

## Report of SMHI's marine monitoring cruise with R/V Svea



Photo: Helena Björnberg, SMHI

<b>Survey period:</b>	2023-06-13 - 2023-06-19
<b>Principals:</b>	Swedish Meteorological and Hydrological Institute (SMHI), Swedish Agency for Marine and Water Management (HaV)
<b>Cooperation partners:</b>	Swedish University of Agricultural Sciences (SLU), Swedish Maritime Agency (SjöV), University of Stockholm (SU)

## SUMMARY

During the expedition, which is part of the Swedish pelagic monitoring program, visits were made to the Skagerrak, the Kattegat, the Sounds and the Baltic Proper.

Concentrations of nutrients in the surface waters, in the form of dissolved inorganic phosphorus and dissolved inorganic nitrogen, were found to be within normal range at the sampled areas, with a few exceptions. Typical for the season are low concentrations of nutrients in the surface waters, due to high biological activity. In the Baltic Proper, the Sound and the Kattegat, silicate levels were within normal range, whilst in the Skagerrak levels could be found to be above normal. Temperatures in the surface water were above normal at all visited areas.

Oxygen levels in the West Sea was in good condition. In the Baltic Proper, levels were very low, with hypoxi (<2 ml/l) occurring from depths of 70-80 metres, with the exception of the Arkona Basin where the situation was better. At the stations where hydrogen sulphide was recorded, the levels had increased since earlier samplings.

The next cruise with R/V Svea is planned to depart 11<sup>th</sup> – 17<sup>th</sup> of July from Kalmar, and end in Lysekil.

## RESULTS

The cruise was performed on board R/V Svea, and was initiated in Stockholm on June 13<sup>th</sup>, terminating in Lysekil June 19<sup>th</sup>.

In general the expedition experienced weak winds, with the highest speeds recorded in the Kattegat at 9 m/s. The air temperature varied between 15 to 21 °C.

Svea's instrument for continuous measurements of surface water, Ferrybox, was operated for the full cruise.

Troubleshooting of one of the two instruments on board Svea measuring currents (ADCP) was carried out and the results were analysed after the cruise. Due to previous malfunction of the MVP (Moving Vessel Profiler), no measurements could be made in June.

During the initiating day of the cruise, two scientists from the Department of Ecology, Environment and Plant Sciences (DEEP) at the University of Stockholm participated. They collected water samples at station BY31 Landsortsdjupet, that usually is sampled between April and October. They also operated their CTD with the CTD of SMHI at three stations.

Furthermore, one journalist and one photographer from Dagens Nyheter spent the first 24 hours on board, to cover the work performed on board. All guests embarked in Stockholm, and were let off in Visby.

Additional phytoplankton samples from the surface waters were taken at Släggö, Å17 and Anholt E for a project carried out by the university of Uppsala and Stockholm. During the whole cruise, extra samples were taken for analyses of DNA, algal toxins and the composition of phytoplankton for two different projects; *Forecast framework of harmful algae blooms to secure future water supply and develop tourism on Gotland* (Formas) samt *Establishment of the Center of Environmental Monitoring of Algal Toxins – from sampling to communication with the public* (Swedish board of Agriculture and the Maritime, Fisheries and Aquaculture Program 2021-2027 (EMFAF))

The report is based on data that has undergone an initial quality control and has been compared with a monthly average over the period of 1991 – 2020. When further quality control has been carried out, certain values might change. Values presented in the report has been rounded to the nearest tenth, therefore some of the values could differ from published data.

Data from this cruise is published as soon as possible on the data host's website, this usually takes place within a week after the cruise has ended. Some analyses are made after the cruise and are published later.

Data can be accessed here:

<https://sharkweb.smhi.se/hamta-data/>

## **The Skagerrak**

Temperature in the surface waters (0 – 10 m) in the Skagerrak had increased with 5-8°C since the last cruise, and varied between 15-18 °C, which is above normal for the season. Salinity in the surface layer of the Å-section varied between 22-30 psu. At P2 further south it was slightly lower, at 20 psu. Släggö, which has a strong influence from the coast, displayed a salinity at 24 psu. At all sampling points, with the exception of Å16 and Släggö, the surface salinity was below normal range. A pycnocline had formed at all stations around 10-15 meters.

Surface concentrations of DIN (Dissolved Inorganic Nitrogen) were low across all stations. The levels of DIP (Dissolved Inorganic Phosphorus) was also low at the visited stations, which is normal for the season. Concentrations of silicate in the surface waters were above normal range at all sampling points, except at Å14 where it was around normal range, and varied between 0,8–1,9 µmol/l across the Å-section. At P2, levels above normal range was recorded at 2,17 µmol/l. At Släggö, concentrations were within normal, measured at 0,8 µmol/l.

Chlorophyll fluorescence measured with CTD, used as an indicator of phytoplankton activity, showed peaks at 10 – 20 meters. The highest levels were found at Å17, with a distinctive peak at 25 meter. High levels of oxygen could be noted higher up in the water column. Secchi depth varied between 9-11 meters.

The oxygen conditions in the bottom waters of the Skagerrak were good, with concentrations of 5,9–6,6 ml/l at the pelagic stations, and 5,6 ml/l at Släggö. This is within normal range for the season.

## **The Kattegat and the Sound**

Temperature in the Kattegat and the Sound were above normal range for the season in the surface waters. Temperature had increased between 6–9 °C since the last cruise, and was noted at 15-18 °C. The sea surface salinity were within normal range, between 18,5–21,3 psu in the Kattegat and 15,0 psu in the Sound. At all sampling points, a pycnocline had formed around 10-15 meters.

Levels of DIN in the surface waters were low across all stations, which is typical for the season. Concentrations of DIP were low at all sampling points and varied between 0,06-0,18 µmol/l. Concentrations of silicate were within normal range at all stations, with levels between 2,2-7,6 µmol/l, with the exception of W Landskrona where levels were slightly above normal at 3,7 µmol/l.

Measurements of chlorophyll fluorescence indicated an activity peak that coincided with the pycnocline at all stations, around 10-20 m. High levels of oxygen could be noted in the surface waters in addition to this. The Secchi depth was at 10 meters.

The oxygen situation in the bottom waters of the Kattegat and the Sounds were good, at levels around 5 ml/l.

## **The Baltic Proper**

Temperature in the sea surface was above normal at most stations, and varied between 12-15 degrees. The warmed up surface layer extended down to 15 - 20 meters. Below, the temperature dropped slightly but increased somewhat again at the halocline which was located at 60-70 m. In the deep waters the temperature was above normal, at around 7 degrees.

The surface salinity varied between 6,3 – 7,7 psu, with the lowest salinity found in the north and the highest in the south. At a few sampling points, the salinity was above normal.

Concentrations of nutrients in the sea surface were mostly within normal range. The levels of DIP had continued to decrease since May and varied between 0,1-0,3  $\mu\text{mol/l}$ , with the lowest values in the eastern and northern part of the Baltic, and the highest levels found in the southern areas (Bornholm and Arkona). Concentrations of DIN had not changed noticeably since May and were close to the detection limit of nitrate (0,1  $\mu\text{mol/l}$ ).

Levels of silicate were within normal range and varied between 6-14  $\mu\text{mol/l}$ . In the southern parts (Arkona and Bornholm), concentrations were found to be above normal.

In the deep waters around Gotland, concentrations of ammonium were found to still be above range from the monthly averages of 1991-2020. Similarly, phosphate levels were above normal, but not to the same extent as ammonium. In the southern parts of the Eastern Gotland Basin and in the Basins of Bornholm and Arkona, concentrations were found to be mostly within normal range. Neither was any hydrogen sulphide detected in the area.

The oxygen conditions of the Baltic Proper continues to be very poor. In all basins, anoxia was recorded. In the Arkona basin, the situation appeared to be the best, with oxygen concentrations just below the anoxia limit at 4 ml/l at one of the stations, and at the other no anoxia was occurring at the time of sampling. In the Bornholm basin and the Bay of Hanö, no hydrogen sulphide was detected, but hypoxi occurred from 70-80 meters, and in the bottom waters oxygen was very close to non-existent, at 0,1-0,3 ml/l. At the most southern station in the Eastern Gotland Basin (BCS III-10), no hydrogen sulphide could be detected either, but hypoxi occurred from 80 meters.

At all other stations, high levels of hydrogen sulphide was recorded in the bottom waters, and below 70-80 meters. The concentrations of hydrogen sulphide was found to be higher than previously, and appears to increase every month, which can be seen in the plots of oxygen trends in the bottom waters where hydrogen sulphide appears as a negative oxygen level.

At the northern stations high levels of chlorophyll fluorescence was seen, and at BY32 a distinctive peak could be observed at 20 meters. The oxygen levels in the surface waters were above 8,5 ml/l, which indicates a high activity of plankton. At the southern stations, more uniform levels of chlorophyll fluorescence were observed in the surface waters.

Secchi depth was recorded at 8 stations and varied between 6-9 meters.

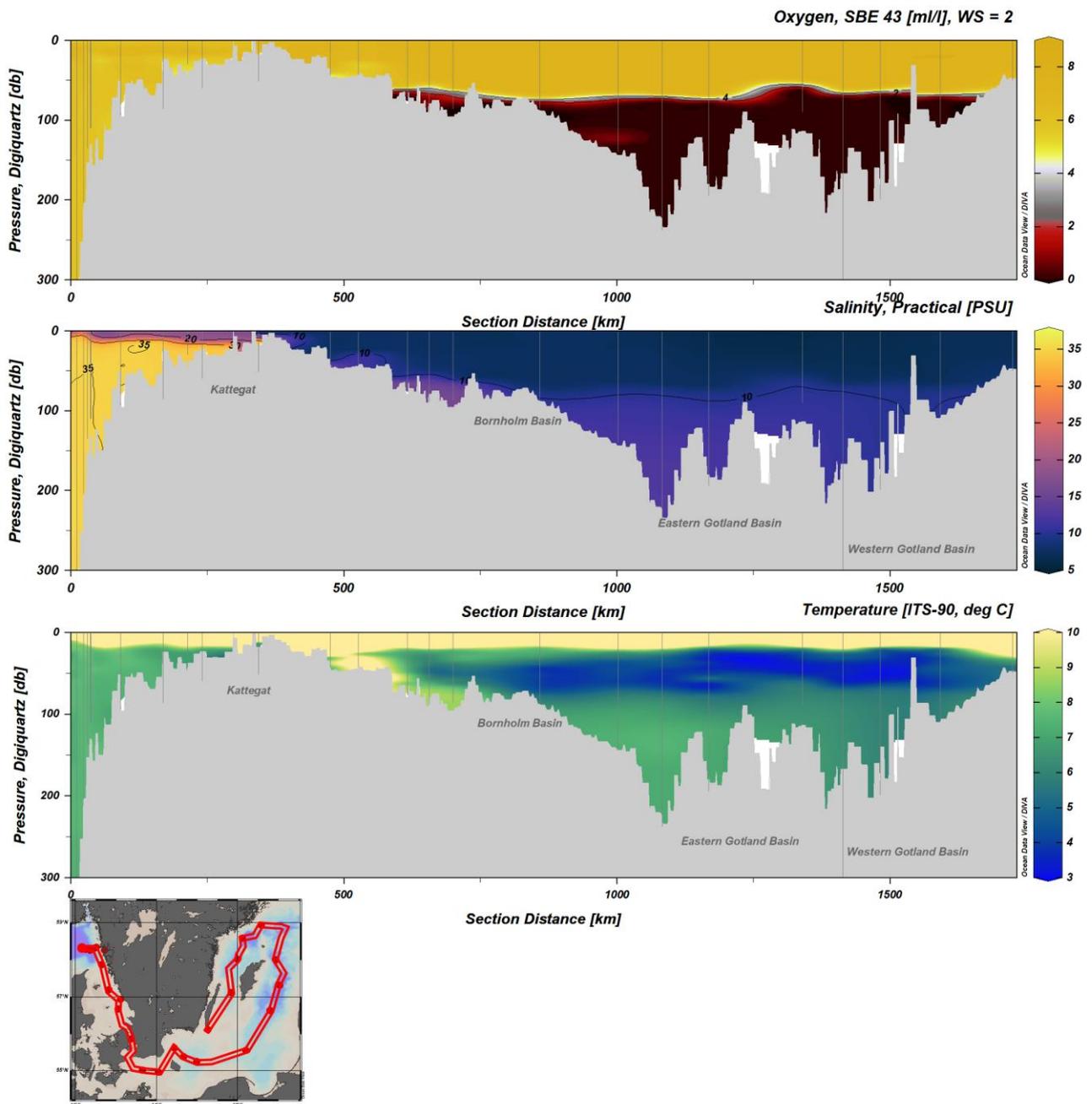


Figure 1. Section showing temperature, salinity and oxygen concentration from the Skagerrak, through the Sound and further up through the Baltic Sea proper according to the map (bottom). The figure is created in Ocean Data View with DIVA-interpolation.

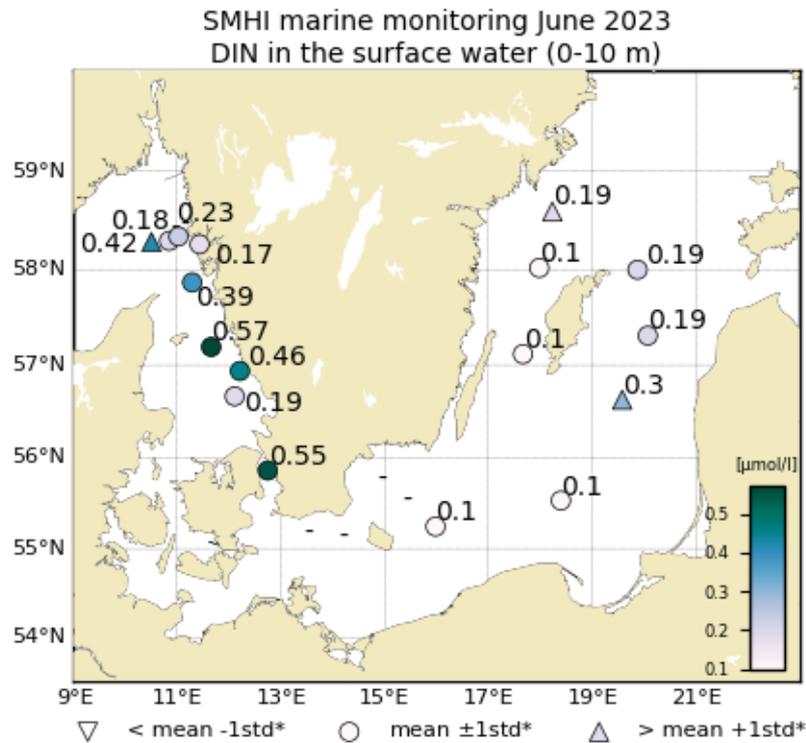


Figure 2. The concentration of dissolved inorganic nitrogen (DIN) in the surface water (0–10m). The mean value is based on monthly data within each basin from 1991–2020.

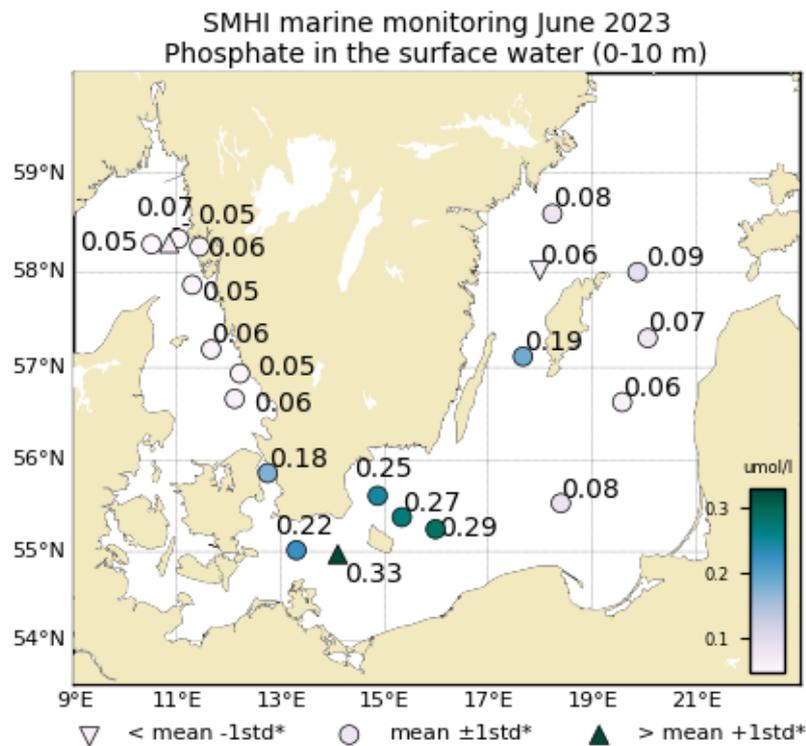


Figure 3. The concentration of phosphate in the surface water (0– 10 m). The mean value is based on monthly data within each basin from 1991–2020.

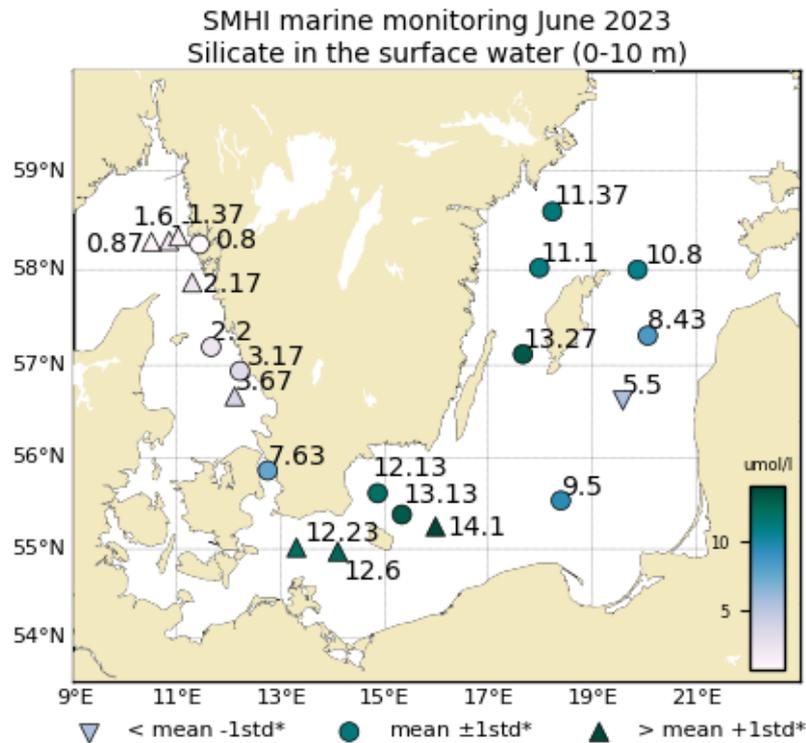


Figure 4. The concentration of silicate in the surface water (0–10 m). The mean value is based on monthly data within each basin from 1991–2020.

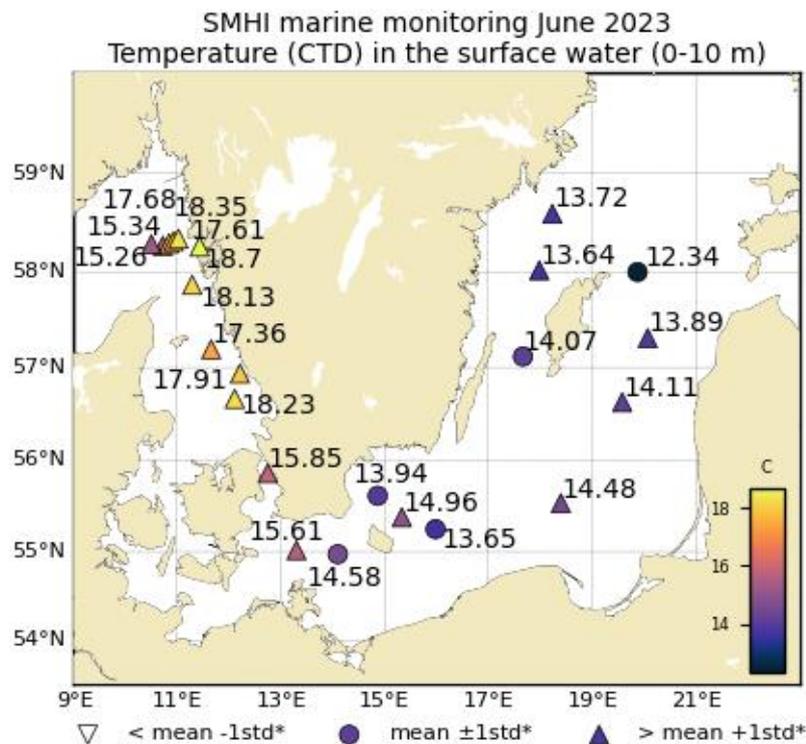


Figure 5. Temperature in the surface water (0–10 m). The mean value is based on monthly data within each basin from 1991–2020.

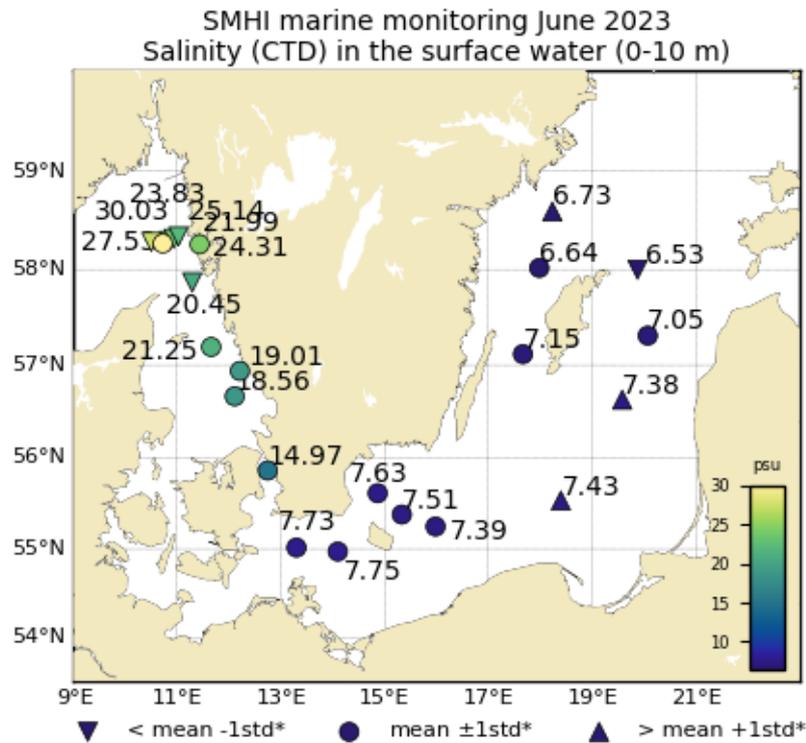


Figure 6. Salinity in the surface water (0–10 m). The mean value is based on monthly data within each basin from 1991–2020.

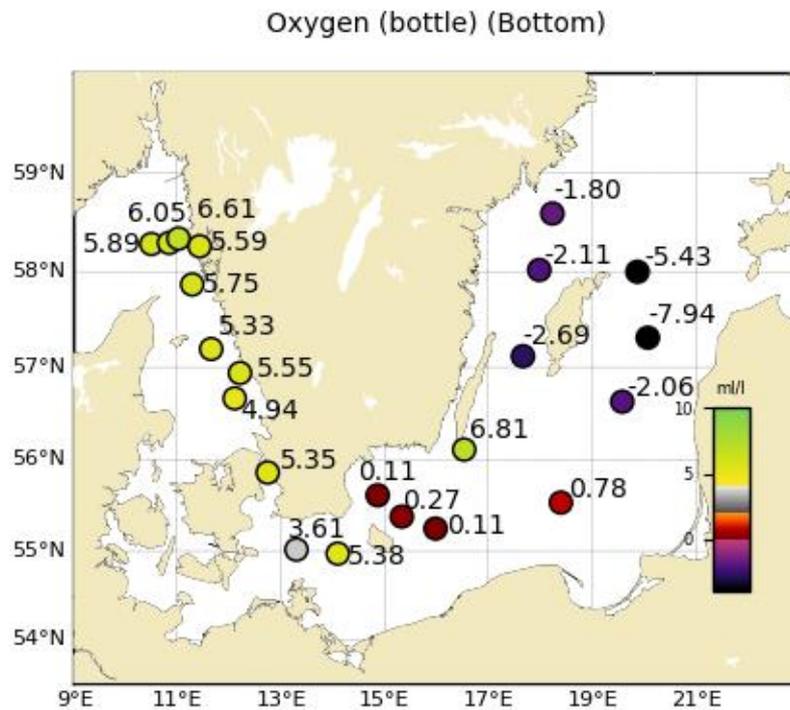


Figure 7. The concentration of oxygen (in ml/l) in the bottom water, about 1 m above the bottom. Note that the value is not compared against statistics in the same way as Figures 2–6 and therefore only circles are shown in the graph. Presence of hydrogen sulphide is illustrated as negative oxygen concentration.

## PARTICIPANTS

<b>Namn</b>	<b>Roll</b>	<b>Institut</b>
Lena Viktorsson	Chief Scientist, oceanographer	SMHI
Johan Kronsell	Oceanographer	SMHI
Ann-Turi Skjevik	Marin biologist	SMHI
Sari Sipilä	Chemist	SMHI
Anna-Kerstin Thell	Chemist	SMHI
Elizaveta Mattson	Guest scientist (Stockholm-Visby)	University of Stockholm
Stefan Svensson	Guest scientist (Stockholm-Visby)	University of Stockholm

## APPENDICES

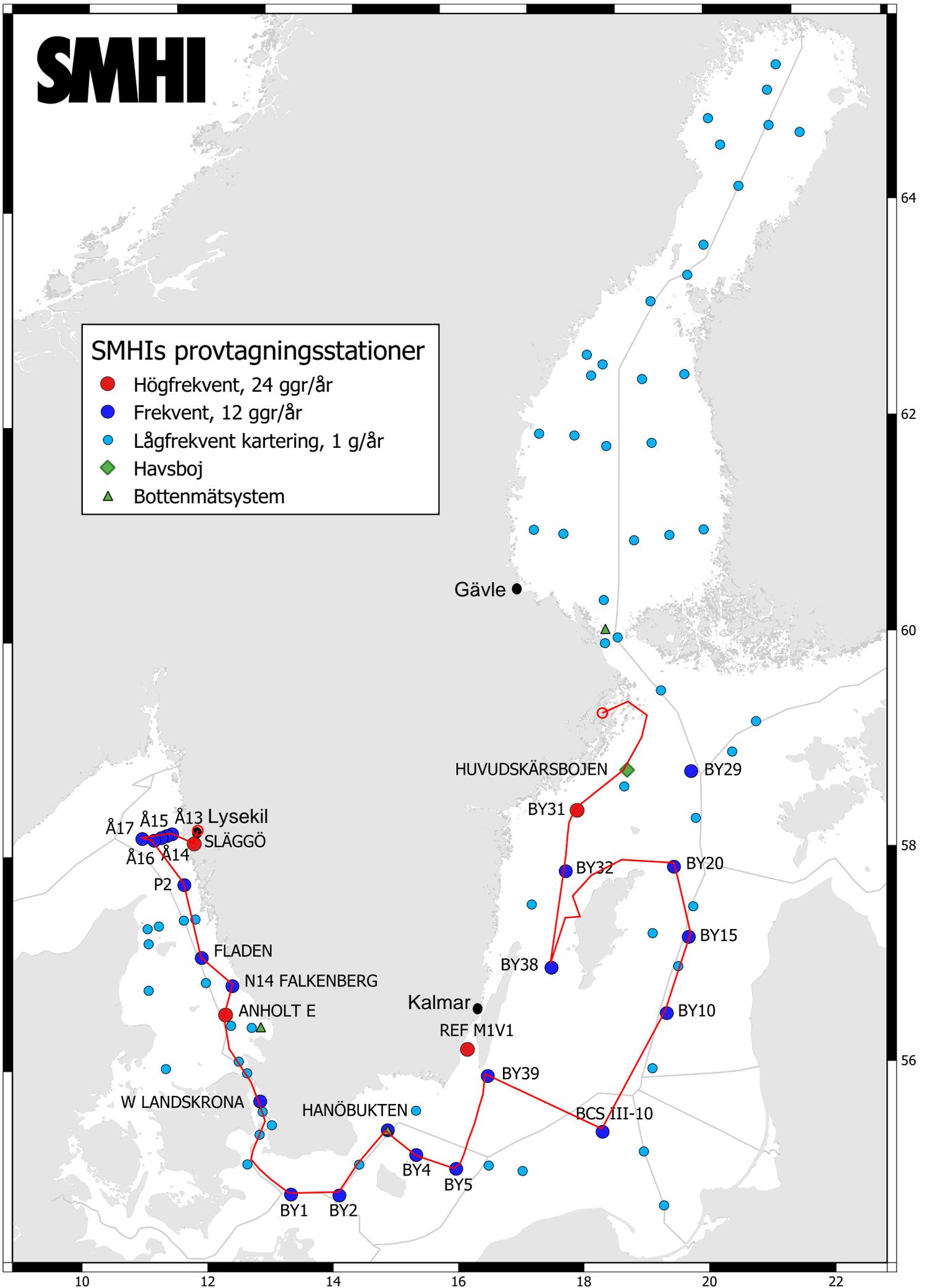
- Track chart
- Table of stations, analysed parameters and number of sampling depths
- Annual cycles of surface waters (0 – 10 m) and oxygen development in the bottom waters
- Vertical profiles

**SMHI**

Havs  
och Vatten  
myndigheten

## SMHIs provtagningsstationer

- Högfrekvent, 24 ggr/år
- Frekvent, 12 ggr/år
- Lågfrekvent kartering, 1 g/år
- ◆ Havsboj
- ▲ Bottenmätsystem

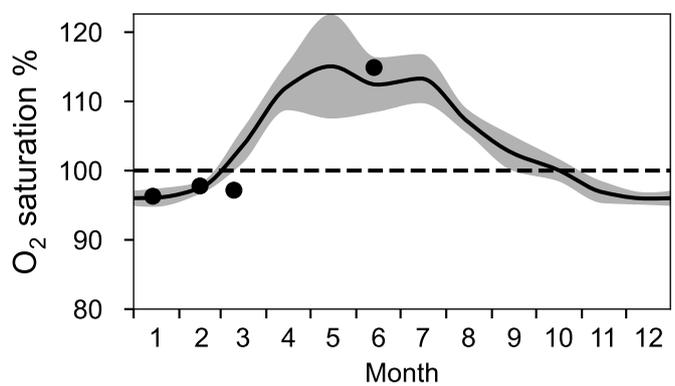
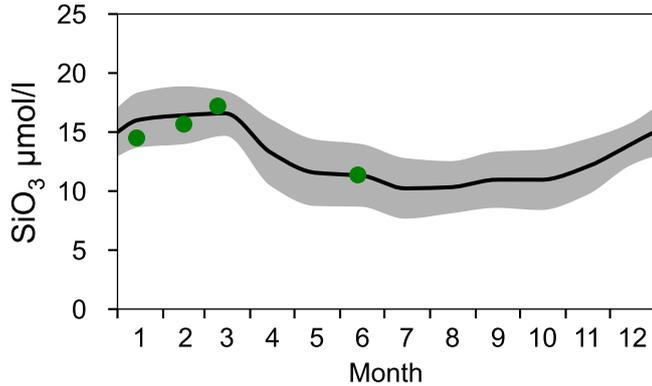
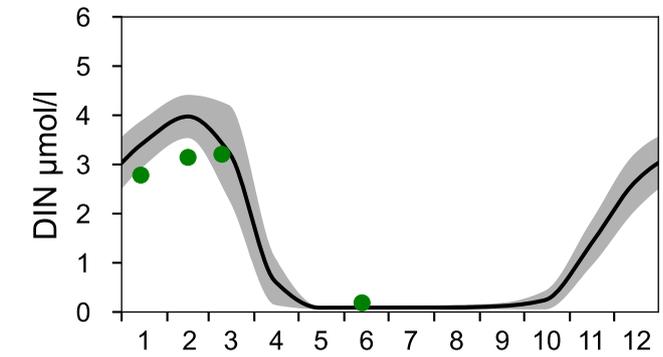
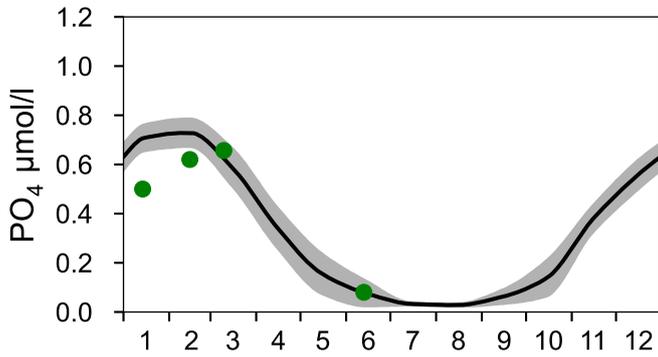
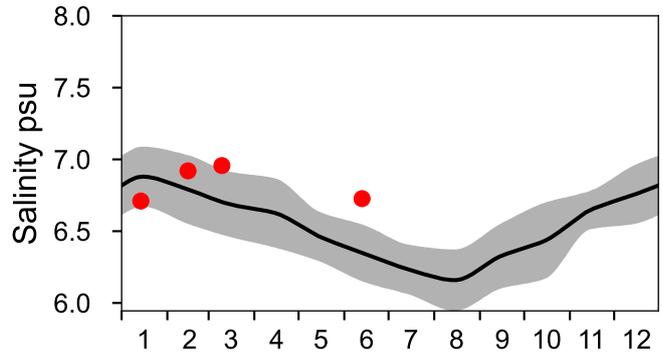
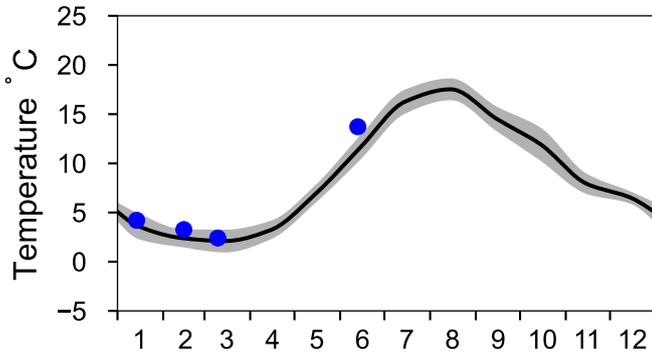




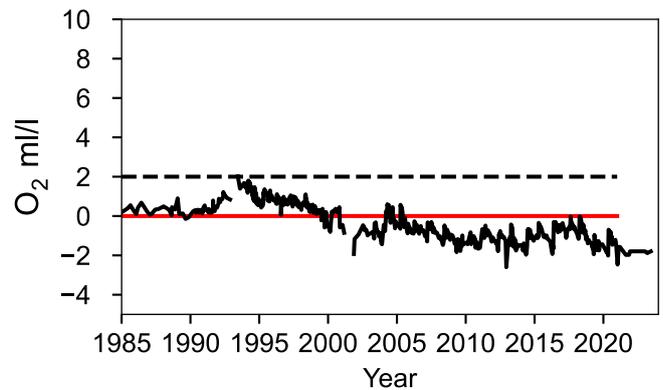
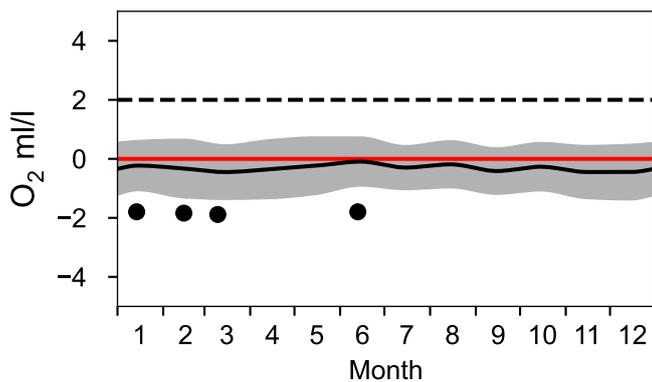
# STATION BY31 LANDSORTSDJ SURFACE WATER (0-10 m)

Annual Cycles

— Mean 2006-2020    St.Dev.    ● 2023

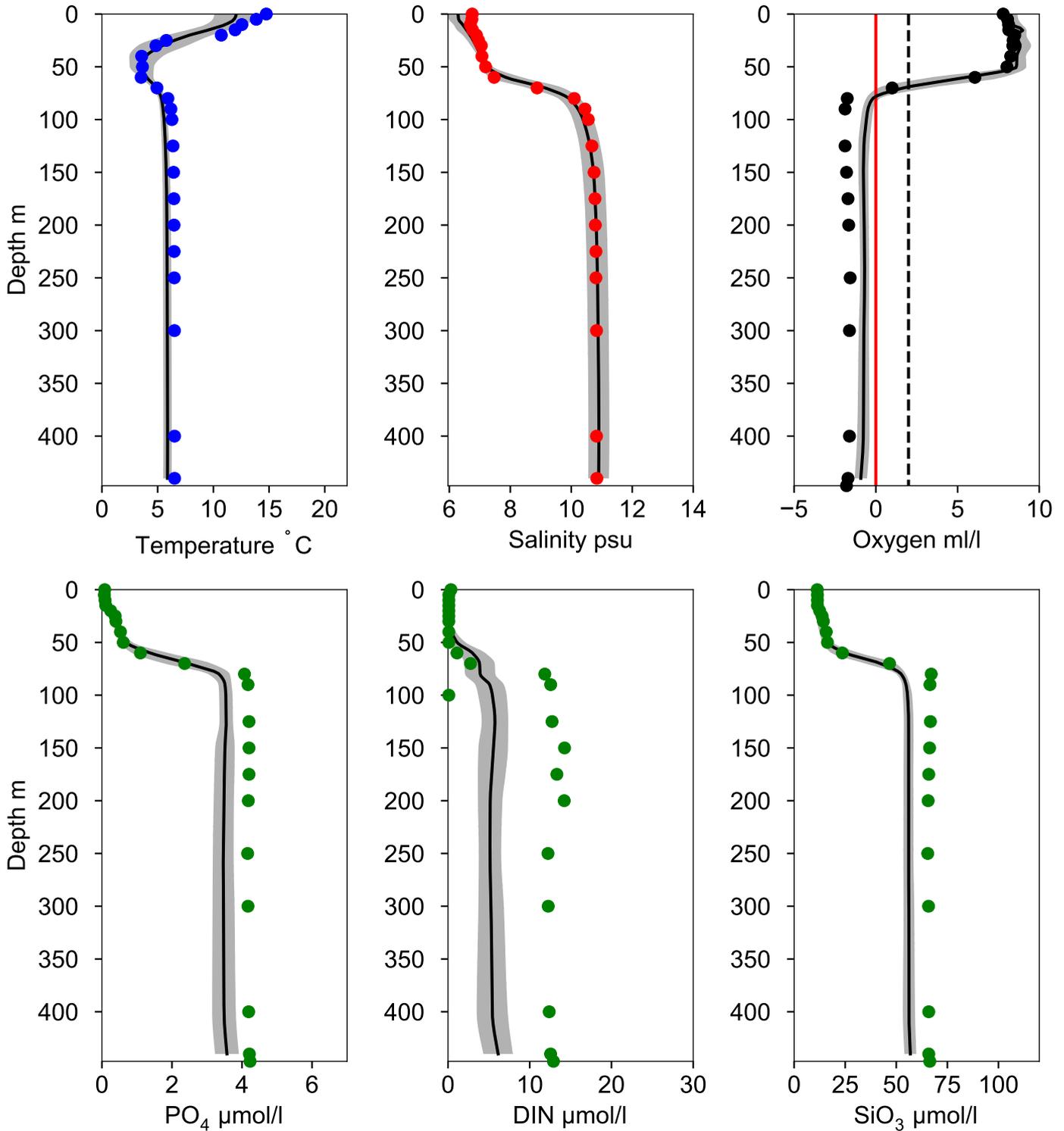


## OXYGEN IN BOTTOM WATER (depth >= 419 m)



# Vertical profiles BY31 LANDSORTSDJ June

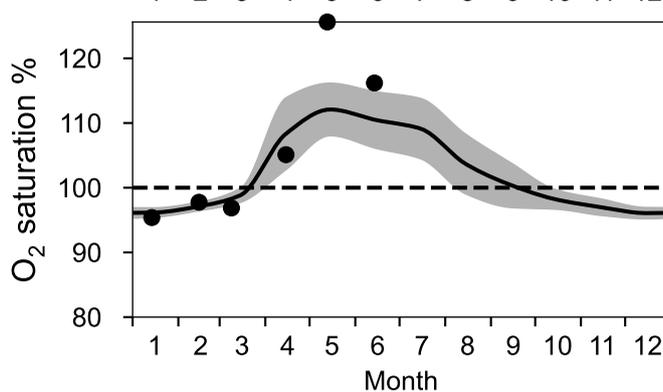
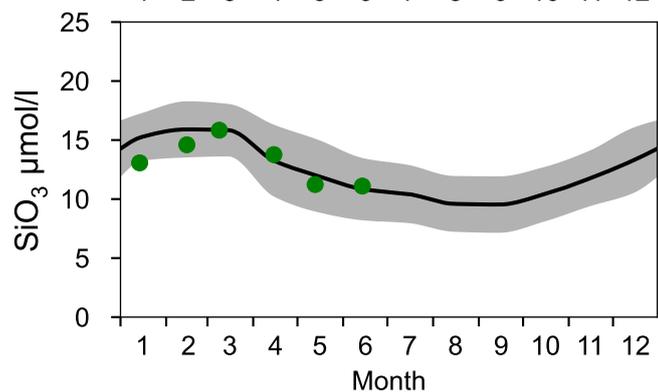
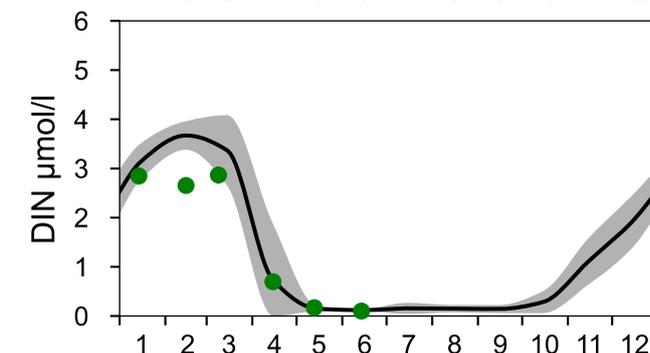
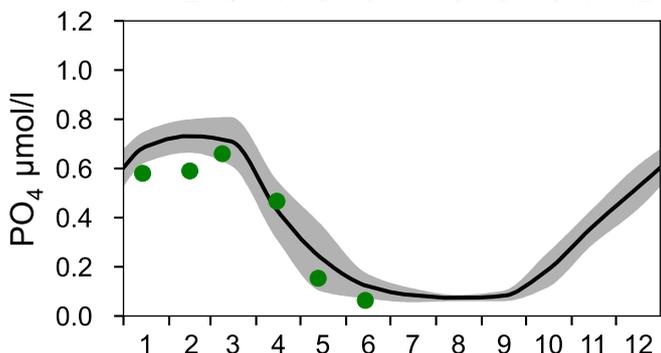
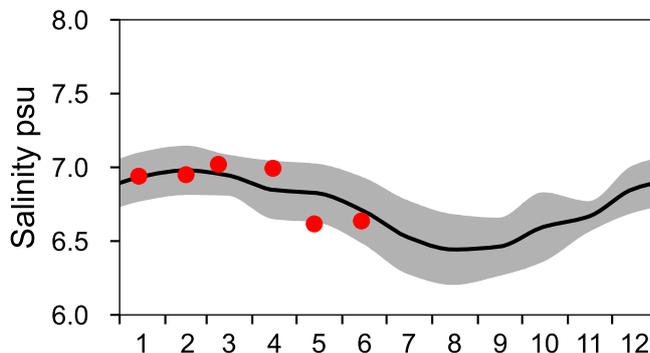
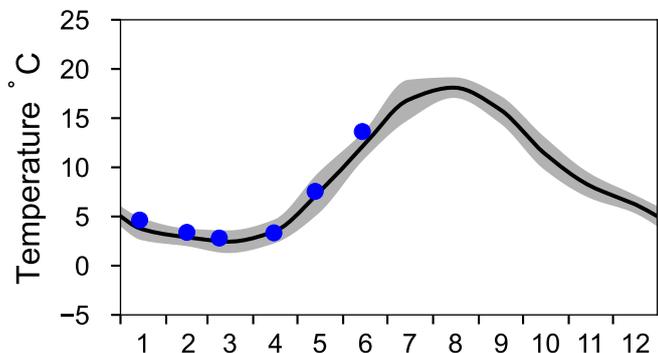
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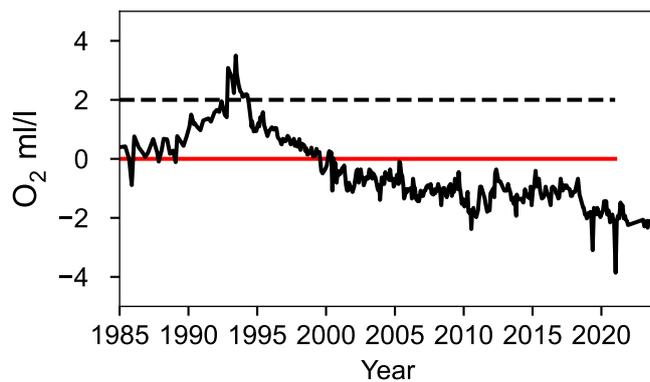
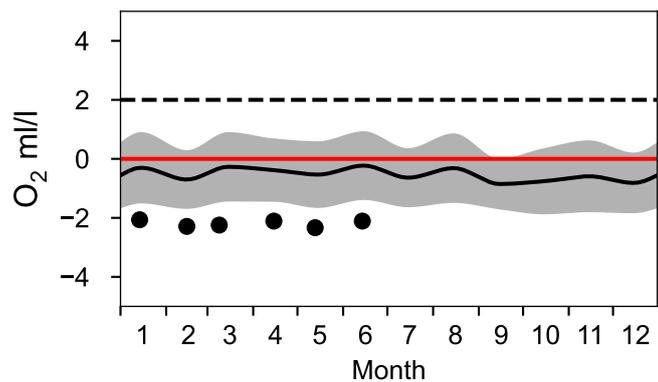
# STATION BY32 NORRKÖPINGSDJ SURFACE WATER (0-10 m)

Annual Cycles

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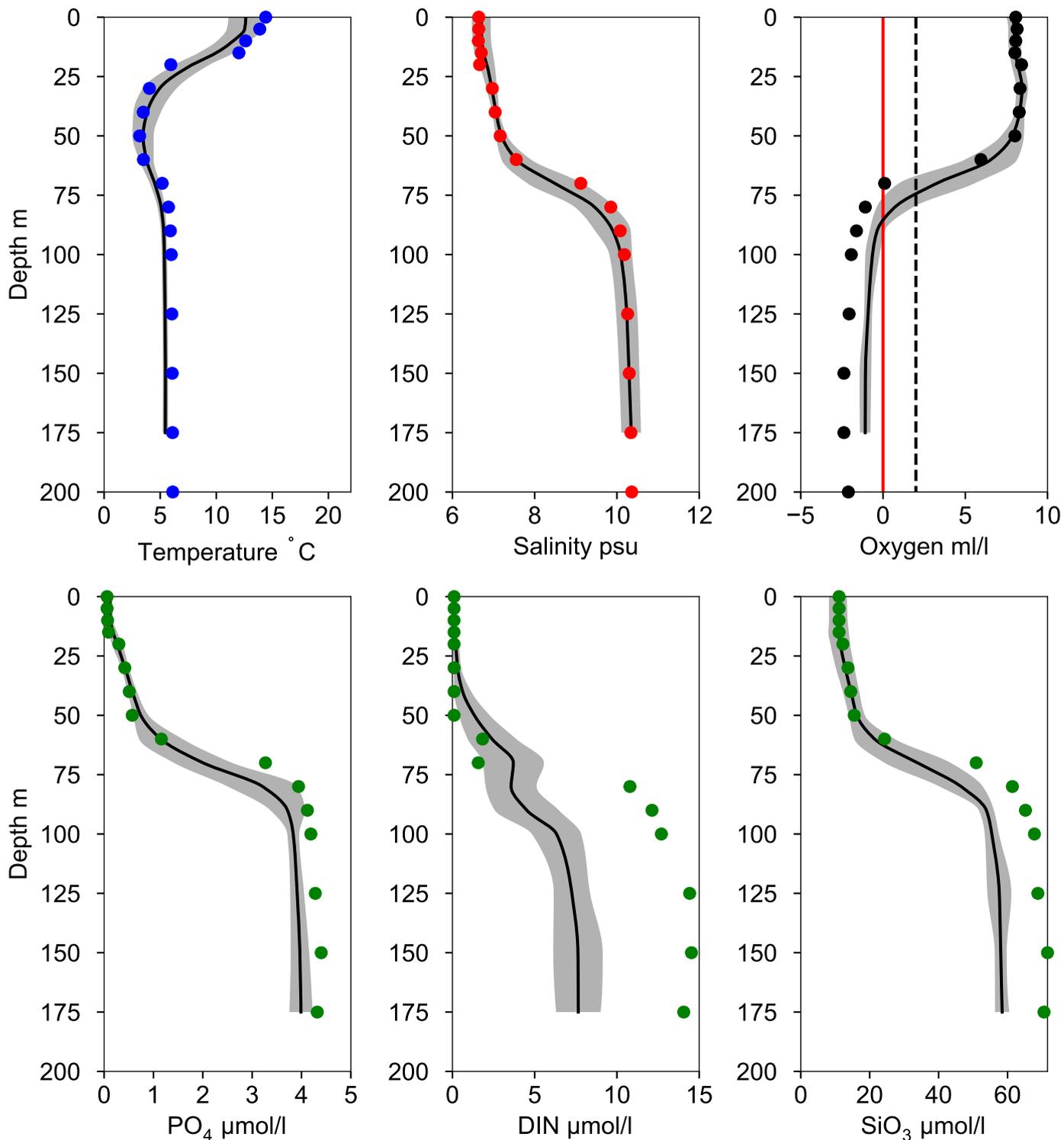


## OXYGEN IN BOTTOM WATER (depth >= 175 m)



# Vertical profiles BY32 NORRKÖPINGSDJ June

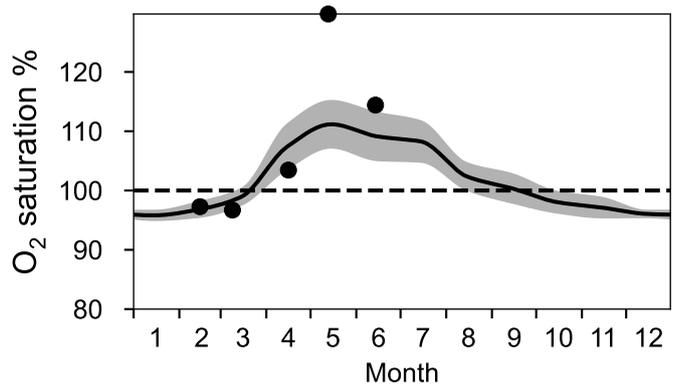
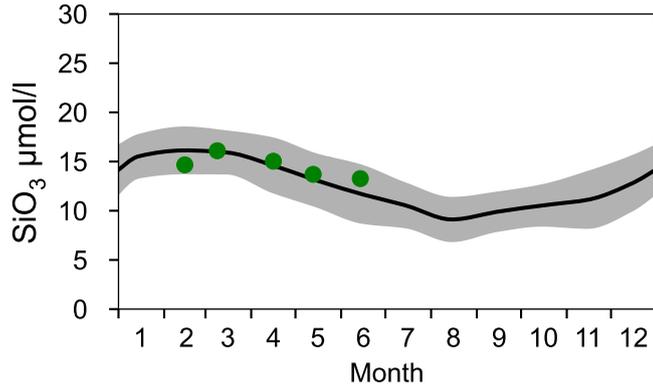
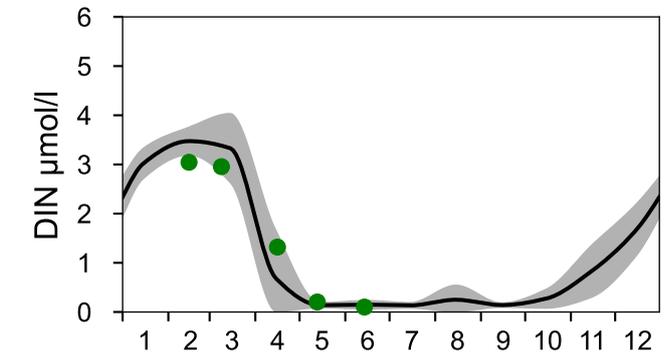
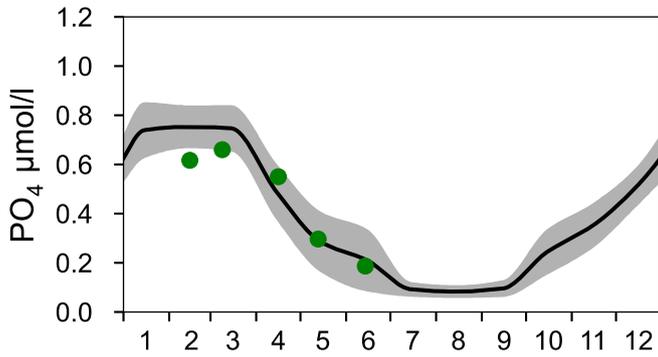
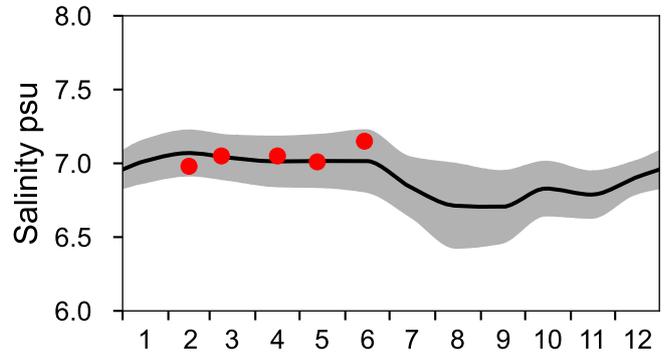
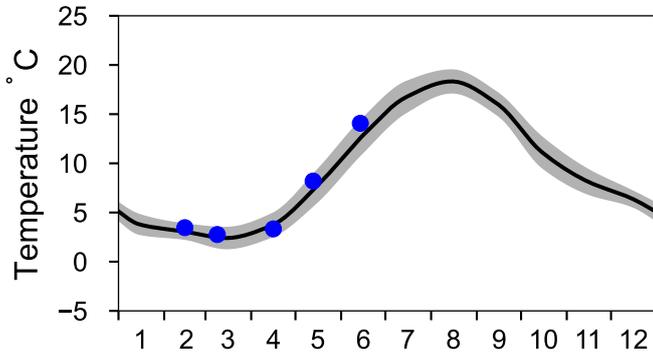
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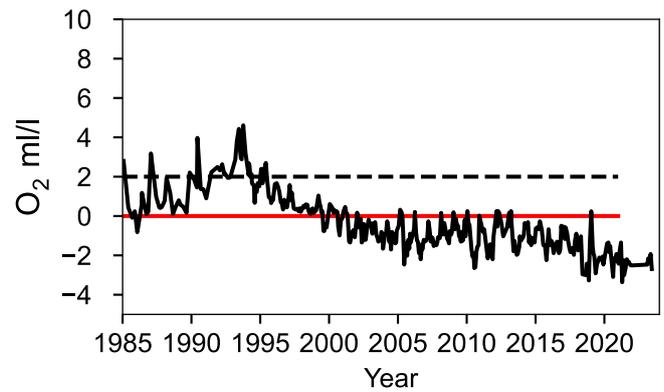
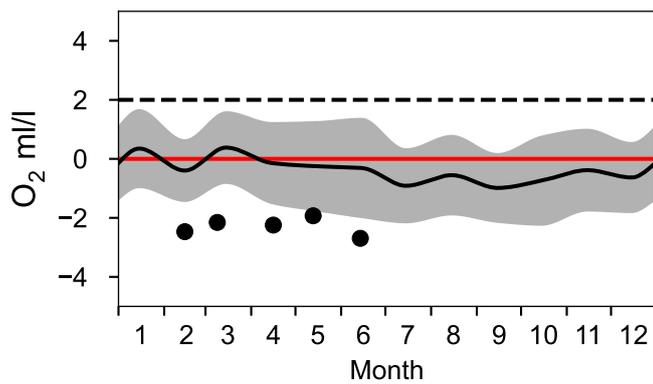
# STATION BY38 KARLSÖDJ SURFACE WATER (0-10 m)

Annual Cycles

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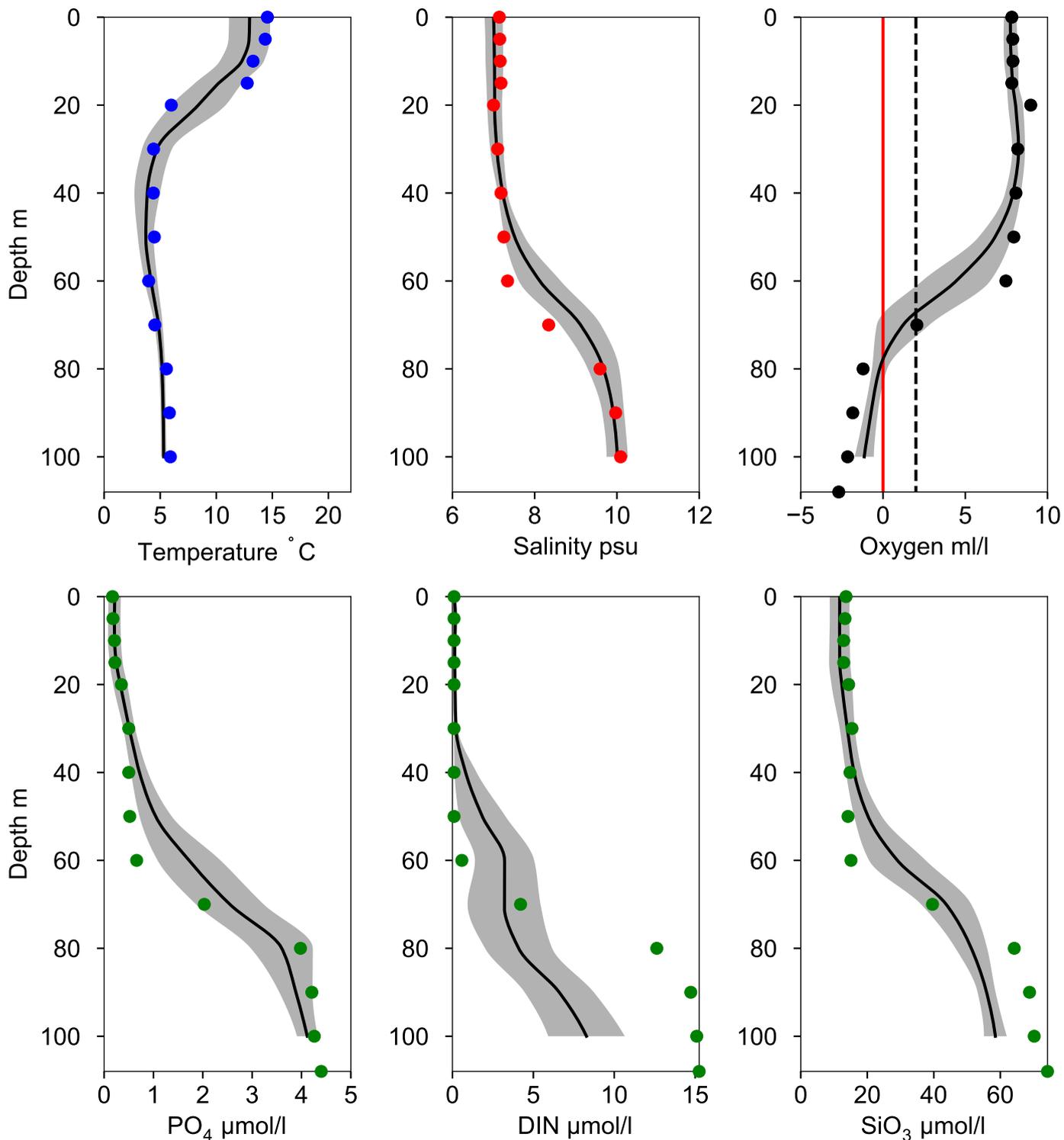


## OXYGEN IN BOTTOM WATER (depth >= 100 m)



# Vertical profiles BY38 KARLSÖDJ June

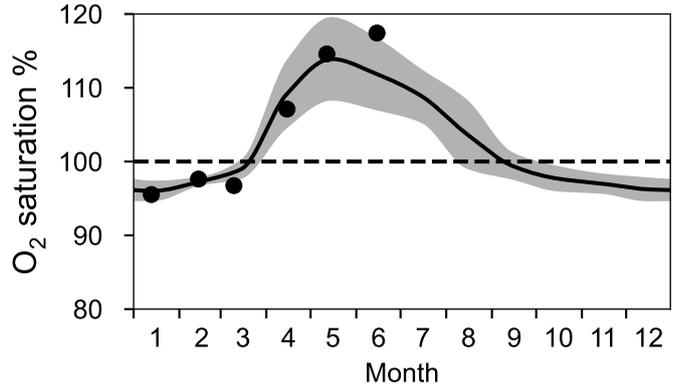
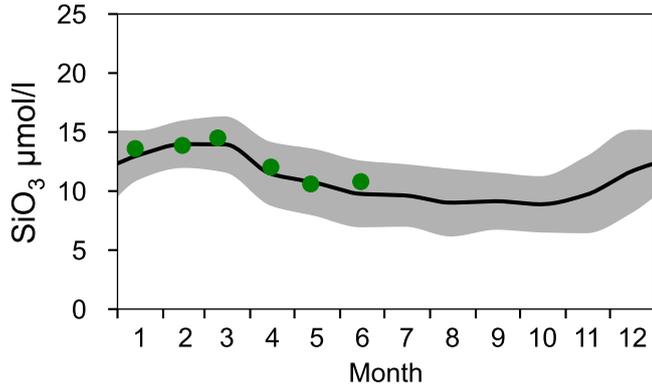
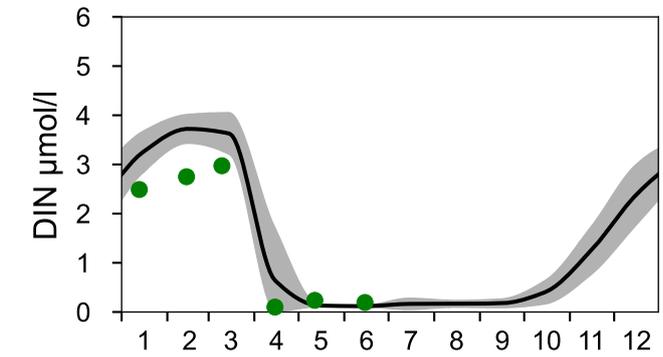
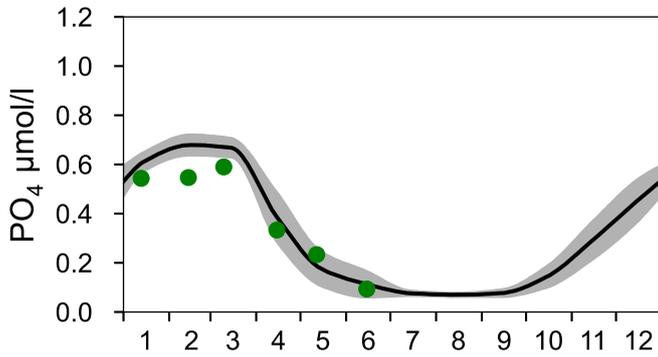
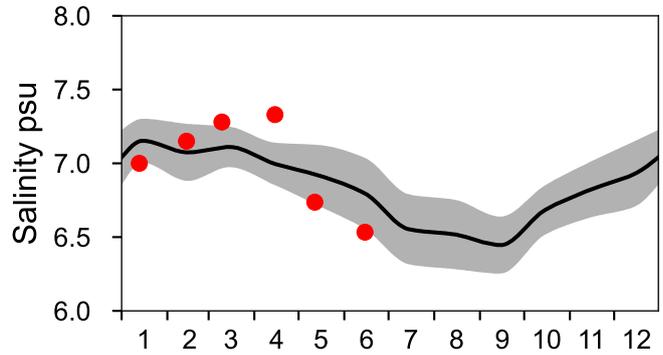
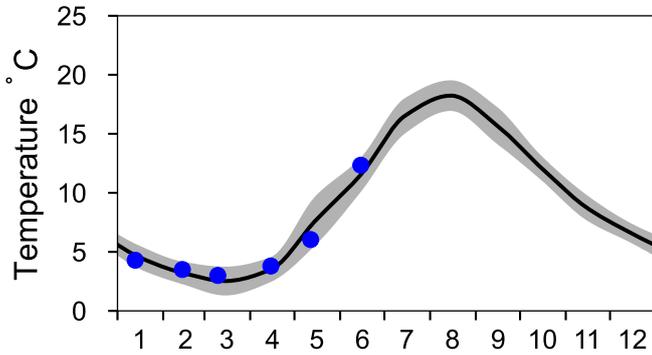
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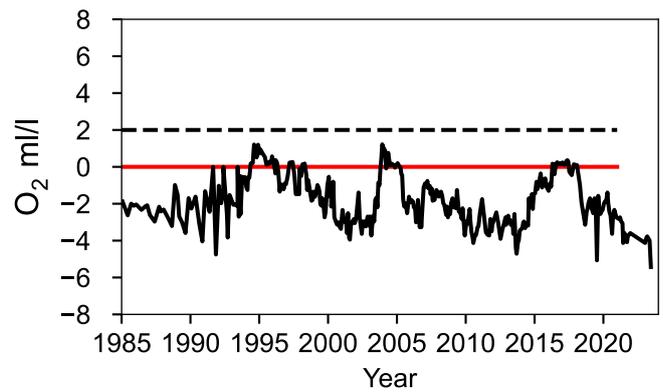
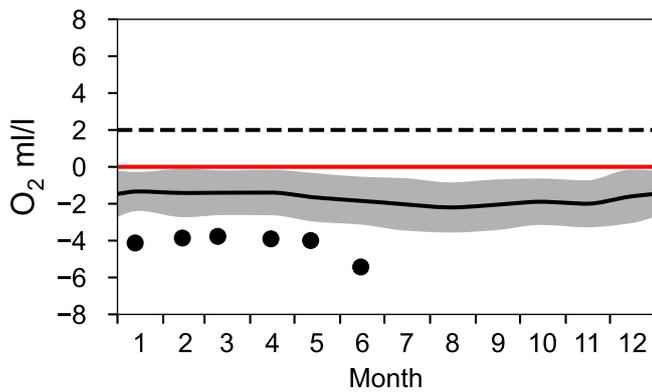
# STATION BY20 FÄRÖDJ SURFACE WATER (0-10 m)

Annual Cycles

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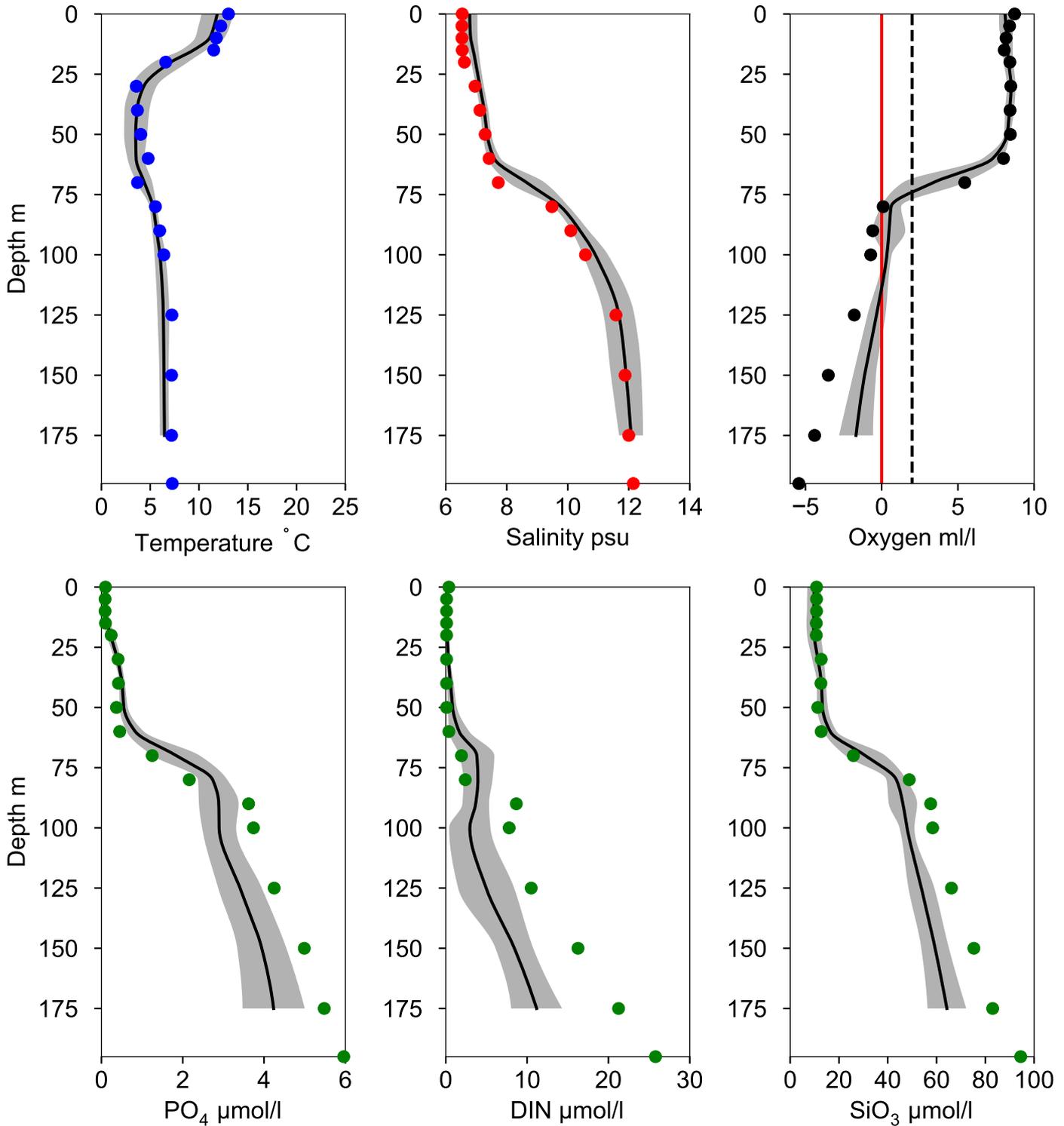


## OXYGEN IN BOTTOM WATER (depth >= 175 m)



# Vertical profiles BY20 FÅRÖDJ June

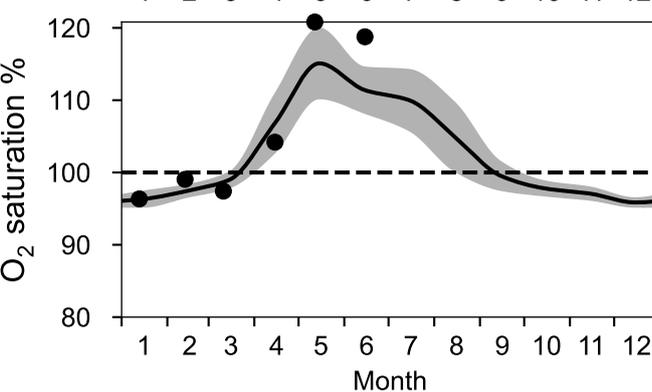
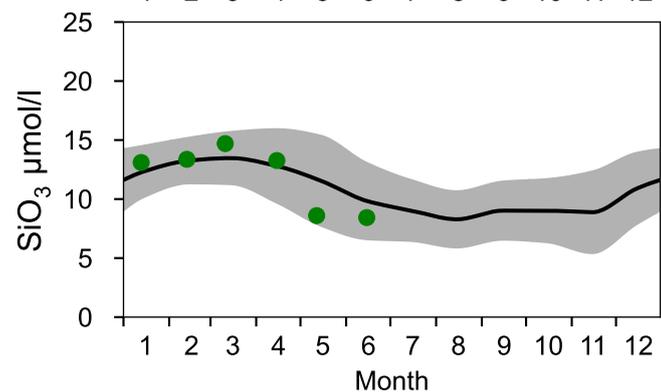
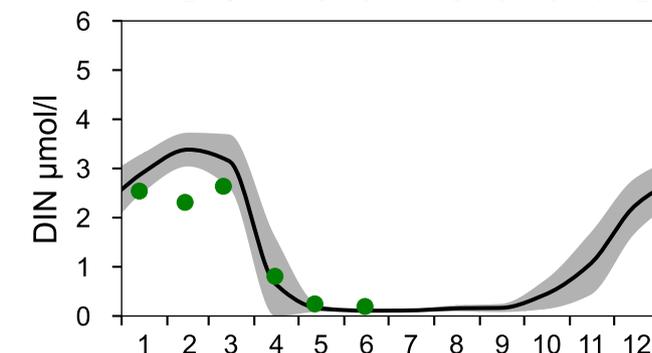
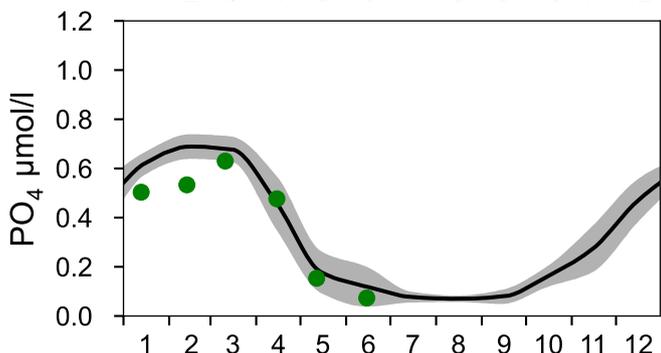
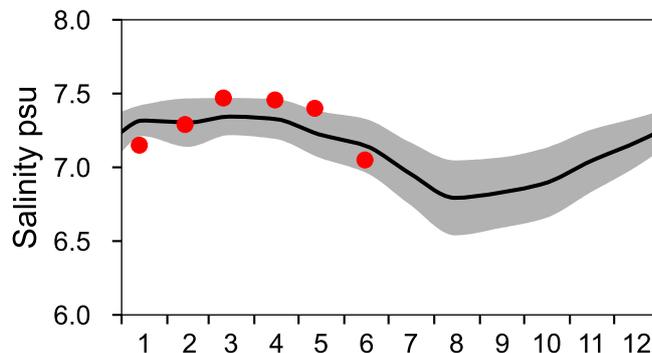
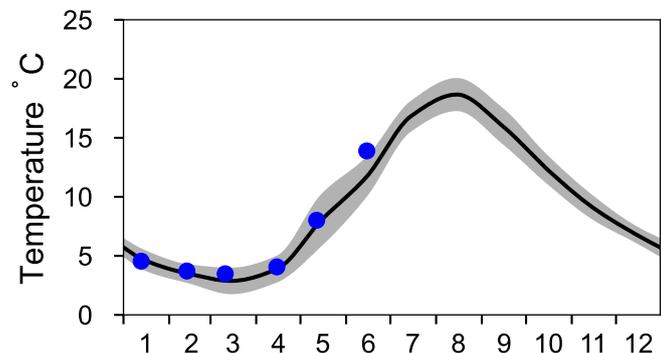
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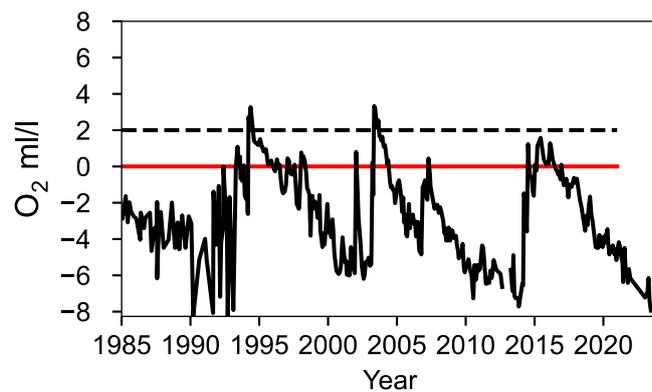
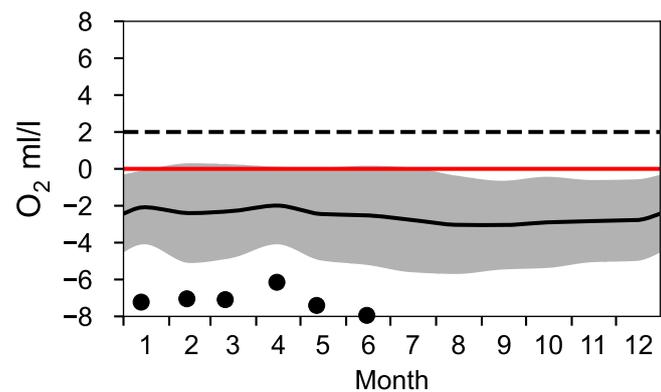
# STATION BY15 GOTLANDSDJ SURFACE WATER (0-10 m)

Annual Cycles

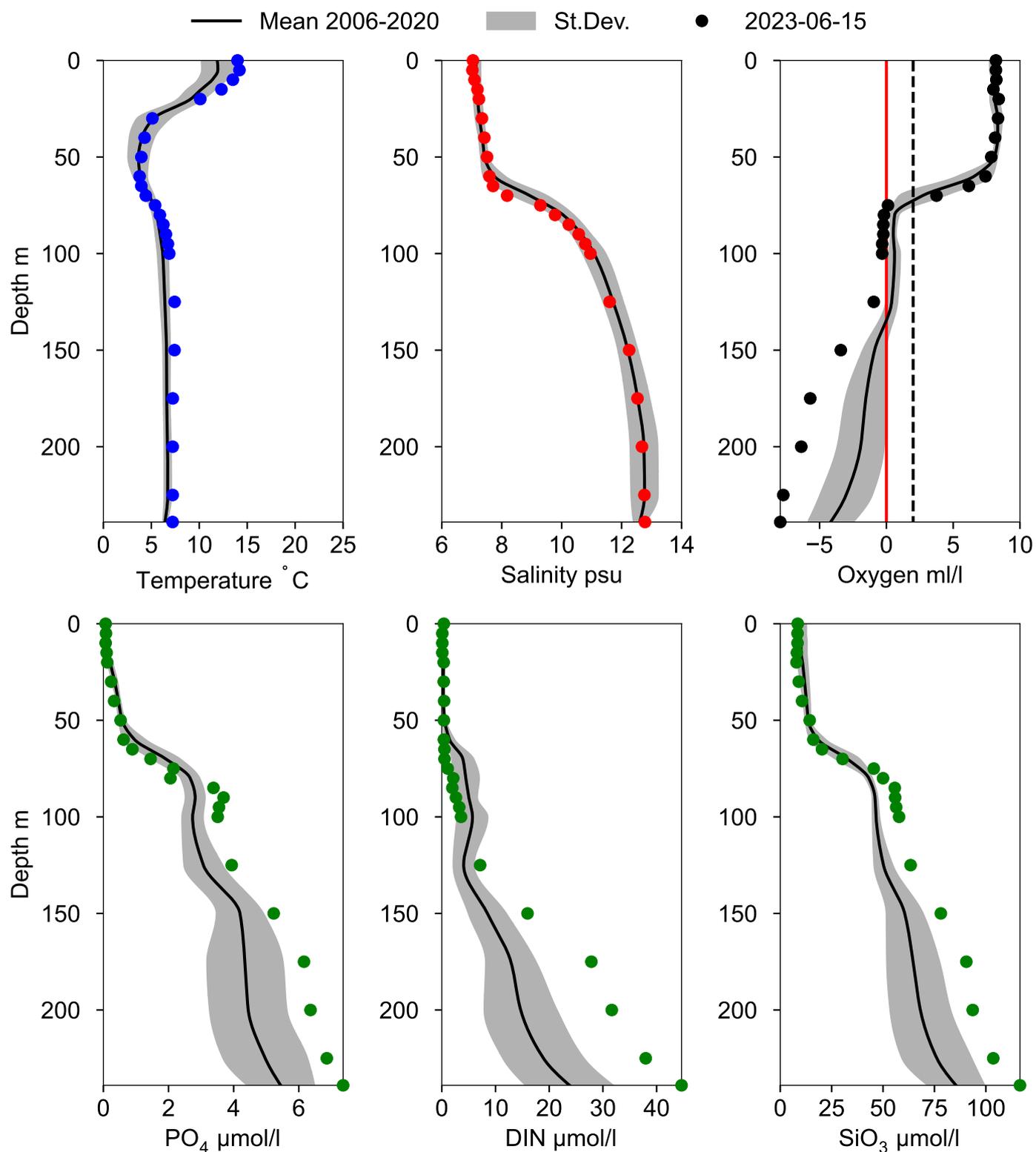
— Mean 2006-2020    St.Dev.    ● 2023



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



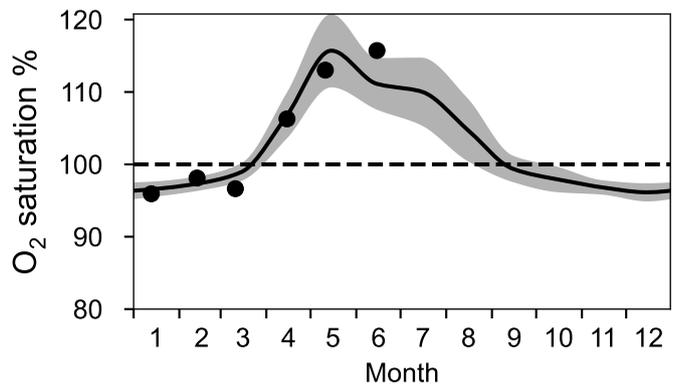
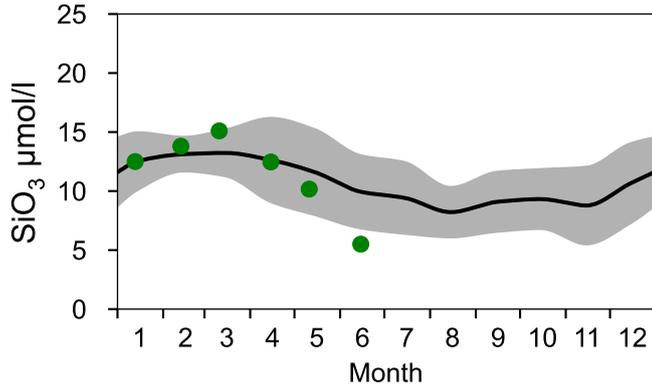
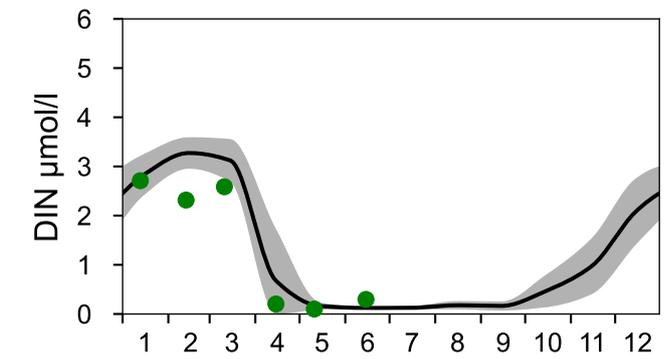
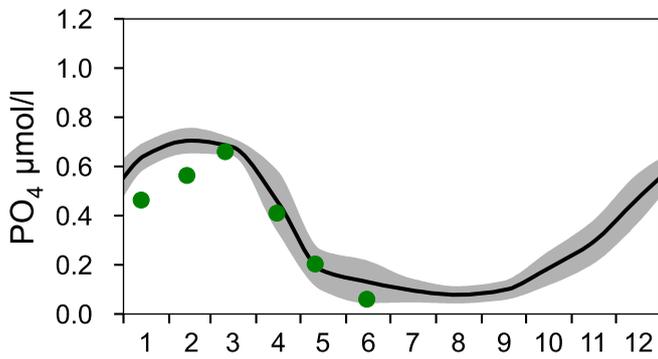
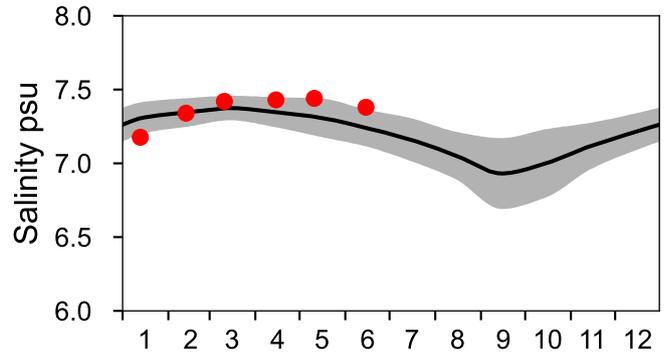
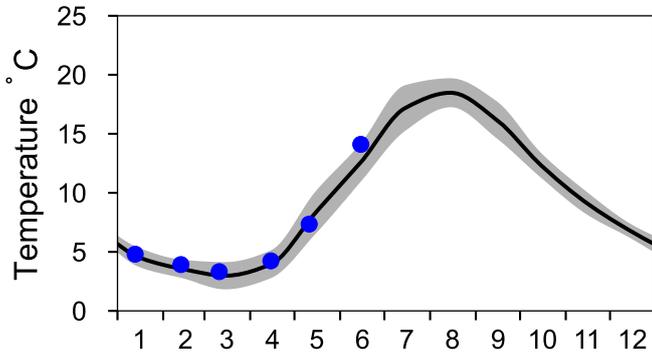
# Vertical profiles BY15 GOTLANDSDJ June



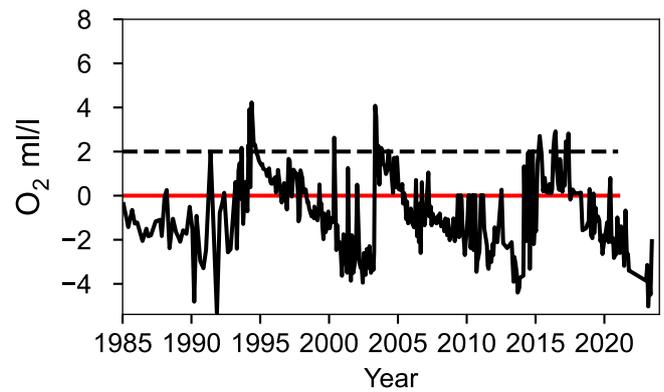
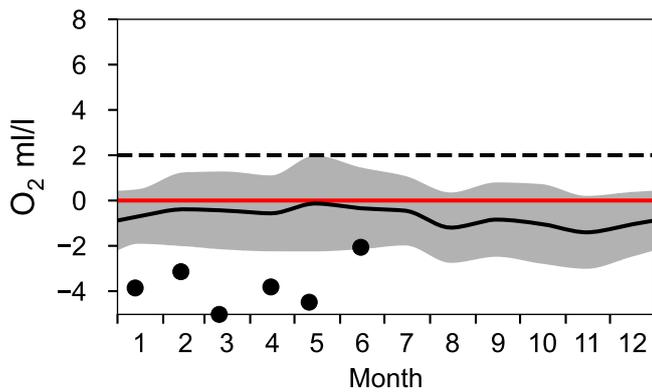
# STATION BY10 SURFACE WATER (0-10 m)

Annual Cycles

— Mean 2006-2020    St.Dev.    ● 2023

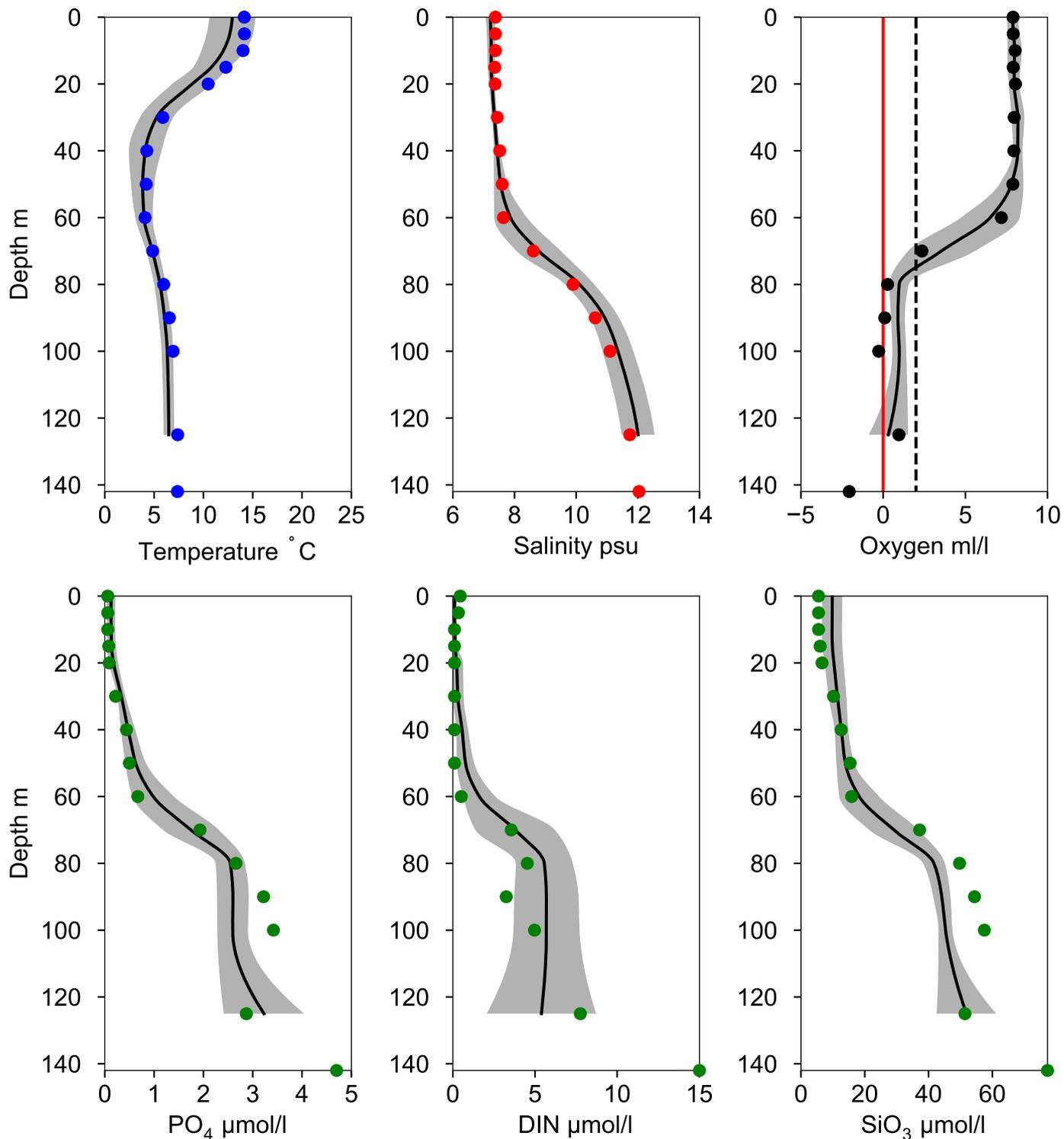


## OXYGEN IN BOTTOM WATER (depth >= 125 m)



# Vertical profiles BY10 June

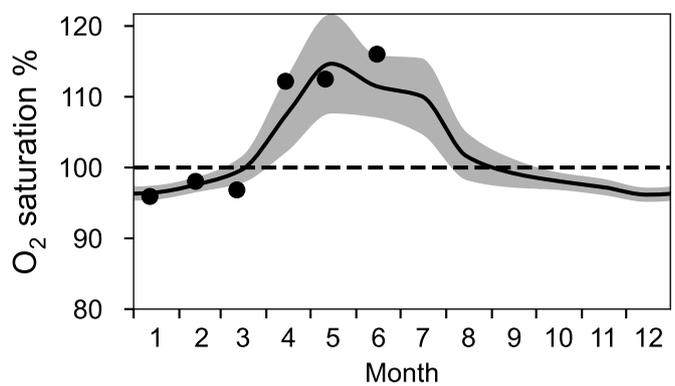
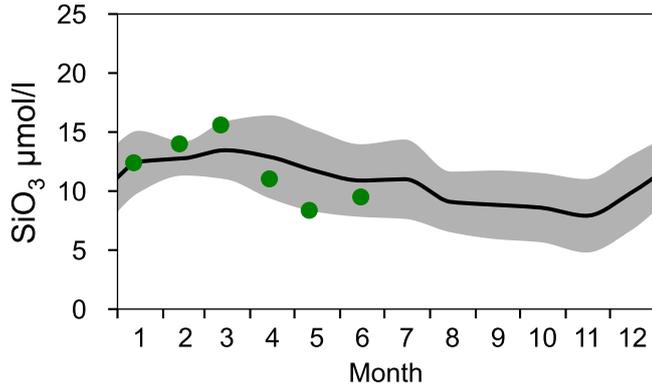
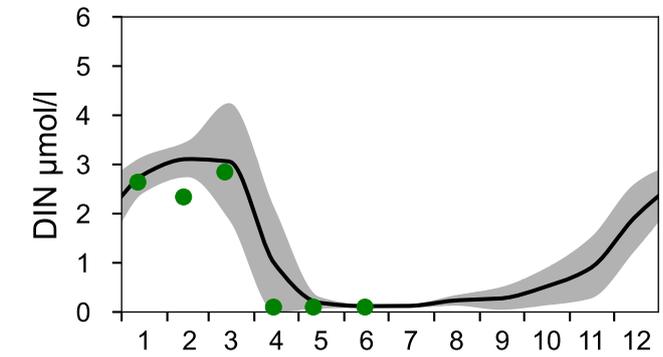
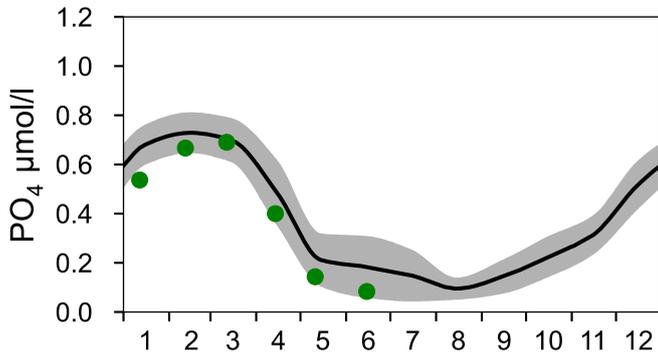
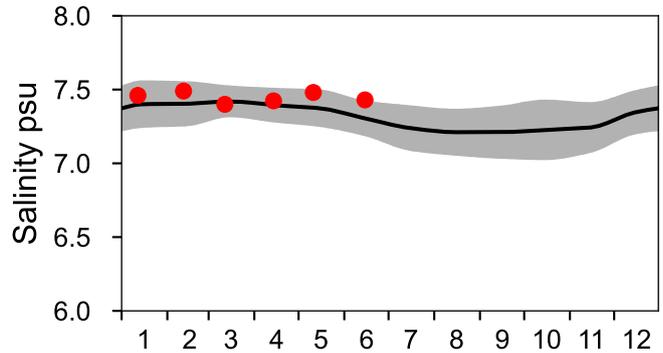
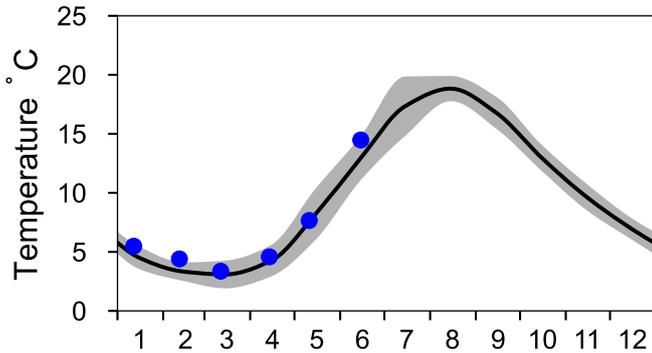
— Mean 2006-2020    ■ St.Dev.    ● 2023-06-15



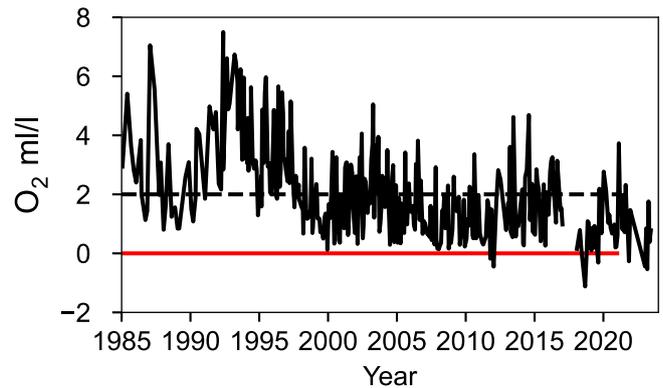
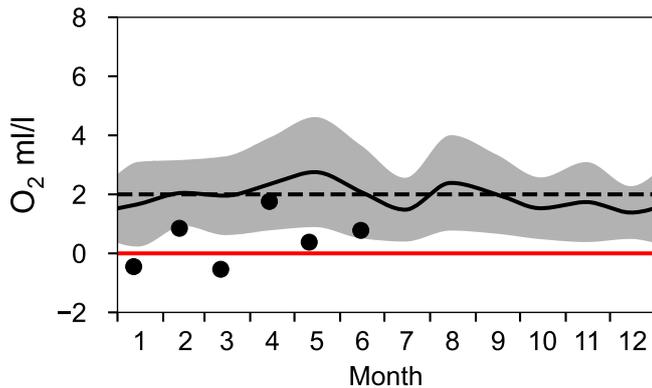
# STATION BCS III-10 SURFACE WATER (0-10 m)

Annual Cycles

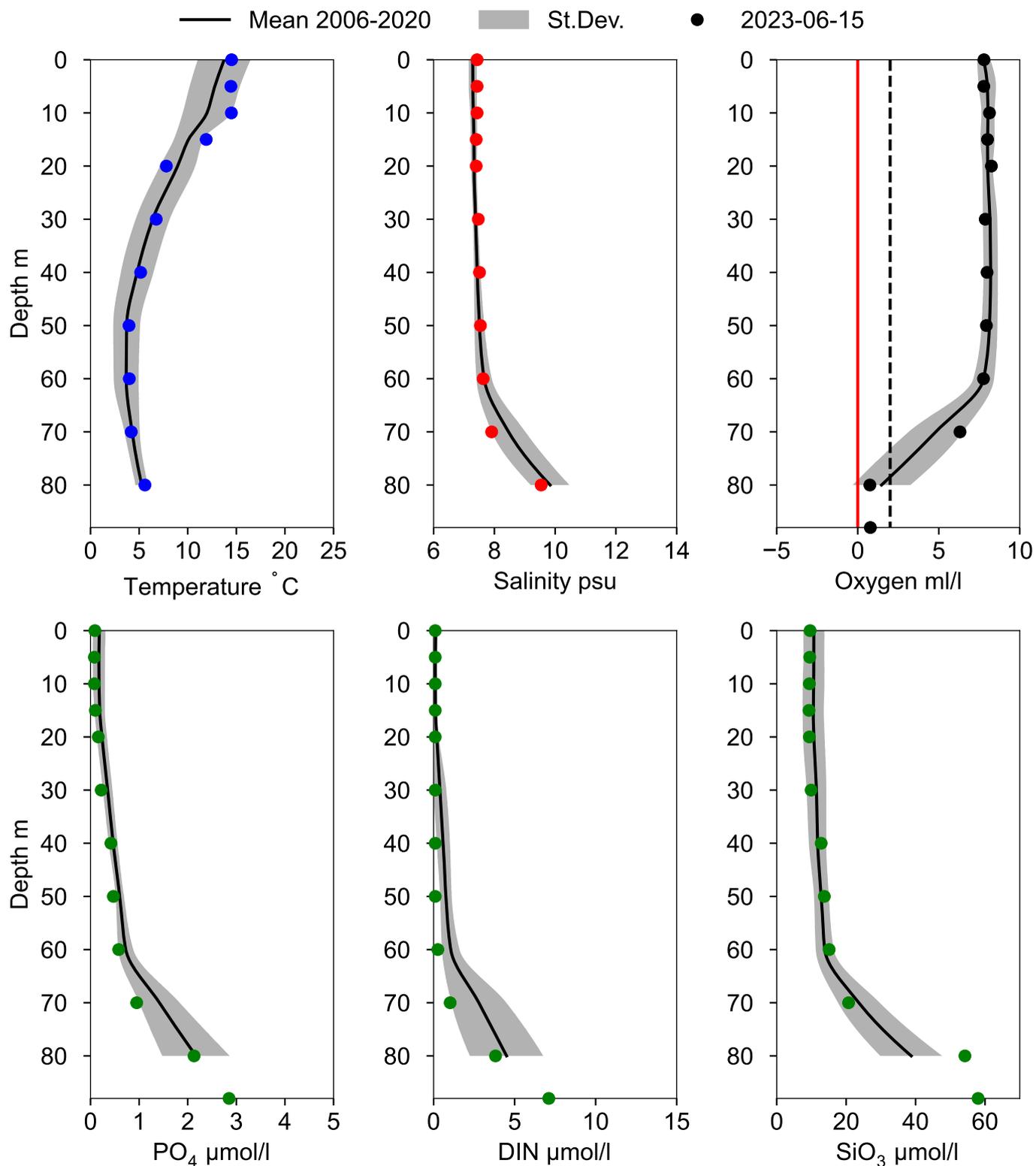
— Mean 2006-2020    St.Dev.    ● 2023



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



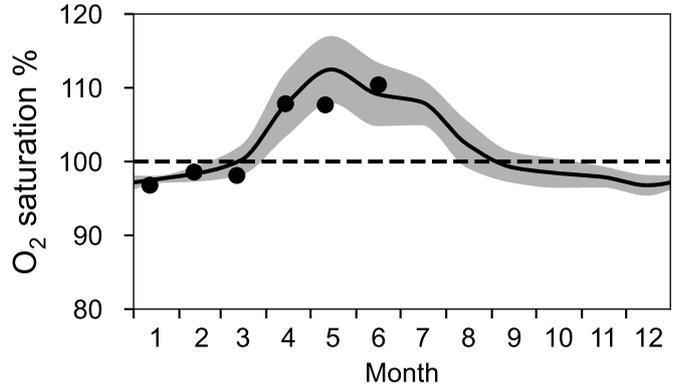
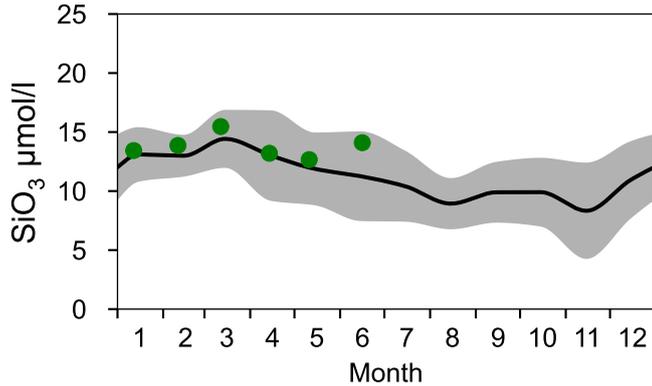
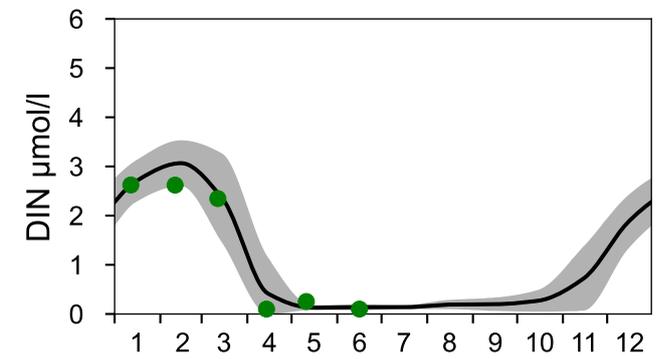
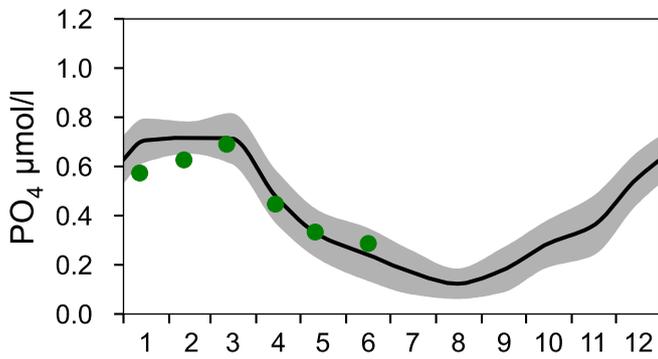
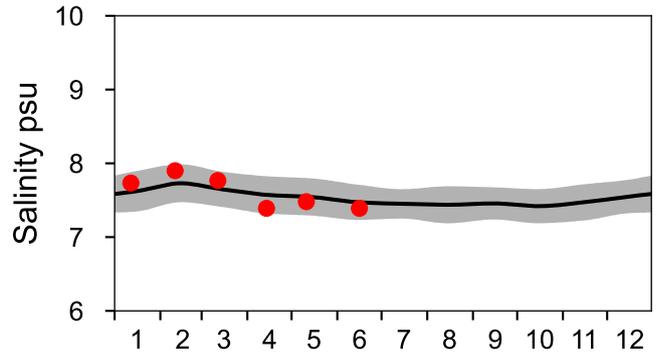
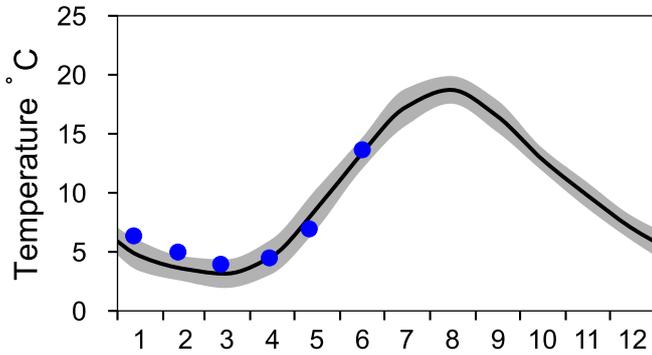
# Vertical profiles BCS III-10 June



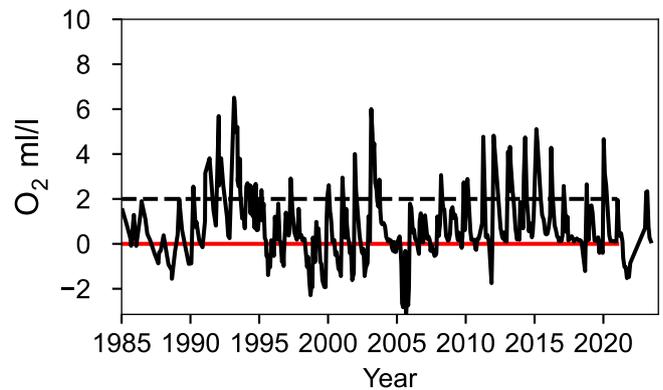
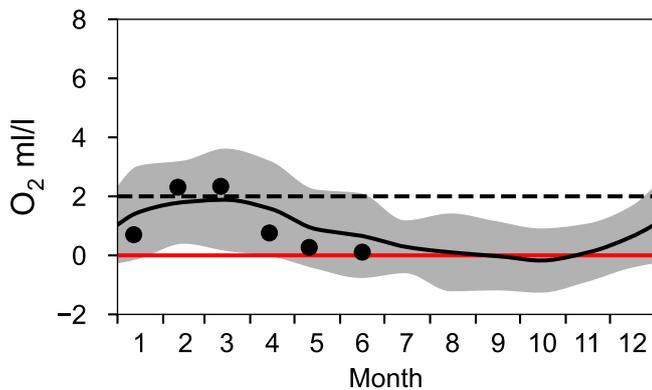
# STATION BY5 BORNHOLMSDJ SURFACE WATER (0-10 m)

Annual Cycles

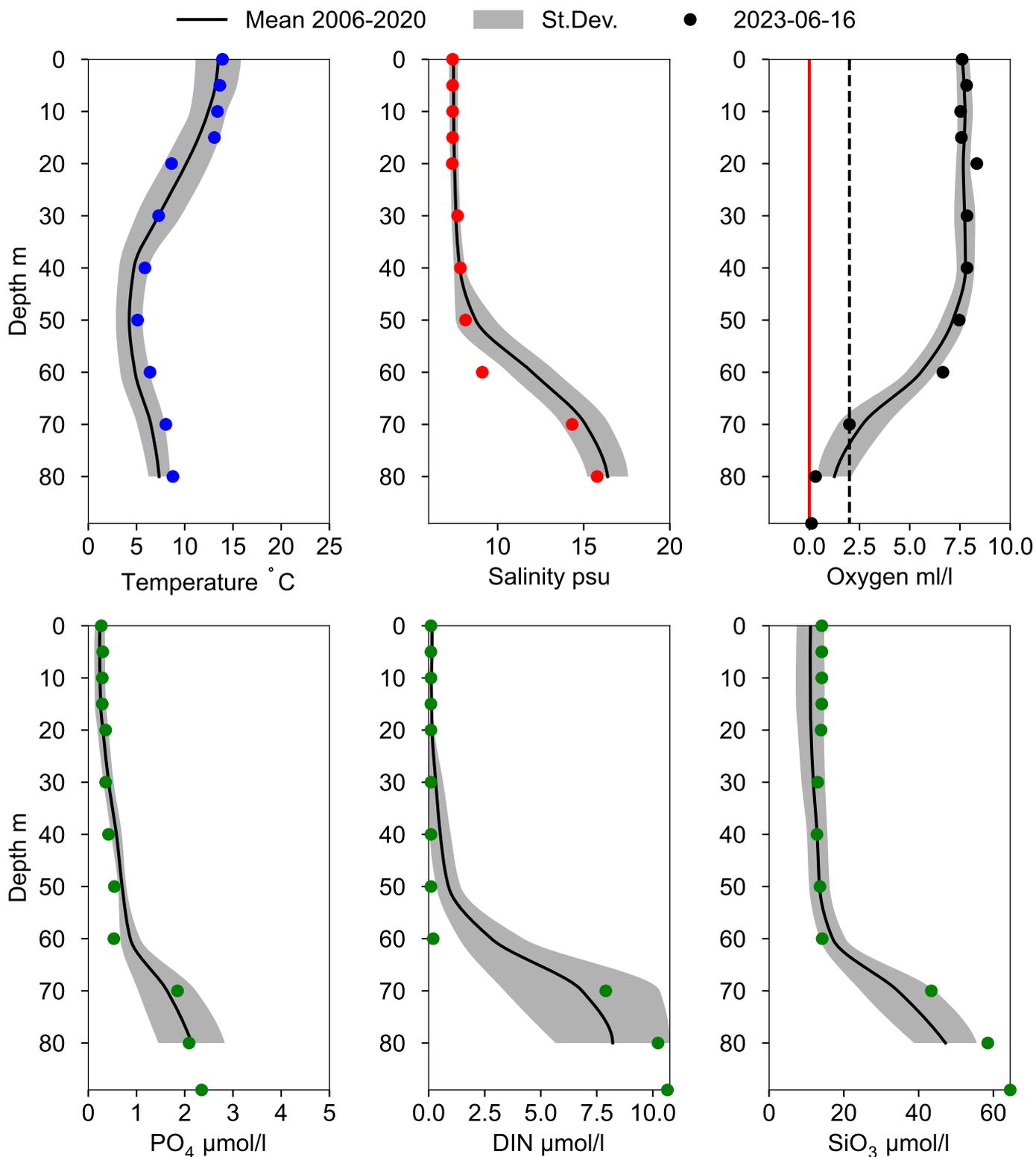
— Mean 2006-2020    St.Dev.    ● 2023



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



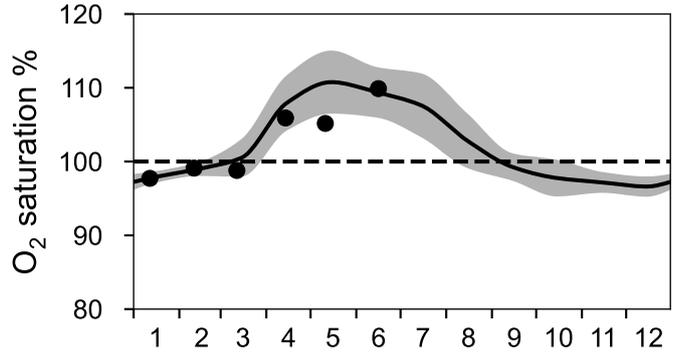
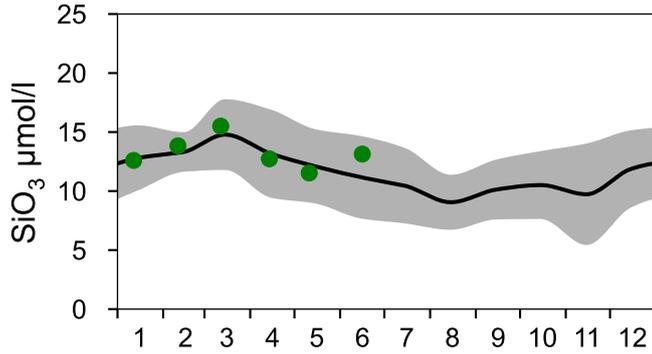
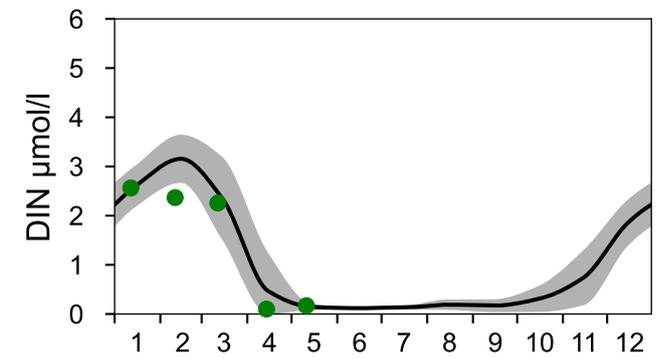
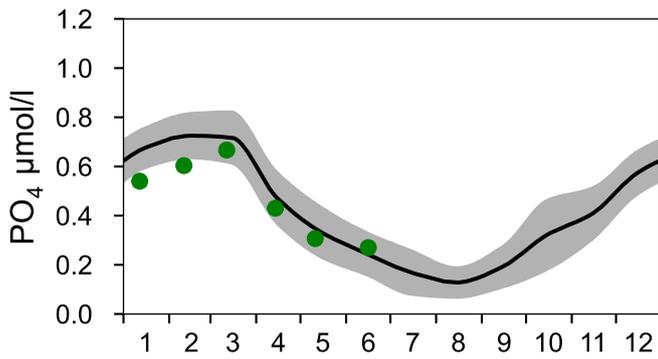
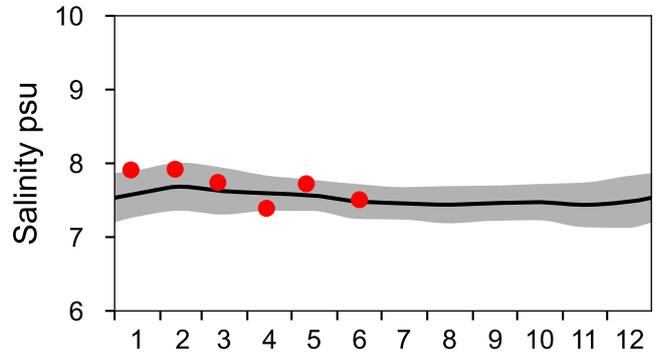
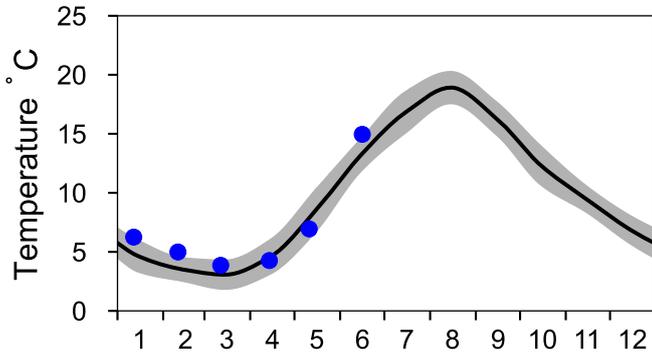
# Vertical profiles BY5 BORNHOLMSDJ June



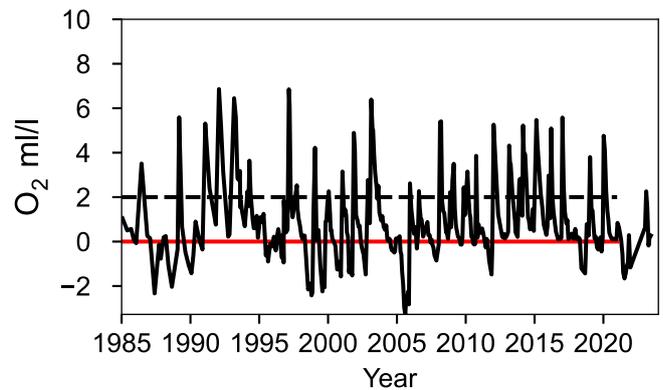
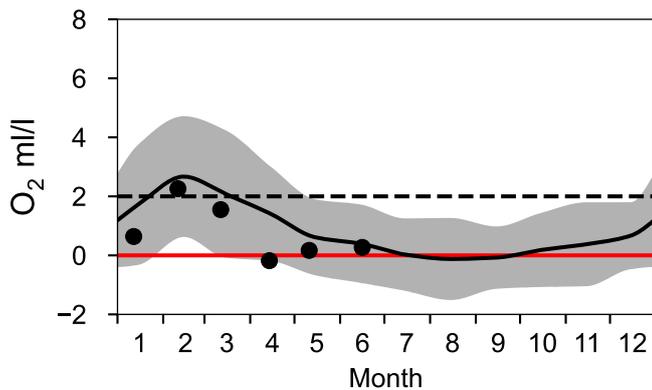
# STATION BY4 CHRISTIANSÖ SURFACE WATER (0-10 m)

Annual Cycles

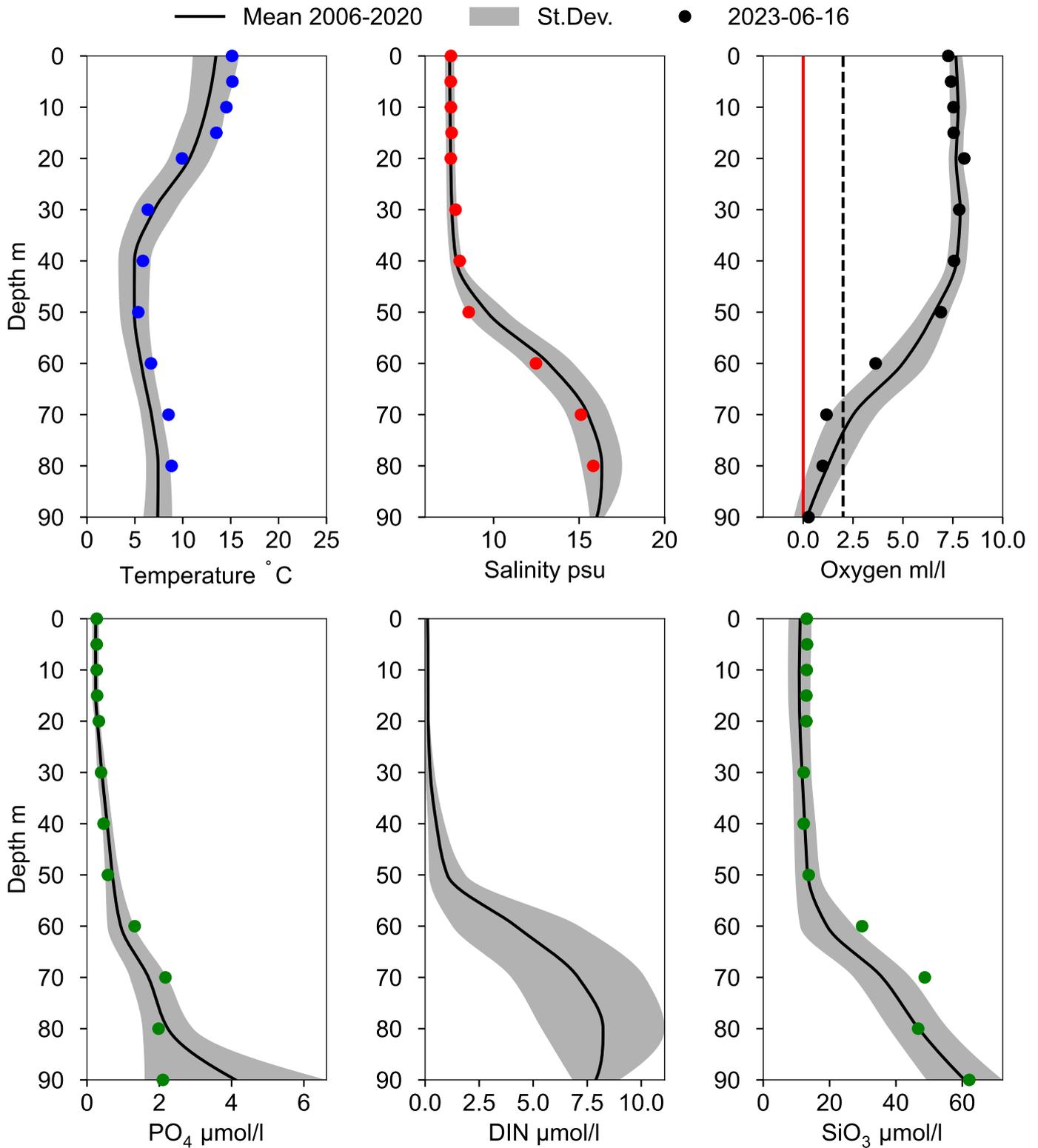
— Mean 2006-2020    St.Dev.    ● 2023



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



# Vertical profiles BY4 CHRISTIANSÖ June



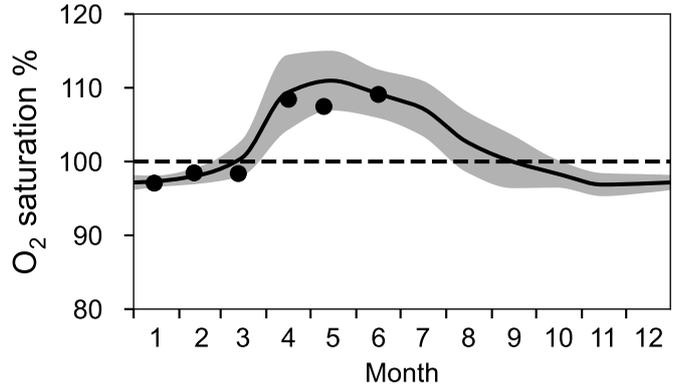
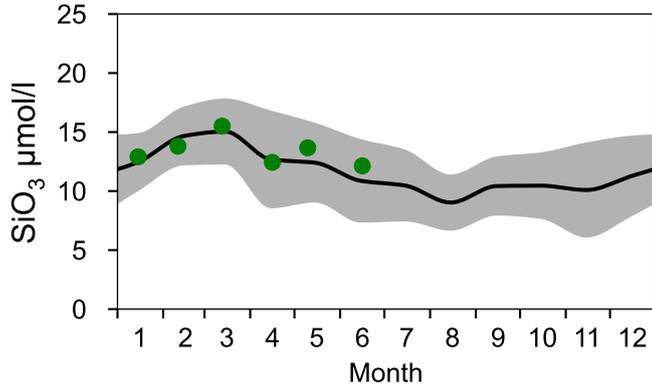
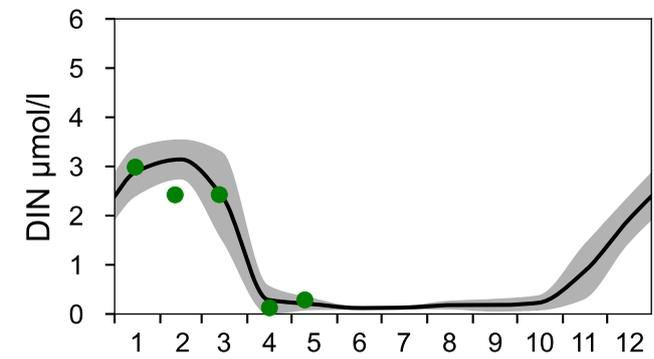
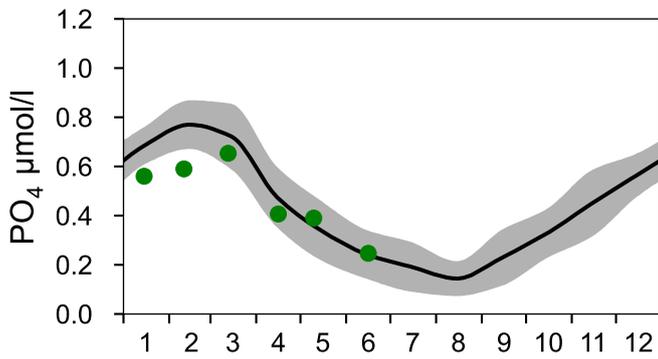
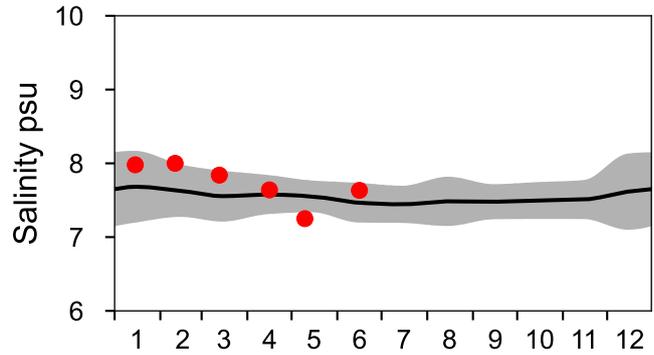
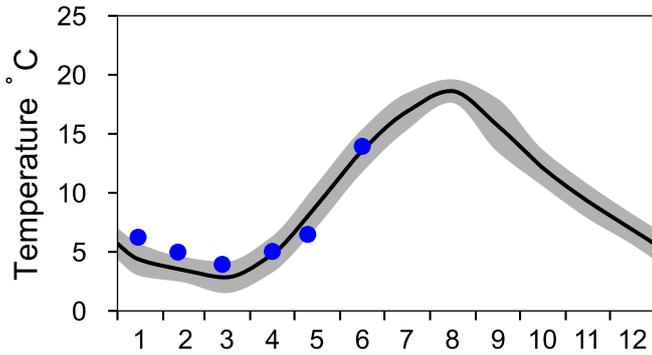
# STATION HANÖBUKTEN SURFACE WATER (0-10 m)

Annual Cycles

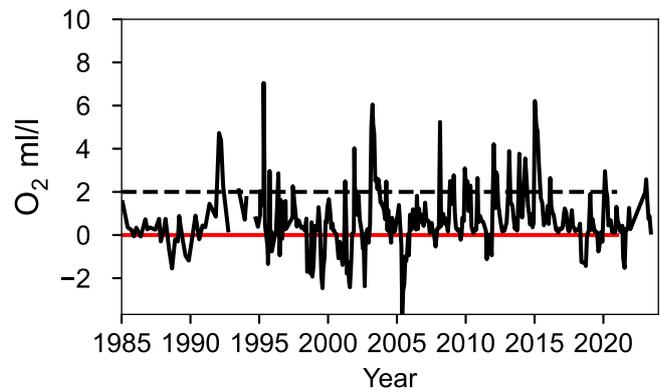
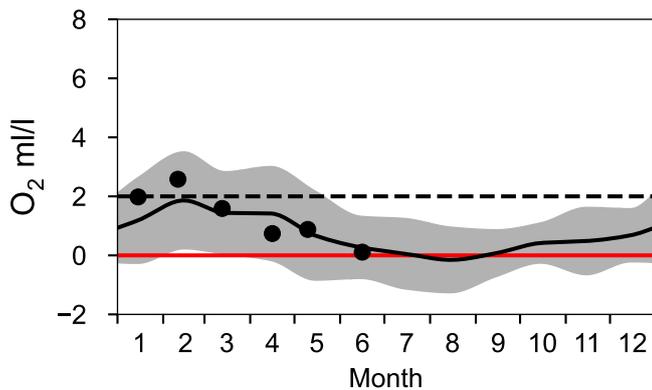
— Mean 2006-2020

■ St.Dev.

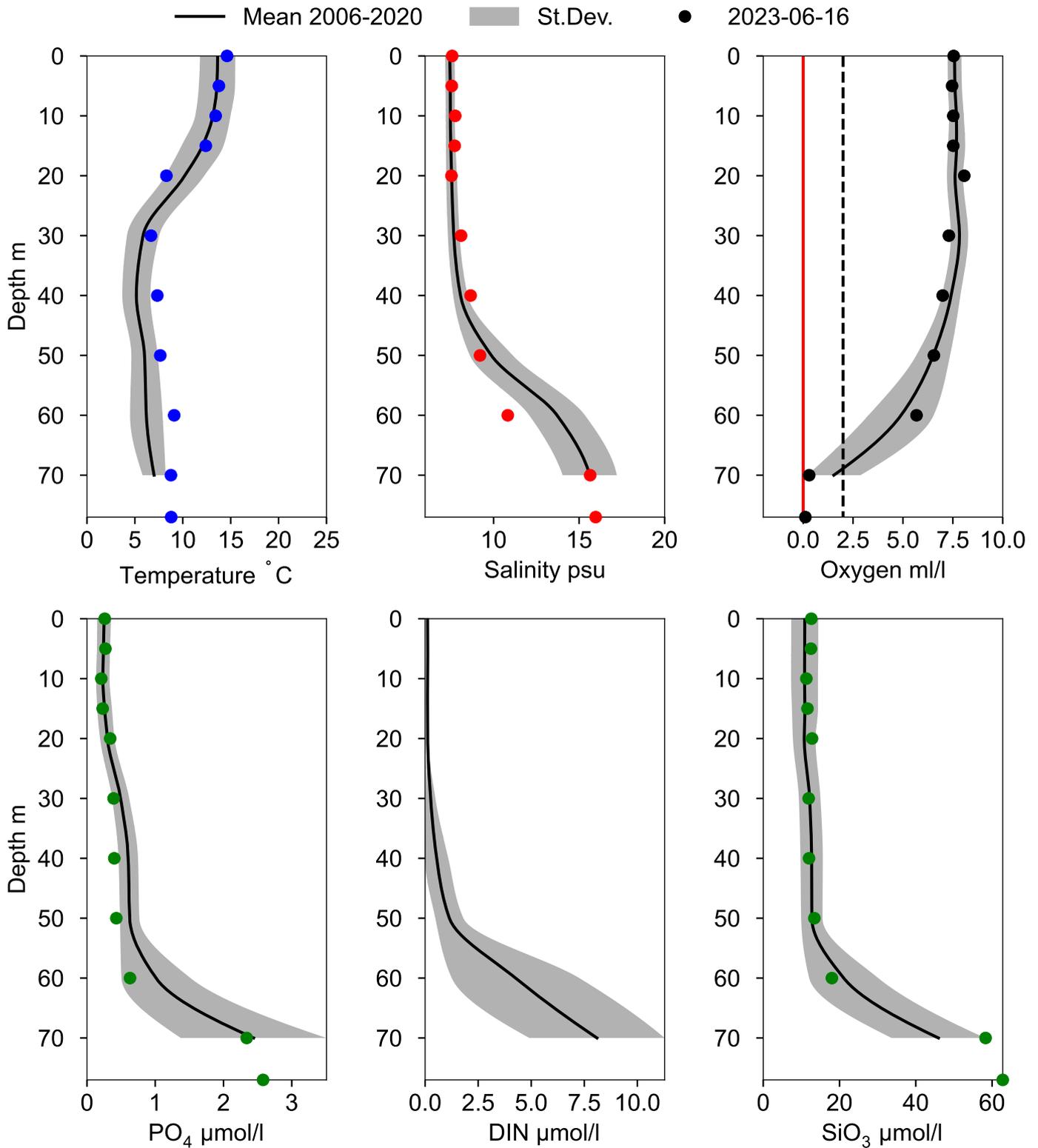
● 2023



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



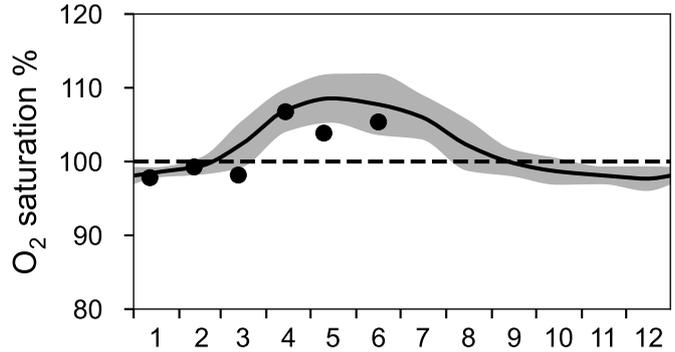
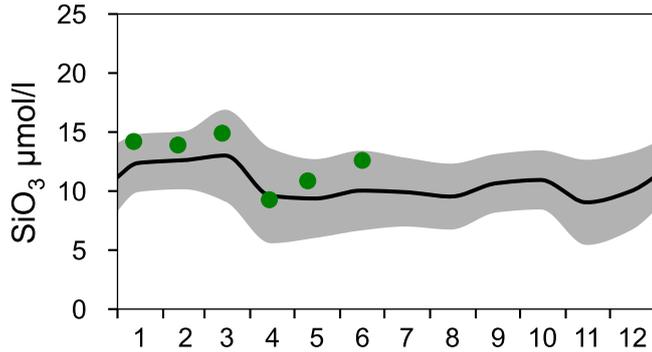
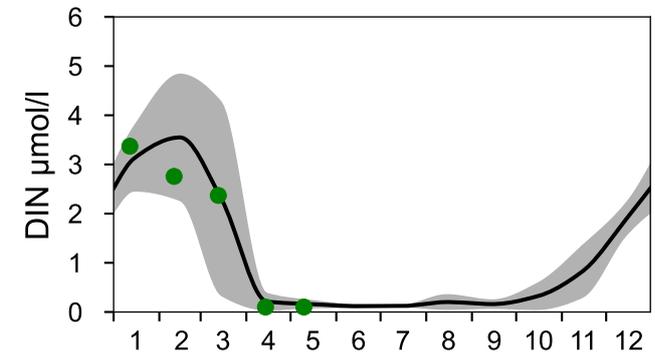
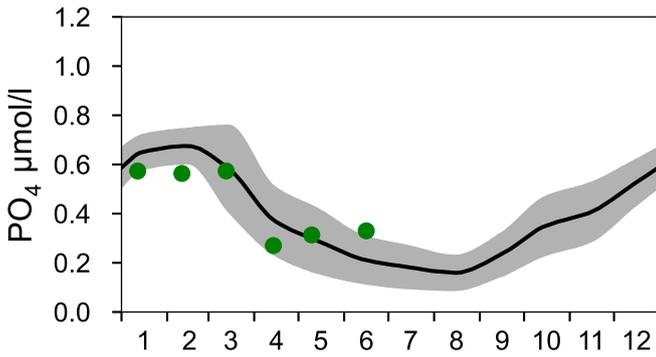
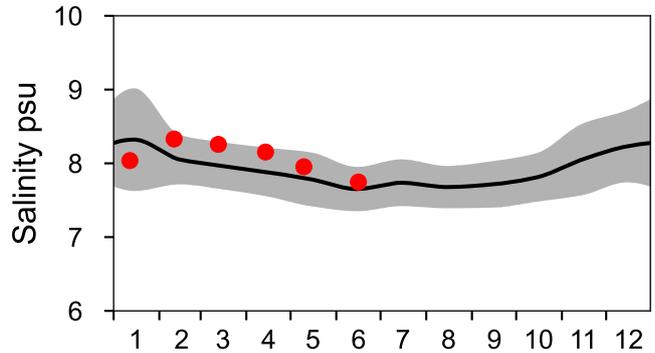
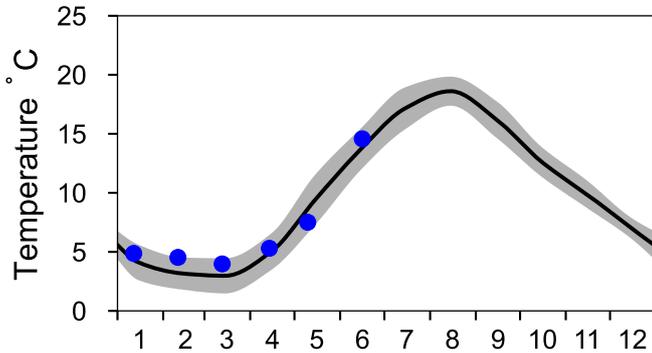
# Vertical profiles HANÖBUKTEN June



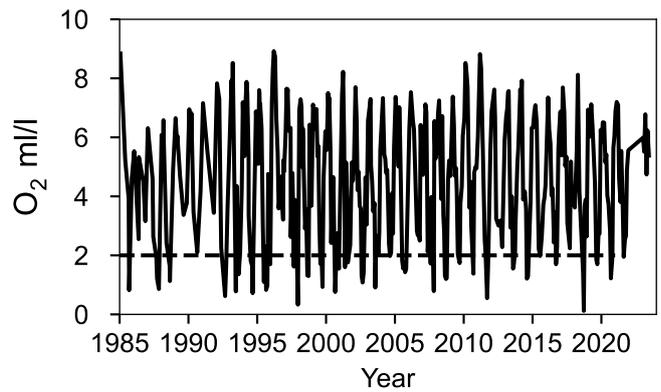
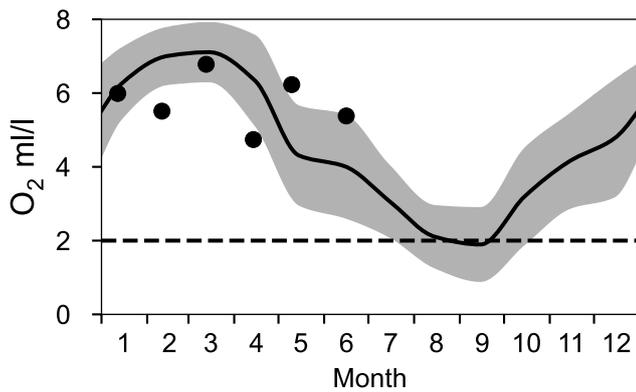
# STATION BY2 ARKONA SURFACE WATER (0-10 m)

Annual Cycles

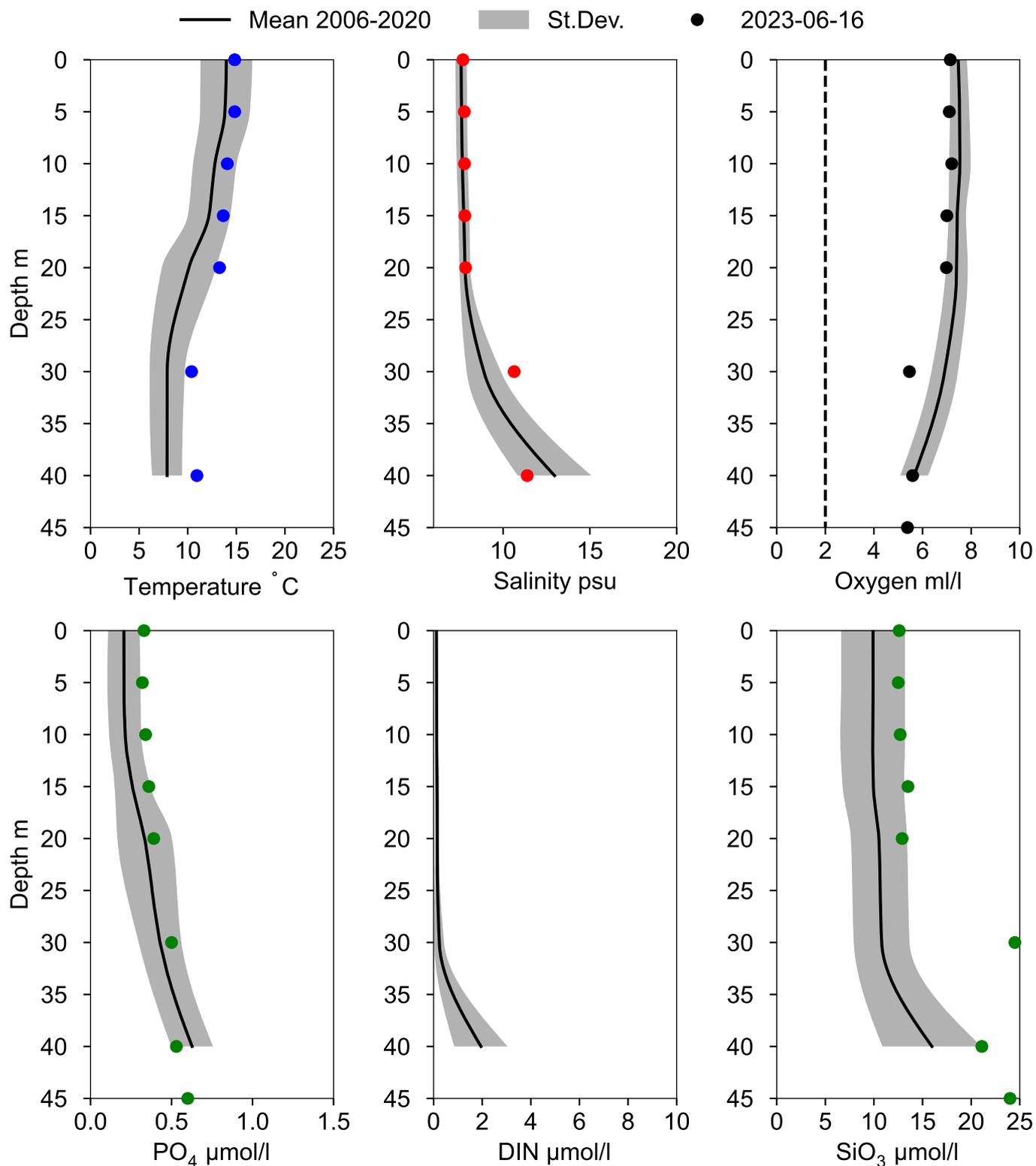
— Mean 2006-2020    St.Dev.    ● 2023



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



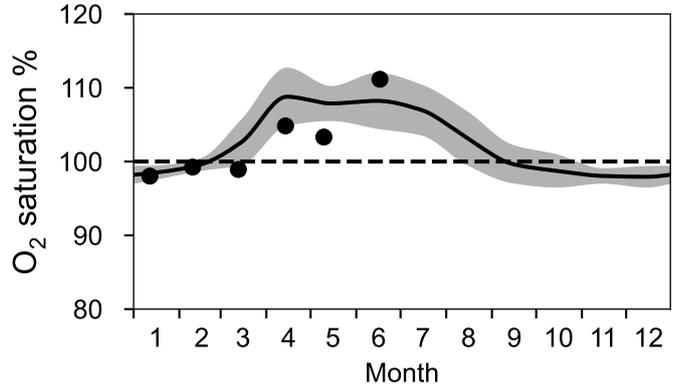
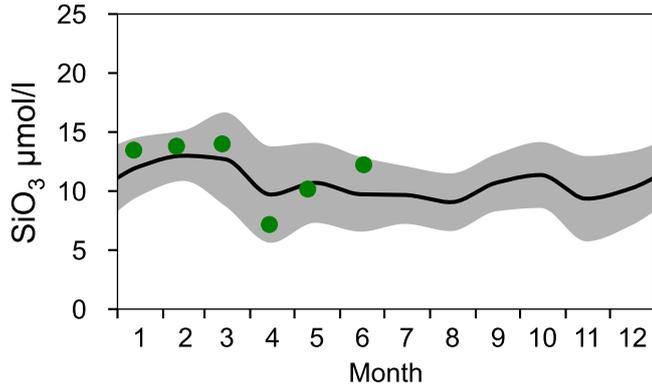
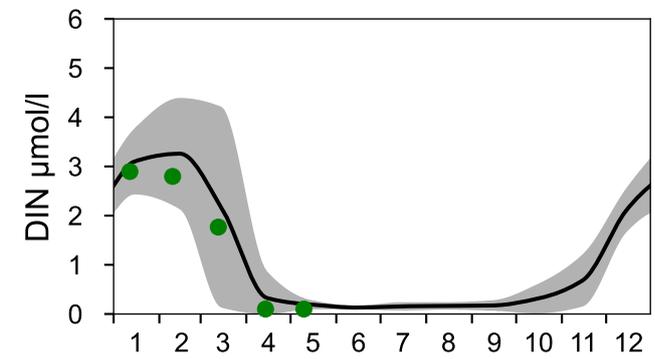
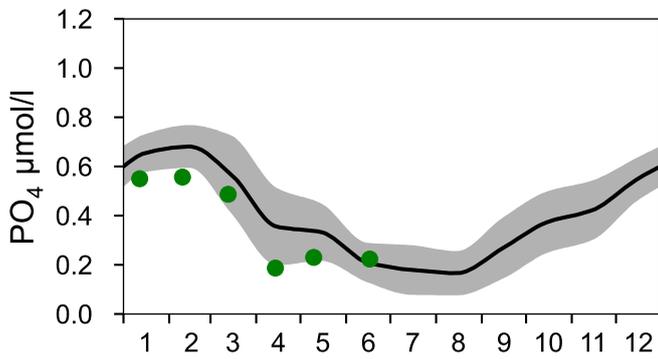
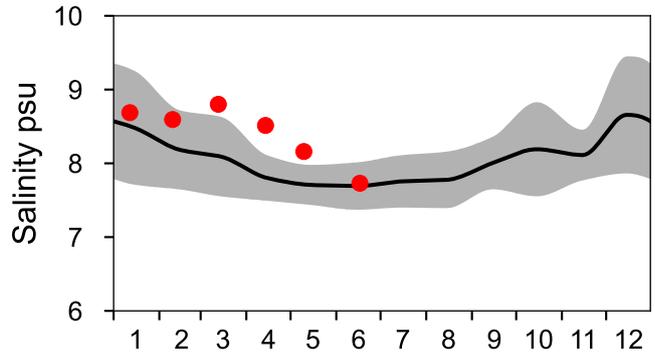
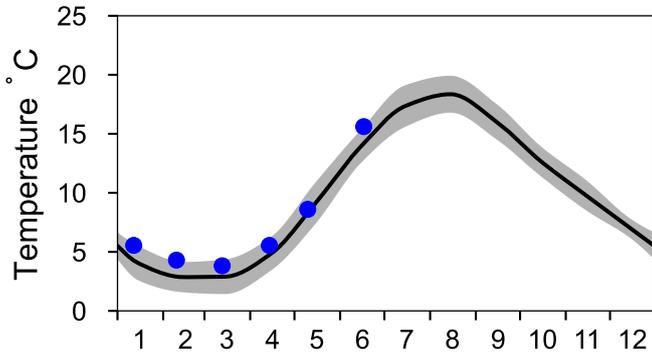
# Vertical profiles BY2 ARKONA June



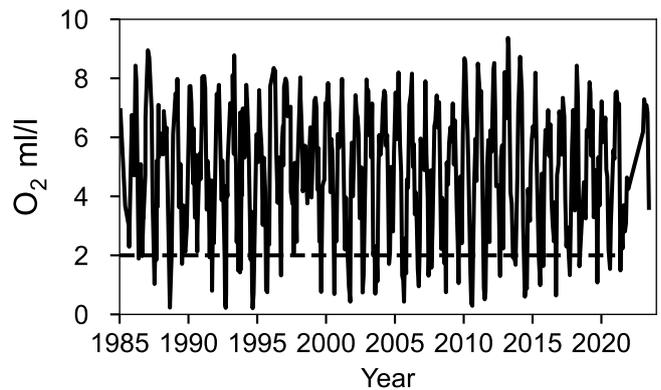
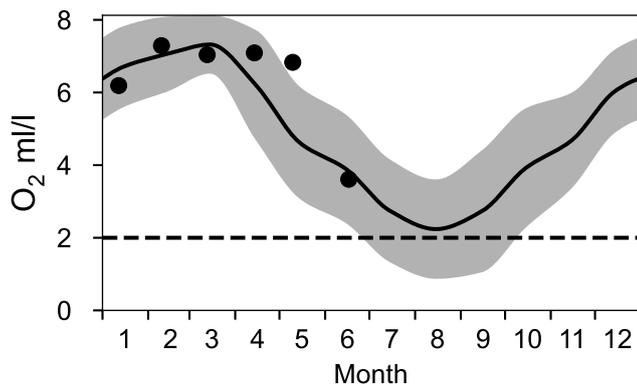
# STATION BY1 SURFACE WATER (0-10 m)

Annual Cycles

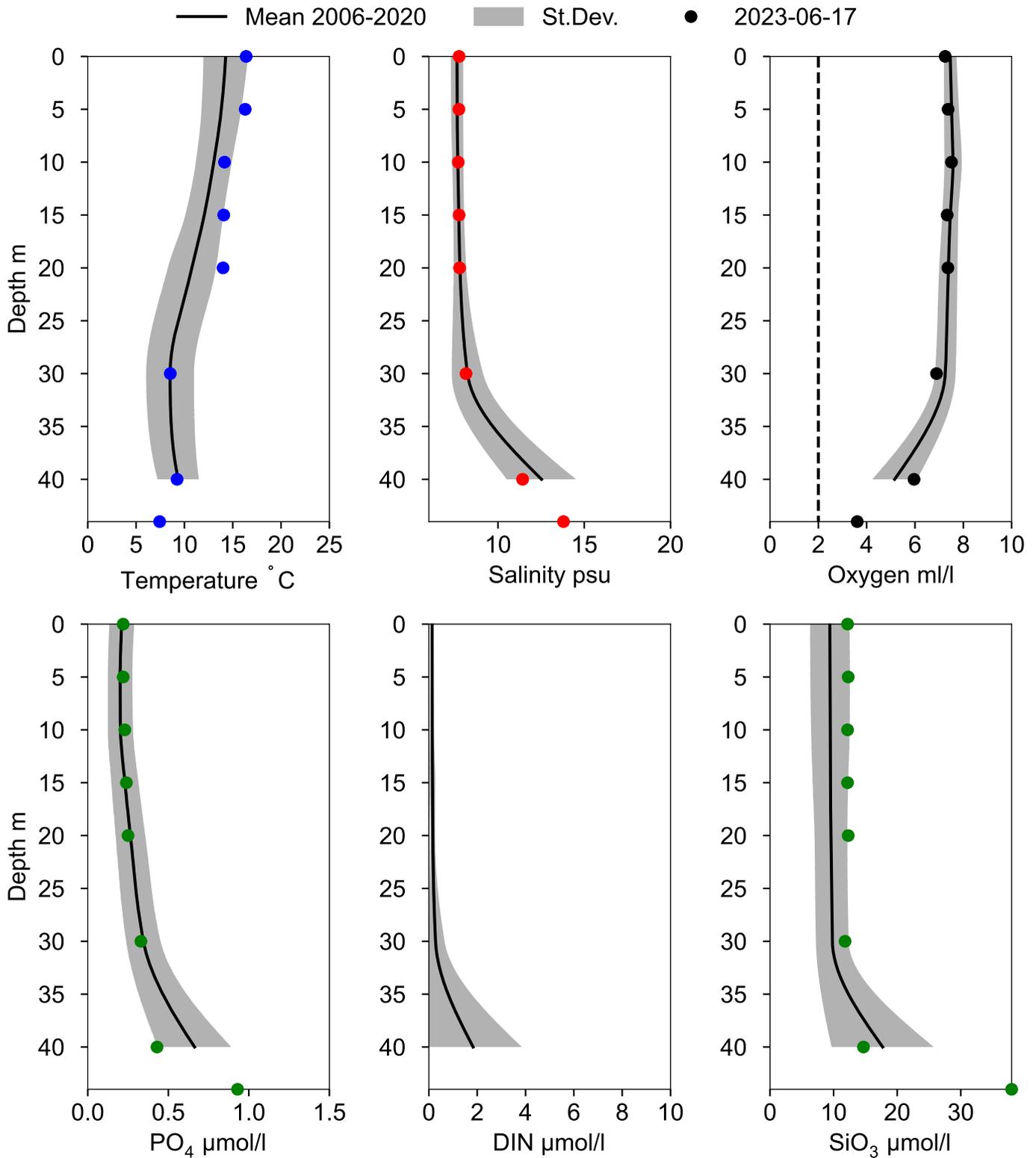
— Mean 2006-2020    St.Dev.    ● 2023



## OXYGEN IN BOTTOM WATER (depth >= 39 m)



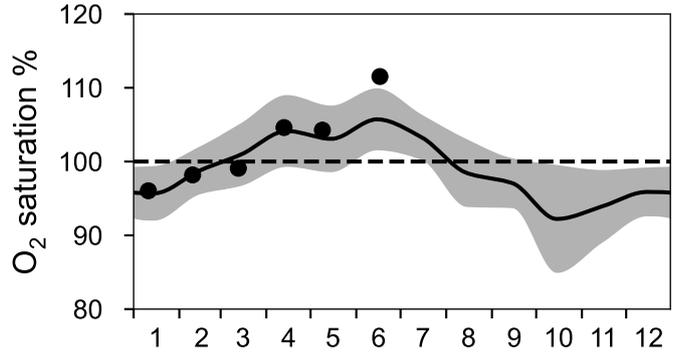
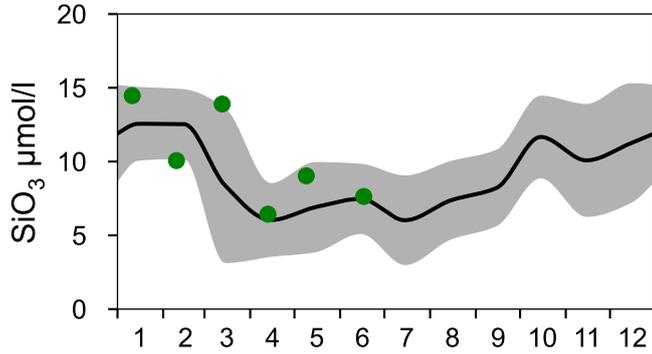
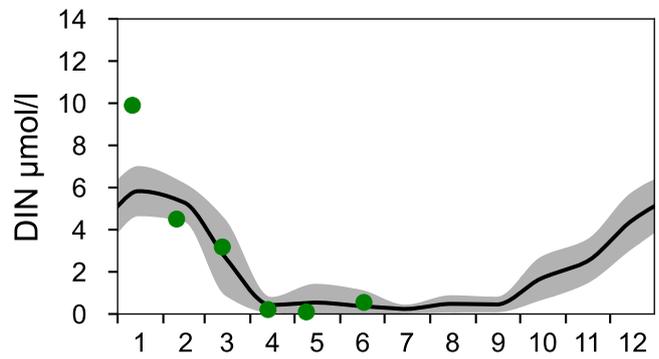
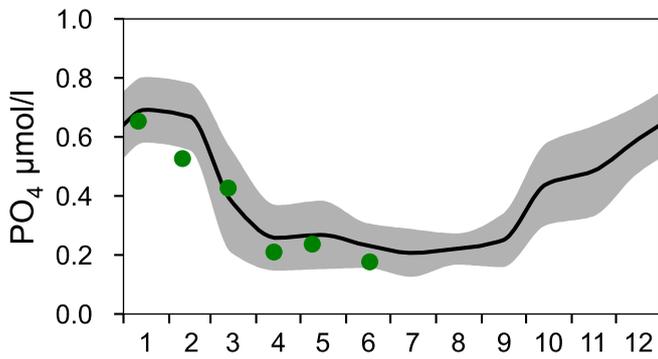
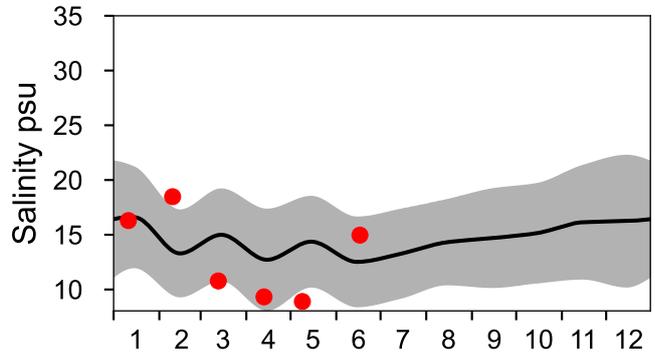
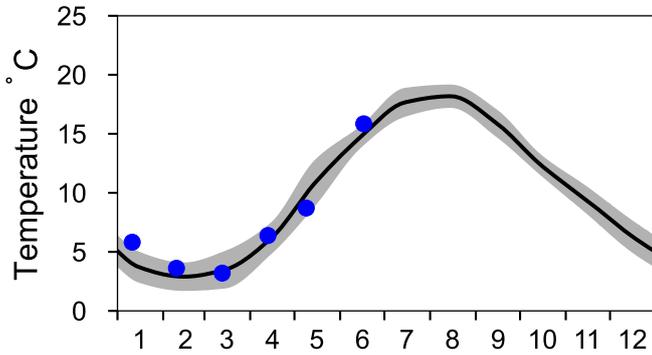
# Vertical profiles BY1 June



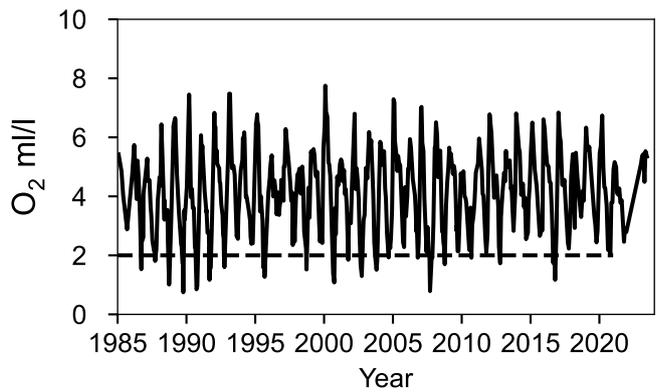
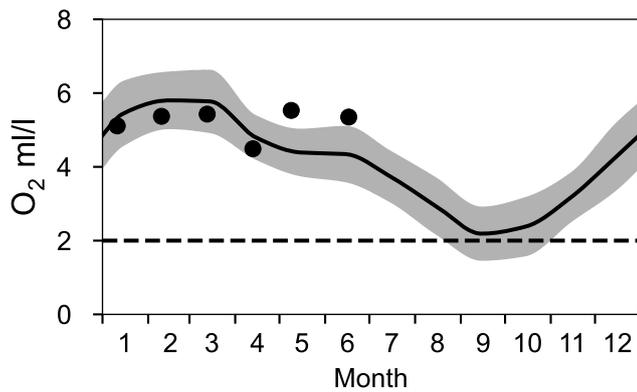
# STATION W LANDSKRONA SURFACE WATER (0-10 m)

Annual Cycles

— Mean 2006-2020    St.Dev.    ● 2023



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

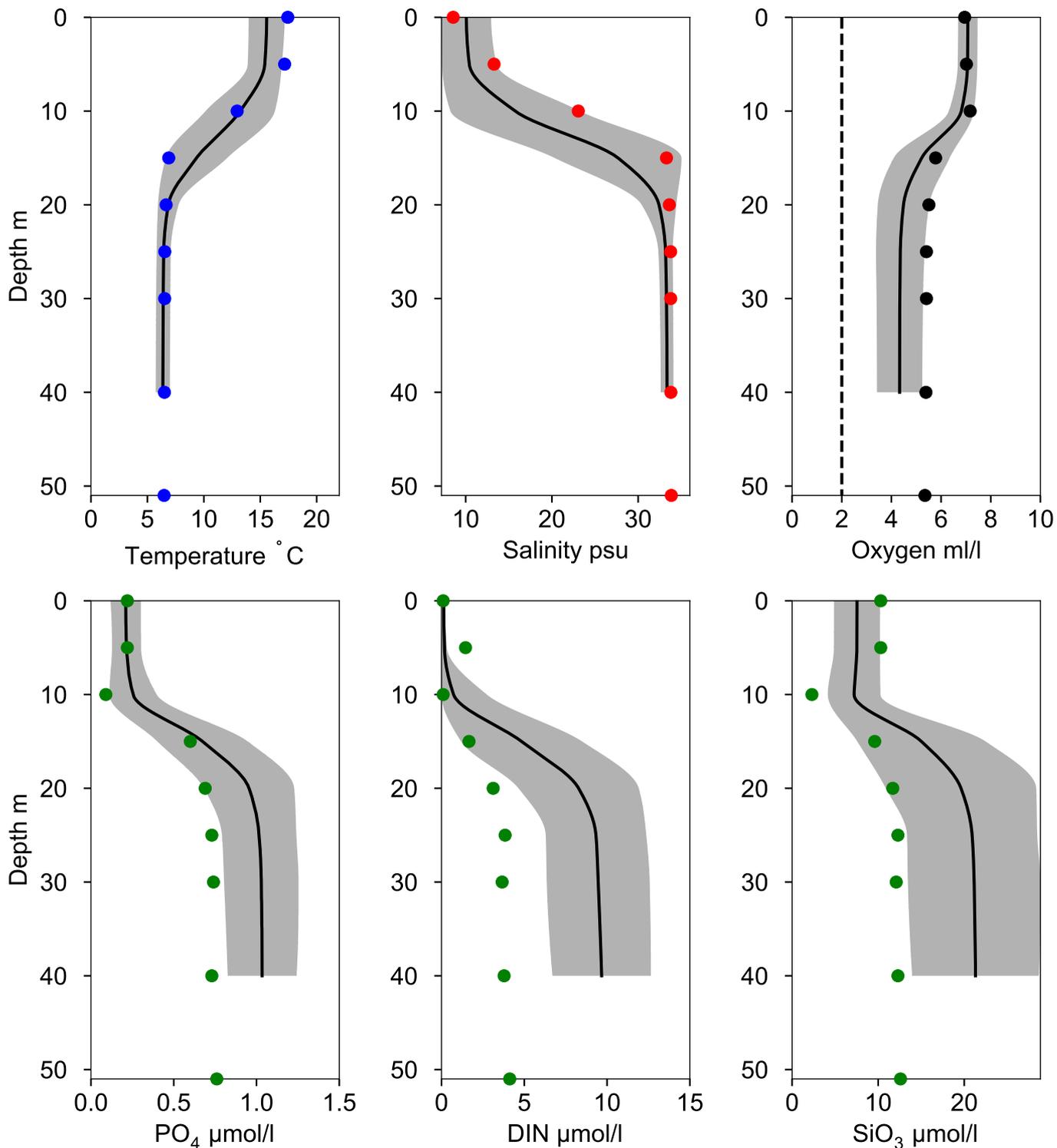


# Vertical profiles W LANDSKRONA June

— Mean 2006-2020

■ St.Dev.

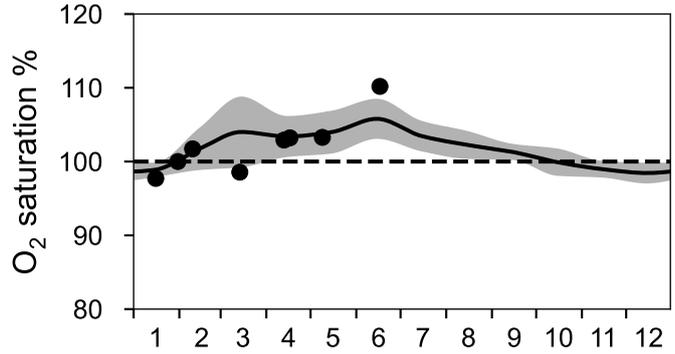
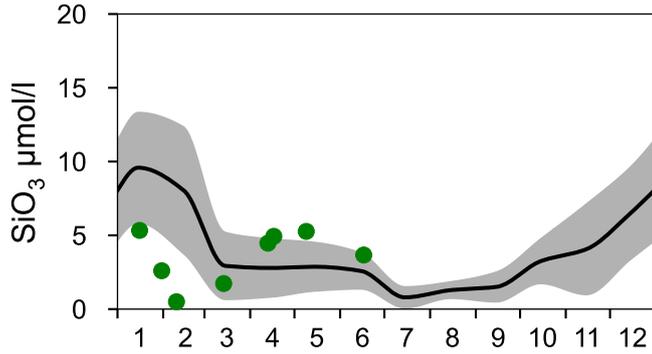
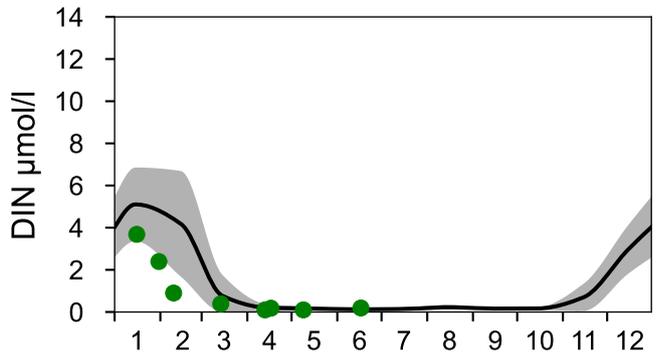
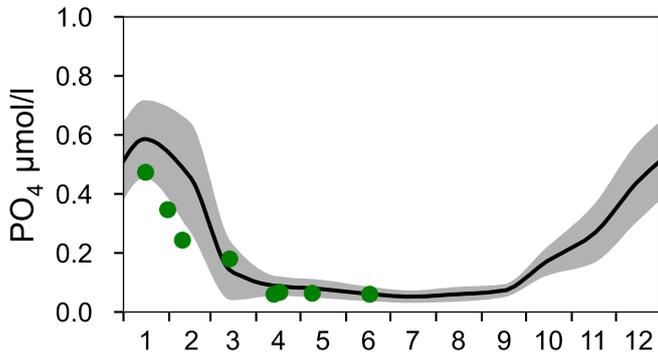
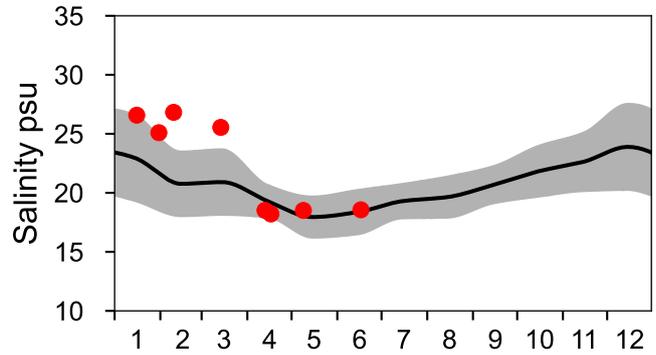
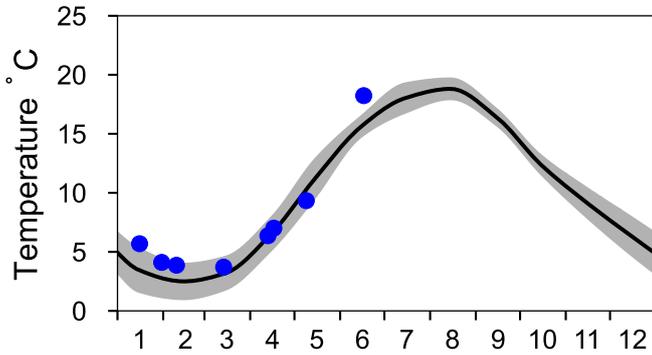
● 2023-06-17



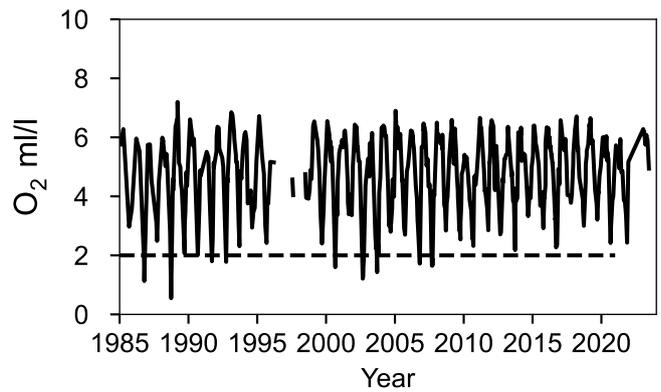
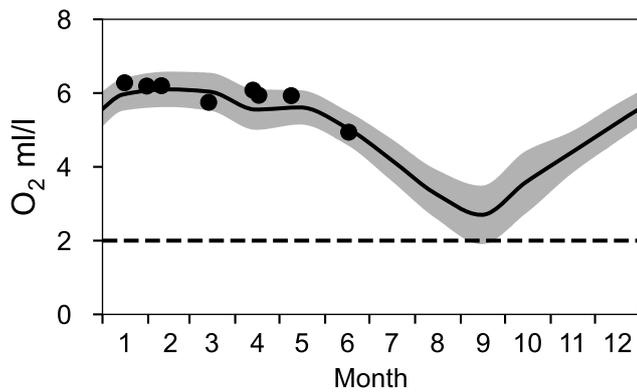
# STATION ANHOLT E SURFACE WATER (0-10 m)

Annual Cycles

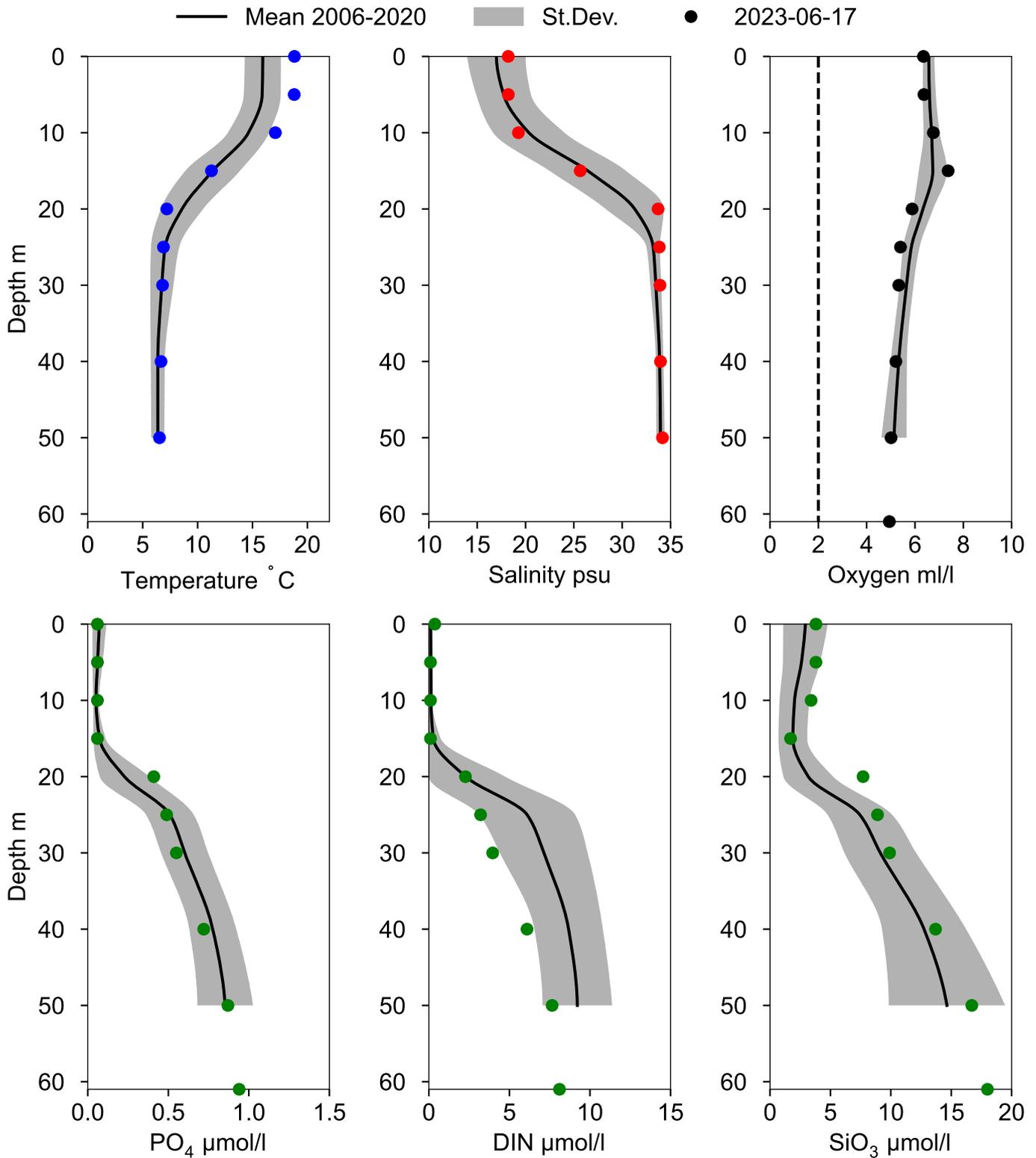
— Mean 2006-2020    St.Dev.    ● 2023



## OXOGEN IN BOTTOM WATER (depth >= 52 m)



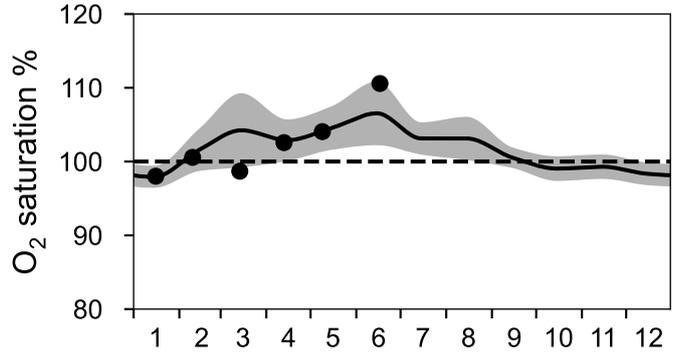
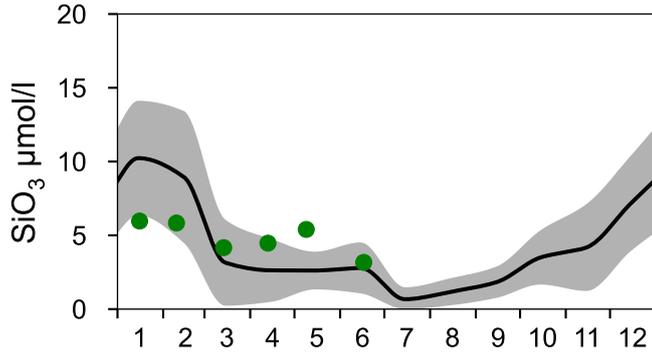
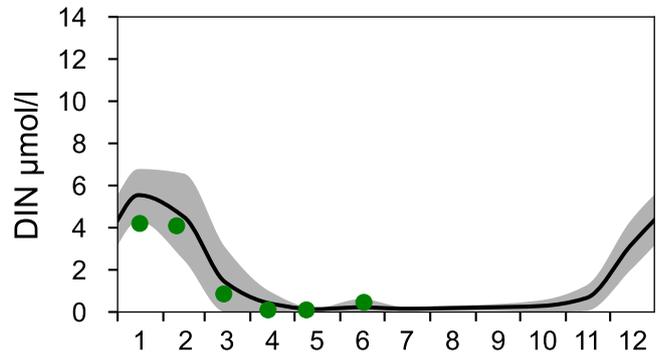
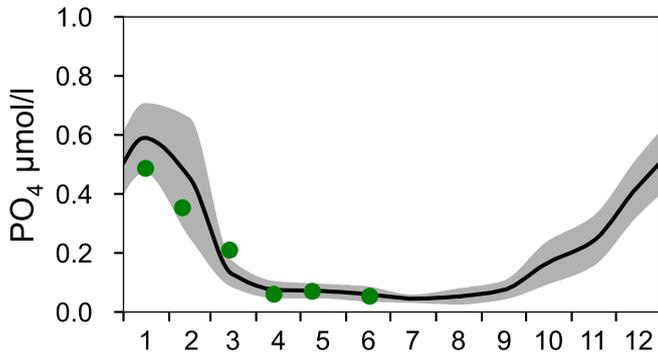
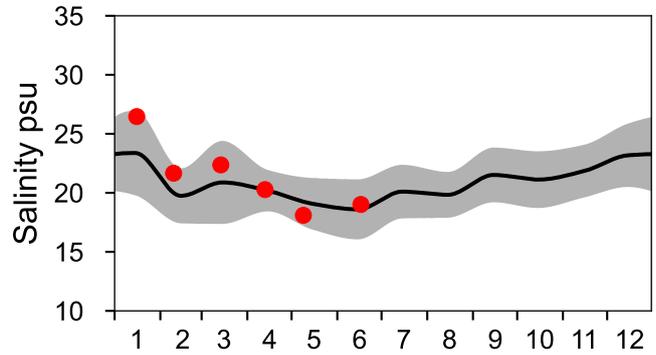
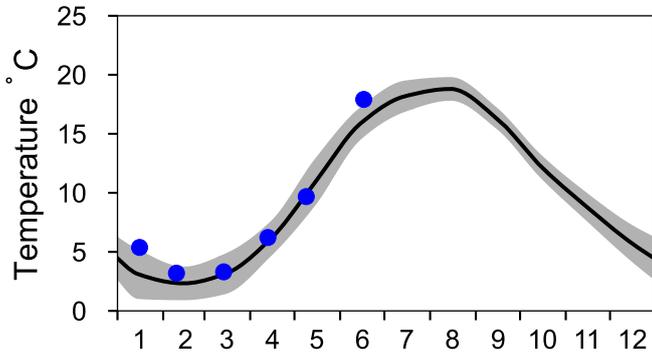
# Vertical profiles ANHOLT E June



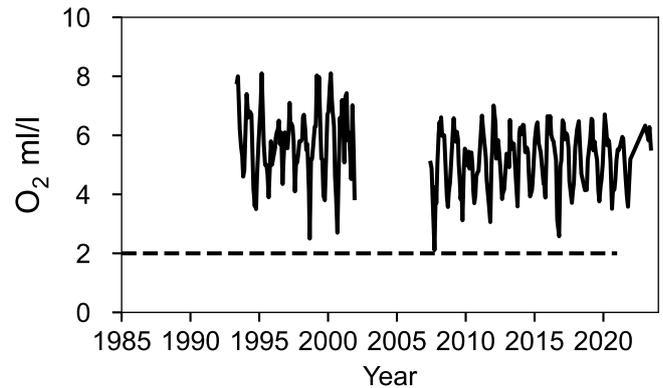
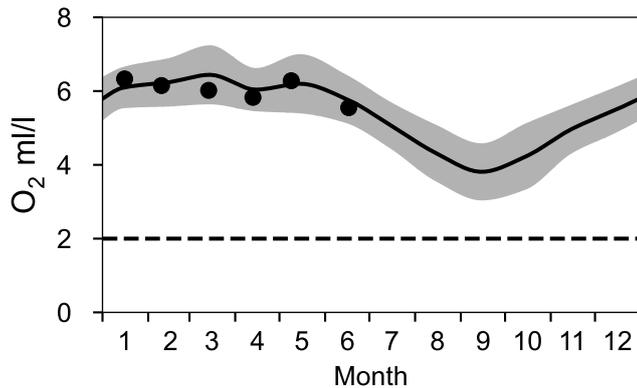
# STATION N14 FALKENBERG SURFACE WATER (0-10 m)

Annual Cycles

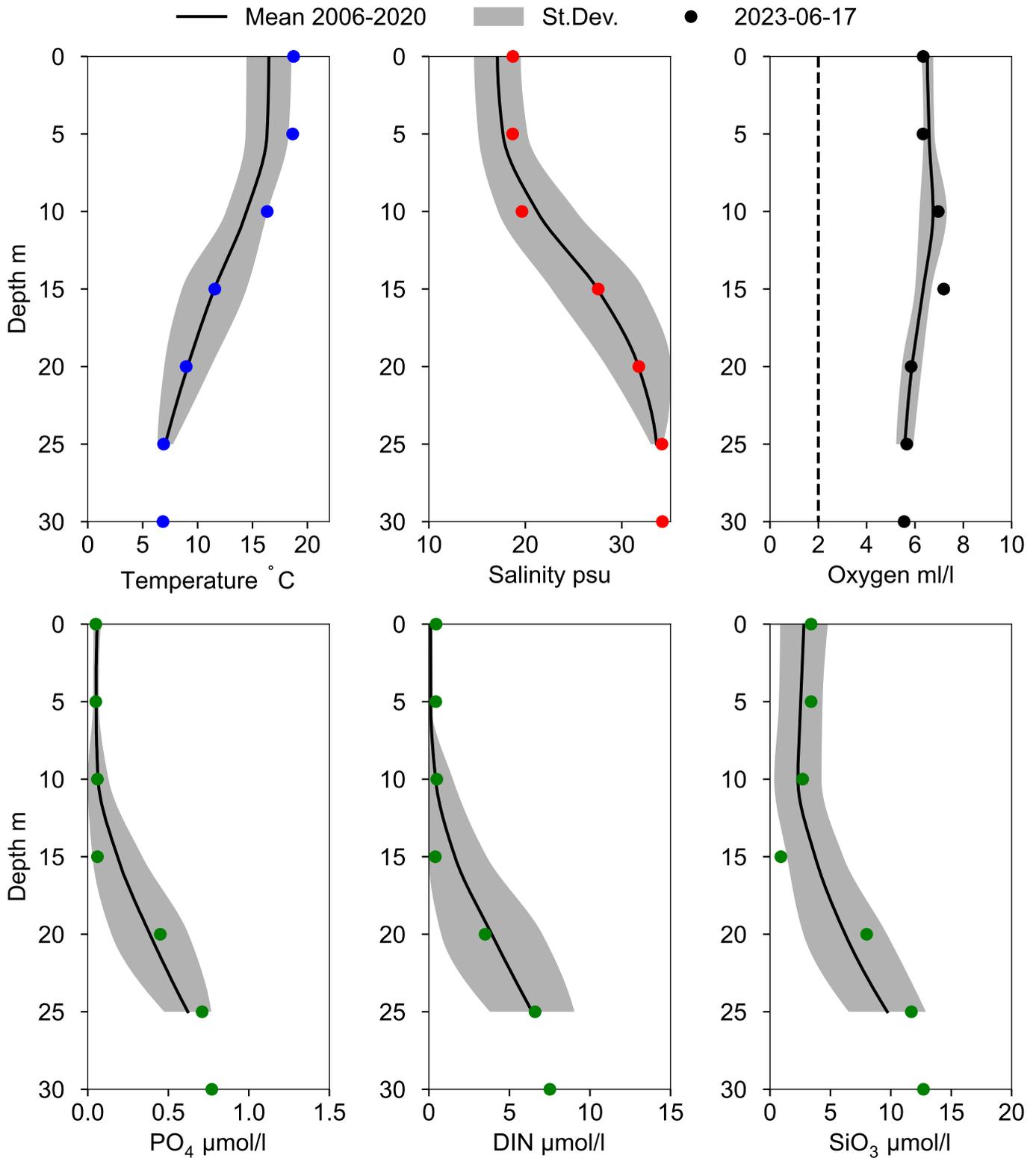
— Mean 2006-2020    St.Dev.    ● 2023



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



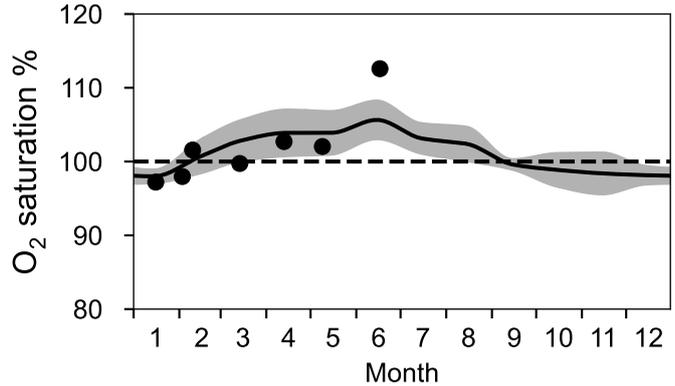
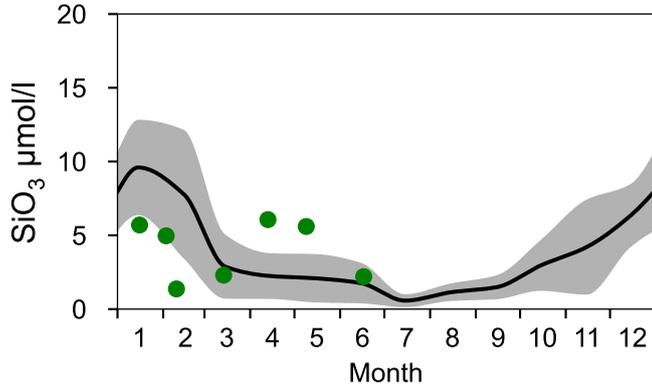
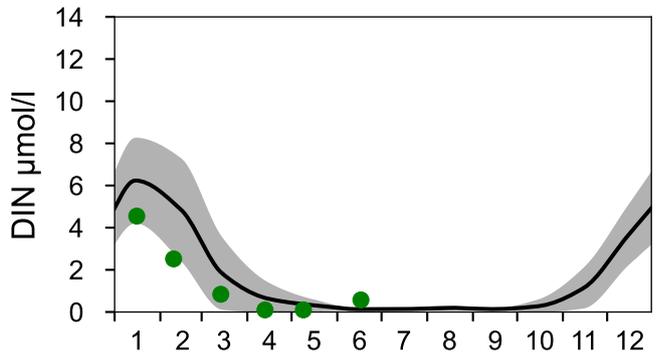
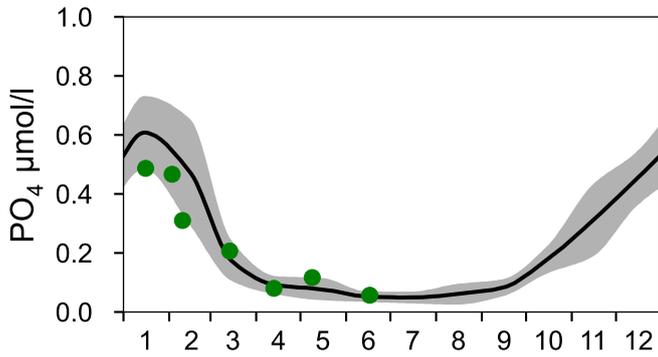
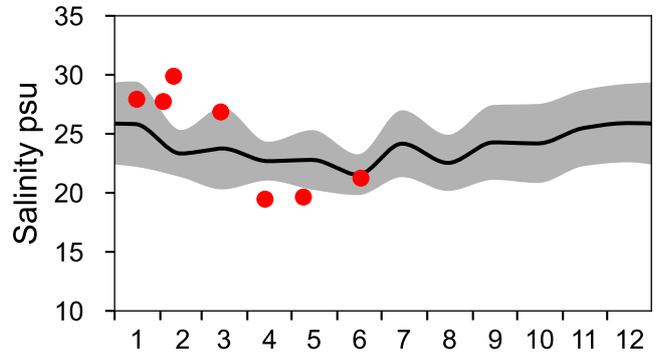
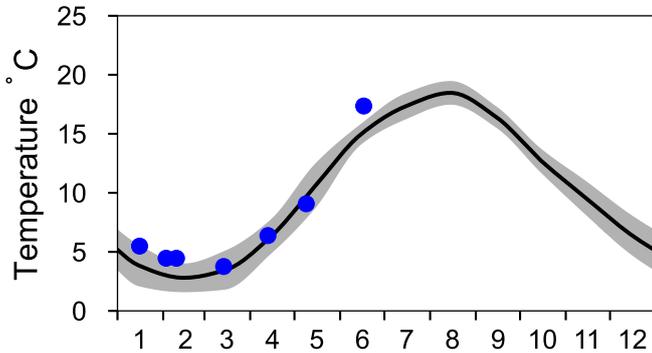
# Vertical profiles N14 FALKENBERG June



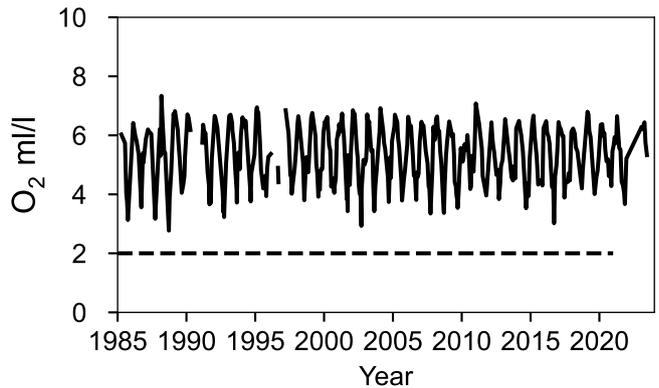
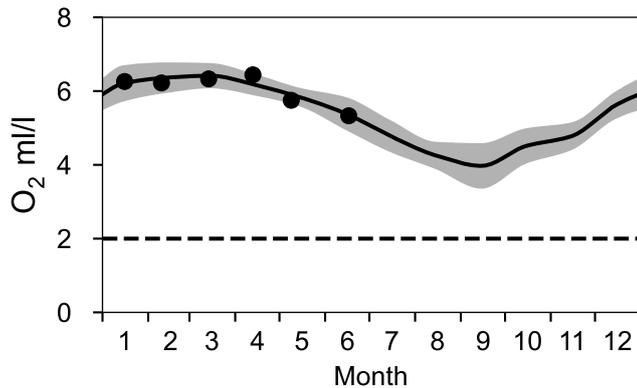
# STATION FLADEN SURFACE WATER (0-10 m)

Annual Cycles

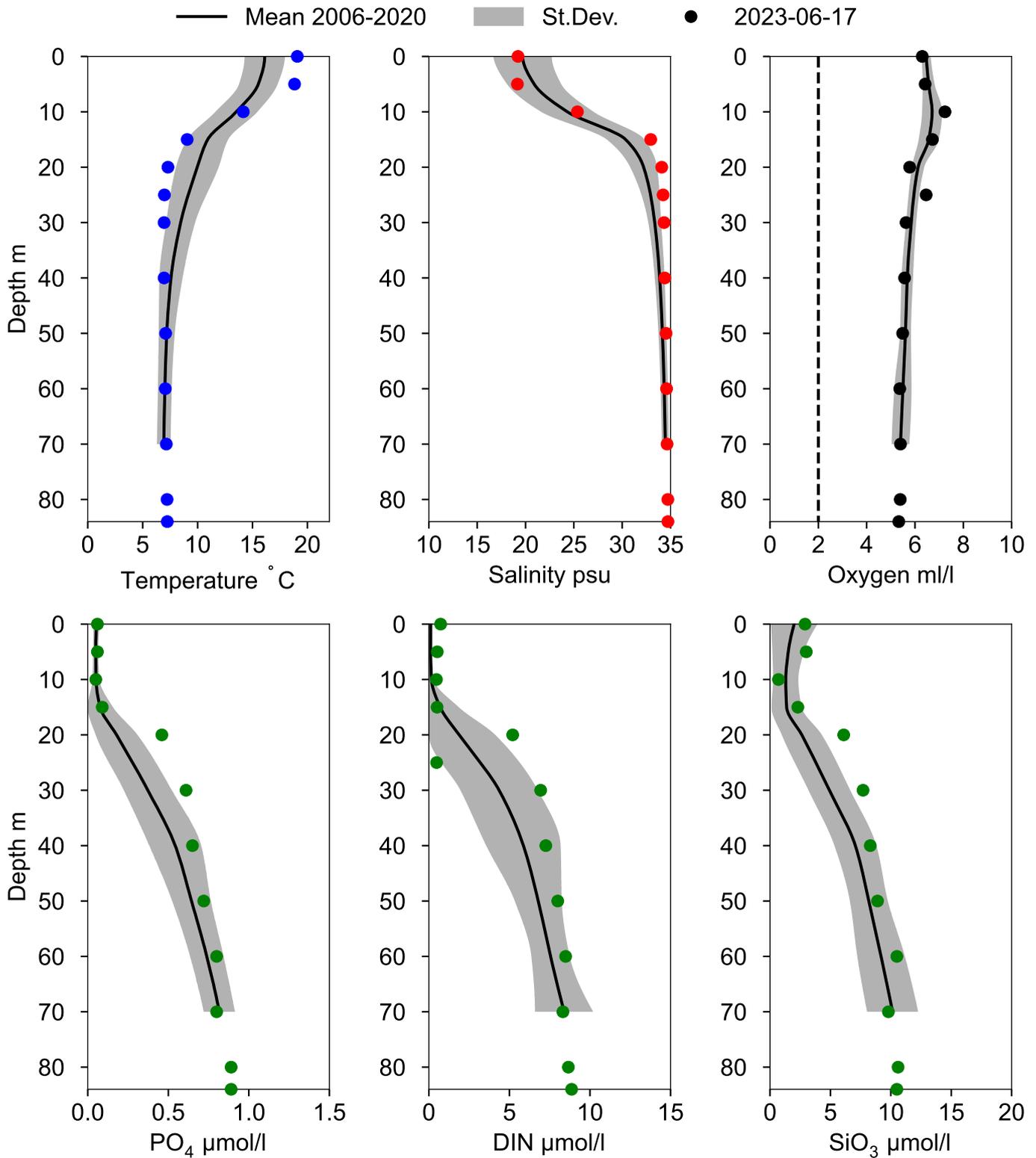
— Mean 2006-2020    St.Dev.    ● 2023



## OXYGEN IN BOTTOM WATER (depth >= 74 m)



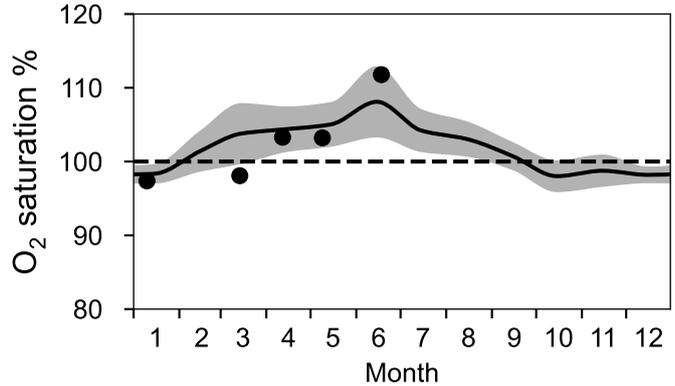
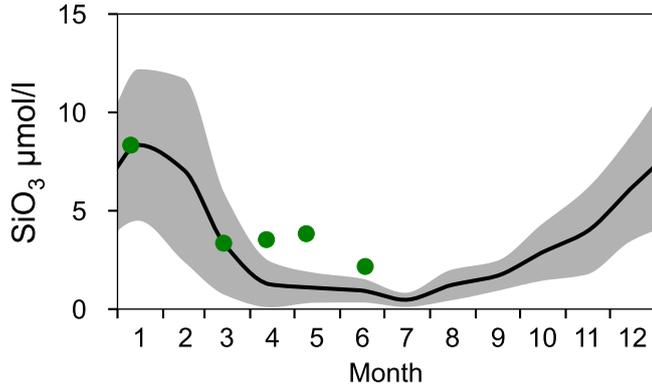
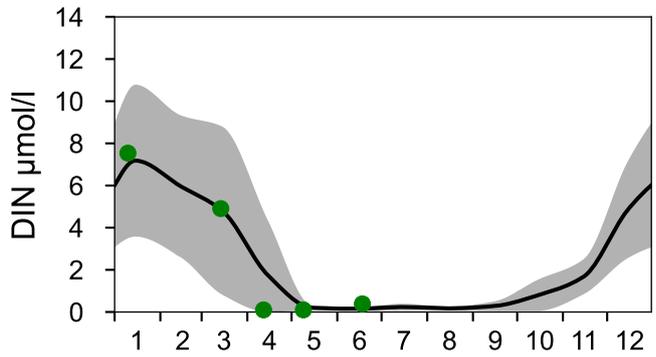
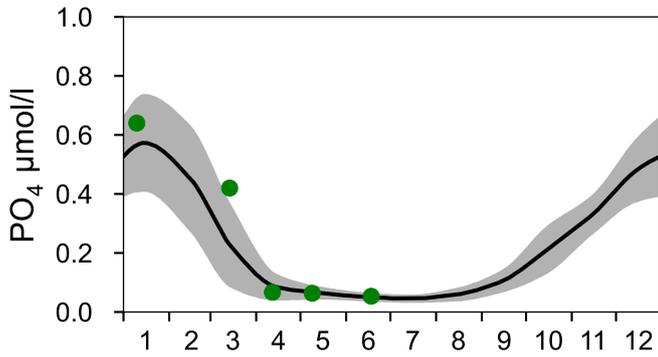
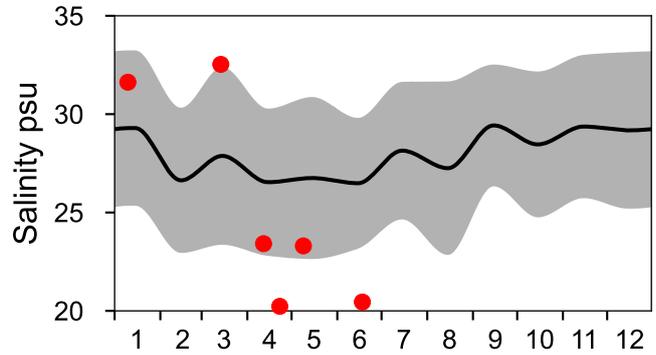
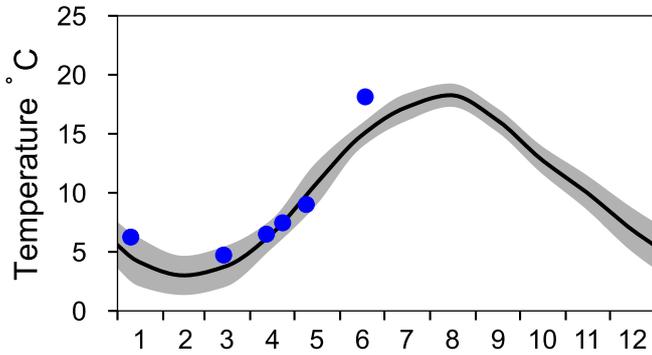
# Vertical profiles FLADEN June



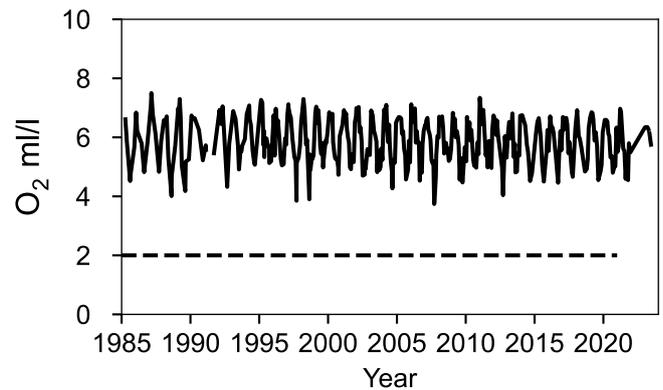
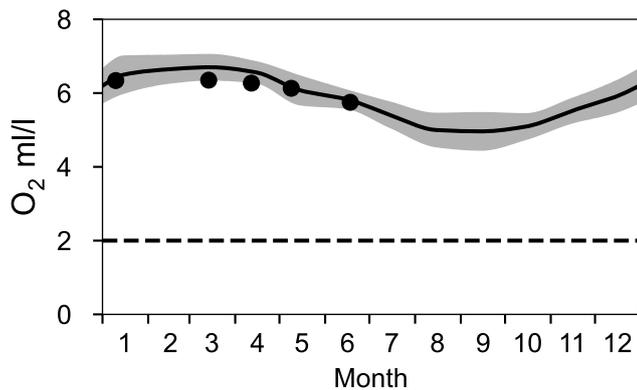
# STATION P2 SURFACE WATER (0-10 m)

Annual Cycles

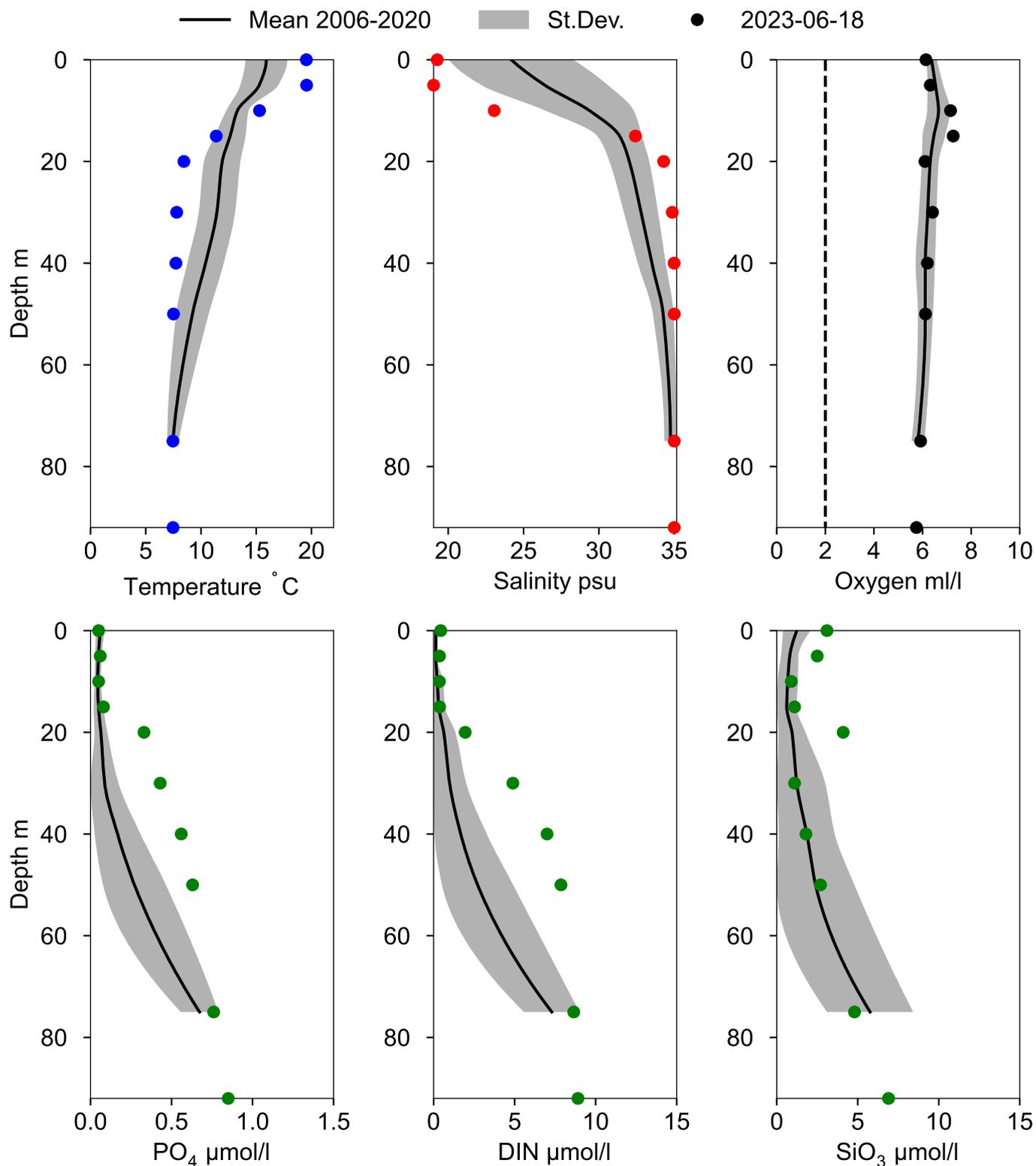
— Mean 2006-2020    St.Dev.    ● 2023



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



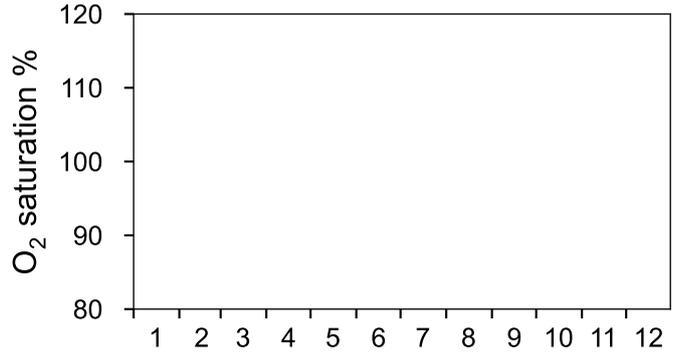
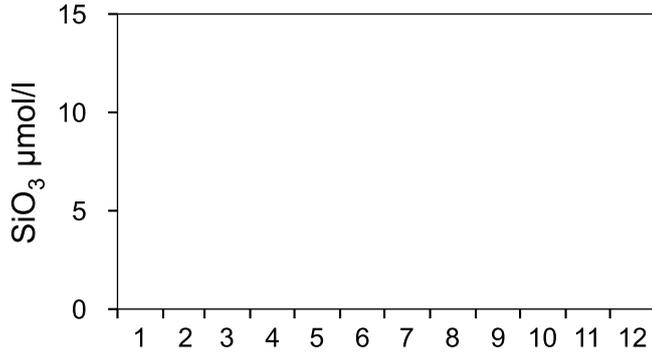
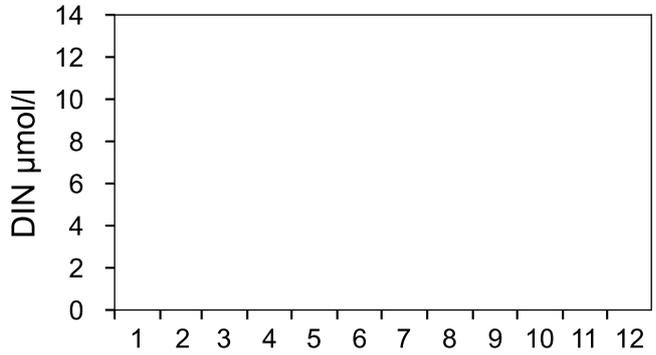
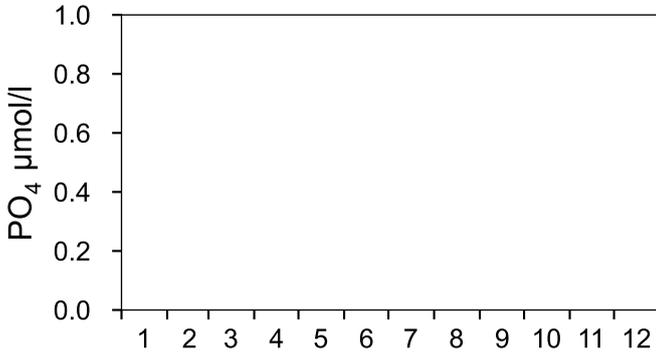
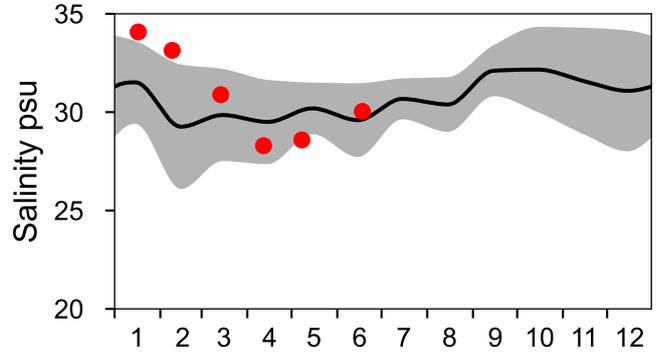
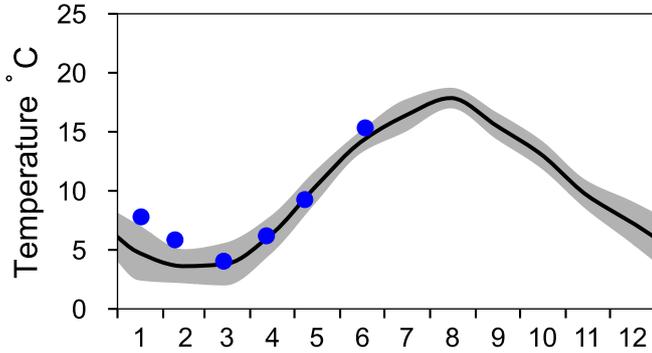
# Vertical profiles P2 June



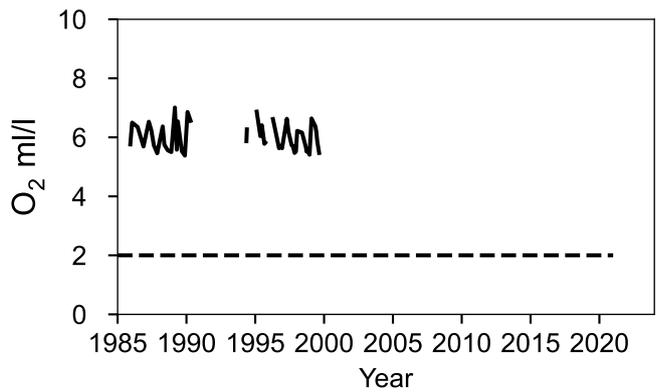
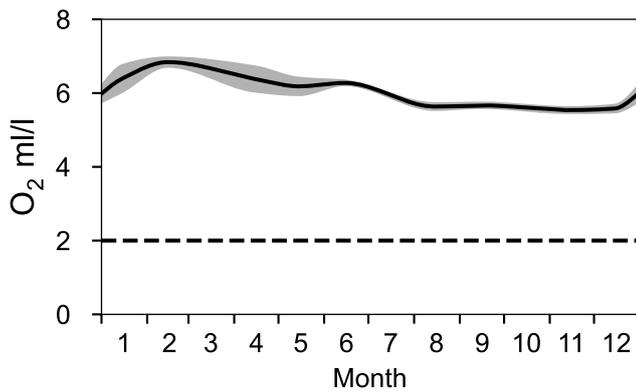
# STATION Å16 SURFACE WATER (0-10 m)

Annual Cycles

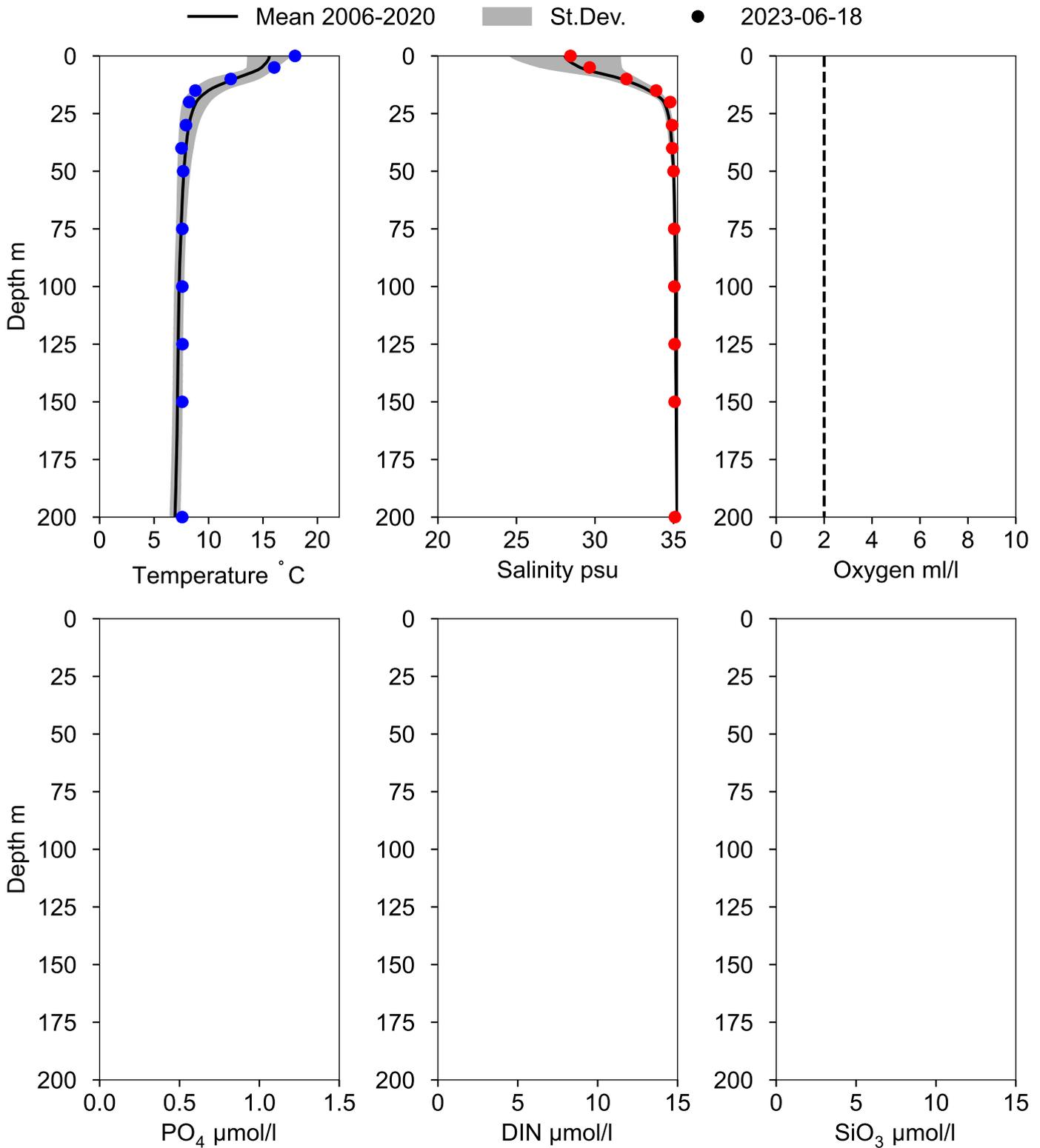
— Mean 2006-2020    St.Dev.    ● 2023



## OXYGEN IN BOTTOM WATER (depth >= 193 m)



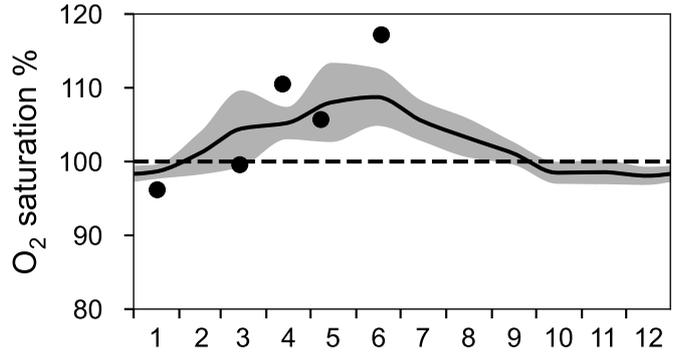
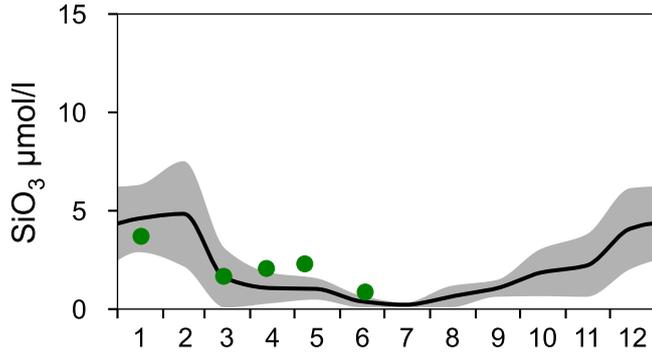
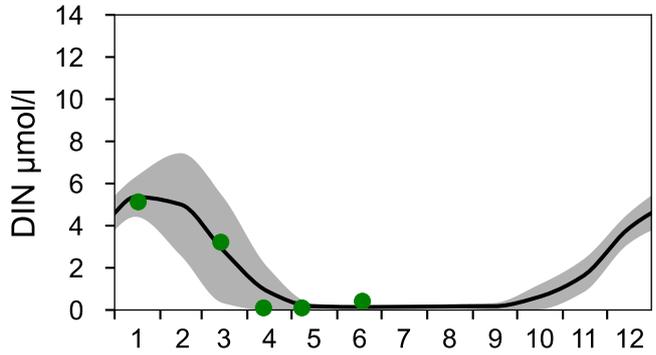
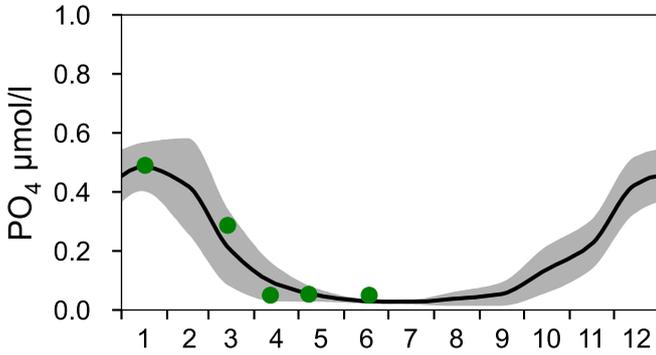
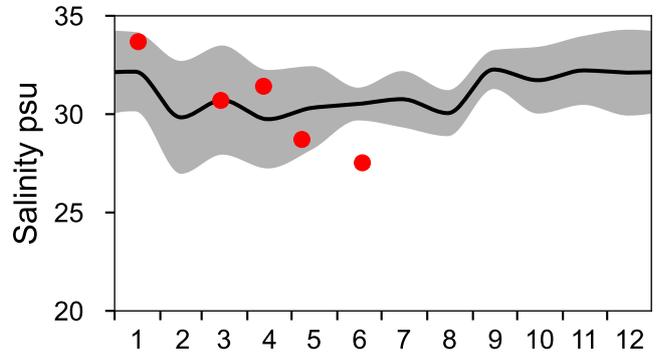
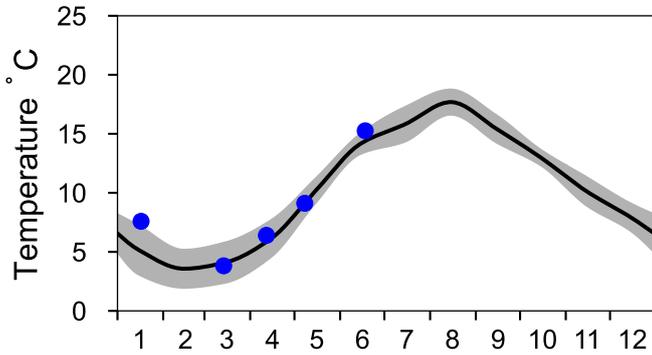
# Vertical profiles Å16 June



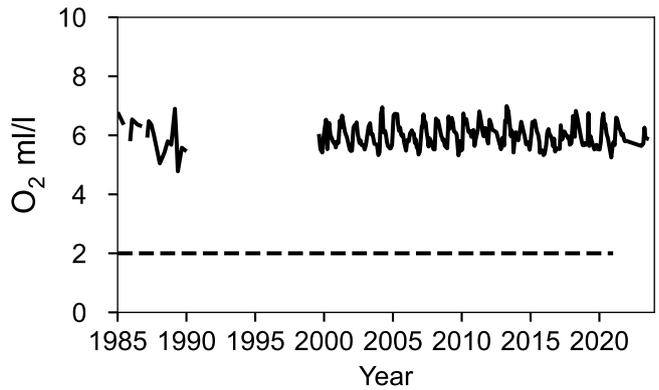
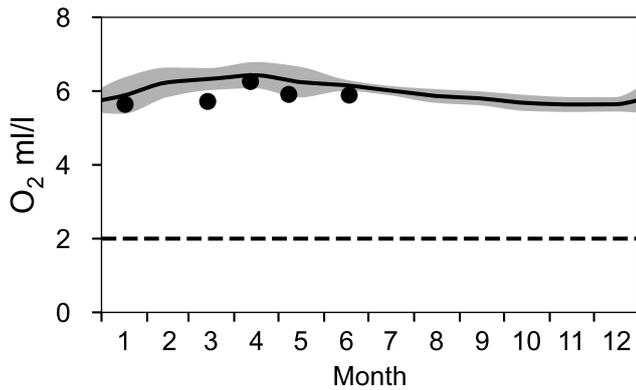
# STATION Å17 SURFACE WATER (0-10 m)

Annual Cycles

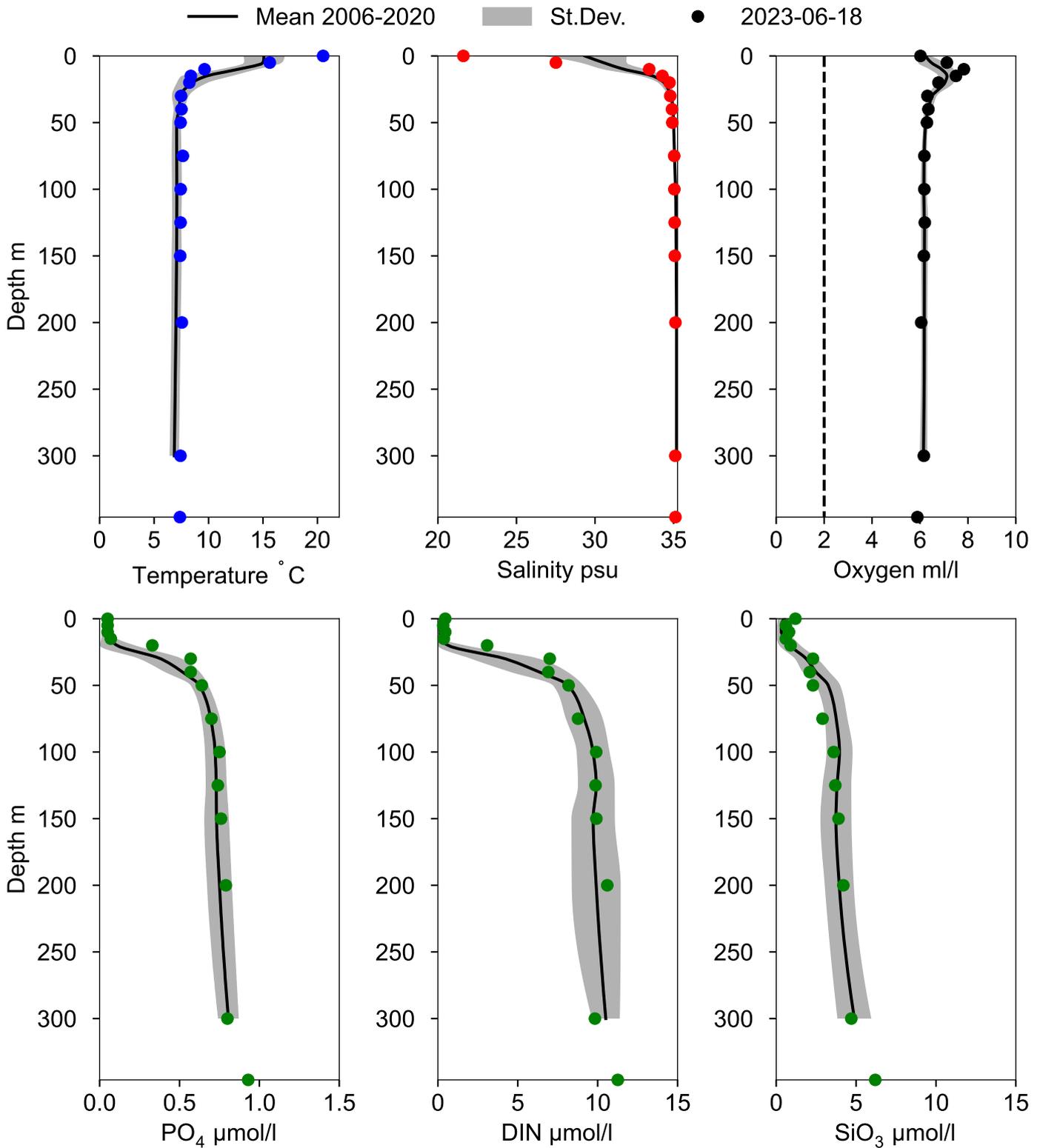
— Mean 2006-2020    St.Dev.    ● 2023



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



# Vertical profiles Å17 June



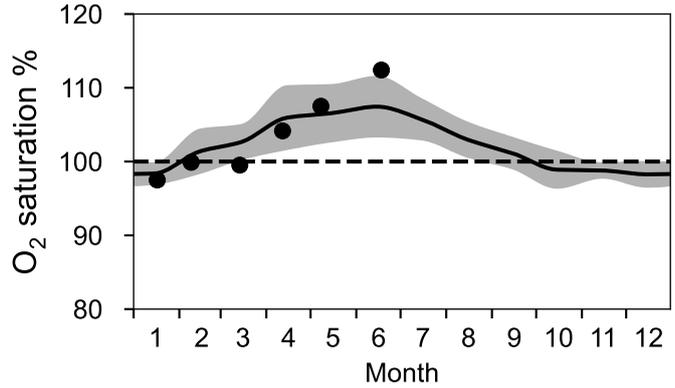
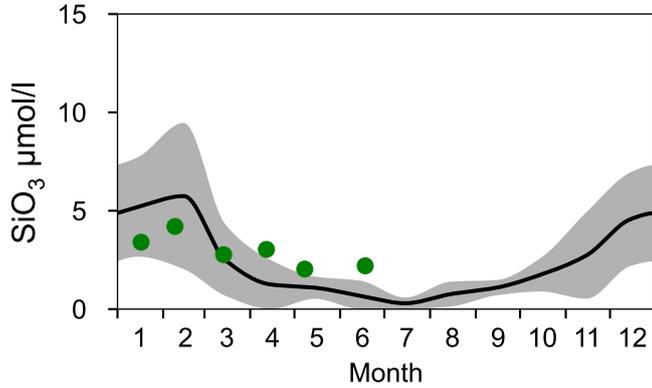
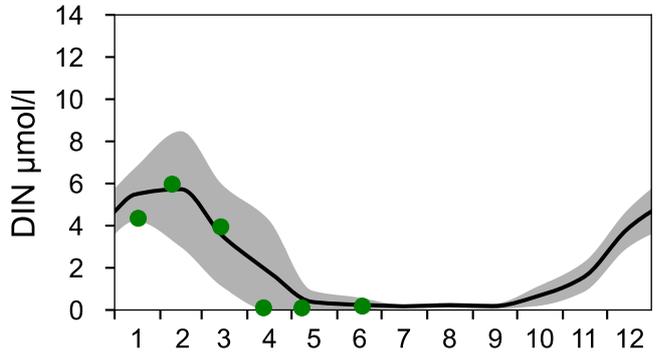
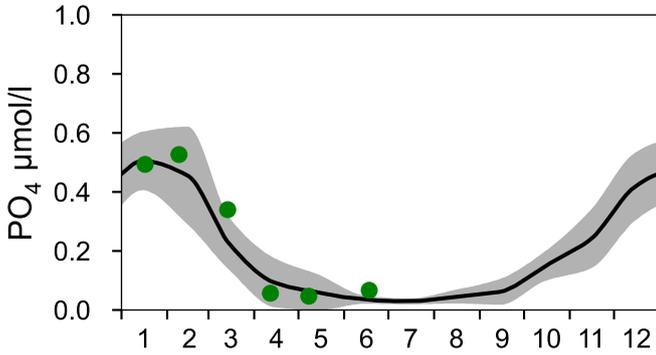
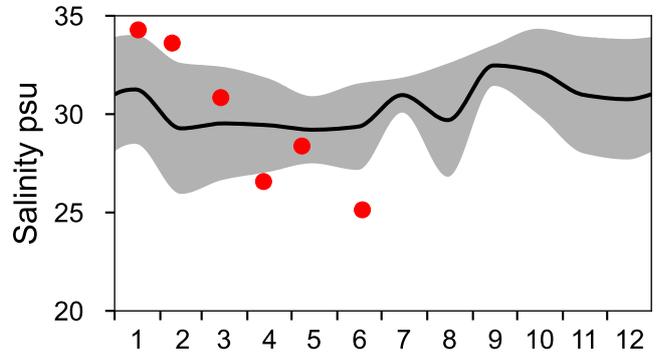
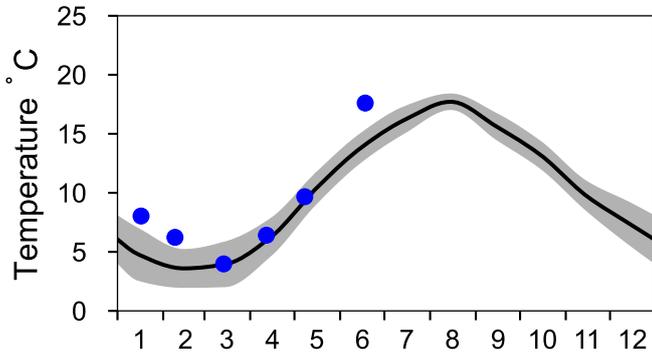
# STATION Å15 SURFACE WATER (0-10 m)

Annual Cycles

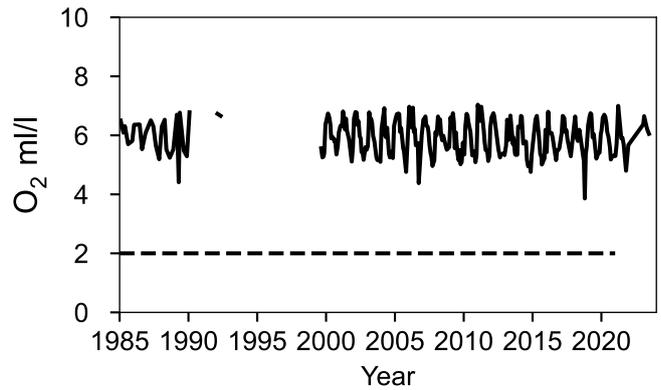
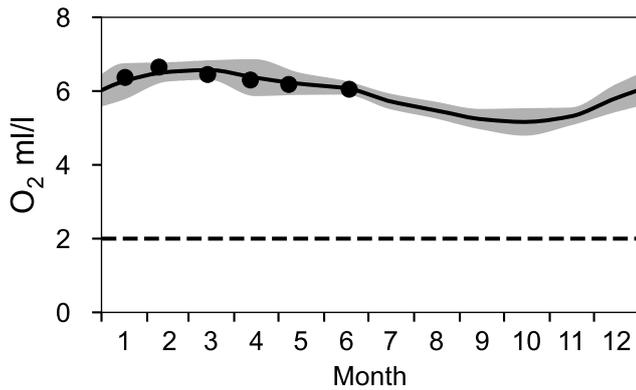
— Mean 2006-2020

■ St.Dev.

● 2023

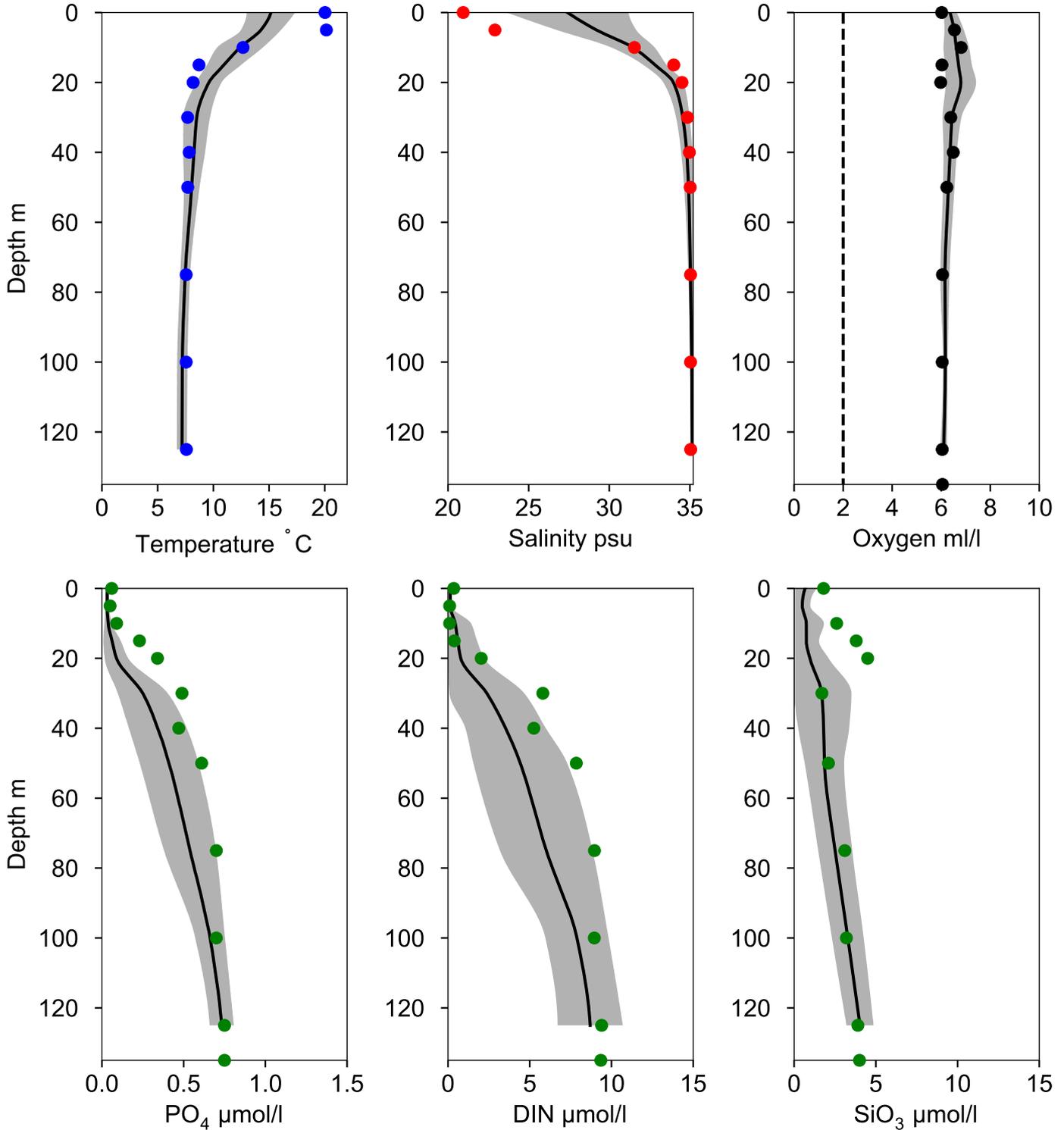


## OXYGEN IN BOTTOM WATER (depth >= 125 m)



# Vertical profiles Å15 June

— Mean 2006-2020    St.Dev.    ● 2023-06-18



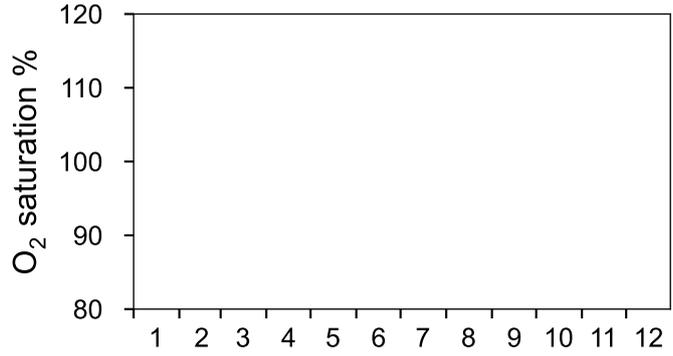
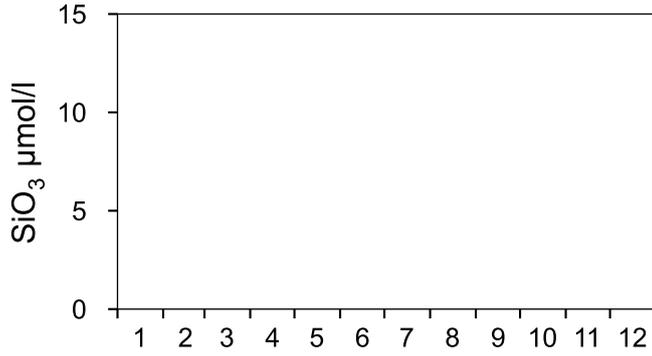
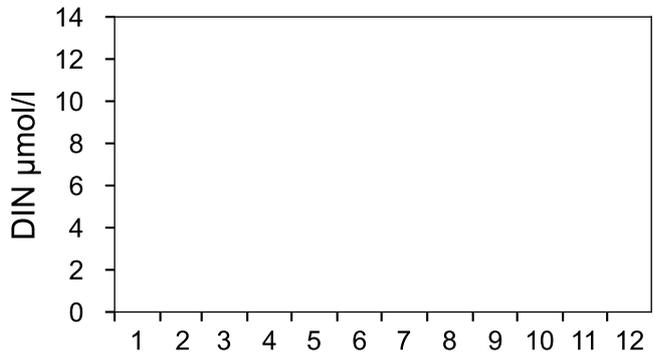
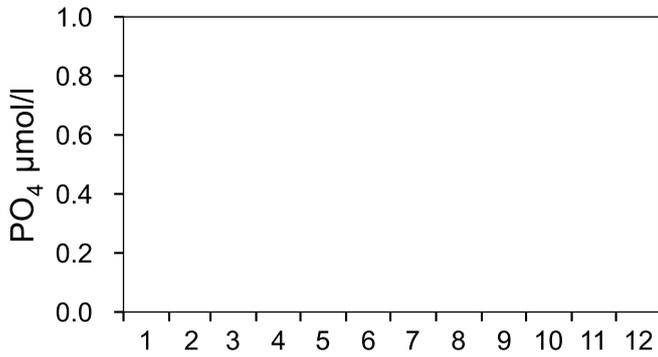
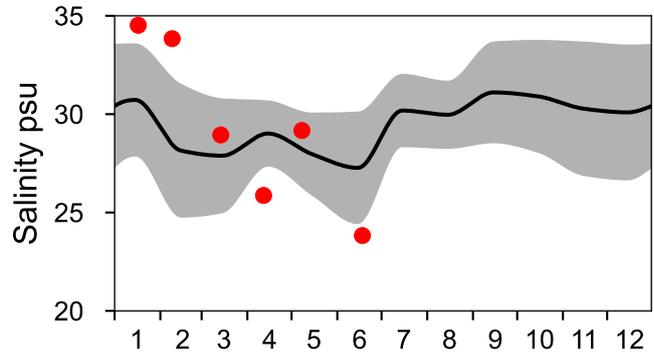
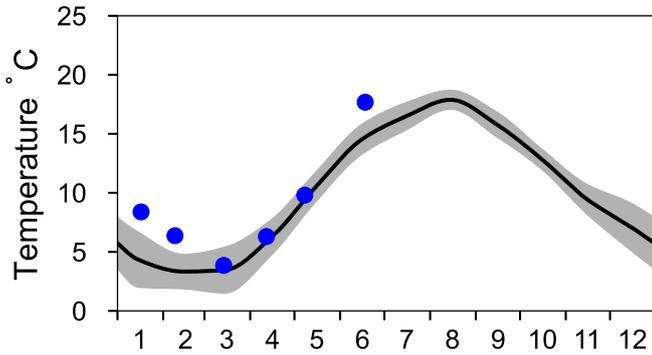
# STATION Å14 SURFACE WATER (0-10 m)

Annual Cycles

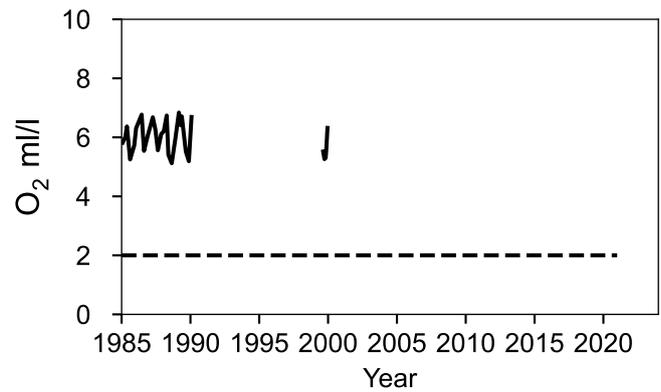
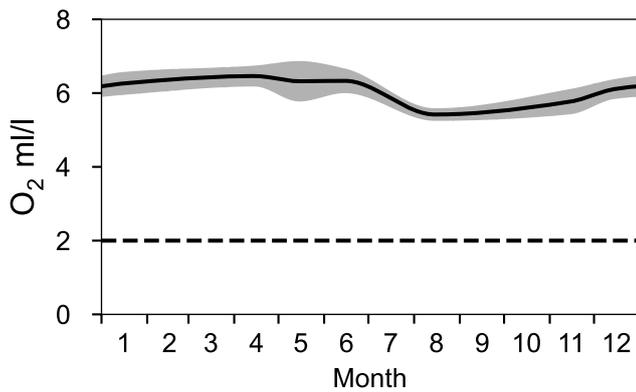
— Mean 2006-2020

■ St.Dev.

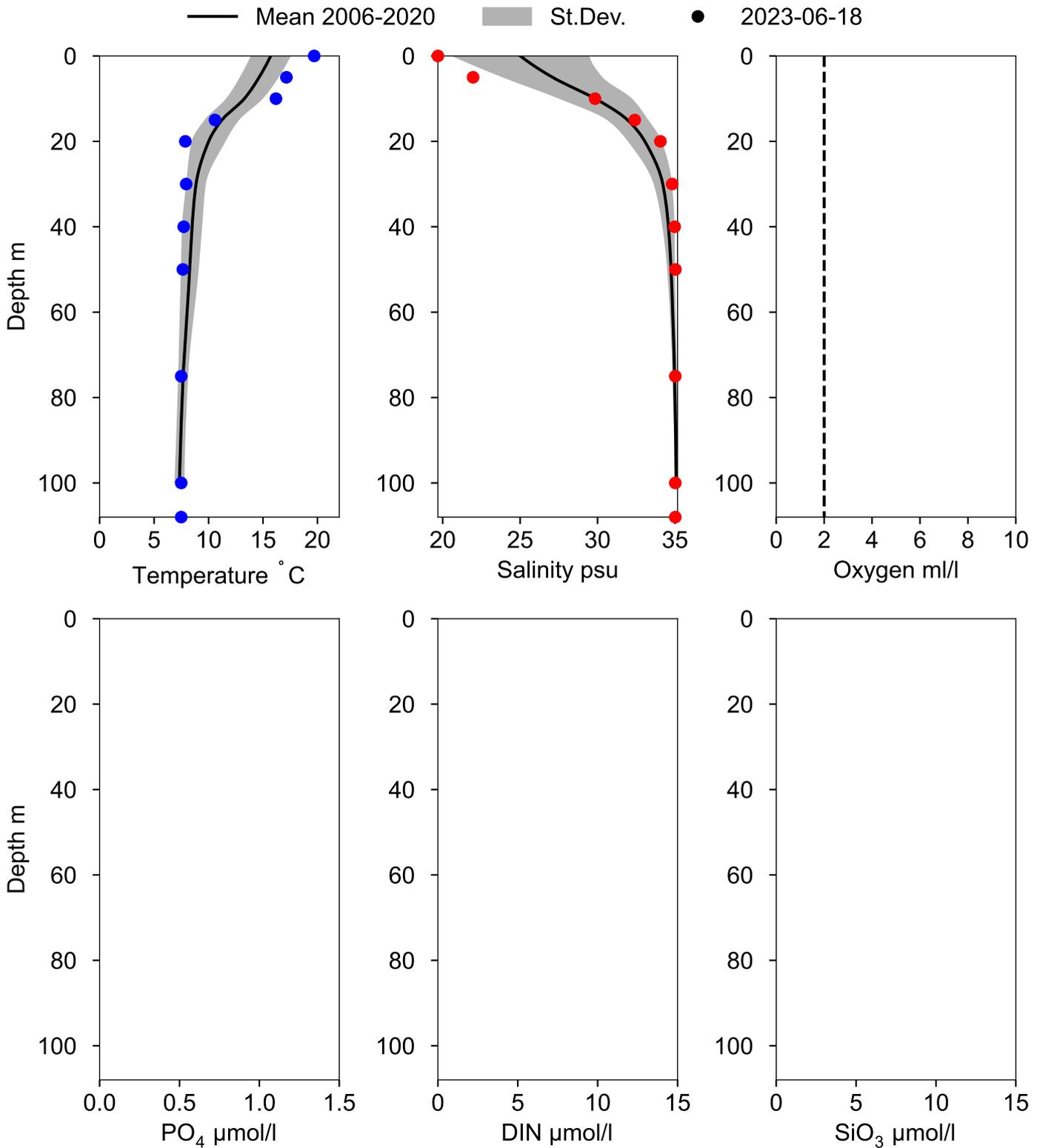
● 2023



## OXYGEN IN BOTTOM WATER (depth >= 100 m)



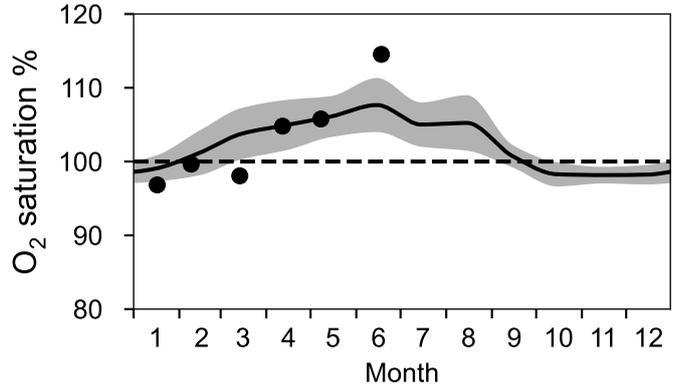
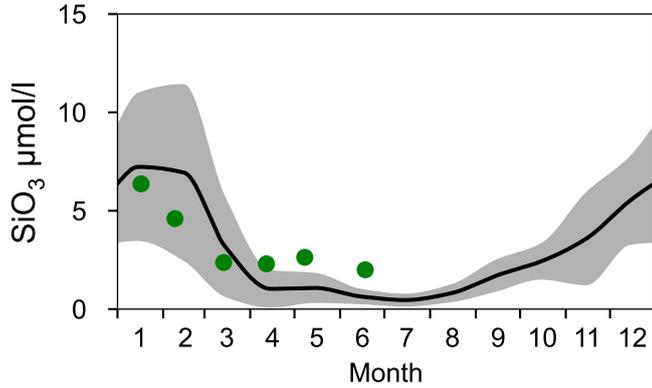
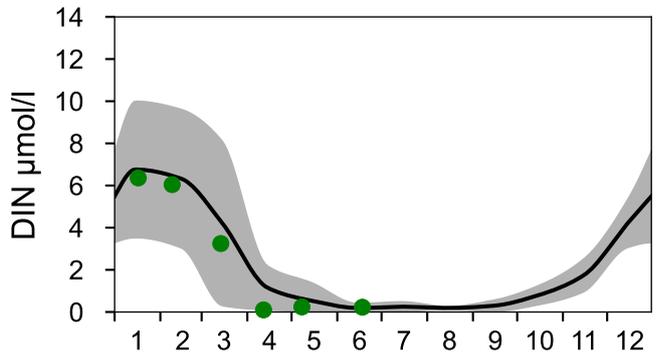
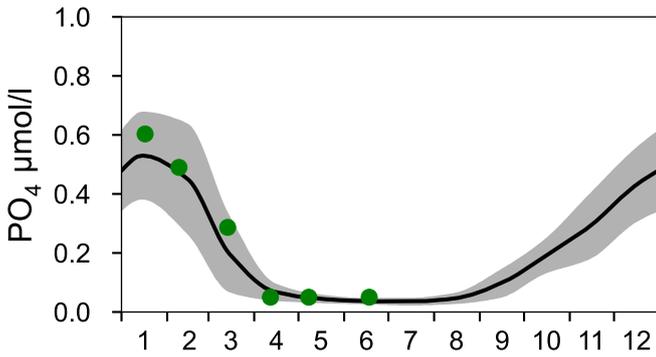
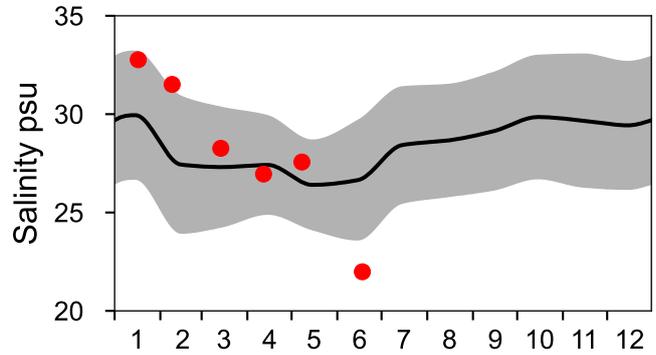
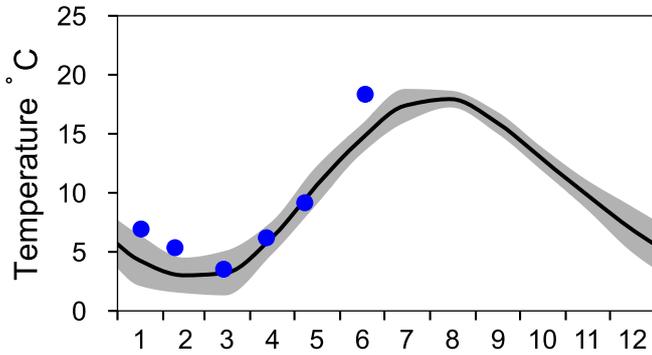
# Vertical profiles Å14 June



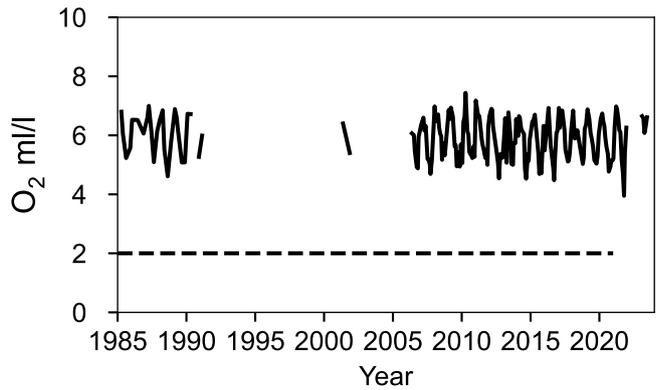
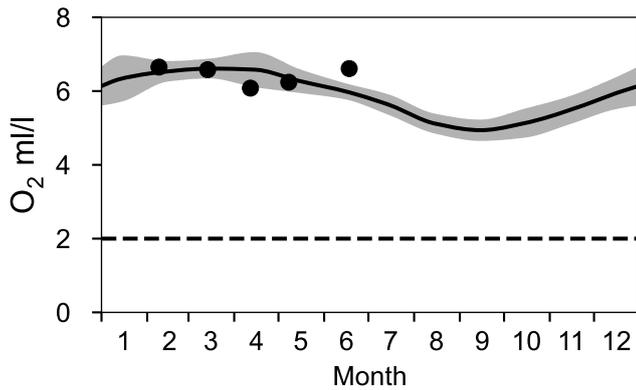
# STATION Å13 SURFACE WATER (0-10 m)

Annual Cycles

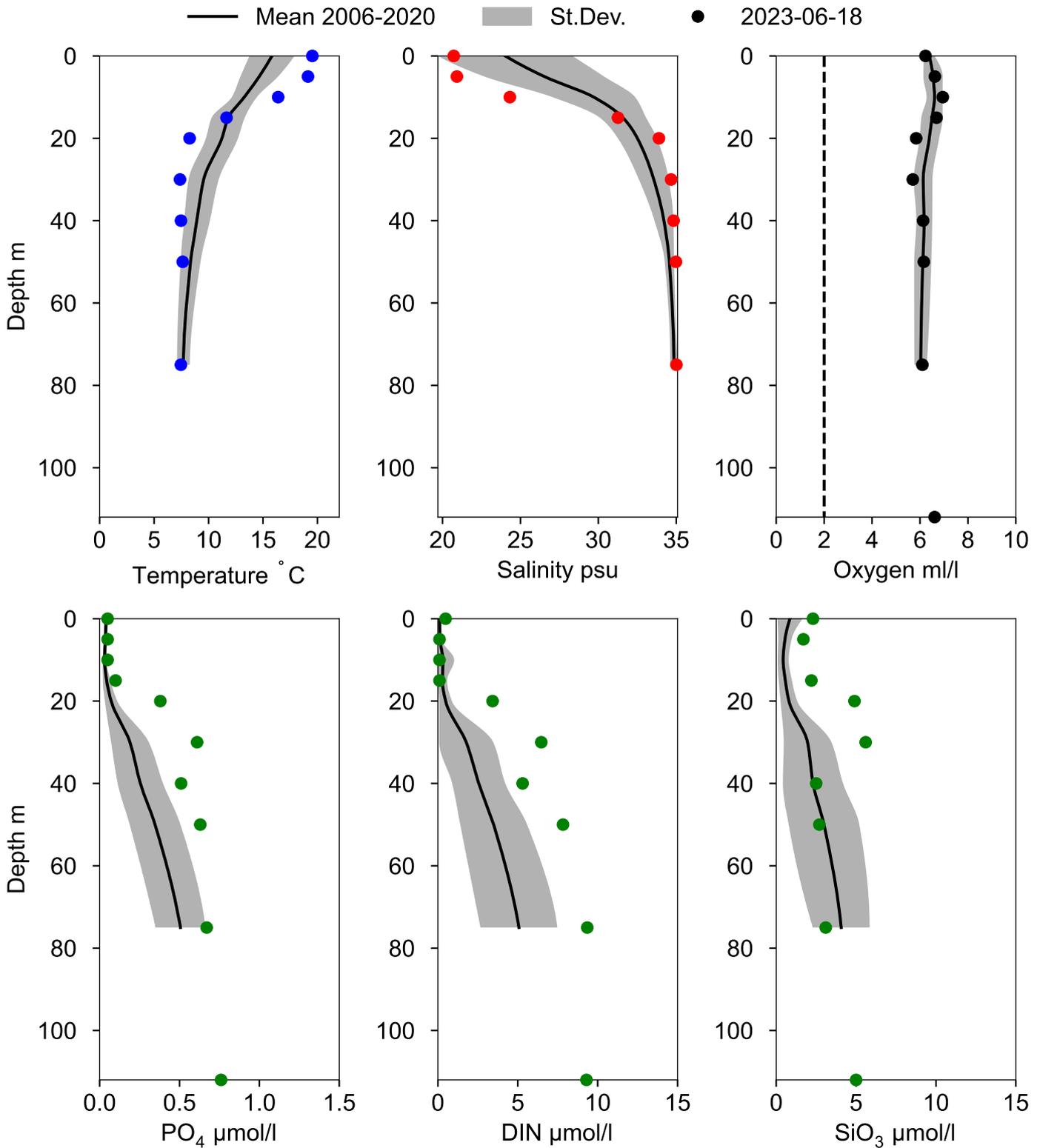
— Mean 2006-2020    St.Dev.    ● 2023



## OXYGEN IN BOTTOM WATER (depth >= 82 m)



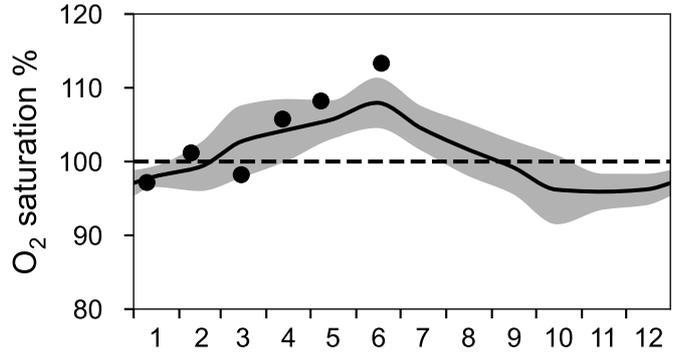
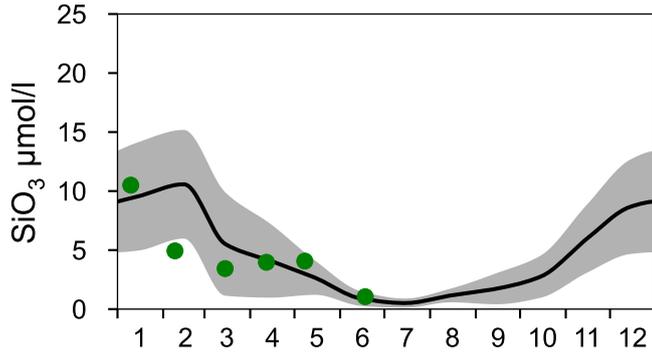
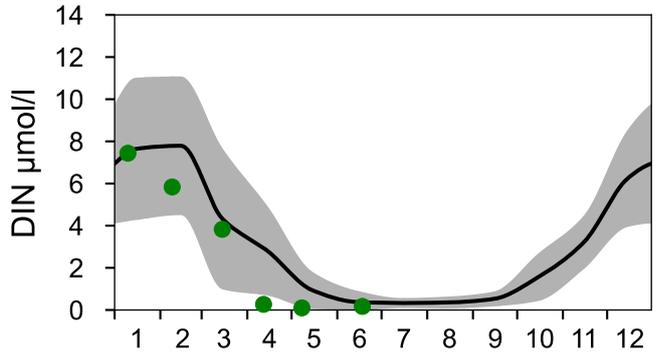
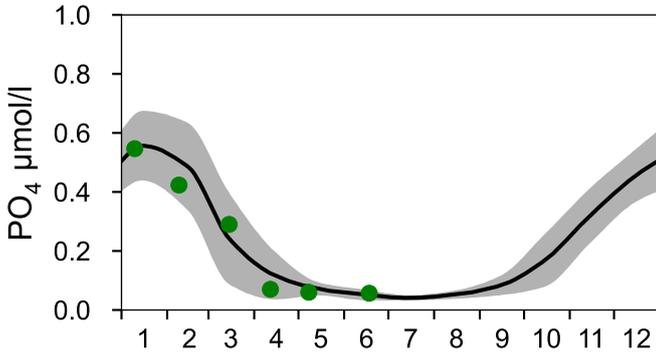
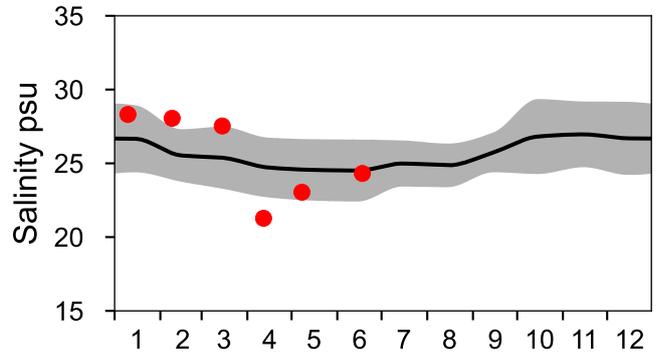
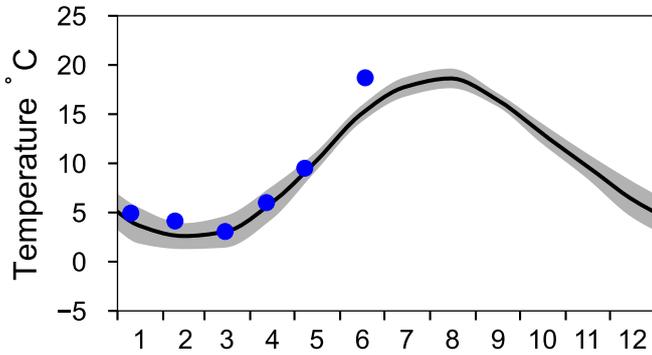
# Vertical profiles Å13 June



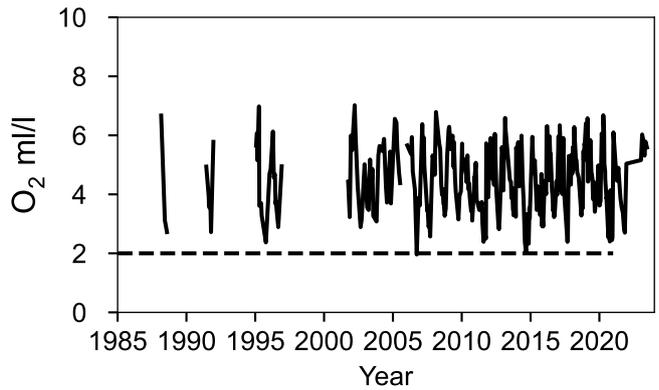
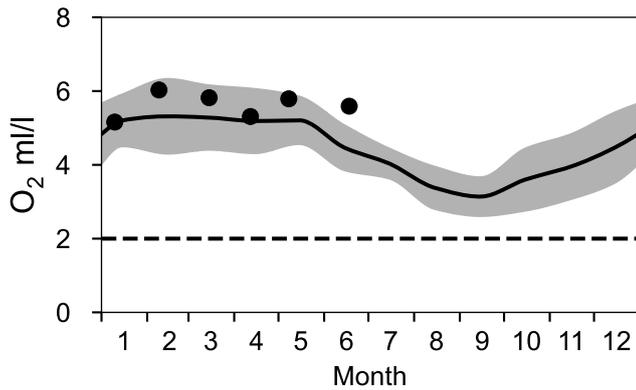
# STATION SLÄGGÖ SURFACE WATER (0-10 m)

Annual Cycles

— Mean 2006-2020    St.Dev.    ● 2023



## OXYGEN IN BOTTOM WATER (depth >= 64 m)



# Vertical profiles SLÄGGÖ June

