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Swedish Meteorological and Hydrological Institute
Oceanographic Laboratory

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Report from the SMHI monitoring cruise with R/V Aranda

Survey period: 2019-06-10 – 2019-06-16
Principal: Swedish Meteorological and Hydrological Institute (SMHI), Swedish Agency for Marine and Water Management (SwAM)
Cooperation partners: Finnish Environment Institute (SYKE)

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SUMMARY

The cruise in June, which is part of the Swedish national marine monitoring program, covered the Skagerrak, the Kattegat, the Sound and the Baltic Proper.

The sea surface temperatures and salinities were normal in all sea areas.
The spring bloom had consumed the majority of the nutrients in the surface water but elevated amounts of silicate were still present in the Baltic Proper. CTD measurements showed high chlorophyll fluorescence in the whole area between 5 and 25 meters with peaks in the Baltic Proper at about 20 meters depth.

Acute hypoxia (< 2ml/l) were noted from 65 - 75 meters depth in the whole area.
Oxygen was found intermediate at BY15 between 105 and 145 meters depth and at BY10 between 75 and 125 meters depth.

Hydrogen sulphide, which is formed during oxygen free conditions, was found in the Eastern and Western Gotland Basins. In the Eastern Gotland Basin, the water was totally depleted from oxygenfrom 145 meters at the Gotland depth (BY15) and from 125 meters in the Fårödjupet (BY20) and BY10 and down to the bottom. In the Western Gotland Basin, oxygenwas absent from 80 meters and downwards and the levels of hydrogen sulphide in the deep water were much higher than normal.

Next regular cruise is scheduled to 14th – 21th of July.

RESULTS

The expedition was performed onboard the Finnish research vessel Aranda and started in Helsinki on the10th of June and ended in Nynäshamn on the 16th of June. The third day of the cruise the wind increased to a gale and thunder was observed very close to the boat, otherwise there were weak winds shifting between northeast and southeast. The air temperature varied between 12 – 19 °C.

During the expedition additional sampling was performed for analysis of DNA-barcoding for the project "*DNA-metabarcoding of marine phytoplankton*" supported by the Swedish Agency for Marine and Water Management (SwAM). The project covers all national marine monitoring stations in the open sea where plankton sampling is done.

At some stations, water samples and plankton samples were taken to measure selenium at EAWAG in Switzerland (Swiss Federal Institute of Aquatic Science and Technology

Two researchers from Stockholm University were on board between Helsinki and Göteborg and took samples for studying ecological species interactions between zooplankton, phytoplankton and bacteria using DNA barcoding.

In total 26 stations were visited and an overview of the stations and which parameters were measured are summarized in the Appendix. At the Huvudskär ocean buoy a reference CTD cast was taken.

Analysis of plankton samples are presented in the separate plankton report "AlgAware" which is published on SMHI's website shortly after the expedition.
https://www.smhi.se/en/publications/algal-situation-reports-2-1056

This report is based on data that have 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 on the data centre's webpage, normally within a week after the cruise.

Data can be downloaded here: http://www.smhi.se/klimatdata/oceanografi/havsmiljodata (only available in Swedish)

Skagerrak

The temperature in the surface water was normal in the Skagerrak and was between 12.7 and 14.7 ºC, coldest in the north and warmest in the south. The surface salinity was normal to slightly below normal and varied from 23 to 30 psu, lowest in the southern part. A halocline and a thermocline were observed between 5 and 10 meters.

There were low concentrations of nutrients in the surface layer which is normal for this part of the year. The phosphate concentration was about 0.5 µmol/l. The concentration of dissolved inorganic nitrogen (DIN) was around the detection limit of 0.3 µmol/l. The silicate concentrations varied between 0.3 and 1.0 µmol/l.

The oxygen concentrations were normal for the season. The levels in the deep water were about 6 ml/l which is high above the limit for acute hypoxia (oxygen < 2ml/l).

Chlorophyll fluorescence peaks were noted in or just below the halocline, between 5 and 20 meters.

Kattegat and the Sound

In the Kattegat, the surface water temperatures varied between 14.7 and 16.8 ºC, which is normal for the season. The salinity in the surface layer varied between 16 and 20 psu, and in the Sound 8 psu was recorded, which is normal to slightly below normal. The halocline and the thermocline coincided in the area and were found at 15 to 20 meters.

The nutrients in the surface water were low which is normal for the season-. Phosphate varied between 0.05 - 0.23 µmol/l, with the highest level in the Sound. DIN was measured to 0.3 µmol/l in the whole area. The concentrations of silicate varied between 1.1 – 7.3 µmol/l, and was also highest in the Sound.
The oxygen conditions in the bottom water were good and the lowest recorded concentration was 4.6 ml/l at W Landskrona.
At all stations in the Kattegat, chlorophyll fluorescence peaks were noted at about 15-20 meters deep.

Baltic Proper

The temperature in the surface layer varied between 12.0 and 13.7ºC, which is normal for this month. The thermocline was found at about 20 meters depth, from the thermocline down to the halocline, colder "winter water" was found. The temperature in the deep water, below the halocline, was higher than normal at all visited stations.

The salinity of the surface layer varied between 6.8 – 7.8 psu, highest in the Arkona Basin and lowest in the Western Gotland Basin. The values are normal to slightly above normal. In the Arkona Basin, the halocline began at about 32 meters and in the Bornholm Basin and in the Hanö Bay from 50 to 60 meters. In the other areas, the halocline was found at depths of about 65 - 70 meters.

The concentration of phosphate in the surface water was generally normal for the season. Phosphate levels varied between 0.09 - 0.23 µmol/l with the lowest levels in the Eastern Gotland Basin. DIN was consumed in the surface water and was below the detection limit of 0.3 µmol/l, which is normal for the season. The concentration of silicate in the surface water varied between 9.1 µmol/l in the Arkona Basin to 16.6 µmol/l in the Western Gotland Basin. In the whole investigated area the levels of silicate were above or much above normal.

At Hanö Bay, near the bottom, the nutrient concentrations were much higher than normal, which may be due to the lack of oxygen. Acute hypoxia (< 2ml/l) were noted from 65 - 75 meters depth in the whole area. Oxygen was found intermediate at BY15 between 105 and 145 meters depth and at BY10 between 75 and 125 meters depth.
Hydrogen sulphide was present in the Eastern and Western Gotland Basins. In the Eastern Gotland Basin, there were total oxygen depletion (with hydrogen sulphide) from 145 meters at the Gotland depth (BY15) and from 125 meters in the Fårödjupet (BY20) and BY10. In the Western Gotland Basin, there were completely oxygen free conditions from 80 meters and the levels of hydrogen sulphide in the deep water were much higher than normal.

From the surface down to about 25 meters depth, with at peak at about 20 meters, high chlorophyll fluorescence was noted throughout the investigated area, indicating an ongoing cyanobacteria bloom.

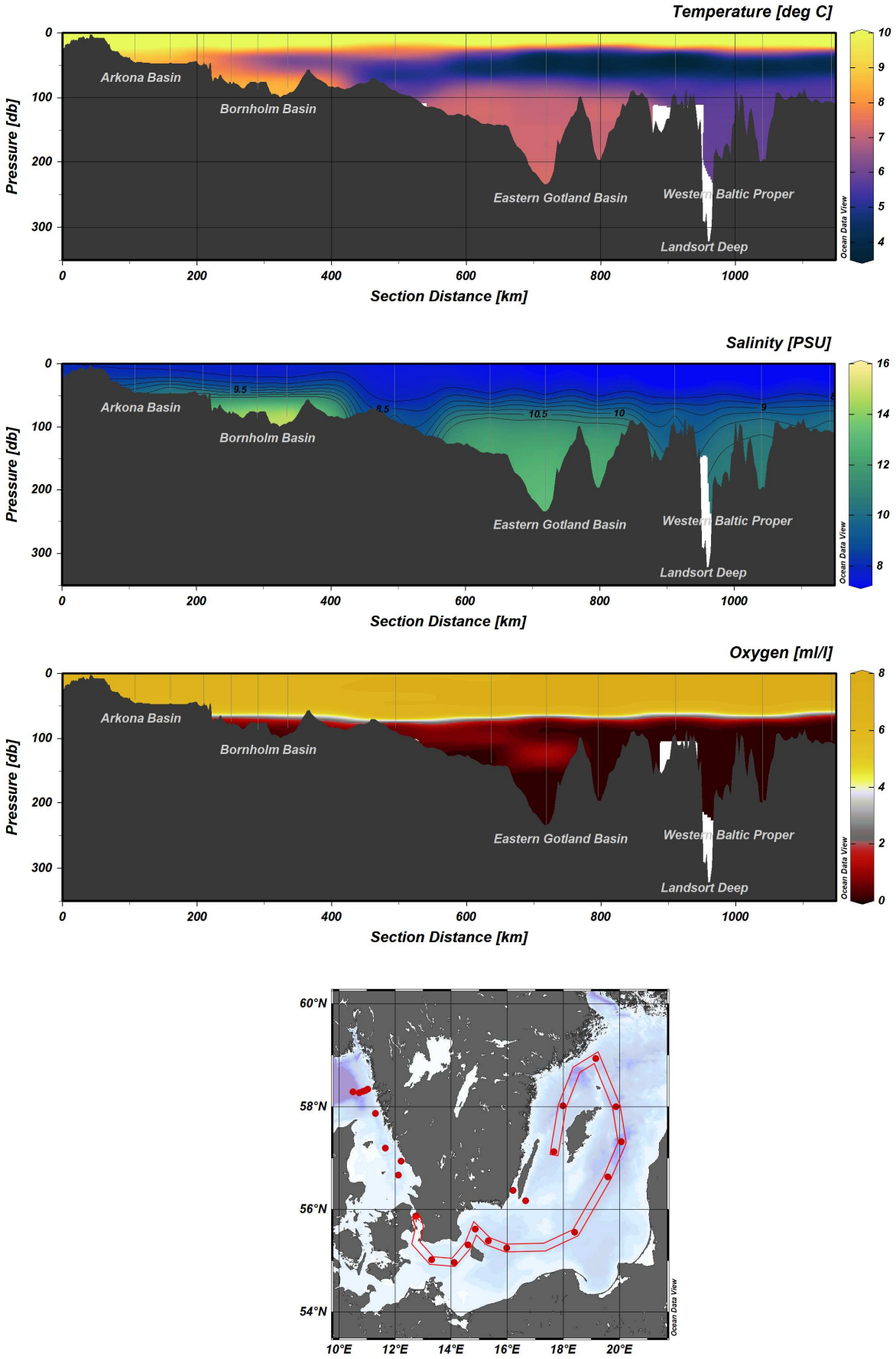

Figure 1. Transect showing temperature, salinity and dissolved oxygen from the Sound, through the Baltic Proper, to the Western Gotland Basin.

Participants

Name	Leg	Responsibility	Institute
Anna-Kerstin Thell		Chief scientist	SMHI
Jenny Lycken		Quality manager	SMHI
Lars Anderson			SMHI
Johan Kronsell			SMHI
Sara Johansson	Göteborg - Nynäshamn		SMHI
Sari Sipilä	Helsinki - Göteborg		SMHI
Andreas Novotny	Helsinki - Göteborg		Stockholms universitet
Baptiste Serandour	Helsinki - Göteborg		Stockholms universitet

Appendix

- Track chart
- Table of 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
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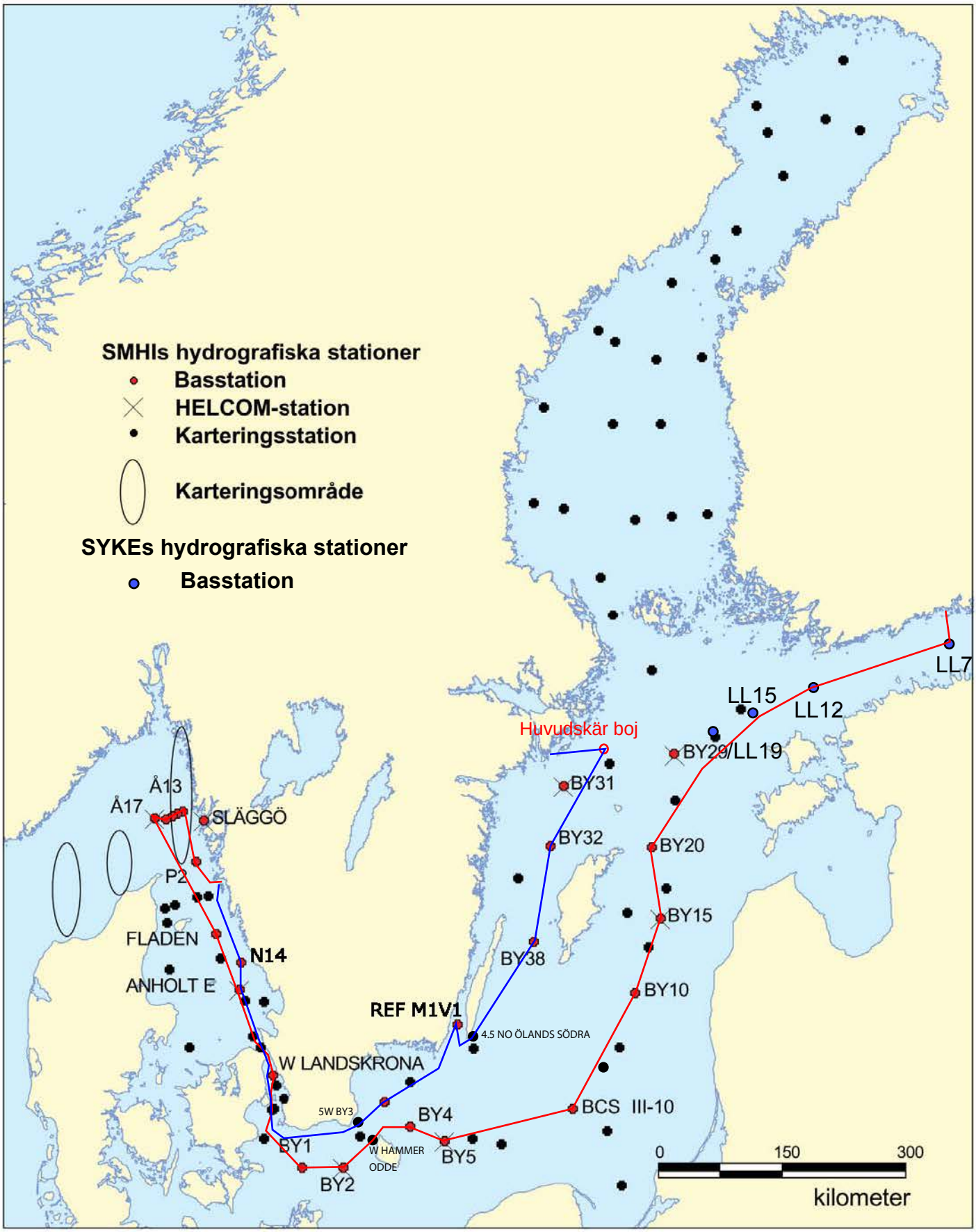
Date: 20190610-20190616
Series: 0357-0383



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Time: 13:39

Ship: AR
Year: 2019

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_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
0357	11	BPEX26	BAS...	BY20 FÅRÖDJ	5759.89	01952.56	20190611	0530	203		07	10	14.4	1018	1630	x---	17	17	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x	-	x	-
0358	11	BPEX21	BAS...	BY15 GOTLANDSDJ	5718.72	02004.02	20190611	0950	249	8	05	8	14.0	1014	2830	xxxx	24	24	x	x	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-
0359	11	BPEX21	BAS...	BY15 GOTLANDSDJ	5718.72	02004.02	20190611	1110	249		05	8	14.0	1014	6830	----	19	0	-	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
0360	11	BPEX13	BAS...	BY10	5638.01	01935.08	20190611	1550	147		06	11	14.6	1012	1130	x---	15	15	x	x	x	x	-	x	x	x	x	x	x	x	x	x	x	-	x	-	-	x
0361	11	BPSE11	BAS...	BCS III-10	5533.32	01824.01	20190611	2310	90		06	9	14.3	1010	9990	x---	12	12	x	x	x	x	-	x	x	-	x	x	x	x	x	x	x	-	x	x	-	-
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0368	11	KAEX29	BAS...	ANHOLT E	5640.12	01206.67	20190613	0650	62	5	24	9	14.9	1007	1630	xxxx	10	10	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	x	x	-	-
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0370	11	SKEX18	BAS...	Å17	5817.06	01030.26	20190613	1800	340		12	6	14.2	1010	2730	xxx-	15	14	x	x	-	x	x	x	x	-	x	x	x	x	x	x	x	x	x	-	x	-
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0379	11	BPWK01	BAS...	REF M1V1	5622.25	01612.12	20190615	1505	21	7	07	5	17.9	1014	2720	xxx-	5	5	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	x	-	-	-
0380	11	BPSE50	EXT...	4.5 NO ÖLANDS SÖDRA	5610	01638.99	20190615	1800	59		04	9	15.2	1011	2730	----	9	0	x	x	x	x	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-
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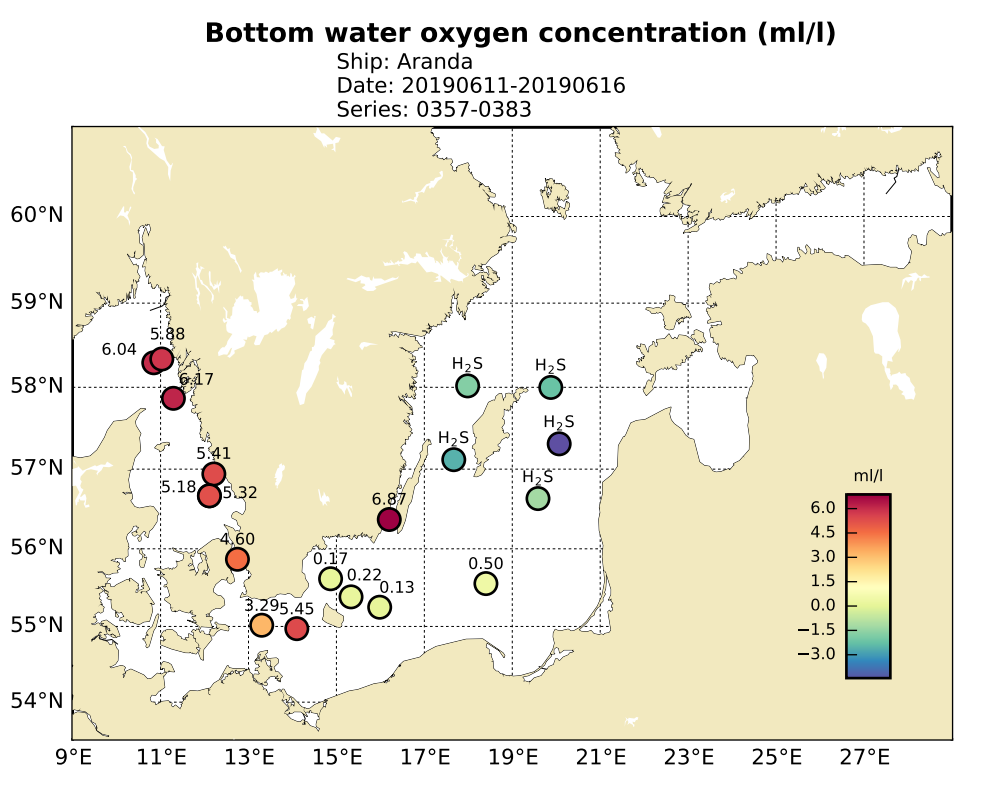
0383	11	BPNX00	EXT...	HUVUDSKÄR	5856.08	01909.45	20190616	1210	88		18	2	17.2	1012	1610	----	12	0	x	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-


Bottom water oxygen concentration (ml/l)
Ship: Aranda
Date: 20190611-20190616
Series: 0357-0383
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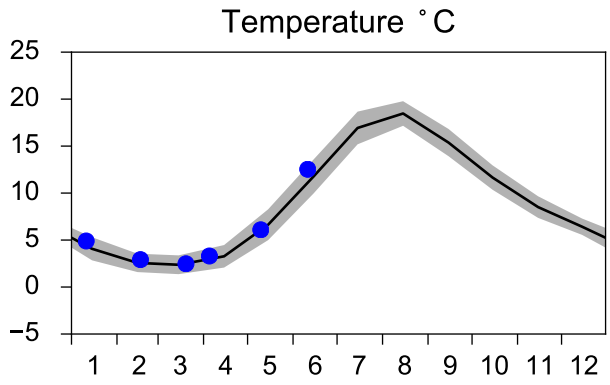
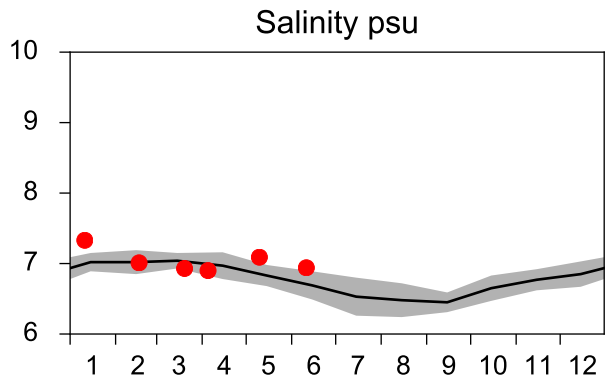
59°N
58°N
57°N
56°N
55°N
54°N
9°E
11°E
13°E
15°E
17°E
19°E
21°E
23°E
25°E
27°E
6.04
5.88
6.17
5.41
5.18
5.32
4.60
3.29
5.45
6.87
0.17
0.22
0.13
0.50
H2S
H2S
H2S
H2S
H2S
ml/l
6.0
4.5
3.0
1.5
0.0
−1.5
−3.0

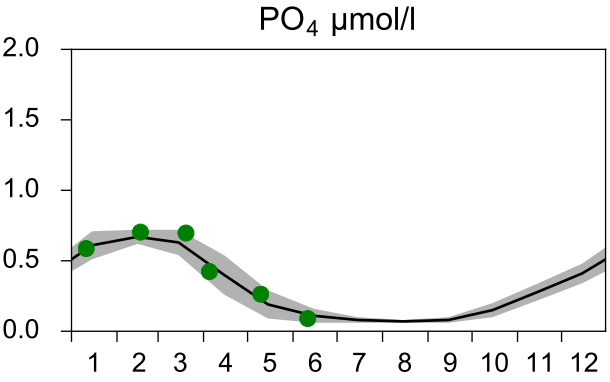
STATION BY20 FÅRÖDJ SURFACE WATER (0-10 m)

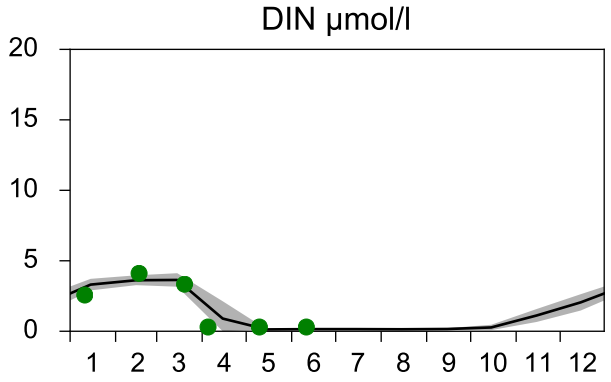
Annual Cycles

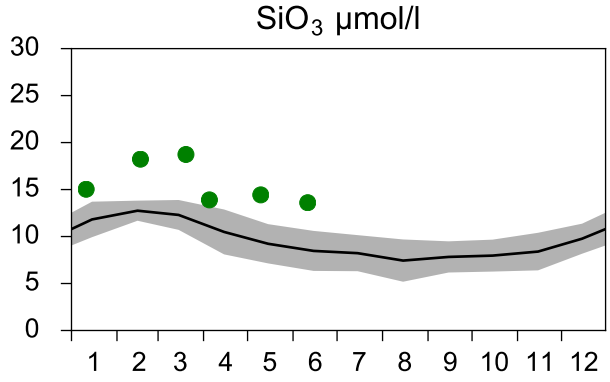
Mean 2001-2015 St.Dev. 2019

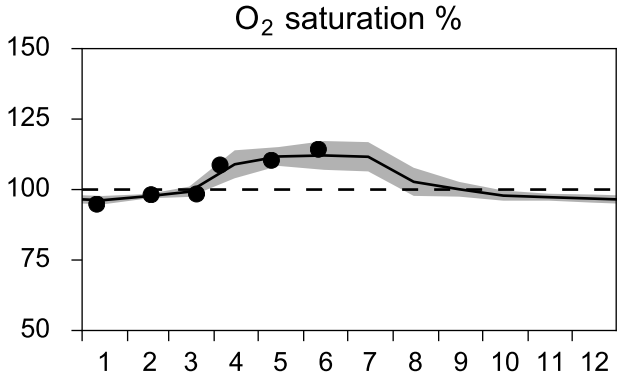




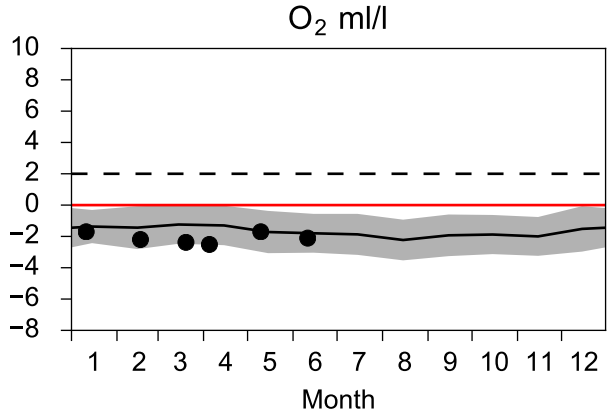


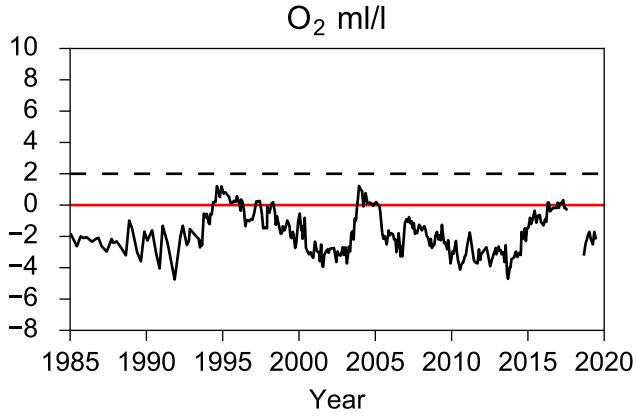




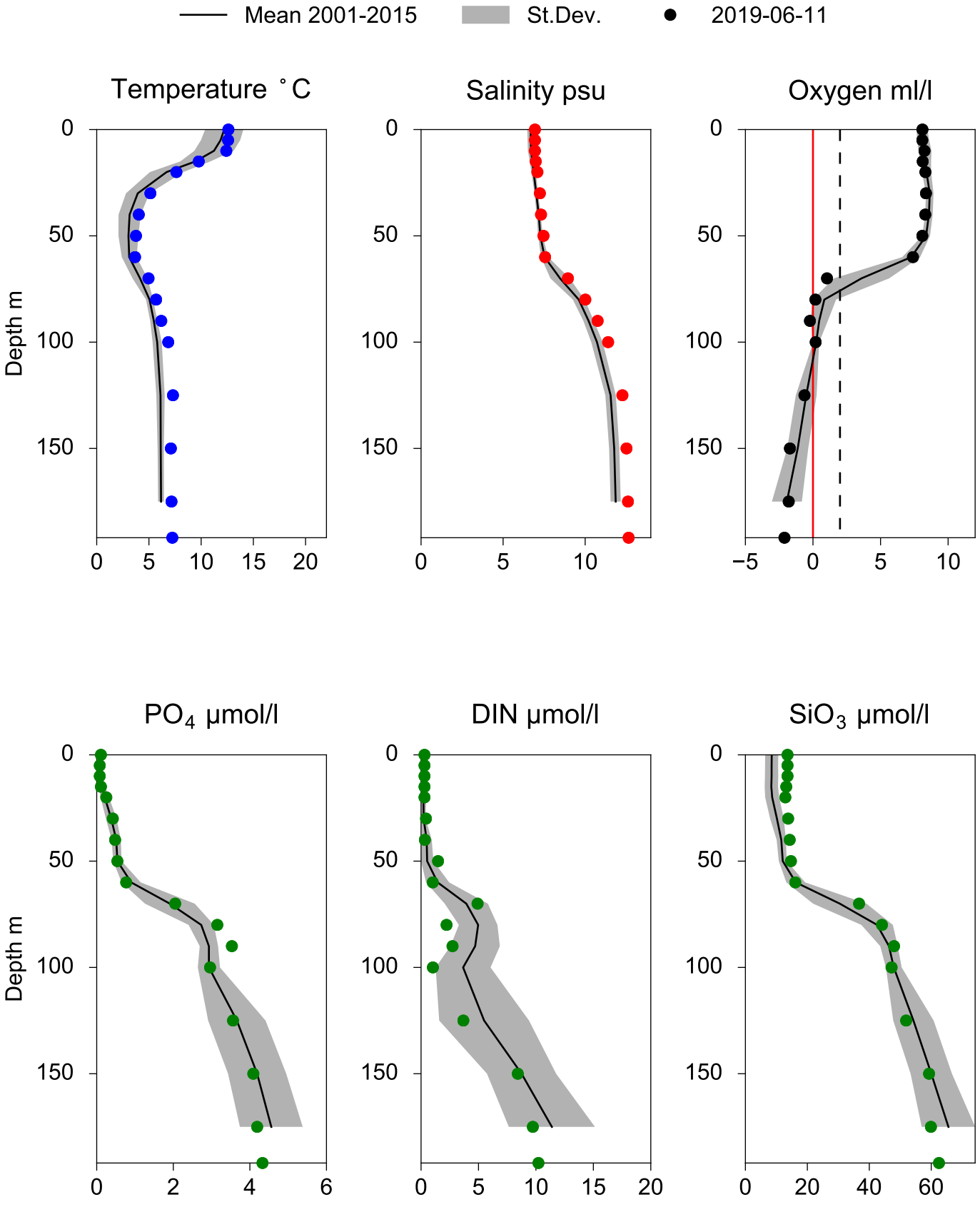


OXYGEN IN BOTTOM WATER (depth >= 175 m)

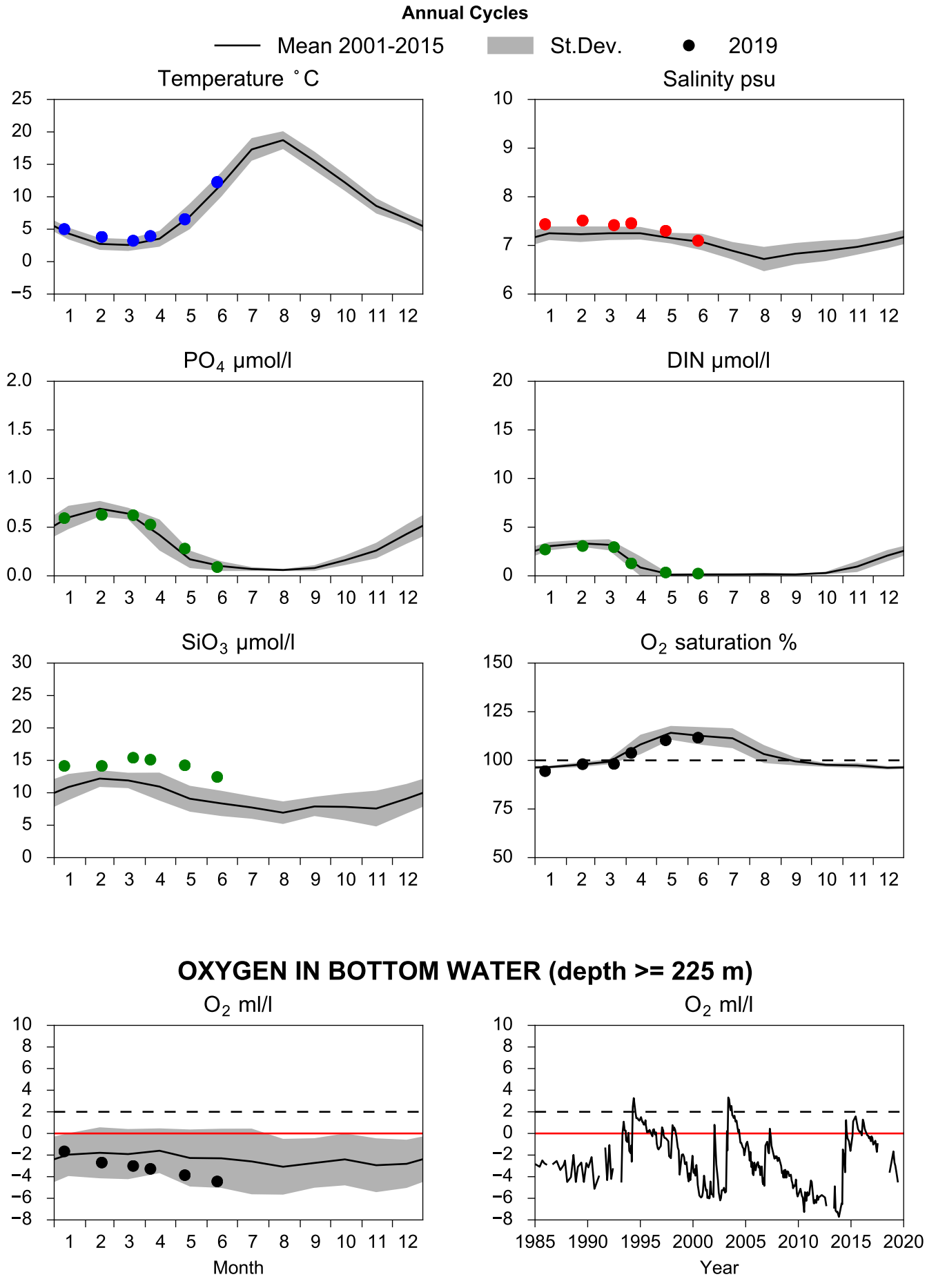




Vertical profiles BY20 FÅRÖDJ
June

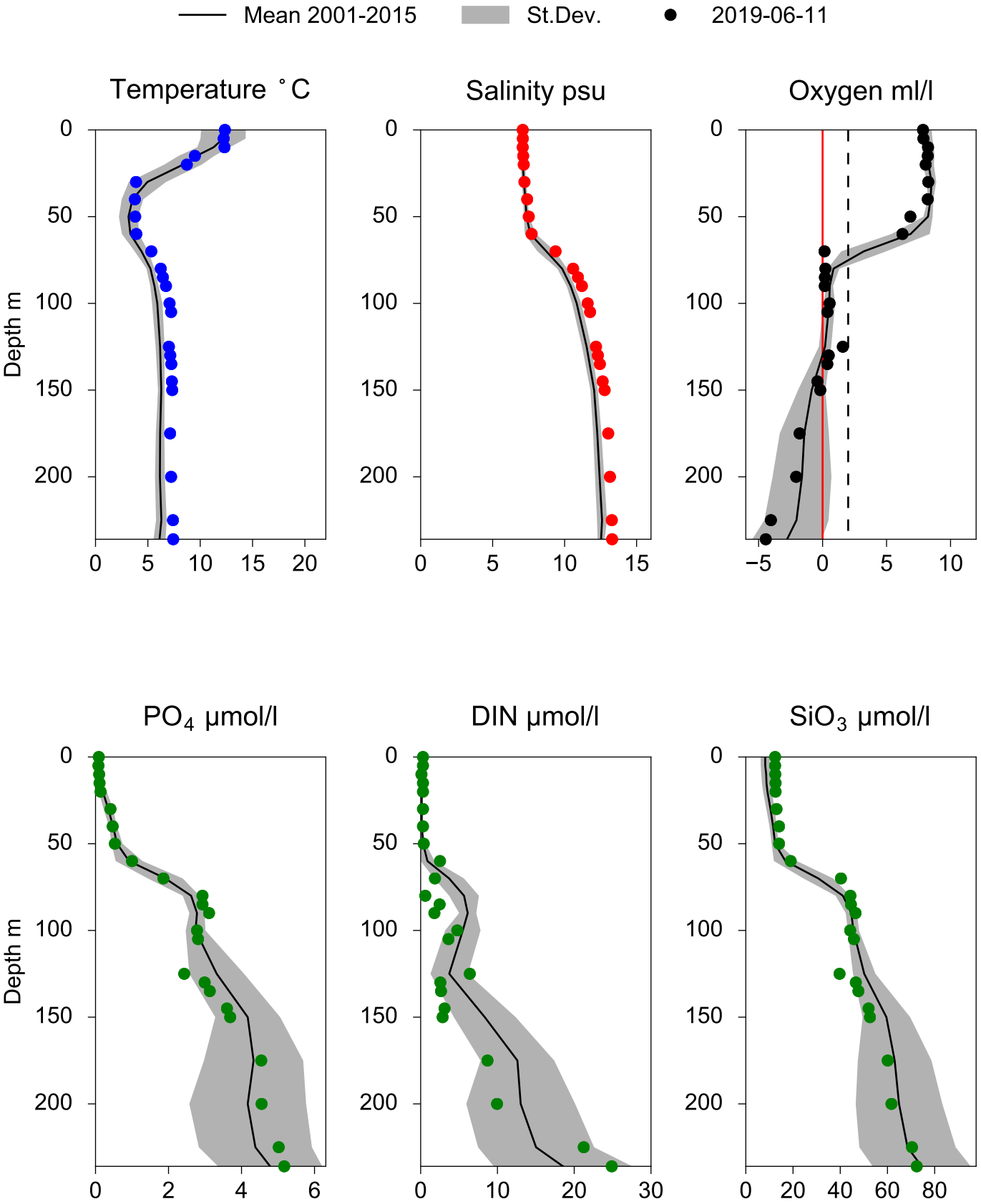


STATION BY15 GOTLANDSDJ SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 225 m)

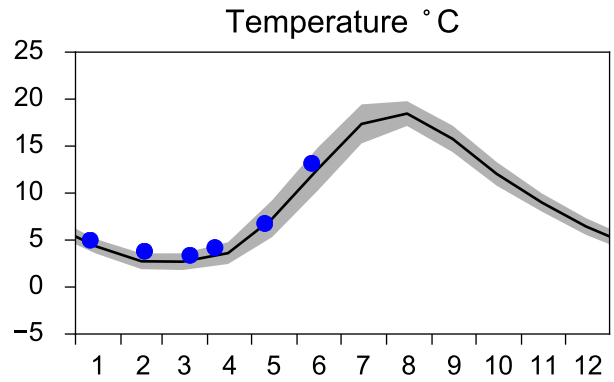
Vertical profiles BY15 GOTLANDSDJ
June

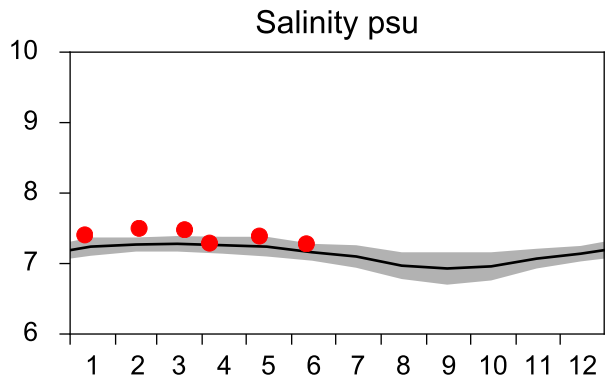


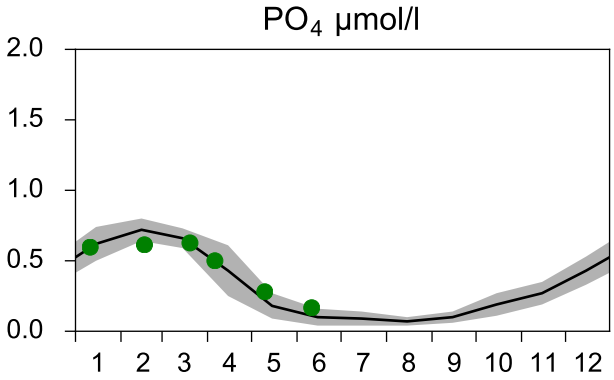
STATION BY10 SURFACE WATER (0-10 m)

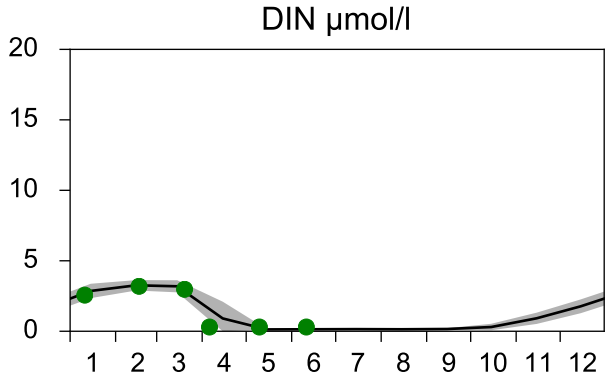
Annual Cycles

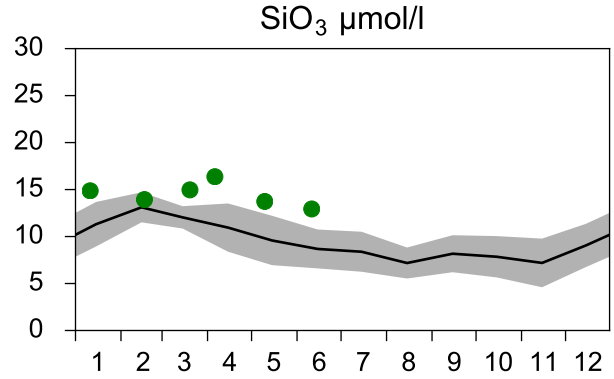
Mean 2001-2015 St.Dev. 2019

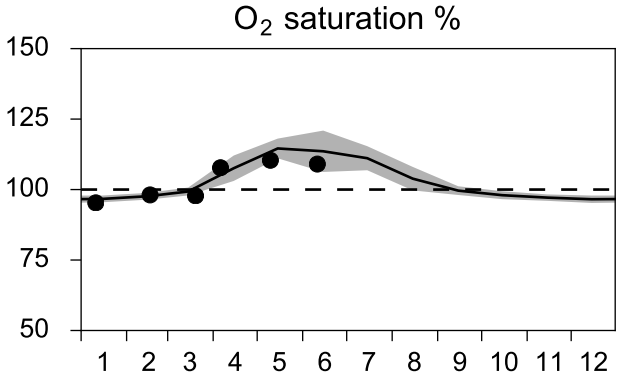




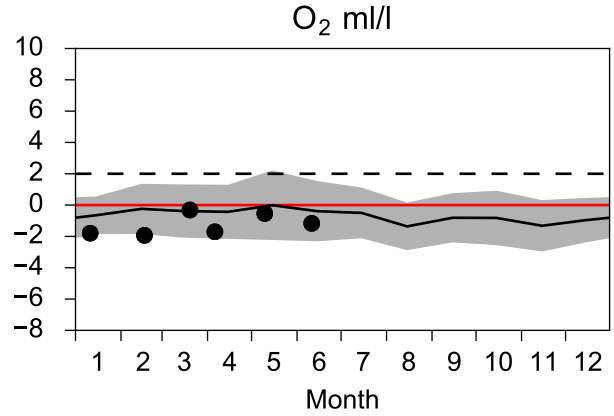


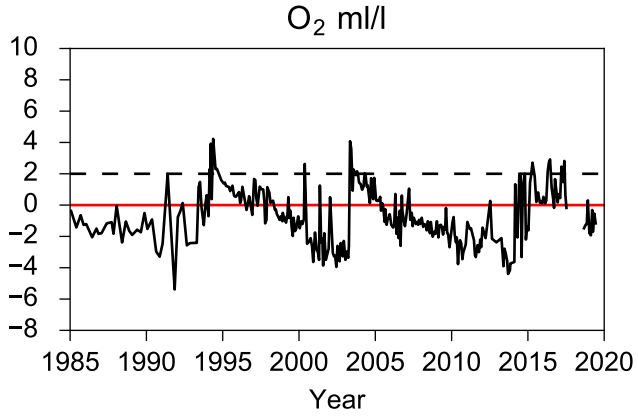




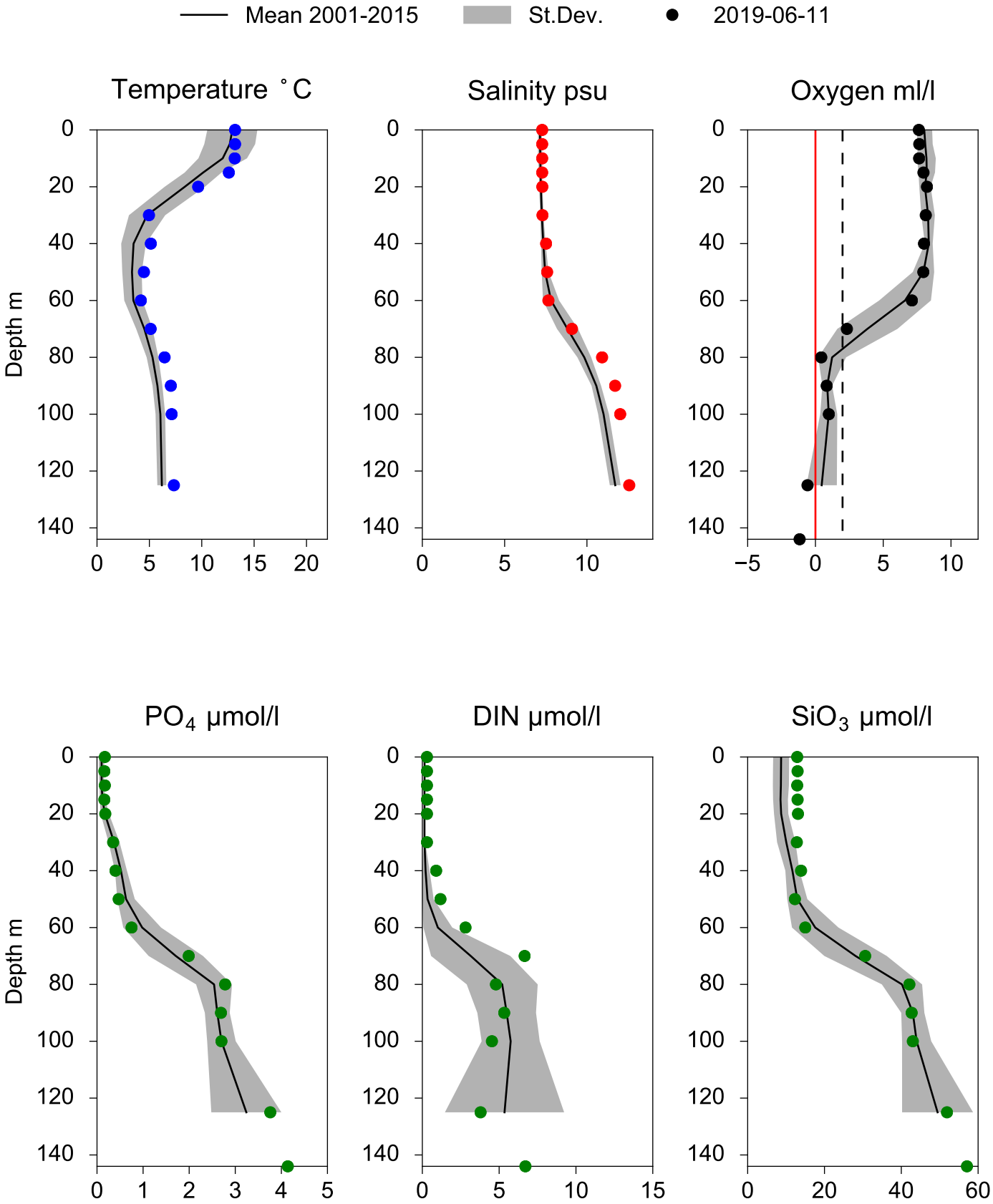


OXYGEN IN BOTTOM WATER (depth >= 125 m)





Vertical profiles BY10
June

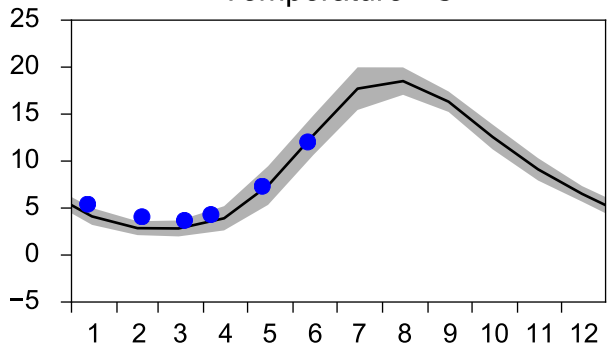


STATION BCS III-10 SURFACE WATER (0-10 m)

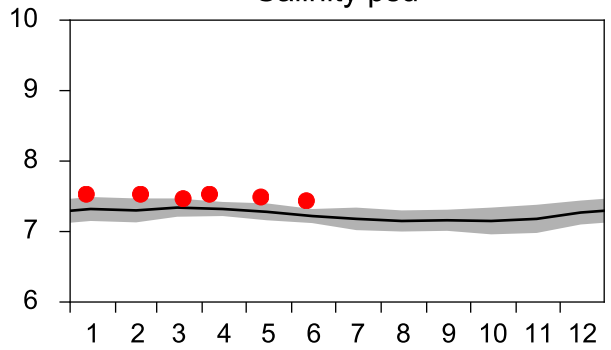
Annual Cycles

Mean 2001-2015 St.Dev. 2019

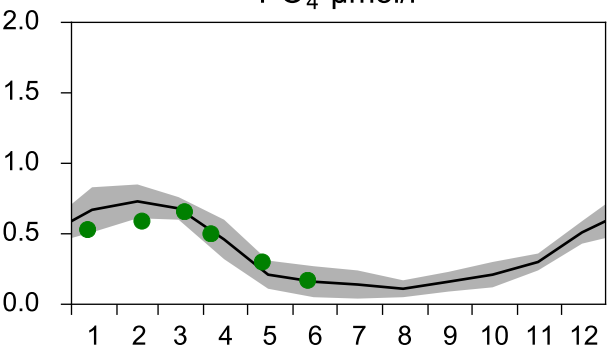
Temperature ˚C



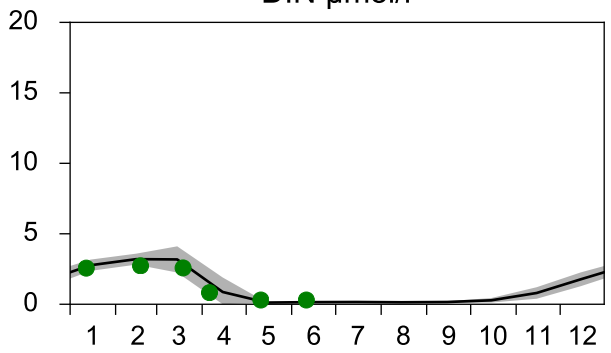
Salinity psu



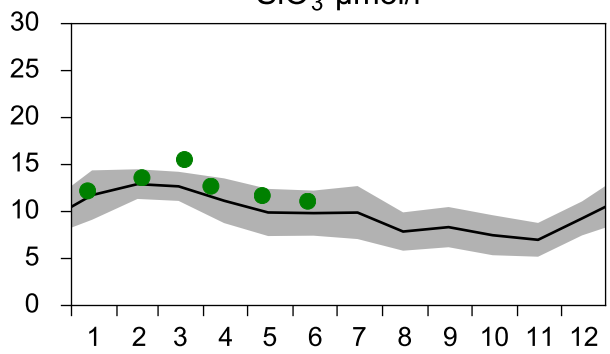
PO_4 µmol/l



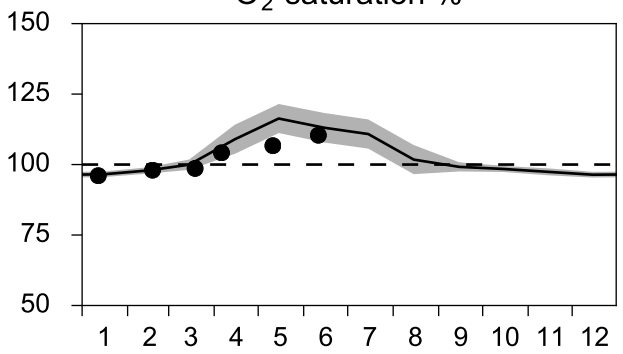
DIN µmol/l



SiO_3 µmol/l

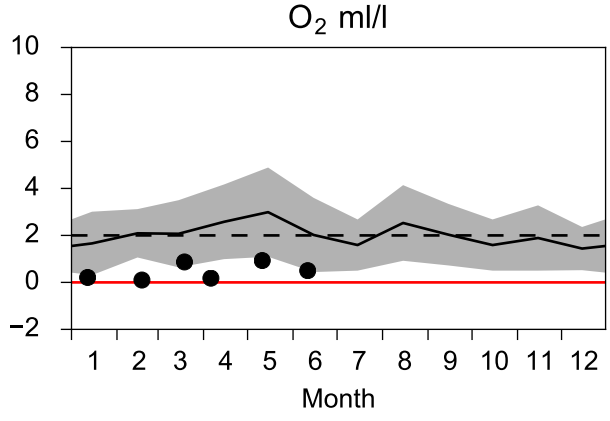


O_2 saturation %

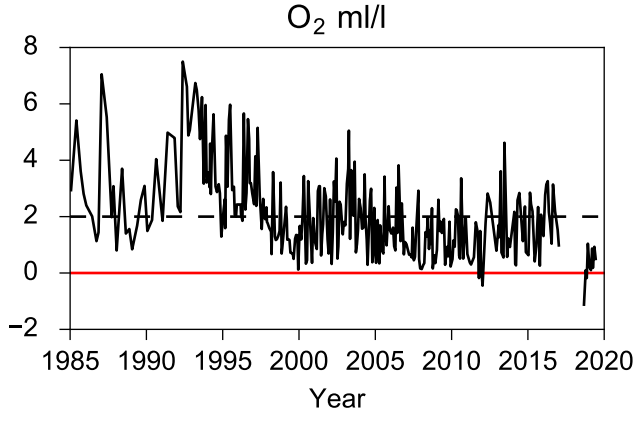


OXYGEN IN BOTTOM WATER (depth >= 80 m)

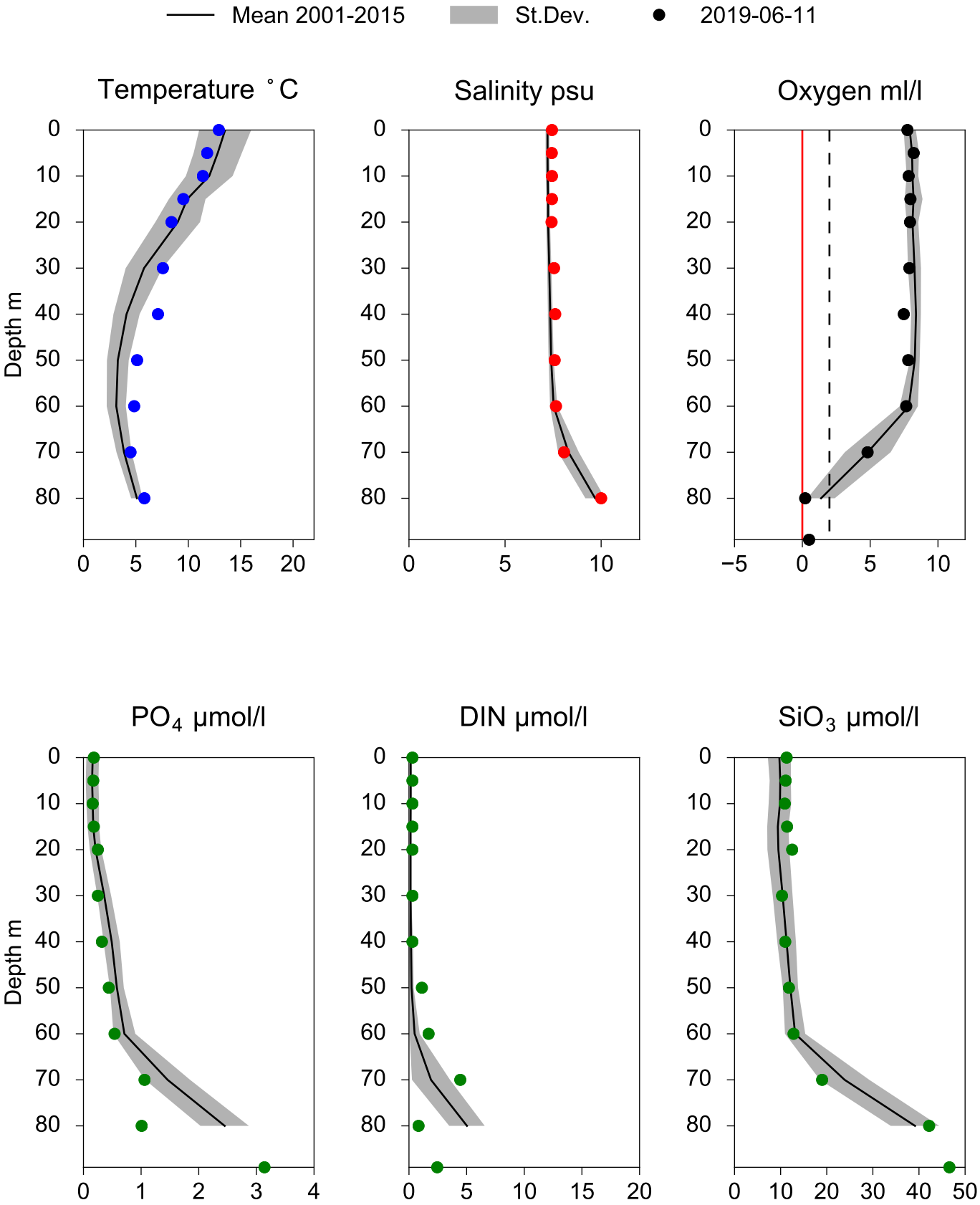
O_2 ml/l



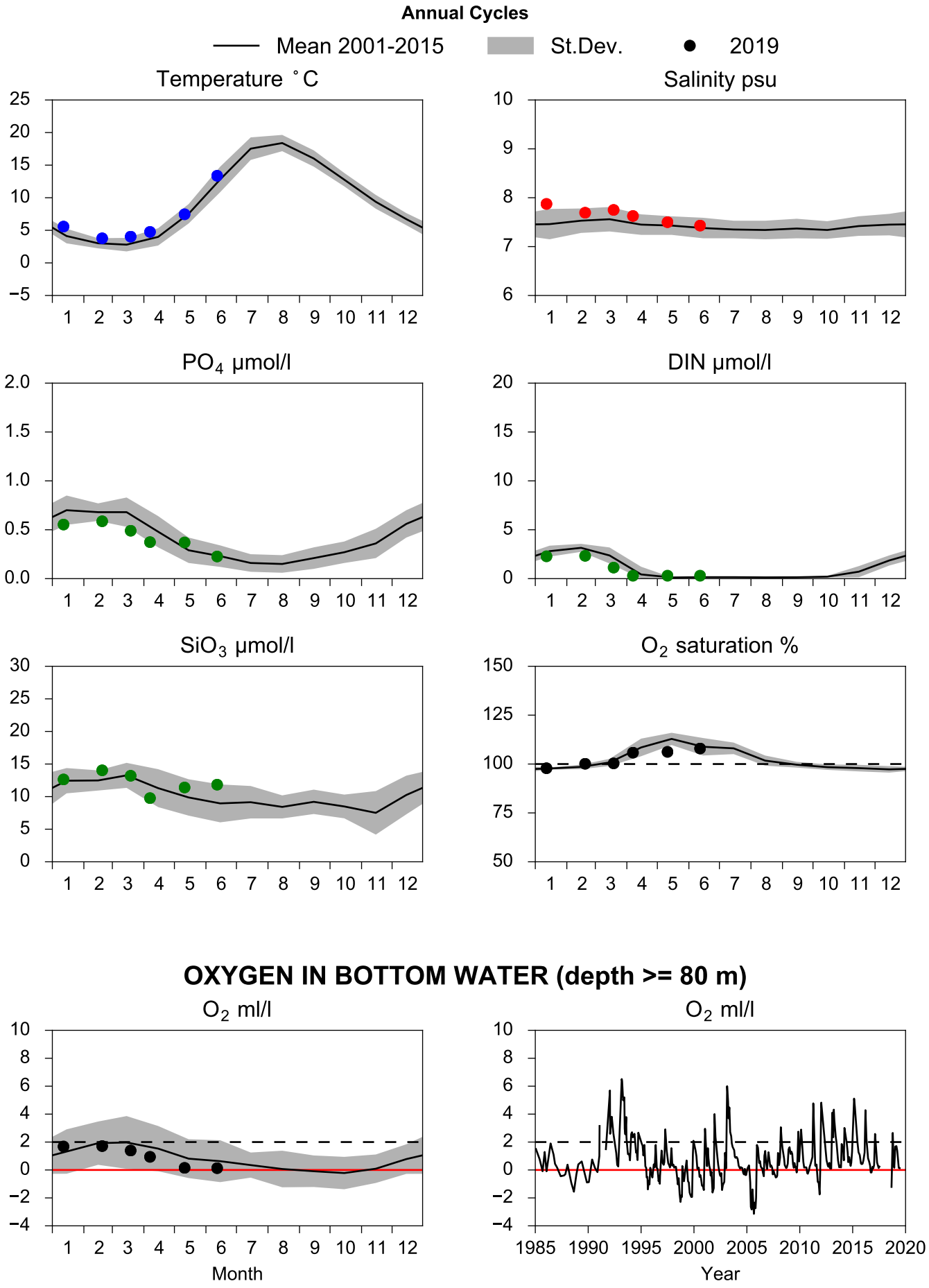
O_2 ml/l



Vertical profiles BCS III-10
June

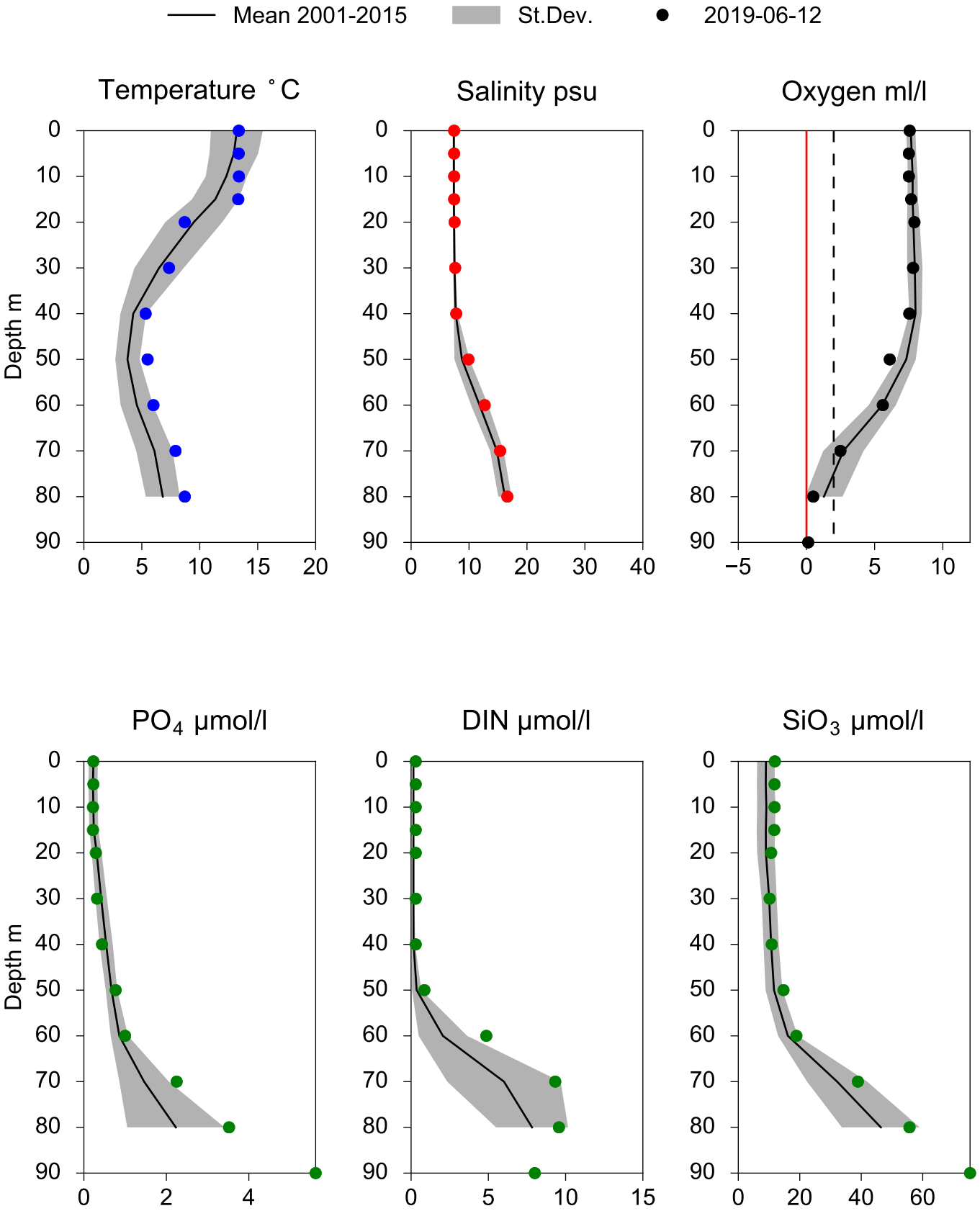


STATION BY5 BORNHOLMSDJ SURFACE WATER (0-10 m)

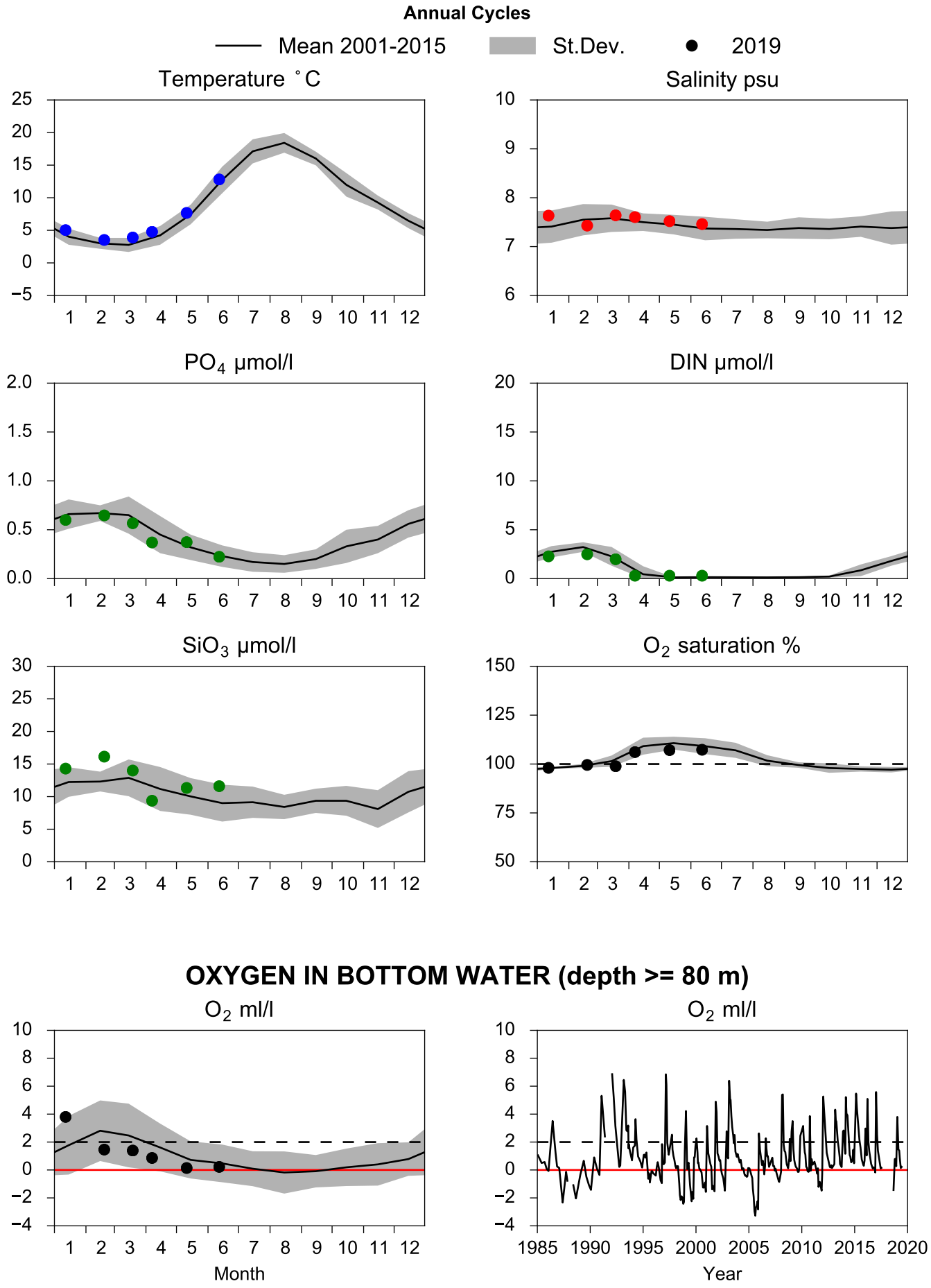


OXYGEN IN BOTTOM WATER (depth >= 80 m)

Vertical profiles BY5 BORNHOLMSDJ
June

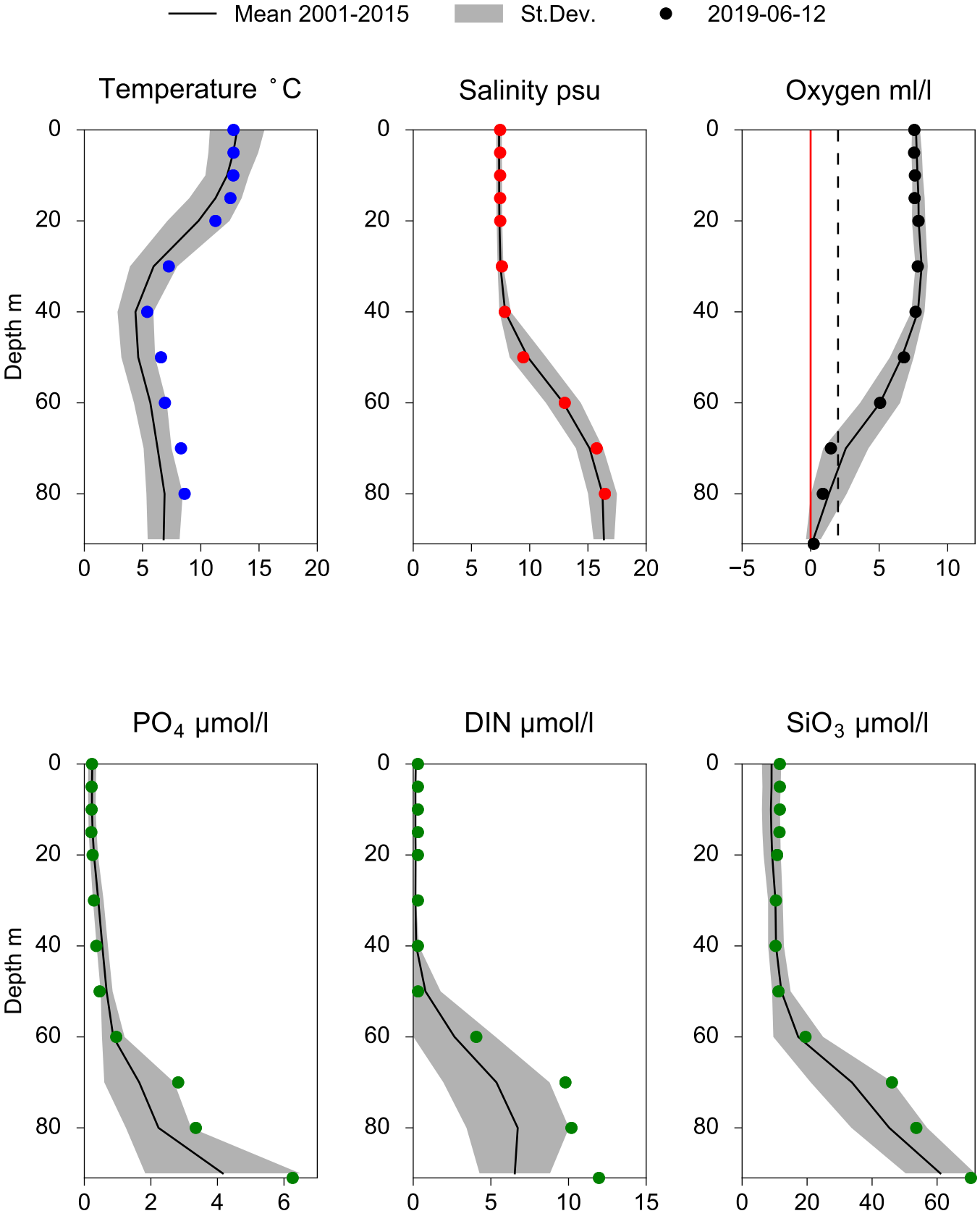


STATION BY4 CHRISTIANSÖ SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 80 m)

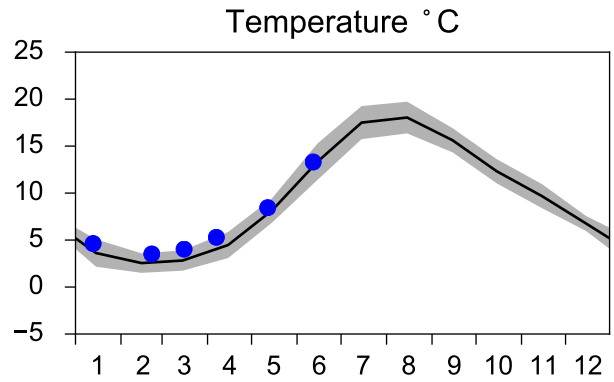
Vertical profiles BY4 CHRISTIANSÖ
June

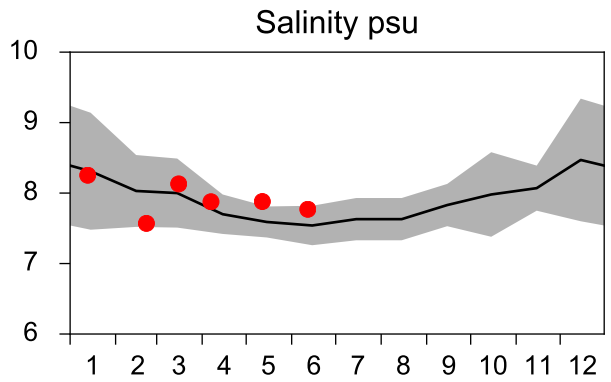


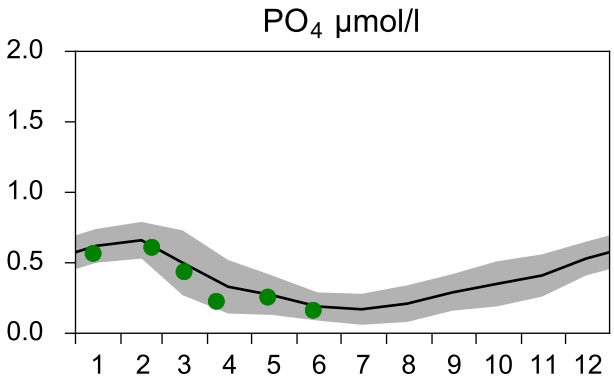
STATION BY1 SURFACE WATER (0-10 m)

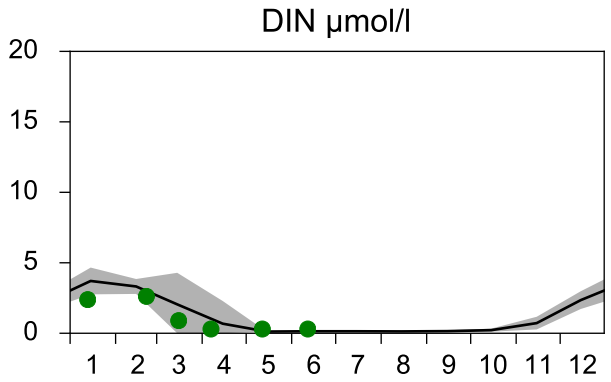
Annual Cycles

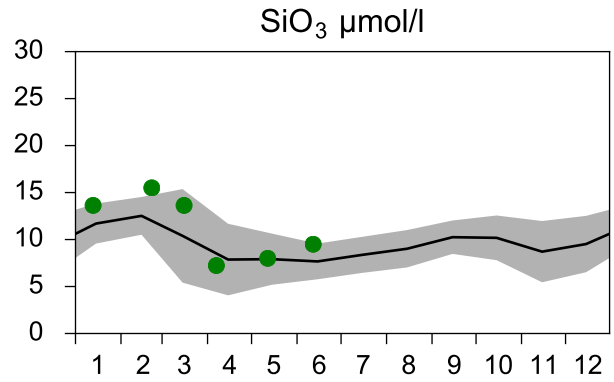
Mean 2001-2015 St.Dev. 2019

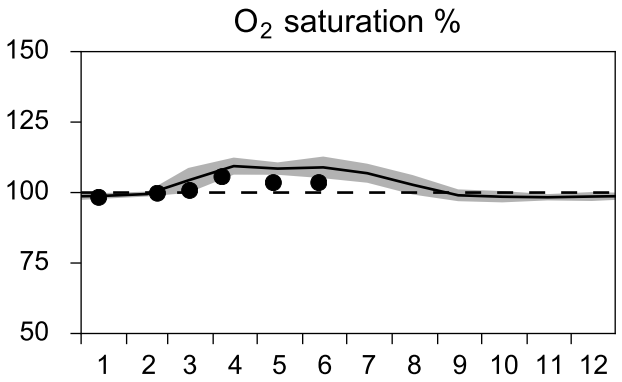




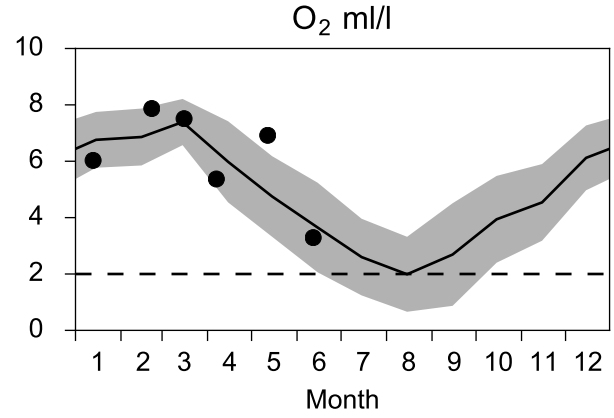


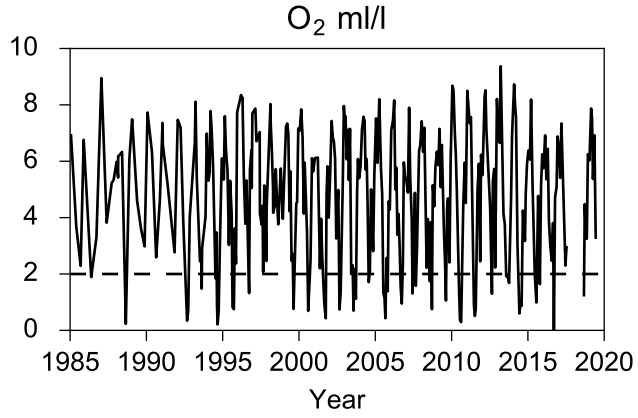




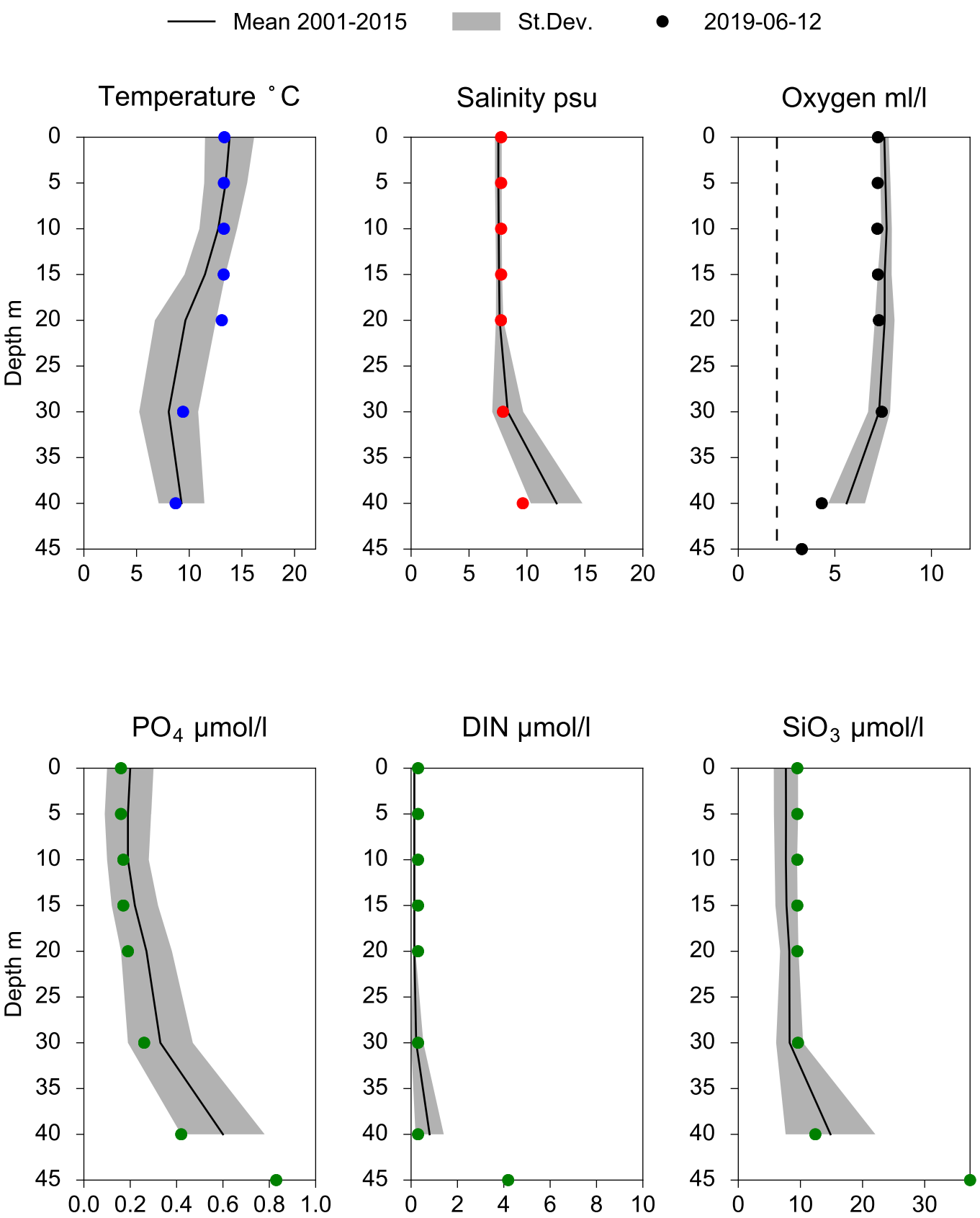


OXYGEN IN BOTTOM WATER (depth >= 40 m)

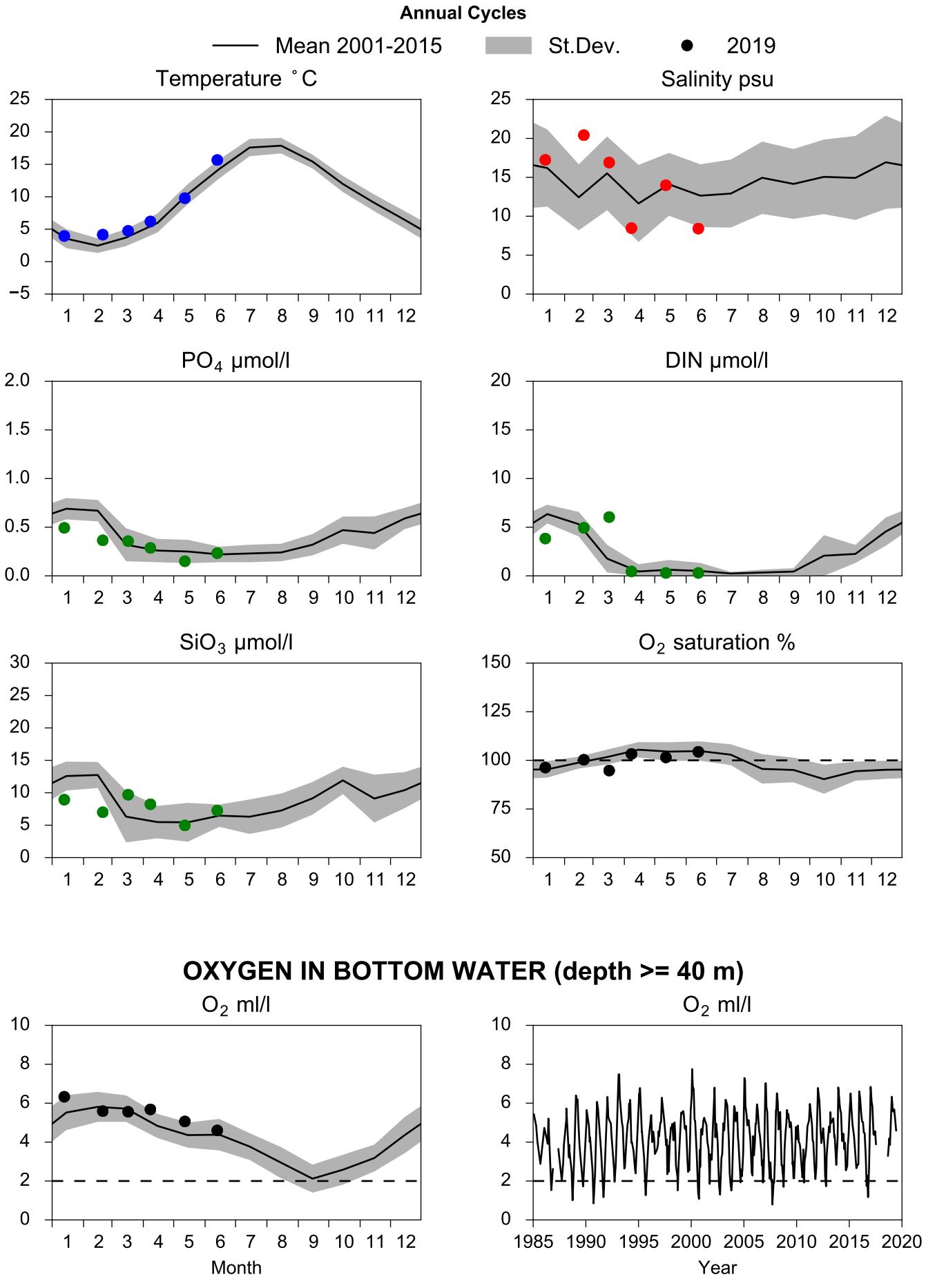




Vertical profiles BY1
June

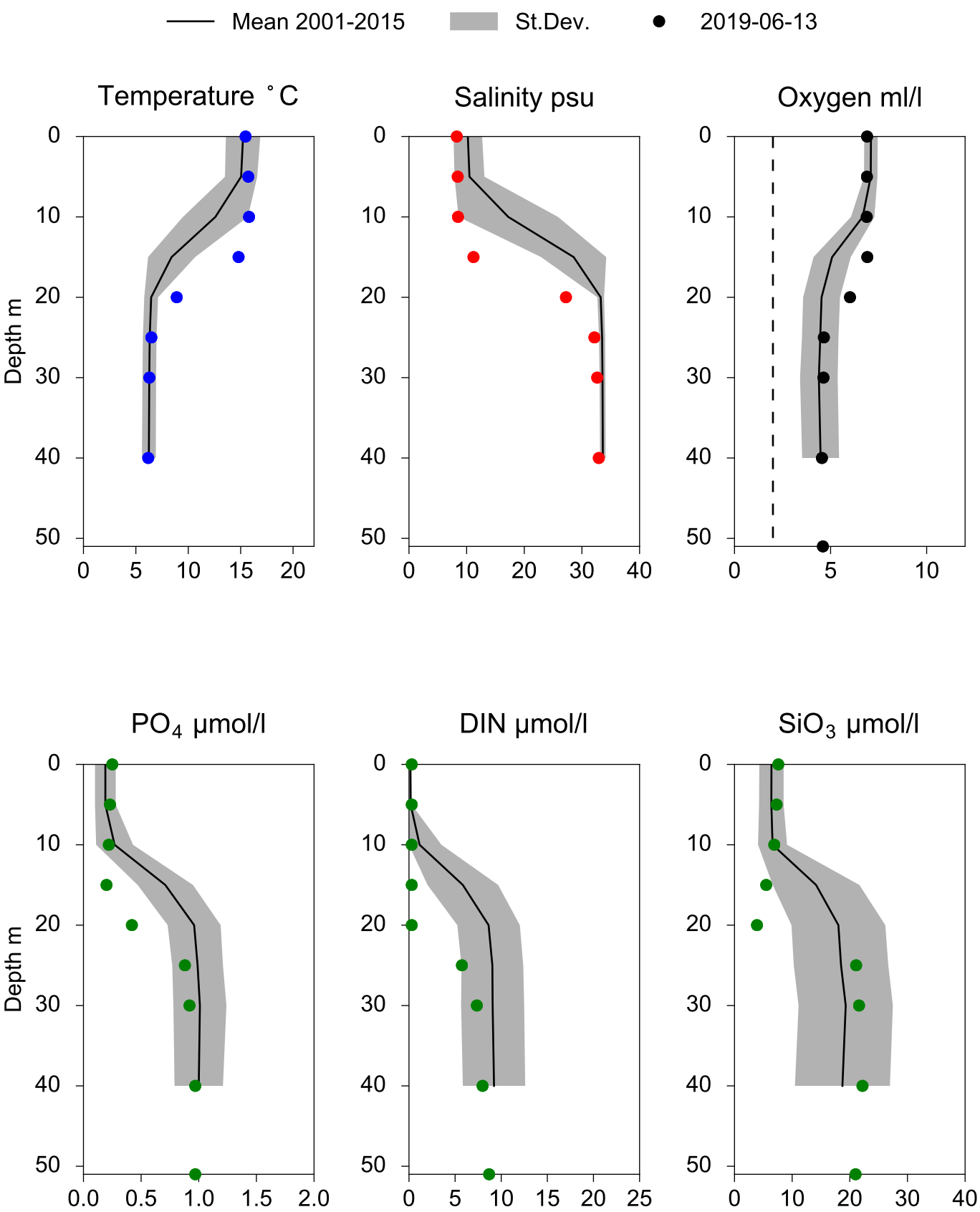


STATION W LANDSKRONA SURFACE WATER (0-10 m)

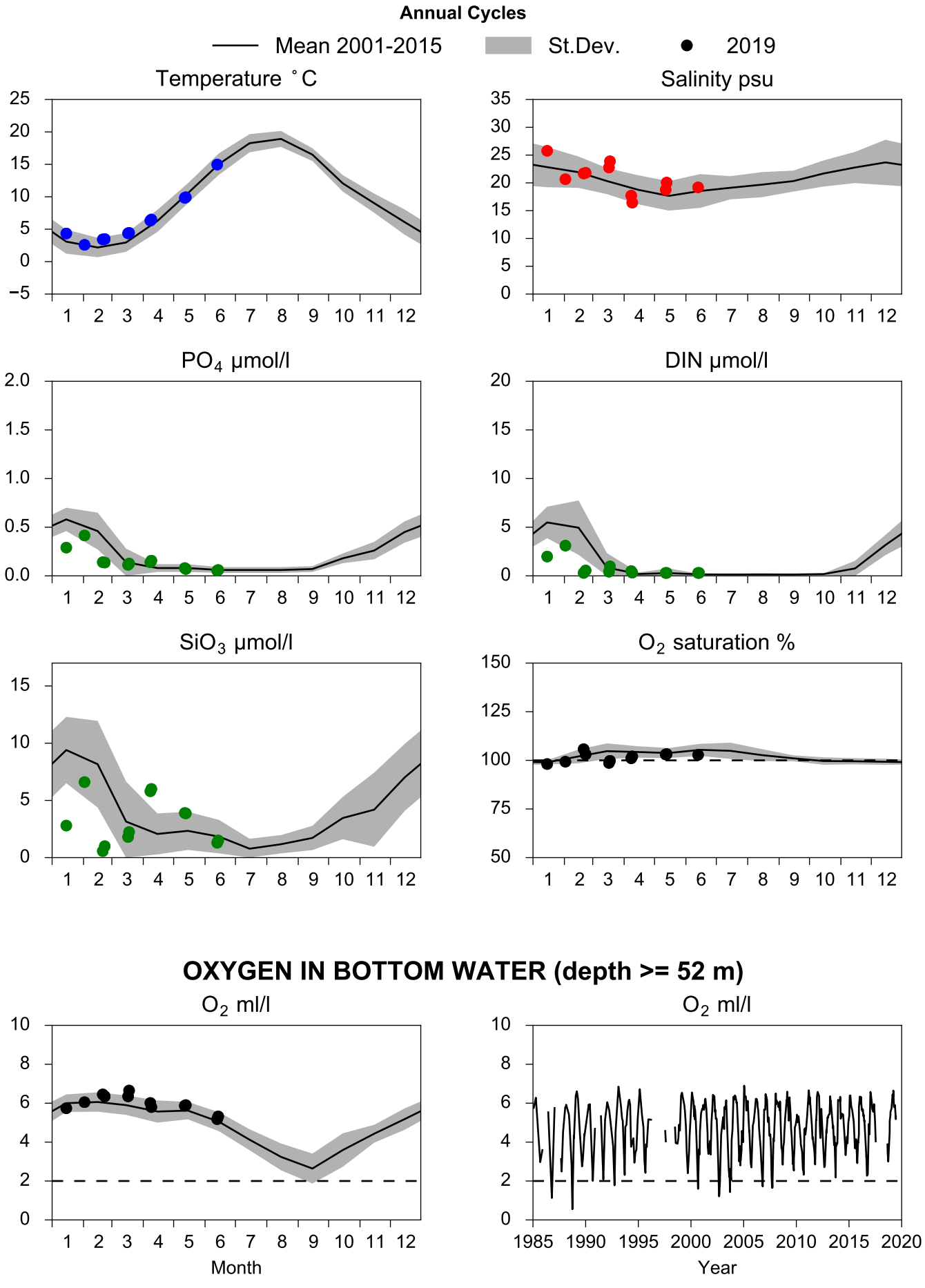


OXYGEN IN BOTTOM WATER (depth >= 40 m)

Vertical profiles W LANDSKRONA
June

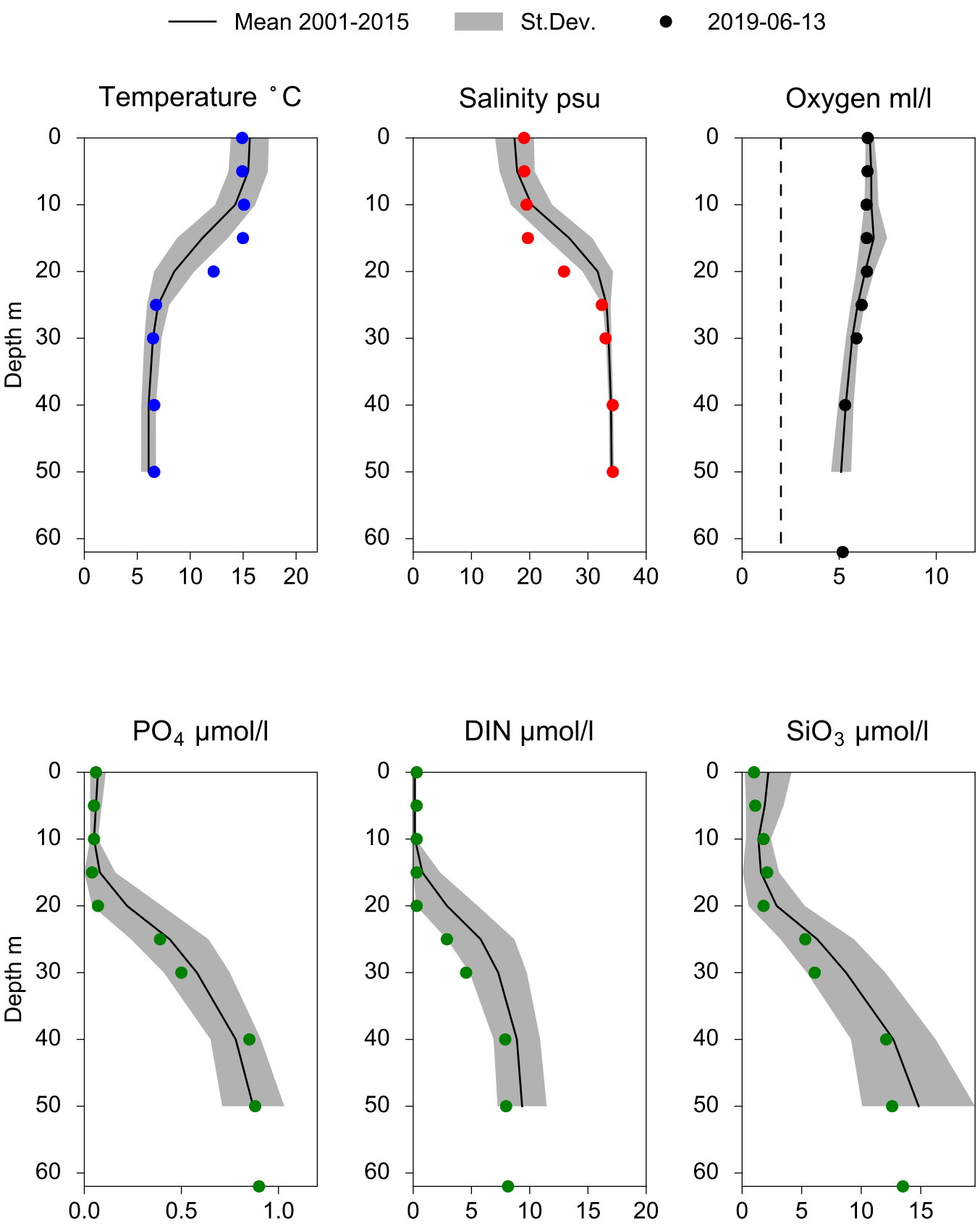


STATION ANHOLT E SURFACE WATER (0-10 m)

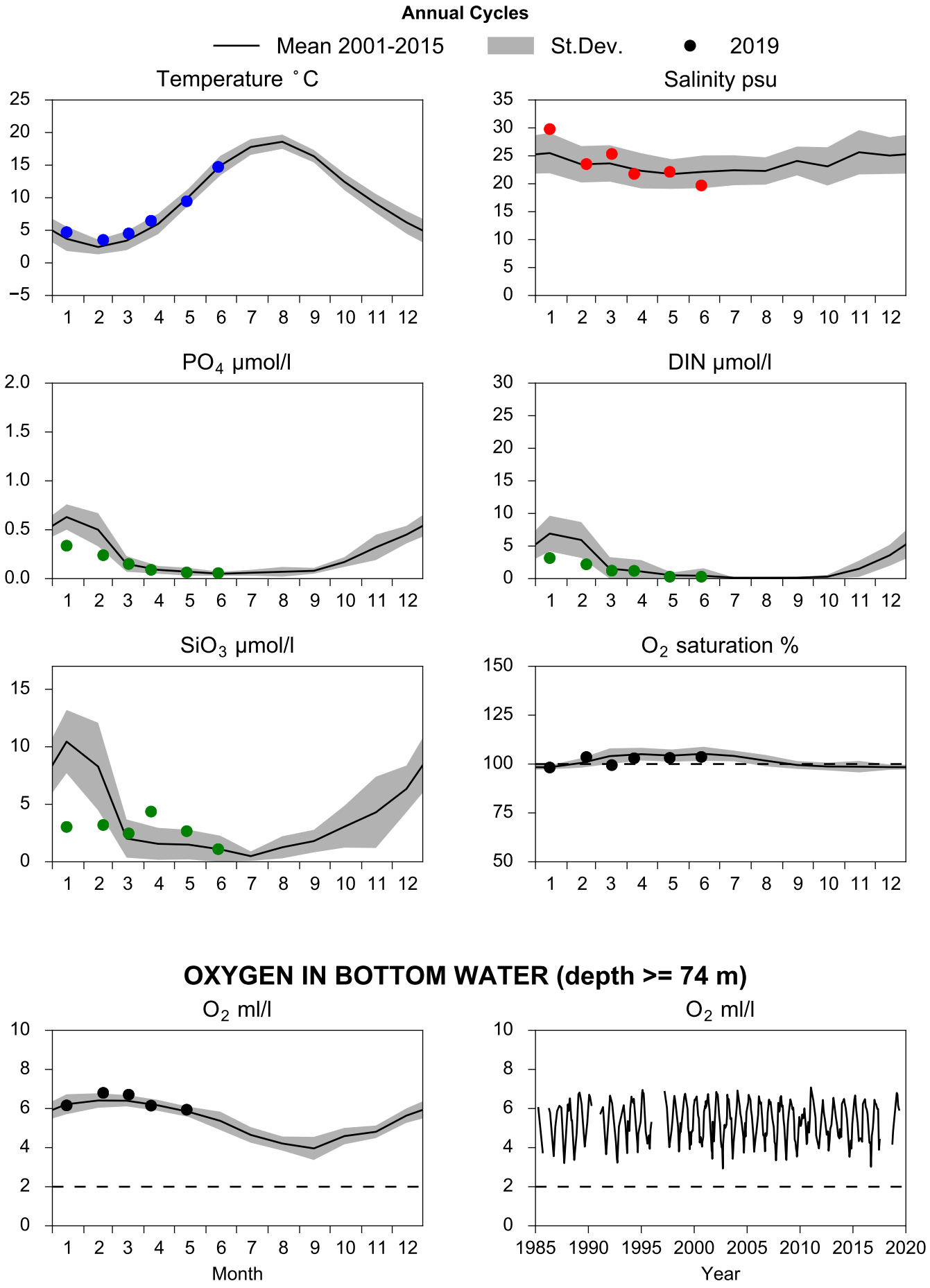


OXYGEN IN BOTTOM WATER (depth >= 52 m)

Vertical profiles ANHOLT E
June

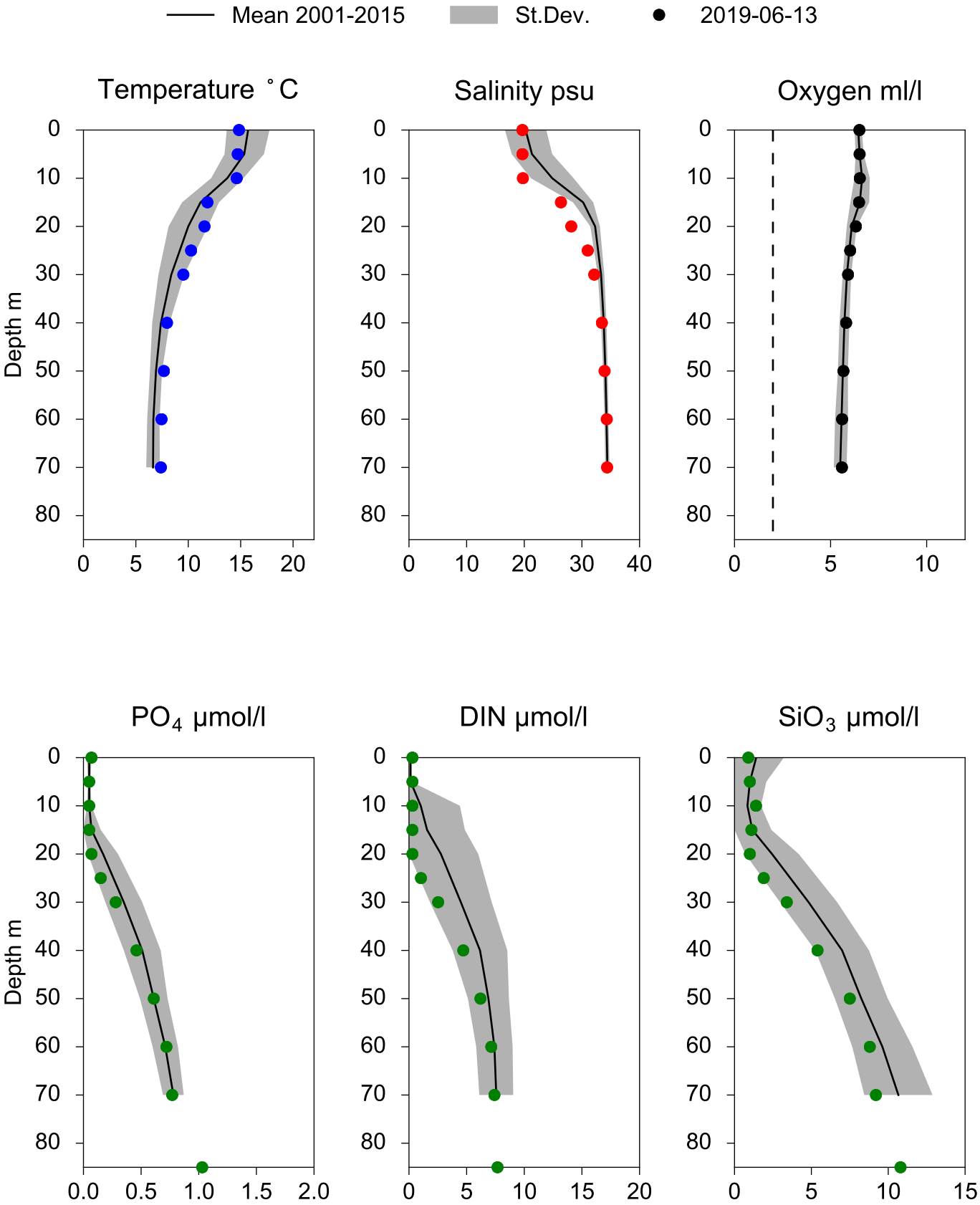


STATION FLADEN SURFACE WATER (0-10 m)



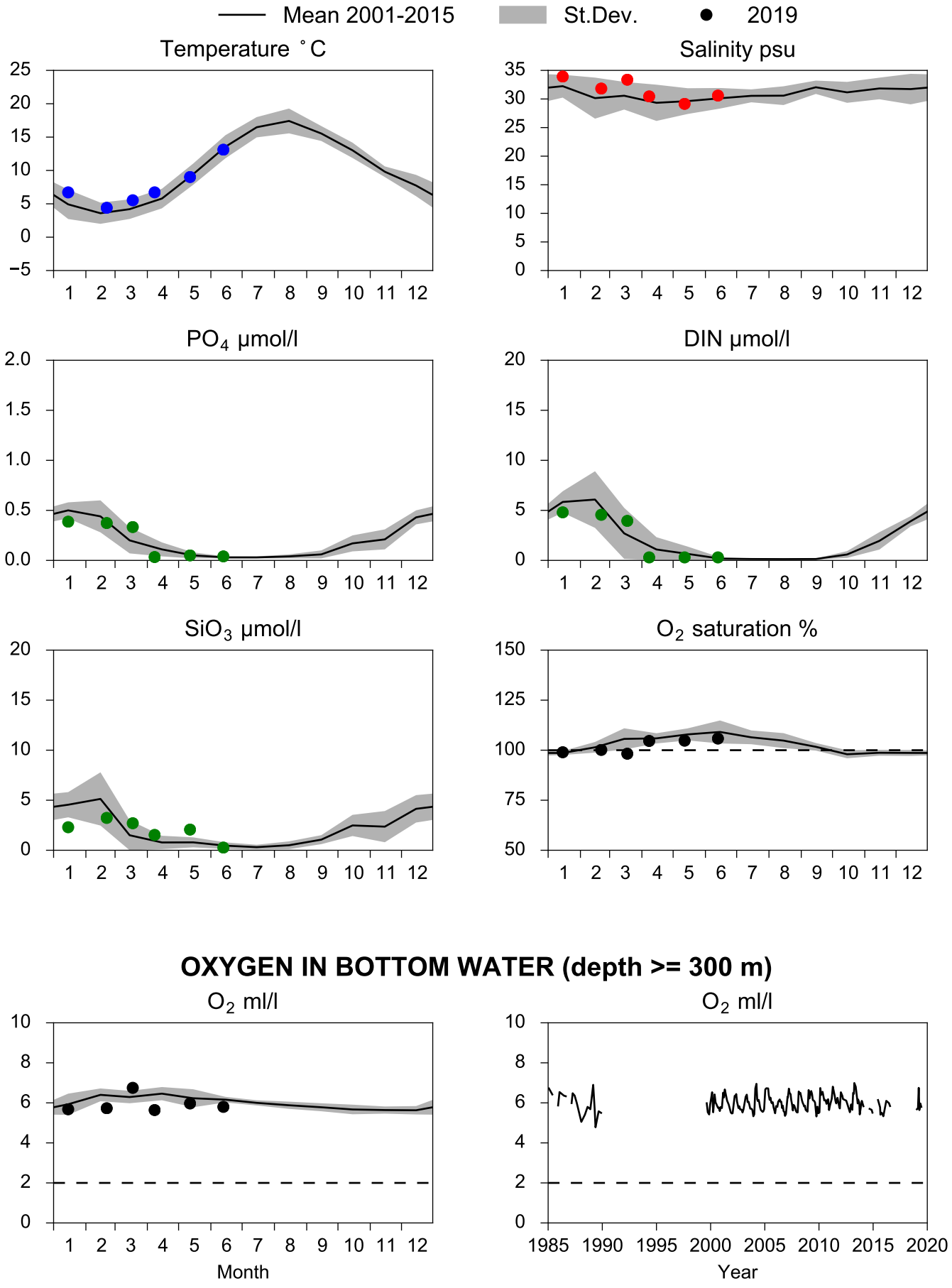
OXYGEN IN BOTTOM WATER (depth >= 74 m)

Vertical profiles FLADEN
June



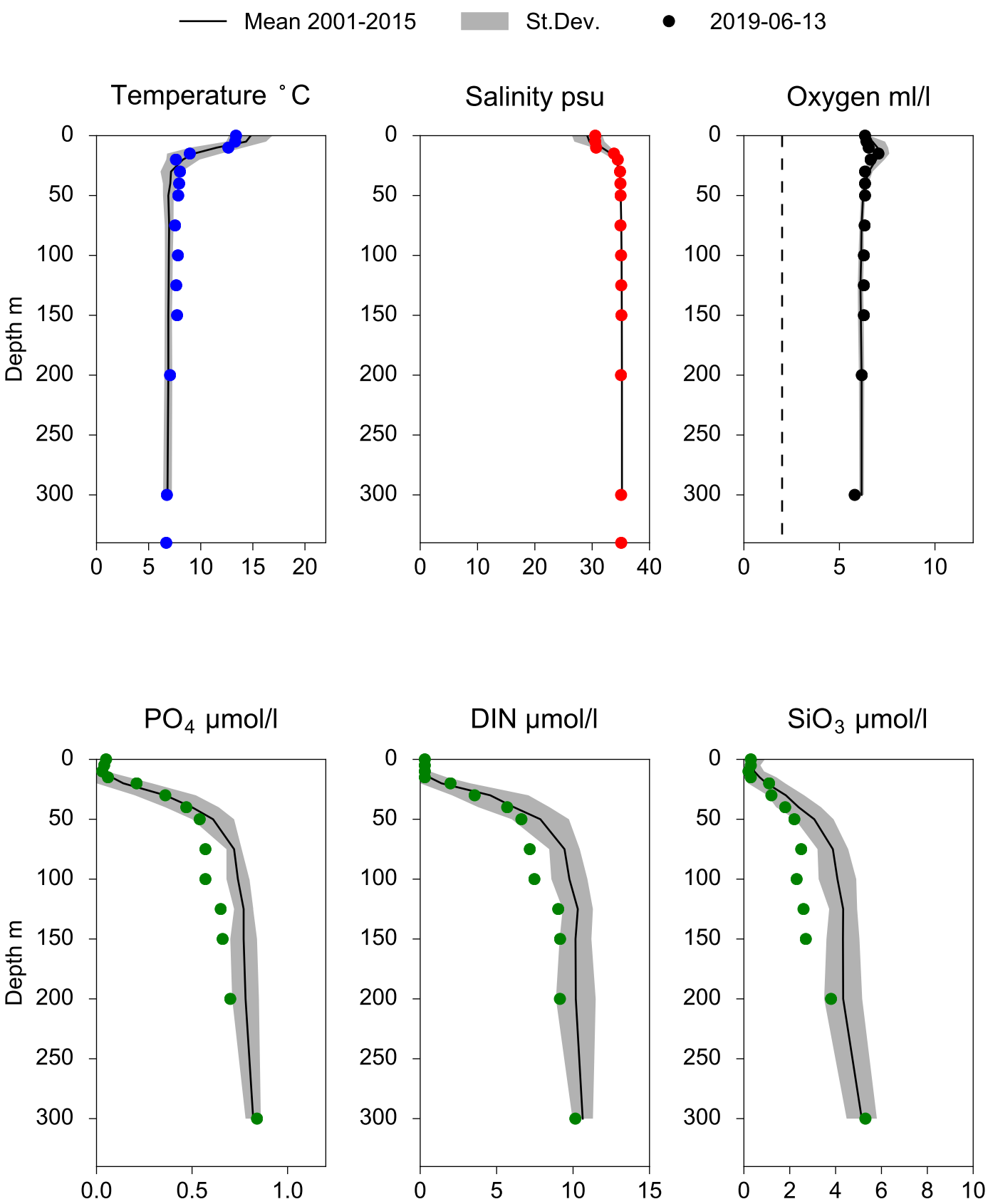
STATION Å17 SURFACE WATER (0-10 m)

Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 300 m)

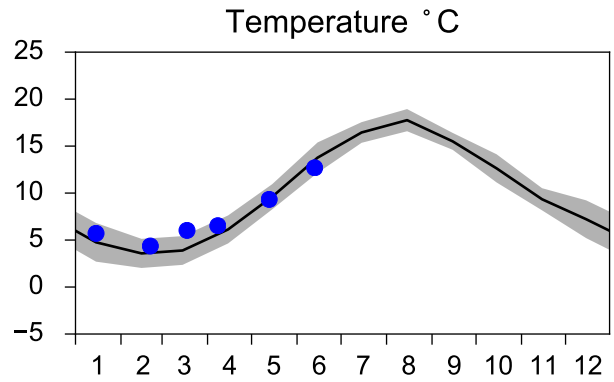
Vertical profiles Å17
June

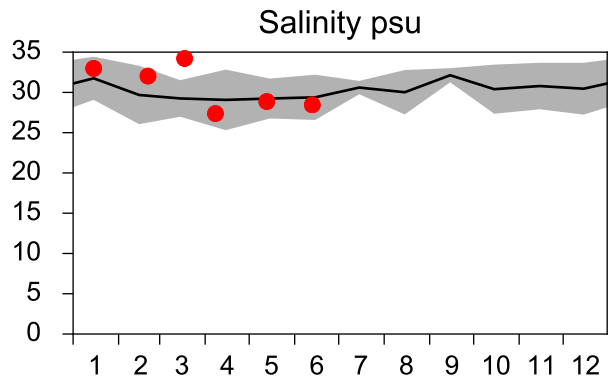


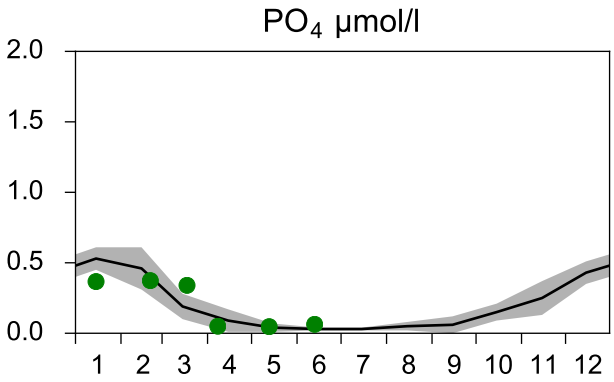
STATION Å15 SURFACE WATER (0-10 m)

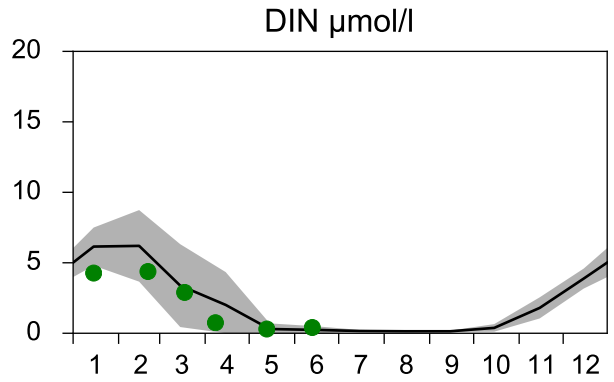
Annual Cycles

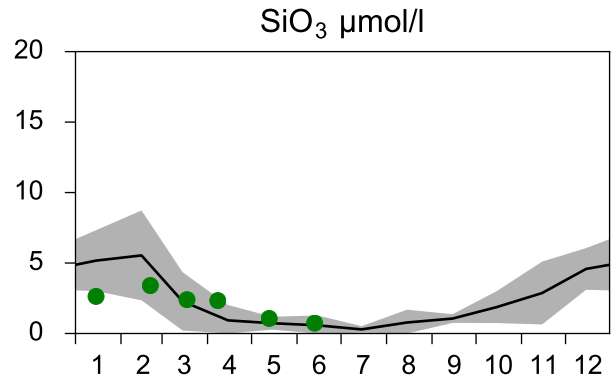
Mean 2001-2015 St.Dev. 2019

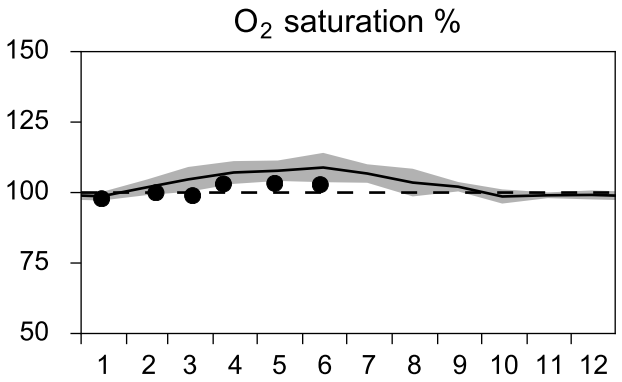




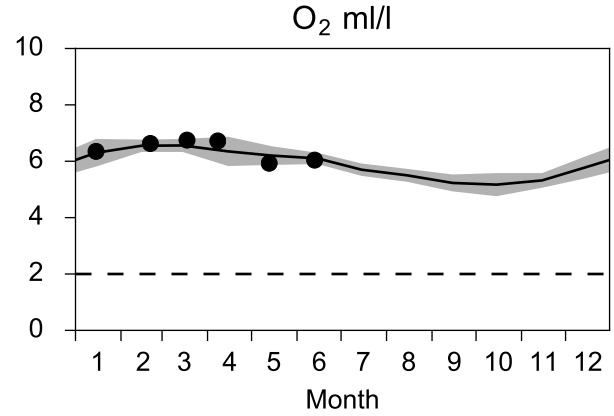


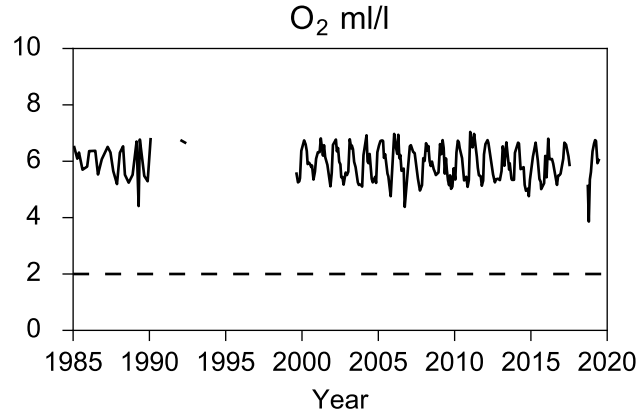




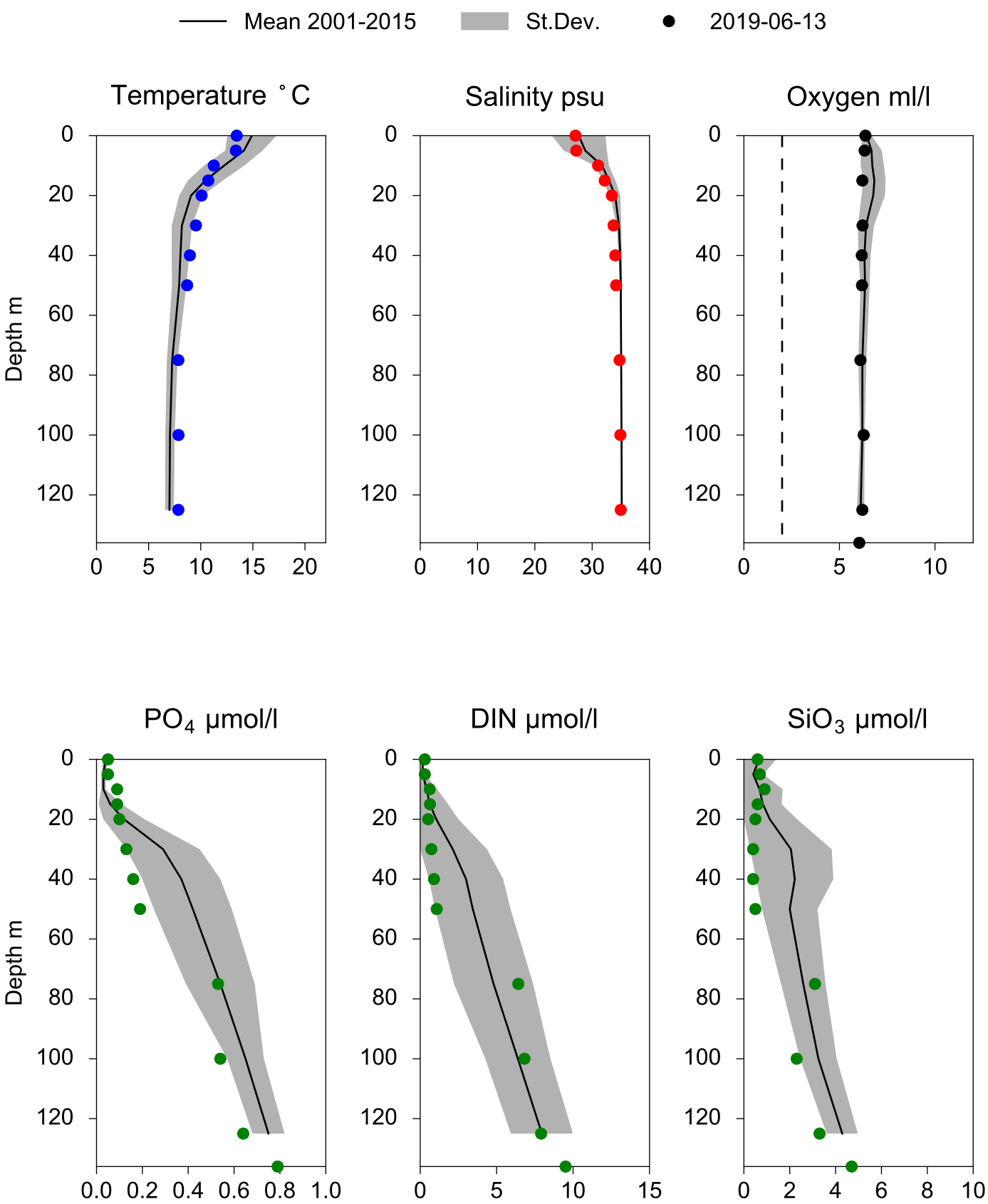


OXYGEN IN BOTTOM WATER (depth >= 125 m)





Vertical profiles Å15
June

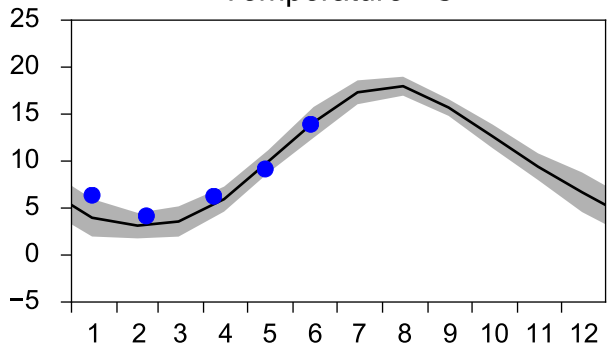


STATION Å13 SURFACE WATER (0-10 m)

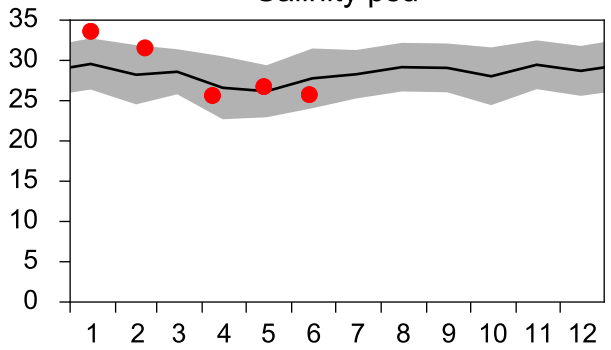
Annual Cycles

Mean 2001-2015 St.Dev. 2019

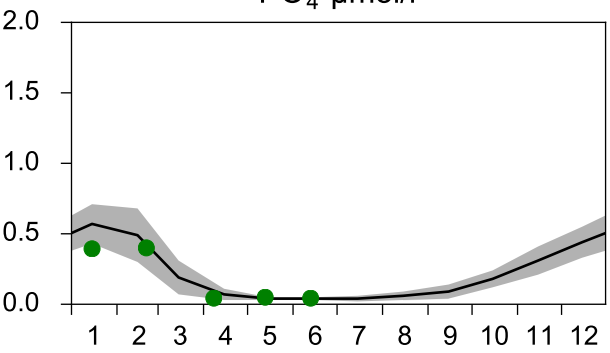
Temperature ˚C



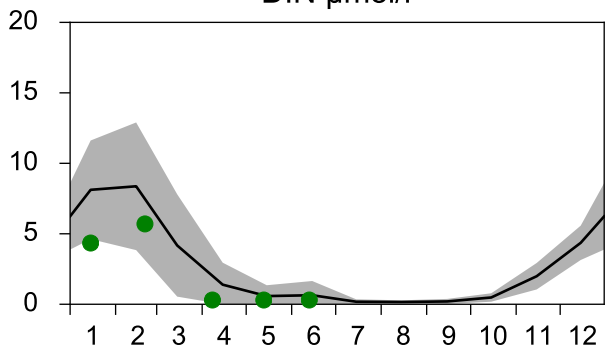
Salinity psu



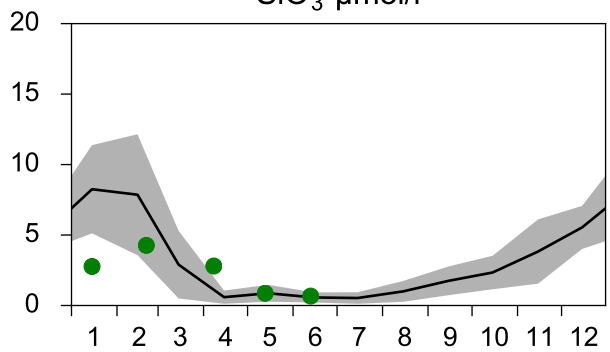
PO_4 µmol/l



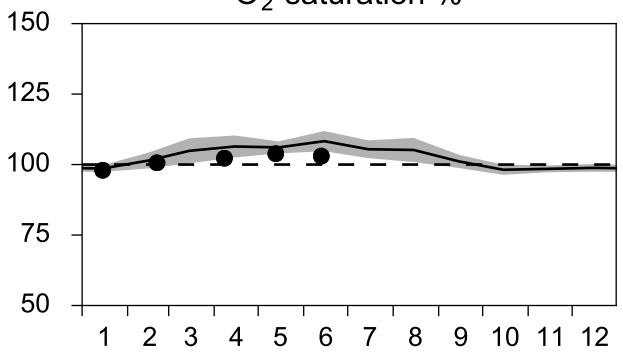
DIN µmol/l



SiO_3 µmol/l

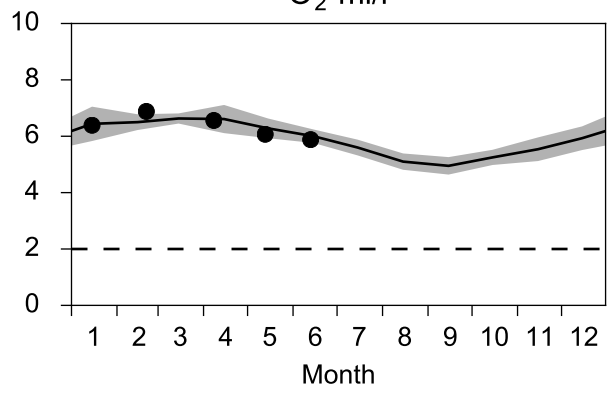


O_2 saturation %

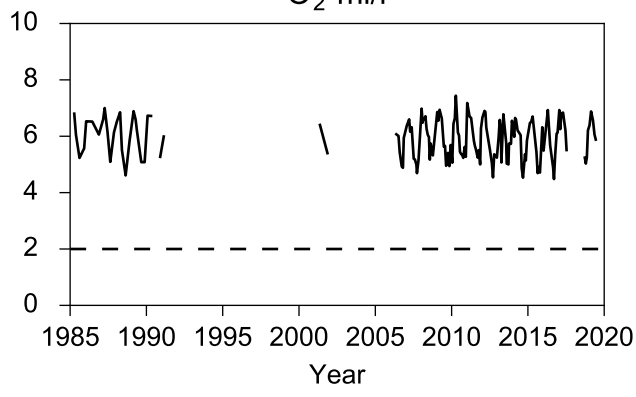


OXYGEN IN BOTTOM WATER (depth >= 80 m)

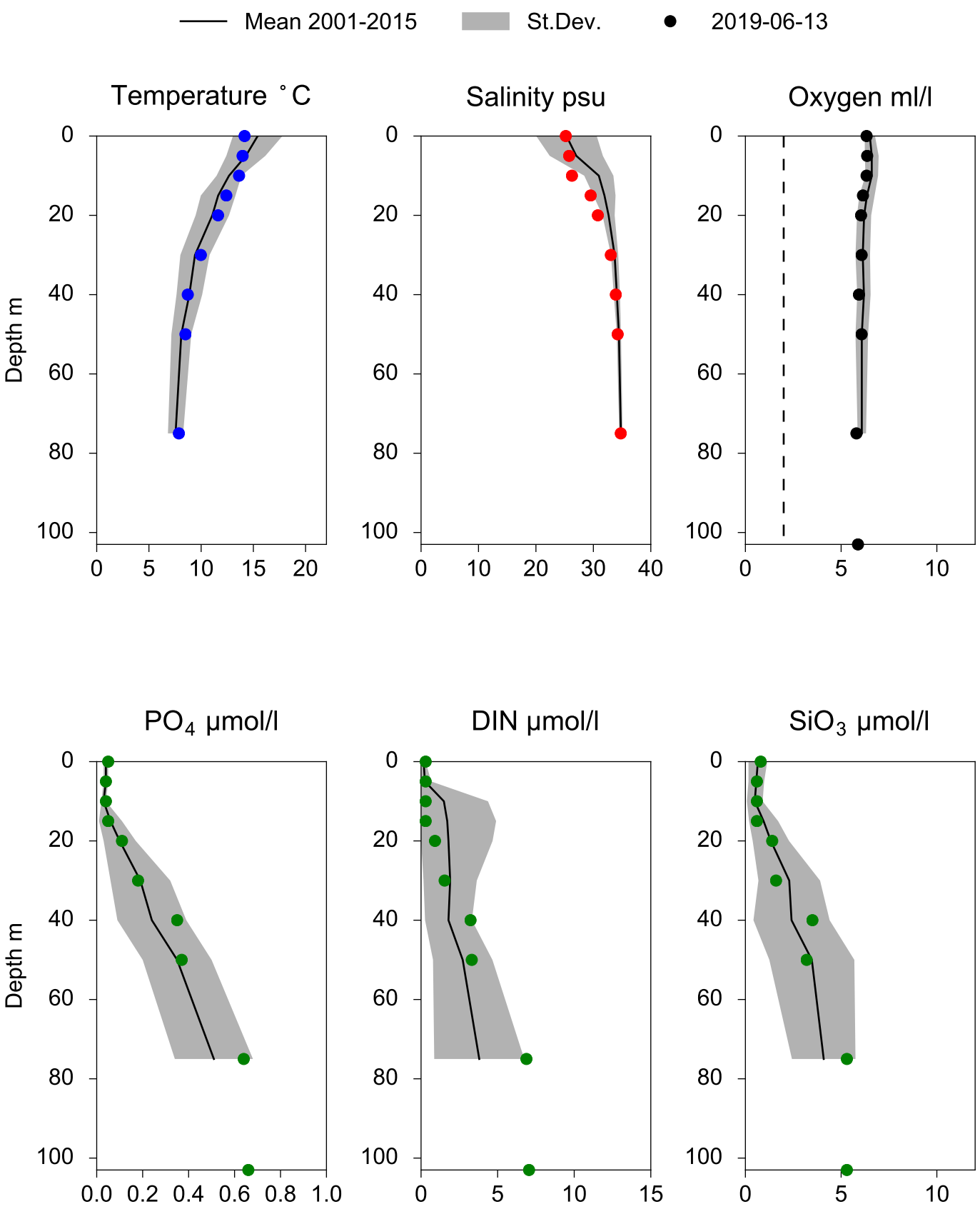
O_2 ml/l



O_2 ml/l



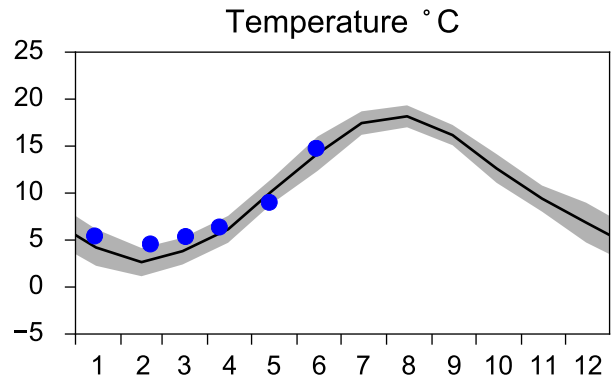
Vertical profiles Å13
June

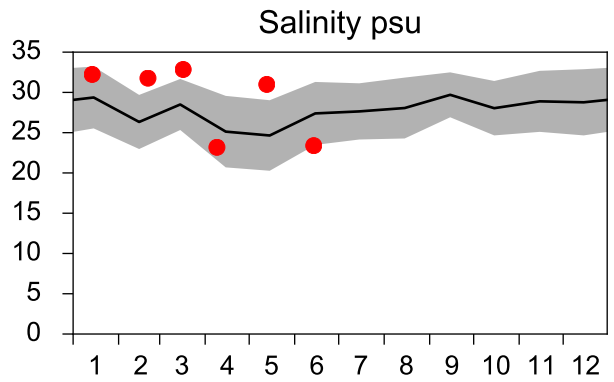


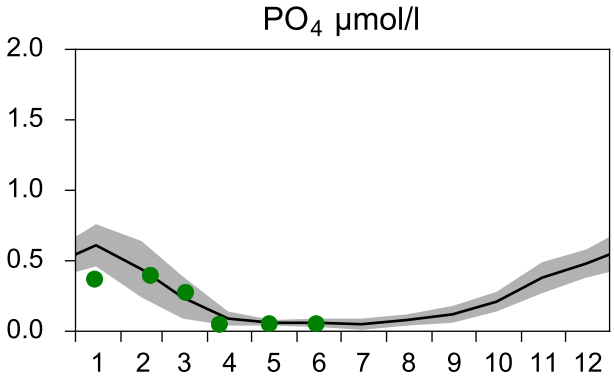
STATION P2 SURFACE WATER (0-10 m)

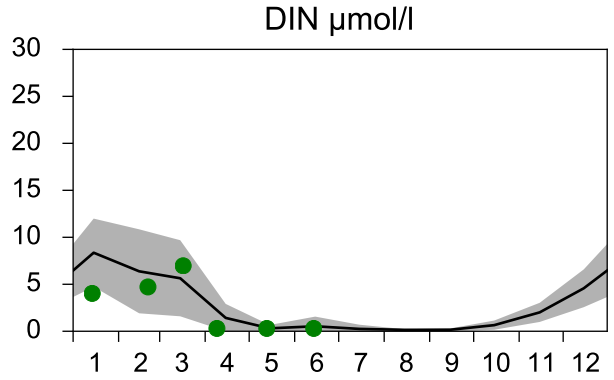
Annual Cycles

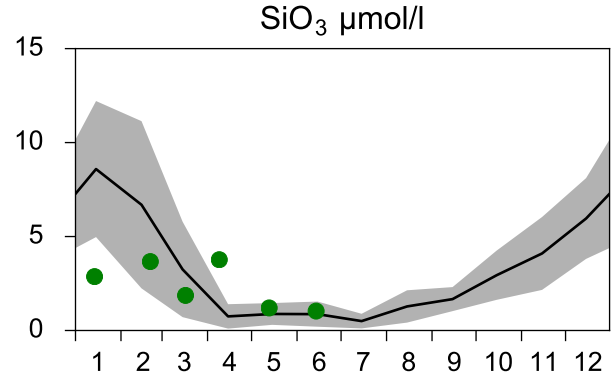
Mean 2001-2015 St.Dev. 2019

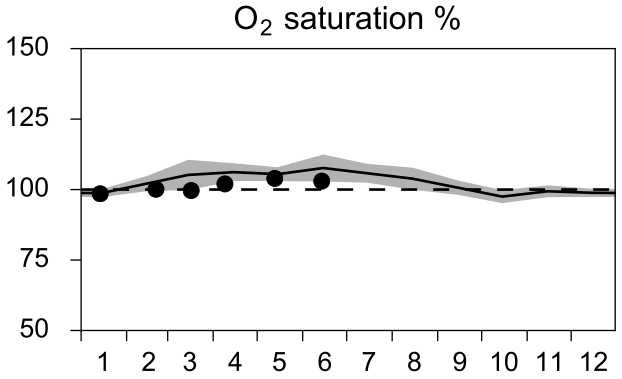




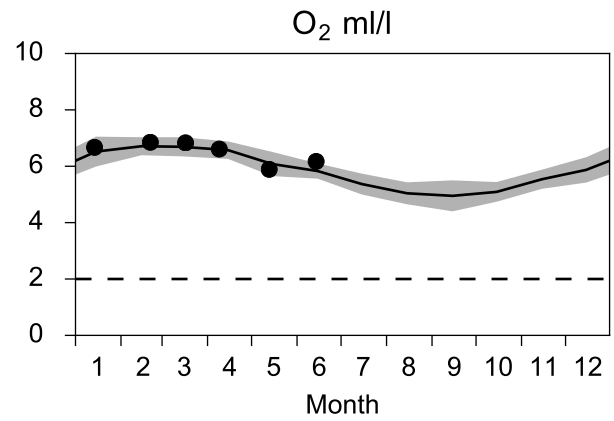


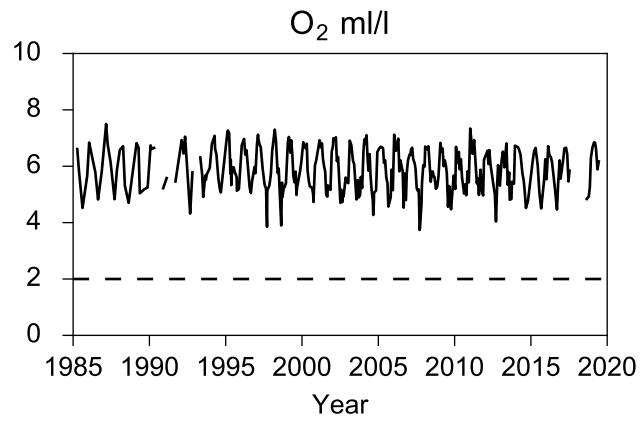




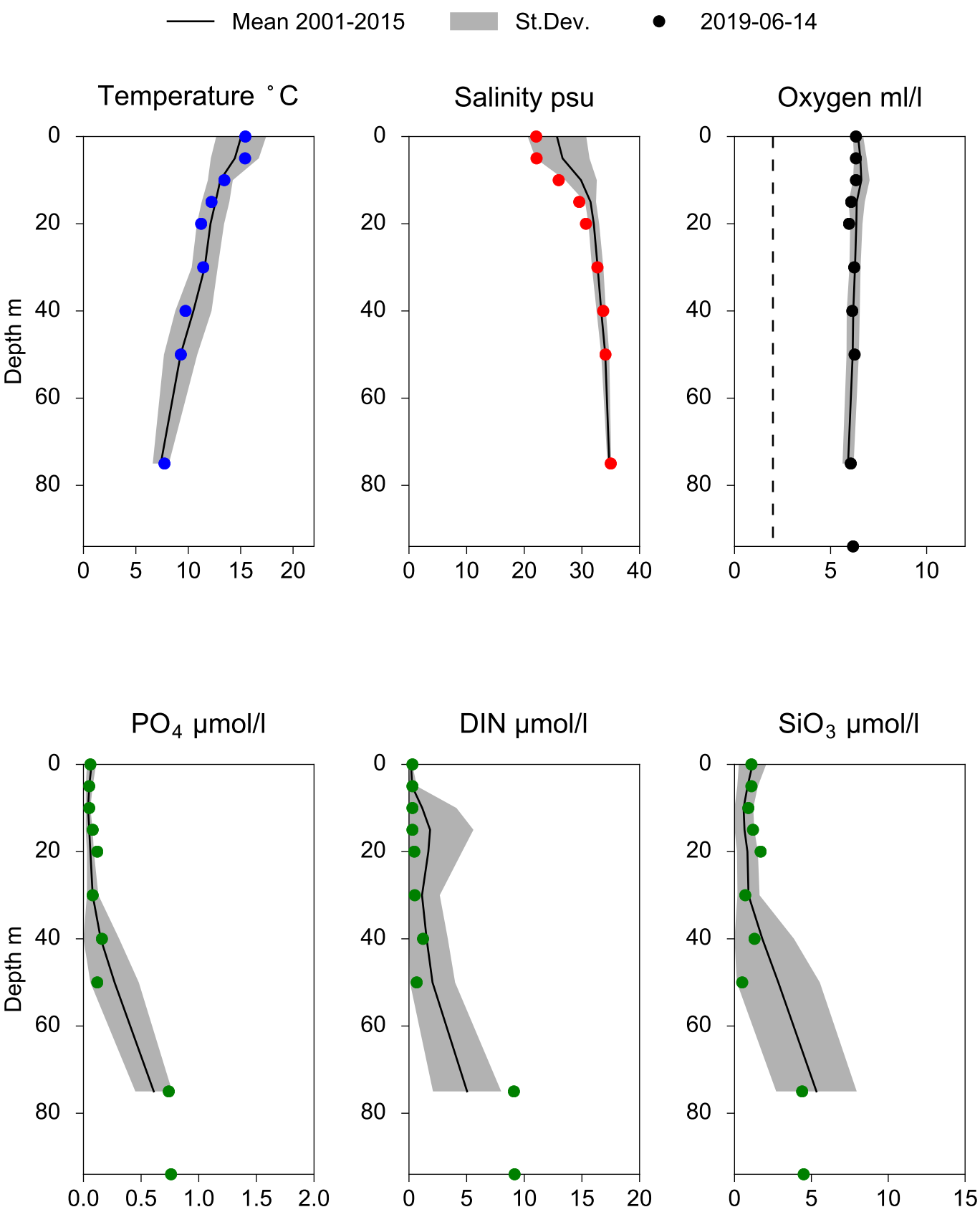


OXYGEN IN BOTTOM WATER (depth >= 75 m)



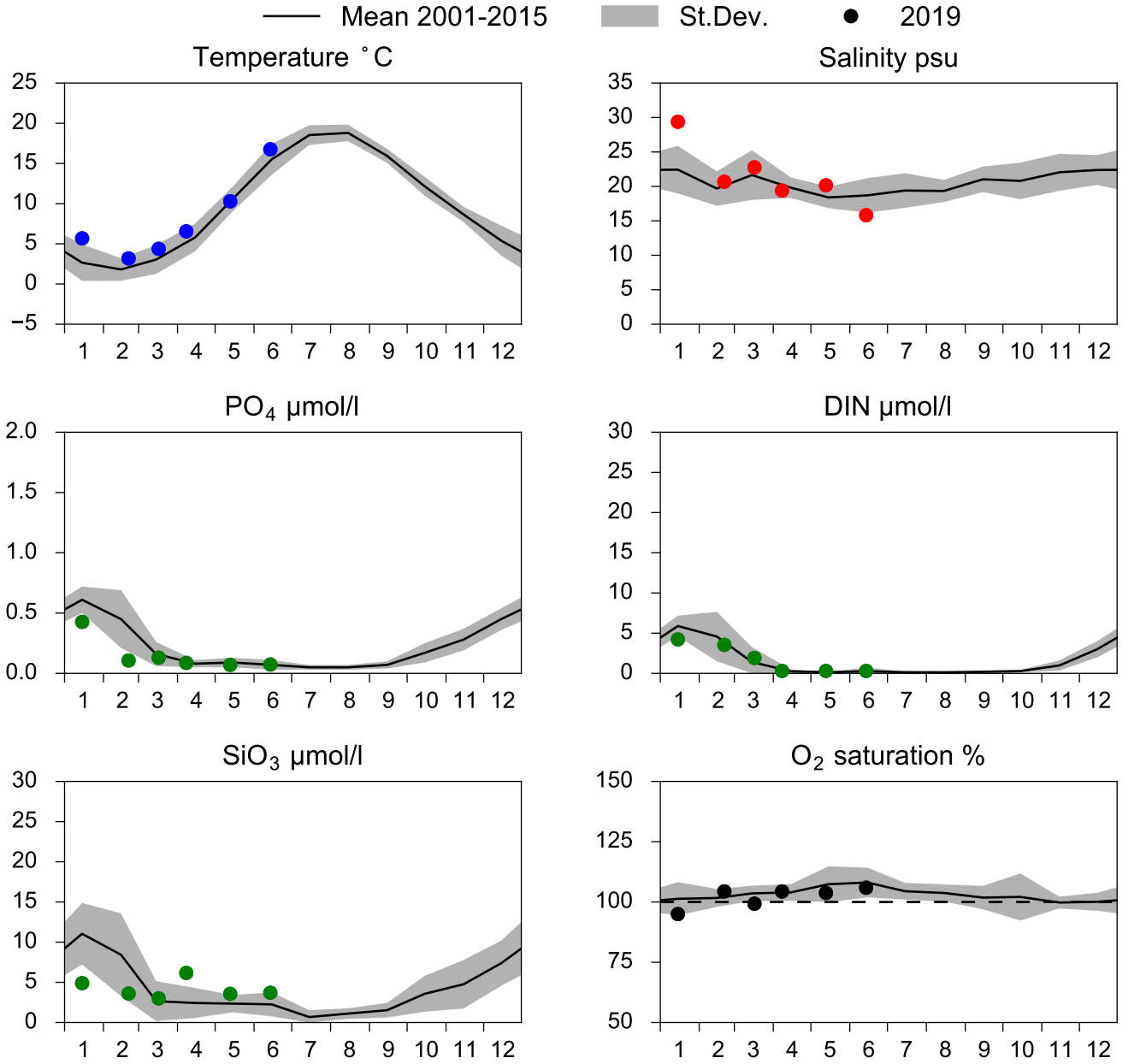


Vertical profiles P2
June

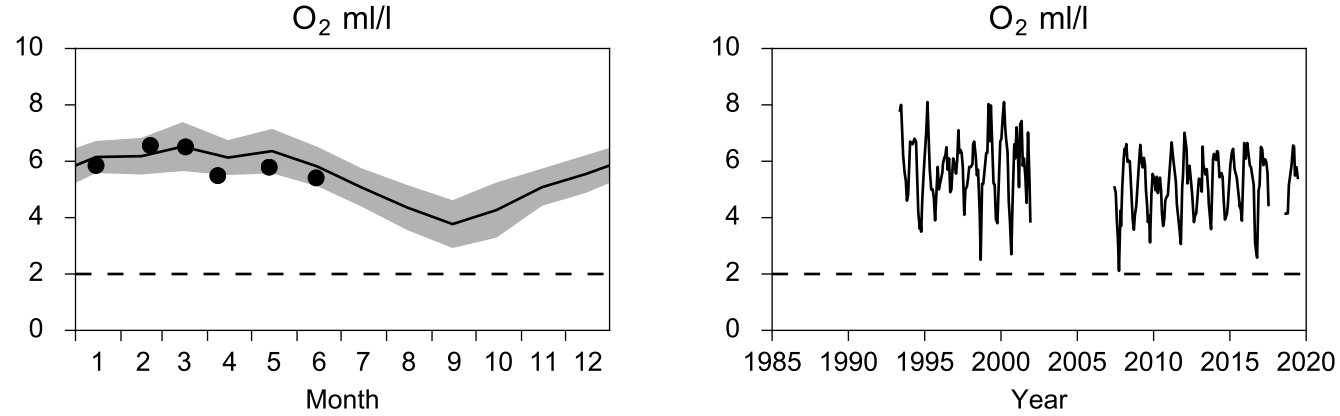


STATION N14 FALKENBERG SURFACE WATER (0-10 m)

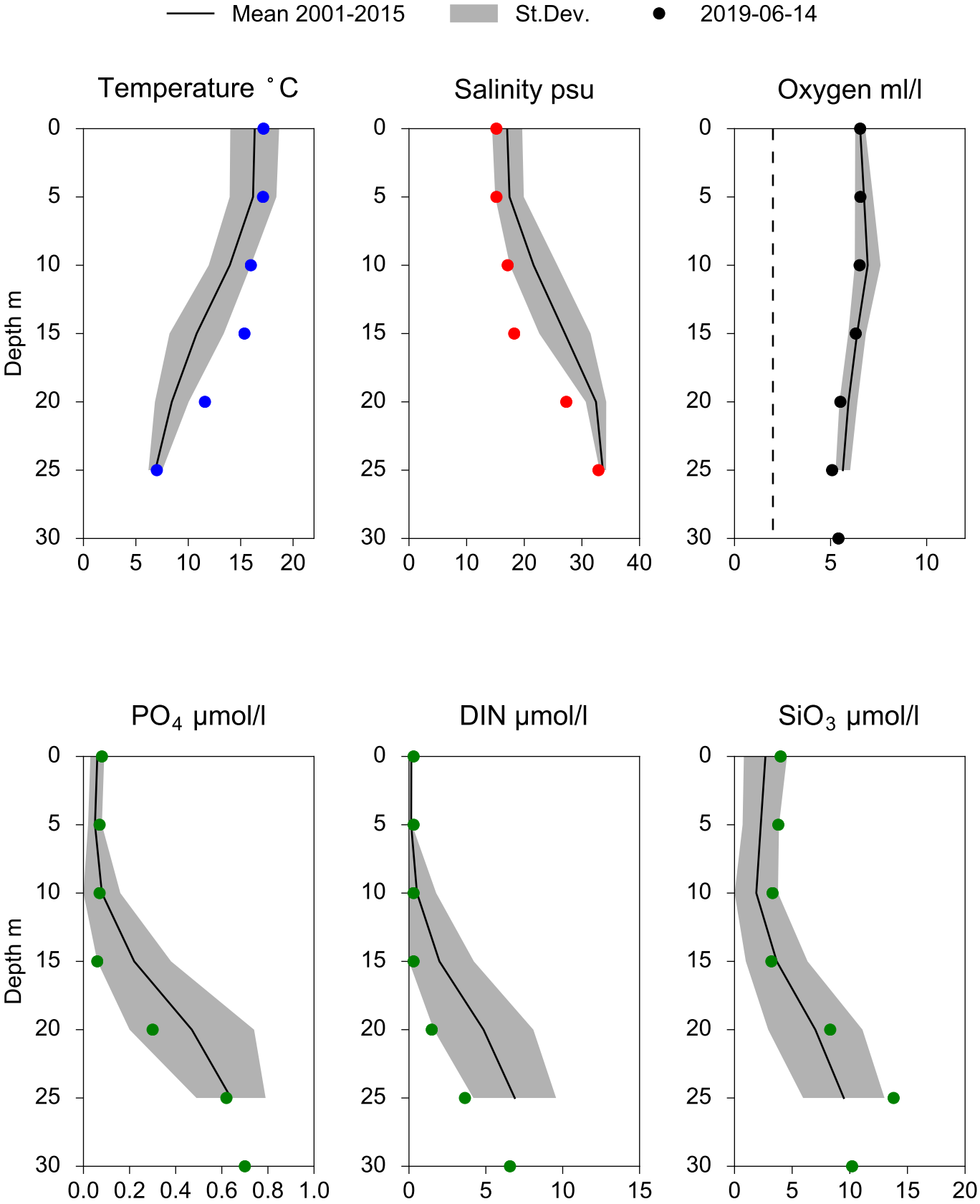
Annual Cycles



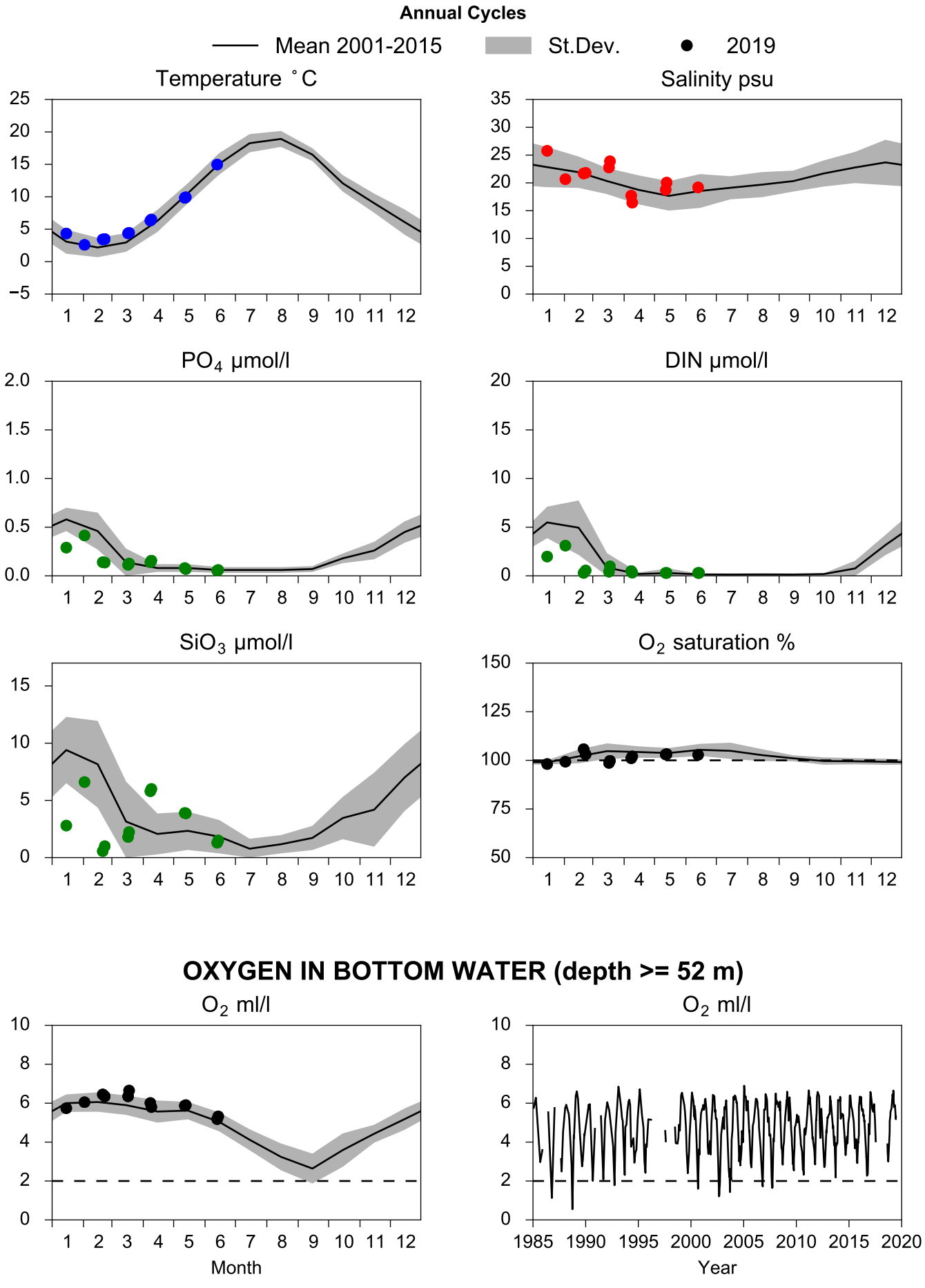
OXYGEN IN BOTTOM WATER (depth >= 25 m)



Vertical profiles N14 FALKENBERG
June

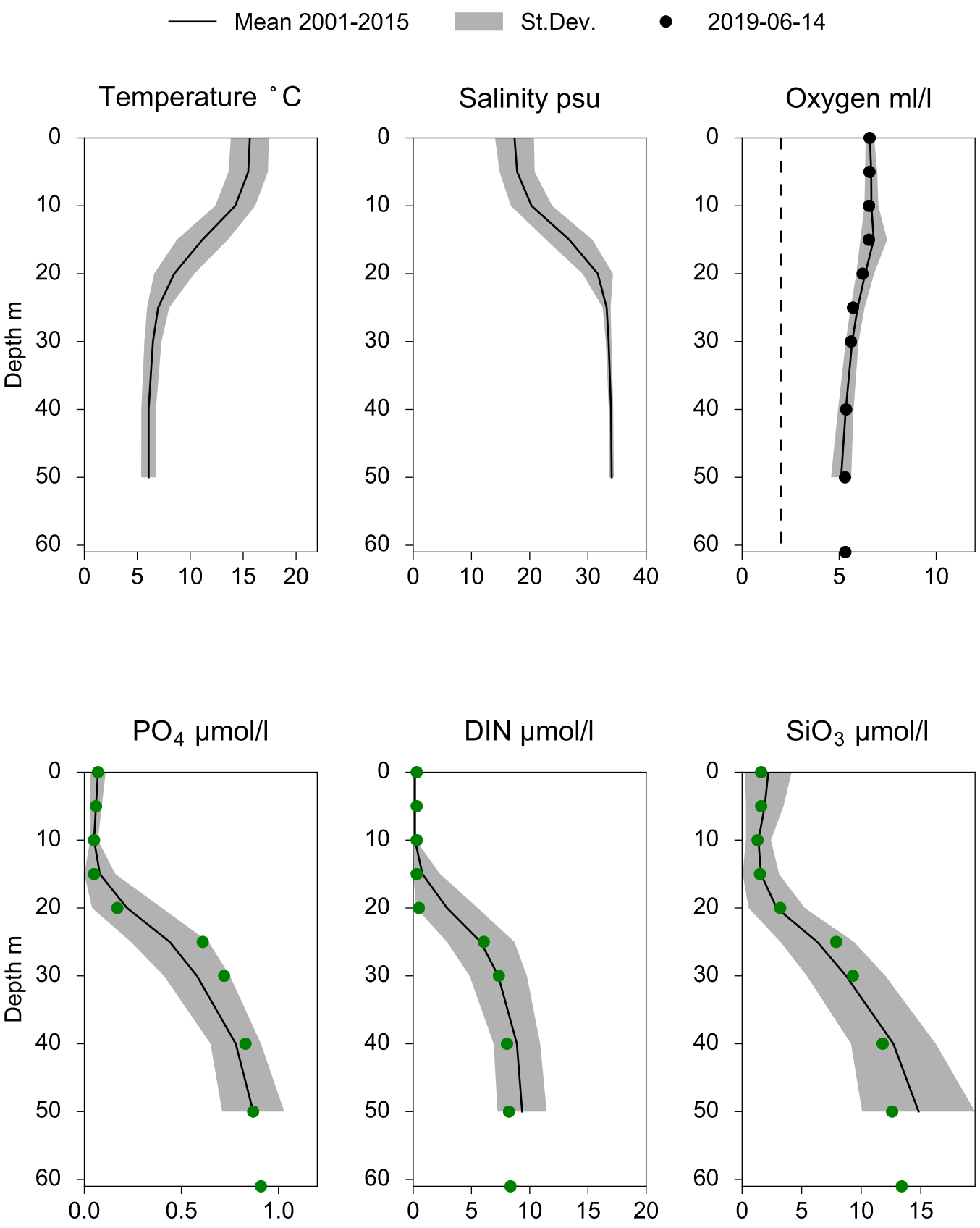


STATION ANHOLT E SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 52 m)

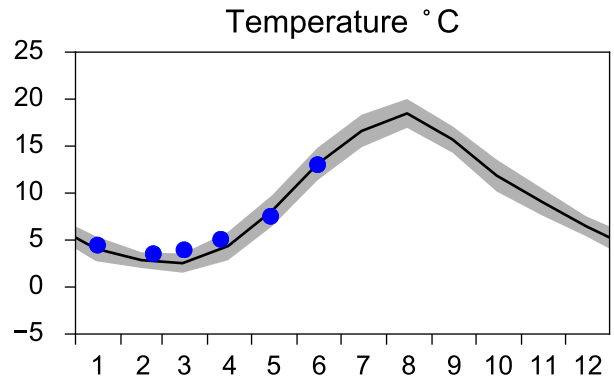
Vertical profiles ANHOLT E
June

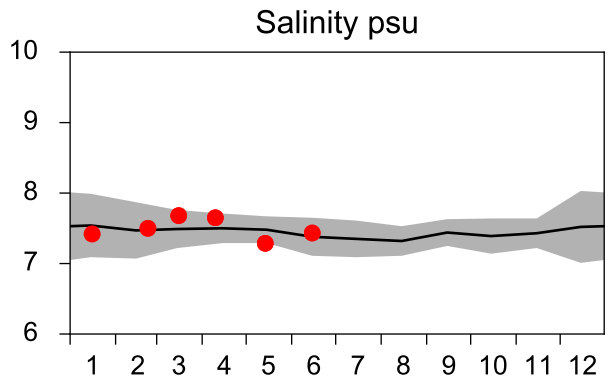


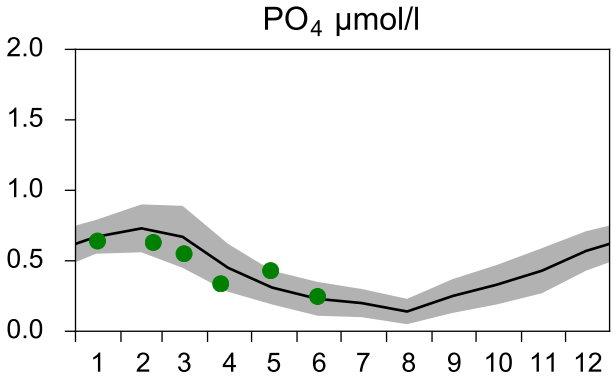
STATION HANÖBUKTEN SURFACE WATER (0-10 m)

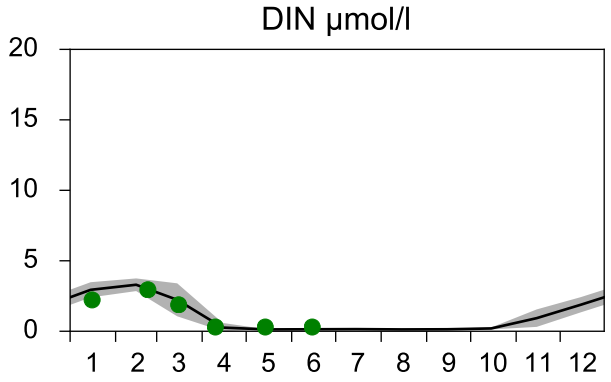
Annual Cycles

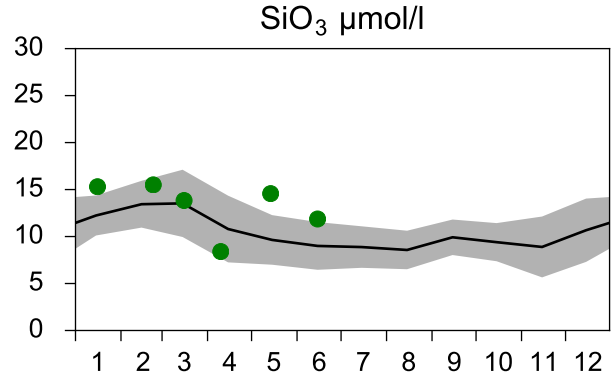
Mean 2001-2015 St.Dev. 2019

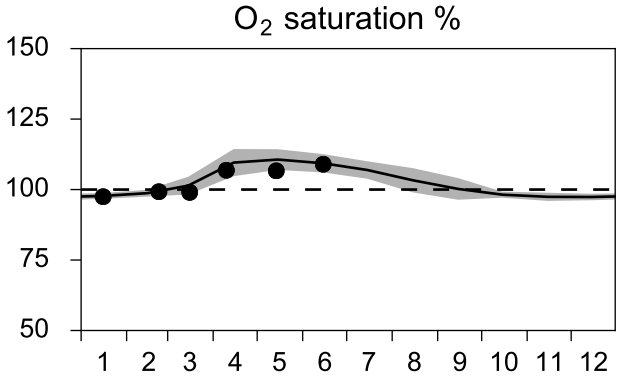




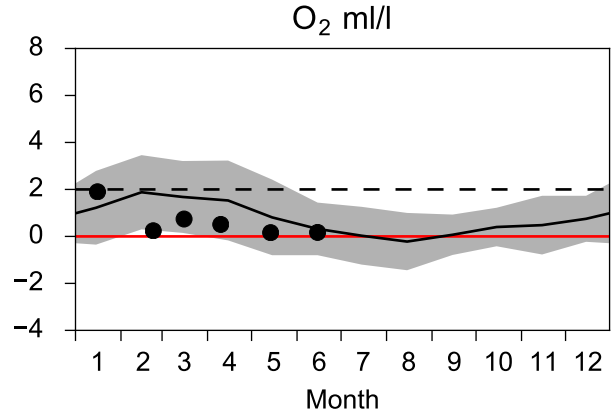


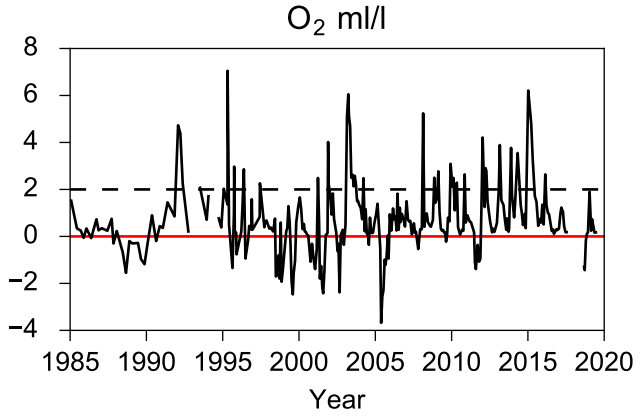




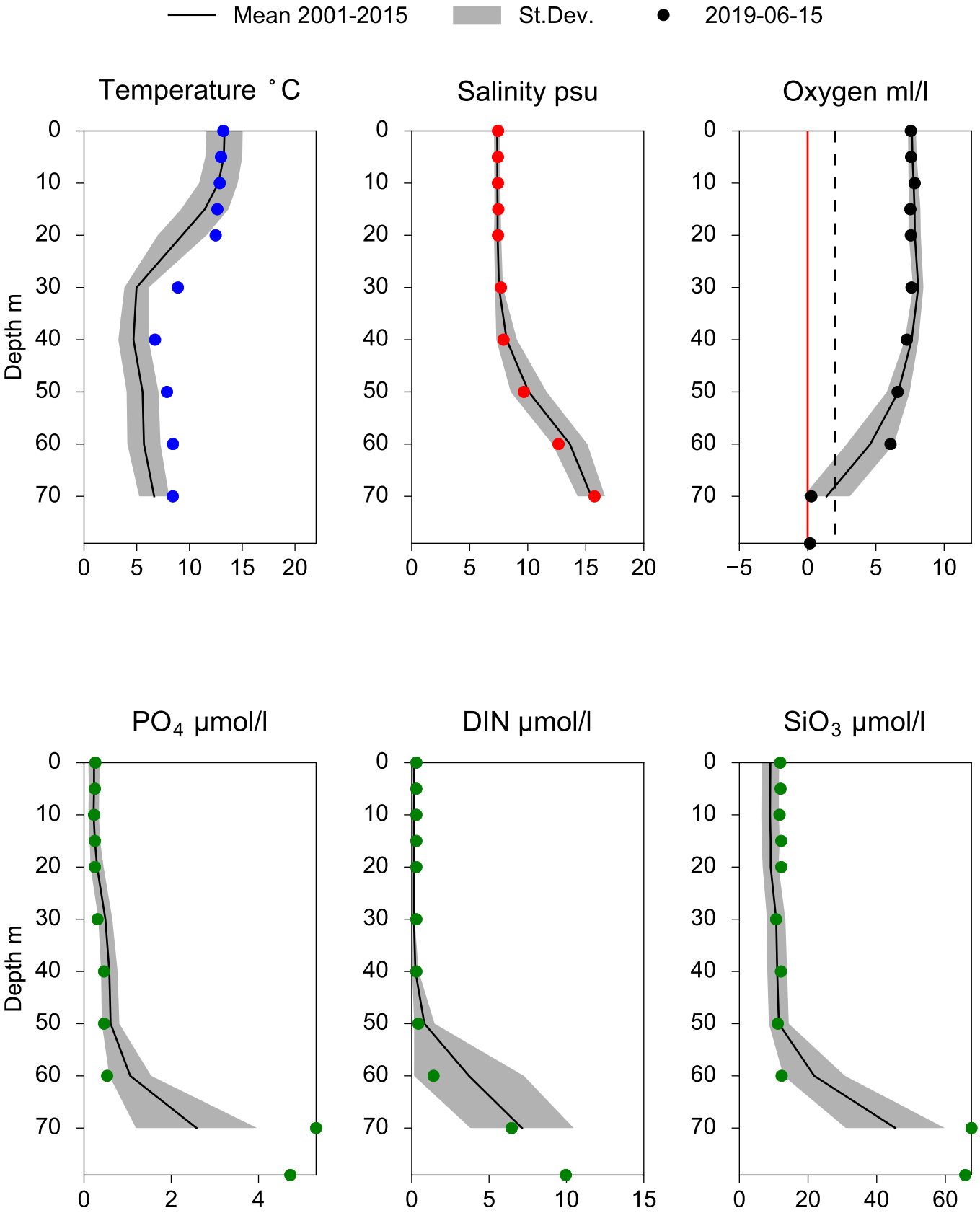


OXYGEN IN BOTTOM WATER (depth >= 70 m)

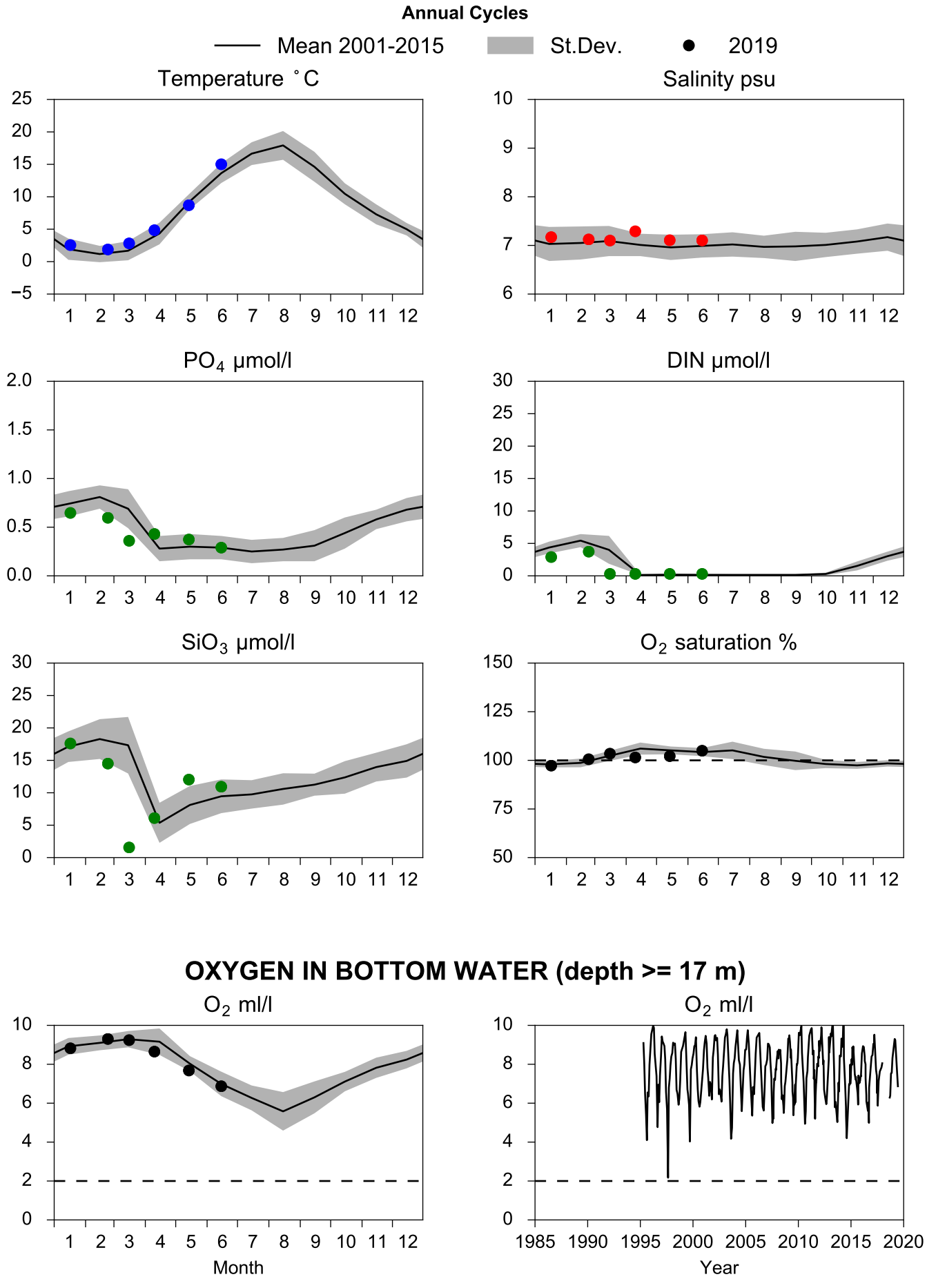




Vertical profiles HANÖBUKTEN
June

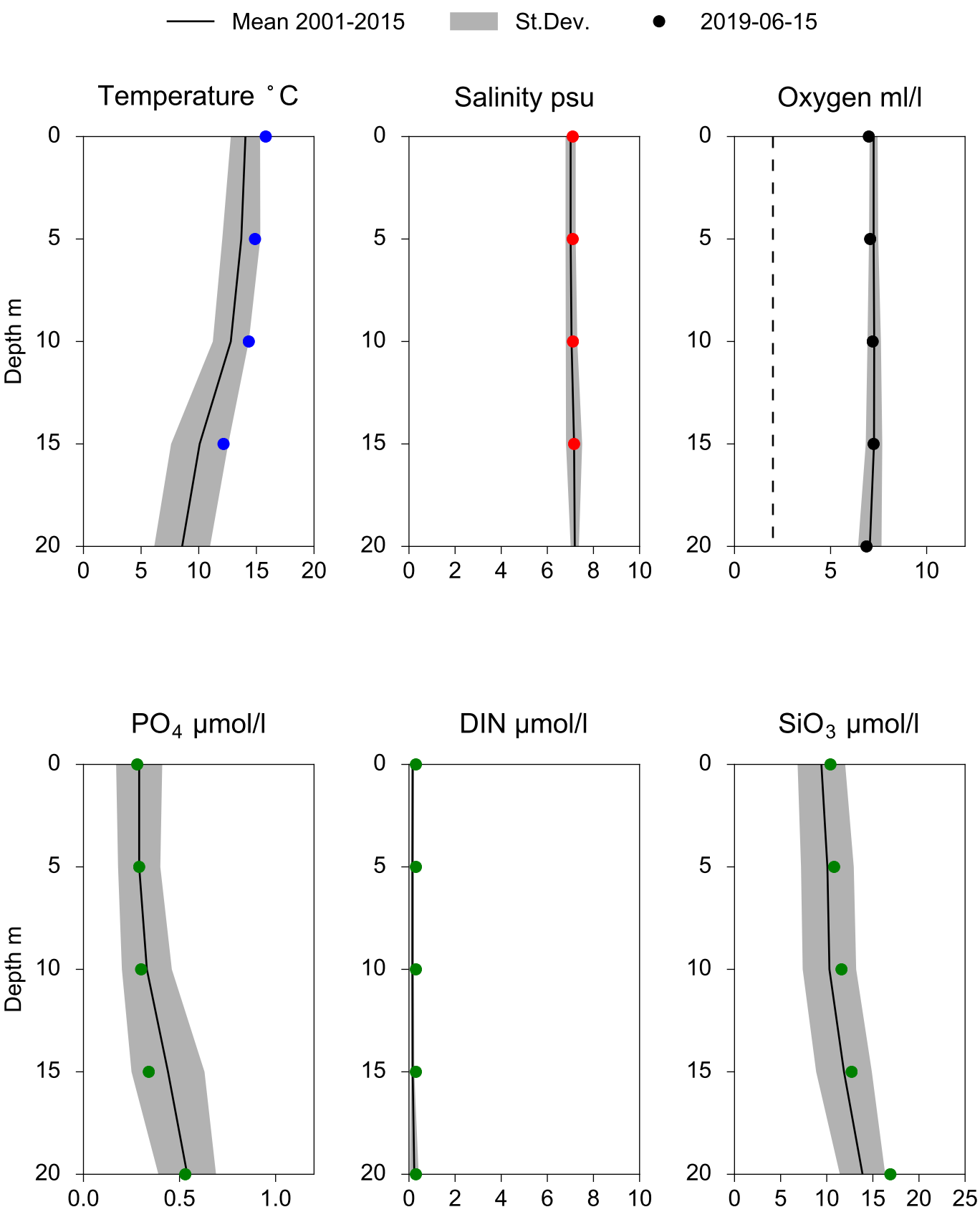


STATION REF M1V1 SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 17 m)

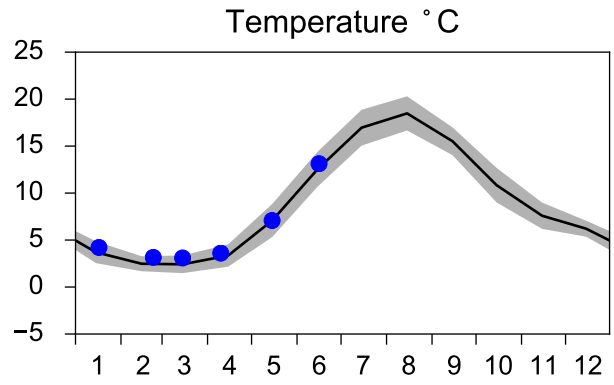
Vertical profiles REF M1V1
June

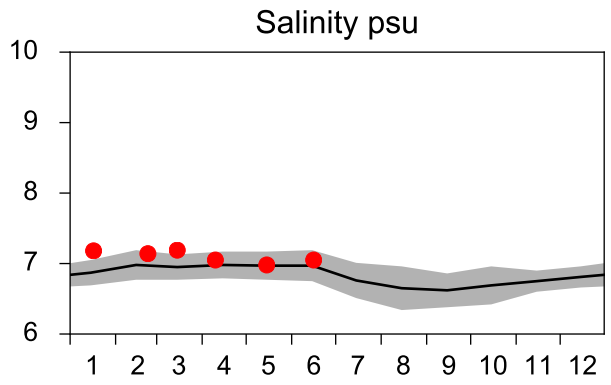


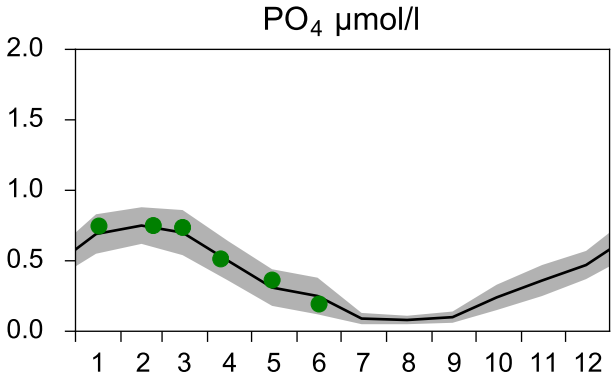
STATION BY38 KARLSÖDJ SURFACE WATER (0-10 m)

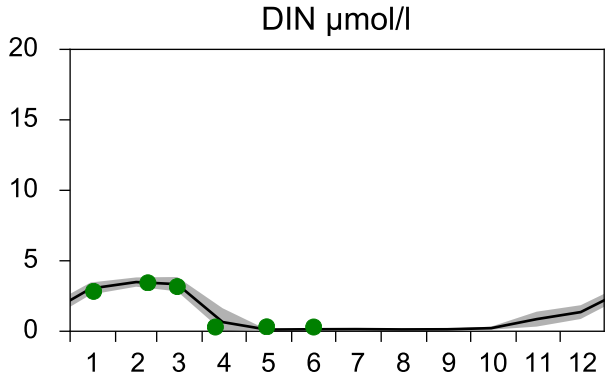
Annual Cycles

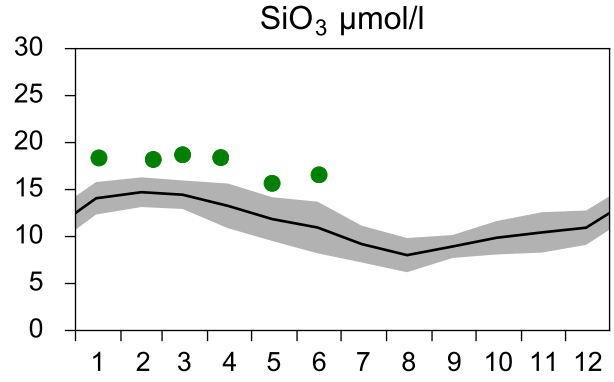
Mean 2001-2015 St.Dev. 2019

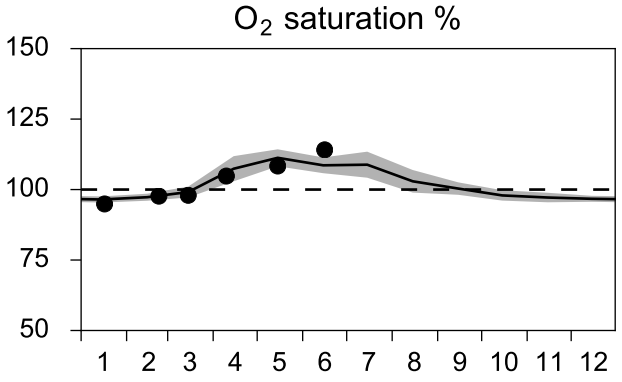




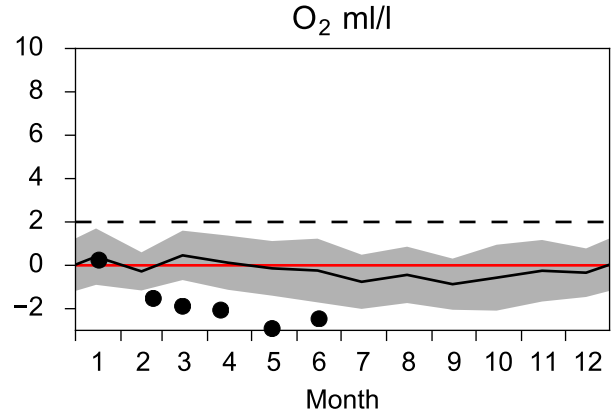


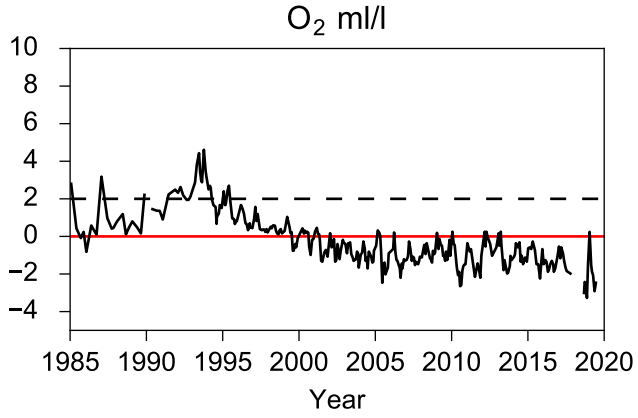




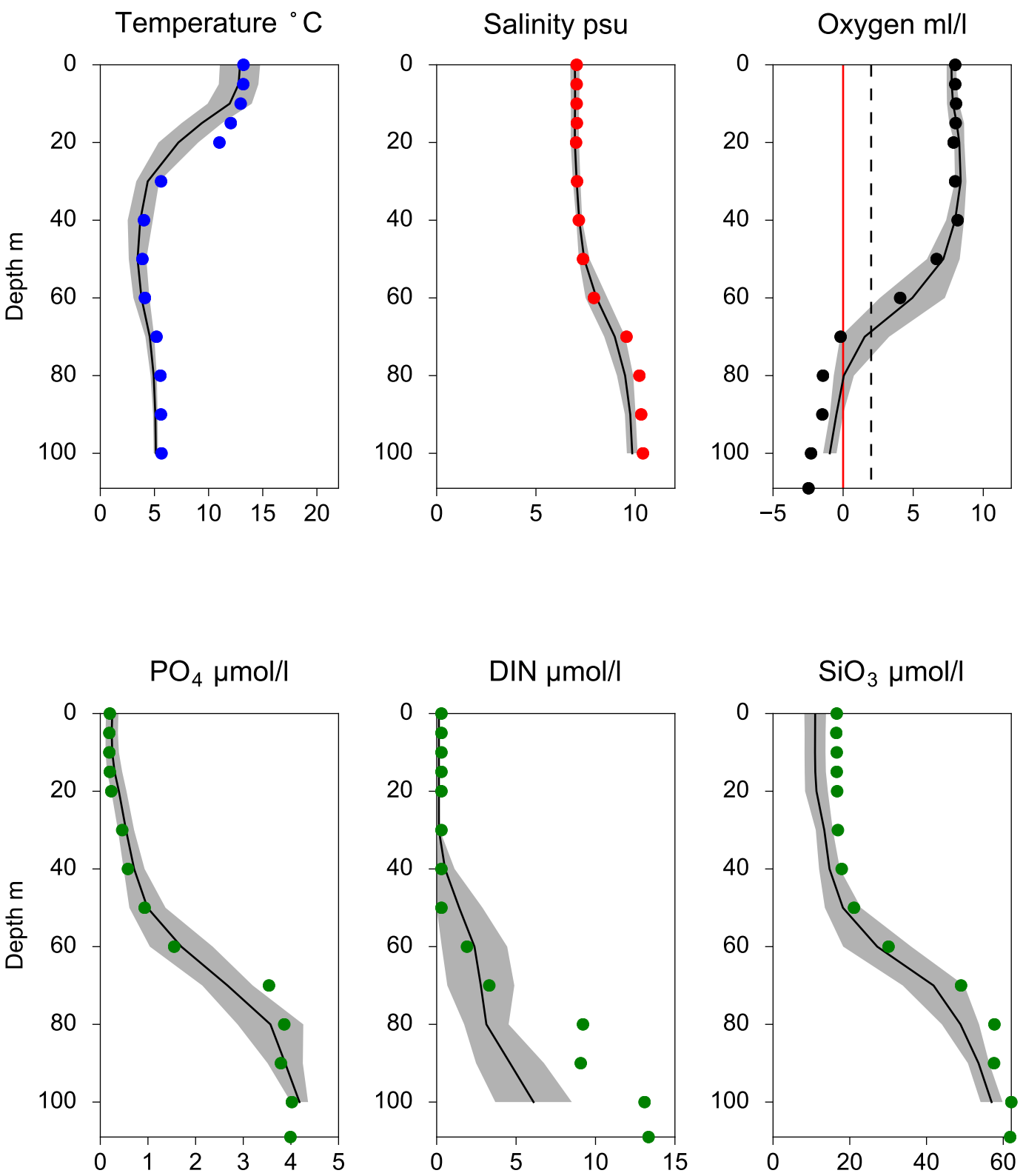


OXYGEN IN BOTTOM WATER (depth >= 100 m)

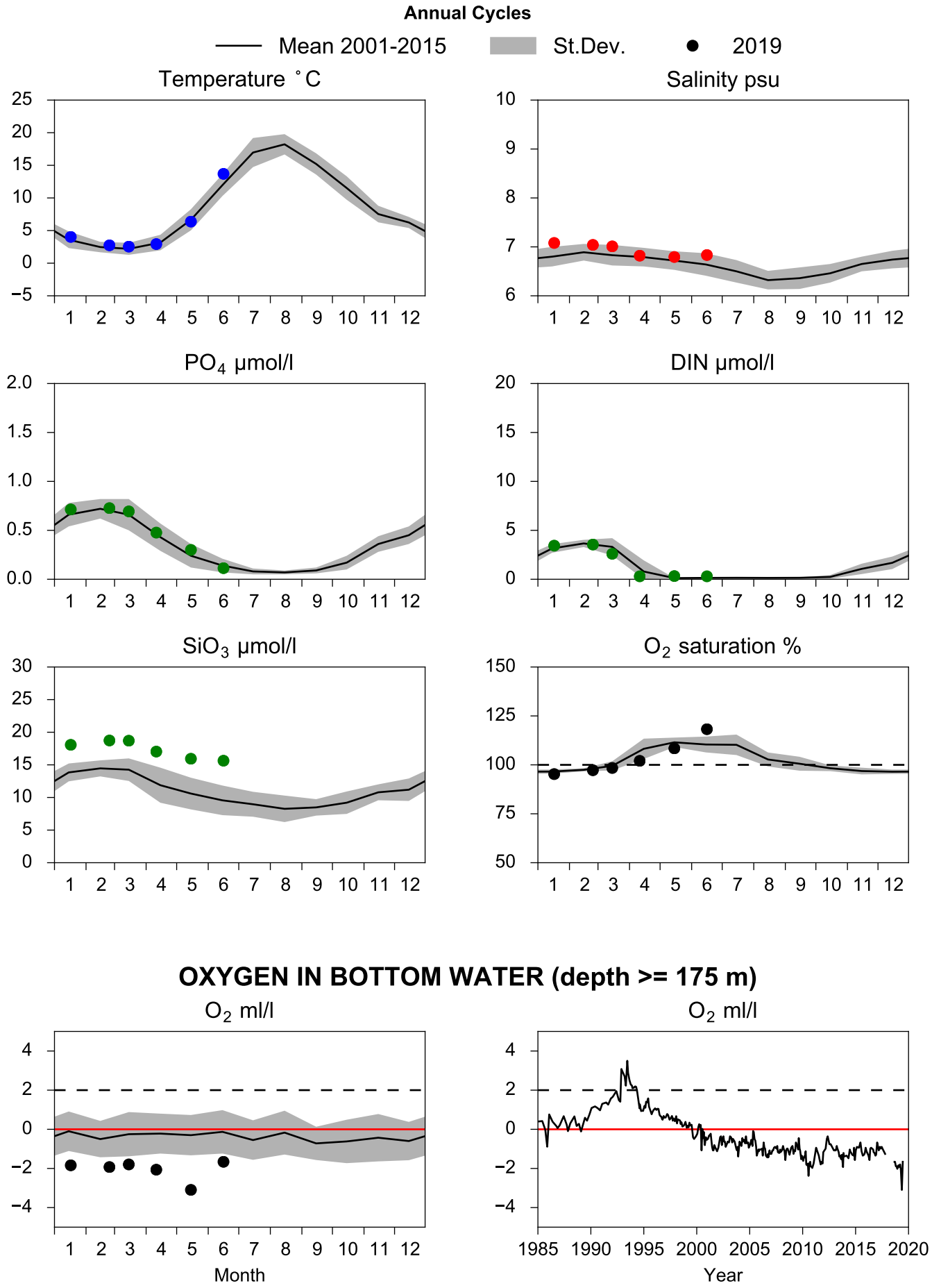




Vertical profiles BY38 KARLSÖDJ
June



STATION BY32 NORRKÖPINGSDJ SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 175 m)

Vertical profiles BY32 NORRKÖPINGSDJ
June