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

photo: Martin Hansson, SMHI

Survey period: 2021-07-13 - 2021-07-19

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.

The warm weather during June and July increased the surface water temperature in all sea areas. All sea areas, except the Skagerrak, had higher temperatures than normal. Salinity remained higher than normal in the eastern part of the Baltic Proper and in parts of its deep water.

Dissolved inorganic nitrogen and phosphorus in the surface water were in principle consumed in all sea areas and generally showed normal levels for the season. The silicate levels in the surface water remained higher than normal in the Baltic Proper. In the Kattegat, where silicate levels in June were higher than normal, levels were now back to normal for the season.

The oxygen situation is still very bad in the Baltic Proper. In Hanö Bight, oxygen-free conditions were observed from depths exceeding 70 meters and the hydrogen sulphide content had increased significantly since the last visit in June. This could be clearly seen in the levels of dissolved inorganic nitrogen and phosphorus as well as silicate as the levels had in principle doubled in the deep water from high levels to very high levels.

In the Bornholm Basin, oxygen-free conditions were noted from a depth of 80 meters. Further east in the southern part of the Eastern Gotland Basin, the bottom water was oxygenated but the levels were very close to zero. In the Eastern Gotland Basin, completely oxygen-free conditions were measured from a depth of 80 meters, and in the Western Gotland Basin, no oxygen conditions were found from depth exceeding 70 meters. The oxygen situation in the bottom water was worse than the monthly average at all stations where hydrogen sulphide was observed.

Acute oxygen deficiency was also noted shallower than usual. In the Arkona Basin, which normally has better oxygen conditions in the bottom water, oxygen levels were measured on the limit of acute oxygen deficiency. In Hanö Bight and in the Bornholm Basin, acute oxygen deficiency was noted from a depth of 65 meters and in the Eastern Gotland Basin from a depth of 70 meters. In the Western Gotland Basin, acute oxygen deficiency was noted already at a depth of 55-60 meters.

Surface accumulations of cyanobacteria were visible on the sea surface in Arkona and in the Bornholm Basin. In the other basins in the Baltic Proper, areas with large amounts of flocks of cyanobacteria were spotted in the upper body of water. More information about the algal situation can be found in the AlgAware report for July;
https://www.smhi.se/en/publications/publications/algal-situation-reports-2-1056

SMHIs next regular cruise with R/V Svea is planned for 14-20 August, starting and ending in Lysekil.

RESULTS

The cruise was carried out on board R/V Svea and started in Lysekil on 13th of July and ended in the same port on 19th of July.

The cruise was dominated by warm, calm and clear weather with light winds. Mist and rain occurred for a short period. In the Eastern Gotland Basin, the wind increased to about 10-12 m/s. But then decreased in the Western Gotland Basin. From Hanö Bight and in the Arkona Basin, the wind increased again to just over 10 m/s. The air temperature varied between 19-27 °C.

Water samples for the analysis of selenium were taken at three stations in the Baltic Proper and two in the Skagerrak and Kattegat for EAWAG in Switzerland. Phytoplankton samples were also taken for Uppsala University at one station in the Skagerrak.

At station L9 in the Laholm Bight a bottom-mounted measuring system is situated that continuously measures temperature, salinity and oxygen content. This measurement system was to be recovered during the June cruise but the uptake failed. A new attempt to recover the measuring system was made during the July cruise and the system was found and could be pulled up. A new bottom measuring system was placed at the same position and will tentatively measure for 5-6 months before it needs to be replaced.

During the cruise, phytoplankton samples were analyzed on board by phytoplankton expert Marie Johansen. The results are presented in the AlgAware report for July:
https://www.smhi.se/en/publications/publications/algal-situation-reports-2-1056
Daily algae monitoring via satellite is performed by SMHI during the summer and is available at
http://www.smhi.se/vadret/hav-och-kust/algsituationen

Svea's MVP (Moving vessel profiles) which is used to measure temperature, salinity and oxygen profiles during transit, have been repaired and the wire/cable has been replaced. Unfortunately, the change was not completely finished, which resulted in the Å-transect in the Skagerrak and the transect at Kriegers Flak therefore had to be cancelled. Testing of the MVP system was done in the Bornholm Basin and the first regular transects were done at Stolpe Ränna. Subsequently, transects were made from BY10-BY15 and from 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 cruise.

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, SMHI's website. This usually takes place within one to two weeks after the cruise has ended. Some analyzes are made after the cruise and are published later.

SHARKweb: http://www.smhi.se/klimatdata/oceanografi/havsmiljodata

The Skagerrak

The water temperature in the surface layer, 0-10m, varied between 16 to 18°C and in the near surface the temperature was around 20°C, which is normal for the season. The salinity of the surface layer varied between 26 to 32 psu, lowest at the coast and in the south and highest at the outermost stations.

A thermocline close to the surface could be observed at about 5-10 meters, probably due to the calm and warm weather. At some stations there was also a secondary thermocline of about 30-40 meters. The salinity stratification, the so-called the halocline, largely coincided with the temperature stratification.

All nutrients in the surface layer were consumed or showed low levels. Dissolved inorganic nitrogen was consumed at all stations except at the station Släggö in the mouth of the Gullmarn fjord where 0.18 µmol/l was measured. Further down in the water column, the levels were normal except at Å17 where the content of dissolved inorganic nitrogen was slightly lower than normal. The content of dissolved inorganic phosphorus, phosphate, showed low levels of about 0.05 µmol/l. Deeper down, concentrations increased but were at normal levels. The silicate content in the surface layer was also low and varied between 0.1-0.2 µmol/l, which is normal for the season. The highest value was noted at the coast at the station Släggö; 0.87 µmol/l. Further down in the deep water, the levels increased but within the normal range.

Chlorophyll fluorescence measurements with CTD showed peaks of about 30-40 meters at the stations in the open Skagerrak, while at the coastal stations there were higher values between 10-20 meters depth. In the southern Skagerrak, at station P2, plankton activity was lower and no clear fluorescence peaks were noted.

The lowest oxygen concentration in the bottom water was measured at Släggö, 3.9 ml/l. In the offshore areas levels in the deep water were measured at 5.5-6.1 ml/l, which is normal.

The Kattegat and the Sound

The temperature in the surface layer, 0-10 meters, varied around 20-21°C, which is much above normal. The salinity of the surface varied between 15-19 psu, which in the northern parts of the Kattegat is slightly lower than normal. In the Sound, the salinity of the surface was 10.5 psu. At all stations, thermocline and halocline coincided between 10-15 meters deep. In the deep water, normal values for the season were generally measured.

Dissolved inorganic nitrogen was completely consumed in the surface, which is normal for the season, the levels were below the detection limit <0.1 µmol/l. Dissolved inorganic phosphorus was also consumed and all surface values were around 0.06 µmol/l. The levels of silicate, which is used by diatoms to form shells of silica, were now completely consumed throughout the Kattegat. In June, higher levels than normal were measured, at e.g. Anholt E much higher than normal with levels above 10 µmol/l. Now the levels were below the detection limit. Probably consumed by diatoms. In the Sound, which normally has a higher concentration, values in the surface water were measured at 8 µmol/l. Below the stratification, in the deep water, the nutrients normally increase and in general, normal levels of all nutrients for the season were noted.

CTD measurements of chlorophyll fluorescence showed high peaks at Fladen, N14 and in the Sound at a depth of 10-25 meters. At the other stations, the plankton activity was low.

Bottom water Oxygen concentrations showed normal values; about 4.9-5.5 ml/l in the Kattegat and 3.8 ml/l in the Sound. At station L9 in Laholms Bight, the bottom measurement system was recovered and a new one was placed out. A reference CTD cast was made at the station. The measurement showed low oxygen levels at the bottom, the levels here were just below 4 ml/l.

The Baltic Proper

The temperature in the surface water, 0-10 meters, was generally above or well above normal throughout the Baltic Proper. Maximum temperatures were measured in the eastern parts where temperatures above 22 °C was noted, otherwise the temperature varied between 19-21 °C. Deeper down in the water column, temperatures above normal were also observed in the Eastern and Western Gotland Basins, in the other areas normal temperatures were found.

A temperature stratification, a so-called thermocline, was found between 10 and 20 meters deep in the entire Baltic Proper. Intermediately, during the thermocline, colder 4-5°C of "winter water" were found and further down in the bottom water, the temperature increased to about 6-7°C.

The salinity of the surface water was higher than normal for the season in the Eastern Gotland Basin, while it was slightly lower than normal in the Western Gotland Basin. In the other areas, the salinity of the surface was normal for the season. Levels ranged from 6.3-7.6 psu. The permanent halocline was found between 60-80 meters deep in the central Baltic Proper. Below the halocline, the salinity was above normal in both Eastern and Western Gotland Basin, at the other stations with sufficient depth, normal values were measured.

The levels of dissolved inorganic nitrogen in the surface water were more or less unchanged since the previous cruise in June, and the levels were below the detection limit, <0.10 µmol/l at all stations except at BY32 where 0.18µmol/l was measured. Even in deep water, the situation was similar to that in June. In the Eastern Gotland Basin at BY15 and BY20, the levels of nitrogen were very low down to just over 100 meters, from 150 meters and down, higher values were measured than normal. In the Western Gotland Basin, concentrations were found that were much higher than normal from around 80-90 meters and deeper. At other stations, normal levels of dissolved inorganic nitrogen were measured. Due to completely oxygen-free conditions in the deep water at Hanö Bight, very high levels of dissolved inorganic nitrogen were found from a depth of 70 meters.

The phosphate content in the surface water was normal for the season at all stations, and varied between 0.09-0.14 µmol/l. In Arkona, higher phosphate levels were noted at a depth of 15 meters, while other deep water showed normal levels, and in the Western Gotland Basin, high phosphate levels were measured at a depth of 70 meters, while other deep water noted normal levels. Below the halocline, the concentrations of phosphate increase, in the Bornholm Basin, Hanö Bight and in the southern part of the Eastern Gotland Basin, levels were measured higher than normal, but at the other stations levels were measured at normal levels in the deep water. In Hanö Bight, the levels were much higher than normal due to oxygen-free conditions from a depth of 70 meters.

The concentration of silicate in the entire water column was generally above normal at all stations. The levels varied from 11-14 µmol/l in the surface, slightly lower compared with the measurements in June to 40-80 µmol/l in the bottom water. Due to completely oxygen-free conditions in the Hanö Bight, very high levels of silicate were found from a depth of 70 meters.

The oxygen situation is still very serious in the Baltic Proper. In Hanö Bight, oxygen-free conditions were observed from depths exceeding 70 meters and the hydrogen sulphide content had increased significantly since the last visit in June. This could be clearly seen in the levels of dissolved inorganic nitrogen and phosphorus as well as silicate where the levels had in principle doubled in the deep water from high levels to very high levels.

Oxygen-free conditions were also noted in the Bornholm Basin, but here from a depth of 80 meters. Further east in the southern part of the Eastern Gotland Basin at BCSIII-10, the deep water was oxygenated but the levels were very close to zero. At BY10, the hydrogen sulphide content had decreased somewhat probably as a result of a smaller inflow at intermediate depths. At BY15 and BY20 in the Eastern Gotland Basin, completely oxygen-free conditions were measured from a depth of 80 meters. No oxygen was found in the Western Gotland Basin from a depth of 70 meters. The oxygen situation at the bottom was worse than the monthly average at all stations where hydrogen sulphide was observed.

Acute oxygen deficiency, i.e. oxygen levels less than 2 ml/l, were also noted shallower than usual. In the Arkona Basin, which normally has better oxygen conditions in the bottom water, oxygen levels were measured at the limit of acute oxygen deficiency, 2.2-4.0 ml/l. In Hanö Bight and in the Bornholm Basin, acute oxygen deficiency was noted from a depth of 65 meters and in the Eastern Gotland Basin from a depth of 70 meters. In the Western Gotland Basin, acute oxygen deficiency was noted already at a depth of 55-60 meters.

At all stations, more or less strong peaks in CTD chlorophyll fluorescence could be observed at a depth of 10-20 meters. Surface accumulations of cyanobacteria were visible on the sea surface in Arkona and in the Bornholm Basin. In other basins, areas with large numbers of cyanobacteria aggregates were spotted. More information about the algal situation can be found in the Algaware report for July: https://www.smhi.se/en/publications/publications/algal-situation-reports-2-1056

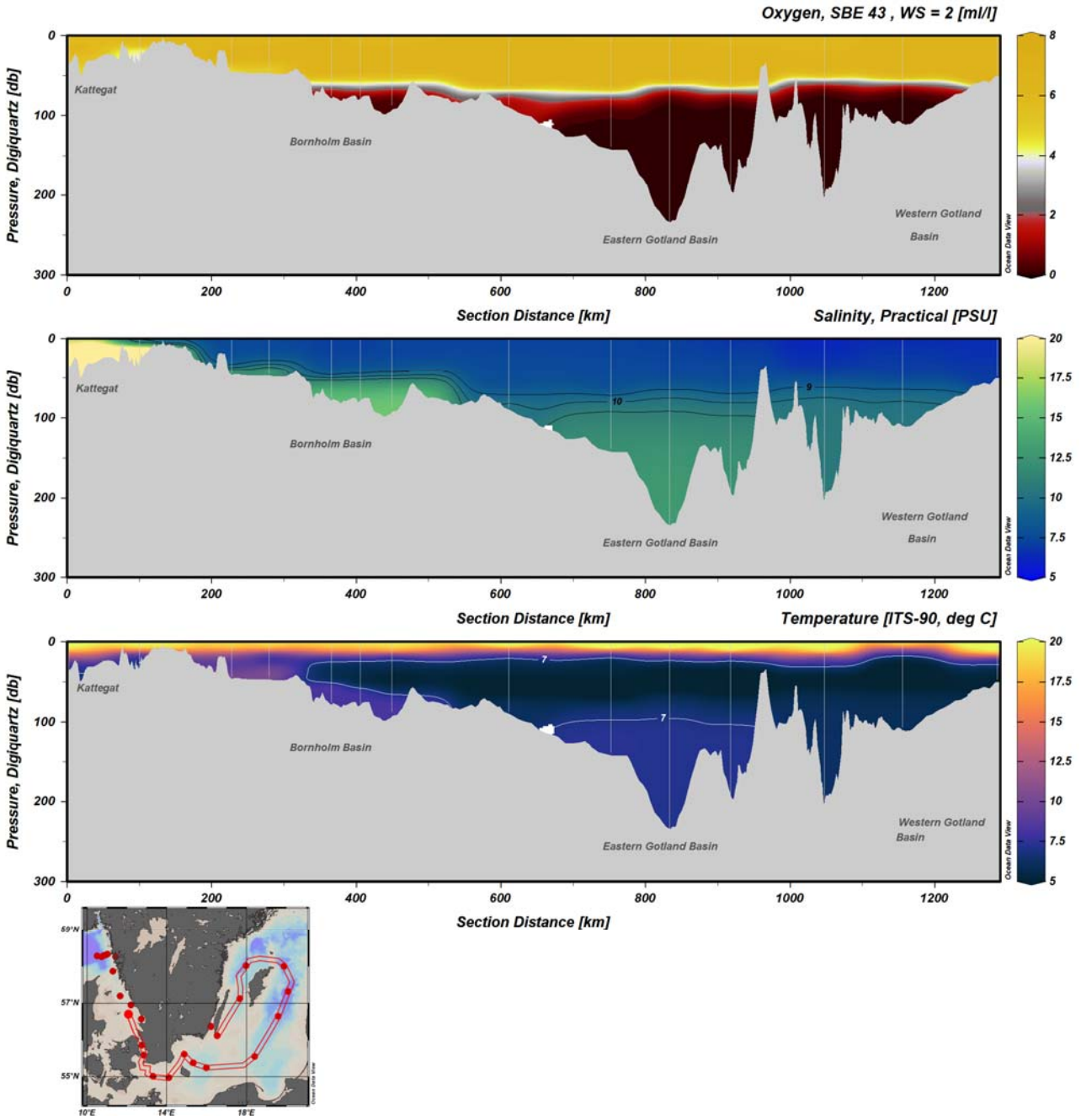


Figure 1. Transect showing CTD and MVP measurements of dissolved oxygen, salinity and temperature from Kattegat, the Sound through the Eastern Gotland Basin to the Western Gotland Basin.

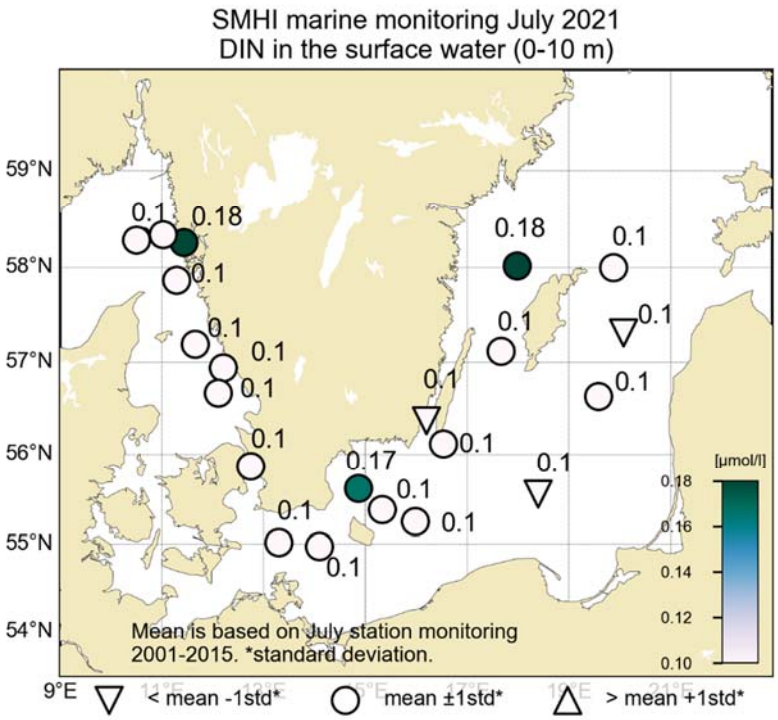


Figure 2. Concentration of dissolved inorganic nitrogen in the surface water (0-10m).

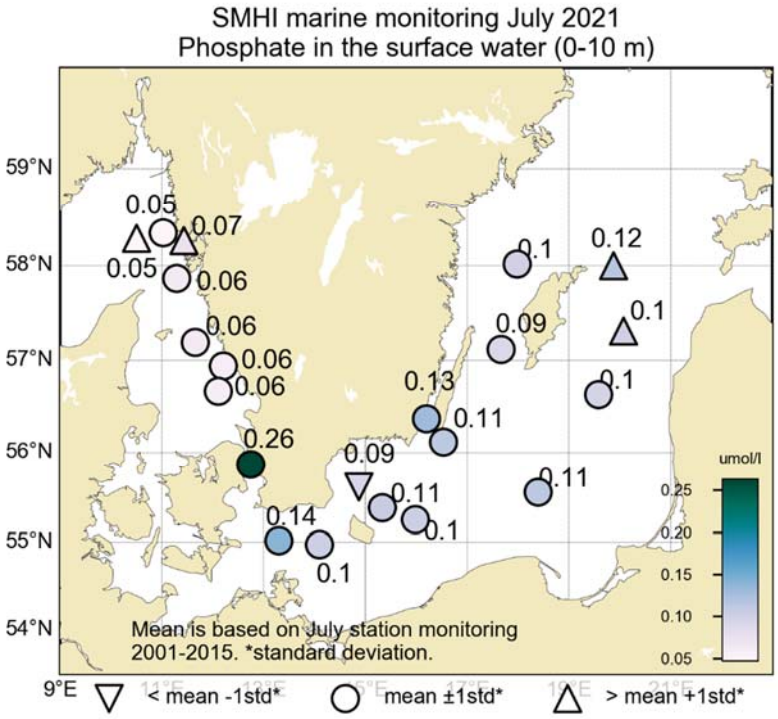


Figure 3. Concentration of phosphate in the surface water (0-10m).

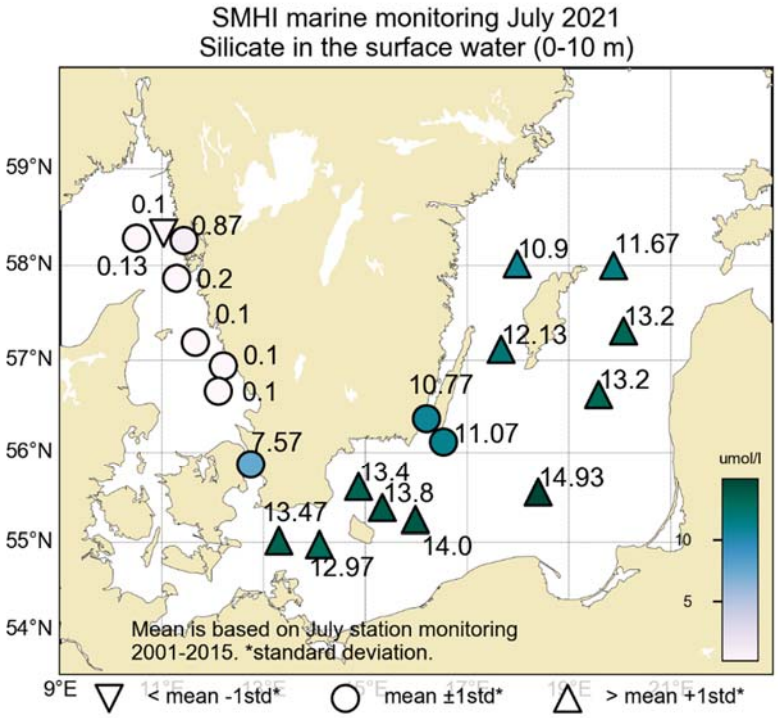


Figure 4. Concentration of silicate in the surface water (0-10m).

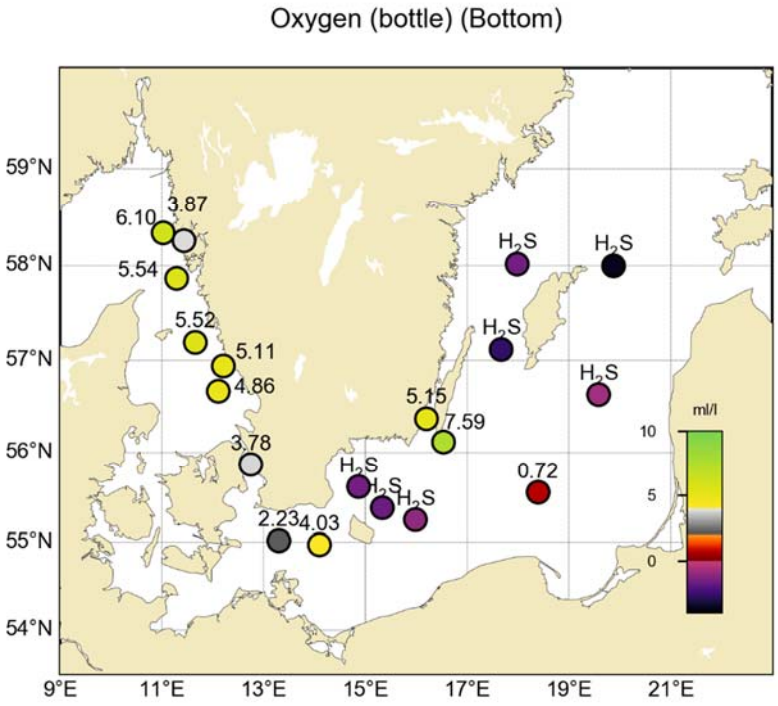


Figure 5. Oxygen concentration in the bottom water.

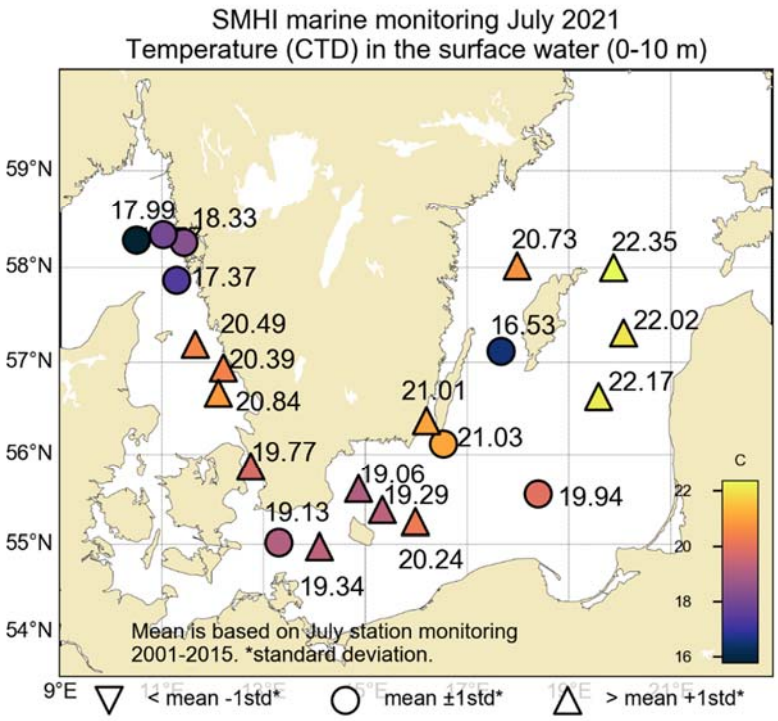


Figure 6. Temperature in the surface water (0-10m).

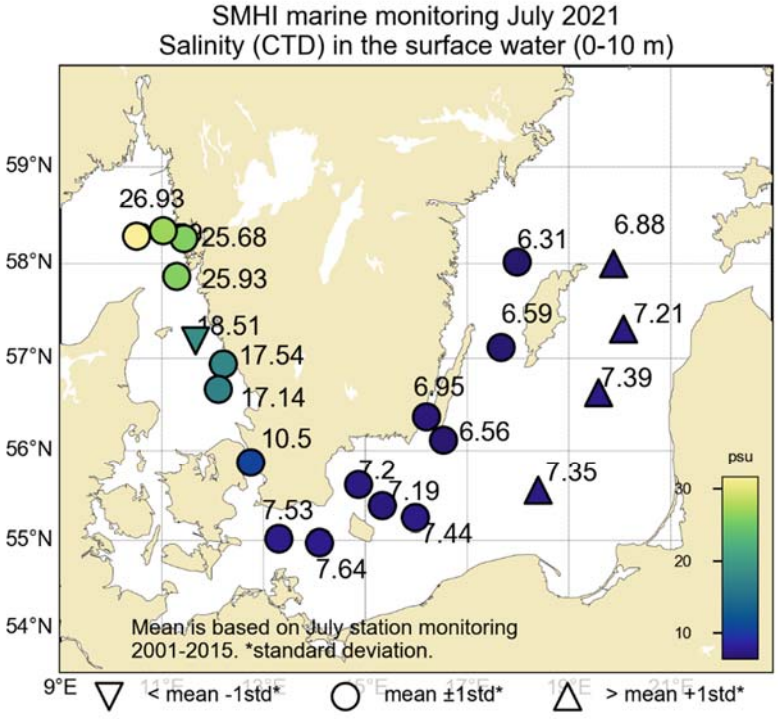


Figure 7. Salinity in the surface water (0-10m).

PARTICIPANTS

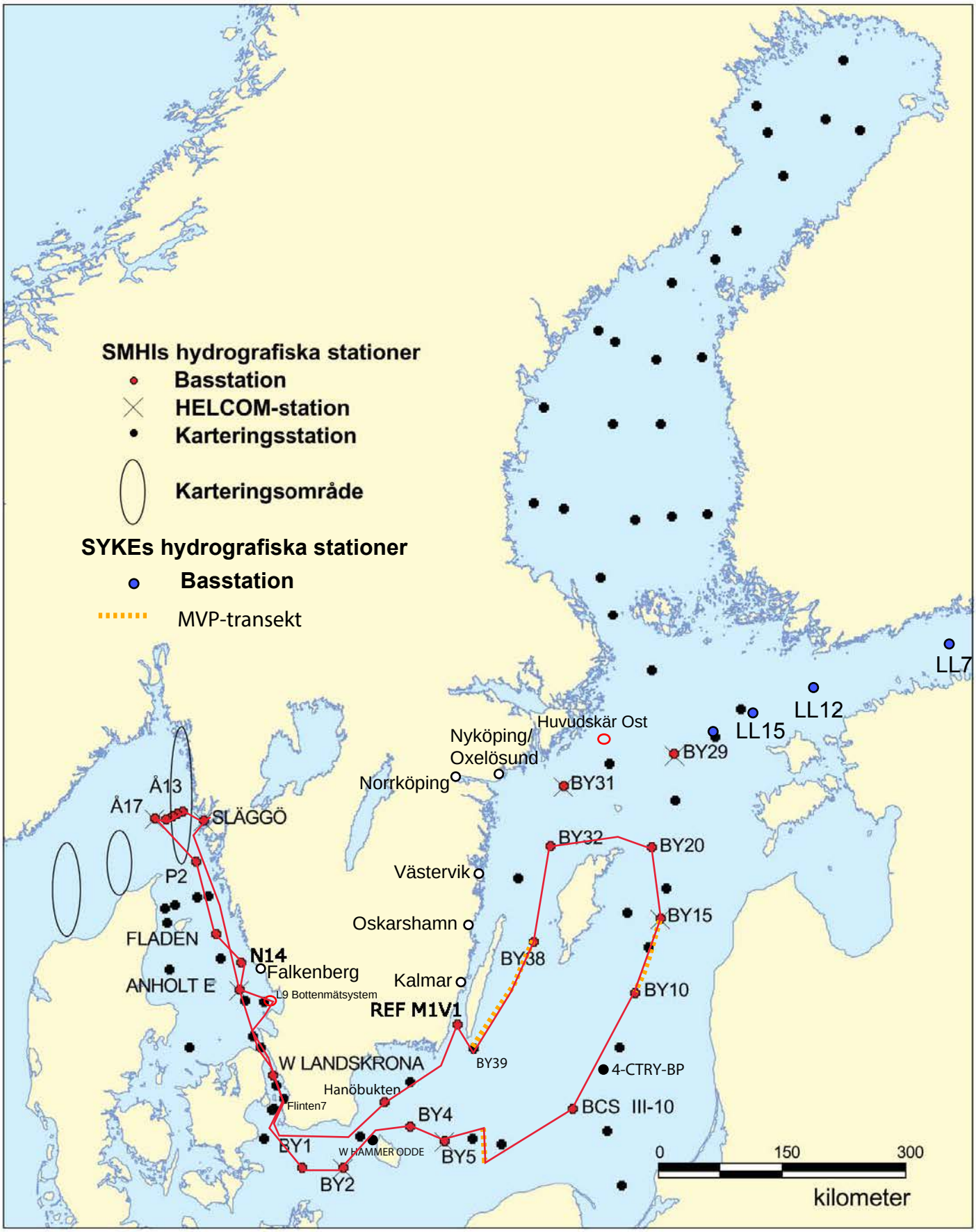
Name	Role	Institute
Martin Hansson	Chief Scientist	SMHI
Sara Johansson	Quality manager	SMHI
Ola Kalén	ADCP expert	SMHI
Marie Johansen	Plankton expert	SMHI
Sari Sipilä	Senior Scientist	SMHI
Daniel Bergman Sjöstrand	Chief Technician	SMHI

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

TRACKCHART
Country: Sweden
Ship: R/V Svea
Date: 20210713-20210719
Series: 0499 - 0525



Date: 2021-07-21
Time: 09:37

Ship: SE
Year: 2021

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	CZPP	No de	No btl	Temp_btl	Temp_ctd	Salt_btl	Salt_ctd	Ph	Doxy_btl	Doxy_ctd	H2s	Phos	Ptot	Ntri	Ntra	Ntrz	Amon	Ntot	Alky	Sio3-si	Humus	Comnt_visit	Comnt_samp
0499	12	FIBG27	BAS...	SLÄGGÖ	5815.58	01126.13	20210713	0007	75	5	32	5	23.2	1015	1310	-x--	9		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
0500	12	SKEX14	BAS...	Å13	5820.43	01101.66	20210713	1015	106	8	06	9	23.6	1016	1210	----	10		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-
0501	12	SKEX15	BAS...	Å14	5818.9	01056.6	20210713	1135	110		06	3	22.6	1016	1320	----	11		x	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
0502	12	SKEX16	BAS...	Å15	5817.68	01050.7	20210713	1300	138	11	01	2	24.0	1016	2720	----	12		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
0503	12	SKEX17	BAS...	Å16	5816.04	01043.35	20210713	1400	202		01	5	20.8	1016	1420	----	13		-	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
0504	12	SKEX18	BAS...	Å17	5817.05	01030.26	20210713	1545	349	12	02	6	22.0	1015	2620	-x--	15		x	x	-	x	x	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-
0505	12	SKEX23	BAS...	P2	5751.99	01117.56	20210713	2030	94		03	5	22.0	1014	9999	----	10		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
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0509	12	KAEL60	EXT...	L9 LAHOLMSBUKTEN	5633.93	01243.16	20210714	1420	19		32	6	24.1	1012	1220	----	5		-	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-
0510	12	SOCX39	BAS...	W LANDSKRONA	5551.99	01244.89	20210714	1730	51	6	09	4	27	1012	1610	----	9		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
0511	12	SOCX00	EXT...	FLINTEN7	5545.28	01250.21	20210714	2020	9		05	1	23.0	1012	1610	----	3		-	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
0512	12	BPSA02	BAS...	BY1	5500.95	01318.05	20210715	0145	47		07	1	19.6	1012	9990	----	8		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
0513	12	BPSA03	BAS...	BY2 ARKONA	5458.28	01405.93	20210715	0515	47		25	5	20.0	1012	2820	-x--	8		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
0514	12	BPSB06	BAS...	BY4 CHRISTIANSÖ	5522.97	01520.03	20210715	1100	92	5	21	1	21.1	1013	4820	----	12		x	x	-	x	-	x	x	x	x	-	x	x	x	x	-	-	x	-	-	-
0515	12	BPSB07	BAS...	BY5 BORNHOLMSDJ	5515	01559.07	20210715	1445	90	6	18	2	24.4	1014	1120	-x-x	12		x	x	-	x	x	x	x	x	x	-	x	x	x	x	-	-	x	-	x	-
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0517	12	BPEX13	BAS...	BY10	5637.99	01935.06	20210716	0955	144	6	28	5	22.5	1017	1420	----	15		x	x	-	x	-	x	x	x	x	-	x	x	x	x	-	-	x	-	-	-
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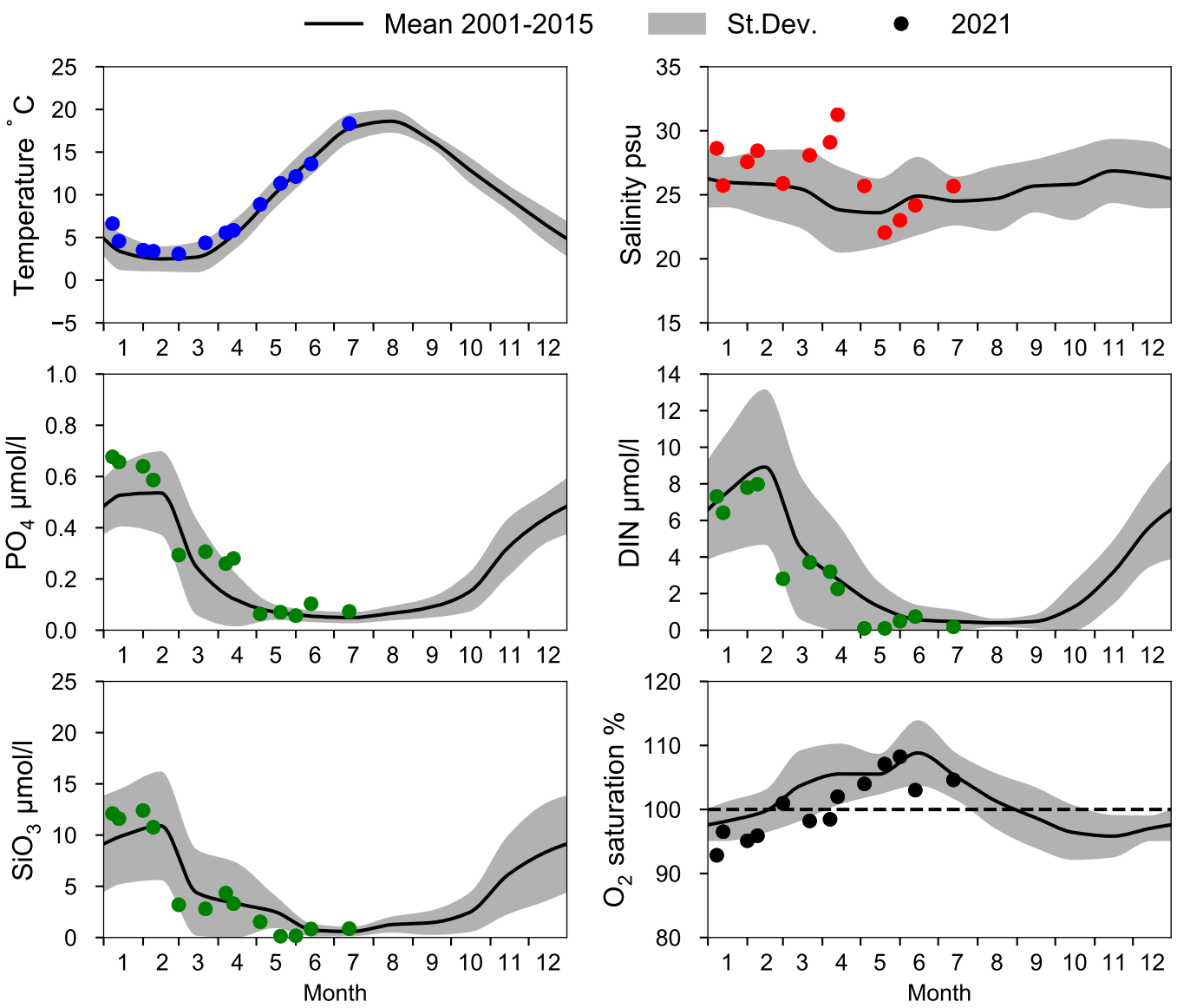
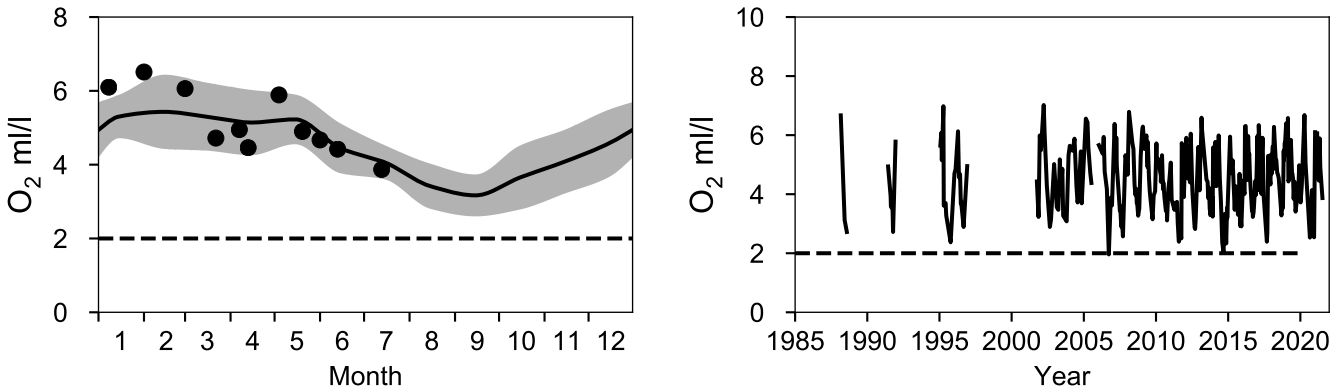
0519	12	BPEX26	BAS...	BY20 FÅRÖDJ	5759.89	01952.73	20210716	2200	197		01	8	20.2	1020	9990	----	17		x	x	-	x	-	x	x	x	x	-	x	x	x	x	-	-	x	-	-	-
0520	12	BPWX38	BAS...	BY32 NORRKÖPINGSDJ	5800.98	01759.05	20210717	0446	202	5	05	1	20.4	1020	2710	----	17		x	x	-	x	-	x	x	x	x	-	x	x	x	x	-	-	x	-	-	-
0521	12	BPWX45	BAS...	BY38 KARLSÖDJ	5707.05	01740.13	20210717	1130	110	4	30	2	21.8	1020	1120	----	14		x	x	-	x	-	x	x	x	x	-	x	x	x	x	-	-	x	-	x	-
0522	12	BPSE49	BAS...	BY39 ÖLANDS S UDDE	5606.97	01632.19	20210717	2000	50		21	7	21.6	1016	1230	----	8		x	x	-	x	-	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
0523	12	BPWK01	BAS...	REF M1V1	5622.25	01612.1	20210717	2320	21		27	7	20.5	1015	9990	-x--	5		x	x	-	x	x	x	x	-	x	-	x	x	x	x	-	-	x	-	-	-
0524	12	BPSH05	BAS...	HANÖBUKTEN	5537.08	01452	20210718	0630	79	6	29	11	19.2	1016	2430	----	11		x	x	-	x	-	x	x	x	x	-	x	x	x	x	-	-	x	-	-	-
0525	12	KAEX29	BAS...	ANHOLT E	5640.11	01206.67	20210719	0045	64		29	6	18.1	1017	9990	-x--	10		x	x	-	x	x	x	x	-	x	-	x	x	x	x	-	-	x	-	x	-

STATION SLÄGGÖ SURFACE WATER (0-10 m)

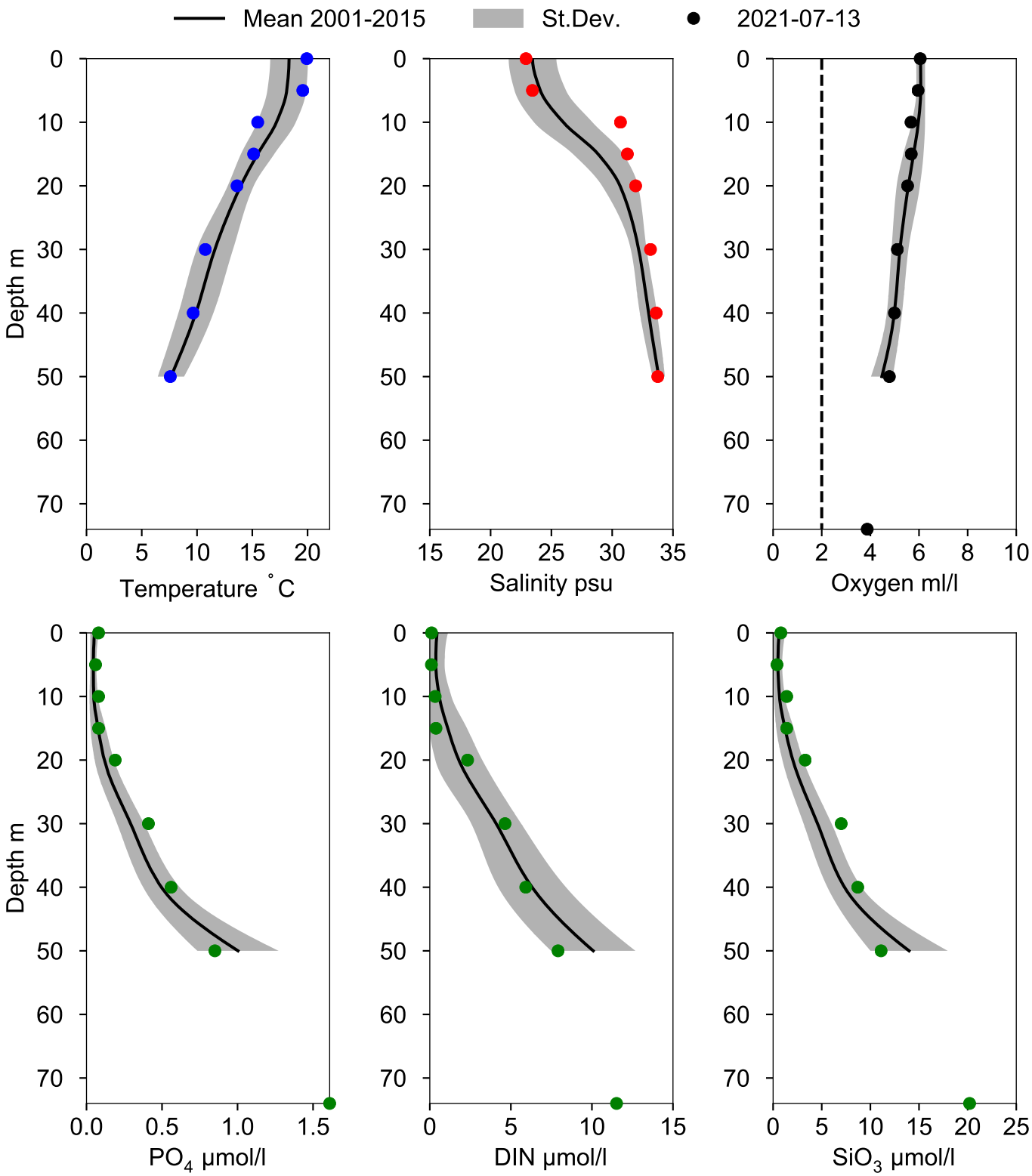
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 64 m)

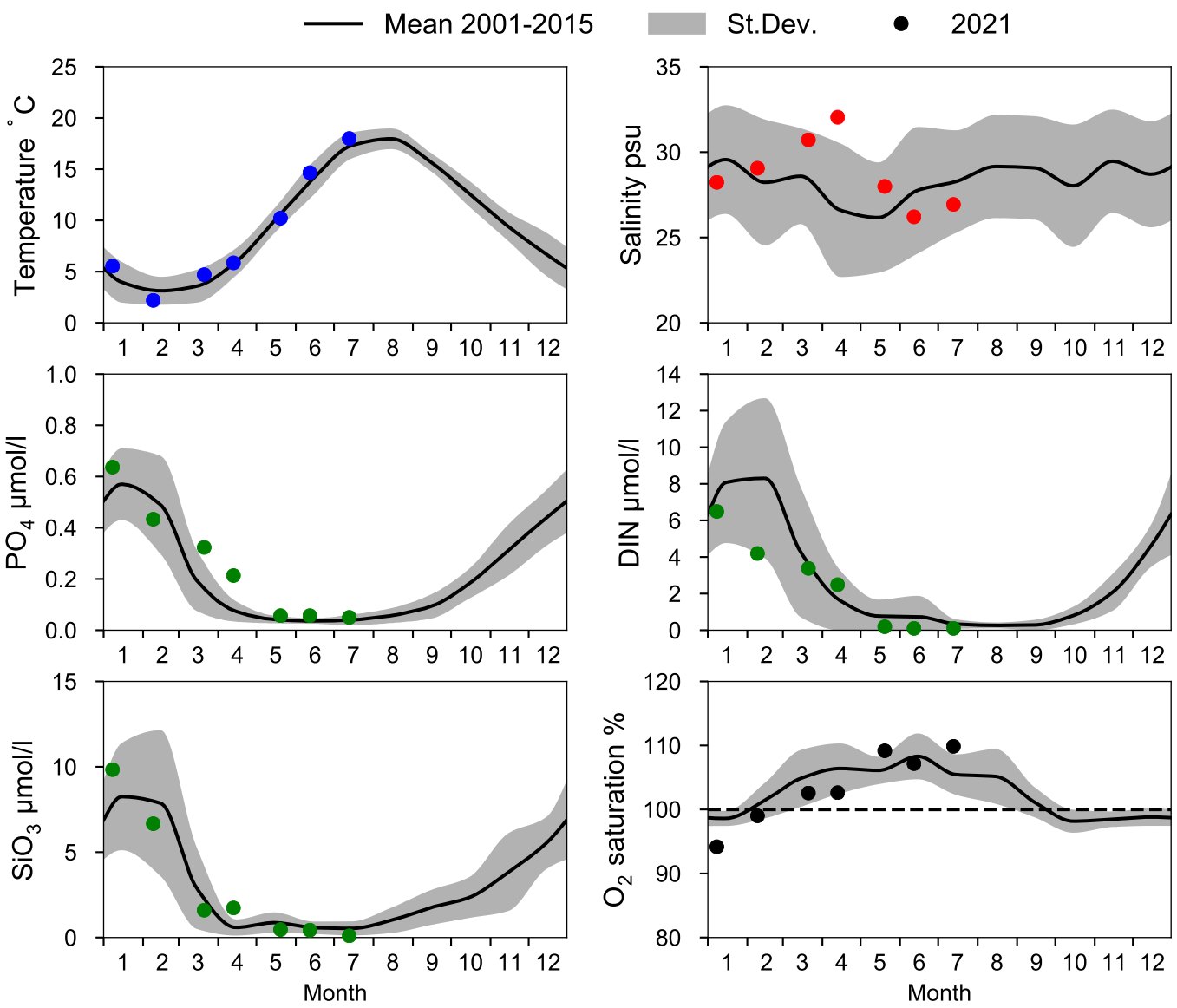


Vertical profiles SLÄGGÖ
July

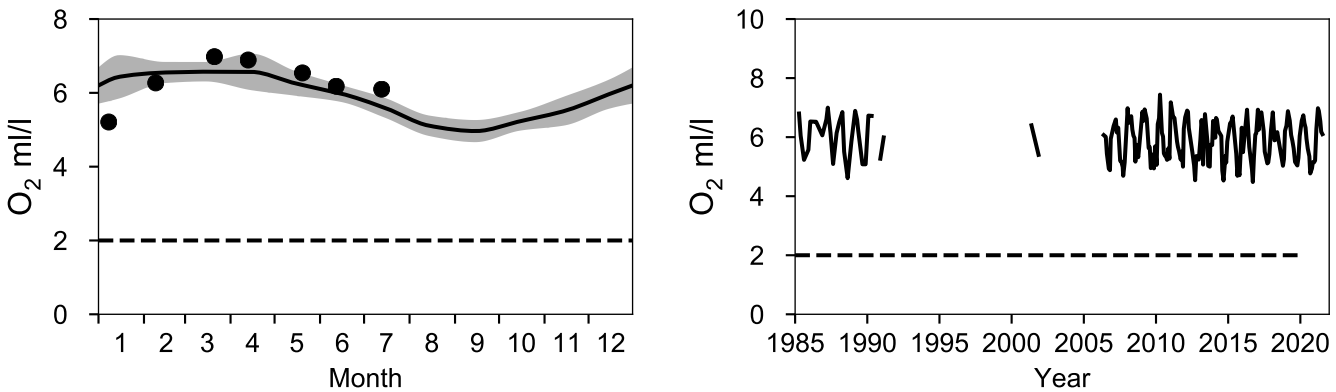


STATION Å13 SURFACE WATER (0-10 m)

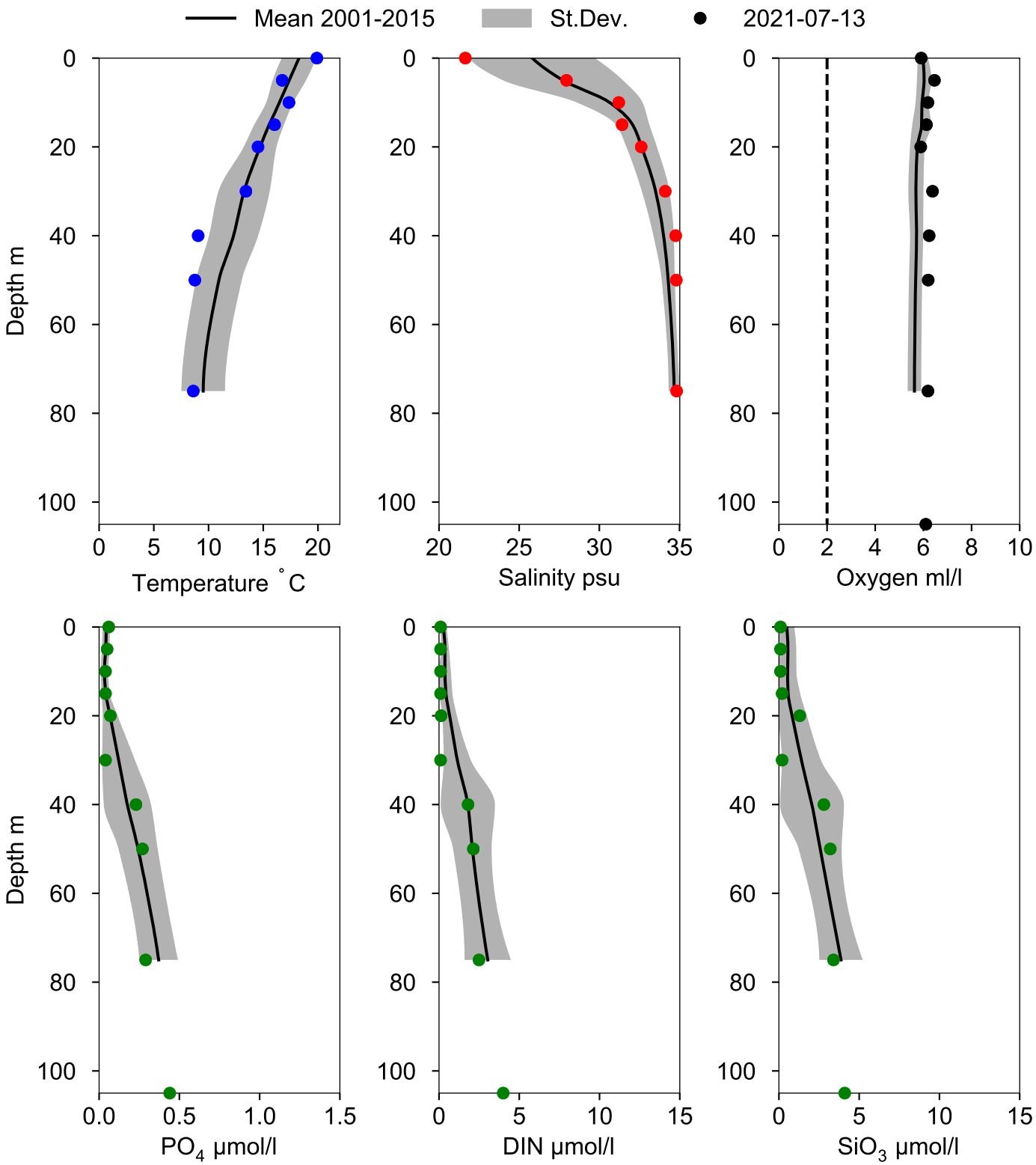
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

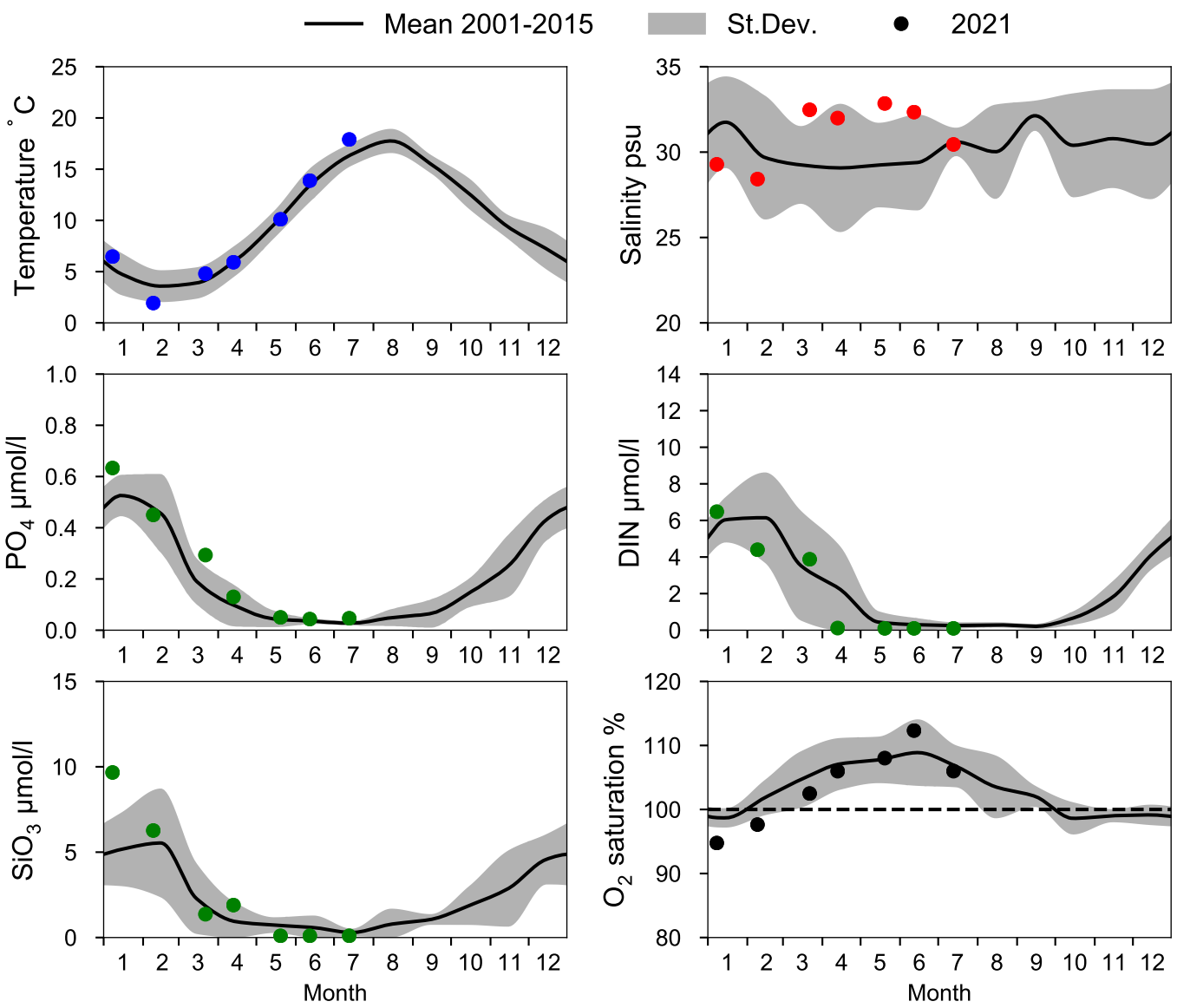


Vertical profiles Å13
July

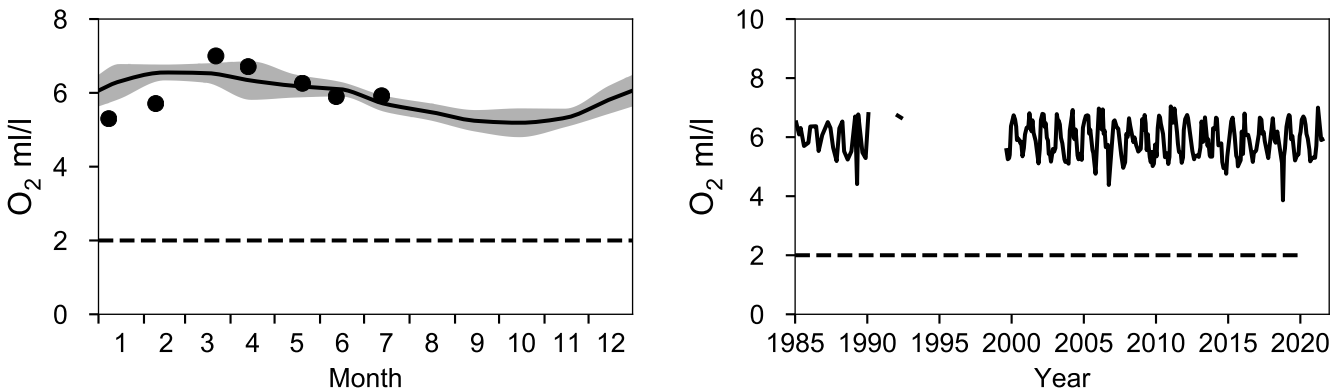


STATION Å15 SURFACE WATER (0-10 m)

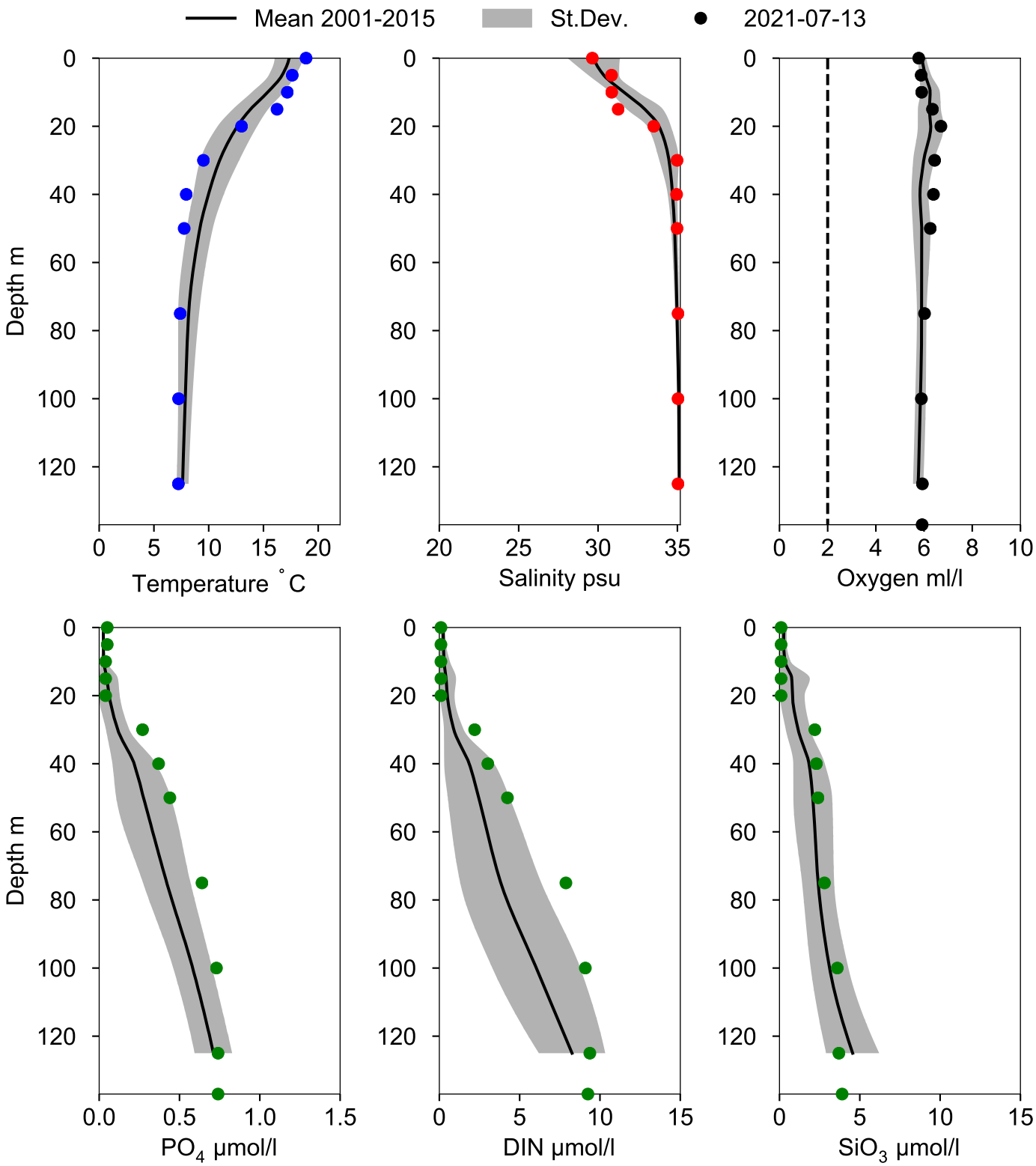
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 125 m)

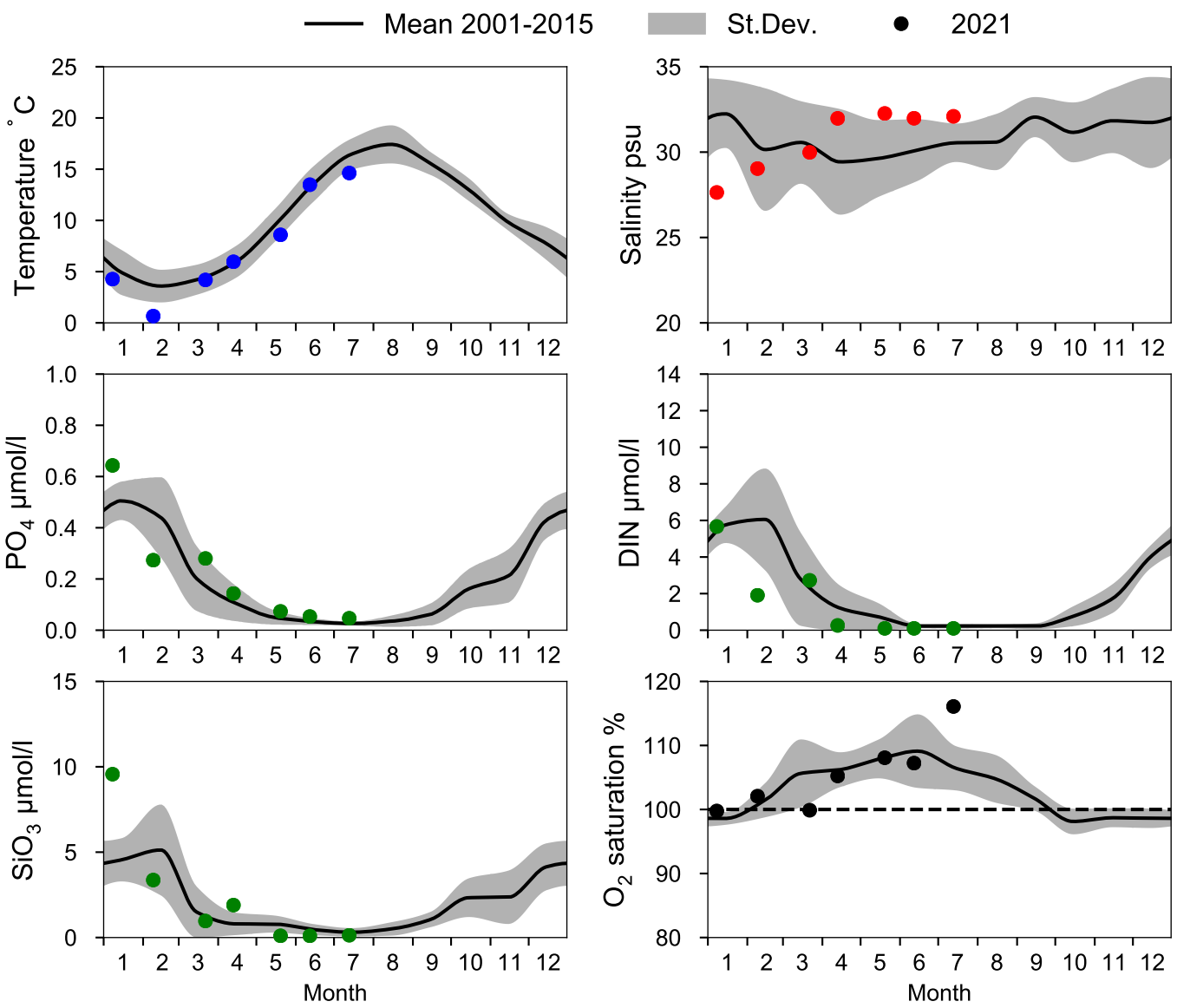


Vertical profiles Å15
July

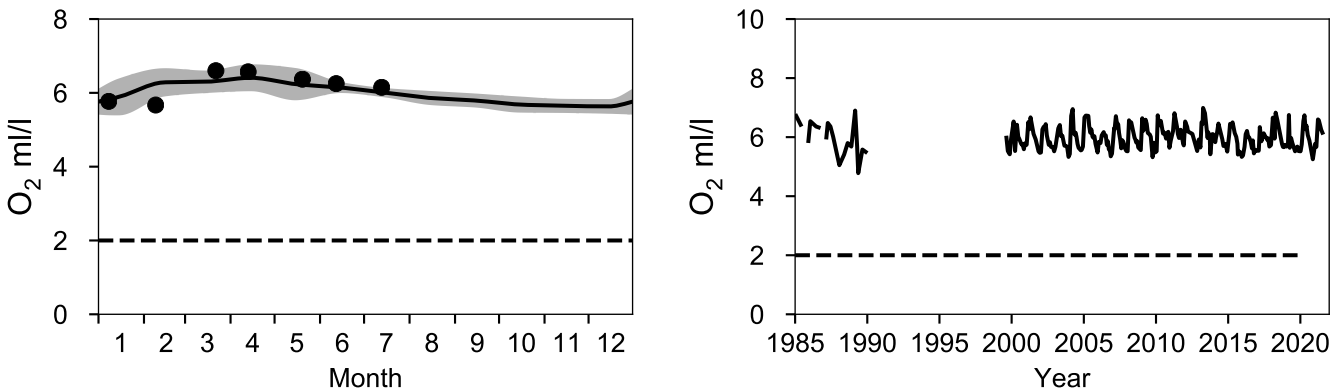


STATION Å17 SURFACE WATER (0-10 m)

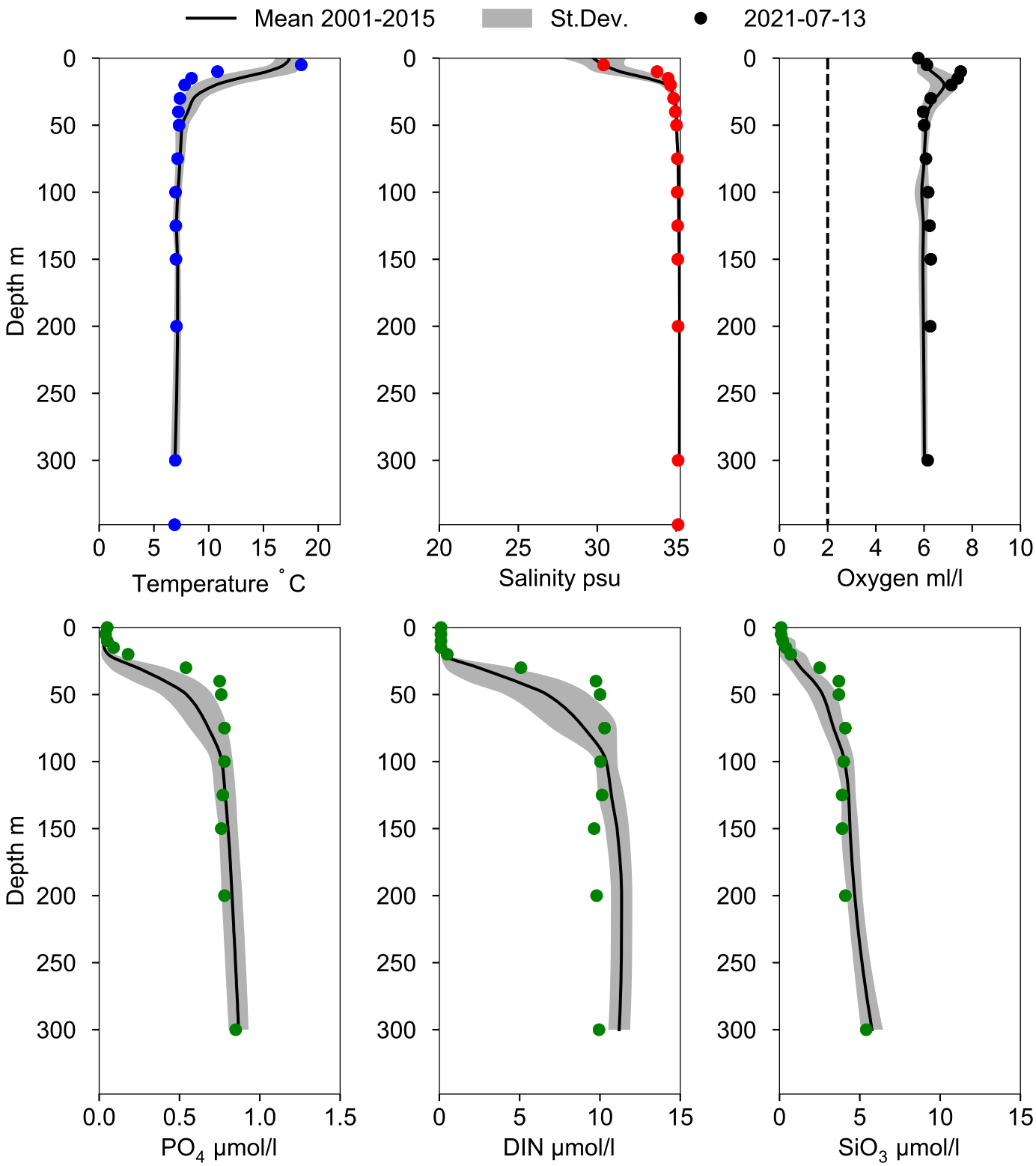
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 300 m)

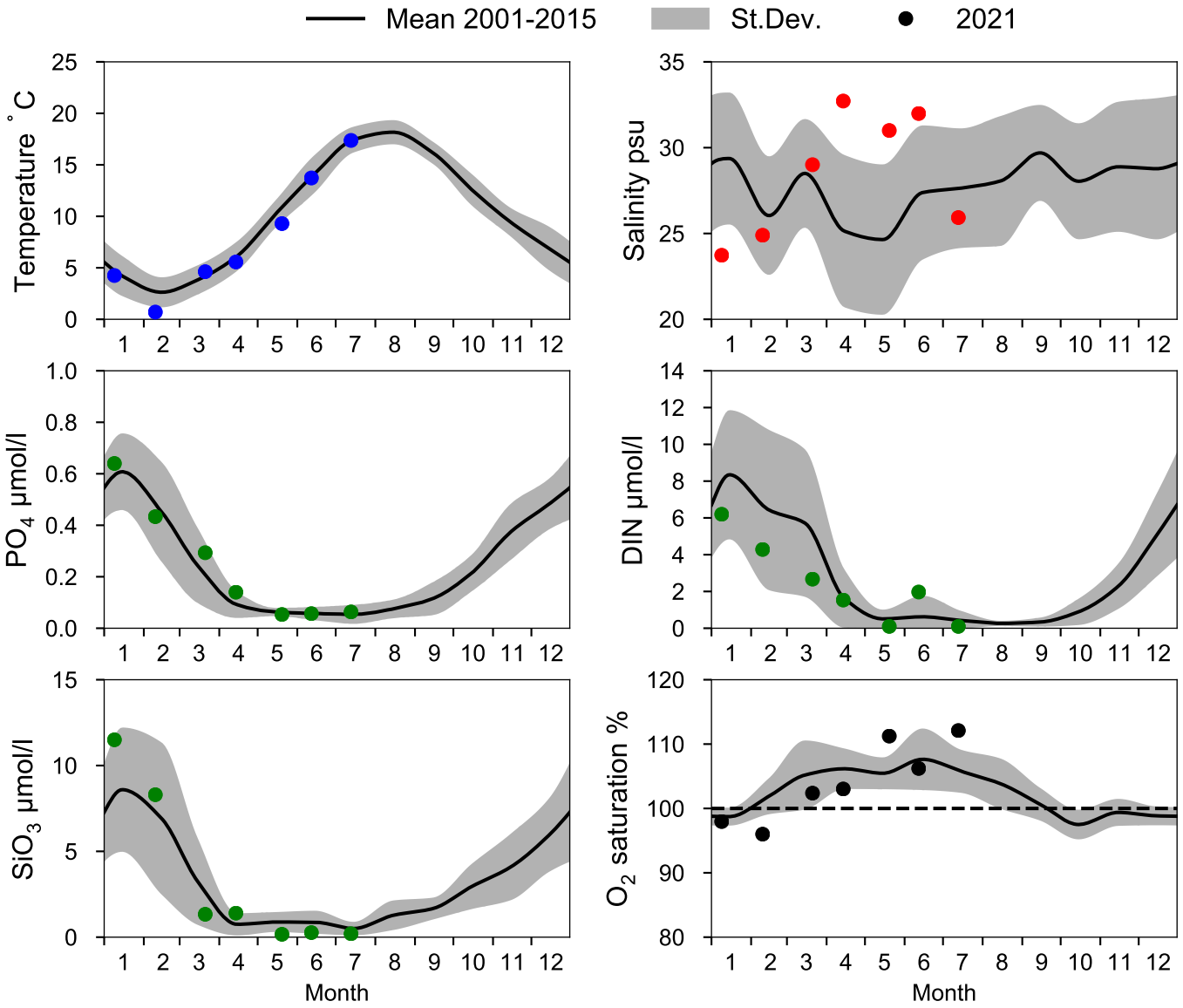


Vertical profiles Å17
July

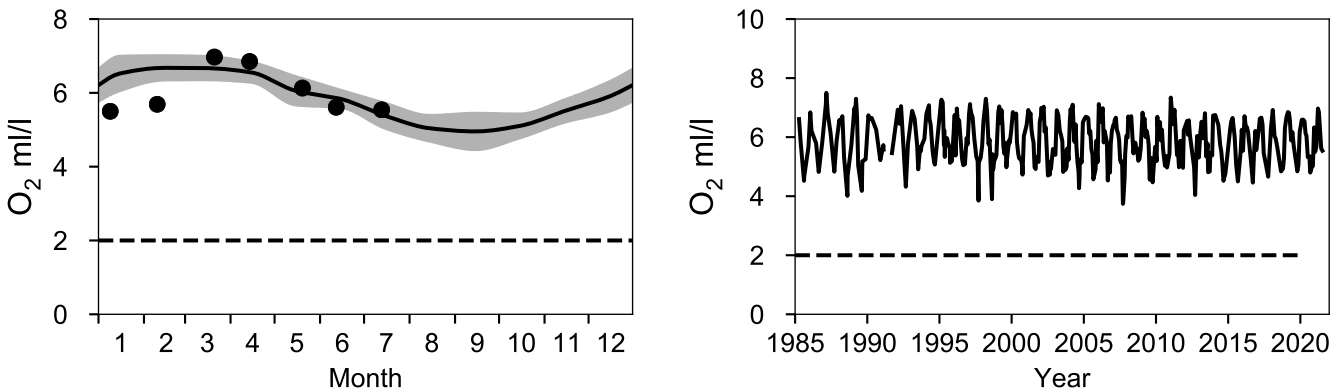


STATION P2 SURFACE WATER (0-10 m)

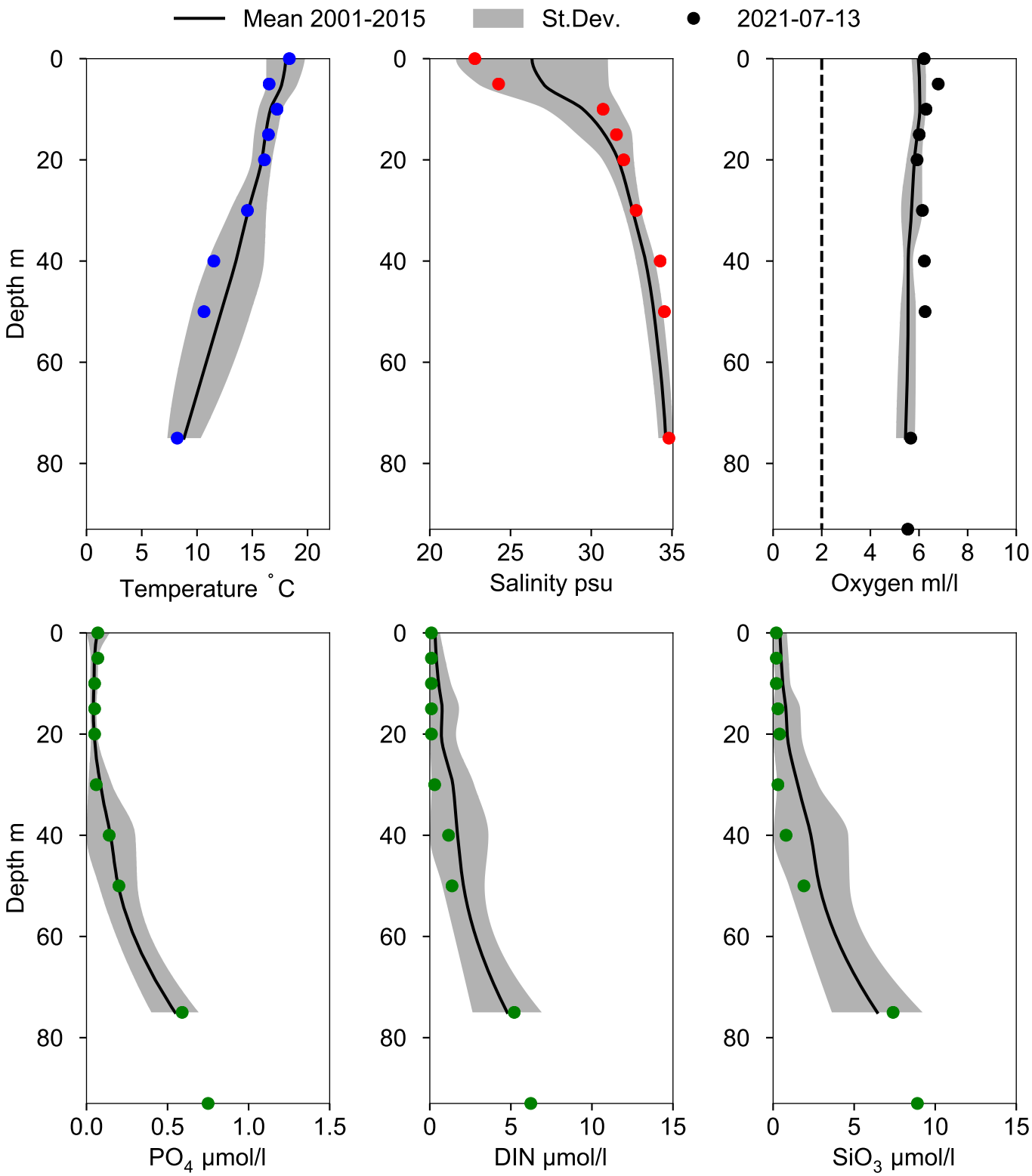
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 75 m)

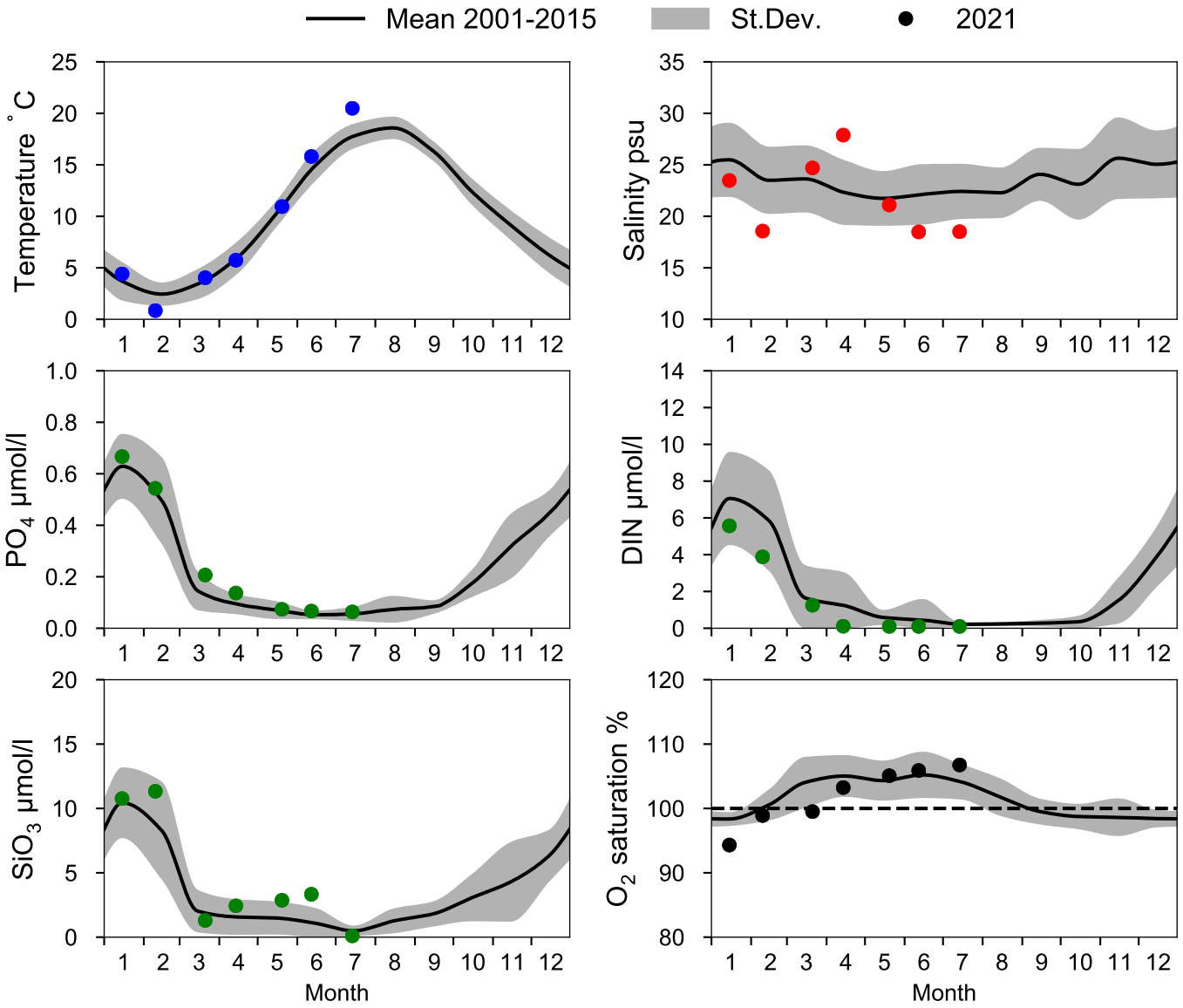


Vertical profiles P2
July

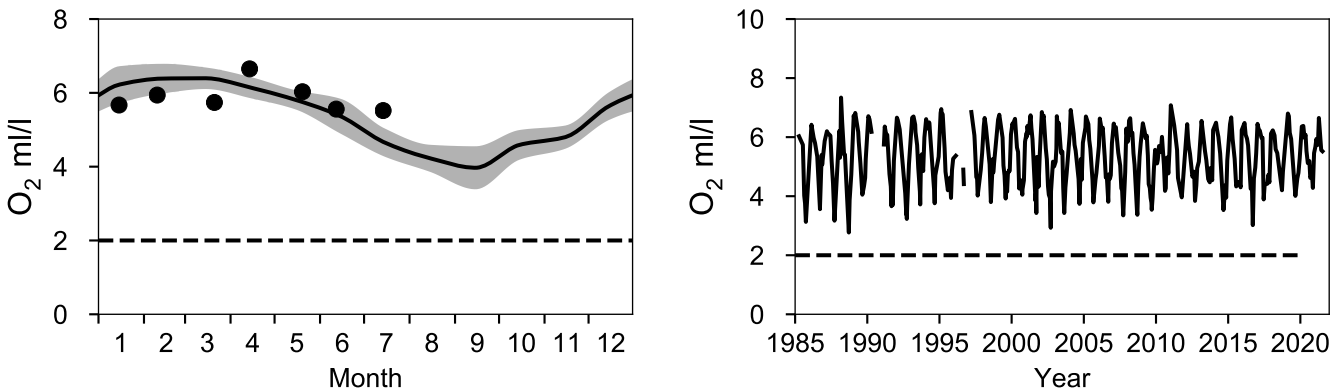


STATION FLADEN SURFACE WATER (0-10 m)

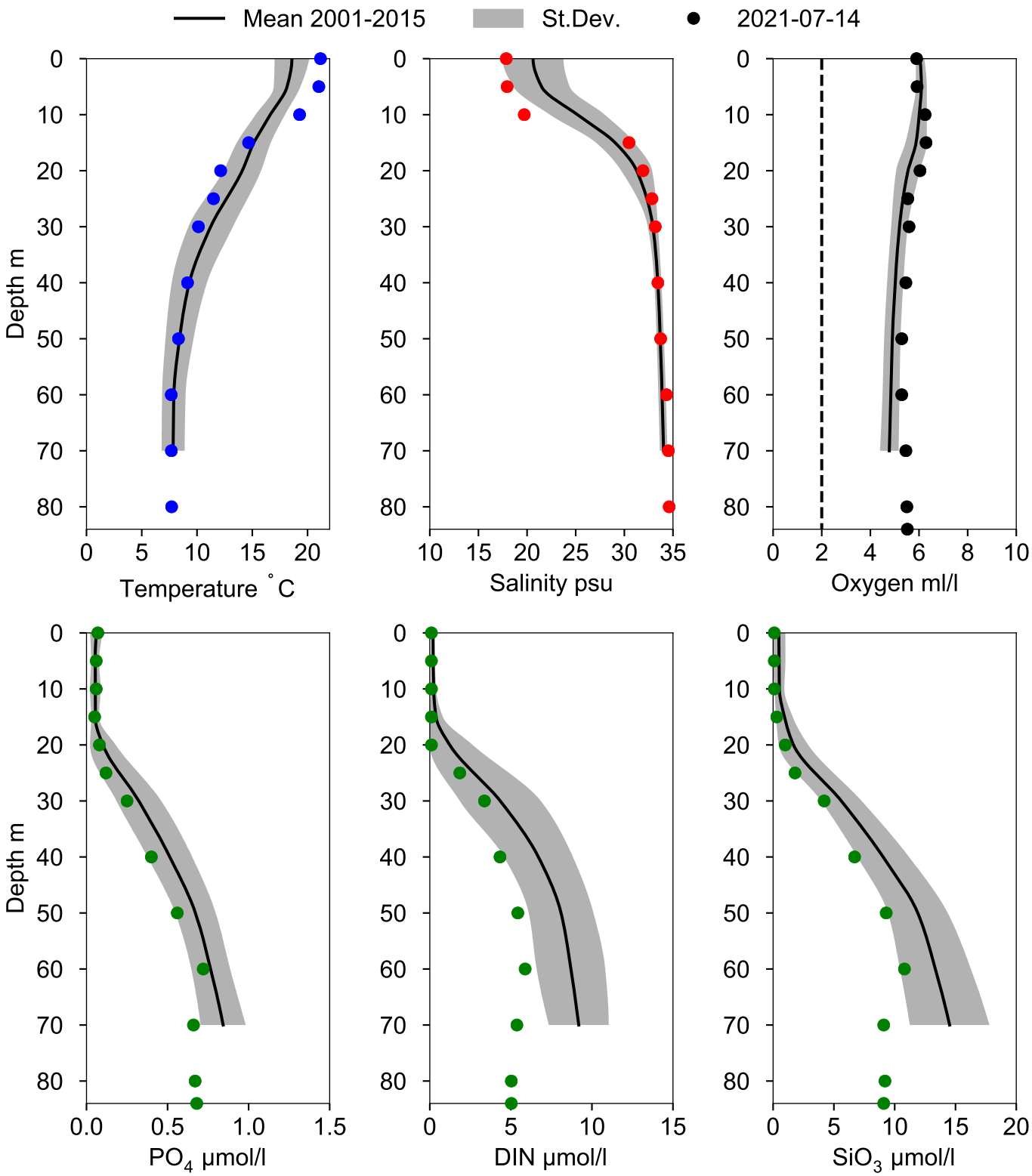
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 74 m)

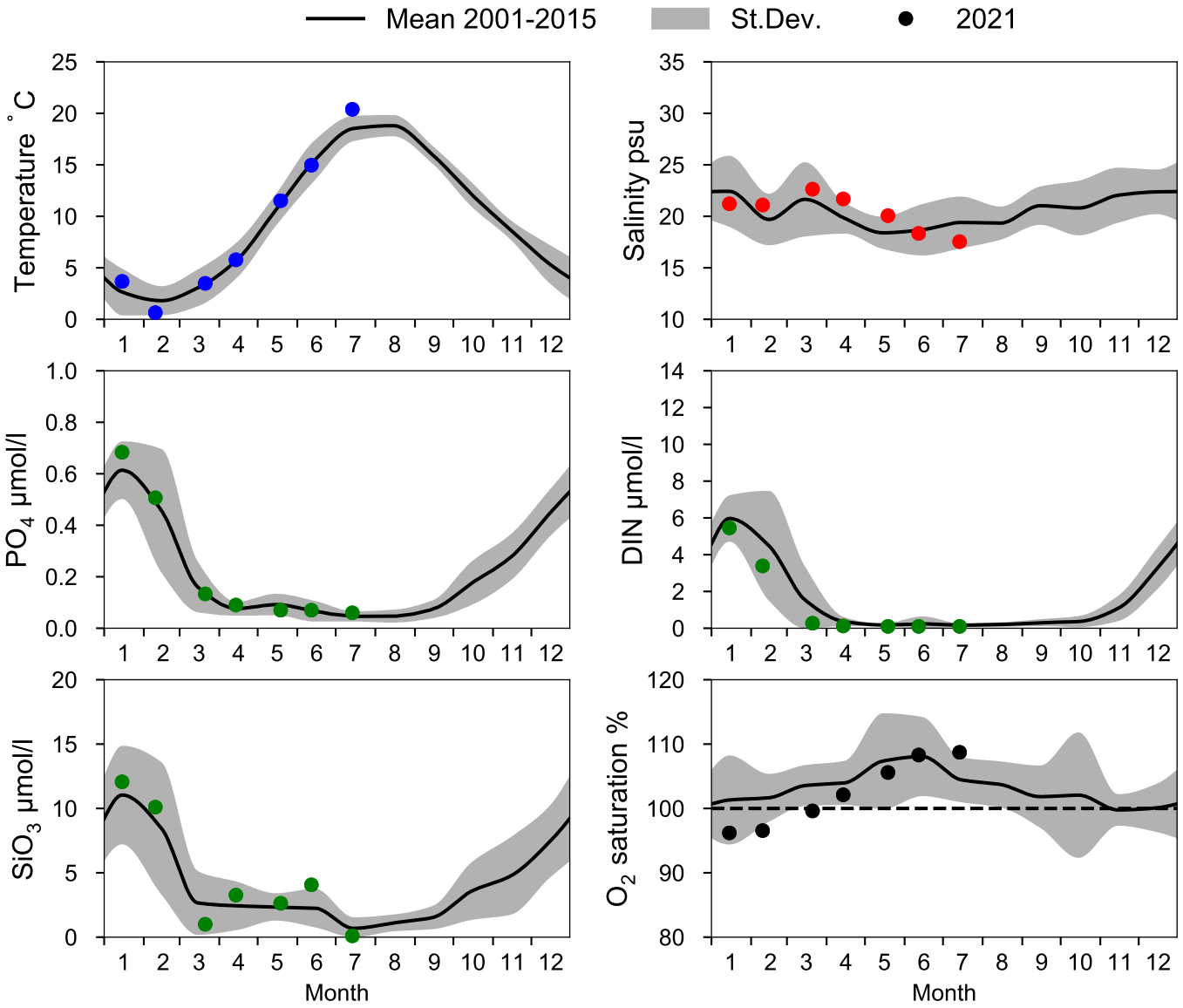


Vertical profiles FLADEN
July

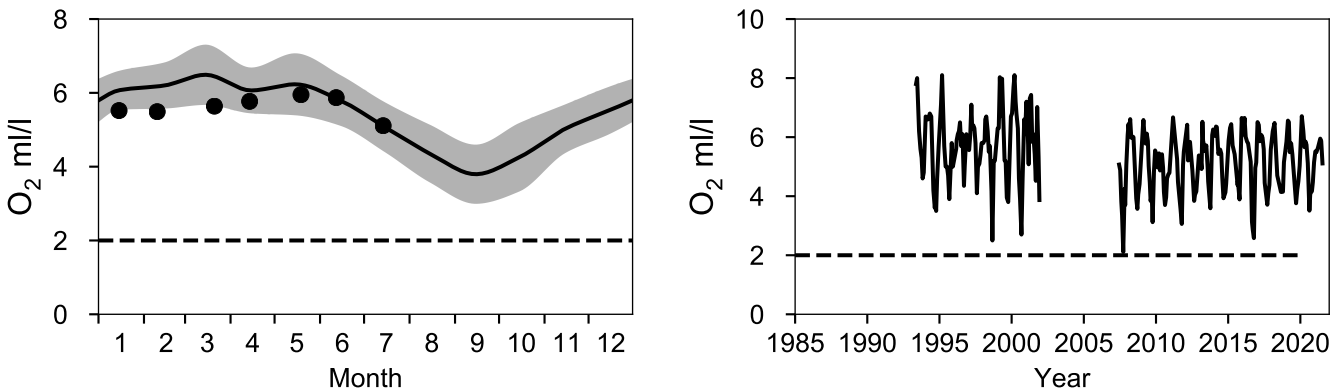


STATION N14 FALKENBERG SURFACE WATER (0-10 m)

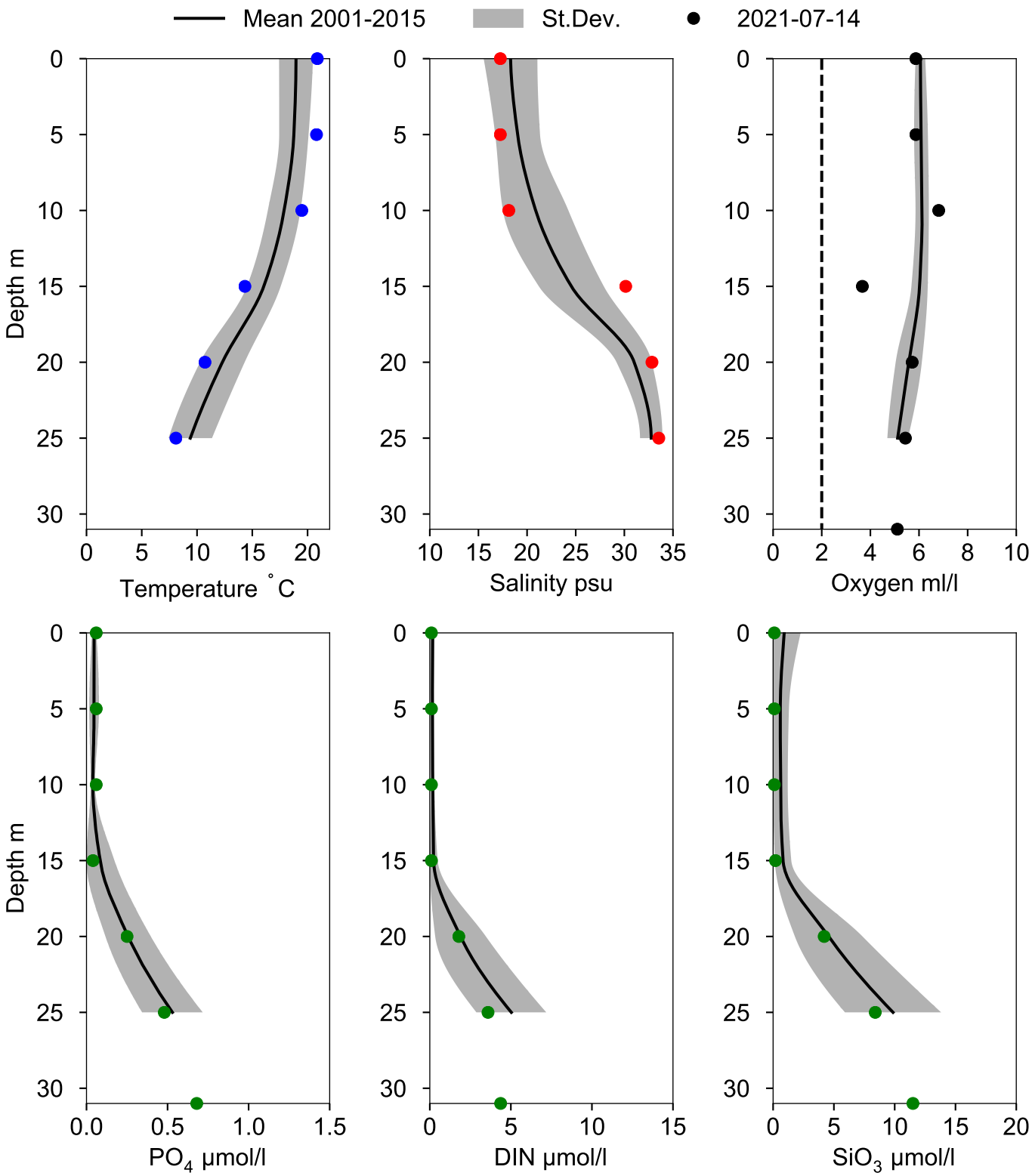
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 20 m)

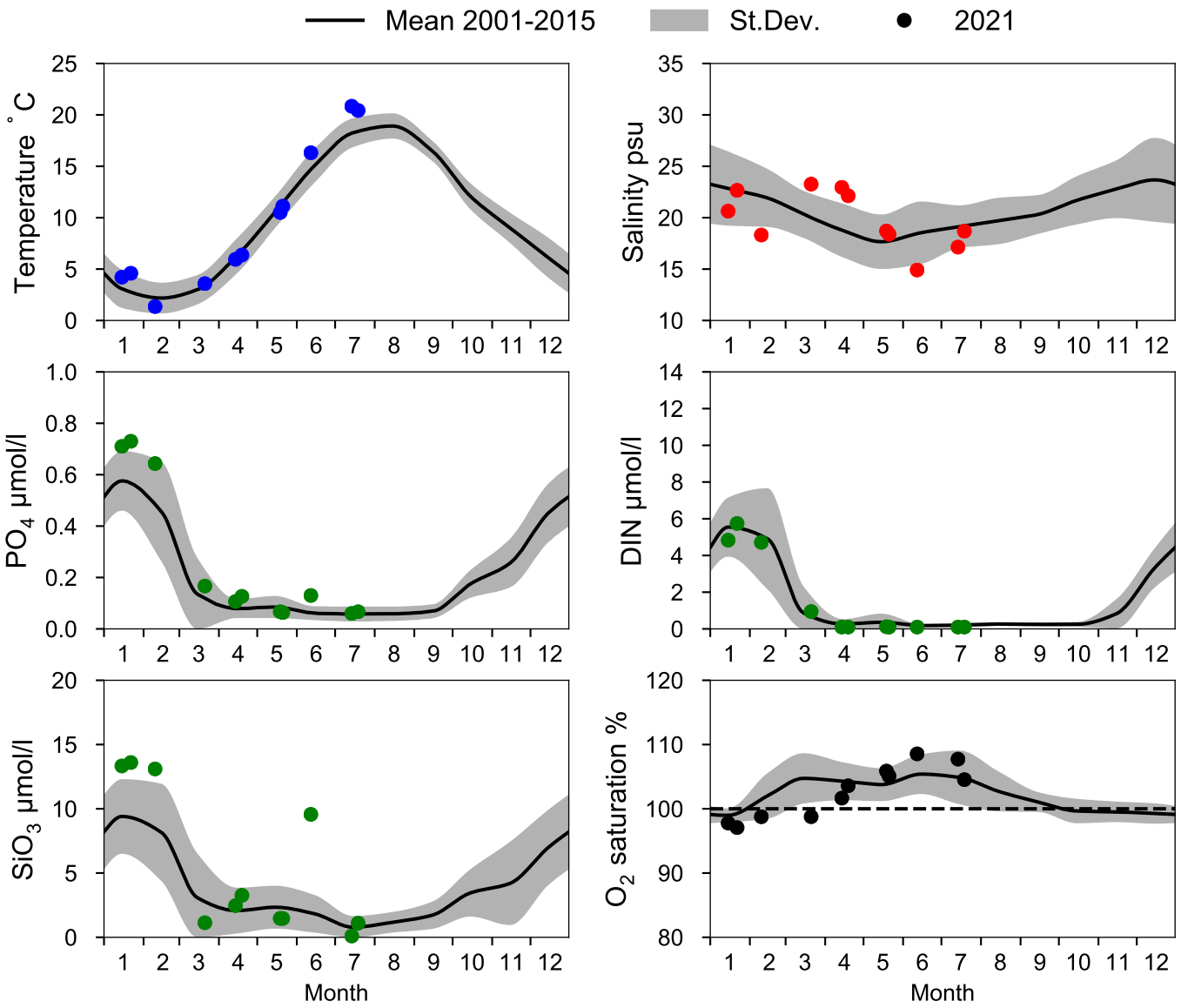


Vertical profiles N14 FALKENBERG
July

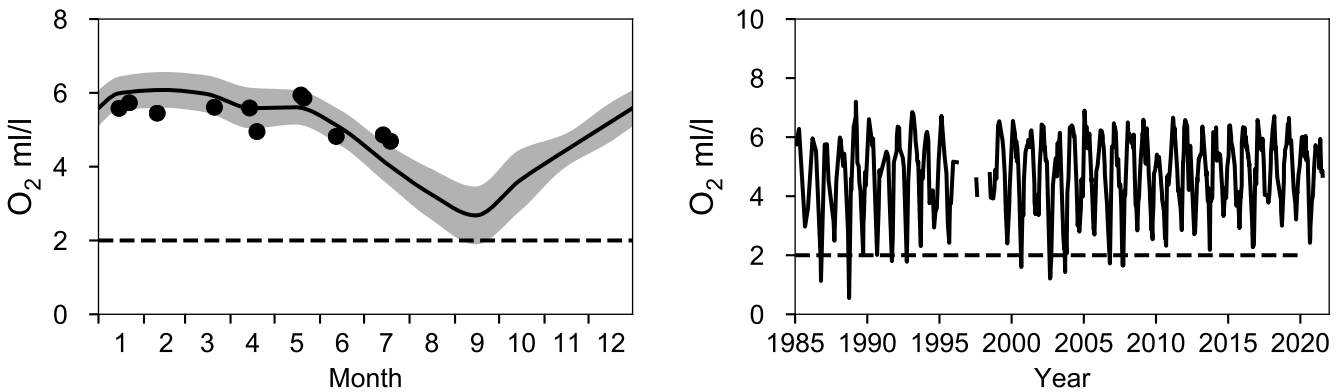


STATION ANHOLT E SURFACE WATER (0-10 m)

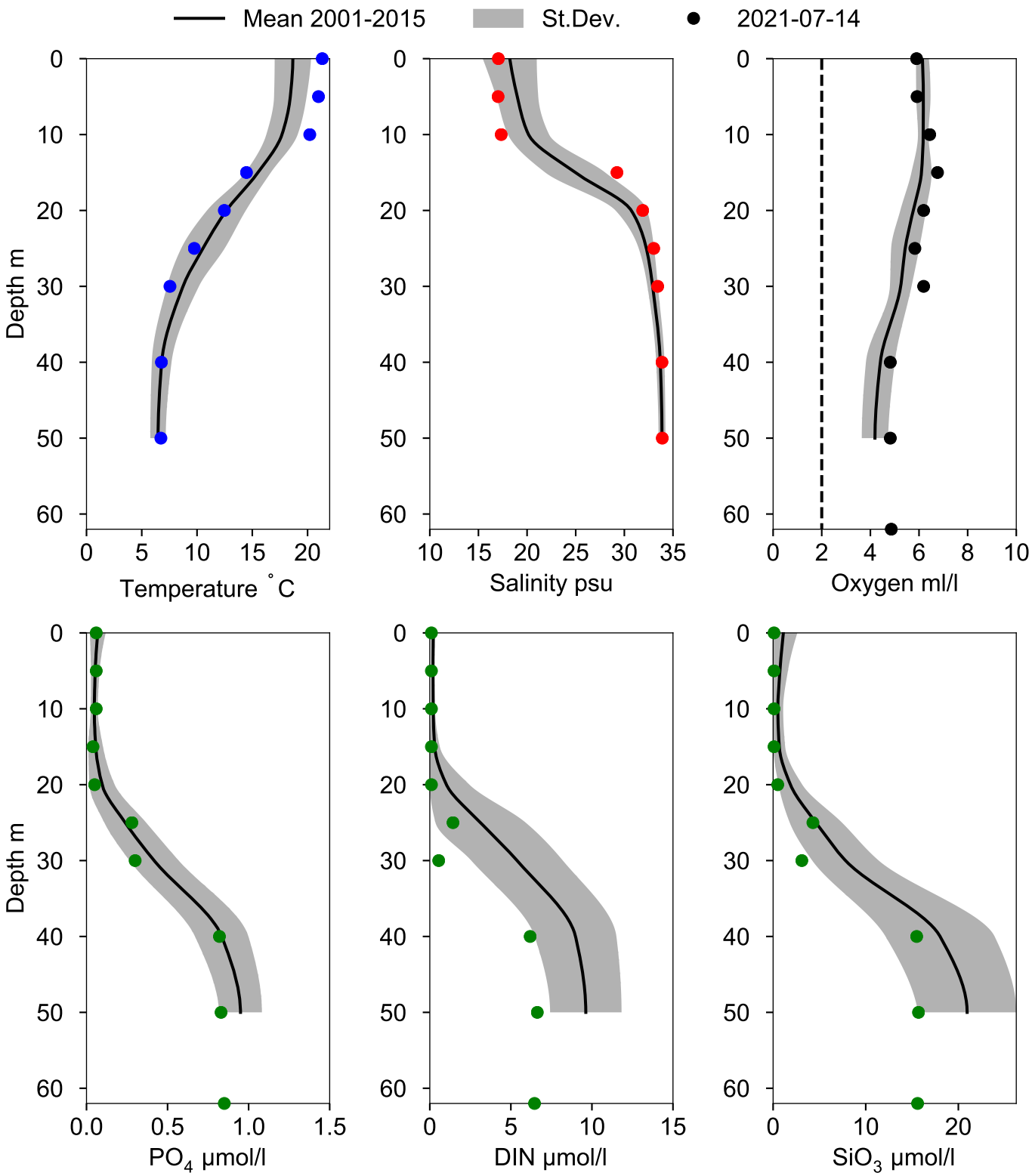
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 52 m)

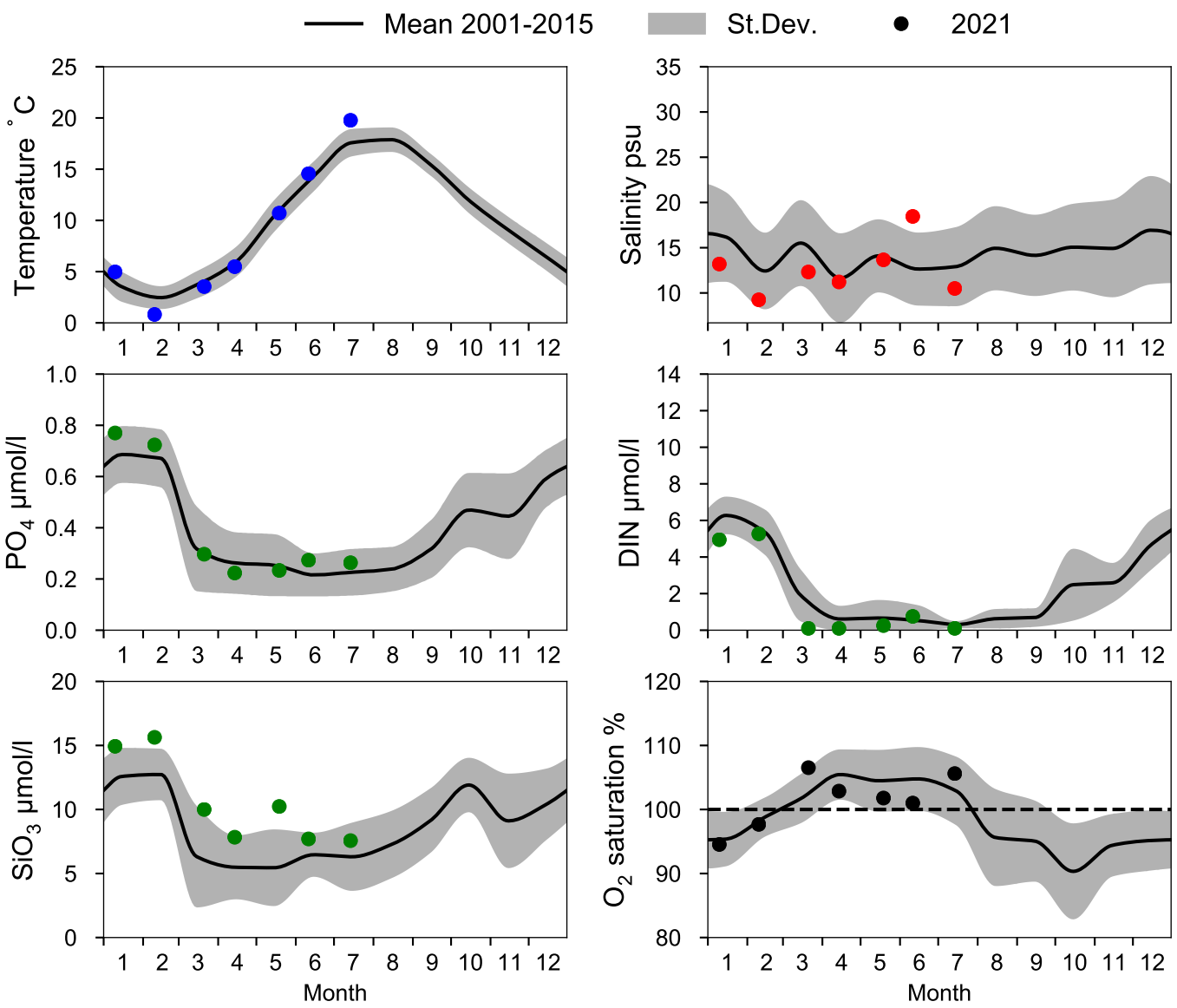


Vertical profiles ANHOLT E
July

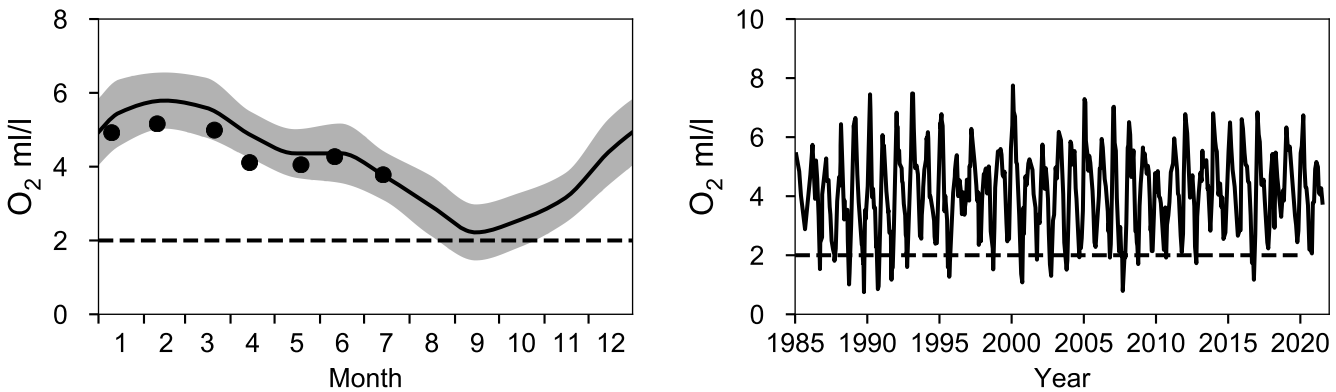


STATION W LANDSKRONA SURFACE WATER (0-10 m)

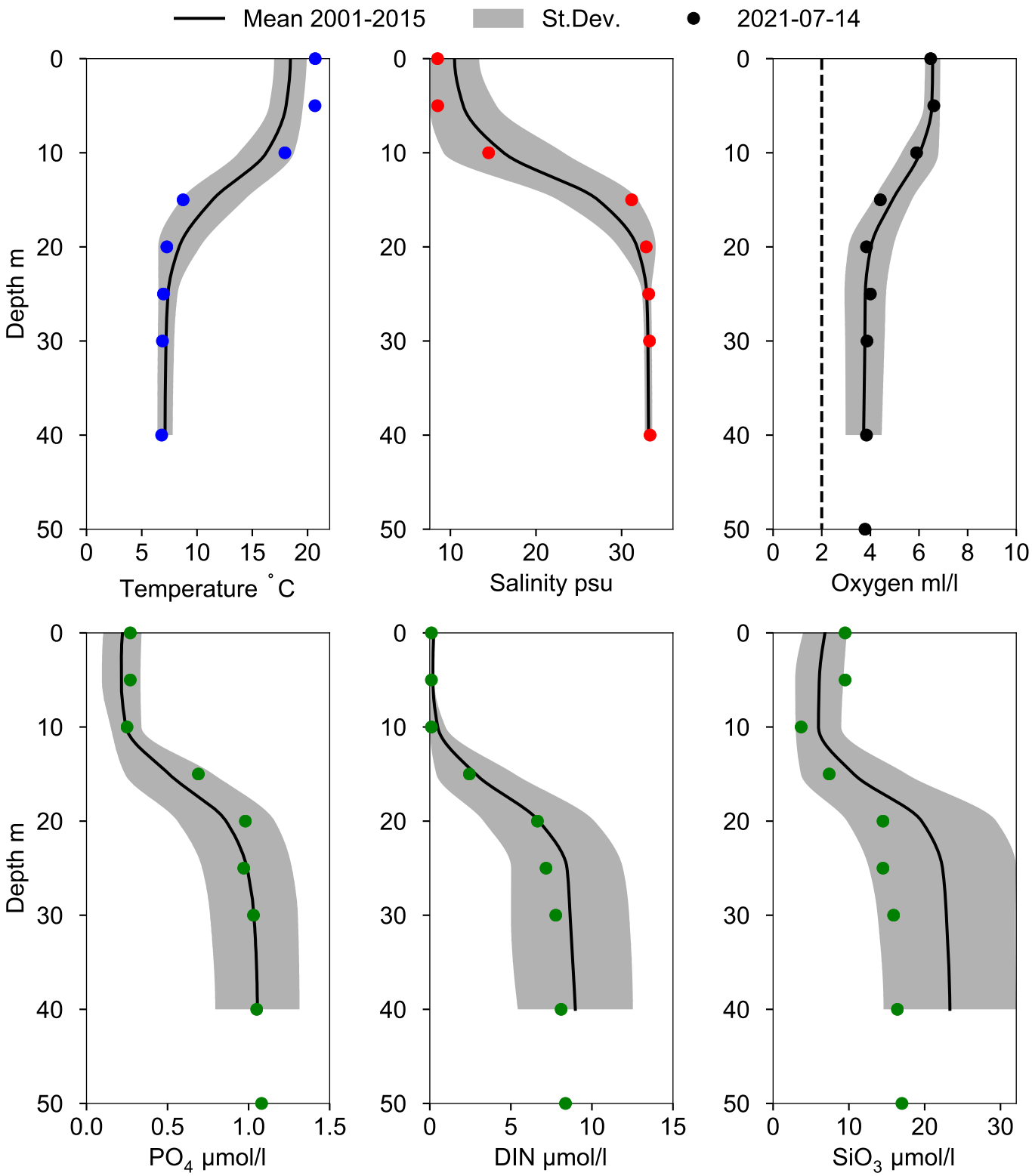
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 40 m)

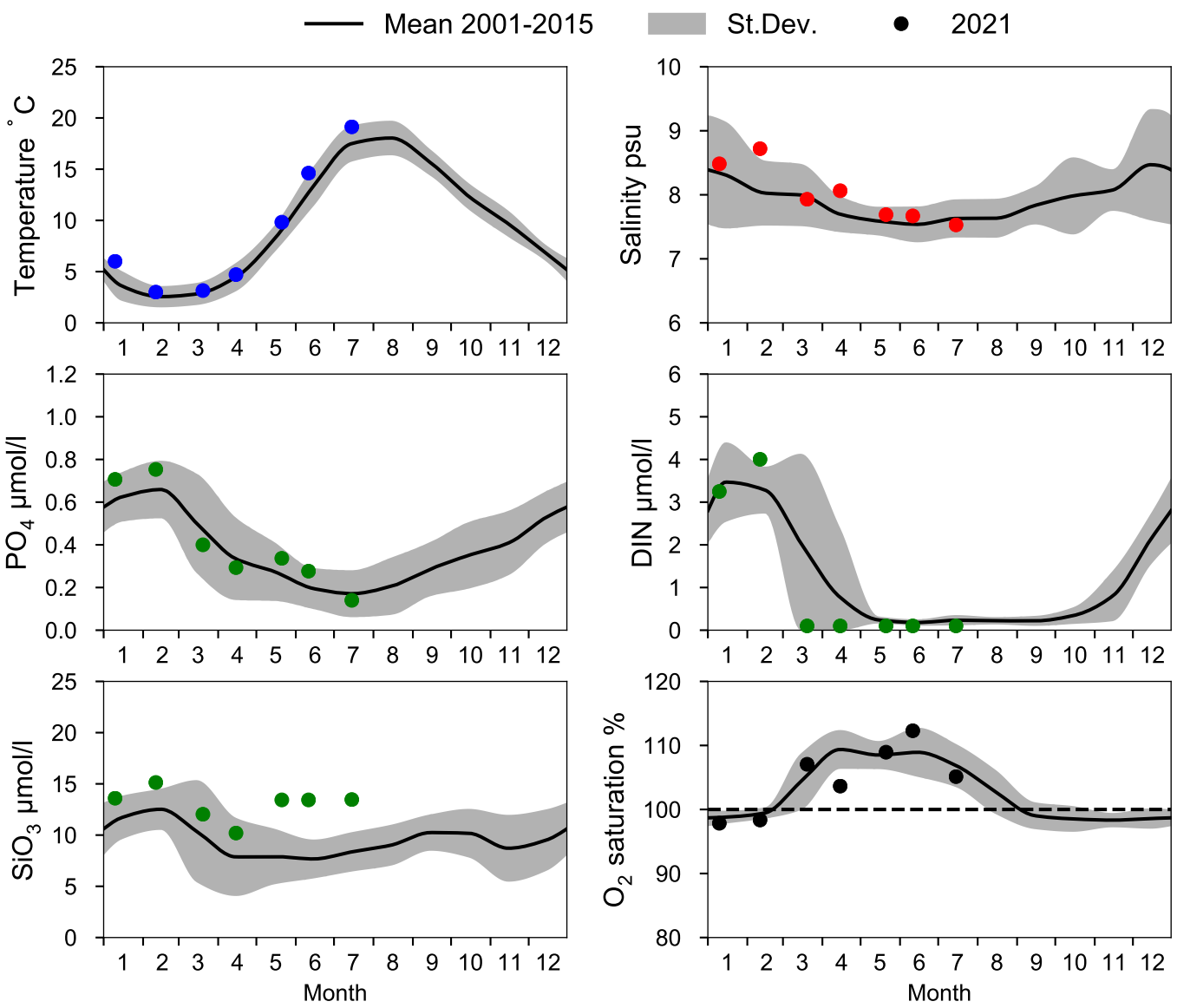


Vertical profiles W LANDSKRONA
July

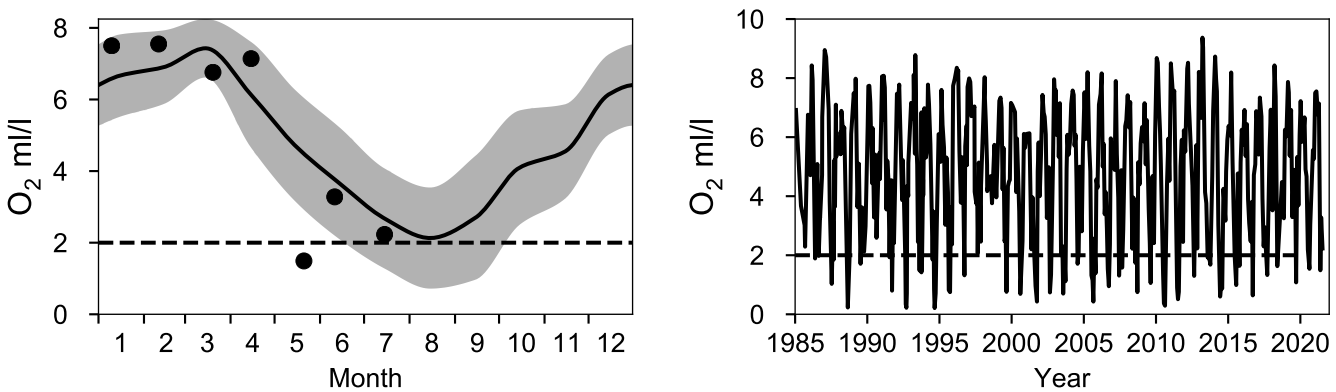


STATION BY1 SURFACE WATER (0-10 m)

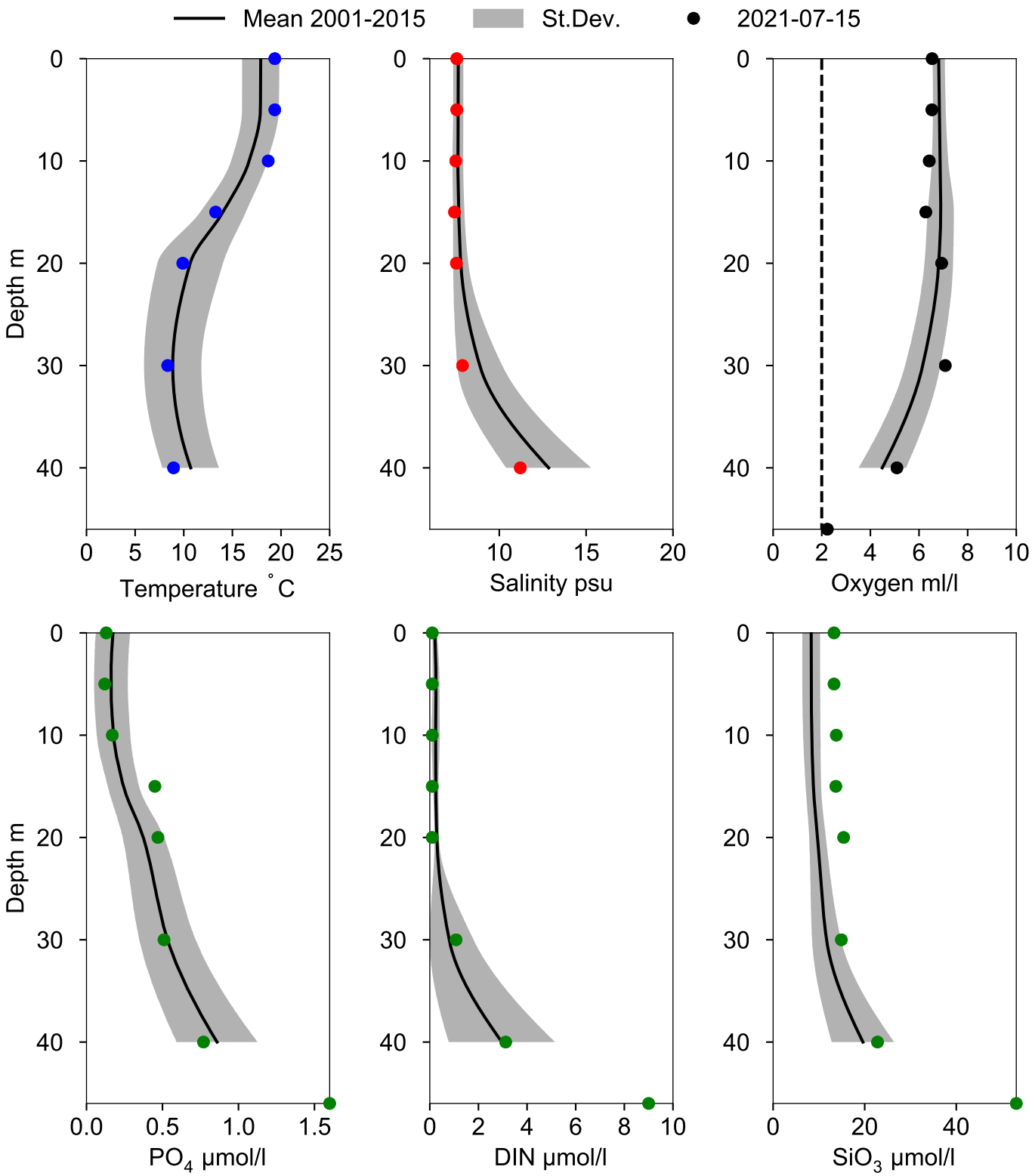
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 39 m)

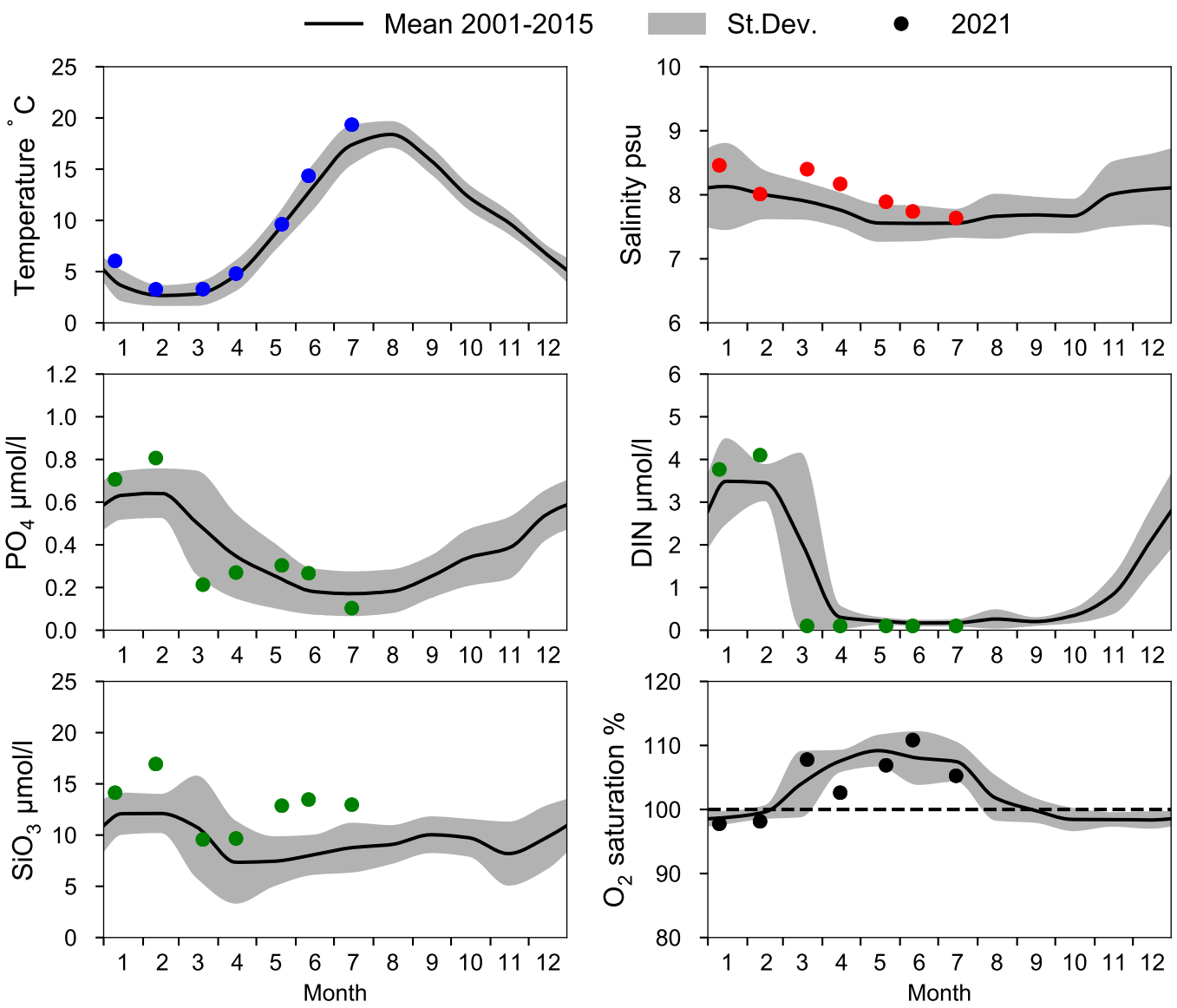


Vertical profiles BY1
July

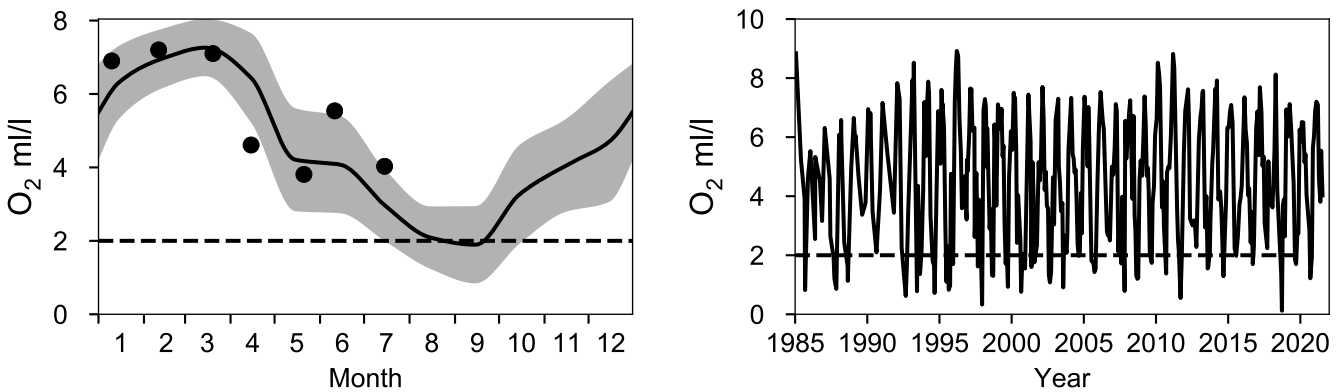


STATION BY2 ARKONA SURFACE WATER (0-10 m)

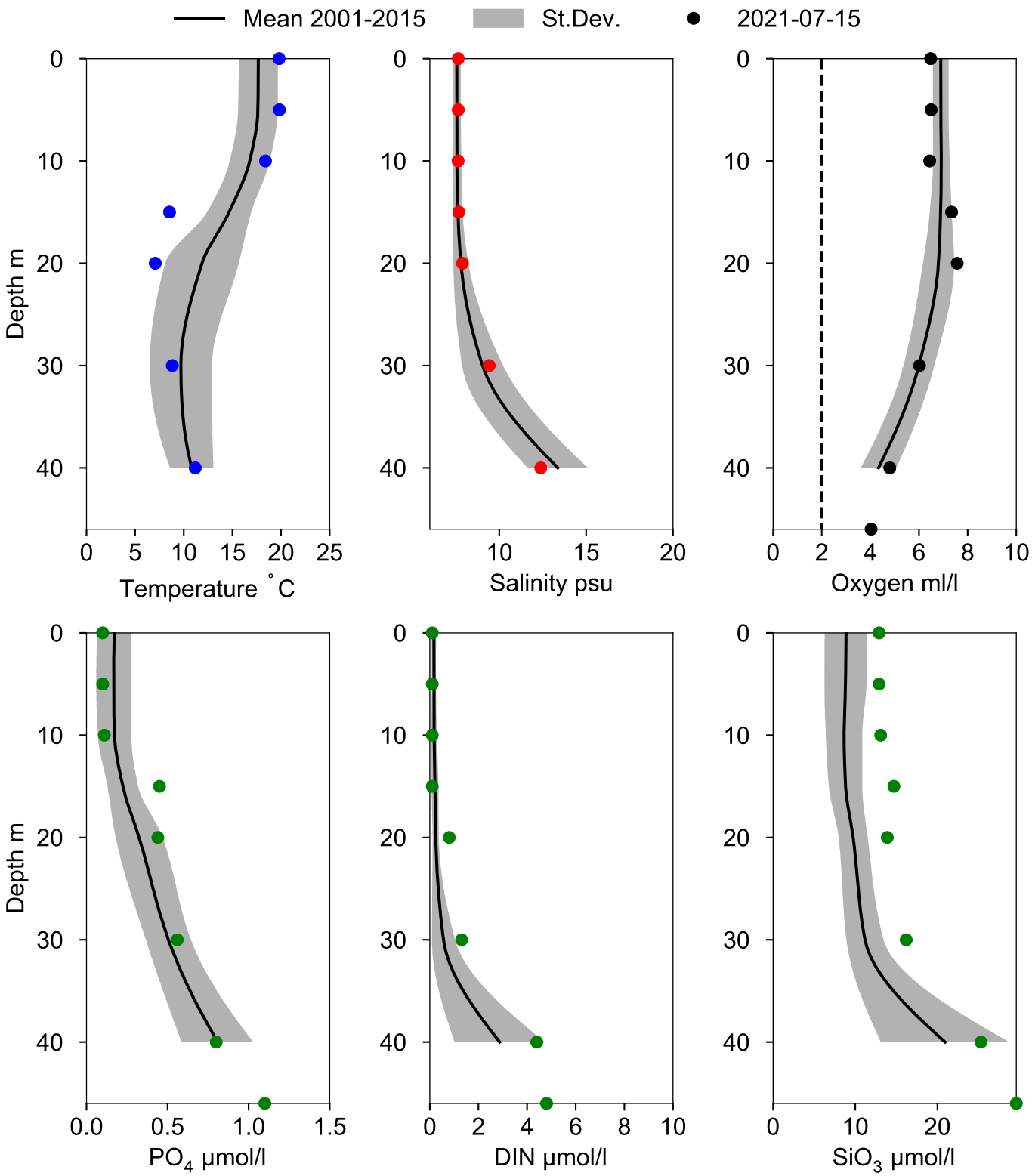
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 40 m)

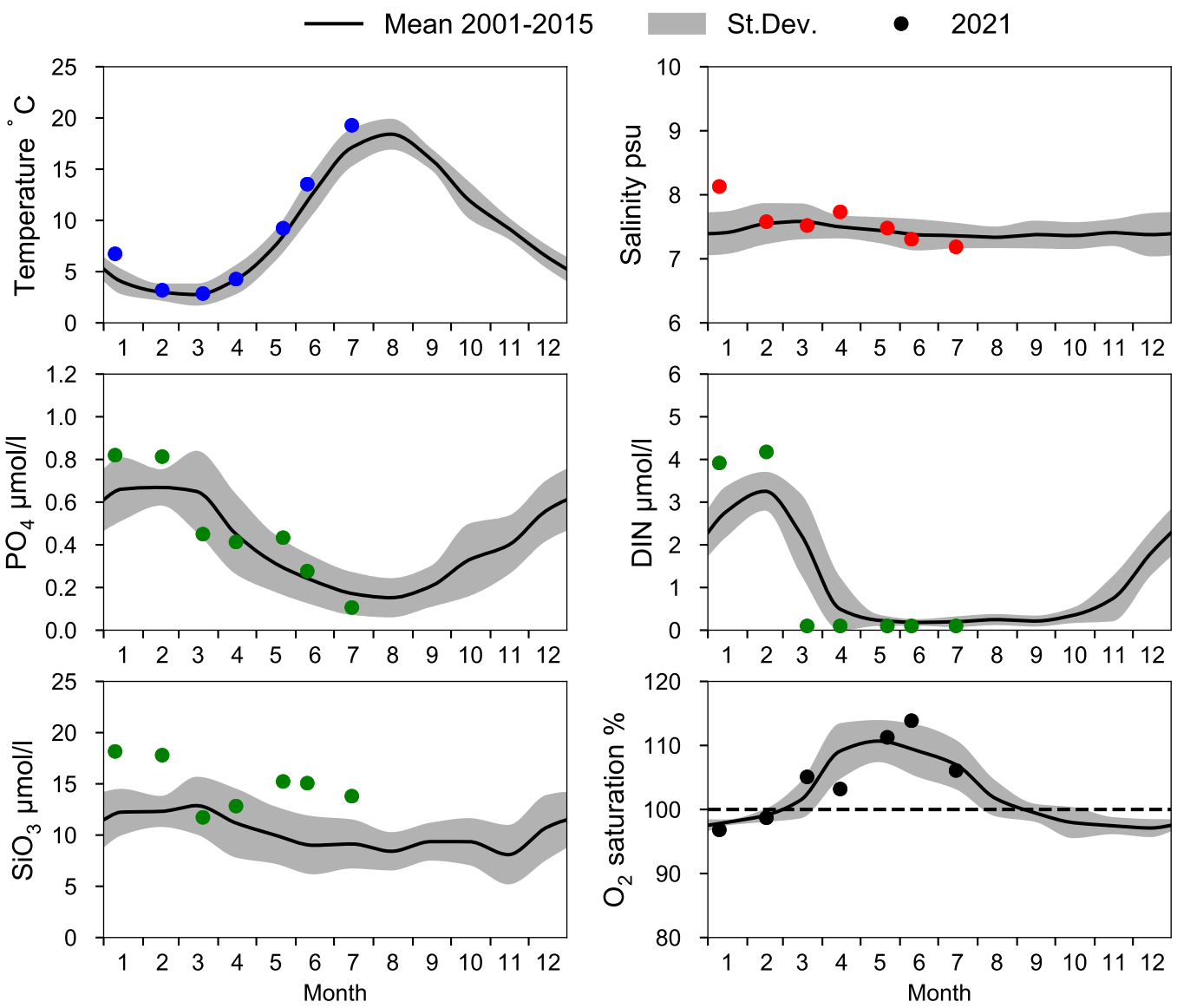


Vertical profiles BY2 ARKONA
July

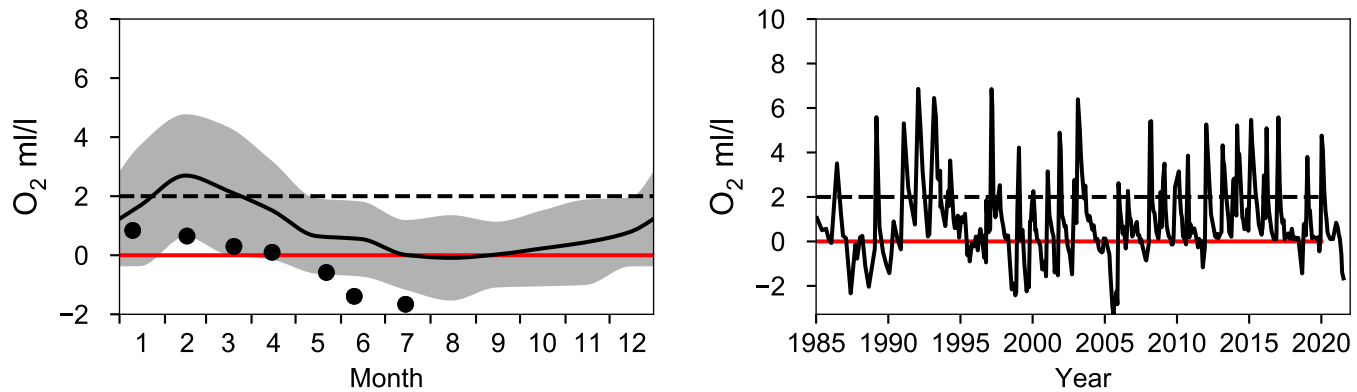


STATION BY4 CHRISTIANSÖ SURFACE WATER (0-10 m)

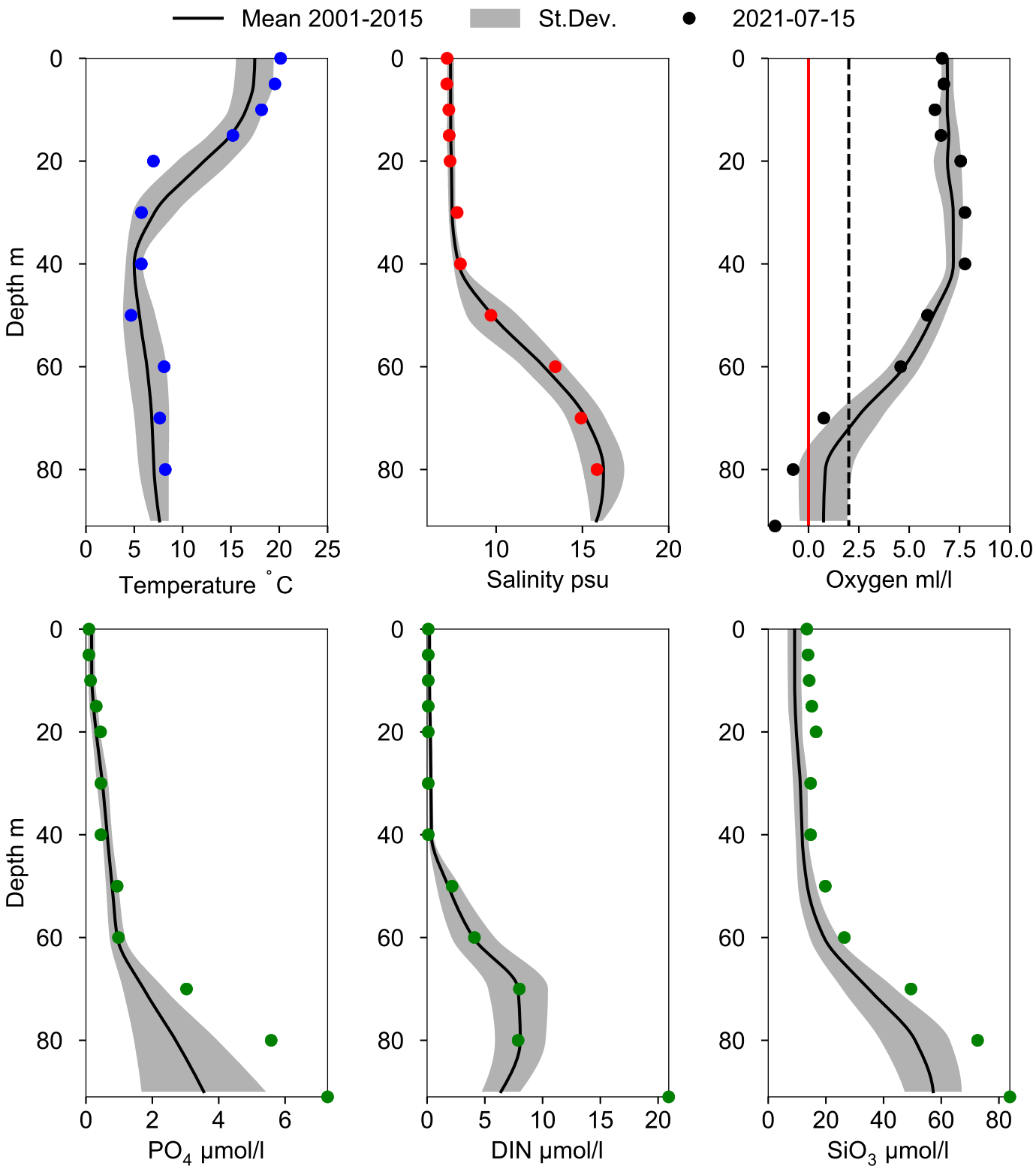
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

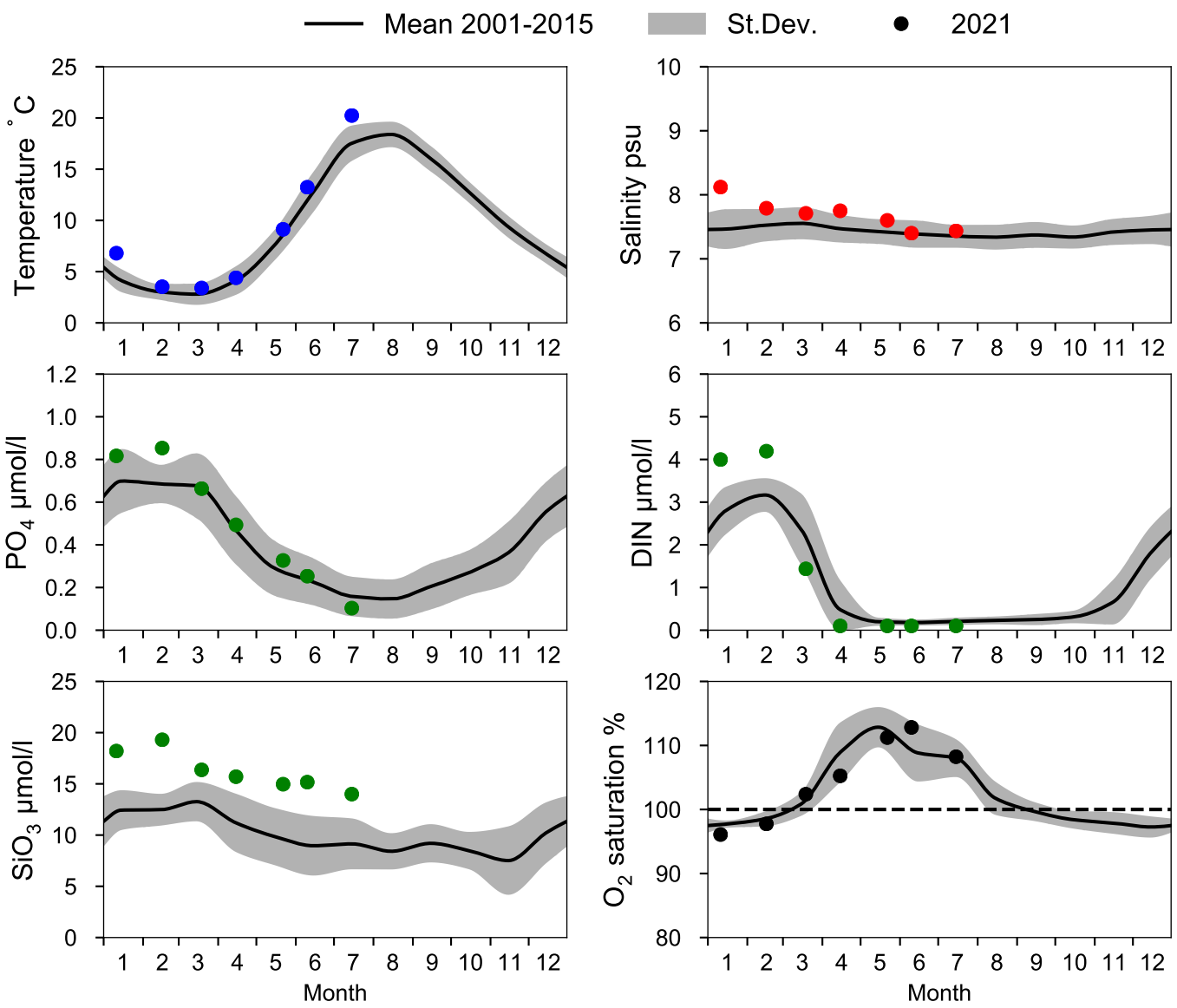


Vertical profiles BY4 CHRISTIANSÖ
July

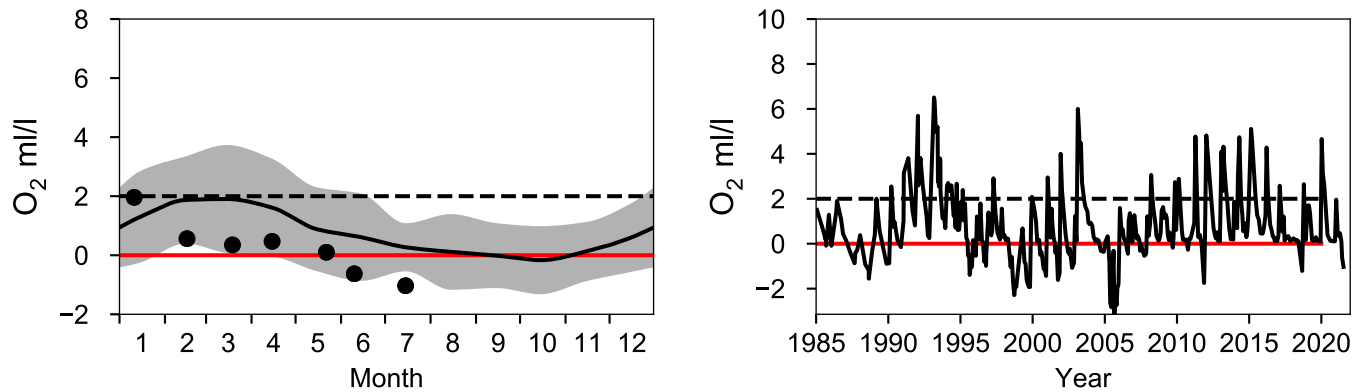


STATION BY5 BORNHOLMSDJ SURFACE WATER (0-10 m)

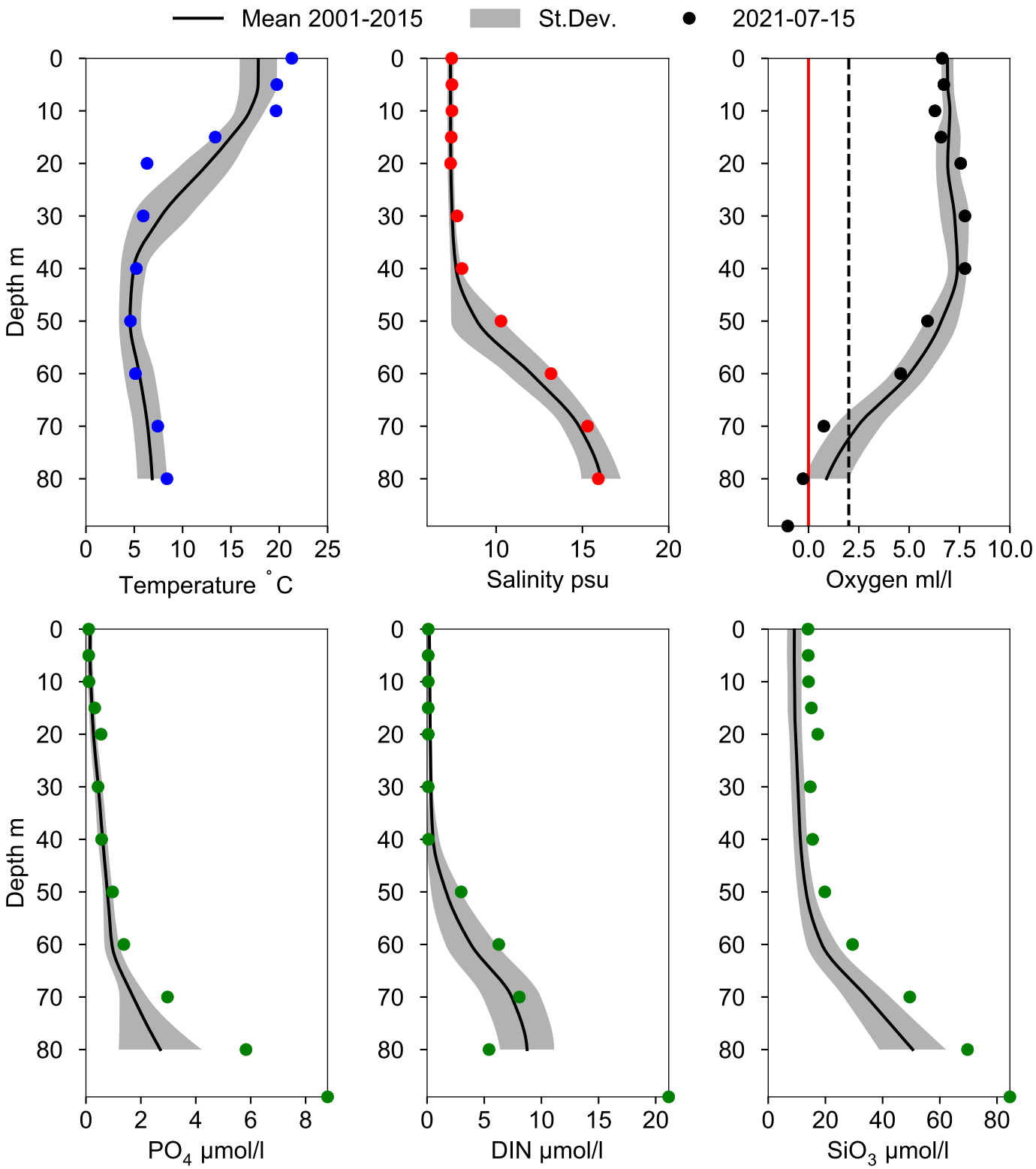
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

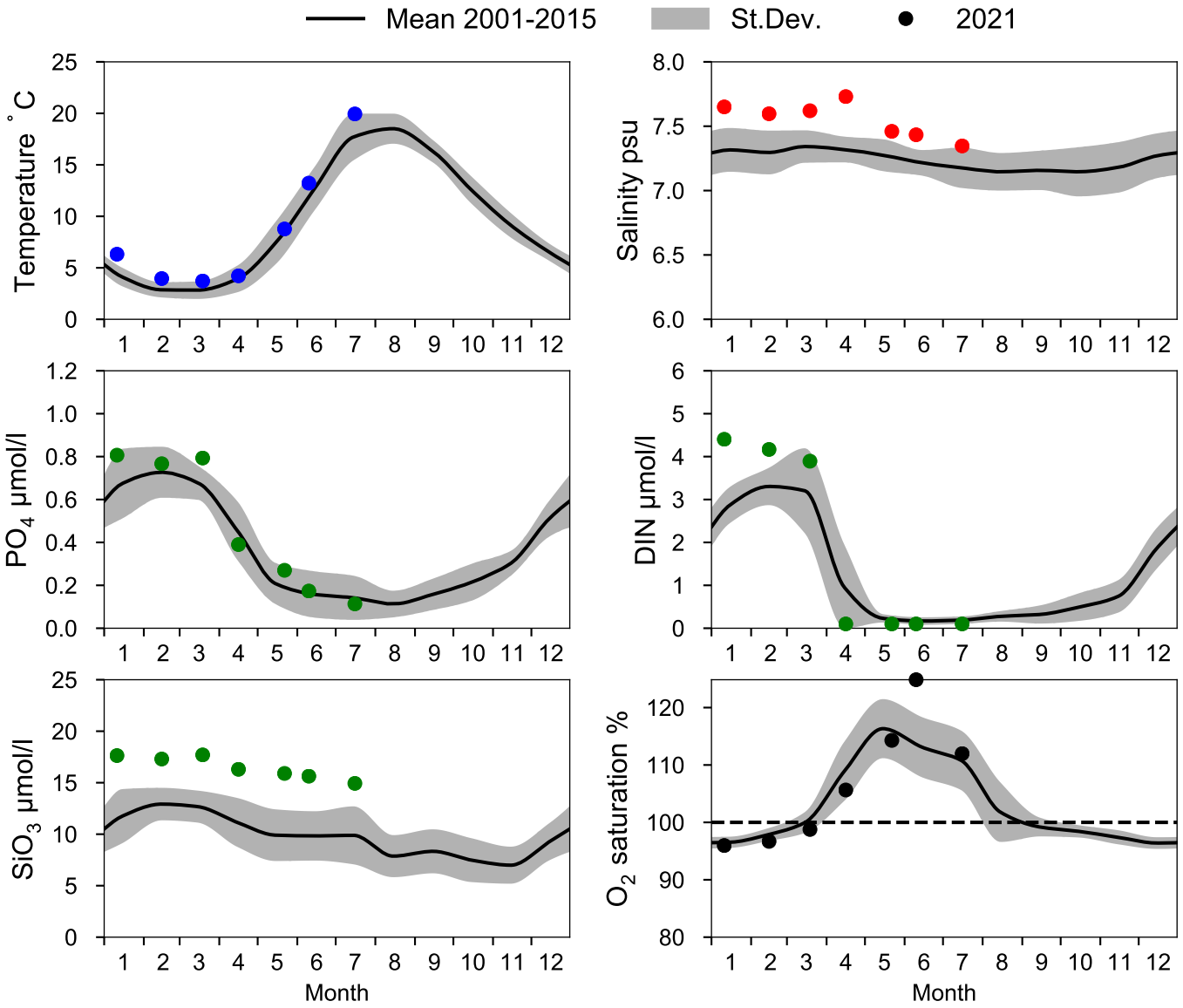


Vertical profiles BY5 BORNHOLMSDJ
July

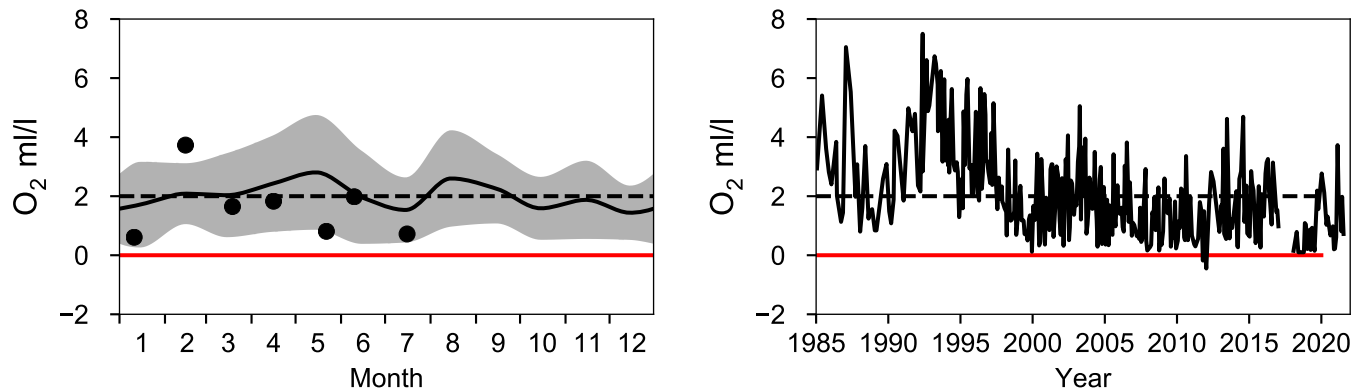


STATION BCS III-10 SURFACE WATER (0-10 m)

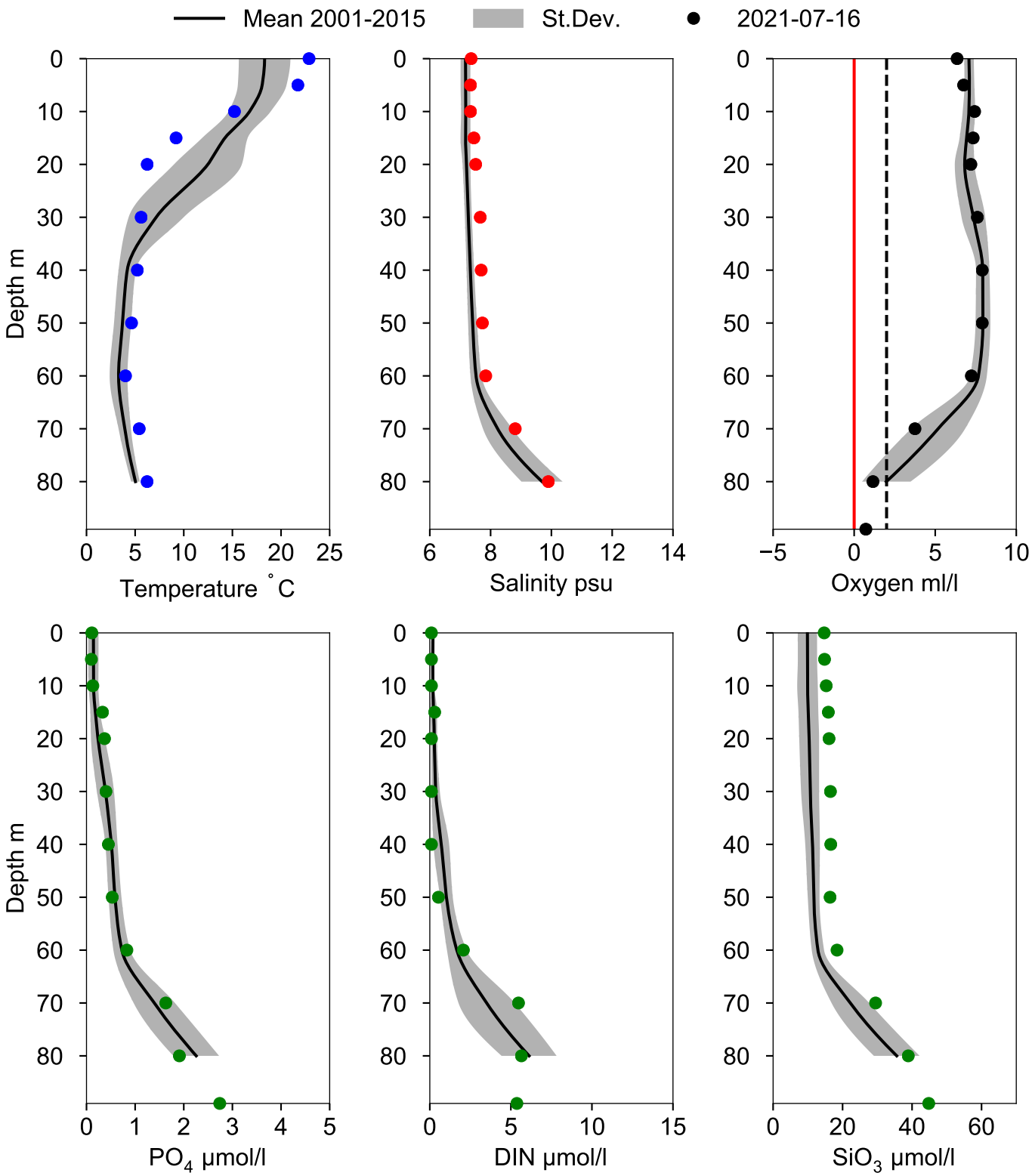
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 80 m)

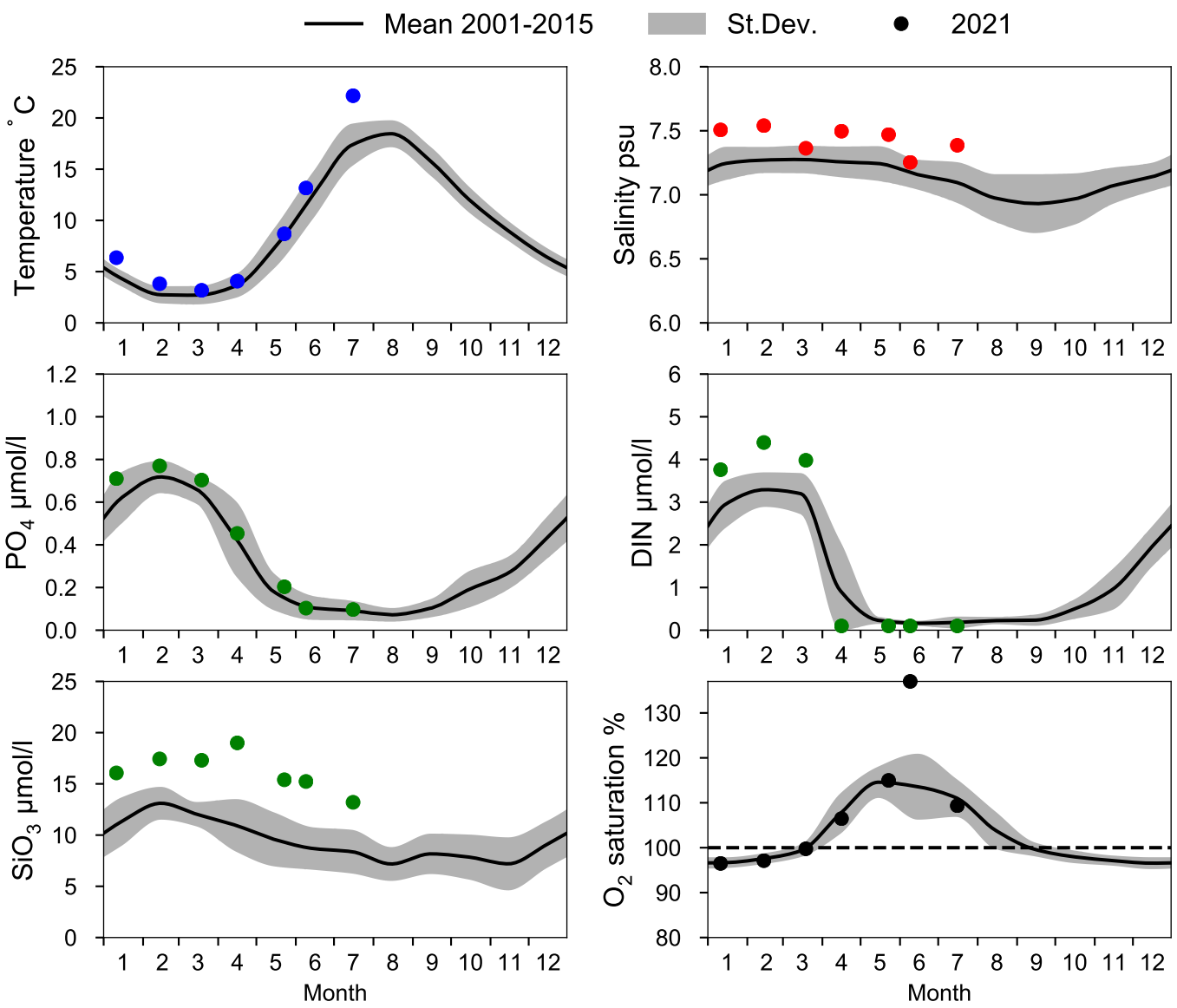


Vertical profiles BCS III-10
July

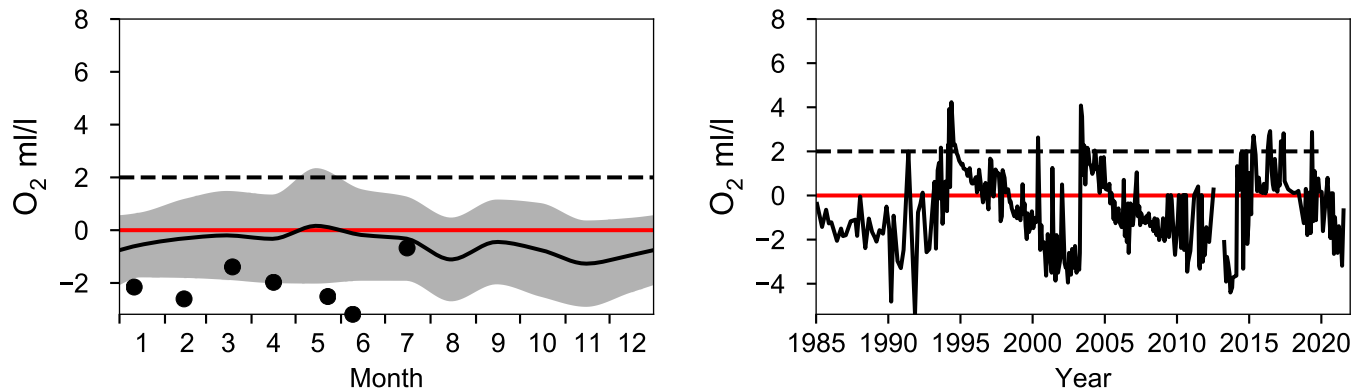


STATION BY10 SURFACE WATER (0-10 m)

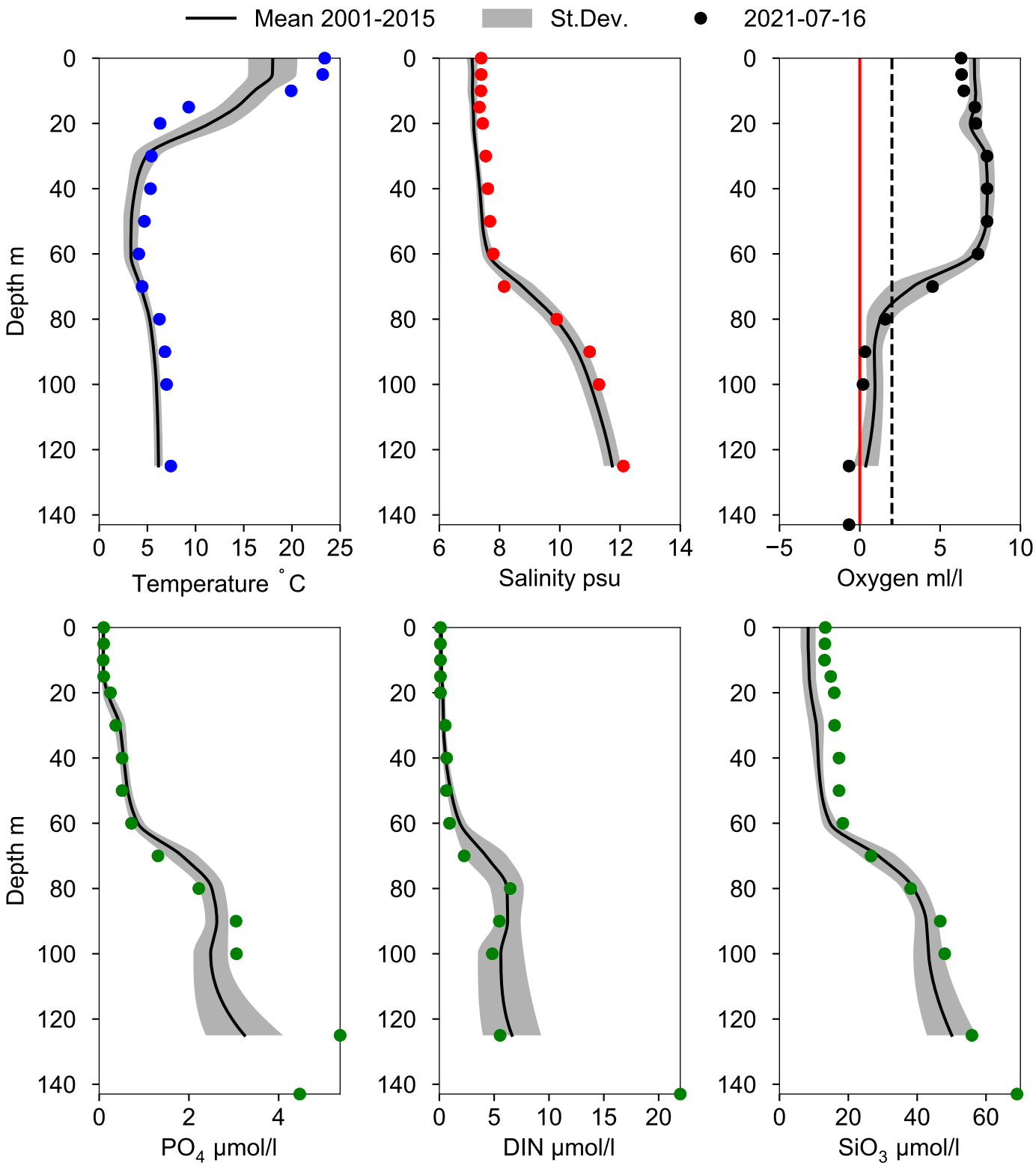
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 125 m)

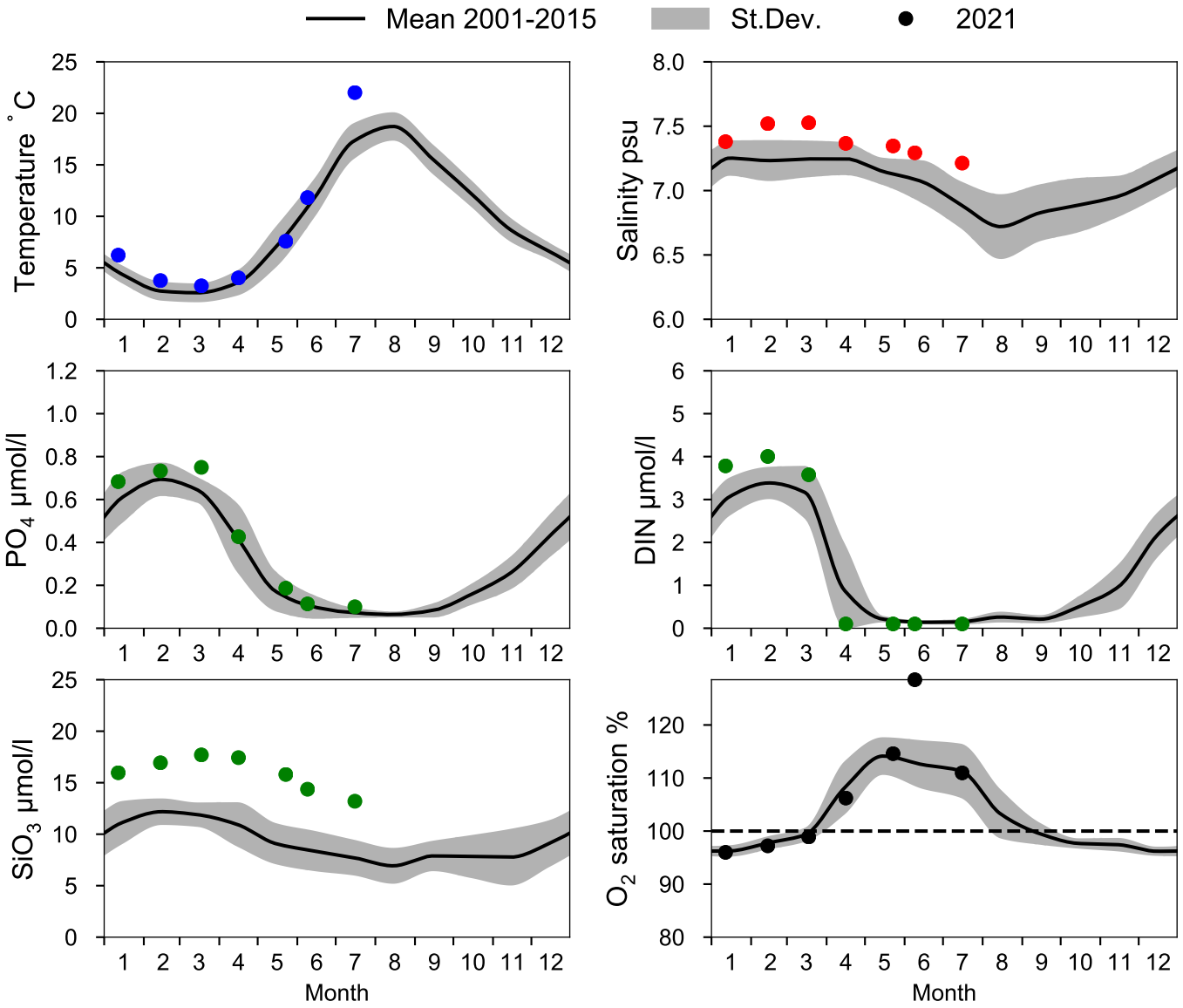


Vertical profiles BY10
July

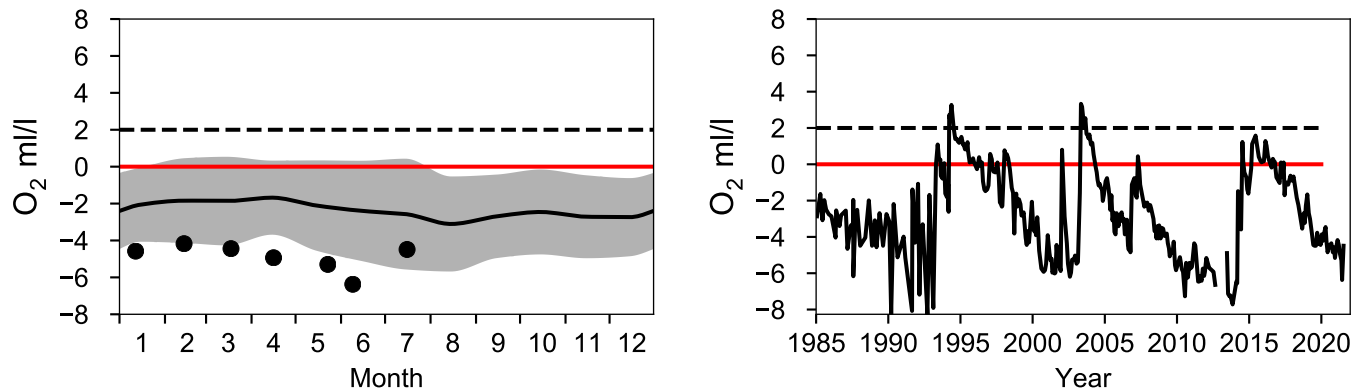


STATION BY15 GOTLANDSDJ SURFACE WATER (0-10 m)

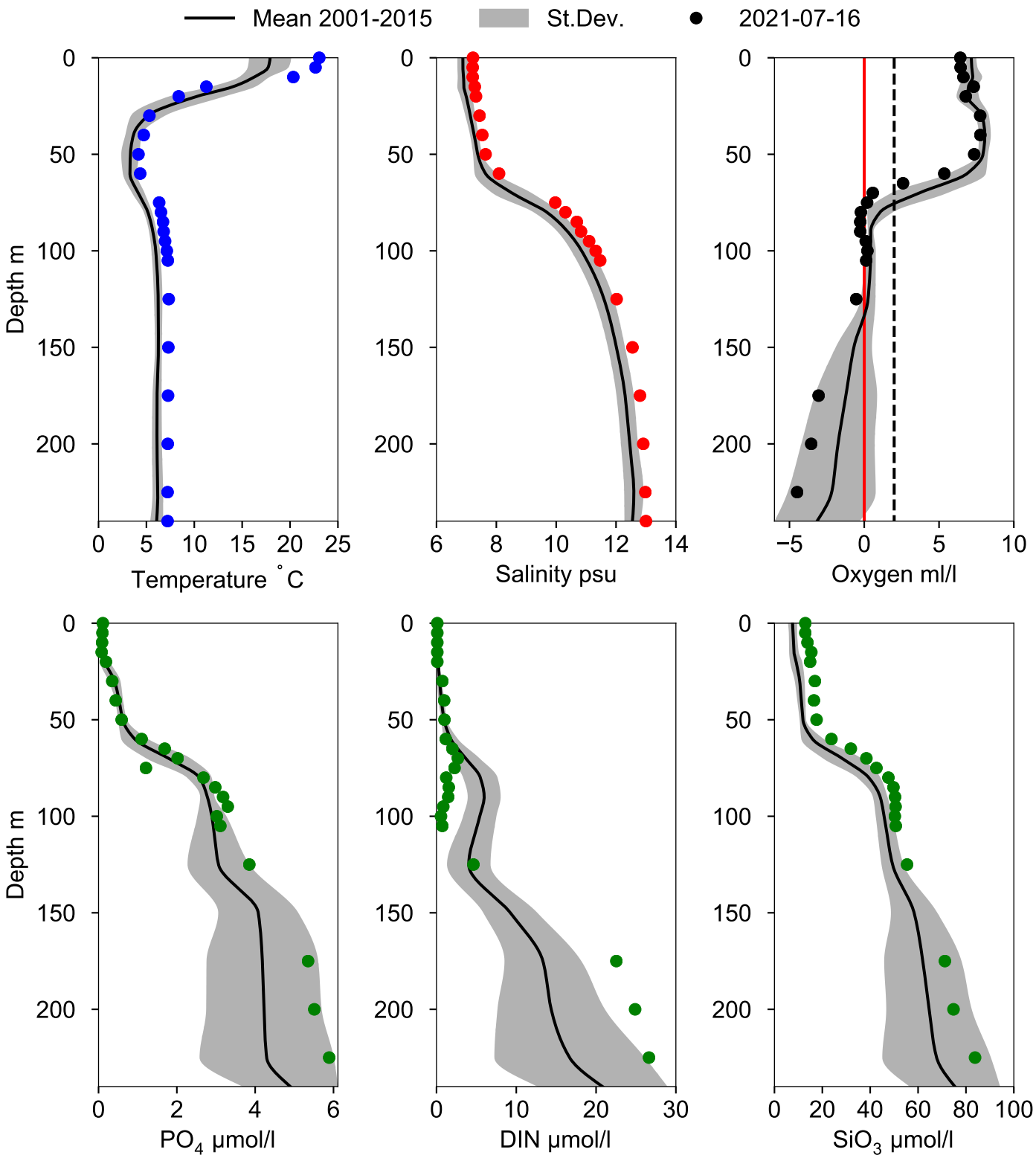
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 224 m)

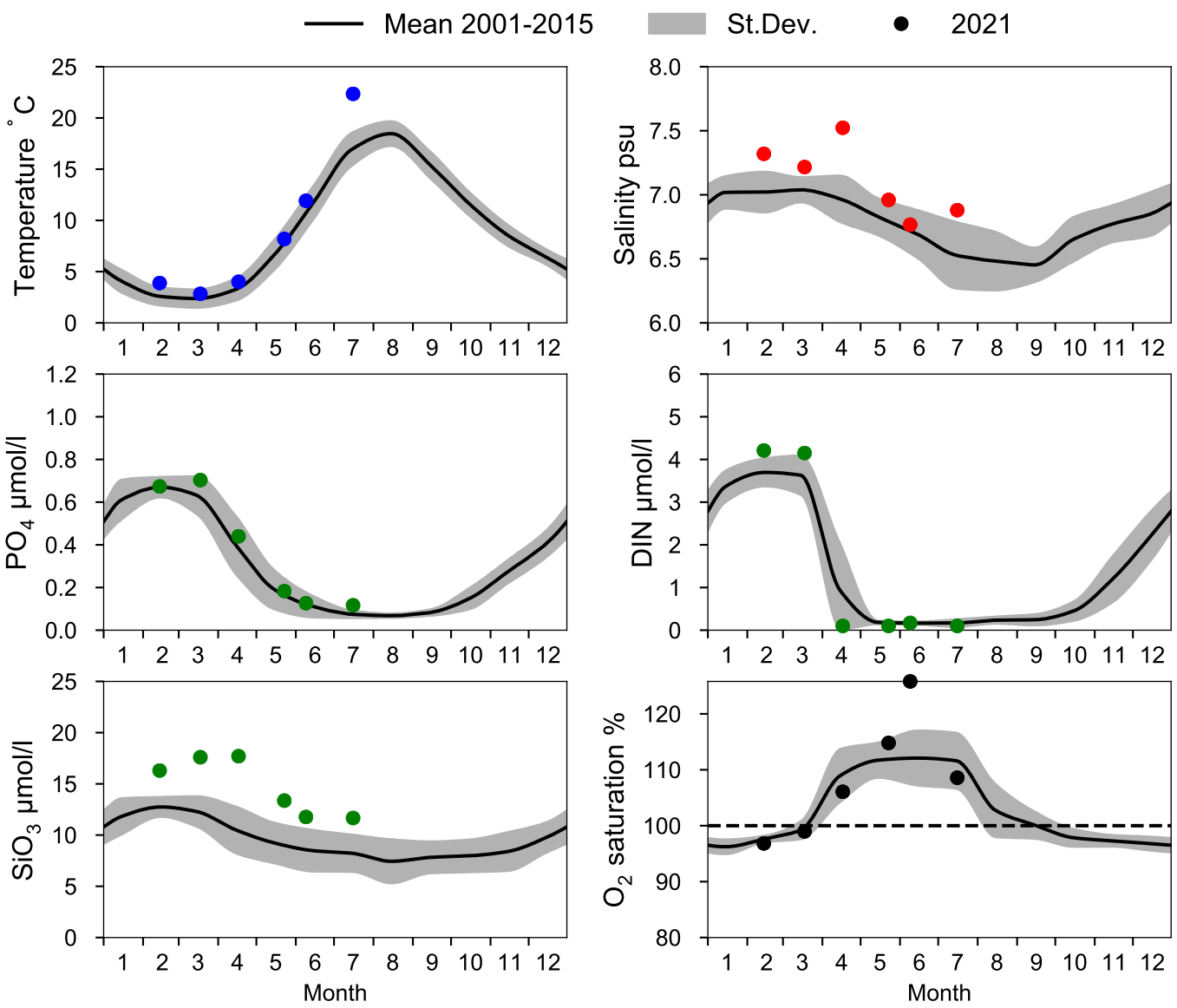


Vertical profiles BY15 GOTLANDSDJ
July

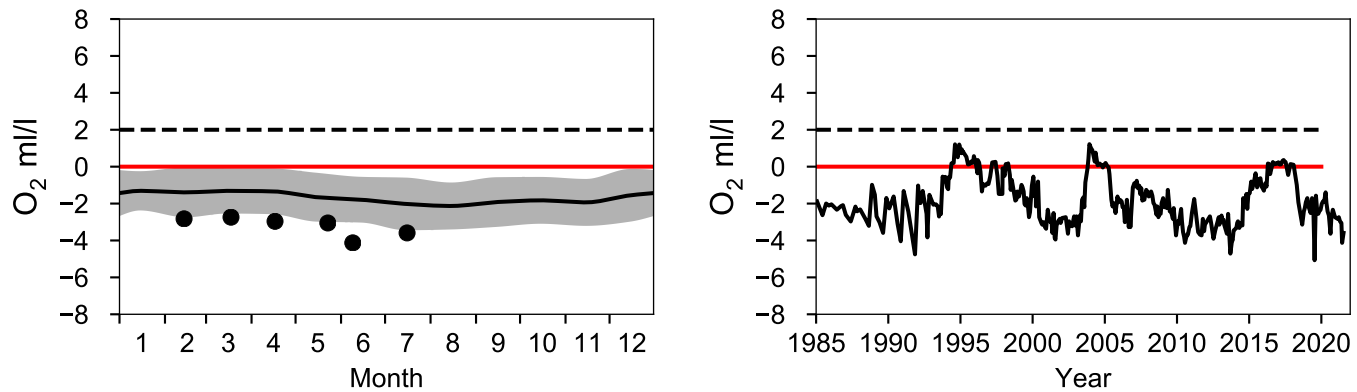


STATION BY20 FÅRÖDJ SURFACE WATER (0-10 m)

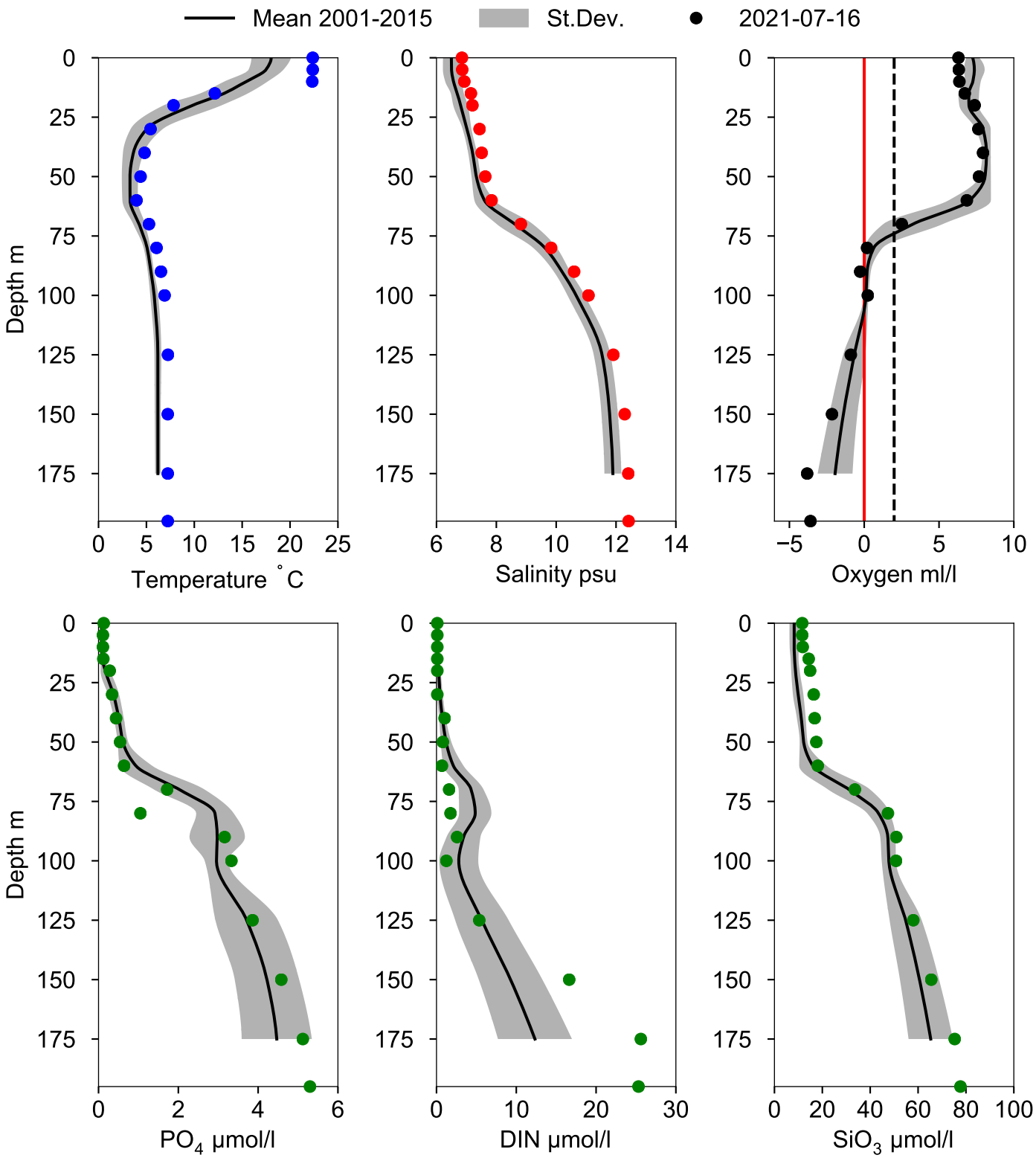
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 175 m)

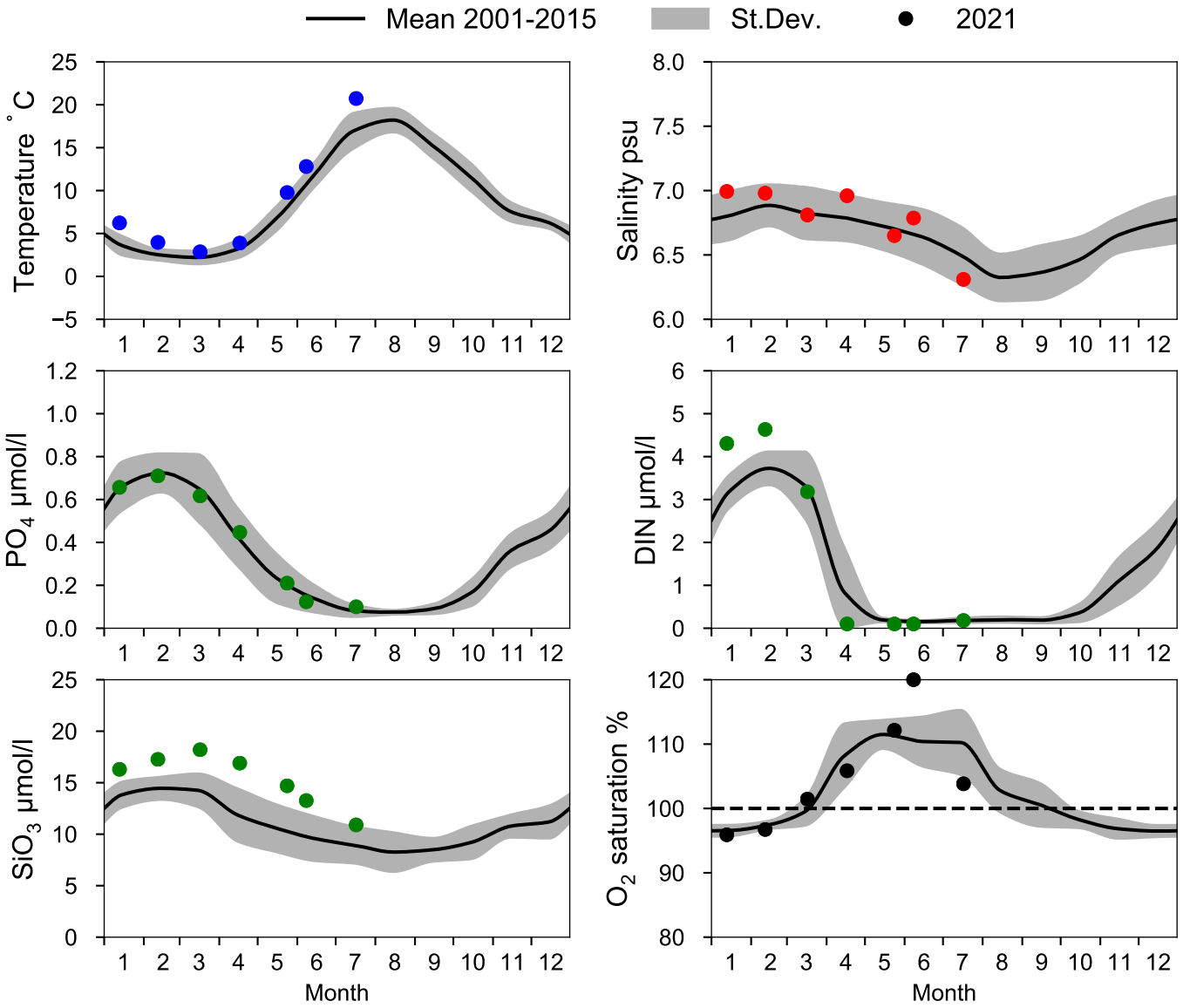


Vertical profiles BY20 FÅRÖDJ
July

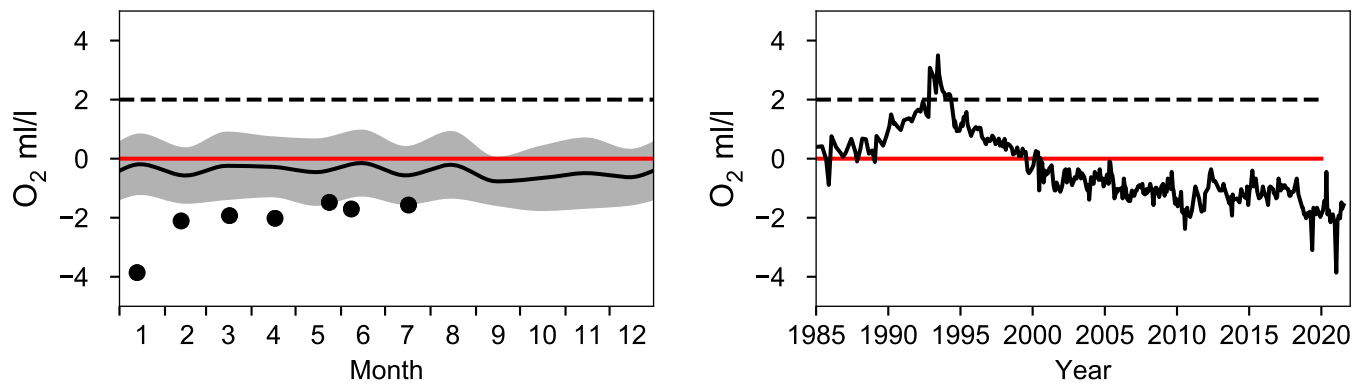


STATION BY32 NORRKÖPINGSDJ SURFACE WATER (0-10 m)

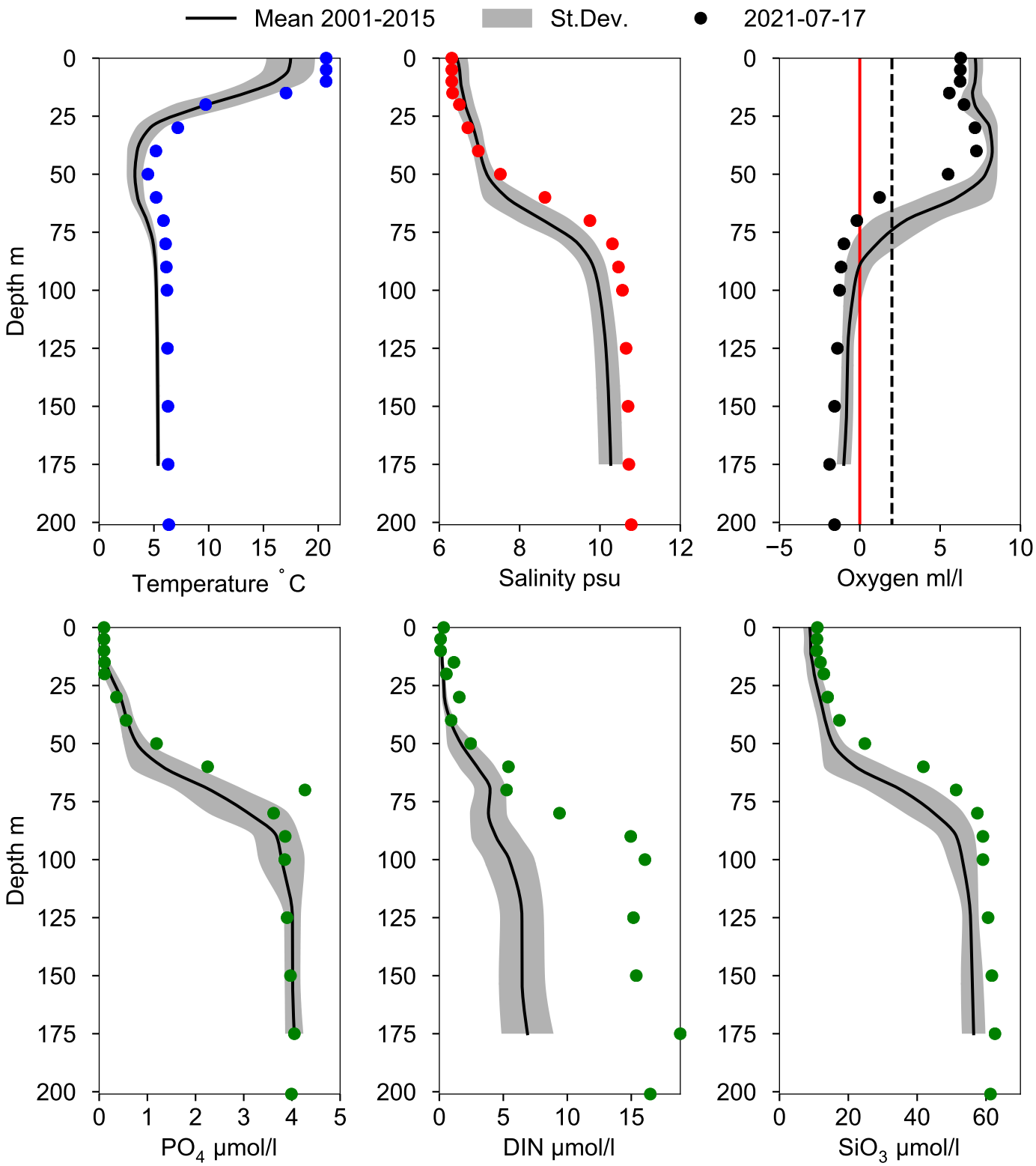
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 175 m)

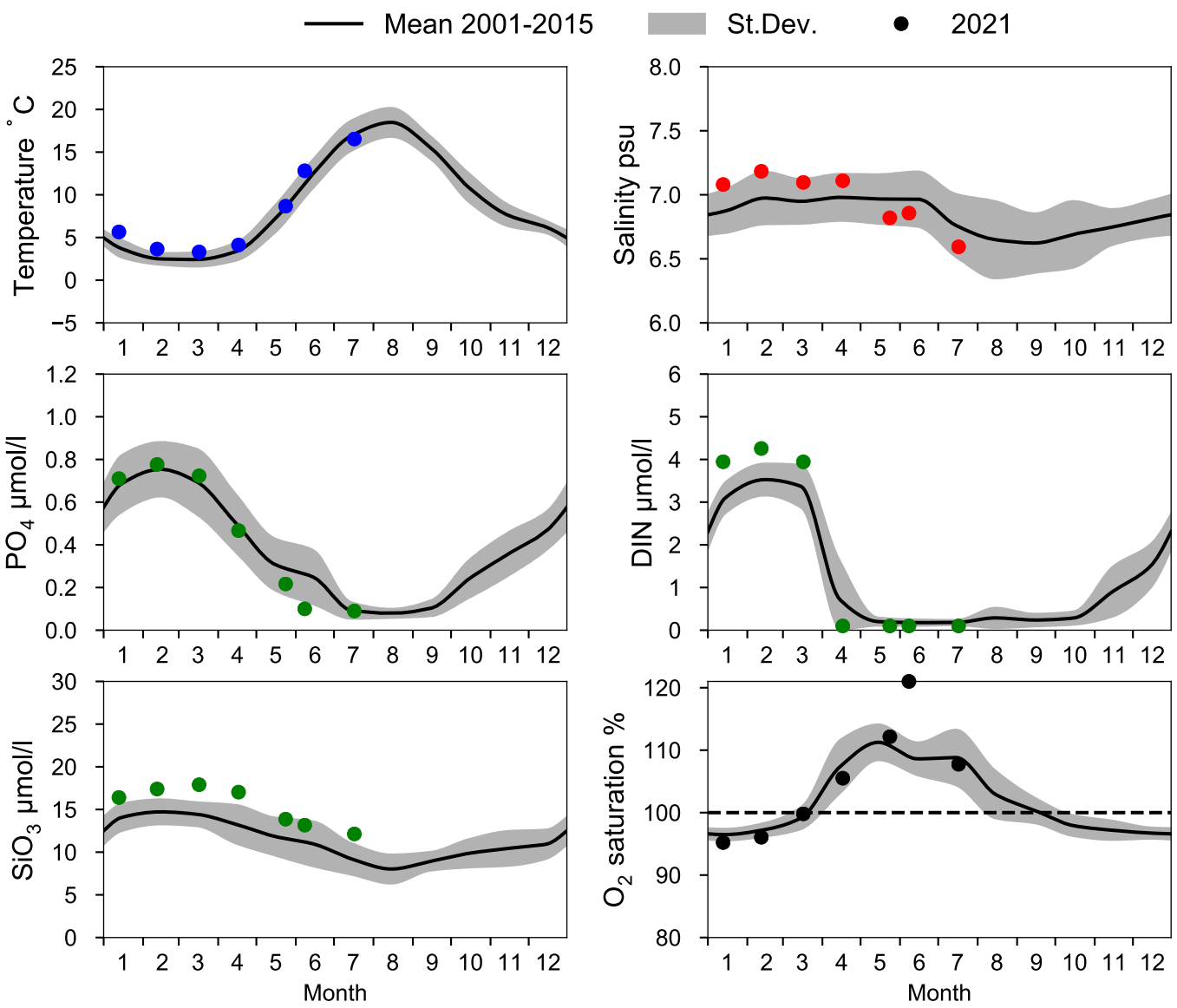


Vertical profiles BY32 NORRKÖPINGSDJ
July

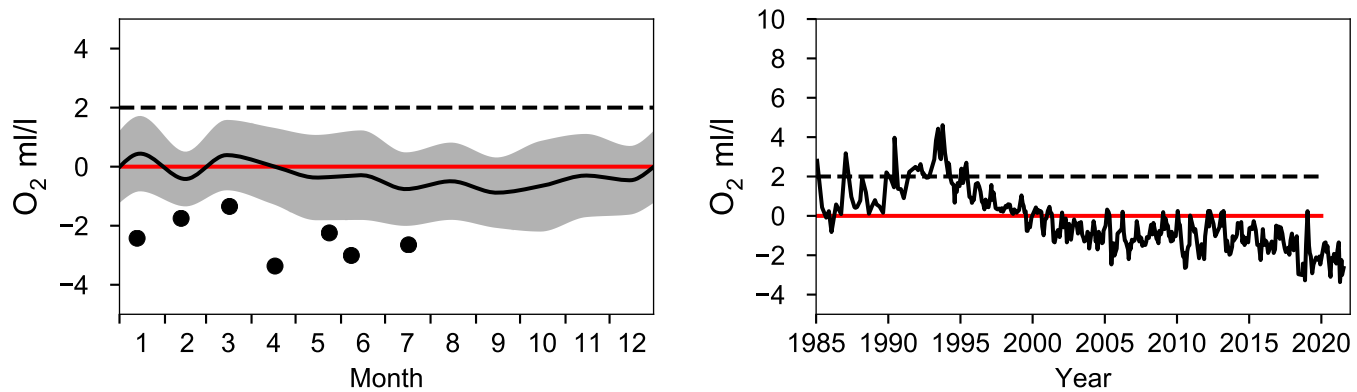


STATION BY38 KARLSÖDJ SURFACE WATER (0-10 m)

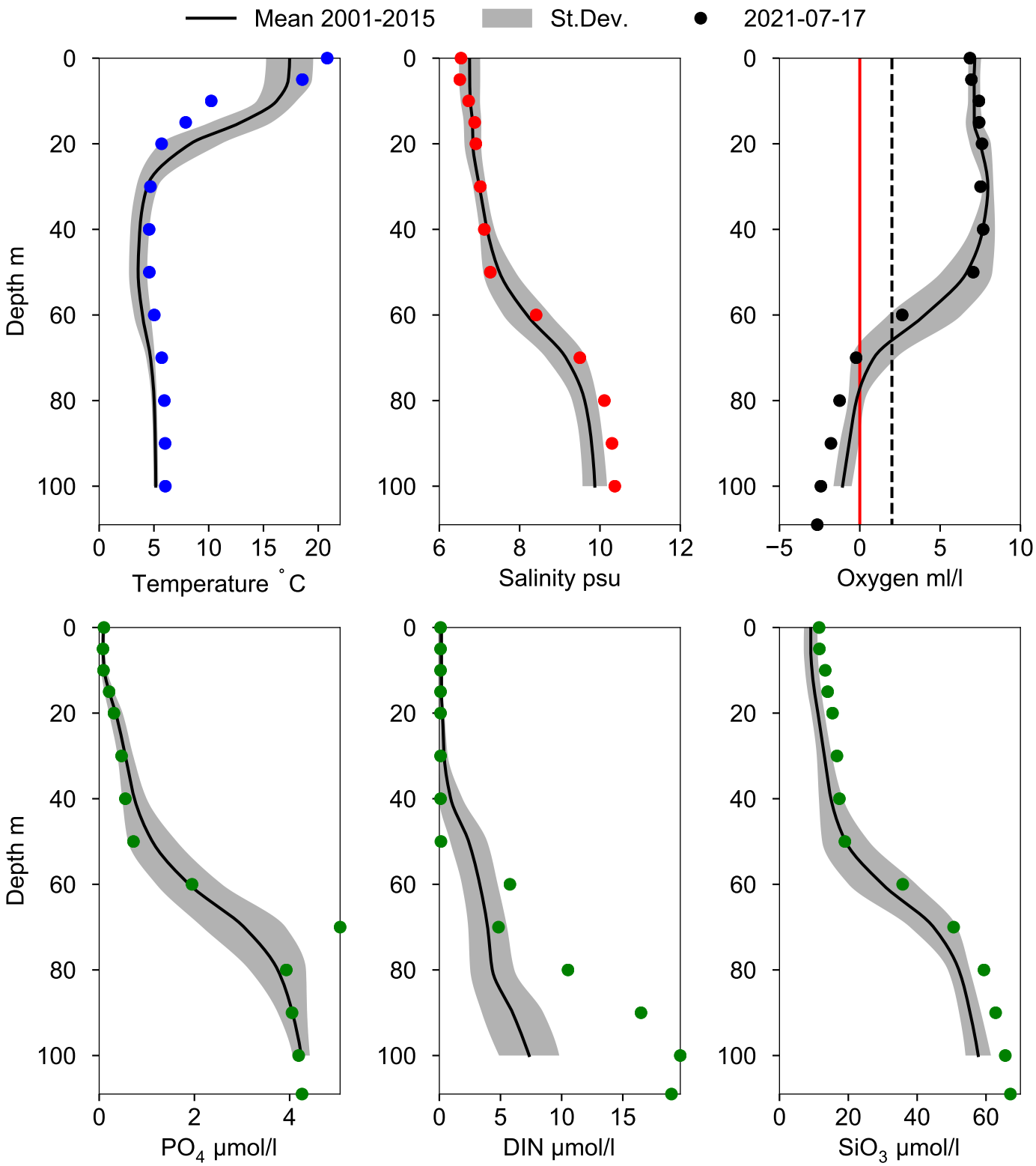
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 100 m)

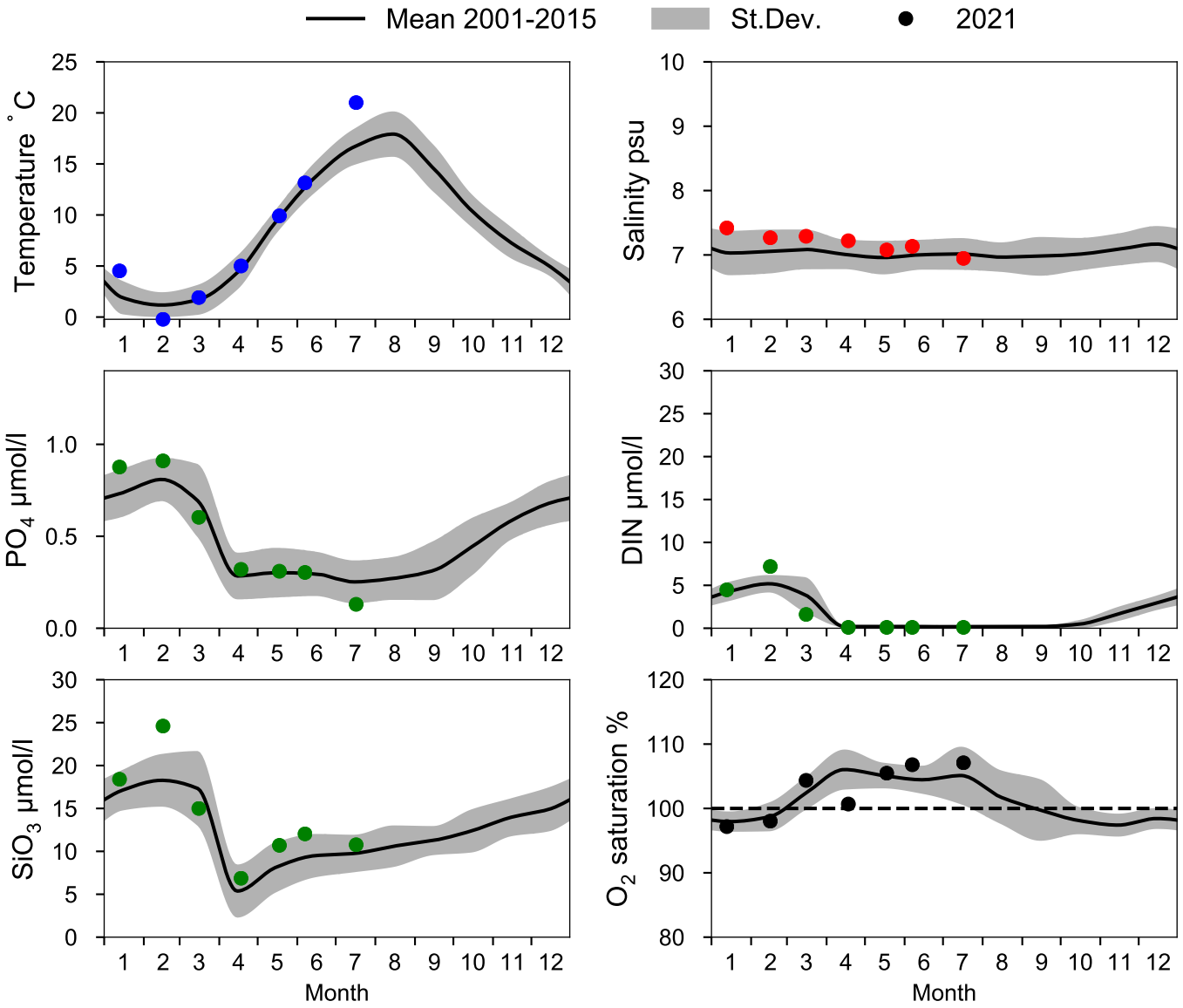


Vertical profiles BY38 KARLSÖDJ
July

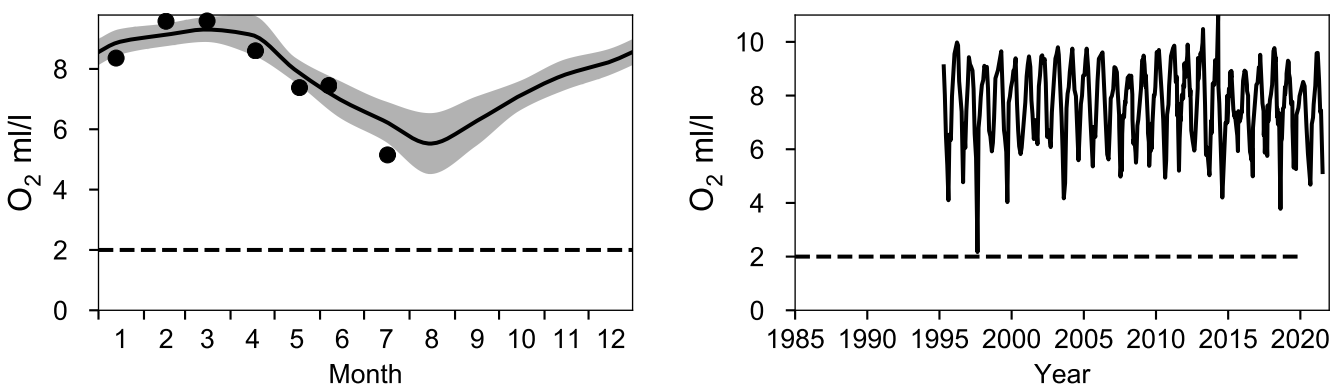


STATION REF M1V1 SURFACE WATER (0-10 m)

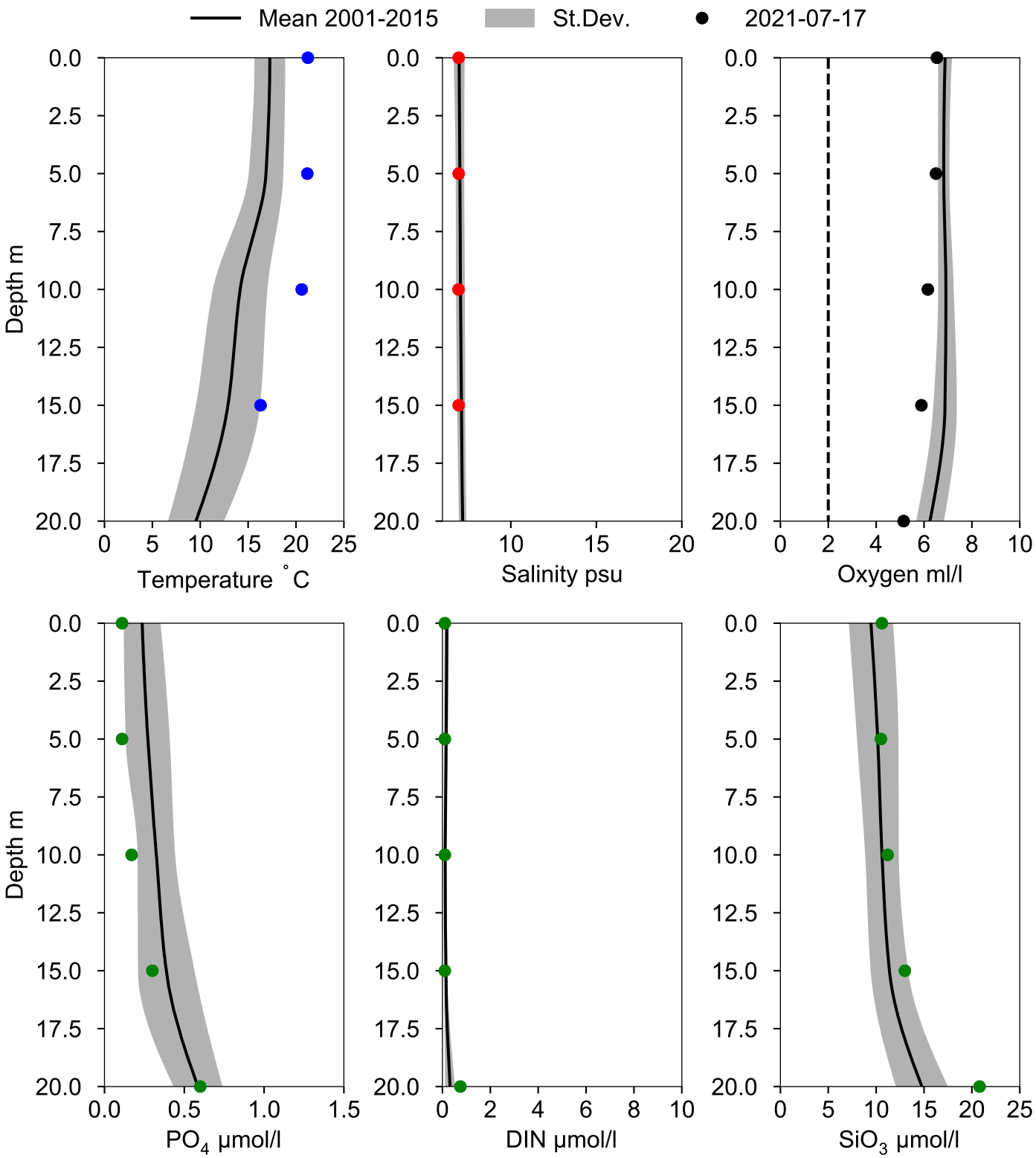
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 15 m)

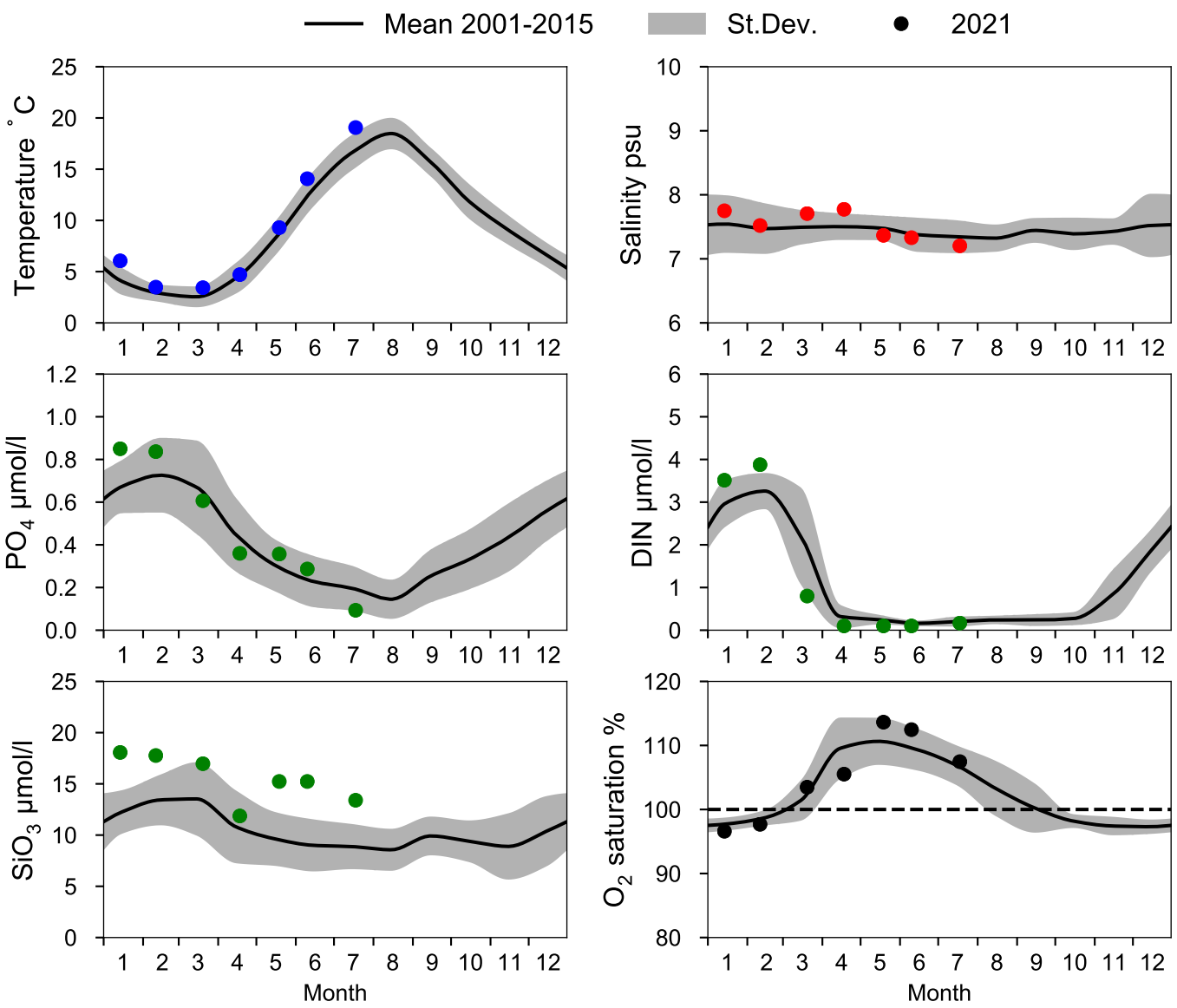


Vertical profiles REF M1V1
July

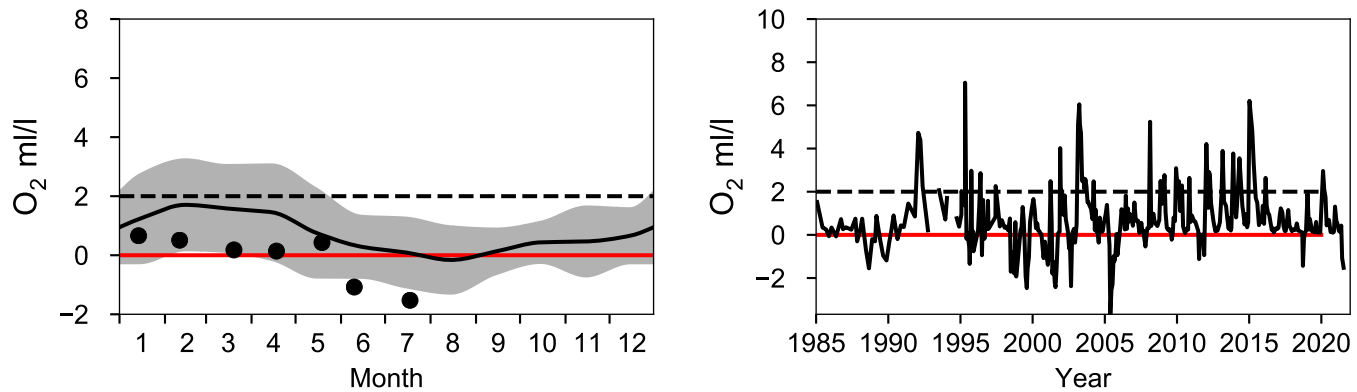


STATION HANÖBUKTEN SURFACE WATER (0-10 m)

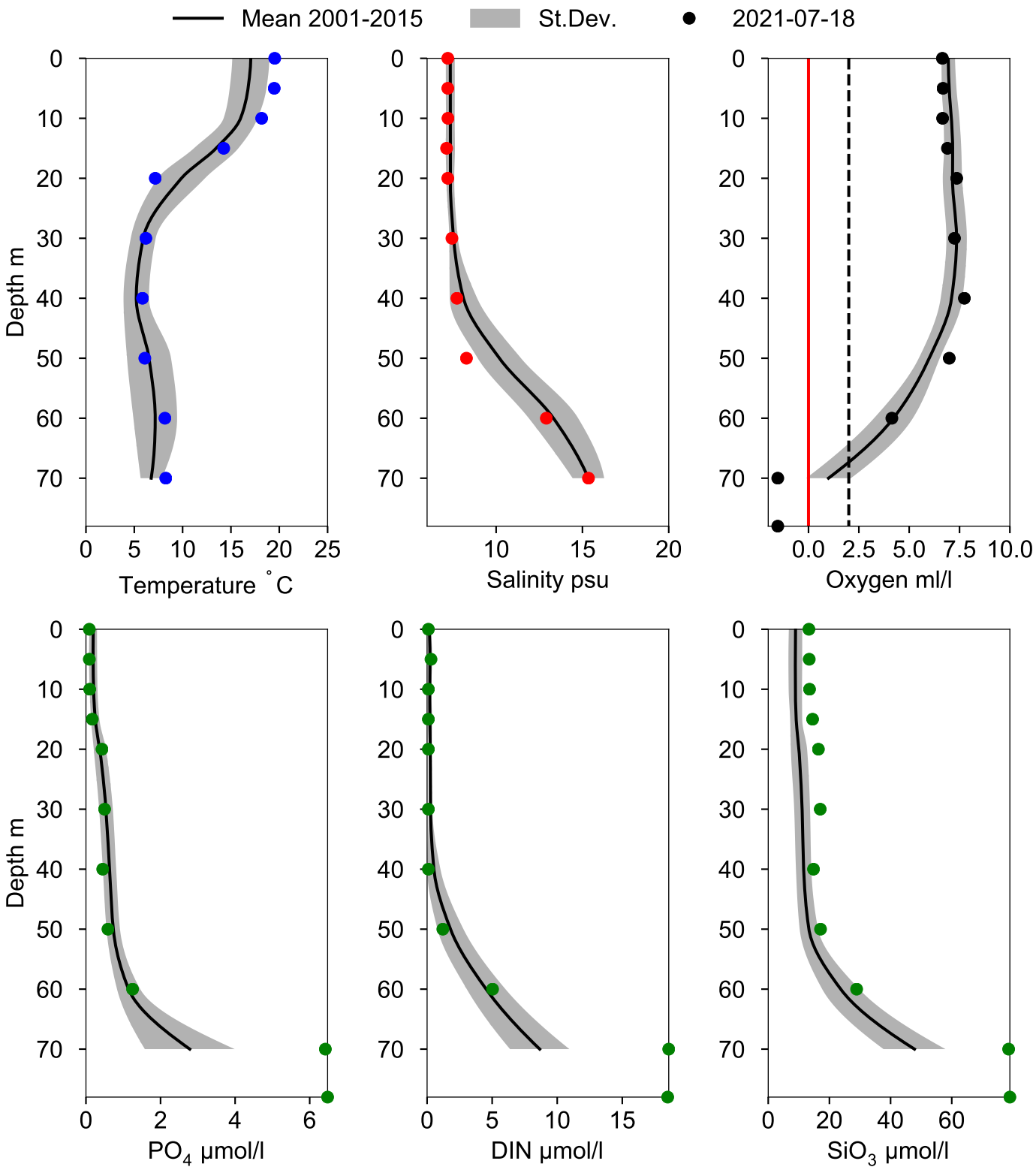
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 70 m)

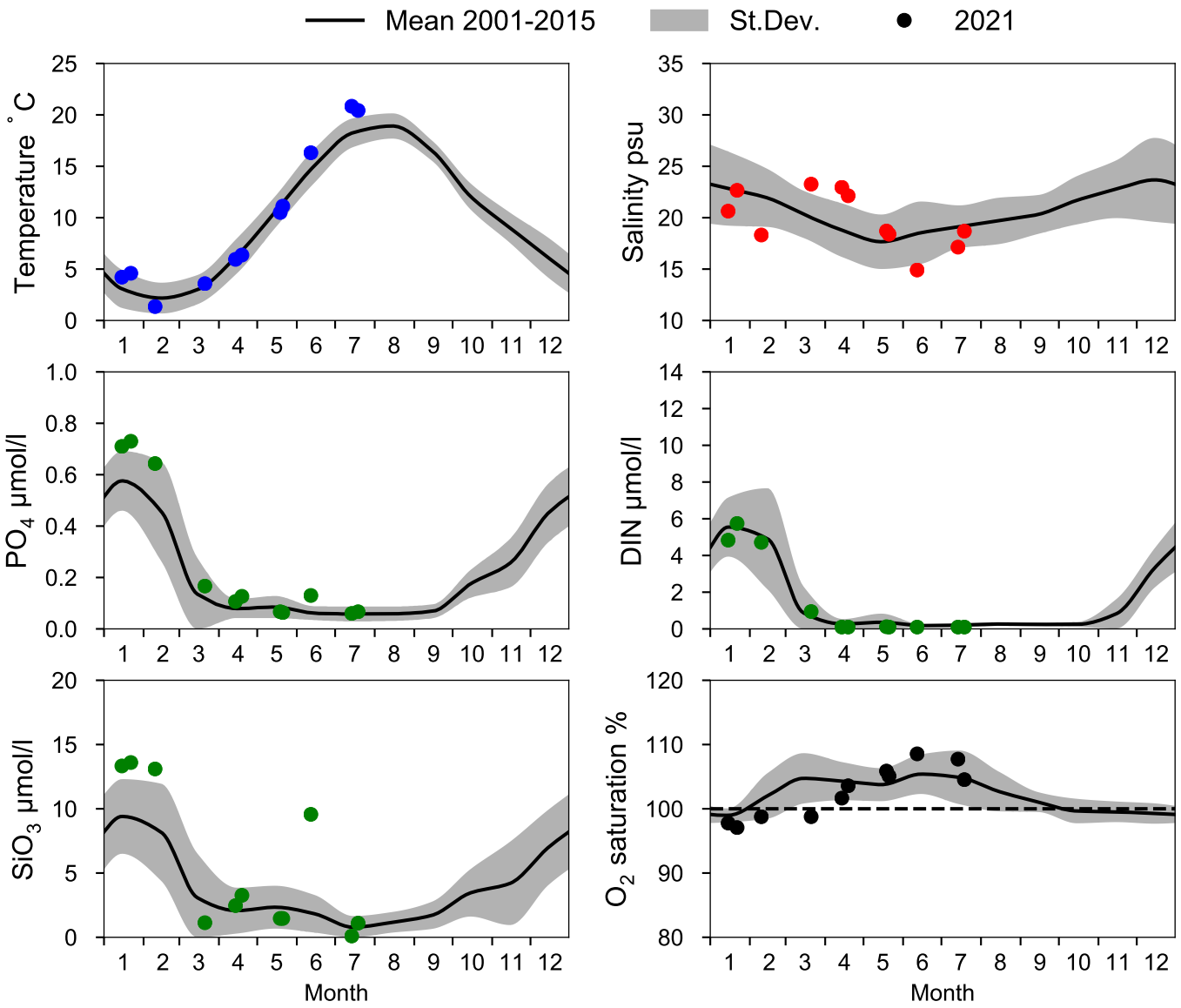


Vertical profiles HANÖBUKTEN
July

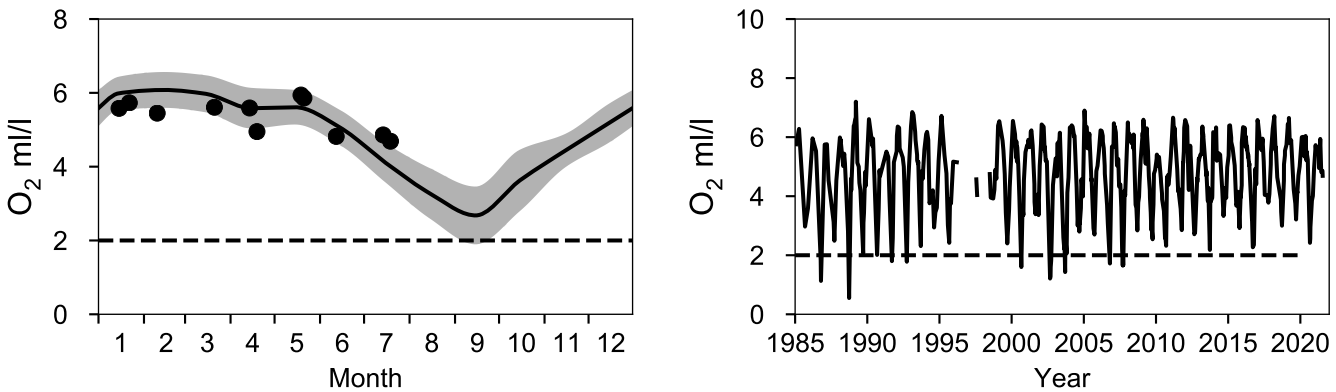
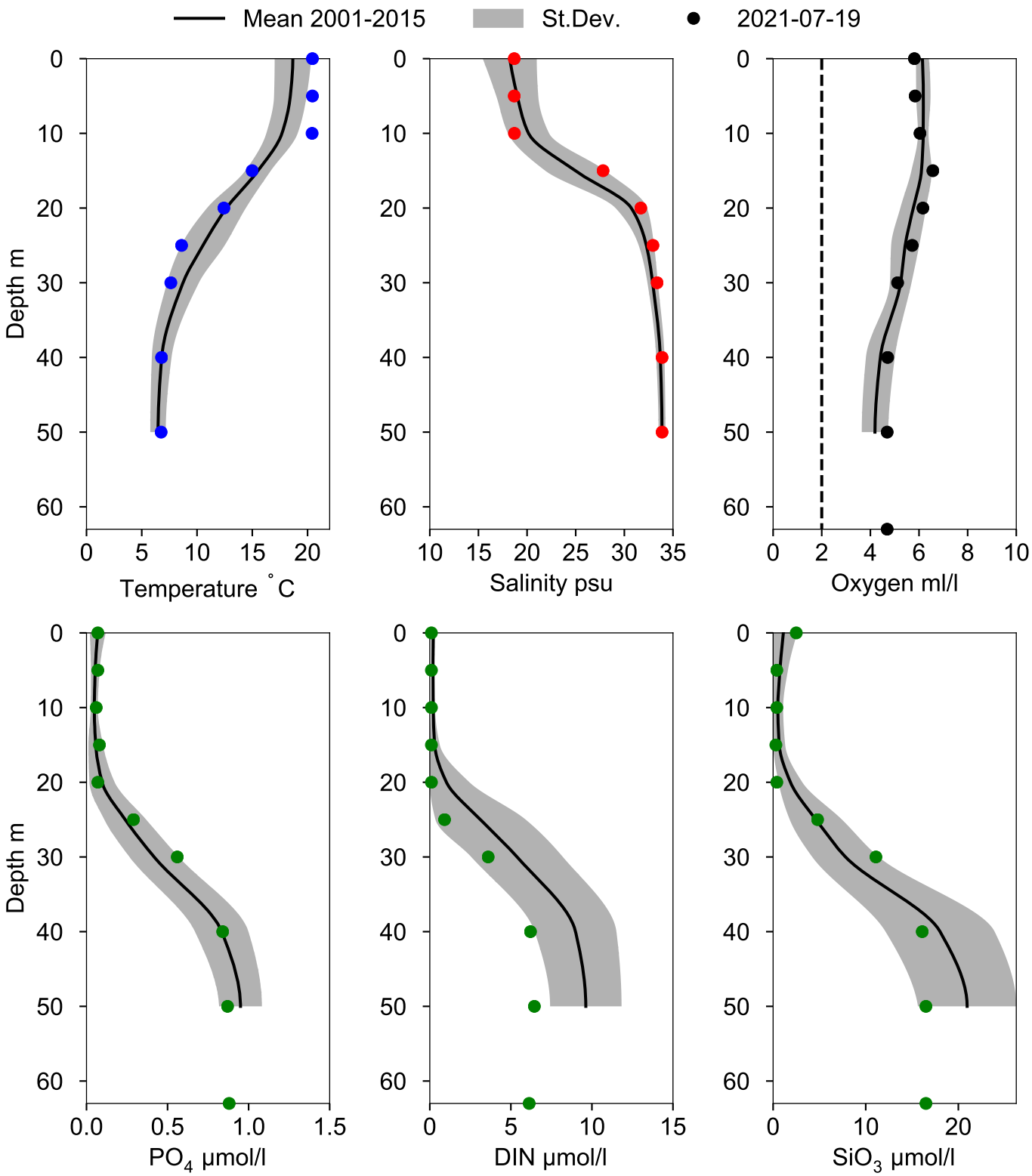


STATION ANHOLT E SURFACE WATER (0-10 m)

Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 52 m)



Vertical profiles ANHOLT E
July