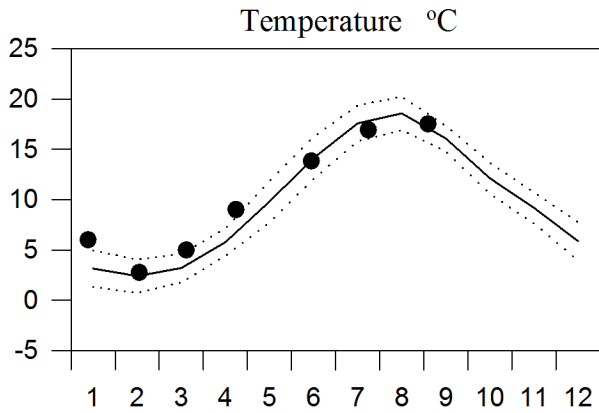
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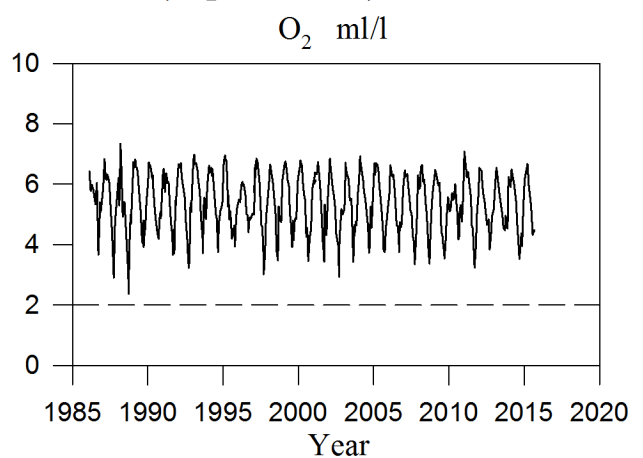
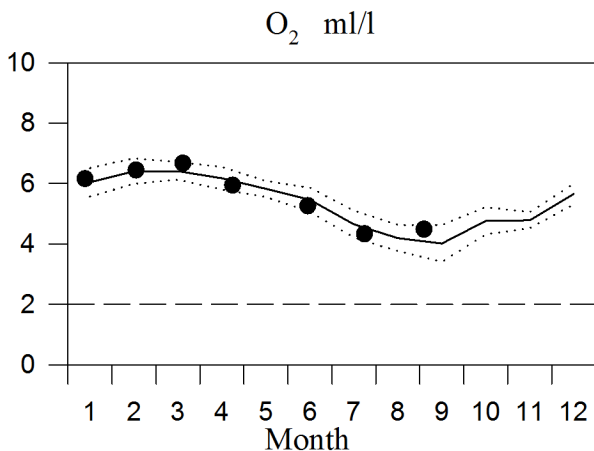
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Annual Cycles

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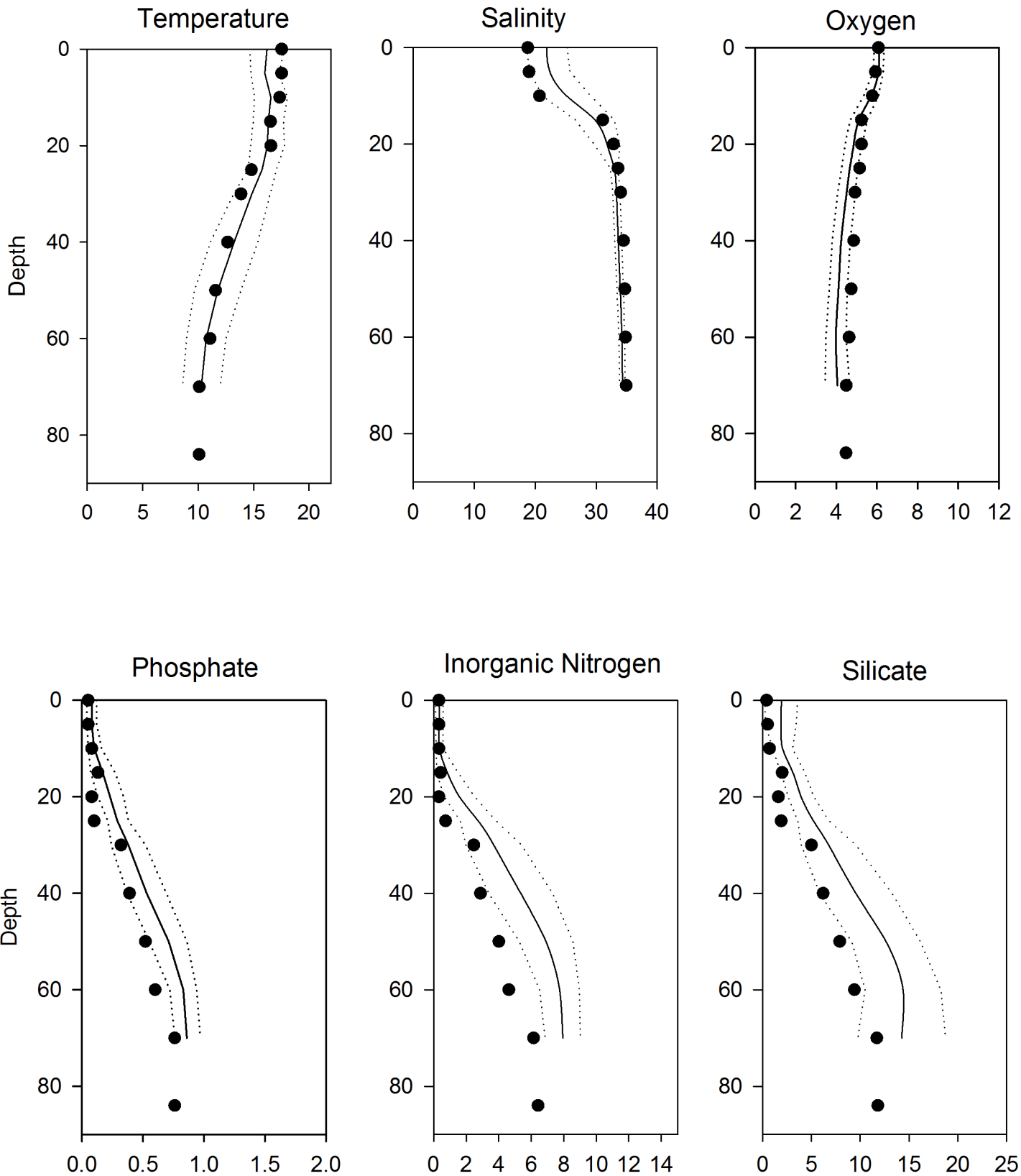


OXYGEN IN BOTTOM WATER (depth > 70m)



Vertical profiles Fladen September

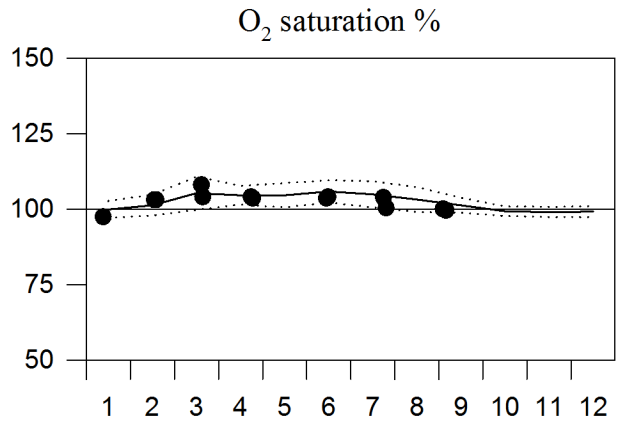
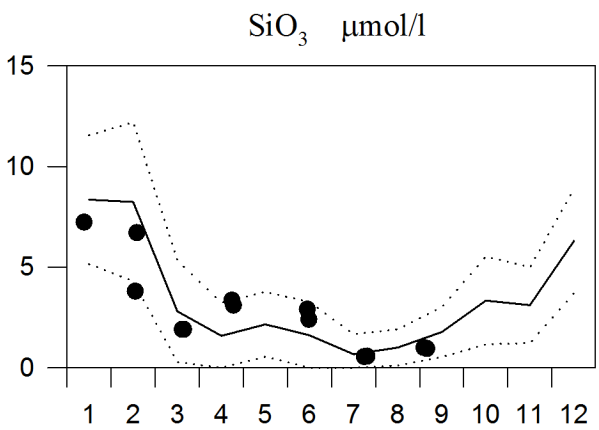
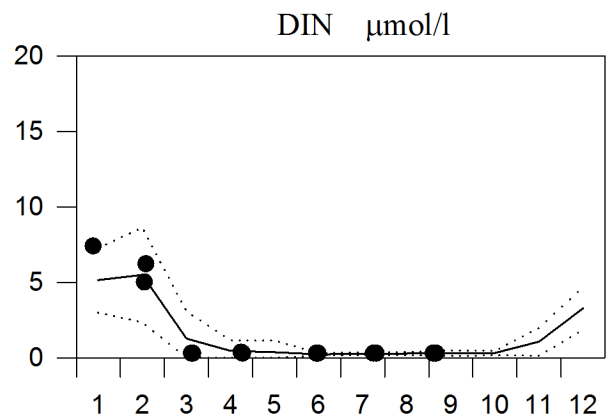
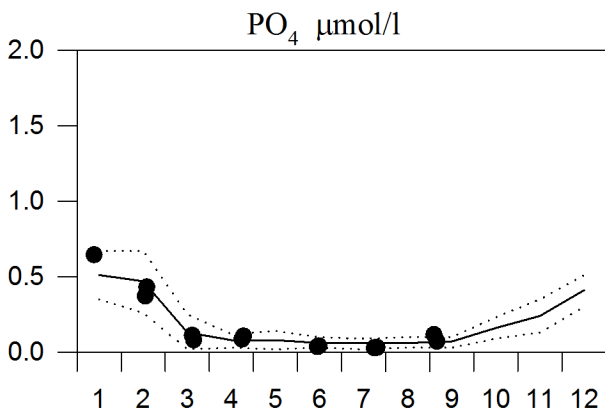
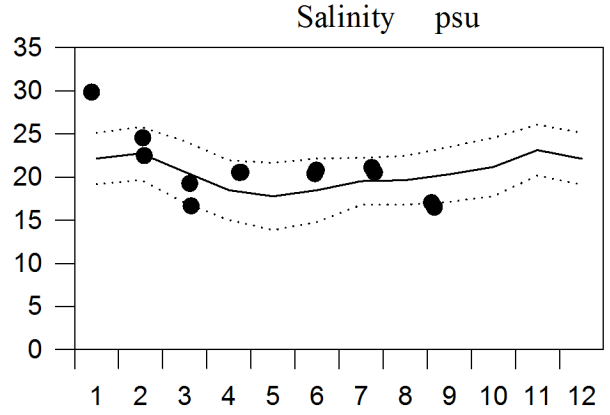
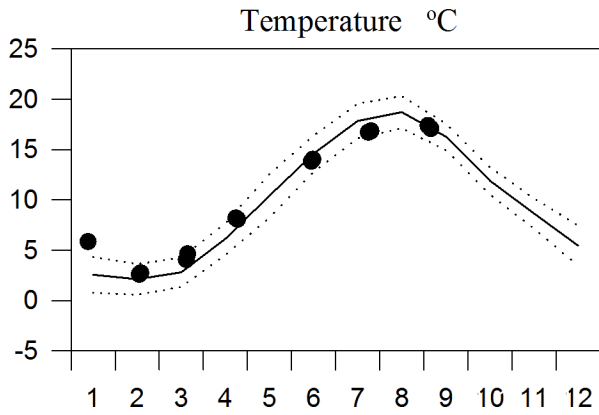
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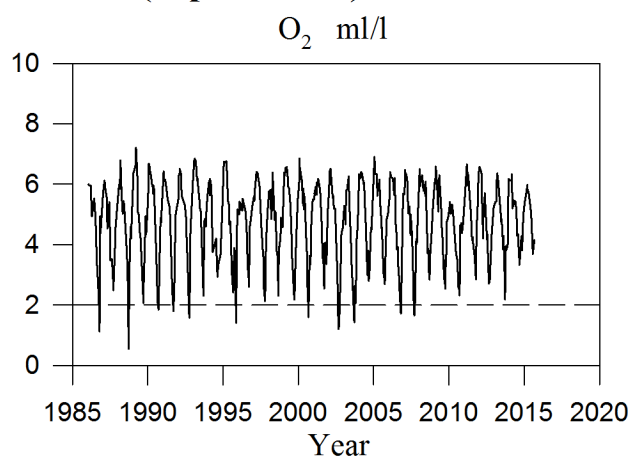
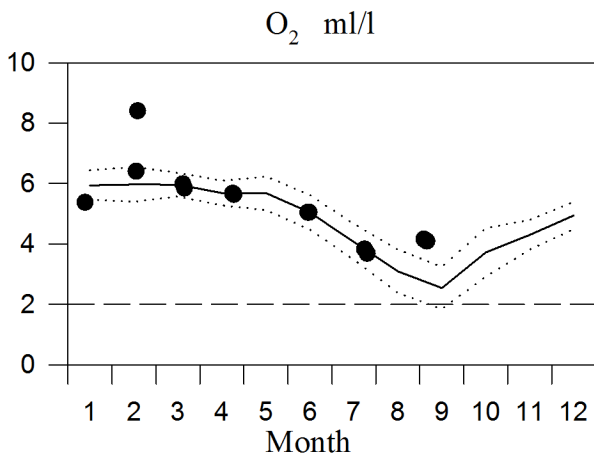
STATION ANHOLT E SURFACE WATER

Annual Cycles

— Mean 1996-2010 ····· St.Dev. ● 2015

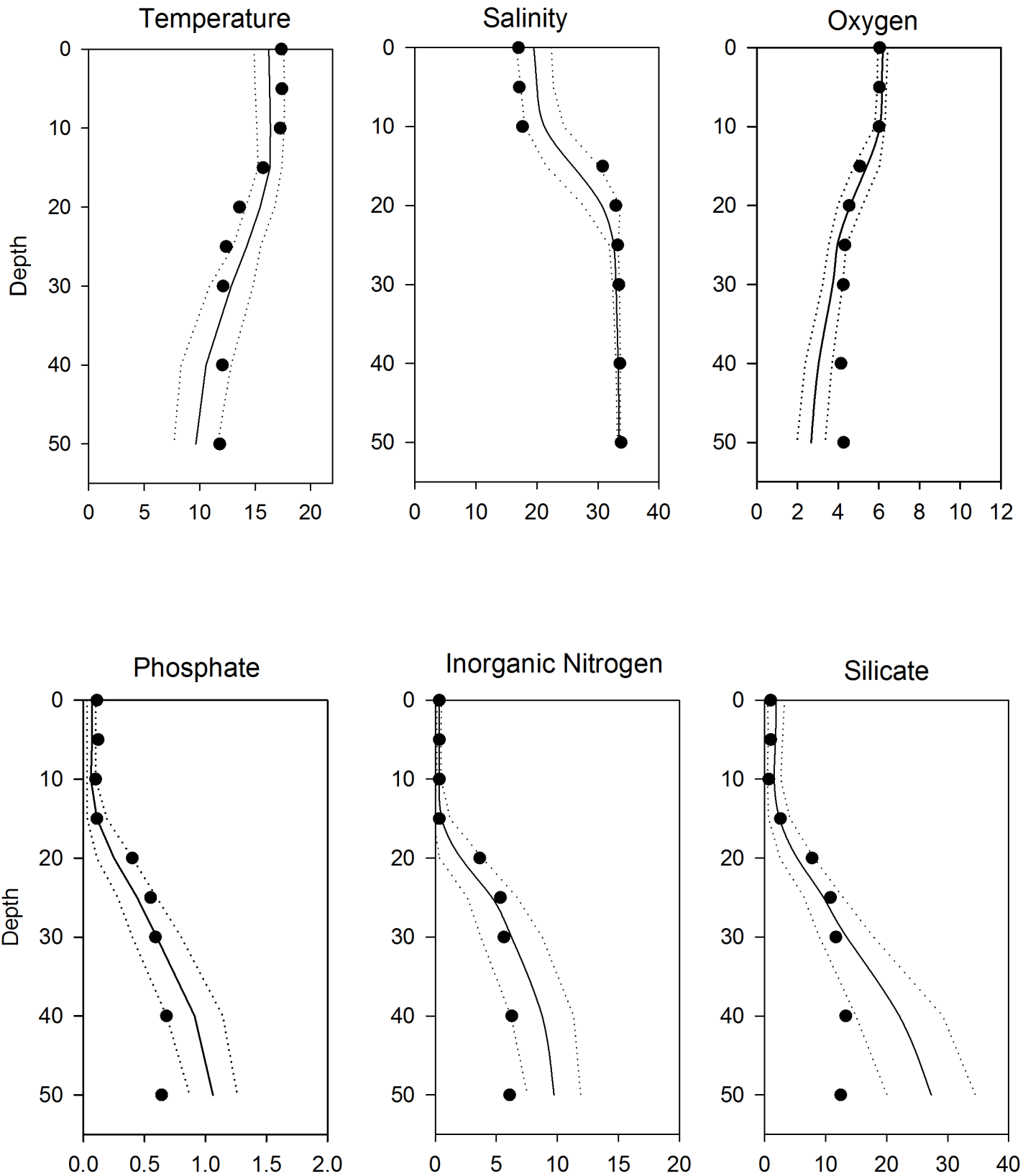


OXYGEN IN BOTTOM WATER (depth > 50m)



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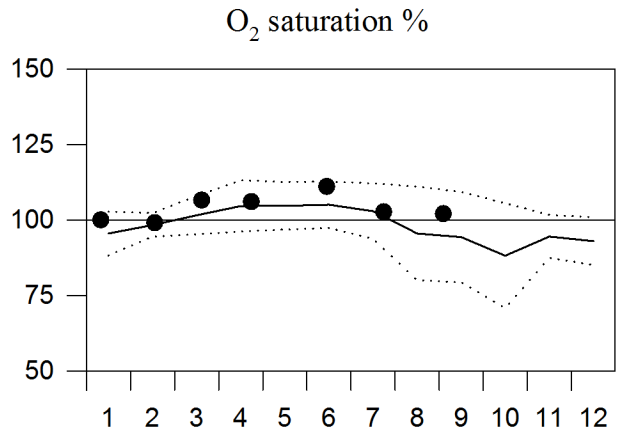
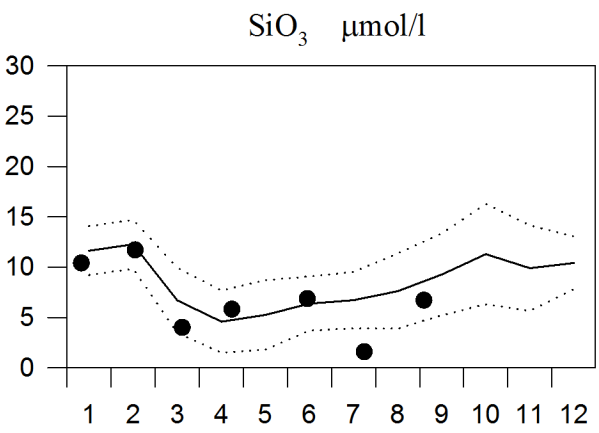
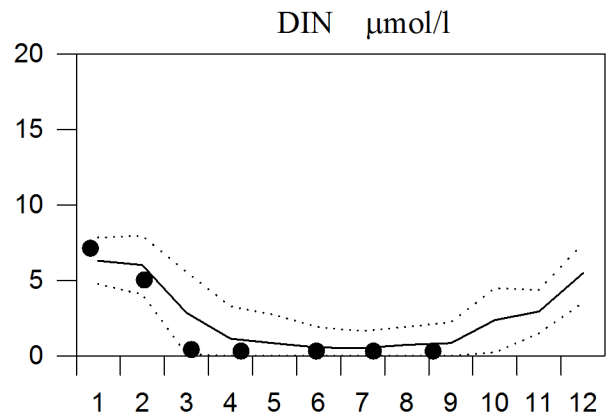
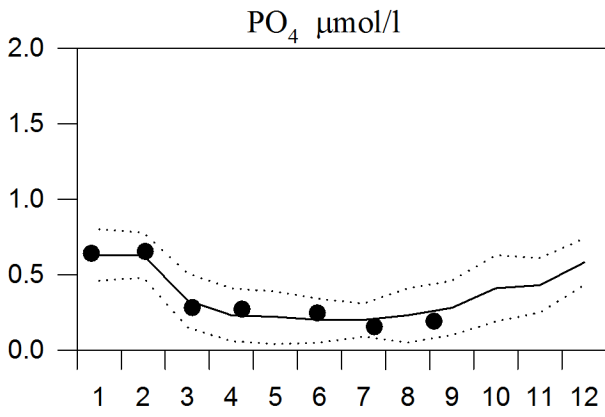
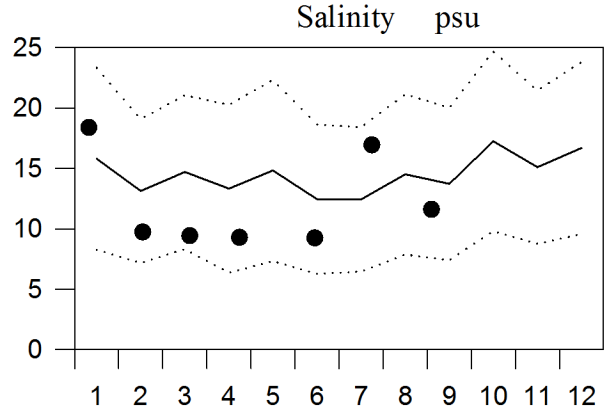
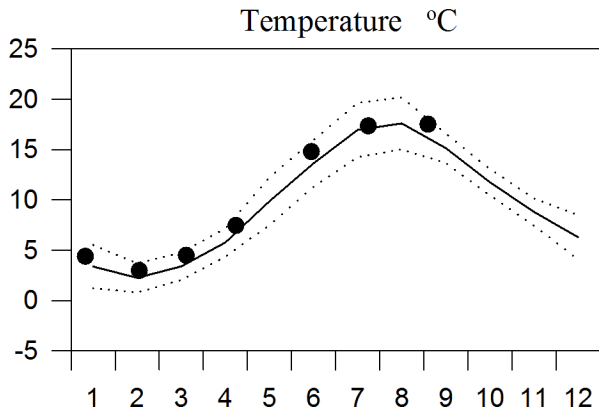
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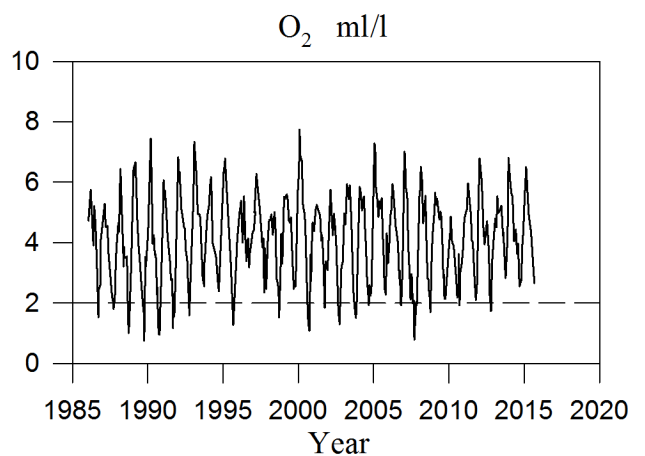
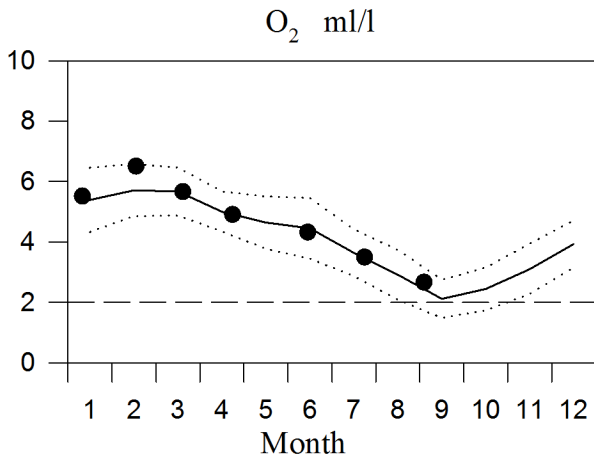
STATION W LANDSKRONA SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

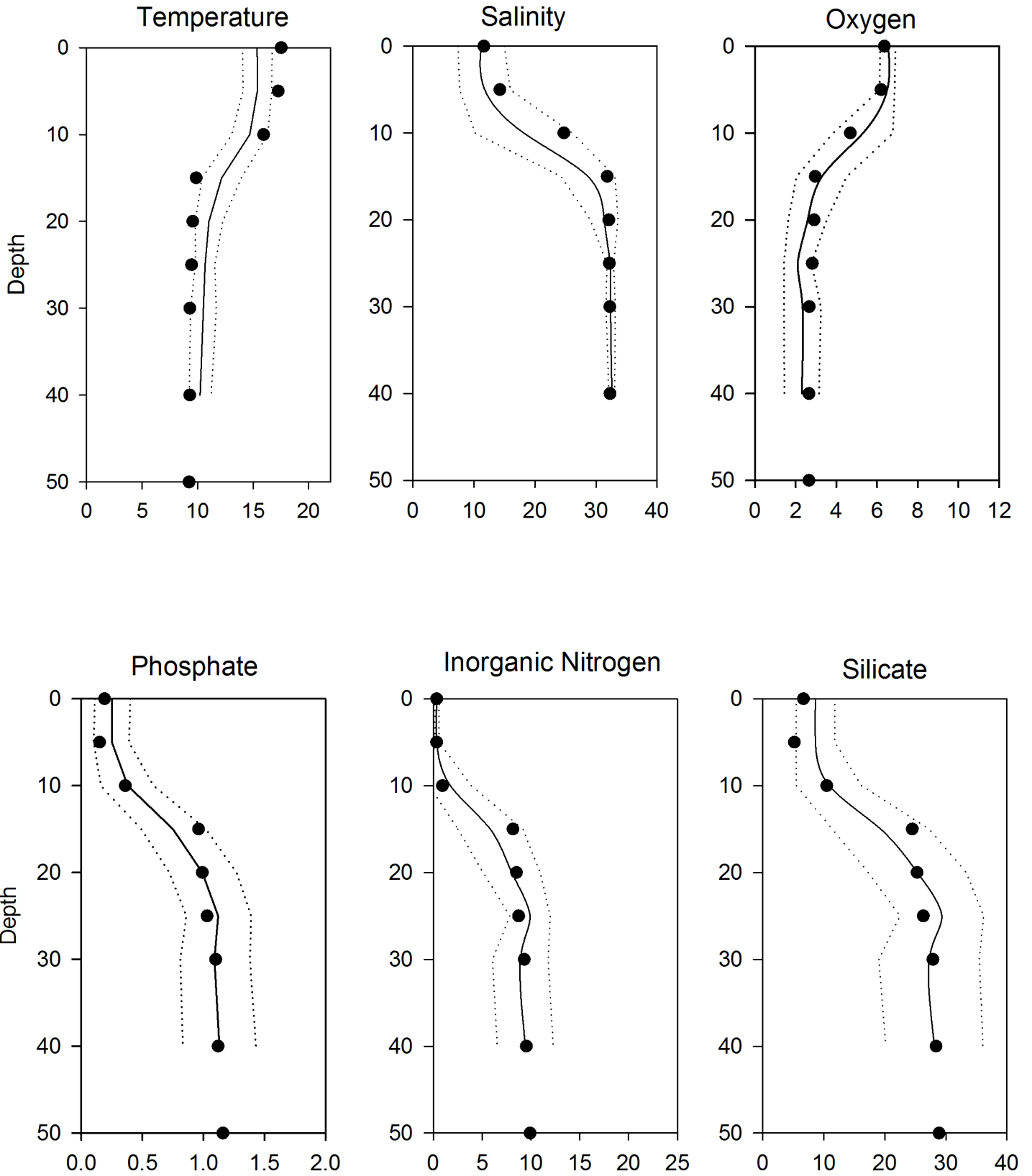


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles W Landskrona September

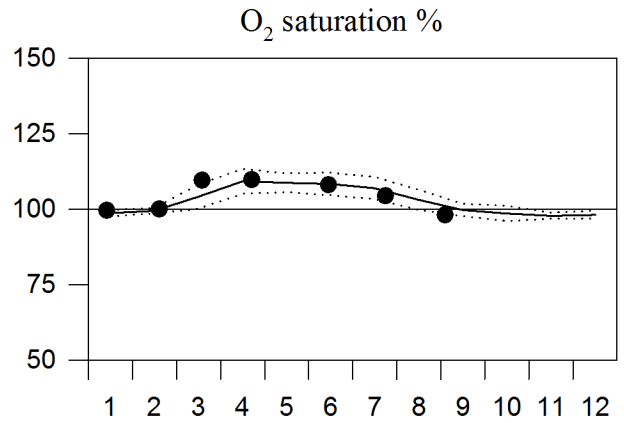
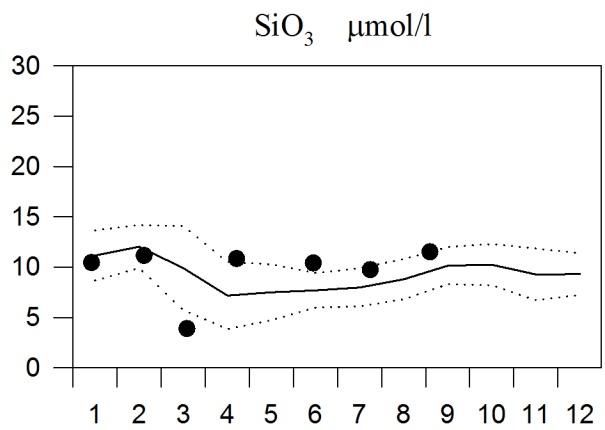
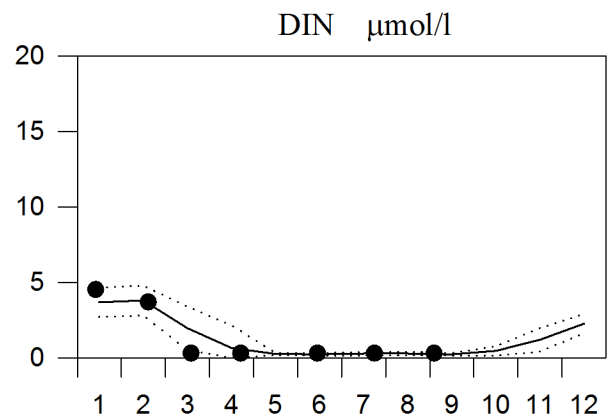
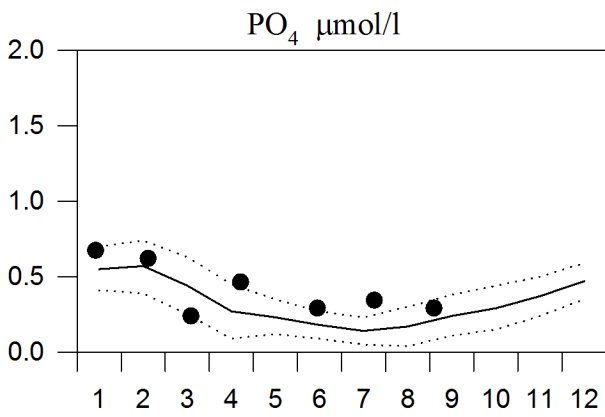
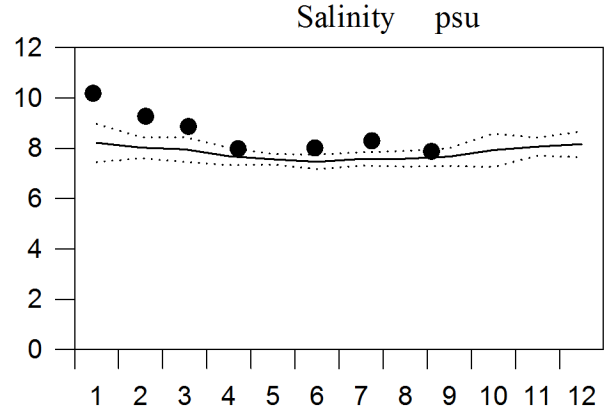
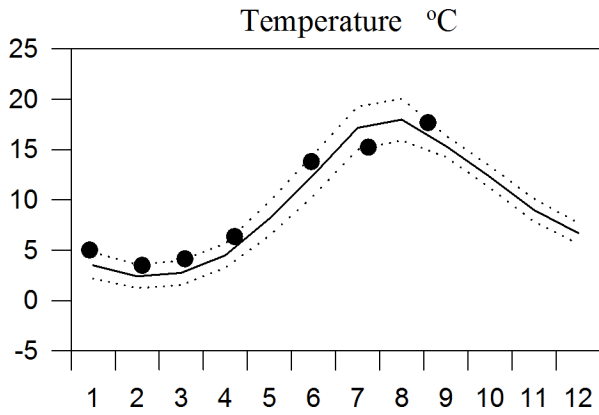
— Mean 1996-2010 St.Dev. ● 2015



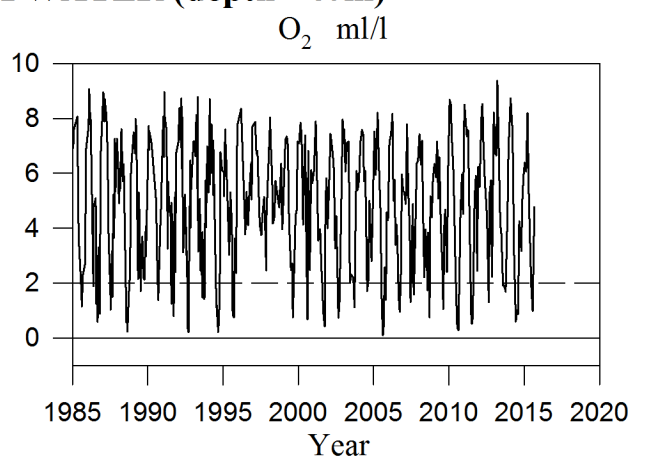
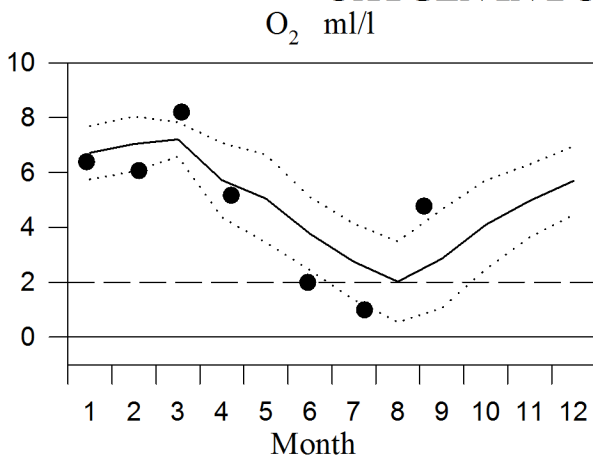
STATION BY1 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

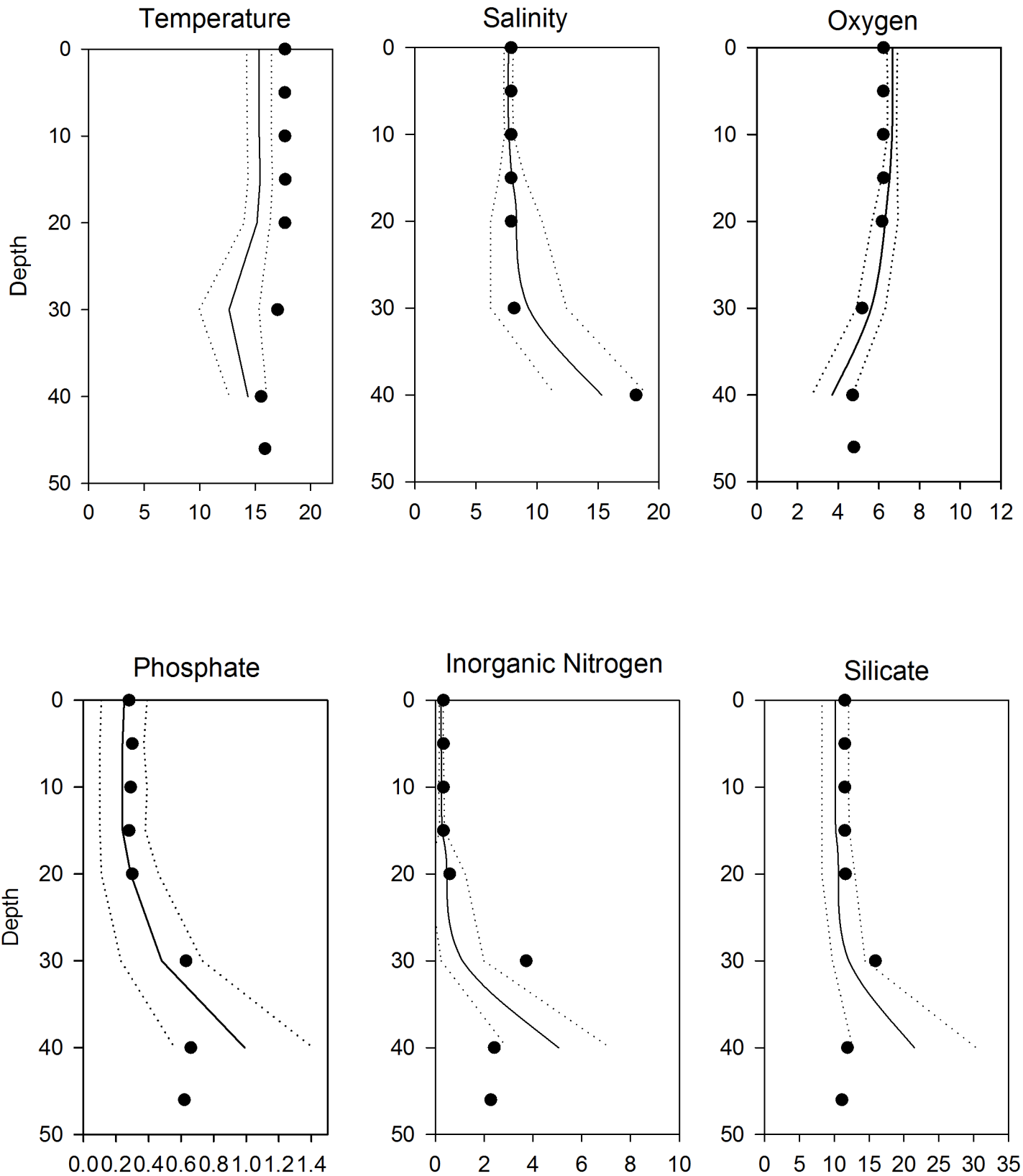


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles BY1 September

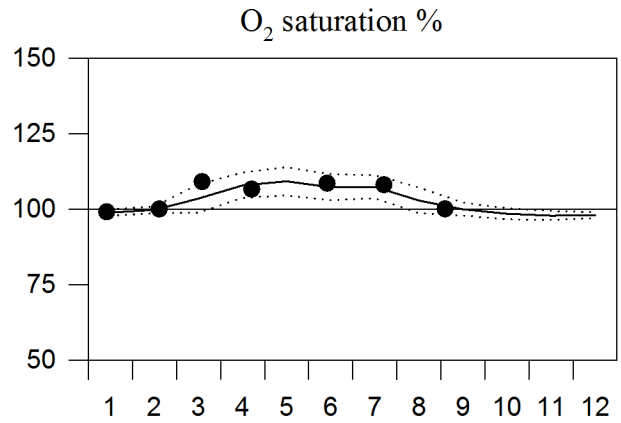
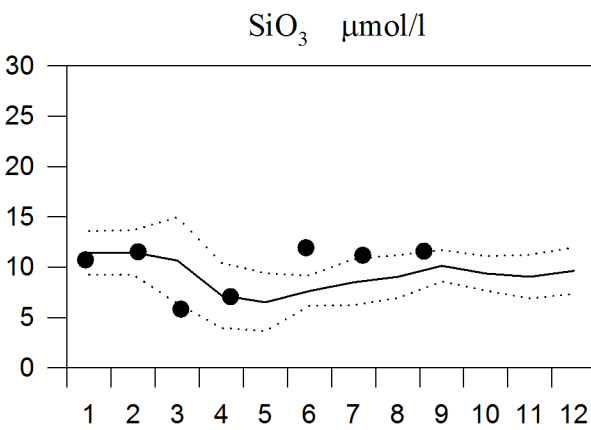
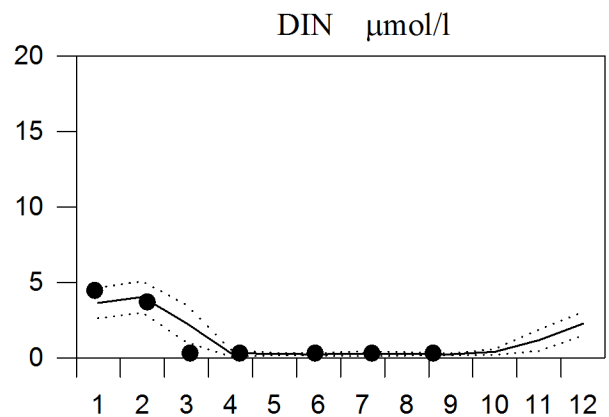
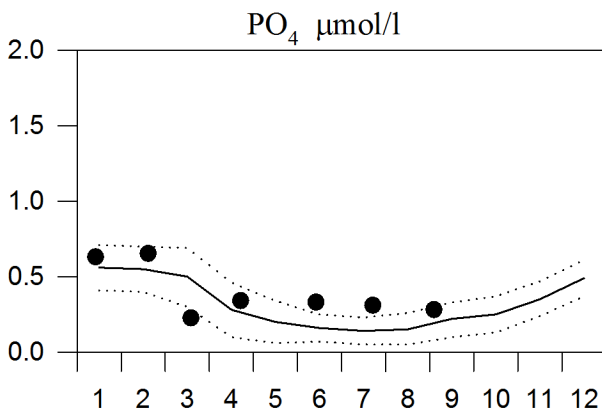
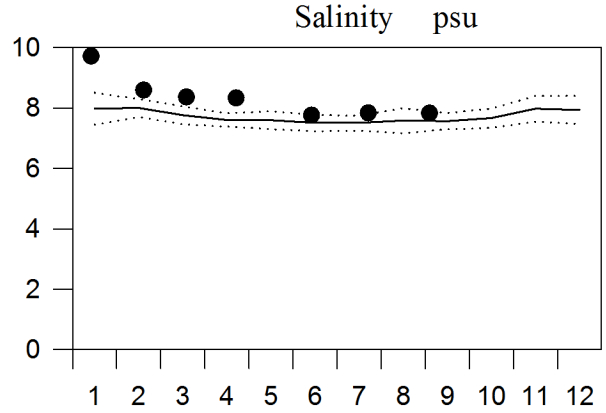
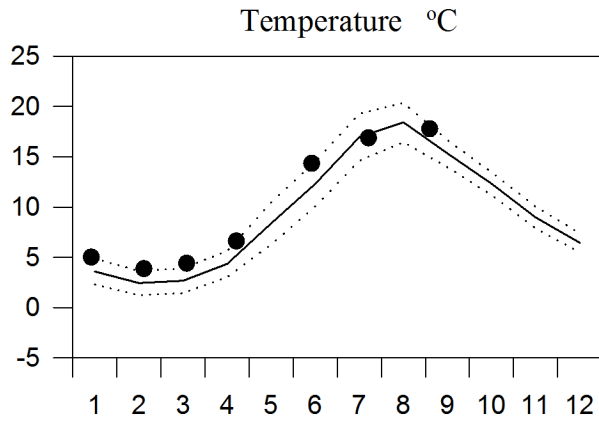
— Mean 1996-2010 ····· St.Dev. ● 2015



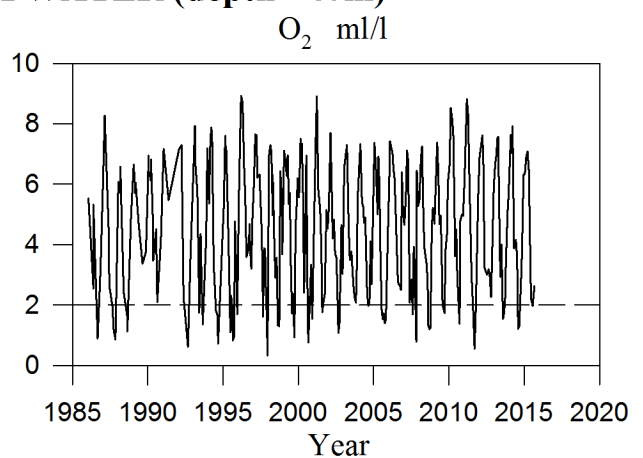
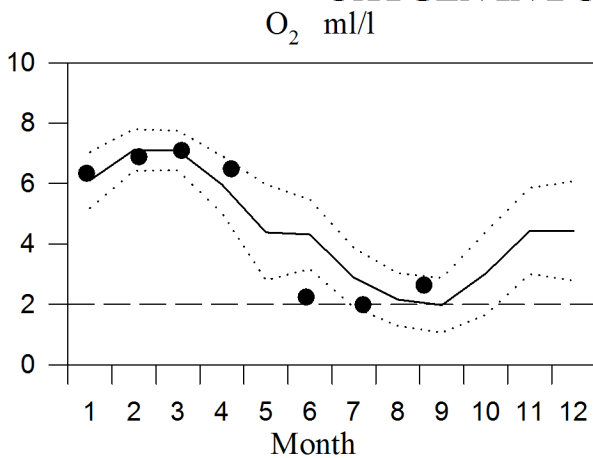
STATION BY2 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

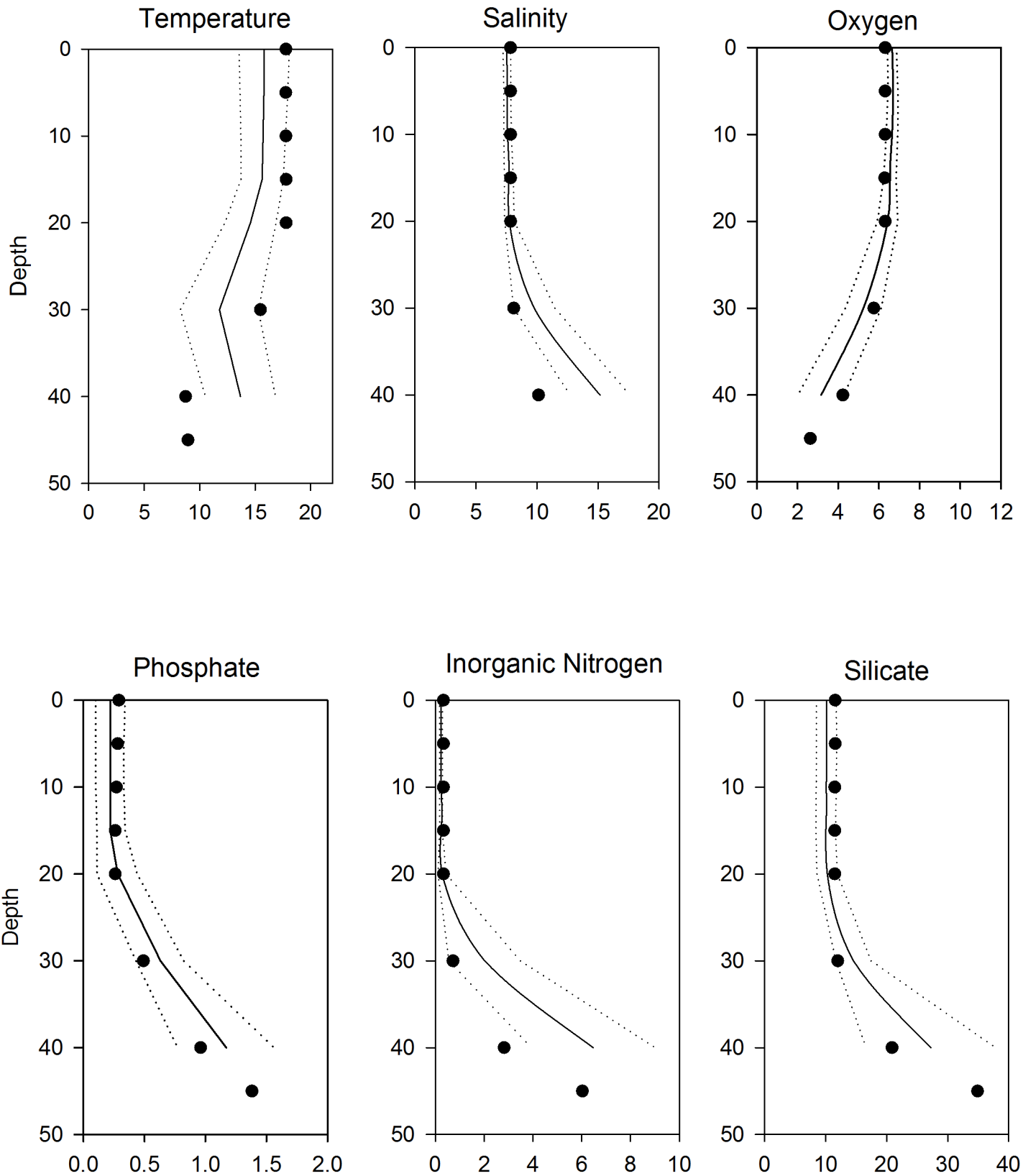


OXYGEN IN BOTTOM WATER (depth >40m)



Vertical profiles BY2 September

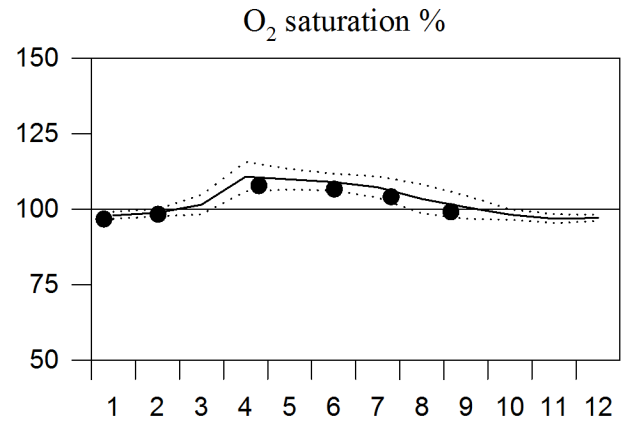
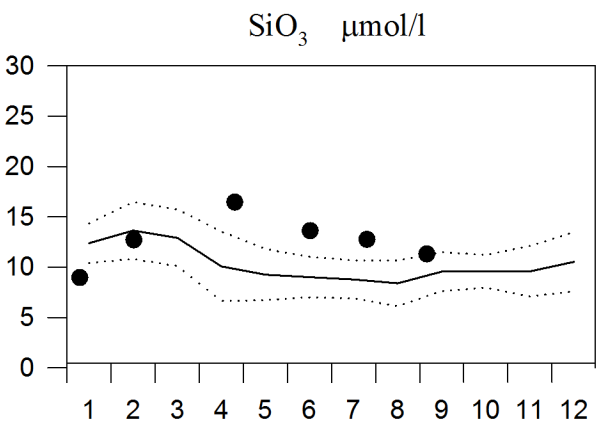
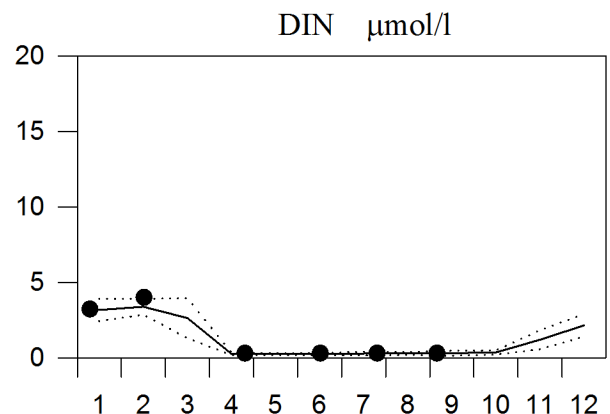
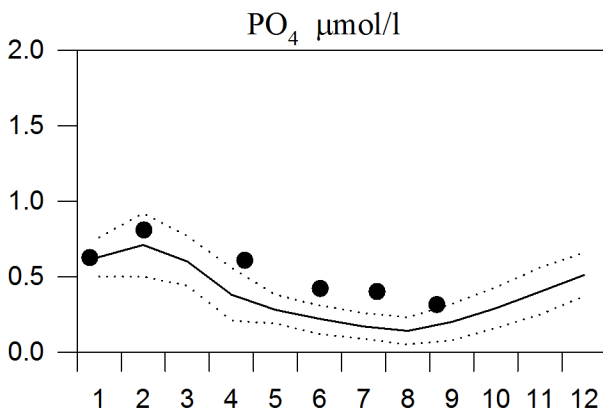
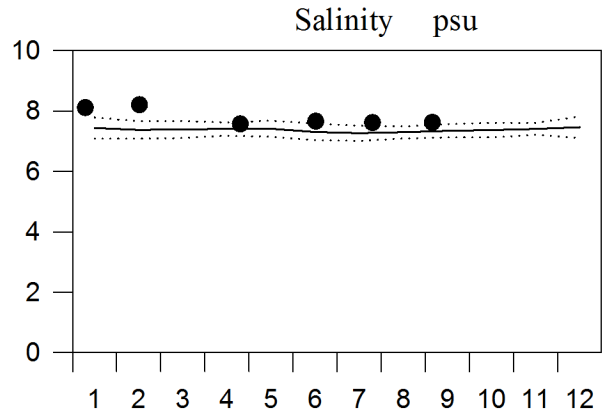
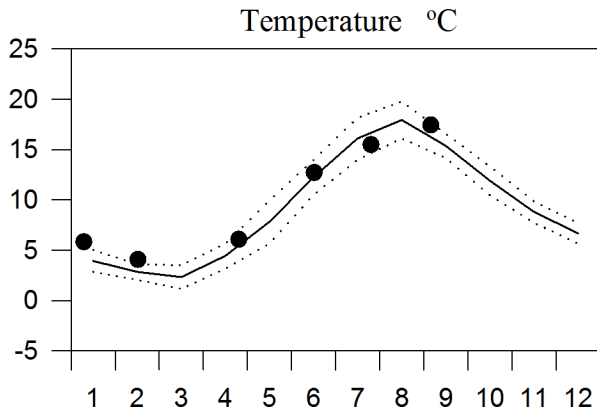
— Mean 1996-2010 ····· St.Dev. ● 2015



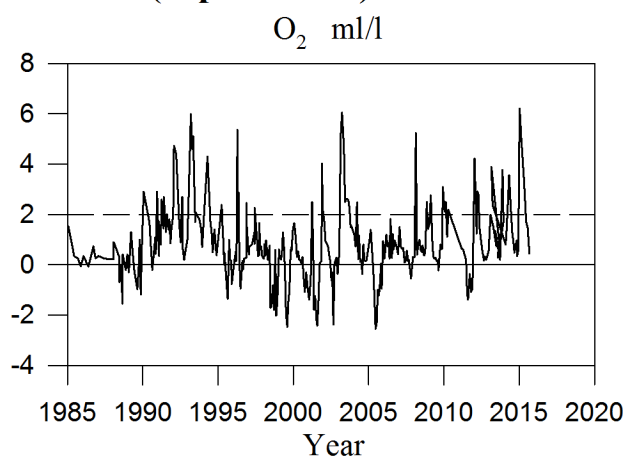
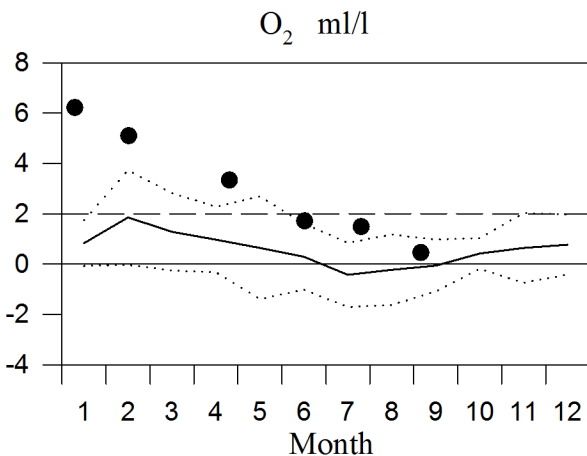
STATION HANÖBUKTEN SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

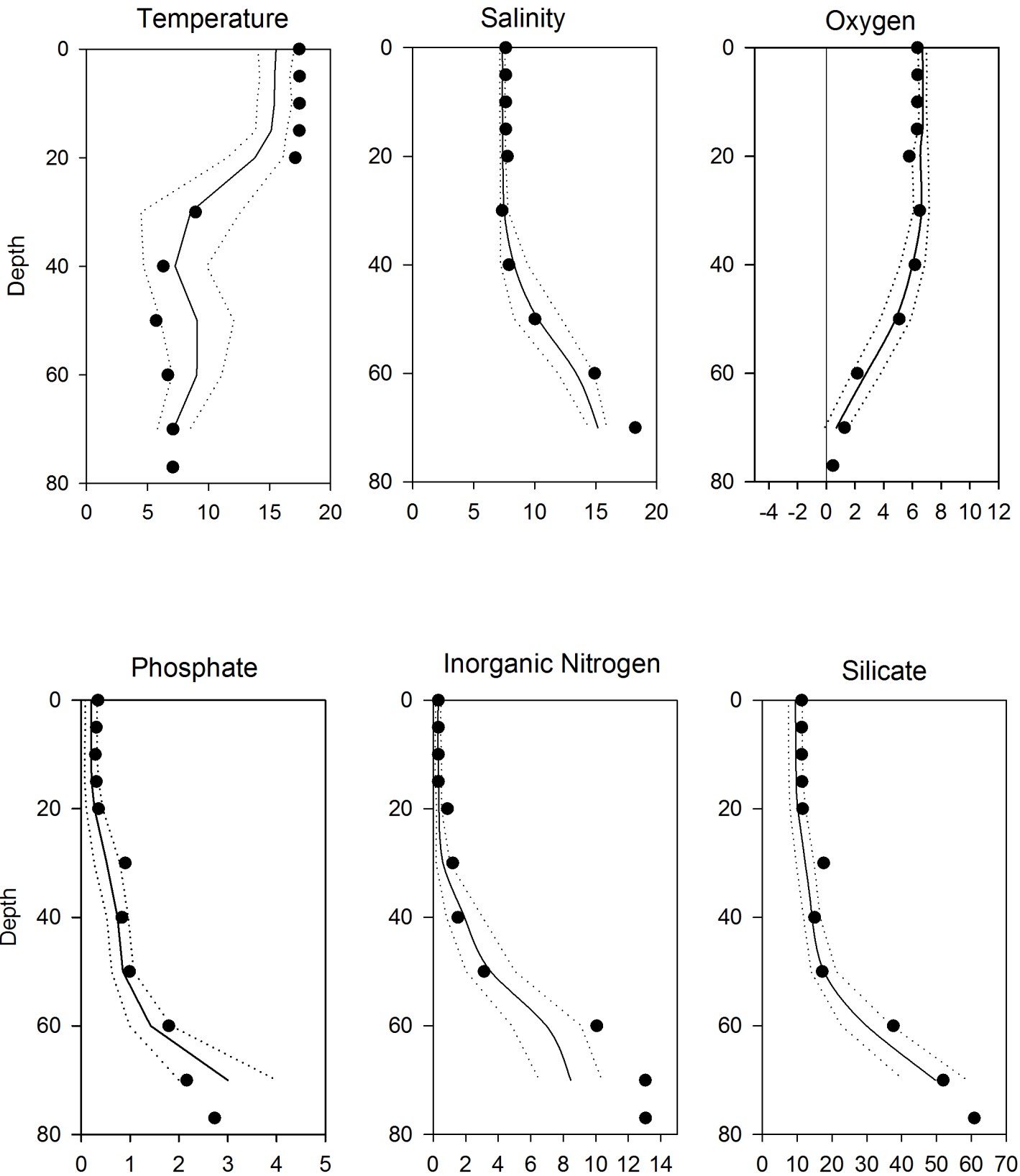


OXYGEN IN BOTTOM WATER (depth > 70m)



Vertical profiles Hanöbukten September

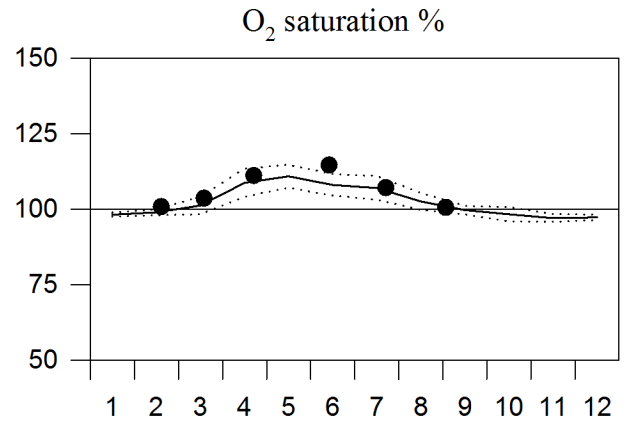
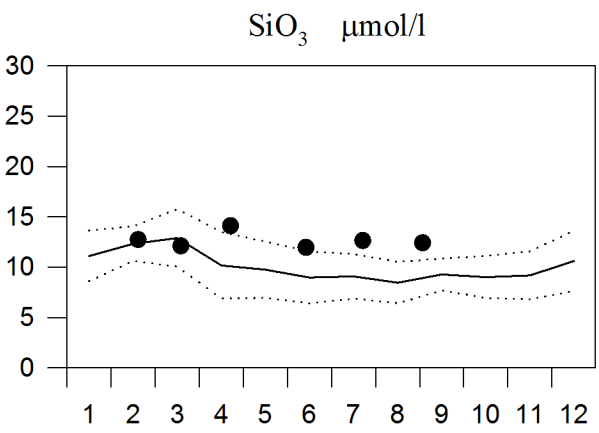
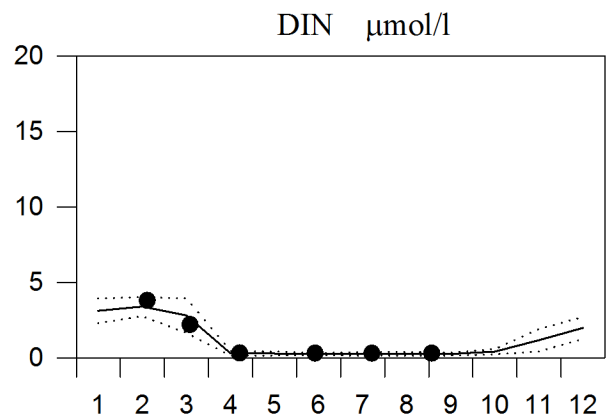
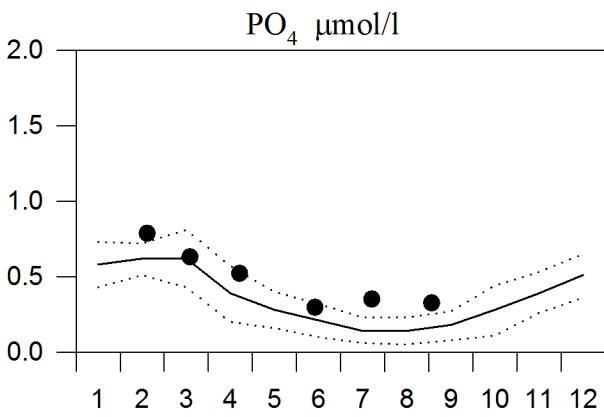
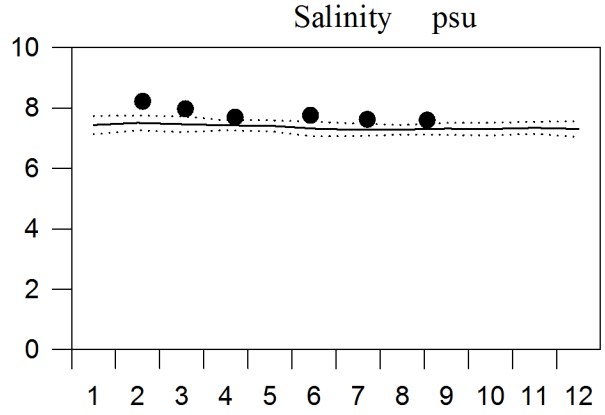
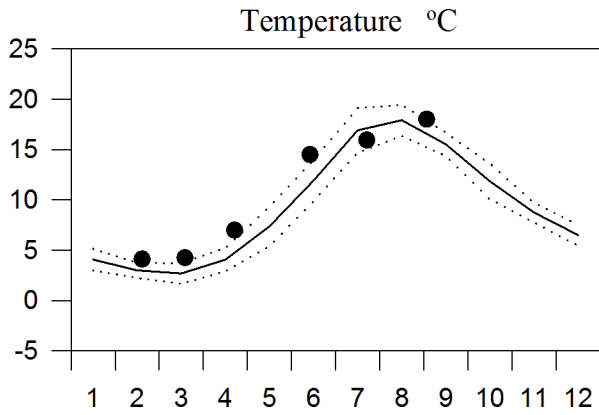
— Mean 1996-2010 ····· St.Dev. ● 2015



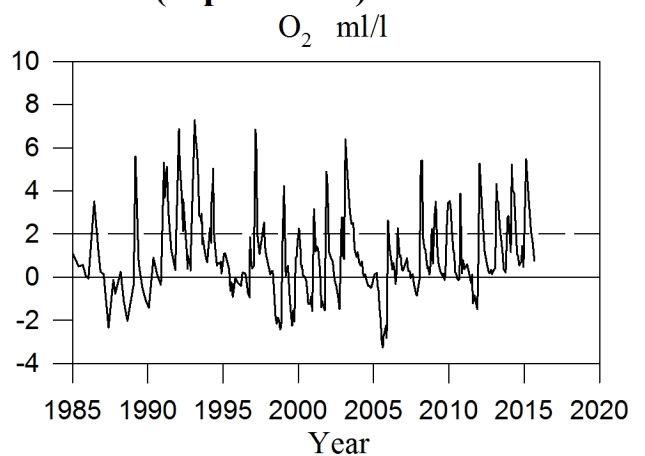
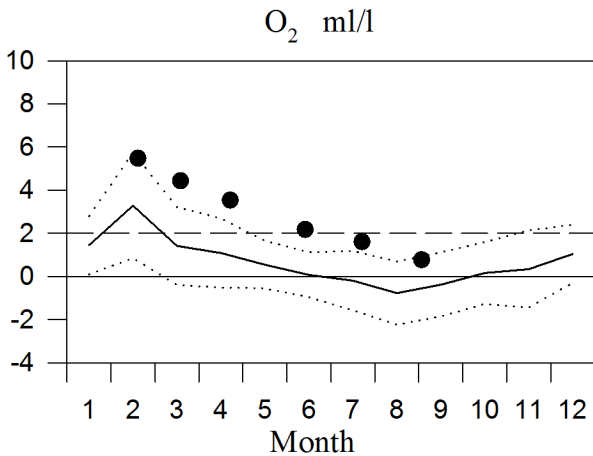
STATION BY4 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

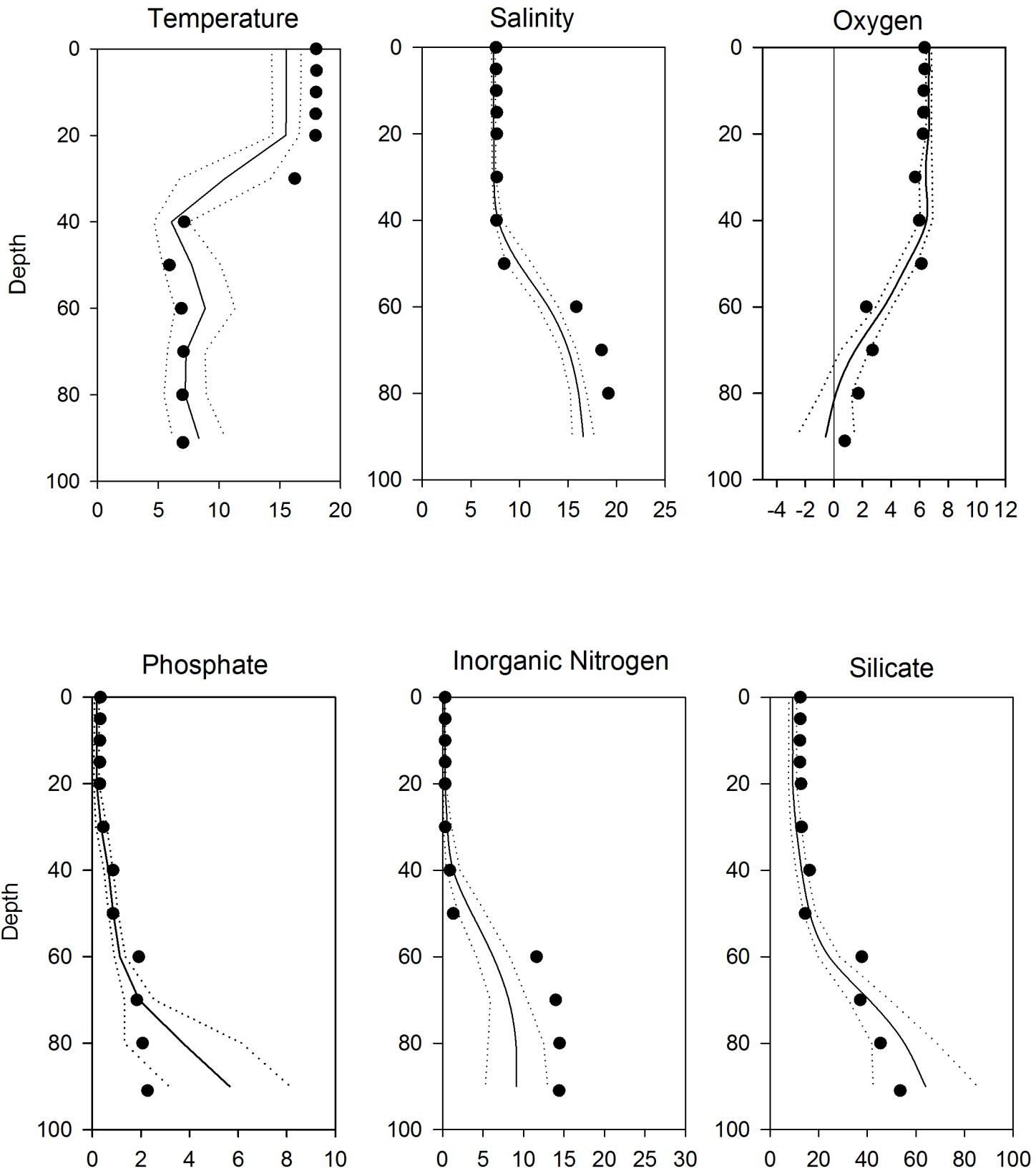


OXYGEN IN BOTTOM WATER (depth >80m)



Vertical profiles BY4 September

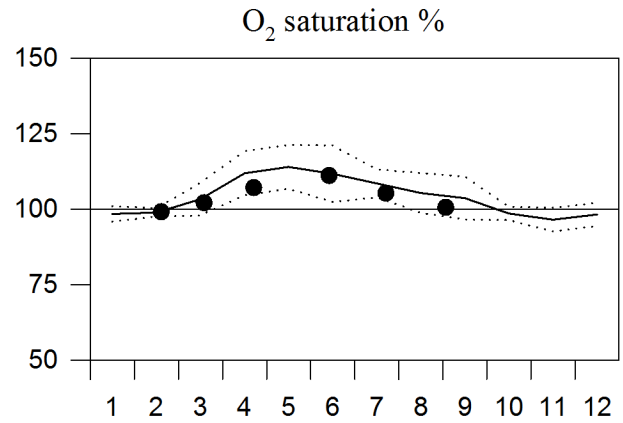
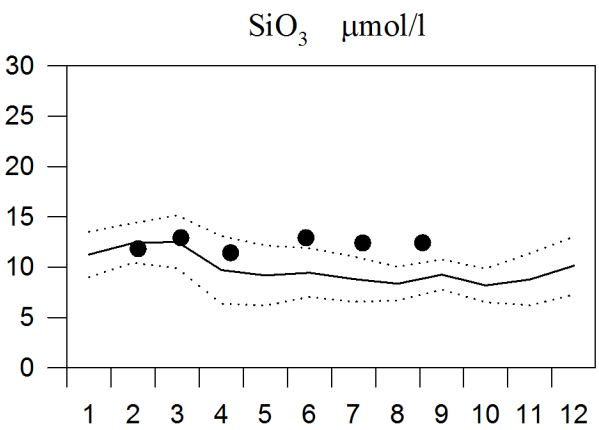
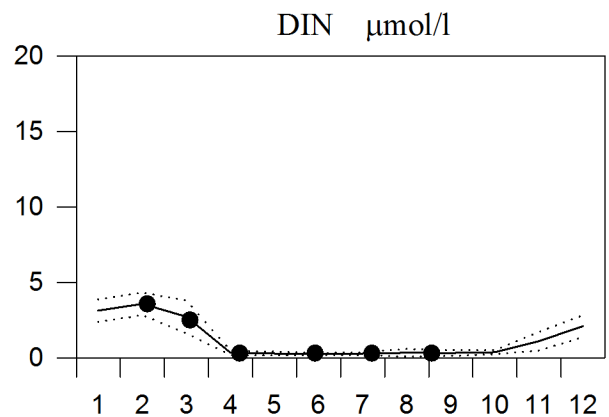
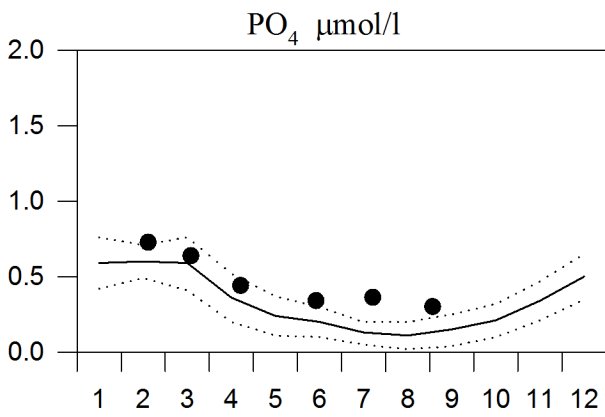
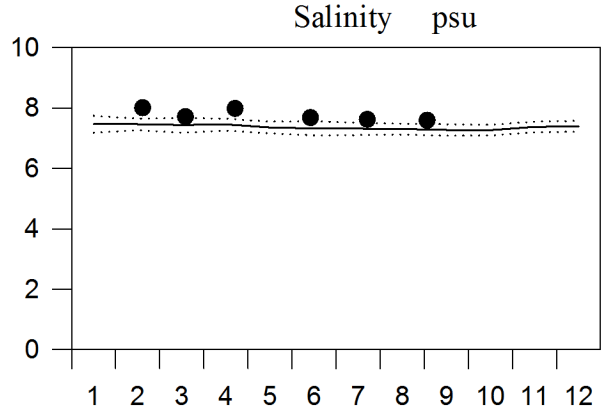
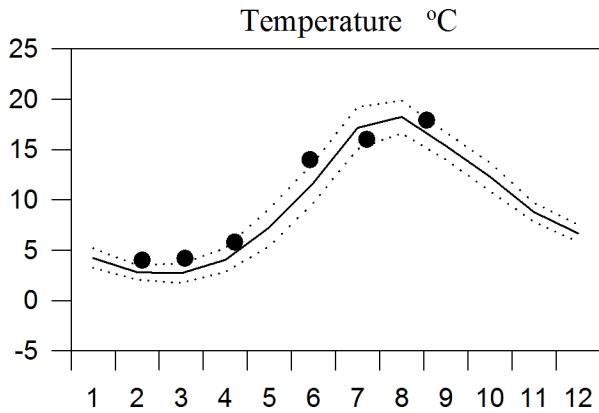
— Mean 1996-2010 ····· St.Dev. ● 2015



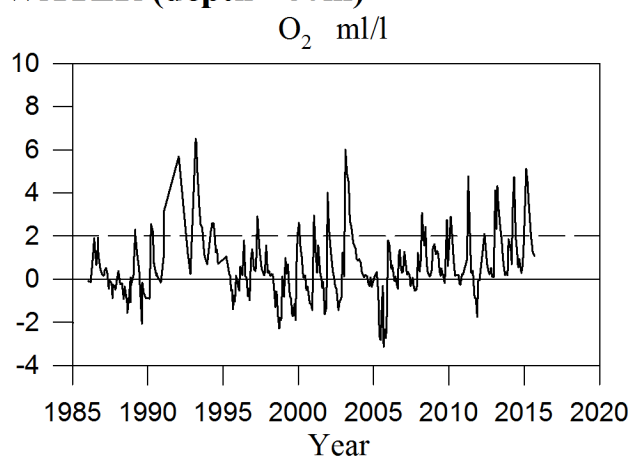
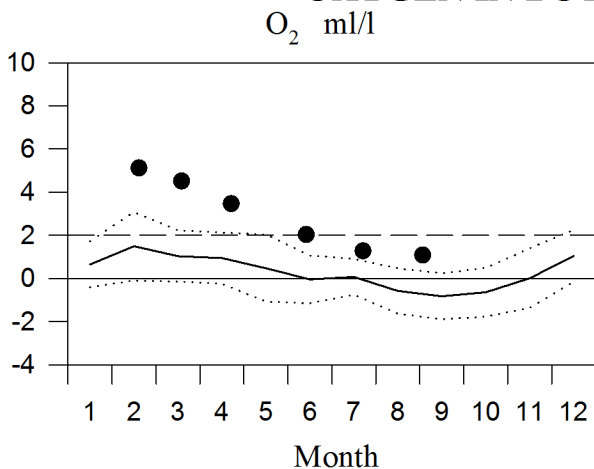
STATION BY5 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

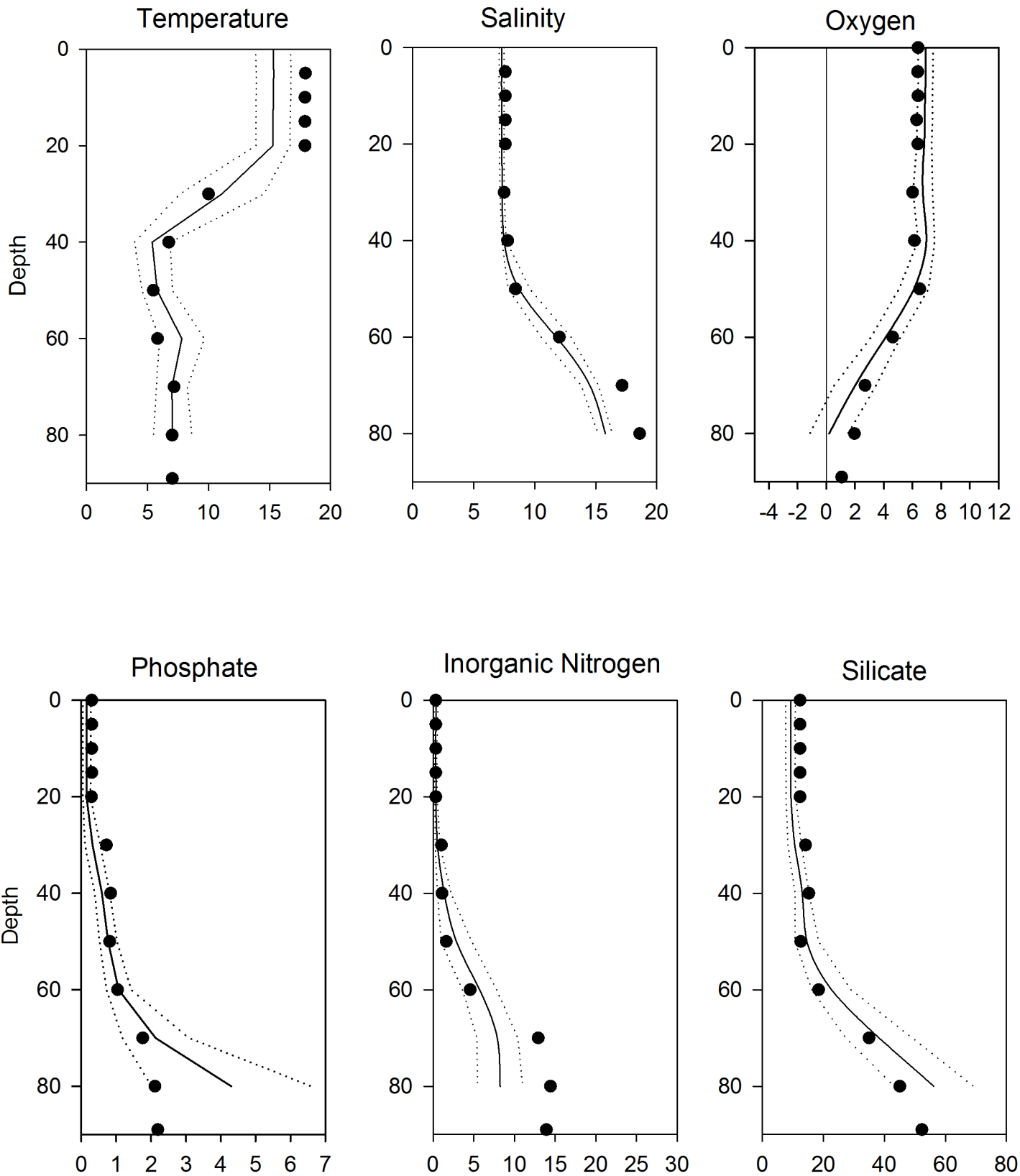


OXYGEN IN BOTTOM WATER (depth >80m)



Vertical profiles BY5 September

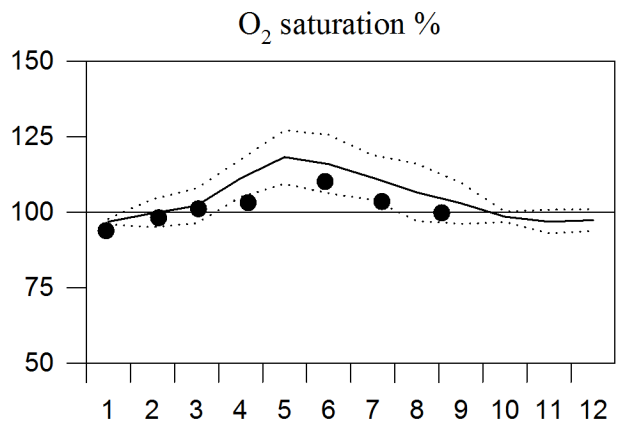
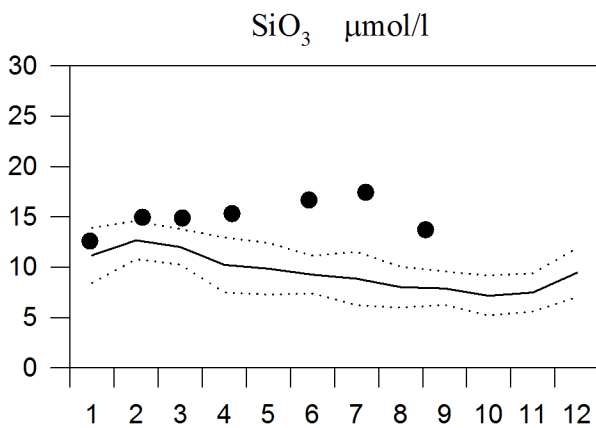
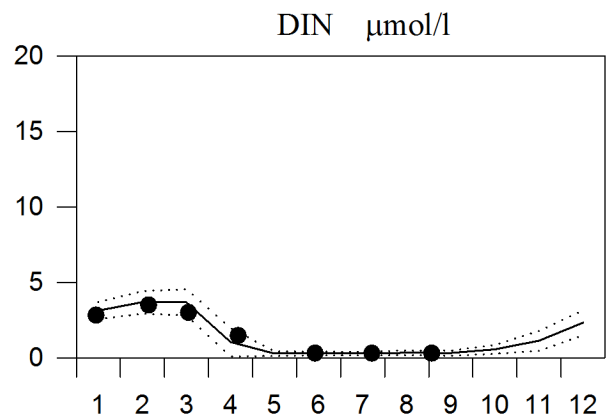
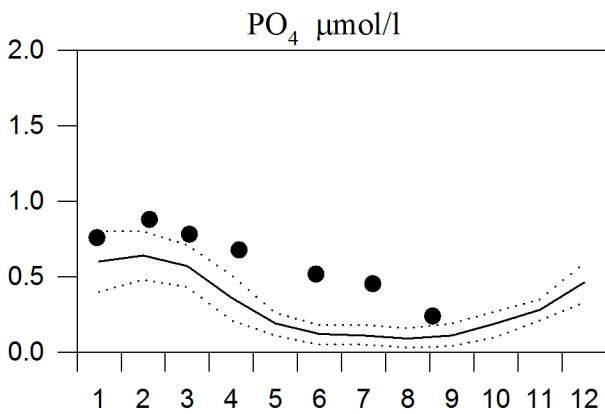
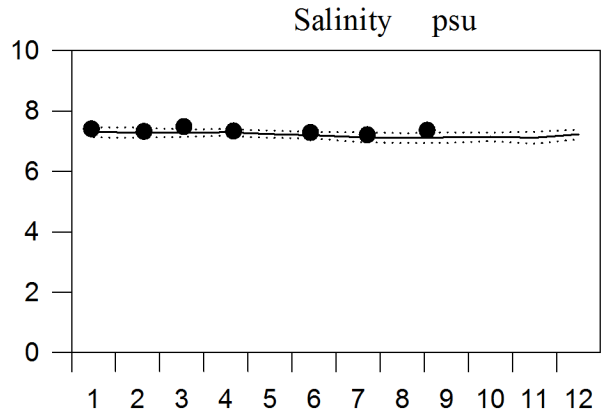
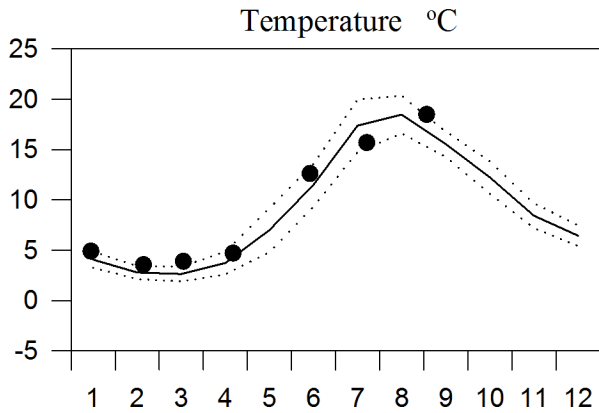
— Mean 1996-2010 ····· St.Dev. ● 2015



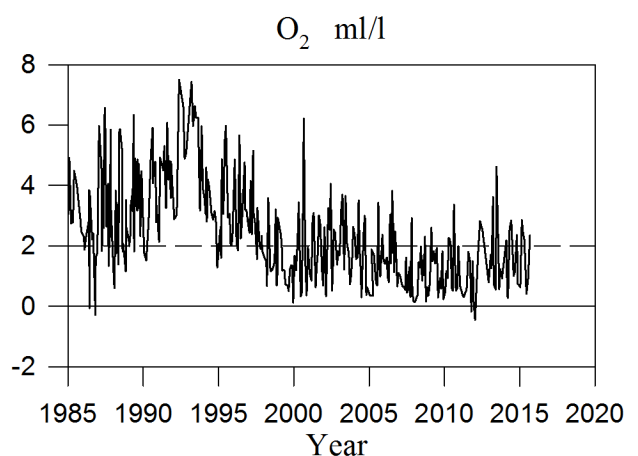
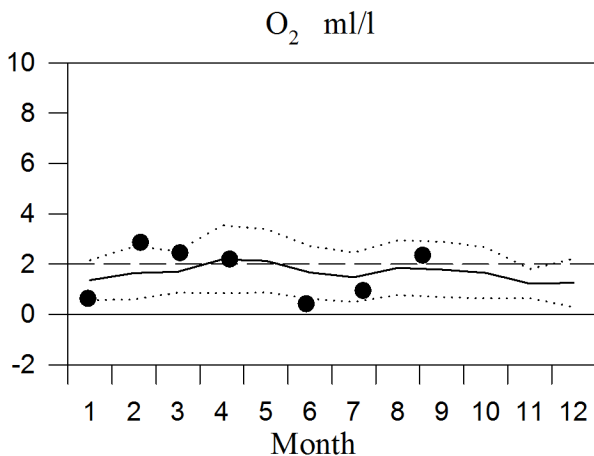
STATION BCS III-10 SURFACE WATER

Annual Cycles

— Mean 1996-2010 ····· St.Dev. ● 2015

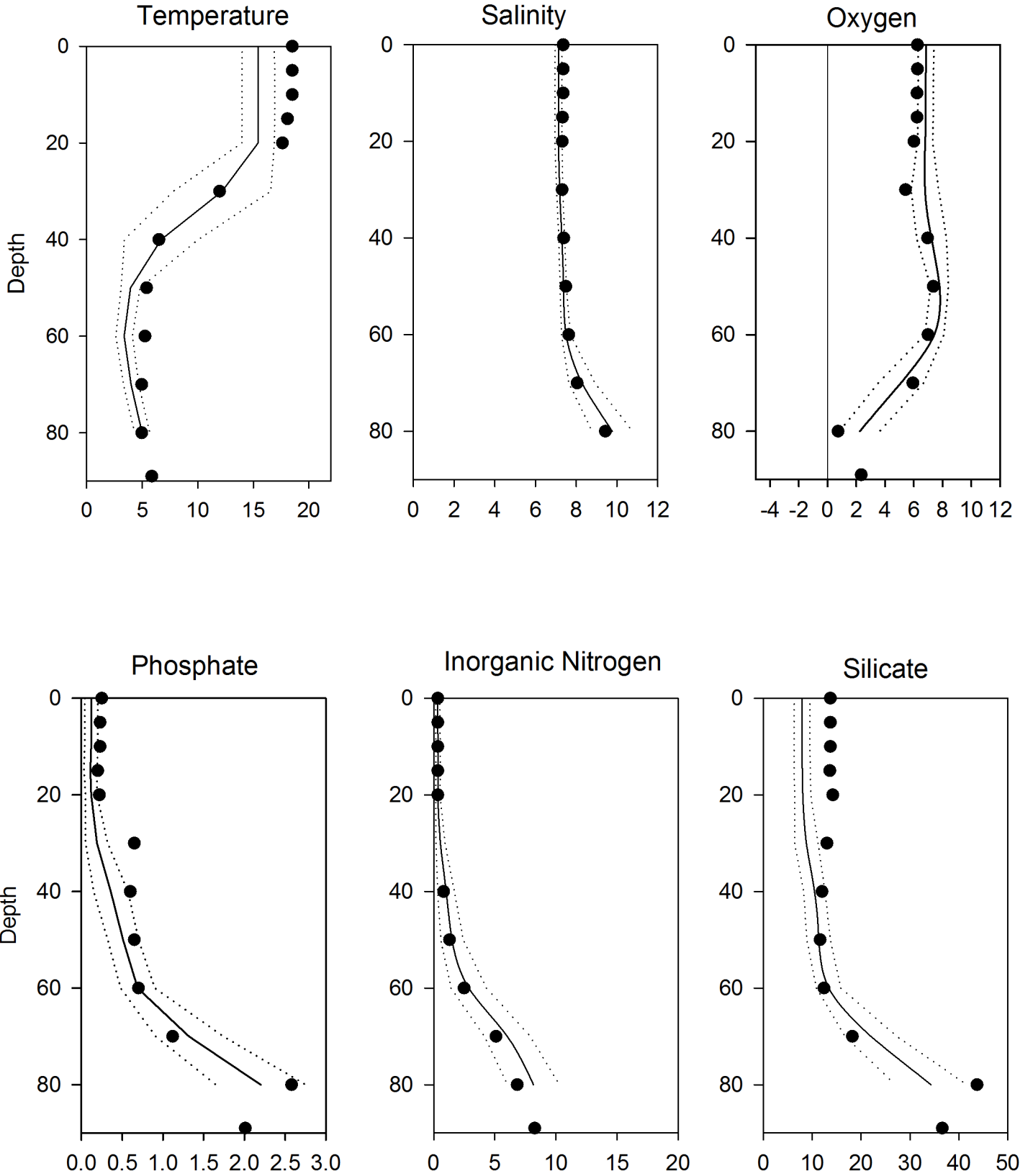


OXYGEN IN BOTTOM WATER (depth > 80m)



Vertical profiles BCS III-10 September

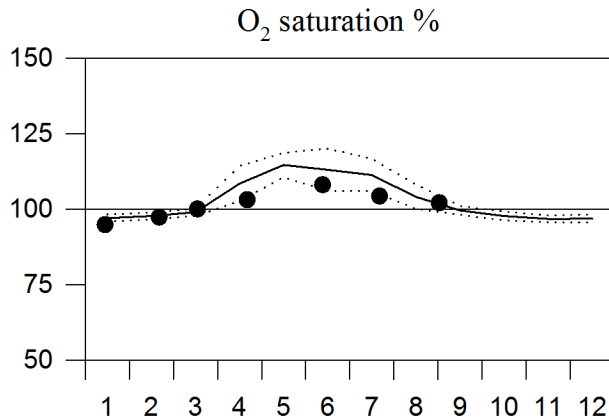
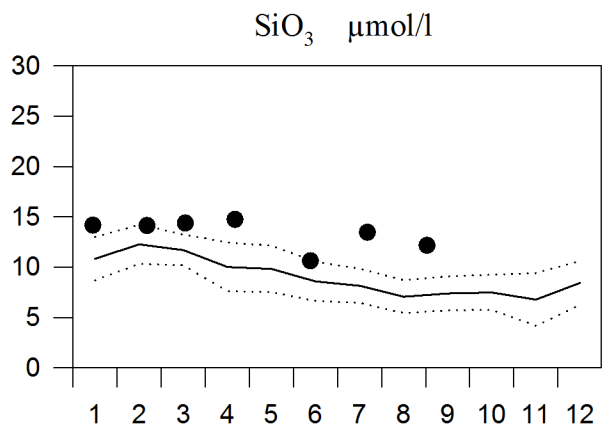
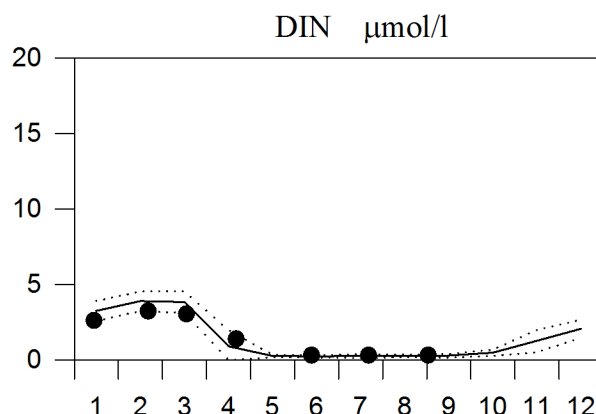
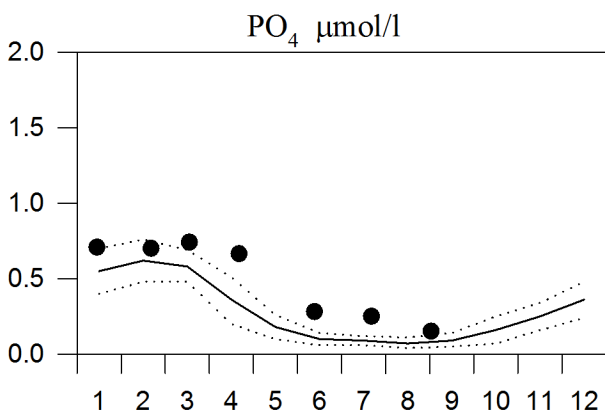
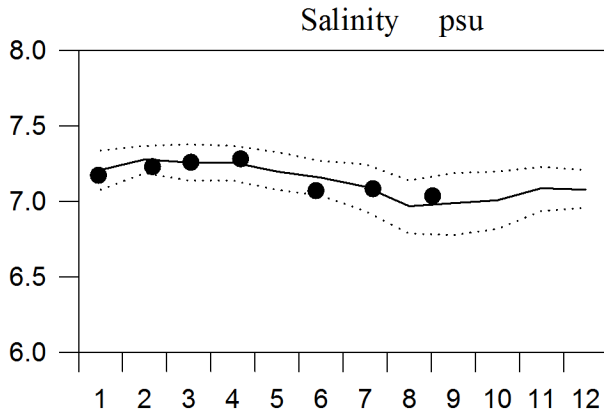
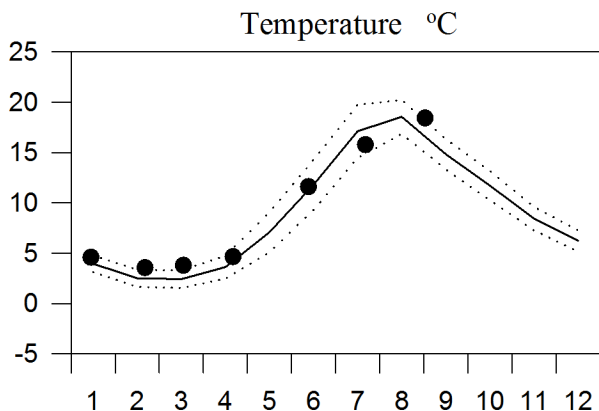
— Mean 1996-2010 ····· St.Dev. ● 2015



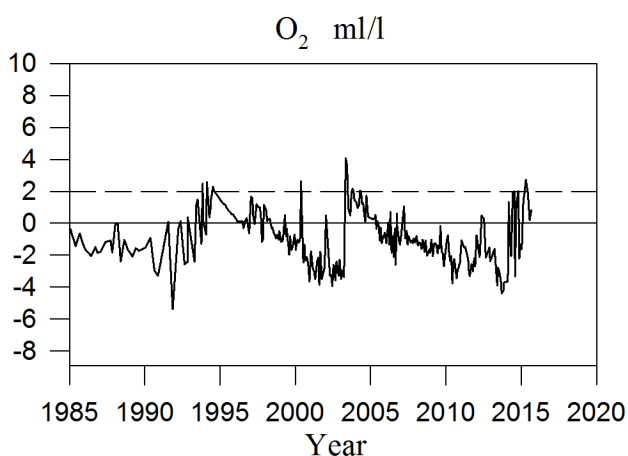
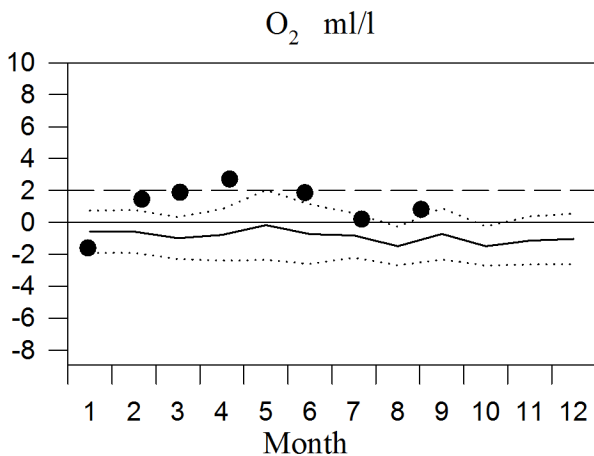
STATION BY10 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

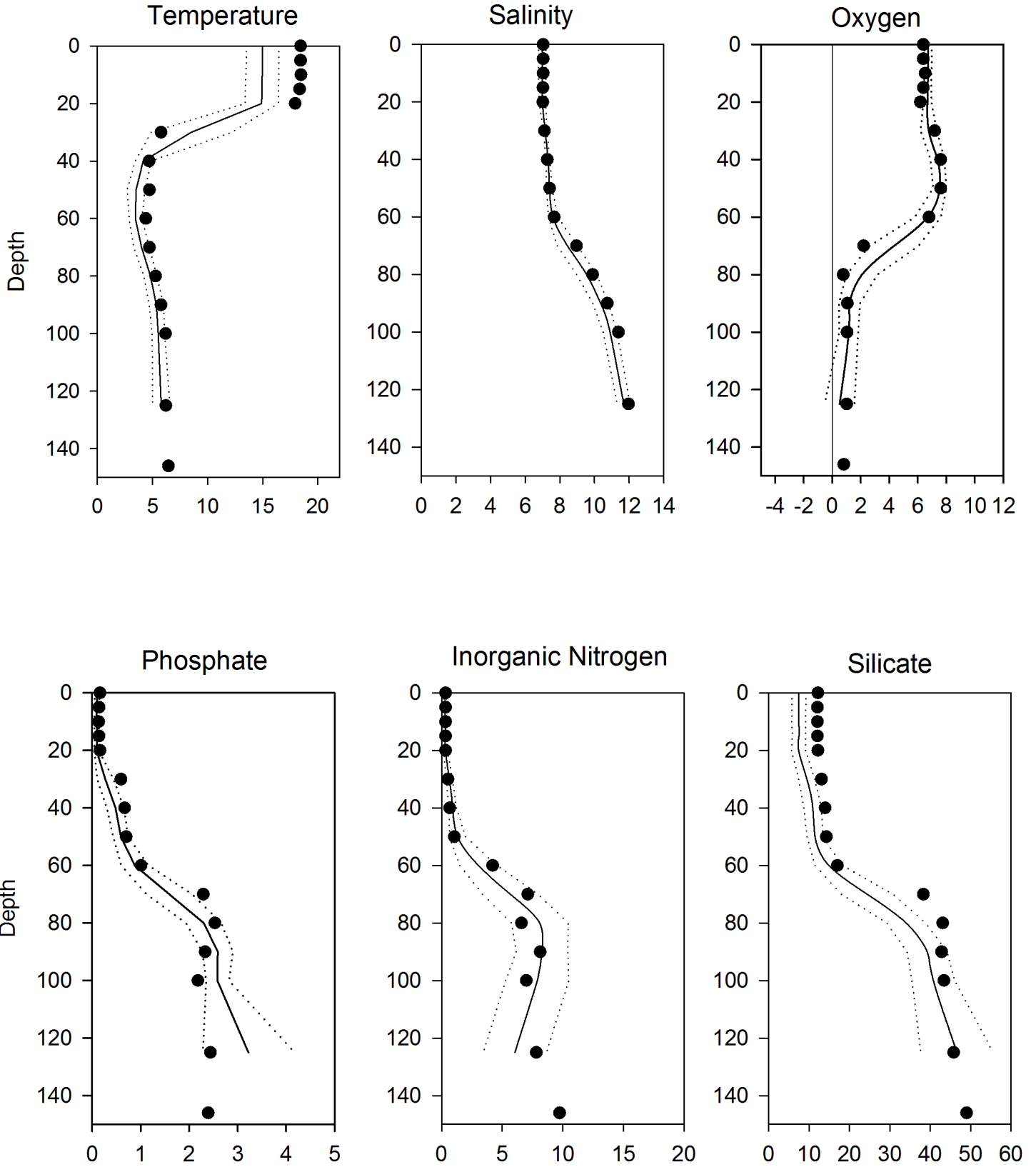


OXYGEN IN BOTTOM WATER (depth >125m)



Vertical profiles BY10 September

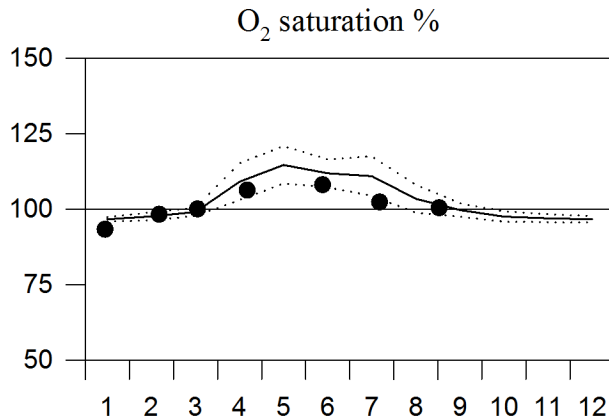
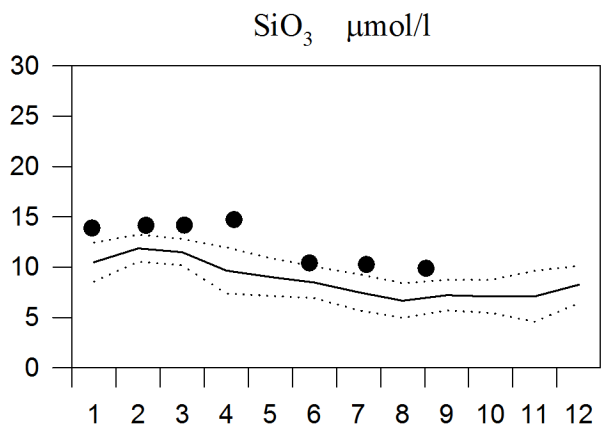
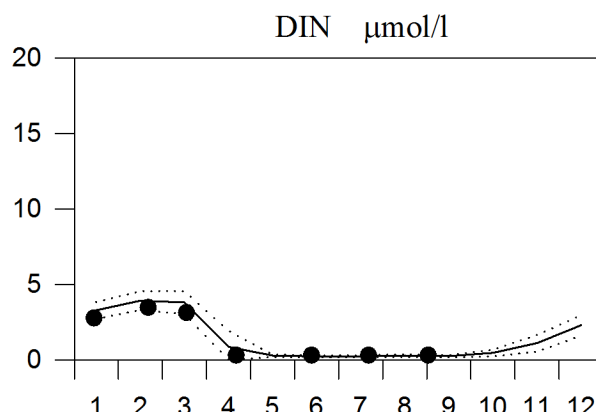
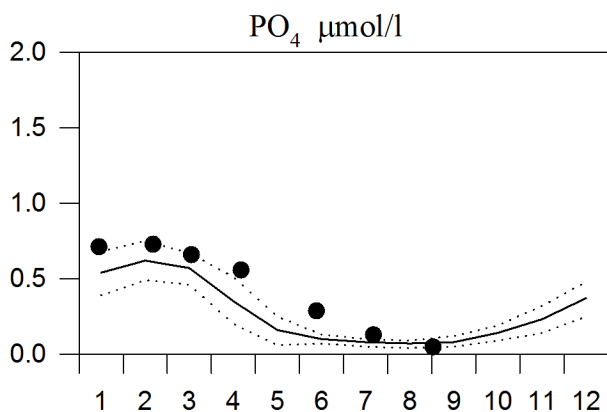
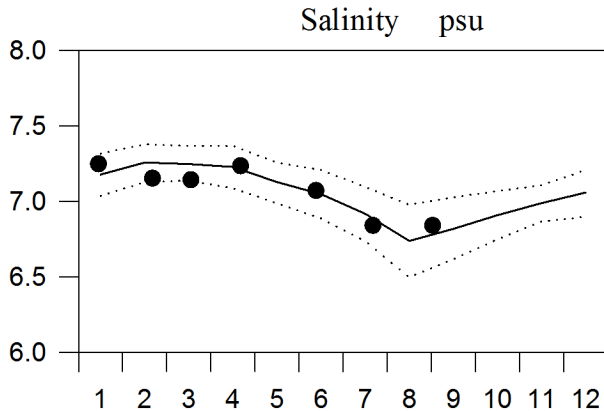
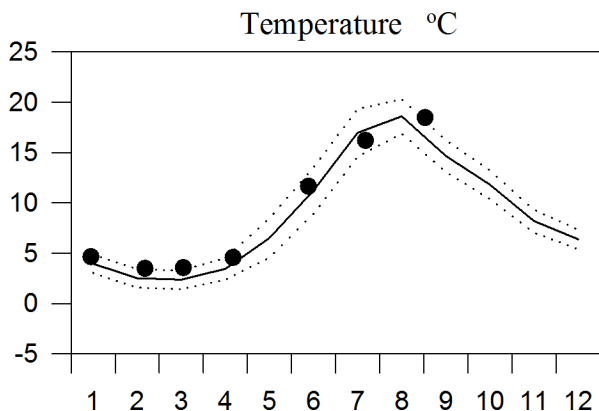
— Mean 1996-2010 ····· St.Dev. ● 2015



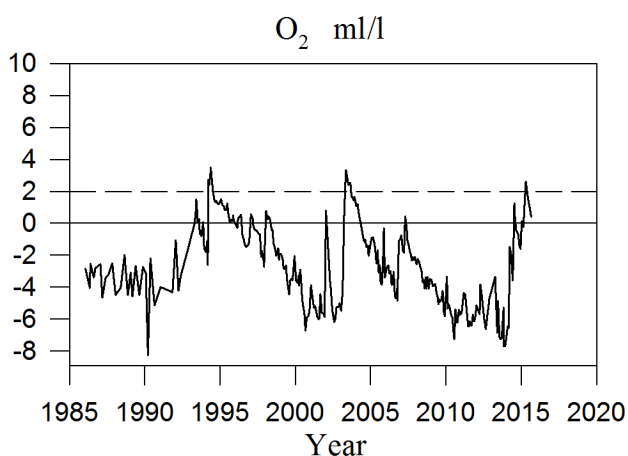
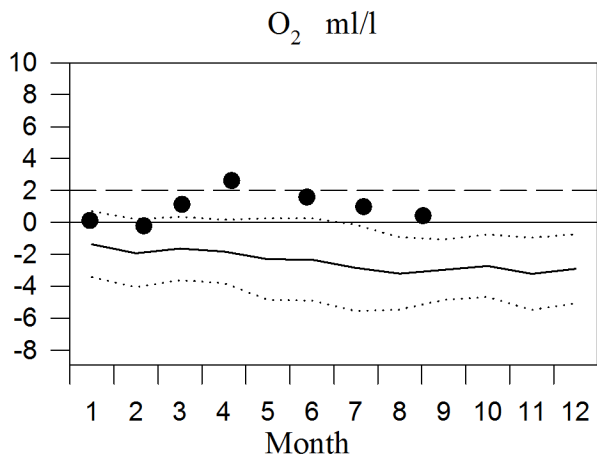
STATION BY15 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

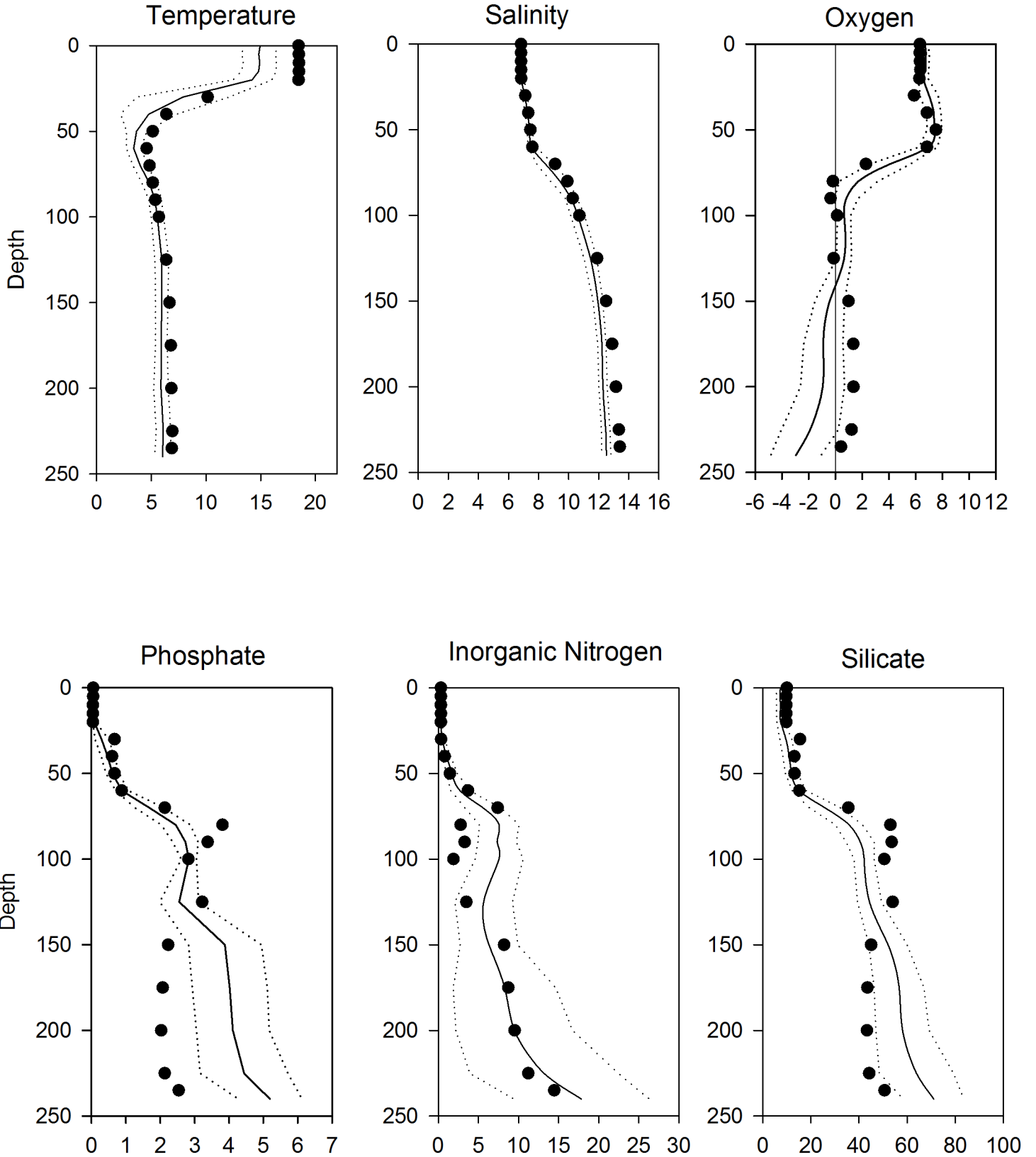


OXYGEN IN BOTTOM WATER (depth >225m)



Vertical profiles BY15 September

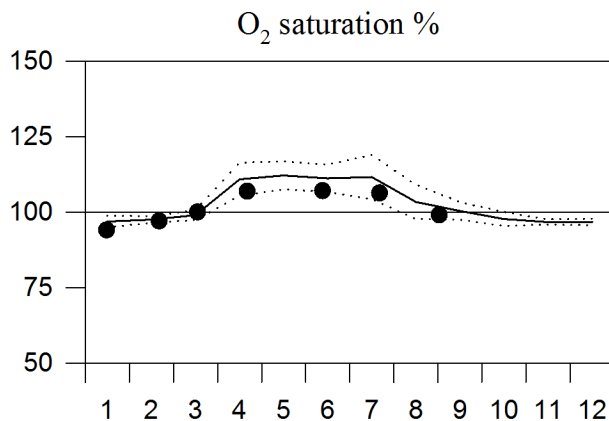
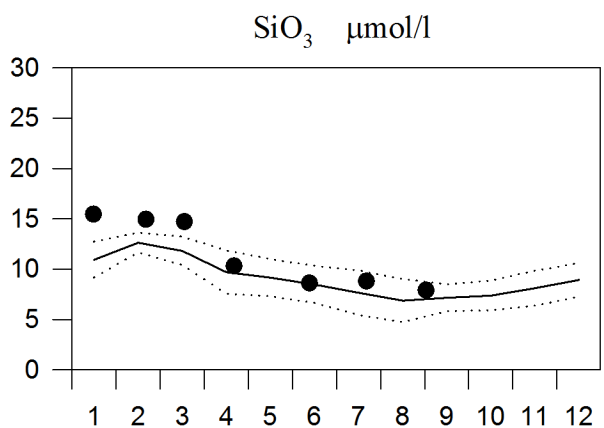
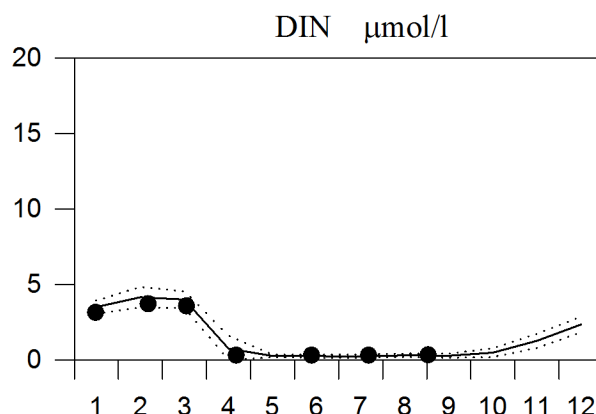
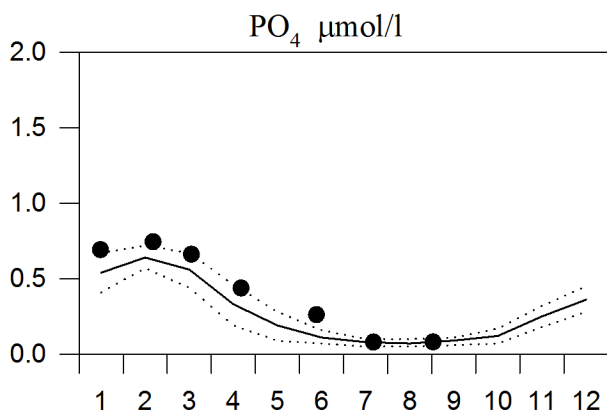
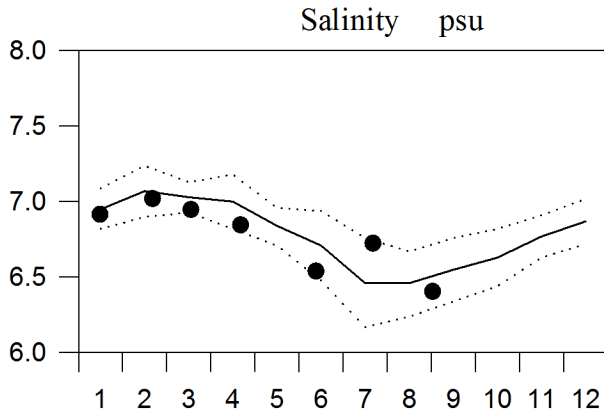
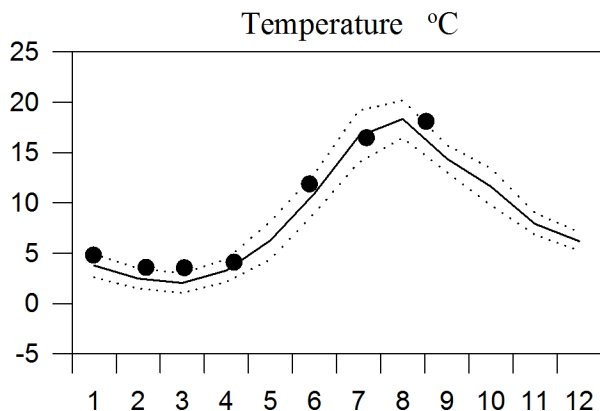
— Mean 1996-2010 ····· St.Dev. ● 2015



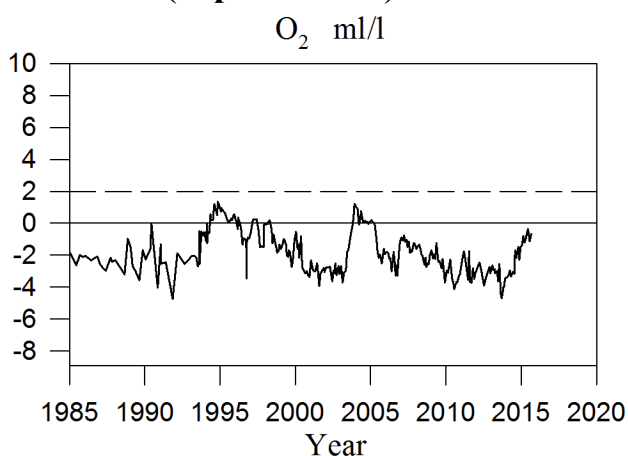
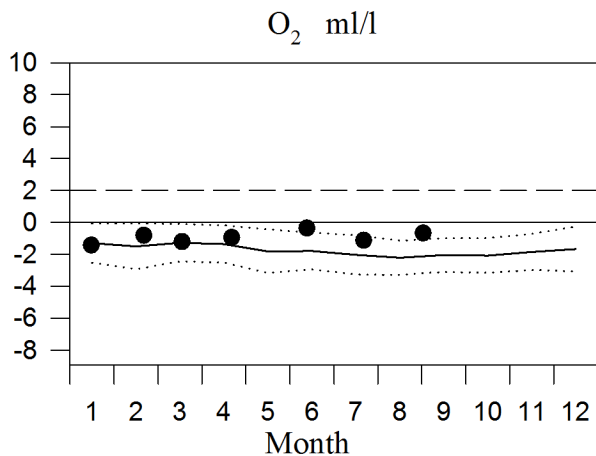
STATION BY20 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

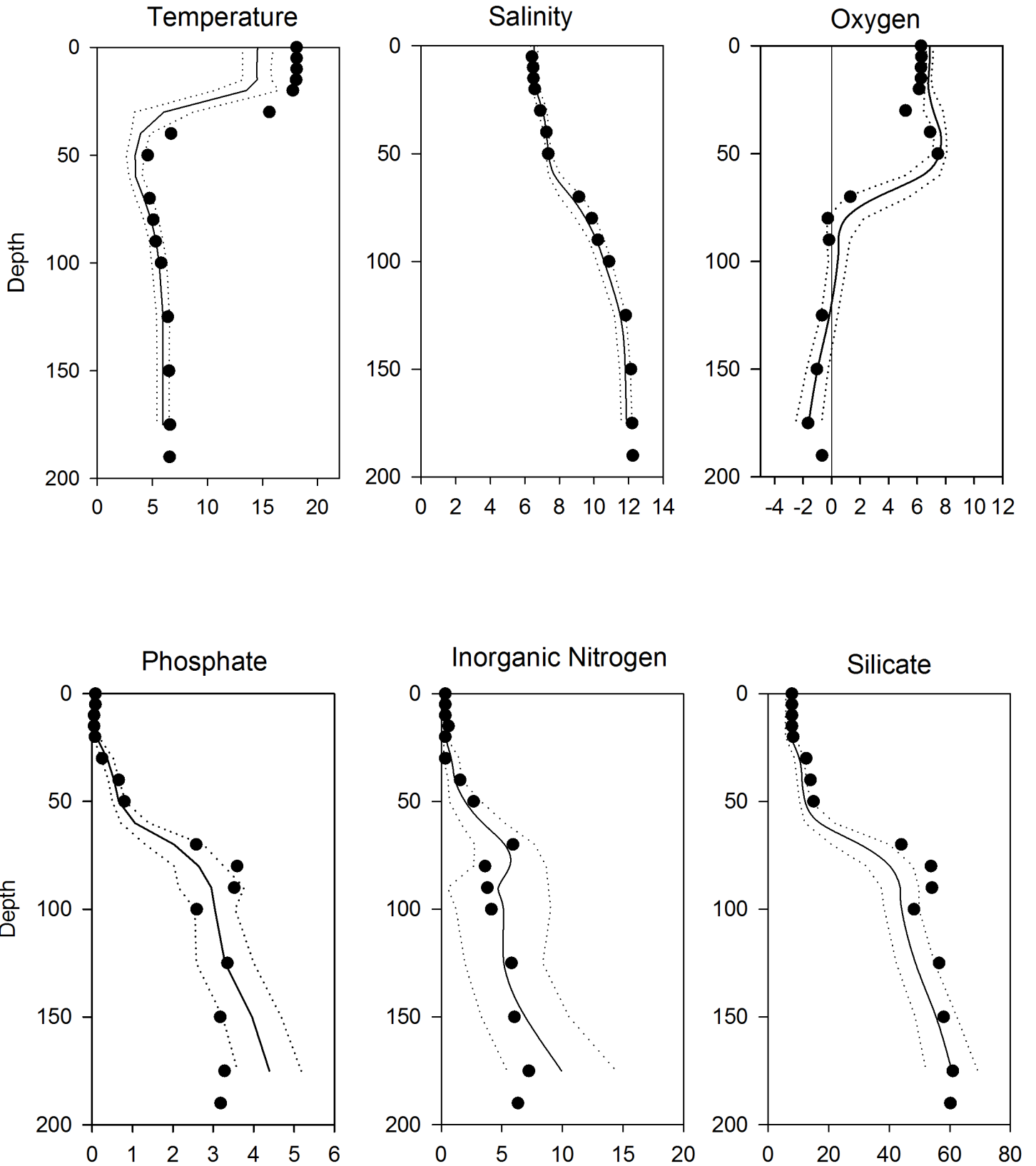


OXYGEN IN BOTTOM WATER (depth >175m)



Vertical profiles BY20 September

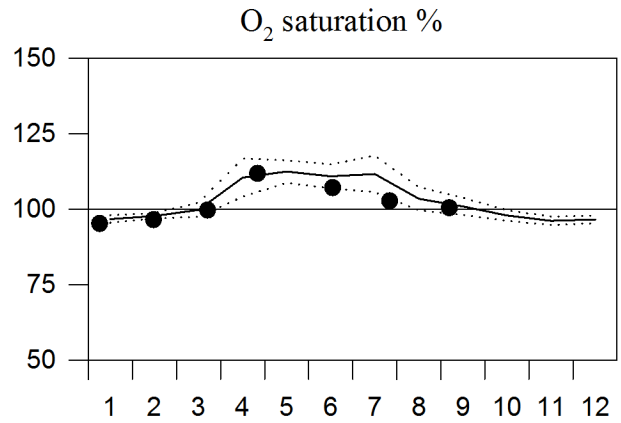
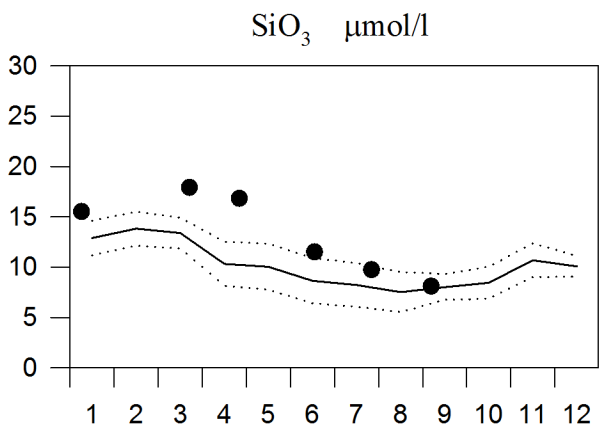
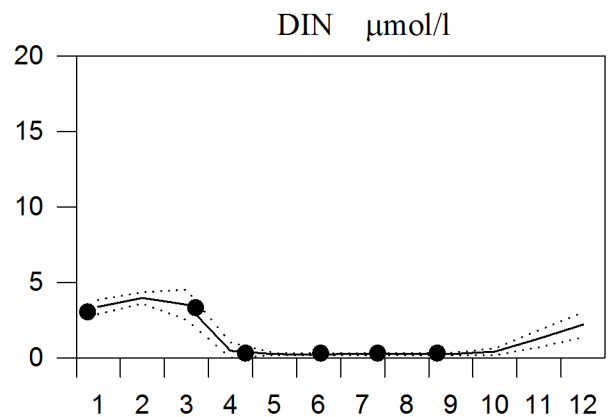
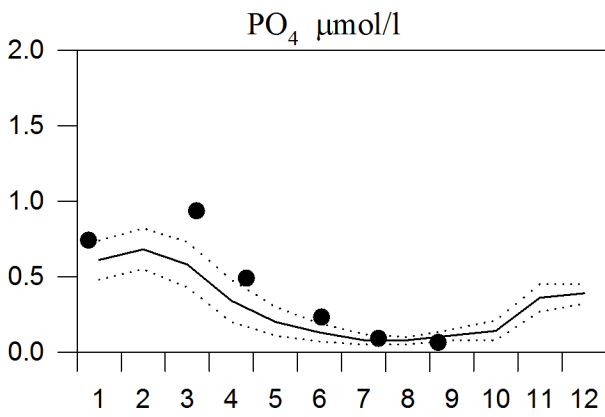
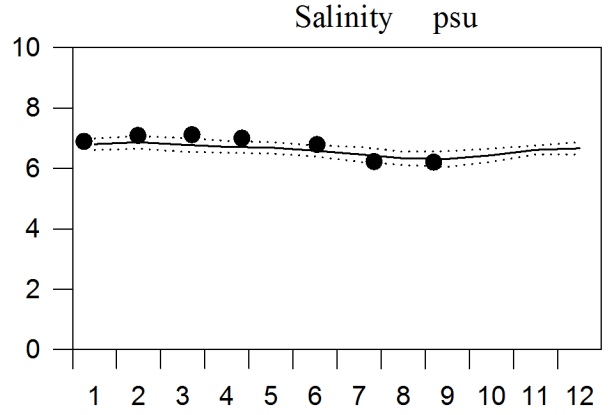
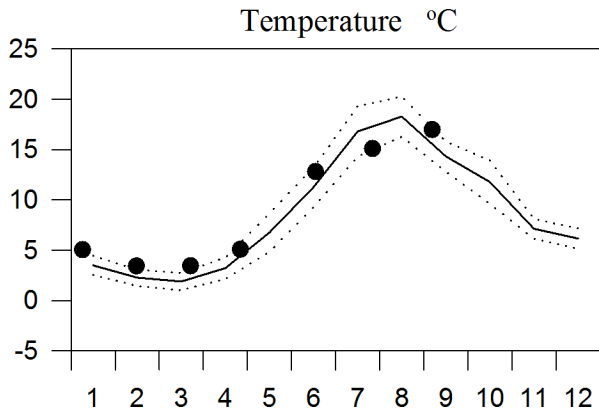
— Mean 1996-2010 ····· St.Dev. ● 2015



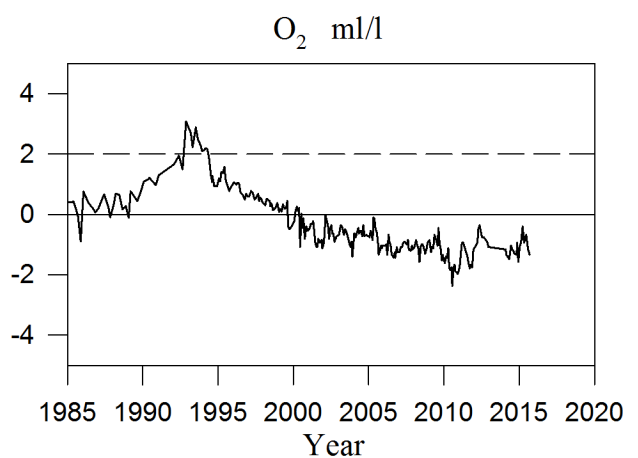
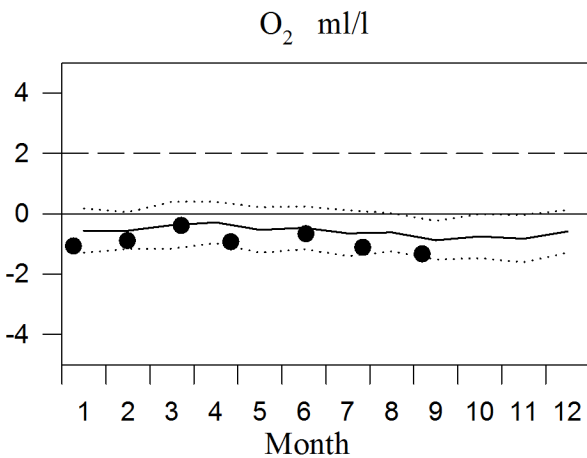
STATION BY32 SURFACE WATER

Annual Cycles

— Mean 1996-2010 ····· St.Dev. ● 2015

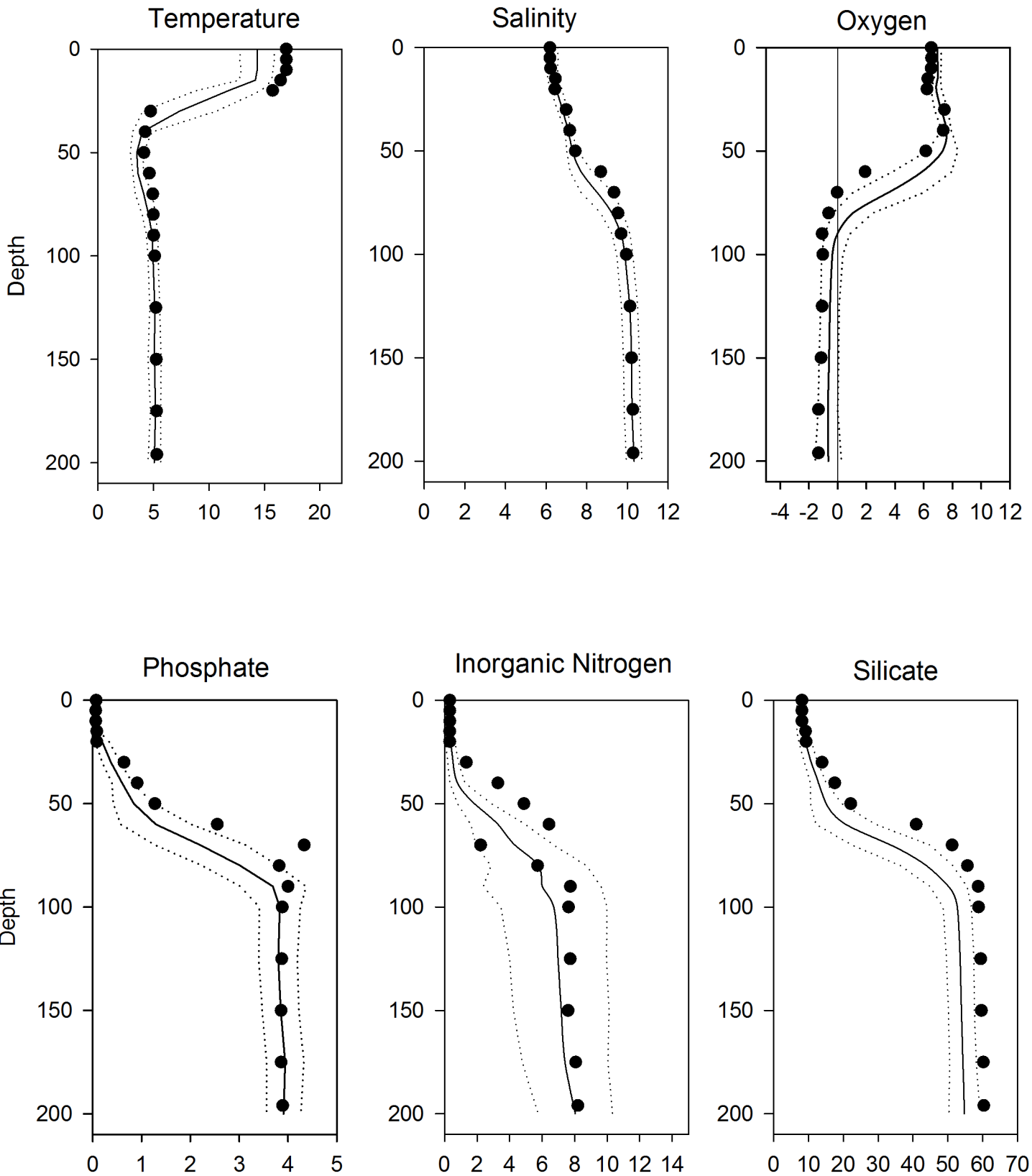


OXYGEN IN BOTTOM WATER (depth > 175m)



Vertical profiles BY32 September

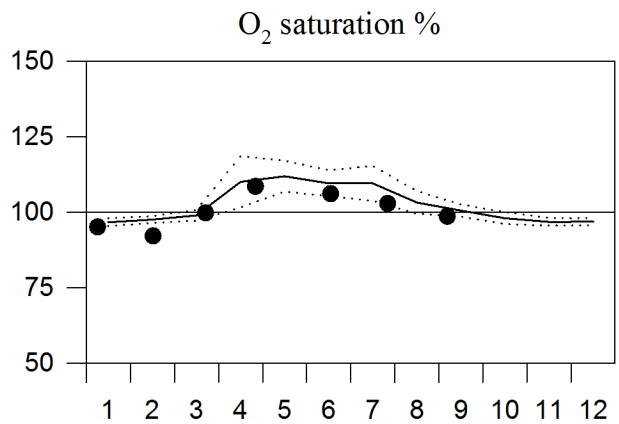
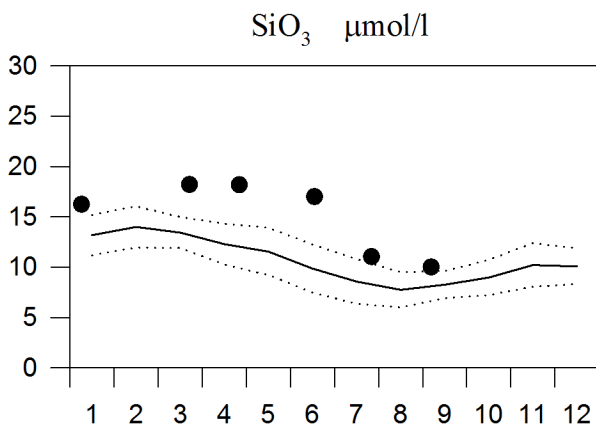
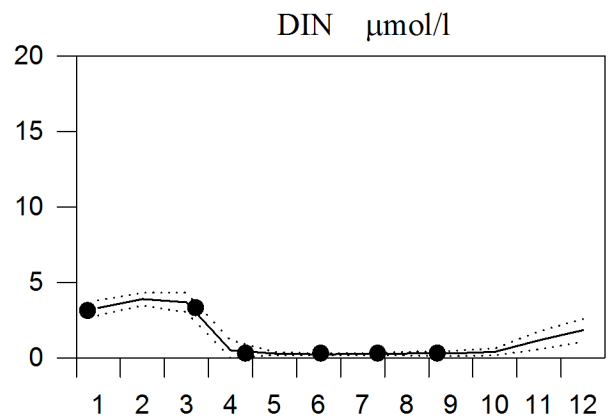
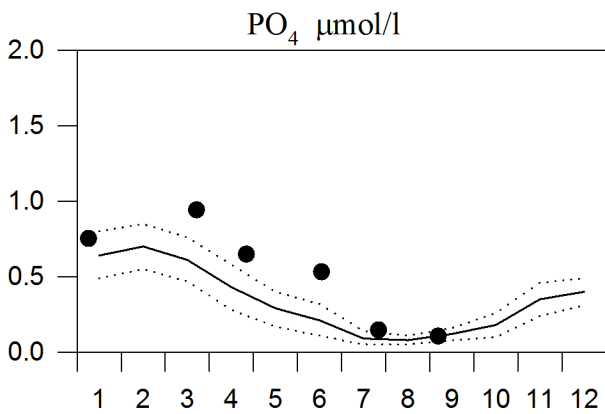
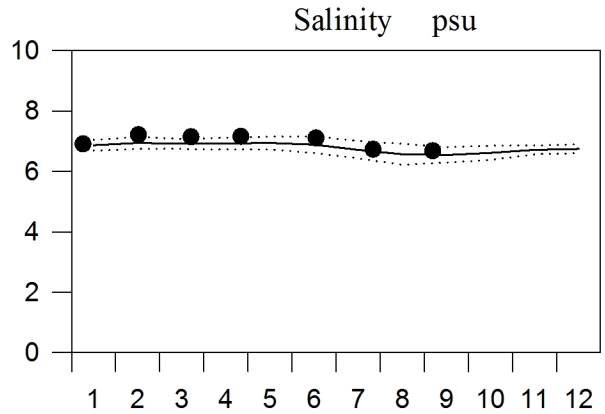
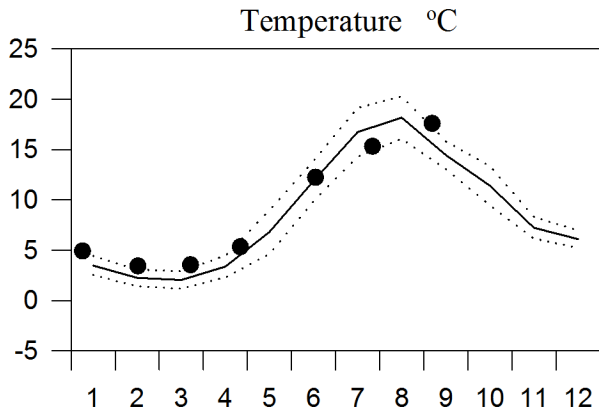
— Mean 1996-2010 ····· St.Dev. ● 2015



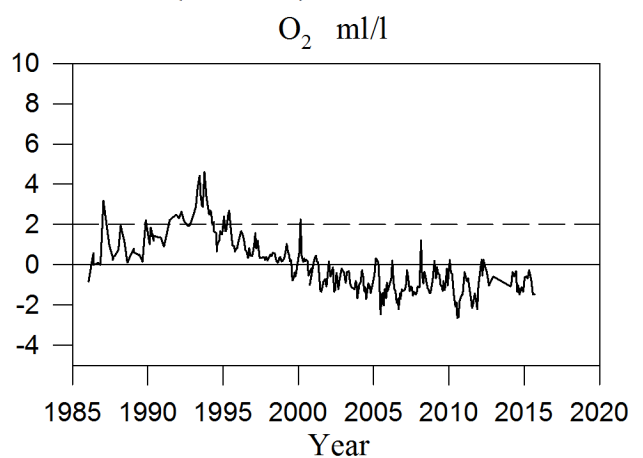
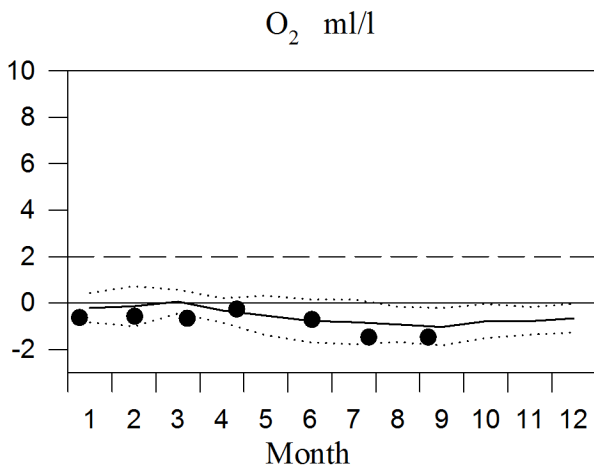
STATION BY38 SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

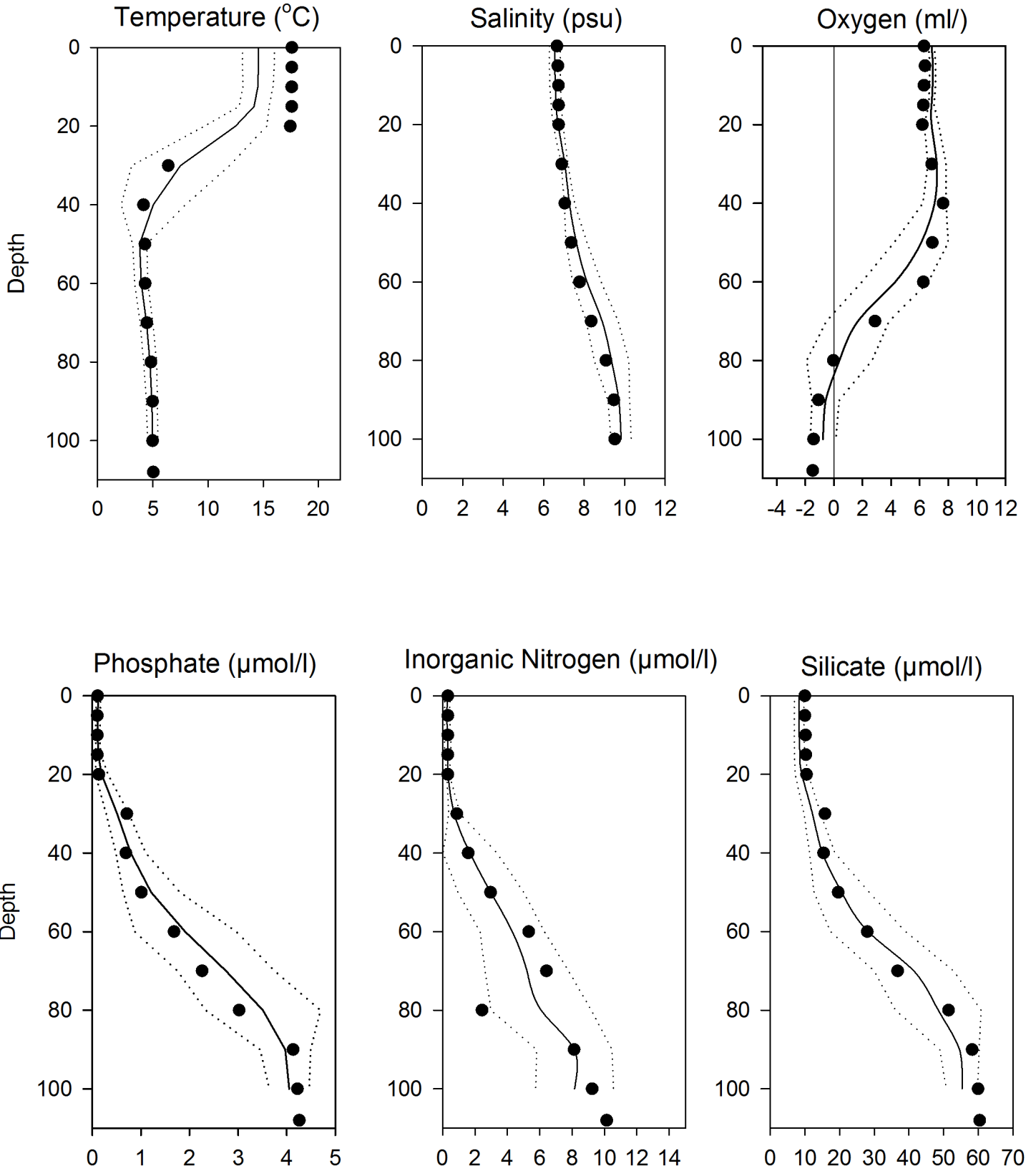


OXYGEN IN BOTTOM WATER (> 100m)



Vertical profiles BY38 September

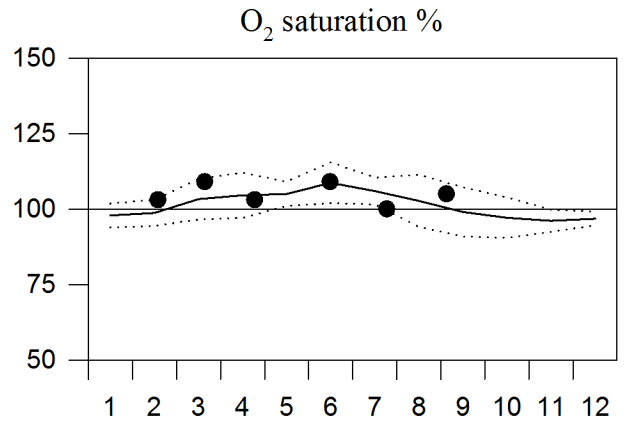
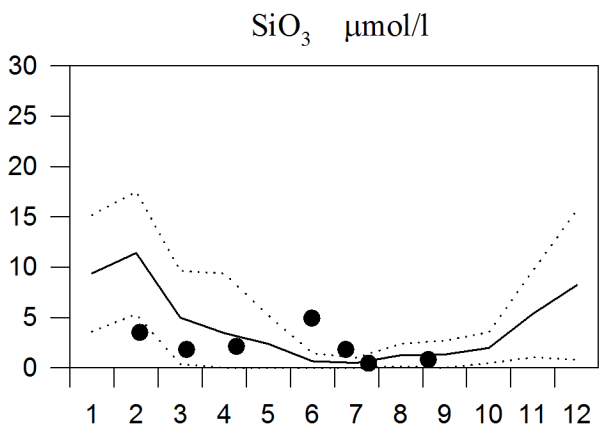
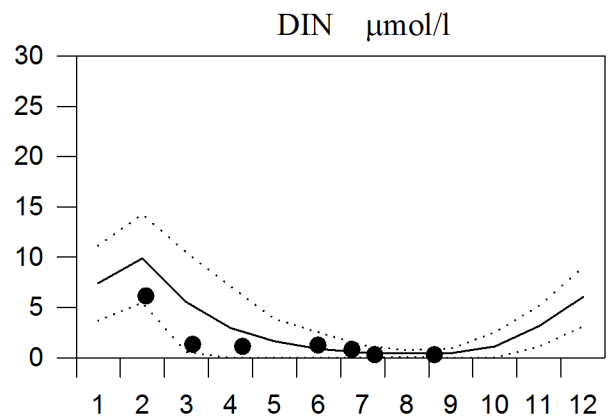
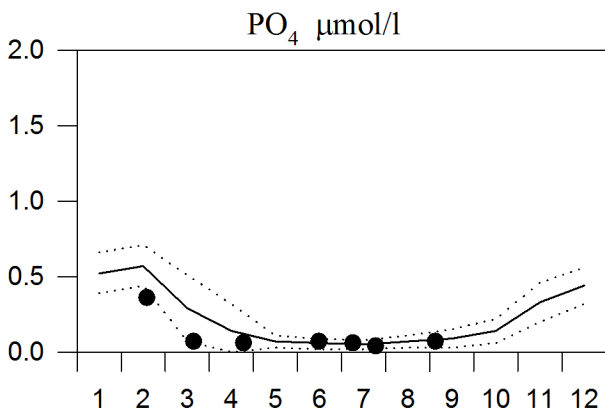
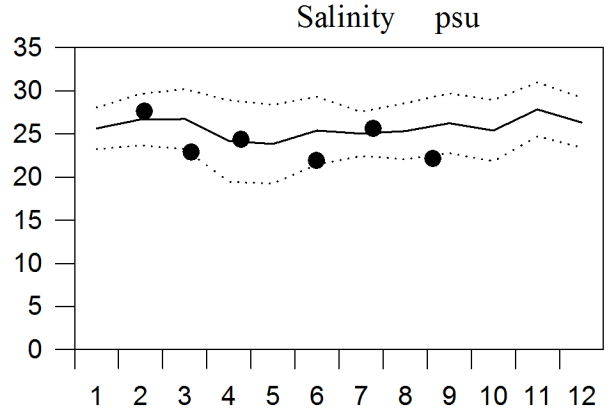
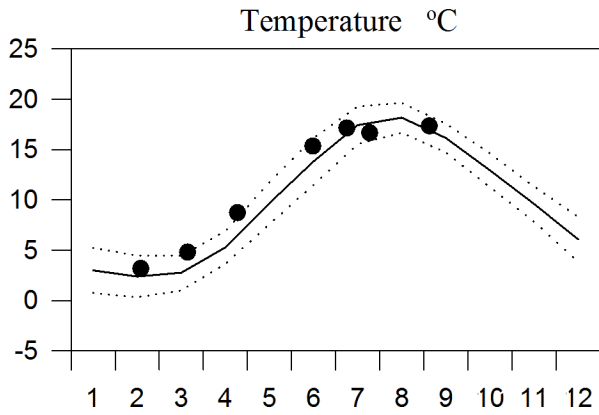
— Mean 1996-2010 ····· St.Dev. ● 2015



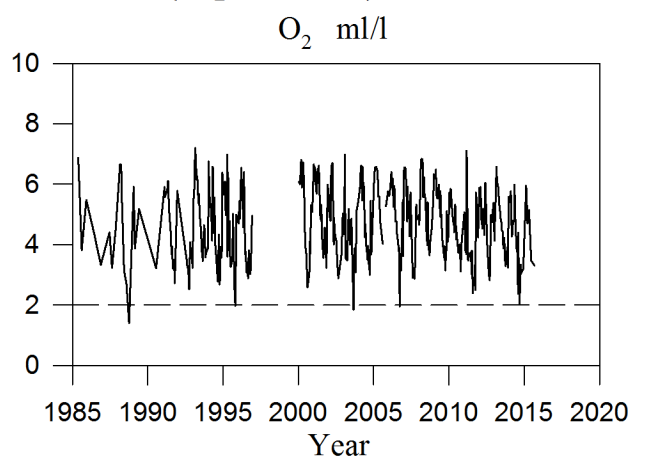
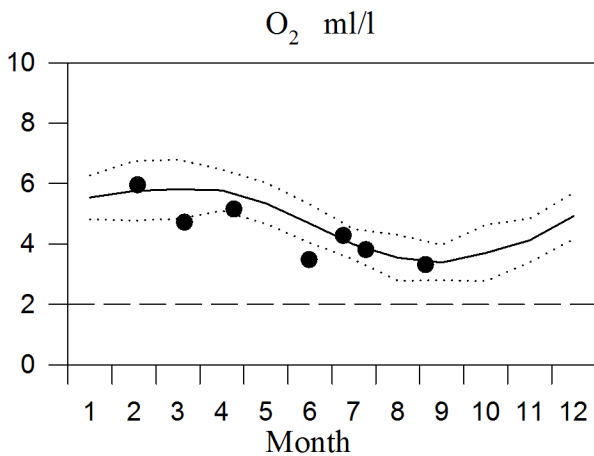
STATION SLÄGGÖ SURFACE WATER

Annual Cycles

— Mean 1996-2010 St.Dev. ● 2015

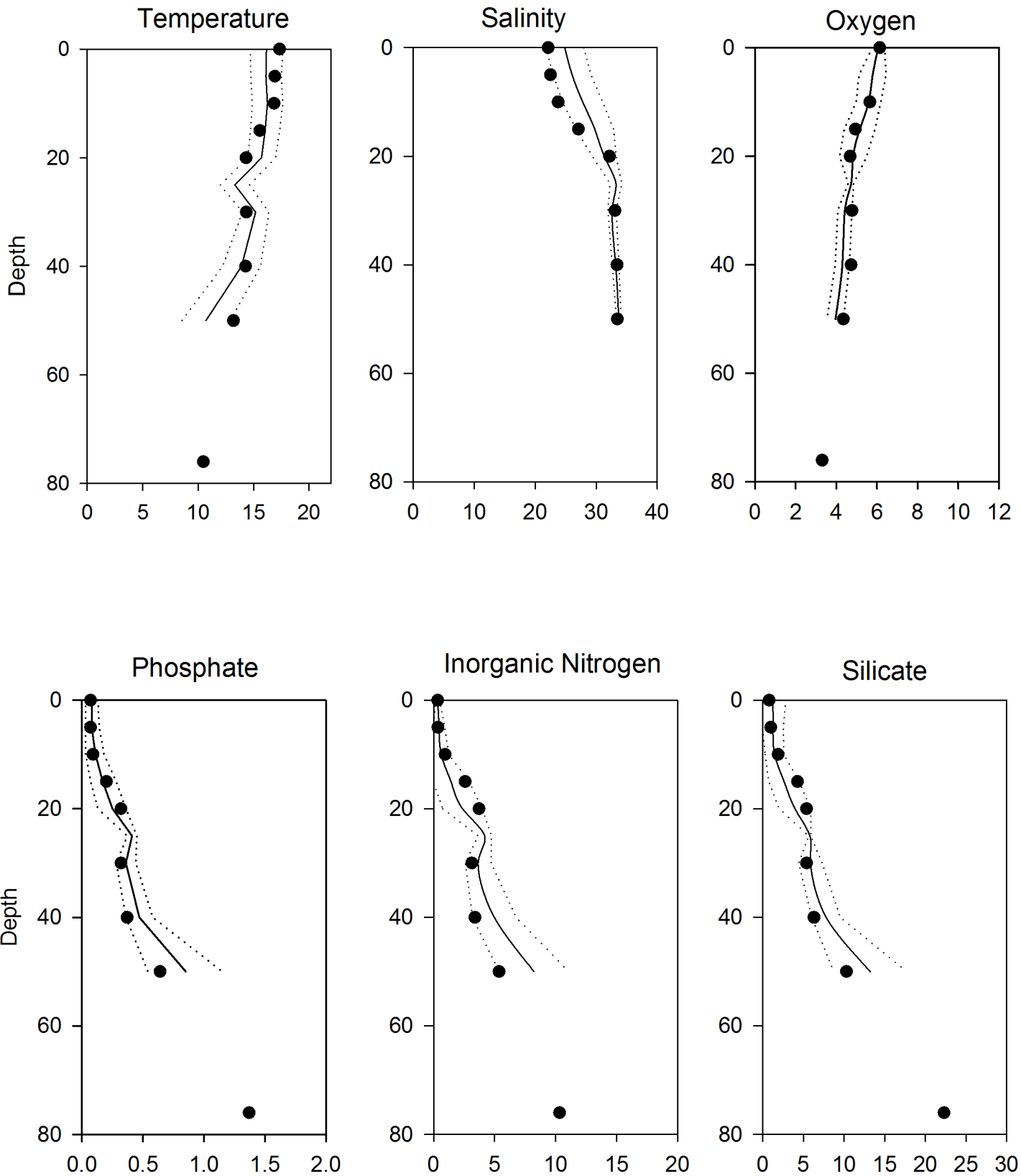


OXYGEN IN BOTTOM WATER (depth >50m)



Vertical profiles Släggö September

— Mean 1996-2010 St.Dev. ● 2015



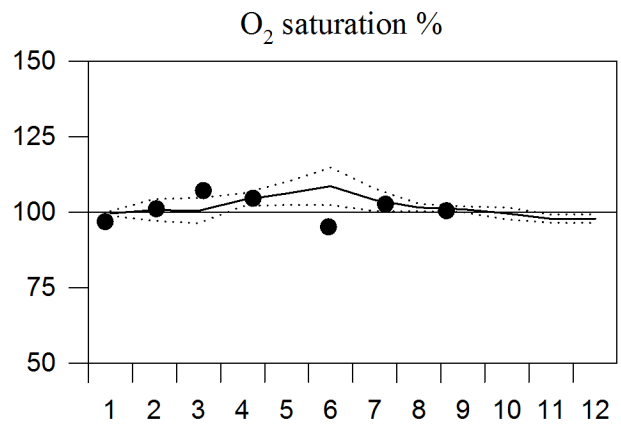
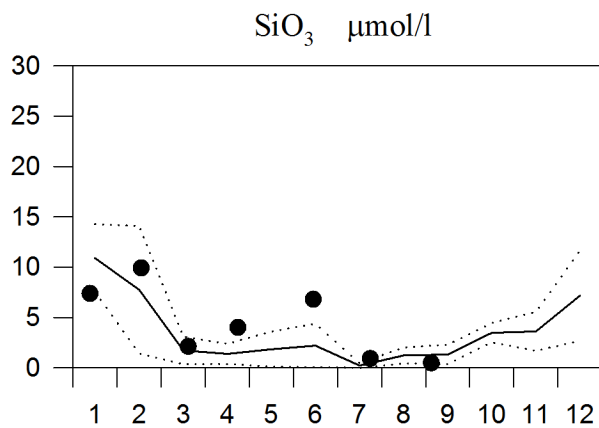
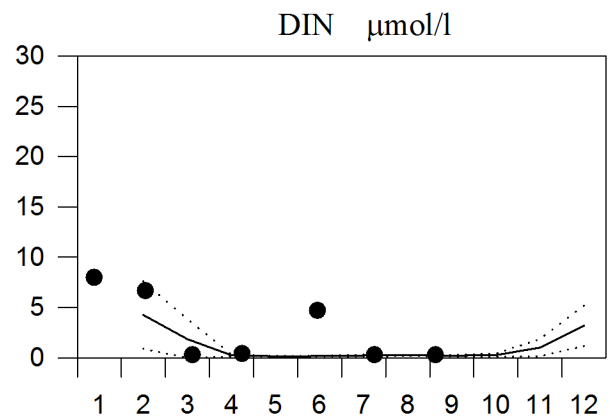
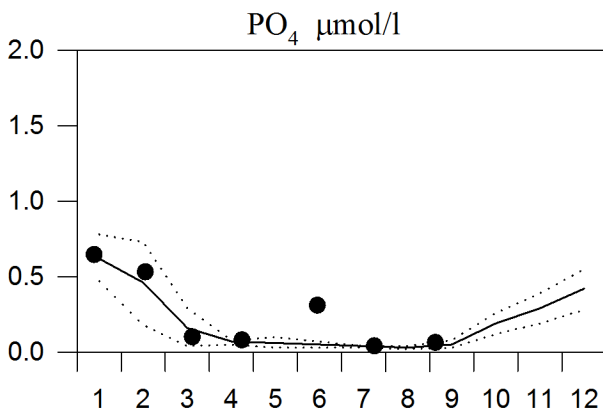
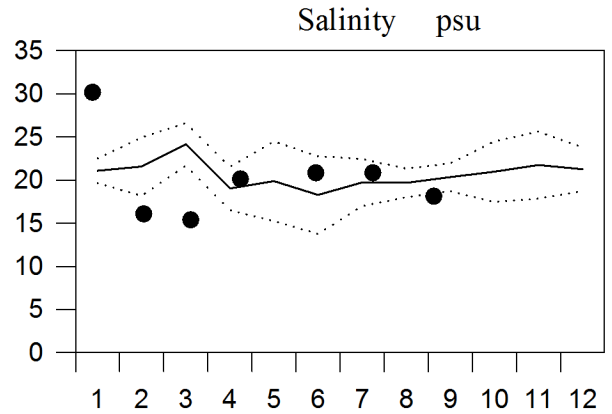
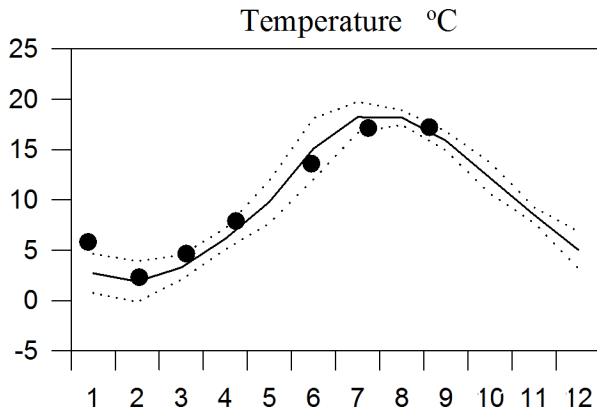
STATION N14 Falkenberg SURFACE WATER

Annual Cycles

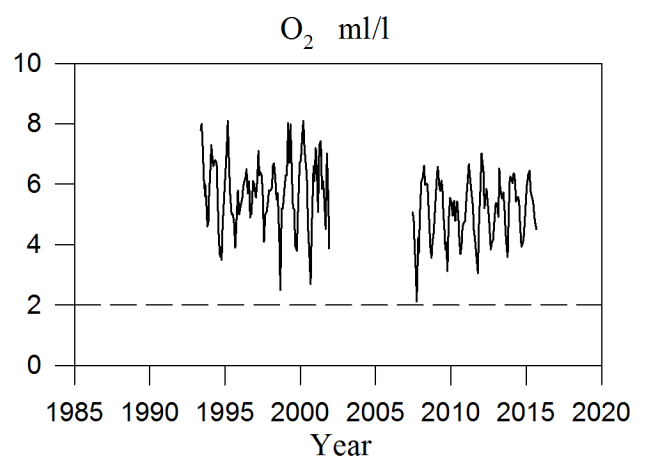
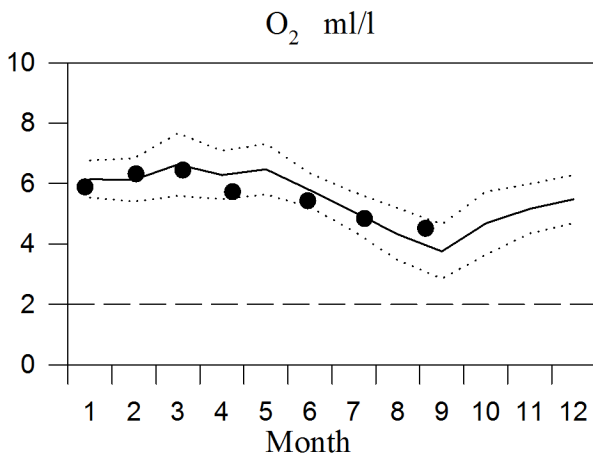
— Mean 2007-2010

..... St.Dev.

● 2015

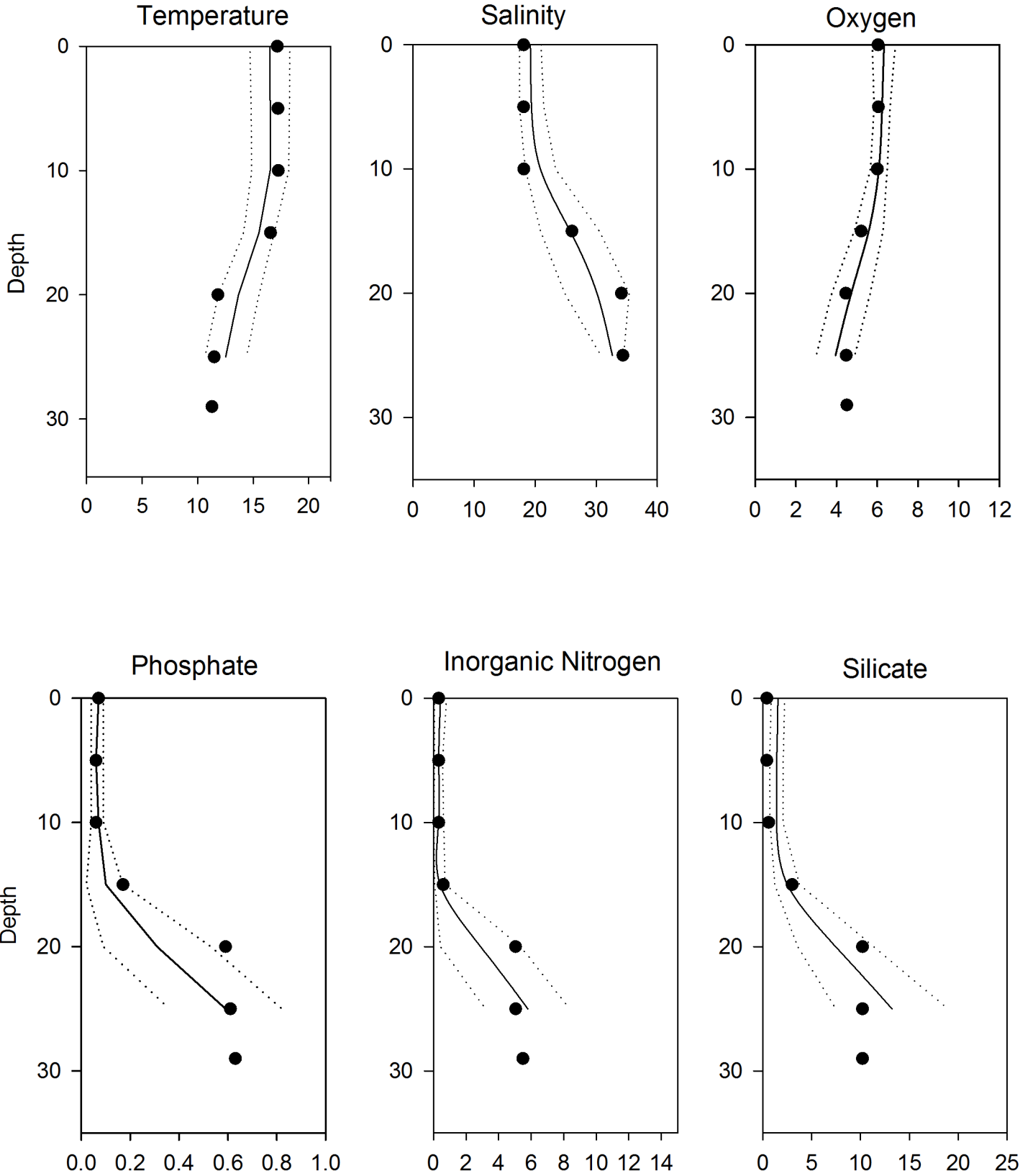


OXYGEN IN BOTTOM WATER (depth > 25m)



Vertical profiles N14 Falkenberg September

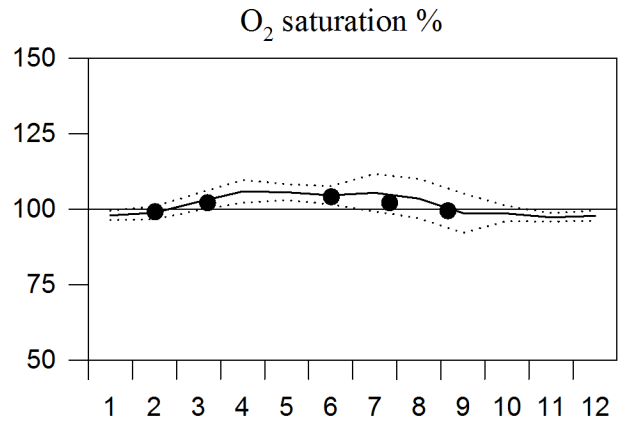
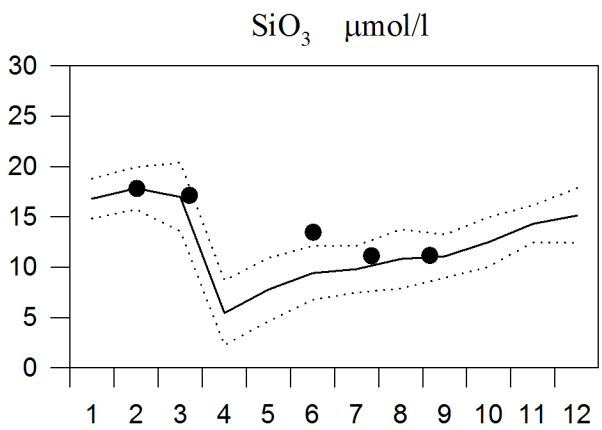
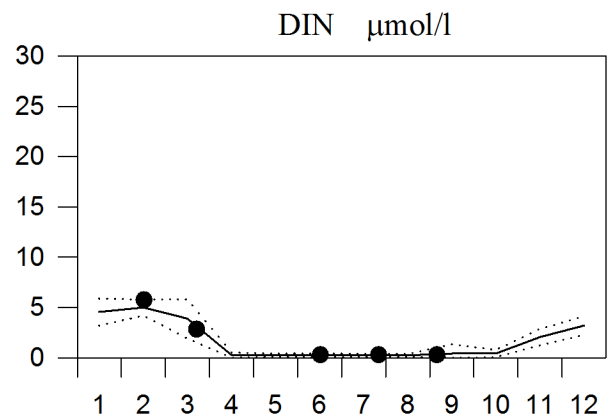
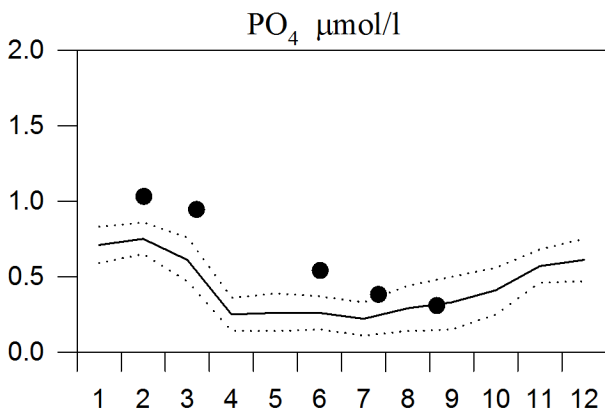
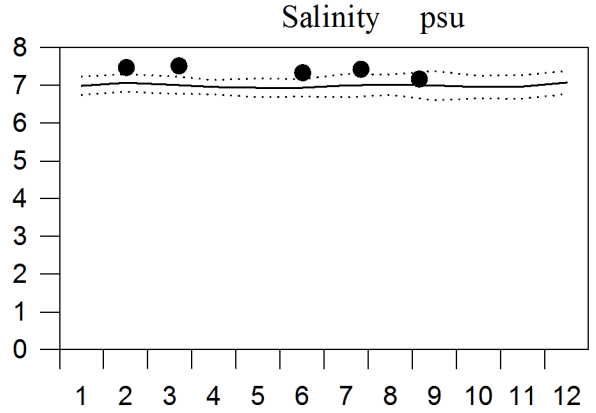
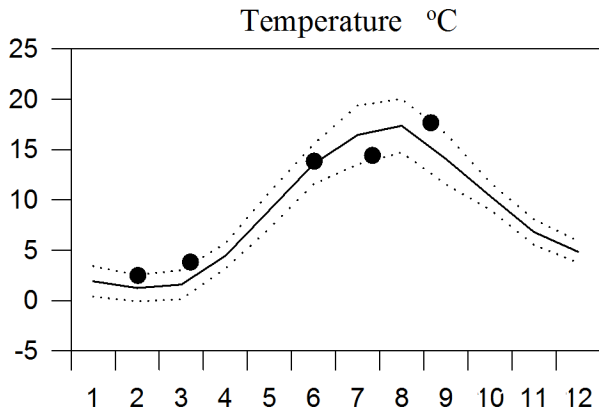
— Mean 1996-2010 St.Dev. ● 2015



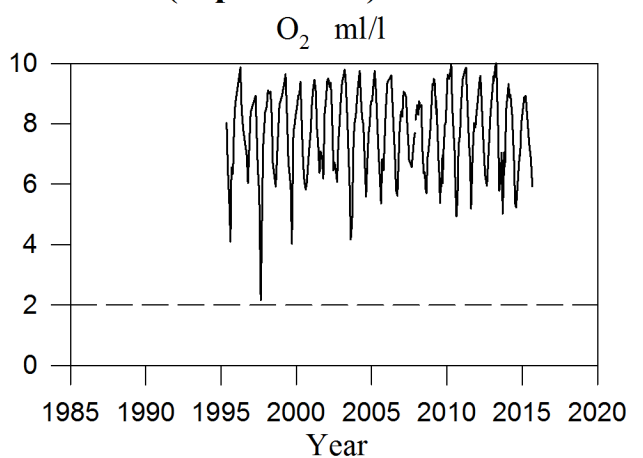
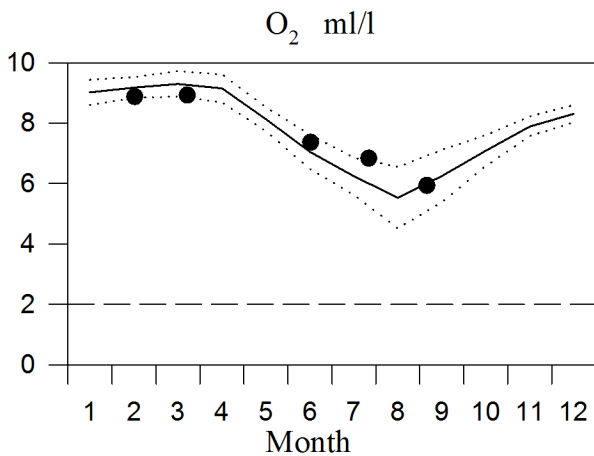
STATION REF M1V1 SURFACE WATER

Annual Cycles

— Mean 1996-2010 ····· St.Dev. ● 2015



OXYGEN IN BOTTOM WATER (depth >15m)



Vertical profiles Ref M1V1 September

— Mean 1996-2010 ····· St.Dev. ● 2015

