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

The guests on board Svea's April cruise, SMHI's group of cruise participants and parts of Svea's crew.

Survey period:	2022-04-20 to 2022-04-26
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)

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Summary

During the cruise, which is part of the Swedish pelagic monitoring program, the Skagerrak, Kattegat, the Sound and the Baltic Proper were visited.

The warming of the surface water had started in all the visited sea areas, but for natural reasons the temperature increase is somewhat slower in the Baltic Sea compared to the Skagerrak and Kattegat. The salinity in large parts of the Baltic Sea's surface water was higher than normal.

The levels of nutrients in the surface water had generally decreased since the last visit in March and were low above the halocline where biological production consumes available nutrients. The silicate concentrations were more variable in the surface layer and levels that were both higher and lower than normal were noted in the Baltic Proper. The varying levels are probably due to varying biological activity in the surface water in the different areas and because certain plankton groups consume silicate during growth.

The oxygen situation was still very bad in most of the Baltic Proper, only in the Arkona Basin was the deep water well oxygenated. In Hanö Bay, Bornholm Basin and in the south eastern Baltic Proper, conditions were slightly better than in March; no hydrogen sulphide could be measured and the oxygen levels were just over 0 ml/l. The improved oxygen conditions near the bottom may be due to a smaller inflow that occurred in early April. This inflow will probably improve the oxygen conditions in Hanö Bay and the Bornholm Basin in the coming months.

In the Western and Eastern Gotland Basin, oxygen-free conditions were found from depths exceeding 80-90 meters and the hydrogen sulphide concentrations are still at record high levels. Acute oxygen deficiency was found already from a depth of 60 meters in the southern part of the Western Gotland Basin and from a depth of 70-80 meters in other basins.

Chlorophyll fluorescence measurements with CTD showed that there was some plankton activity, in the form of fluorescence peaks at a depth of about 10-15 meters in the outer Skagerrak. In the Kattegat, high plankton activity was noted with fluorescence peaks that coincided with the stratification at a depth of 10-20 meters, and in the Baltic Proper, some activity was found above the halocline in the eastern parts, however, no strong fluorescence peaks were observed.

SMHI's next cruise with R / V Svea is planned for 19 - 25 May, starting and ending in Kalmar.

Results

The cruise was carried out on board R/V Svea and started in Lysekil on 20 April and ended in the same port on 26 April.

The weather during the cruise was dominated by calm and beautiful weather. In the southern Baltic Sea and around Gotland, the wind increased to between 10-15 m/s. The wind direction was mainly north to northeast and the air temperature varied between 4-12°C.

During the first two days of the expedition a group of visitors from Swedish governmental agencies followed the work on board R/V Svea, the Swedish Ocean Ambassador, SMHI's Director General, the Swedish Agency for Marine and Water Management's Director General, SMHI's head of the Marine Environment Unit, FORMAS head of Environmental Department, communicators from SMHI and the head of SLU's ship unit participated. The purpose of the visit was to show SMHI's work on board R/V Svea during an ongoing expedition. The guests also had the opportunity to meet and discuss common marine issues, at the same time as they received a presentation of the ship and experience the research vessel R/V Svea with crew in action.

More information about the visit can be found e.g. on SMHI's website: https://www.smhi.se/nyhetsarkiv/flera-myndigheter-med-ombord-under-smhis-aprilexpedition-1.182710

At Å17, problems arose with the communication with CTD rosette, which is used for water sampling. Therefore, water samples are missing in the profile from Å17. After extensive troubleshooting, the fault was located at the CTD winch's cable connection and a number of stations then had to be sampled with sampling bottles taken from wires and an external replacement CTD. During the last day of the cruise, station Fladen was sampled with the ordinary CTD rosette from the A-frame in the stern of Svea. The CTD winch's cable connection was repaired by a service technician the day after Svea went into port in Lysekil. Despite the extensive technical problems during the expedition, all stations were sampled according to plan.

In addition to regular sampling, extra phytoplankton samples were taken for Stockholm University at three stations in the Skagerrak and Kattegat.

Transects with Svea's MVP (Moving Vessel Profiles) which are used to measure temperature, salinity and oxygen profiles during cruising speed were made on several occasions during the expedition; at the Å- transect in the Skagerrak, across Stolpe Furrow in the southern Baltic Sea, between BY10 and BY15, between BY15 and Östergarnsholm and between BY32-BY38-BY39 in the Western Gotland Basin.Both the Ferrybox (continuous measurements at a depth of 4 meters) and Svea's both ADCPs (current measurement) were running during the expedition.

This report is based on data that has undergone an initial quality control. When additional quality review has been performed, certain values may change. Data from the expedition is published as soon as possible on the data host's, SMHI, website (SHARKweb). This usually takes place within one to two weeks after the expedition has ended. Some analyzes are made after the expedition and are published later.

Download data from SHARKweb: https://www.smhi.se/data/oceanografi/datavardskap-oceanografi-och-marinbiologi/ladda-ner-data-1.135101

The Skagerrak

The warming of the surface water had started due to the warm and sunny weather and the temperature in the surface water varied around 8°C. Below that, from a depth of about 10-20 meters, the temperature dropped to about 5-6 °C and then increased slightly towards the deep water to about 7°C. The temperature in the entire profile was normal for the season. At the innermost stations, Släggö and Å13, the salinity was much lower than normal in the surface, just over 20 psu. At the other stations on the Å-transect, the salinity increased gradually from 26 to a maximum of 32 psu at Å17 furthest west. In the deep water, the salinities were normal. Temperature and salinity stratification coincided at a depth of 5-15 meters.

The levels of nutrients had decreased since the last visit in March and were generally low above the halocline where biological production consumes available nutrients.
The content of dissolved inorganic nitrogen (DIN) was low but within the normal range for the season. Only at station Å17 slightly higher concentrations were measured. In the deep water, below the stratification, the DIN levels increased but were within the normal range except at station P2, in the southern Skagerrak, where lower levels than normal were observed down to a depth of 40 meters. Below this depth, the levels increased and were normal for the season.

Phosphate (dissolved inorganic phosphorus or DIP) also showed lower levels than in March above the halocline and with the highest values at station Å17 of just under 0.15 µmol/l. Concentrations of nutrients then increased slightly with depth. The levels of silicate, which is used by diatoms to form shells, were again normal in the surface at all stations, except at Å17 where values higher than normal were measured. The concentration of silicate was normal throughout the water column at all stations.

The oxygen situation in the Skagerrak was good with levels above 6 ml/l closest to the bottom. At the coastal station Släggö, which is located in the Gullmars fjord and where low oxygen levels can occur in the deep water, the oxygen content at the bottom had decreased, compared to the previous month and was now 5.2 ml/l, but this still indicates good oxygen conditions at the bottom.

Chlorophyll fluorescence measurements with CTD showed that there was some plankton activity, in the form of fluorescence peaks at a depth of about 10-15 meters in the outer Skagerrak, at the stations Å15, Å16 and Å17. At the coastal stations, plankton activity was low and no clear fluorescence peaks were noted. The Secchi disk depth varied between 7-8 meters.

The Kattegat and the Sound

The temperature of the surface water in the Kattegat was above normal for the season and varied around 7-8 °C. The warming of the surface water had also started in the Kattegat, but it was not as clear as in the Skagerrak. Below the surface layer, the temperature was relatively constant down to the bottom, about 6 °C.

The salinity was lower than normal in the surface water at all stations in the Kattegat and the Sound except at Fladen in the northern Kattegat where normal concentrations were noted. In the deep water, the salinity increased to approx. 34 psu. The temperature and salinity stratification were strong and was found at a depth of about 10-20 meters.

Nutrients in the form of DIN, in the surface water, were in principle consumed and the levels were just above the detection limit, which is normal during this part of the year. In the deep water, the levels were normal or slightly lower than normal. The phosphate or DIP content was also low, but higher than normal levels were noted at Anholt E. In the deep water, the levels were normal. The concentrations of silicate in the surface water were normal or just above normal for the season. In the deep water the levels increased but were within the normal range.

The oxygen levels in the Kattegat and the Sound were at normal levels and there were good oxygen conditions in the entire water column. The concentration in the deep water varied around 5-6 ml/l at all stations.

CTD measurements of chlorophyll fluorescence showed high plankton activity with fluorescence peaks coinciding with the stratification at a depth of 10-20 meters. The Secchi disk depth was 9-10 meters.

The Baltic Proper

The warming of the surface water in the Baltic Proper had started, but for natural reasons the temperature increases somewhat more slowly in the Baltic Proper compared to the Skagerrak and the Kattegat. The temperature in the surface water varied around 4-6°C which is normal. The temperature was lowest in the northern parts and higher further south and closer to the coast. As a result of the warming, a near-surface thermocline had started to form at a depth of about 20-25 meters. Below this was a cold layer of "winter water" that extends down to the permanent stratification in the Baltic Proper at a depth of 60-80 meters in the deeper basins. Below the permanent stratification there is a warmer deep water with temperatures of 6-7°C. The temperature in the deep water was generally above normal in all the deep basins around Gotland.

The salinity of the surface layer was generally higher than normal and varied between 7-8 psu. Salinity higher than normal was also noted in the deep water.

As in March, the levels of nutrients in the form of DIN (dissolved inorganic nitrogen) were low or completely consumed in the well-mixed upper layer. Below the permanent stratification in the deep water, the levels of DIN increased and in the deeper basins where there is oxygen-free water with high levels of hydrogen sulphide, the levels of DIN were much higher than normal.

The content of DIP (dissolved inorganic phosphorus in the form of phosphate), was normal above the halocline throughout the Baltic Sea. Below the halocline, the levels were also higher than normal and also here the high levels coincided with oxygen-free conditions and high hydrogen sulphide levels.

The silicate concentrations were more variable in the surface layer and higher levels than normal were noted in the northern parts of the Western and Eastern Gotland Basin and at the coastal station RefM1V1. Lower than normal levels were noted at BCS III-10 in the southeast. In the southwestern parts, the levels were normal. The varying levels are probably due to varying biological activity in the surface water in the different areas and when certain plankton groups take up silicate during growth.

The oxygen situation continues to be very bad in most parts of the Baltic Proper, only in the Arkona Basin the deep water was well oxygenated. In Hanö Bay, the Bornholm Basin and in the south-

eastern Baltic Proper, at BCS III-10, where hydrogen sulphide was measured in the bottom water in March, conditions were now somewhat better; no hydrogen sulphide could be measured and the oxygen levels were just over 0 ml/l. The improved oxygen conditions near the bottom may be due to a smaller inflow (~ 25 km3) that occurred in early April through the Sound. This inflow could be clearly seen at BY2 in the Arkona Basin as a 5-meter-thick layer at the bottom with high salinity (~ 15 psu) and oxygen content (~ 7 ml/l) and will probably improve the oxygen conditions in Hanö Bay and Bornholm Basin in the coming months.

In the Western and Eastern Gotland Basins, oxygen-free conditions were found from depths exceeding 80-90 meters depth and the levels of hydrogen sulphide are still at record high levels, much higher than normal. Acute oxygen deficiency (<2 ml/l O_2) was already found from a depth of 60 meters in the southern part of the Western Gotland Basin and from a depth of 70-80 meters in other deep basins.

The plankton activity measured by fluorescence from the CTD showed some activity above the halocline in the eastern part of the Baltic Proper. However, no strong peaks were observed. The Secchi disk depth varied between 10-14 meters.

More information about the algae situation can be found in the Algaware report for April: https://www.smhi.se/publikationer/publikationer/algrapporter

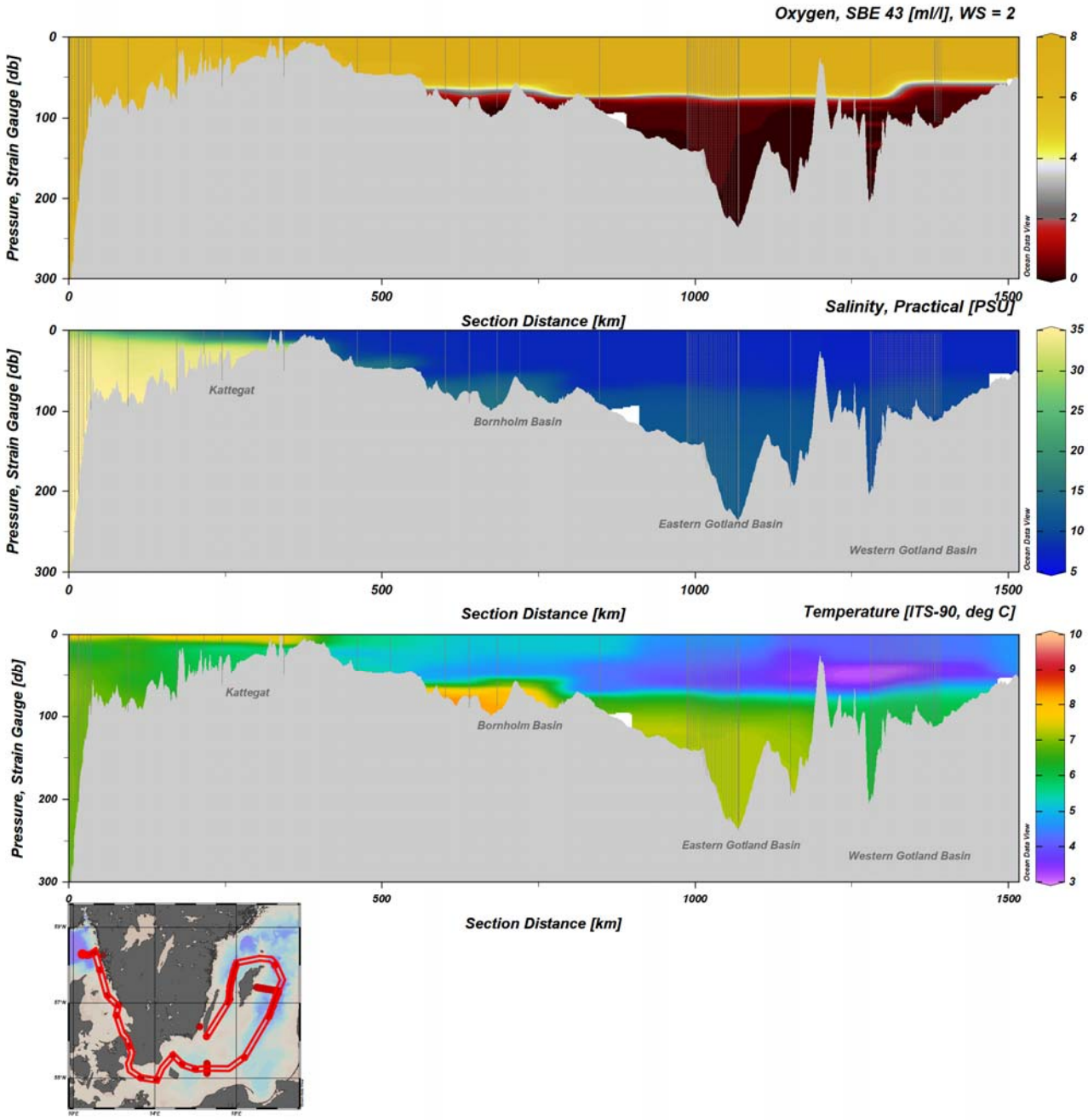


Figure 1. Transect showing oxygen concentration, salinity and temperature from measurements with CTD and MVP. Starting in Skagerrak via the Kattegat and the Sound to the Eastern Gotland Basin and further into the Western Gotland Basin.

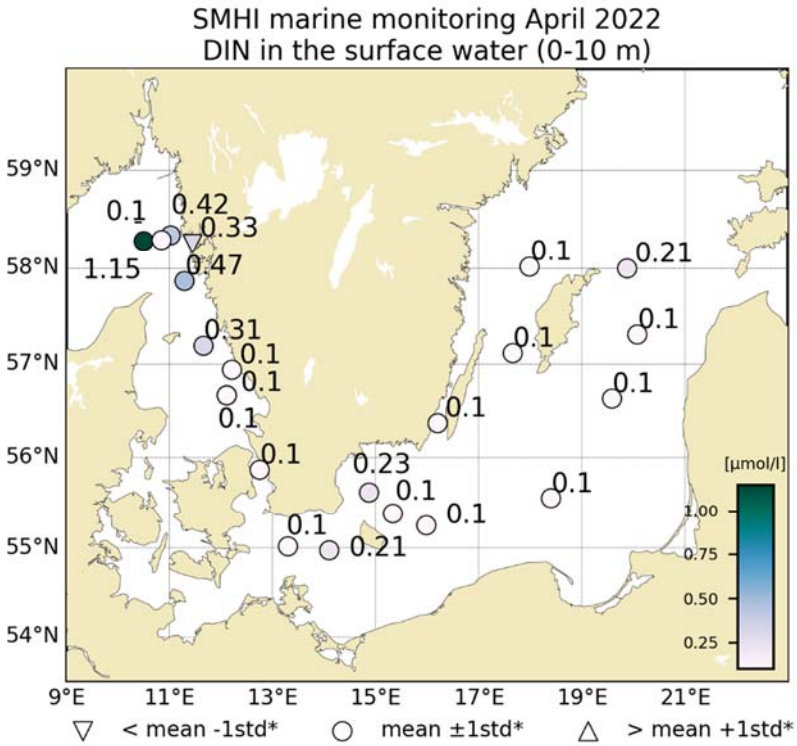


Figure 2. Concentration of dissolved inorganic nitrogen in the surface water (0 - 10m).

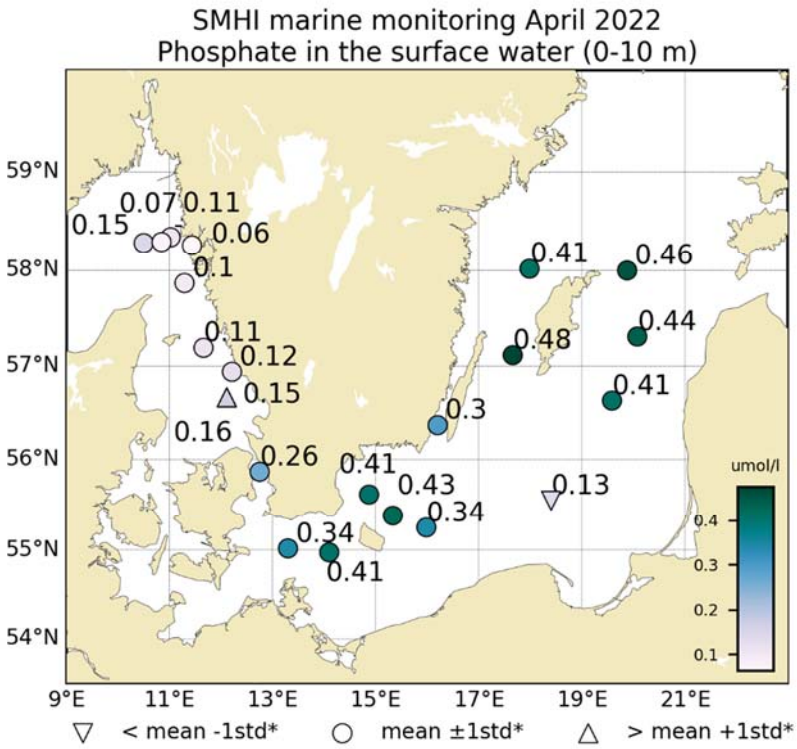


Figure 3. Concentration of phosphate in the surface water (0 - 10m).

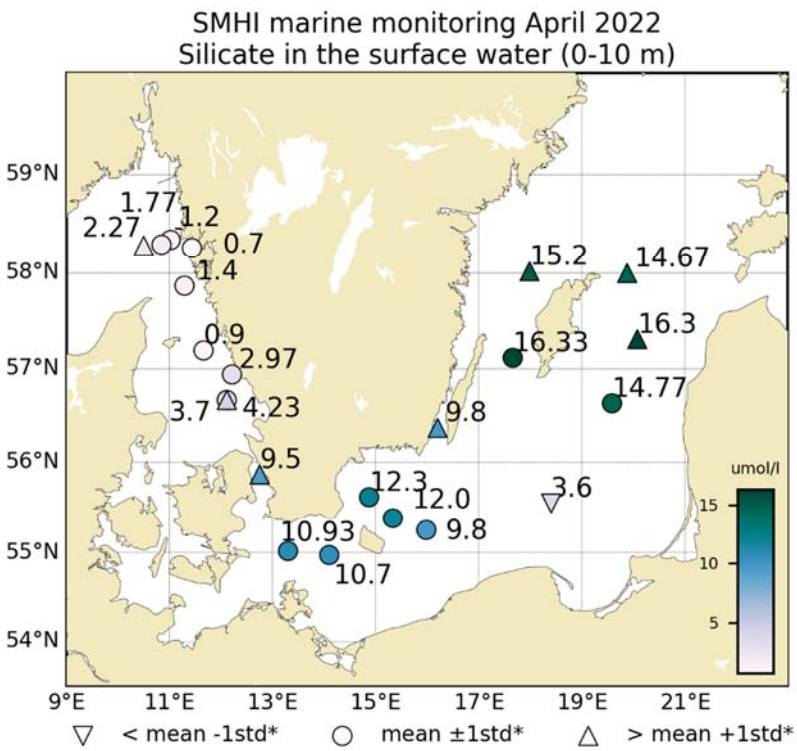


Figure 4. Concentration of silicate in the surface water (0 - 10m).

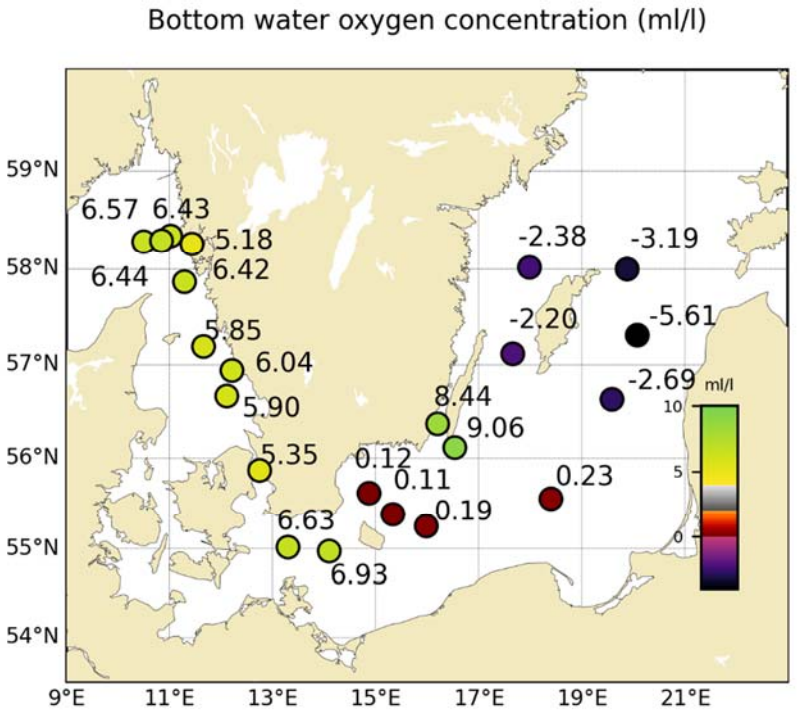


Figure 5. Oxygen concentration in the bottom water.
Negative oxygen values indicate that hydrogen sulphide is present.

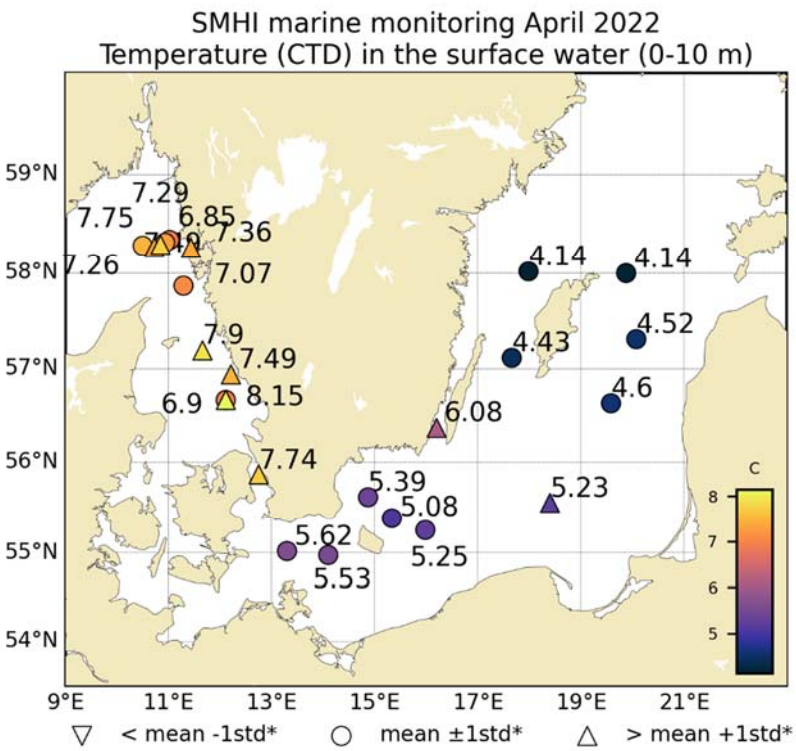


Figure 6. Temperature in the surface water (0 - 10m).

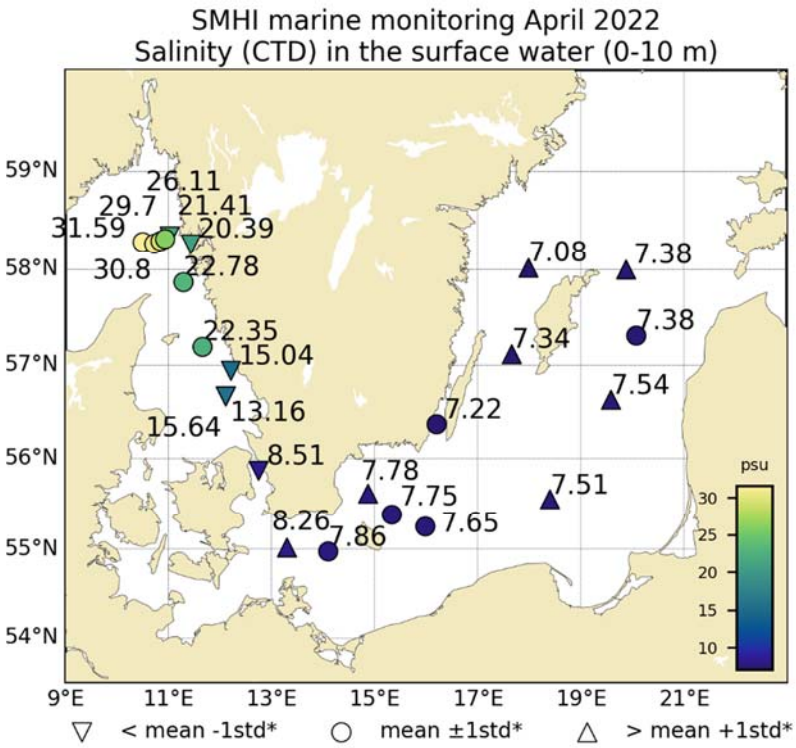


Figure 7. Salinity in the surface water (0 - 10m).

Participants

Name	Role	Institute
Sara Johansson	Chief scientist	SMHI
Johan Kronsell	Quality manager	SMHI
Martin Hansson		SMHI
Madeleine Nilsson		SMHI
Sari Sipilä		SMHI

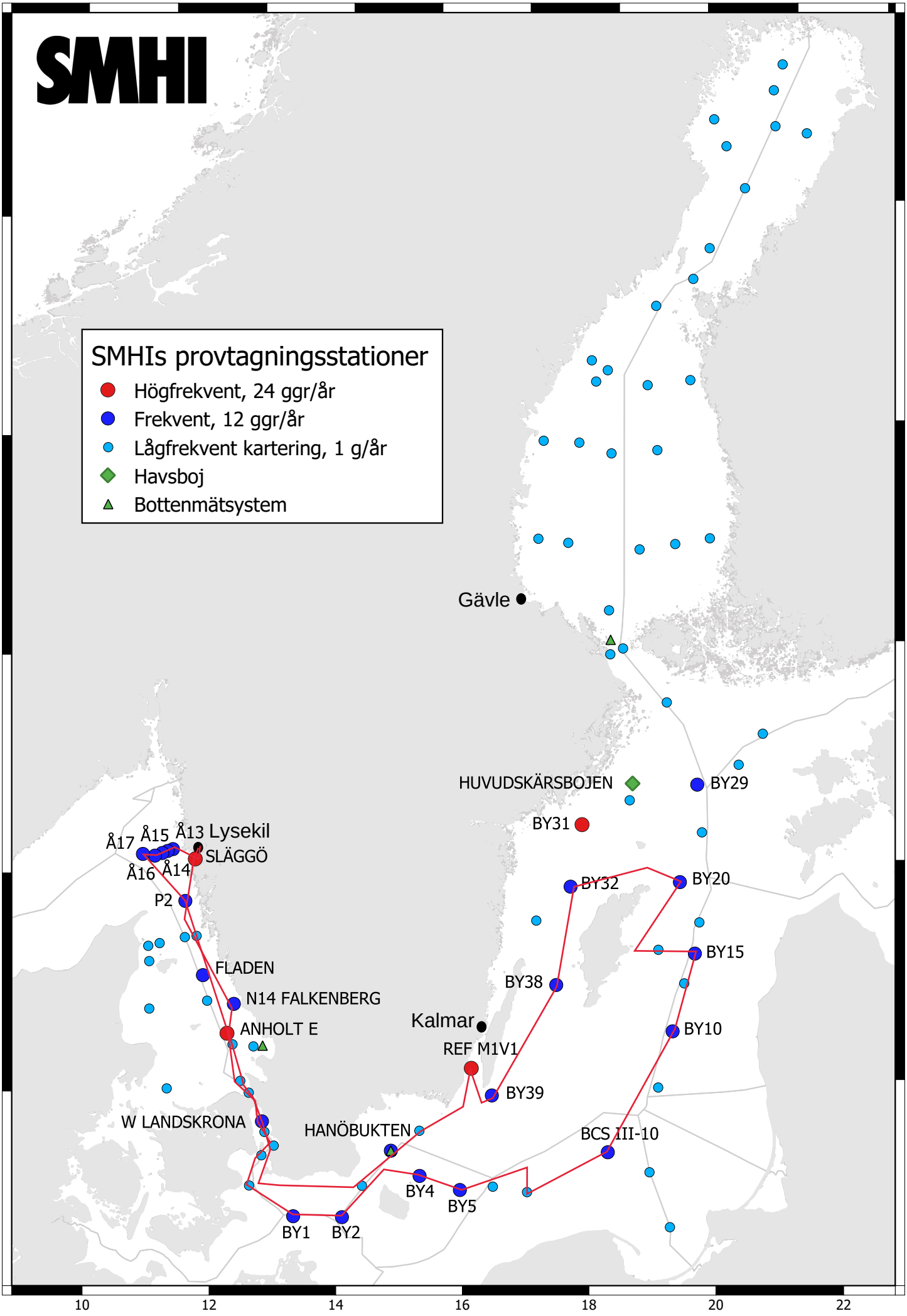
Guests onboard; Lysekil to Malmö

Name	
Helen Ågren	Sea Ambassador, Ministry of Foreign Affairs
Håkan Wirtén	Director General, SMHI
Jacob Granit	Director General, HaV
John Tumpane	Head of Environment department, FORMAS
Anders Hultén	Head of the Marine Environment Unit, SMHI
Susann Nilsson	Chancellor, Ministry of Foreign Affairs
Lars Thorell	Head of the R/V Svea Unit, SLU
Madeleine Säll	Communicator, SMHI
Pia Andersson	PL / Event Manager, SMHI

Appendices

- Track chart
- Table over stations, sampled parameters and number of sampling depths
- Vertical profiles for regular monitoring stations
- Monthly average surface water plots for regular monitoring stations

SMHI
Havs
och Vatten
myndigheten


SMHI
SMHIs provtagningsstationer
Högfrekvent, 24 ggr/år
Frekvent, 12 ggr/år
Lågfrekvent kartering, 1 g/år
Havsboj
Bottenmätsystem
Gävle
HUVUDSKÄRSBOJEN
BY29
BY31
BY32
BY20
BY15
BY38
BY10
Å17
Å15
Å13
Lysekil
SLÄGGÖ
Å16
Å14
P2
FLADEN
N14 FALKENBERG
ANHOLT E
Kalmar
REF M1V1
BY39
W LANDSKRONA
HANÖBUKTEN
BCS III-10
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Date: 2022-05-06
Time: 11:54

Ship: SE
Year: 2022

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	Wind vel	Air temp C	Air pres hPa	WCWI elac aove tueo hdsb	CZPP hohp loy apt o p	No de	No btl	Temp_bottle	Temp_cast	Salt_bottle	Salt_cast	Phos_bottle	Phos_cast	Doxy_bottle	Doxy_cast	H2S	Phosphate	Nitrite	Nitrate	Nitrite	Ammonia	Alkalinity	Silicate	Shipmen-s	Cruise	Comment_visit	Comment_sample
0253	07	FIBG27	BAS...	SLÄGGÖ	5815.59	01126.15	20220420	0800	72	7	07	6	10.9	1022	1120	xx--	9		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-
0254	07	SKEX14	BAS...	Å13	5820.56	01101.34	20220420	1130	97	8	35	6	10.0	1021	1120	x---	10		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
0255	07	SKEX18	BAS...	Å17	5817.01	01029.95	20220420	1435	352	8	36	6	9.9	1020	1130	xx--	15		x	x	-	x	x	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-
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0263	07	BPSB06	BAS...	BY4 CHRISTIANSÖ	5522.97	01520.02	20220422	0730	91	13	05	11	5.5	1014	1240	x---	12		x	x	-	x	-	x	x	x	x	-	x	x	x	x	-	-	x	-	-	-
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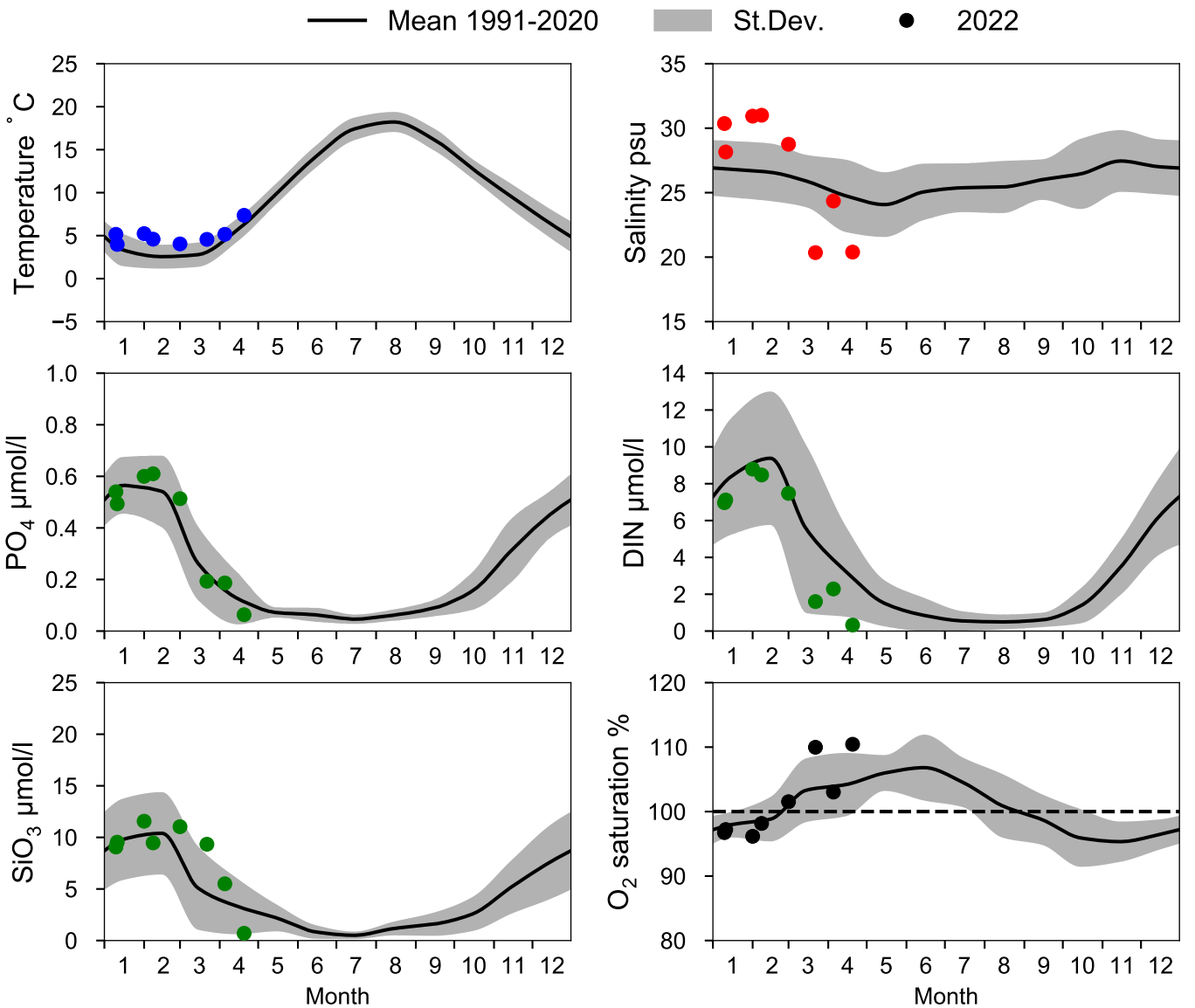
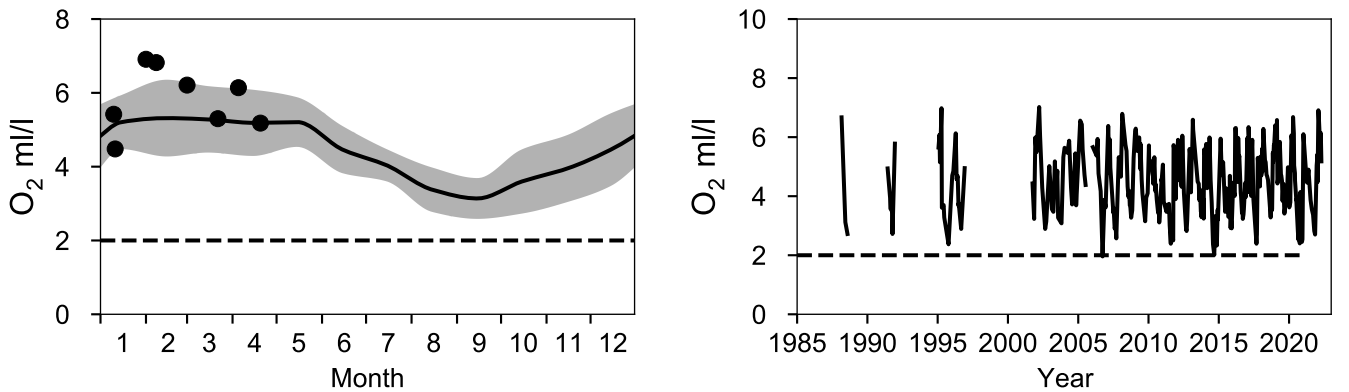
0276	07	KAEX29	BAS...	ANHOLT E	5640.11	01206.65	20220426	0425	63	9	28	3	8.9	1013	1130	xx--	10		-	x	-	x	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-
0277	07	KANX50	BAS...	N14 FALKENBERG	5656.4	01212.72	20220426	0945	31	9	28	7	6.5	1014	4420	xx--	7		x	x	-	x	-	x	-	x	x	x	x	-	-	x	-	-	x	-	x	-
0278	07	KANX25	BAS...	FLADEN	5711.58	01139.60	20220426	1040	77	9	32	4	8.8	1015	1330	x---	12		x	x	-	x	-	x	-	x	x	x	x	-	-	x	-	-	x	-	x	-

STATION SLÄGGÖ SURFACE WATER (0-10 m)

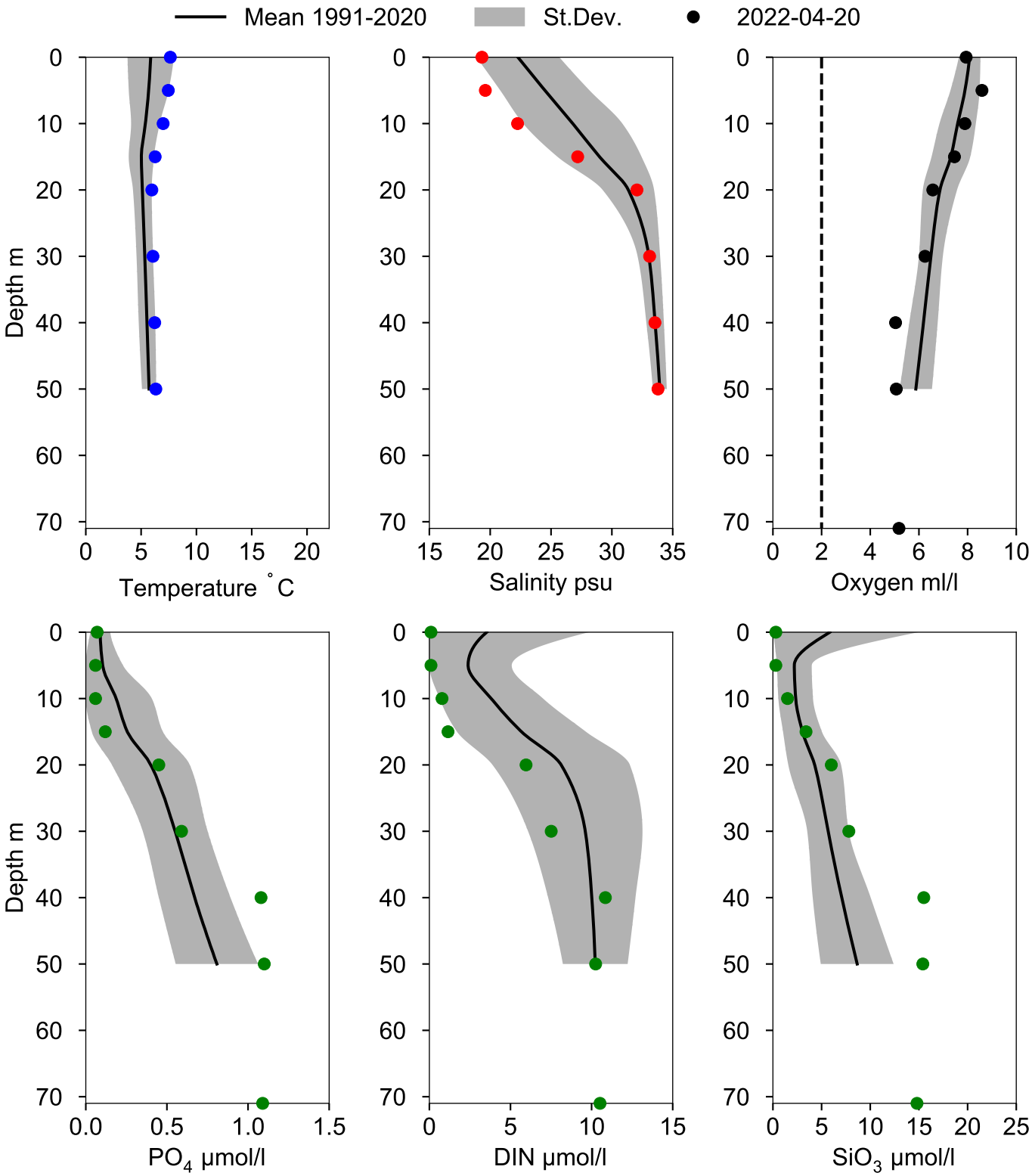
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 64 m)

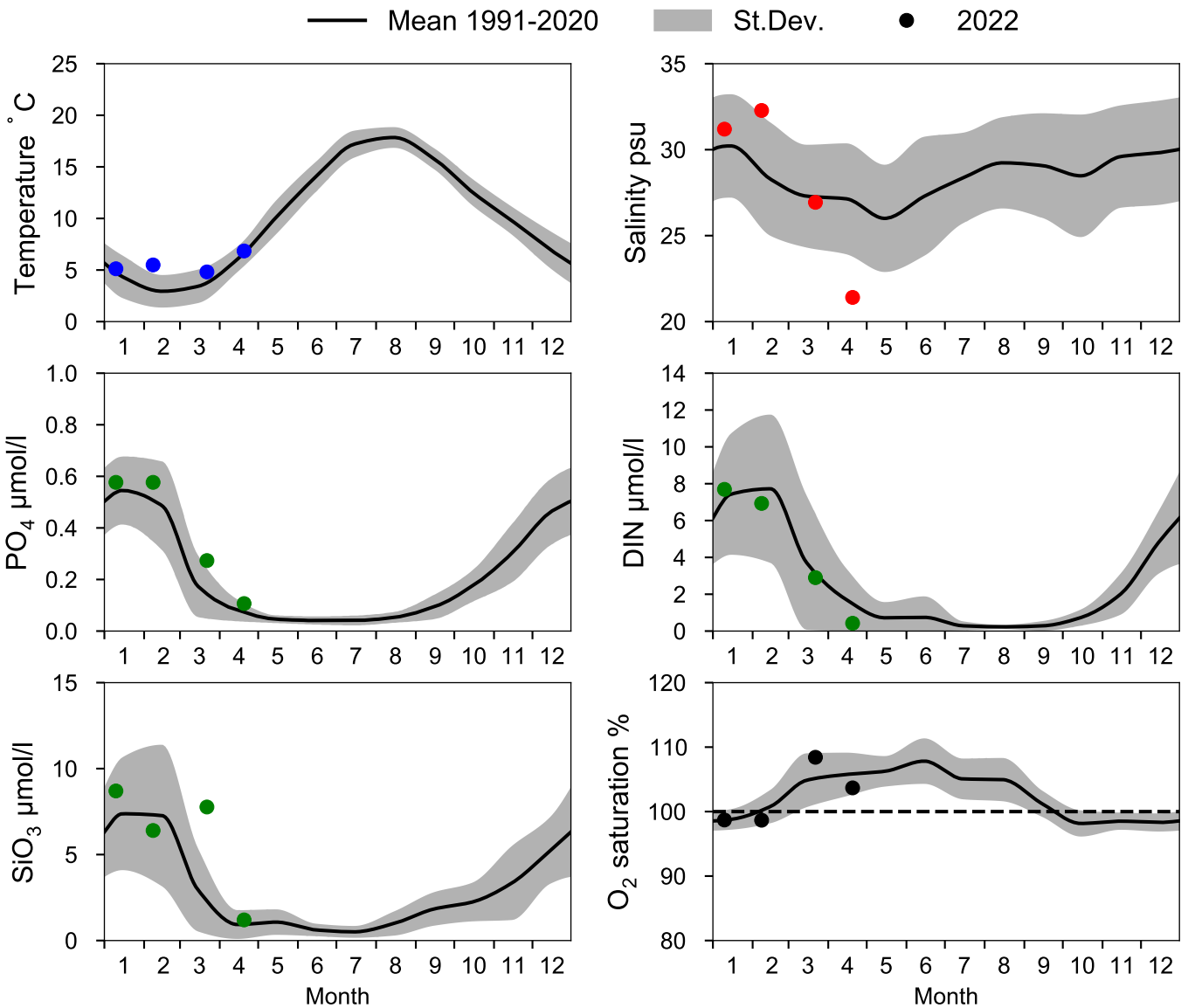


Vertical profiles SLÄGGÖ
April

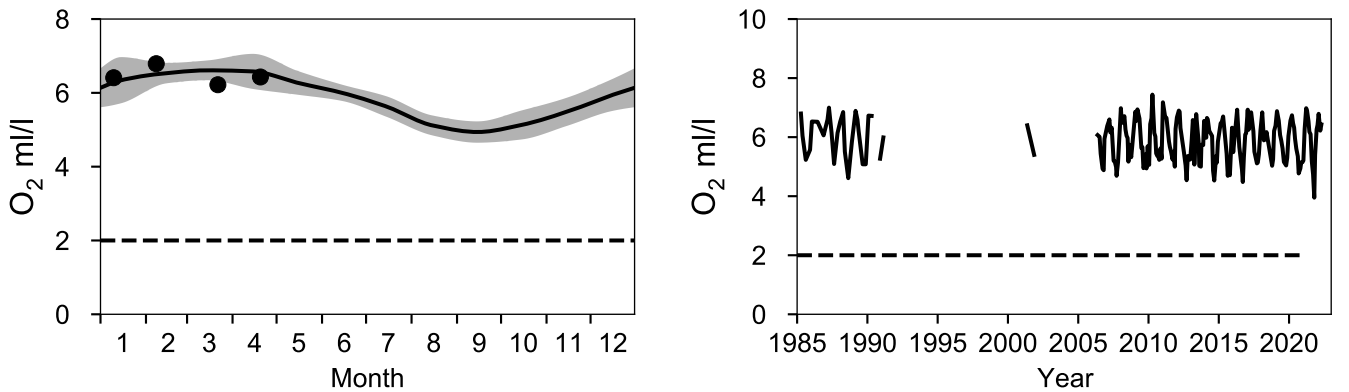


STATION Å13 SURFACE WATER (0-10 m)

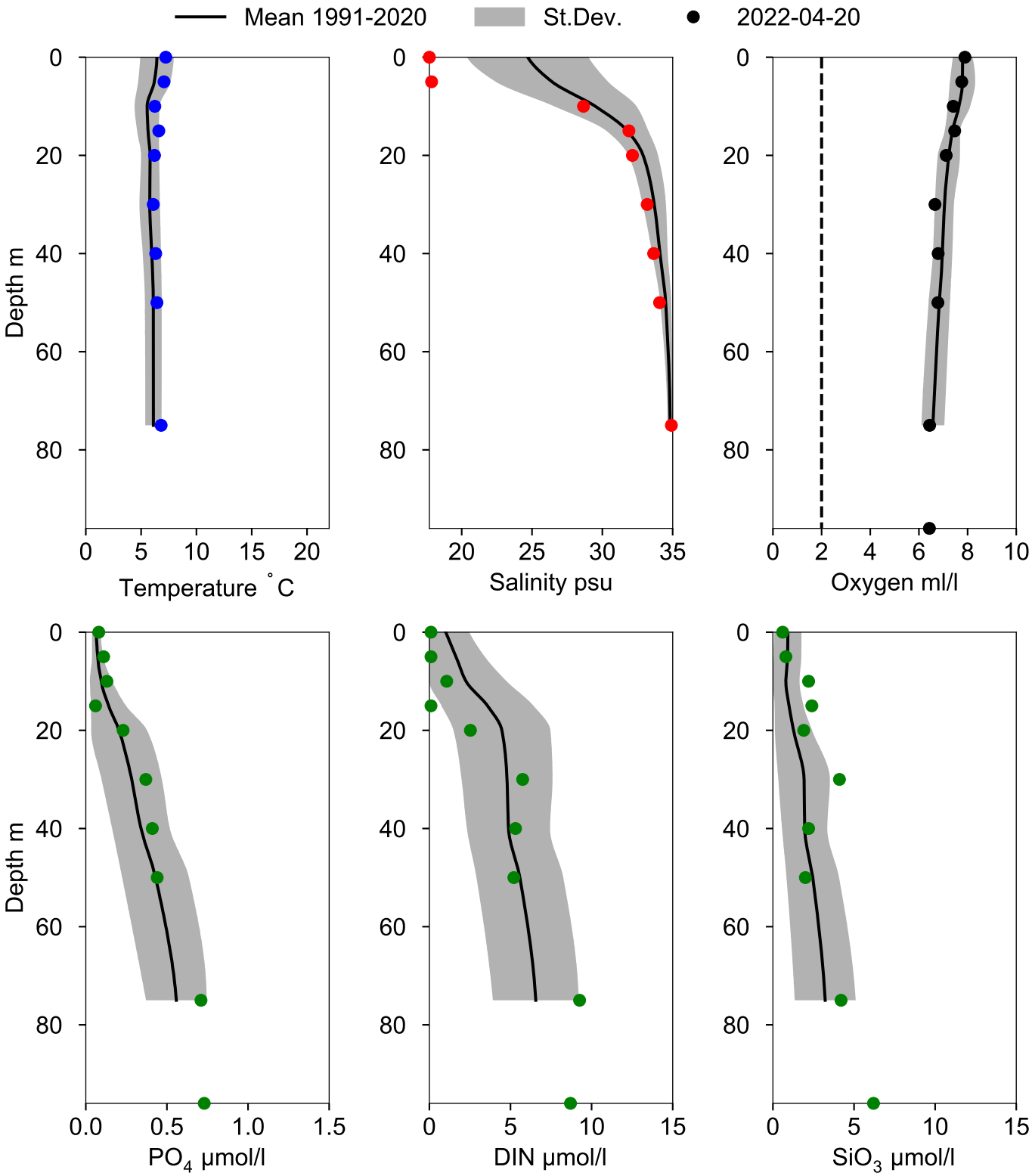
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 82 m)

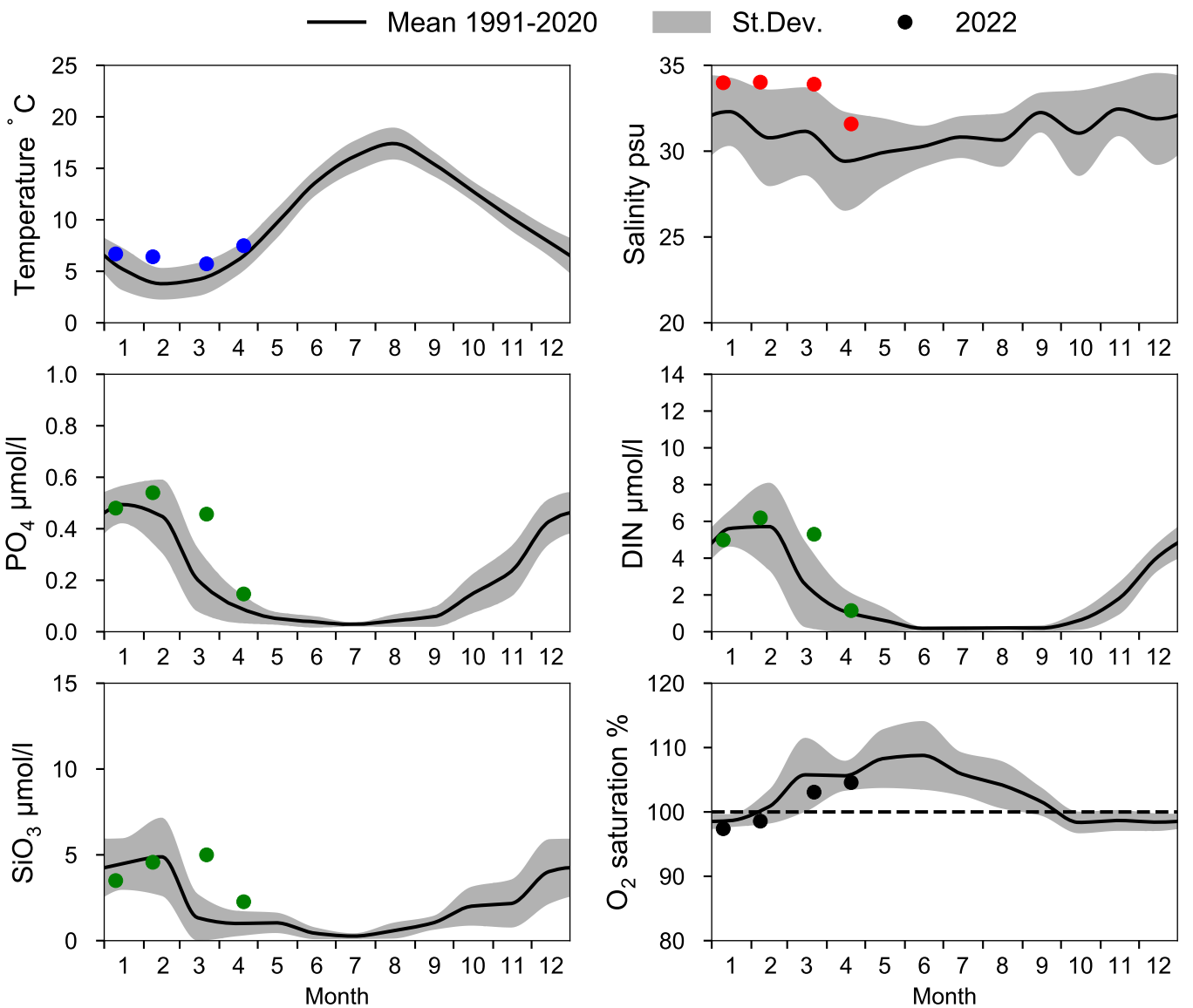


Vertical profiles Å13
April

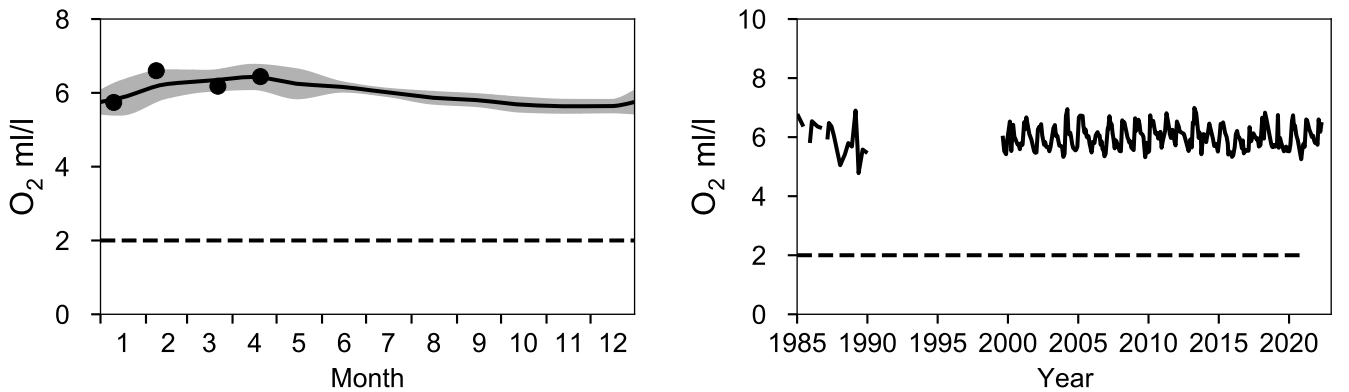


STATION Å17 SURFACE WATER (0-10 m)

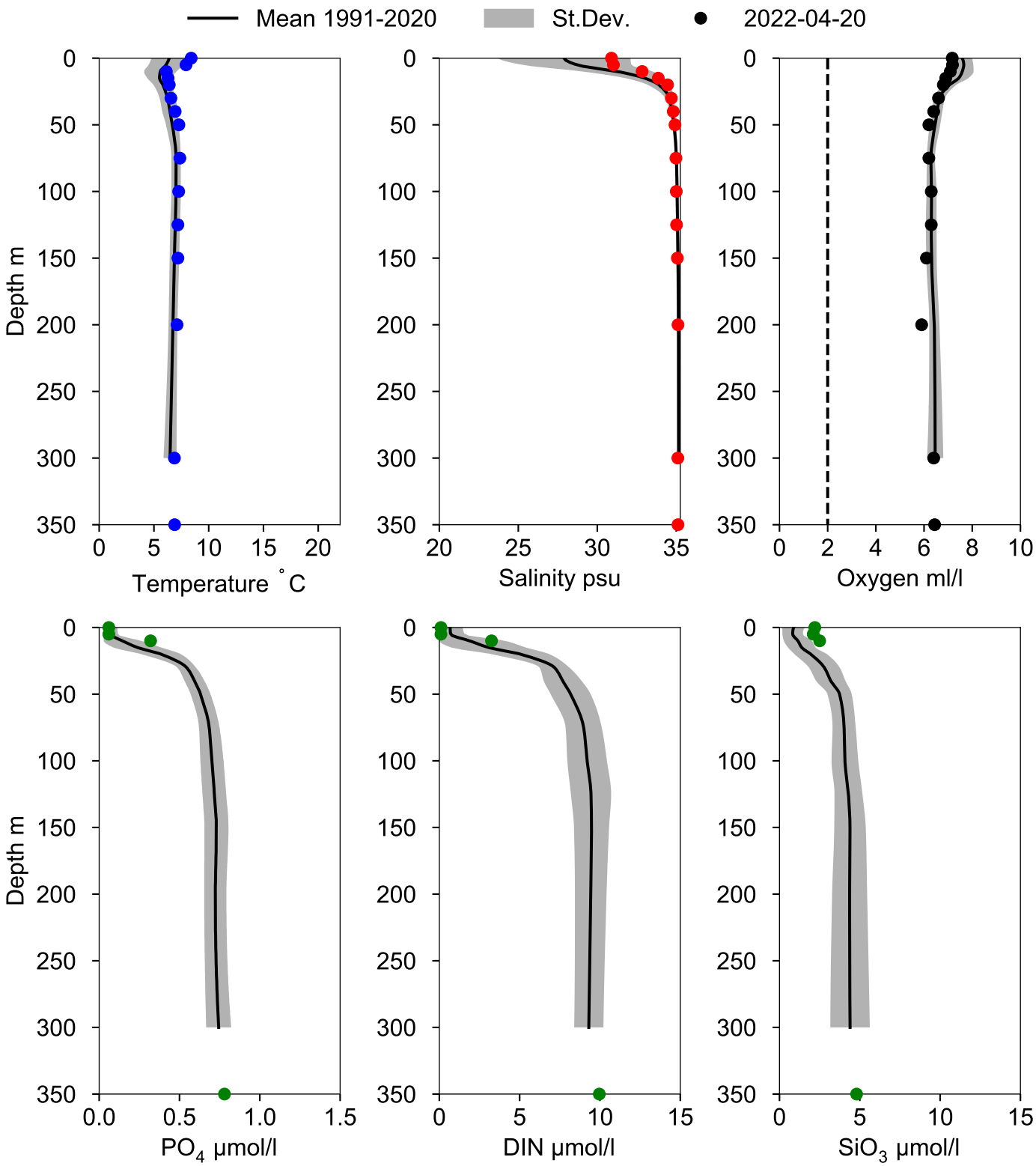
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 300 m)

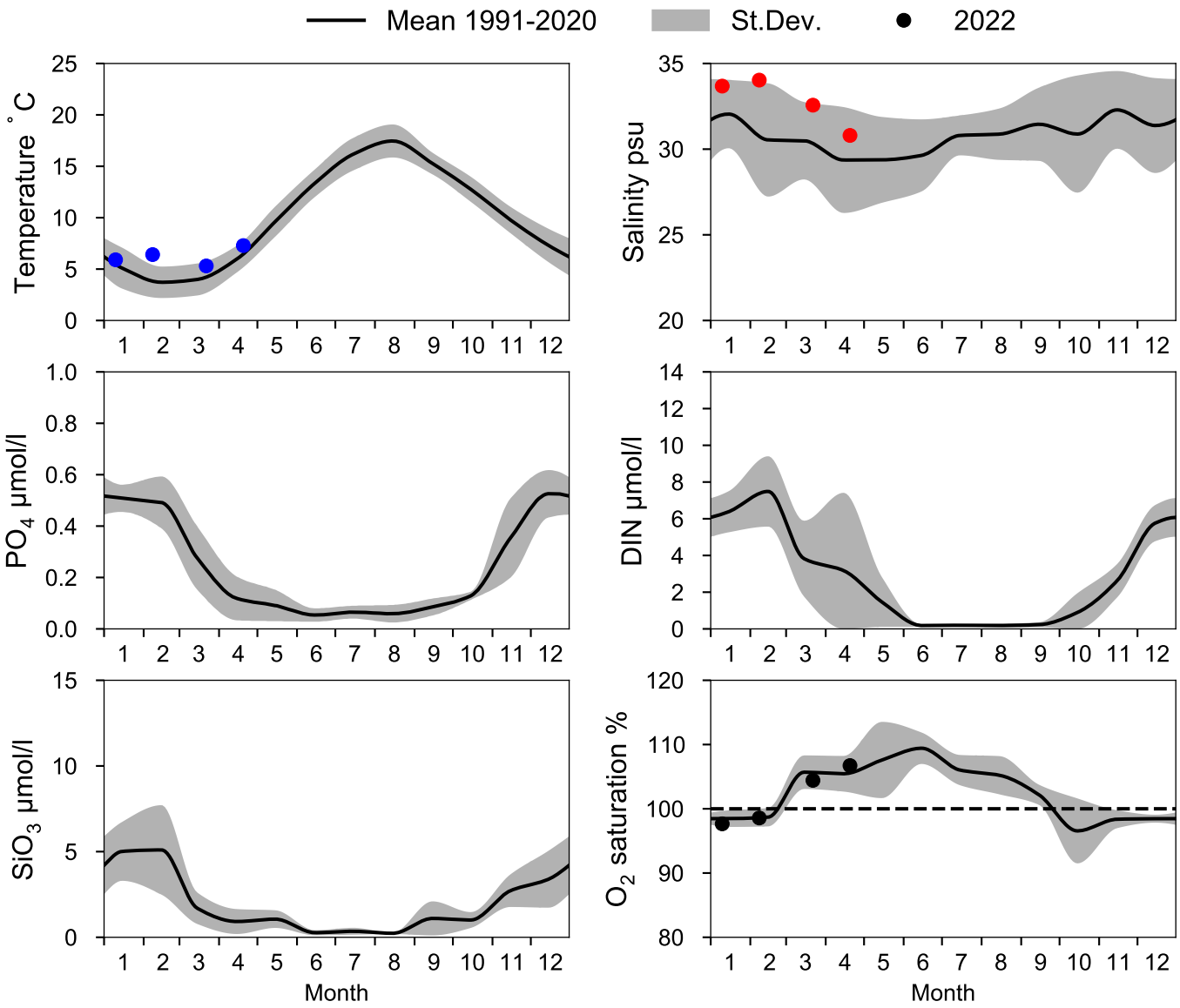


Vertical profiles Å17
April

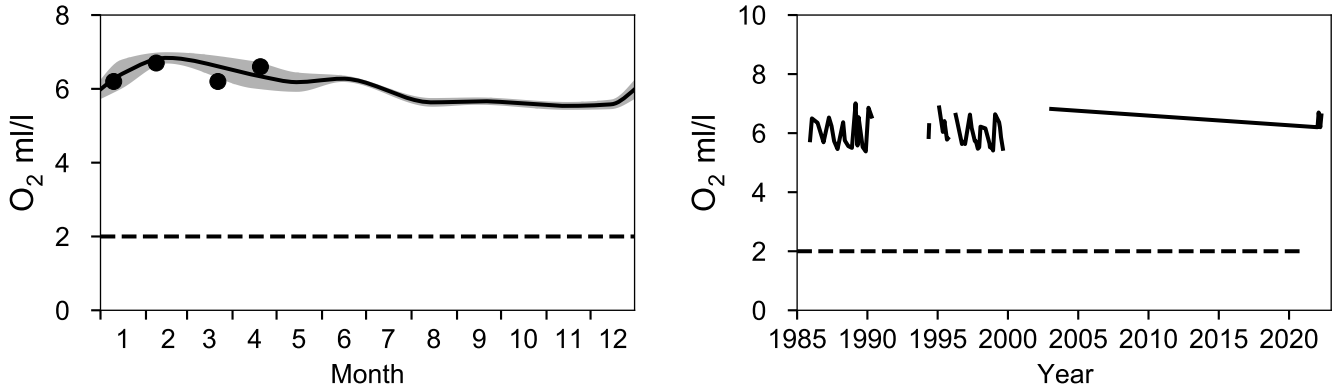


STATION Å16 SURFACE WATER (0-10 m)

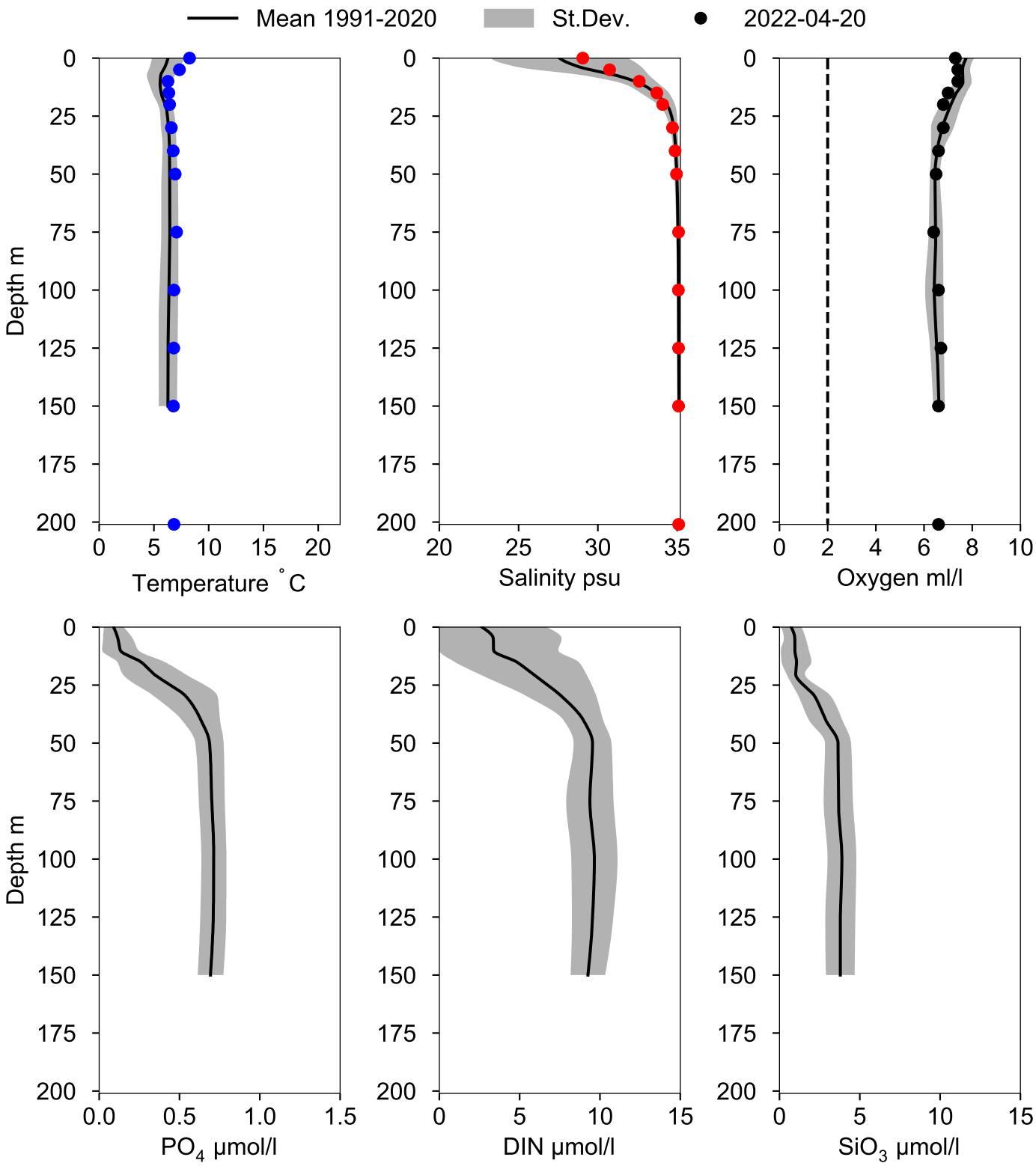
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 193 m)

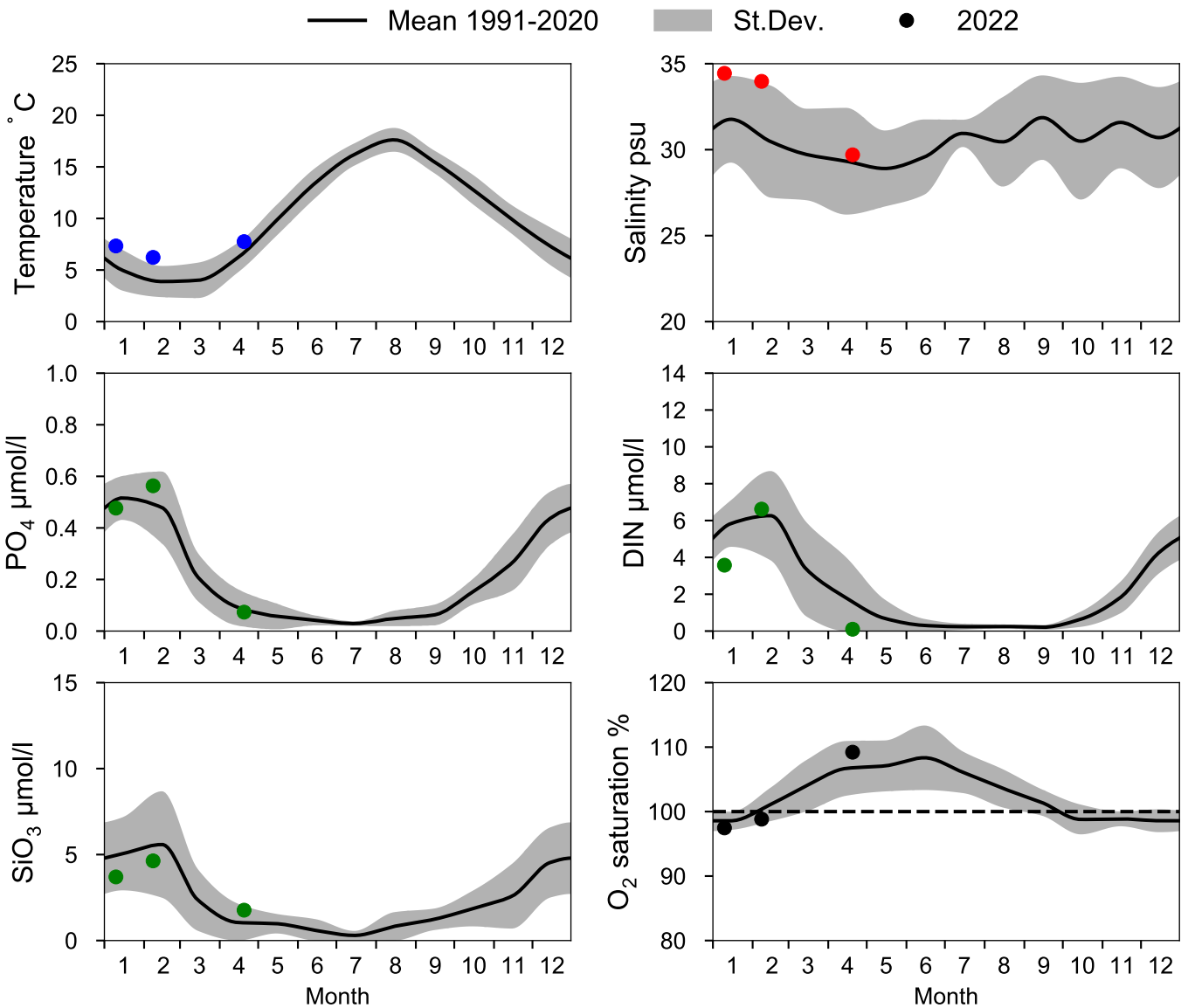


Vertical profiles Å16
April

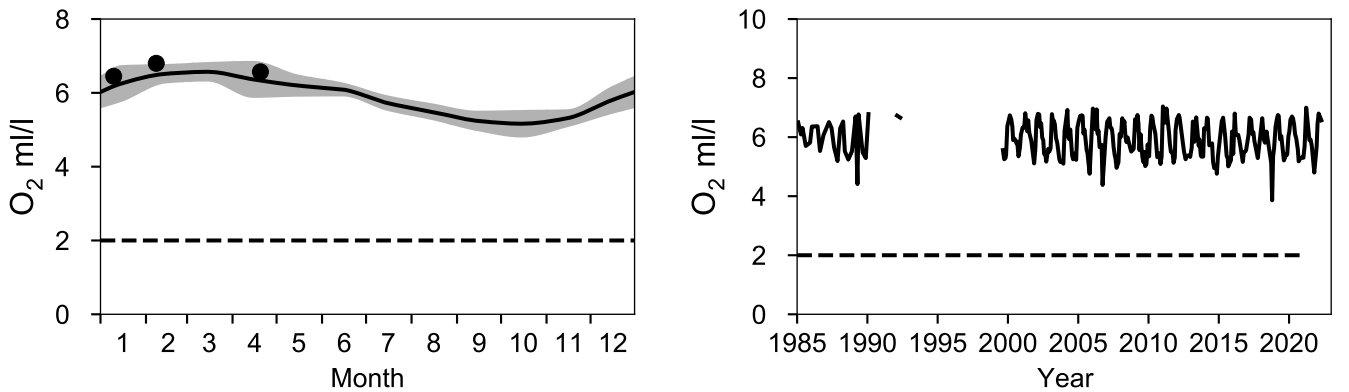


STATION Å15 SURFACE WATER (0-10 m)

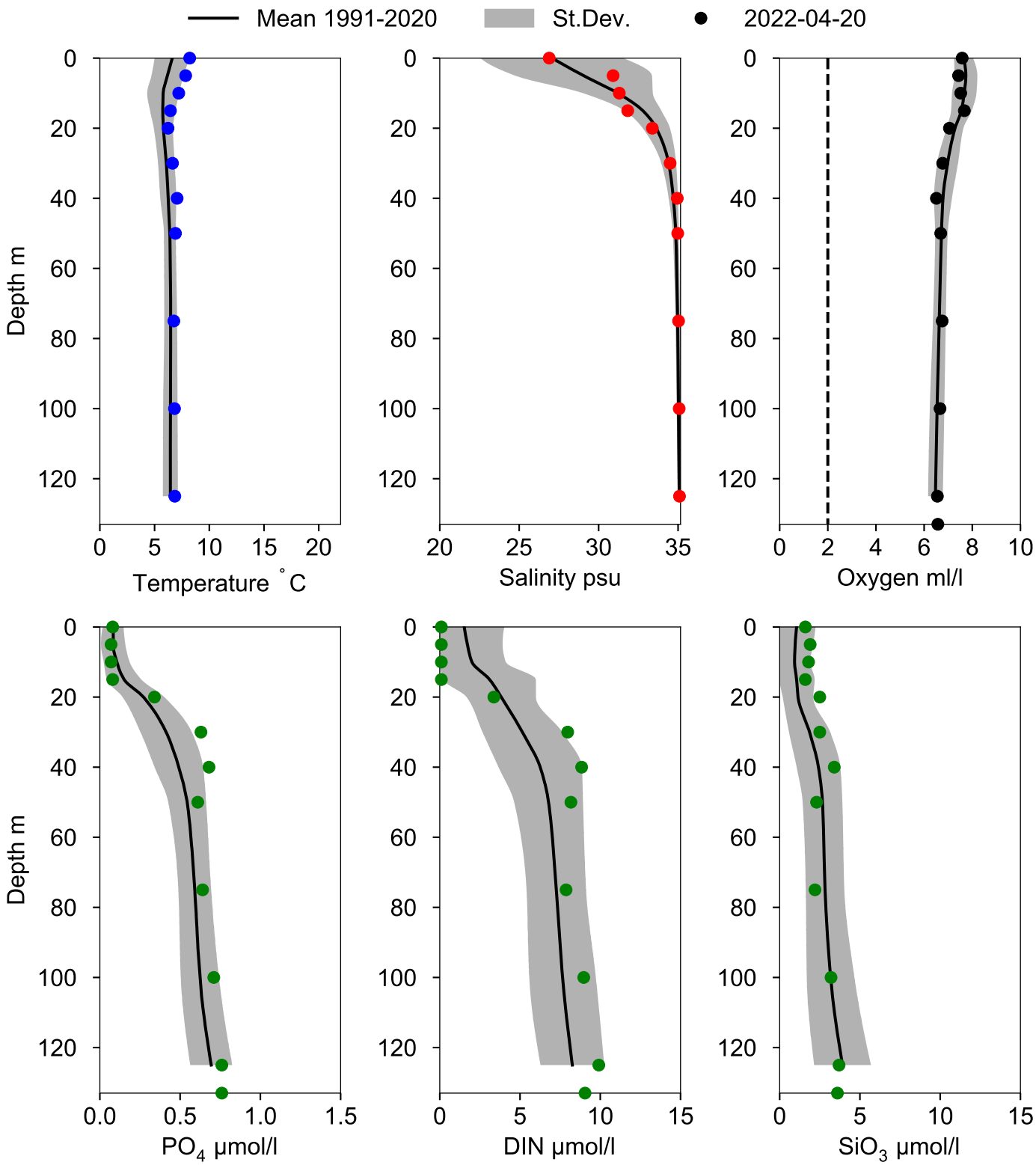
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 125 m)

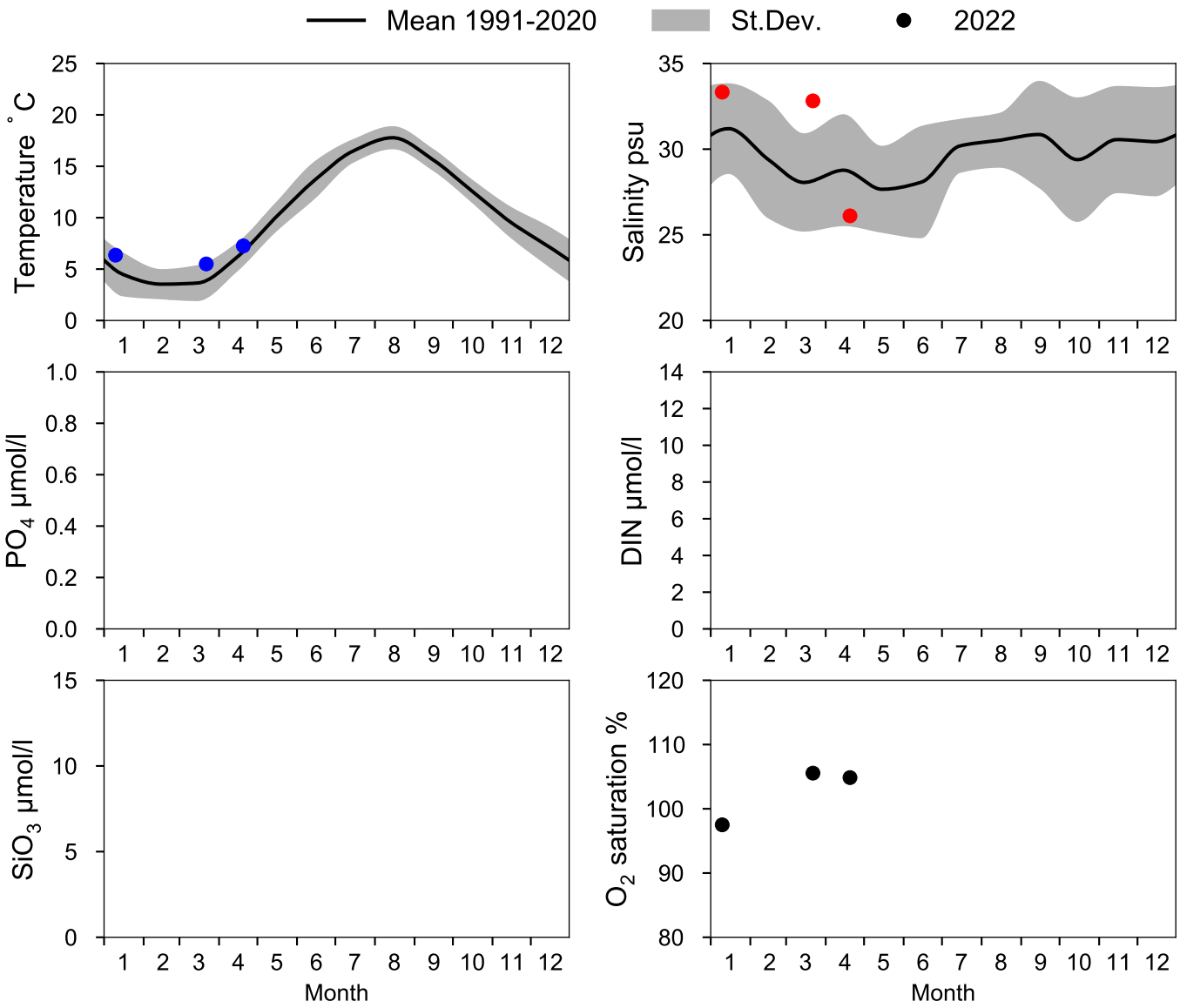


Vertical profiles Å15
April

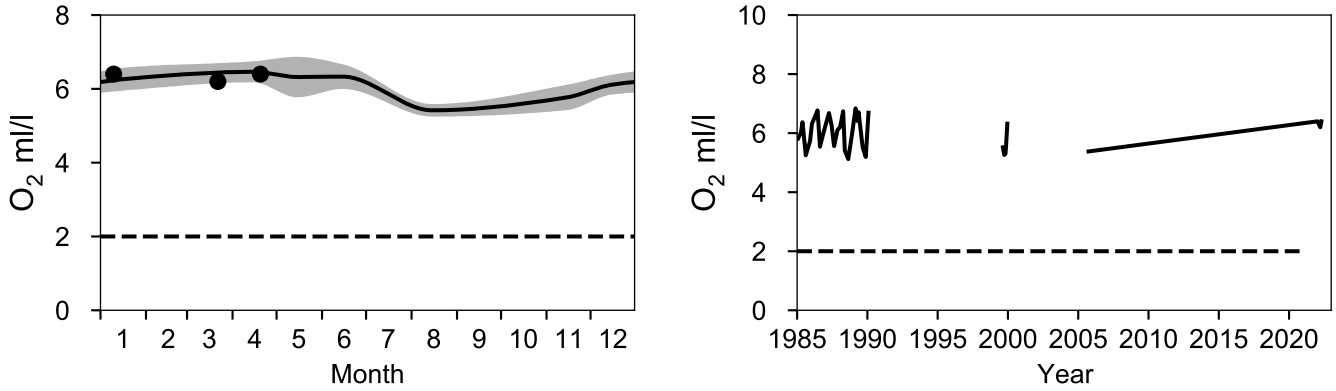


STATION Å14 SURFACE WATER (0-10 m)

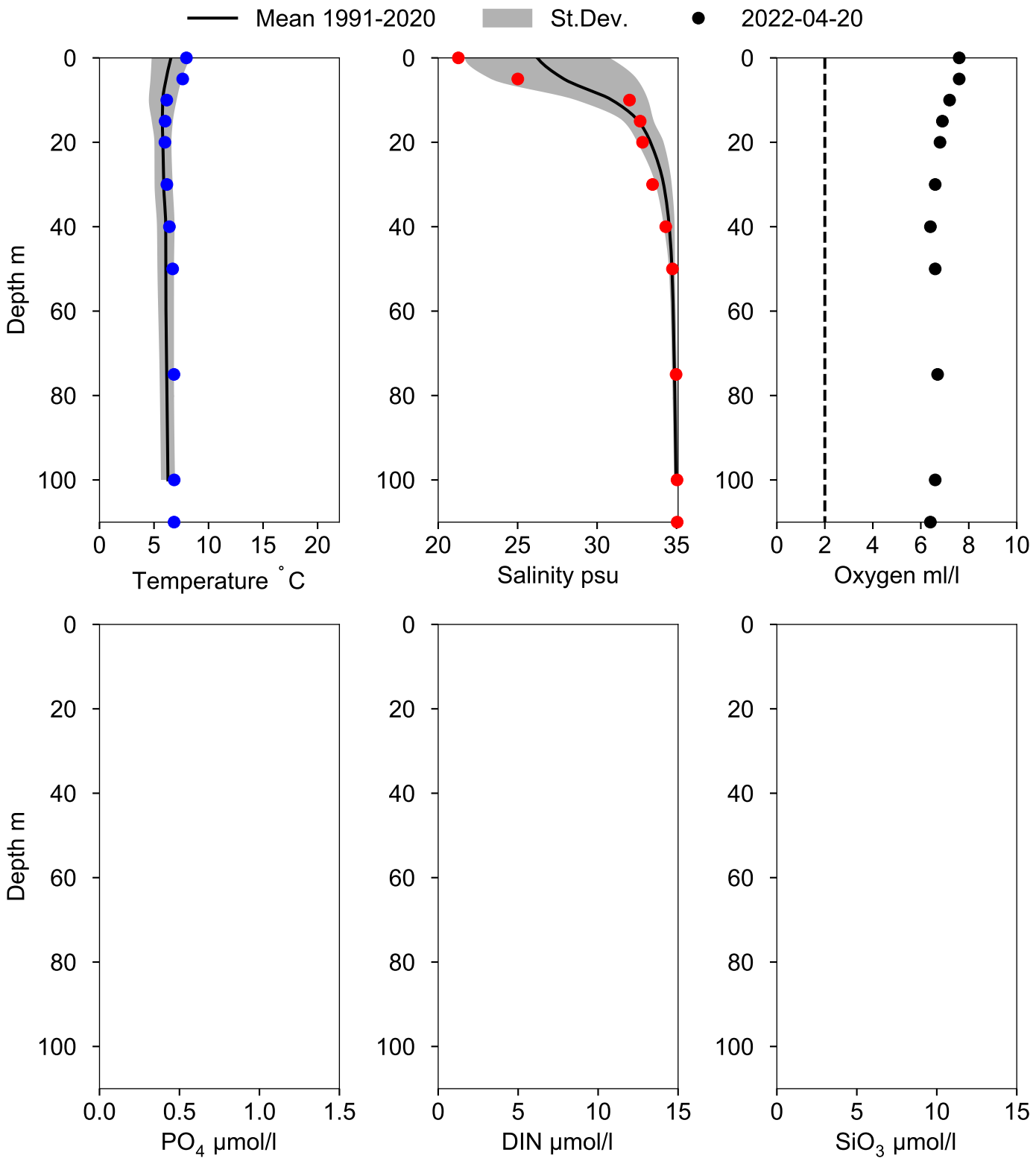
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 100 m)

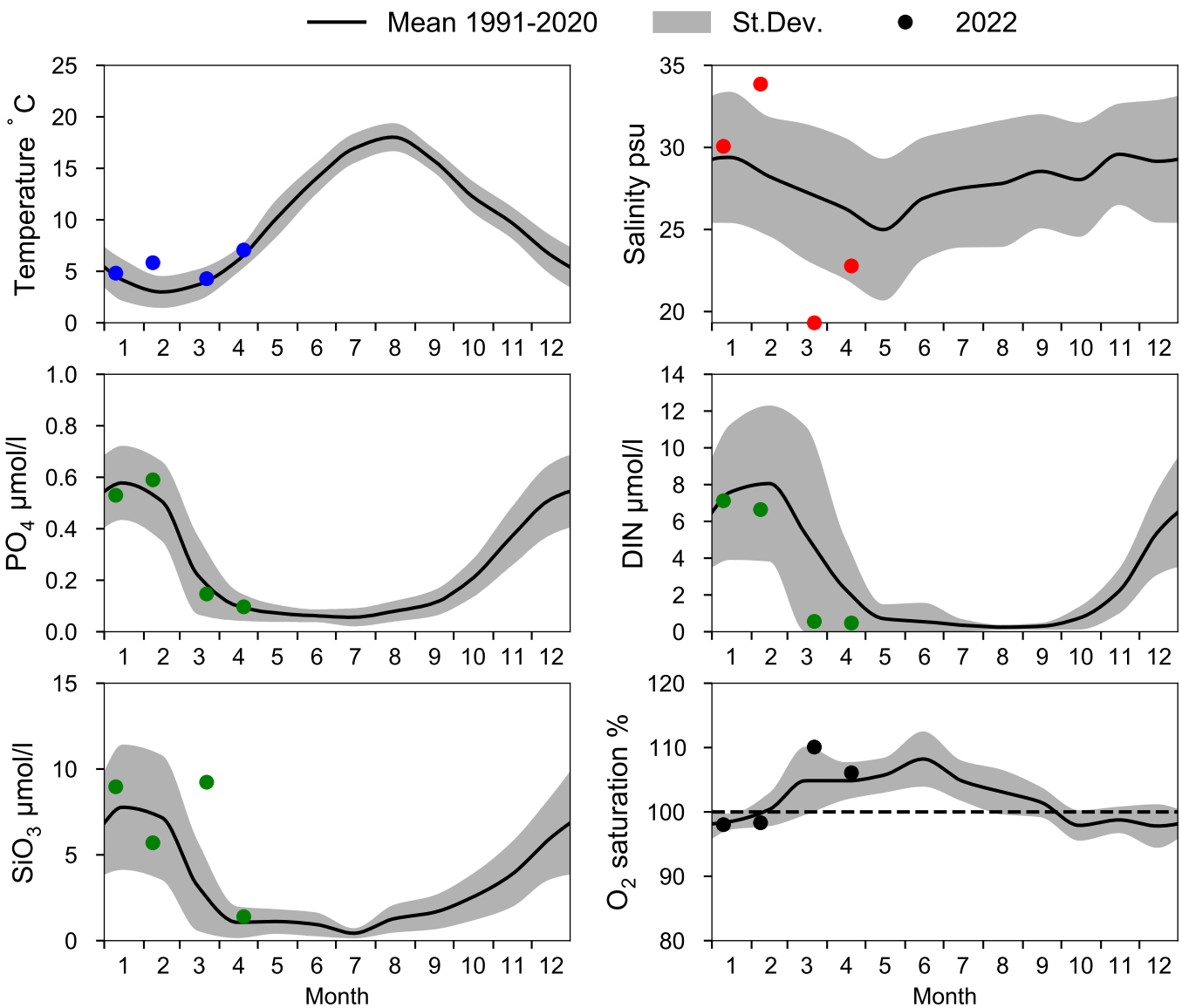


Vertical profiles Å14
April

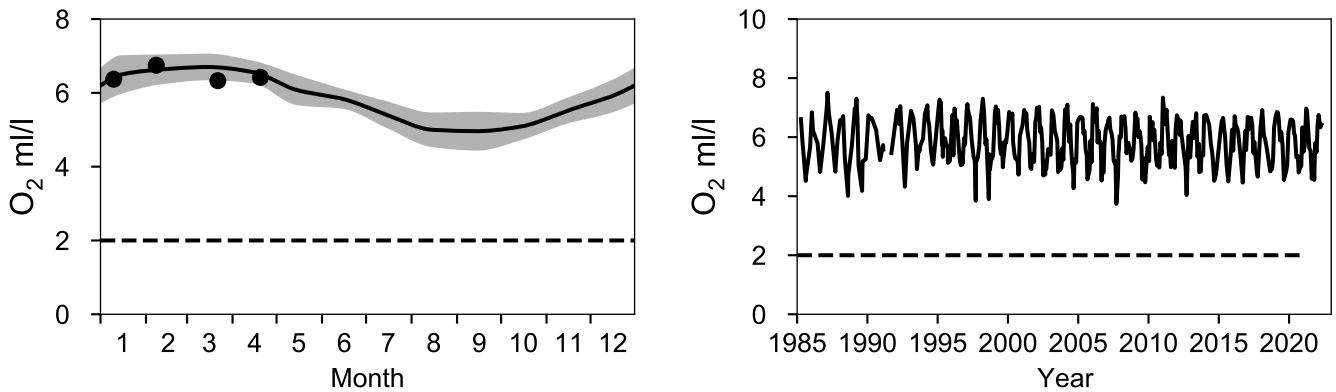


STATION P2 SURFACE WATER (0-10 m)

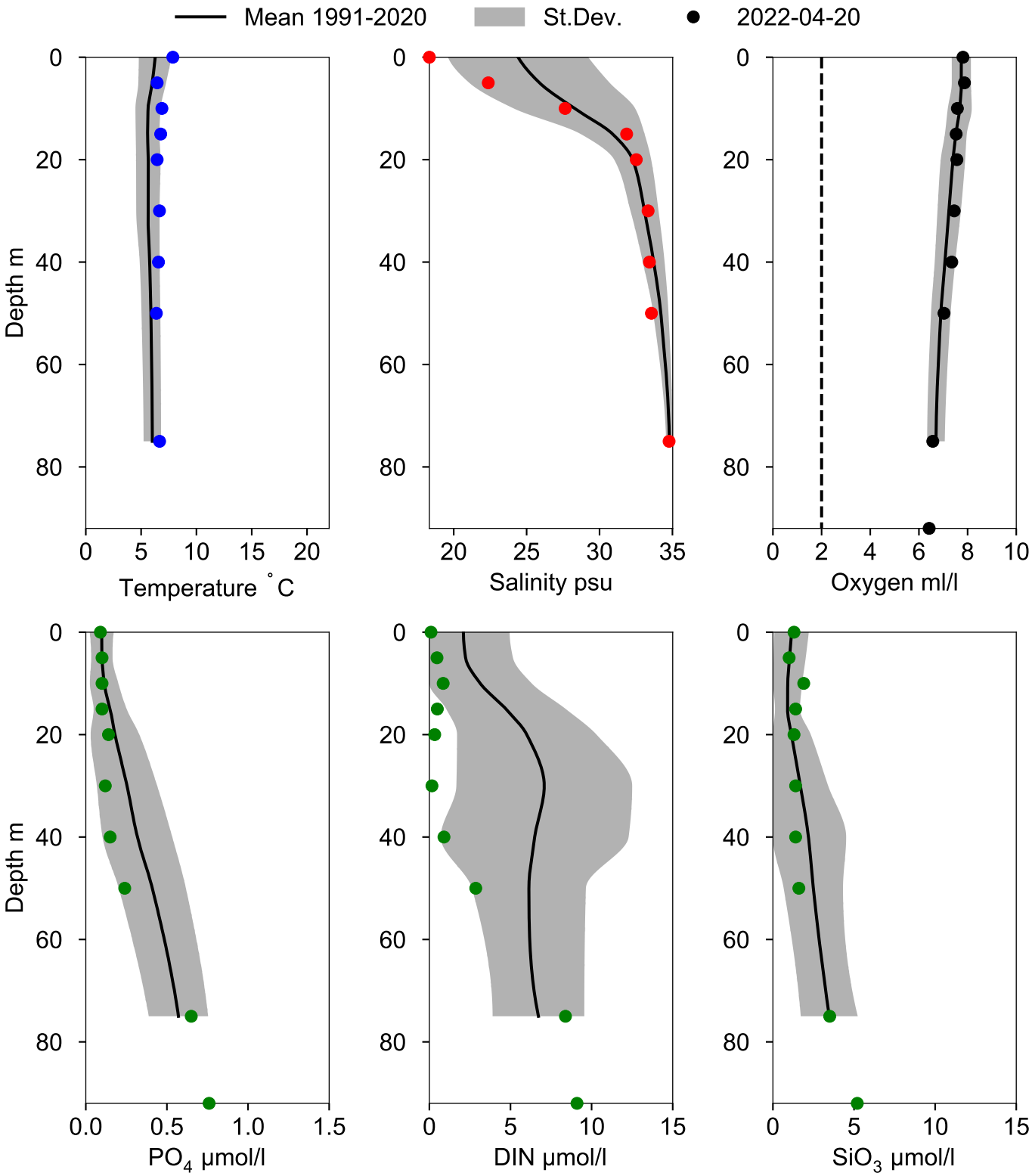
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 75 m)

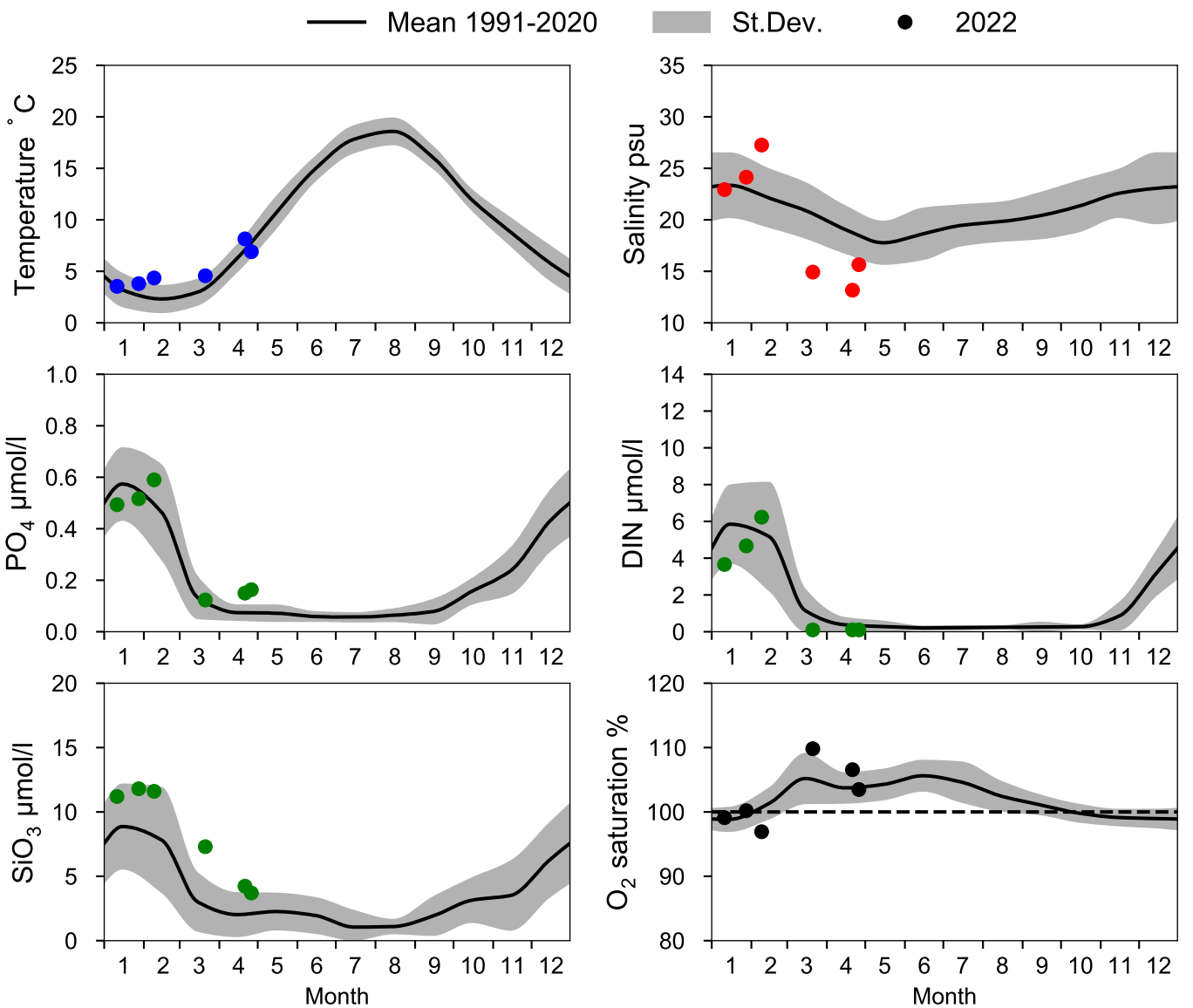


Vertical profiles P2
April

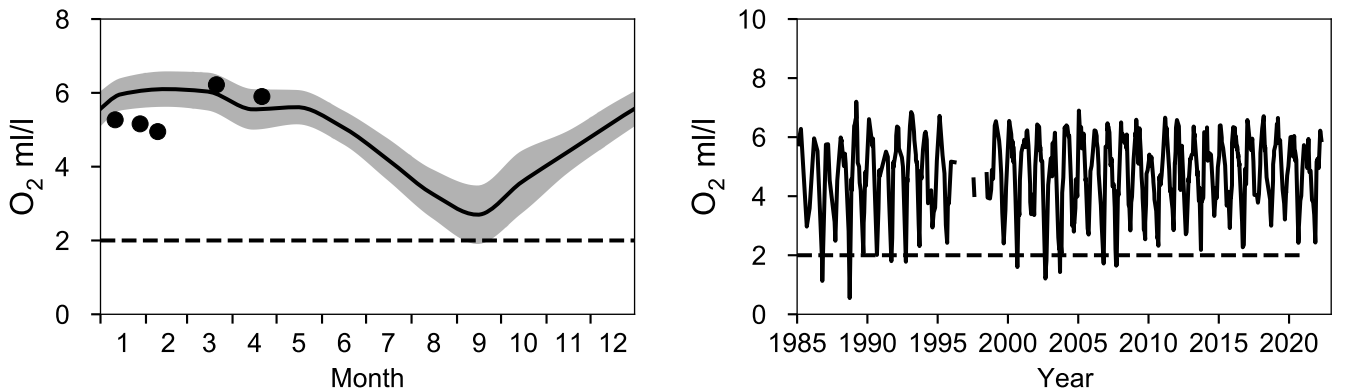


STATION ANHOLT E SURFACE WATER (0-10 m)

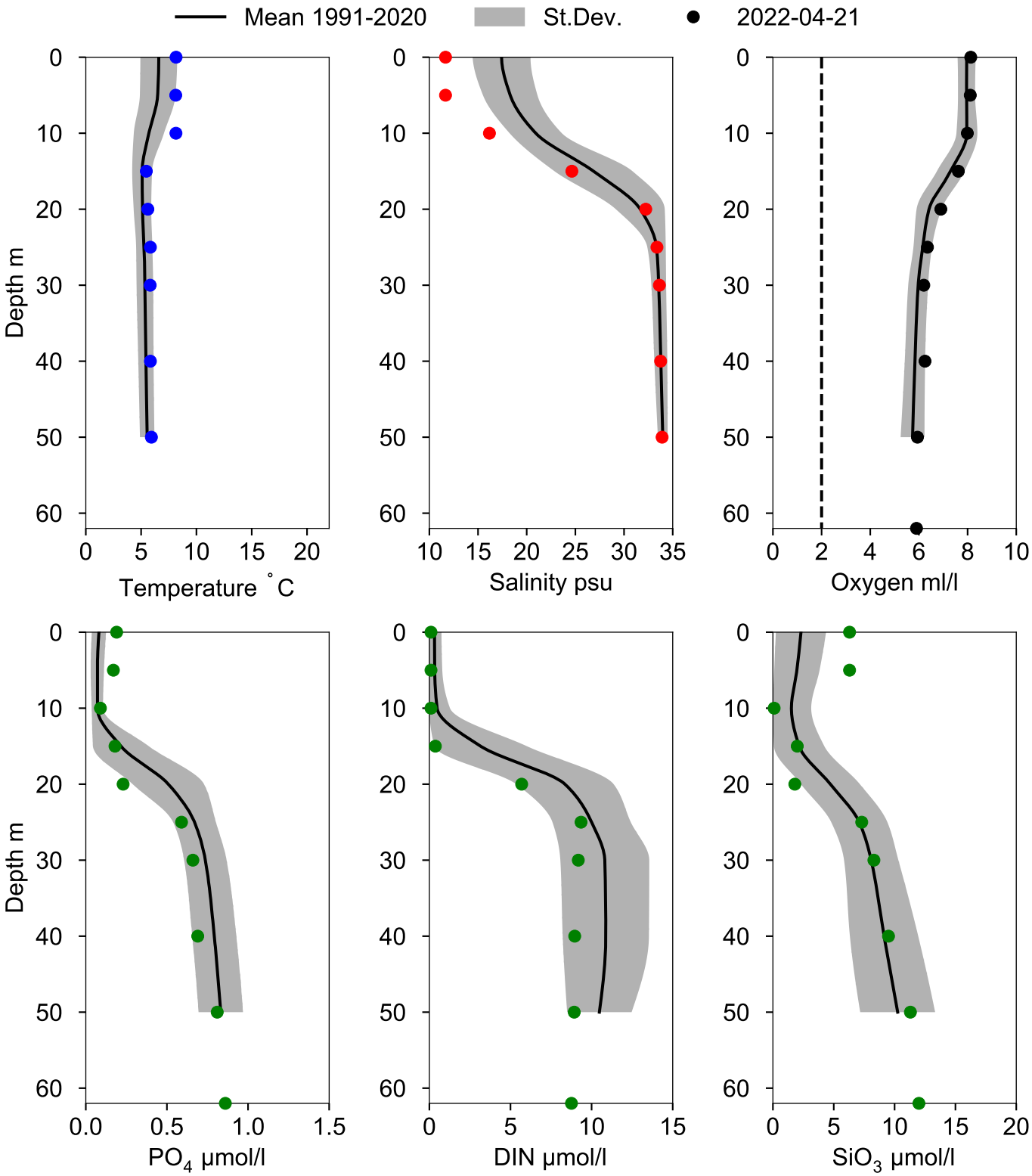
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 52 m)

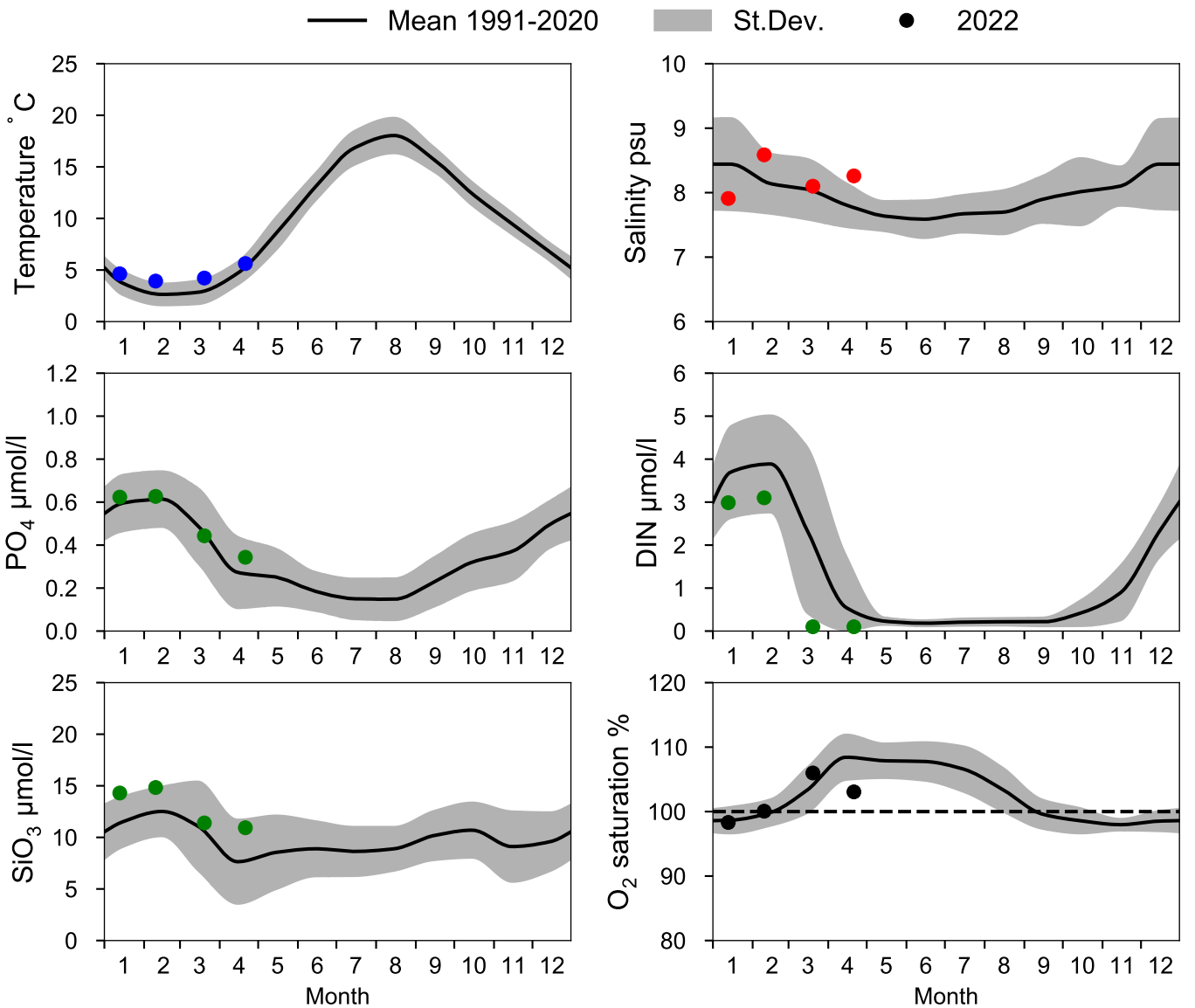


Vertical profiles ANHOLT E
April

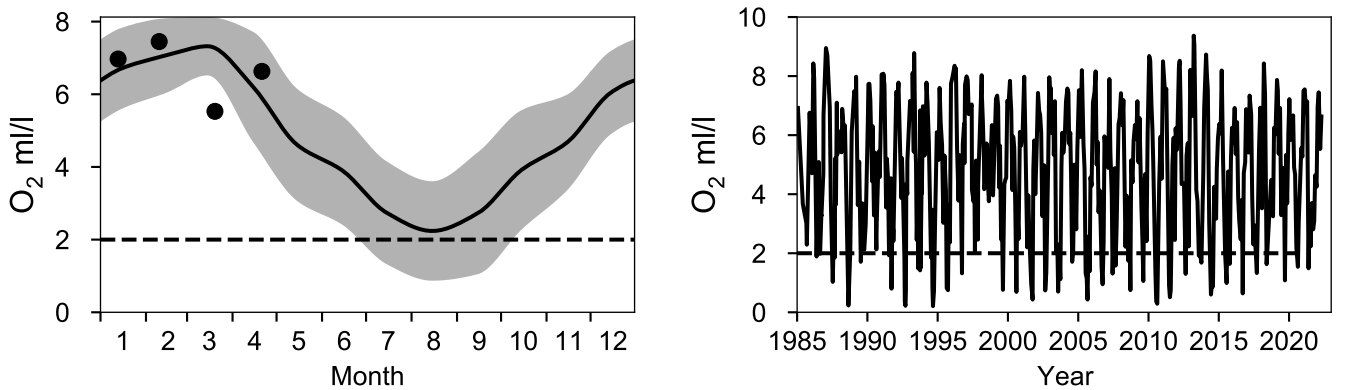


STATION BY1 SURFACE WATER (0-10 m)

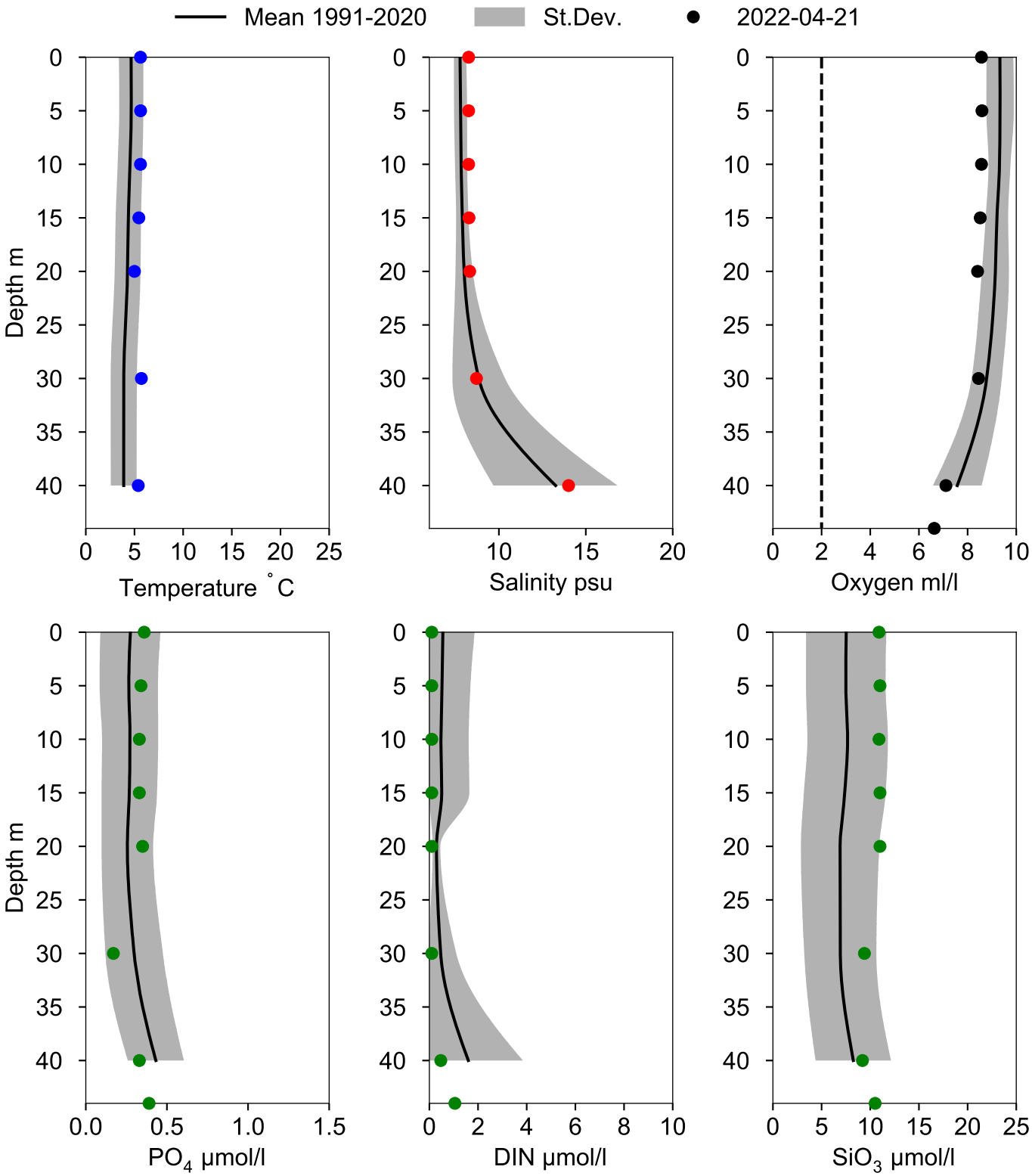
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 39 m)

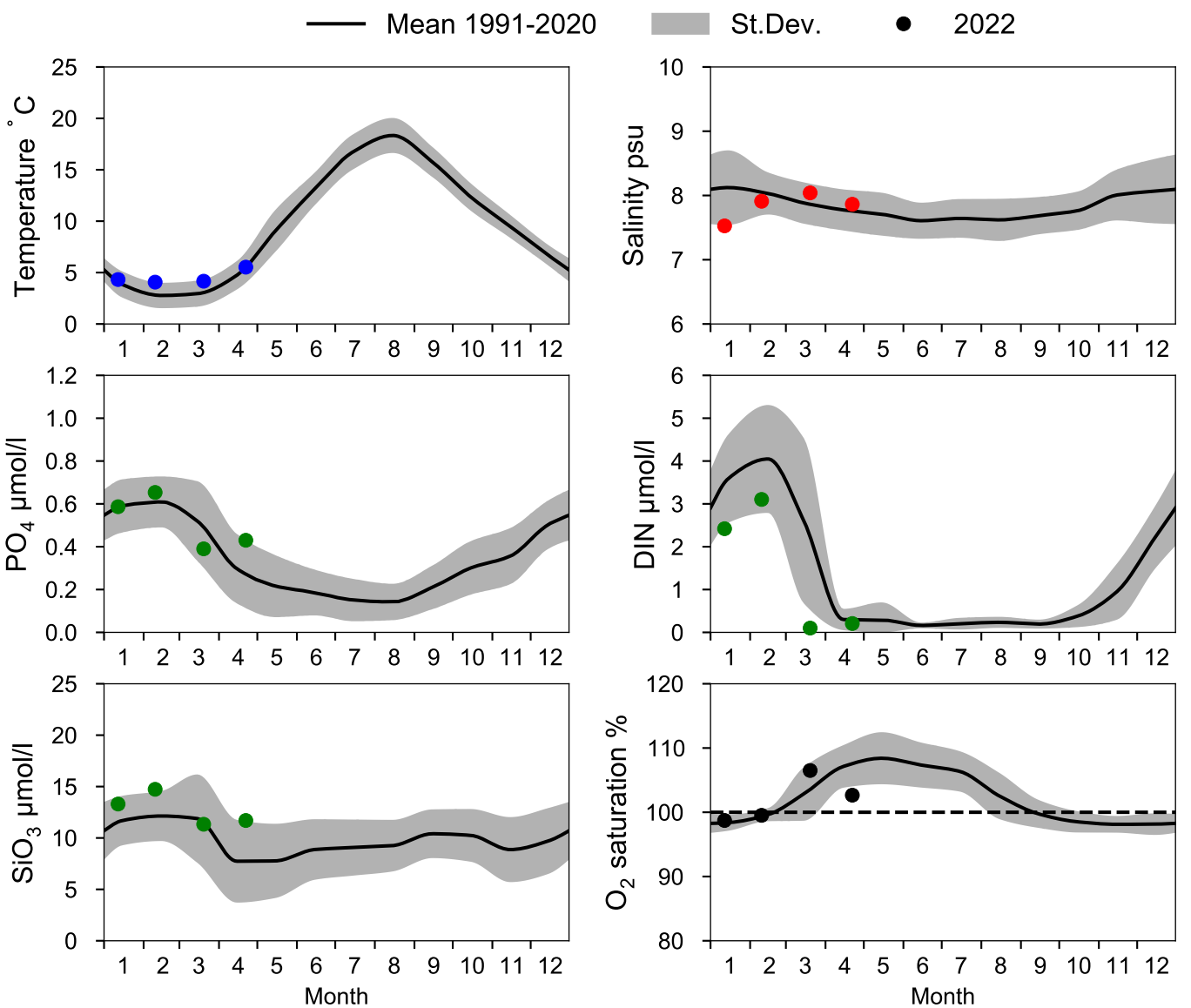


Vertical profiles BY1
April

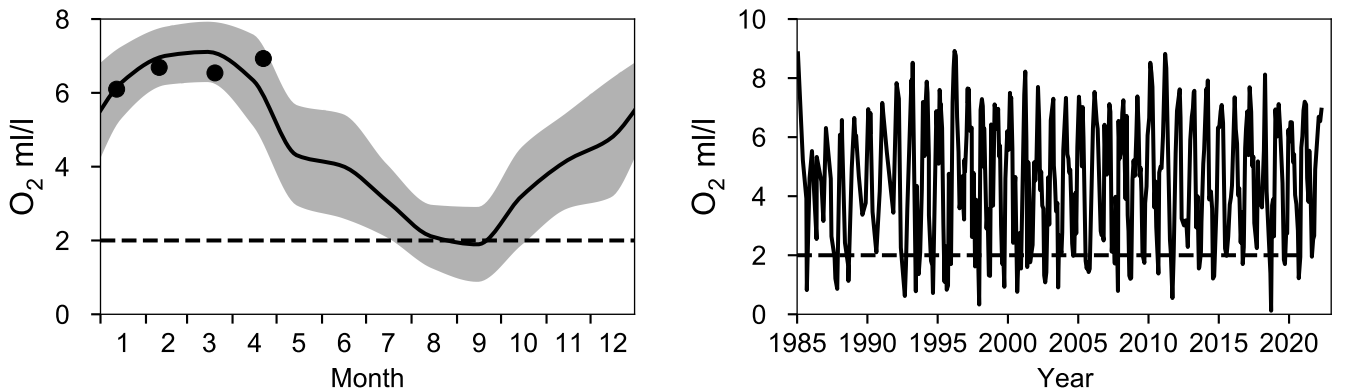


STATION BY2 ARKONA SURFACE WATER (0-10 m)

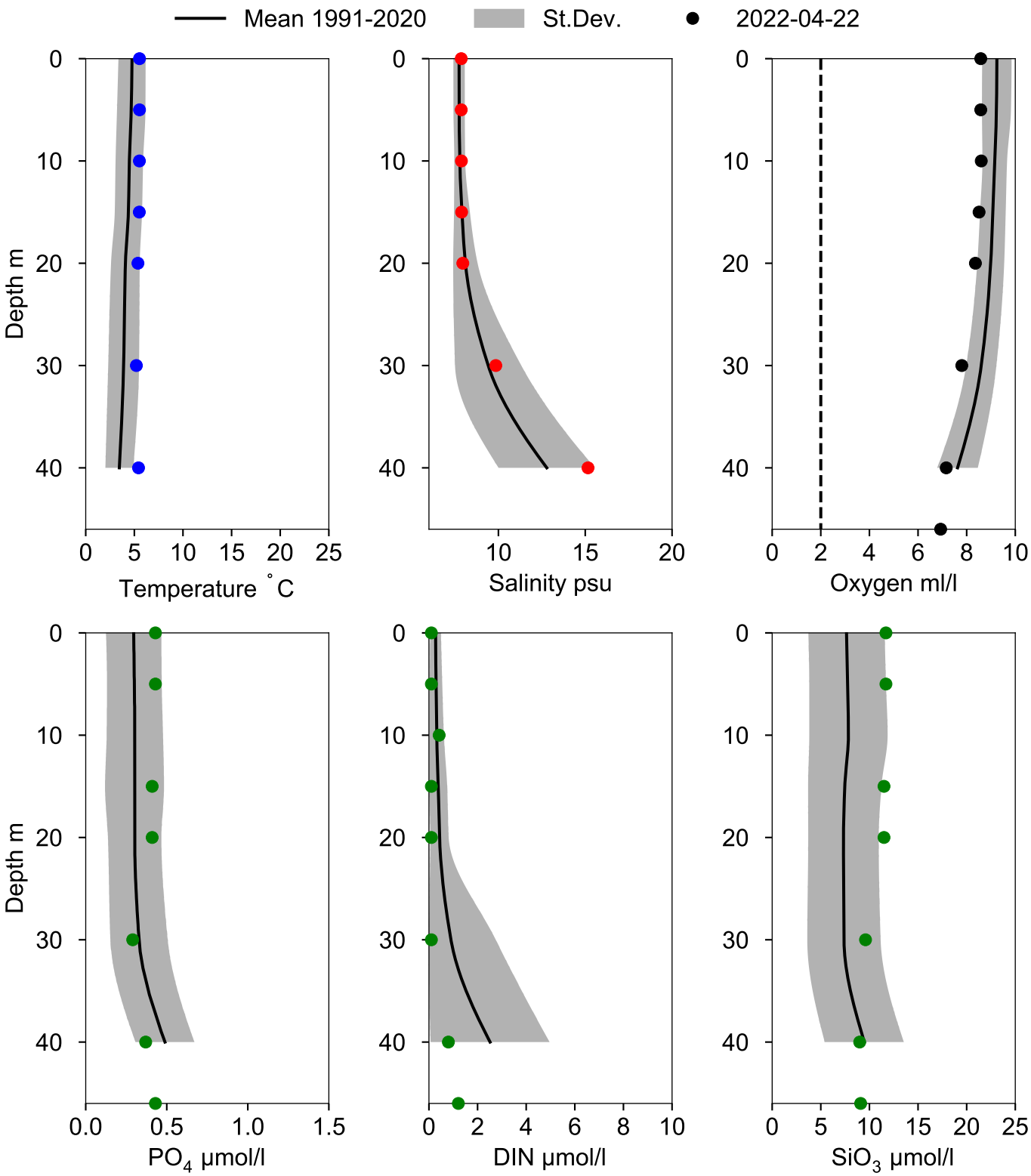
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 40 m)

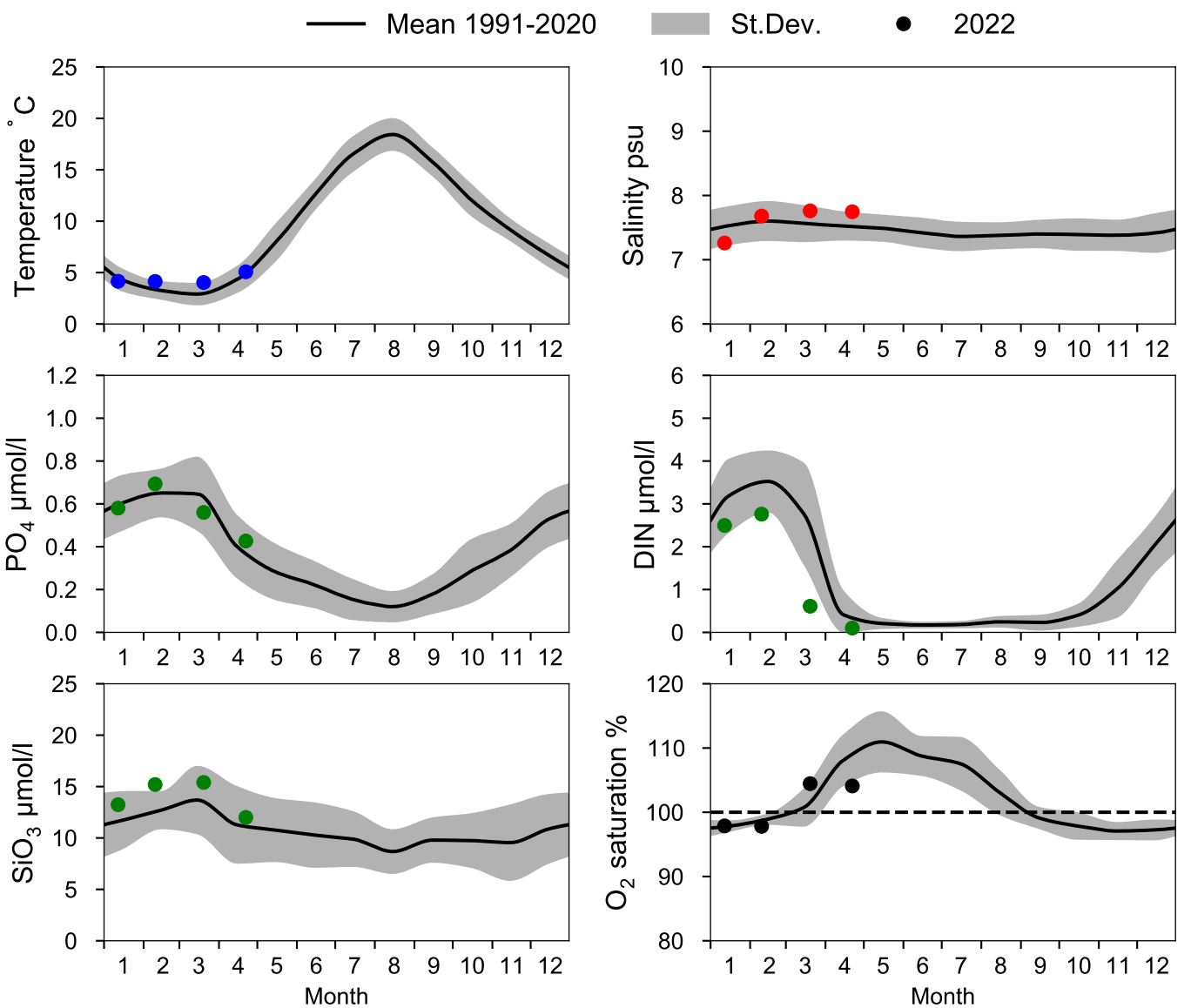


Vertical profiles BY2 ARKONA
April

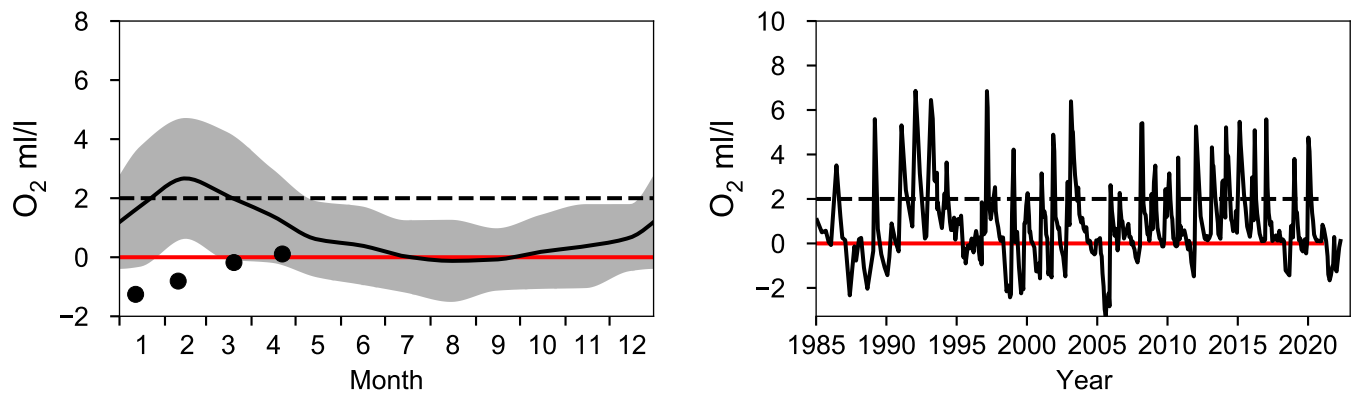


STATION BY4 CHRISTIANSÖ SURFACE WATER (0-10 m)

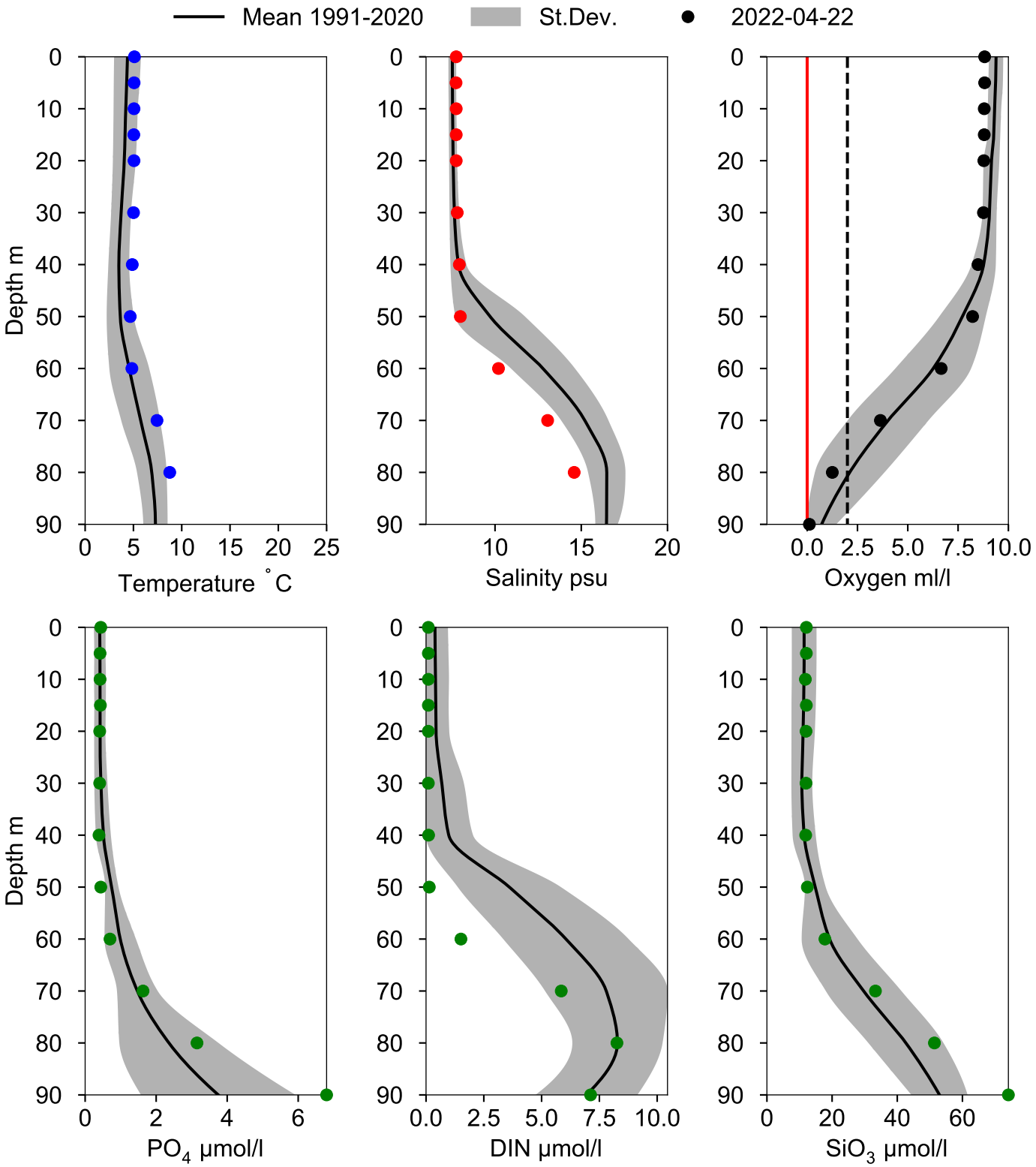
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

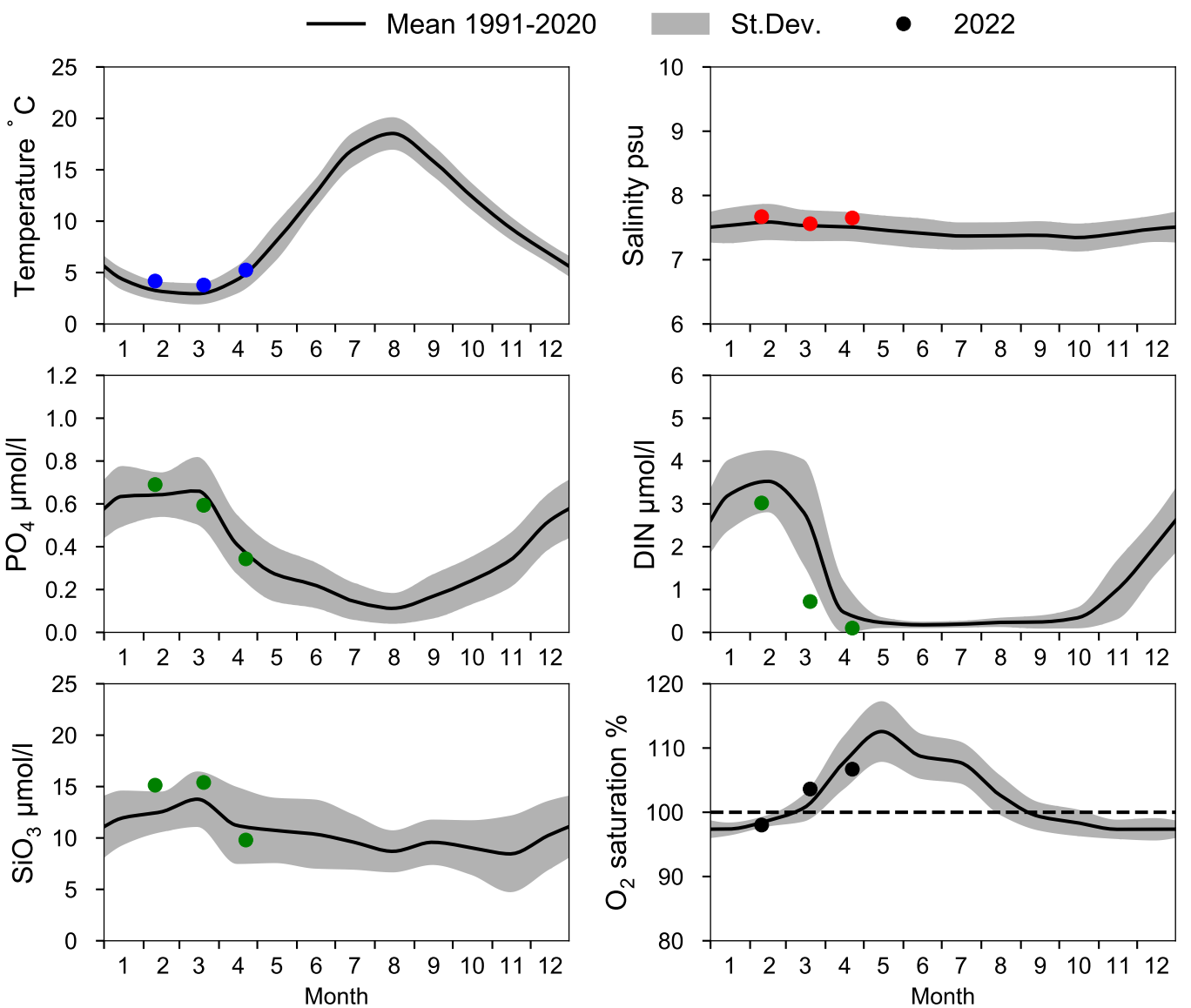


Vertical profiles BY4 CHRISTIANSÖ
April

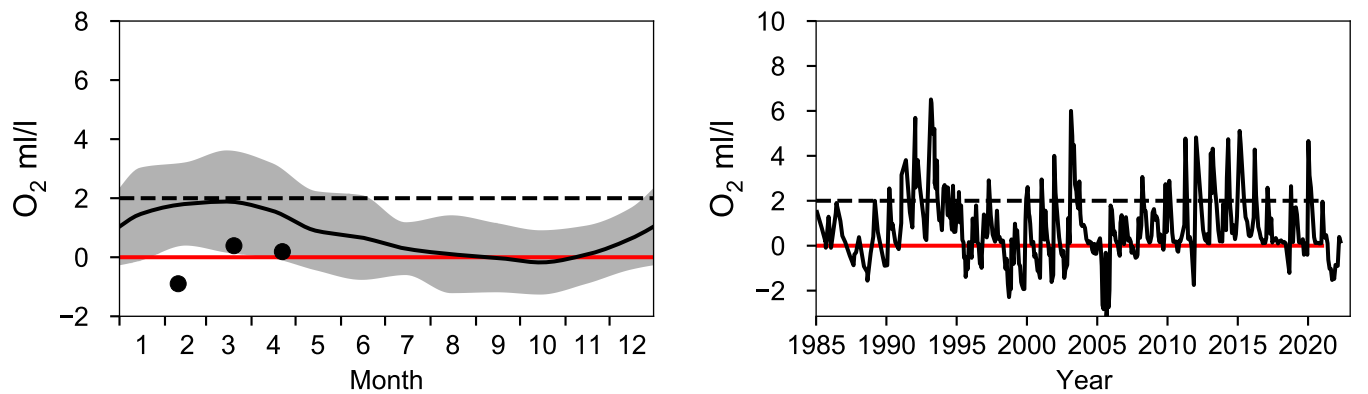


STATION BY5 BORNHOLMSDJ SURFACE WATER (0-10 m)

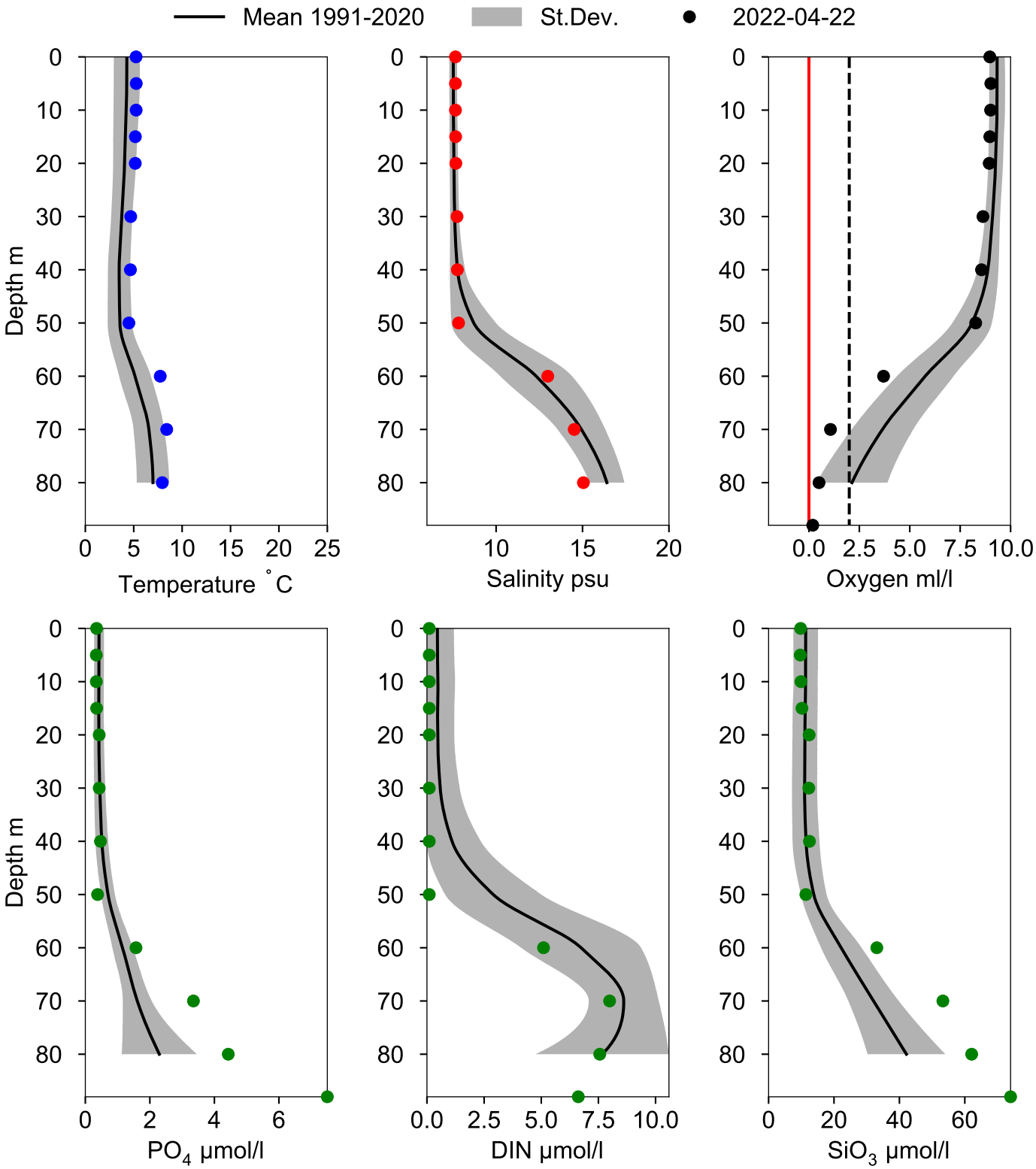
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

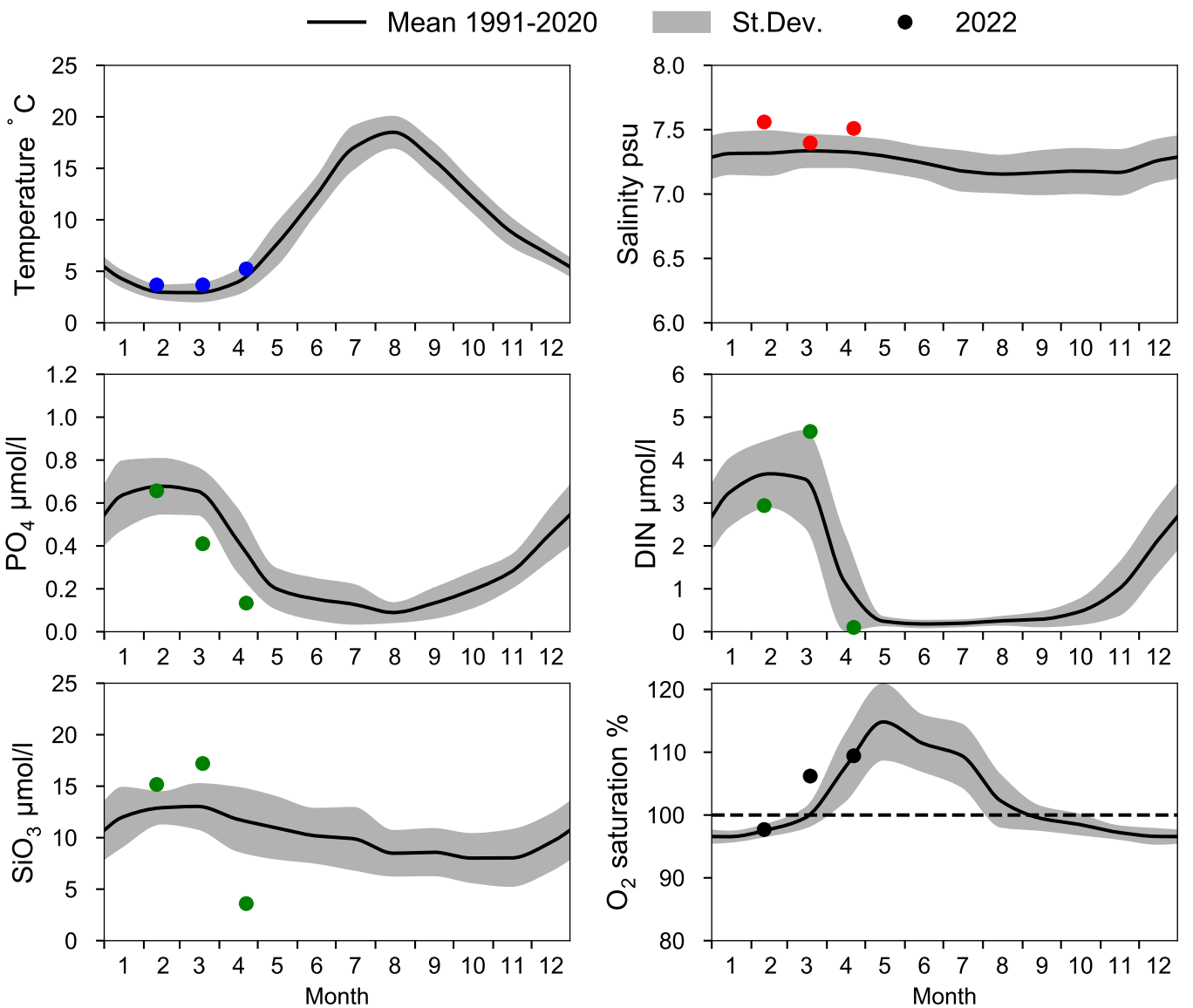


Vertical profiles BY5 BORNHOLMSDJ
April

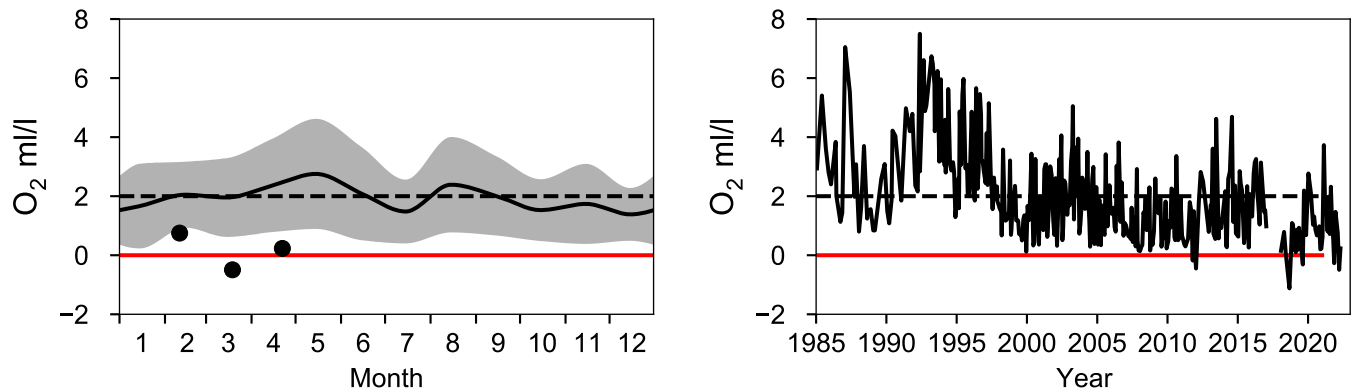


STATION BCS III-10 SURFACE WATER (0-10 m)

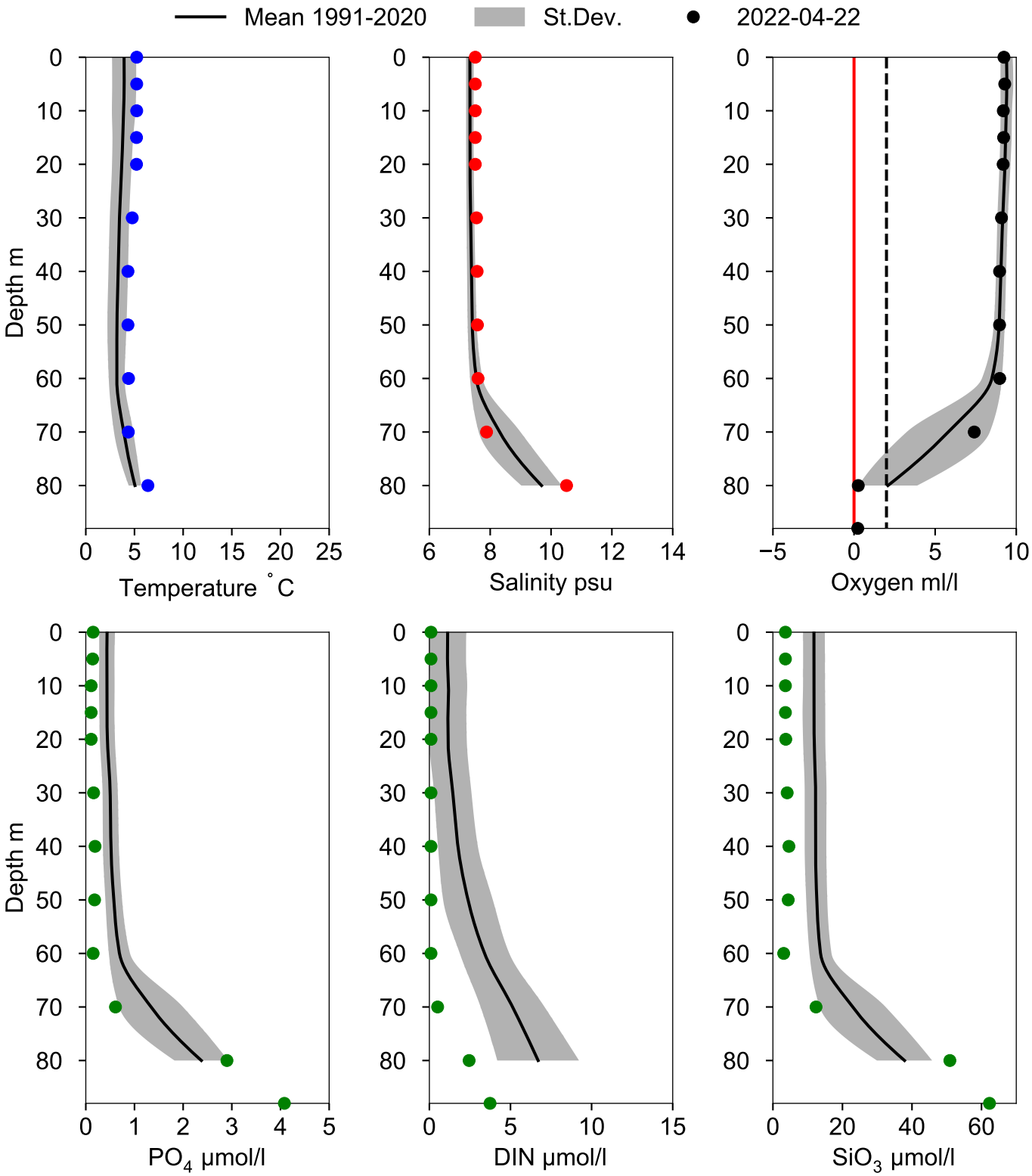
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

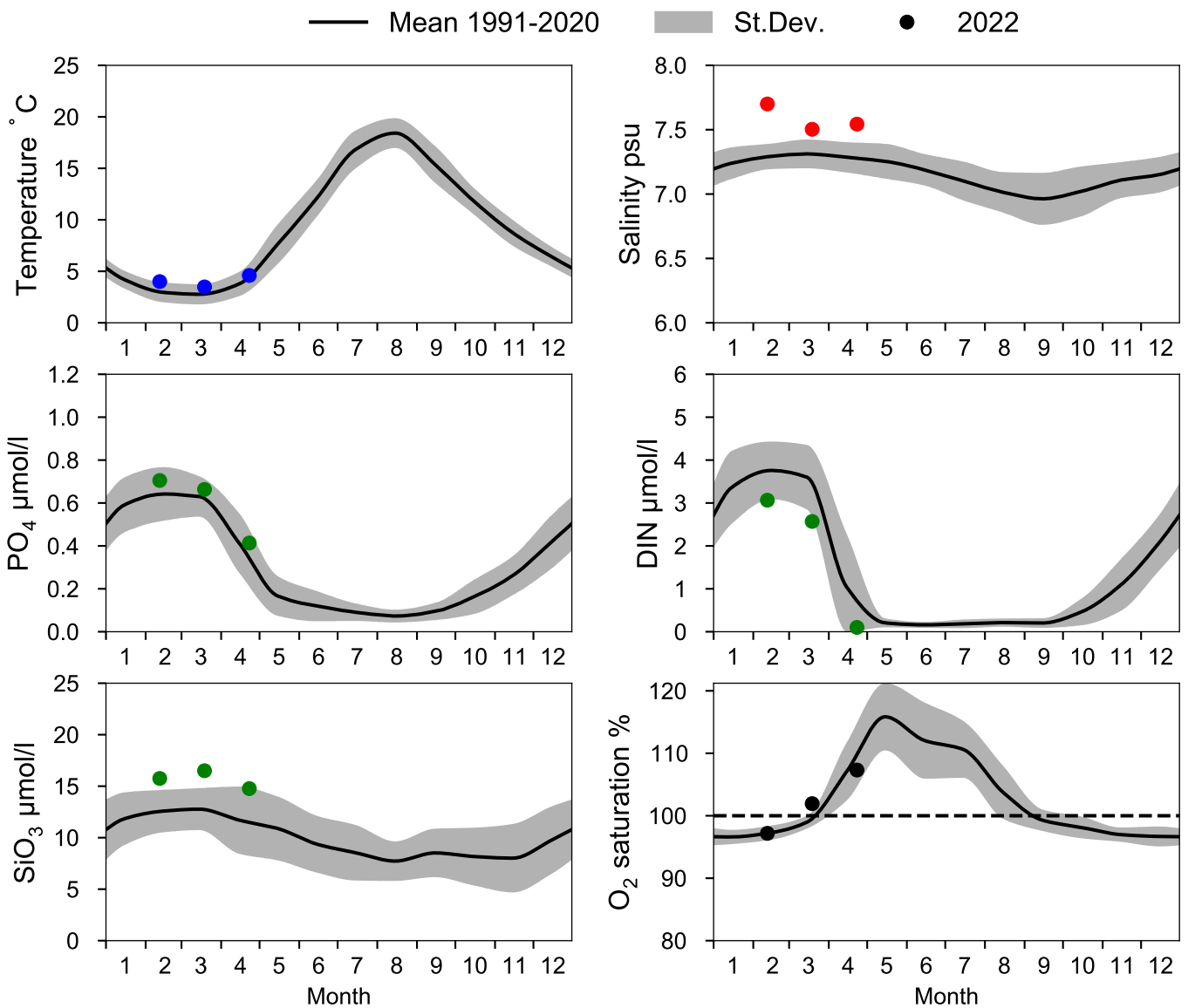


Vertical profiles BCS III-10
April

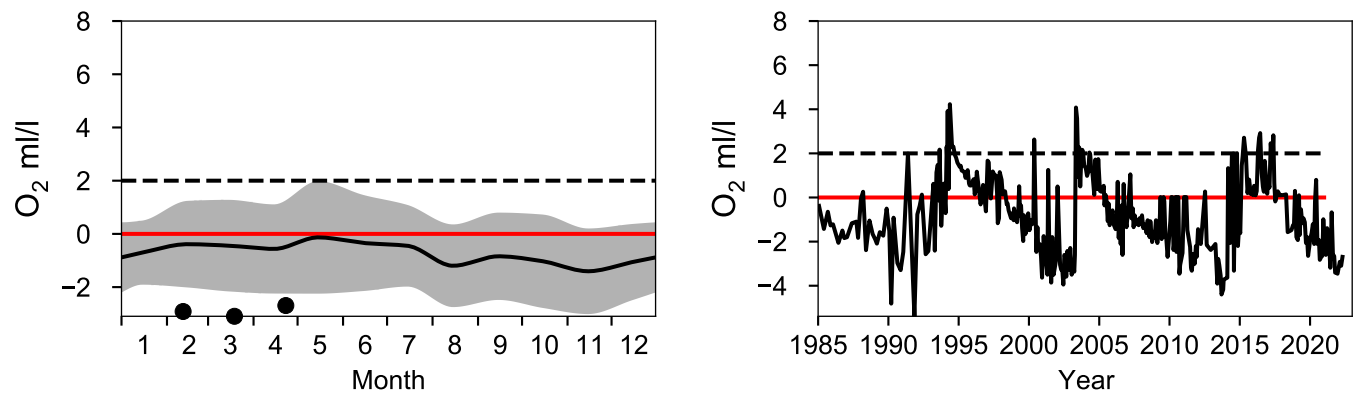


STATION BY10 SURFACE WATER (0-10 m)

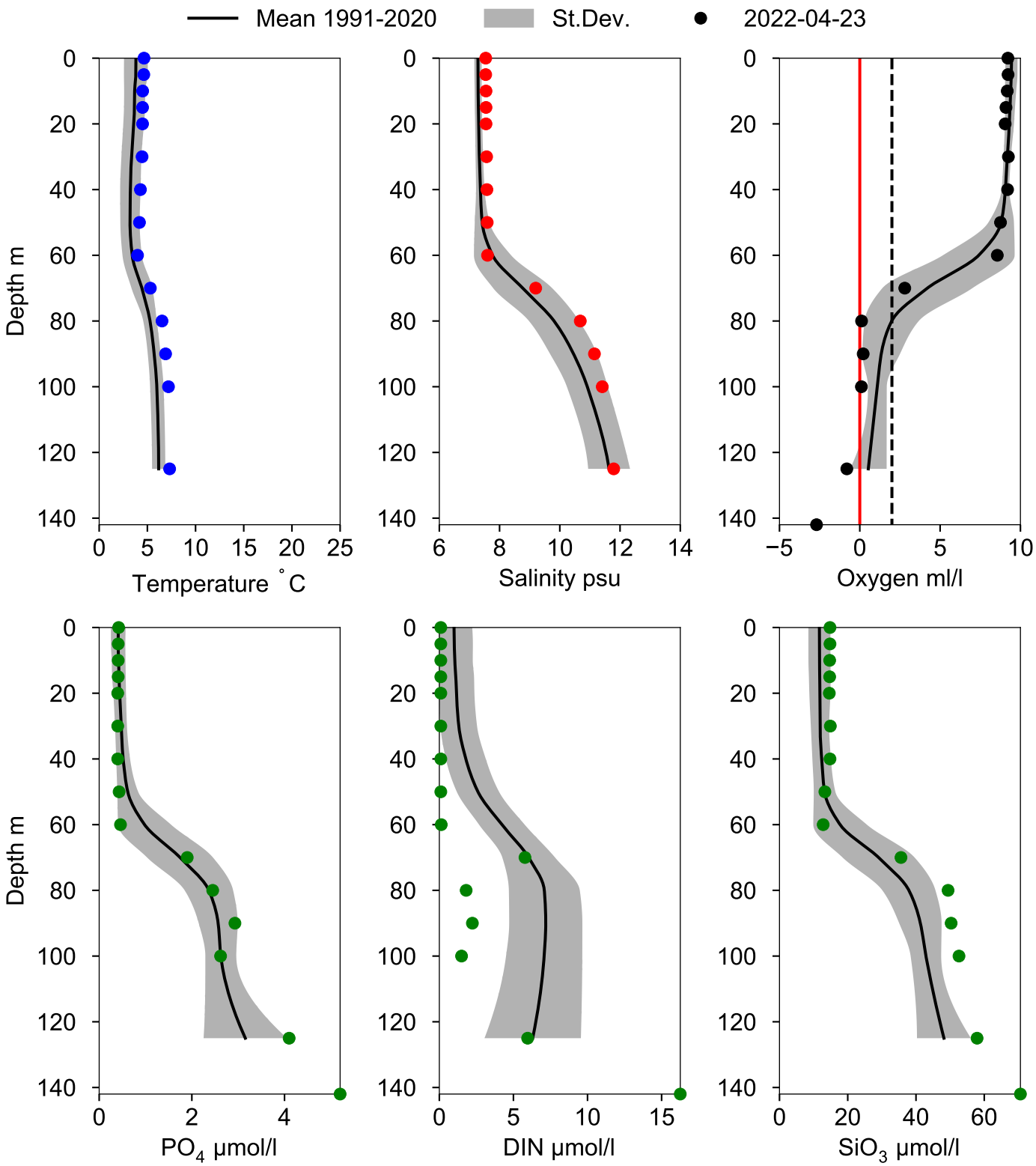
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 125 m)

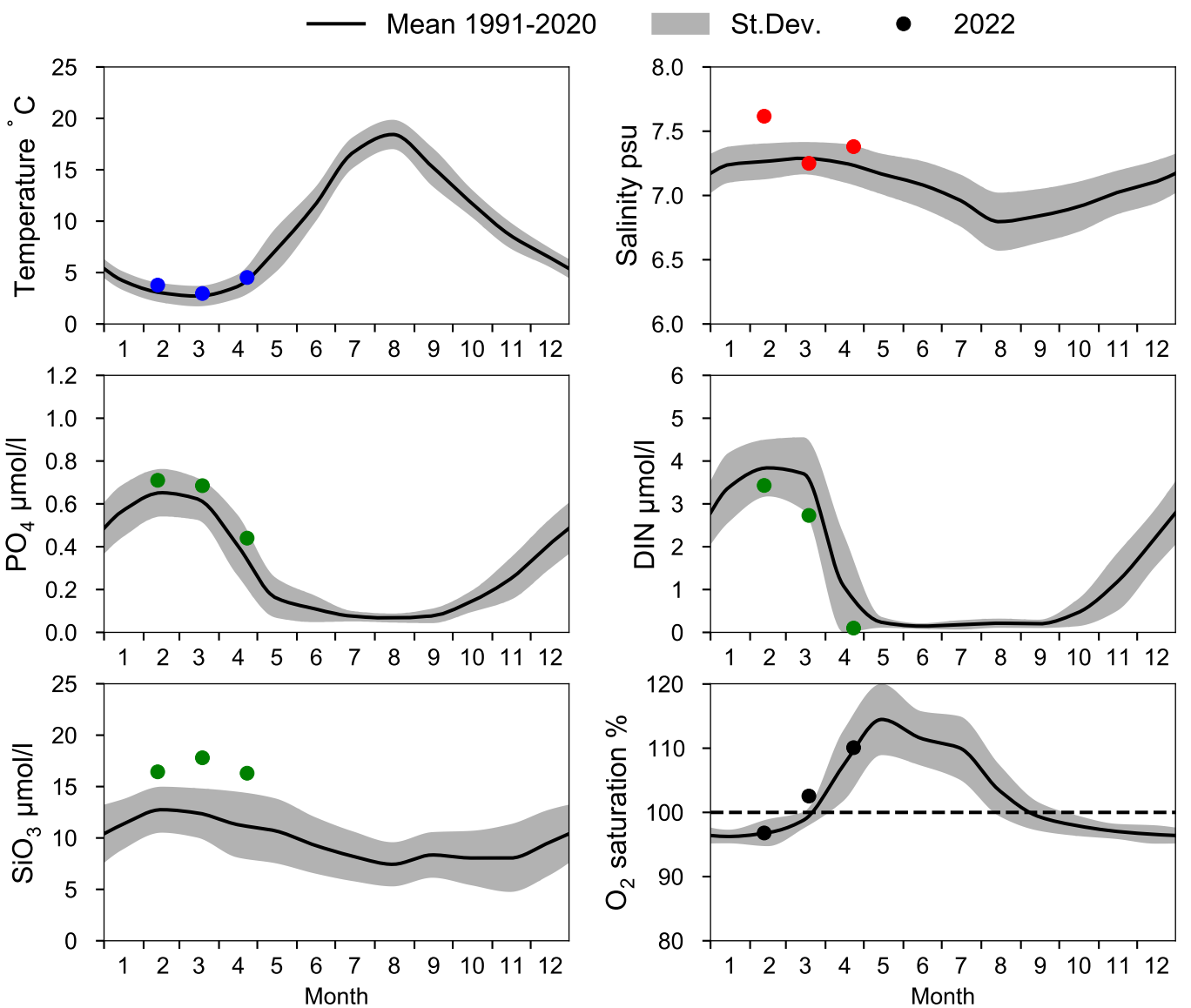


Vertical profiles BY10
April

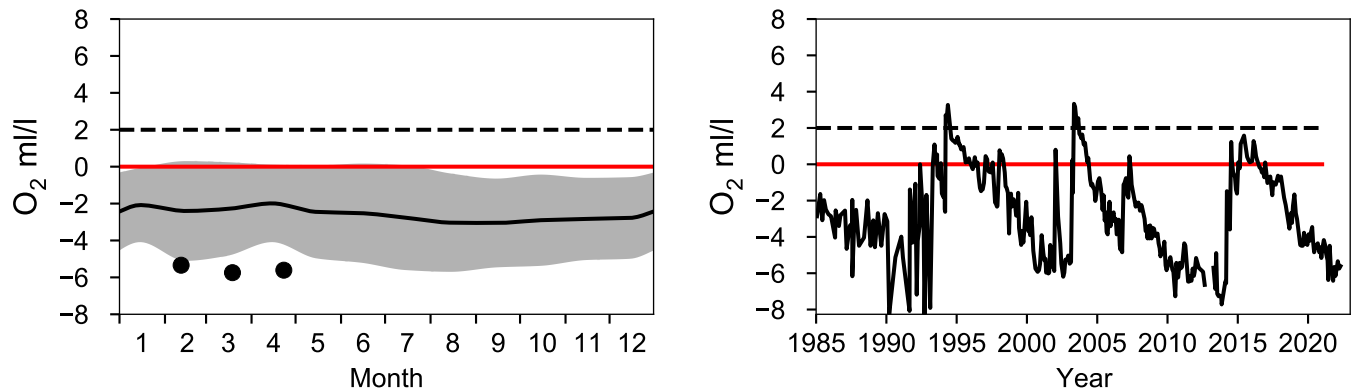


STATION BY15 GOTLANDSDJ SURFACE WATER (0-10 m)

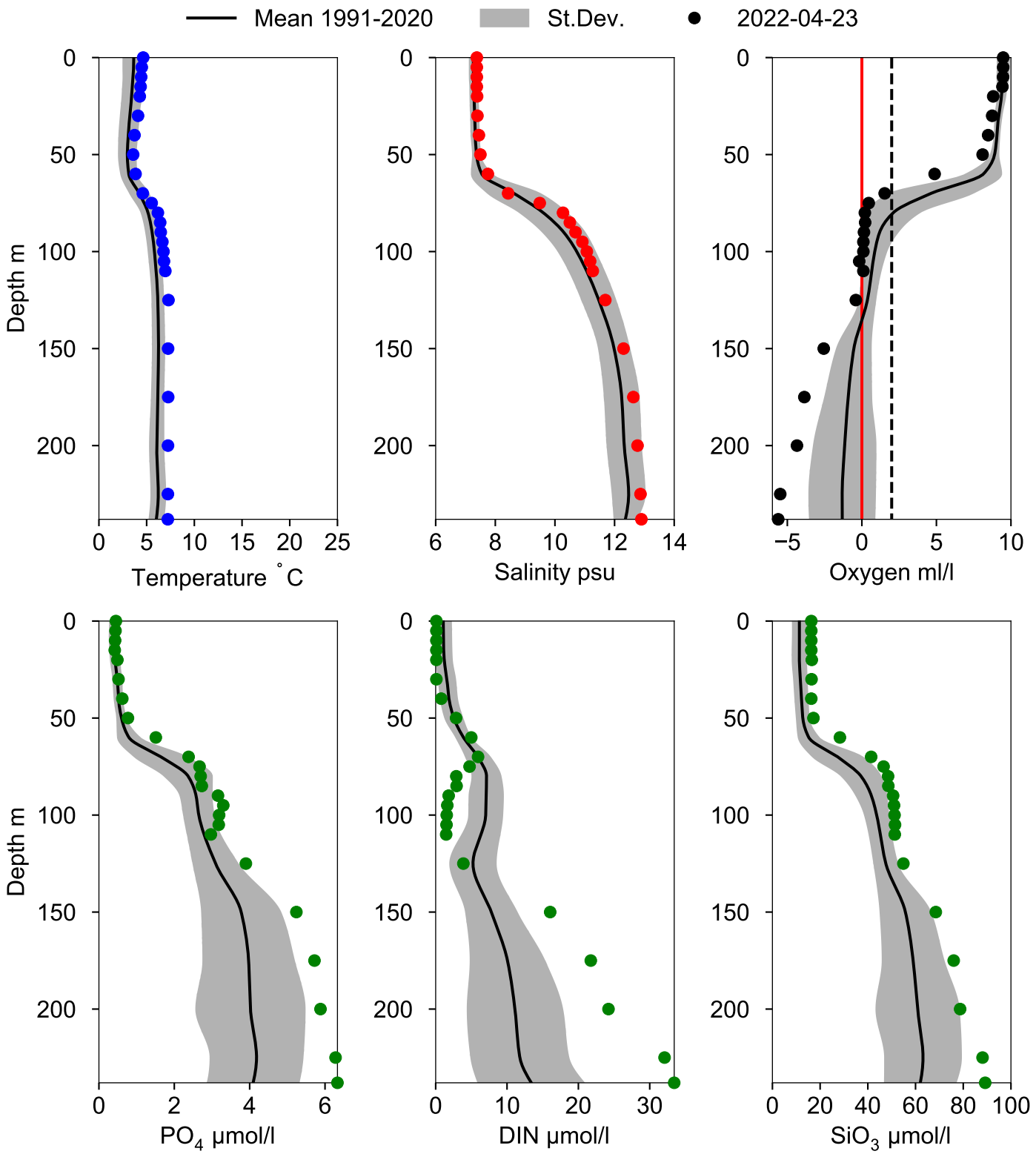
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 225 m)

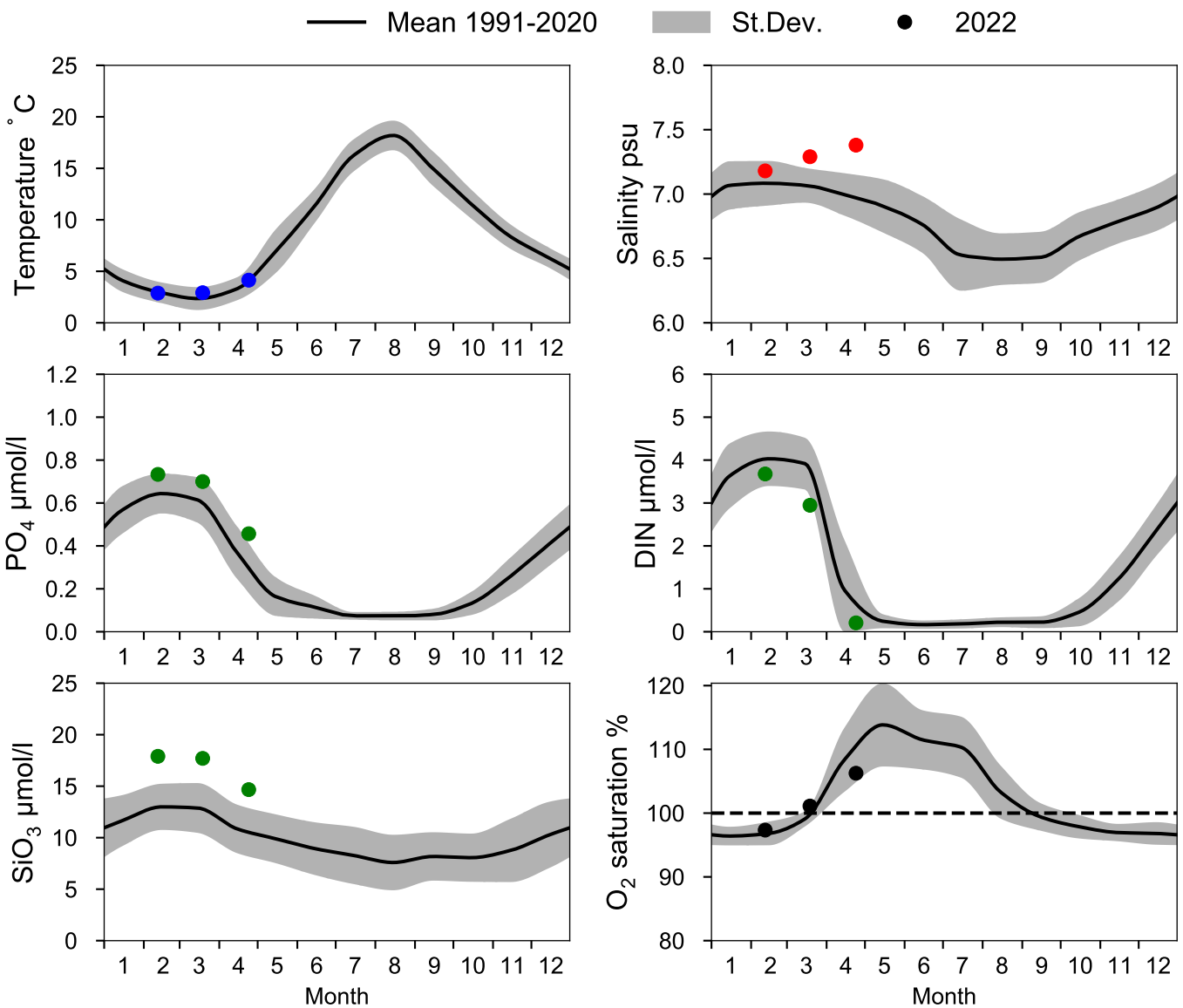


Vertical profiles BY15 GOTLANDSDJ
April

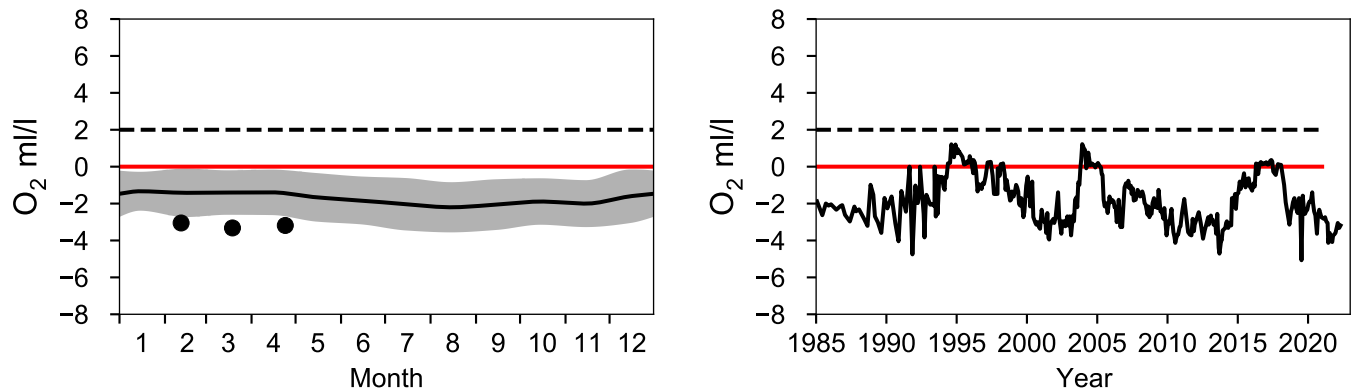


STATION BY20 FÅRÖDJ SURFACE WATER (0-10 m)

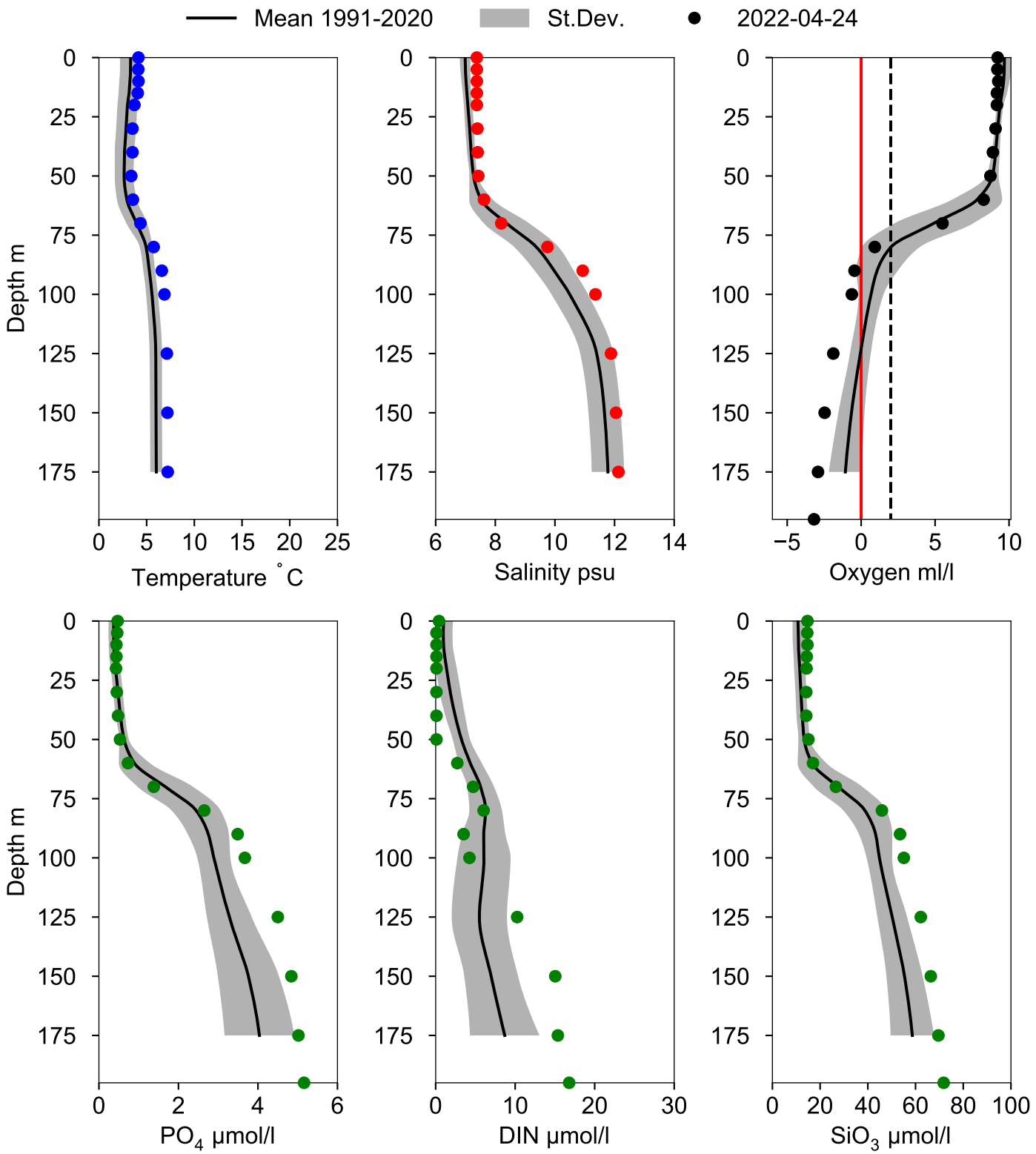
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 175 m)

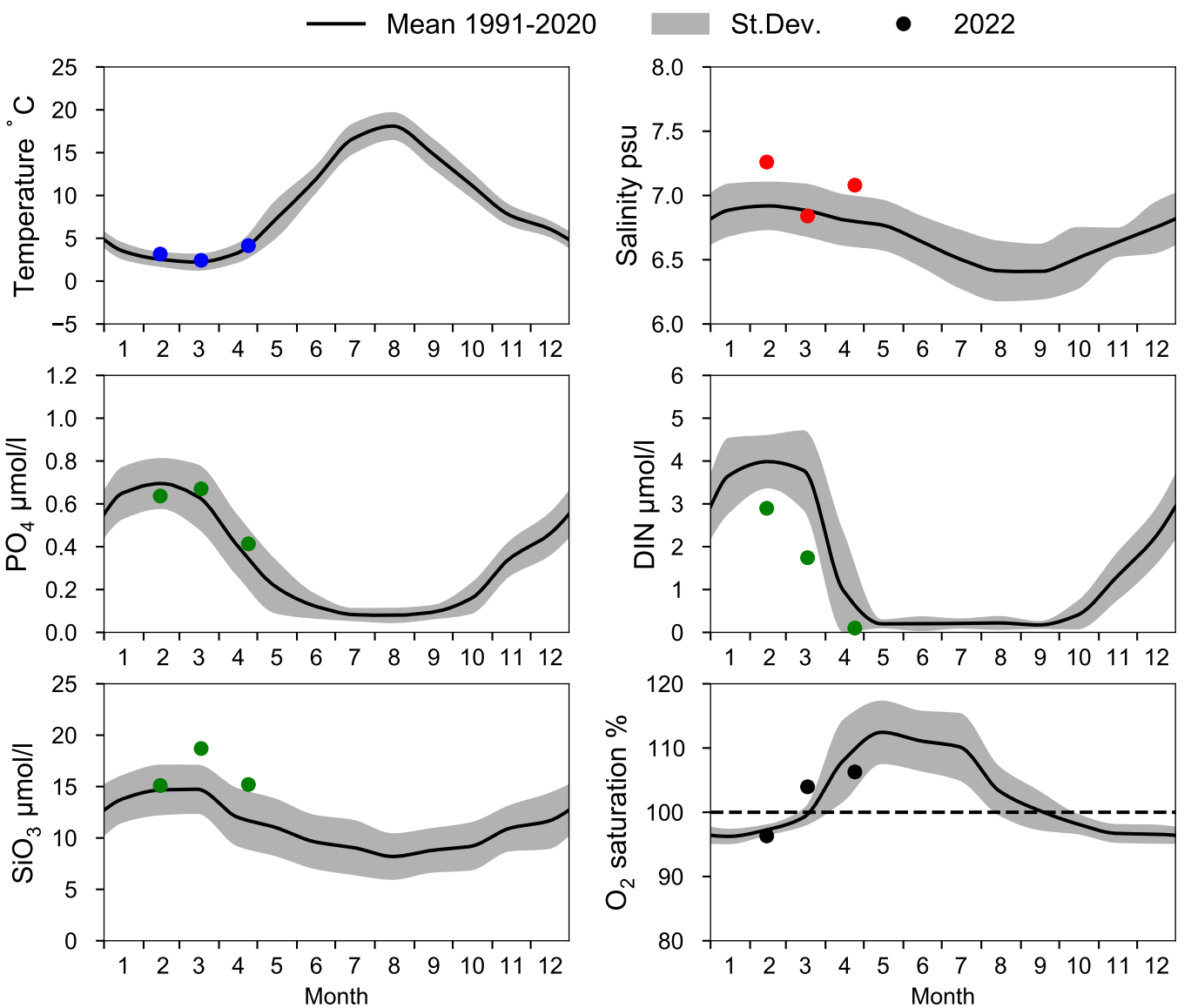


Vertical profiles BY20 FÅRÖDJ
April

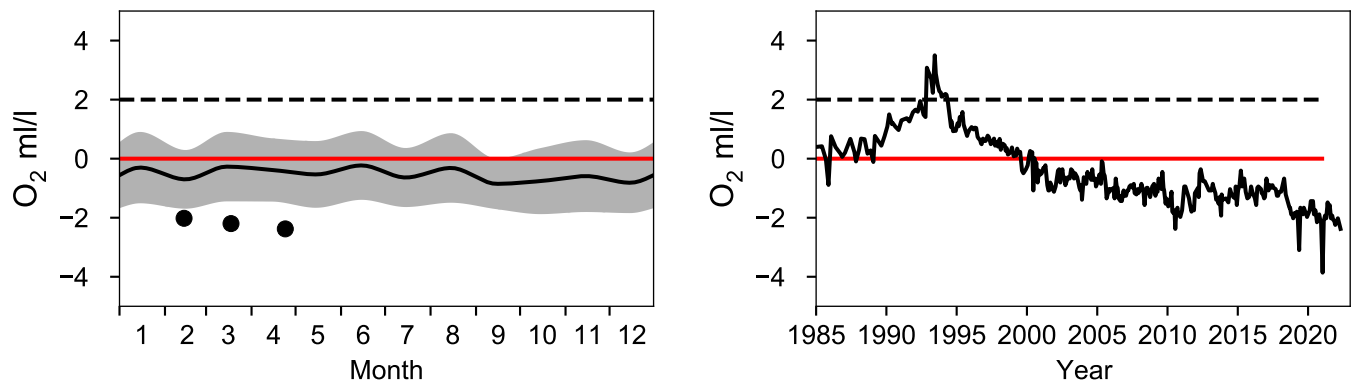


STATION BY32 NORRKÖPINGSDJ SURFACE WATER (0-10 m)

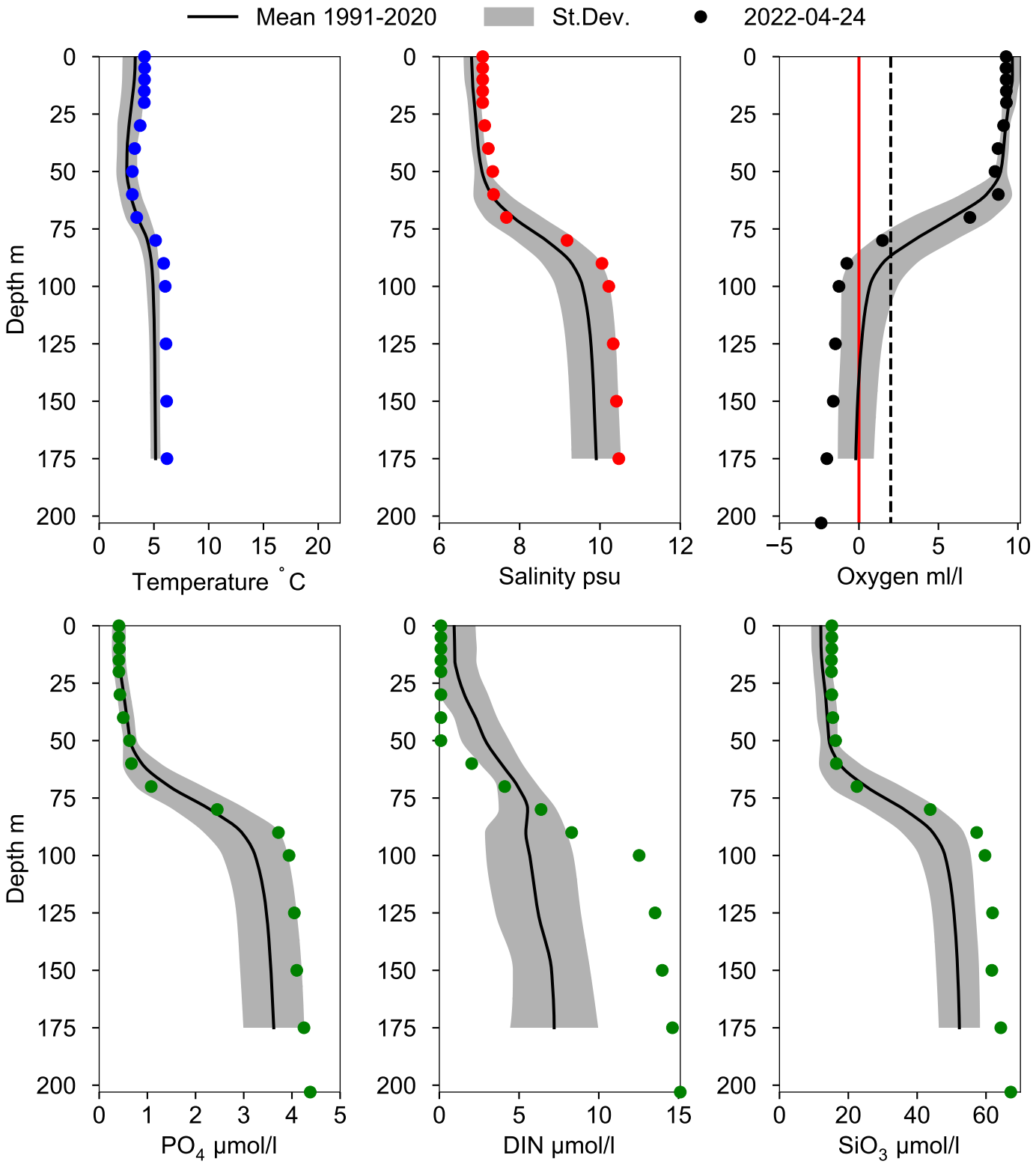
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 175 m)

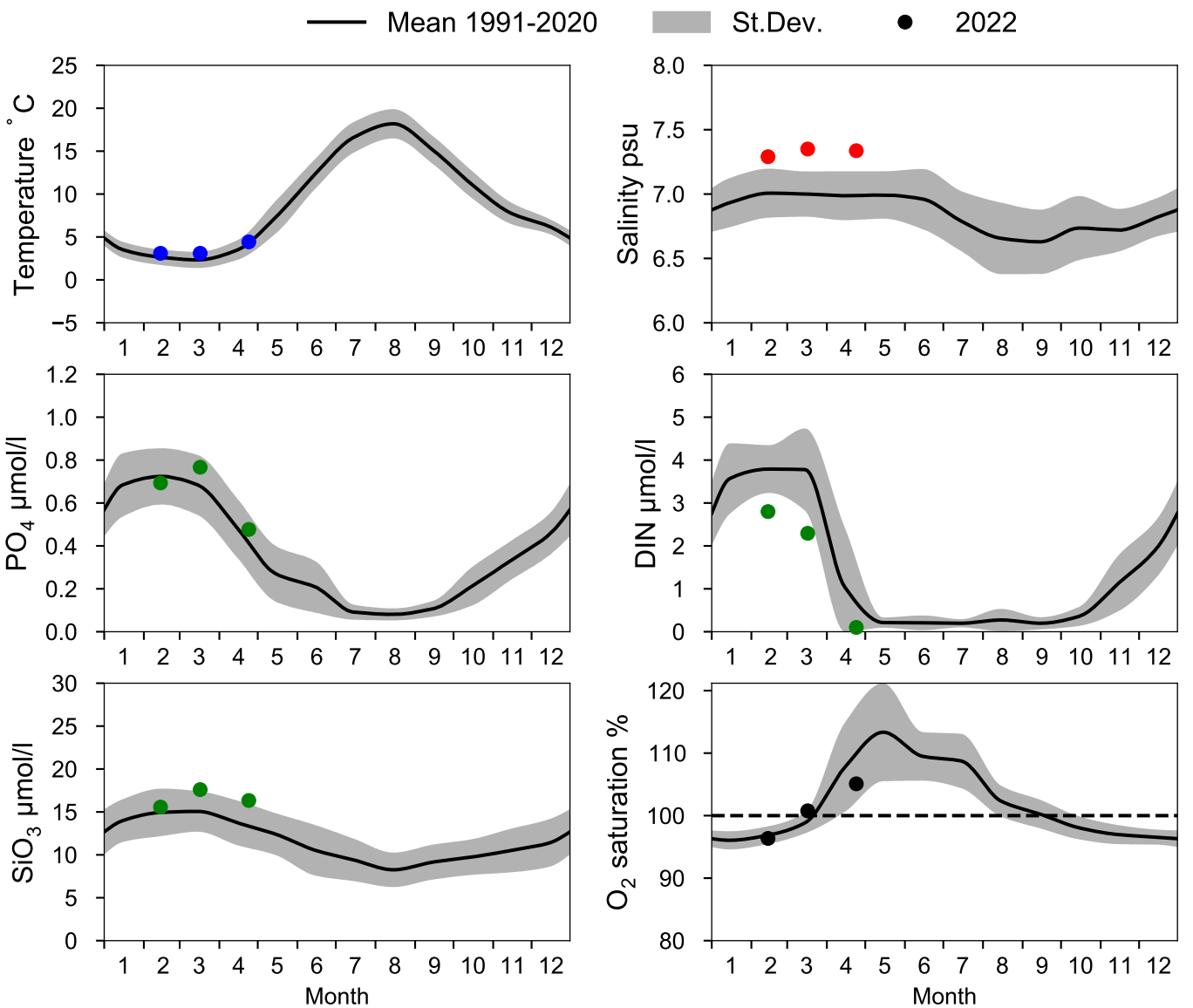


Vertical profiles BY32 NORRKÖPINGSDJ
April

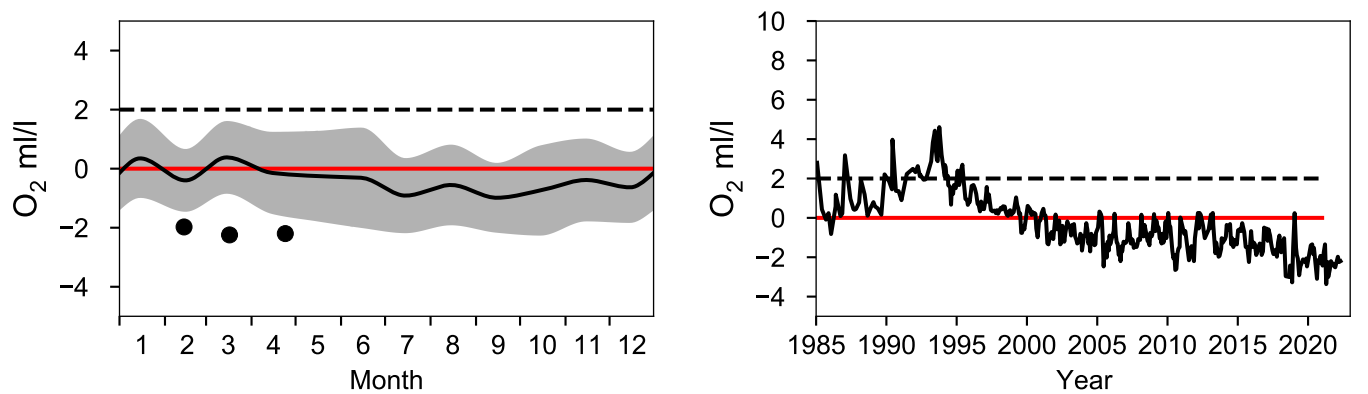


STATION BY38 KARLSÖDJ SURFACE WATER (0-10 m)

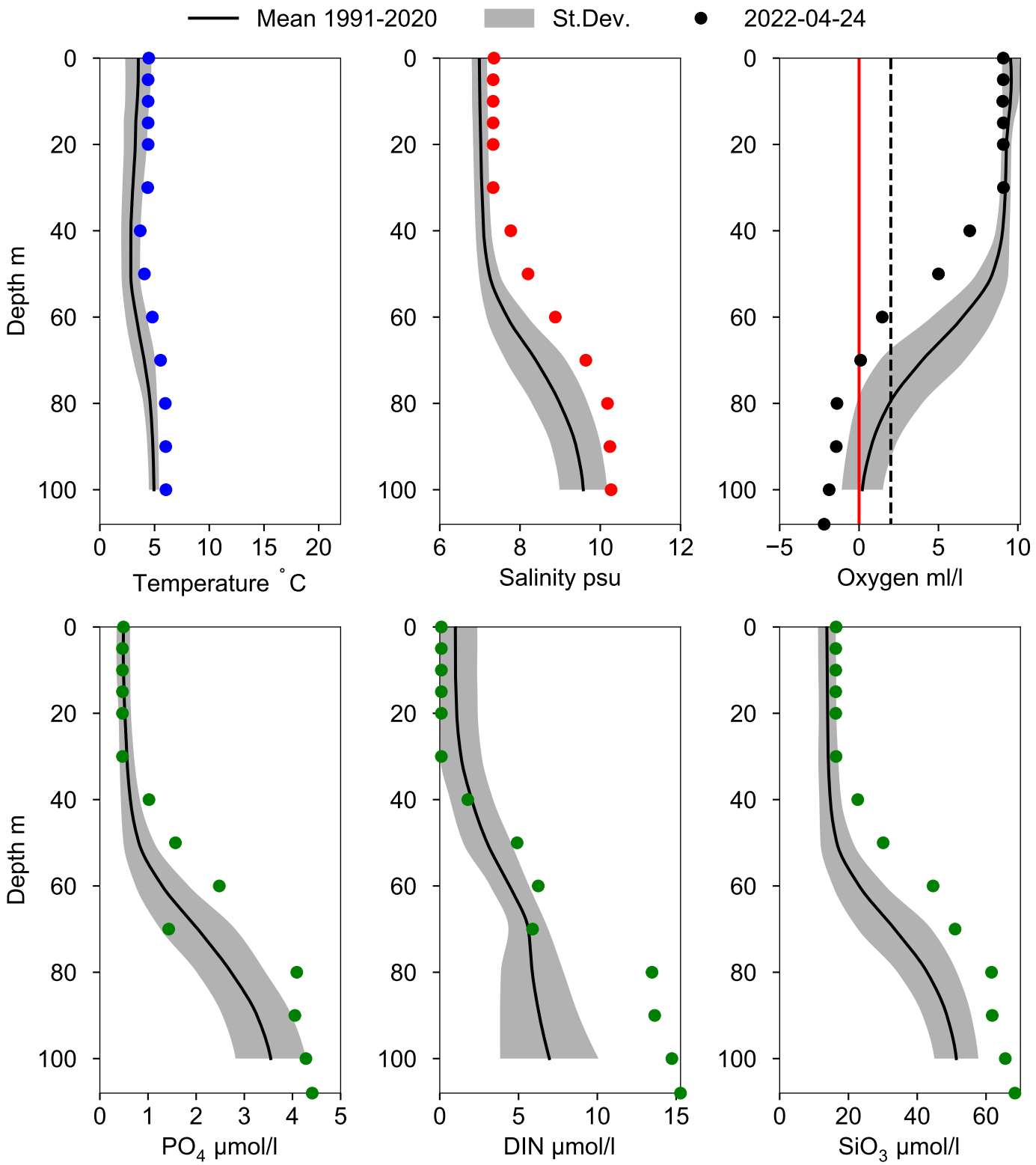
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 100 m)

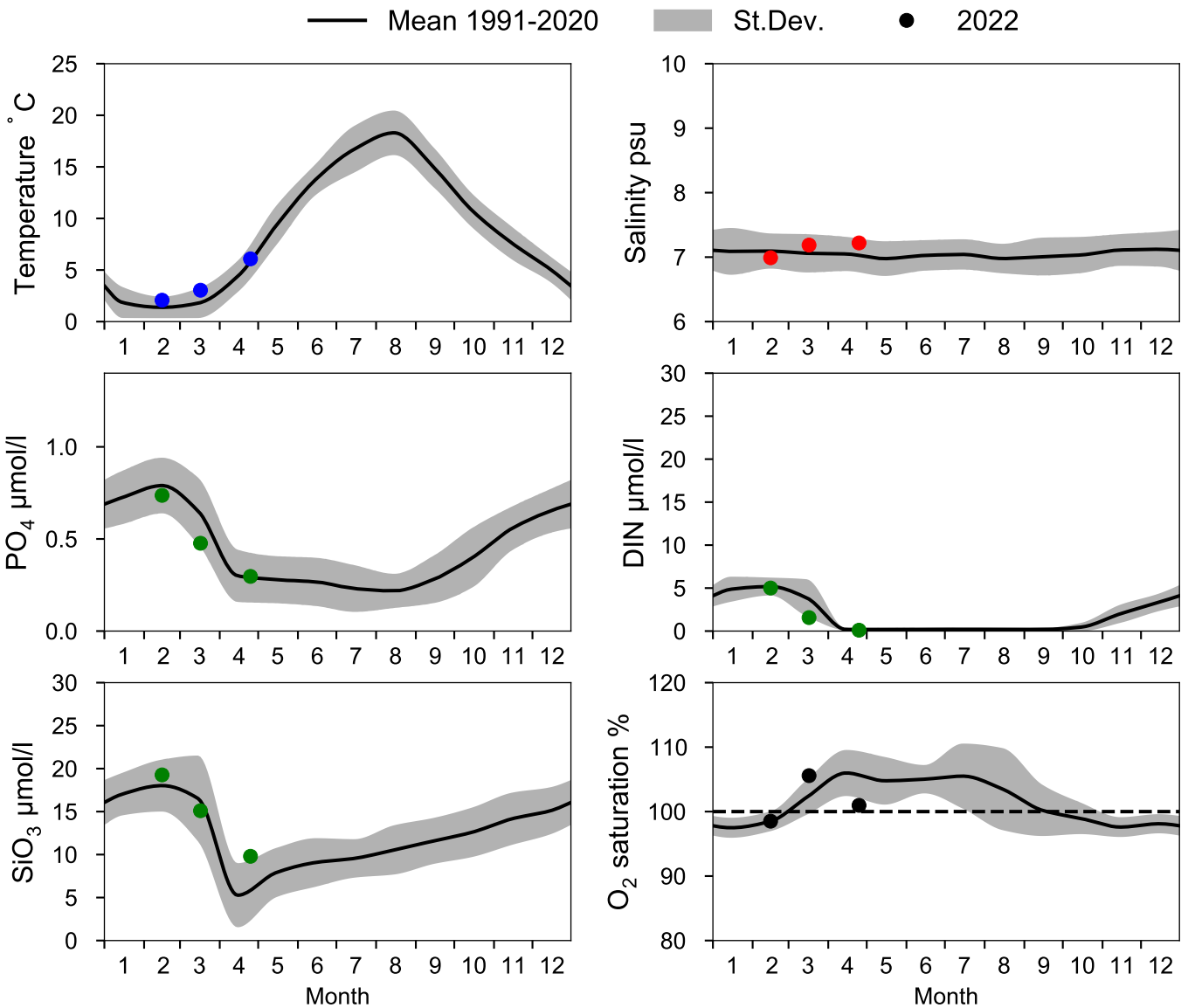


Vertical profiles BY38 KARLSÖDJ
April

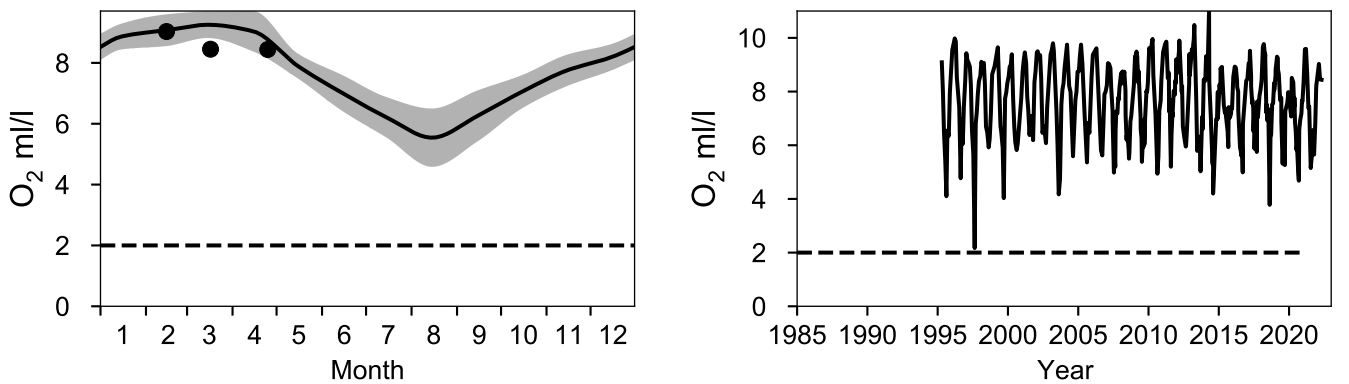


STATION REF M1V1 SURFACE WATER (0-10 m)

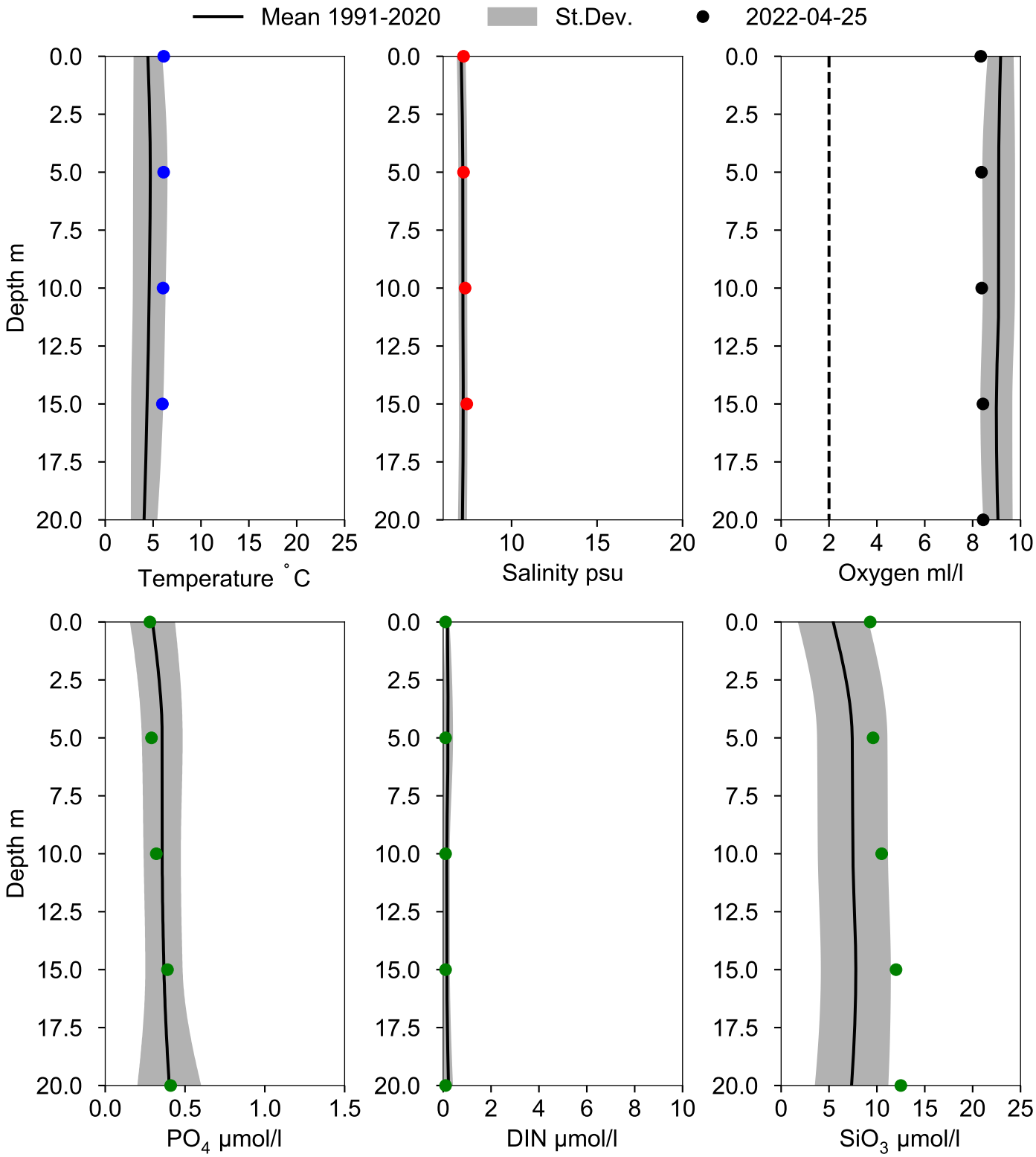
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 15 m)

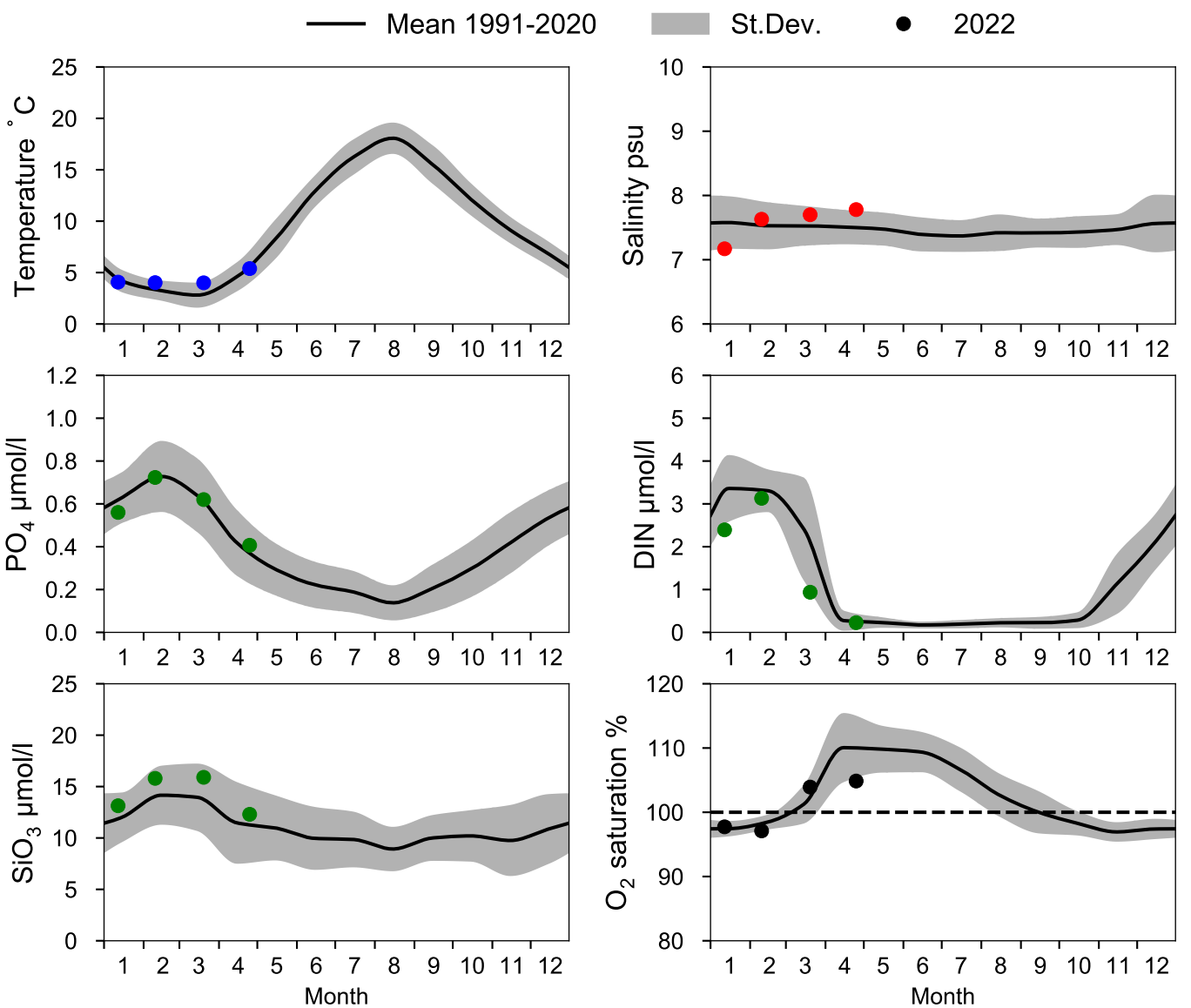


Vertical profiles REF M1V1
April

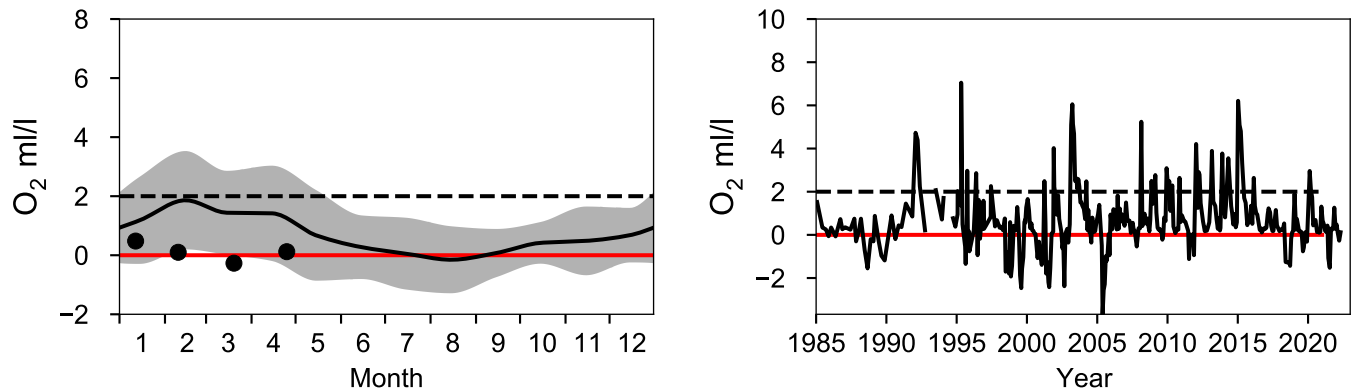


STATION HANÖBUKTEN SURFACE WATER (0-10 m)

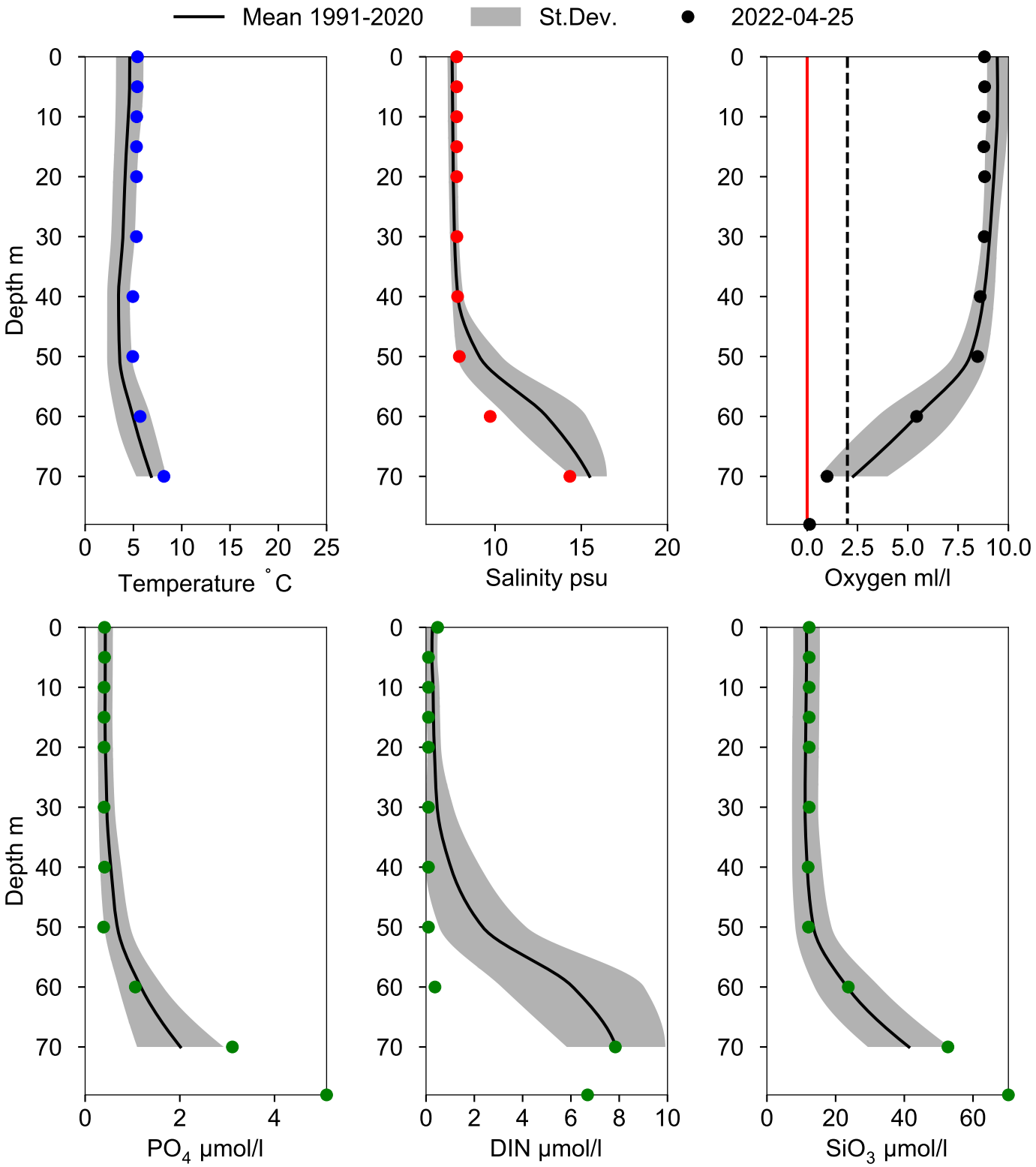
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 70 m)

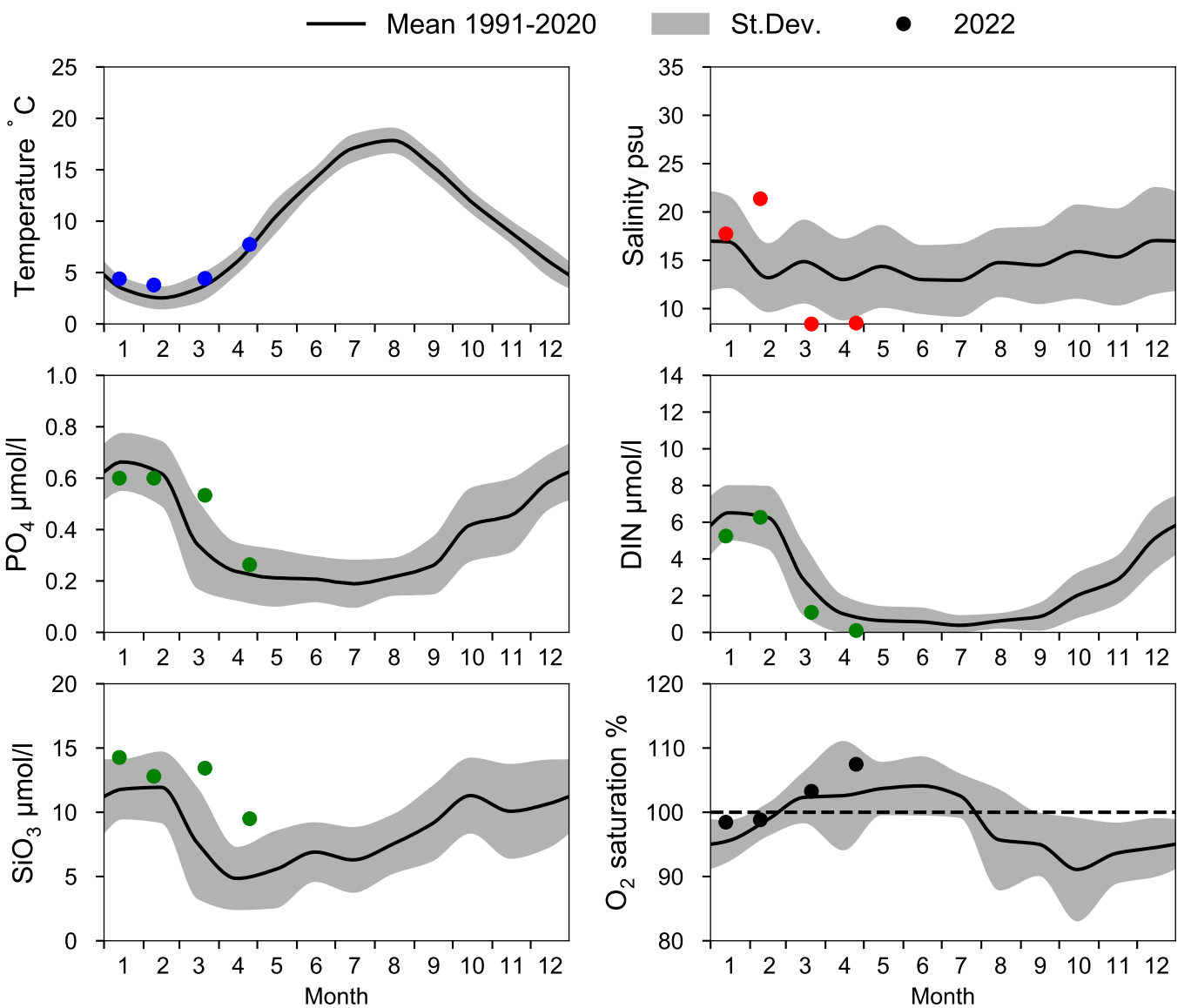


Vertical profiles HANÖBUKTEN
April

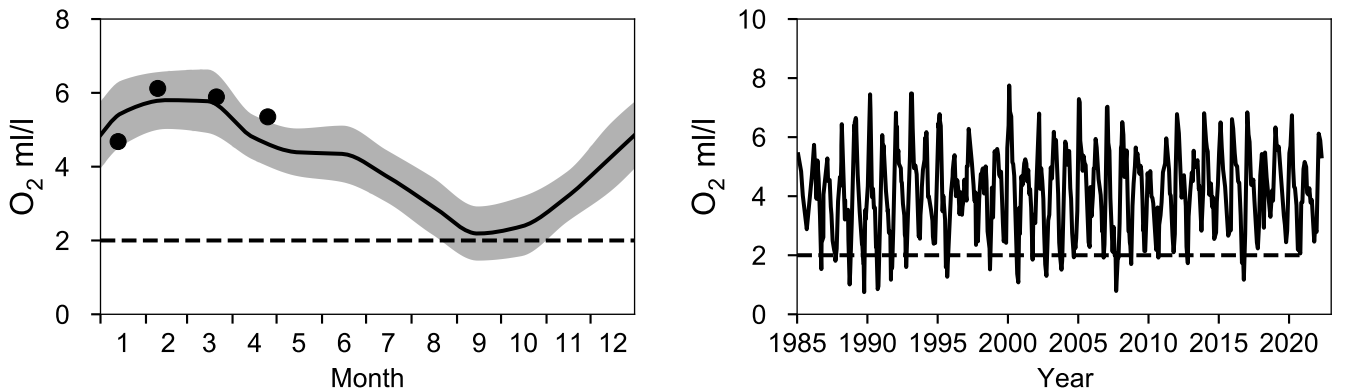


STATION W LANDSKRONA SURFACE WATER (0-10 m)

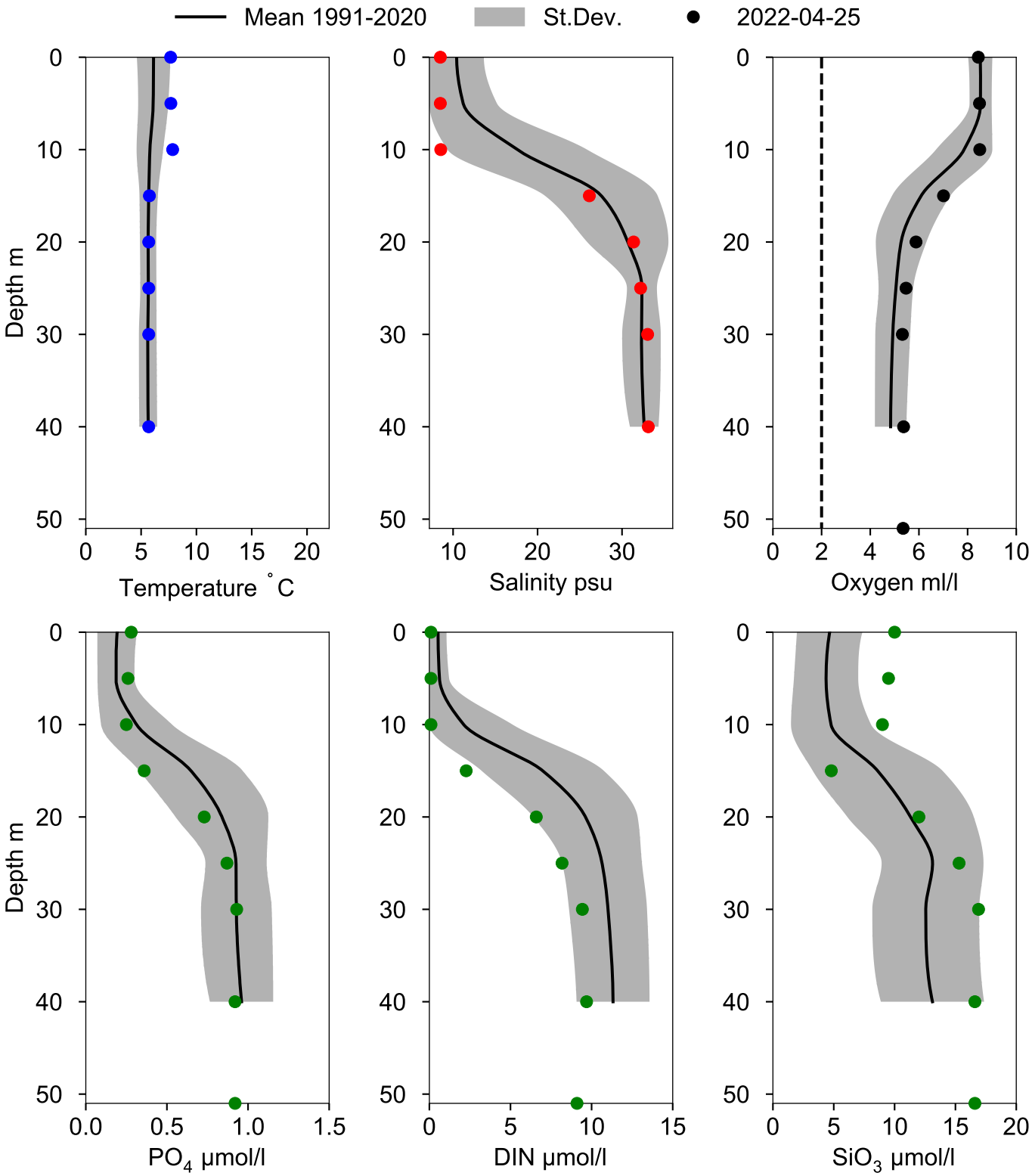
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 40 m)

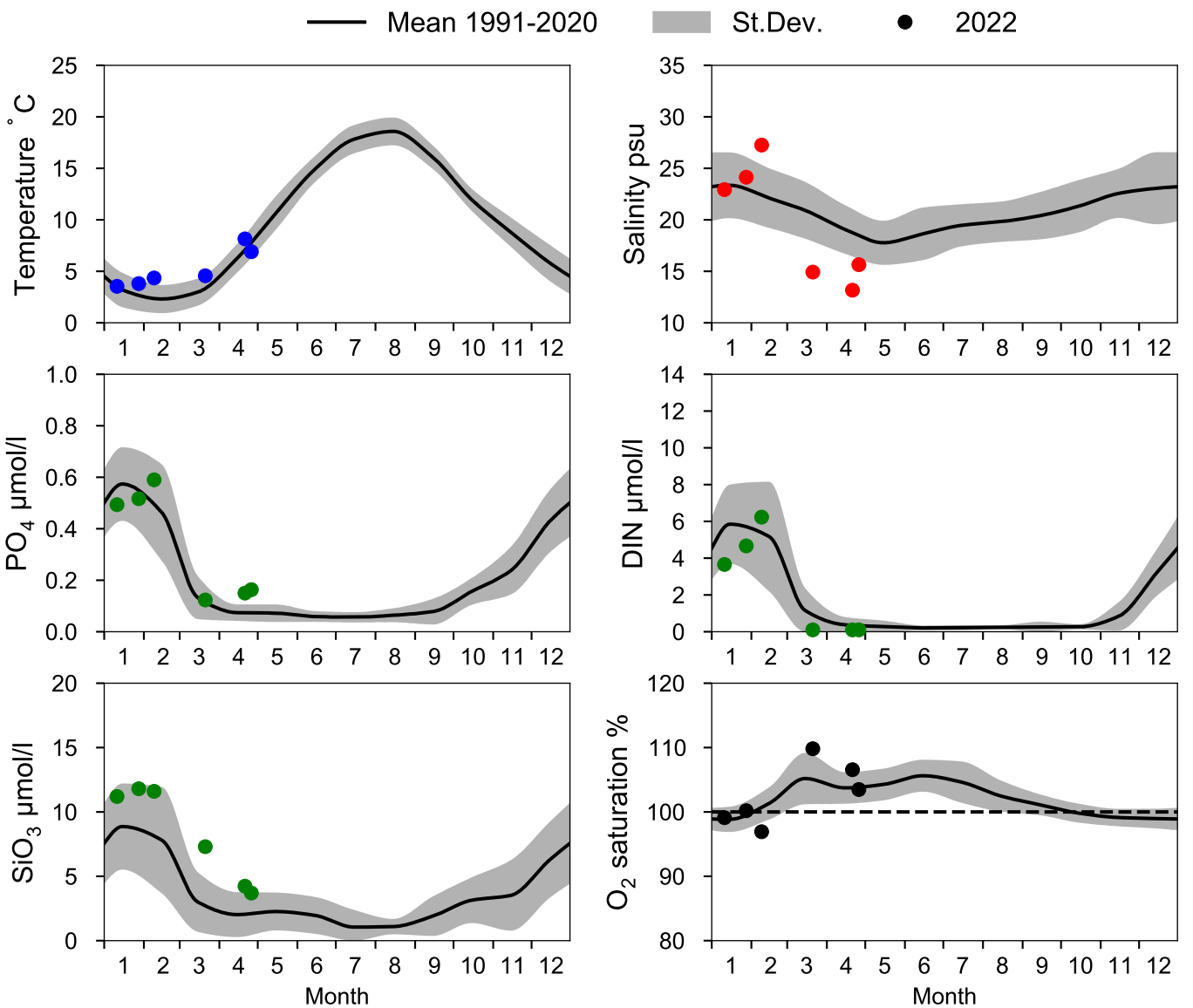


Vertical profiles W LANDSKRONA
April

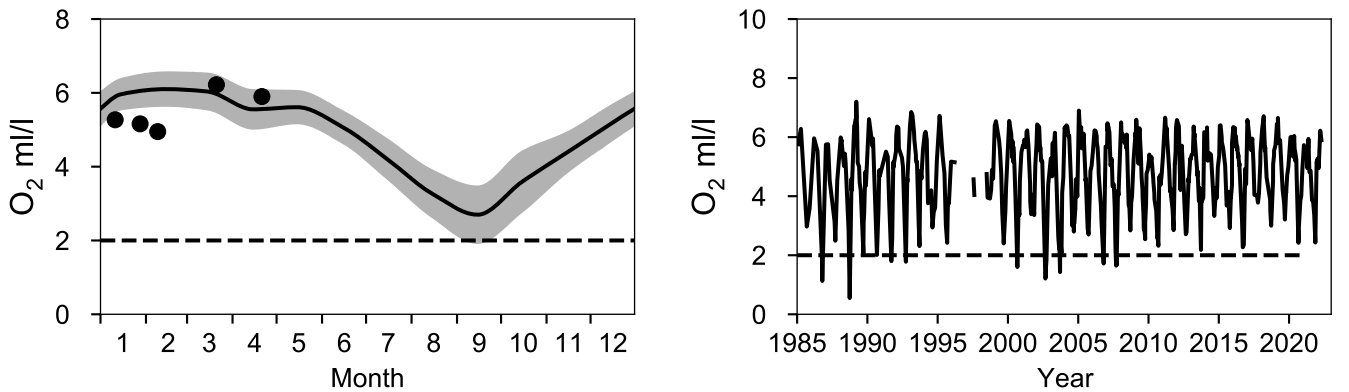


STATION ANHOLT E SURFACE WATER (0-10 m)

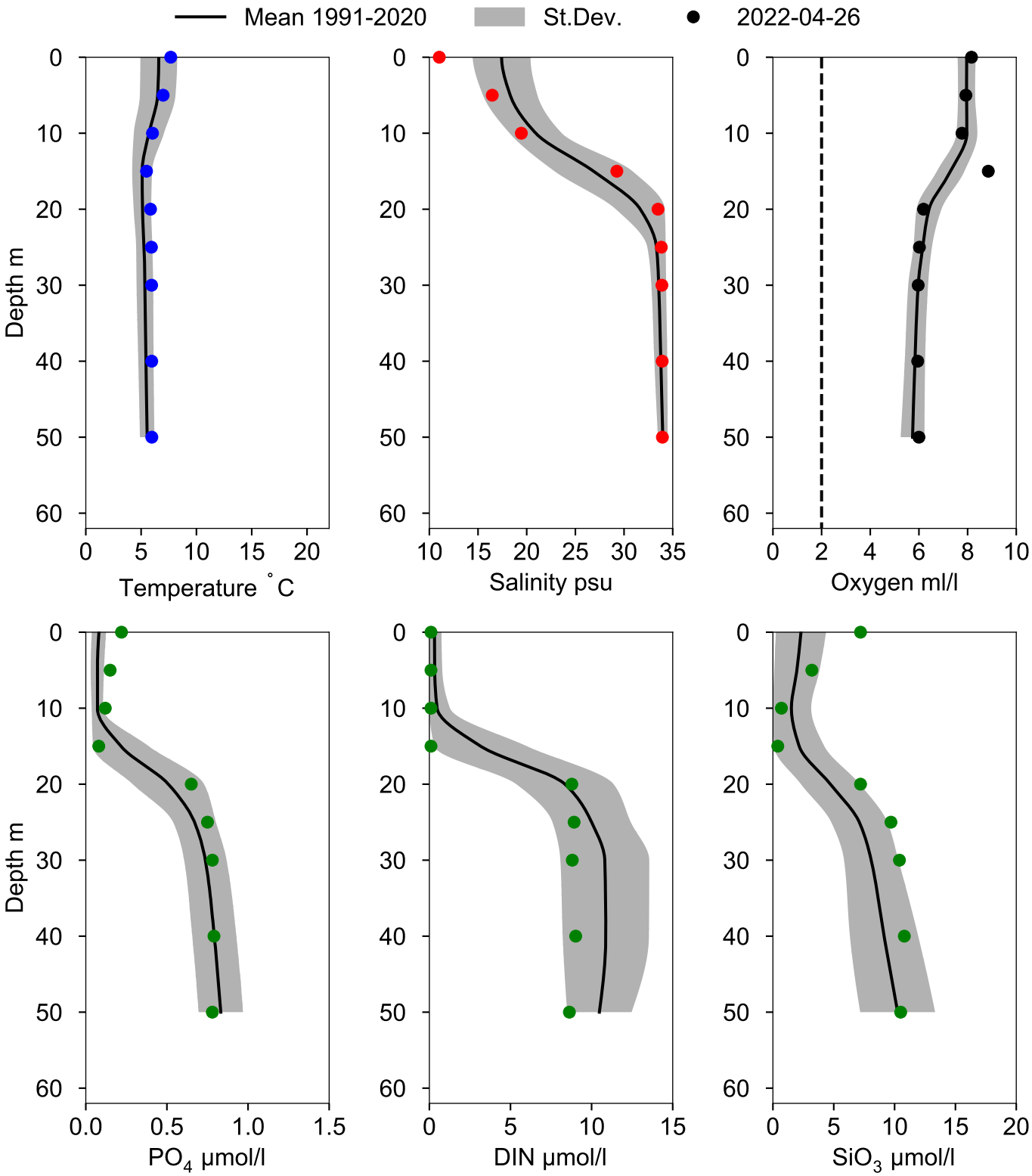
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 52 m)

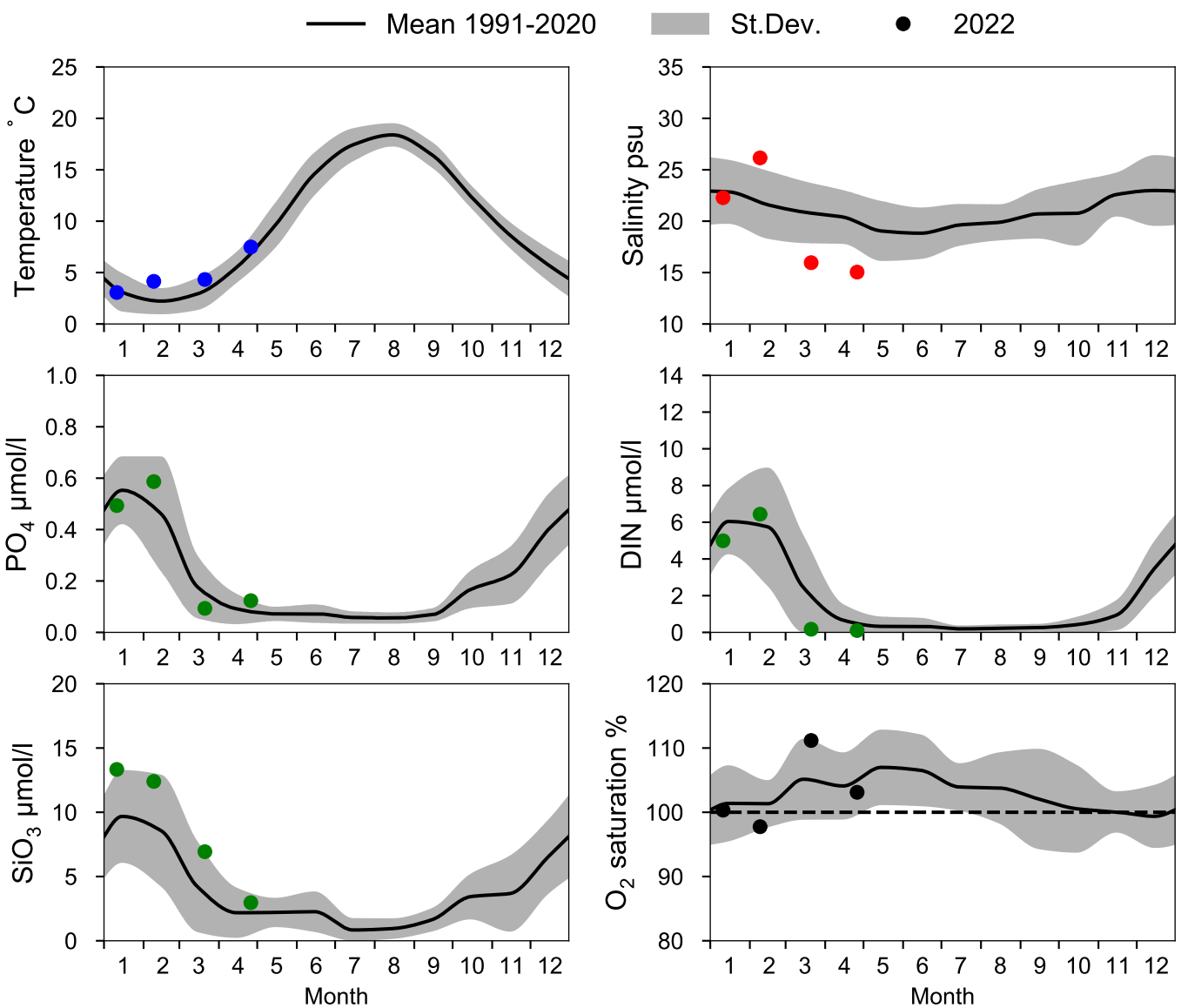


Vertical profiles ANHOLT E
April

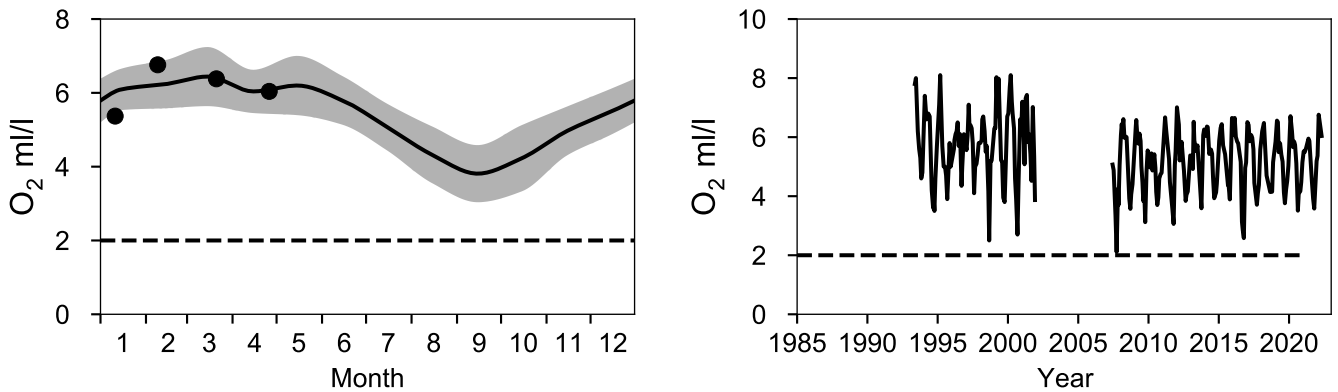


STATION N14 FALKENBERG SURFACE WATER (0-10 m)

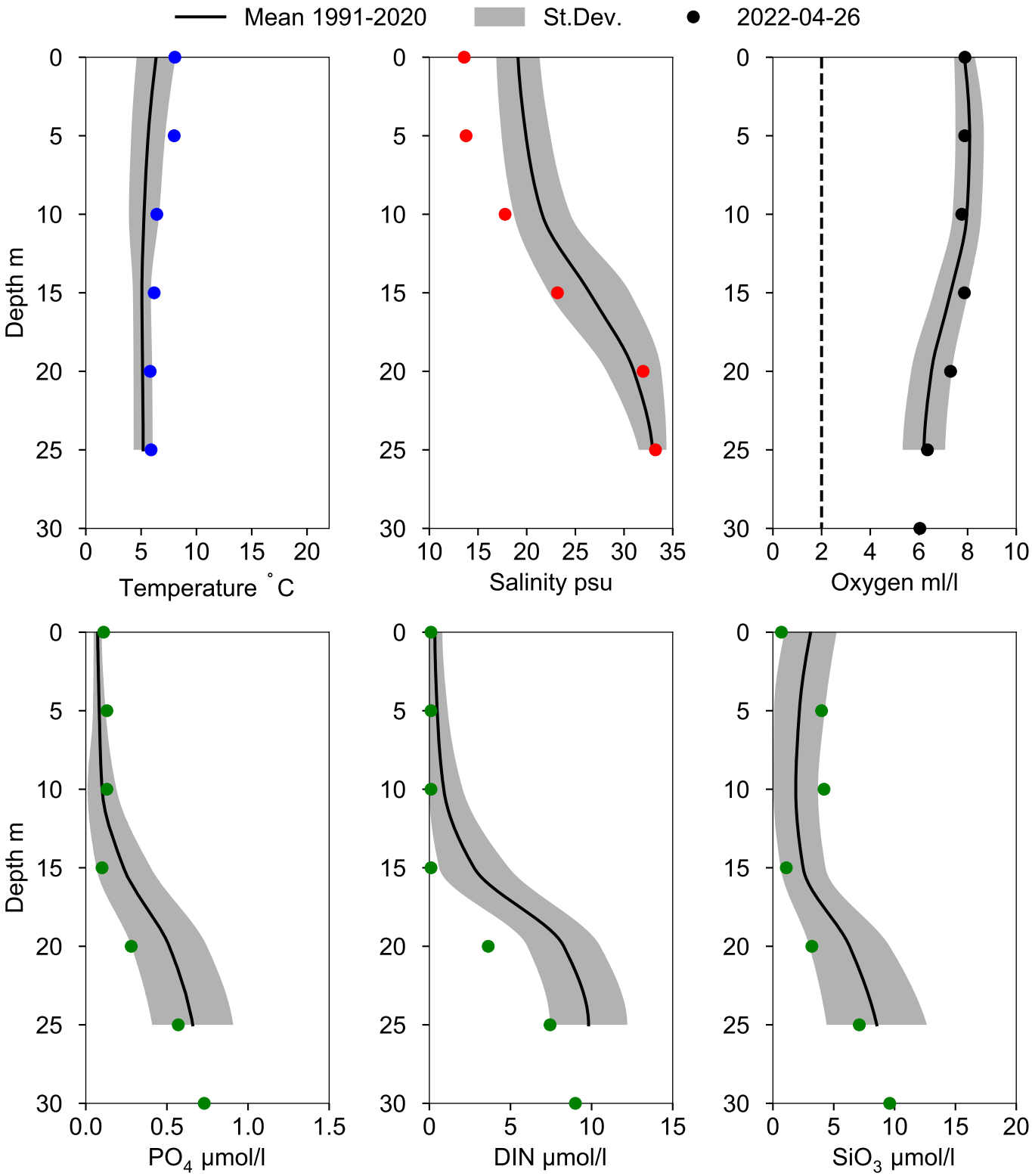
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 25 m)

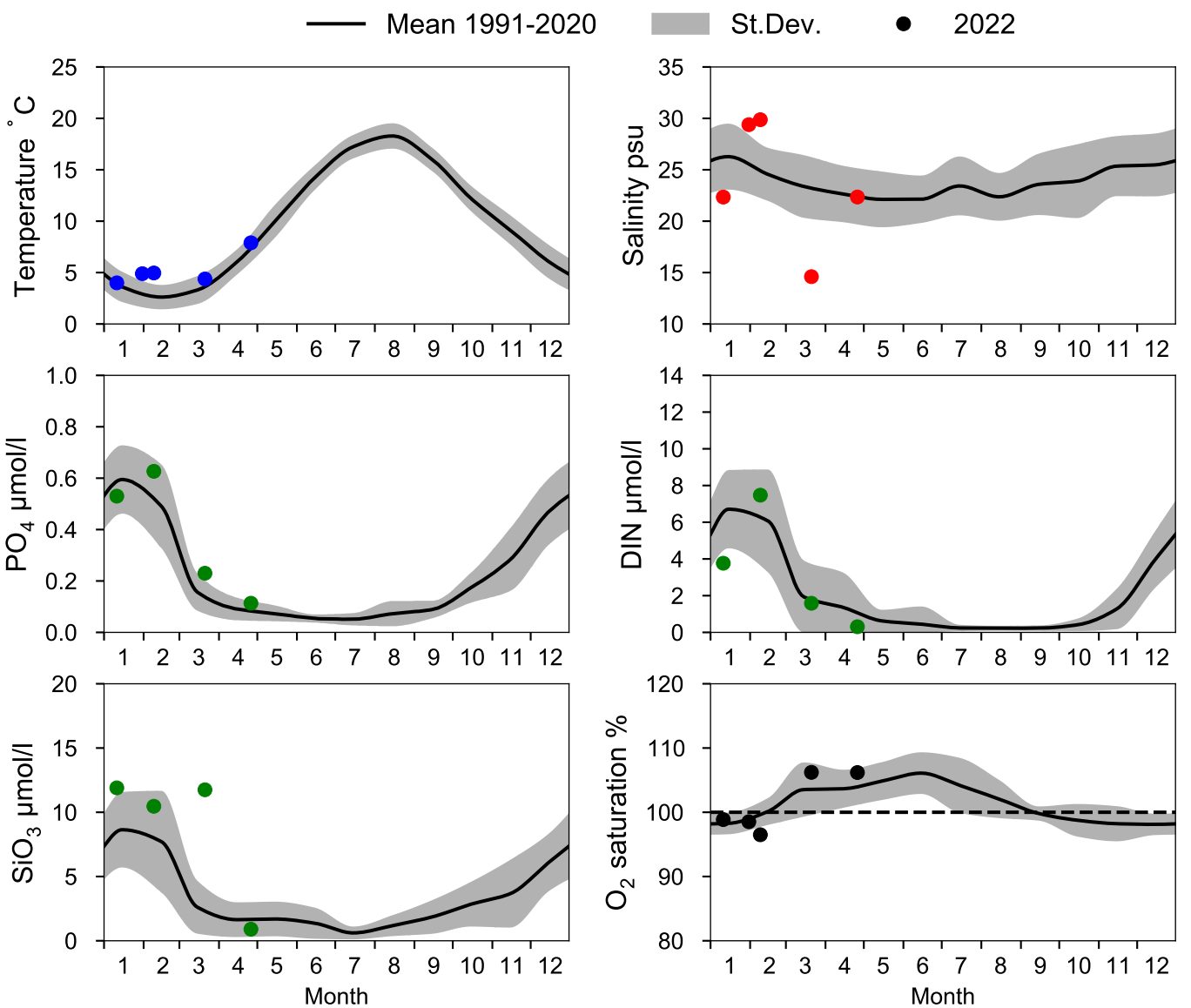


Vertical profiles N14 FALKENBERG
April

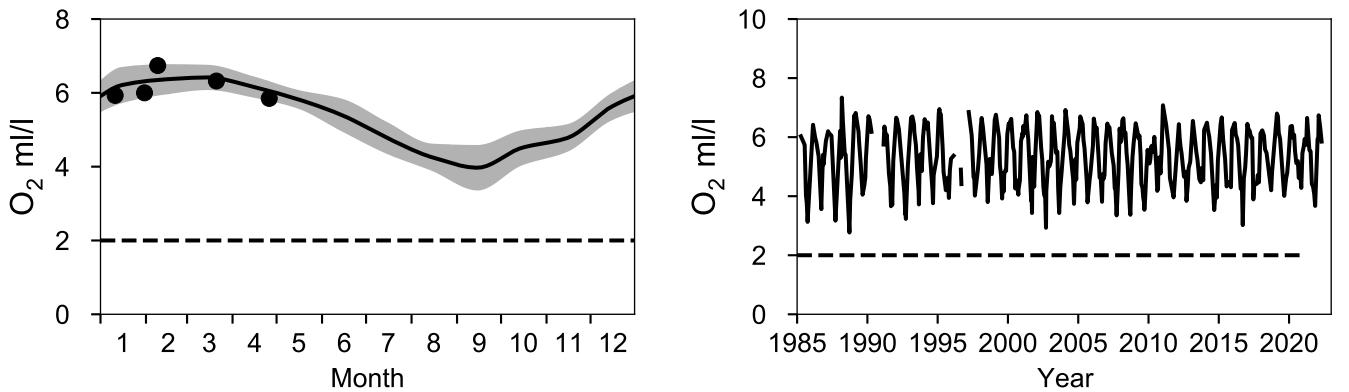
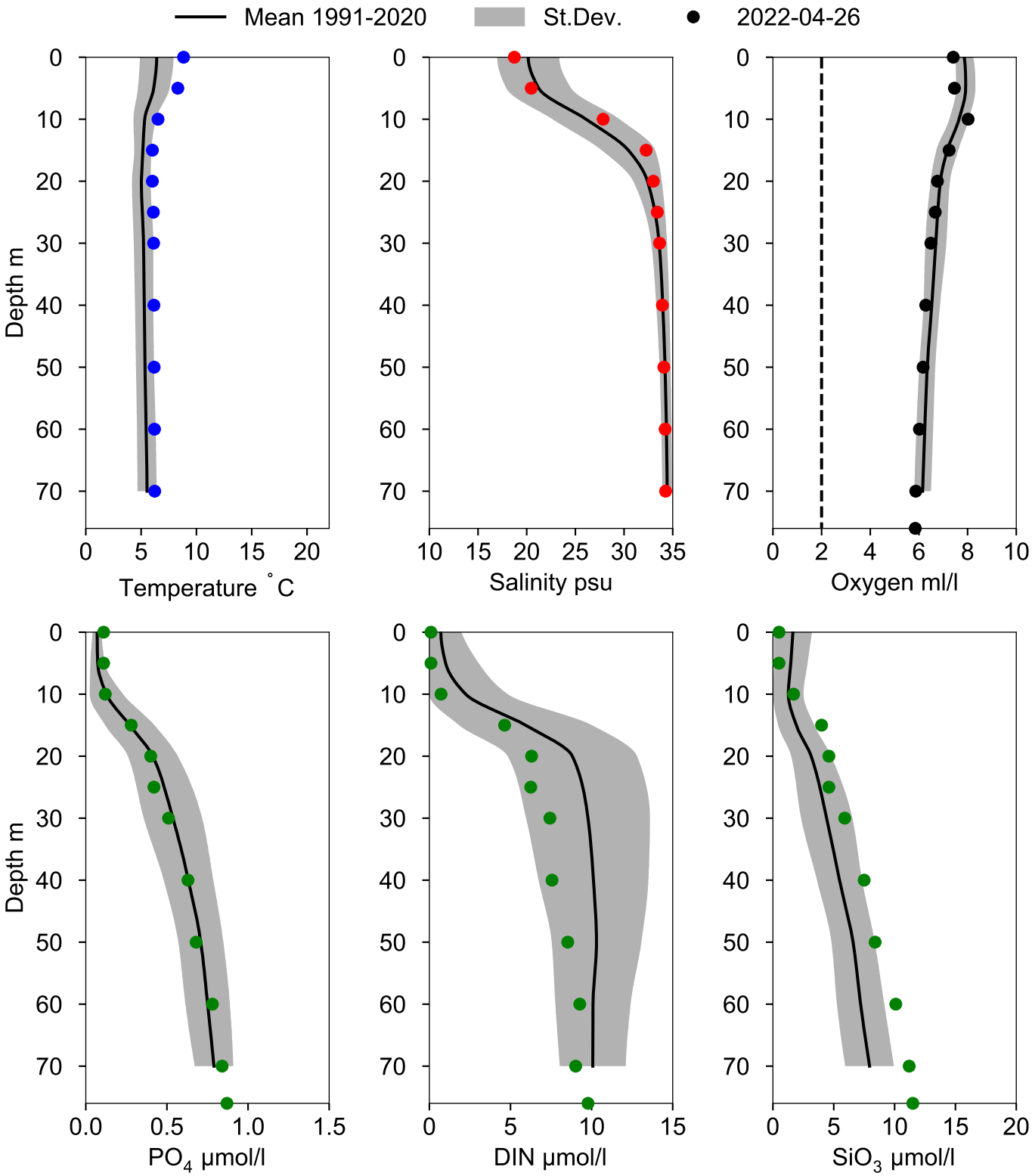


STATION FLADEN SURFACE WATER (0-10 m)

Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 74 m)



Vertical profiles FLADEN
April