

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



Sampling of zooplankton.

Photo: Mikael Hedblom, SMHI

Survey period: 2023-10-18 – 2023-10-25

Principals: Swedish Meteorological and Hydrological Institute (SMHI),
Swedish Agency for Marine and Water Management (SwAM)

Cooperation partners: Swedish University of Agricultural Sciences (SLU),
Swedish Maritime Administration (SMA)

SUMMARY

During the cruise, which is part of the national marine monitoring programme of Sweden, oceanographic environmental monitoring was performed in the Skagerrak, the Kattegat, the Sound and the Baltic Proper.

The conditions in the sea areas around Sweden were largely influenced by the storm that passed over the region before and during the cruise. The strong easterly wind led to significant mixing of the surface water, resulting in a cooling effect and lower temperatures than normal were recorded. The salinity of the surface water was also higher than usual in many areas, indicating strong wind-induced mixing. Nutrient levels also showed higher concentrations than normal in large areas of the Baltic Proper. A similar situation was observed in the Skagerrak.

In the deep basins around Gotland, nutrient concentrations remained much higher than normal, reflecting the poor oxygen conditions and record-high concentrations of hydrogen sulphide in the deep areas. In the Western Gotland Basin, oxygen-free conditions were noted from a depth of 70 meters, and in the Eastern Gotland Basin, the corresponding depth was about 80 meters.

In the southeastern Baltic Proper, no hydrogen sulphide was noted at the bottom, but a weak pulse of oxygenated water (~1.5 ml/l) was observed at around 80 meters depth. In the Bornholm Basin and Hanö Bay, oxygen conditions near the bottom were oxygen-free, with oxygen deficiency noted from a depth of 60-70 meters.

During September, the oxygen conditions near the bottom in the Arkona Basin were very poor, with oxygen levels near zero. By October, the conditions had improved considerably, although oxygen deficiency was still noted in the eastern parts.

Technical problems during the cruise prevented the use of the regular CTD rosette throughout the entire expedition. Backup equipment had to be used, leading to the absence of certain depths and analyses in the southern Baltic Proper, as well as in the Skagerrak and Kattegat.

The next regular cruise is scheduled to start on 10th November and will start in Falkenberg and end in Kalmar.

RESULTS

The cruise was carried out with R/V Svea, starting in Kalmar on October 18th and ending in Lysekil on October 25th. The winds during the cruise were initially brisk but quickly escalated to storm force as the storm named "Babet" swept across the Baltic Sea. After the storm had passed, the winds became weak but intensified again as Svea reached Kattegat and Skagerrak. Due to the impact of the storm "Babet," stations in northern Baltic Proper; BY31, BY29, and Huvudskärsbojen were canceled. In the Kattegat, station N14 was canceled due to time constraints. The air temperature ranged from 4 to 12°C.

In addition to SMHI's regular environmental monitoring, extra sampling of phytoplankton in the Kattegat and Skagerrak was carried out for Uppsala University, along with additional water samples for eDNA analysis for the AMIME project, in collaboration with two researchers from SciLifeLab – KTH.

Representatives from the National Oceanographic Data Center at SMHI and from the Swedish Armed Forces "METOCC" also participated on the cruise to learn about SMHI's activities on board Svea.

Technical issues with the CTD-rosette in the middle of the journey meant that stations from the Arkona Basin onward could not be sampled with the CTD rosette. Instead, a smaller CTD (SBE19) and water samplers suspended on a wire were used, resulting in a slightly lower number of sampling depths. The technical problems were rectified immediately after the cruise, and SMHI now has functional CTD equipment for the upcoming November cruise.

One of Svea's ADCPs (current measurement) and the Ferrybox (continuous measurements at 4 meters depth) were operational during the cruise. The MVP (Moving Vessel Profiler) could also be used on this trip after a few months of suspension due to technical issues.

This report is based on data that has undergone an initial quality control and is compared to monthly means from the period 1991 - 2020. When additional quality control has been performed, certain values may change. Values in the report have been rounded and by that can differ a bit from values published in the data base. Data from this cruise are 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 downloaded here:

<https://www.smhi.se/en/services/open-data/national-archive-for-oceanographic-data/download-data-1.153150>

The Skagerrak

The cooling of the surface water had begun, and the temperature in the surface water was now around 11-12°C down to 10-15 meters depth, which is cooler than normal. Below this, somewhat warmer water was found down to around 50-70 meters depth, where the temperature stabilized at around 8°C towards the bottom. The salinity in the surface water varied from 28 psu at the coastal station Släggö in Gullmarsfjorden to about 31 psu in the open sea. Salinity stratification was observed between 20-50 meters depth.

All nutrients in the surface water had increased slightly, and at some stations, concentrations higher than normal were noted. The elevated nutrient levels are likely due to prolonged east winds causing upwelling along the west coast, where colder, more saline, and nutrient-rich deep water reaches the surface layer. Normal nutrient concentrations were found in the deep water.

The oxygen situation was good at all stations in the Skagerrak, with values within the normal range for the season. The lowest concentration in the bottom water was measured at Släggö: 4.2 ml/l.

Due to the regular CTD-rosette malfunctioning, there are no fluorescence measurements from this sea area.

The Kattegat and the Sound

In Kattegat, the cooling of the surface water had also begun, and was approximately 6-7 °C lower than in September. However, the surface temperature in Kattegat and Öresund was normal for the month at all stations, around 12°C. The salinity was lower than normal in the surface in the Sound, normal in the central parts, and higher than normal in the northern parts. A strong halocline was observed between 10 to 20 meters at all stations, and a weak temperature stratification (thermocline) was also noted at approximately the same depth.

Nutrient levels had started to increase and were normal except in the central parts, at Anholt E, where higher than normal concentrations were observed. In the deep water, generally normal nutrient levels for the season were noted.

The oxygen situation in the deep water of Kattegat usually improves during the fall due to mixing. A clear improvement was noted during the October cruise when oxygen levels in the bottom water had increased from around 2 ml/l (acute oxygen deficiency) to 3.4 ml/l, which is just below the threshold for oxygen deficiency at 4 ml/l.

Due to the regular CTD malfunctioning, there are no fluorescence measurements from this sea area.

The Baltic Proper

The conditions in the Baltic Proper were largely influenced by the storm “Babet” that passed over the area before and during the cruise. The strong winds led to significant mixing of the surface water, causing a cooling effect. Temperatures around 10-13 degrees were noted, which is normal or below normal for the season. The salinity in the surface water was also higher than normal in all areas, indicating strong wind-induced mixing. Nutrient levels also showed higher concentrations than normal in all areas, except from DIN that was lower than normal in the Western Gotland Sea and normal in the Arkona basin.

Stratification occurred at around 40-60 meters depth, and temperature and salinity stratification largely coincided.

Below the stratification, nutrient concentrations increased. In the deep basins around Gotland, concentrations remained much higher than normal, reflecting the very poor oxygen conditions and record-high concentrations of hydrogen sulphide in the deep areas. In the Western Gotland Basin, oxygen-free conditions were noted from a depth of 70 meters and oxygen deficiency from 60 meters. Just outside Visby, an additional station was sampled, and there, oxygen deficiency was noted from 45 meters depth, with acute oxygen deficiency from around 60 meters depth. In the Eastern Gotland Basin, the corresponding depths were about 10 meters deeper.

At the station BCSIII-10 in the southeastrn Baltic Proper, no hydrogen sulphide was noted at the bottom, but a weak pulse of oxygenated water (~1.5 ml/l) was observed at around 80 meters depth.

In the Bornholm Basin and Hanö Bay, oxygen conditions near the bottom were oxygen-free, with oxygen deficiency noted from 60-70 meters depth.

In September, the oxygen conditions near the bottom in the Arkona Basin were very poor, with oxygen levels near zero. By October, the conditions had improved significantly, with levels above 2 ml/l at BY2 and above 4 ml/l at BY1.

Fluorescence measurements from the CTD probe indicated some plankton presence in the surface water above the thermocline at all stations, but it was generally low.

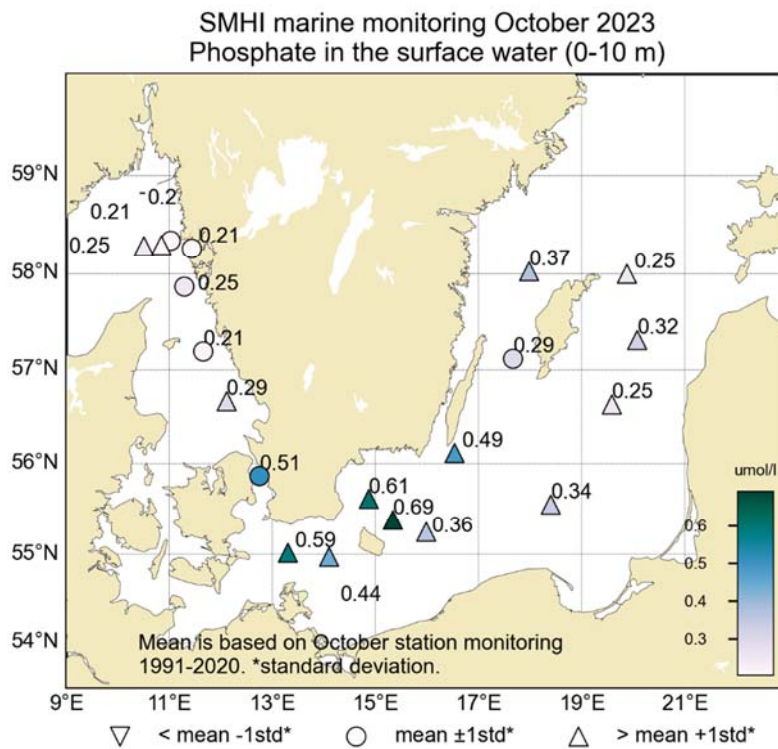


Figure 2. Concentration ($\mu\text{mol/l}$) of phosphate in the surface water (0-10m). Mean is based on data from the month within each basin during the years 1991 – 2020.

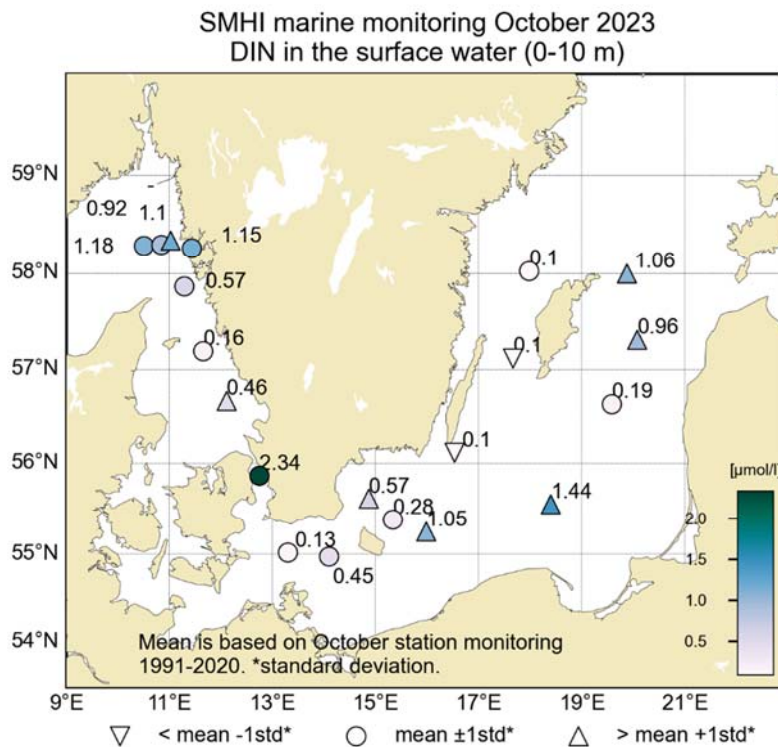


Figure 3. Concentration ($\mu\text{mol/l}$) of dissolved inorganic nitrogen (DIN) in the surface water (0-10m). Mean is based on data from the month within each basin during the years 1991 – 2020.

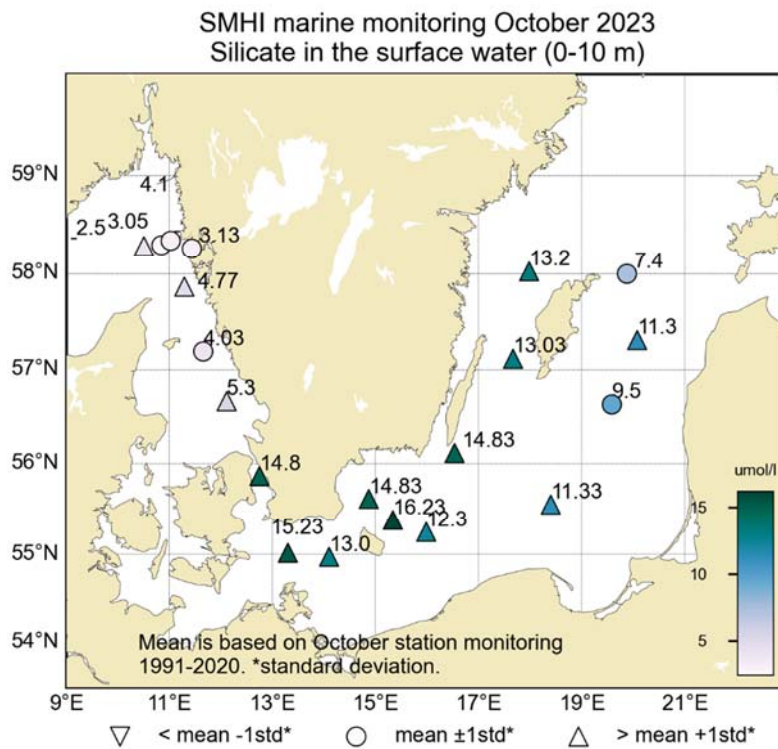


Figure 4. Concentration ($\mu\text{mol/l}$) of silicate in the surface water (0-10m). Mean is based on data from the month within each basin during the years 1991 – 2020.

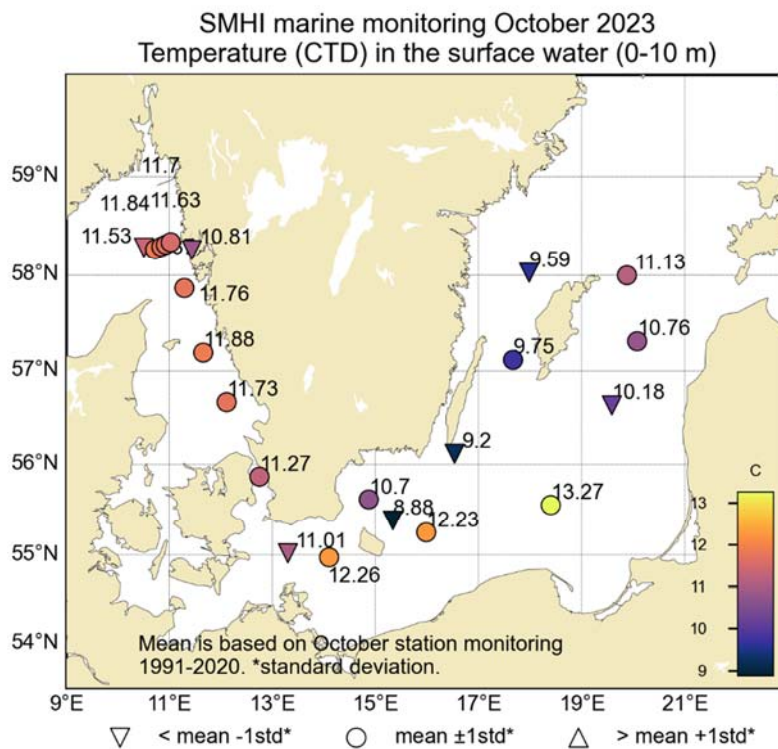


Figure 5. Temperature in the surface water (0-10m). Mean is based on data from the month within each basin during the years 1991 – 2020.

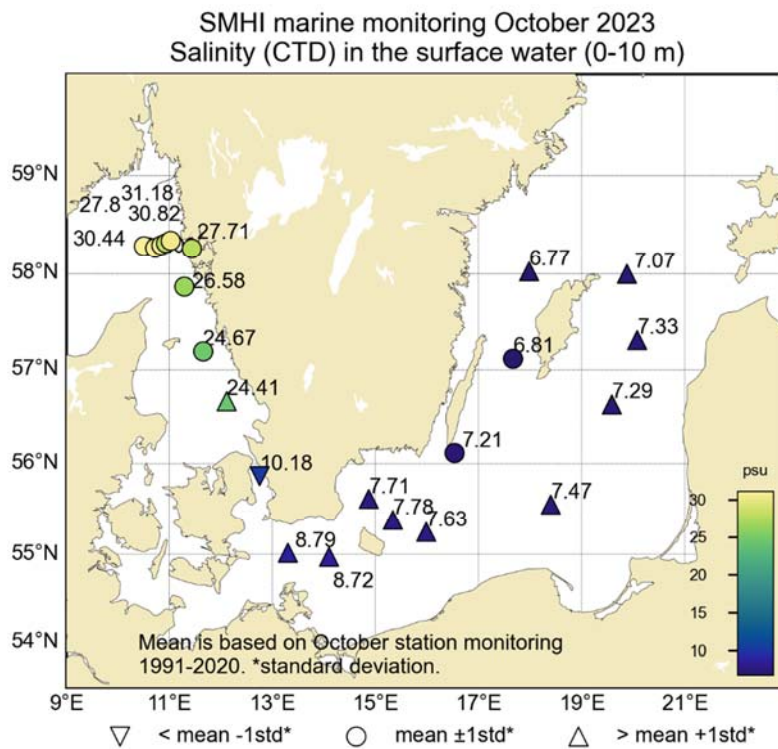


Figure 6. Salinity in the surface water (0-10m). Mean is based on data from the month within each basin during the years 1991 – 2020.

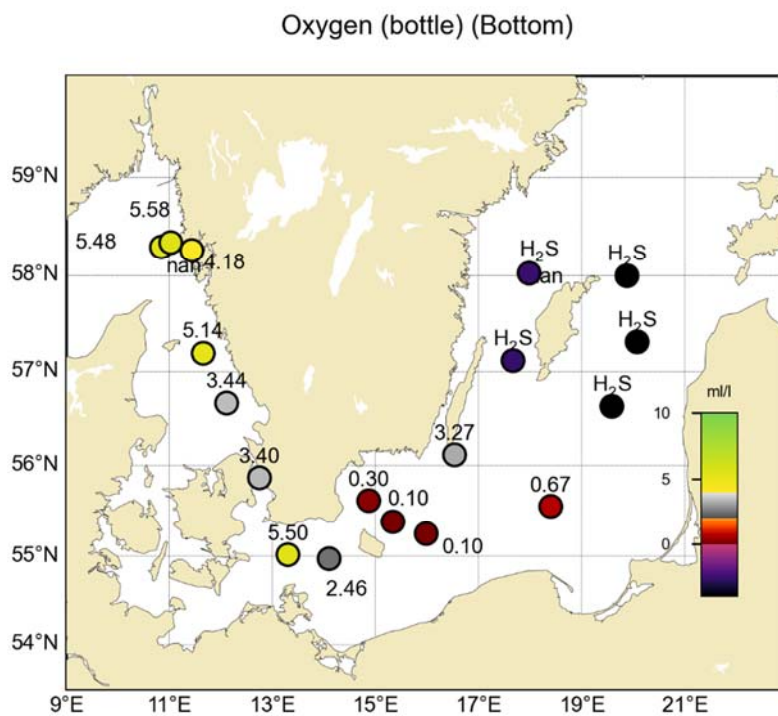


Figure 7. Dissolved oxygen concentration in the bottom water, approximately 1 meter above the seabed. Note that the values have not been compared to statistics in the same way as in figures 2–6, that's why only circles are shown.

PARTICIPANTS

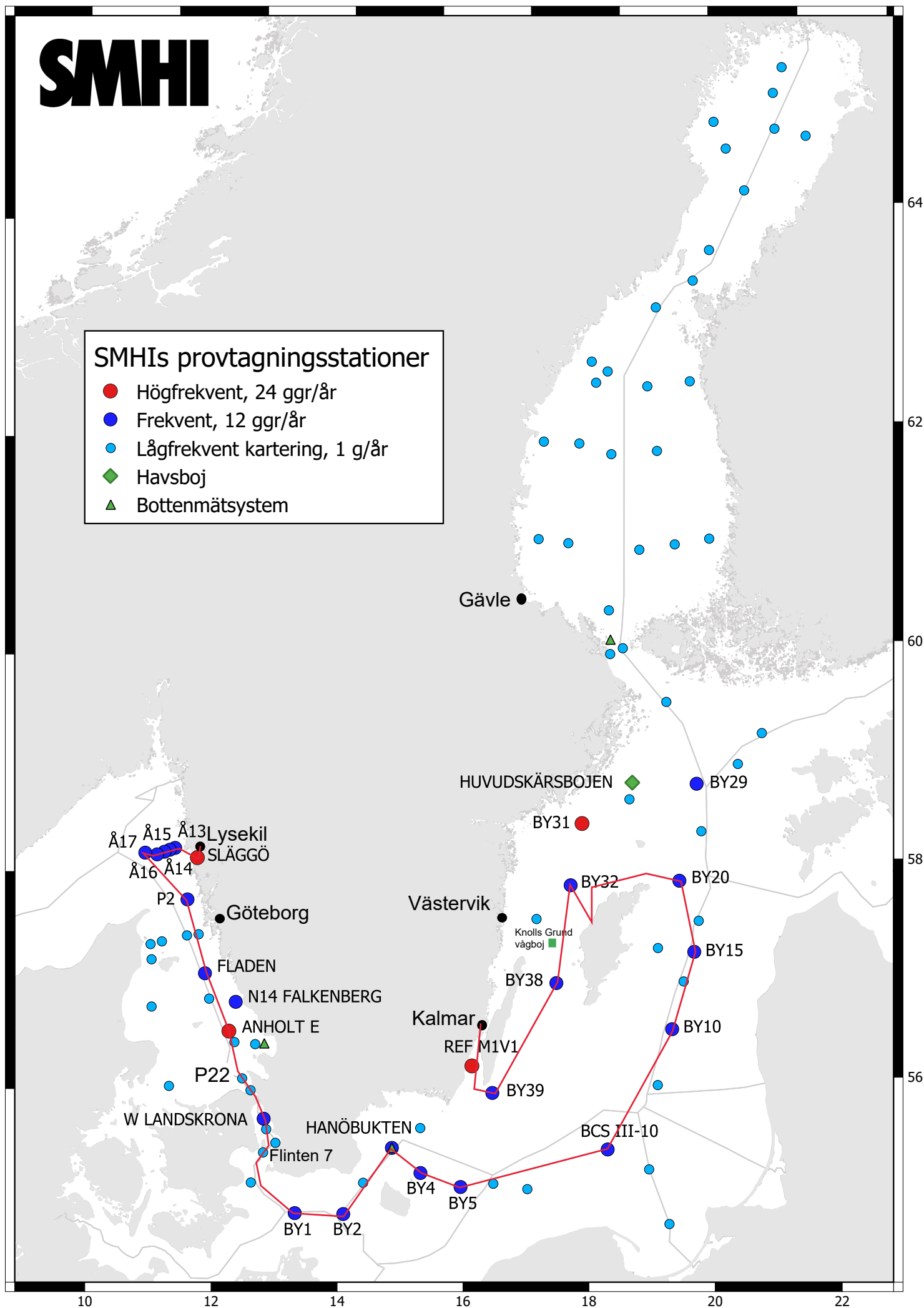
Namn	Roll	Från
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Emma Kroon	Scientist	SciLifeLab - KTH
Emma-Sophie Nyberg	Oceanographer	Försvarsmakten - METOCC

APPENDICES

- Track chart
- Table over stations, analyzed parameters and number of sampling depths
- Map of dissolved oxygen in the bottom water
- Vertical profiles for regular monitoring stations
- Monthly average surface water plots for regular monitoring stations

SMHIs provtagningsstationer

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



Time: 10:28

Ser no	Cru no	Stat code	Proj	Stat name	Lat	Lon	Start date yyyymmdd	Start time hhmm	Bottom depth m	Secchi depth m	Wind dir vel	Air temp C	Air pres hPa	WCWI elac aove hdsb	CZPP hoyp loy o p	No de btl	T e m m l l	T s a l l	P h o x x	D o o s s o	H 0 2 t r i a z n t y 3 u n n - s t t	N N N N A N A S H C C
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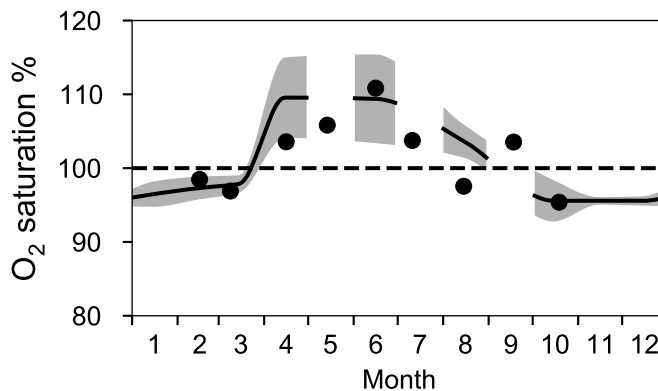
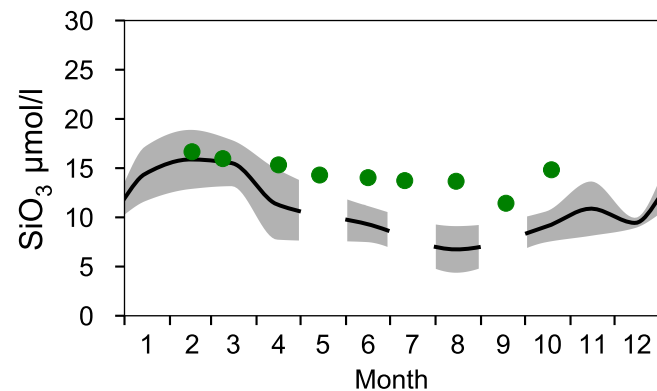
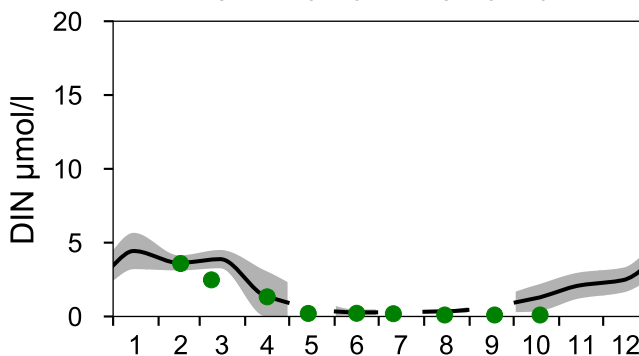
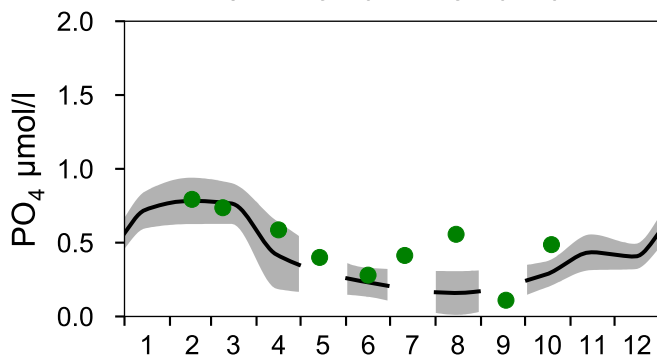
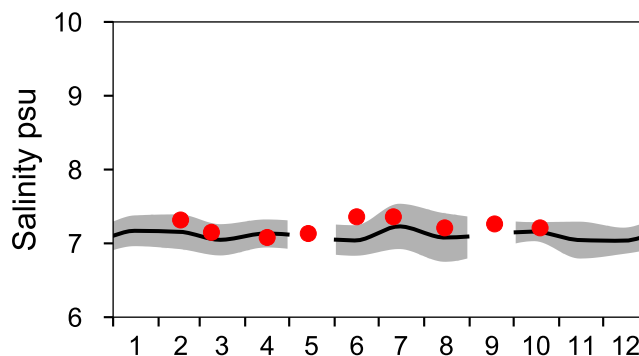
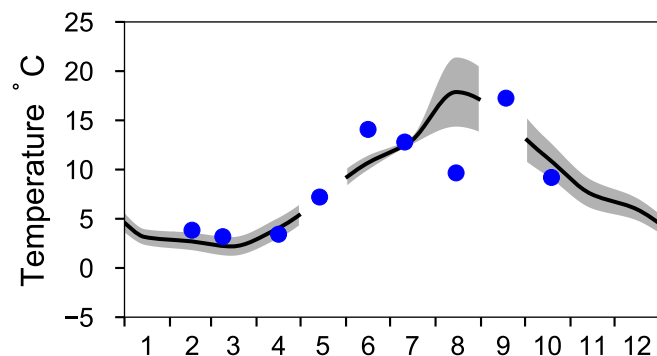
STATION BY39 ÖLANDS S UDDE SURFACE WATER (0-10 m)

Annual Cycles

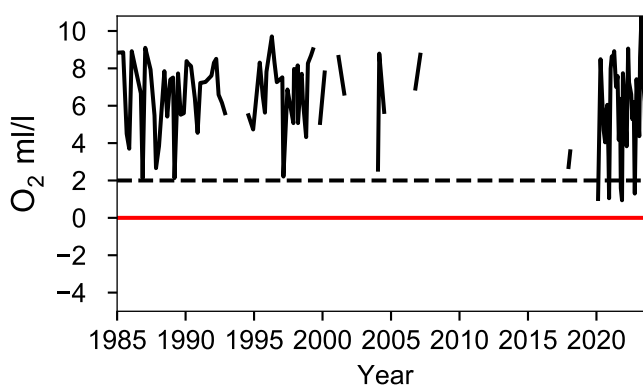
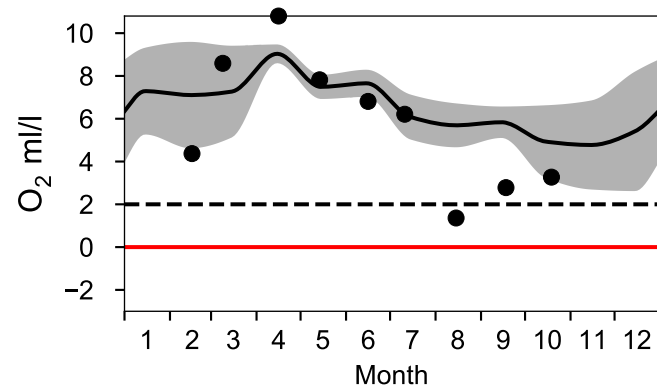
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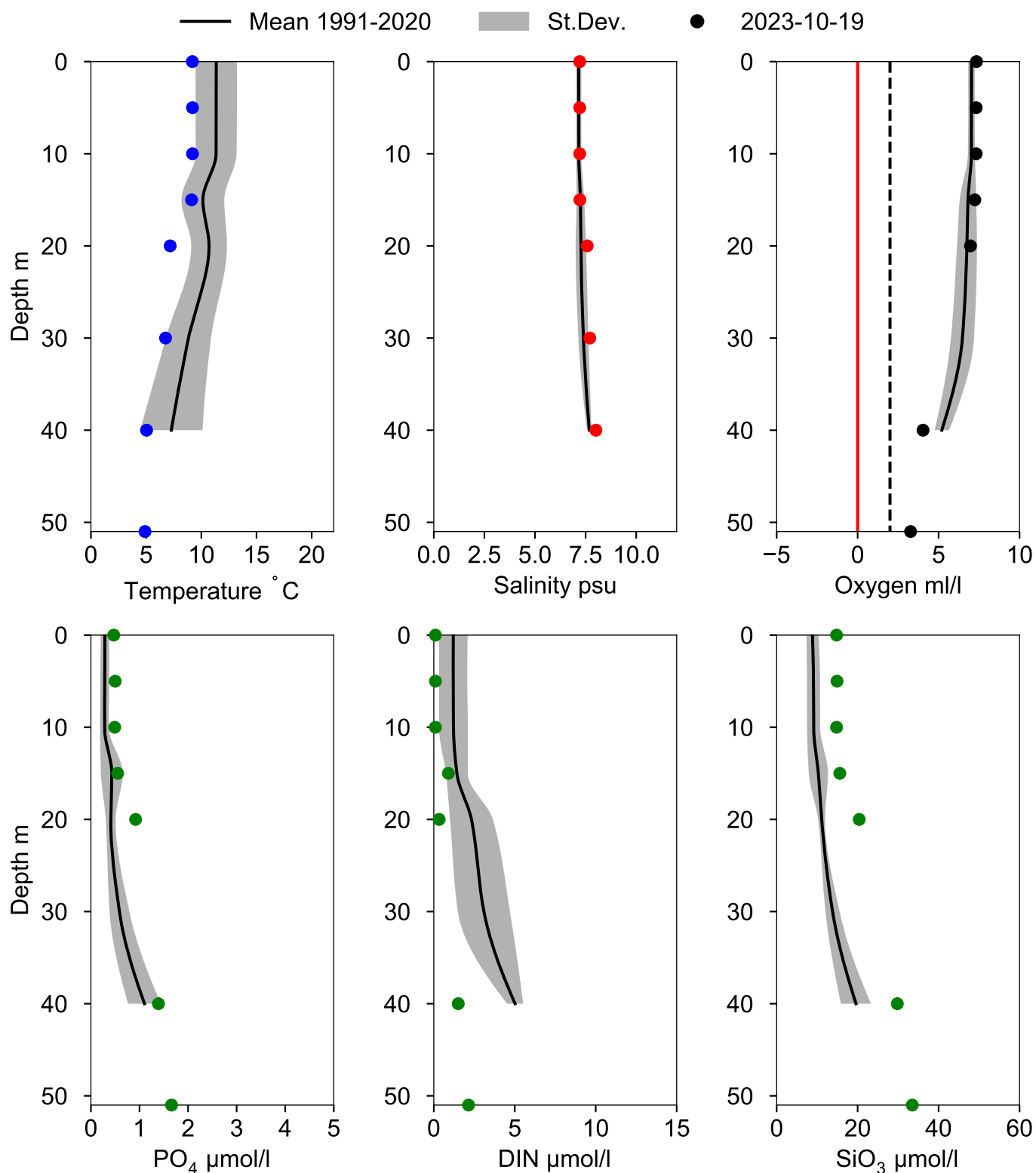
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OXYGEN IN BOTTOM WATER (depth >= 40 m)



Vertical profiles BY39 ÖLANDS S UDDE October



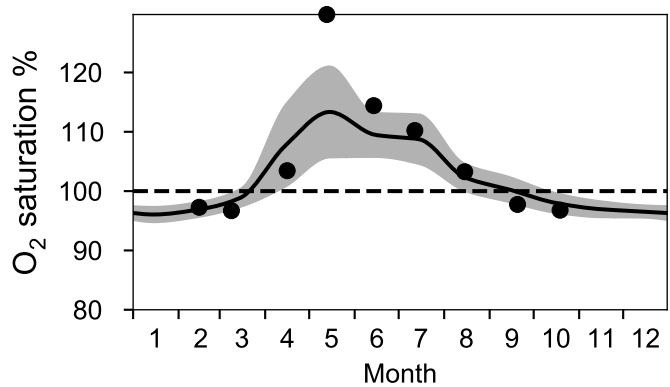
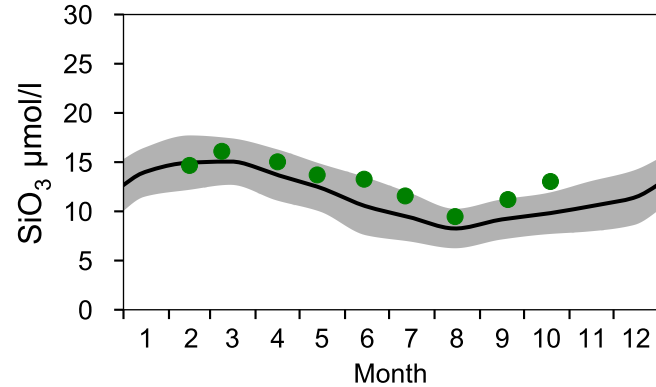
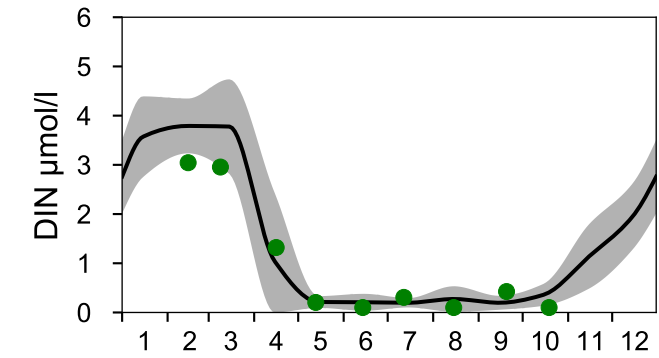
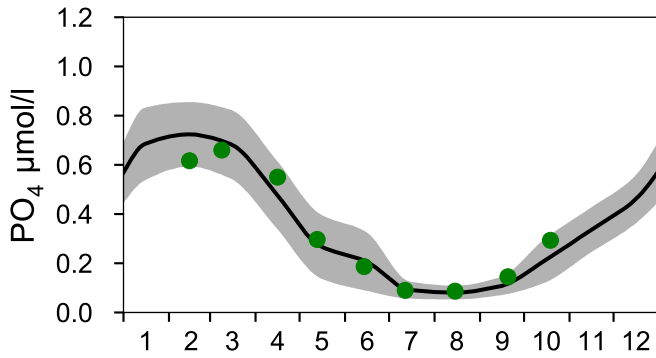
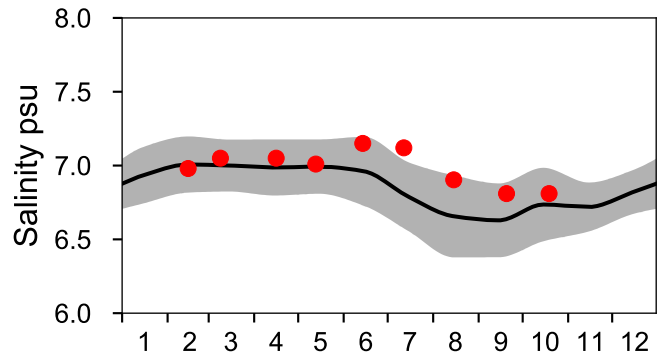
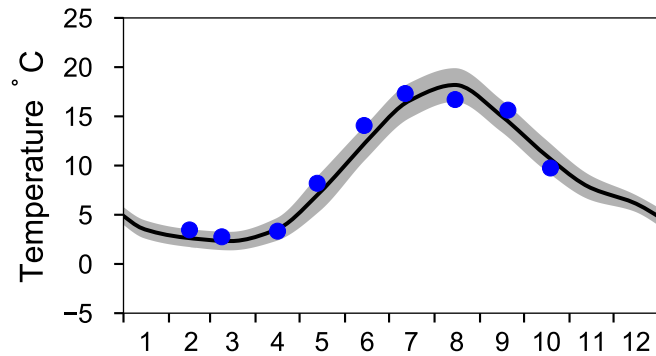
STATION BY38 KARLSÖDJ SURFACE WATER (0-10 m)

Annual Cycles

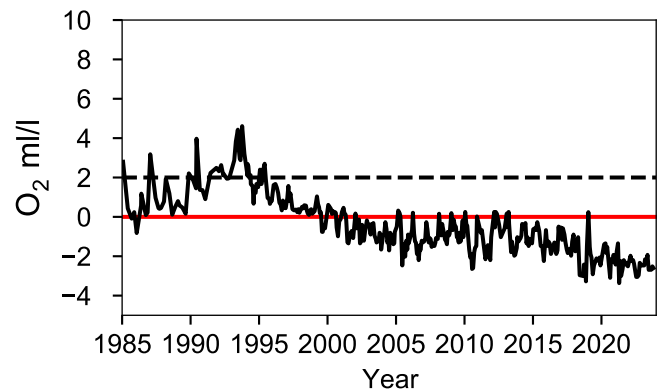
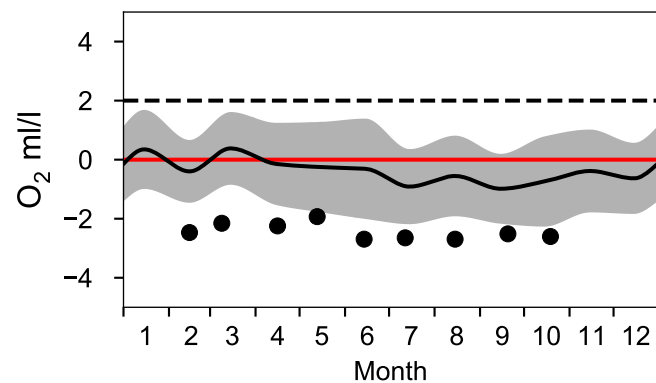
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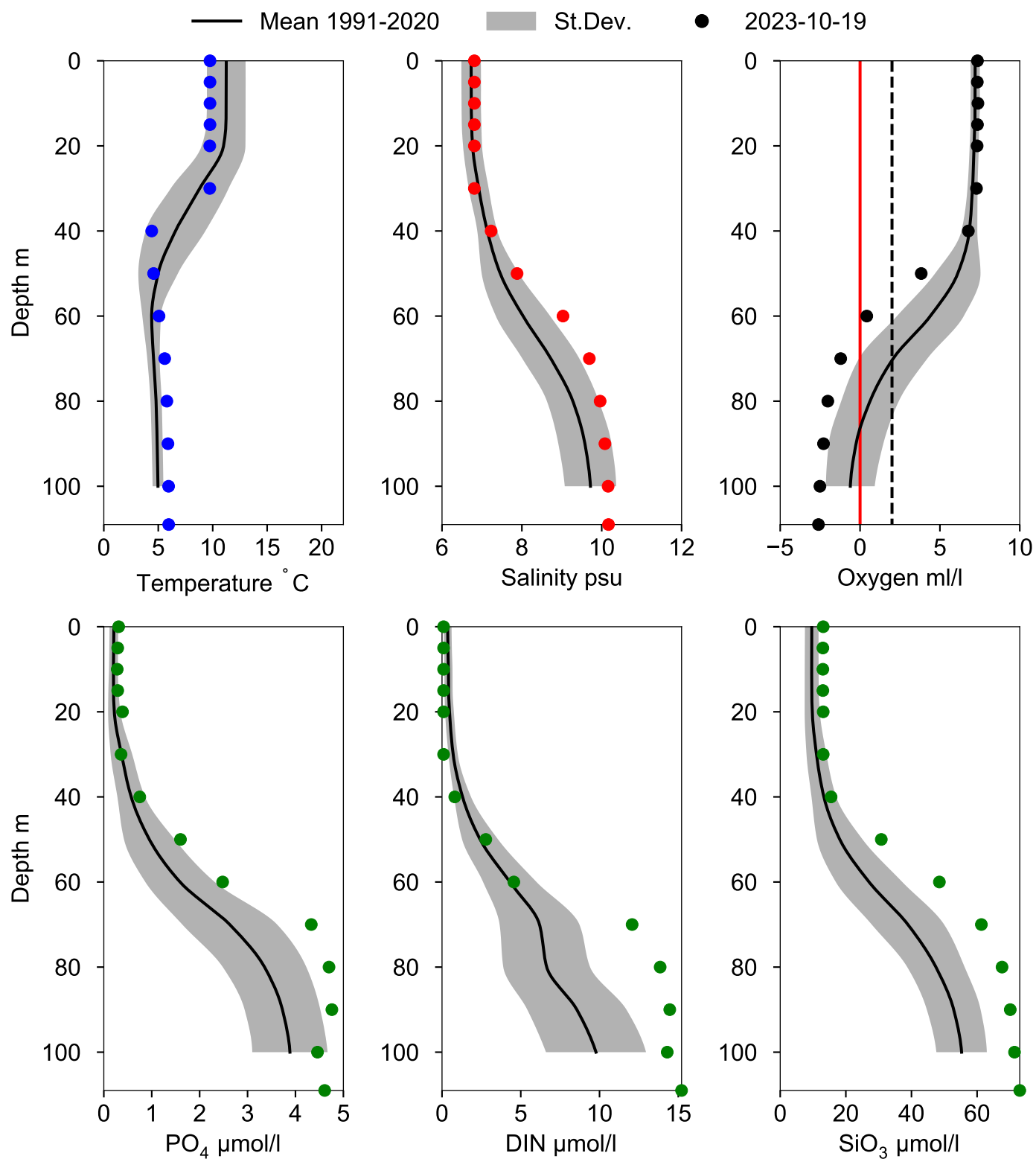
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OXYGEN IN BOTTOM WATER (depth >= 100 m)



Vertical profiles BY38 KARLSÖDJ October



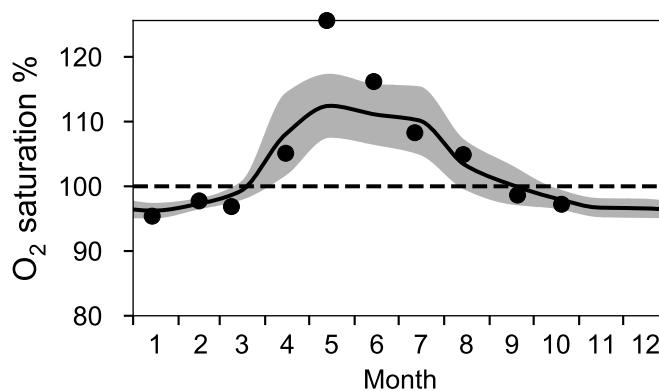
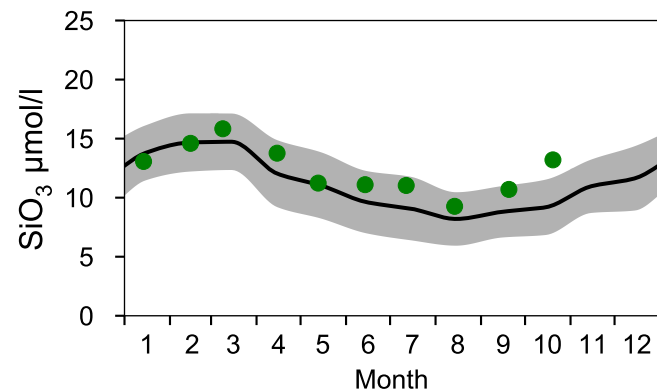
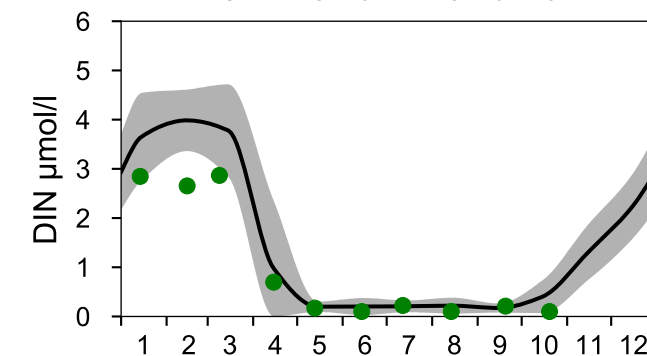
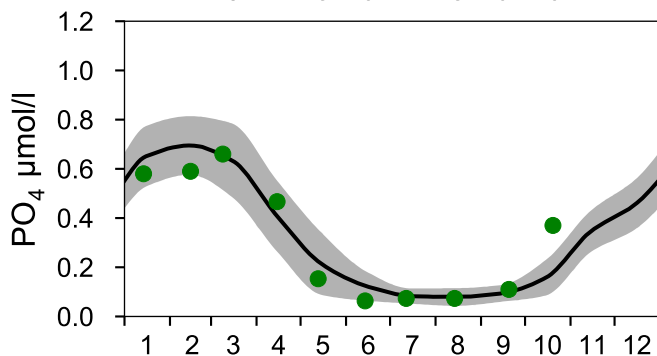
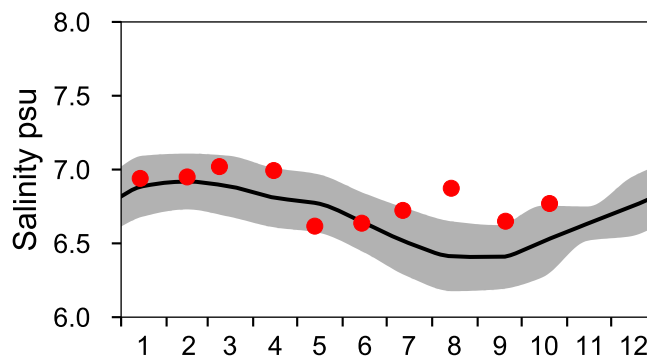
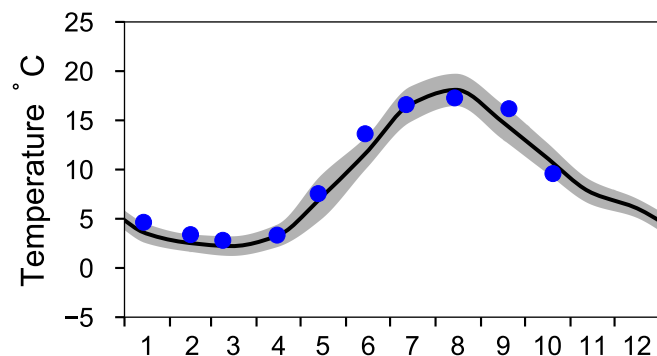
STATION BY32 NORRKÖPINGSDJ SURFACE WATER (0-10 m)

Annual Cycles

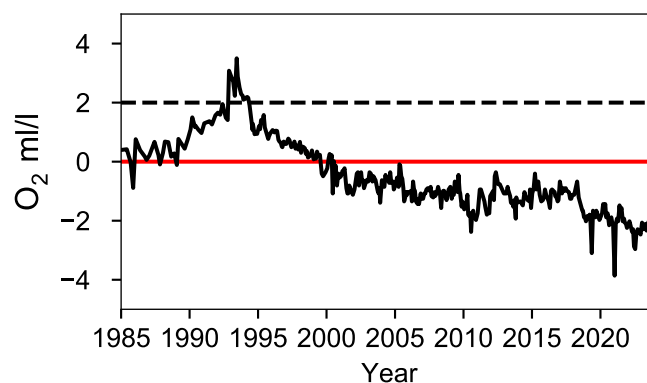
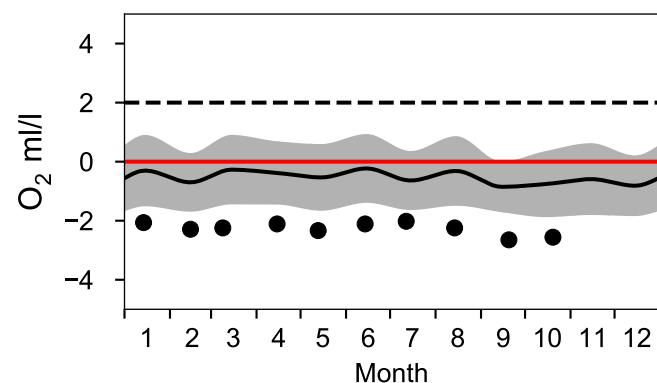
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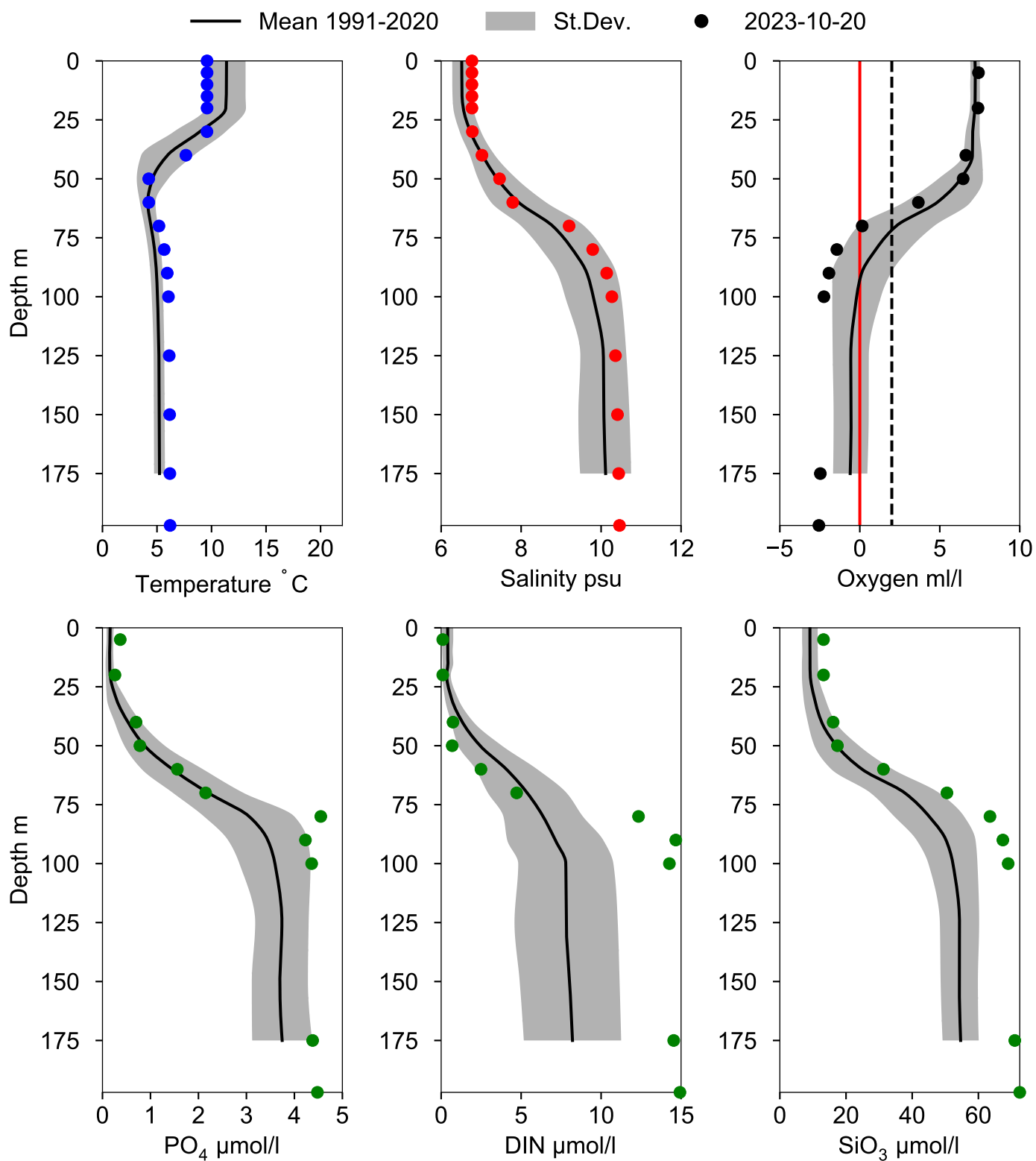
● 2023



OXYGEN IN BOTTOM WATER (depth >= 175 m)



Vertical profiles BY32 NORRKÖPINGSDJ October



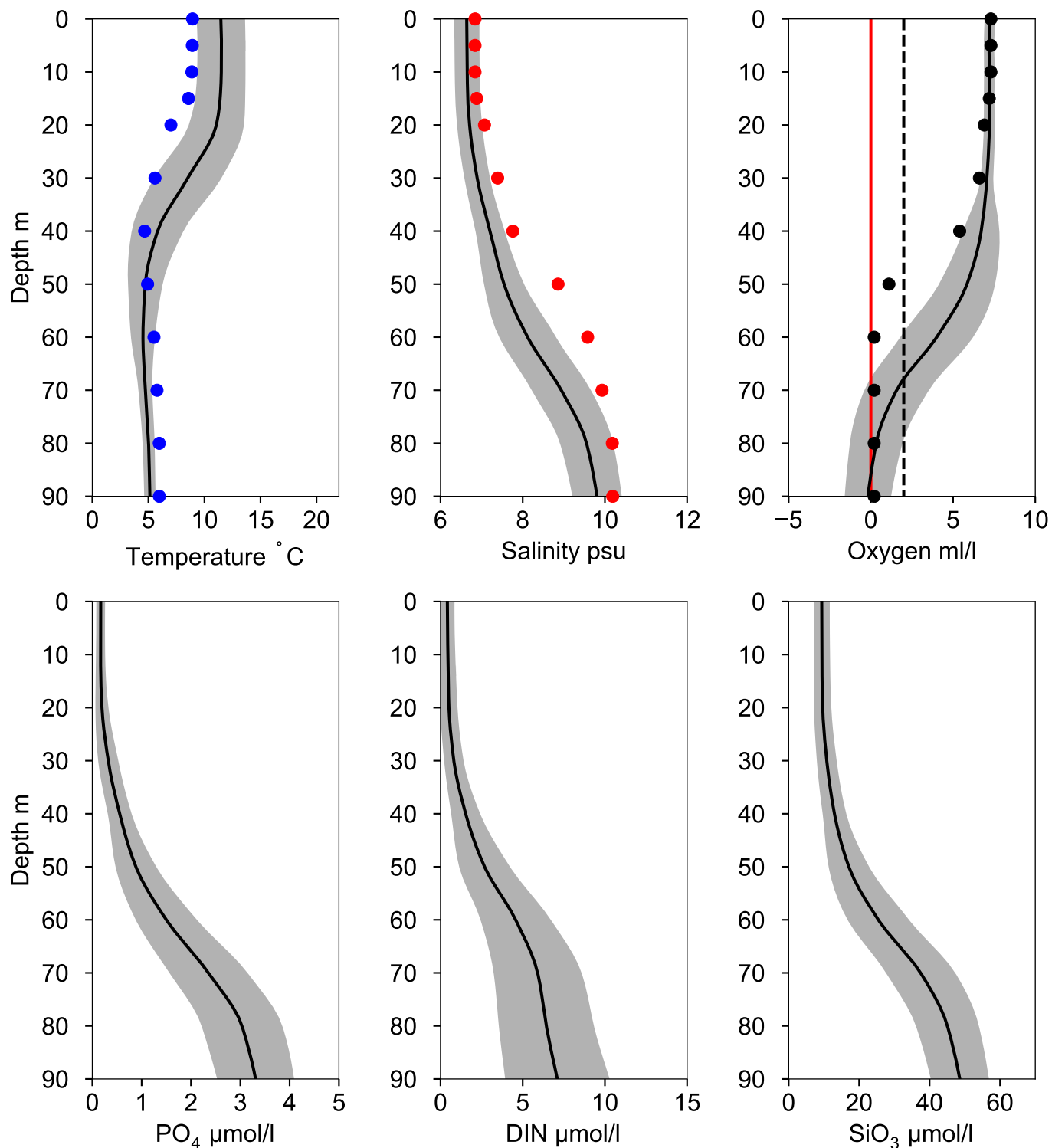
Vertical profiles BABET-1 October

Statistics based on data from: Västra Gotlandshavet

— Mean 1991-2020

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● 2023-10-21



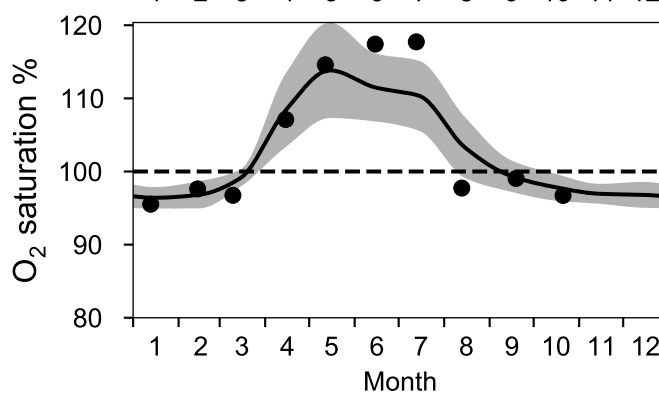
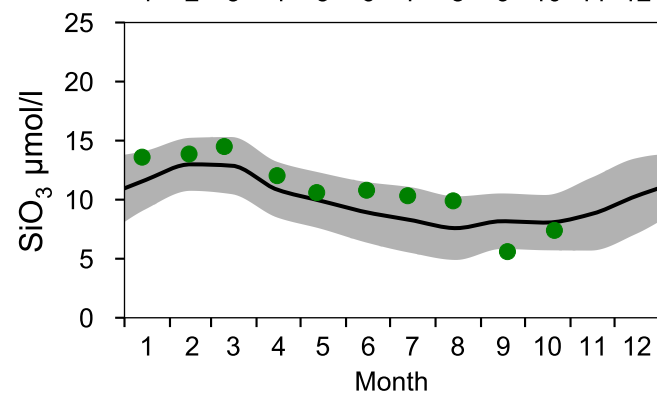
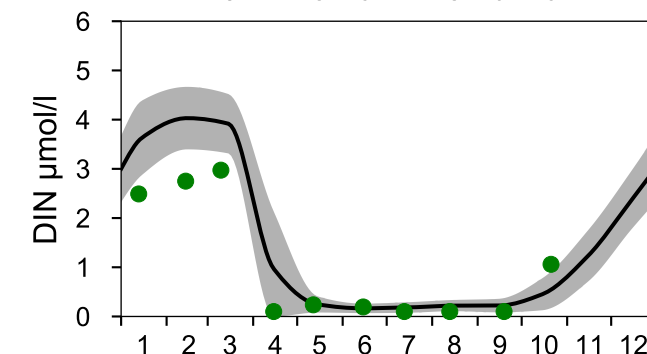
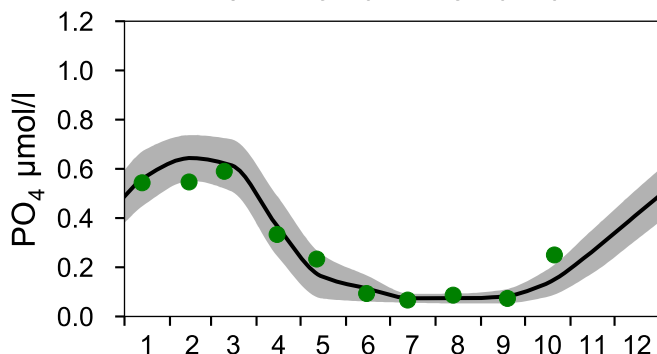
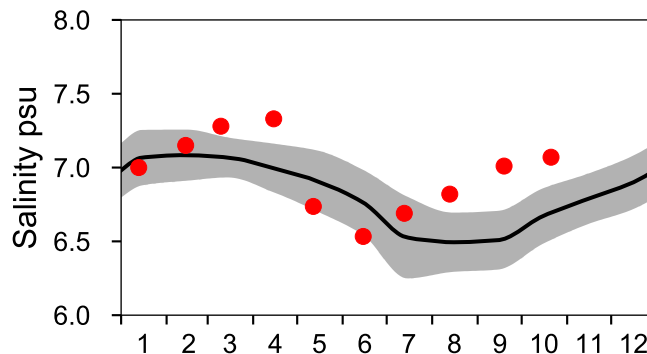
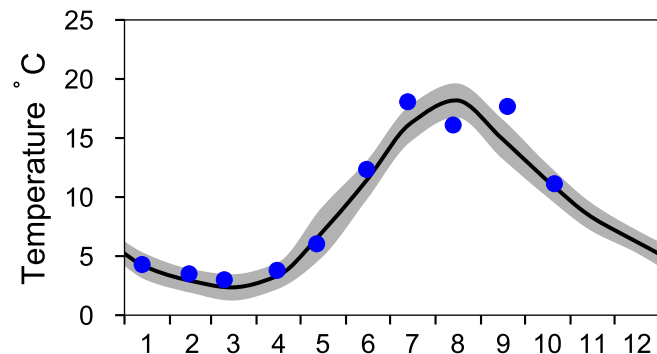
STATION BY20 FÅRÖDJ SURFACE WATER (0-10 m)

Annual Cycles

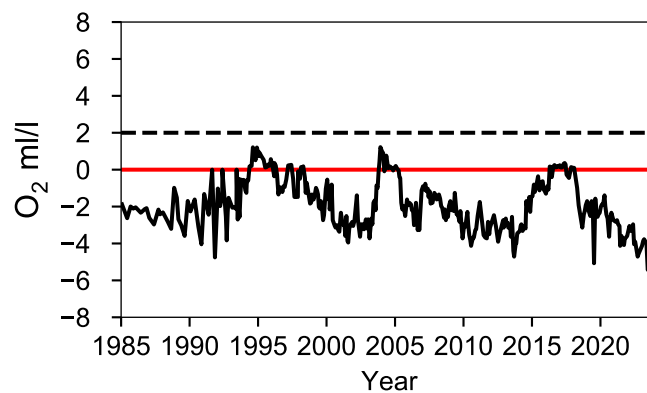
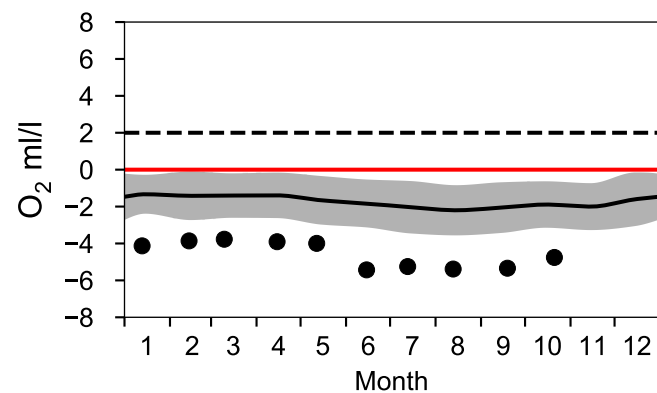
— Mean 1991-2020

■ St.Dev.

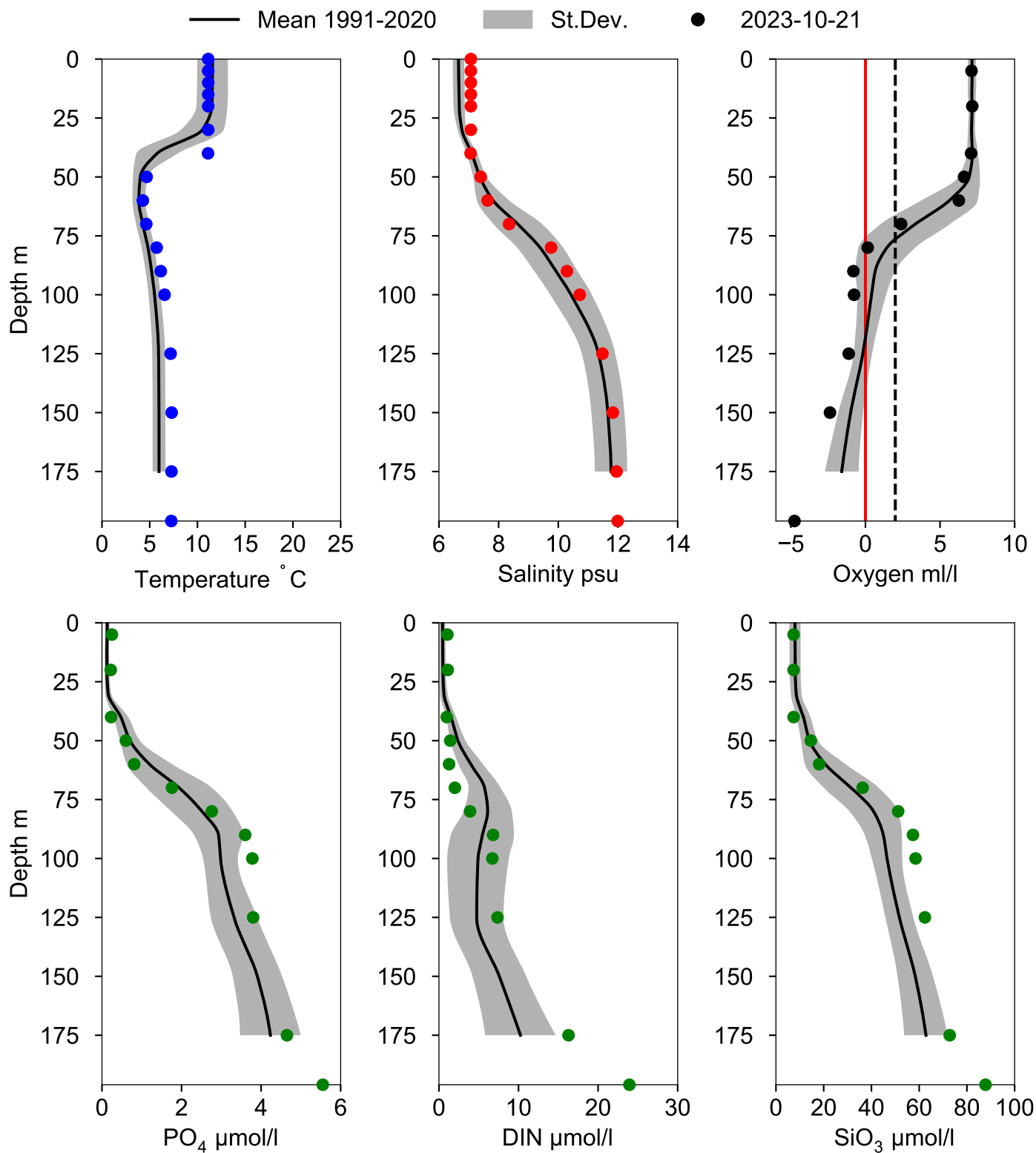
● 2023



OXYGEN IN BOTTOM WATER (depth >= 175 m)



Vertical profiles BY20 FÅRÖDJ October



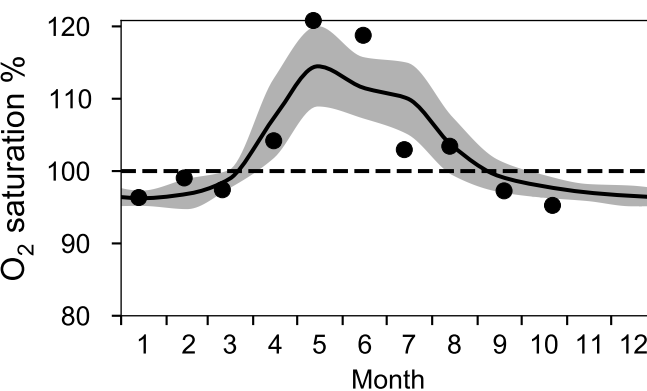
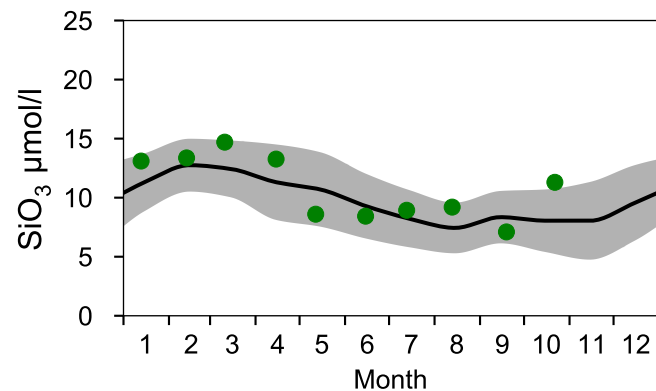
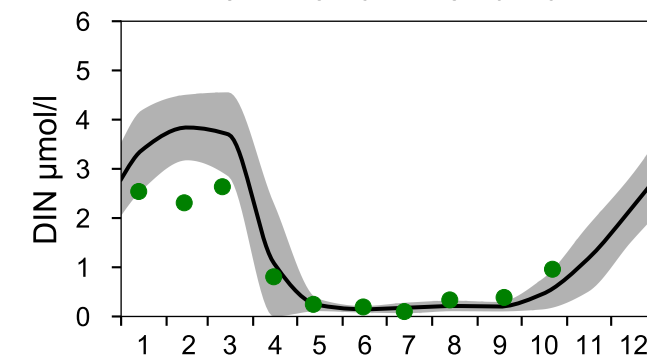
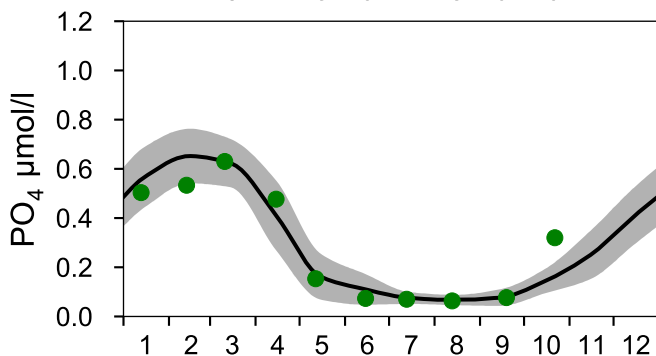
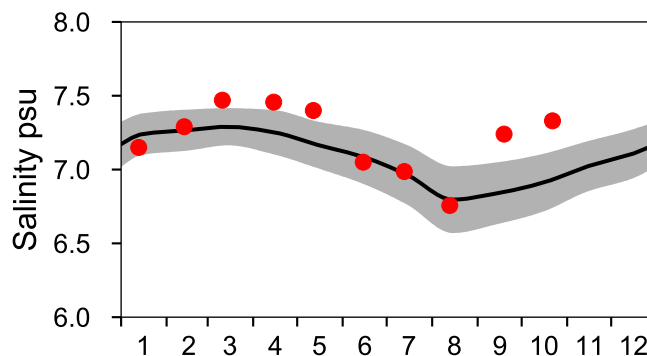
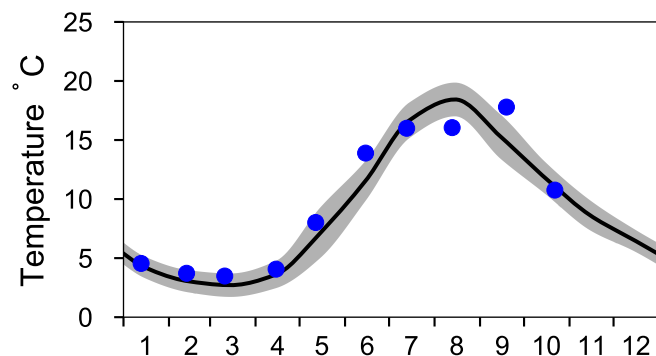
STATION BY15 GOTLANDSDJ SURFACE WATER (0-10 m)

Annual Cycles

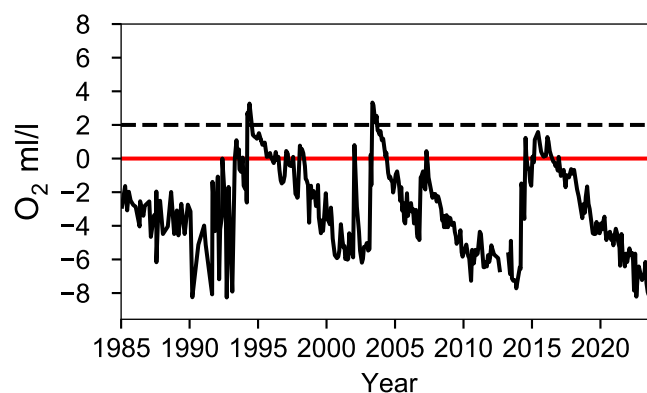
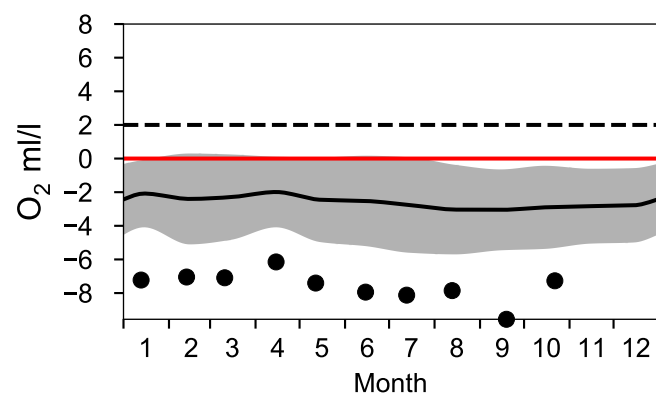
— Mean 1991-2020

■ St.Dev.

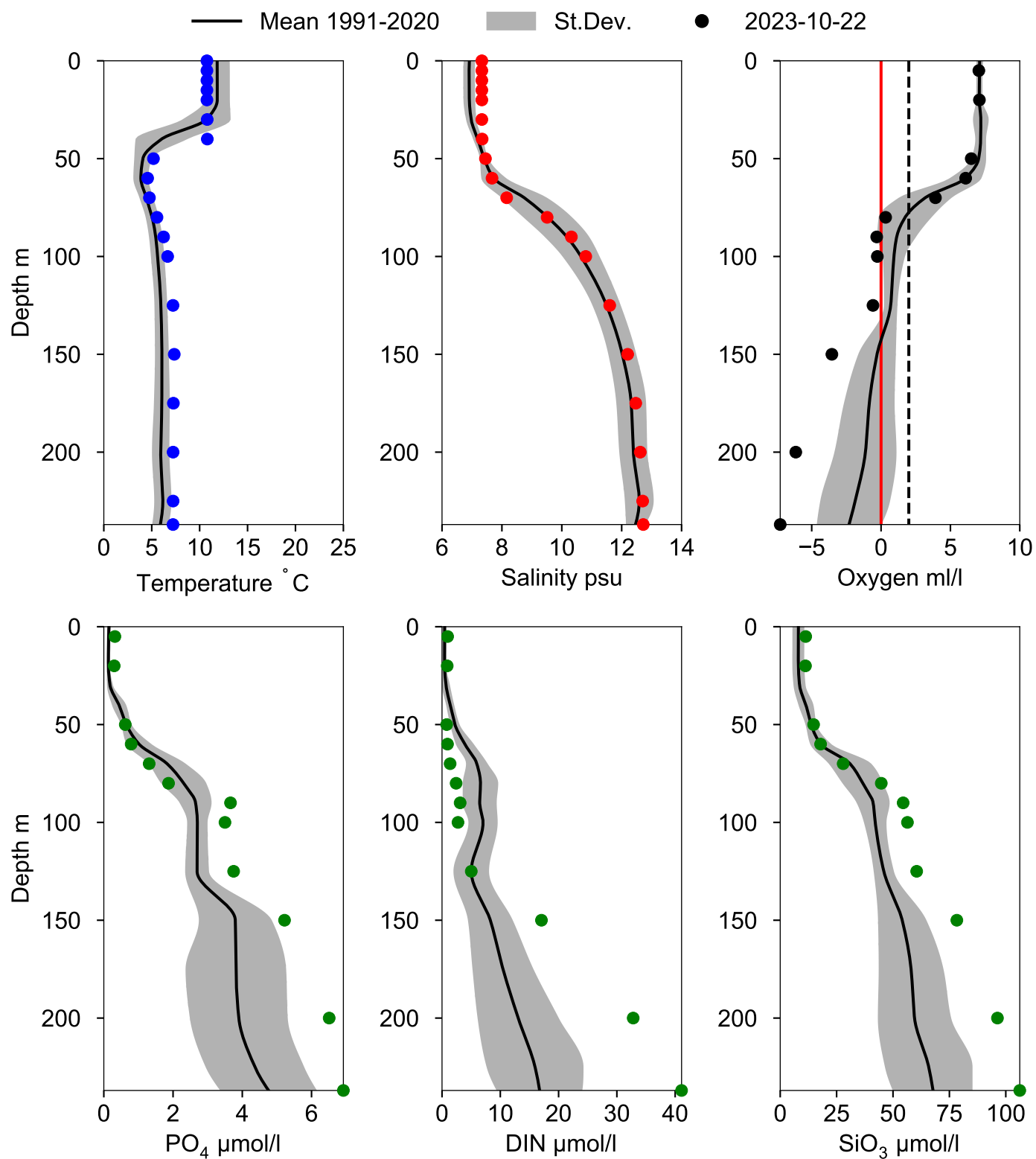
● 2023



OXYGEN IN BOTTOM WATER (depth >= 225 m)



Vertical profiles BY15 GOTLANDSDJ October



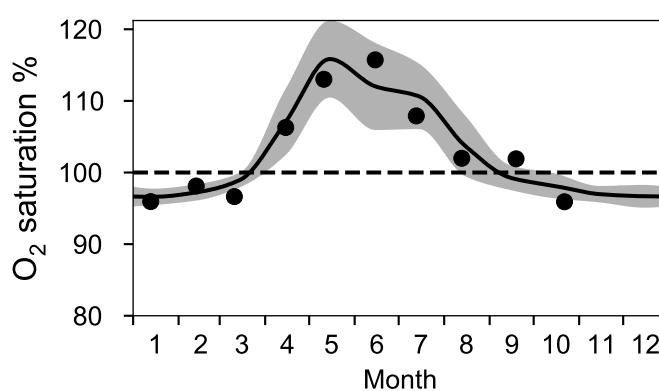
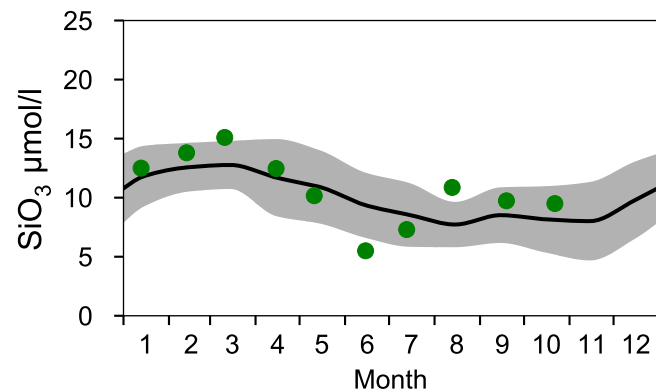
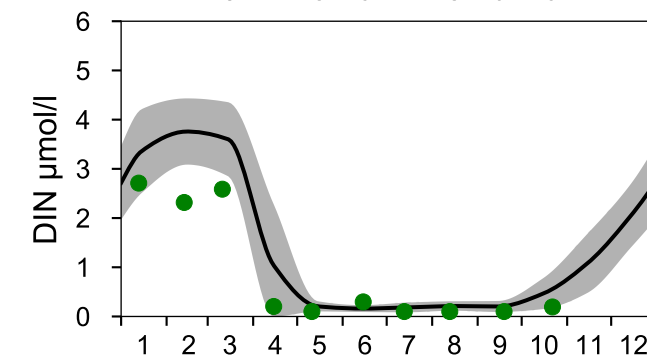
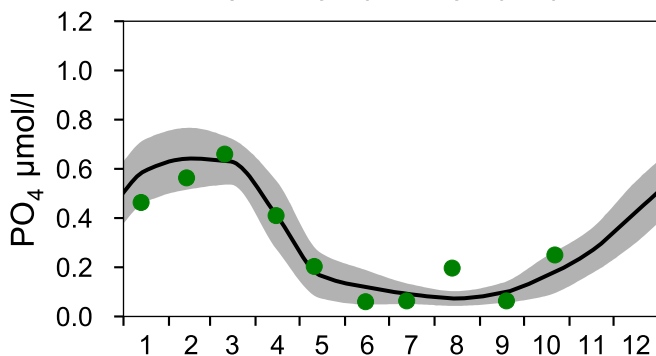
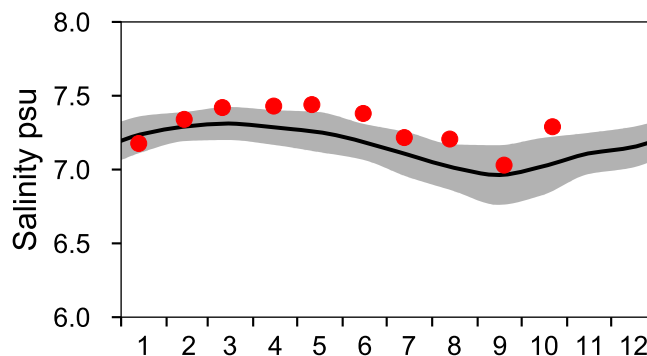
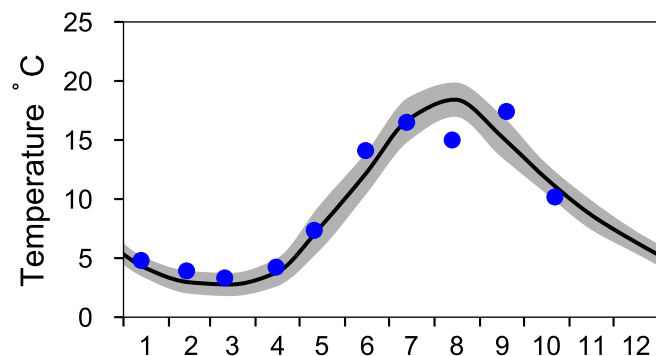
STATION BY10 SURFACE WATER (0-10 m)

Annual Cycles

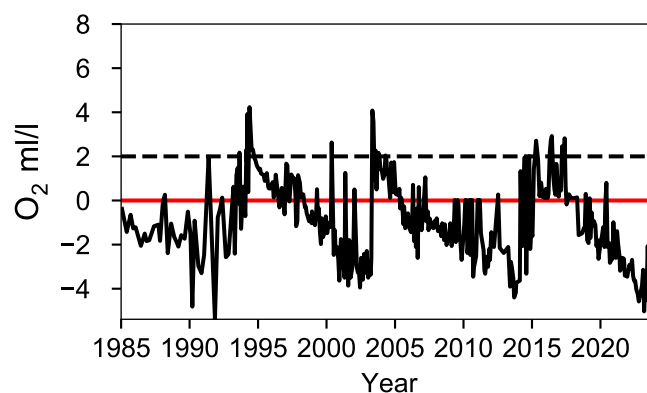
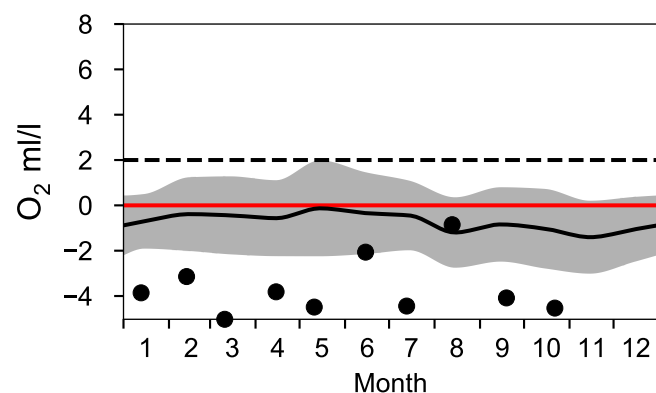
— Mean 1991-2020

■ St.Dev.

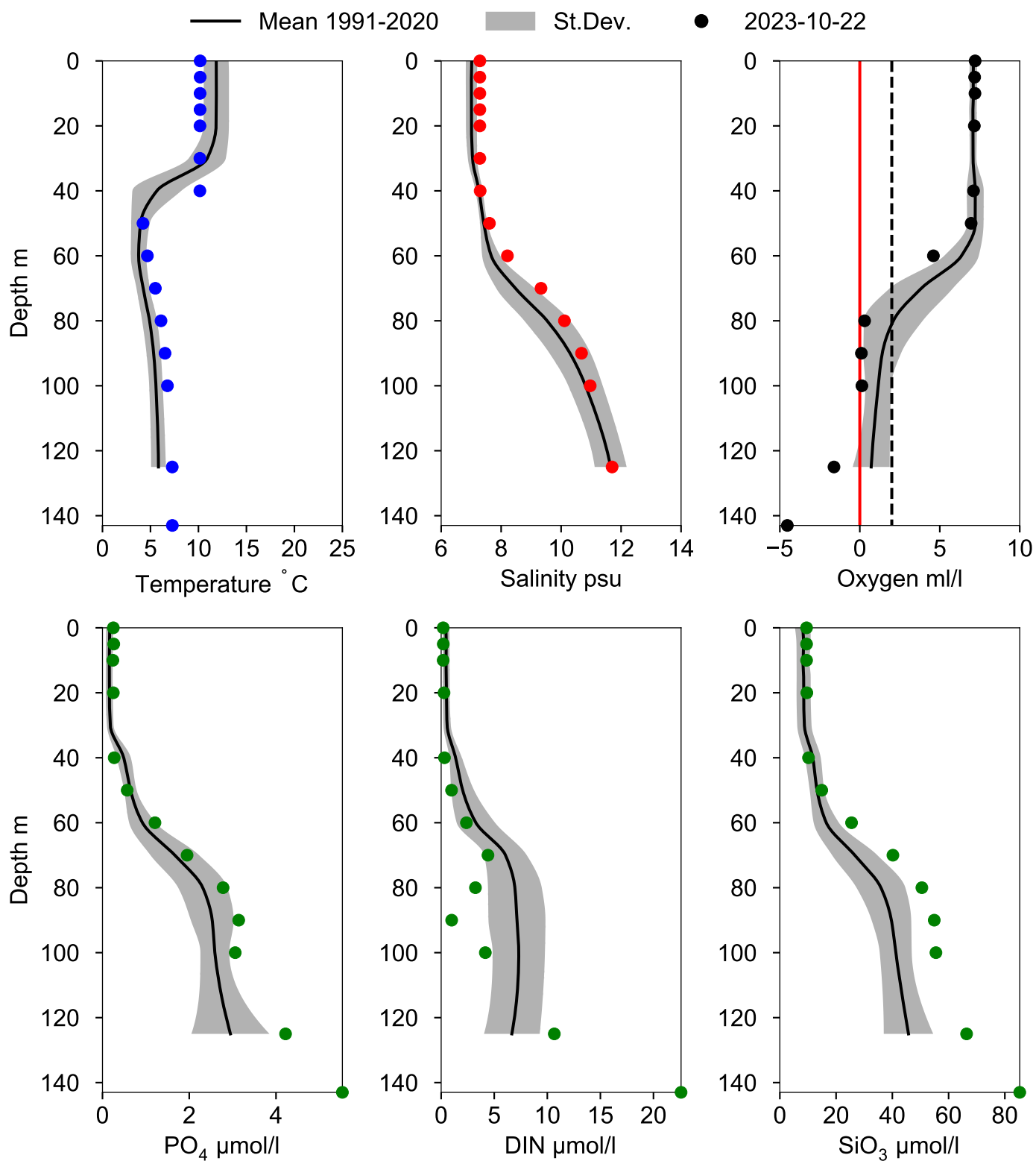
● 2023



OXYGEN IN BOTTOM WATER (depth >= 125 m)



Vertical profiles BY10 October



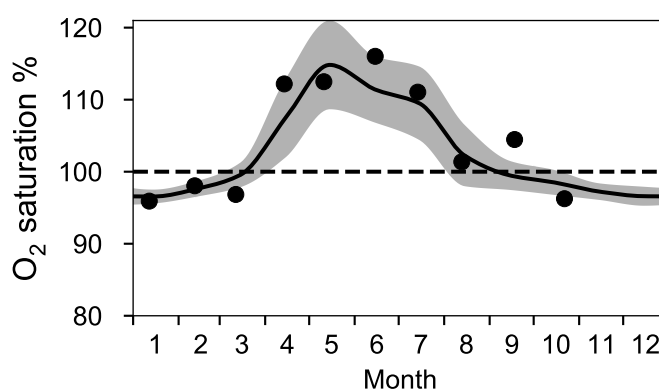
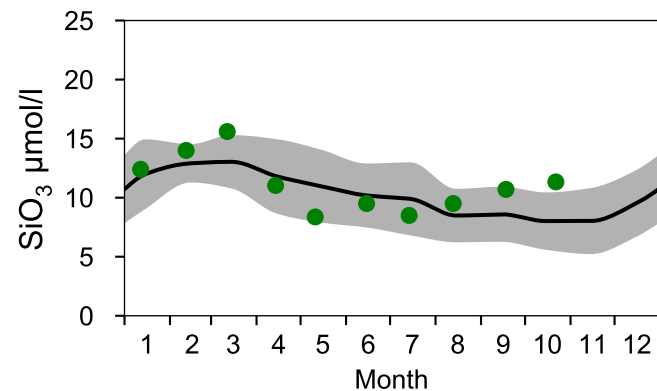
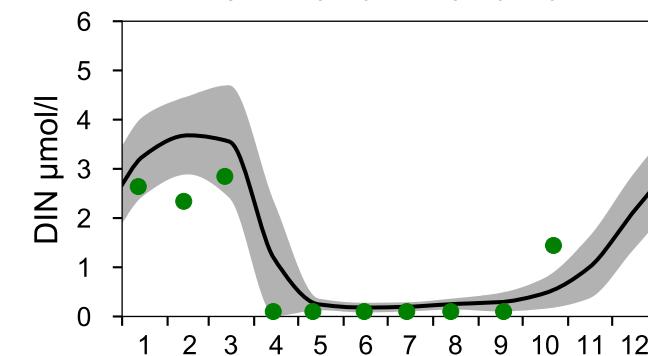
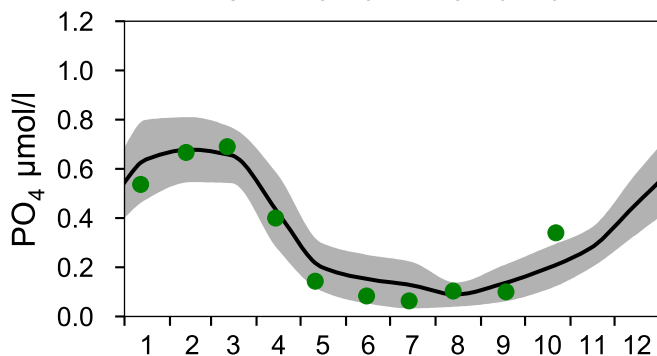
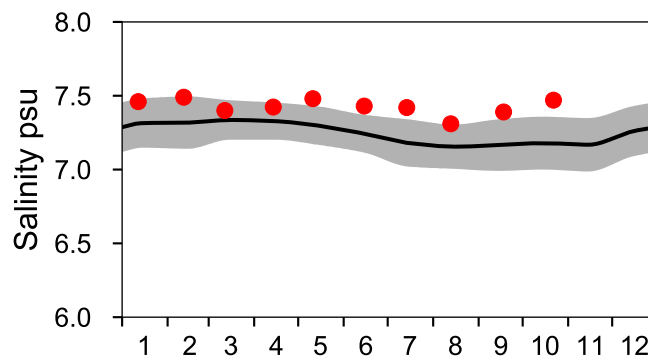
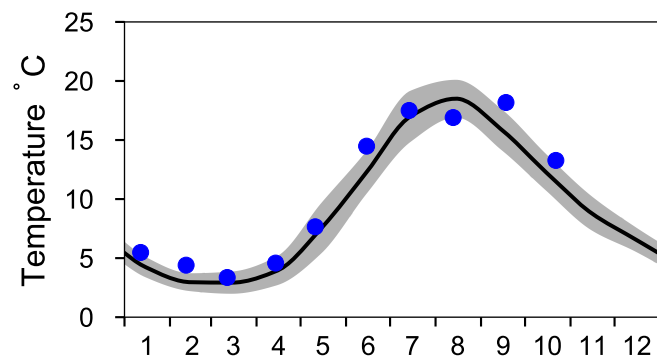
STATION BCS III-10 SURFACE WATER (0-10 m)

Annual Cycles

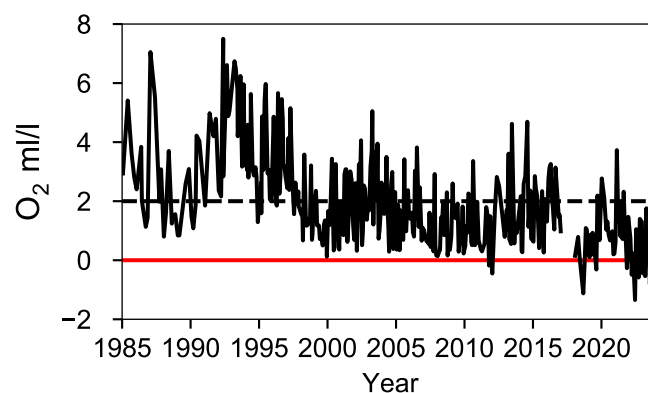
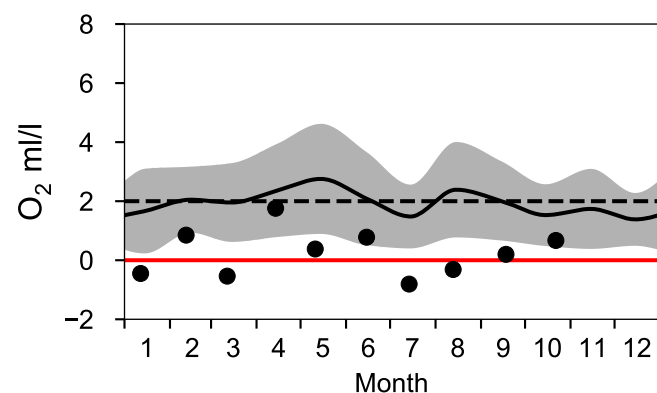
— Mean 1991-2020

■ St.Dev.

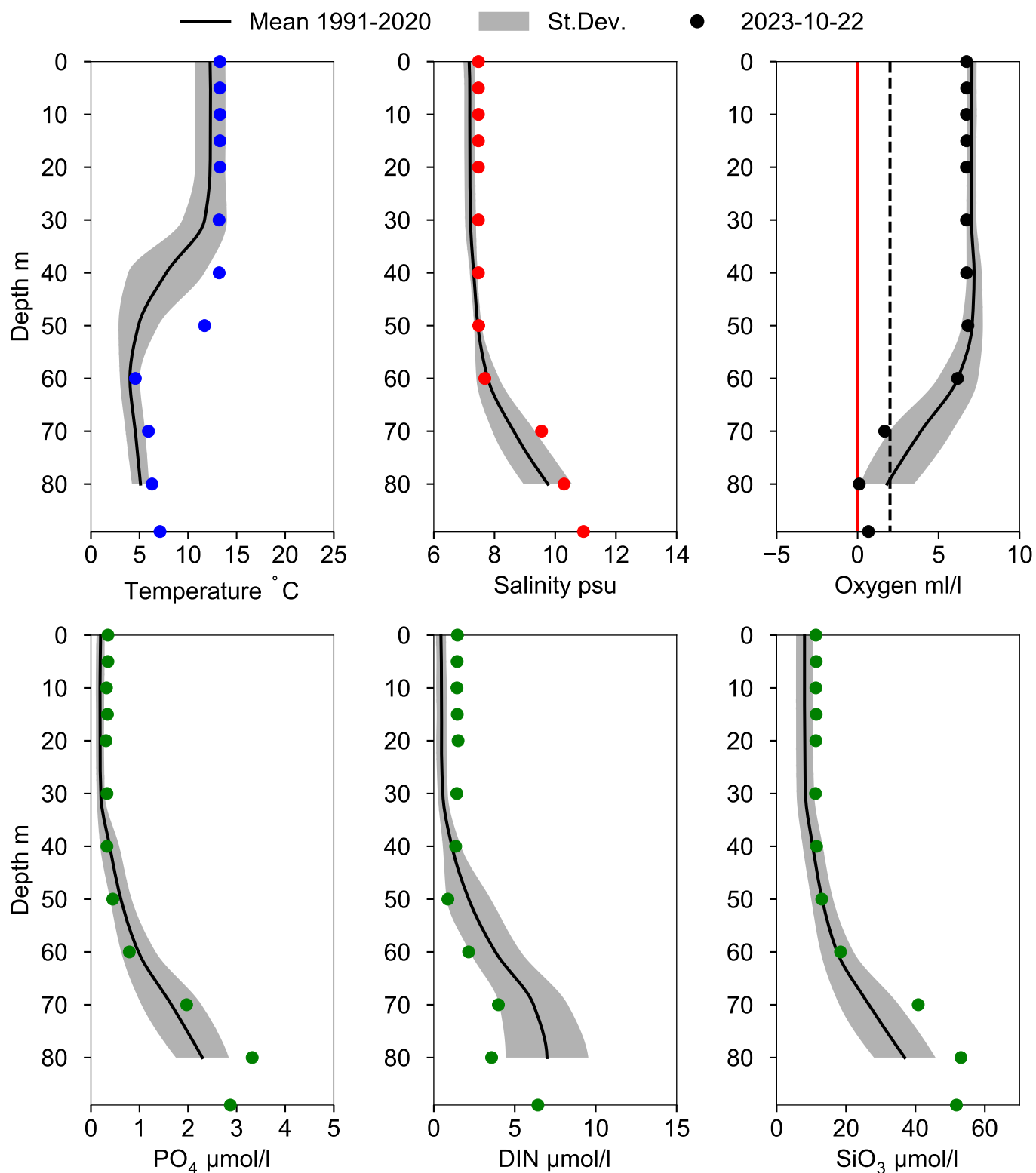
● 2023



OXYGEN IN BOTTOM WATER (depth >= 80 m)



Vertical profiles BCS III-10 October



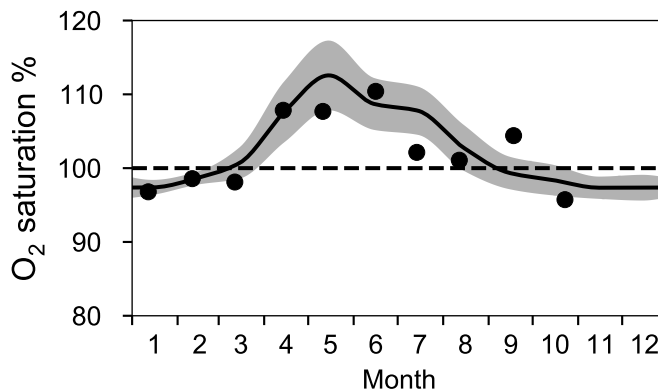
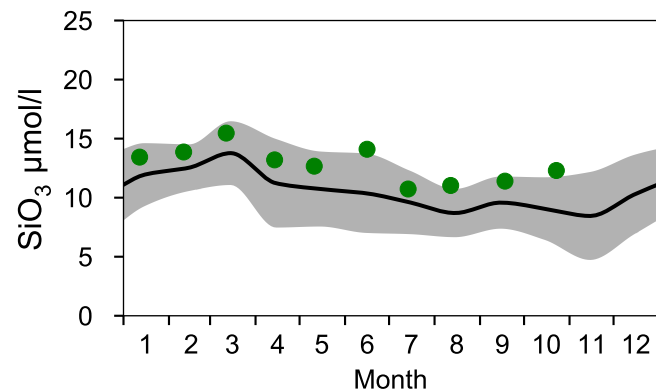
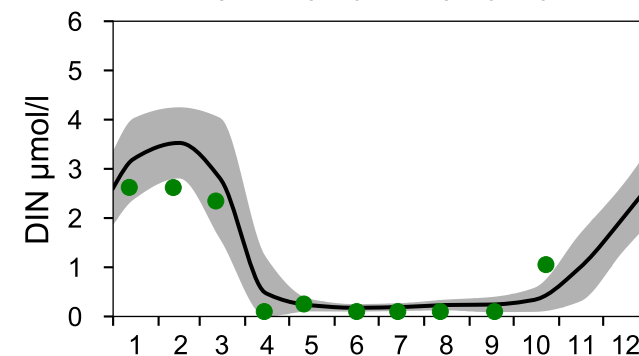
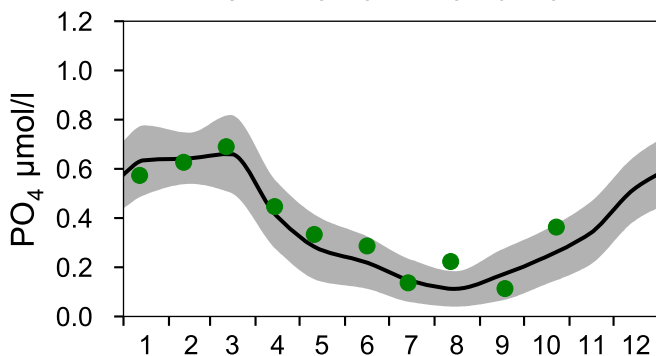
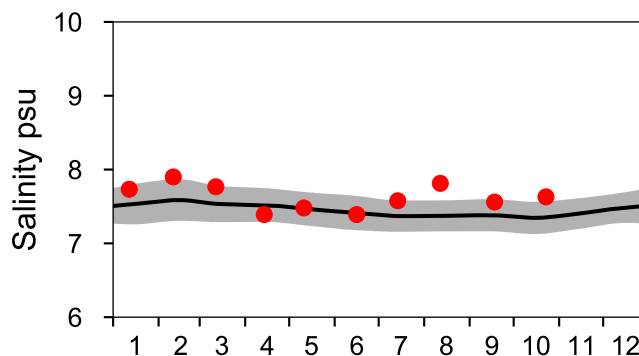
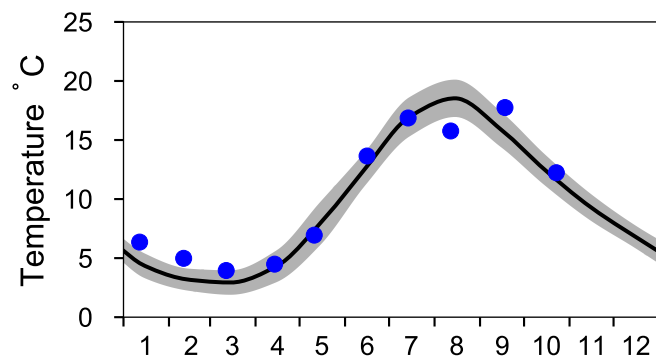
STATION BY5 BORNHOLMSDJ SURFACE WATER (0-10 m)

Annual Cycles

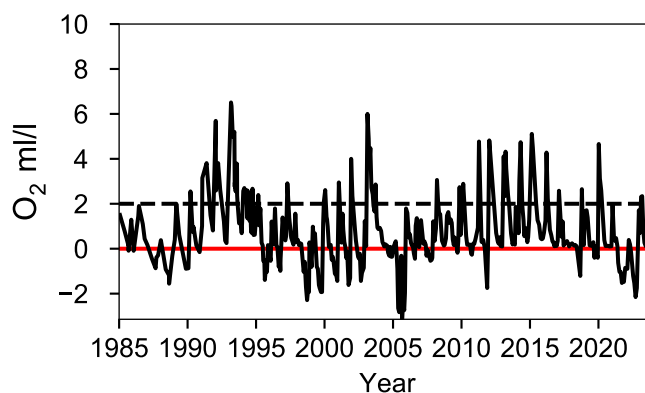
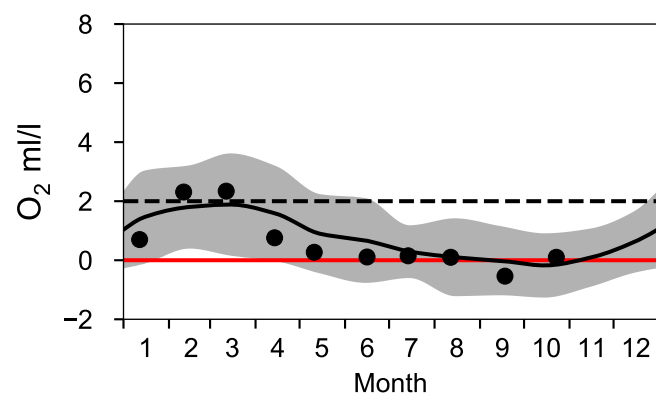
— Mean 1991-2020

■ St.Dev.

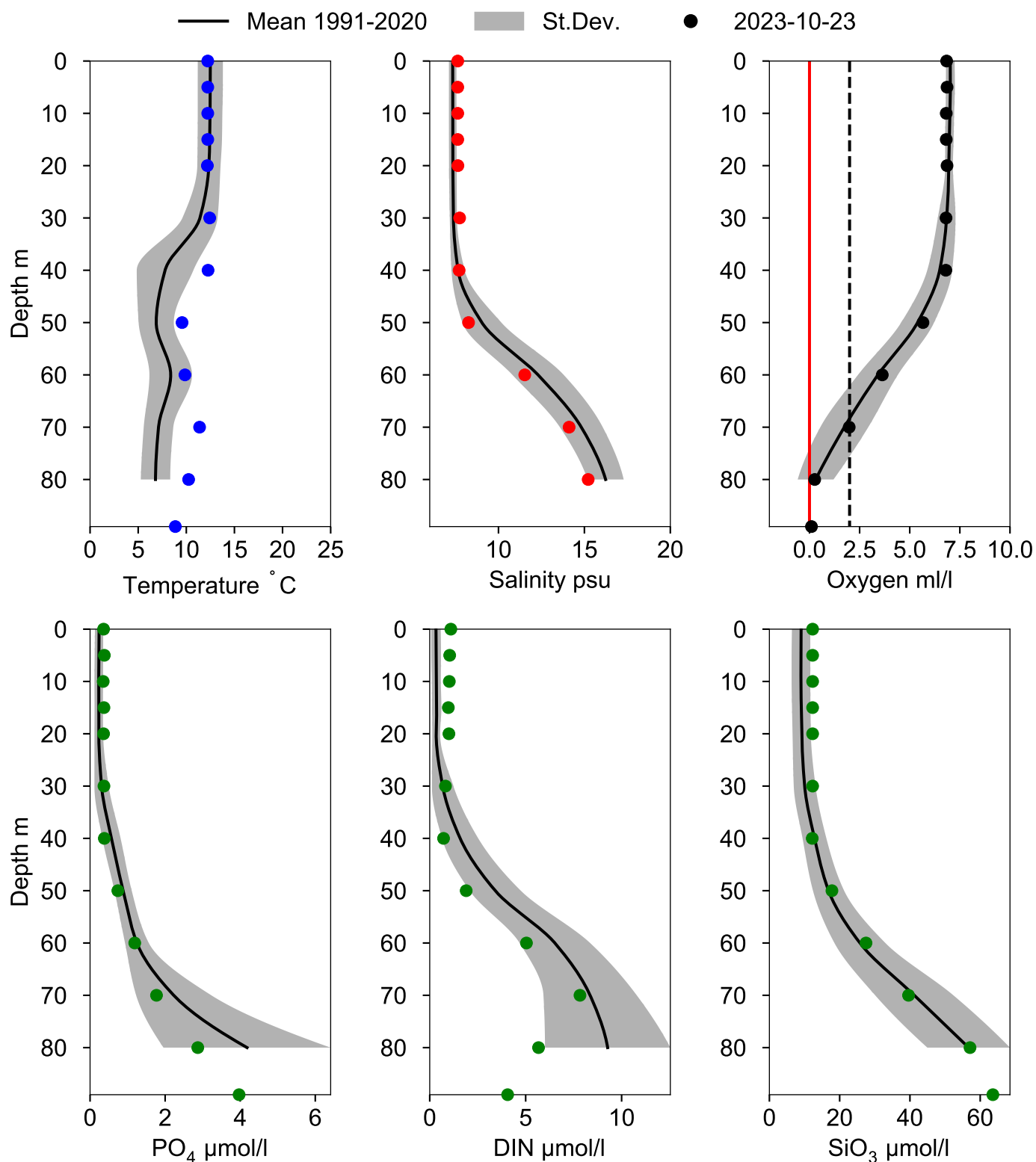
● 2023



OXYGEN IN BOTTOM WATER (depth >= 80 m)



Vertical profiles BY5 BORNHOLMSDJ October



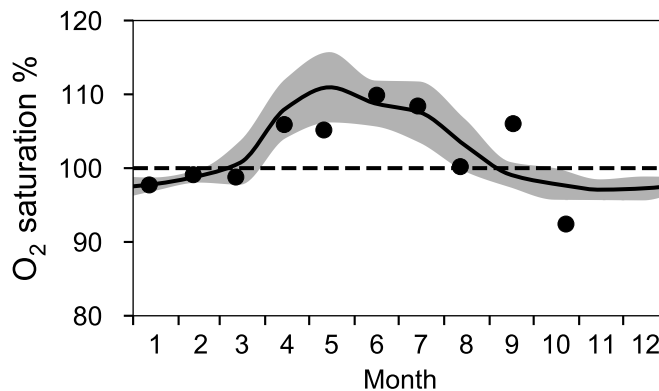
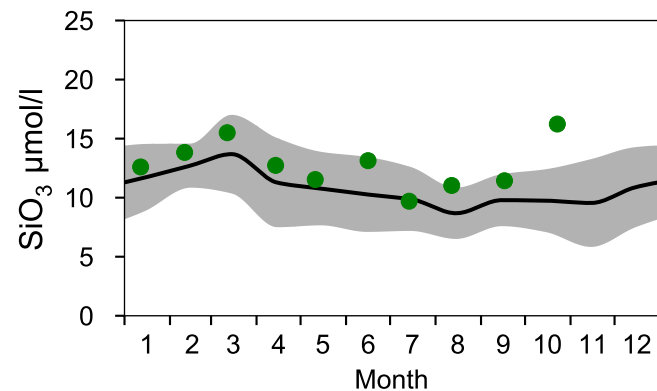
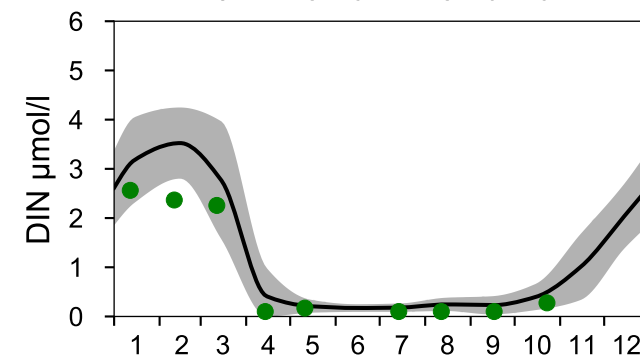
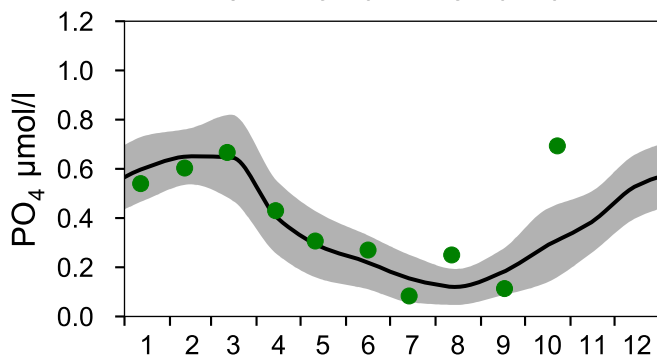
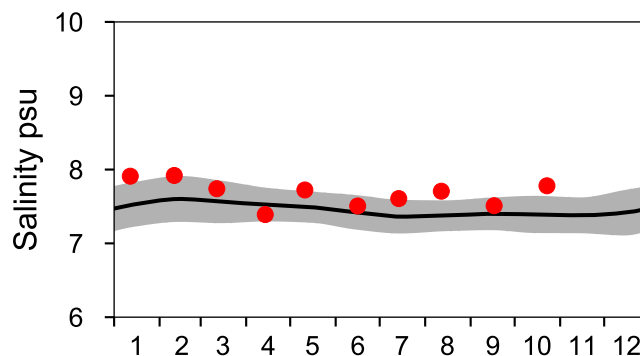
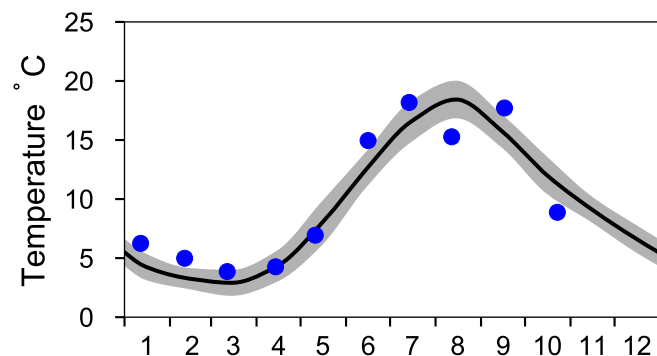
STATION BY4 CHRISTIANSÖ SURFACE WATER (0-10 m)

Annual Cycles

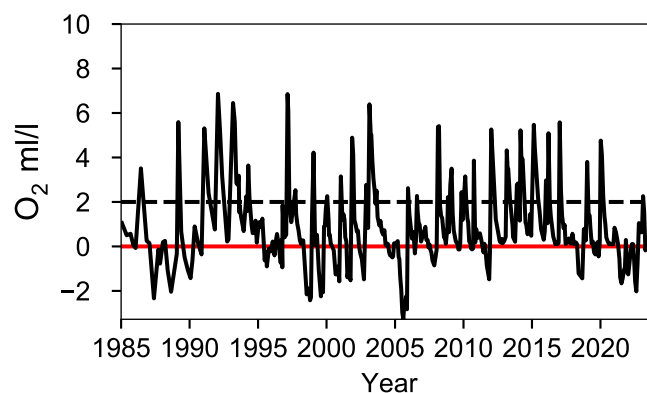
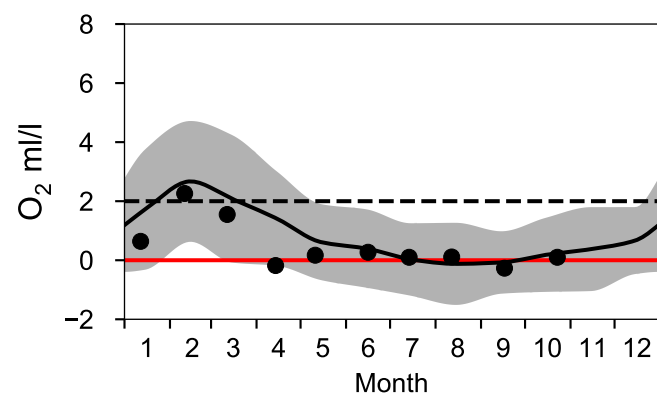
— Mean 1991-2020

■ St.Dev.

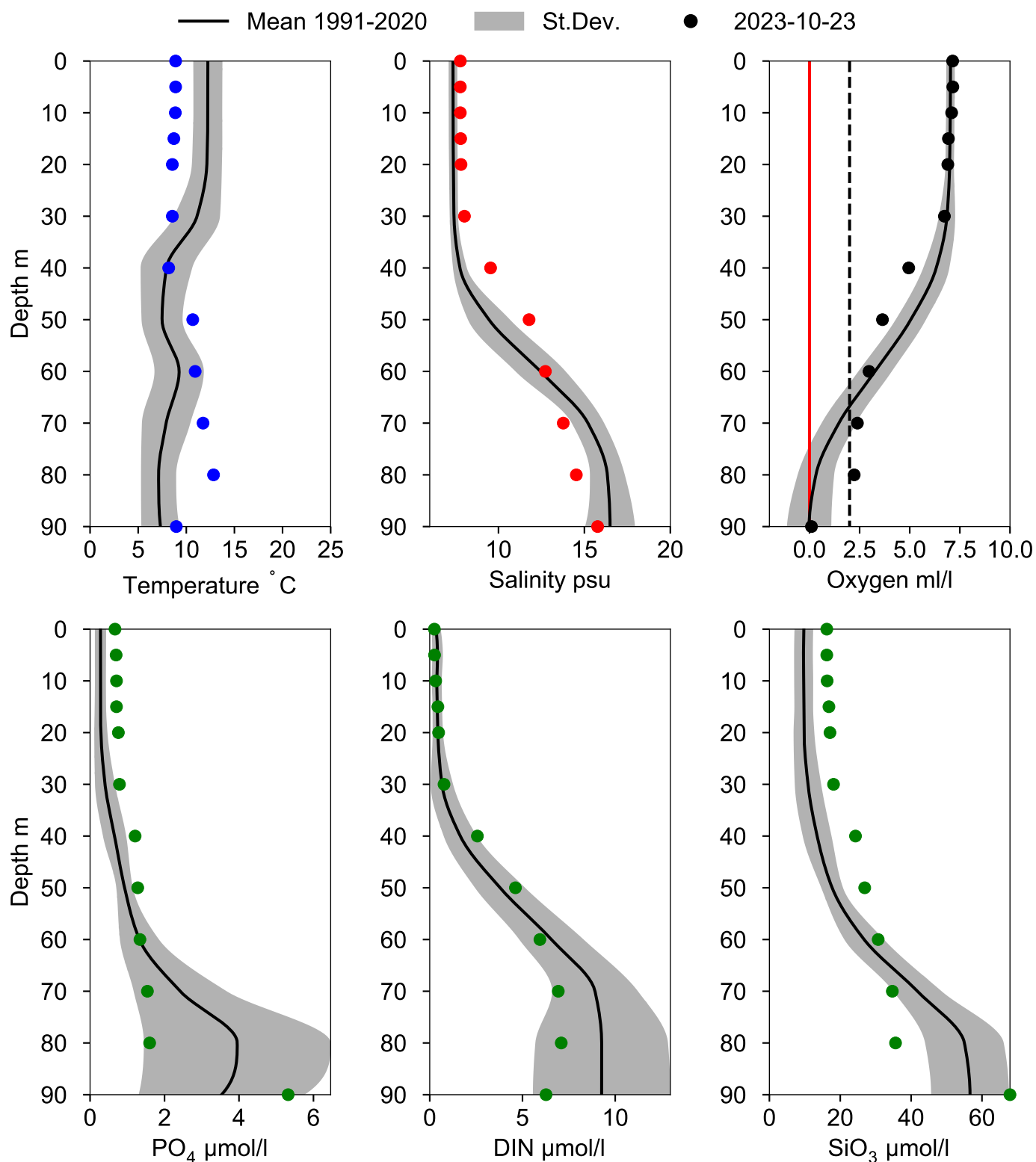
● 2023



OXYGEN IN BOTTOM WATER (depth >= 80 m)



Vertical profiles BY4 CHRISTIANSÖ October



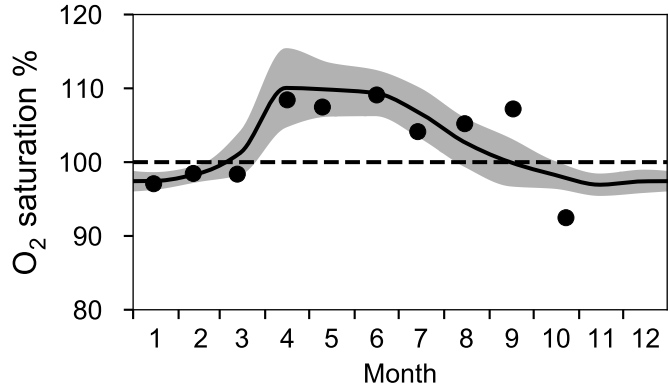
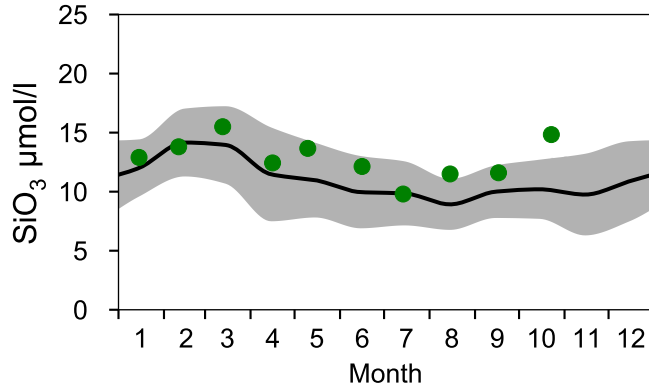
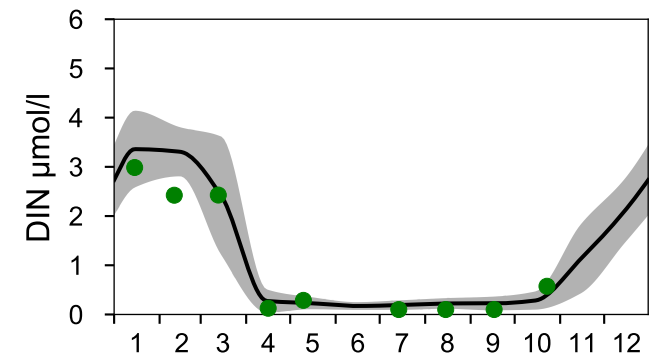
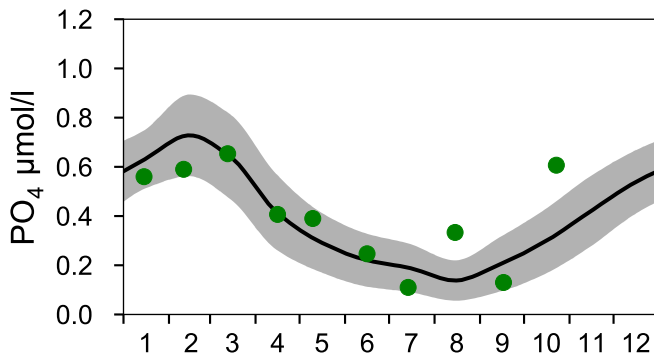
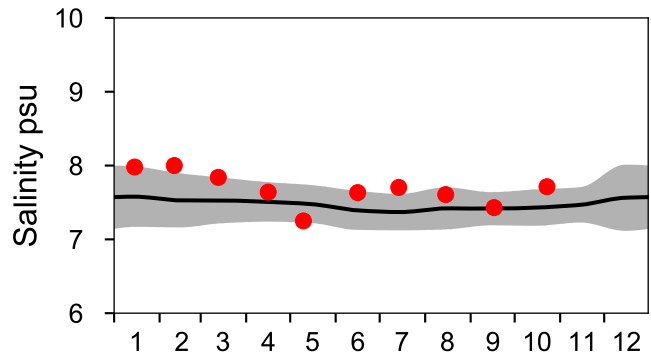
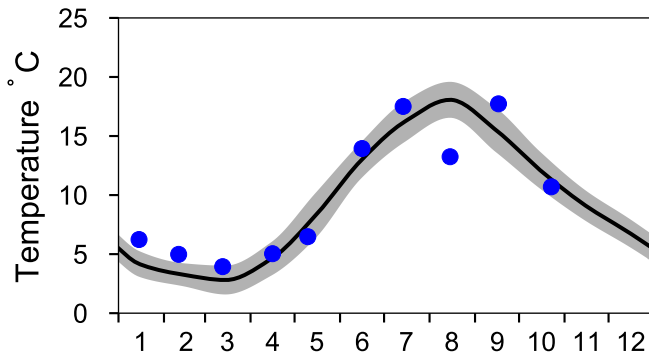
STATION HANÖBUKTEN SURFACE WATER (0-10 m)

Annual Cycles

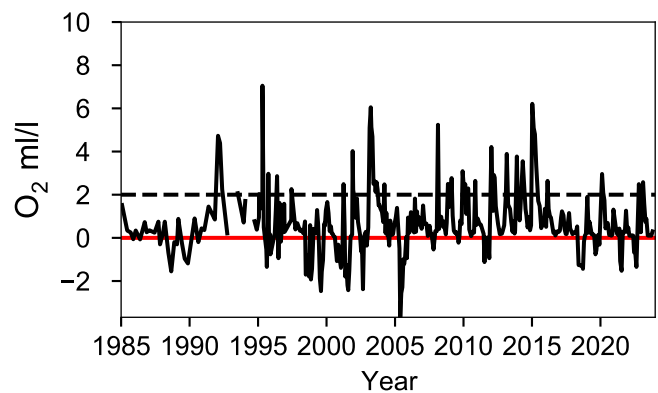
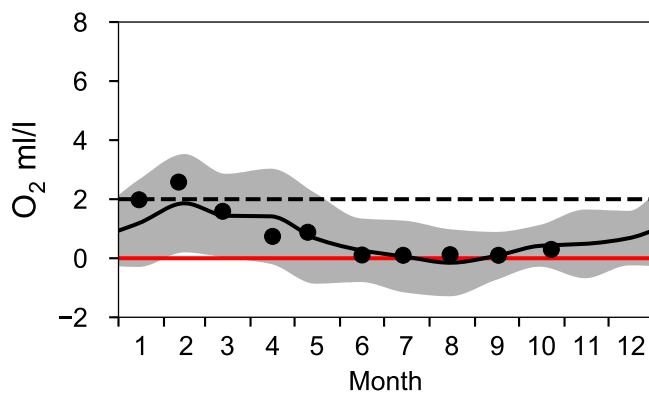
— Mean 1991-2020

■ St.Dev.

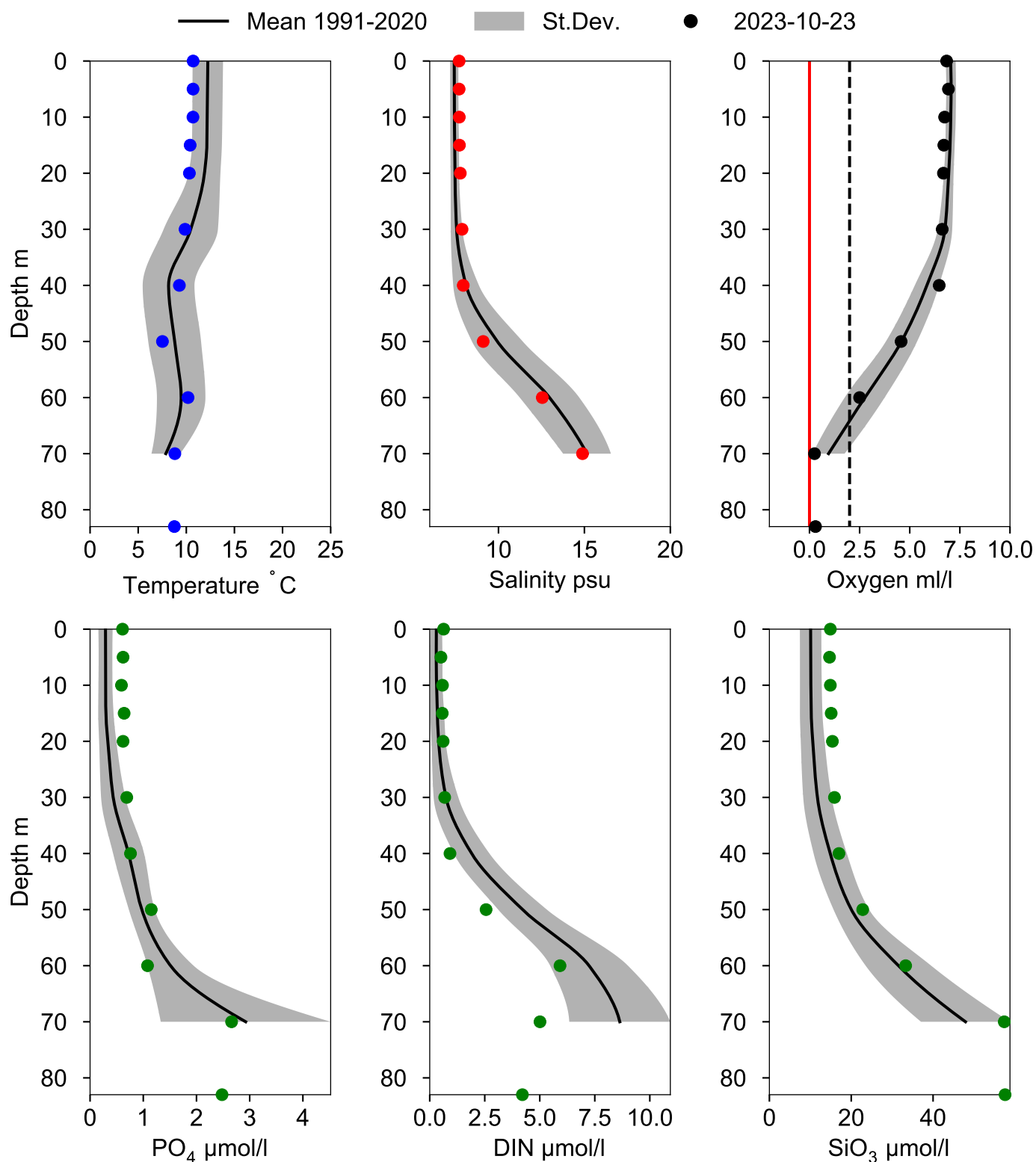
● 2023



OXYGEN IN BOTTOM WATER (depth >= 70 m)



Vertical profiles HANÖBUKTEN October



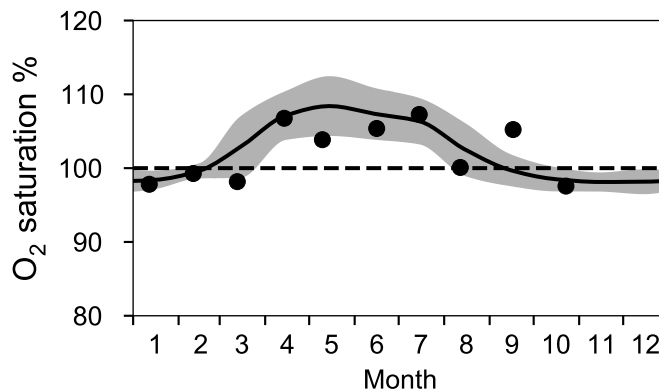
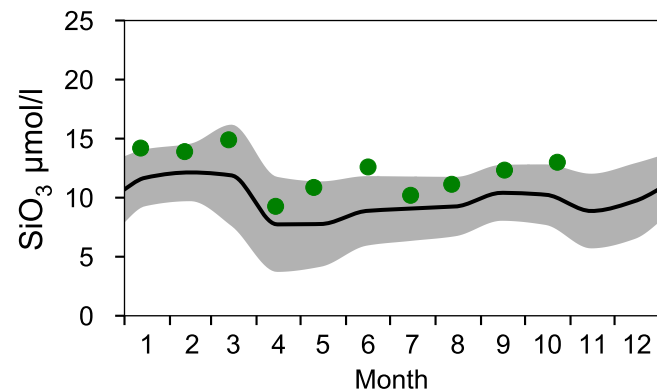
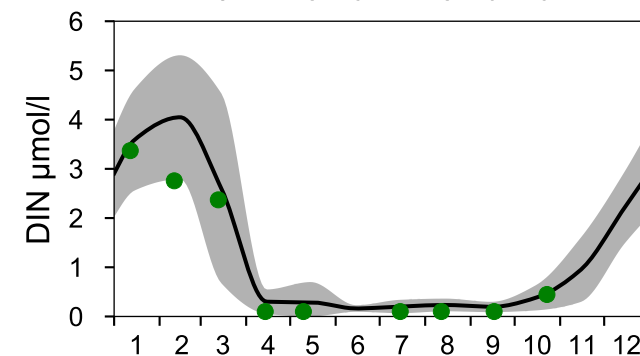
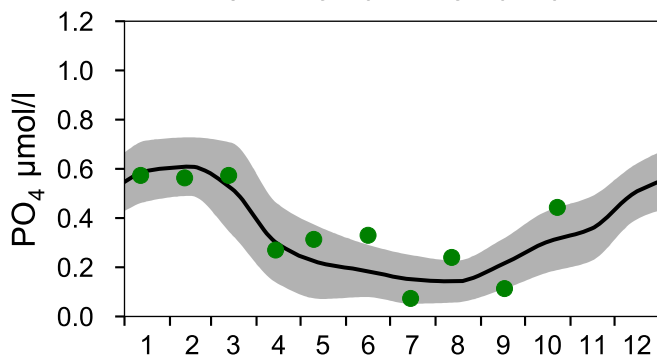
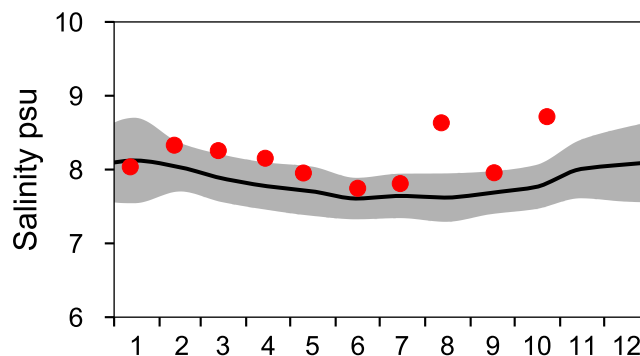
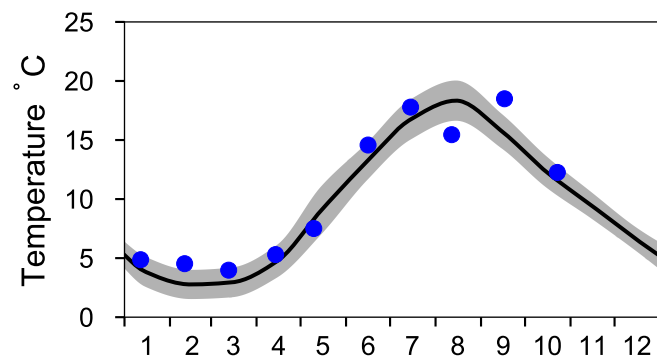
STATION BY2 ARKONA SURFACE WATER (0-10 m)

Annual Cycles

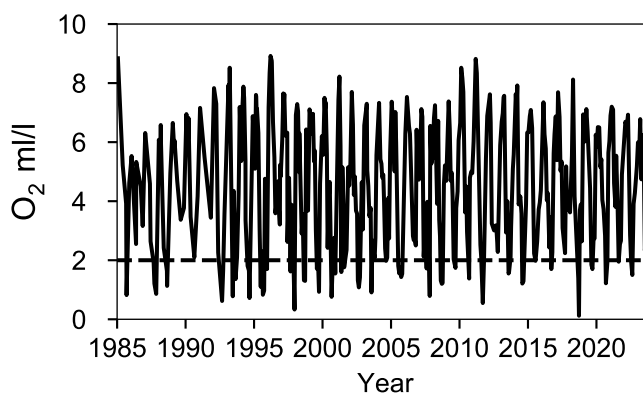
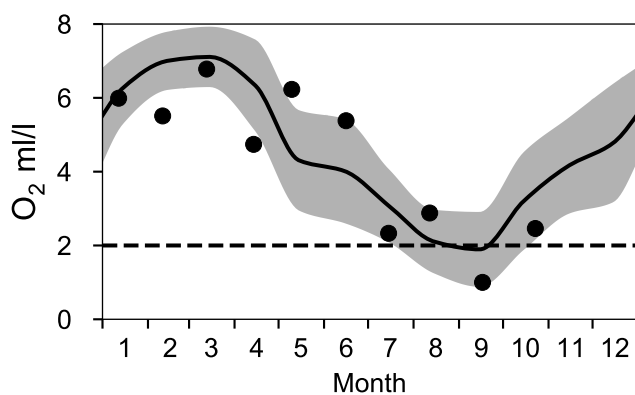
— Mean 1991-2020

■ St.Dev.

● 2023

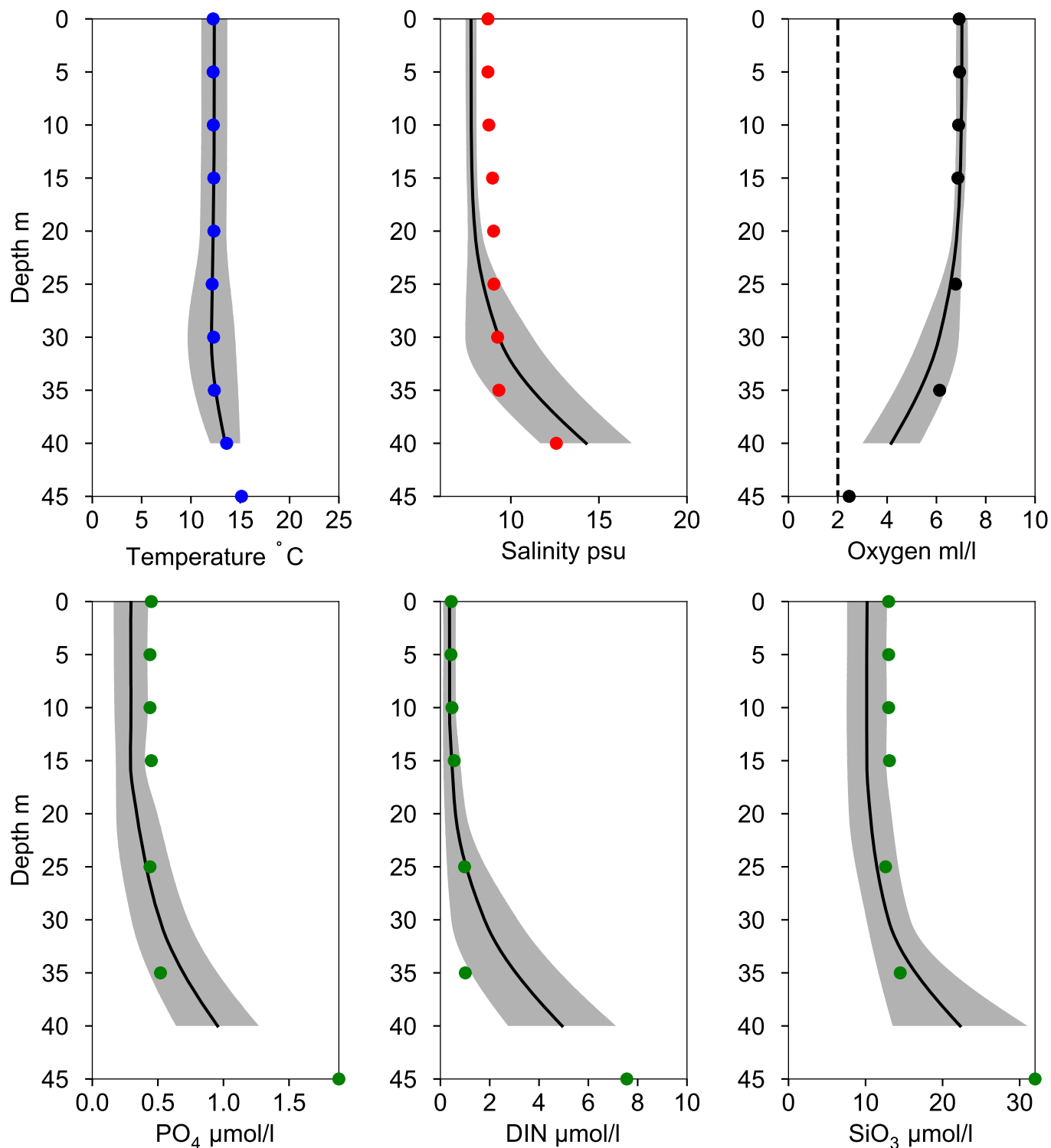


OXYGEN IN BOTTOM WATER (depth >= 40 m)



Vertical profiles BY2 ARKONA October

— Mean 1991-2020 St.Dev. ● 2023-10-23



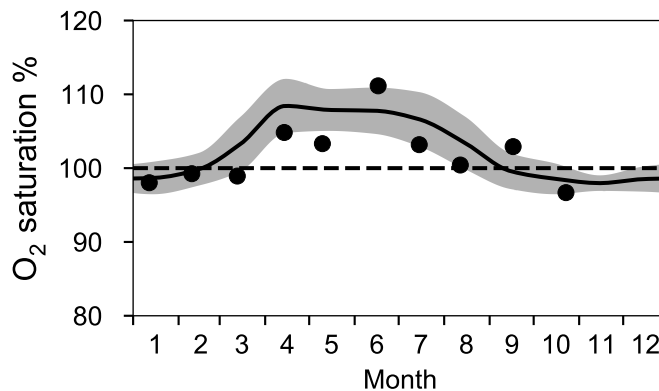
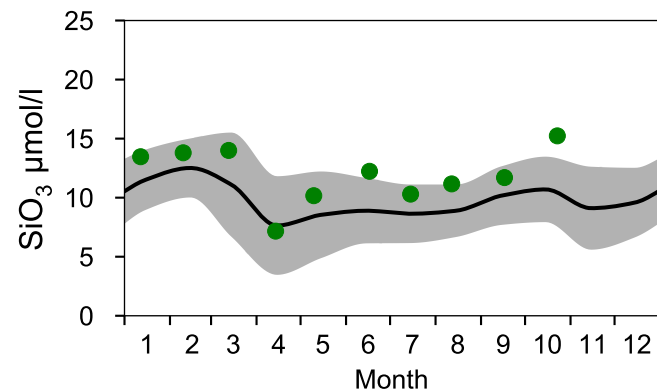
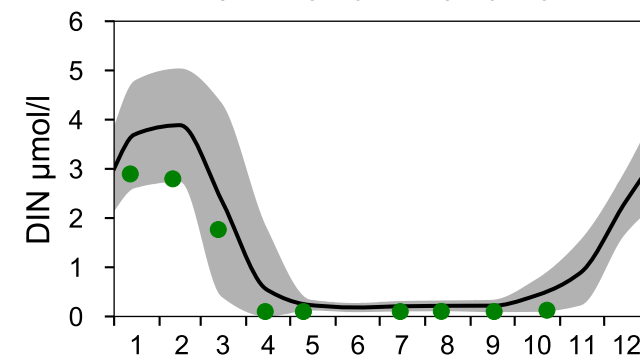
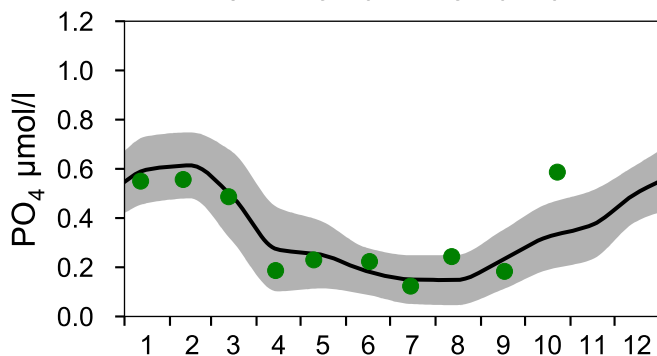
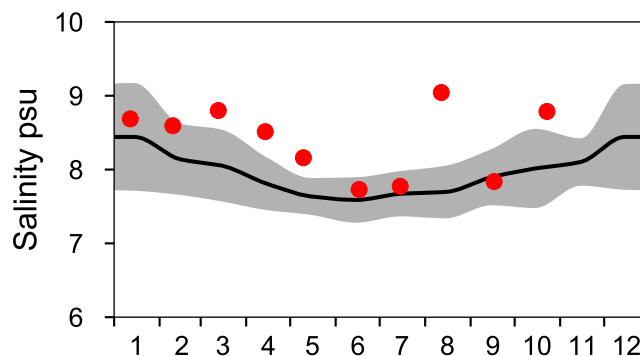
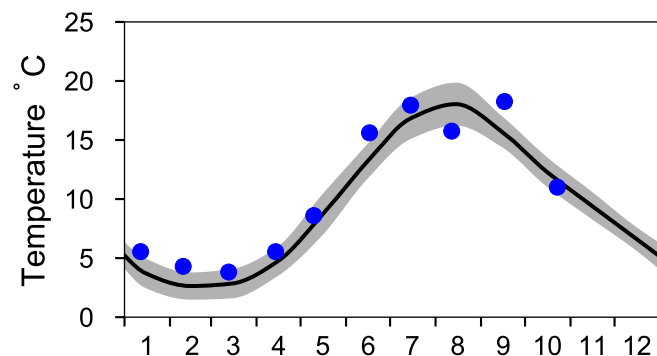
STATION BY1 SURFACE WATER (0-10 m)

Annual Cycles

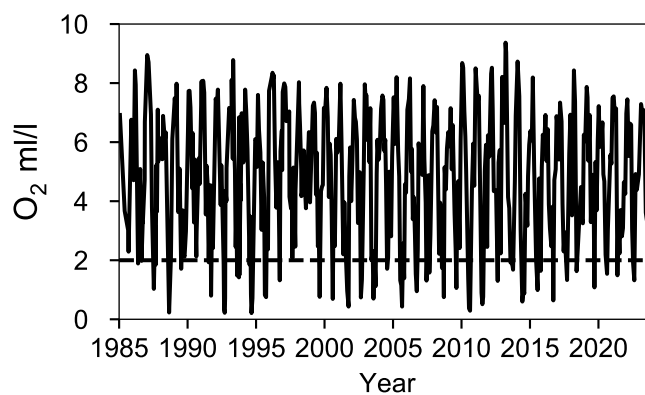
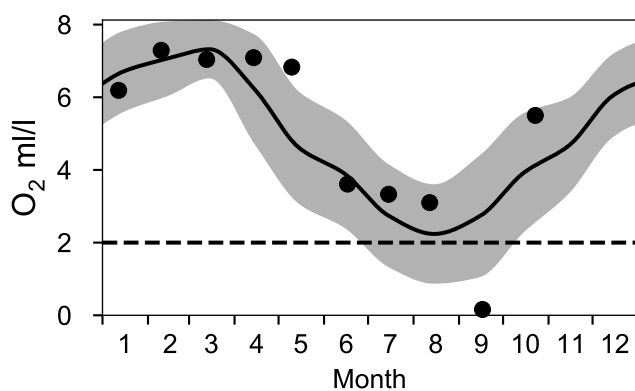
— Mean 1991-2020

■ St.Dev.

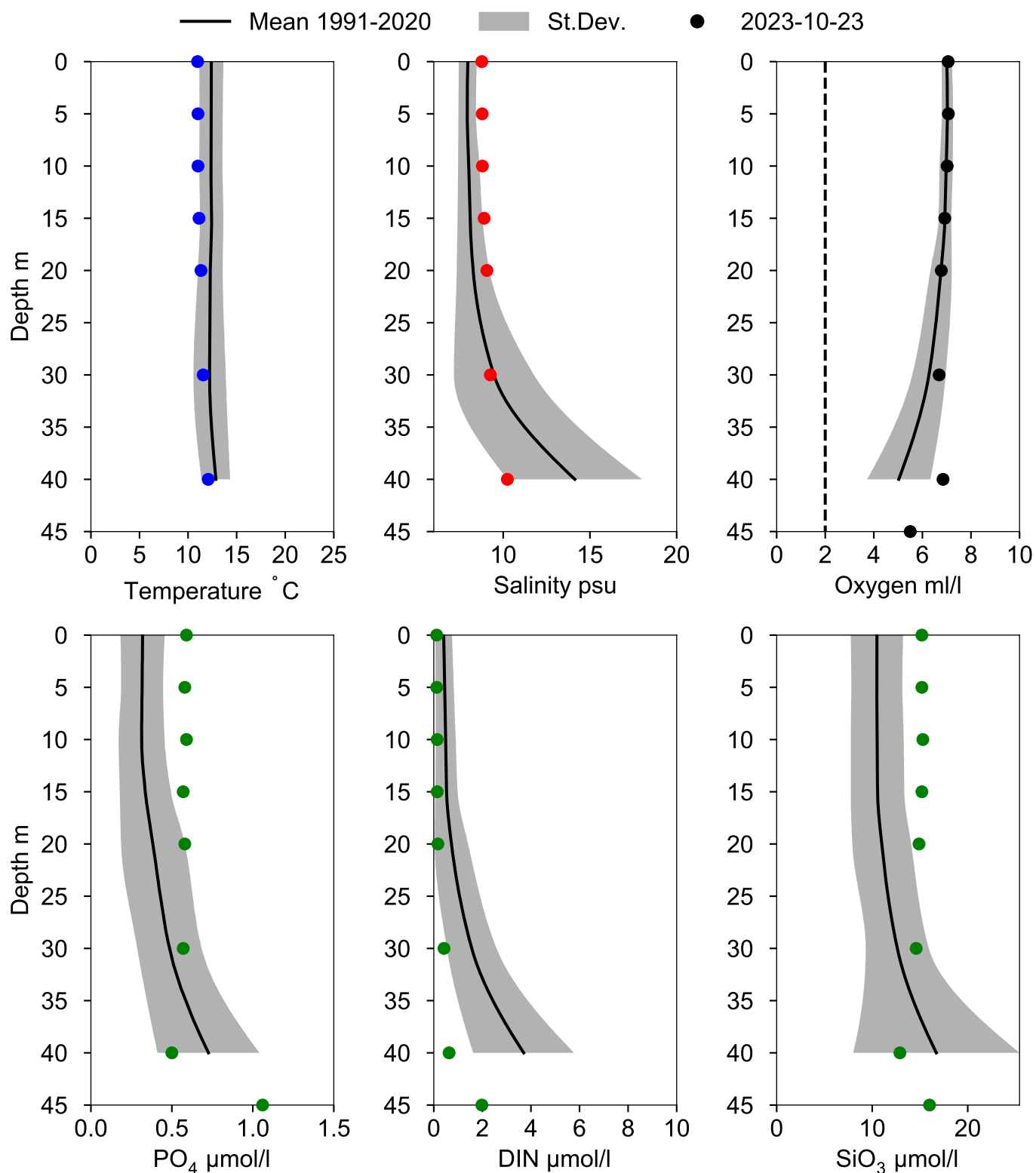
● 2023



OXYGEN IN BOTTOM WATER (depth >= 39 m)



Vertical profiles BY1 October



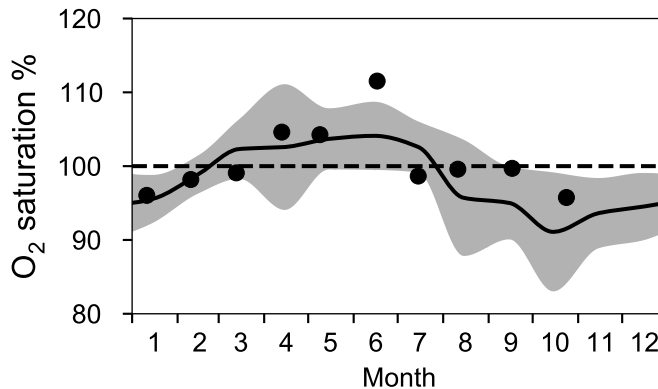
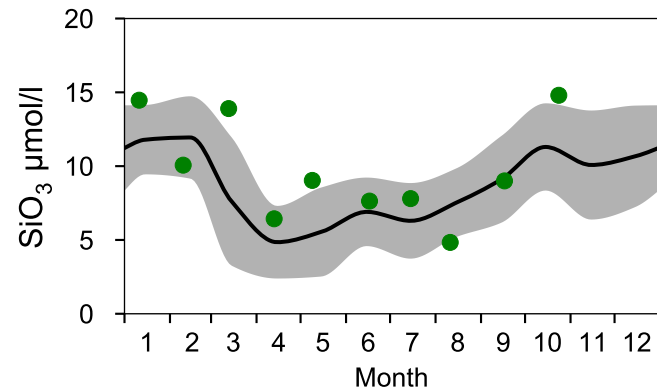
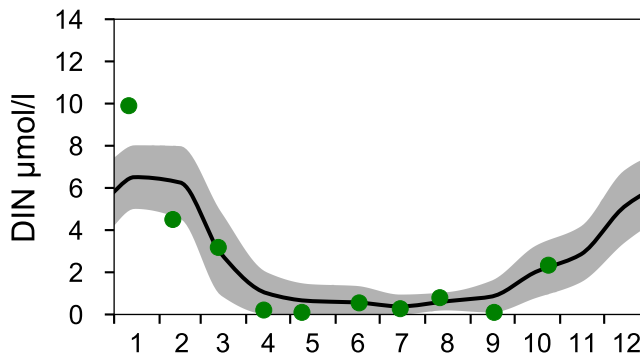
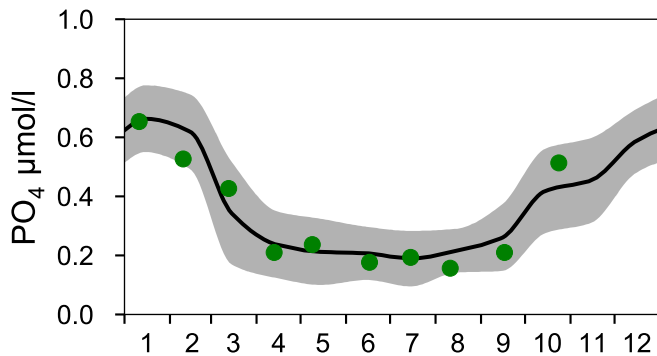
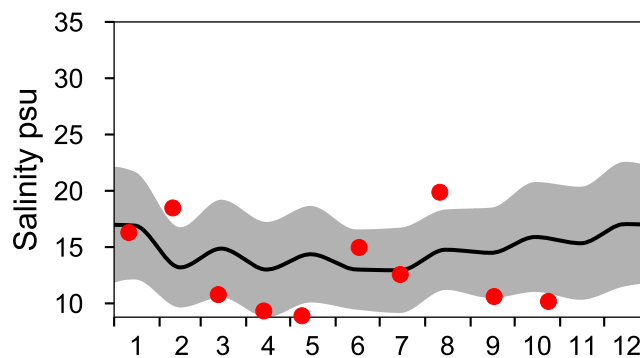
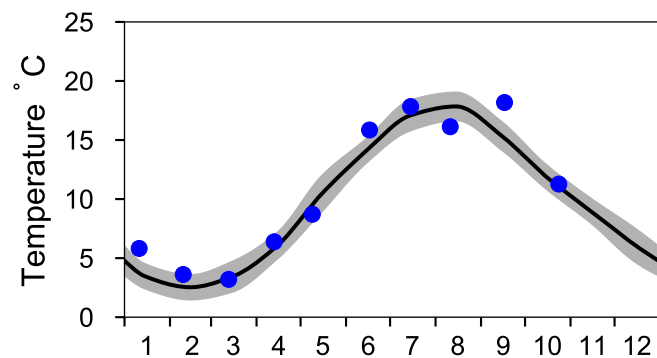
STATION W LANDSKRONA SURFACE WATER (0-10 m)

Annual Cycles

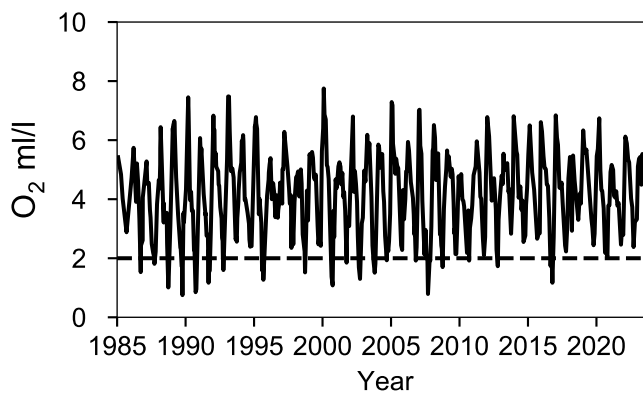
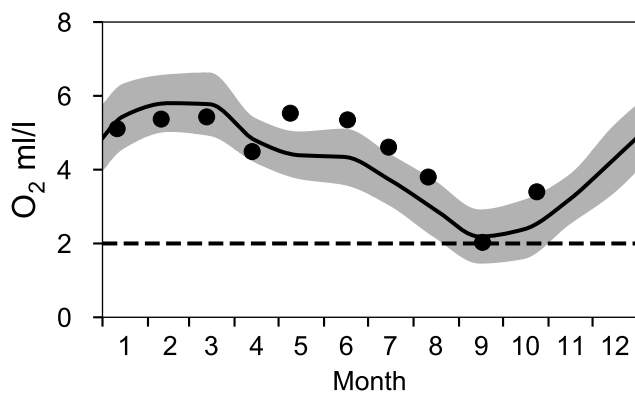
— Mean 1991-2020

■ St.Dev.

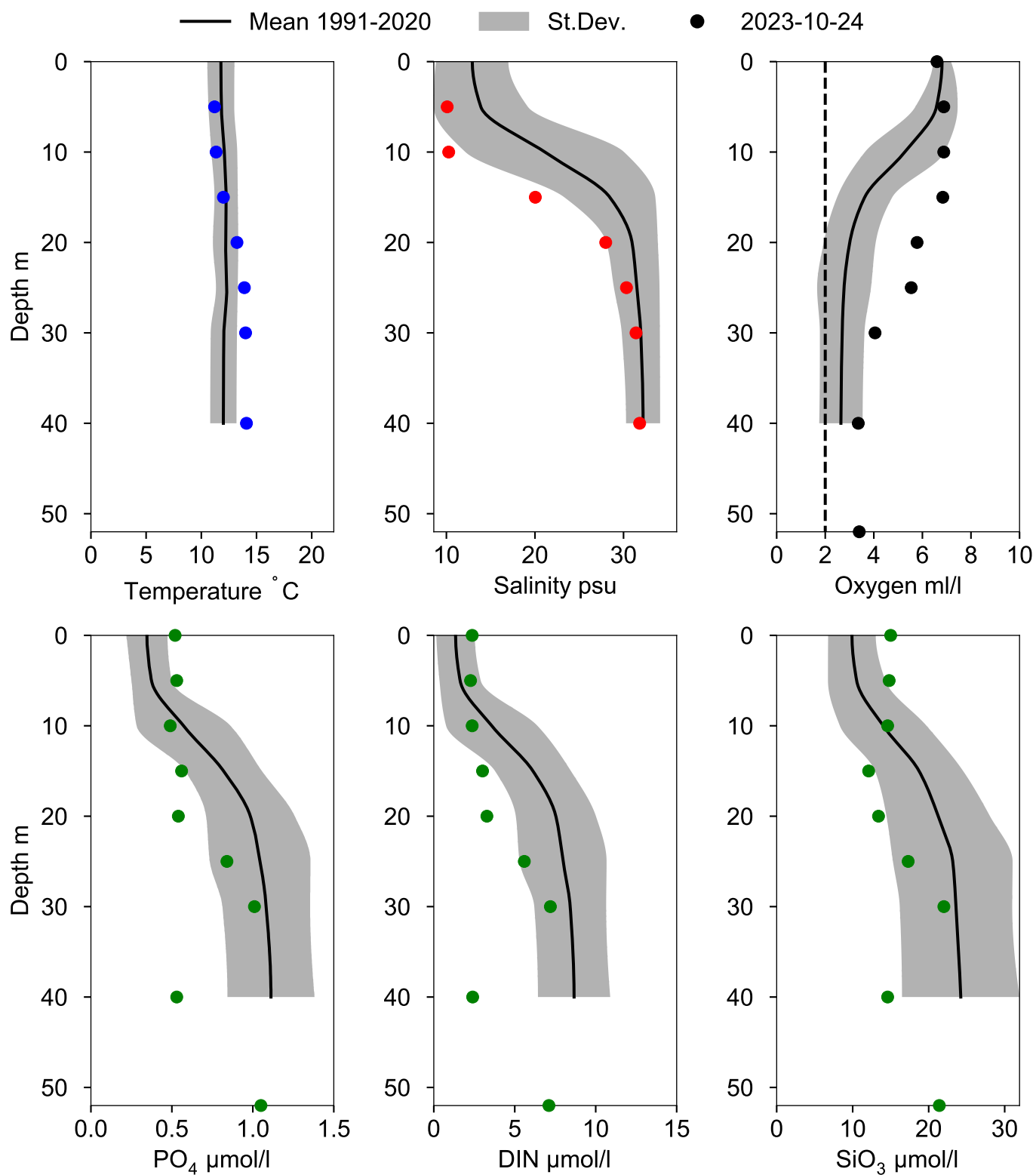
● 2023



OXYGEN IN BOTTOM WATER (depth >= 40 m)



Vertical profiles W LANDSKRONA October



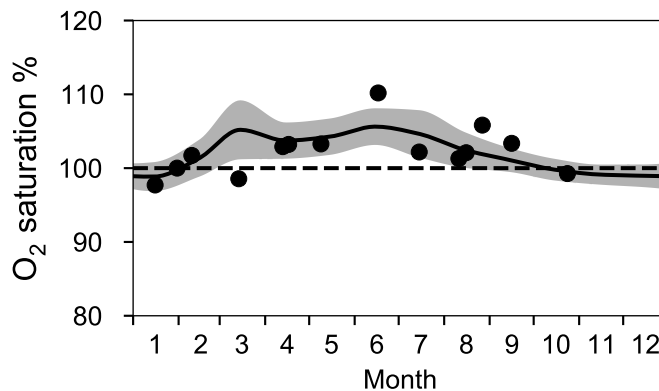
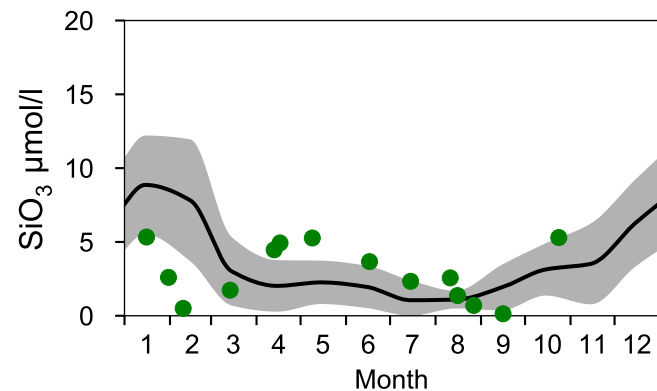
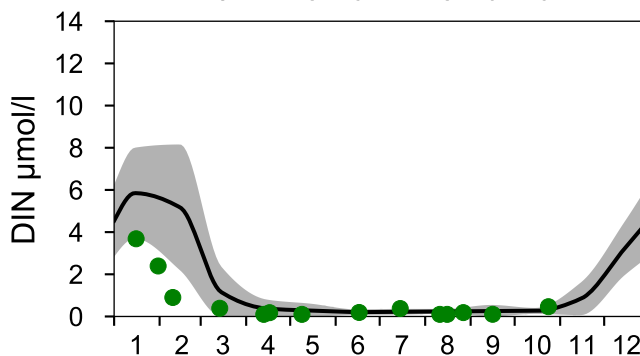
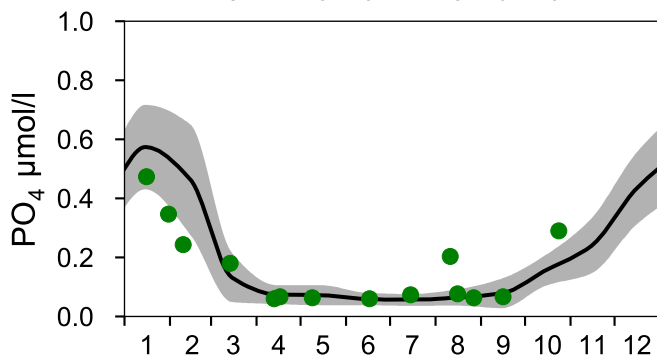
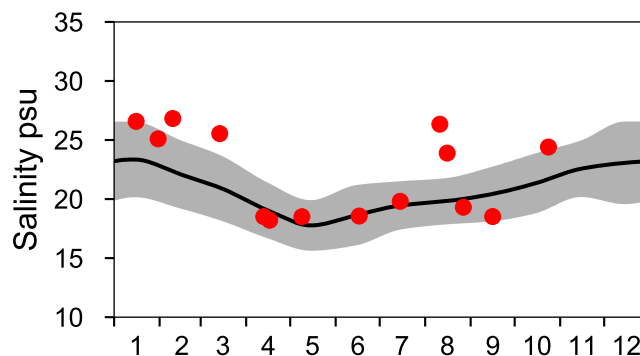
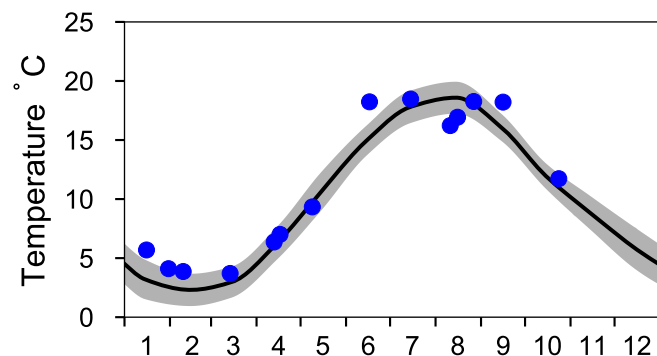
STATION ANHOLT E SURFACE WATER (0-10 m)

Annual Cycles

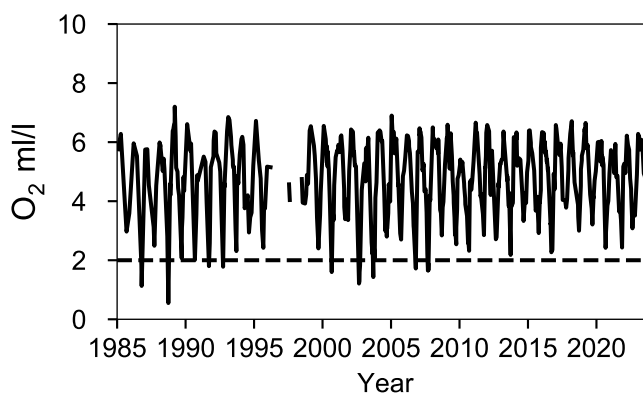
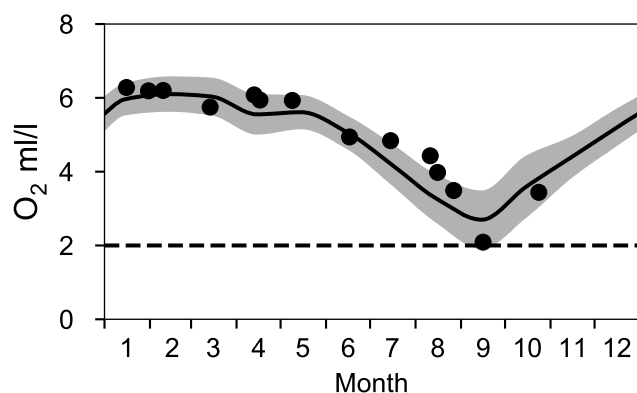
— Mean 1991-2020

■ St.Dev.

● 2023



OXYGEN IN BOTTOM WATER (depth >= 52 m)

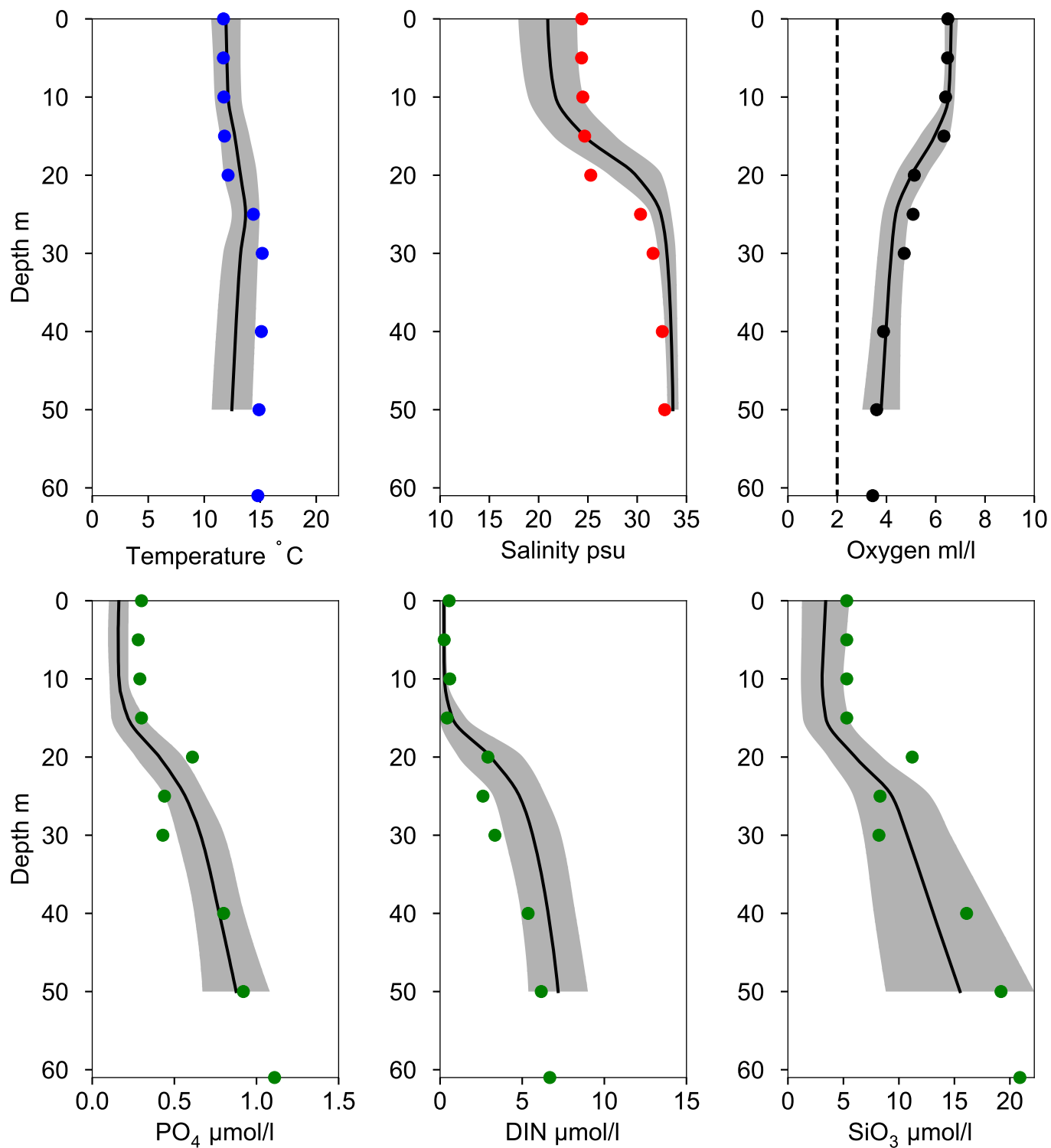


Vertical profiles ANHOLT E October

— Mean 1991-2020

■ St.Dev.

● 2023-10-24



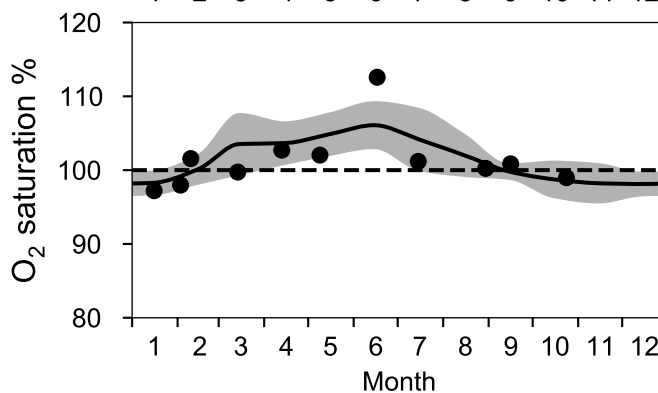
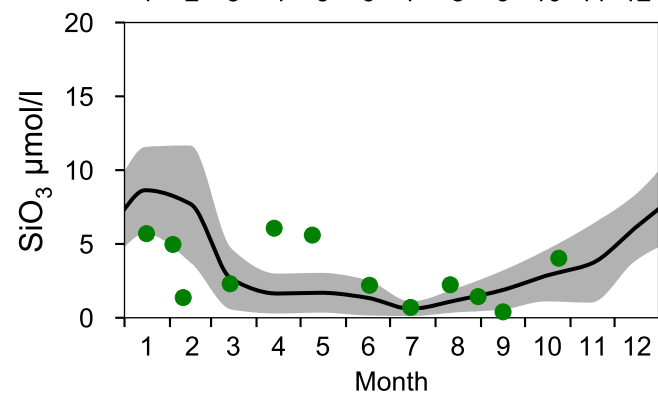
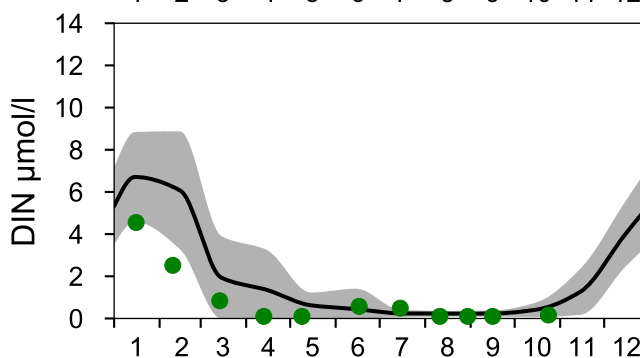
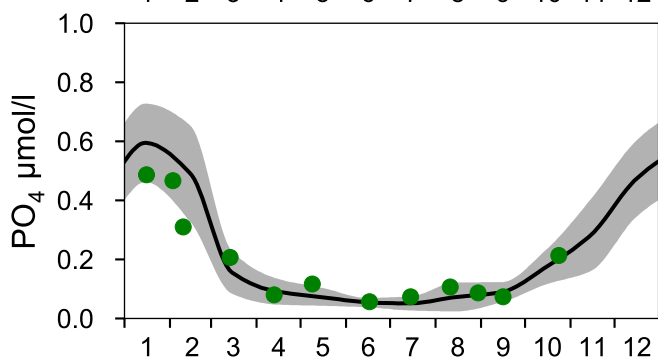
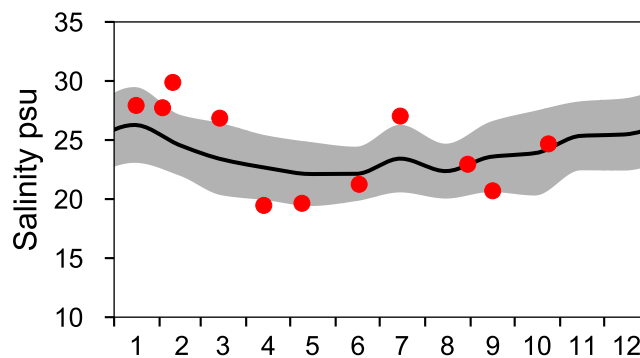
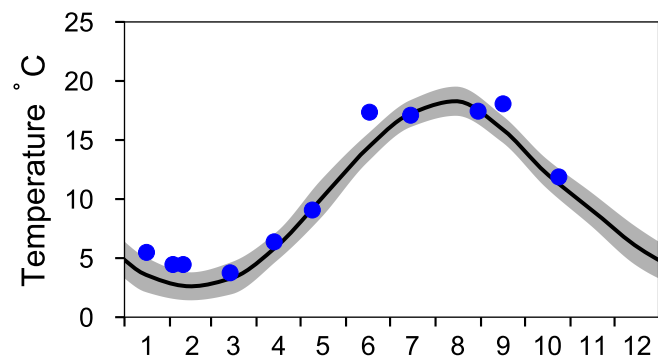
STATION FLADEN SURFACE WATER (0-10 m)

Annual Cycles

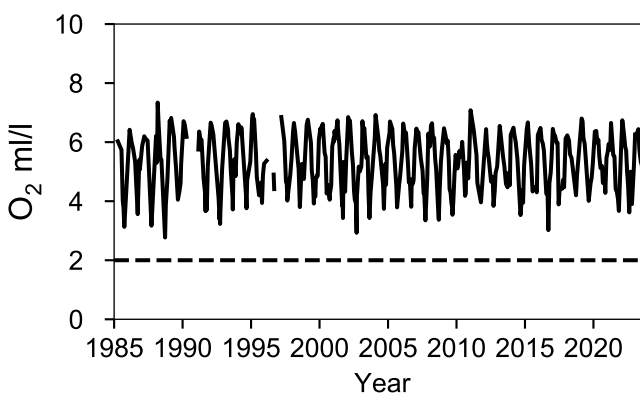
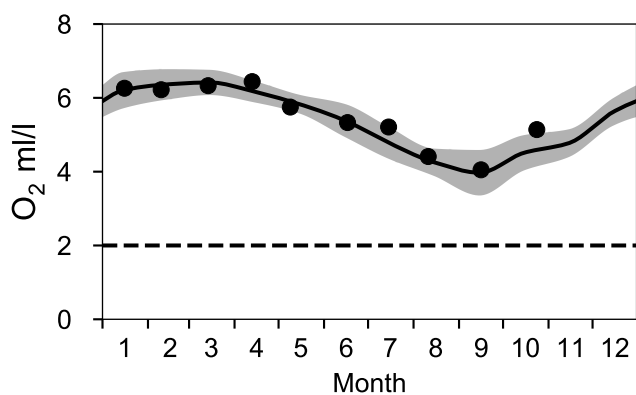
— Mean 1991-2020

■ St.Dev.

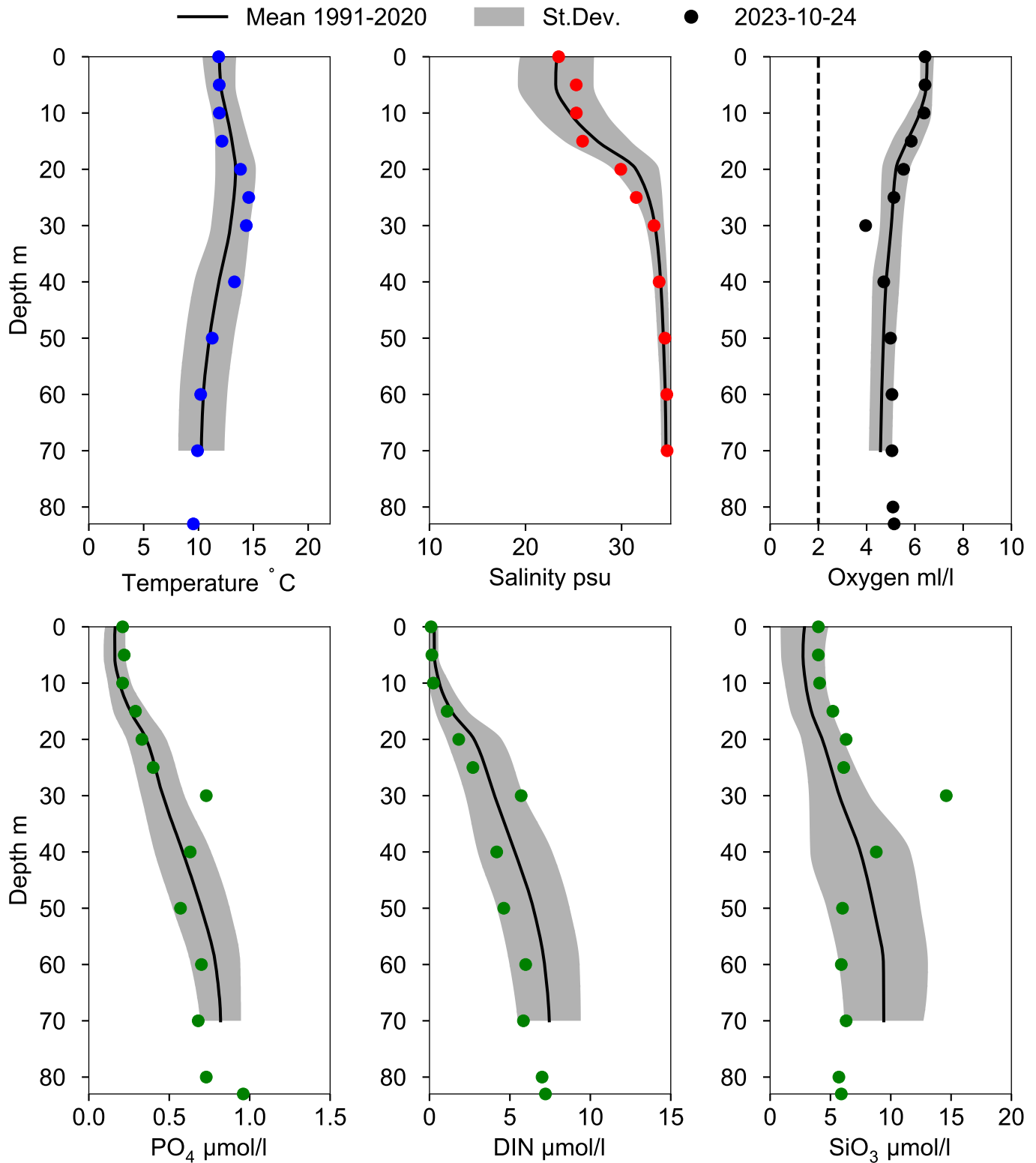
● 2023



OXYGEN IN BOTTOM WATER (depth >= 74 m)



Vertical profiles FLADEN October



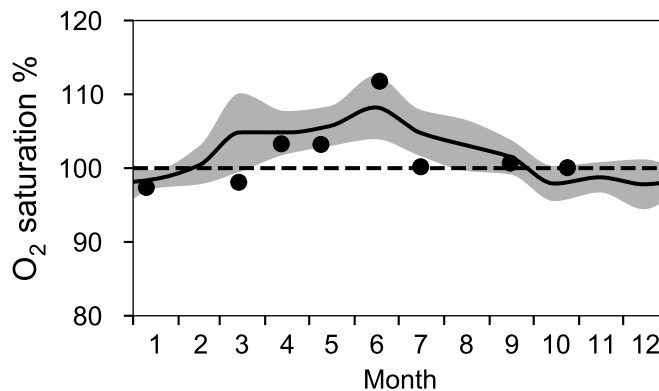
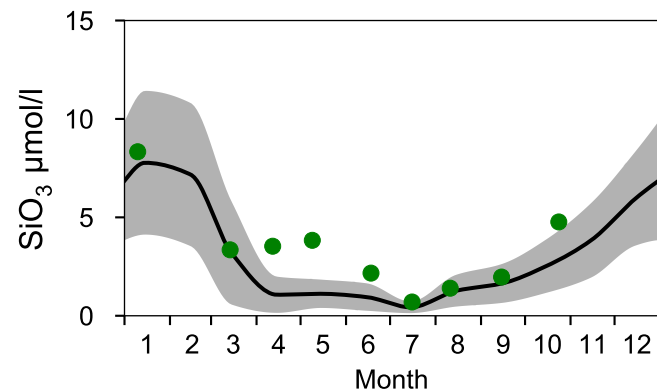
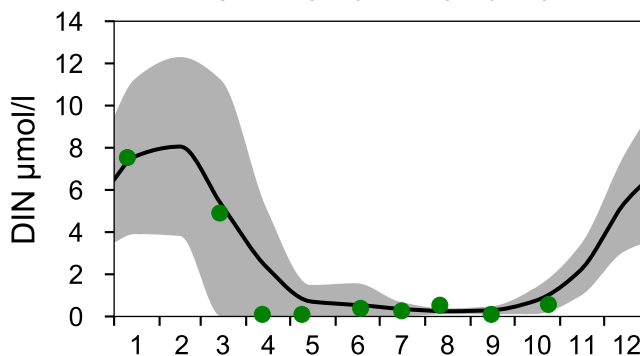
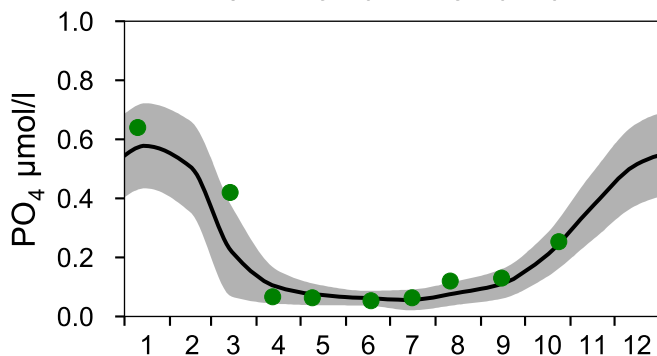
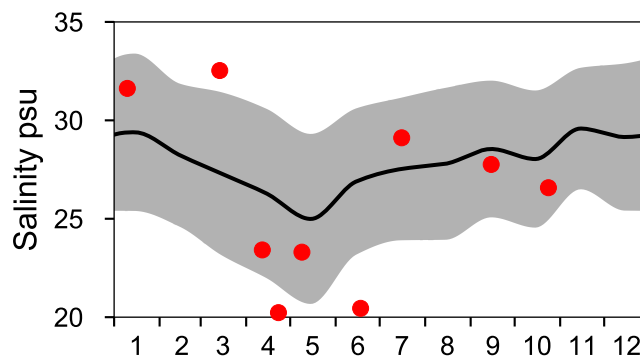
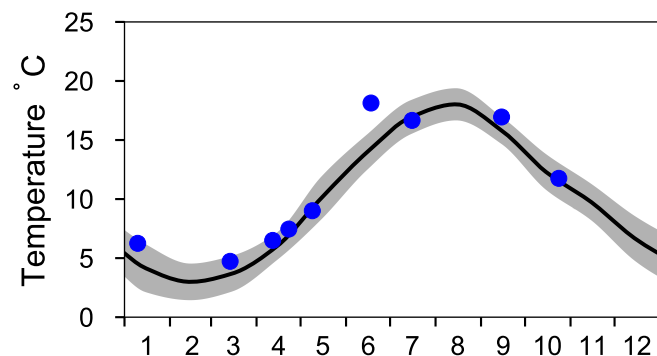
STATION P2 SURFACE WATER (0-10 m)

Annual Cycles

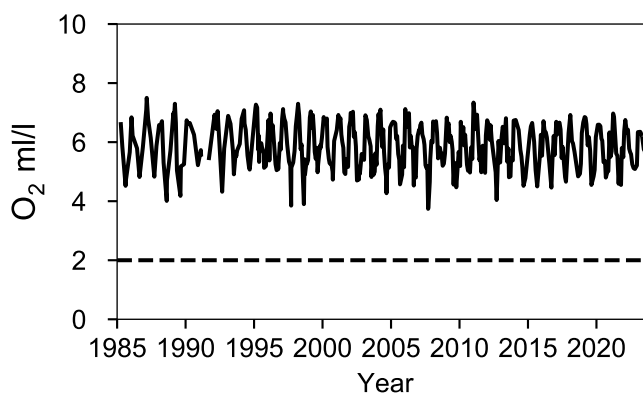
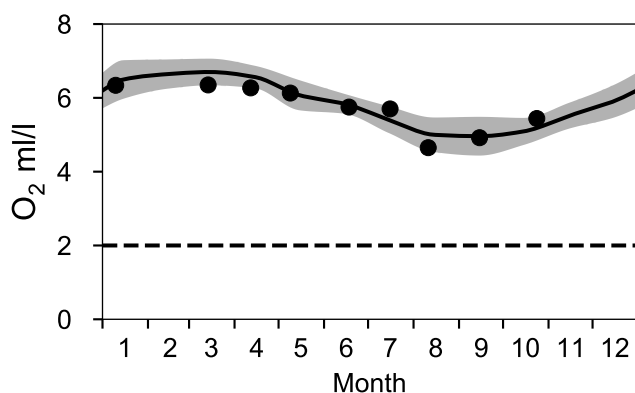
— Mean 1991-2020

■ St.Dev.

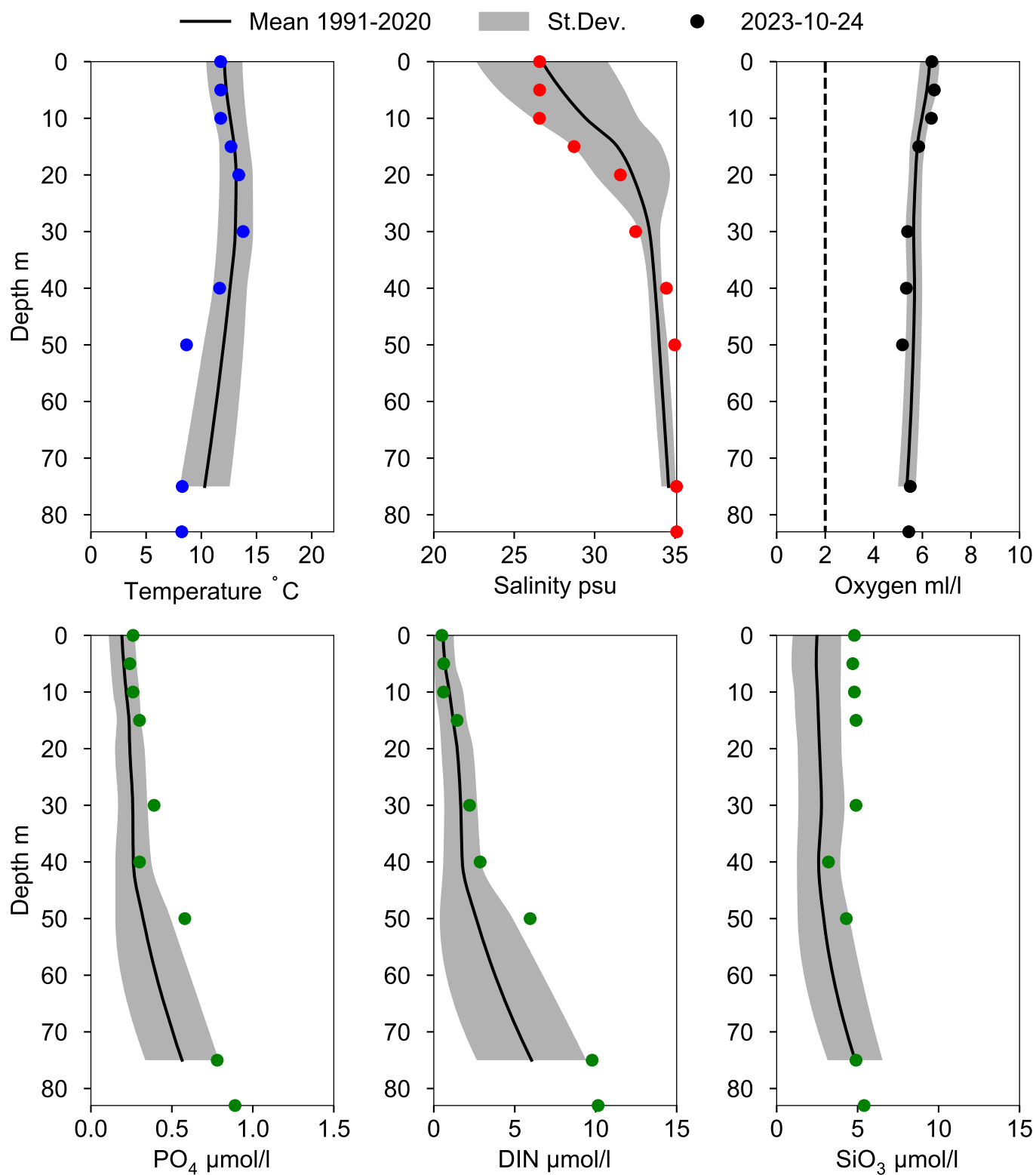
● 2023



OXYGEN IN BOTTOM WATER (depth >= 75 m)



Vertical profiles P2 October



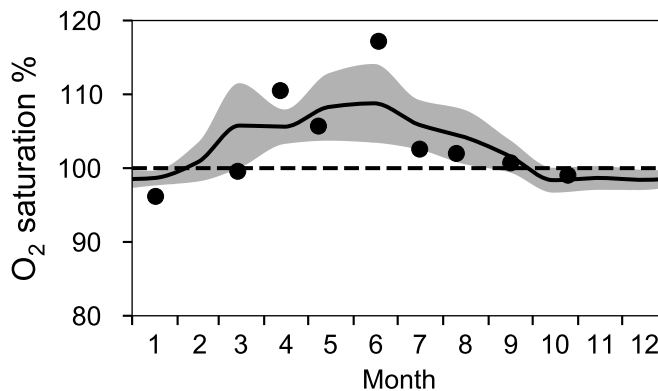
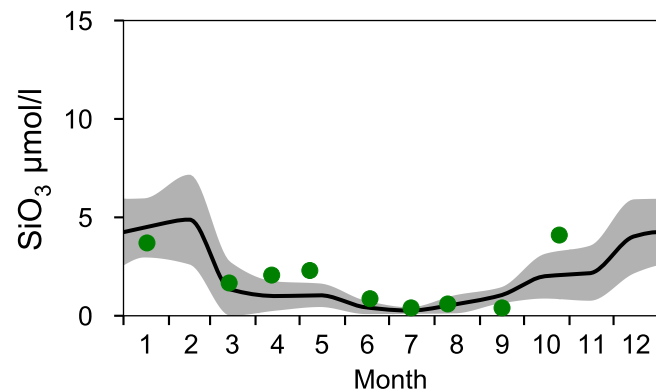
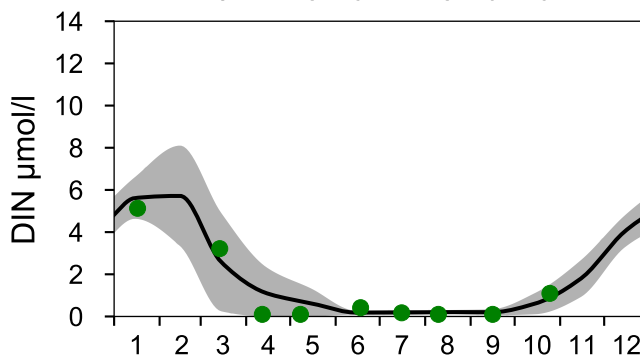
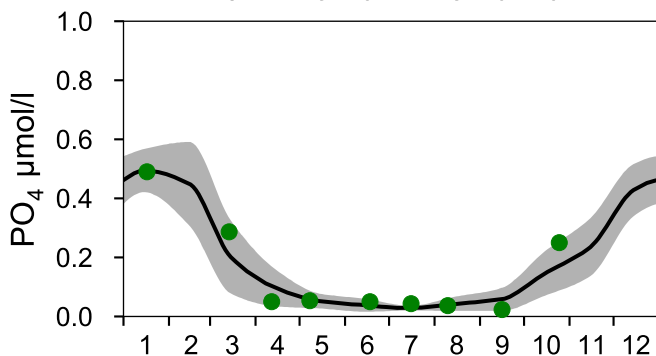
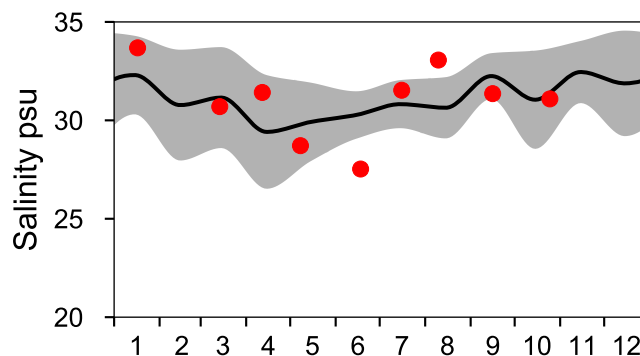
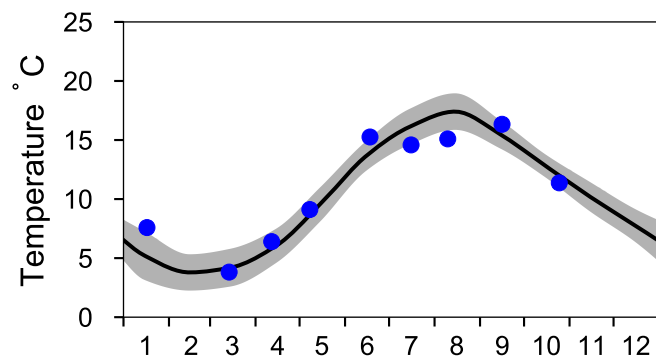
STATION Å17 SURFACE WATER (0-10 m)

Annual Cycles

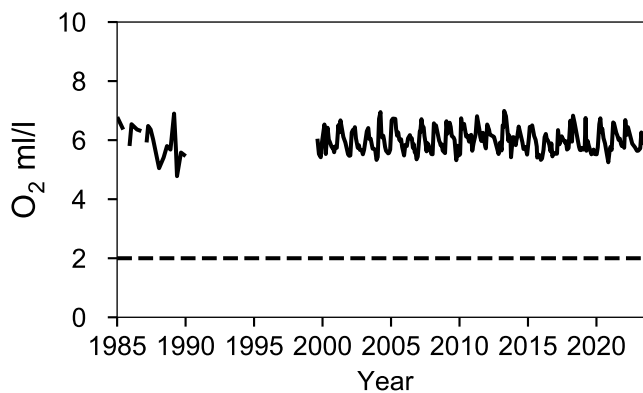
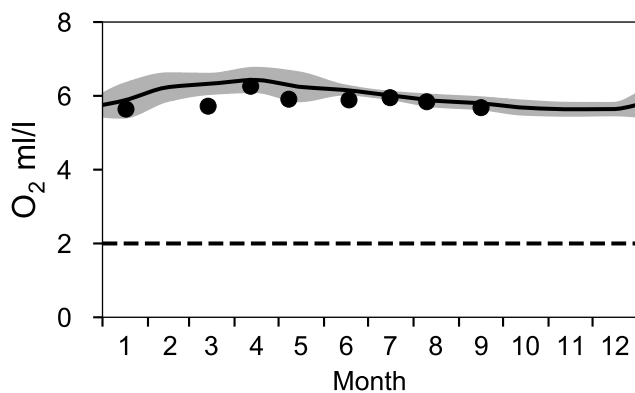
— Mean 1991-2020

■ St.Dev.

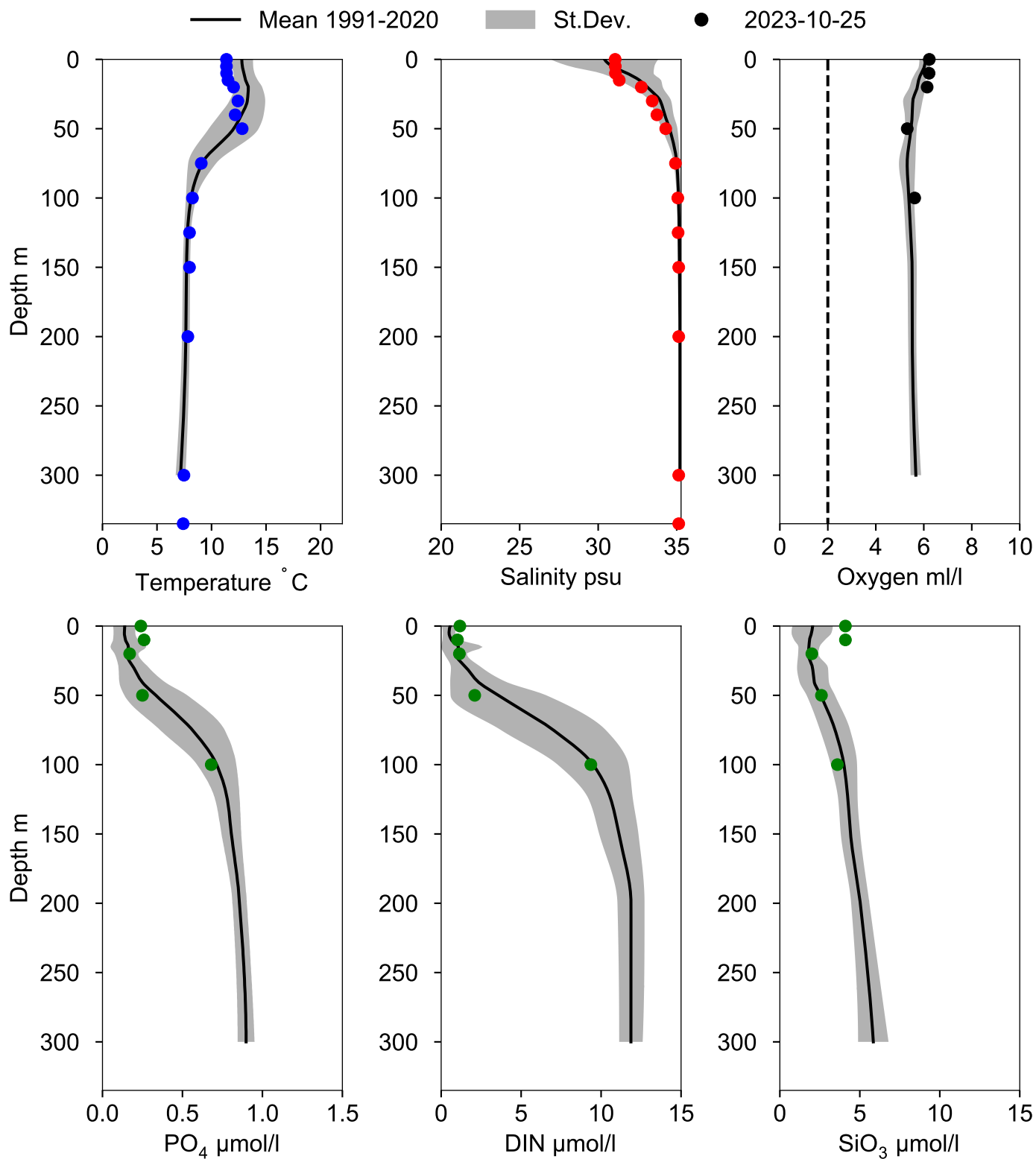
● 2023



OXYGEN IN BOTTOM WATER (depth >= 300 m)



Vertical profiles A17 October



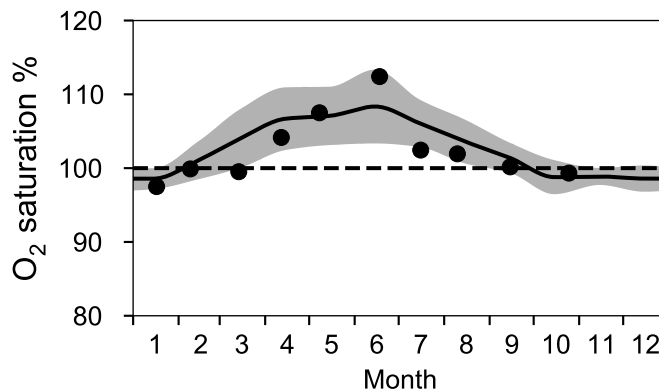
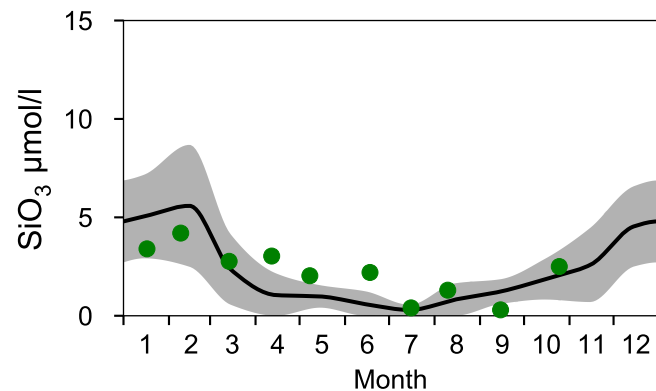
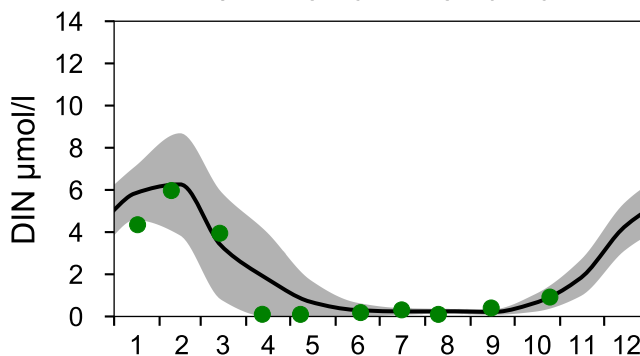
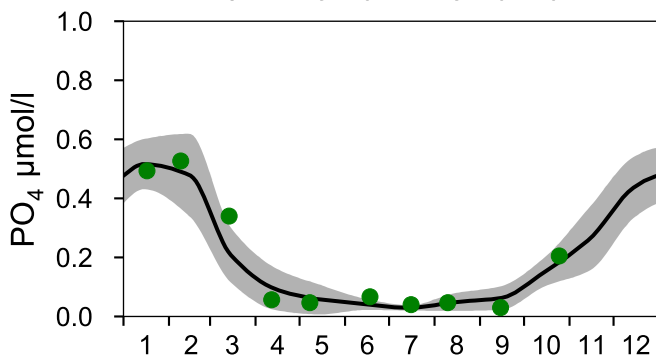
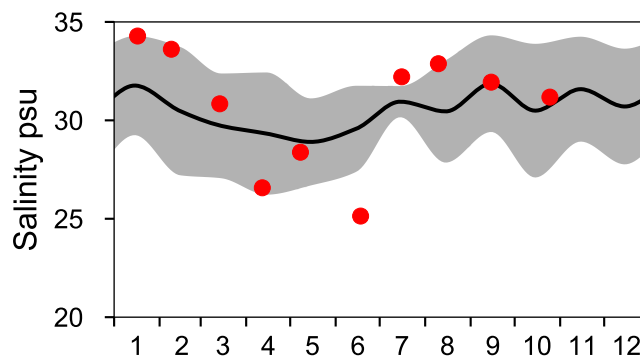
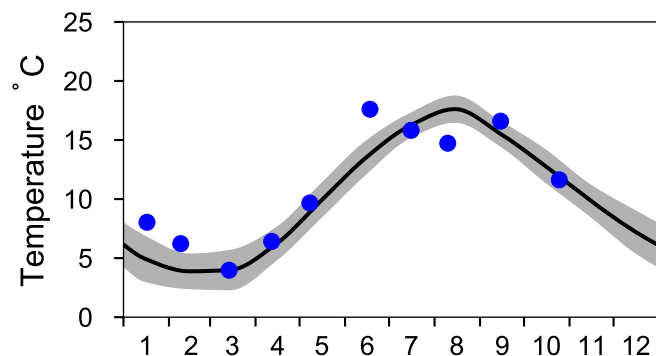
STATION Å15 SURFACE WATER (0-10 m)

Annual Cycles

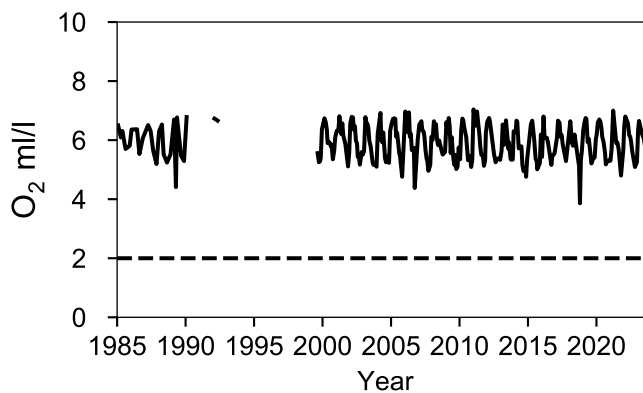
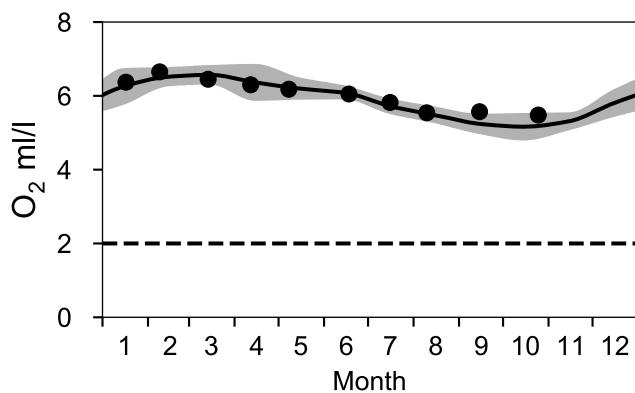
— Mean 1991-2020

■ St.Dev.

● 2023

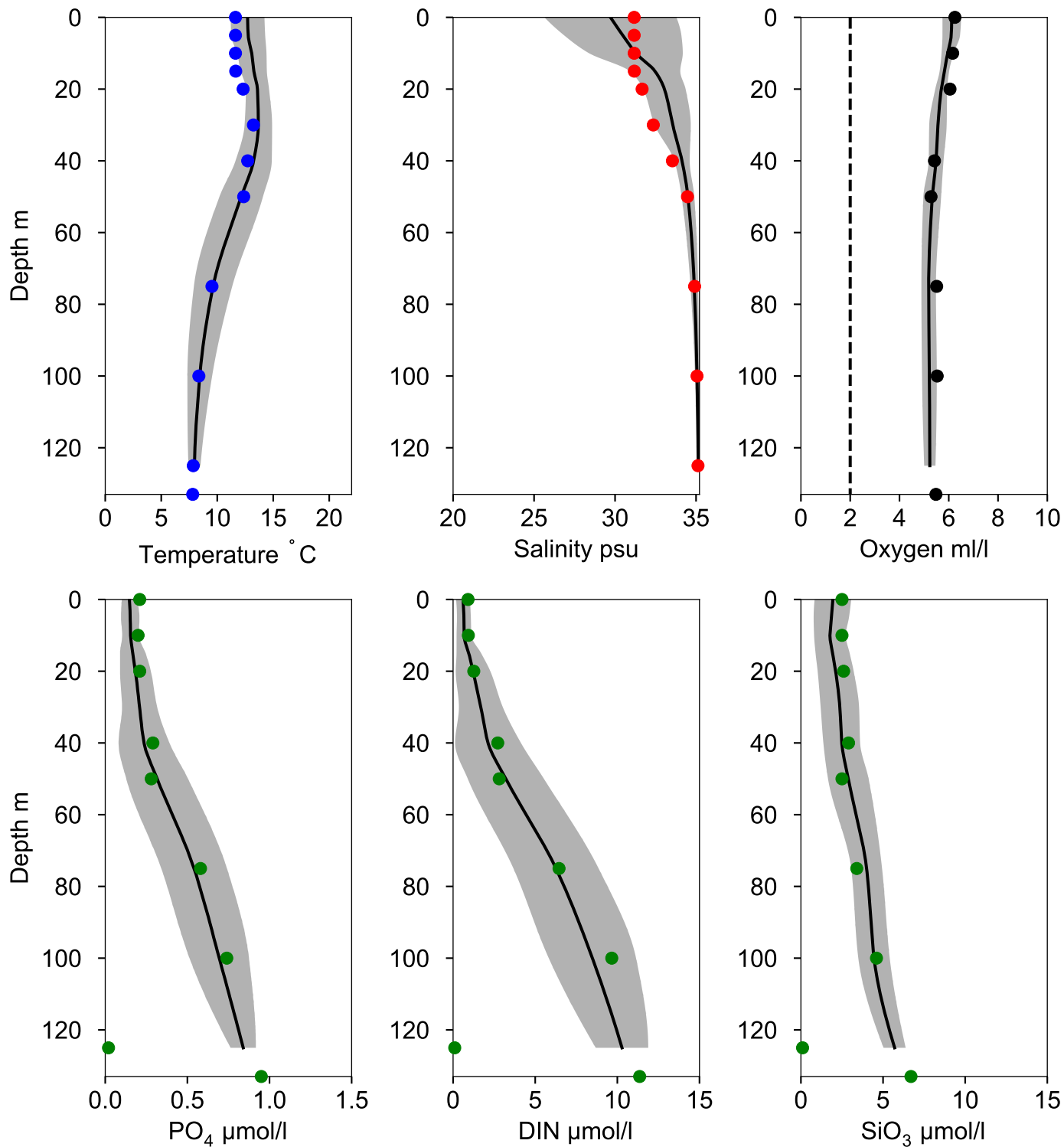


OXYGEN IN BOTTOM WATER (depth >= 125 m)



Vertical profiles A15 October

— Mean 1991-2020 St.Dev. ● 2023-10-25



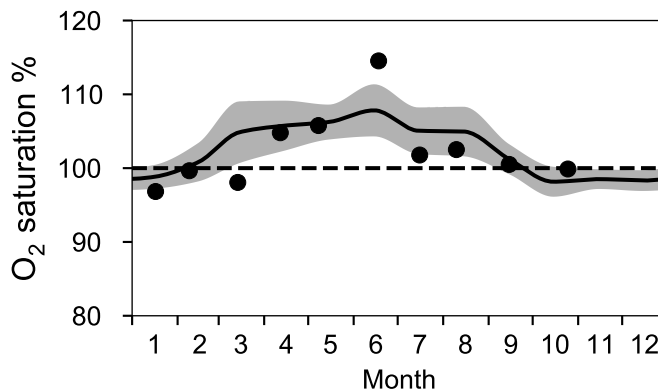
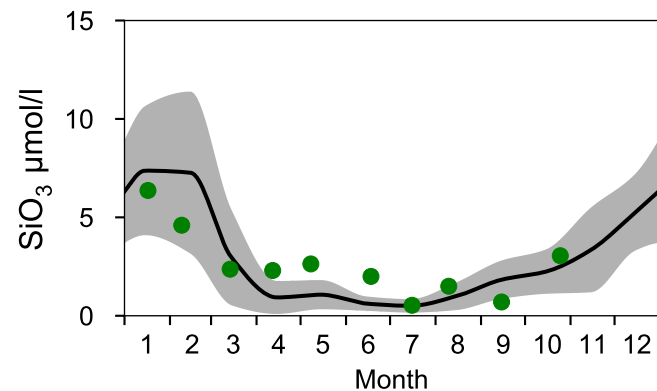
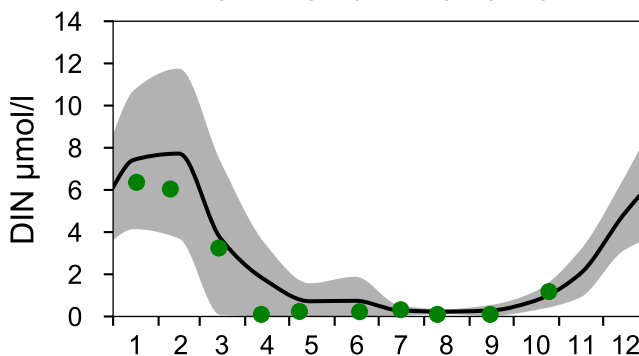
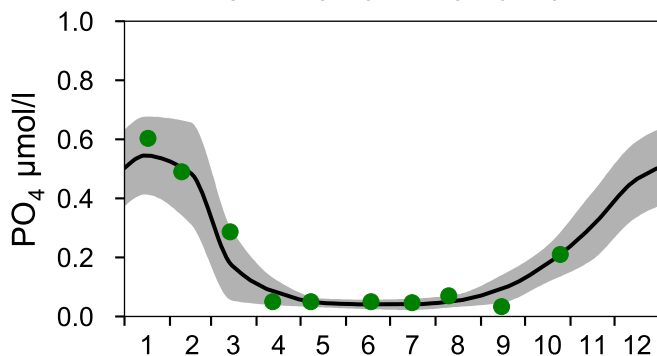
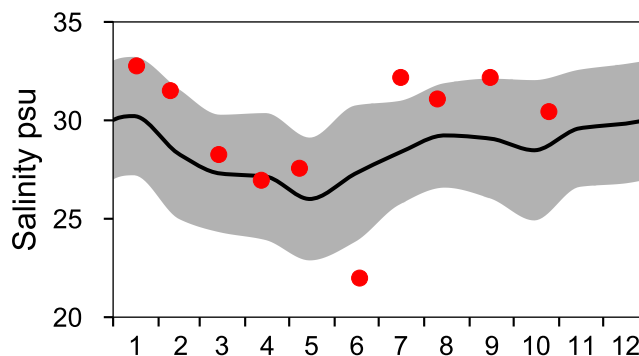
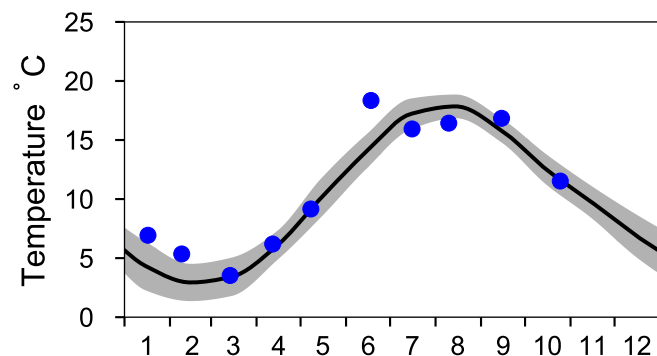
STATION Å13 SURFACE WATER (0-10 m)

Annual Cycles

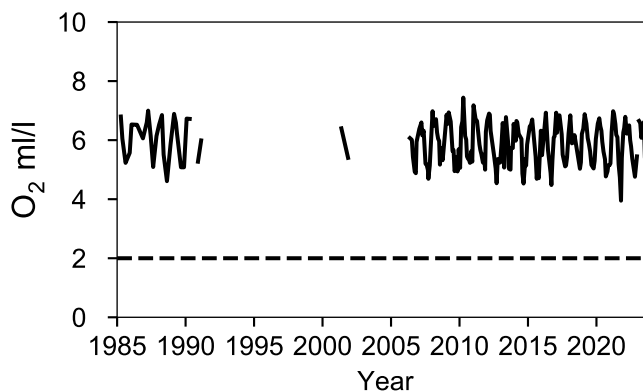
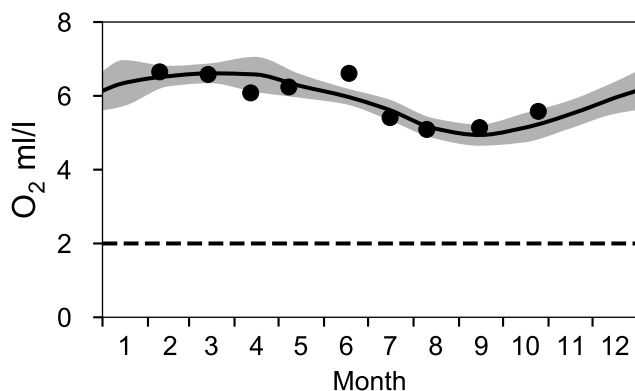
— Mean 1991-2020

■ St.Dev.

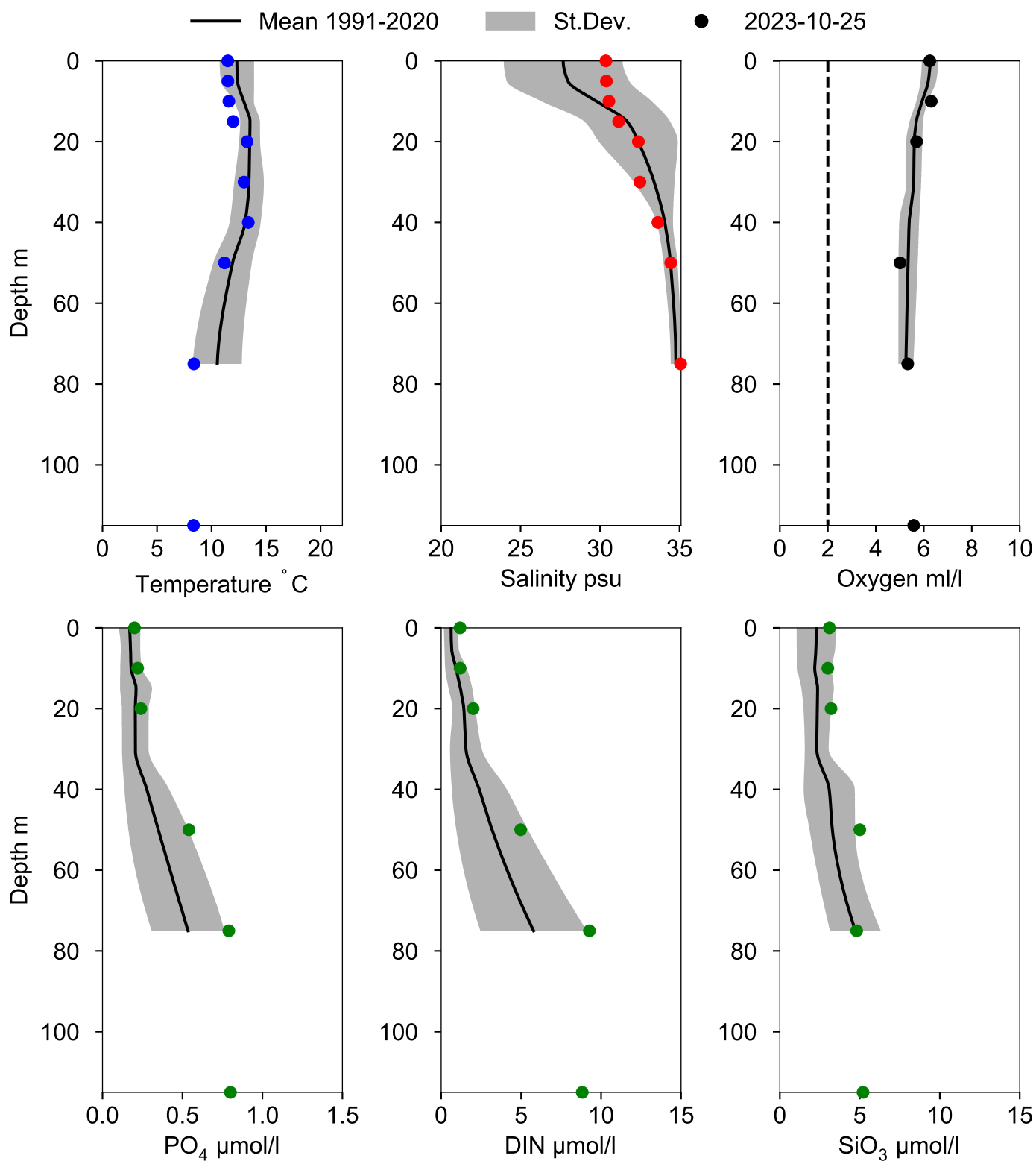
● 2023



OXYGEN IN BOTTOM WATER (depth >= 82 m)



Vertical profiles A13 October



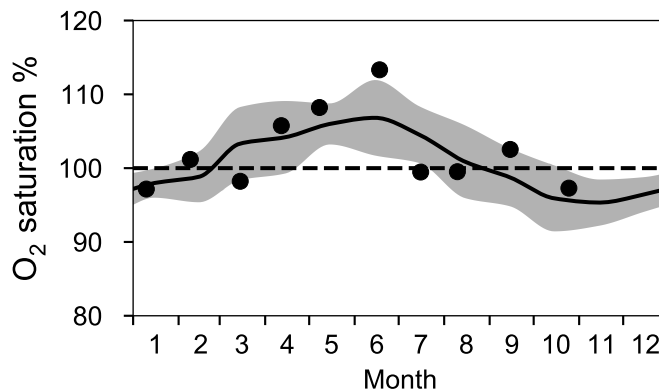
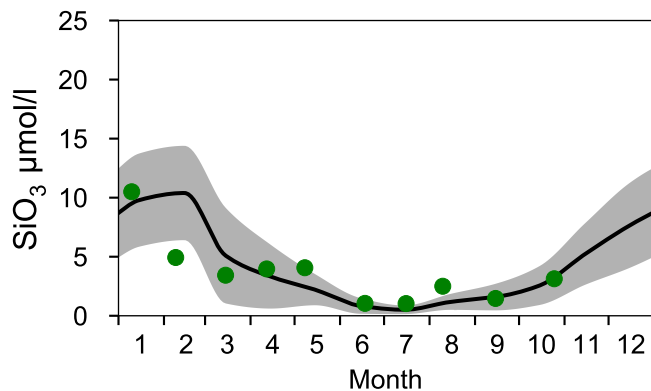
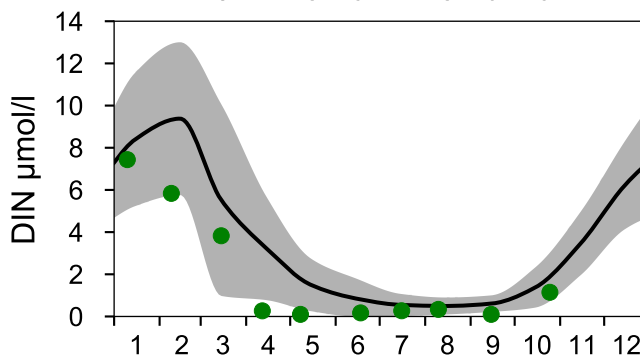
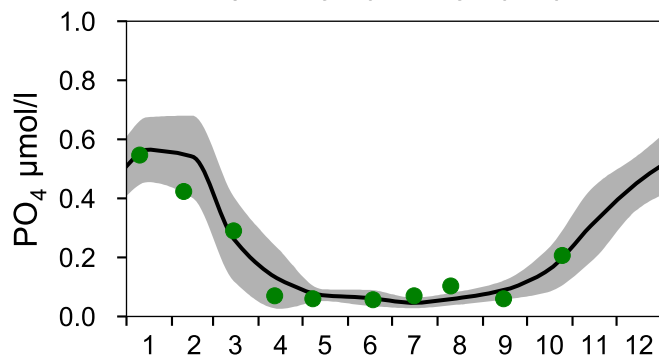
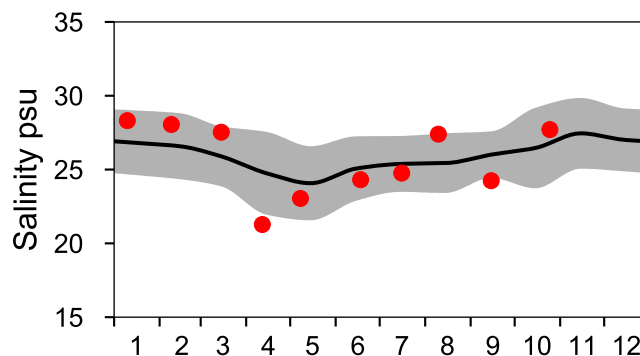
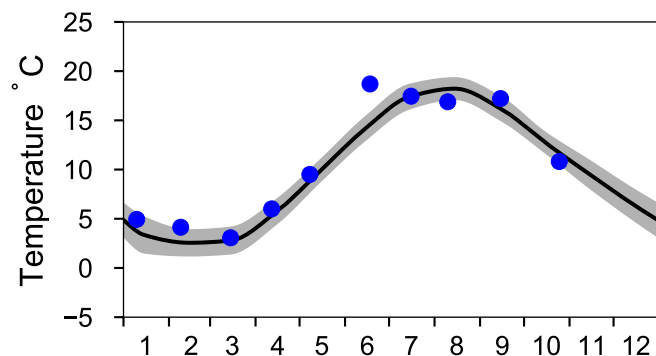
STATION SLÄGGÖ SURFACE WATER (0-10 m)

Annual Cycles

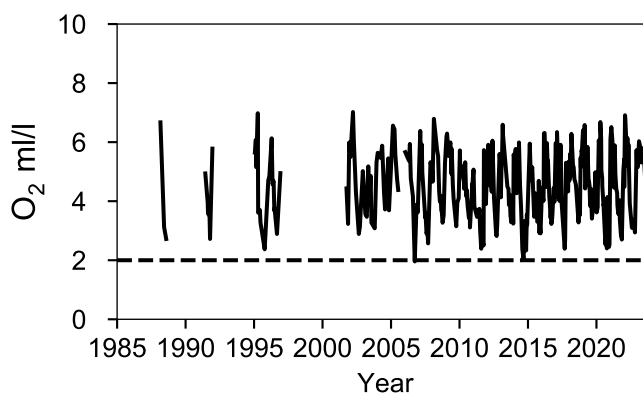
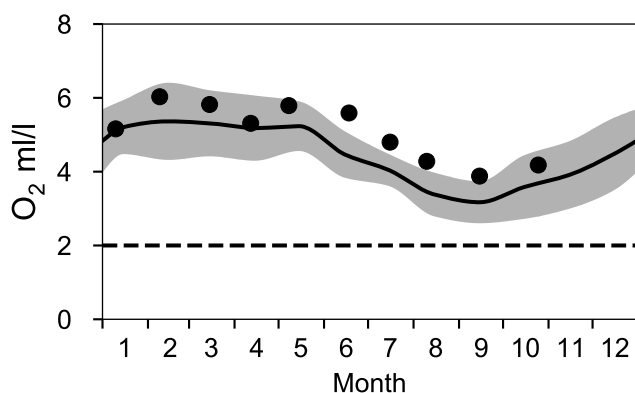
— Mean 1991-2020

■ St.Dev.

● 2023



OXYGEN IN BOTTOM WATER (depth >= 64 m)



Vertical profiles SLÄGGÖ October

