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

Photo: Ola Kalén, SMHI

Survey period: 2022-05-19 to 2022-05-25

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)

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Summary

During the expedition, which is part of the Swedish national marine monitoring programme, the Skagerrak, the Kattegat, the Sound and the Baltic Proper were visited.

Warming of the surface water had continued since last expedition in all the visited sea areas. In the Skagerrak, the Kattegat and in the southern basins of the Baltic Proper, the surface water temperature was higher than normal for the season. Salinity in in the surface water was higher than normal in large parts of the Baltic Proper while normal values were measured in the Kattegat and the Skagerrak.

Concentrations of nutrients in the surface water were generally low above the halocline where biological production had consumed available nutrients. The silicate concentrations were above normal in several of the Baltic Proper basins and generally normal in the Kattegat and the Skagerrak.

The oxygen situation continues to be bad in most of the Baltic Proper, only in the Arkona Basin was the bottom water well oxygenated. In the Hanö Bay and the Bornholm Basin, hydrogen sulphide was again present in the bottom water. The station in the southeastern Baltic Proper could not be visited in May.

In the Western and Eastern Gotland Basins, oxygen-free conditions were found from depths exceeding 70-90 metres and concentrations of hydrogen sulphide remained at record high levels at several stations. Acute oxygen deficiency (< 2ml O_2/l) was found from 80 metres depth in the Eastern Gotland Basin and in the Western Gotland Basin oxygen concentration at 60 metres was good but already at 70 metres depth, hydrogen sulphide was detected.

Chlorophyll fluorescence measurements done with the CTD showed low plankton activity in all sea areas, only a few stations had fluorescence peaks indicating a bit higher plankton activity.

SMHI's next cruise with R/V Svea is planned for 13th to 18th of June, starting in Stockholm and ending in Lysekil.

RESULTS

The cruise was carried out on board R/V Svea and started in Kalmar the 19th of May and ended at the same port the 25th. A short stop at Lysekil harbour was made on the 23rd of May.

The weather during the expedition was calm and mostly overcast. During most of the week the wind speed was 6-8 m/s, only during the second visit at Anholt E the wind speed was higher; 17m/s. The winds came mostly from southwest and the temperature was between 8-15°C.

The station in the southeastern Baltic Proper, BCSIII-10, was not sampled during May due to external circumstances. All other planned stations were visited and sampled.

The technical problems experienced during the April cruise were fixed and all equipment worked as expected.

In addition to the regular sampling, extra phytoplankton samples were taken for Stockholm University at two stations in the Skagerrak and one in the Kattegat. This is part of an ongoing project ending in February 2023. An IFCB (Imaging FlowCytobot) was also used throughout the expedition, see appendix. As soon as possible, it will be included in the regular monitoring program. The IFCB was, and will be, connected to the same water flow as Svea's ferrybox.

Svea's MVP (Moving Vessel Profiler) which is used to measure temperature, salinity and oxygen profiles during transit at cruising speed were used at 4 transects; BY39-BY38, BY10-BY15, across the Slupsk Furrow and at the Å-transect in the Skagerrak.

Both the ferrybox (continuous measurements at 4 metres depth) and Svea's ADCP (Acoustic Doppler Current Profiler) were collecting data during the whole cruise.

This report is based on data that has passed a first quality control. When data are published at the national oceanographic data centre, some values might have changed after further quality controls have been performed. Data from this cruise will be published as soon as possible at the data centre's webpage, normally within a week after the cruise. Some analyses are done after the expedition and will be 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

Warming of the surface water (0-10 m) had continued since last cruise and the surface temperature varied from 11°C to just over 12°C. All stations had a thin well mixed surface layer, and decreasing temperatures below. At Å17 furthest west, the CTD[1] showed just over 12°C down to a depth of 9 metres, below this - all the way down to the bottom - about 7°C. At the other stations the thermocline was not as distinct and the temperature decreased more evenly with increased depth. At Släggö the temperature was above normal in most parts of the water column. The salinity in the surface was about 26 psu at Släggö and between 27-31 psu at the other stations. This is normal for the season, except at P2 where it was above normal. The stratification in salinity coincided with that in temperature at all stations, which is very visible in the CTD profile at P2.

Levels of nutrients were generally low above the halocline where biological production had consumed available nutrients, below the halocline there were increasing concentrations of nutrients. The content of dissolved inorganic nitrogen in the surface water, often referred to as DIN[2], was below limit of quantification at all offshore stations from the surface down to a depth of 20 metres, which is normal for the season. At the coastal station Släggö, concentrations of 0.43 µmol/l were measured in the surface water, also normal for the season. For the offshore stations, levels were found to be slightly above normal at the deeper sampling depths, otherwise mostly normal levels.

Concentrations of phosphate, dissolved inorganic phosphorus or DIP[3], were in the offshore surface water normal for the season, about 0.05 µmol/l. At Släggö, slightly higher levels in the surface water were measured; 0.10 µmol/l. Concentrations of silicate, which is used by diatoms to form shells, were slightly above normal at the surface at the westernmost stations, normal at the other stations. In the deep water mostly normal concentrations.

The oxygen situation in the Skagerrak was good with concentrations above 6 ml/l close to the bottom, except at P2 where concentrations were just below 6 ml/l. At the coastal station Släggö, the oxygen concentration was lower compared to the offshore stations, it was measured to 4.5 ml/l. This is however completely normal, which can be seen in the figure with monthly averages.

Chlorophyll fluorescence measurements from the CTD showed low plankton activity from the surface down to about 30-40 metres depth and no larger fluorescence peaks were noted. The results from the IFCB also confirmed the low plankton activity in the surface water. The secchi depth was 8 metres at the coast and 11-12 metres offshore.

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1 CTD which stands for Conductivity, Temperature, Depth, is a profiling instrument. SMHI's CTD is also equipped with sensors that measure for example oxygen and fluorescence.

2 Dissolved inorganic nitrogen, the sum of nitrate, nitrite and ammonium.

3 Dissolved inorganic phosphorus occurs only as phosphate.

The Kattegat and the Sound

The surface water temperature in the Kattegat was above normal for the season, around 13°C, which means a warming of 5-6°C compared to last month's expedition. The surface water temperature had also risen in the Sound, but by just over 4°C, to around 12°C. This was a little above normal for the season at all stations. Below the surface layer, the temperature was largely constant down to the bottom, around 6°C at all stations. The salinity was normal in the surface water with 17-20 psu in the Kattegat and just over 13 psu in the Sound. Below the halocline, which was found at a depth of 10-20 metres, the salinity was relatively constant all the way down to the bottom, it varied between 33-34 psu at visited stations.

Nutrients in the form of DIN were in principle consumed in the surface water of Kattegat, which is normal for the season. Only at Fladen levels above limit of quantification were measured; 0.17 µmol/l. Slightly higher values were observed in the surface of the Sound; 0.34 µmol/l, but also this were normal concentrations. The concentrations of phosphate and silicate were normal for the season in the surface water in both the Kattegat and the Sound. In the deep water, generally normal concentrations of all nutrients were found.

Oxygen concentrations in the bottom water of the Kattegat were around 6 ml/l, which is normal for the season. In the Sound, the oxygen content was a bit above 5 ml/l, which was slightly above normal.

CTD measurements of chlorophyll fluorescence indicated low plankton activity. At Anholt E and N14 Falkenberg there were small fluorescence peaks at a depth of about 15 metres, at the other stations there was a low constant fluorescence signal down to the halocline. The secchi depth was 7-9 metres.

The Baltic Proper

Heating of the surface water in the Baltic Proper had continued since last month, the temperature had risen about 5°C in the southern parts and 4°C at the other stations. The surface water temperature at the southern stations and at the coastal station in Kalmar Strait was between 10-11°C, which was above normal for the season, normal in Kalmar Strait. For the stations in the Eastern and Western Gotland Basins, mostly normal surface temperatures were measured, between 8-9°C. Here a shallow thermocline at a depth of about 20 metres was observed. Below it was a colder layer that extended down to the more permanent stratification of the Baltic Proper at a depth of 60-80 metres in the deeper basins. The temperature in the deep water was generally above normal at the deepest stations.

Salinity in the surface water was higher or slightly higher than normal at all stations visited and varied between 7-8 psu, with the exception of BY38 in the northern part of the Western Gotland Basin, where salinity was normal and measured to just under 7 psu. The difference compared to normal values was largest at the stations in the Eastern Gotland Basin, this can be seen in the figures with monthly averages. In the deeper water bodies, generally normal or slightly above normal salinities were observed.

Concentration of nutrients in the form of DIN in the surface water was below limit of quantification at all stations. This is normal or slightly below normal for the season. In the deep water in the Eastern and Western Gotland Basins, levels of DIN were significantly above normal at depths where hydrogen sulphide was present. This was particularly evident at BY38 and BY32 from depths of 80 and 90 metres respectively.

The phosphate, the concentrations in the surface water of the Baltic Proper were normal for the season. In the southern parts, the concentration was 0.28 µmol/l at several stations. In north slightly lower levels were observed at the easternmost stations and increasing westward. Highest concentrations were measured in the Kalmar Strait with 0.37 µmol/l. In the deep water at the deeper stations, generally normal concentrations were found. At BY4 in the Bornholm Basin, several values above normal levels were measured in the deep water.

Silicate concentrations in the surface water at most stations were between 11-12 µmol/l, except for the stations in the Western Gotland Basin and at BY10 where concentrations were higher or slightly higher. In the Hanö Bay, the Bornholm Basin and at BY32 in the Western Gotland Basin, the concentrations were normal. For the other stations concentrations were slightly above normal for the season.

As usual, the oxygen situation was very bad in most of the Baltic Proper, only in the Arkona Basin, which is the shallowest basin with a bottom depth of just over 45 m, the bottom water was well oxygenated. In the Hanö Bay and the Bornholm Basin, acute oxygen deficiency (< 2ml O_2/l) was found at 70 metres depth and hydrogen sulphide was measured in the bottom water. This was a deterioration compared to the previous month, when low levels of oxygen were found in the bottom water of these basins.

In the Western Gotland Basin, oxygen-free conditions were found already at a depth of 70 metres at one of the stations, and hydrogen sulphide above limit of quantification was measured at 80 metres depth. Concentration of hydrogen sulphide in the deep water were higher than normal. In the Eastern Gotland Basin, oxygen-free conditions were measured at a depth of 90 metres, and hydrogen sulphide was detected from 100 metres depth. At BY15 and BY10, levels of hydrogen sulphide were higher than normal in the deep water.

Fluorescence measurements from the CTD indicated some plankton activity down to the thermocline, with the exception of the coastal station Ref M1V1 in the Kalmar Straight, which had a constant level down to the bottom. Overall, there was a uniform activity in the surface layer and only at BY1 in the western Arkona Basin a fluorescence peak with a slightly higher values were present - there at a depth of 20-25 metres. The secchi depth was measured to 7-10 metres.

More information about the algae situation can be found in the Algaware report for May:
https://www.smhi.se/en/publications/publications/algal-situation-reports-2-1056

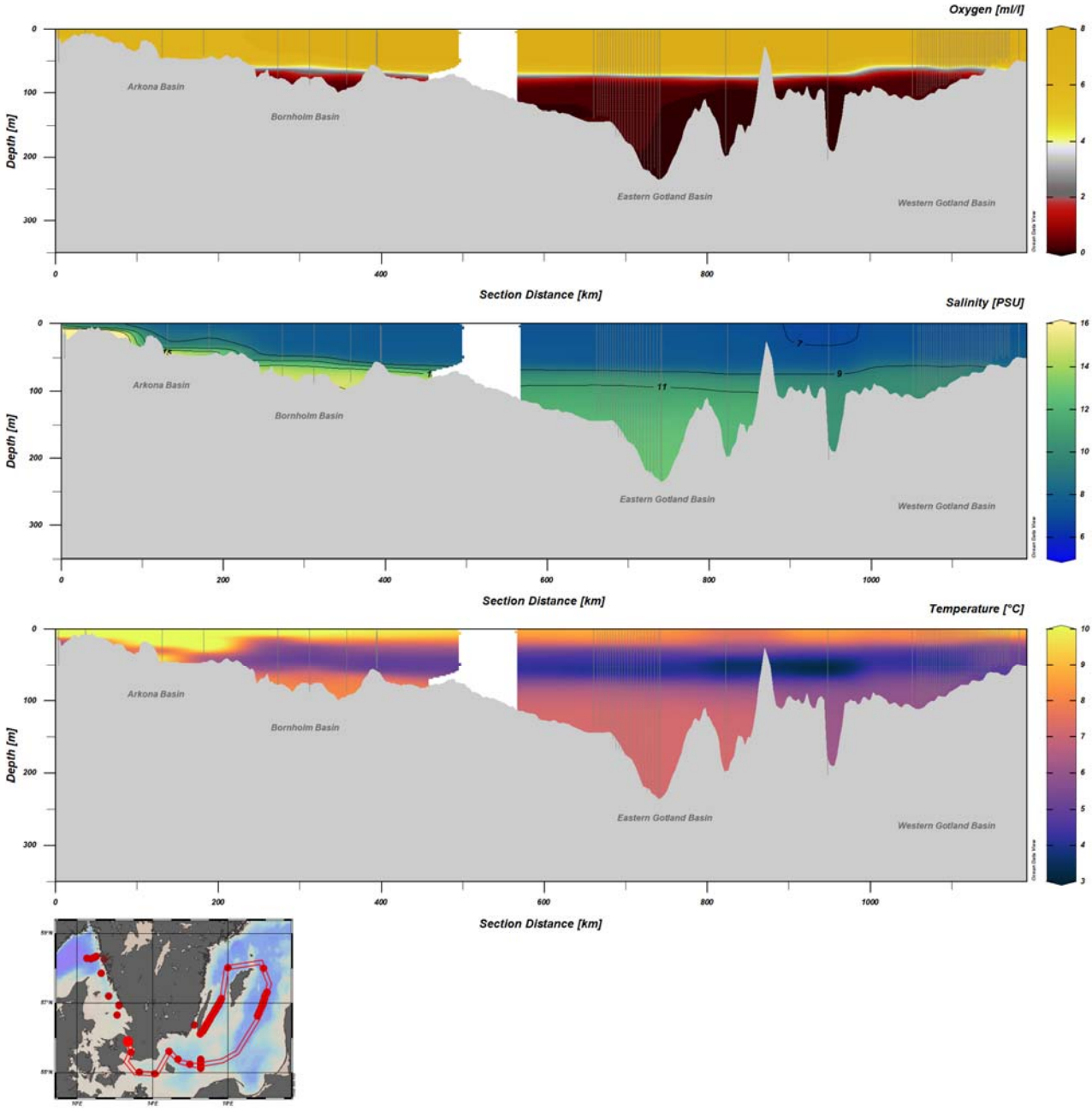


Figure 1. Transect showing CTD and MVP measurements of dissolved oxygen, salinity and temperature from the Sound through the Eastern Gotland Basin into the Western Gotland Basin.

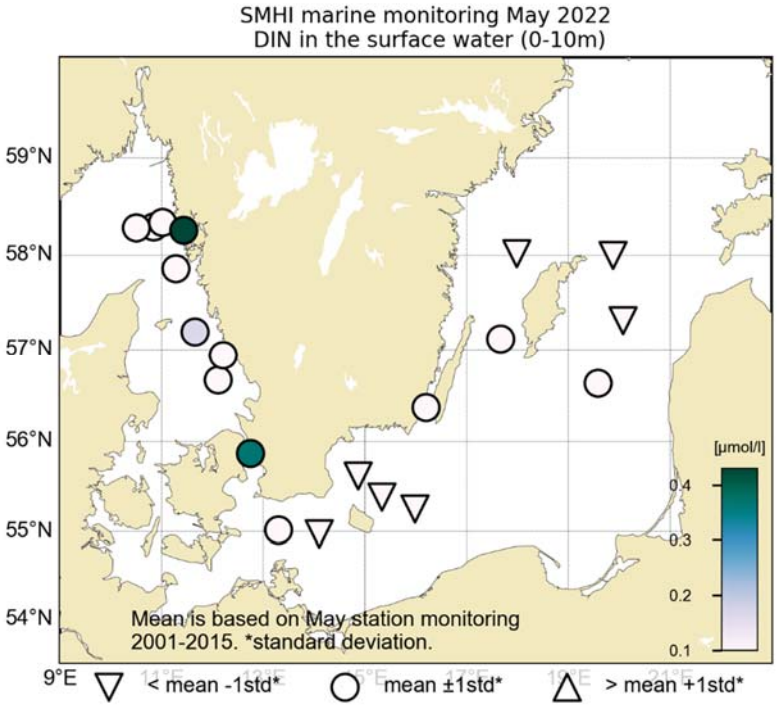
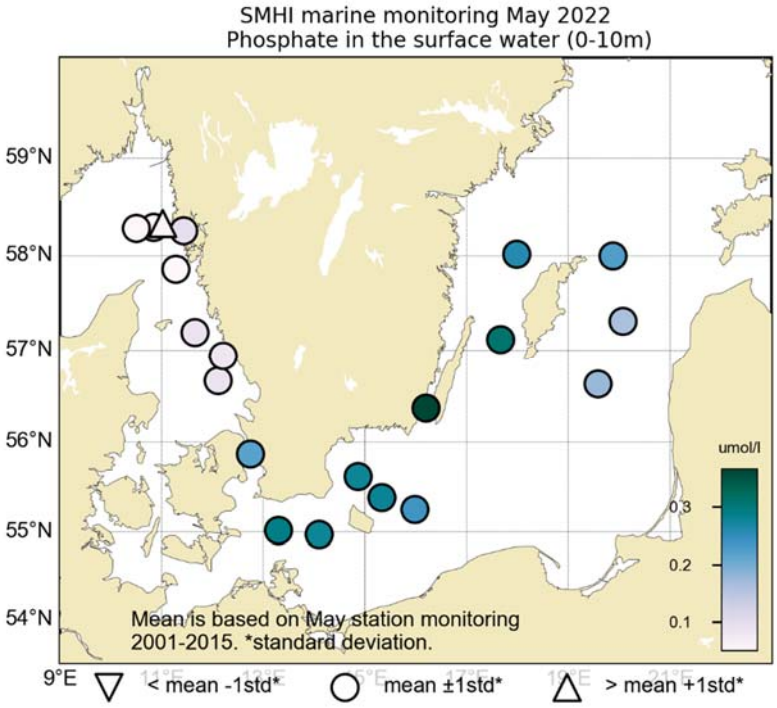
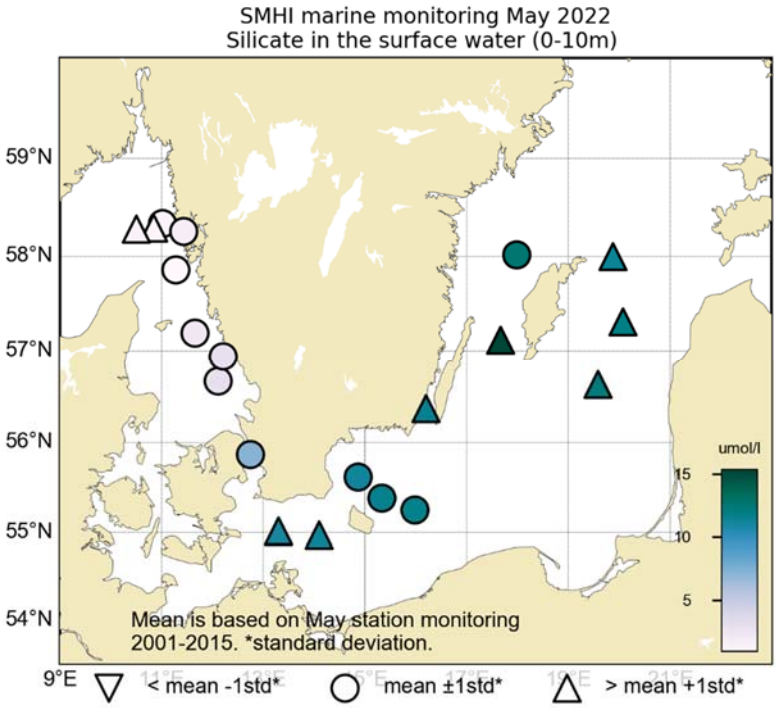


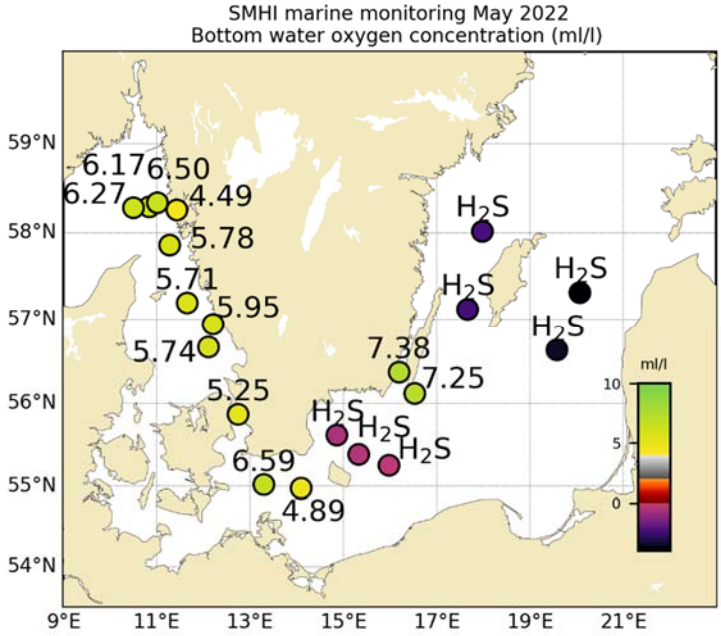
Figure 2. Concentration of dissolved inorganic nitrogen in the surface water (0-10 m).



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



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



Figur 5. Oxygen concentration in the bottom water.

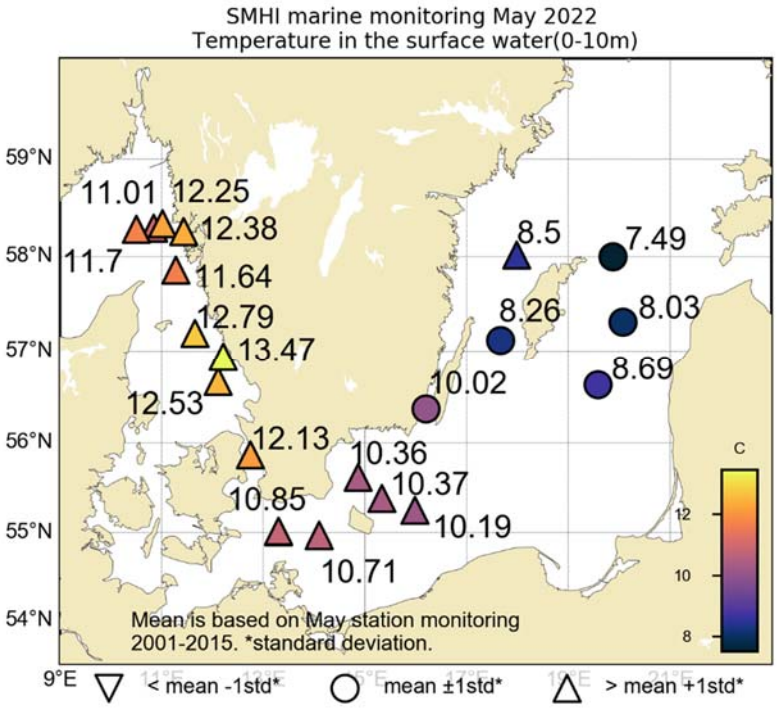


Figure 6. Temperature in the surface water (0-10m).

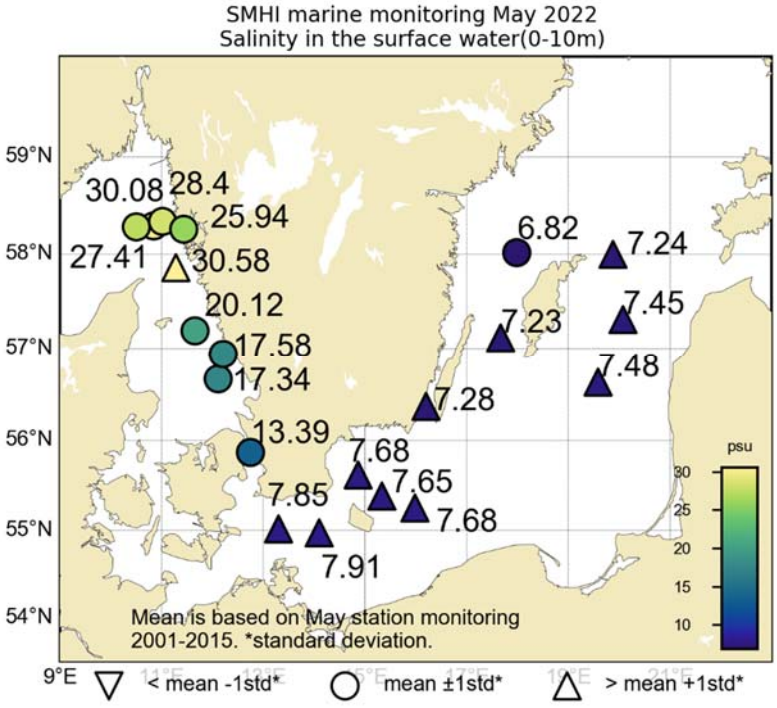


Figure 7. Salinity in the surface water (0-10m).

PARTICIPANTS

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Johan Kronsell	Chief Scientist	SMHI
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Johanna Linders		SMHI
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Kristin Andreasson		SMHI
Bengt Karlson		SMHI

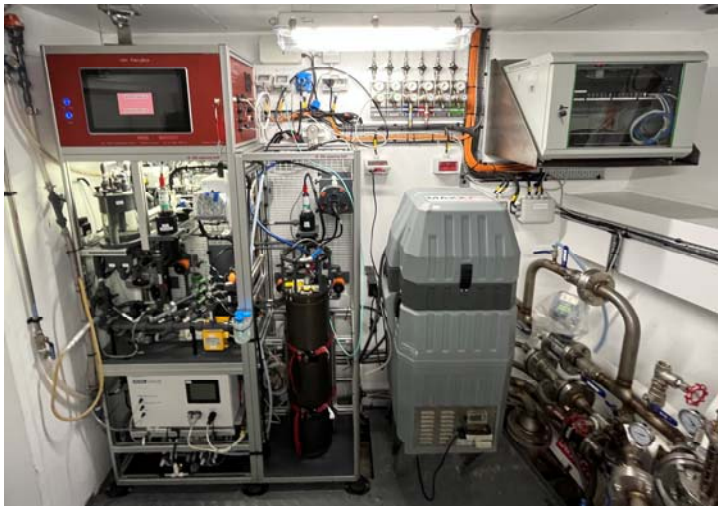
APPENDICES

- Information about the IFCB
- 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

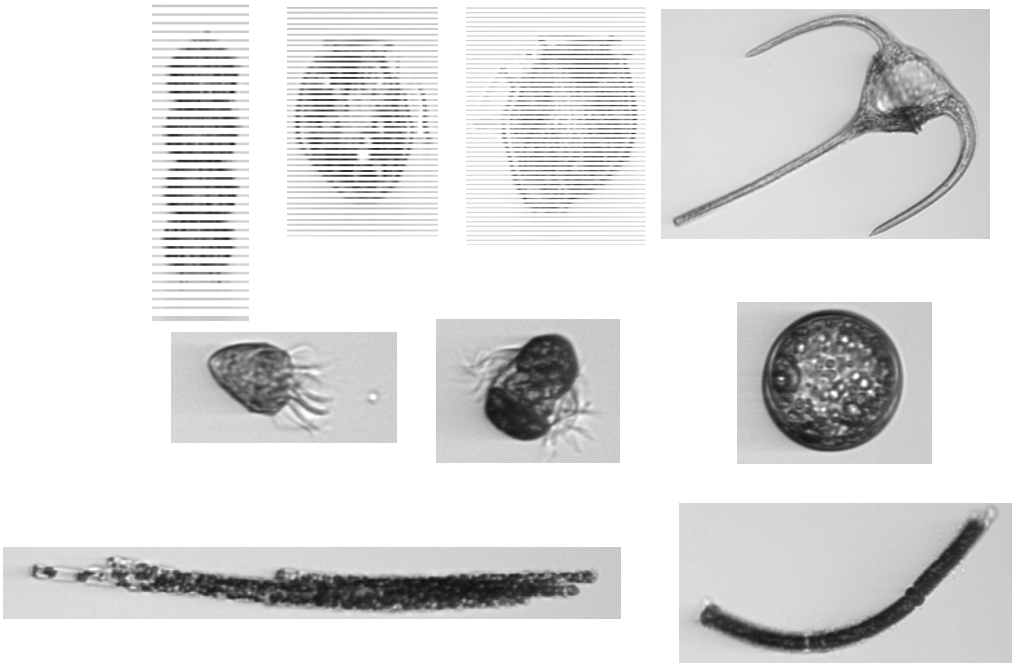
Automatiska växtplanktonanalyser under gång
Växtplankton är havets viktigaste primärproducenter och utgör grunden i den marina näringsväven. Växtplanktonprovtagning sker normalt vid ca tio stationer under SMHI:s miljöövervakningsexpedtioner. Proverna analyseras med mikroskop på laboratorium iland efter expeditionerna. Under expeditionen i maj utförde SMHI automatiska växtplankton-analyser under gång. Havsvatten från ca 5 m djup tas in kontinuerligt under gång. Ungefär två gånger i timmen sker automatisk växtplanktonalys med ett instrument kallat Imaging FlowCytobot (IFCB) vilket innebär att hundratals prover analyseras under en veckolång expedition. Plankton fotograferas och automatisk bildanalys gör det möjligt att identifiera och räkna organismerna. Systemet för automatisk växtplanktonanalys är under utveckling och kan komplettera traditionell analys av prover.

Automatic phytoplankton analyzes underway
Phytoplankton are the sea's most important primary producers and form the basis of the marine food web. Phytoplankton sampling normally takes place at about ten stations during SMHI's environmental monitoring cruises. The samples are analyzed with a microscope in a laboratory ashore after the expeditions. During the expedition in May, SMHI performed automatic phytoplankton analyzes underway. Seawater from a depth of about 5 m is taken in continuously. Approximately twice an hour, automatic phytoplankton analysis is performed with an instrument called the Imaging FlowCytobot (IFCB). This results in hundreds of samples analyzed during a week-long cruise. Plankton are photographed and automatic image analysis makes it possible to identify and count the organisms. The system for automatic phytoplankton analysis is under development and can complement traditional analysis of samples.



I det så kallade FerryBox-rummet på Svea finns flera typer av automatiska mätinstrument för mätning och provtagning under gång. Den cylinderformade apparaten i mitten innehåller ett avancerat mätinstrument kallat Imaging FlowCytobot och används för automatisk växtplanktonalys.

In the so-called FerryBox room onboard Svea, there are several types of automatic instruments for measurements and sampling underway. The cylindrical device in the middle contains an advanced measuring instrument called the Imaging FlowCytobot and is used for automated phytoplankton analysis.



Fotografier av plankton från Imaging FlowCytobot. Från vänster till höger:
Översta raden: *Pedinella catenata, Dinophysis acuminata, Dinophysis norvegica* och *Tripos muelleri*, mellersta raden: *Strombidium* sp., *Mesodinium rubrum* och en oidentifierad kiselalg, nedre raden: *Aphanizomenon flos-aquae* och *Nodularia spumigena*. Skalan på bilderna varierar.

Photos of plankton from the Imaging FlowCytobot. Left to right:
Top row: *Pedinella catenata*, *Dinophysis acuminata*, *Dinophysis norvegica* and *Tripos muelleri*, middle row: *Strombidium* sp., *Mesodinium rubru*m and an unidentified diatom, bottom row: *Aphanizomenon flos-aquae* and *Nodularia spumigena*. The scale in the images varies.

Bengt Karlson, SMHI

TRACKCHART
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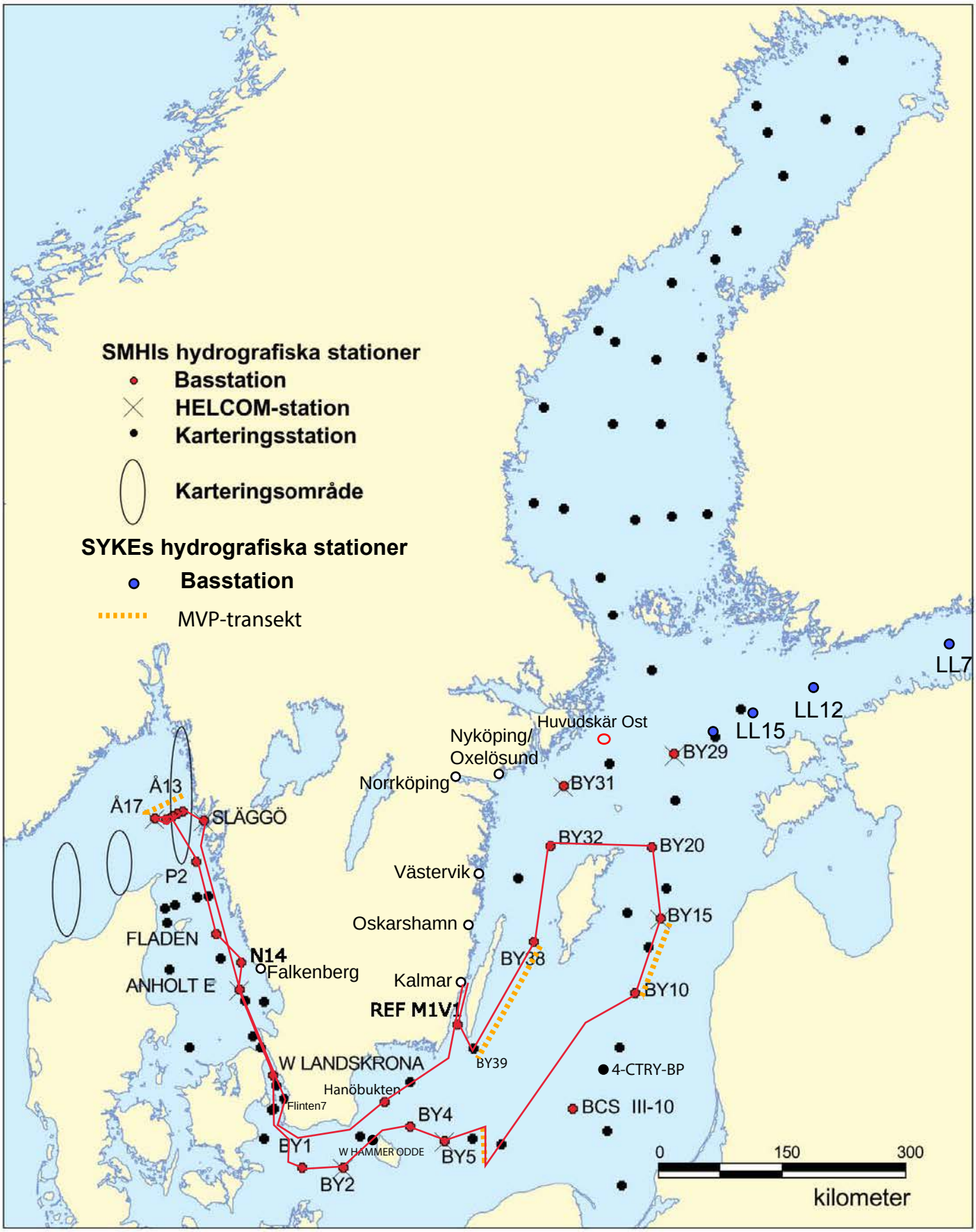

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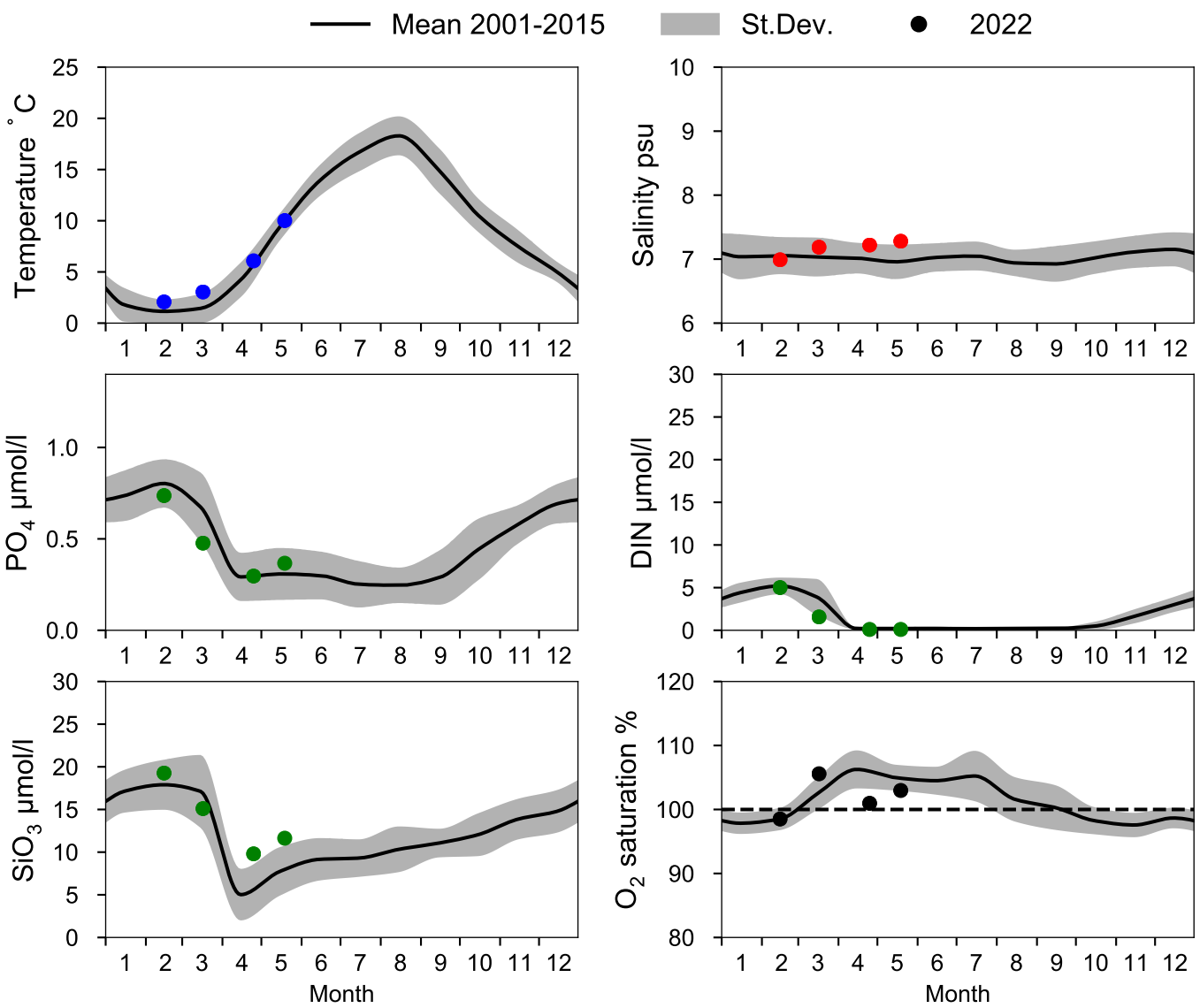
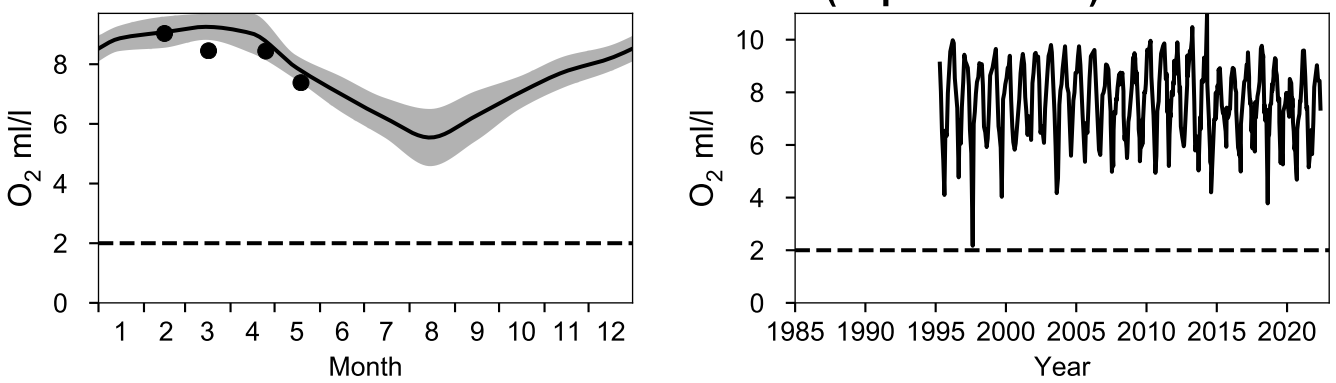
0506	10	SKEX14	BAS...	Å13	5820.45	01101.12	20220523	1145	91		17	9	12.6	1008	1330	x---	10		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-
0507	10	FIBG27	BAS...	SLÄGGÖ	5815.59	01126.16	20220523	1350	74	8	22	8	15.4	1006	1220	xx--	9		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-
0508	10	KAEX29	BAS...	ANHOLT E	5640.11	01206.65	20220524	0340	61		10	17	11.5	998	1650	x---	10		x	x	-	x	x	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-
0509	10	SOSX00	EXT...	FLINTEN	5535.31	01250.63	20220524	1150	8		24	6	13.2	1000	2820	----	3		-	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
0510	10	BPSH05	BAS...	HANÖBUKTEN	5537.02	01451.97	20220524	2130	79		23	6	11.3	1005	9990	x---	11		x	x	-	x	-	x	x	x	x	-	x	x	x	x	-	-	x	-	-	x

STATION REF M1V1 SURFACE WATER (0-10 m)

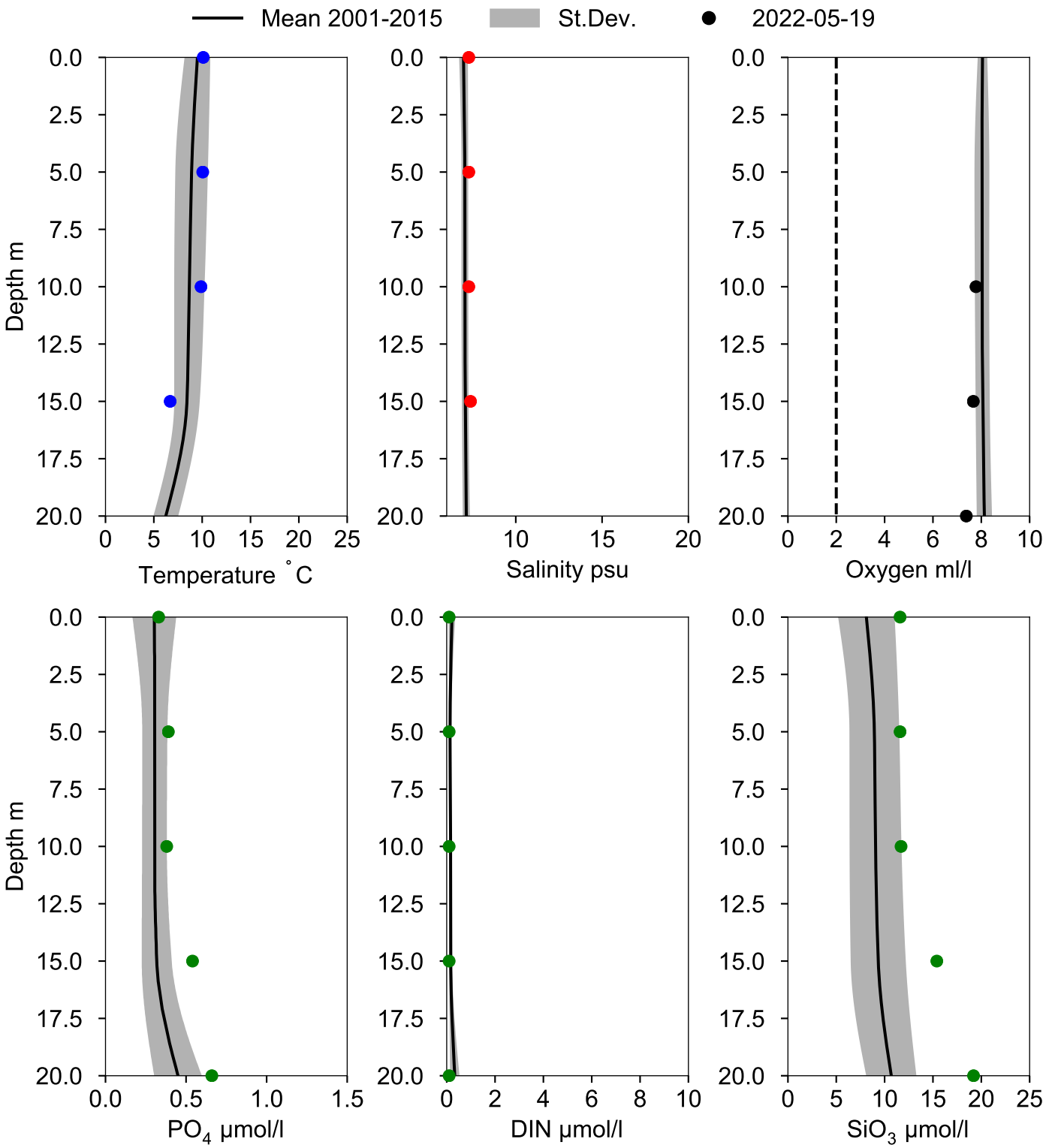
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 15 m)

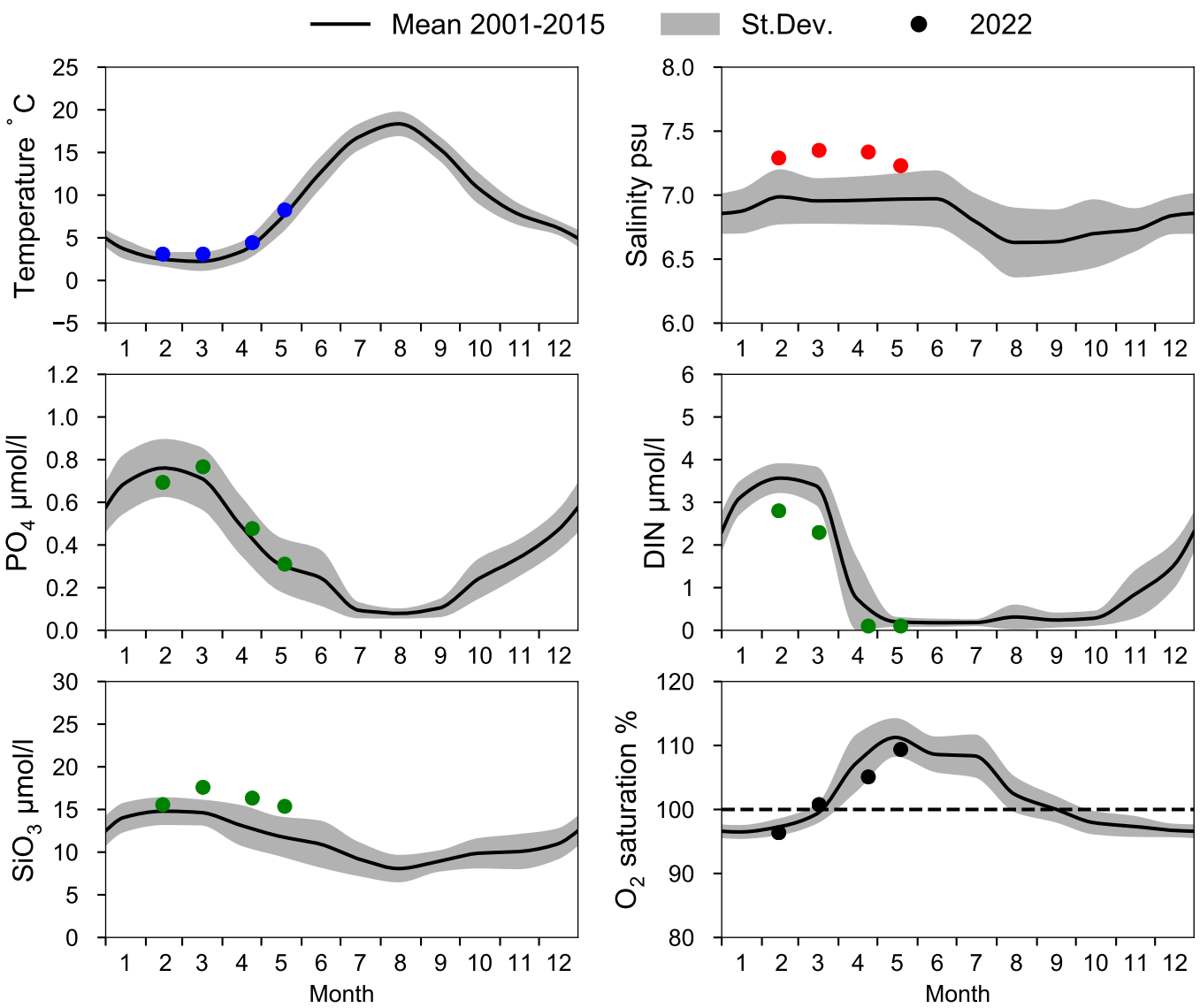


Vertical profiles REF M1V1
May

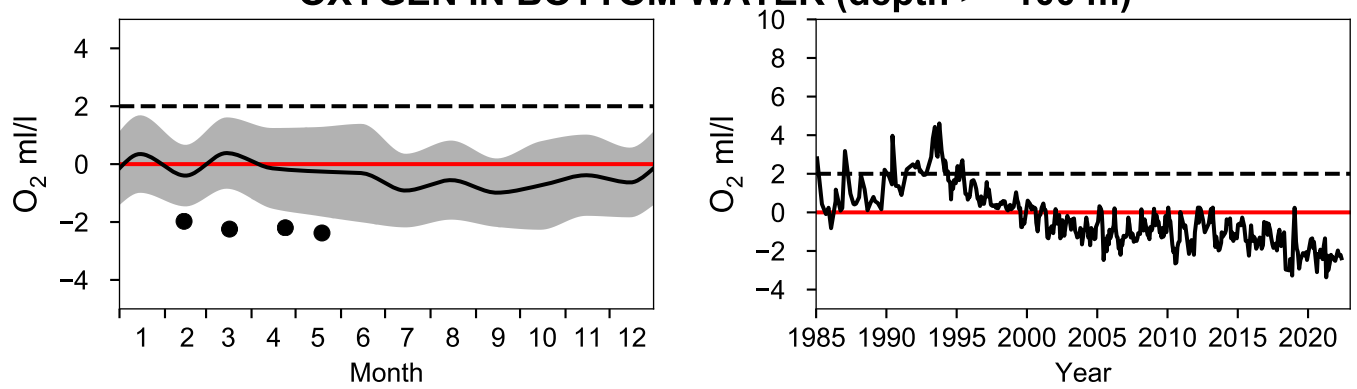


STATION BY38 KARLSÖDJ SURFACE WATER (0-10 m)

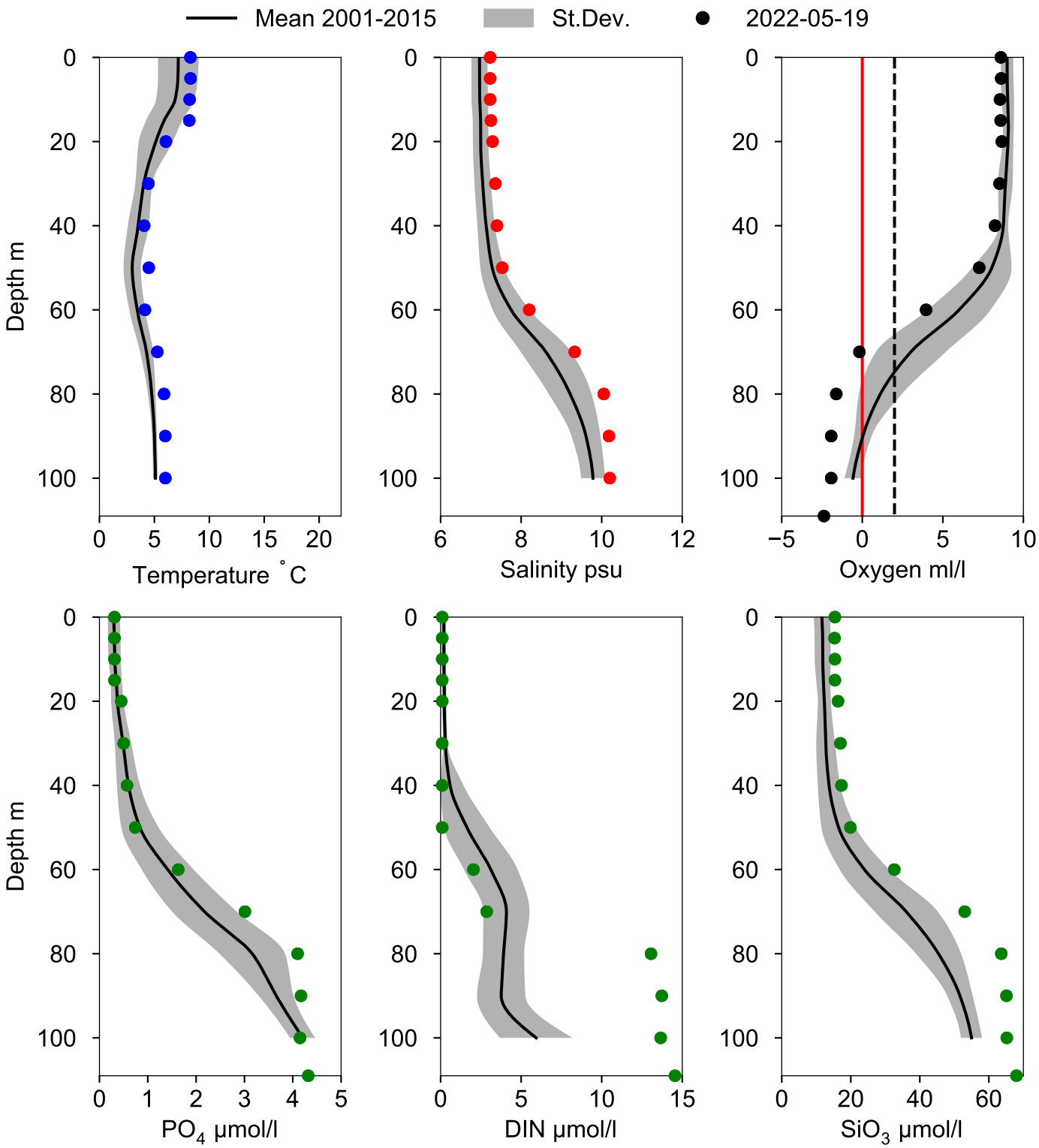
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 100 m)

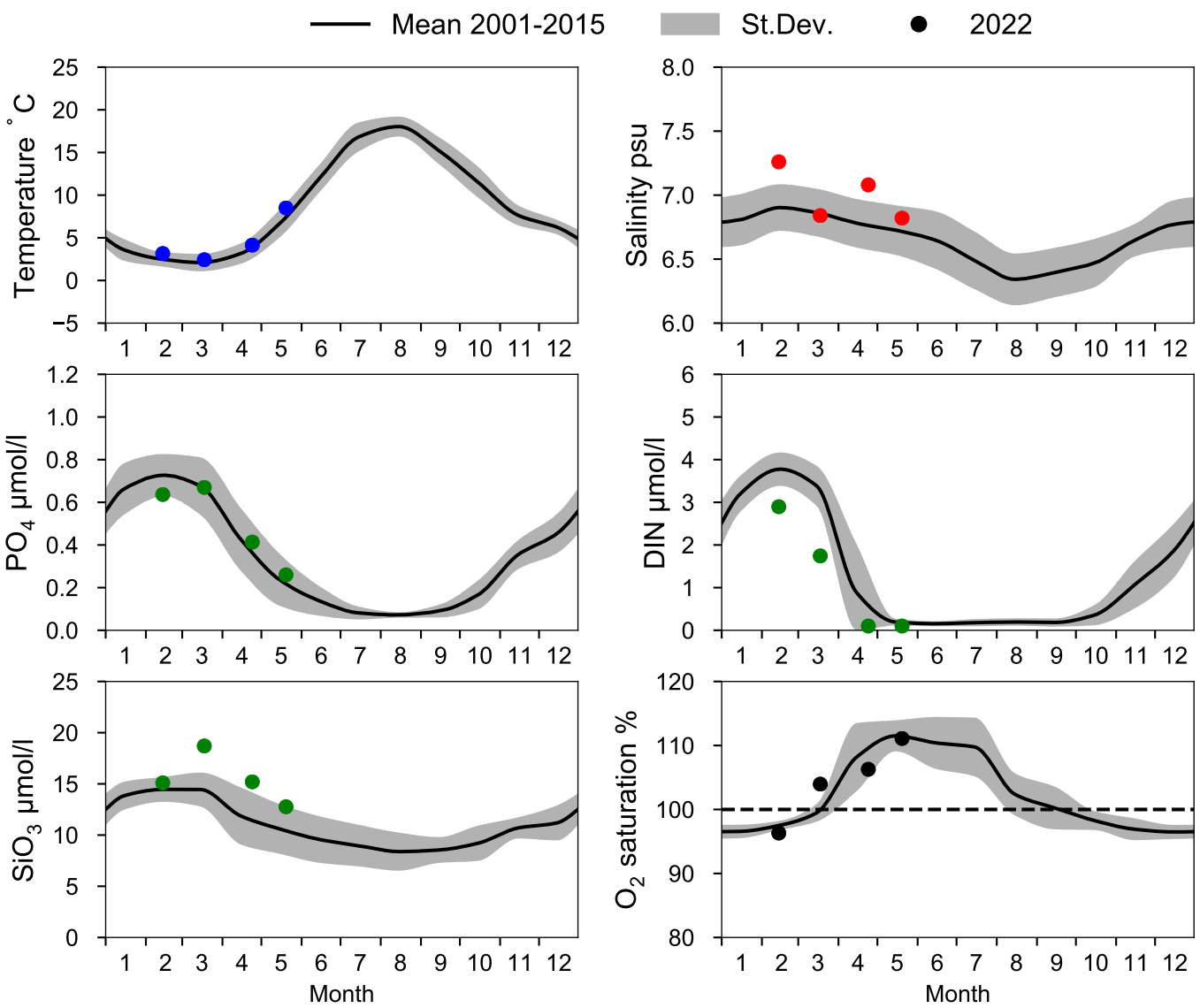


Vertical profiles BY38 KARLSÖDJ
May

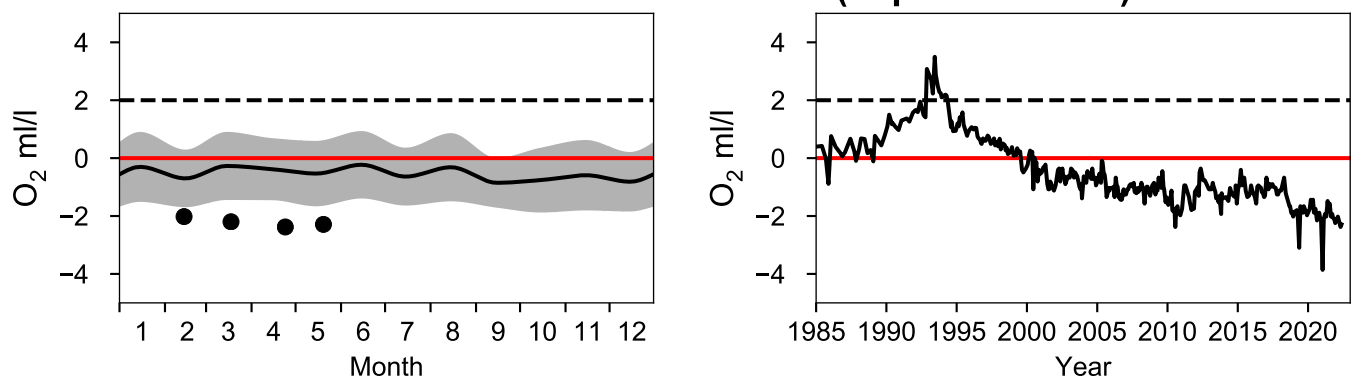


STATION BY32 NORRKÖPINGSDJ SURFACE WATER (0-10 m)

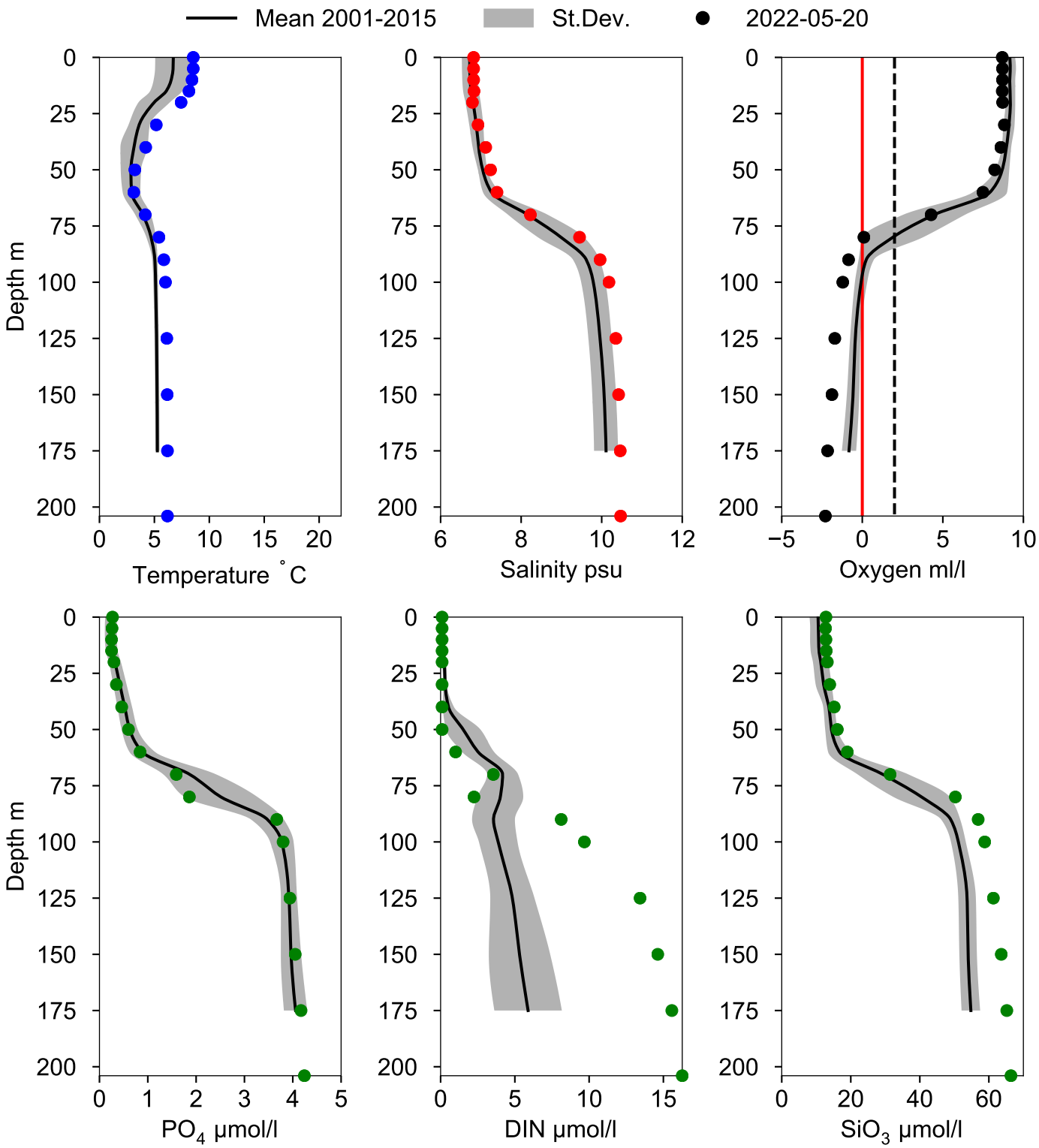
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 175 m)

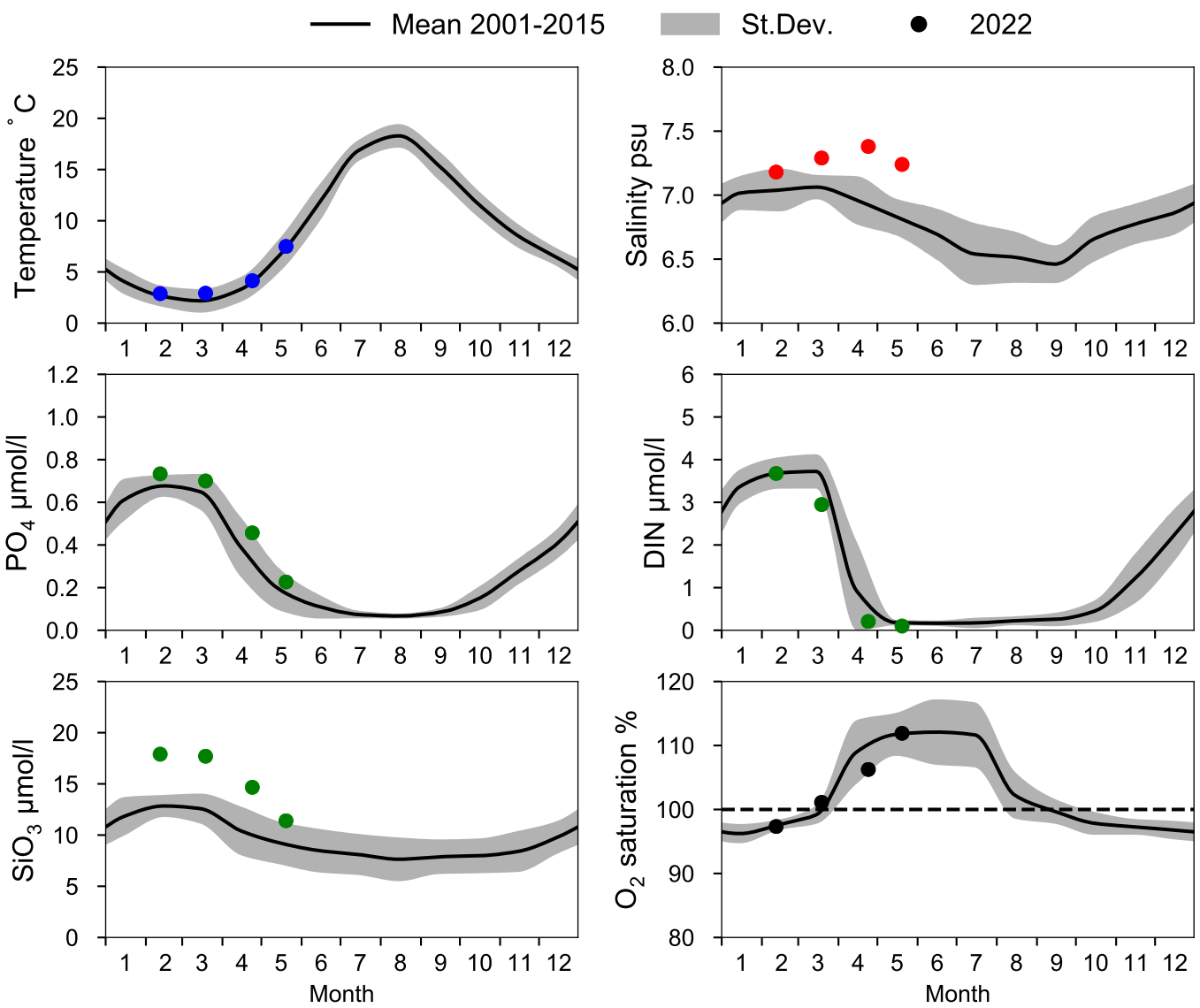


Vertical profiles BY32 NORRKÖPINGSDJ
May

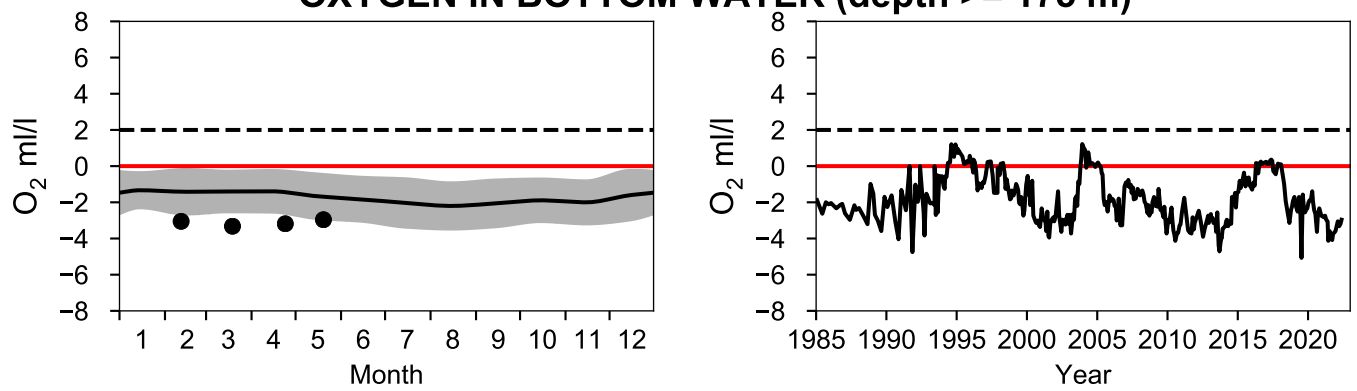


STATION BY20 FÅRÖDJ SURFACE WATER (0-10 m)

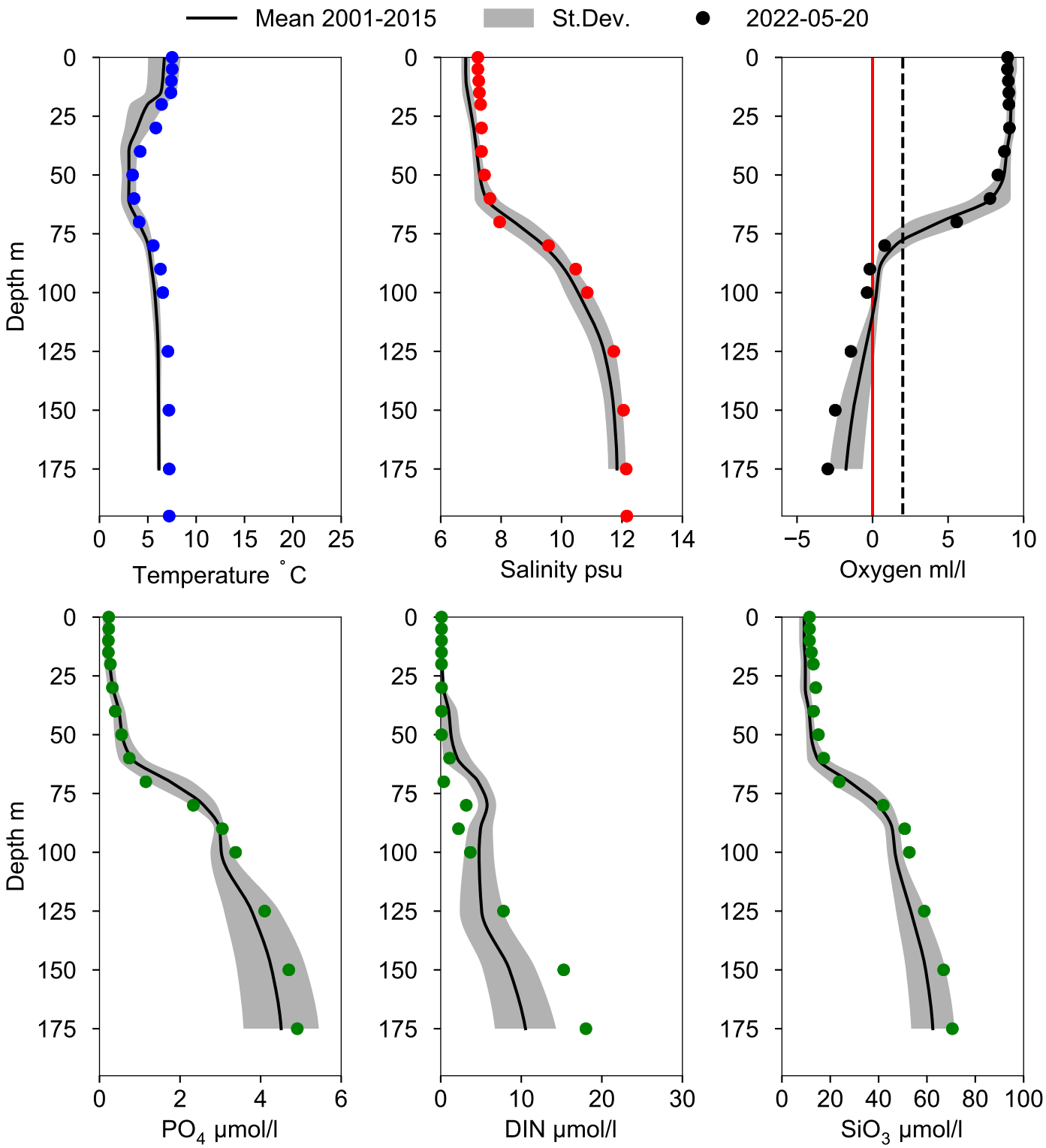
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 175 m)

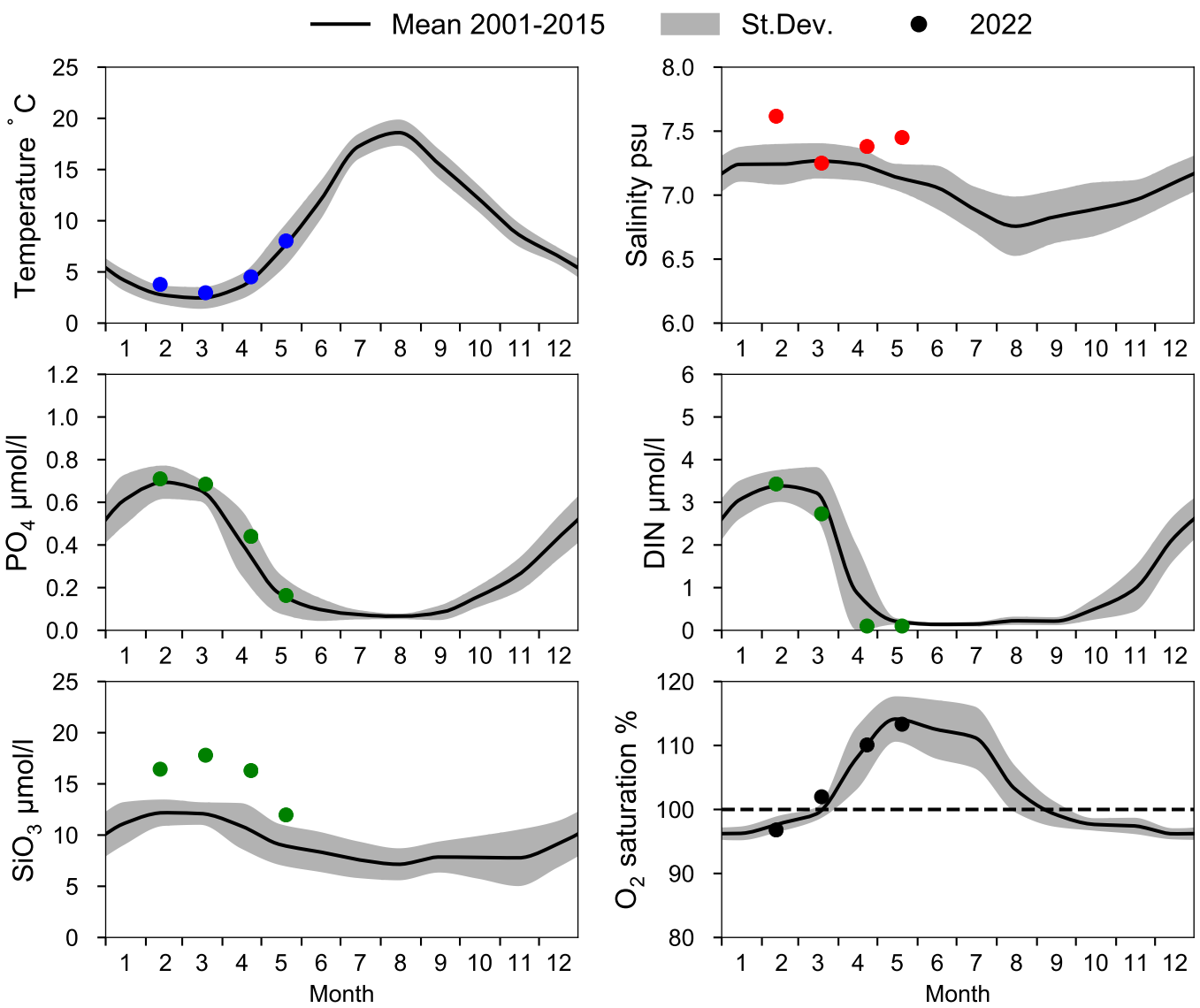


Vertical profiles BY20 FÅRÖDJ
May

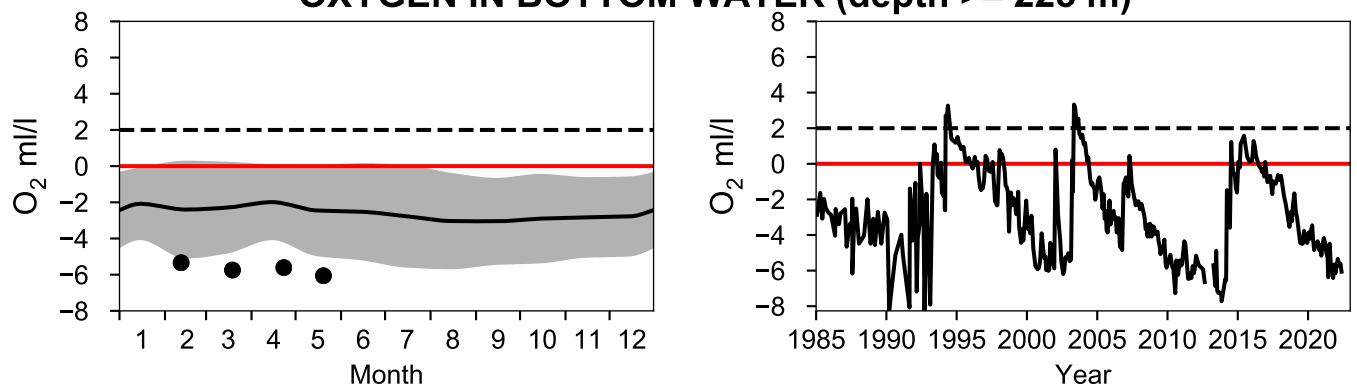


STATION BY15 GOTLANDSDJ SURFACE WATER (0-10 m)

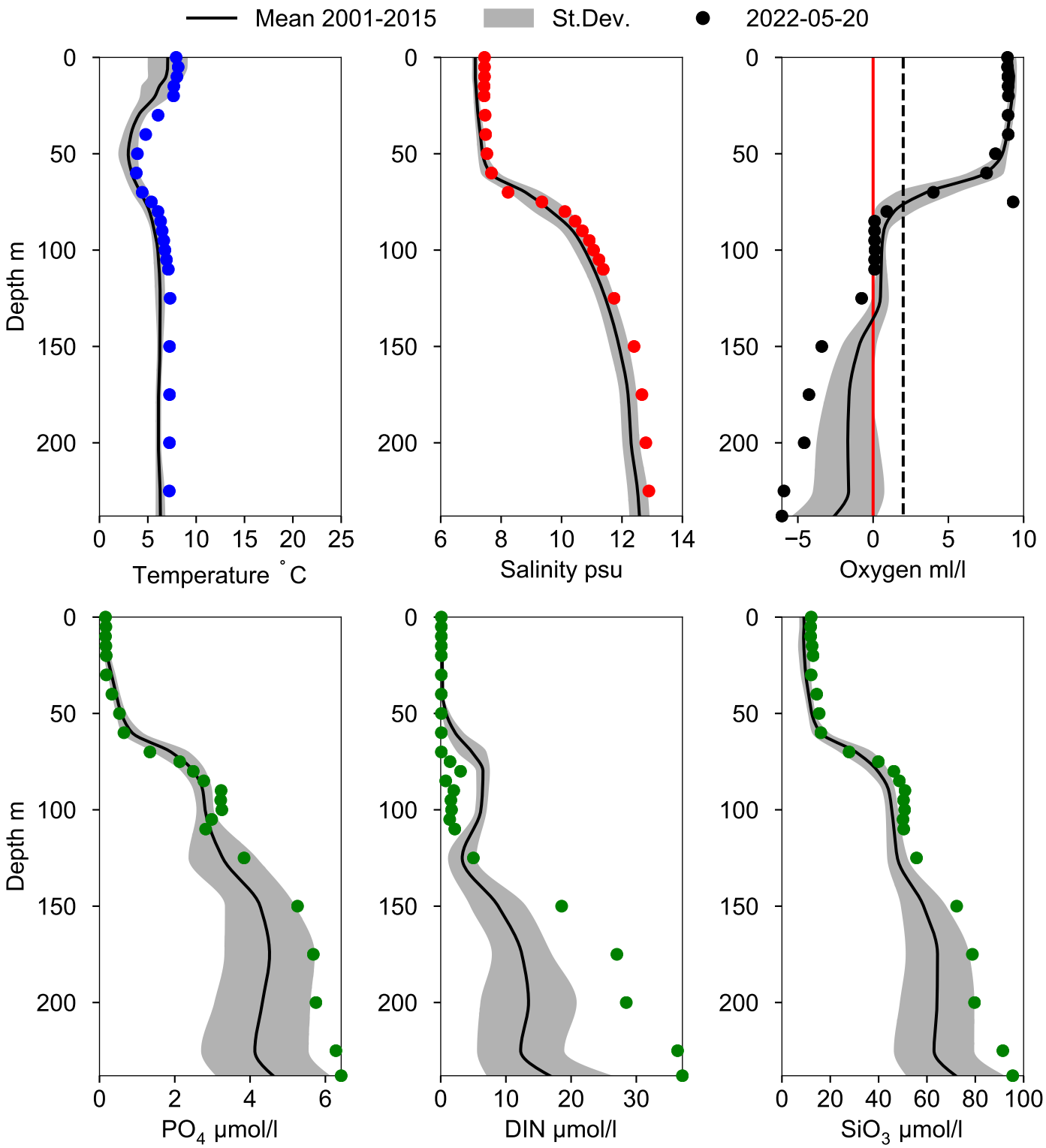
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 225 m)

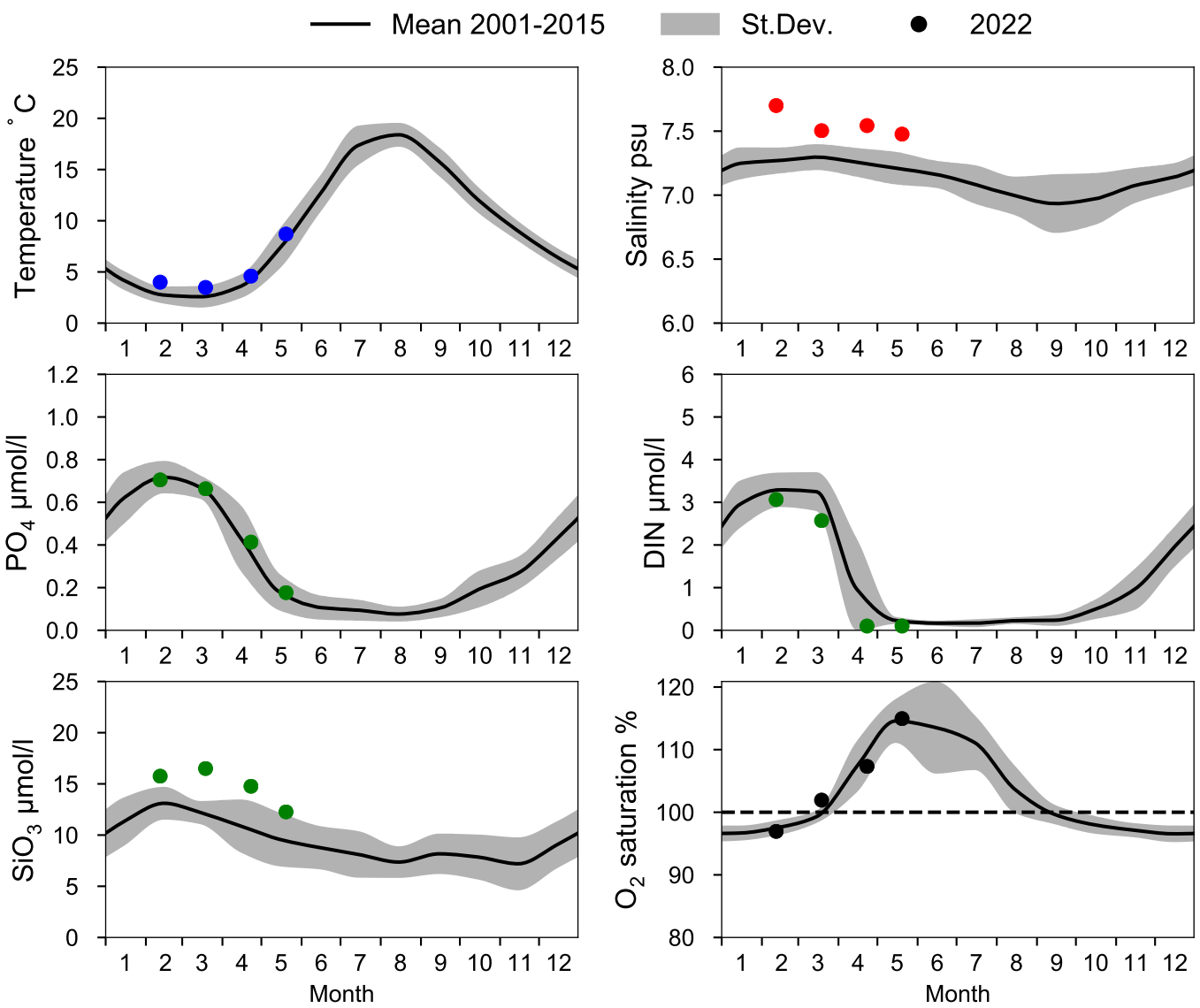


Vertical profiles BY15 GOTLANDSDJ
May

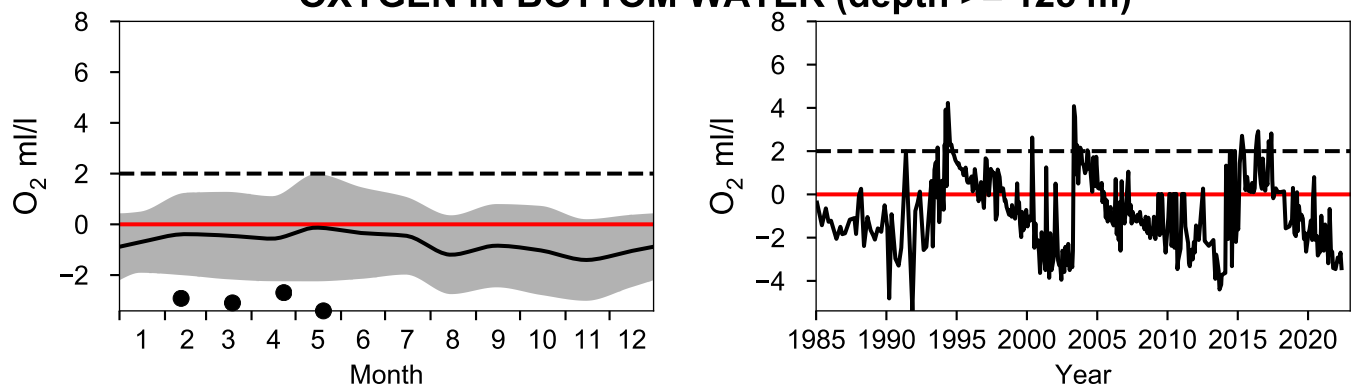


STATION BY10 SURFACE WATER (0-10 m)

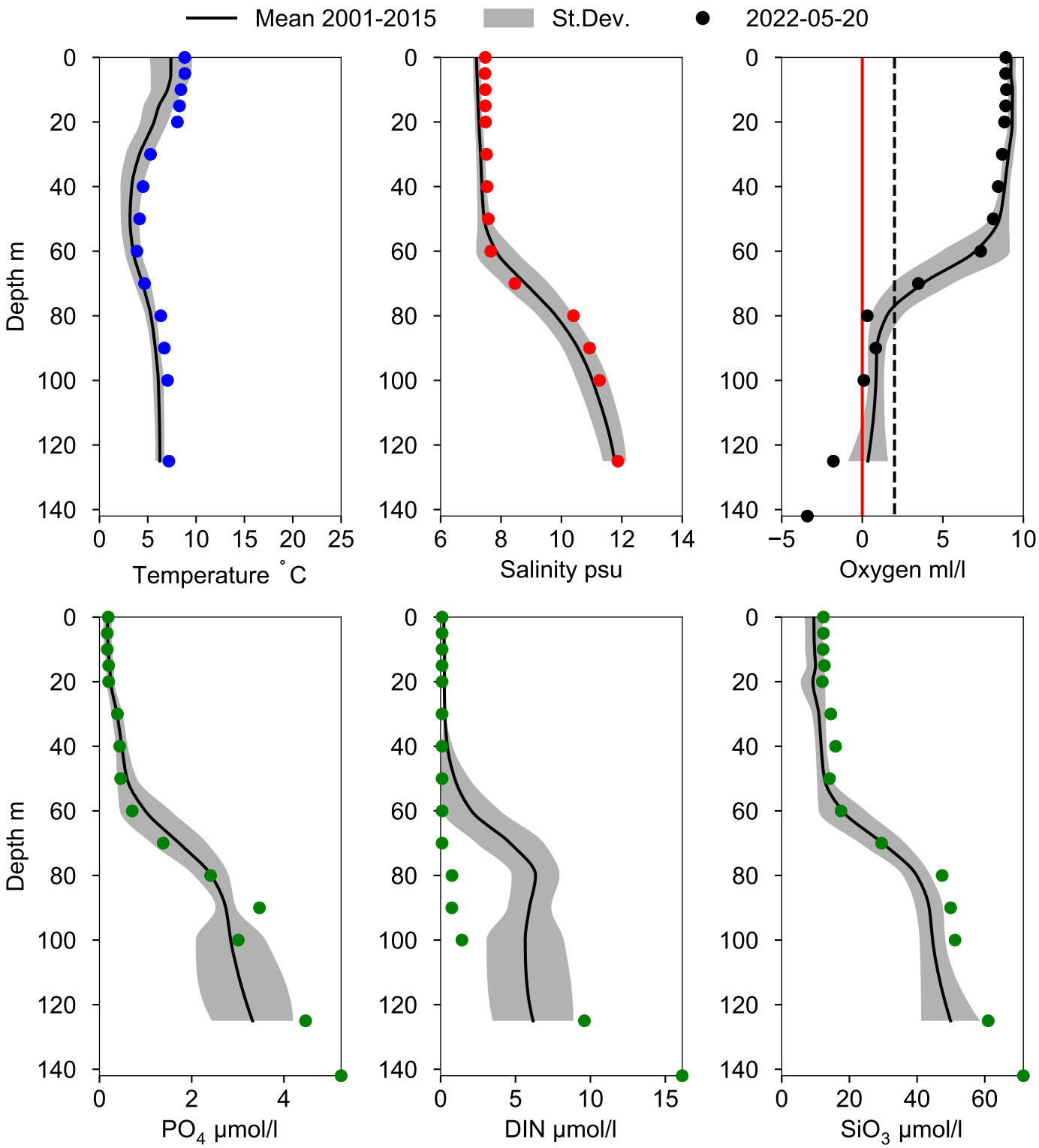
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 125 m)

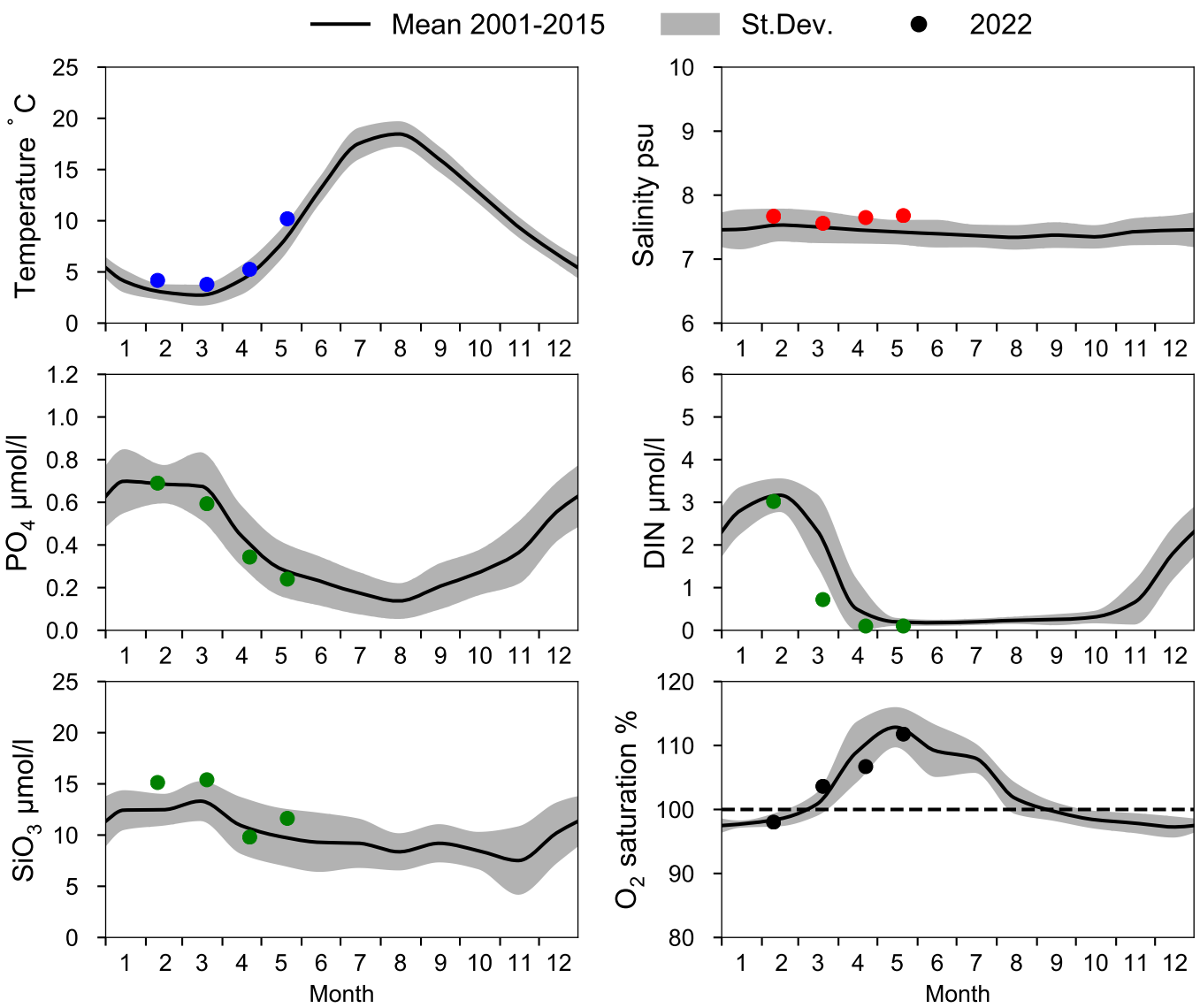


Vertical profiles BY10
May

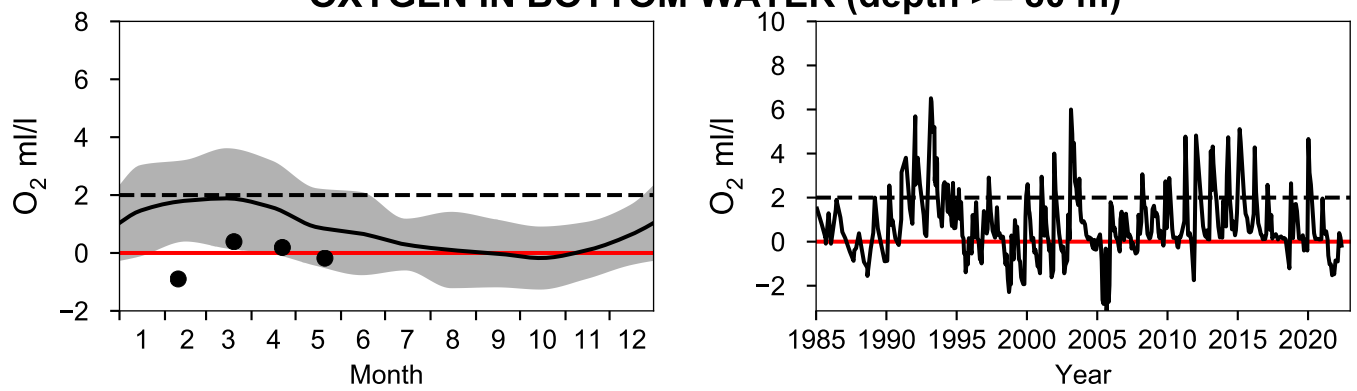


STATION BY5 BORNHOLMSDJ SURFACE WATER (0-10 m)

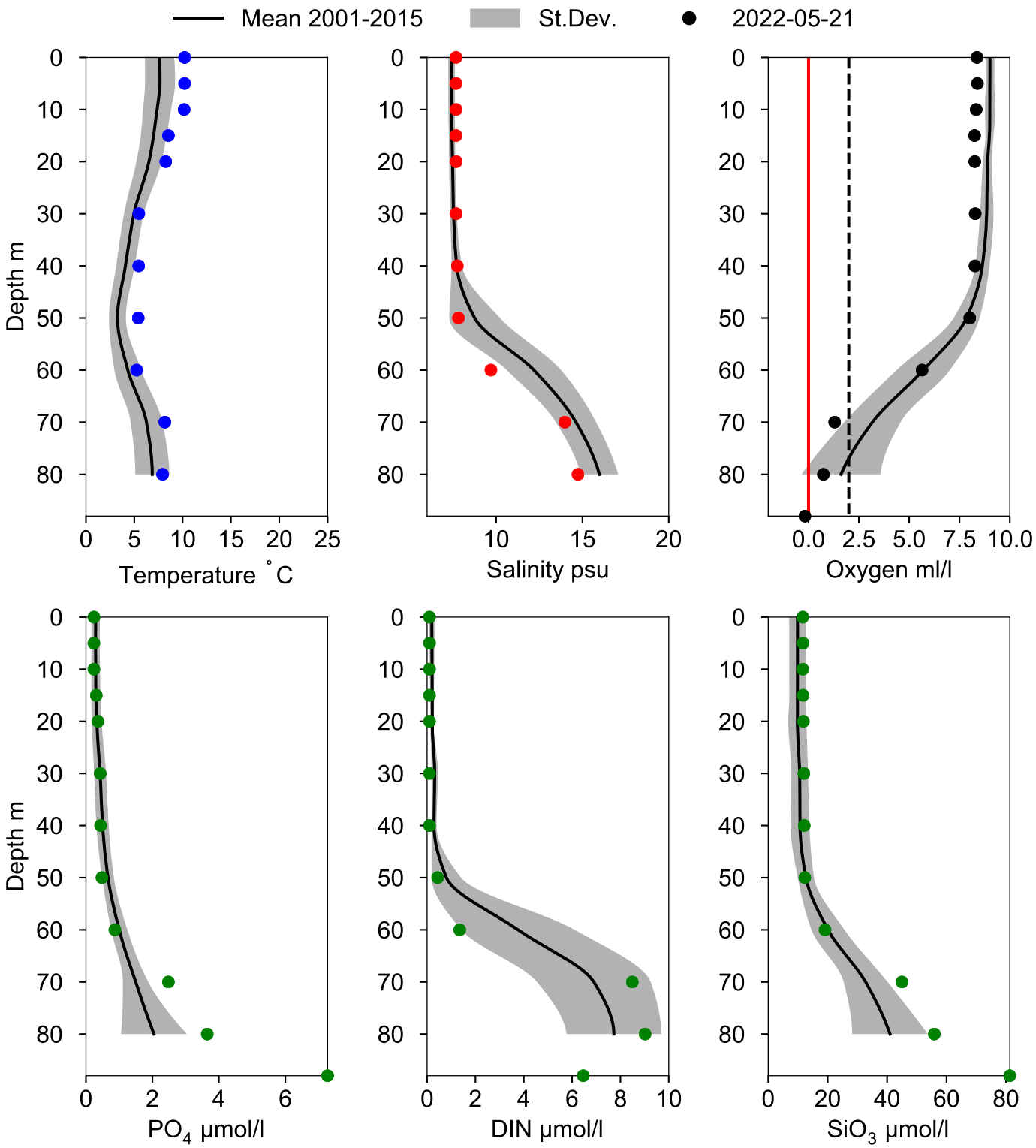
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

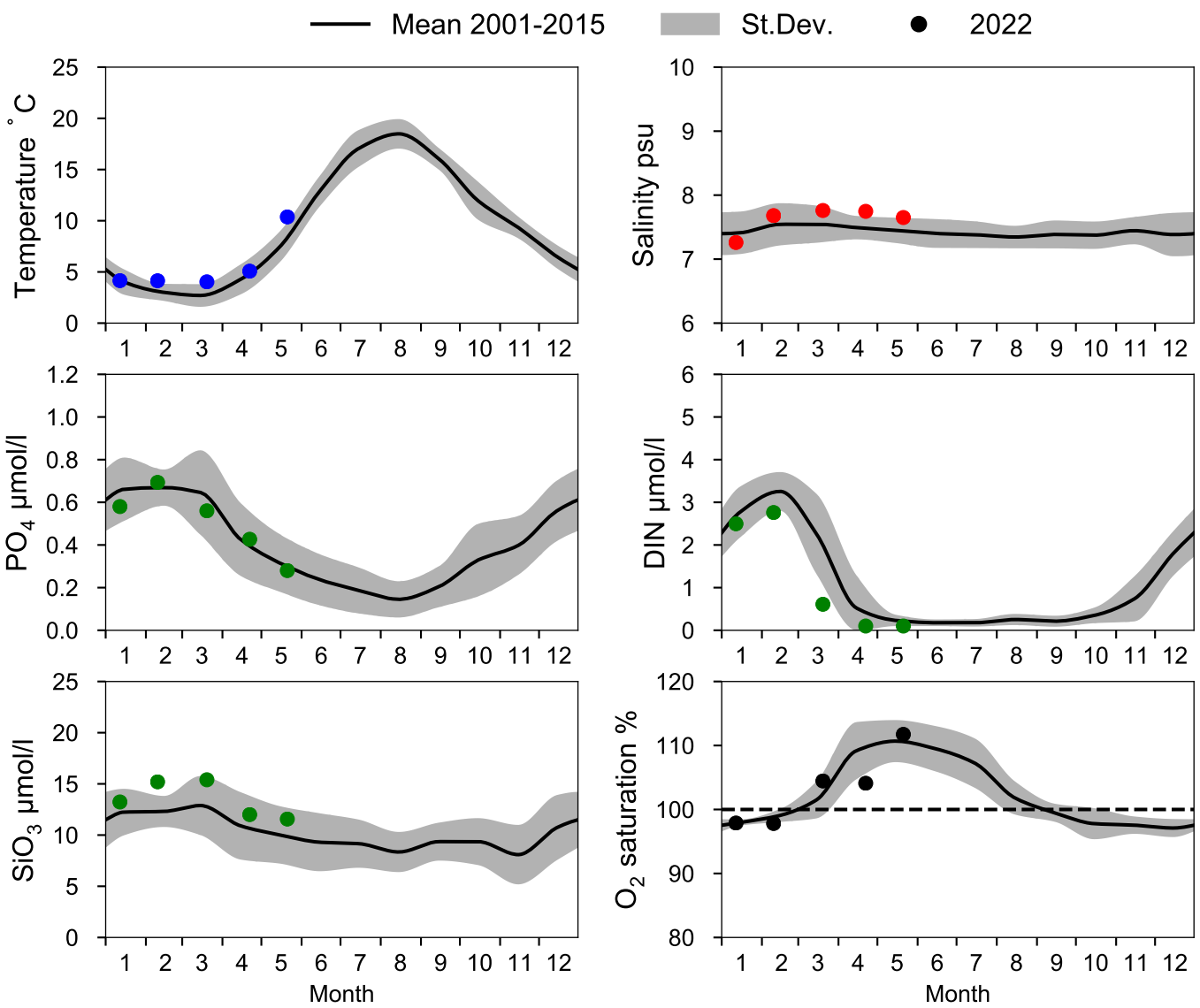


Vertical profiles BY5 BORNHOLMSDJ
May

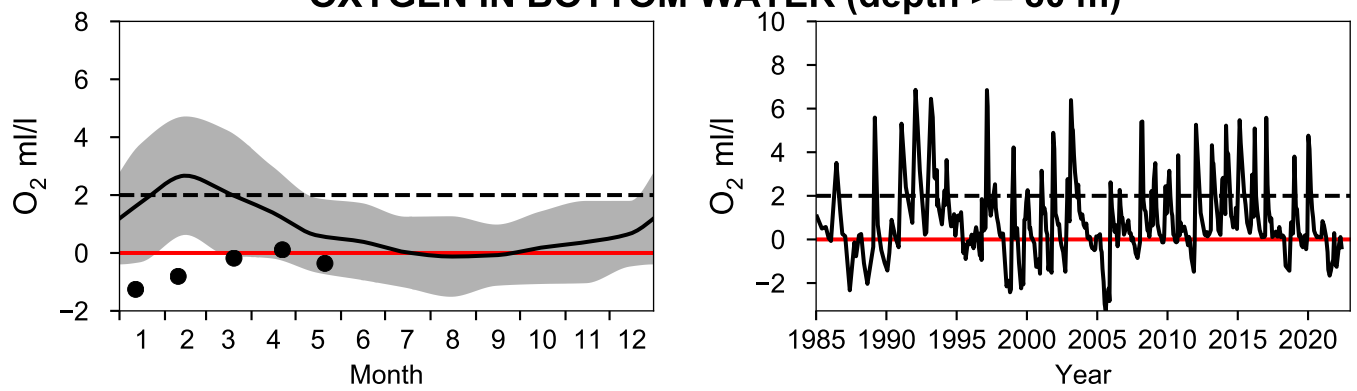


STATION BY4 CHRISTIANSÖ SURFACE WATER (0-10 m)

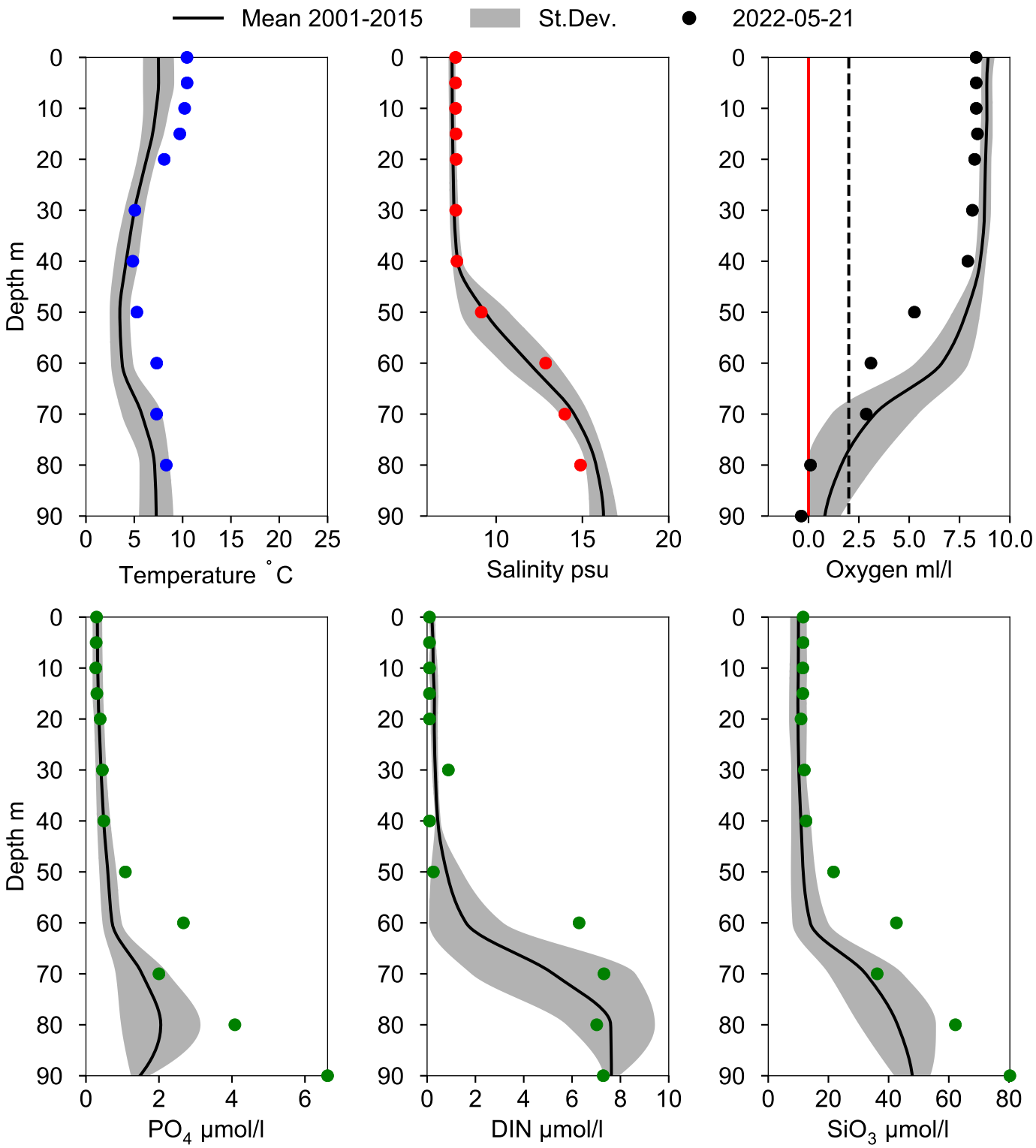
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

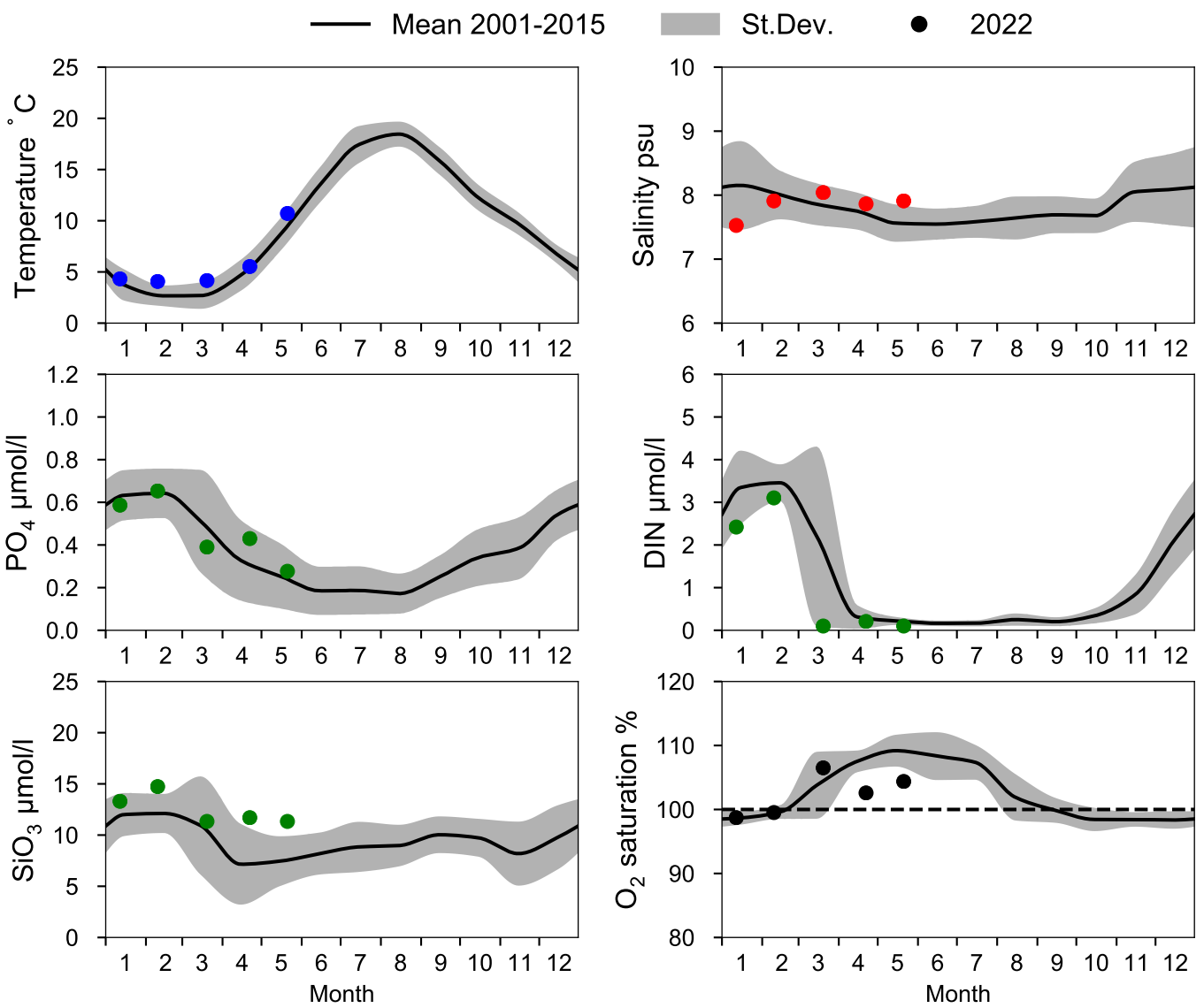


Vertical profiles BY4 CHRISTIANSÖ
May

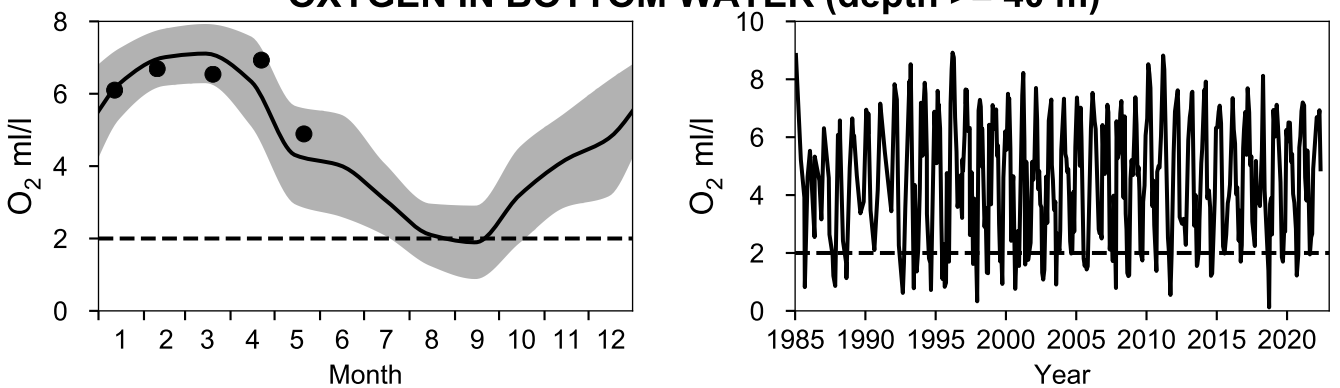


STATION BY2 ARKONA SURFACE WATER (0-10 m)

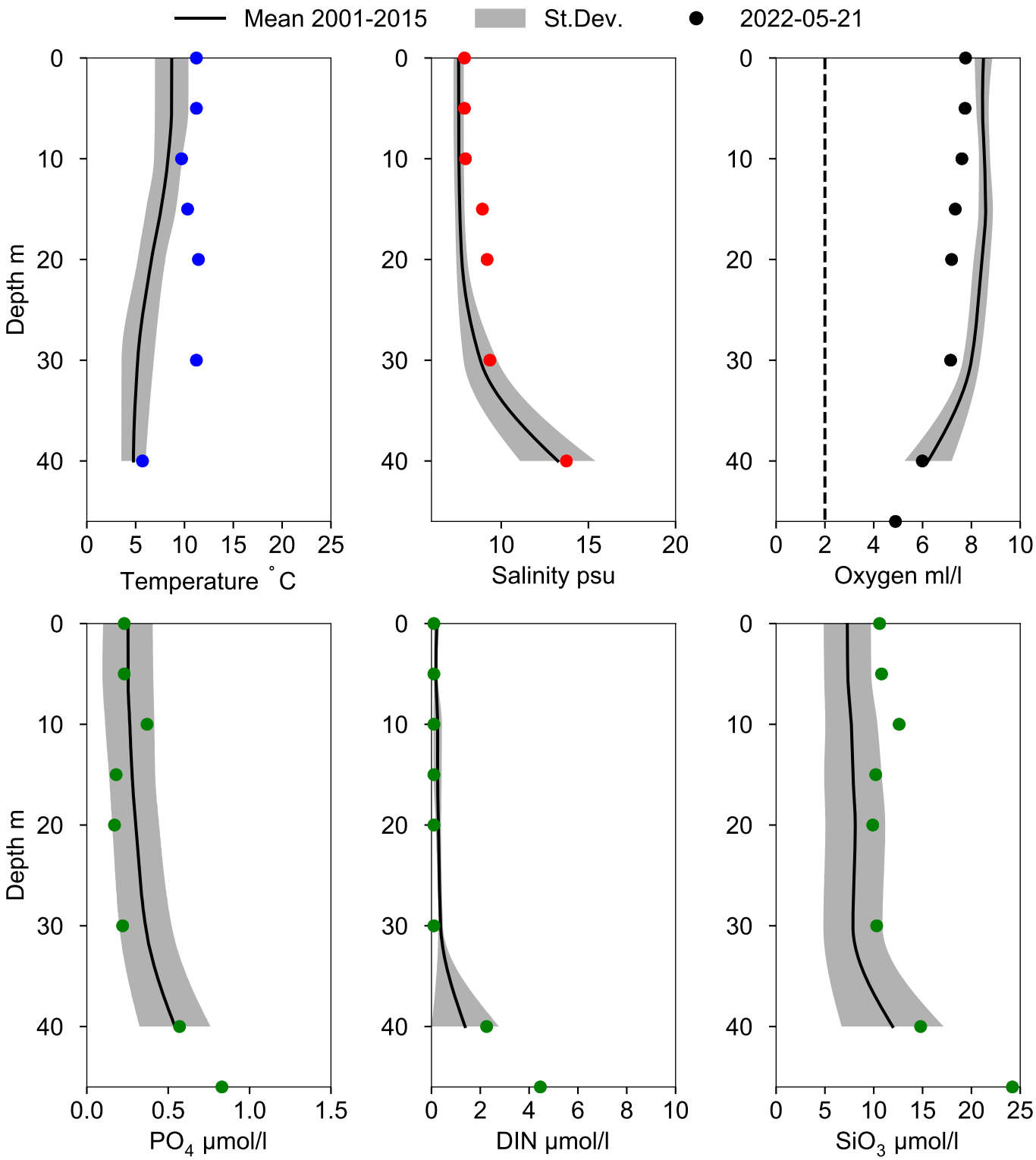
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 40 m)

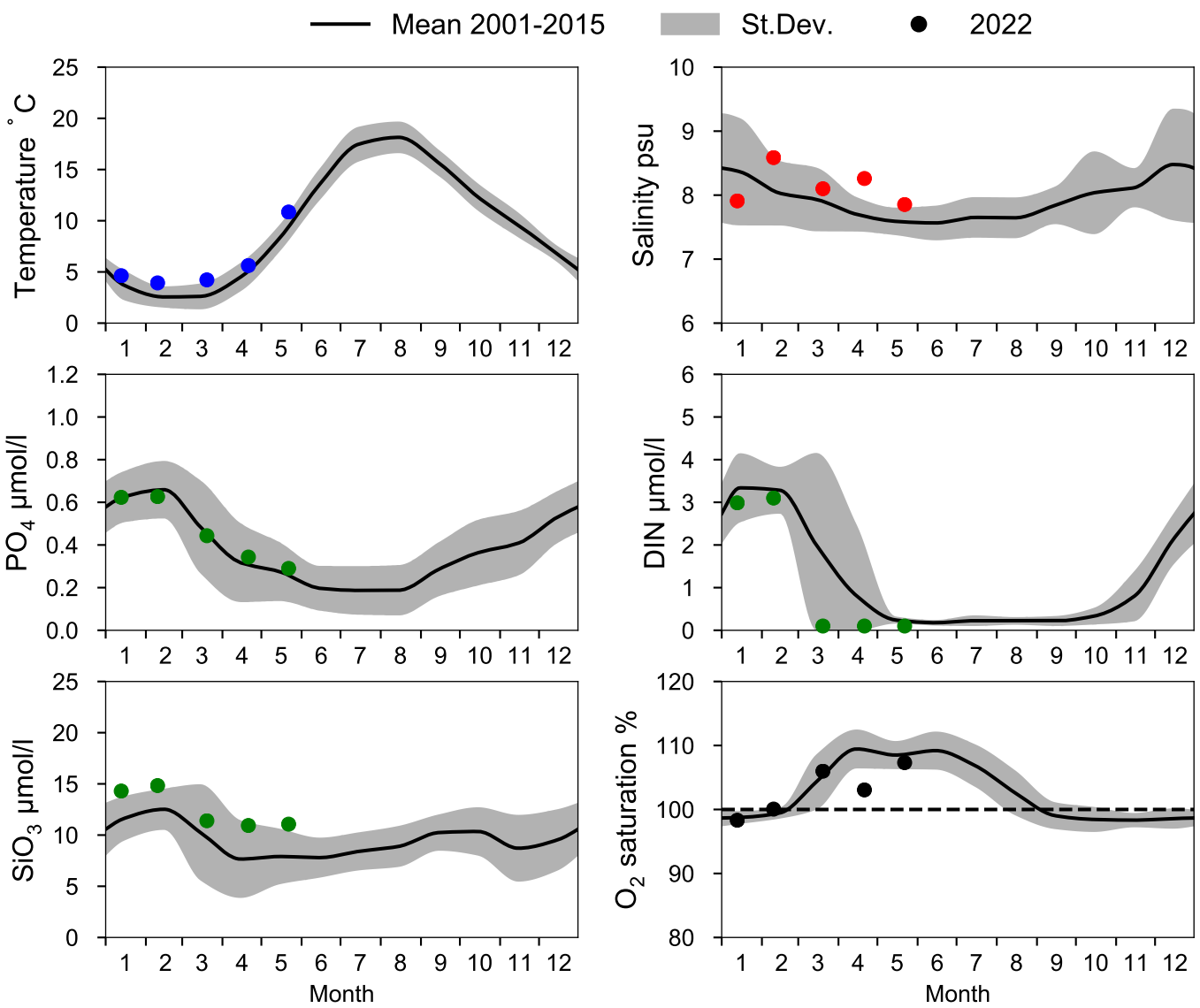


Vertical profiles BY2 ARKONA
May

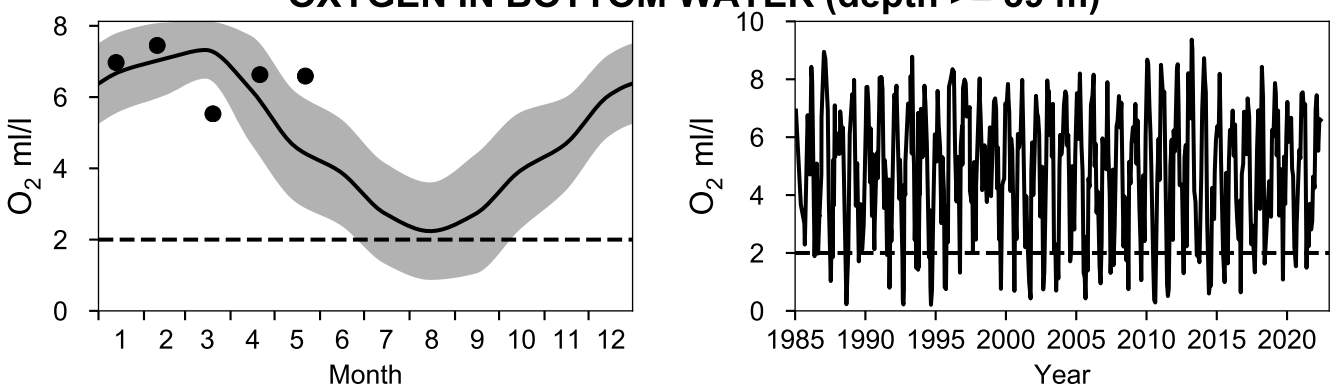


STATION BY1 SURFACE WATER (0-10 m)

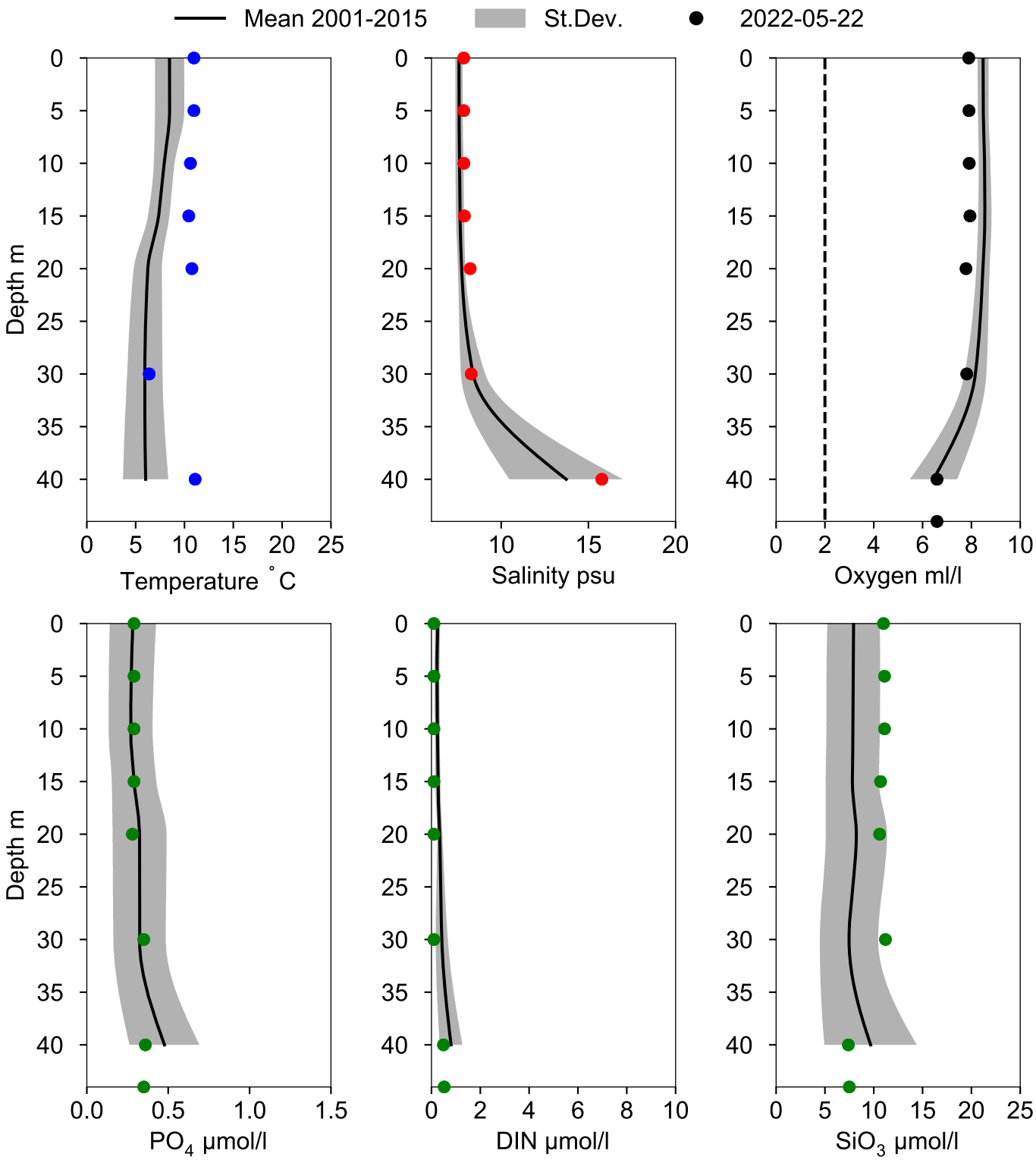
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 39 m)

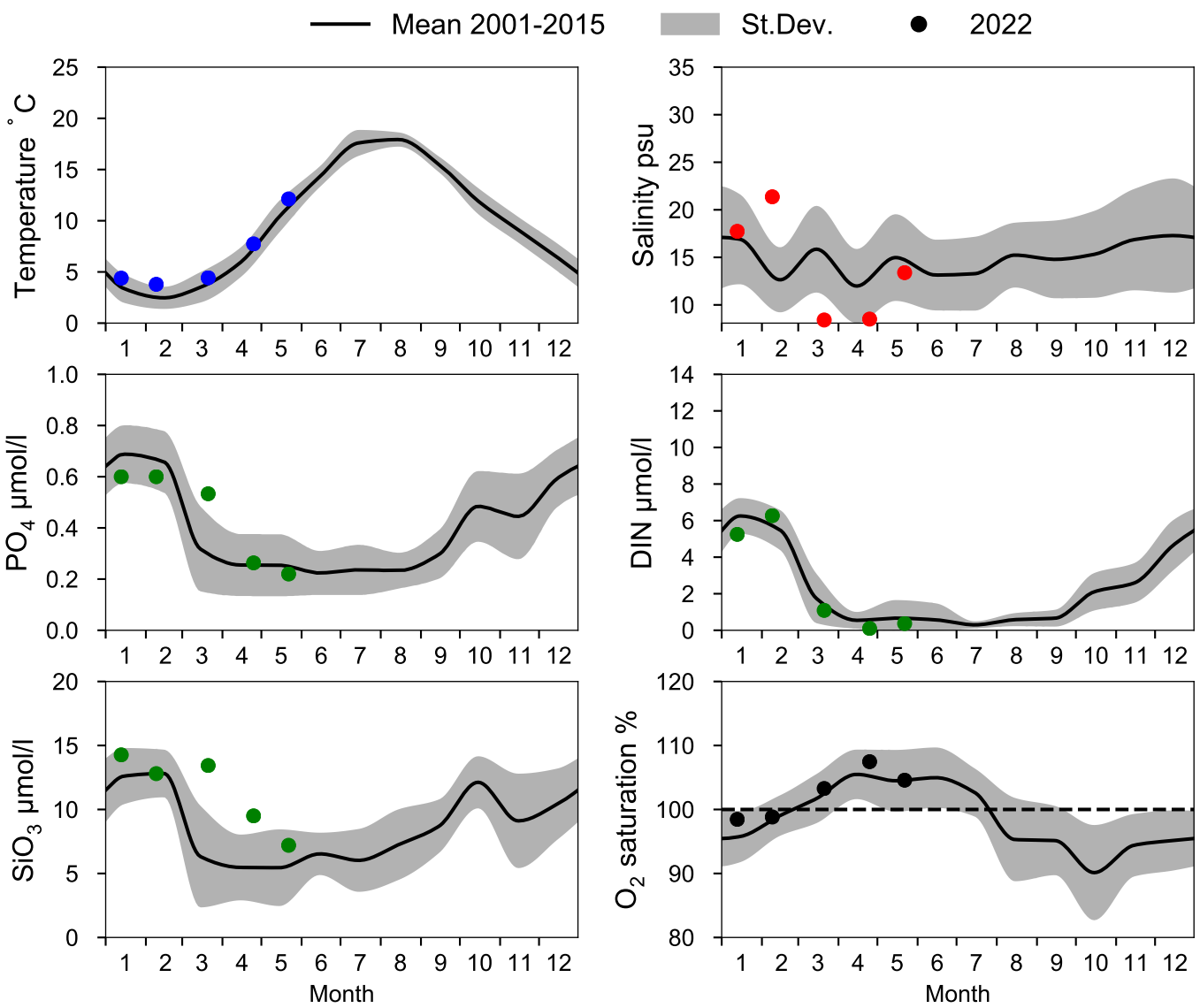


Vertical profiles BY1
May

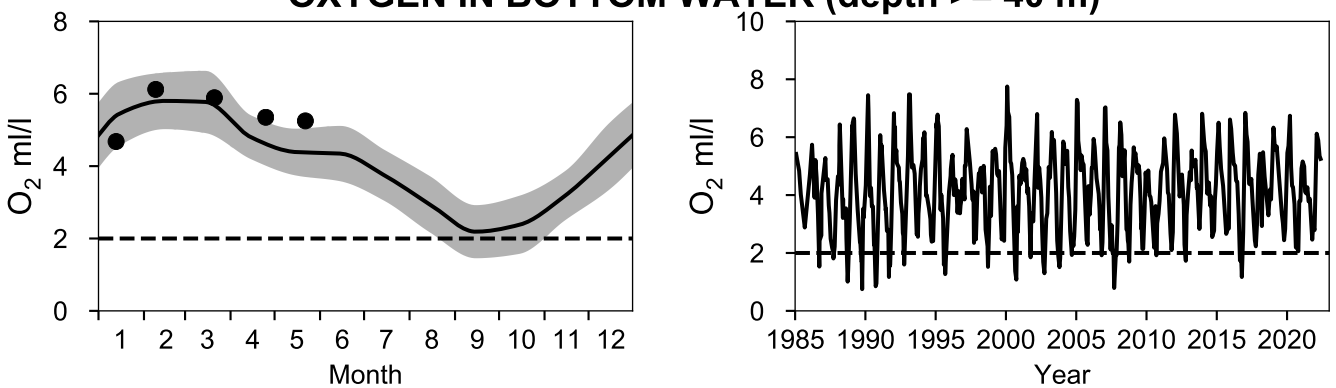


STATION W LANDSKRONA SURFACE WATER (0-10 m)

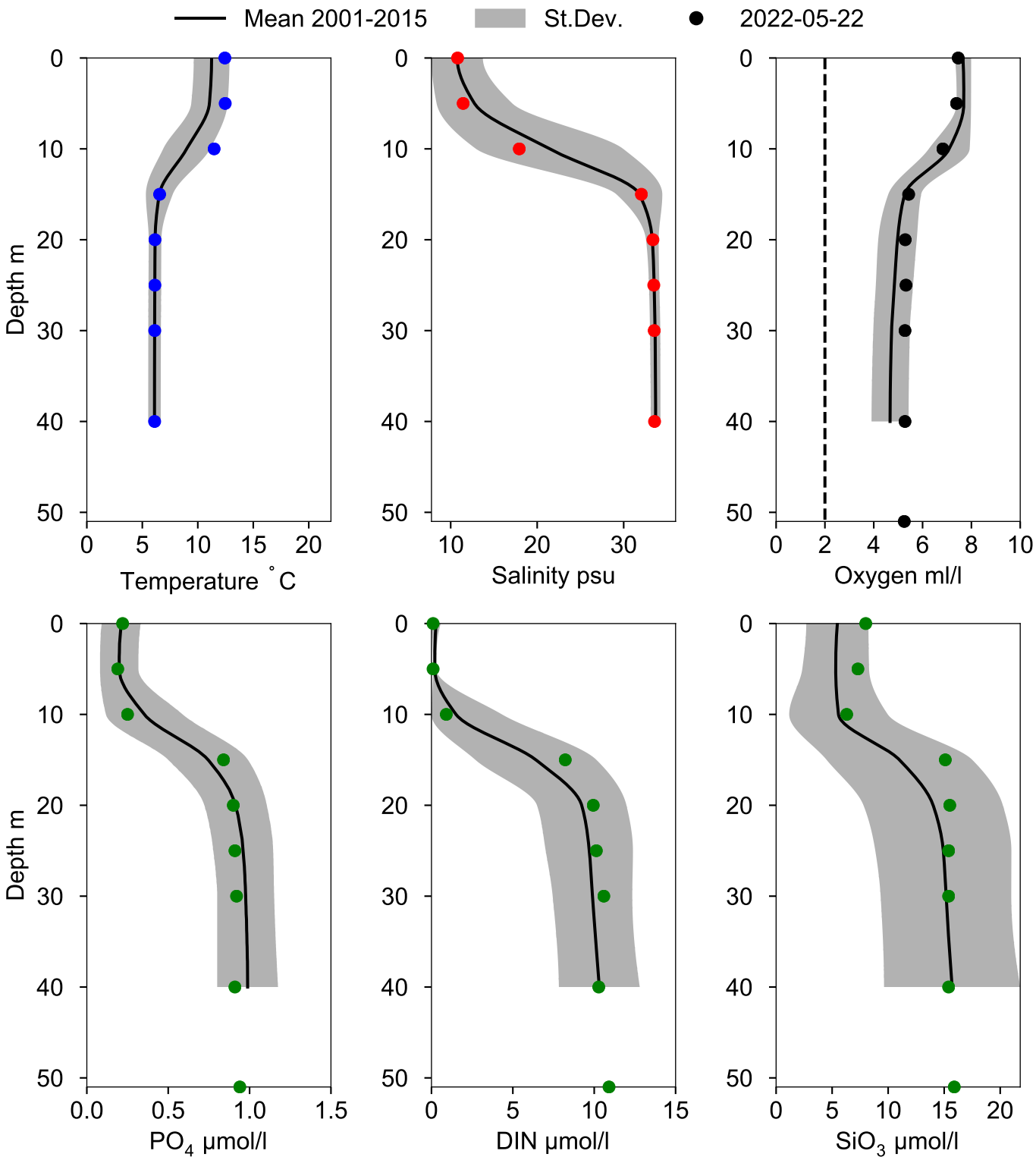
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 40 m)

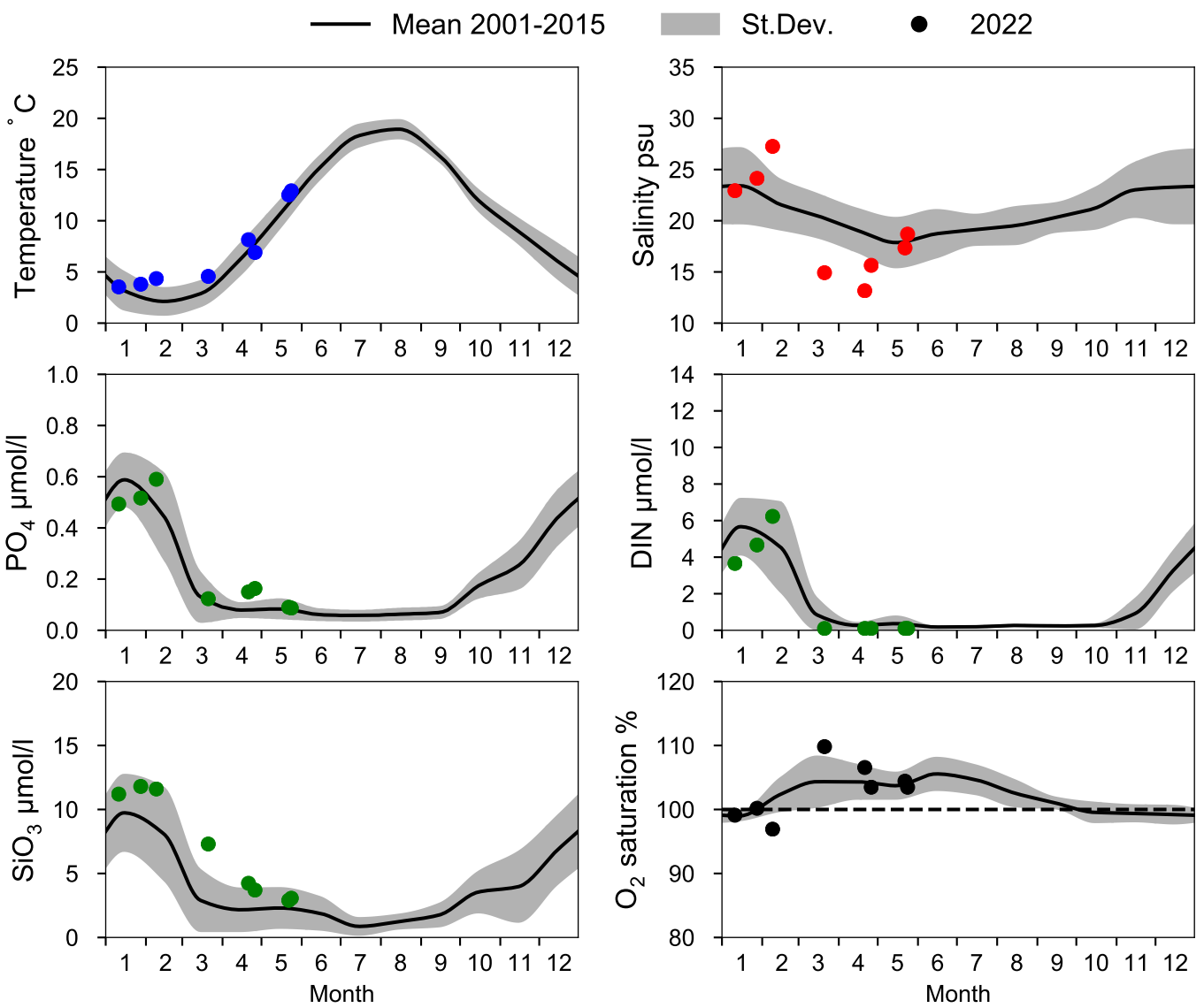


Vertical profiles W LANDSKRONA
May

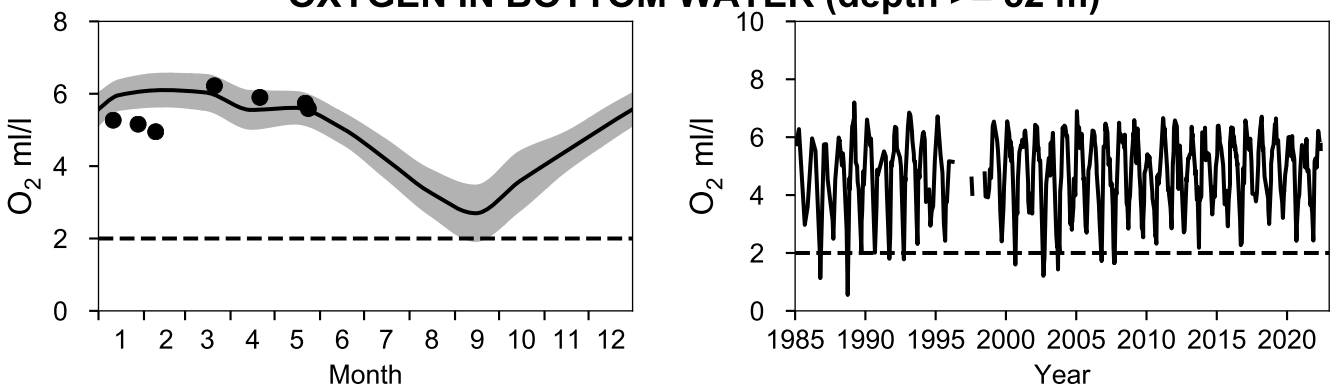


STATION ANHOLT E SURFACE WATER (0-10 m)

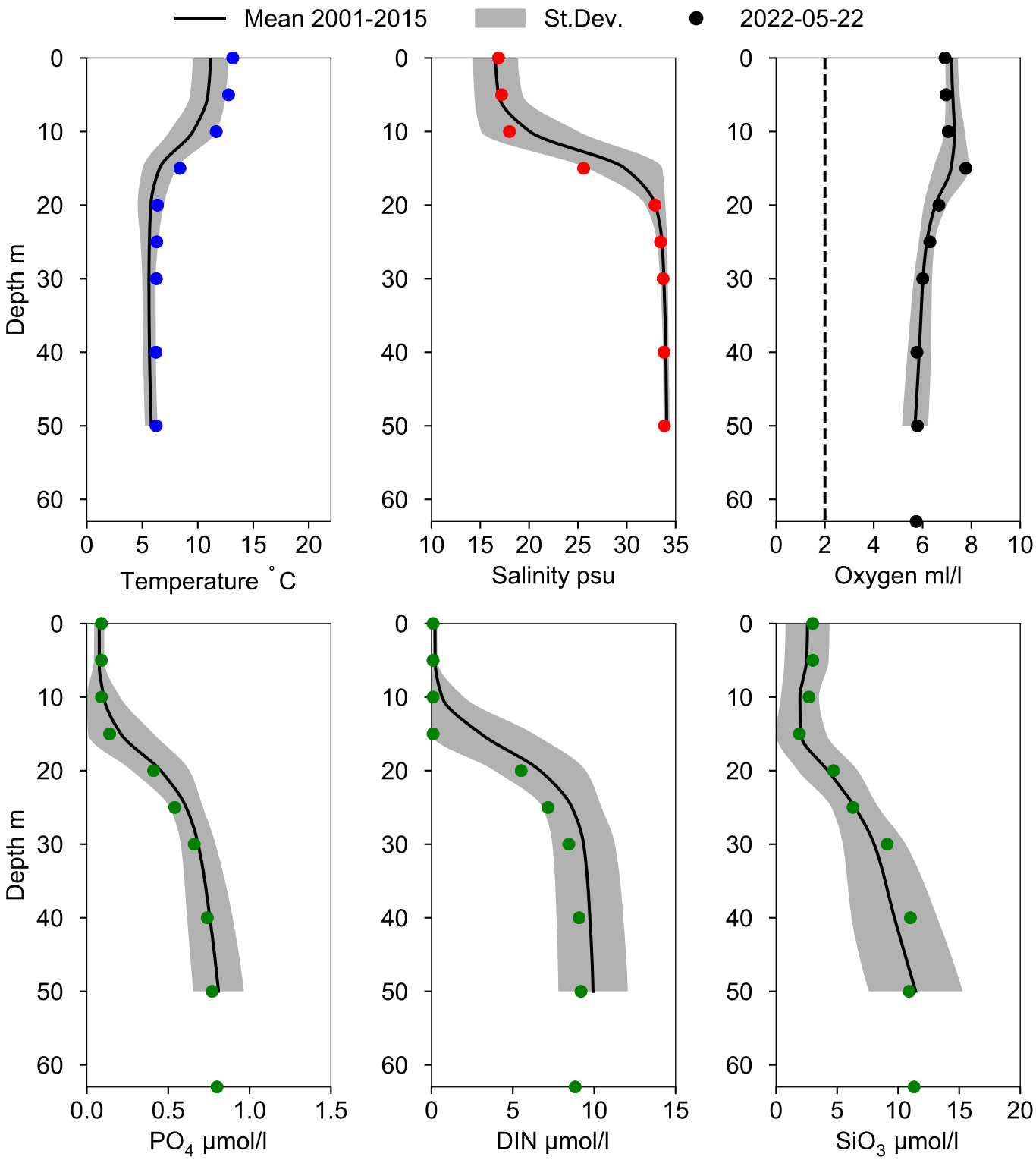
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 52 m)

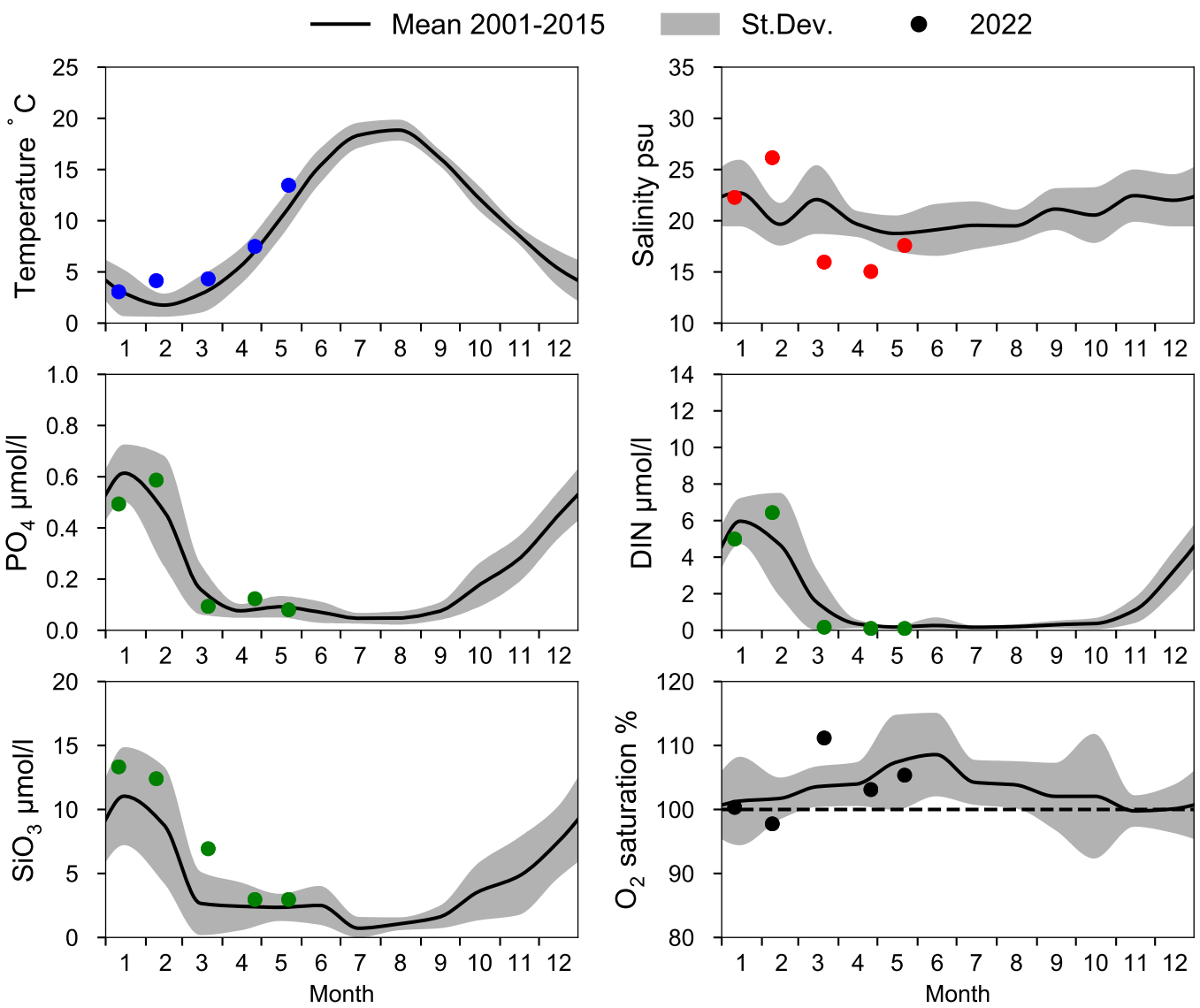


Vertical profiles ANHOLT E
May

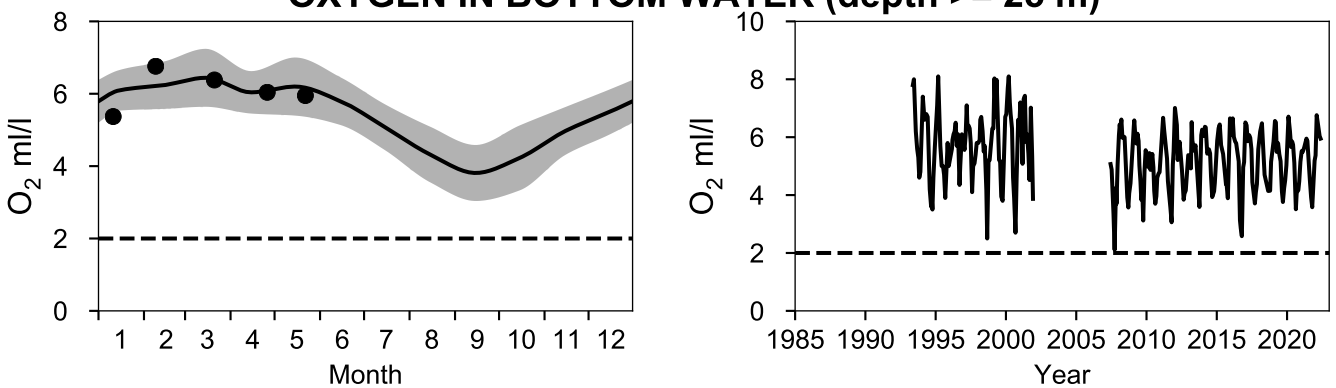


STATION N14 FALKENBERG SURFACE WATER (0-10 m)

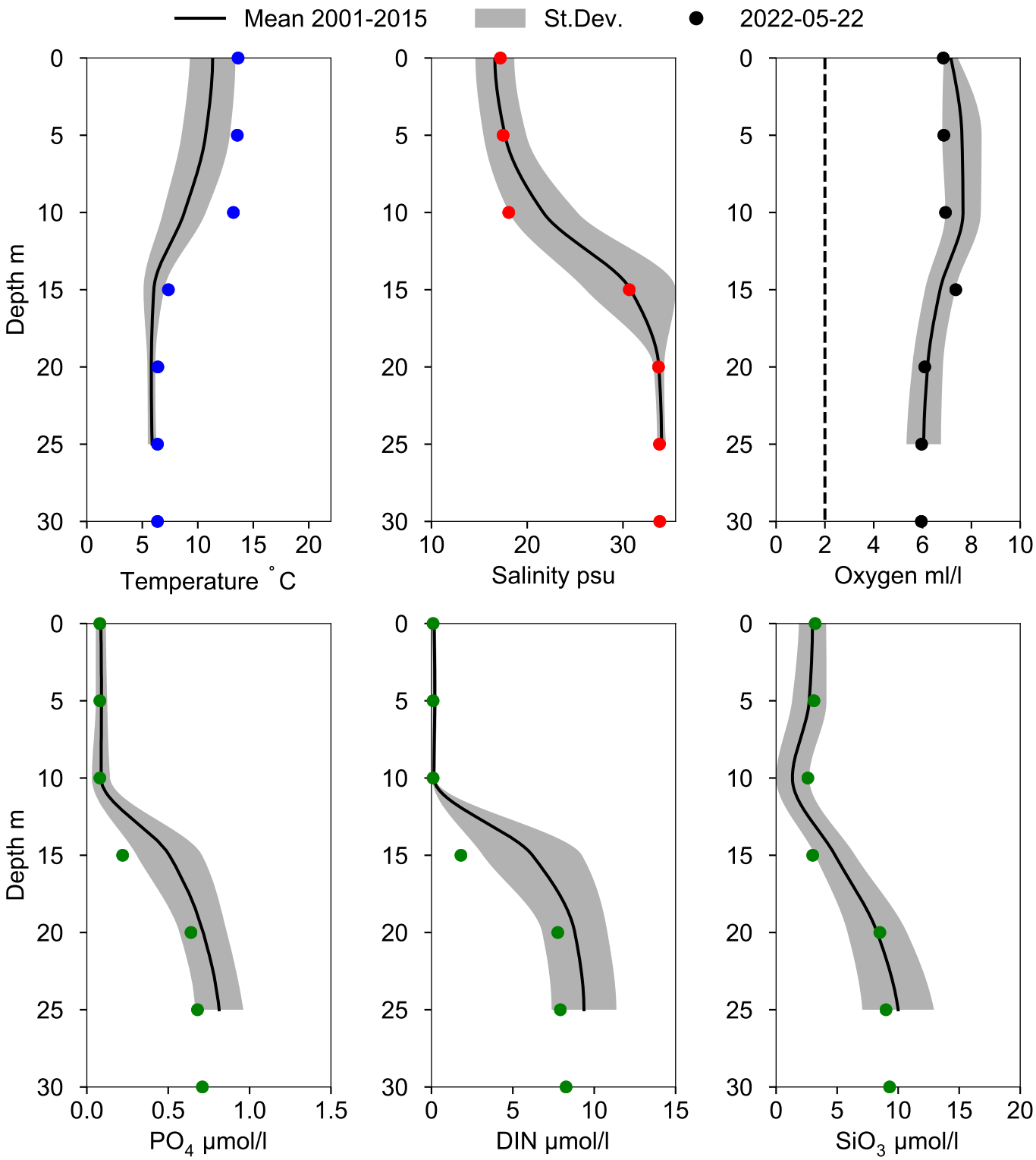
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 25 m)

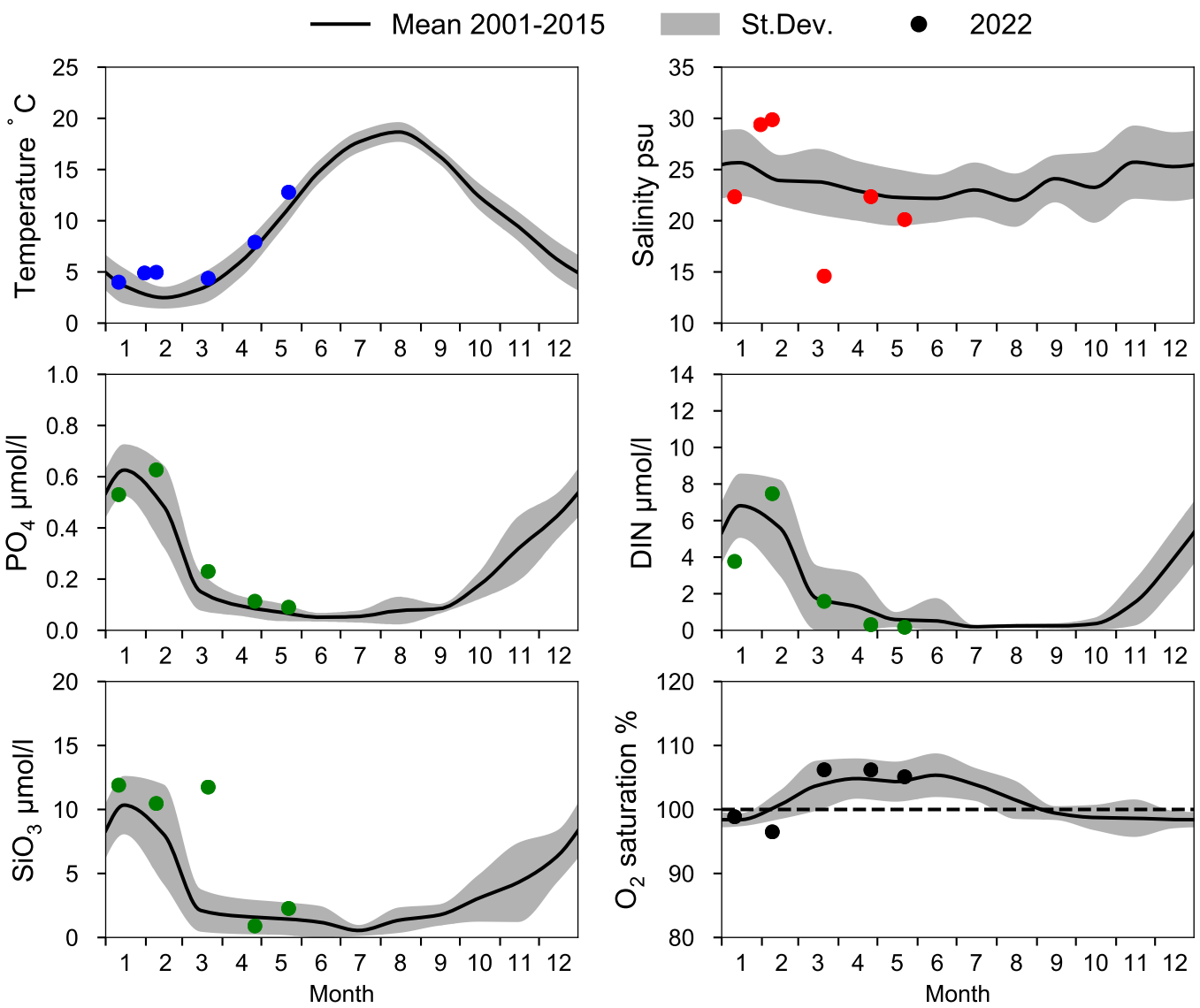


Vertical profiles N14 FALKENBERG
May

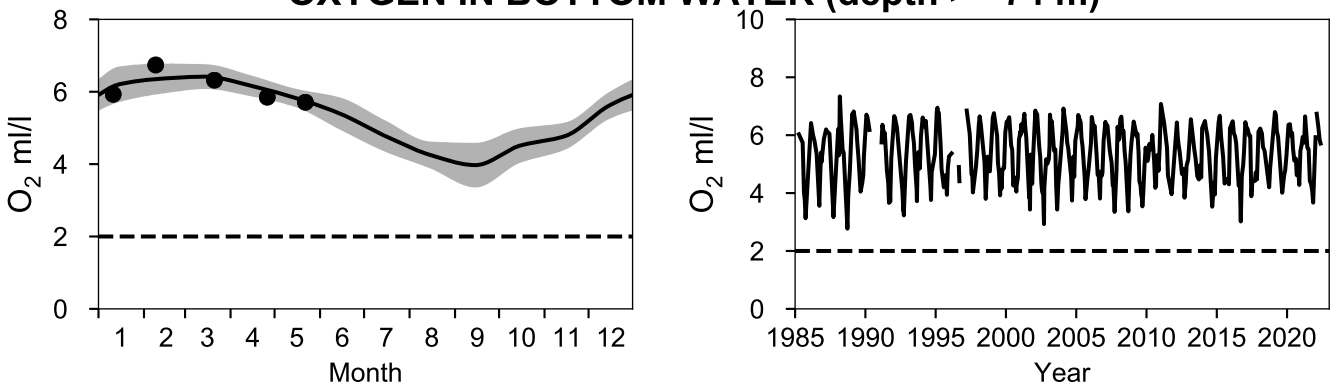


STATION FLADEN SURFACE WATER (0-10 m)

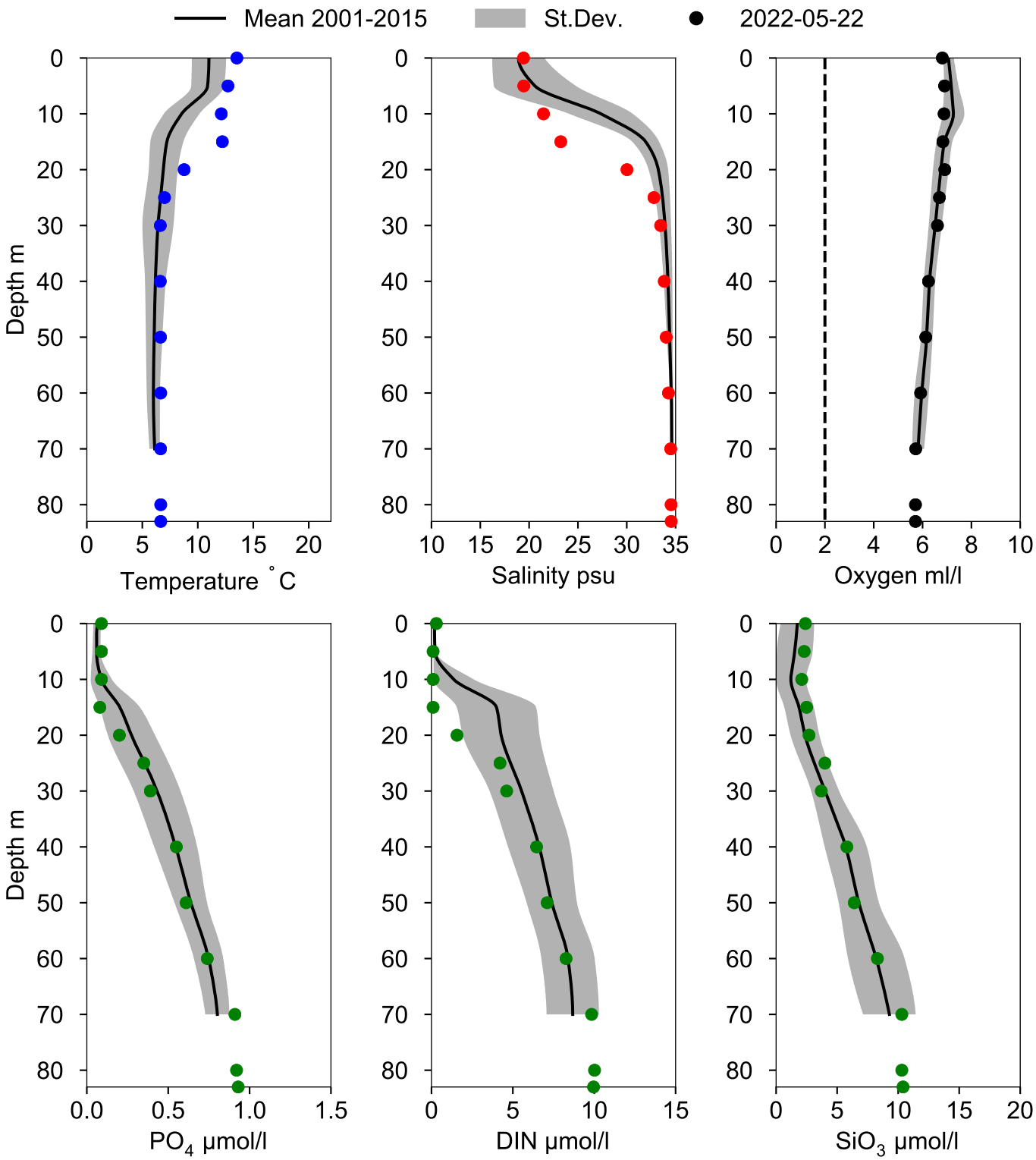
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 74 m)

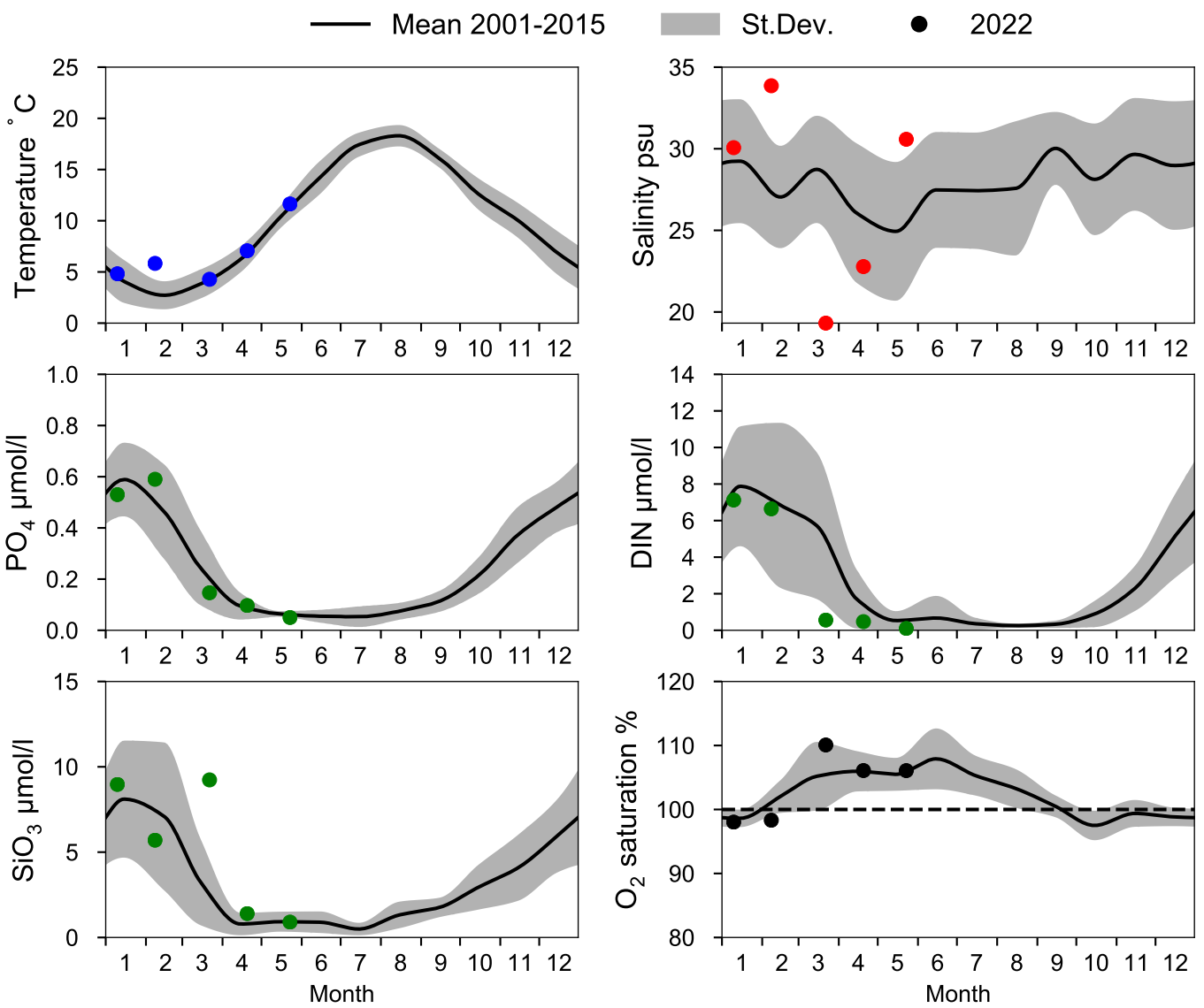


Vertical profiles FLADEN
May

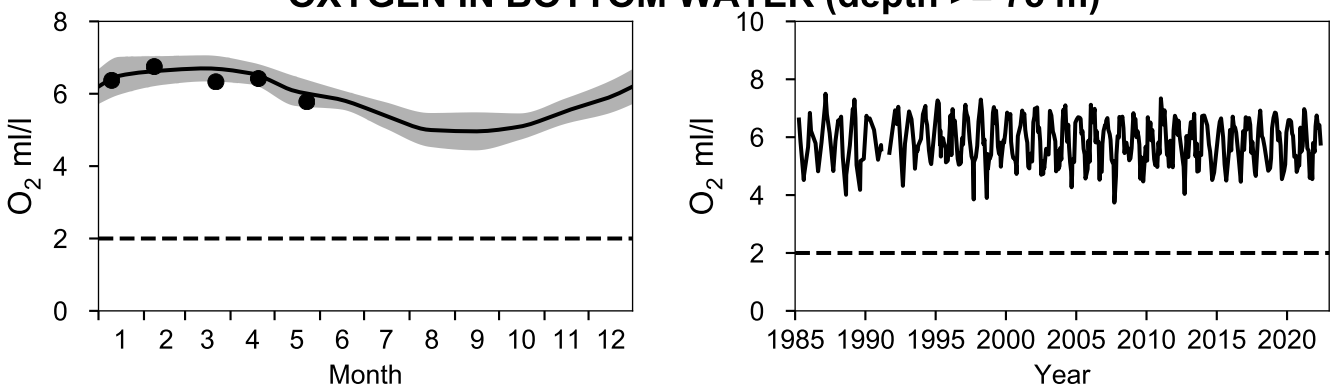


STATION P2 SURFACE WATER (0-10 m)

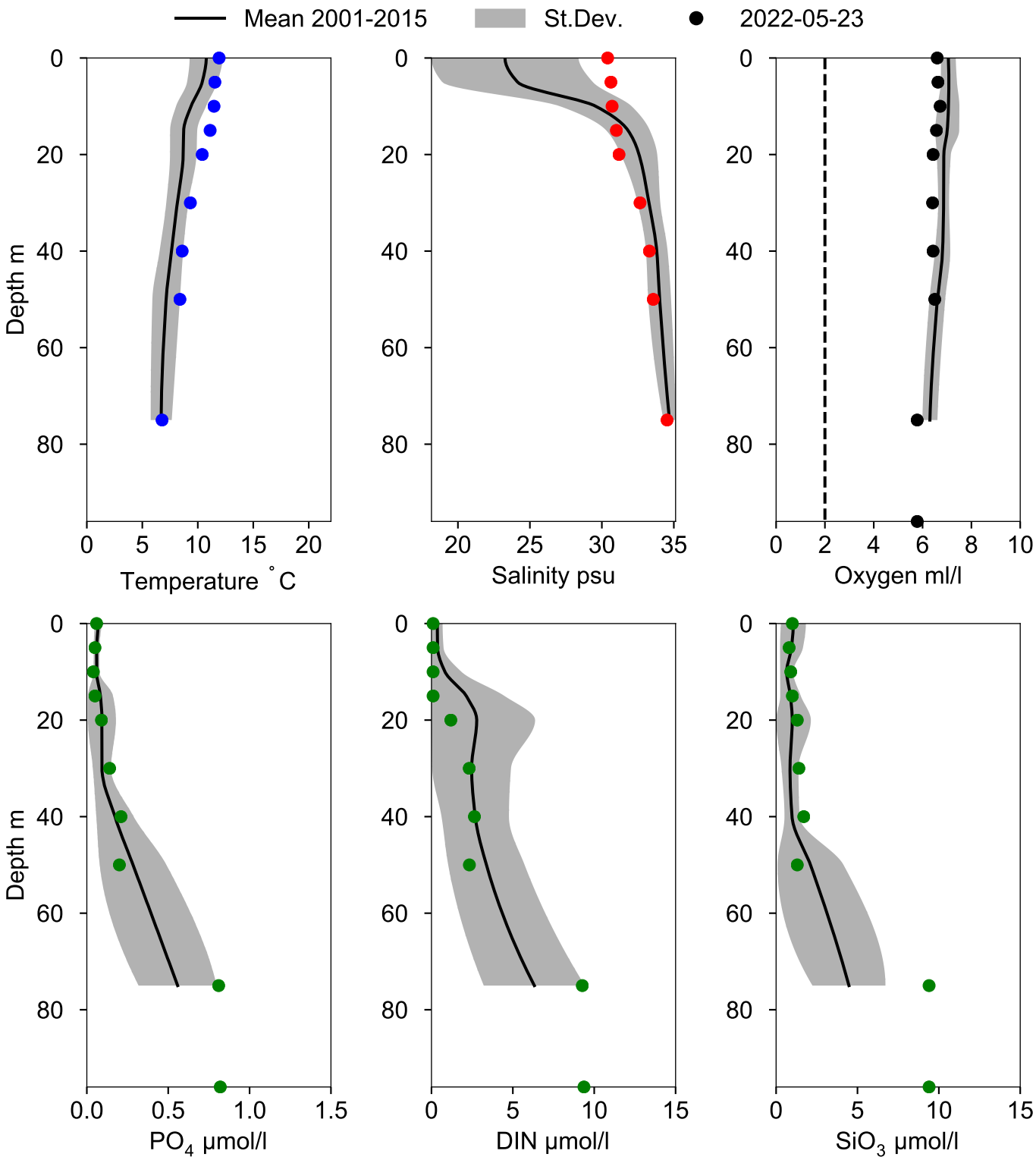
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 75 m)

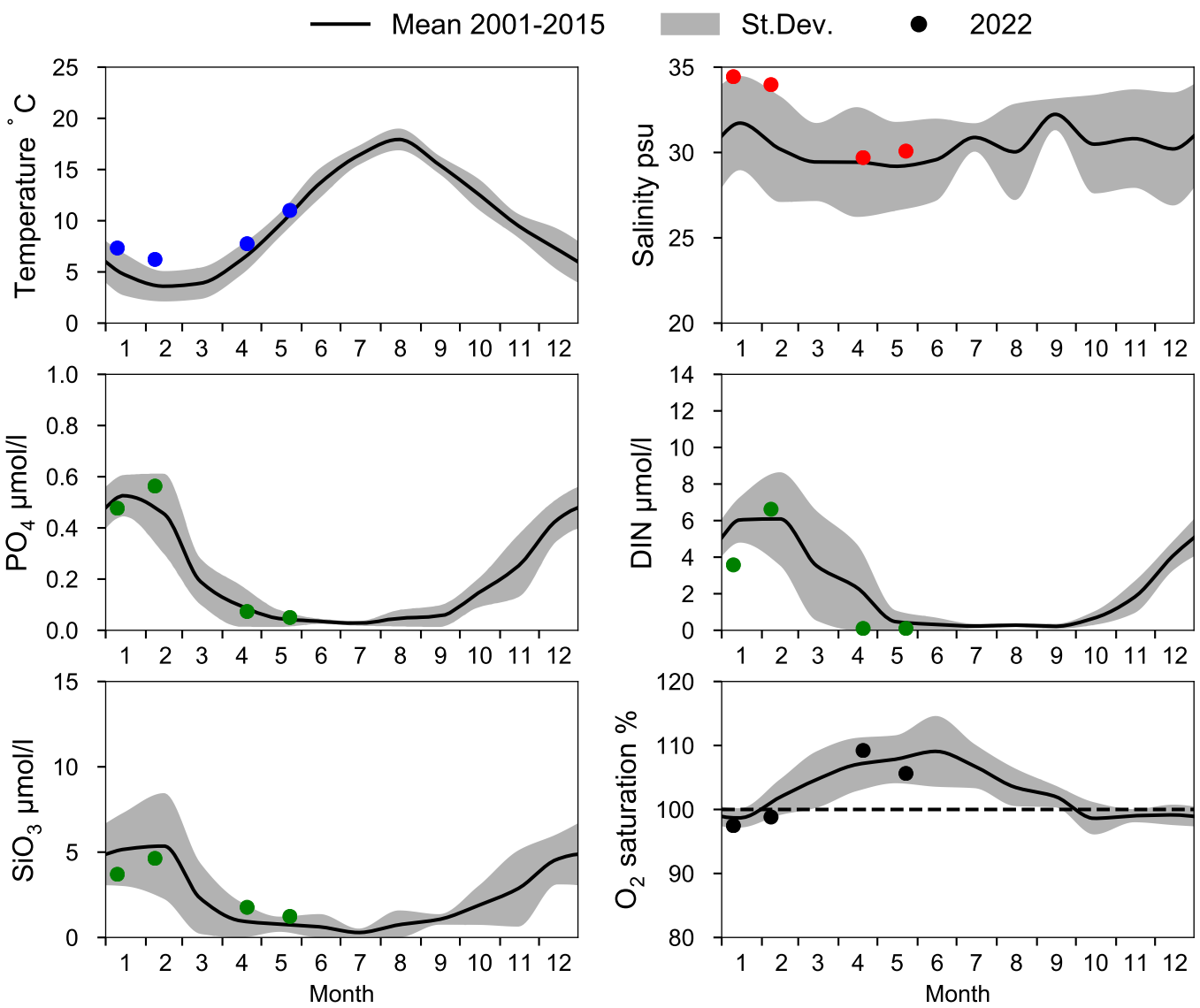


Vertical profiles P2
May

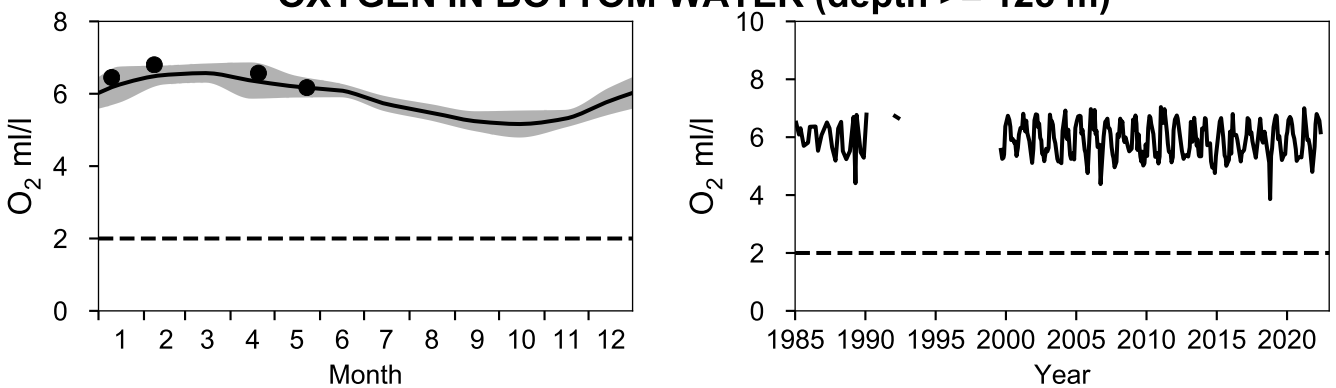


STATION Å15 SURFACE WATER (0-10 m)

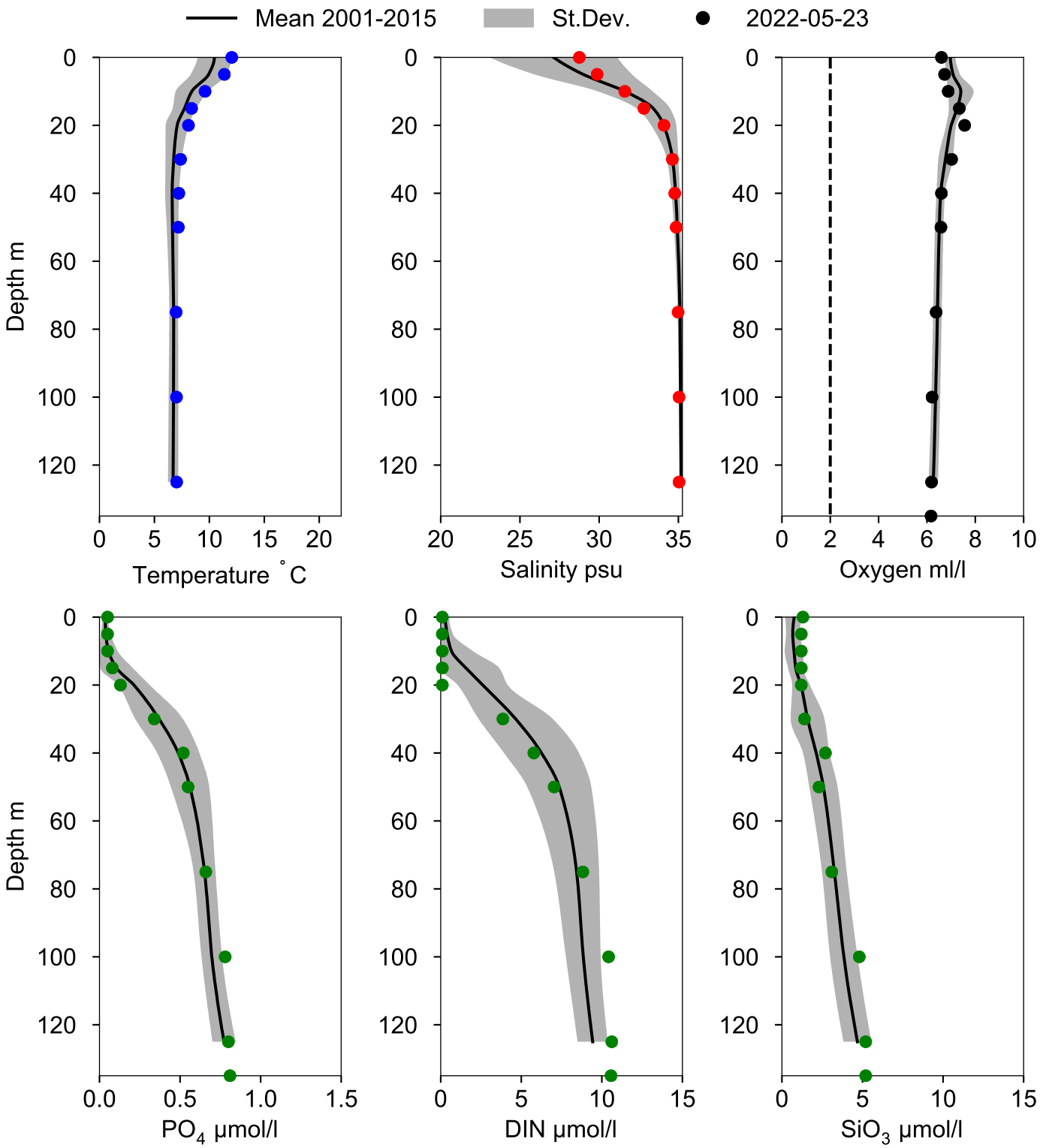
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 125 m)

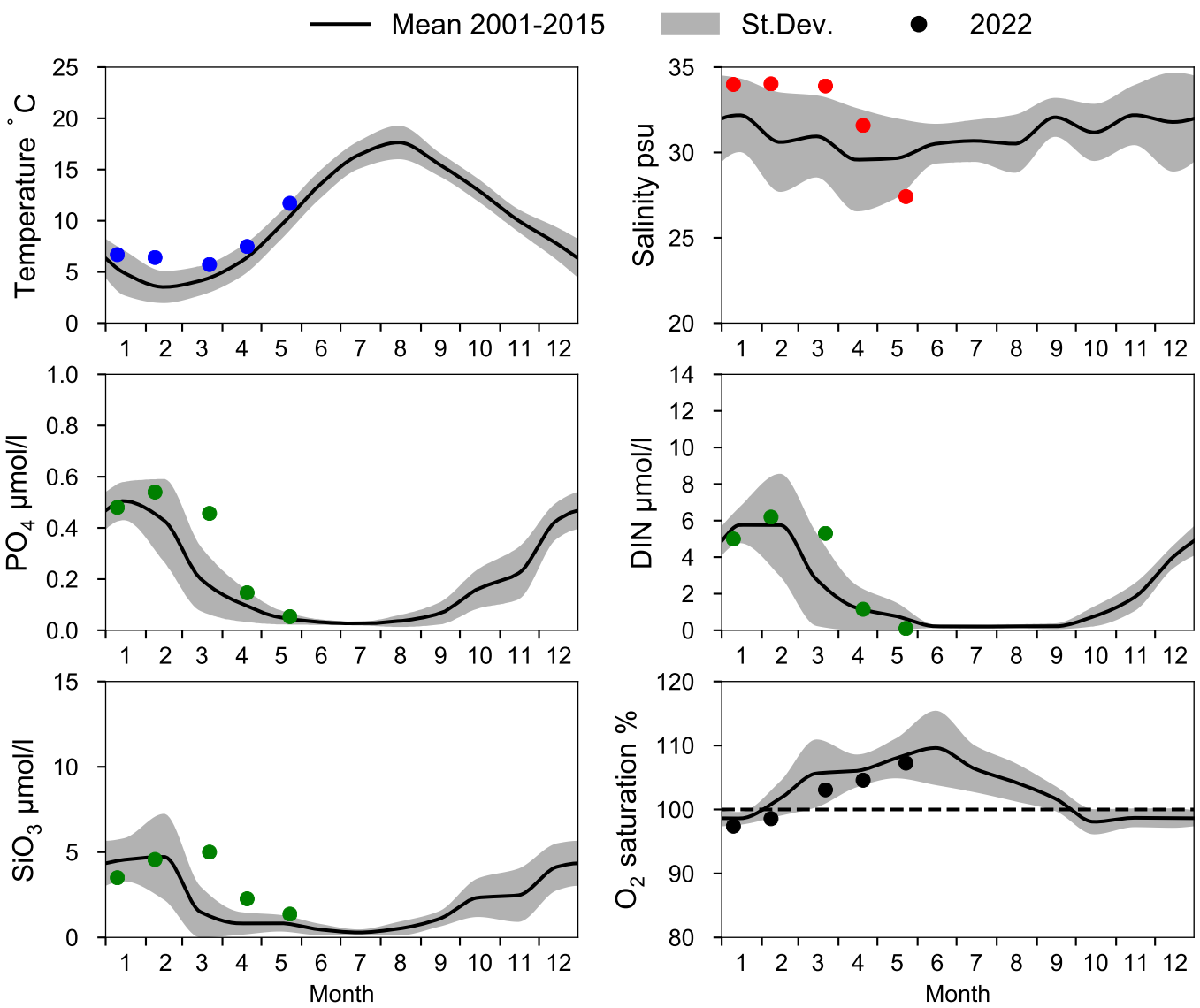


Vertical profiles Å15
May

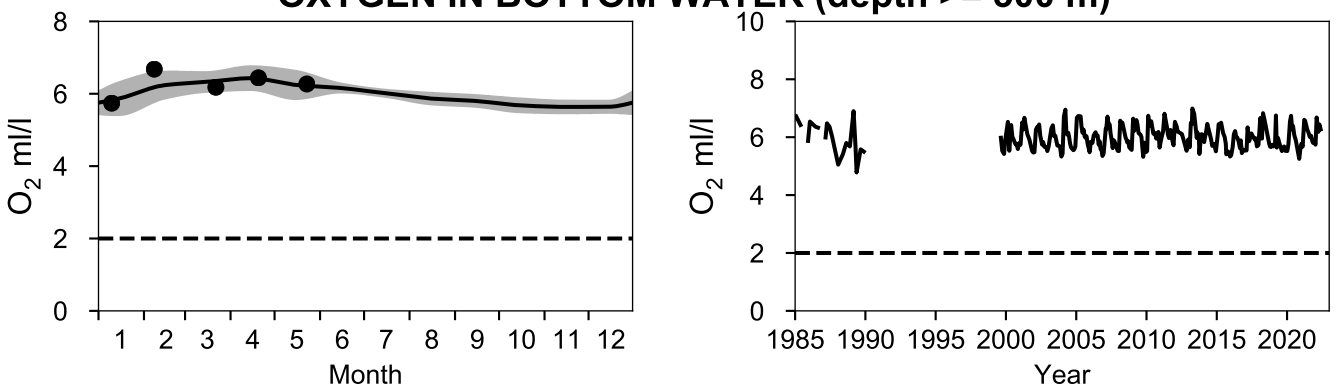


STATION Å17 SURFACE WATER (0-10 m)

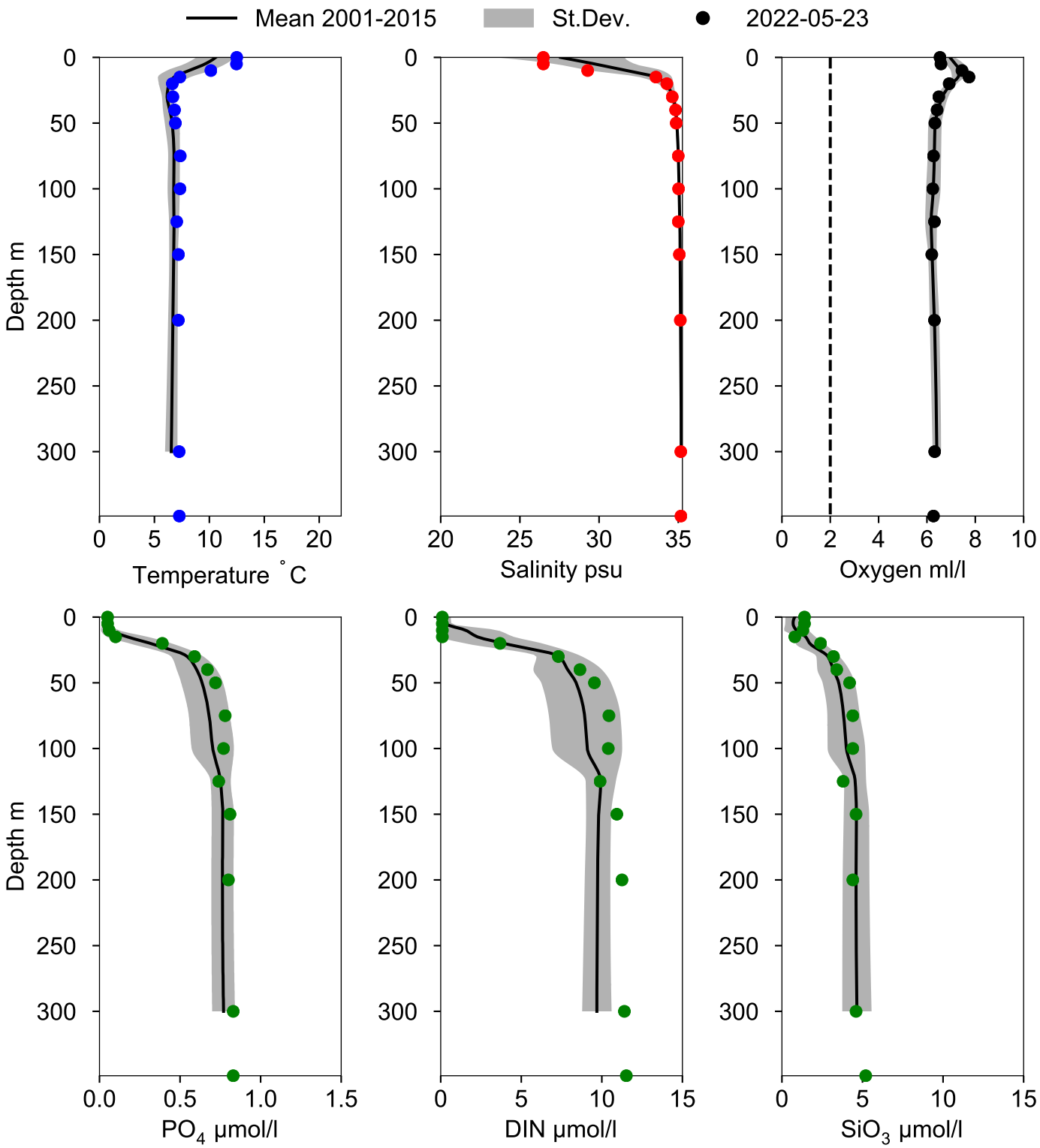
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 300 m)

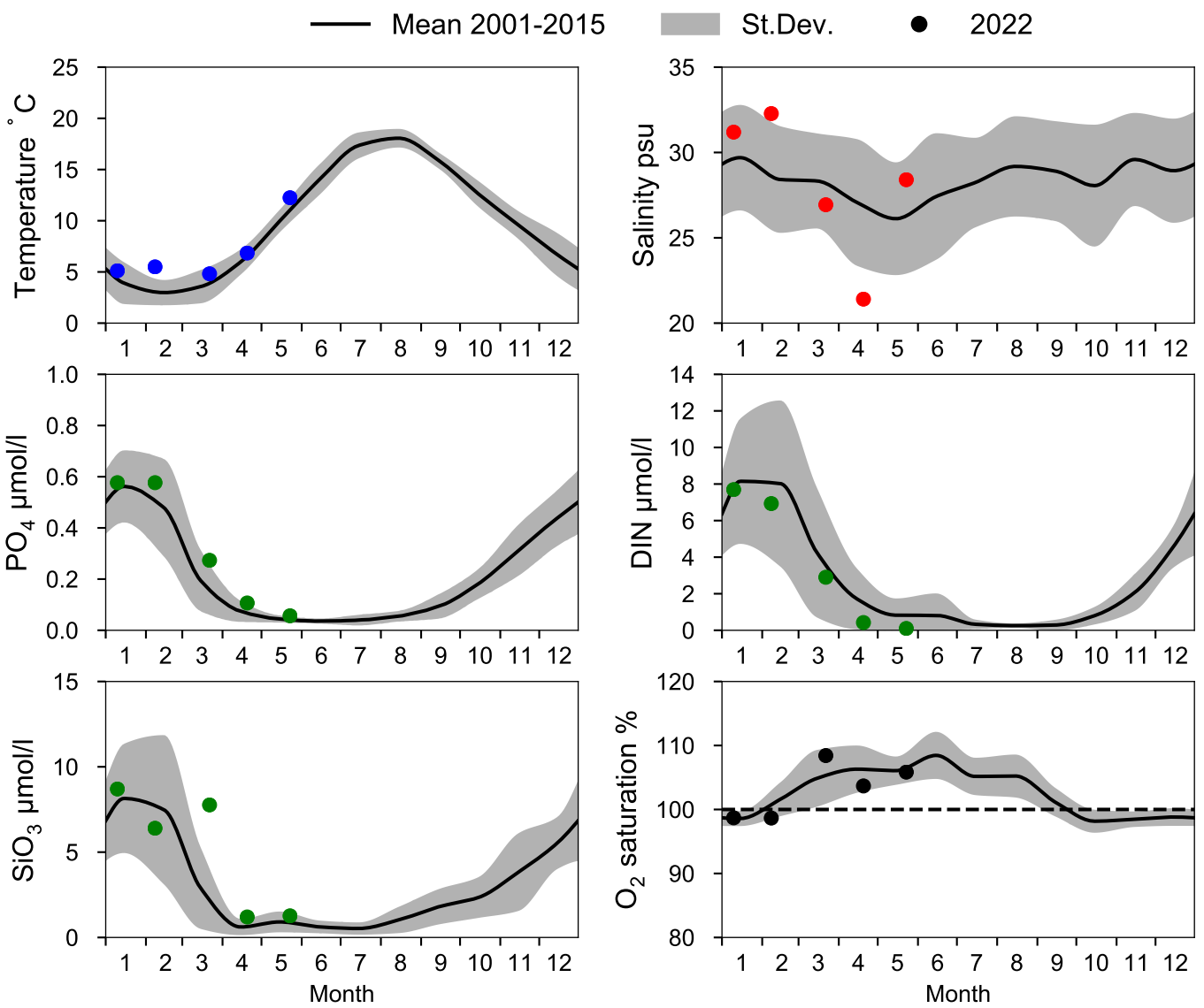


Vertical profiles Å17
May

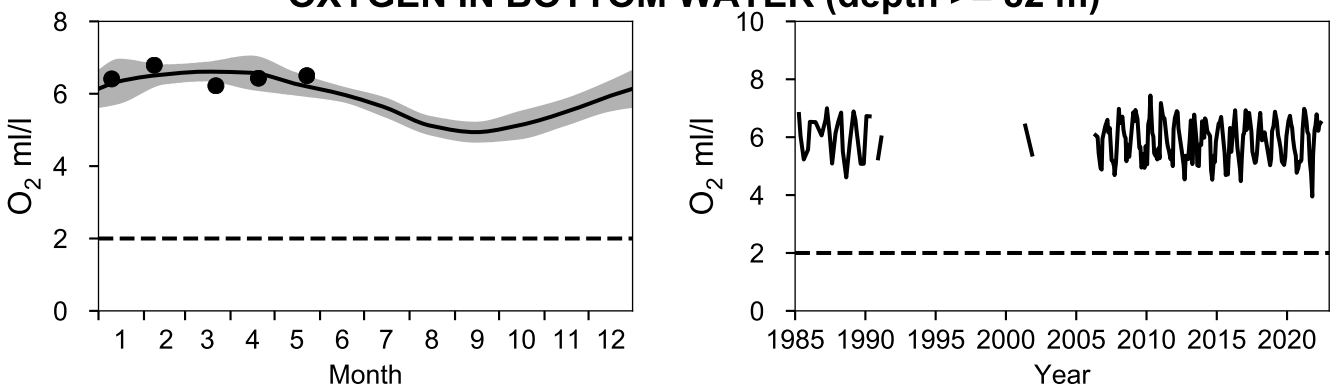


STATION Å13 SURFACE WATER (0-10 m)

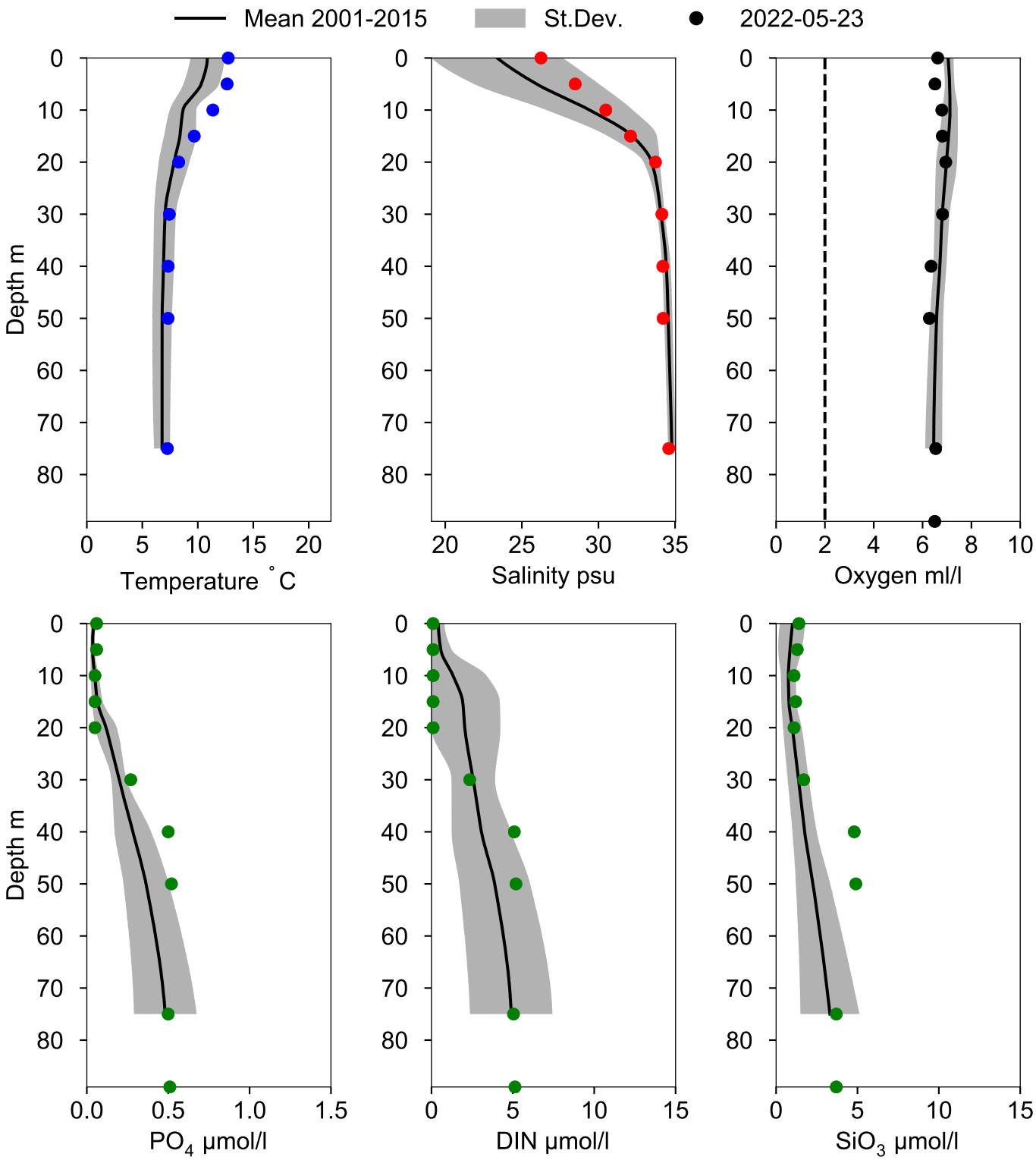
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 82 m)

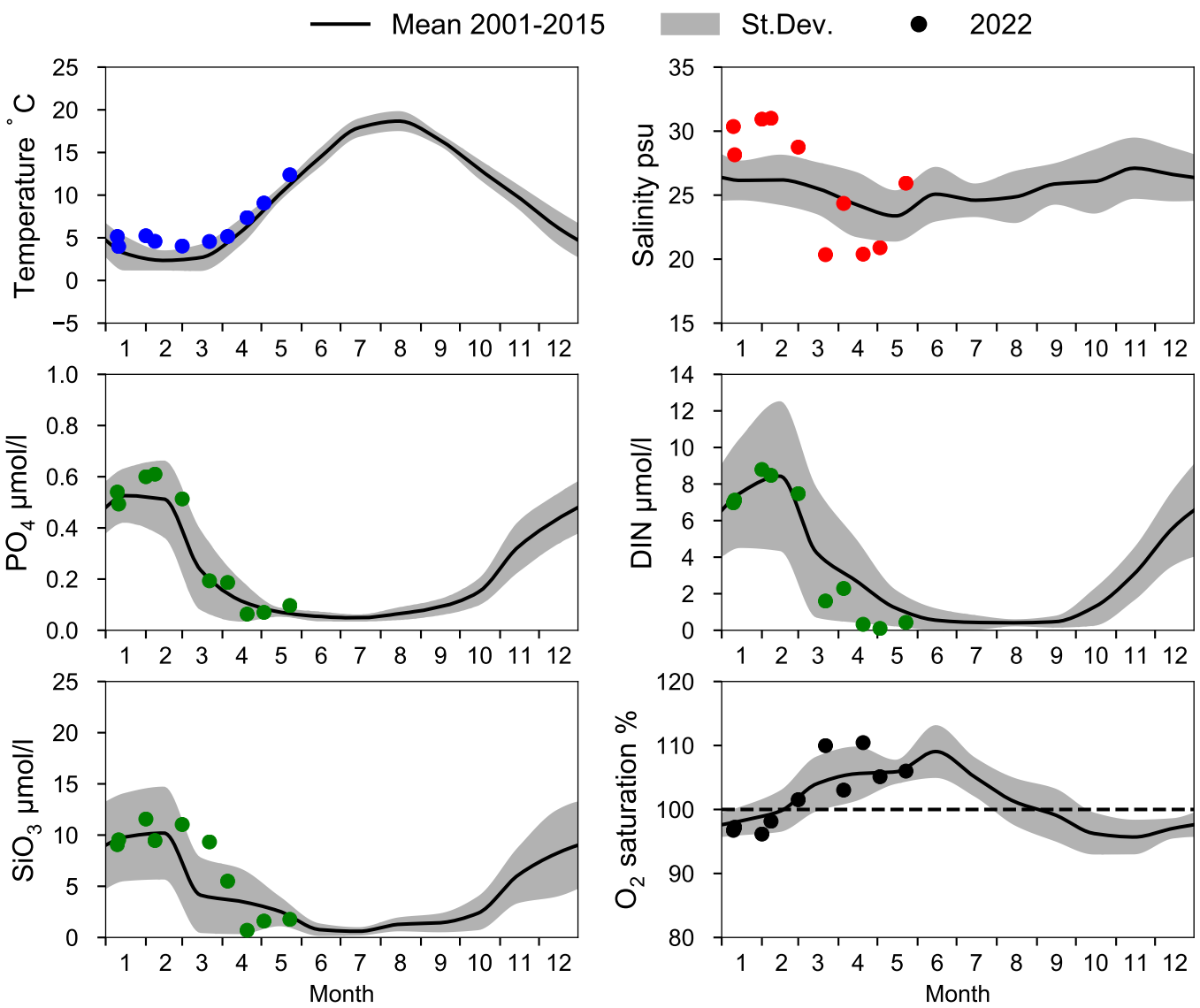


Vertical profiles Å13
May

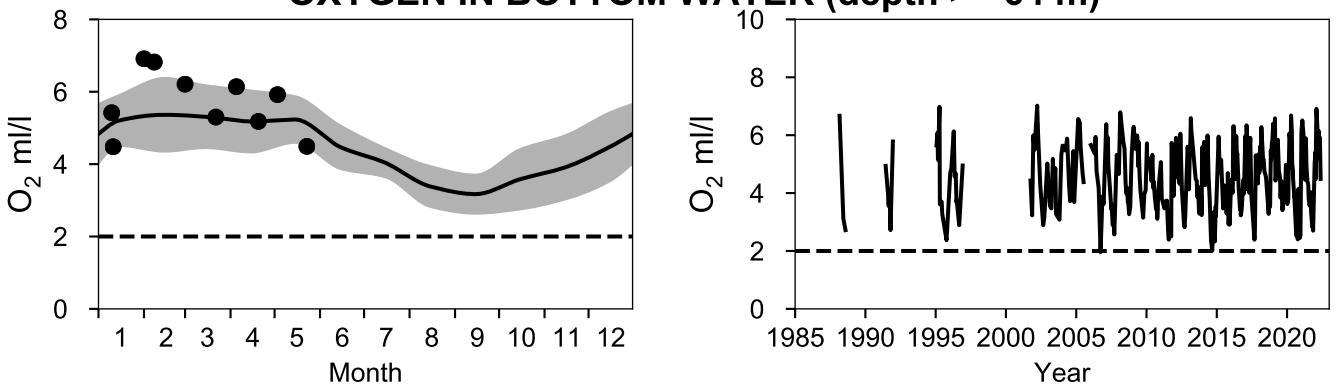


STATION SLÄGGÖ SURFACE WATER (0-10 m)

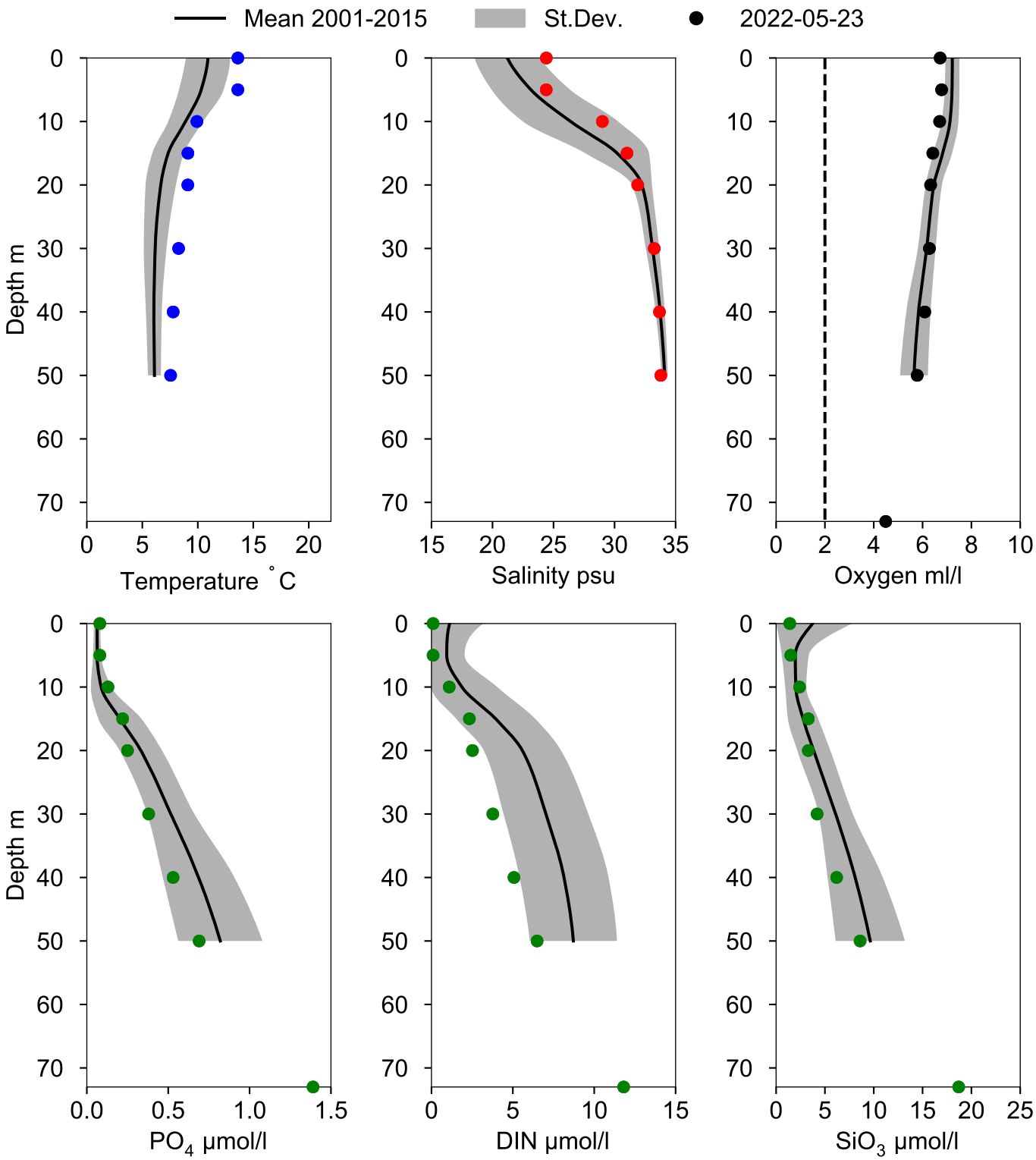
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 64 m)

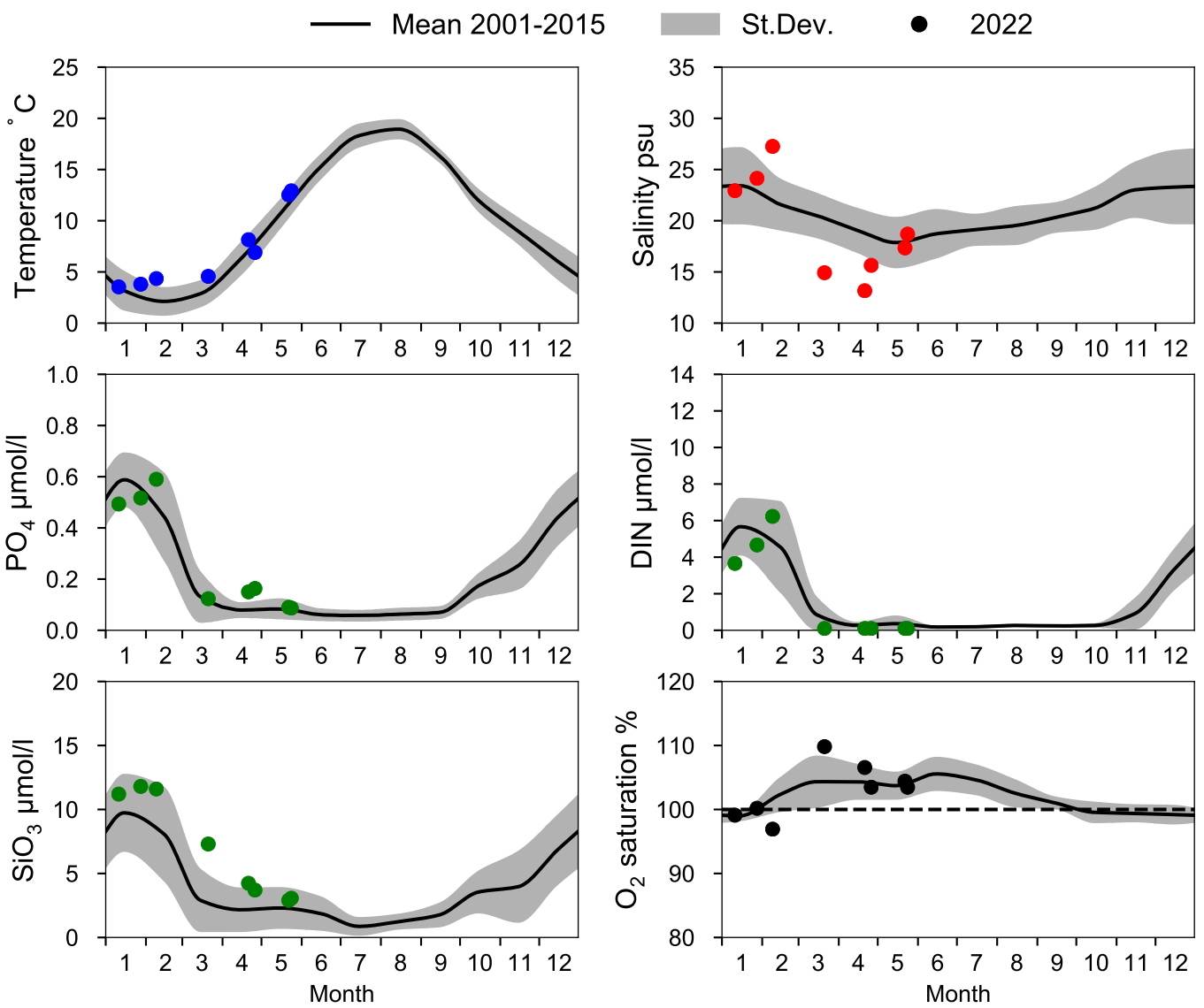


Vertical profiles SLÄGGÖ
May

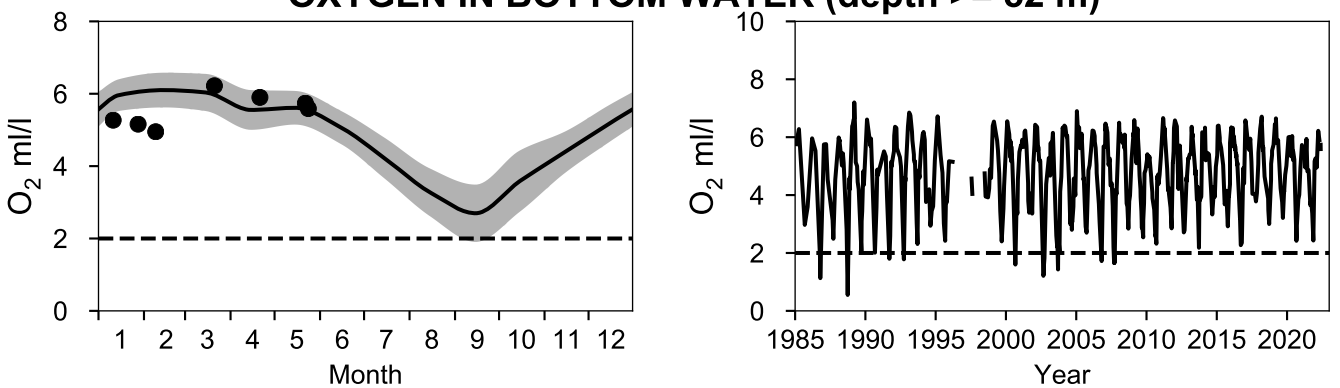


STATION ANHOLT E SURFACE WATER (0-10 m)

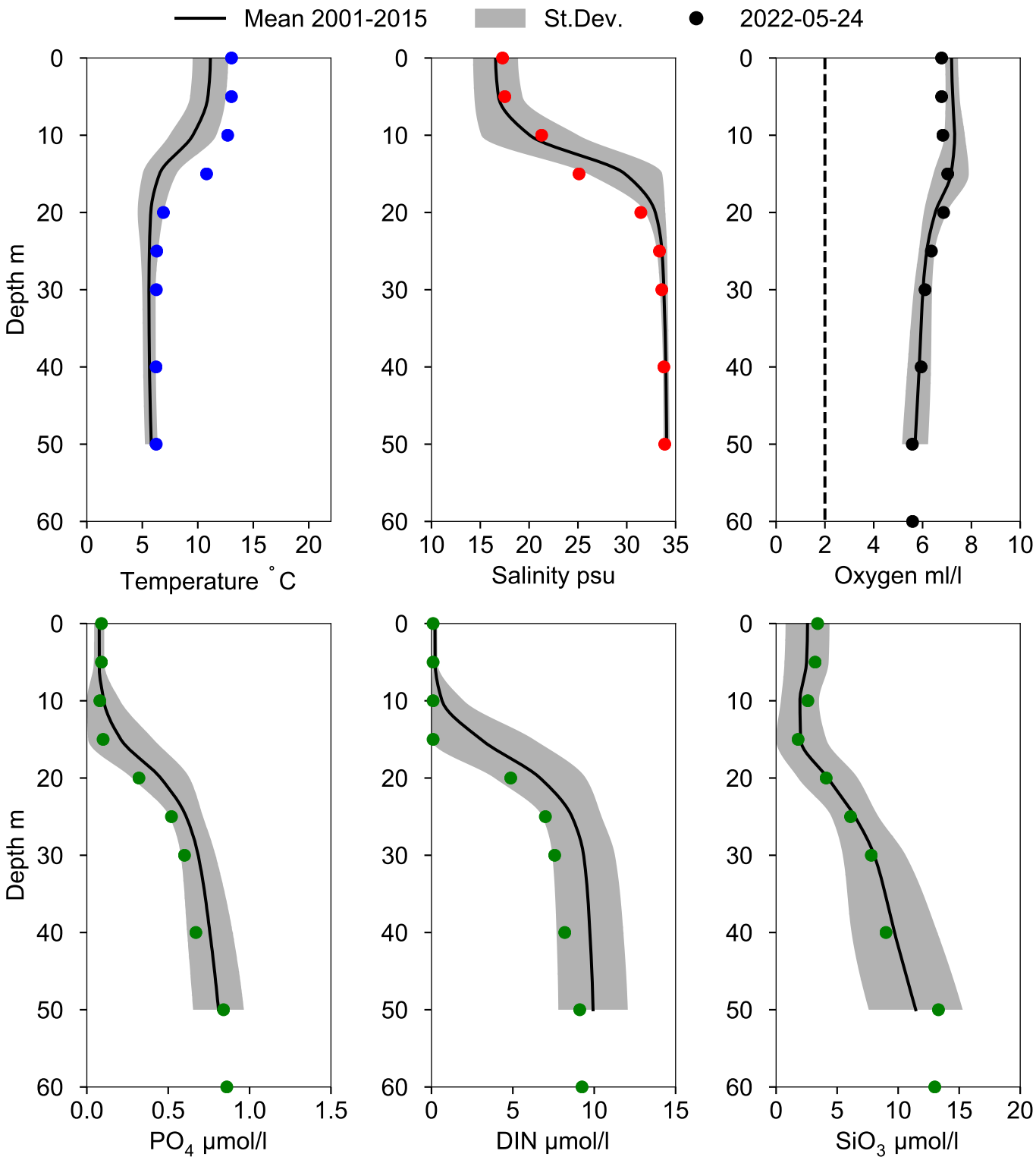
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 52 m)

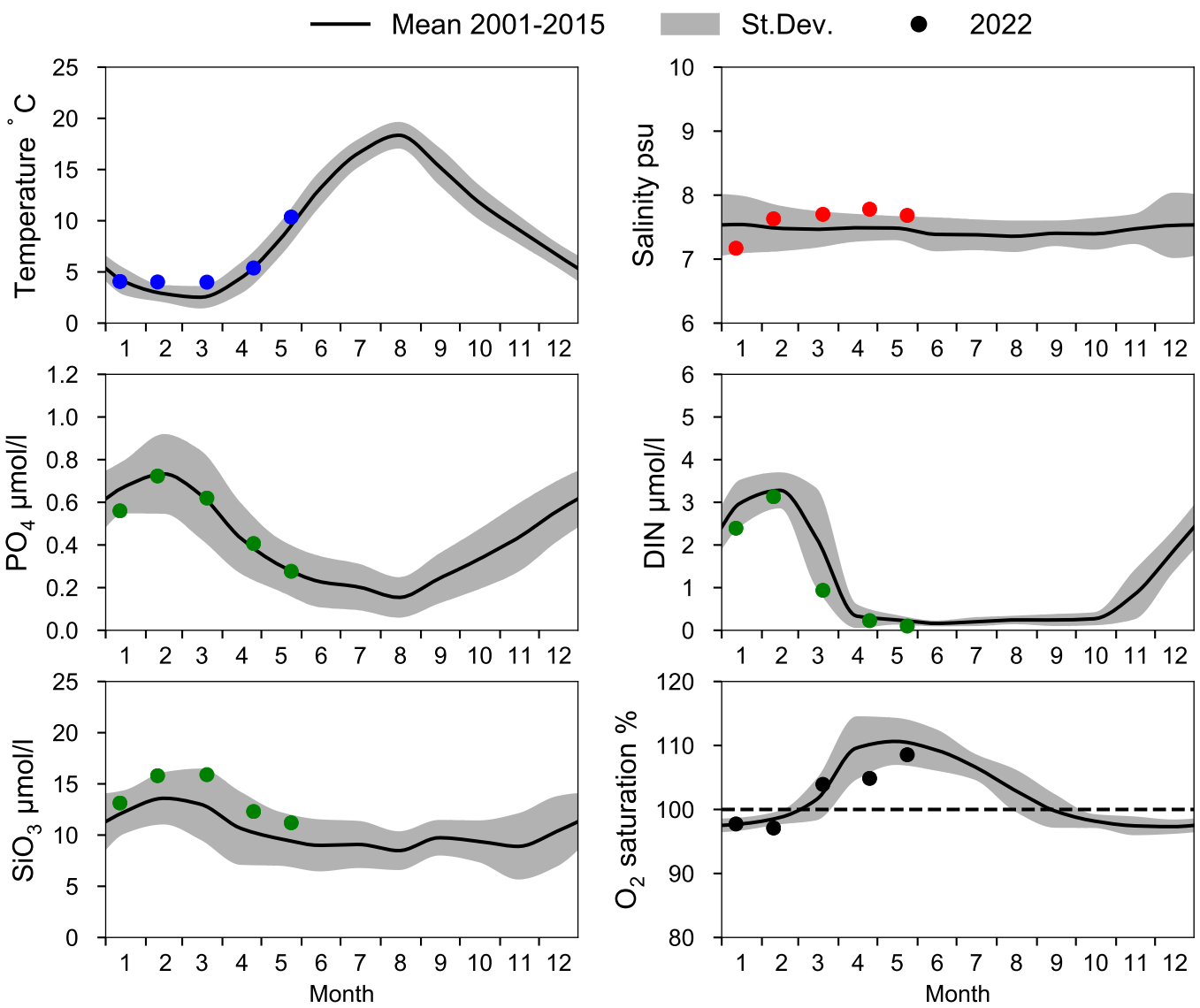


Vertical profiles ANHOLT E
May

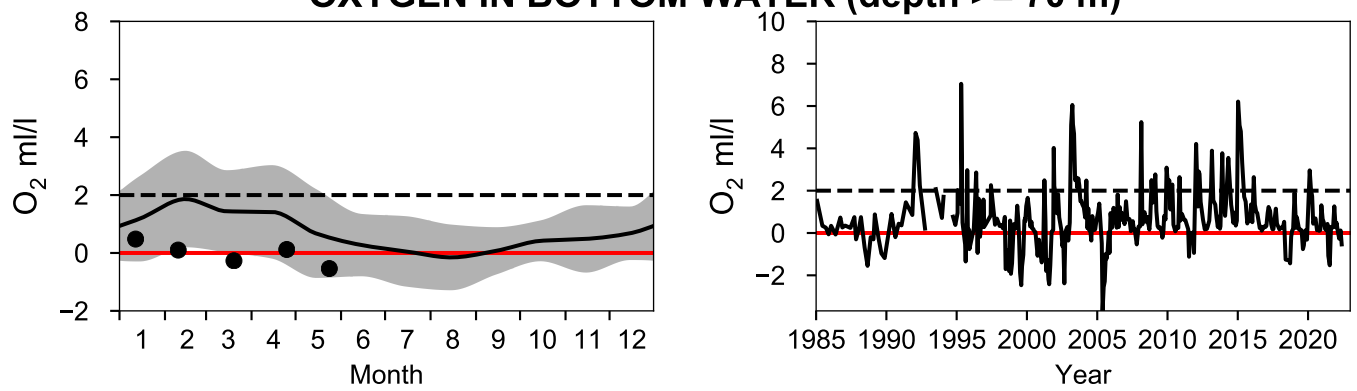


STATION HANÖBUKTEN SURFACE WATER (0-10 m)

Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 70 m)



Vertical profiles HANÖBUKTEN
May