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2014-10-28 Dnr: S/GBG-2014-161

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



**Survey period:** 2014-10-20 - 2014-10-28

Survey area: Skagerrak, Kattegat, the Sound and the Baltic Proper

**Principal:** SMHI and the Swedish Agency for Marine and Water Management

#### **SUMMARY**

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

Water temperature in the surface layer was slightly above normal in the whole investigated area. Nutrients in the surface layer showed normal concentrations, except for elevated silicate concentrations in the western and eastern Gotland basin. In the western part of Skagerrak a thin layer containing very high concentrations of nutrients was detected.

The Arkona Basin was well oxygenated, while in the Bornholm Basin and Hanö Bight acute hypoxia occurred from depths exceeding 60 to 70 metres. Oxygen conditions in the eastern Gotland basin had deteriorated in the central parts, where acute hypoxia ( < 2ml/l) was found from 70 to 80 metres depth and anoxia from 125 metres. Nevertheless, in the southern parts of the eastern Gotland basin bottom water containing relatively high oxygen content was registered. In the western Gotland basin hypoxia was found from 70 metres depth and anoxia from below 80 metres depth.

The next cruise is planned for week 46 (10-17 Nov) and will cover Skagerrak, Kattegat, the Sound and the Baltic Proper.



#### PRELIMINARY RESULTS

The cruise was performed on board the Finnish research vessel Aranda, and began in Helsinki on  $20^{th}$  October and ended in the same port on the  $28^{th}$ . During the early part of the expedition winds were weak to moderate, coming mainly from east. After the first days the winds turned to westerly or south-westerly and increased to gale force. Air temperature varied between  $10\text{-}13^{\circ}\text{C}$ .

In order to get a better picture of the oxygen situation in the Eastern Gotland Basin an extra station, apart from the ordinary ones, was visited. A bottom-mounted rig with a recording oxygen sensor was deployed northeast of Öland's Southern Ground. The system will measure the oxygen level at a depth of 58 m, every 10 minutes, for about 5 months, in order to give a better picture of how fast the oxygen levels vary close to the halocline.

Two researchers from University of Helsinki took part in the expedition in order to study the formation of  $N_2O$  in hypoxic waters, where this strong greenhouse gas is formed through a denitrification process. The goal was to study the formation of  $N_2O$  following the inflow of water that took place in Feb-Mar 2014, and which oxygenated large parts of the Baltic Sea deep water – this subsequently led to widespread hypoxic conditions. In constant anoxia the accumulation of  $N_2O$  ends, which is why the current situation of hypoxia is interesting to study.

#### The Skagerrak

The thermocline was weakly developed close to the coast, while in the more central parts it was distinct and found at depths between 40 to 60 metres. Temperature in the upper layer was slightly above normal for the season, ca.13 degrees. The halocline was also weakly developed in the coastal areas, where the salinity was around 33 psu in the surface water, which is higher than normal, while it was more distinct further west, where it was found at 10-20 metres depth. Nutrient levels in the surface layer had increased slightly since the previous survey. Phosphate concentrations varied between 0.10 and 0.33  $\mu$ mol/l, silicate from 0.6 to 3.4  $\mu$ mol/l, while concentrations of inorganic nitrogen (nitrite + nitrate) ranged between 0.25 and 1.16  $\mu$ mol/l. All values normal for the season. At 15 m depth at station Å17, furthest west, a thin layer of water with extremely high nutrient concentrations was found, probably originating from the southern North Sea. Some plankton activity, based on fluorescence measurements, was recorded in the central regions, while the activity was low near the coast. The lowest oxygen value encountered in the bottom water was found at station Släggö, in the mouth of the Gullmar fjord, at 3 ml/l.

#### The Kattegat and the Sound

The thermocline was located at a depth of about 15 metres, but was very weak. Temperature in the surface layer was slightly above normal, about  $12.5^{\circ}$ C. Surface salinity was normal, ca. 22 psu, in Kattegat and 17.5 psu in the Sound. The halocline was found at 15 metres depth in the Kattegat and at 7 metres in the Sound. Nutrients showed normal concentrations for the season, phosphate between 0.13 and 0.18  $\mu$ mol/l, nitrite + nitrate from below detection limit (< 0.10  $\mu$ mol/l) to 0.17  $\mu$ mol/l, and silicate in the range of 1.9 to 3.3  $\mu$ mol/l. In the Sound levels were generally higher, phosphate was at 0.42  $\mu$ mol/l and silicate at 11  $\mu$ mol/l. Fluorescence measurements indicated some plankton activity in the surface layer in the whole area. Oxygen concentrations in the bottom water were typical for the season and varied between 2.8 and 4.1 ml/l, lowest in the Sound.



#### The Baltic Proper

The water temperatures were above normal in the whole area, varying from 11.4 to  $14.3^{\circ}$ C, and the thermocline was found at 30 metres depth. The salinity in the surface layer was normal in the major part of the area, at between 6.5 and 7.9 psu. In the Eastern Gotland Basin, however, surface salinity was clearly below normal, ca. 6.6 psu. The halocline was found at depths between 60 and 70 metres in the western and eastern Gotland Basins, while it was shallower located, between 35 and 50 metres, in the southern parts. All nutrients in the surface layer showed normal values for the season, silicate between 9 -  $12 \mu mol/l$ , phosphate in the interval 0.15 to  $0.30 \mu mol/l$ , while inorganic nitrogen (nitrite + nitrate) varied from below detection limit up to  $0.6 \mu mol/l$ , highest in the Western Gotland Basin.

Effects of the inflow (25 km³) through the Sound that occurred in August were still obvious in the southern parts. In addition, during September and October two new inflows of ~20 km3 and ~8 km3 were registered through the Sound. The Arkona Basin was now well oxygenated, while acute hypoxia was present in the Bornholm Basin and Hanö Bight, at depths exceeding 60-70 metres. In the northern and central parts of the Eastern Gotland Basin acute hypoxia occurred from 70 - 80 metres, and hydrogen sulphide was found at depths exceeding 125-135 metres. In the southern parts of the basin (BY10 and BY9 W) an oxygen minimum (~1 ml/l) was detected at 90 to 100 metres, while oxygen concentrations close to the bottom, at 143 and 124 metres respectively, were about 2 ml/l. At station BCSIII-10 in the southeast an oxygen minimum (0.6 ml/l) was encountered at 80 metres, while at 90 metres depth the concentration was 2.4 ml/l.

In the western Gotland basin the oxygen situation was severe, as acute hypoxia was found from depths exceeding 70 metres and hydrogen sulphide from below 80 to 90 metres depths.

#### **PARTICIPANTS**

	Institute		
Chief Scientist	SMHI		
Quality responsible	SMHI		
Daniel Bergman-Sjöstrand			
	SMHI		
(Lysekil – Helsingfors)	SMHI		
(Helsingfors – Lysekil)	SMHI		
(Lysekil – Helsingfors)	SMHI		
	SMHI		
	University of Helsinki		
	University of Helsinki		
	Quality responsible d (Lysekil – Helsingfors) (Helsingfors – Lysekil)		

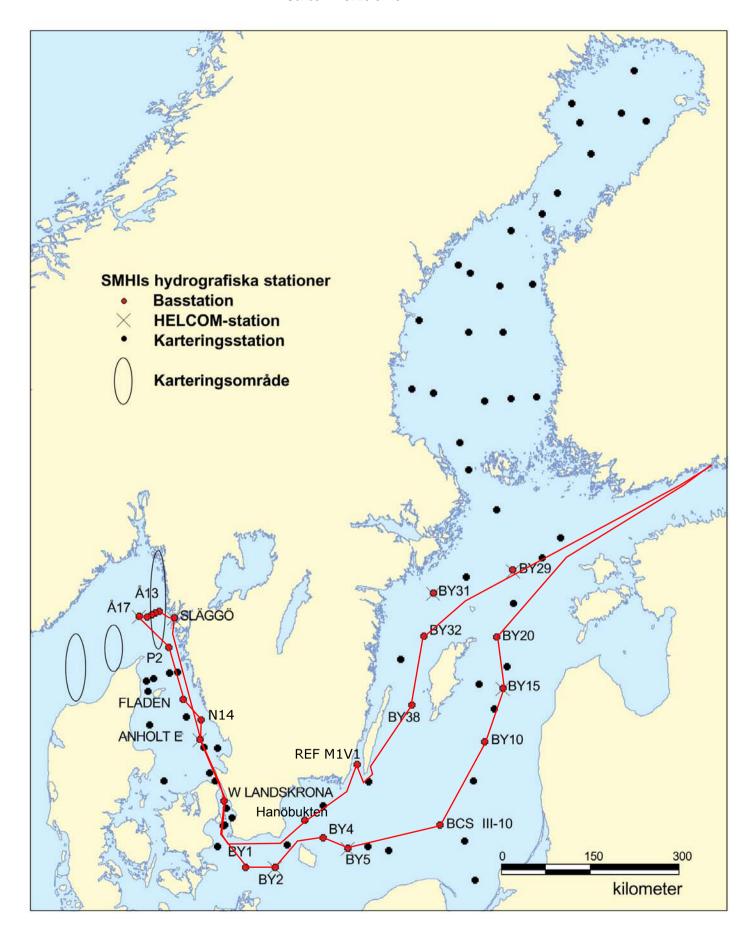
#### **APPENDICES**

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

TRACKCHART

Country: Sweden
Ship: R/V ARANDA
Date: 20141020-20141028

Series: 0720-0746



SMHI	****	Hydrographic	Ship: 01-Aranda	****	Date: 2014-10-27
Ocean enh	****	series	Year: 2014	*****	Time: 14:05

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							hd PrP l n l si
0720 BPEX26BAS BY20 FÅRÖDJ	N5800 E1953	20141021 0520			03 4		2730 xx 17 x x - x x x x x x x x - x x
0721 BPEX21BAS BY15 GOTLANDSDJ	N5720 E2003	20141021 1030		11	08 3		2740 x -xxxx 19 x x x x x x x x x x x x x x x
0722 BPEX21EXT BY15 GOTLANDSDJ	N5720 E2003	20141021 1215		11	08 3		2740 x 5 x x - x x x x x x x x - x
0723 BPEX13BAS BY10	N5638 E1935	20141021 1730			12 9		9990 xx 15 x x - x x x x x x x x - x x
0724 BPSE00BAS BY9W	N5607.20 E1901.00				11 12		9990 x 14 x x - x x
0725 BPSE11BAS BCS III-10	N5533.3 E1824	20141022 0350			13 10		9990 xxx 12 x x - x - x x x x x x - x x
0726 BPSB07BAS BY5 BORNHOLMSDJ	N5515 E1559	20141022 1230		9	09 10		2840 x -xxxx 12 x x x x - x x x x x x x x x x
0727 BPSB06BAS BY4 CHRISTIANSÖ	N5523 E1520	20141022 1605			07 11		9990 xx 12 x x - x - x x x x x x - x
0728 BPSA03BAS BY2 ARKONA	N5500 E1405	20141022 2300			07 9		9990 xxxx 8 x x - x - x x x x x x - x x x
0729 BPSA02BAS BY1	N5500 E1318	20141023 0325			09 8		9990 xx 8 x x - x - x x x x x x - x -
0730 SOCX39BAS W LANDSKRONA	N5552.0 E1245.0	20141023 0945		4.5	14 10		2830 xx 9 x x - x - x x x x x x - x -
0731 KAEX29BAS ANHOLT E	N5640.0 E1207.0	20141023 1440		7	16 14		2840 x -xxx 10 x x x x - x x x x x x x x x x
0732 KANX50BAS N14 FALKENBERG	N5656.40 E1212.70				15 16		9990 x -xxx 7 x x x x - x x x x x x x x
0733 KANX25BAS FLADEN	N5711.5 E1140	20141023 2050			18 15		9990 xx 12 x x - x - x x x x x x - x
0734 SKEX23BAS P2	N5752 E1118	20141024 0100			19 15		9990 xx 10 x x - x - x x x x x x - x
0735 SKEX18BAS Å17	N5816.5 E1030.8	20141024 0540			19 14		4850 xxx 14 x x x x - x x x x x x x x x
0736 SKEX17BAS Å16	N5816 E1043.5	20141024 0720			14 17		2850 x 13
0737 SKEX16BAS Å15	N5817.7 E1051	20141024 0835			18 16		5850 xx 12 x x - x - x x x x x x - x
0738 SKEX15BAS Å14	N5819 E1056.5	20141024 0935			17 16		5850 x 11
0739 SKEX14BAS Å13	N5820.2 E1102	20141024 1040			18 15		2850 xx 10 x x - x - x x x x x x - x
0740 FIBG27BAS SLÄGGÖ	N5815.5 E1126.0	20141024 1245			17 11		2820 xxxx 9 x x - x - x x x x x x - x -
0741 KAEX29BAS ANHOLT E	N5640.0 E1207.0	20141025 0540			20 14		9990 x -xxx 10 x x x x - x x x x x x x x x x
0742 BPSH05BAS HANÖBUKTEN	N5537 E1452	20141025 2320			24 9		9990 xx 11 x x - x - x x x x x x - x -
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0744 BPWX00EXT 4.5 NO BY39	N5610.06 E1638.64				23 10		1240 x 8 x
0745 BPWX45BAS BY38 KARLSÖDJ	N5707 E1740	20141026 1900			22 15		9990 xx 14 x x - x x x x x x x x - x x
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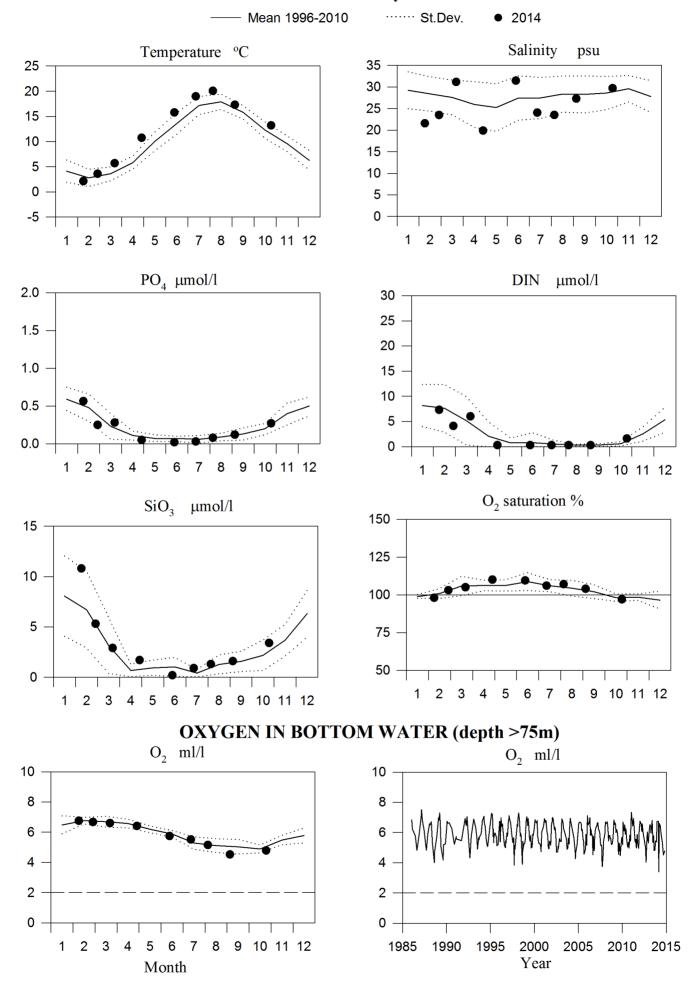
### Bottom water oxygen concentration (ml/1)

Country: Finland

Ship : Aranda
Date : 20141021-20141027
Series : 0720-0746

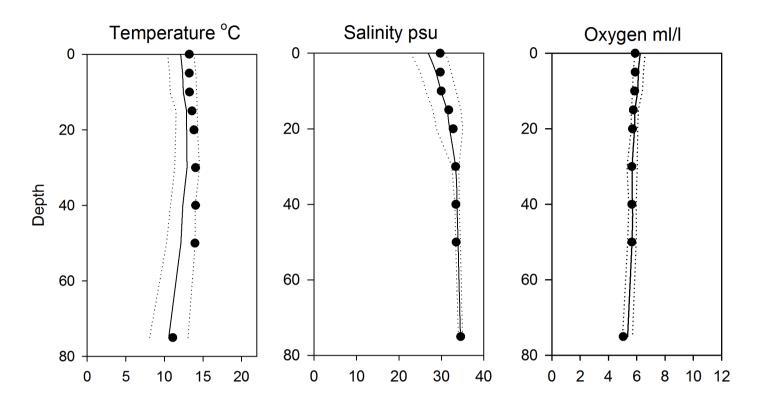


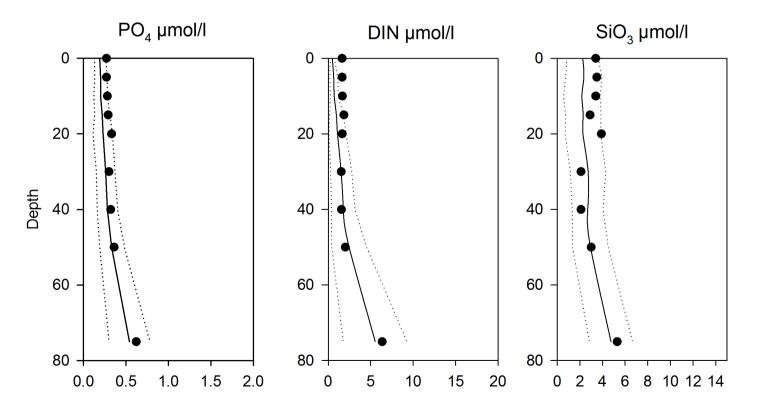
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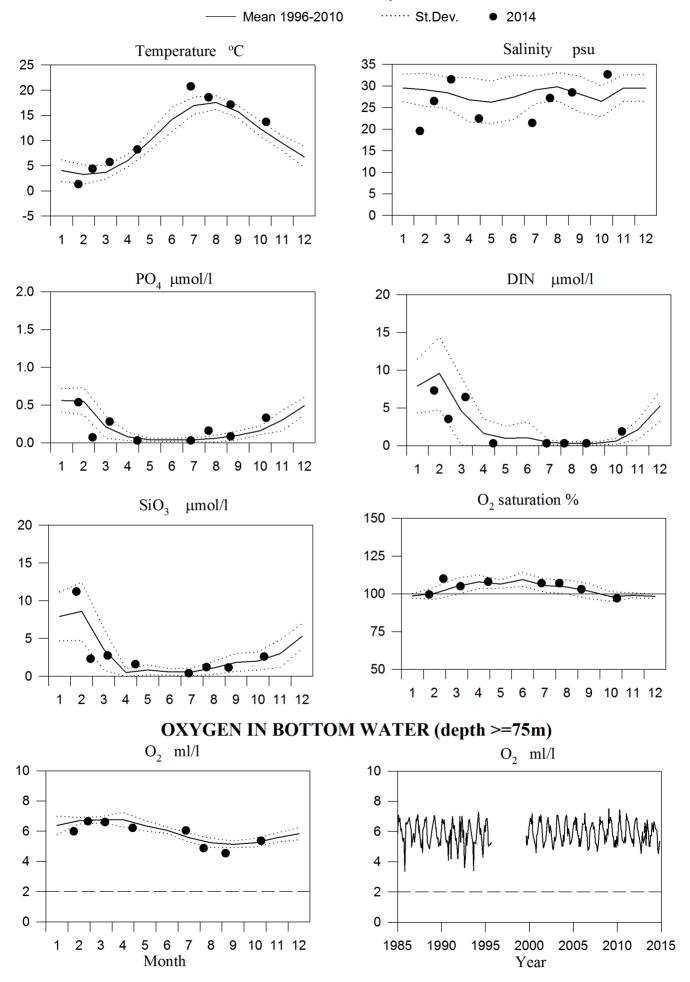
# Vertical profiles P2 October

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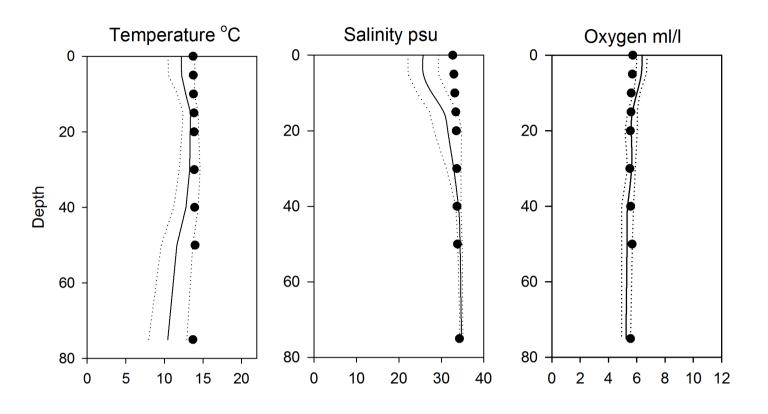


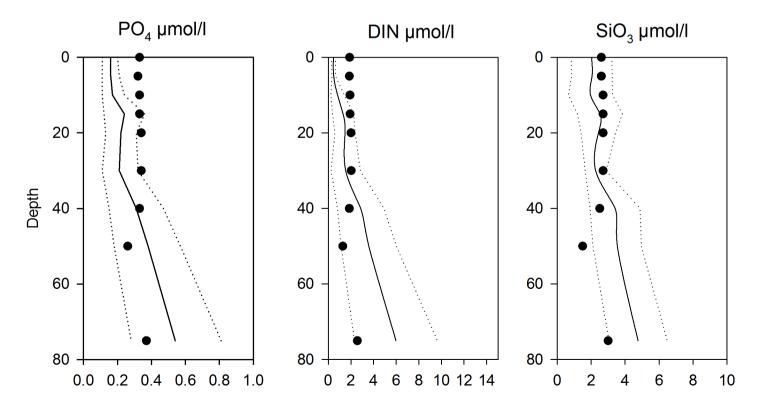
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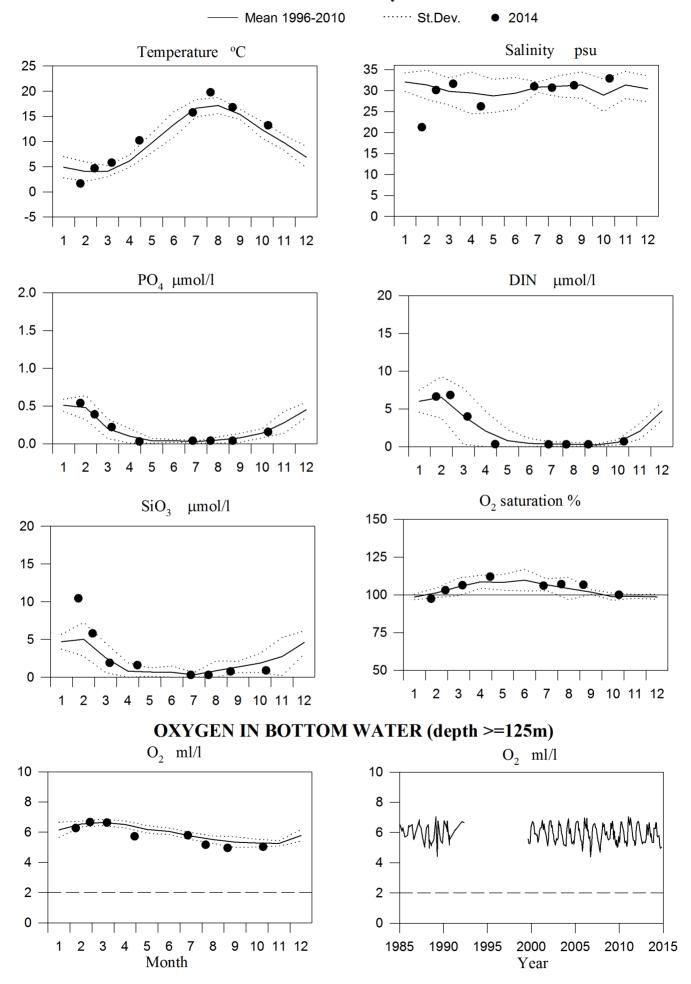
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——— Mean 1996-2010 St.Dev. ● 2014



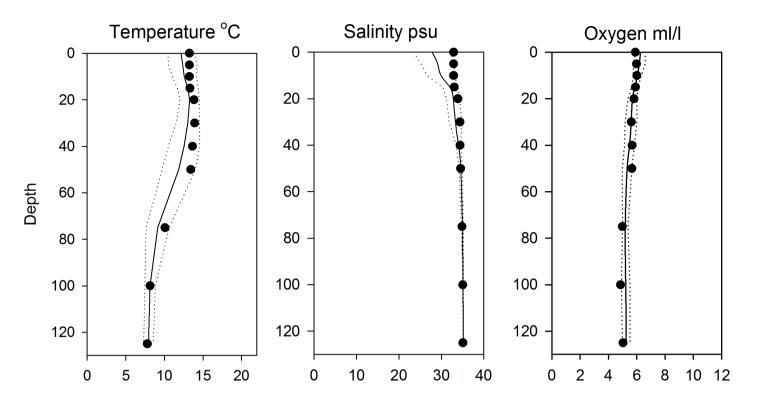


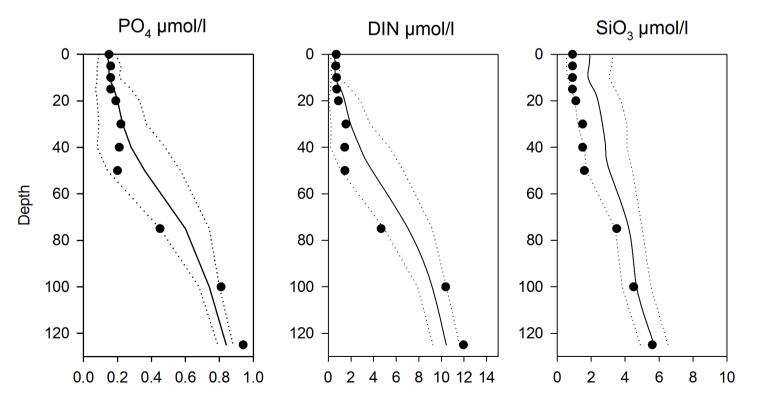
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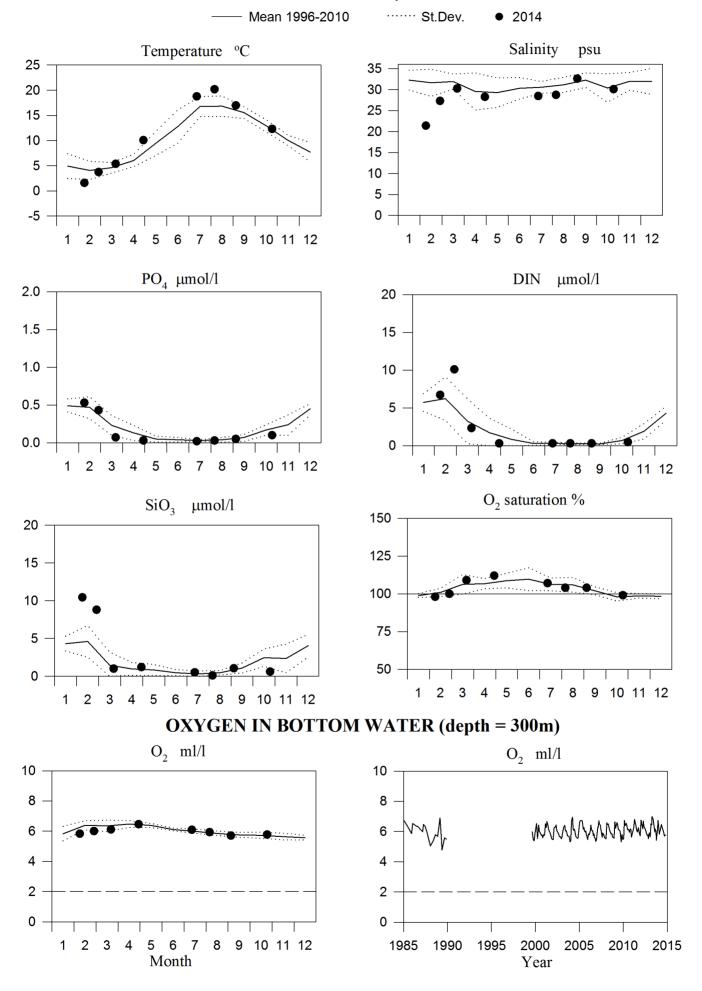
# Vertical profiles Å15 October

——— Mean 1996-2010 St.Dev. ● 2014



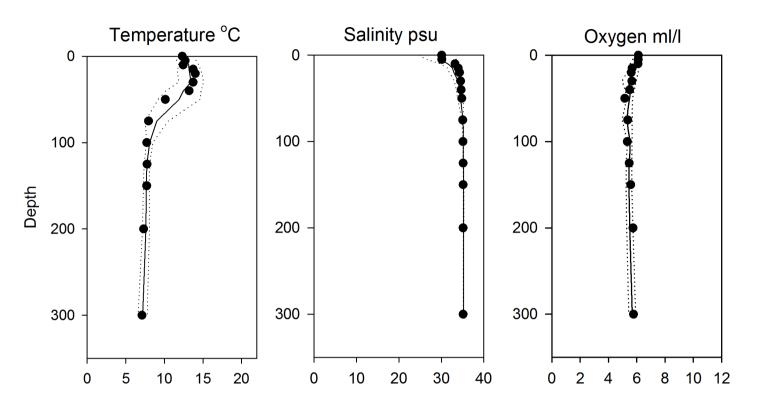


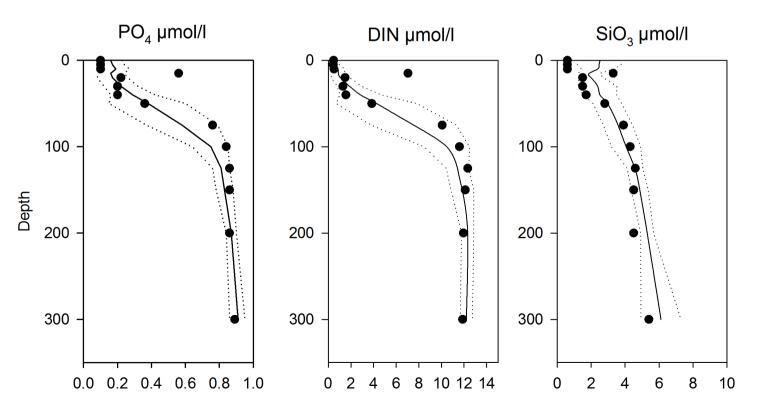
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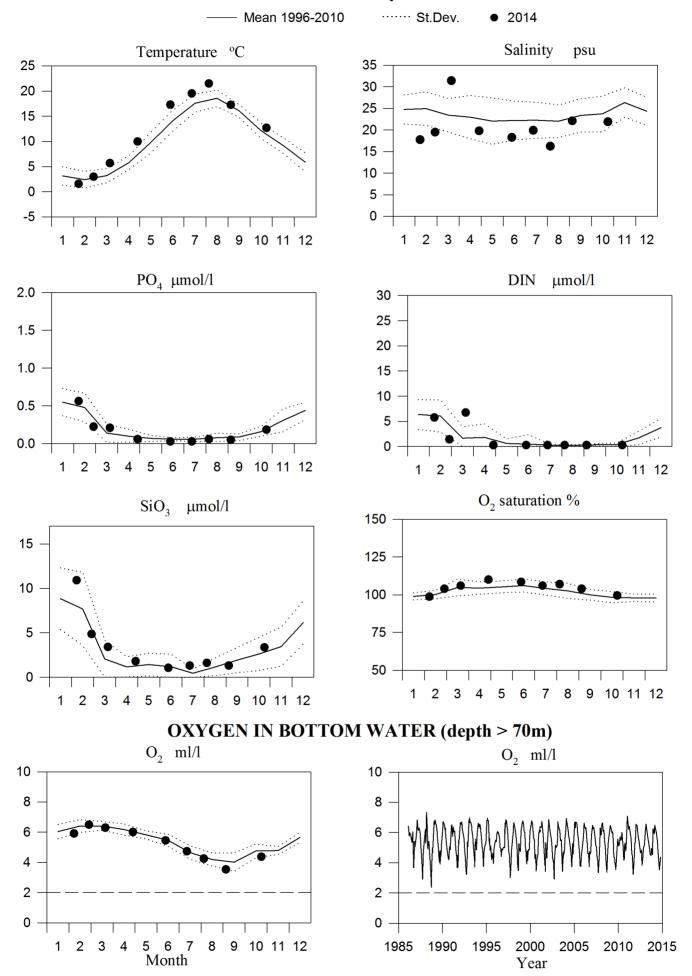
# Vertical profiles Å17 October

—— Mean 1996-2010 St.Dev. ● 2014



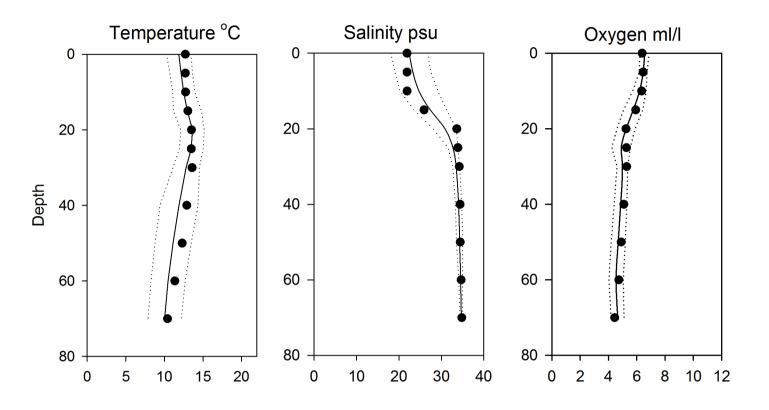


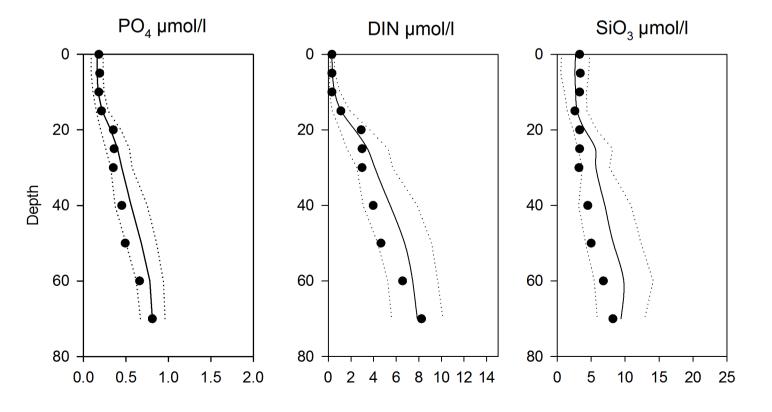
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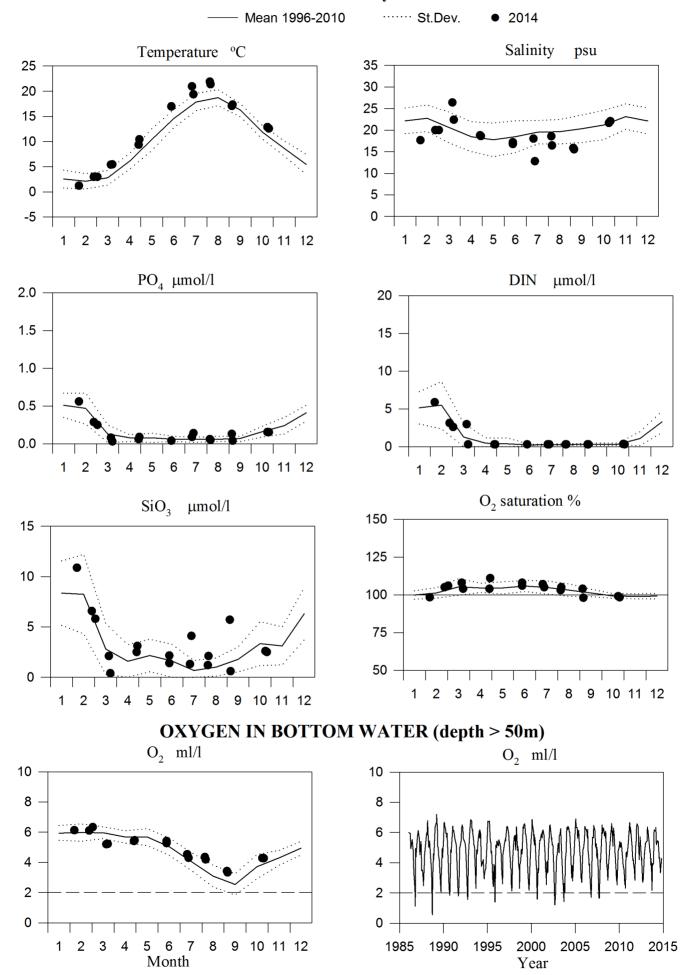
# Vertical profiles Fladen October

—— Mean 1996-2010 St.Dev. ● 2014



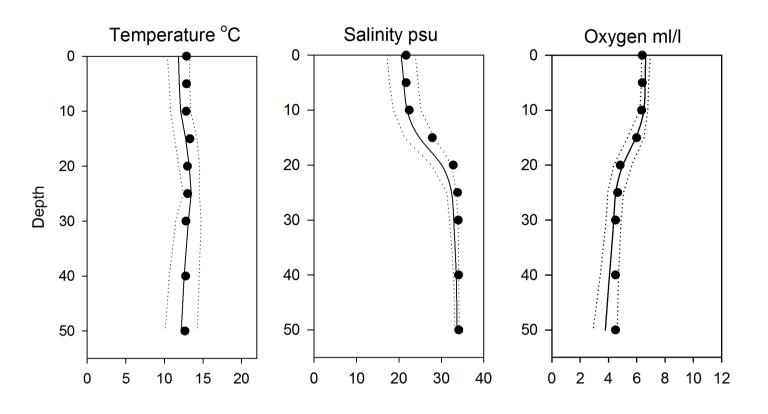


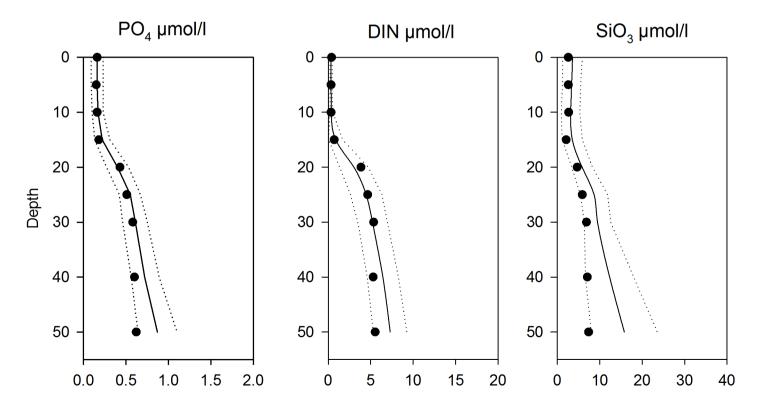
### STATION ANHOLT E SURFACE WATER



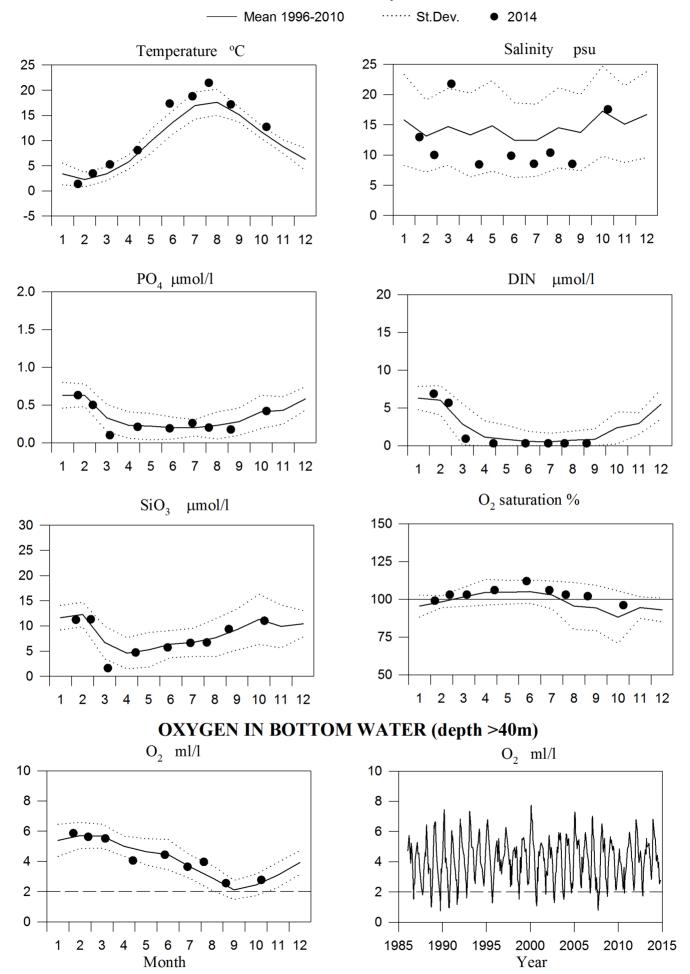
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—— Mean 1996-2010 St.Dev. ● 2014



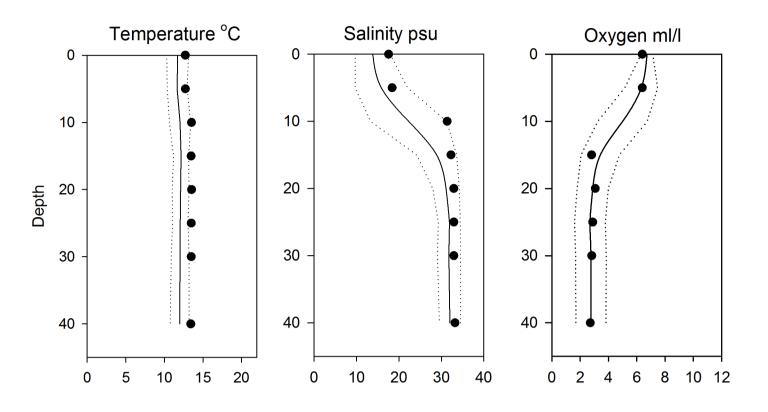


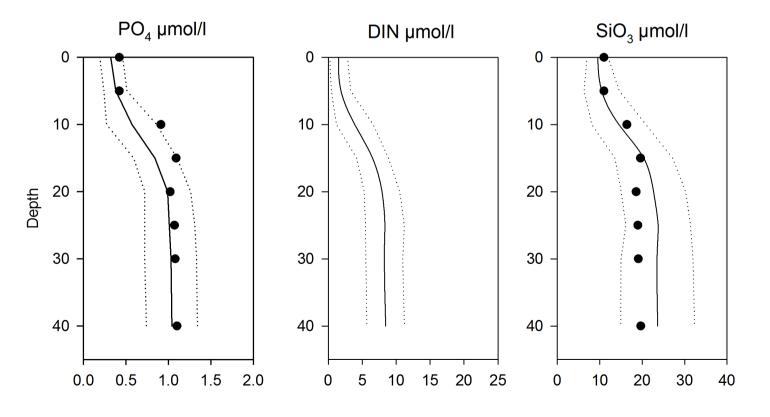
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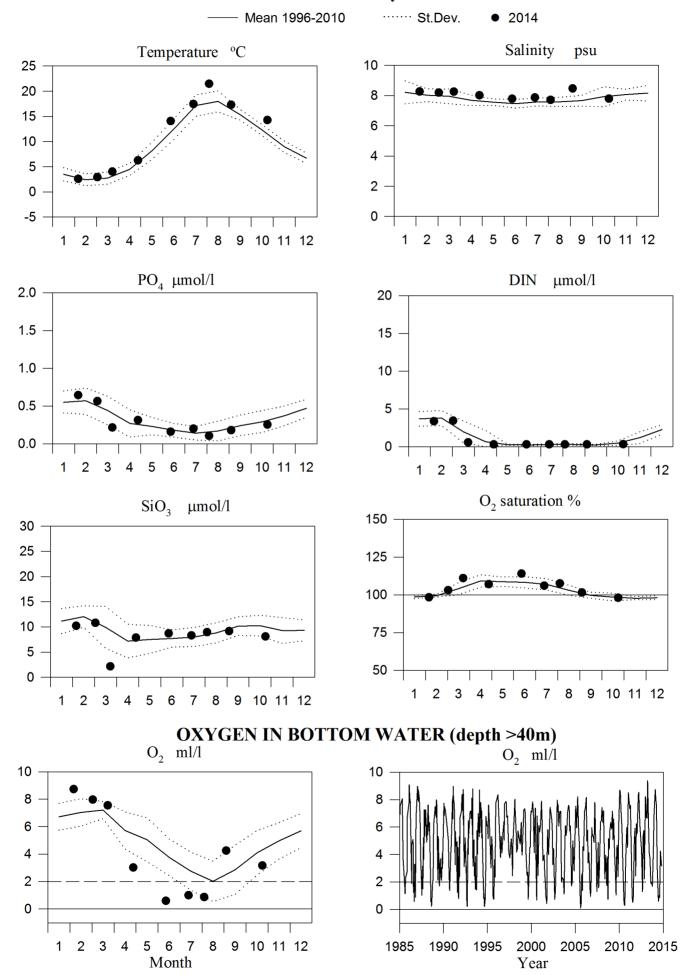
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—— Mean 1996-2010 St.Dev. ● 2014

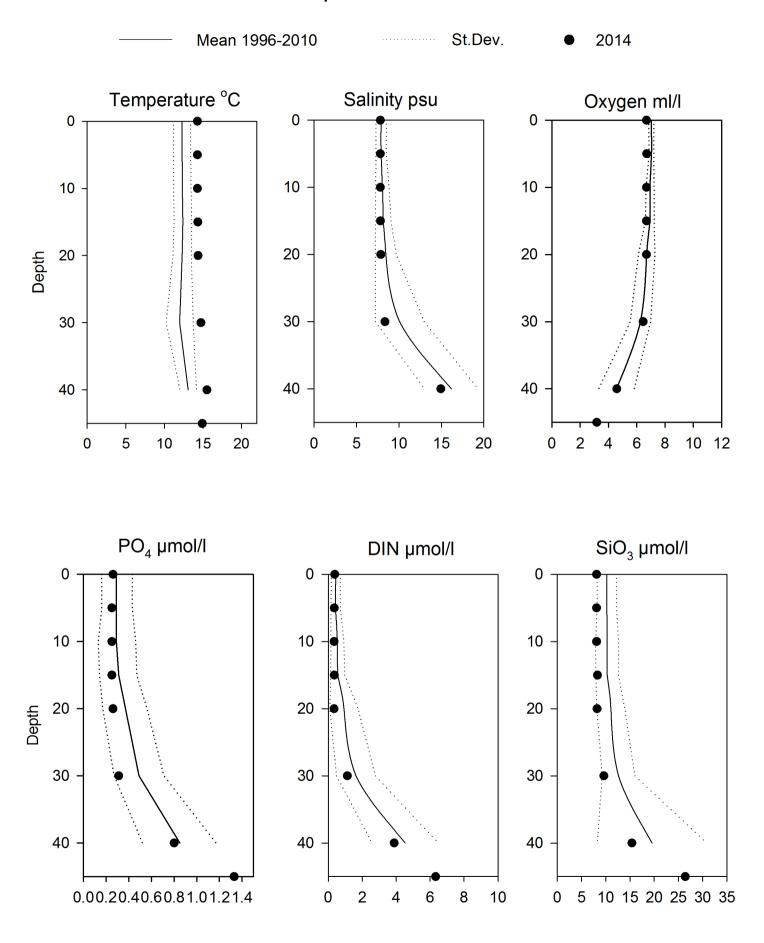




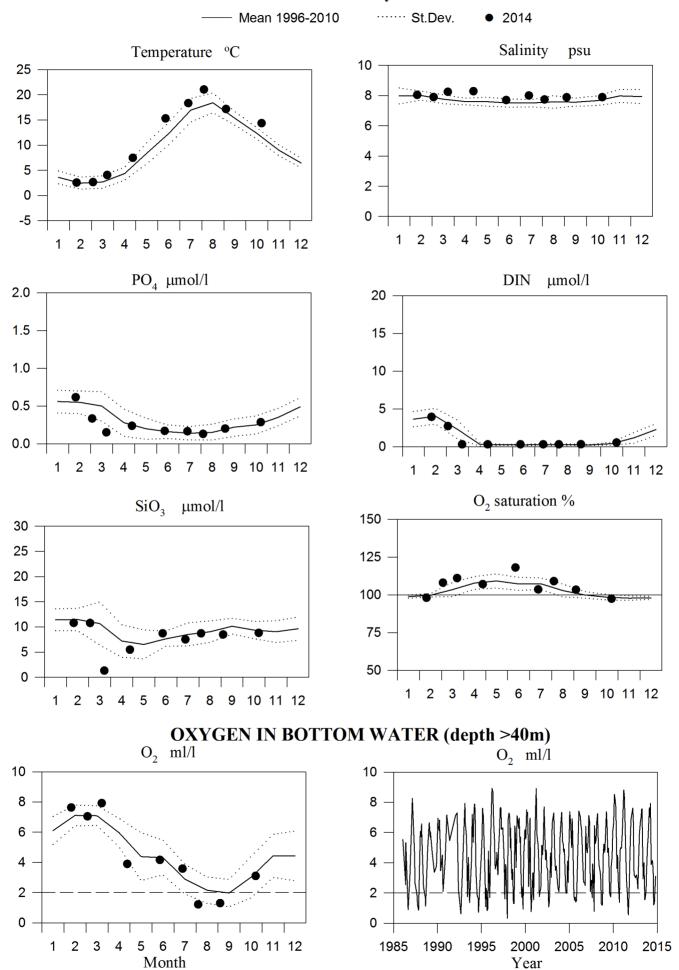
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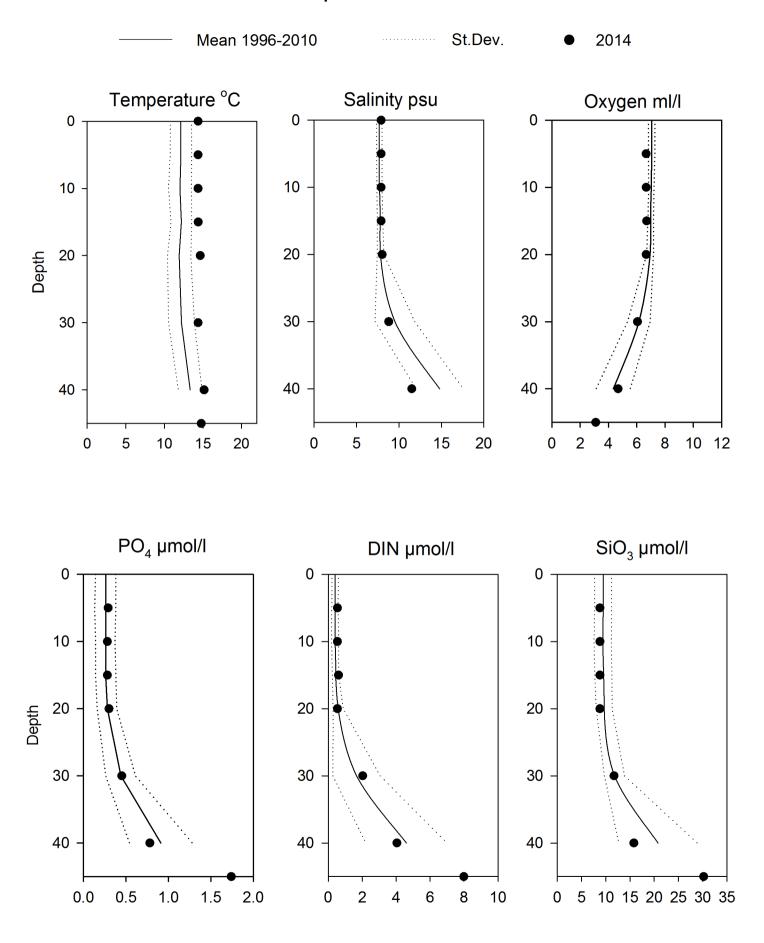
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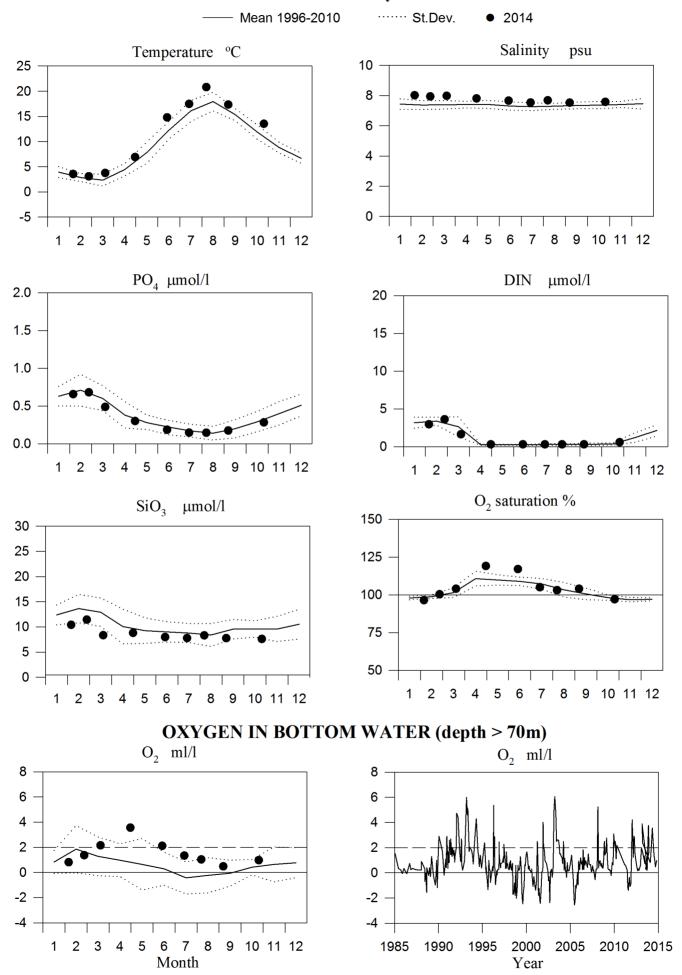
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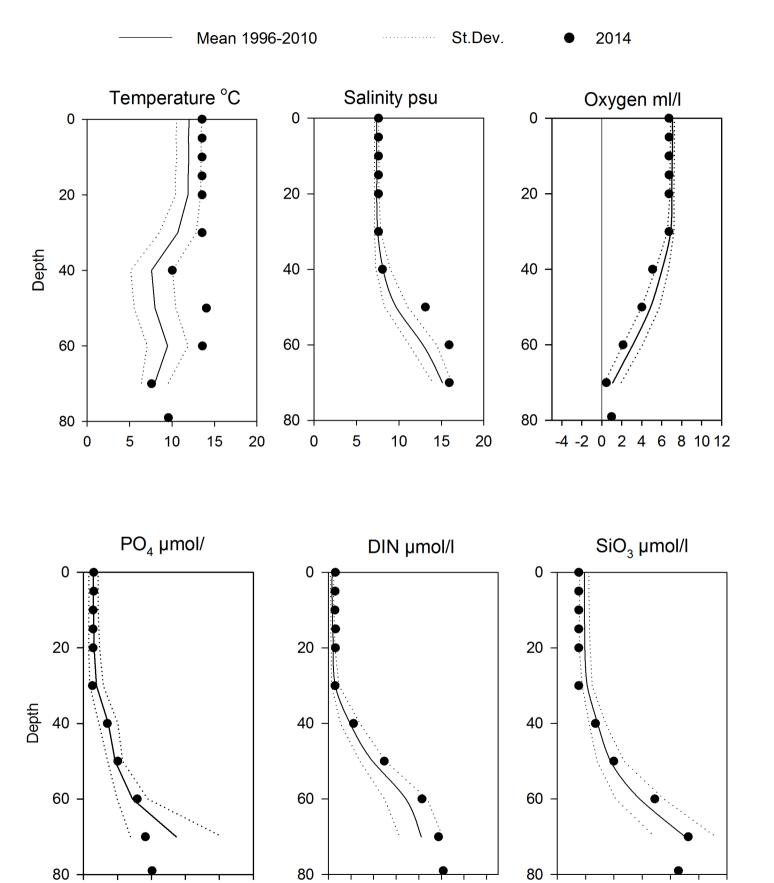
# Vertical profiles BY2 October



### STATION HANÖBUKTEN SURFACE WATER



### Vertical profiles Hanöbukten October

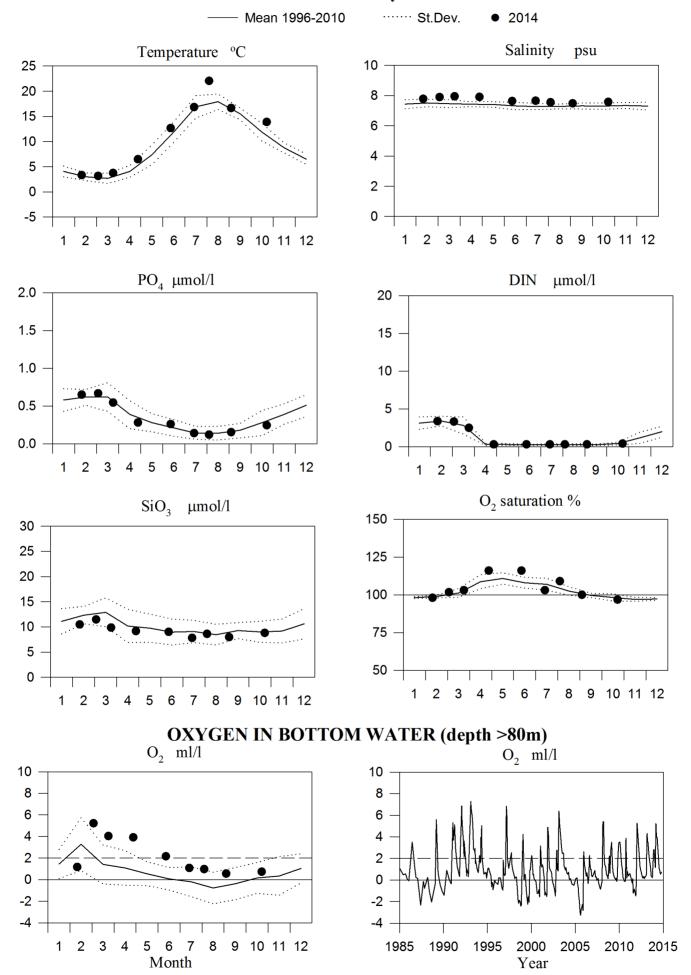


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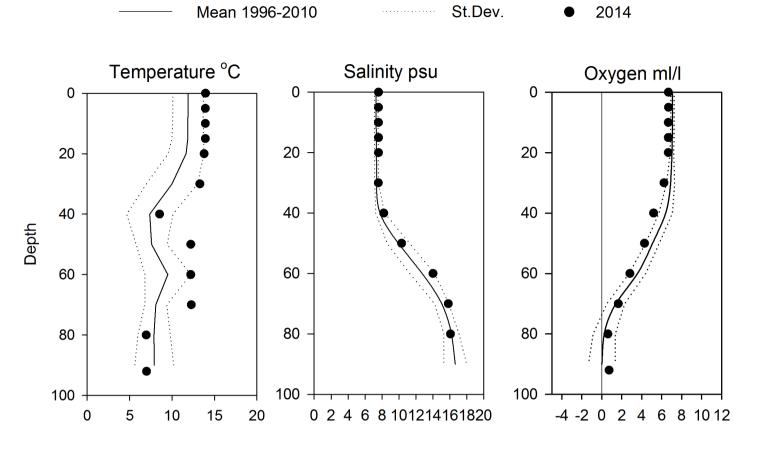
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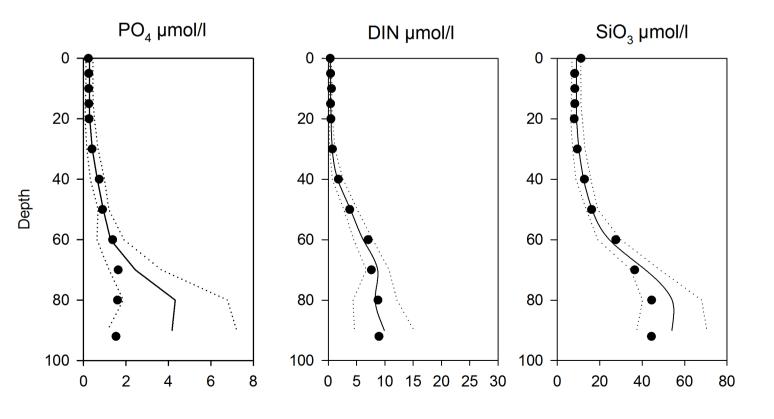
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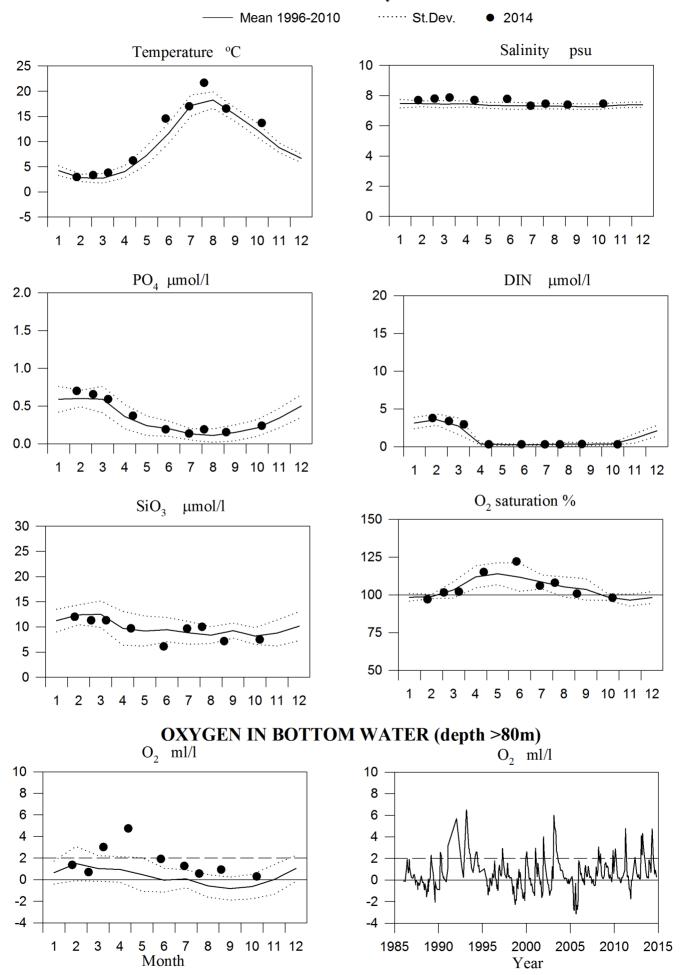


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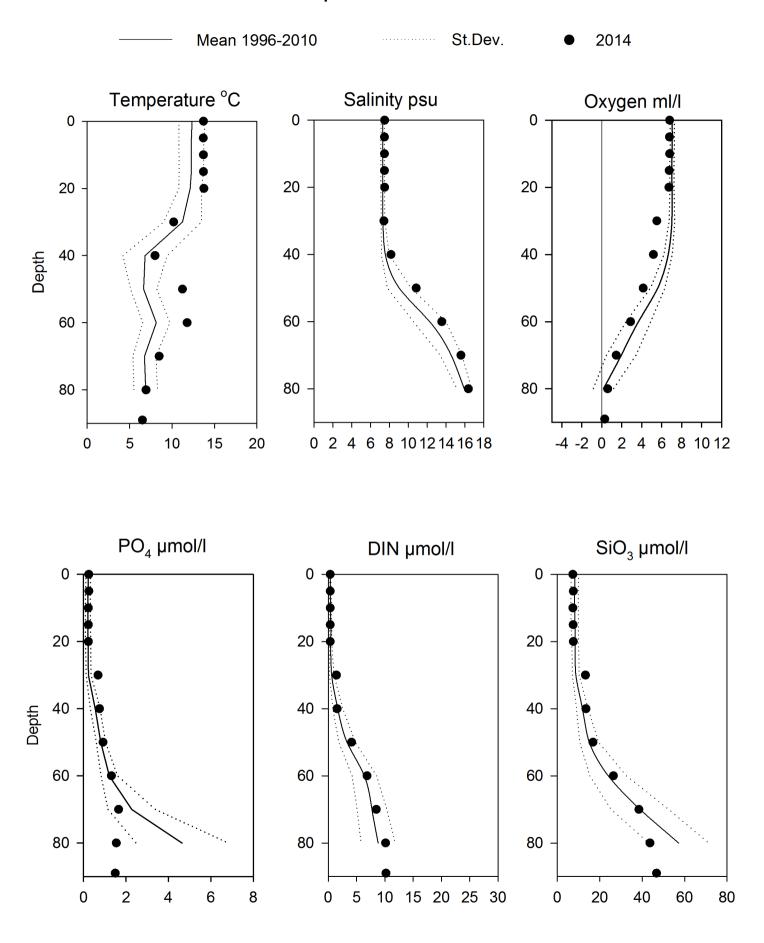




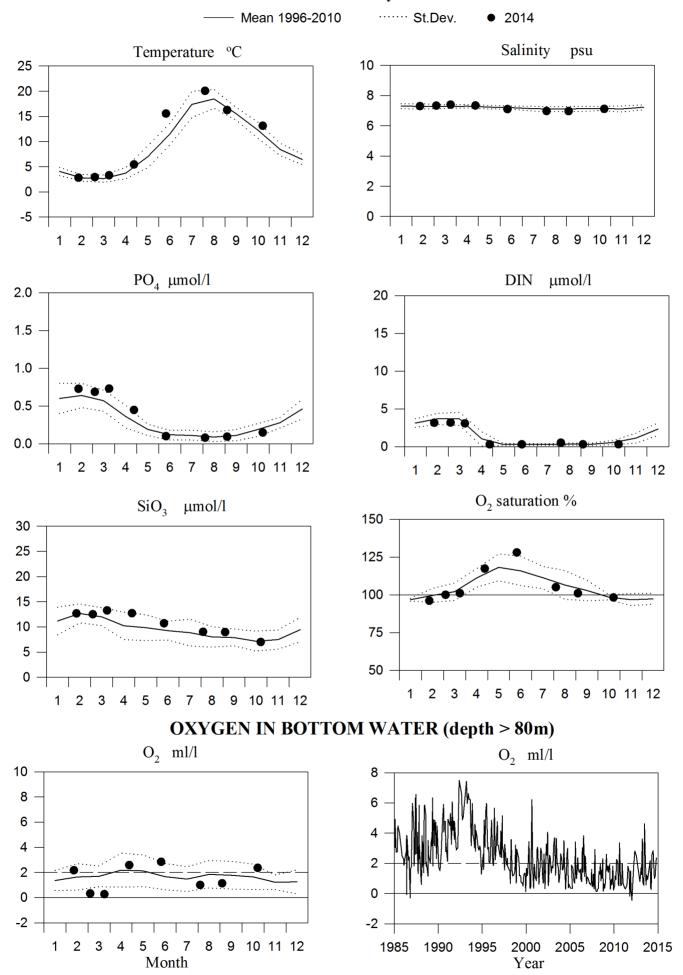
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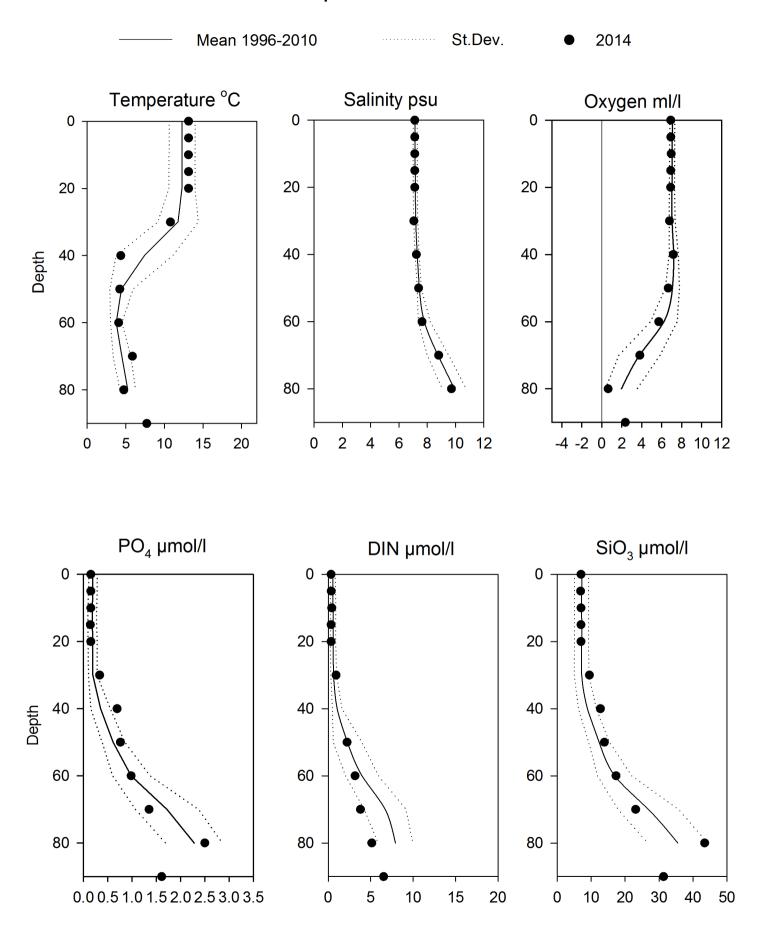
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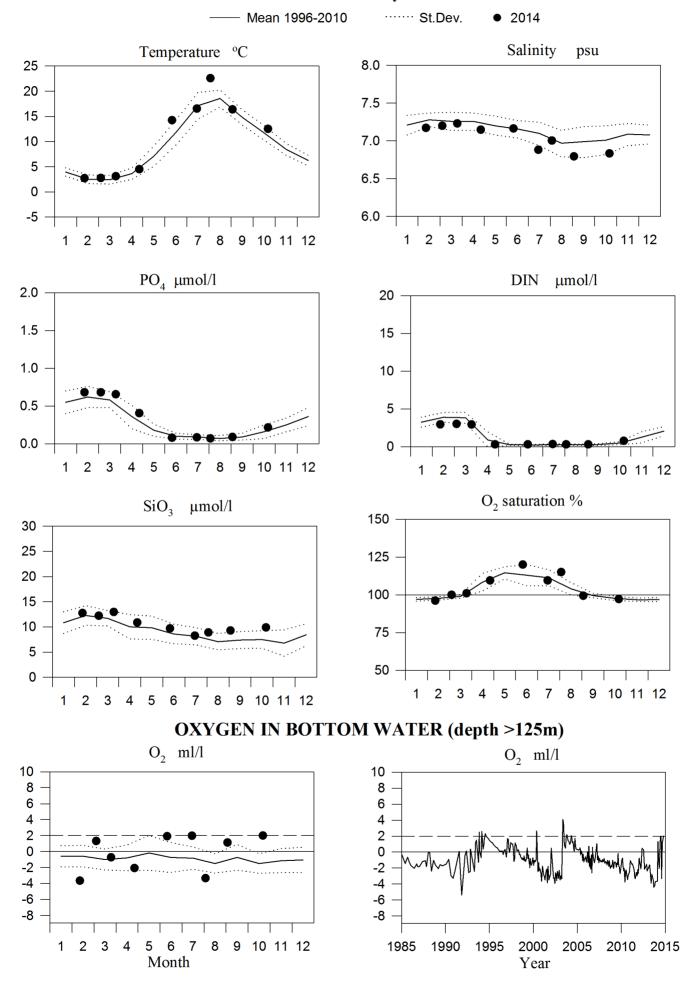
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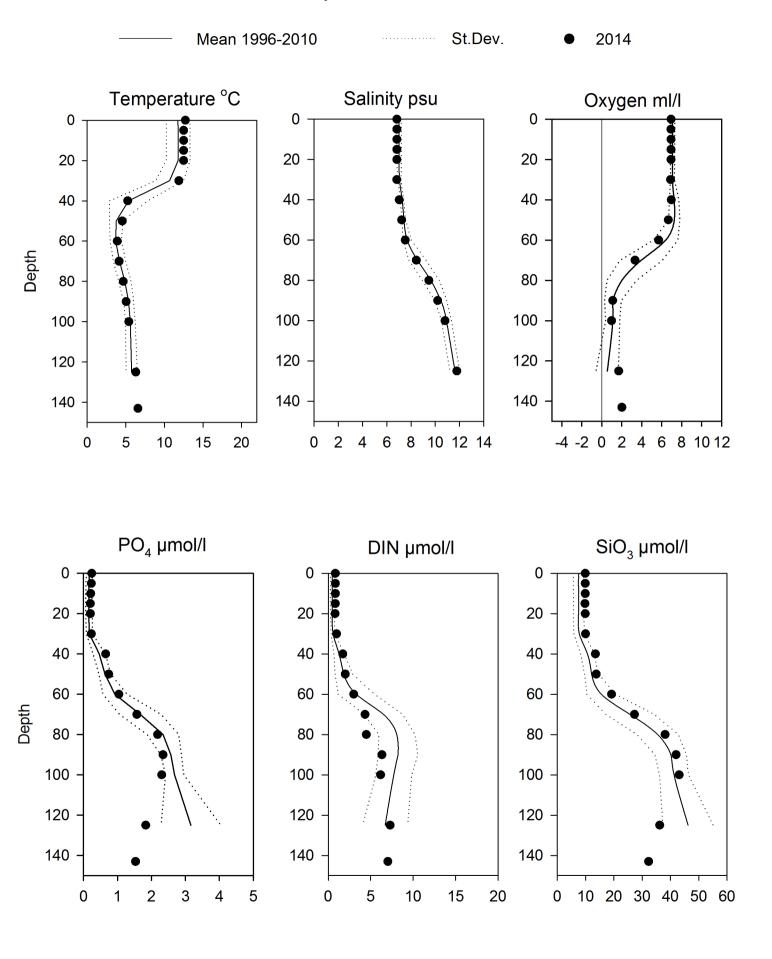
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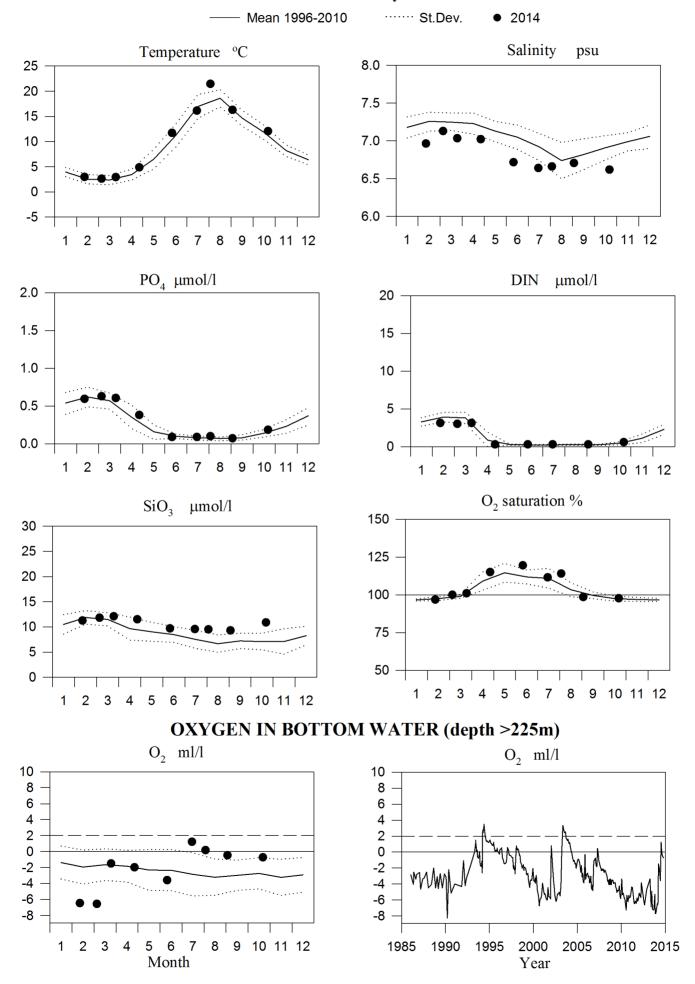
### STATION BY10 SURFACE WATER



### Vertical profiles BY10 October



### STATION BY15 SURFACE WATER

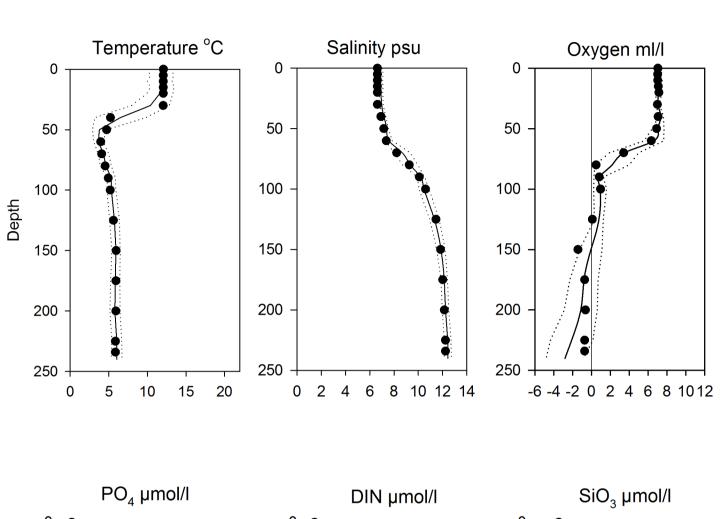


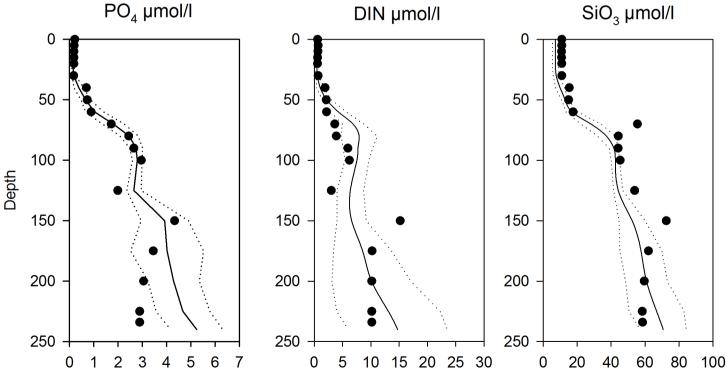
### Vertical profiles BY15 October

St.Dev.

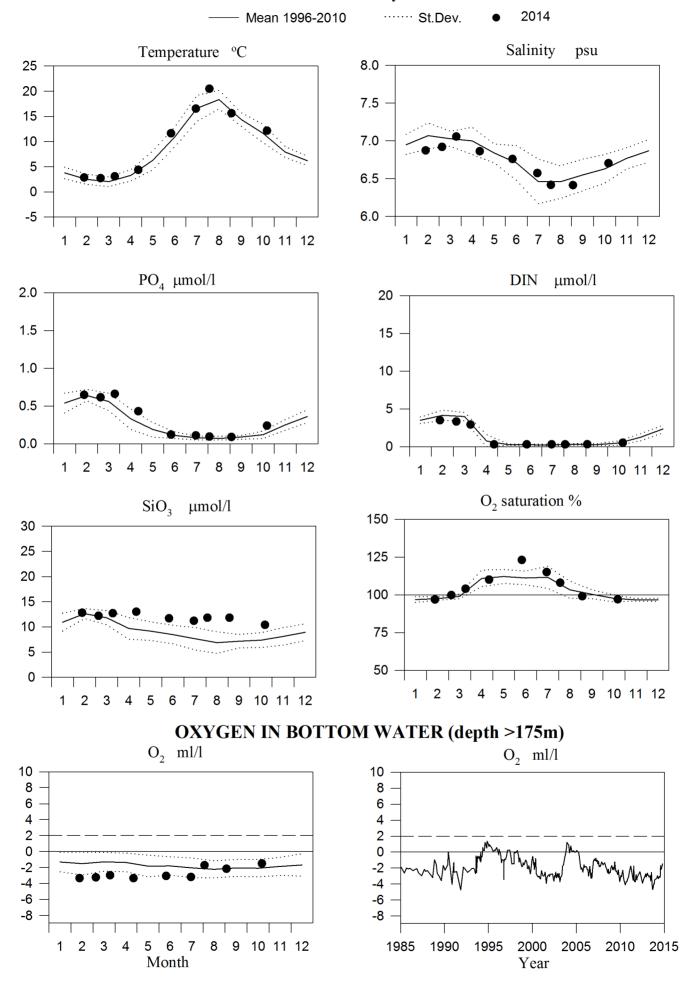
2014

Mean 1996-2010

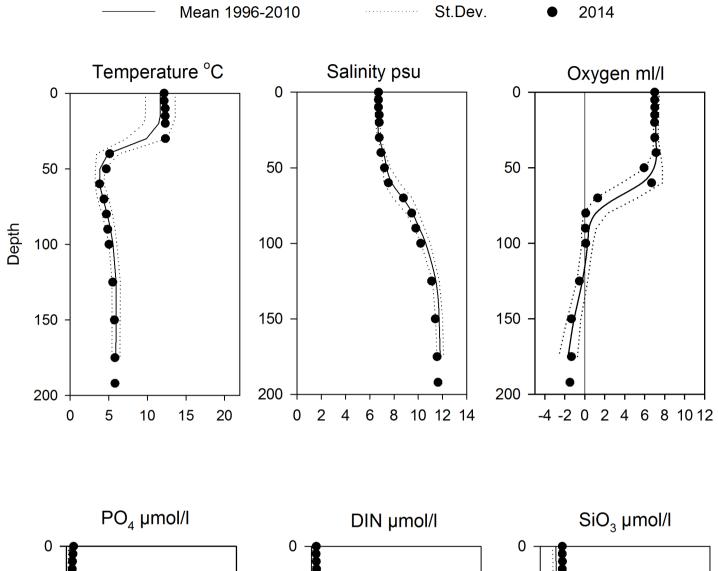


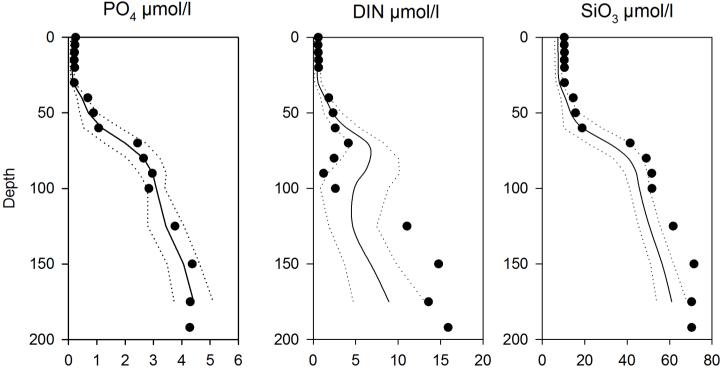


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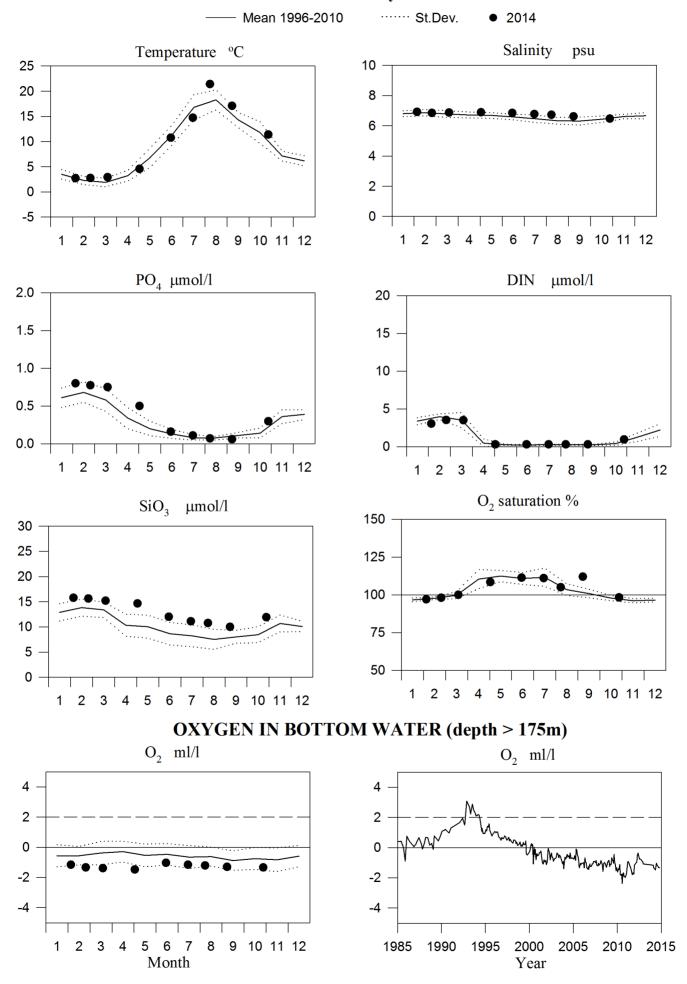


## Vertical profiles BY20 October

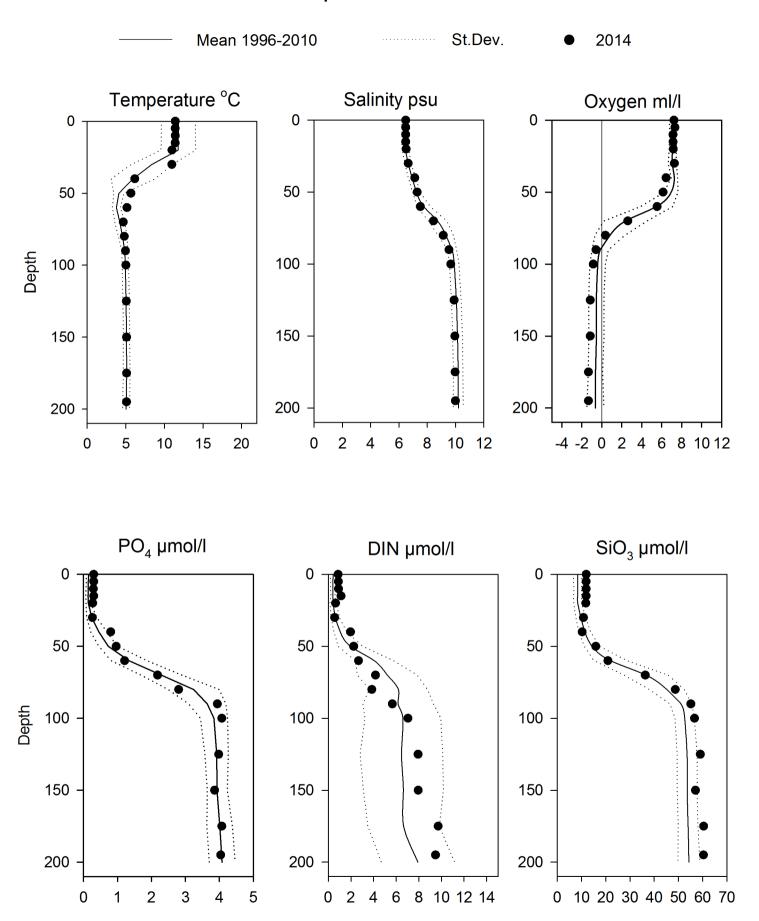




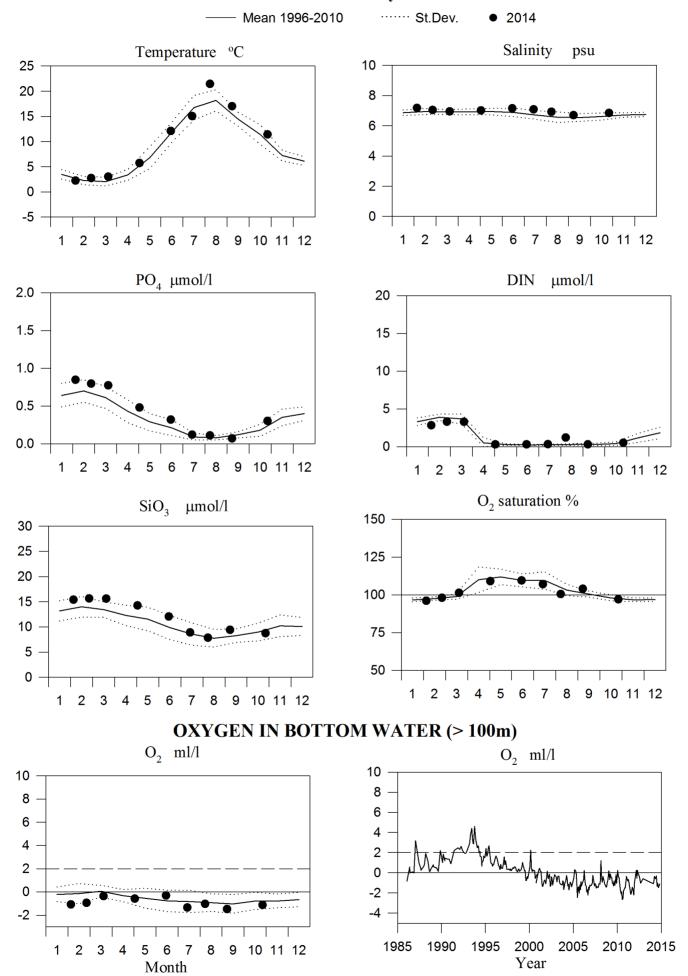
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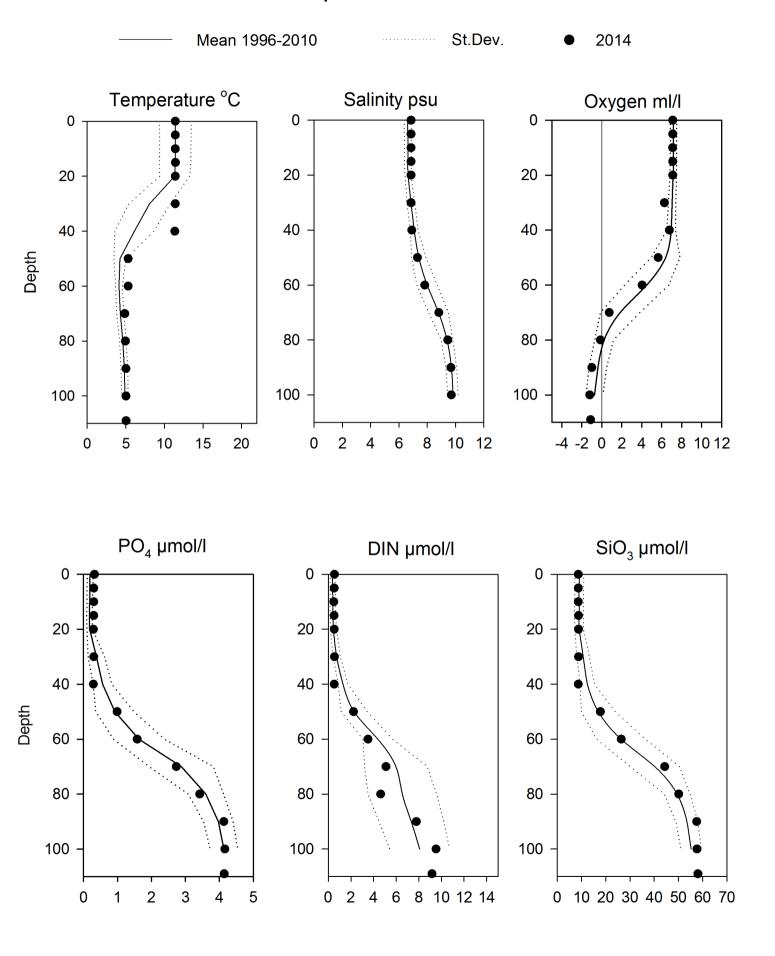
## Vertical profiles BY32 October



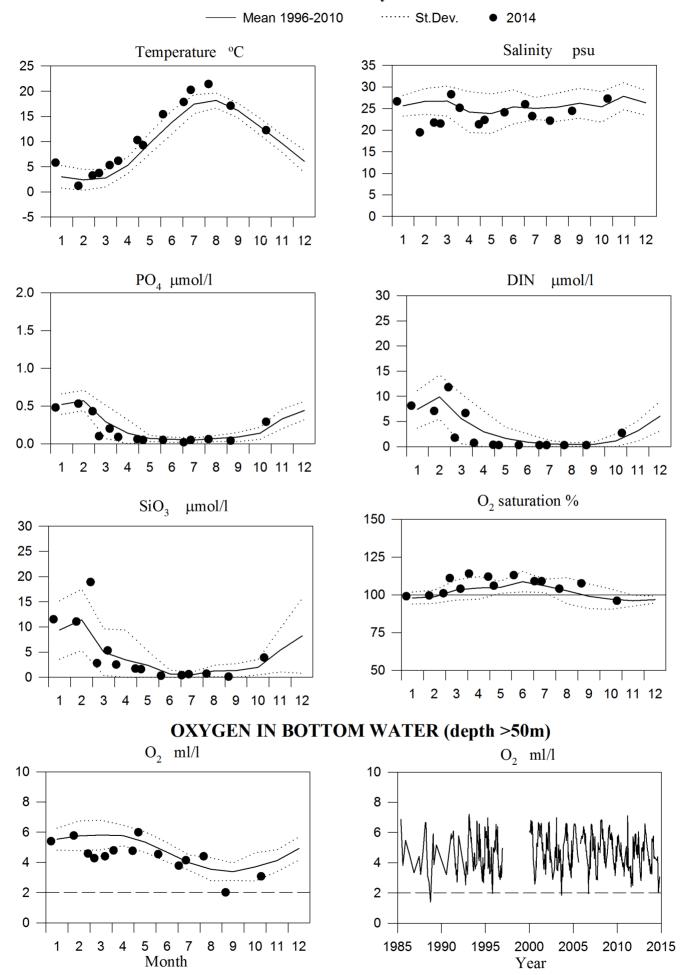
### STATION BY38 SURFACE WATER



## Vertical profiles BY38 October

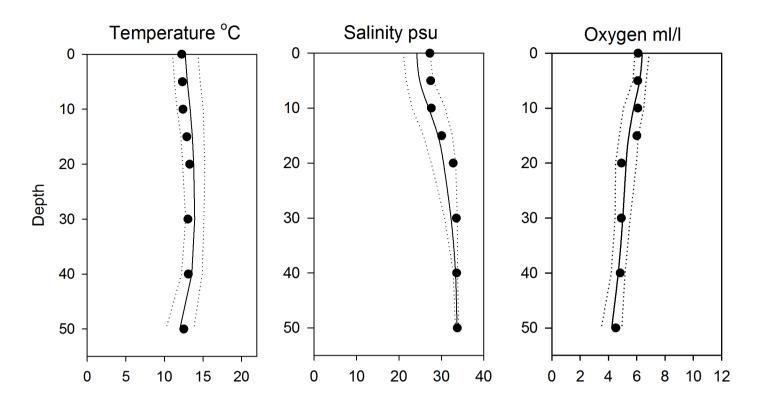


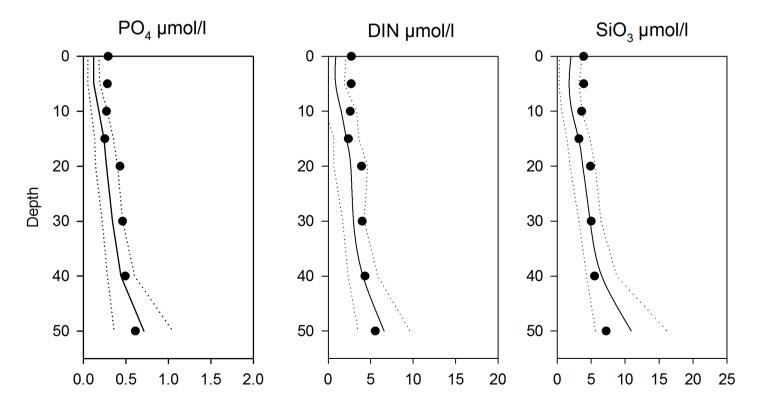
## STATION SLÄGGÖ SURFACE WATER



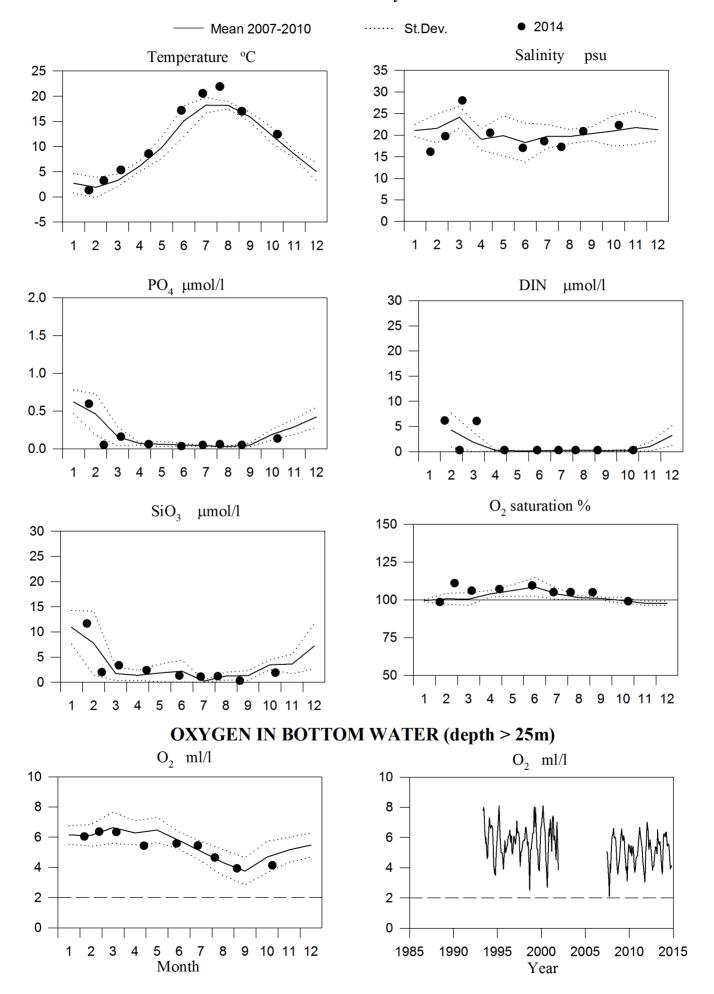
# Vertical profiles Släggö October

—— Mean 1996-2010 St.Dev. ● 2014



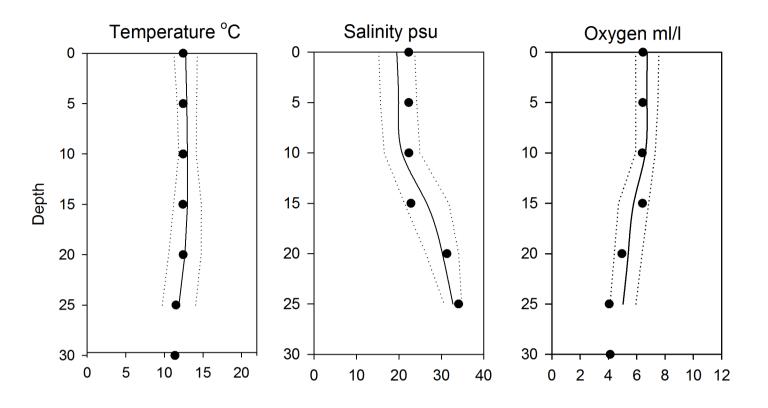


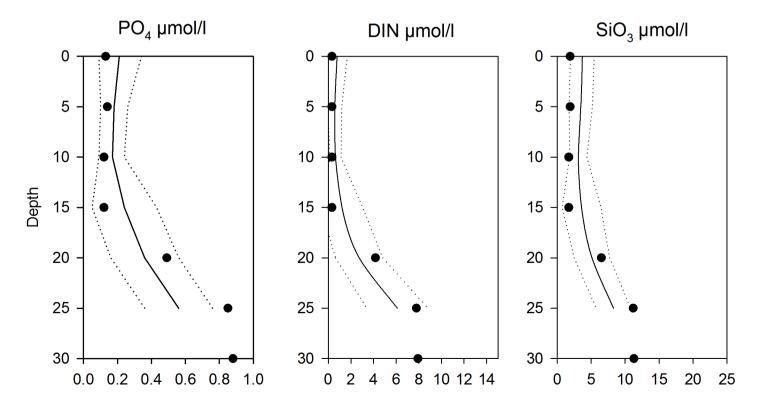
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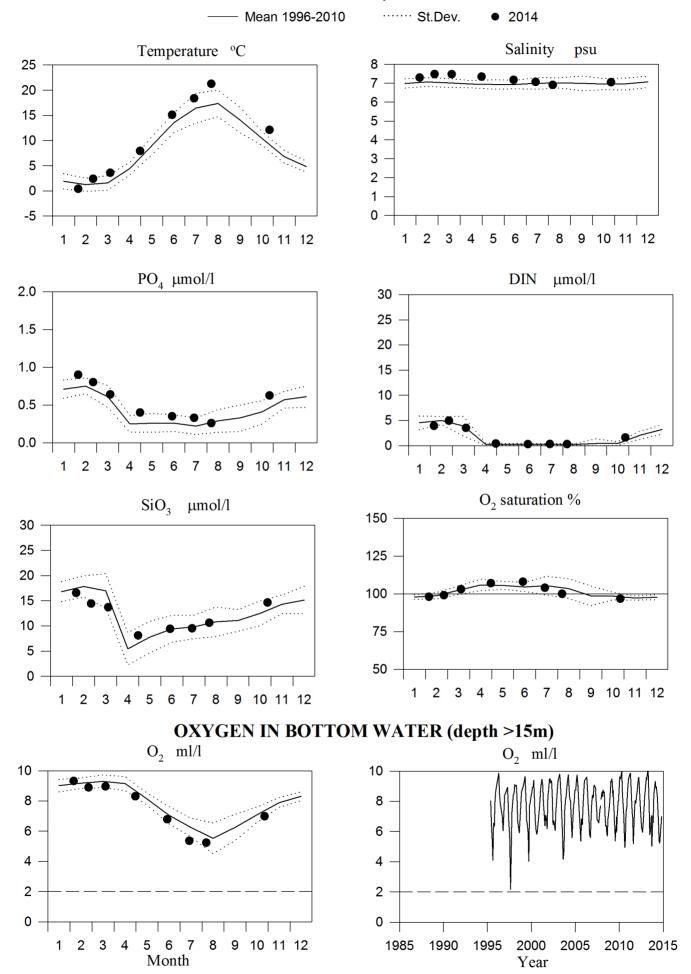
## Vertical profiles N14 Falkenberg October

—— Mean 1996-2010 St.Dev. ● 2014





### STATION REF M1V1 SURFACE WATER



## Vertical profiles Ref M1V1 October

—— Mean 1996-2010 St.Dev. ● 2014

