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2017-07-19
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Report from the SMHI monitoring cruise with R/V Aranda

Survey period: 2017-07-10 - 2017-07-17
Principal: Swedish Meteorological and Hydrological Institute (SMHI), Swedish Agency for Marine and Water Management (SwAM).
Cooperation partners: Finnish Environment Institute (SYKE)

SUMMARY

The July cruise, which is part of the Swedish national marine monitoring programme, covered the Skagerrak, the Kattegat, the Sound, the Baltic Proper and the Gulf of Finland. Phytoplankton was analysed on board.

Oxygen concentrations close to zero were observed in the deep water everywhere in the Baltic Proper except for in the Arkona Basin. Anoxic conditions, when hydrogen sulphide forms, were measured in the Western Gotland Basin from about 80 metres depth, in the Eastern Gotland Basin nearest the bottom at BY20 and at BY15 Gotlandsdjupet from 220 meters. At the previous expedition in June, hydrogen sulphide was present at the bottom at 4-CTRY-BP but now it was again oxygenated. Areas with acute hypoxia (dissolved O_2 < 2 ml/l) were found in the Bornholm Basin at 80 meters and in the Eastern Gotland Basin and the Western Gotland Basin starting at around 70 metres.

The nutrients DIN and DIP were generally depleted in the surface water which is normal at this time of year. In the southwestern Baltic Proper small amounts of phosphate was measured. Surface concentrations of silicate were still above normal in the Baltic Proper.

The surface water temperature was normal for the season except from the Eastern Gotland Basin where it was colder than normal; the variations were 14.8-17.6 °C on the west coast of Sweden and between 12.9 and 16.5 °C in the Baltic Proper. The salinity in the surface water was normal except from the Skagerak where it was higher than normal. Salinity variations were 14.2-32 psu on the west coast and 6.4-8.0 psu in the Baltic Proper.

Next regular cruise is scheduled to start in September and at that time with another ship.

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RESULTS

The expedition was conducted aboard the Finnish research vessel Aranda, it started in Helsinki on the 10th of July and ended in the same harbour the 17th. The winds during the expedition were dominated by mainly weak winds from west – southwest. The strongest wind was in outer Skagerak with 13 m/s.

Phytoplankton samples were analysed aboard during the expedition by phytoplankton expert Marie Johansen, the results will eventually be published in the July Algaware report; https://www.smhi.se/en/publications/algal-situation-reports-2-1056, a summary can be found below:

The diatom *Proboscia alata* was found in high concentrations at all stations in the Skagerrak and in Kattegat. The species diversity was generally low at all stations on the west coast. In the Baltic Proper surface aggregations could be seen from the bridge of the ship north east of Gotland and along the east coast of Öland. Small surface accumulations in forms of small streaks were also seen from sampling position close to south of Öland. The amount of cyanobacteria in the water column in most of the Baltic indicates that as soon as the wind stress goes down surface accumulations can start to appear quickly.

SMHI performs daily algae monitoring by satellite during the summer, results are available at https://www.smhi.se/en/weather/sweden-weather/the-algae-situation.

During the expedition net samples of jelly fish was made in order to develop methods for monitoring. The samples were photographed and the images will later be analysed.

An international team of scientists from the EU funded project JERICO-NEXT took part in the cruise. The aim of the work was to use novel methods to investigate the plankton community with a focus on harmful algae, e.g. toxin producing cyanobacteria. Preliminary results show that the toxin producing species *Nodularia spumigena* was common in the Baltic Proper, especially in the NW part. Also other types of harmful algae were found. Picoplankton, i.e. very small plankton (< 2µm) were the most abundant phytoplankton. Samples were collected at the monitoring stations and continuously underway using a pumped system sampling from 5 m depth. An underwater camera system (UVP5) mounted on the CTD rig revealed the distribution of aggregates of cyanobacteria, zooplankton etc. Flow cytometry and imaging in flow systems (CytoSense and FlowCam), a type of automated microscope, was used to study the composition and distribution of phytoplankton. On board microscopy was used to complement and validate results from automated sensors. Novel methodology (FRRF) to study photosynthesis related parameters of the plankton were also used. More information about the project: www.jerico-ri.eu

This report is based on data that have passed a first quality control. When data are published at the nation 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 center's webpage, normally within a week after the cruise.

Download data here: http://www.smhi.se/klimatdata/oceanografi/havsmiljodata (only available in Swedish)

The Skagerrak

The surface water temperature in the Skagerrak was highest close to the coast and lower than normal at the outer parts. The temperature varied between 14.8 and 17.6 °C. The salinity in the surface was higher than normal and varied between 27 psu at Släggö and 32 psu at the outer parts. The surface water was well mixed down to 5-10 meters where thermocline and halocline coincided. A deeper stratification was found around 30-50 meters.

All concentrations of nutrients in the surface water were very low which is normal for this time of year. The level of dissolved inorganic nitrogen, DIN, (which is the sum on nitrate, nitrite and ammonia) was depleted down to 50 meters at P2, 20 meters at Å17-Å13 and to 15 meters at the coast (Släggö). The concentrations of dissolved inorganic phosphorous, DIP, (only available in the form of phosphate) as well as silicate were near the detection limit in the entire area. At P2 below 40 meters concentrations of silicate was lower than normal.

Concentrations of dissolved oxygen were normal in the entire water column at all sampled stations. The concentration of oxygen at Å15, 50 meters, was higher than surrounding water and this coincided with a peak in fluorescence.

The fluorescence sond at the CTD generally showed higher levels of fluorescence below the thermocline in a layer between 10-50 meters.

The Kattegat and the Sound

In the Kattegat and the Sound surface water temperature was mostly normal and varied between 16.5-17.2°C, warmest close to the coast of Kattegat at N14 Falkenberg. The surface salinity was also normal and varied from 14.2 psu in the Sound to 24.6 psu at the most northern station Fladen. The surface water was well mixed down to about 10 meters where the thermocline coincided with the halocline.

All concentrations of nutrients were normal for the season in the entire Kattegat and the Sound. In Kattegat, DIN was depleted down to 20 meters and phosphate down to 15 meters. The concentration of silicate in the surface water varied between 0.9-1.1 µmol/l. In surface water of the Sound, the concentration of phosphate was 0.2 µmol/l, silicate about 10 µmol/l while the dissolved inorganic nitrogen was depleted.

Fluorescence measurements with the CTD showed higher levels below the thermocline than at the surface.

Oxygen concentrations close to the bottom in the area were at normal levels around 4.4 ml/l in the Kattegat and 3.9 ml/l in the Sound.

The Baltic Proper

The temperature in the surface water in the Baltic Proper was lower than normal and varied between 12.9 to 16.5 °C. The salinity in the surface water was normal, 6.4-8.0 psu, and in the northern part of the Eastern Gotland Basin it was lower than the last expedition in June. A clear halocline was found about 60-70 meters except from in the Arkona Basin which is more shallow and because of

that has a more shallow halocline at about 35 meters. The surface temperature is warmed up during this time of year and a thermocline has developed at 20 meters. The temperature is lower below the thermocline and increases again below the halocline. The salinity in the Eastern Gotland Basin deep water, below the halocline, was higher than normal.

The dissolved inorganic nitrogen was depleted in the surface water down to 50 meters in the Gotland Basins, to 40 meters in the Bornholm Basin and down to 30 meters in the Arkona Basin. The amount of nutrients is generally increasing below the halocline as a consequence of mineralisation. Some stations are reached by inflows of deep water with larger oxygen content and this some of the ammonia, a mineralisation product, is oxidised and the level of dissolved inorganic nitrogen decreases. This process is seen in the Bornholm Basin and in the Eastern Gotland Basin where the dissolved inorganic nitrogen was lower close to the bottom. The dissolved inorganic nitrogen at BY15 Gotland Deep was lower than normal below 175 meters but the level increased again at 220 meters because of oxygen depletion.

There was still phosphate left in the surface water but in very low concentrations; in the Gotland Basins about 0.07 µmol/l and in the southwestern parts of Baltic Proper about 0.2 µmol/l. The concentrations of silicate above the halocline were still above normal in the entire Baltic Proper and varied as the lowest from 12.3 µmol/l in the Easter Gotland Basin to the highest 15.9 µmol/l in the Bornholm Basin.

Oxygen concentrations close to zero were observed in the deep water everywhere in the Baltic Proper except for in the Arkona Basin. Anoxic conditions, when hydrogen sulphide forms, were measured in the Western Gotland Basin from about 80 metres depth, in the Eastern Gotland Basin nearest the bottom at BY20 and at BY15 Gotlandsdjupet from 220 meters. At the previous expedition in June, hydrogen sulphide was present at the bottom at 4-CTRY-BP but now it was again oxygenated. Areas with acute hypoxia (dissolved O_2 < 2 ml/l) were found in the Bornholm Basin at 80 meters and in the Eastern Gotland Basin and the Western Gotland Basin starting at around 70 metres. In the Arkona Basin the entire water column was well oxygenated.

Fluorescence measurements with the CTD showed high phytoplankton activity just above the thermocline. The lack of nutrients in the form of DIN suggests that it is nitrogen-fixing cyanobacteria that can fix atmospheric nitrogen when DIN is scarce, this was also confirmed aboard by analysing samples in microscope.

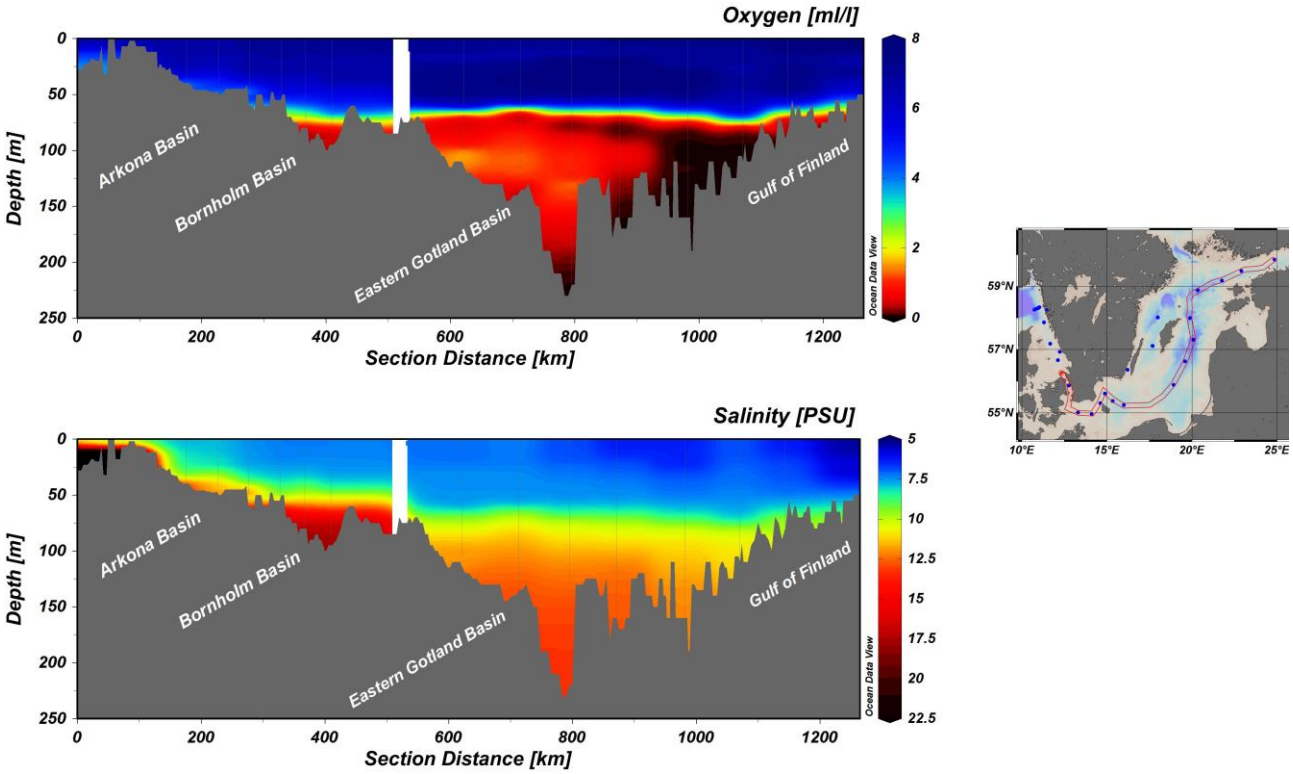

Figure 1. Transect showing oxygen and salinity through the Baltic Proper, from the Sound to the Gulf of Finland.

PARTICIPANTS

Name		**From**
Karin Wesslander	Chief Scientist	SMHI
Marie Johansen		SMHI
Sara Johansson		SMHI
Ann-Turi Skjevik		SMHI
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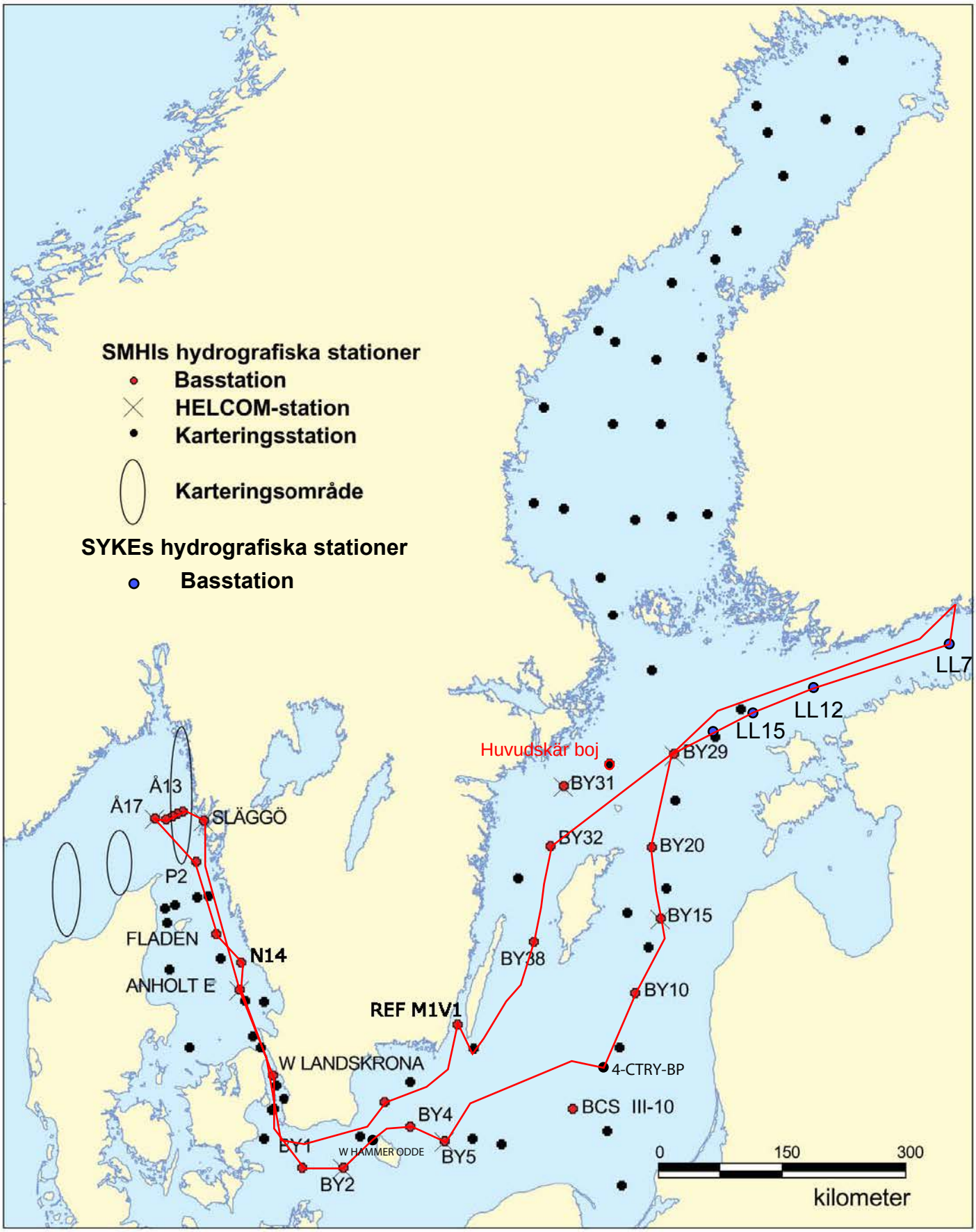
Fabrice Lizon		University of Lille, France
Sirpa Lehtinen		SYKE
Lars Stemman		Observatoire Océanologique de Villefranche sur Mer Villefranche-sur-Mer, Alpes Maritimes, France

APPENDICES

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

SMHI
Havs
och Vatten
myndigheten


SMHIs hydrografiska stationer
Basstation
HELCOM-station
Karteringsstation
Karteringsområde
SYKEs hydrografiska stationer
Basstation
LL7
LL12
LL15
BY29
Huvudskär boj
BY31
BY32
BY20
BY15
BY38
BY10
4-CTRY-BP
BCS III-10
REF M1V1
W LANDSKRONA
BY4
BY5
W HAMMER ODDE
BY1
BY2
Å13
Å17
SLÄGGÖ
P2
FLADEN
N14
ANHOLT E
0
150
300
kilometer

Date: 2017-07-17
Time: 11:41

Ship: AR
Year: 2017

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 (Weather, Cloud, Wave, Ice)	CZPP (Chlorophyll, Zooplankton, Phytoplankton, Phytoplankton_sp)	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
0518	10	GFXX29	SYK	BY23 / LL7	5950.79	02450.27	20170710	1130	102	3	27	3	15.6	1013	1220	x---	13	13	x	x	x	x	-	x	x	x	x	x	x	x	x	x	x	-	x	-	x	x
0519	10	BPNX60	SYK	LL12	5929.01	02253.81	20170710	1740	83	4	25	3	15.4	1012	1120	x---	11	11	x	x	x	x	-	-	x	x	x	x	x	x	x	x	x	-	x	-	x	-
0520	10	BPNX62	SYK	LL15	5911	02144.80	20170710	2200	131		11	6.5	16.1	1011	9990	----	15	1	x	x	x	x	-	-	x	x	-	-	-	-	-	-	-	-	-	-	x	-
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0522	10	BPEX26	BAS...	BY20 FÅRÖDJ	5759.89	01952.72	20170711	0740	199	5	11	5.8	15.3	1001	4930	x---	17	17	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x	-	x	-
0523	10	BPEX21	BAS...	BY15 GOTLANDSDJ	5718.73	02004.57	20170711	1240	240	4	27	8	15.7	1002	2830	xxxx	19	18	x	x	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-
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0530	10	BPSA03	BAS...	BY2 ARKONA	5458.27	01405.93	20170712	2030	47		31	10	15.6	1007	9990	xxx-	8	8	x	x	x	x	-	x	x	-	x	x	x	x	x	x	x	-	x	x	x	-
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0536	10	SKEX23	BAS...	P2	5752	01117.52	20170713	2340	93		27	13	14.9	1012	9990	x---	10	10	x	x	x	x	-	x	x	-	x	x	x	x	x	x	x	-	x	-	x	-
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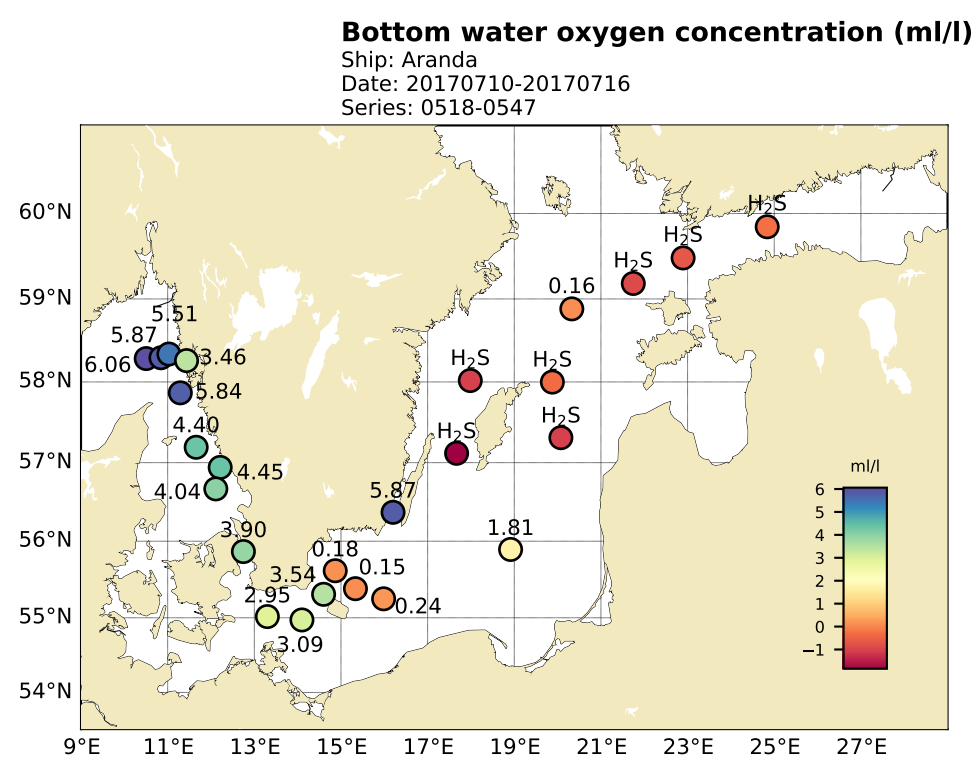
Bottom water oxygen concentration (ml/l)
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Date: 20170710-20170716
Series: 0518-0547
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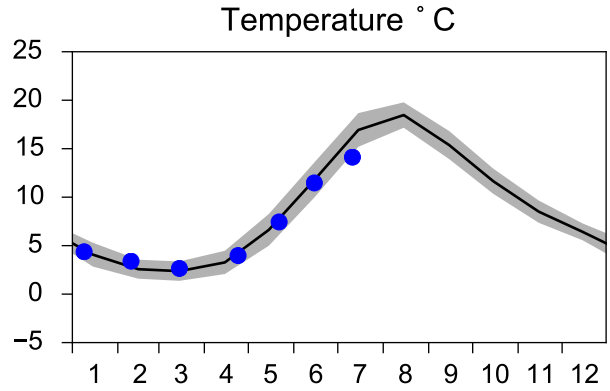
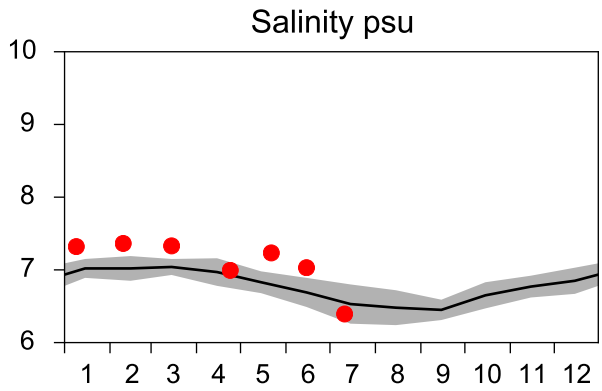
59°N
58°N
57°N
56°N
55°N
54°N
9°E
11°E
13°E
15°E
17°E
19°E
21°E
23°E
25°E
27°E
5.51
5.87
6.06
3.46
5.84
4.40
4.45
4.04
3.90
5.87
0.18
3.54
0.15
2.95
0.24
3.09
H2S
H2S
H2S
H2S
H2S
H2S
0.16
1.81
ml/l
6
5
4
3
2
1
0
−1

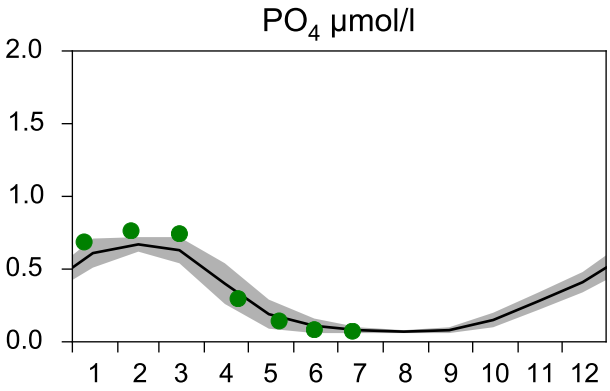
STATION BY20 FÅRÖDJ SURFACE WATER (0-10 m)

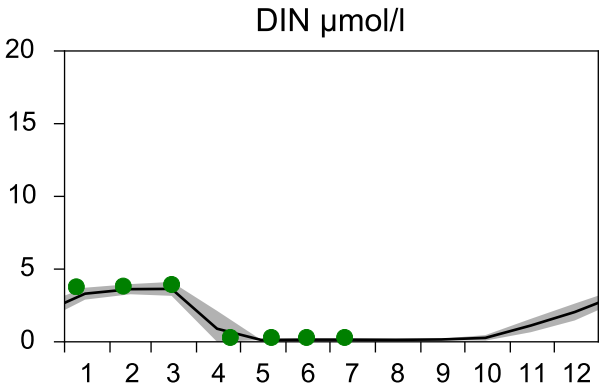
Annual Cycles

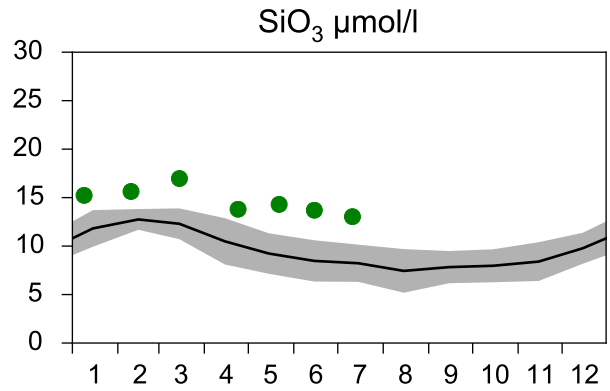
Mean 2001-2015 St.Dev. 2017

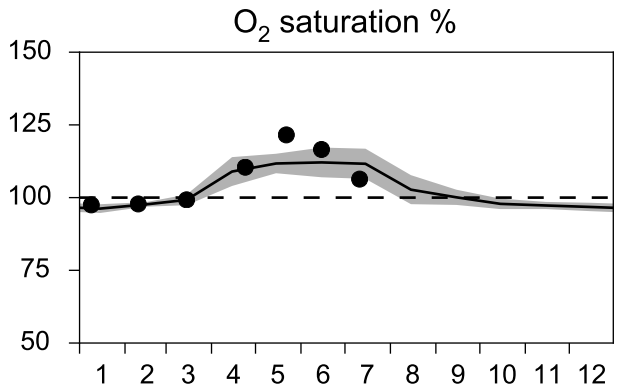




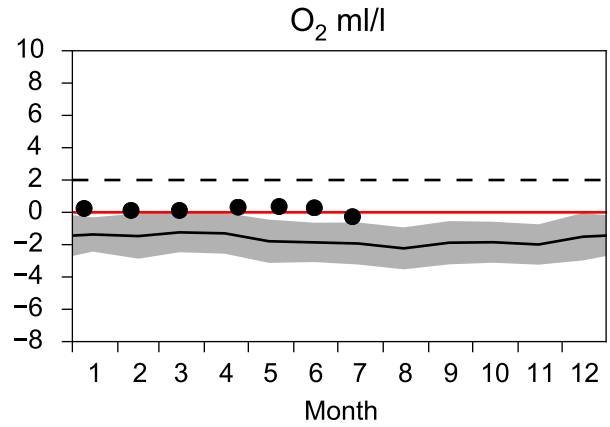


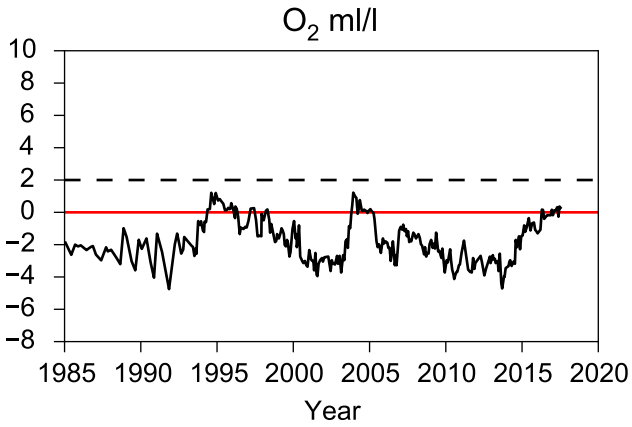




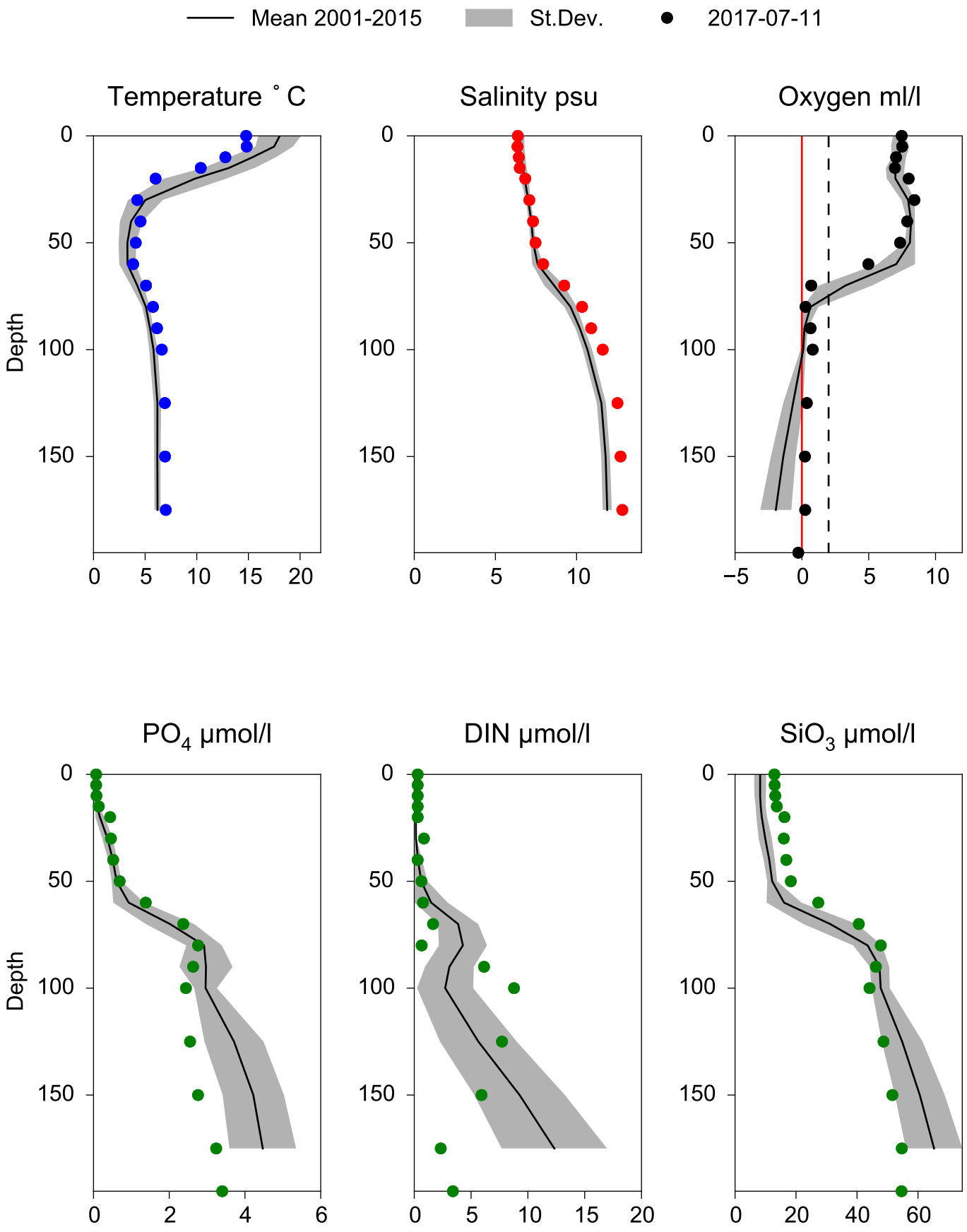


OXYGEN IN BOTTOM WATER (depth >= 175 m)

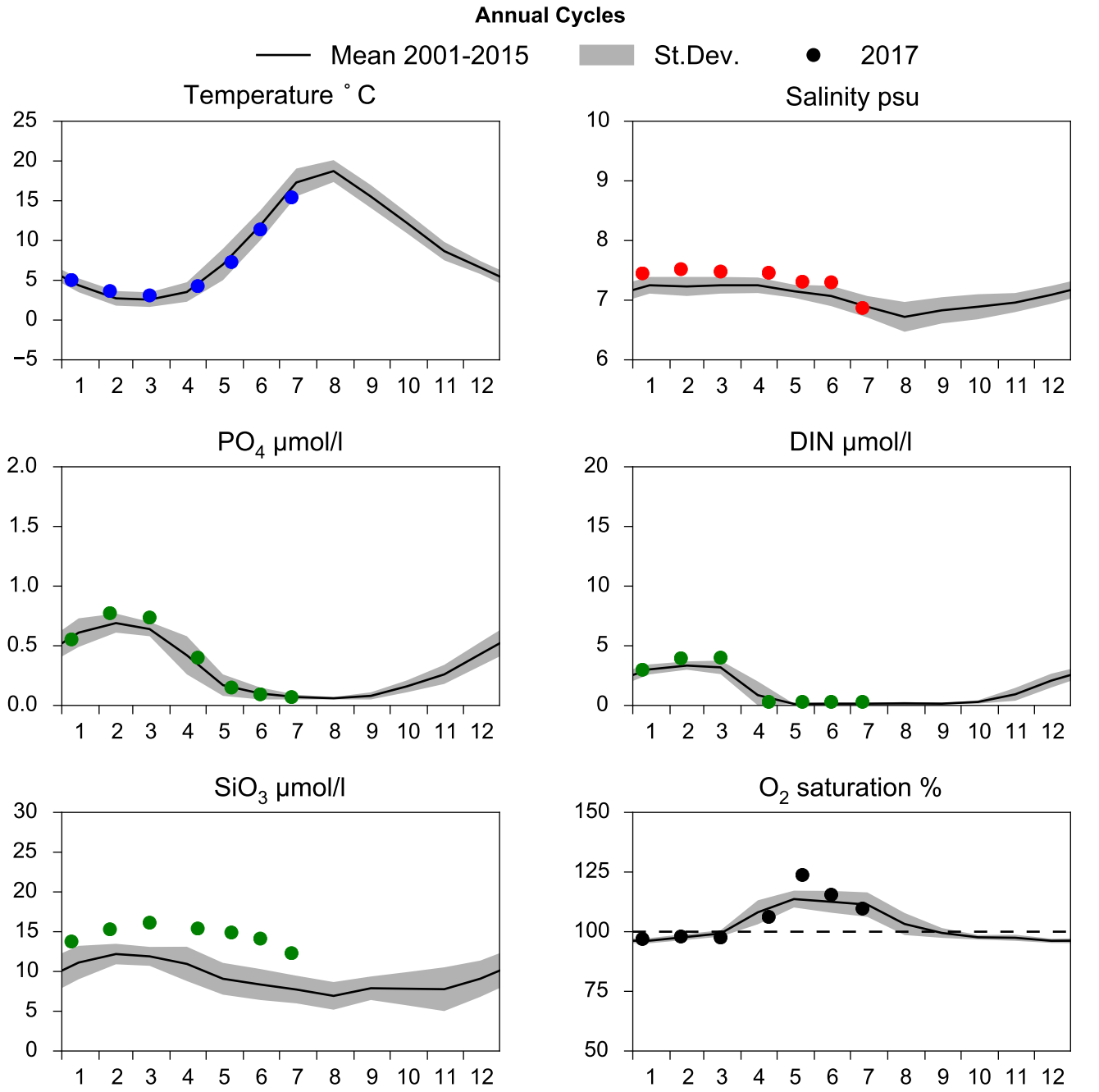




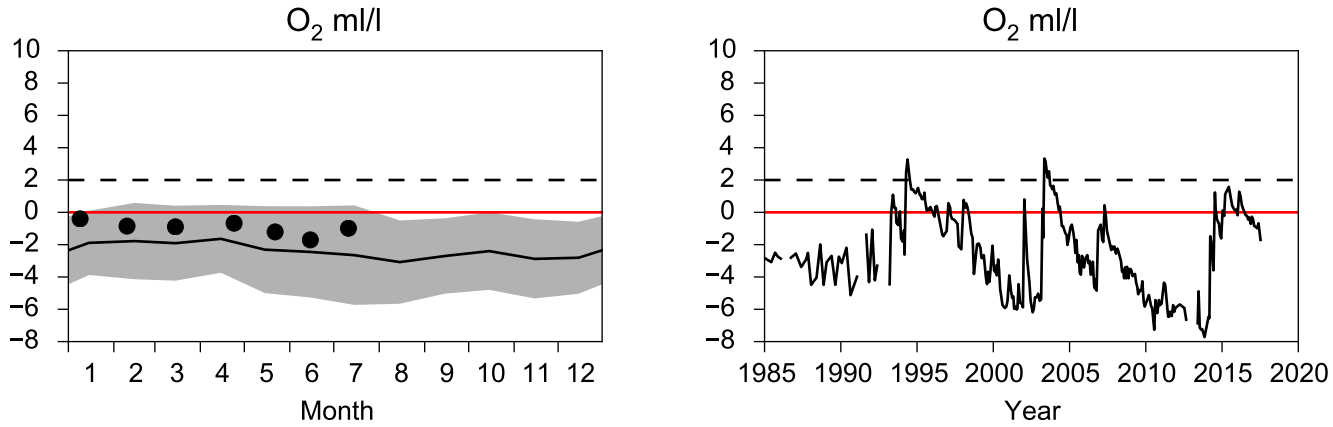
Vertical profiles BY20 FÅRÖDJ
July



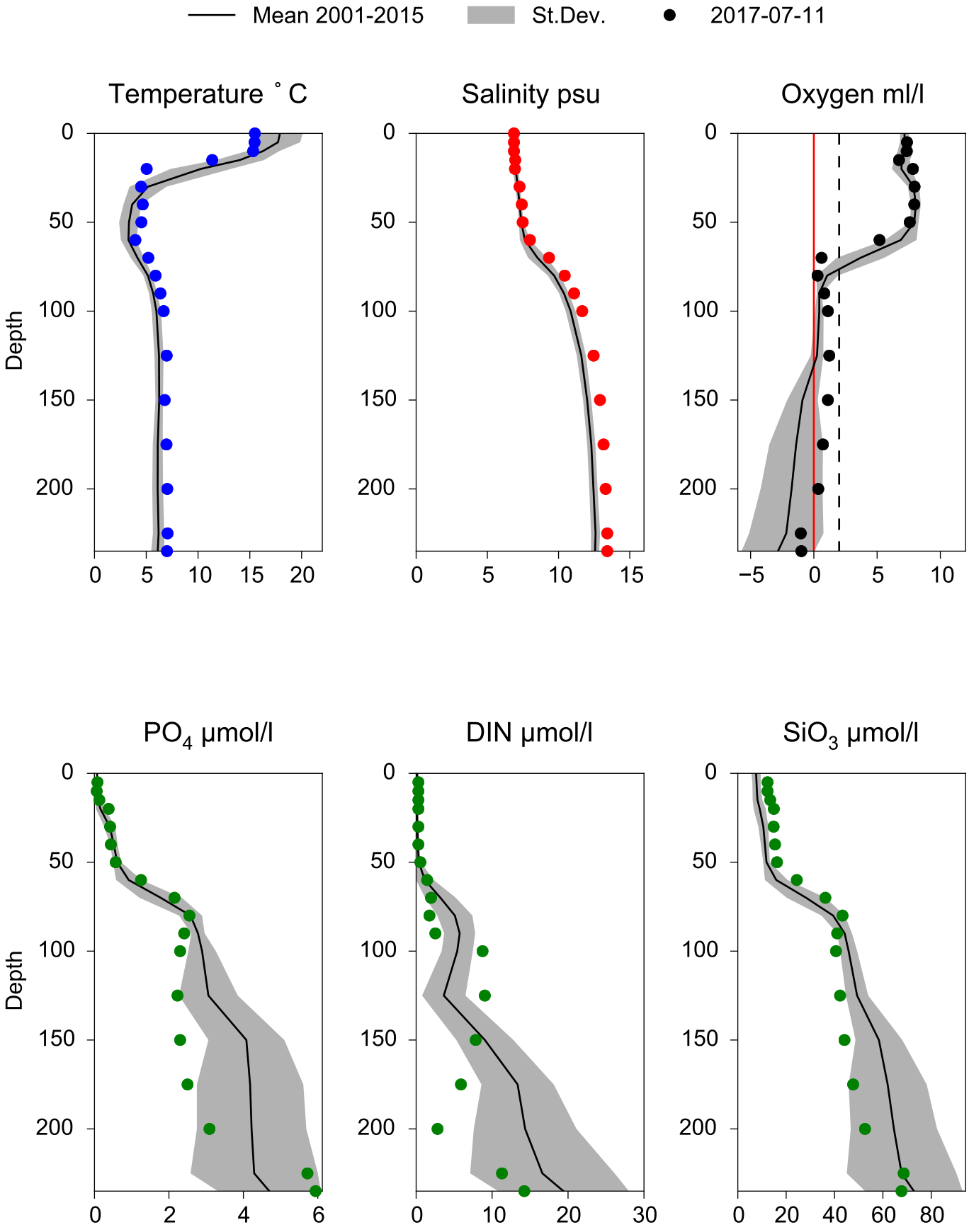
STATION BY15 GOTLANDSDJ SURFACE WATER (0-10 m)



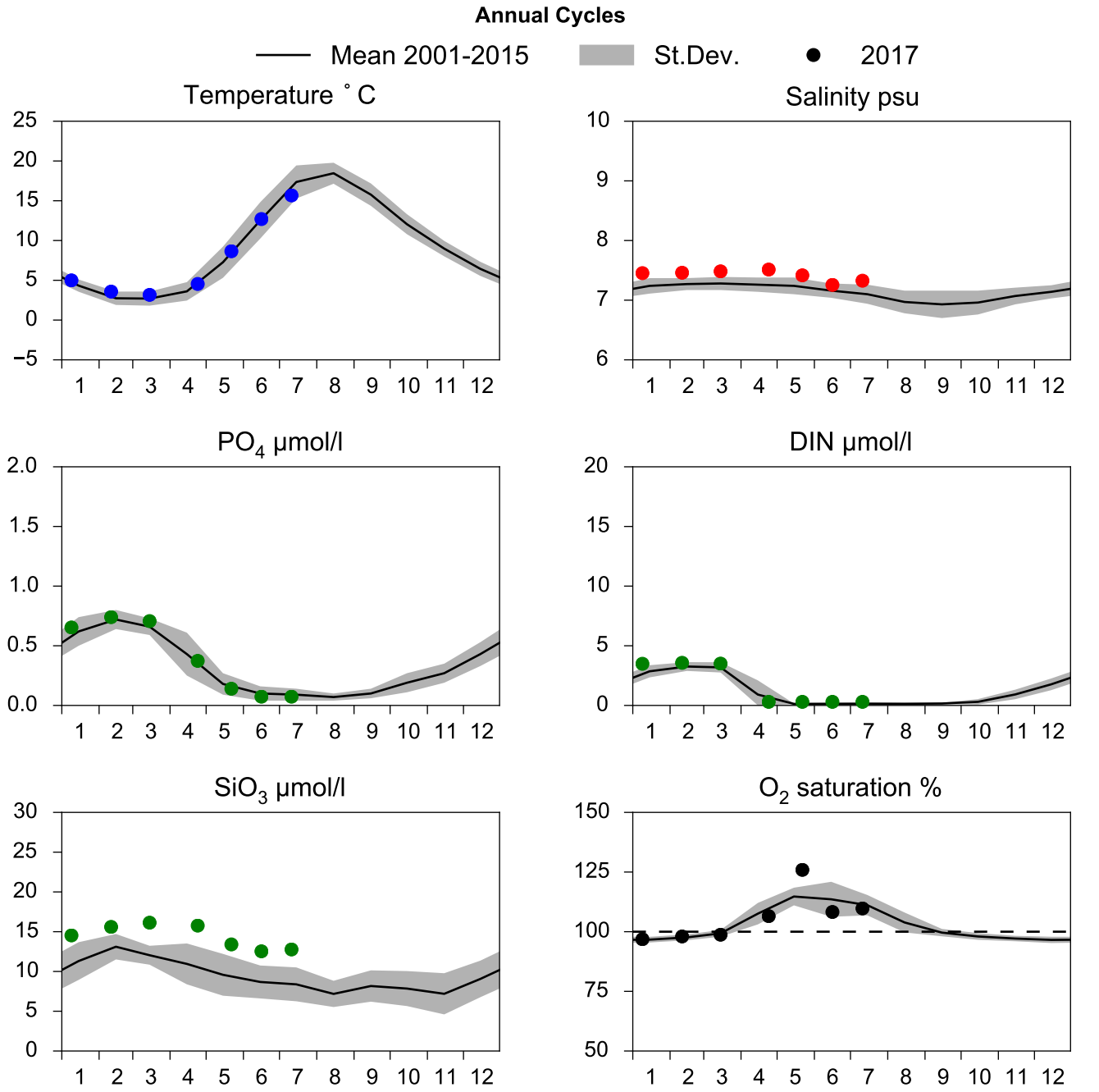
OXYGEN IN BOTTOM WATER (depth >= 225 m)



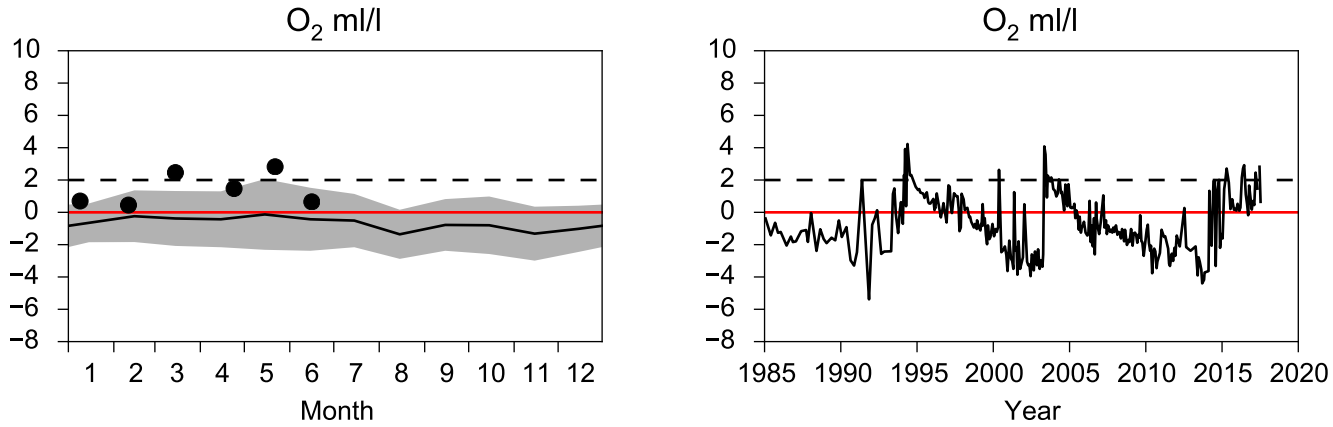
Vertical profiles BY15 GOTLANDSDJ
July



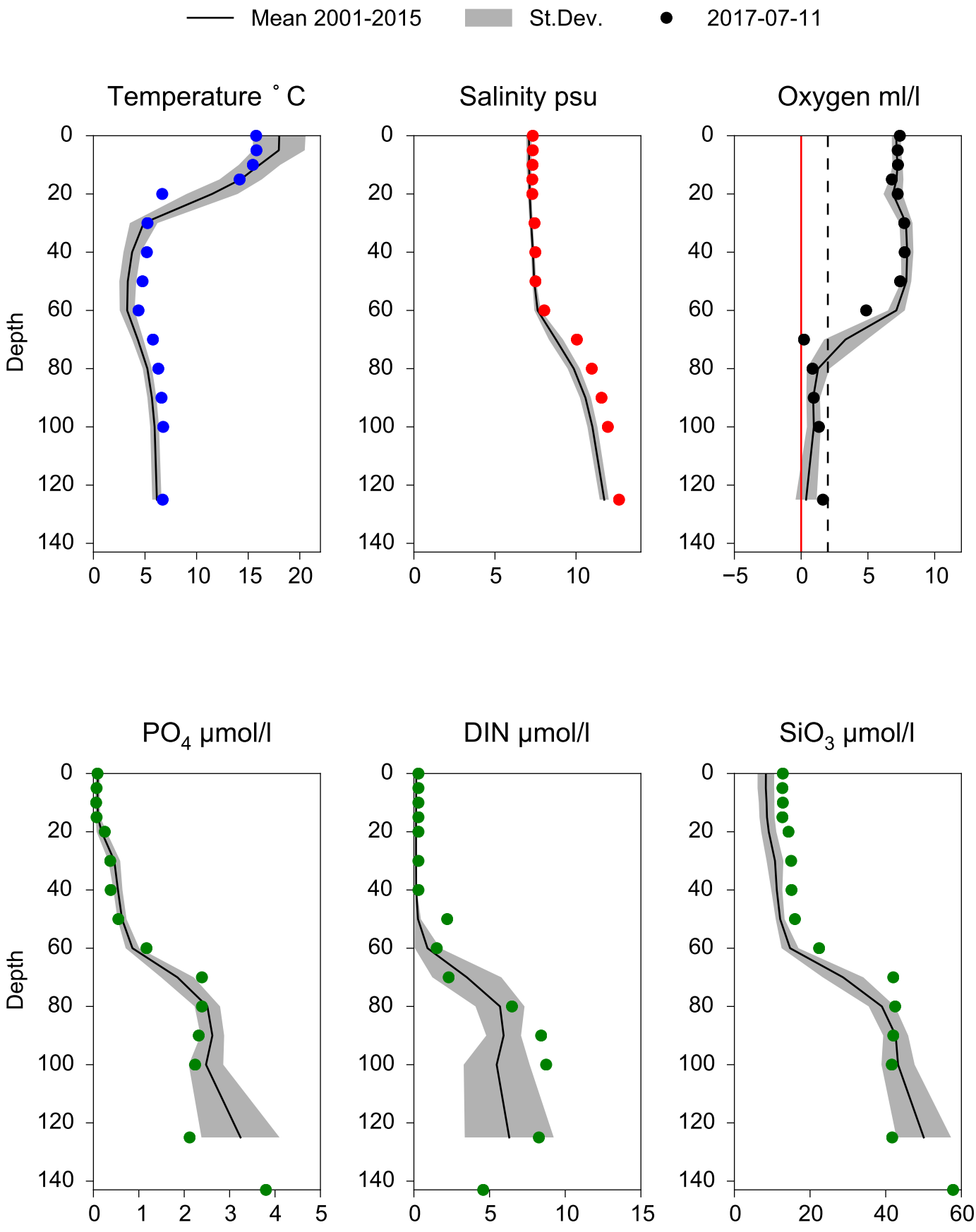
STATION BY10 SURFACE WATER (0-10 m)



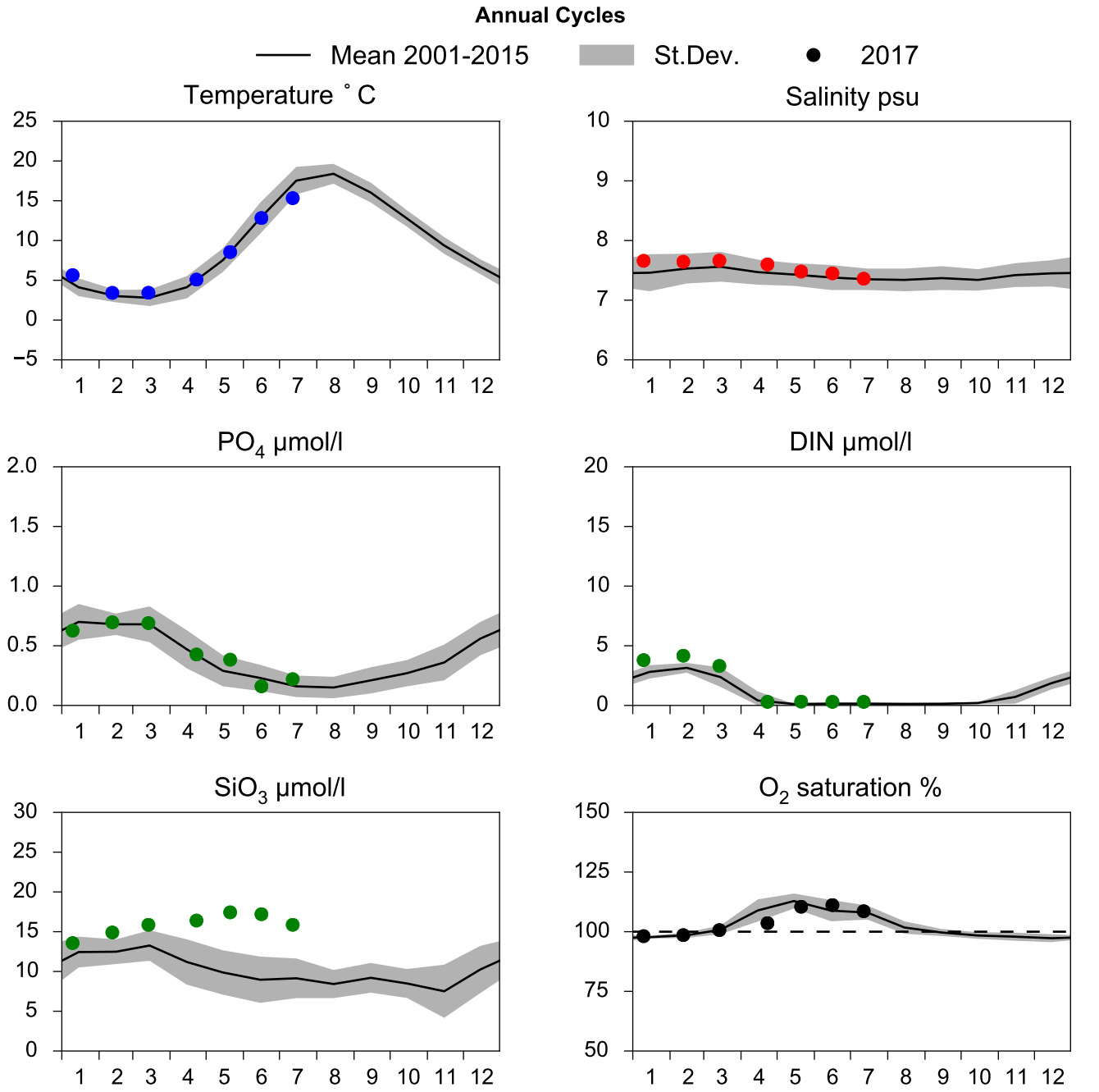
OXYGEN IN BOTTOM WATER (depth >= 125 m)



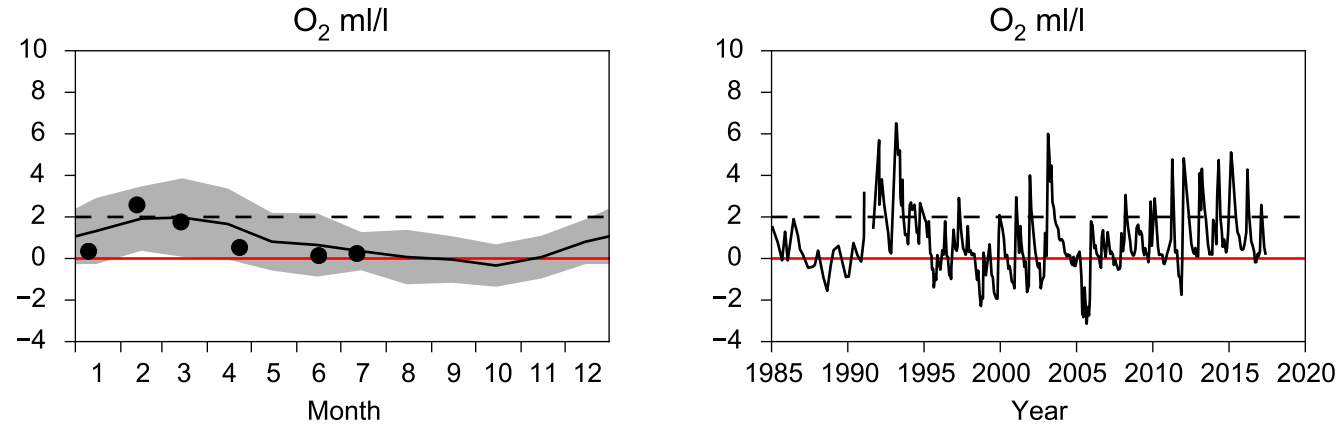
Vertical profiles BY10
July



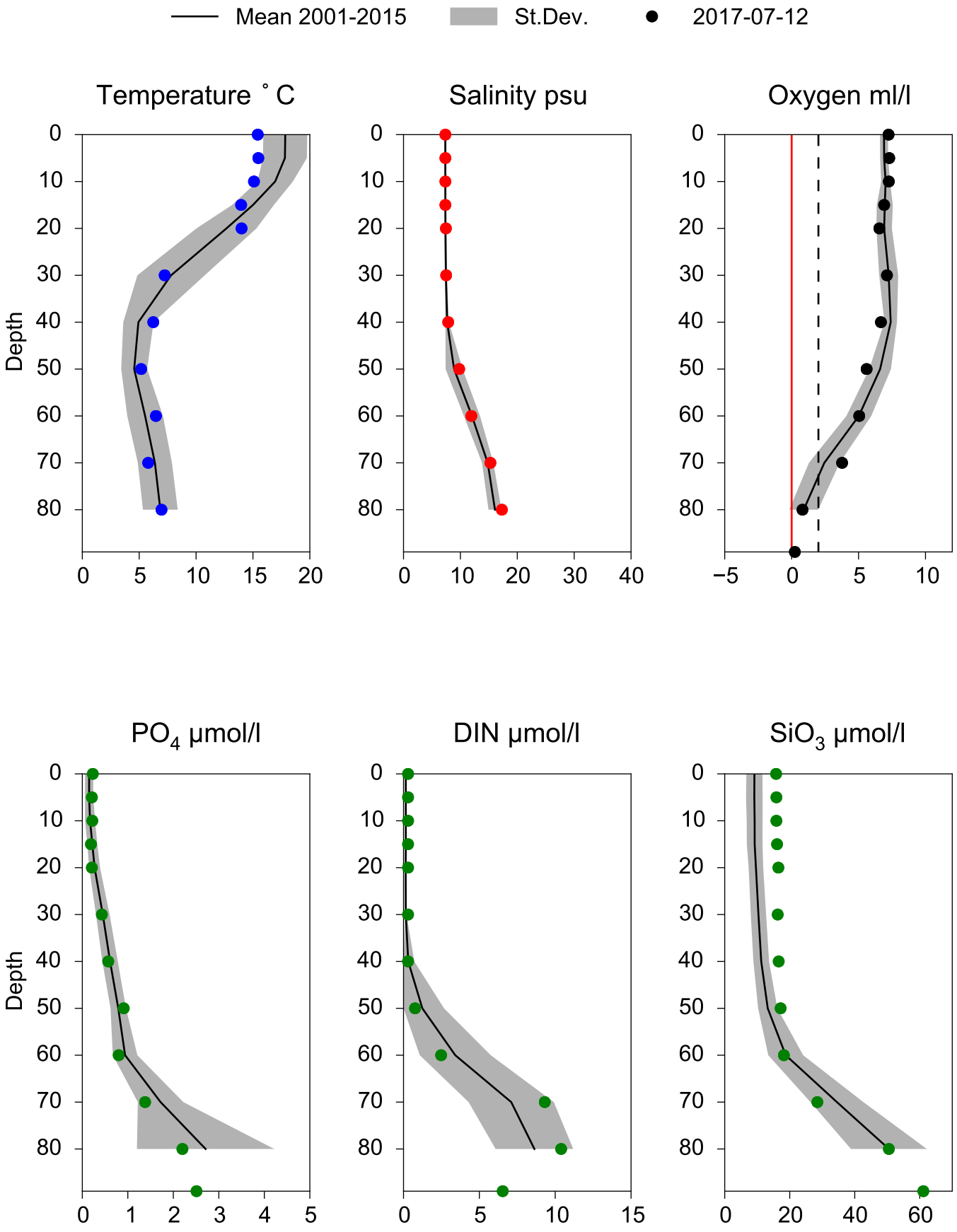
STATION BY5 BORNHOLMSDJ SURFACE WATER (0-10 m)



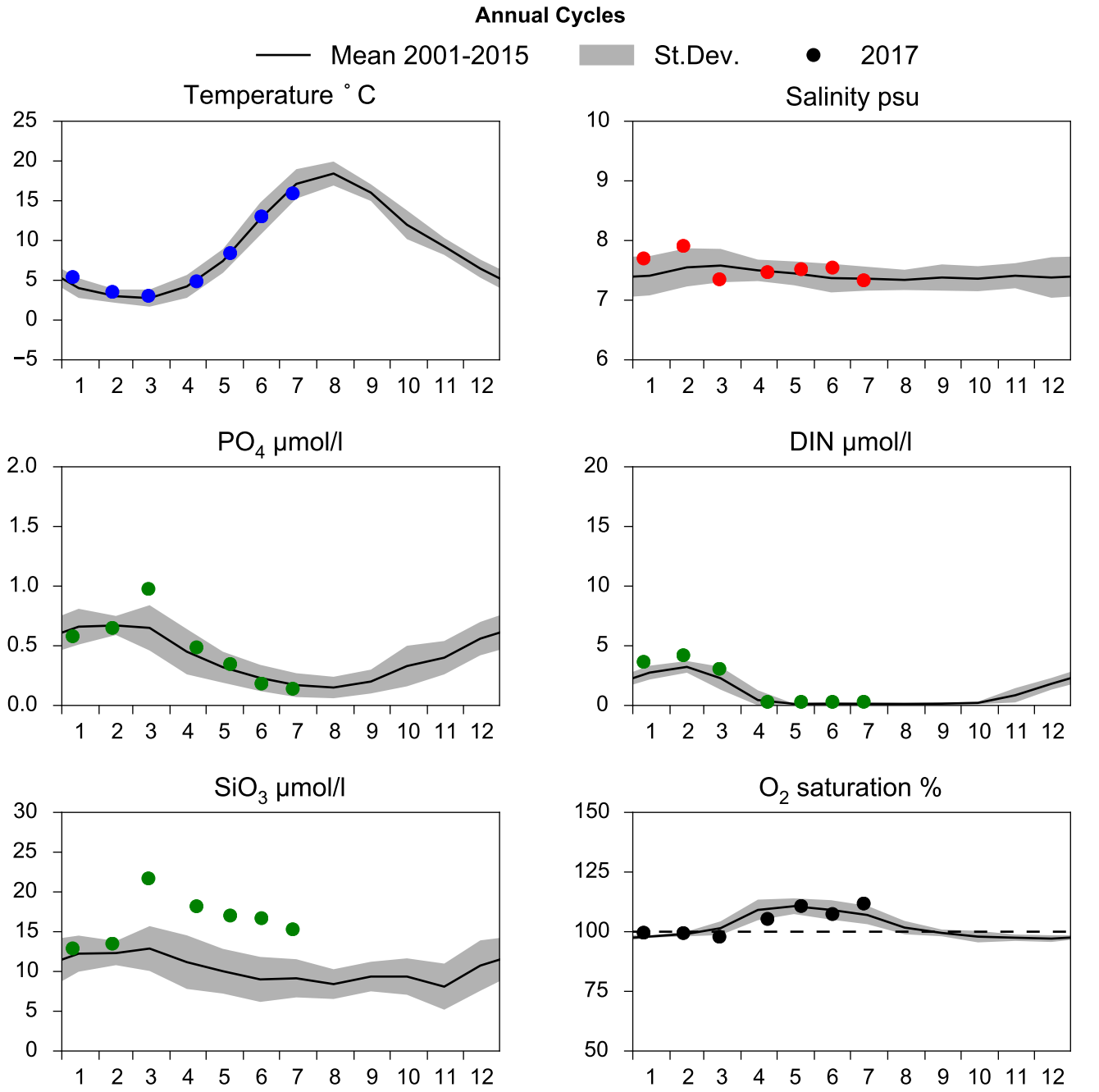
OXYGEN IN BOTTOM WATER (depth >= 80 m)



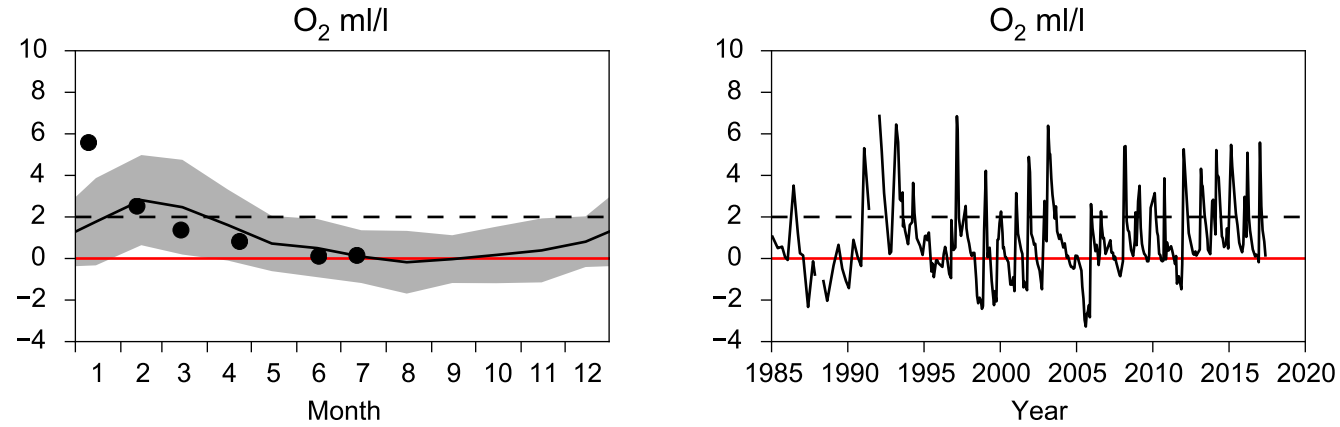
Vertical profiles BY5 BORNHOLMSDJ
July



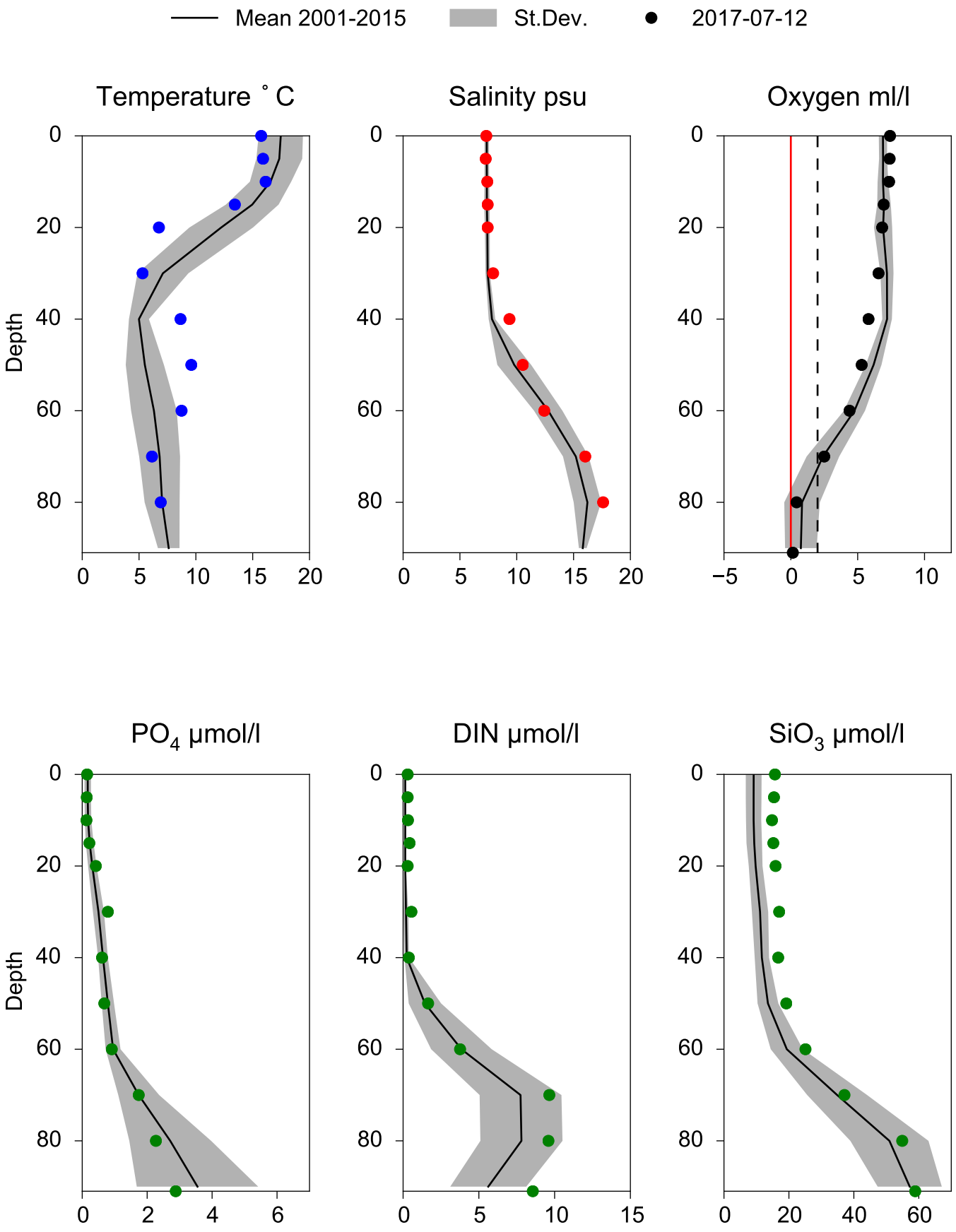
STATION BY4 CHRISTIANSÖ SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 80 m)



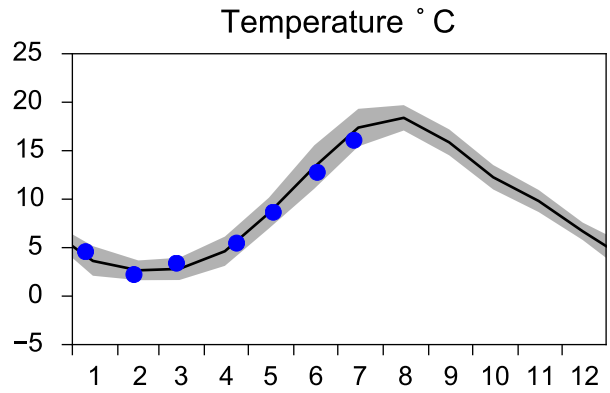
Vertical profiles BY4 CHRISTIANSÖ
July

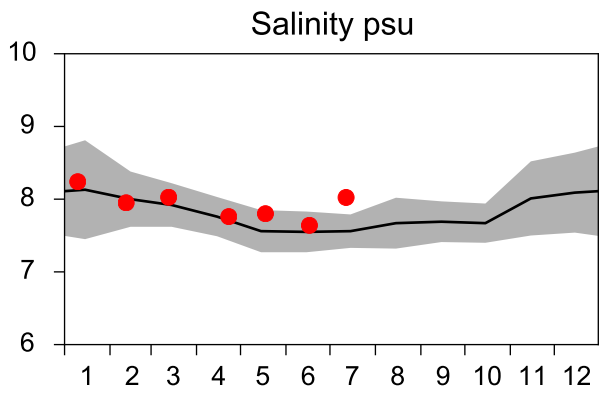


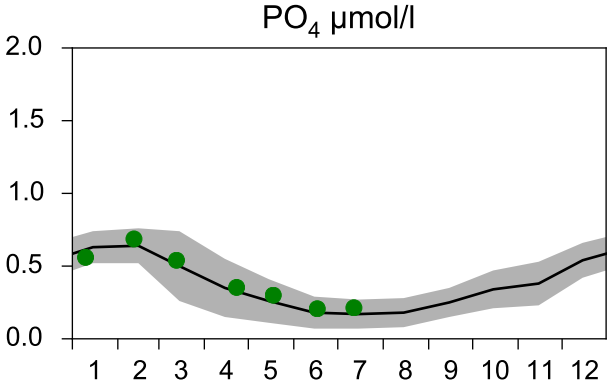
STATION BY2 ARKONA SURFACE WATER (0-10 m)

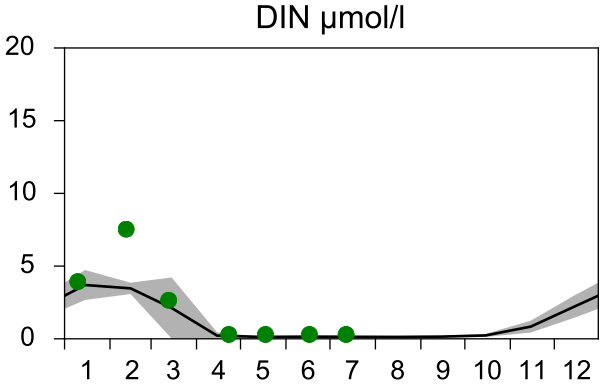
Annual Cycles

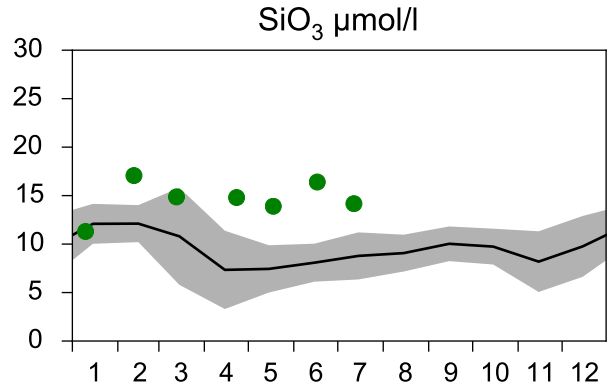
Mean 2001-2015 St.Dev. 2017

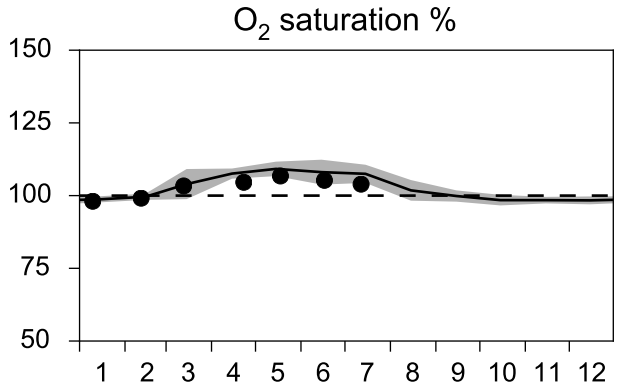




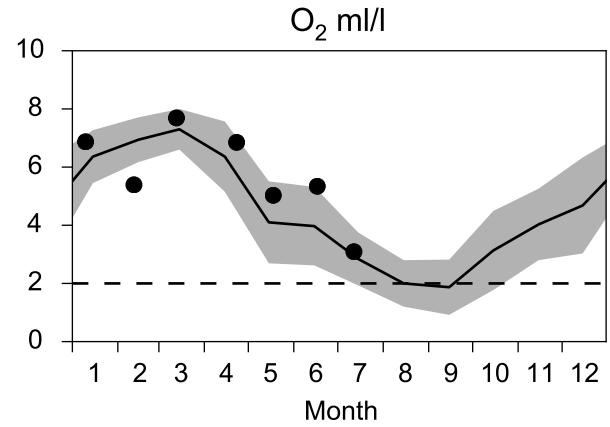


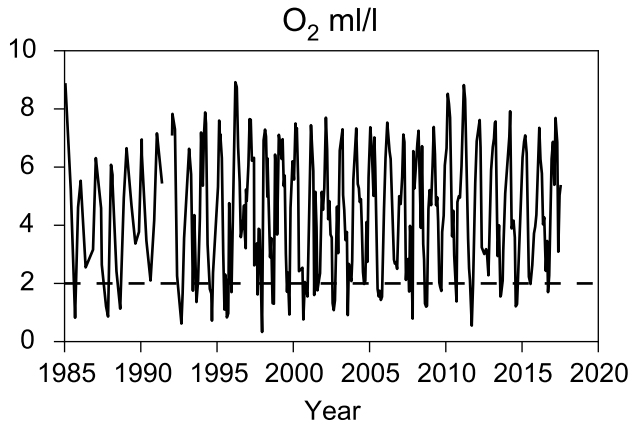




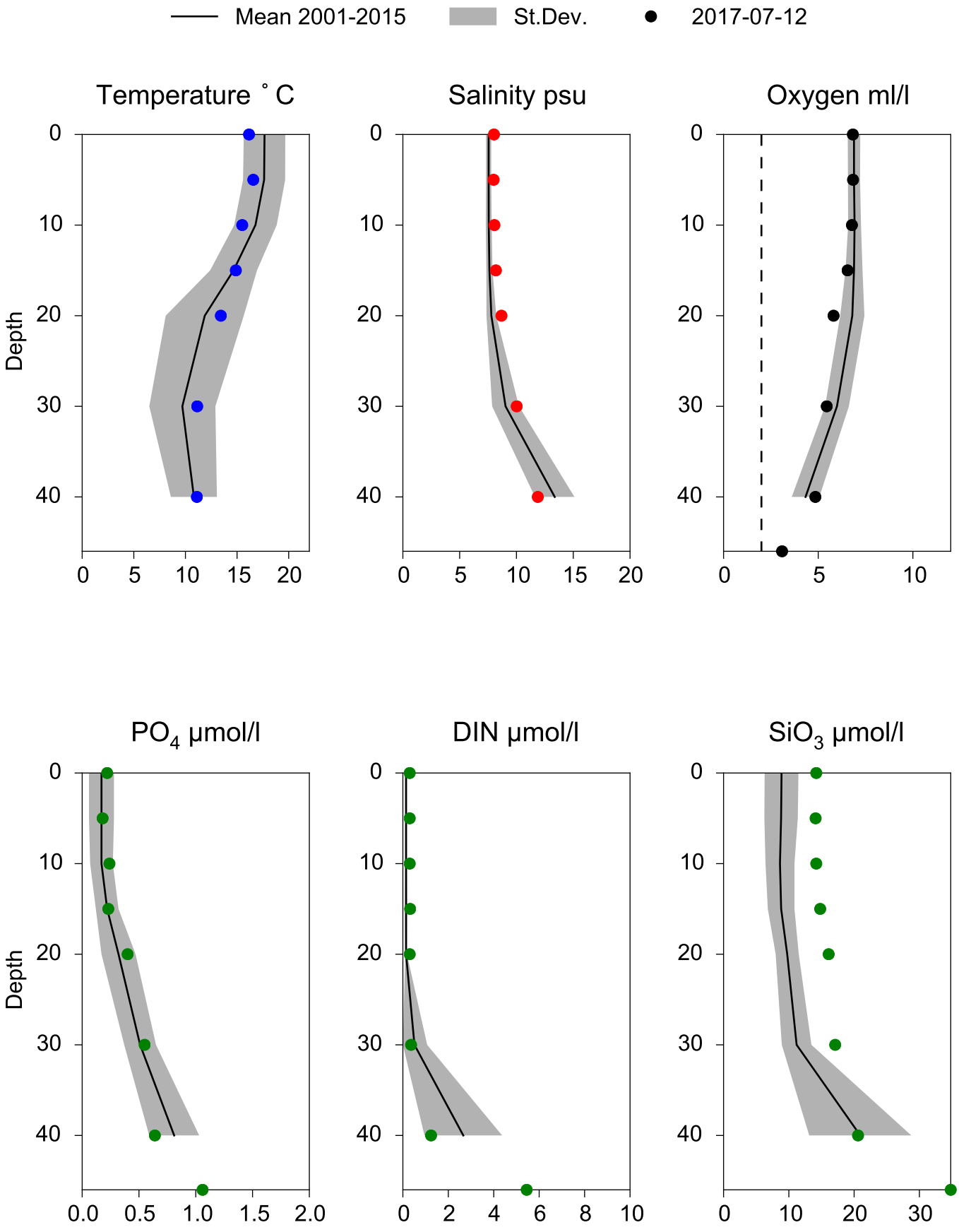


OXYGEN IN BOTTOM WATER (depth >= 40 m)

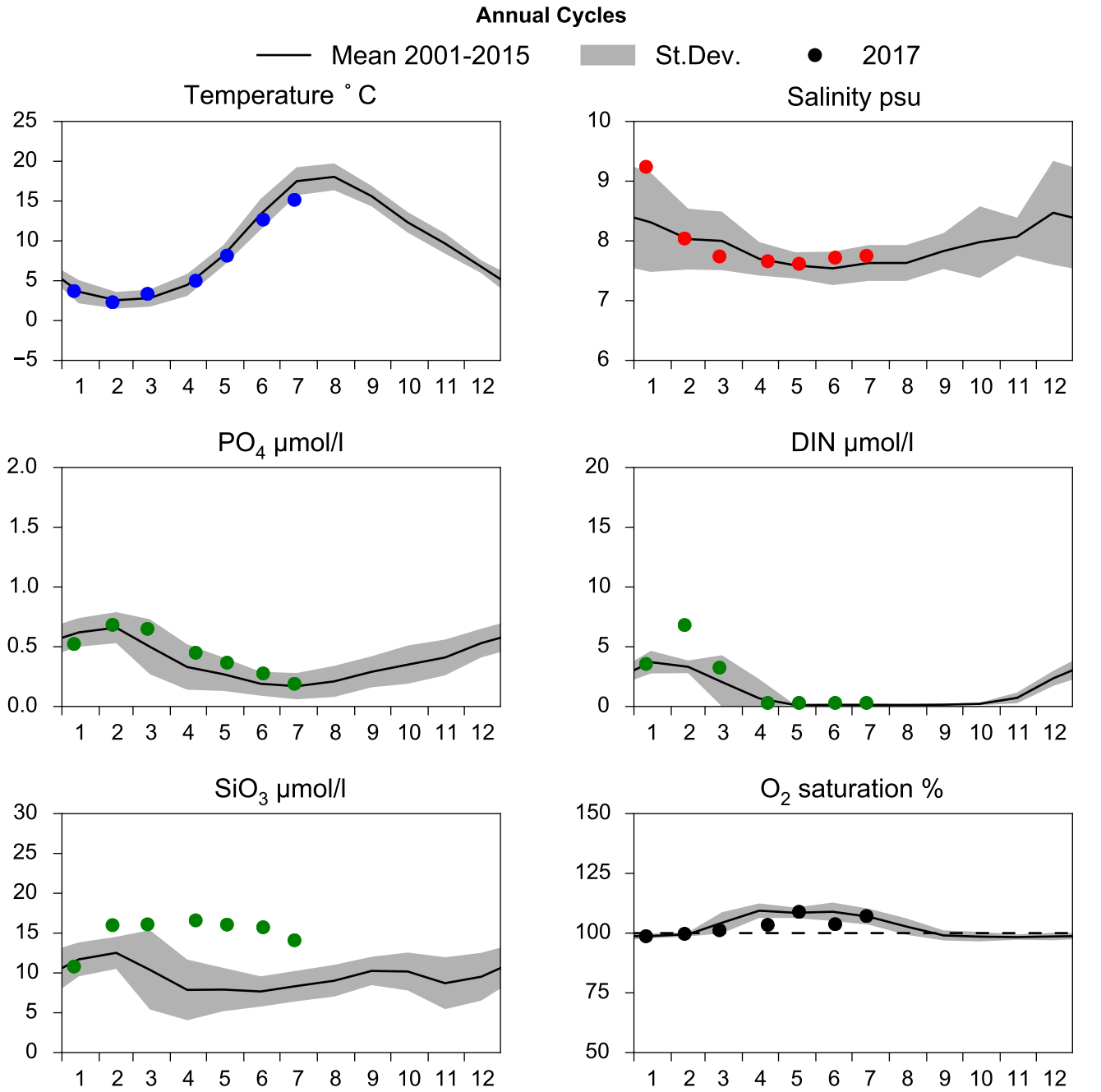




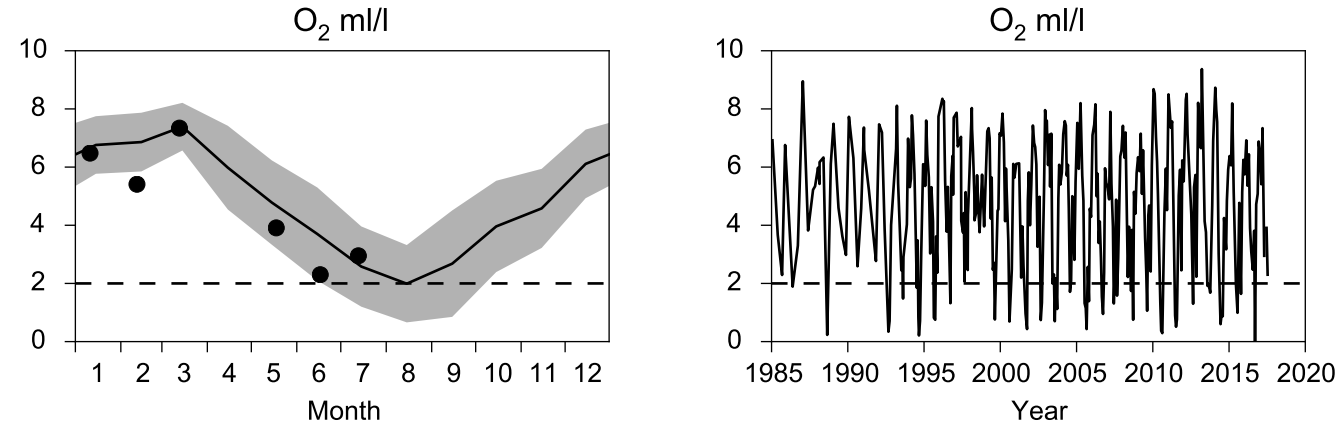
Vertical profiles BY2 ARKONA
July



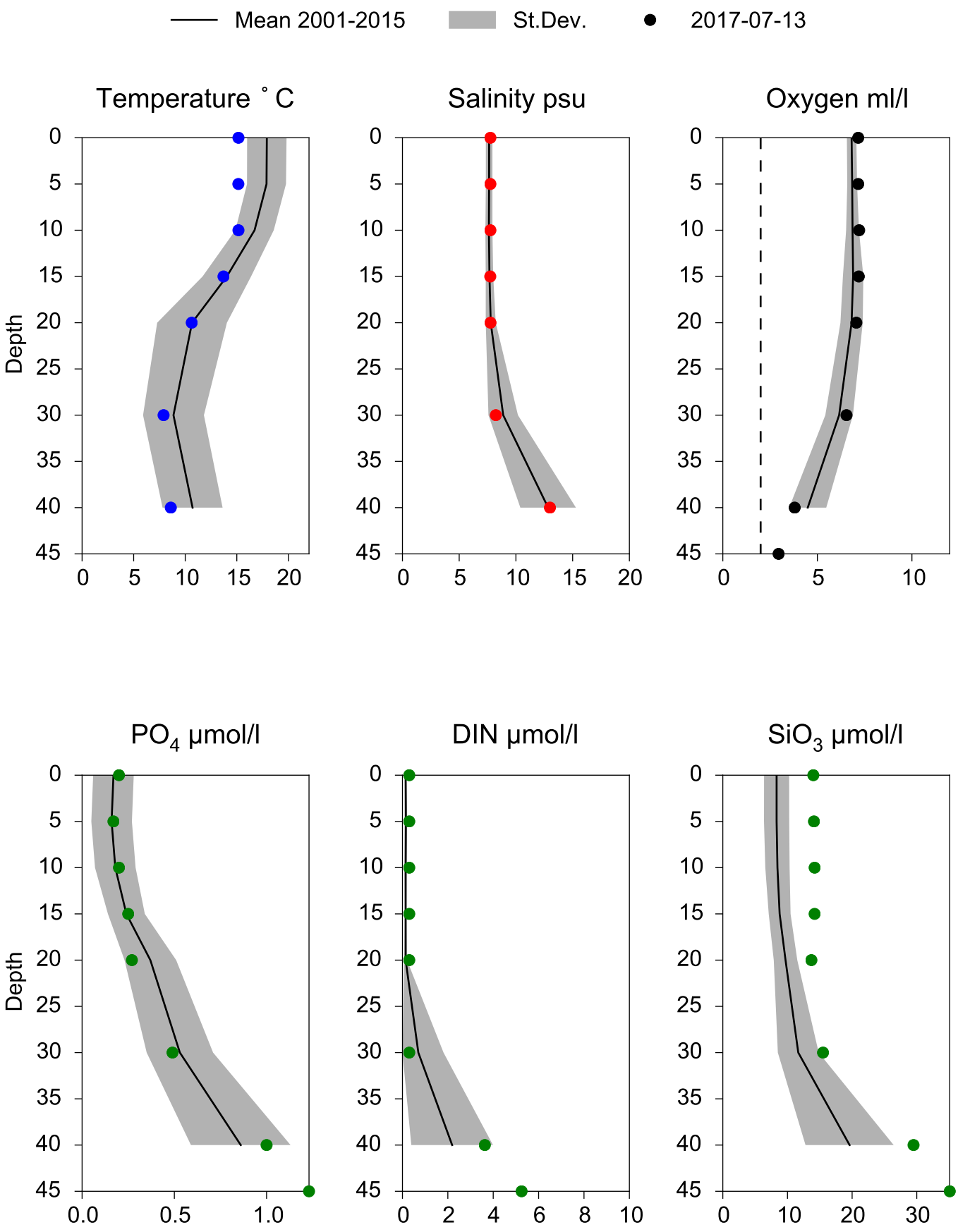
STATION BY1 SURFACE WATER (0-10 m)



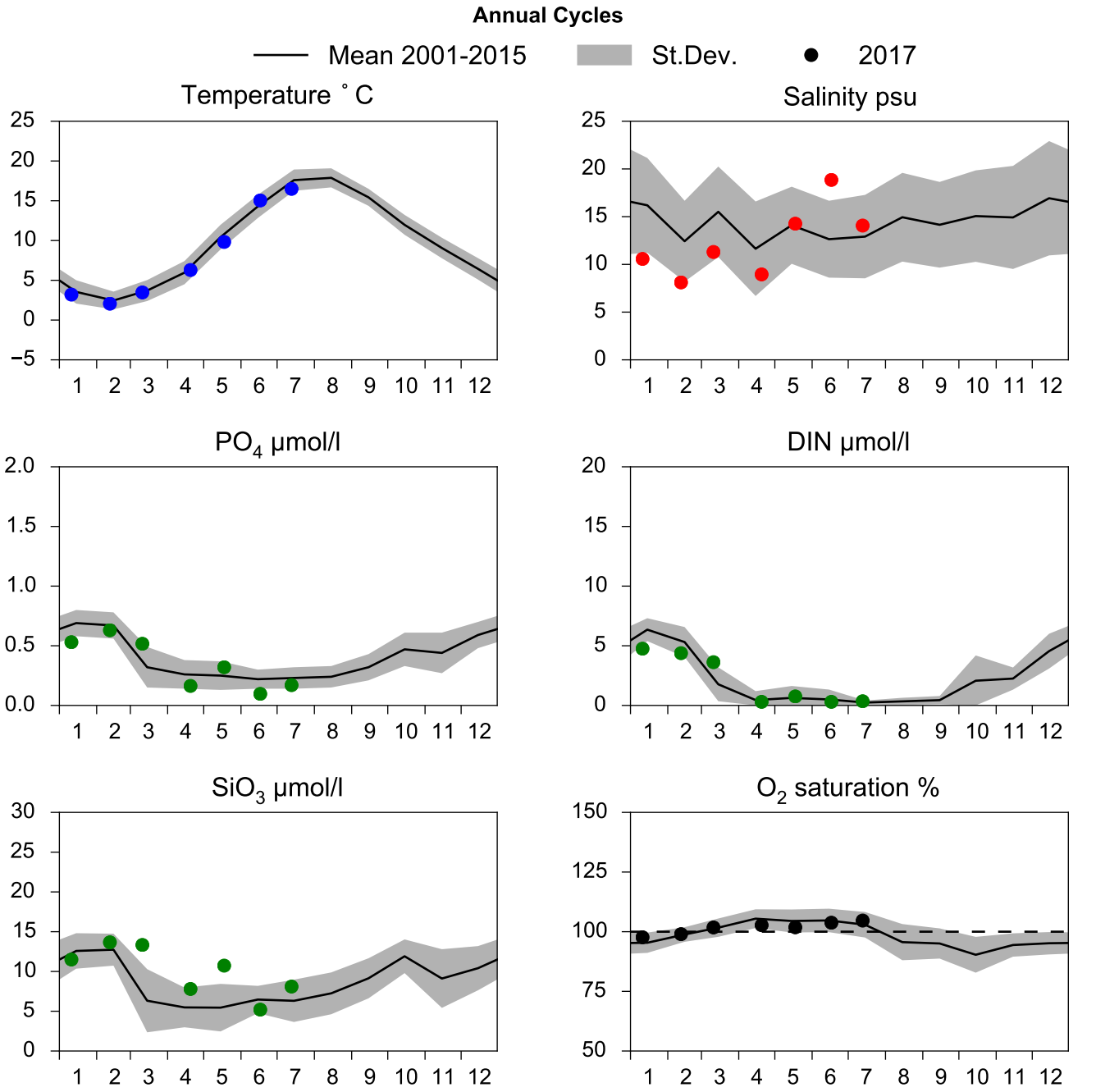
OXYGEN IN BOTTOM WATER (depth >= 40 m)



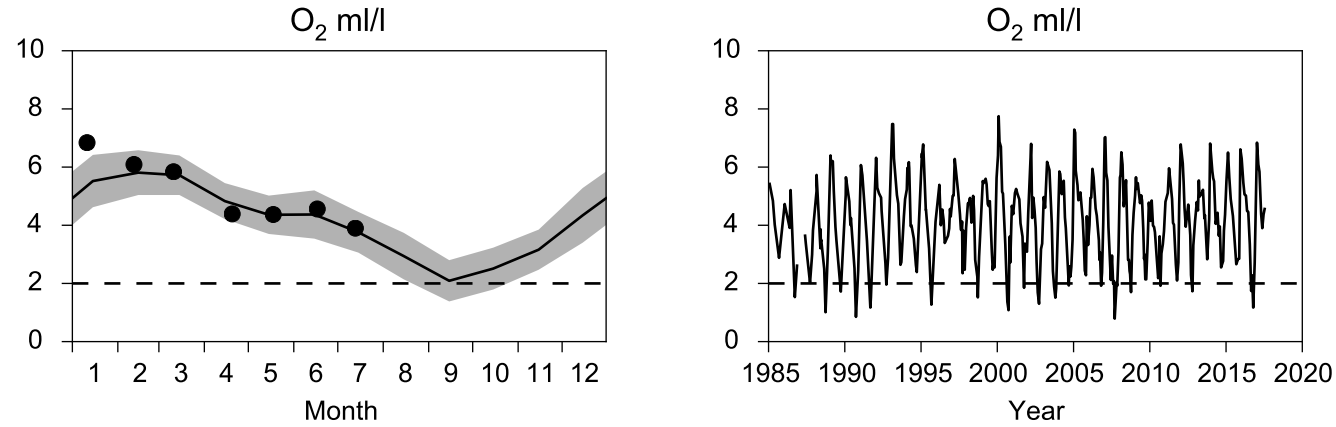
Vertical profiles BY1
July



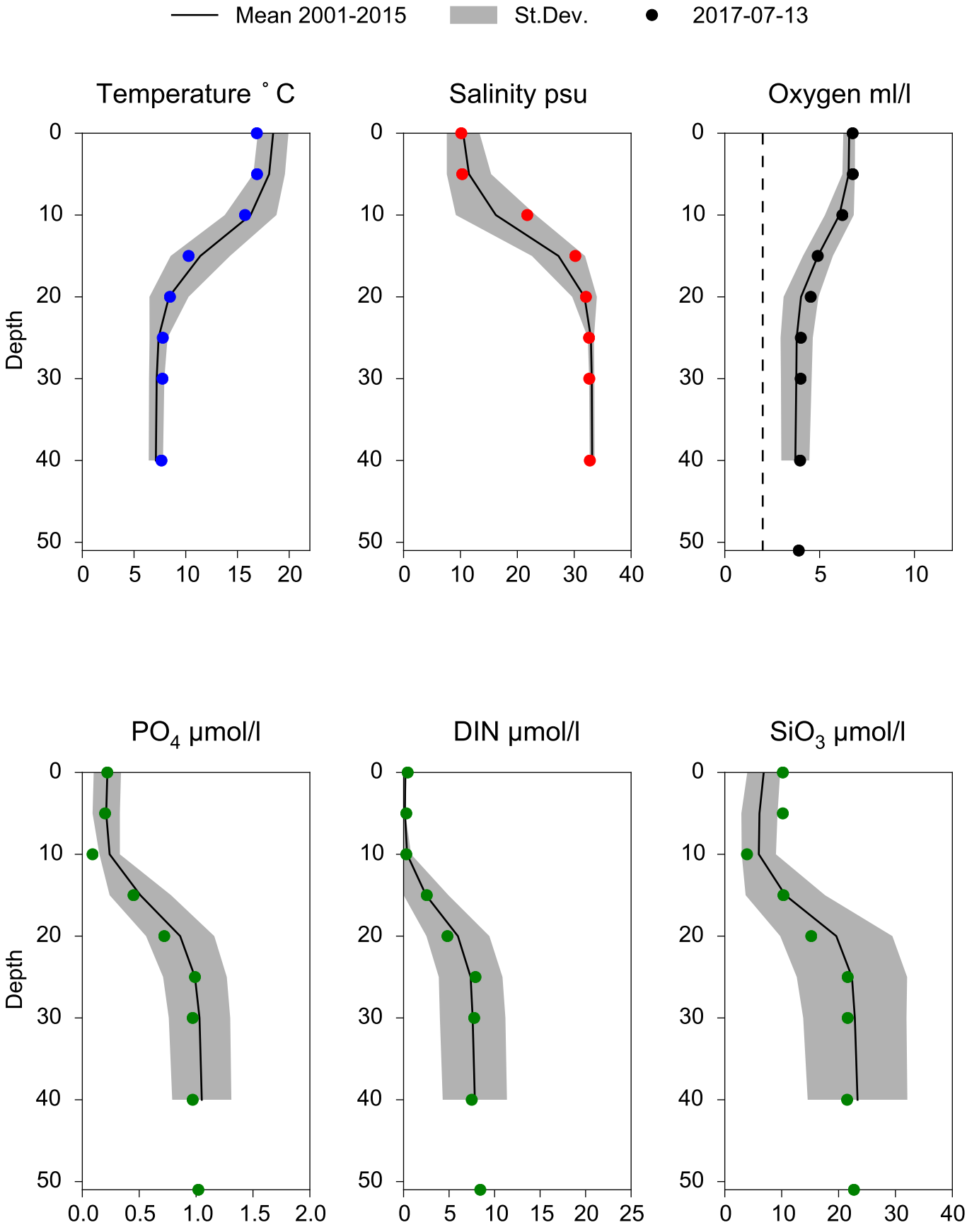
STATION W LANDSKRONA SURFACE WATER (0-10 m)



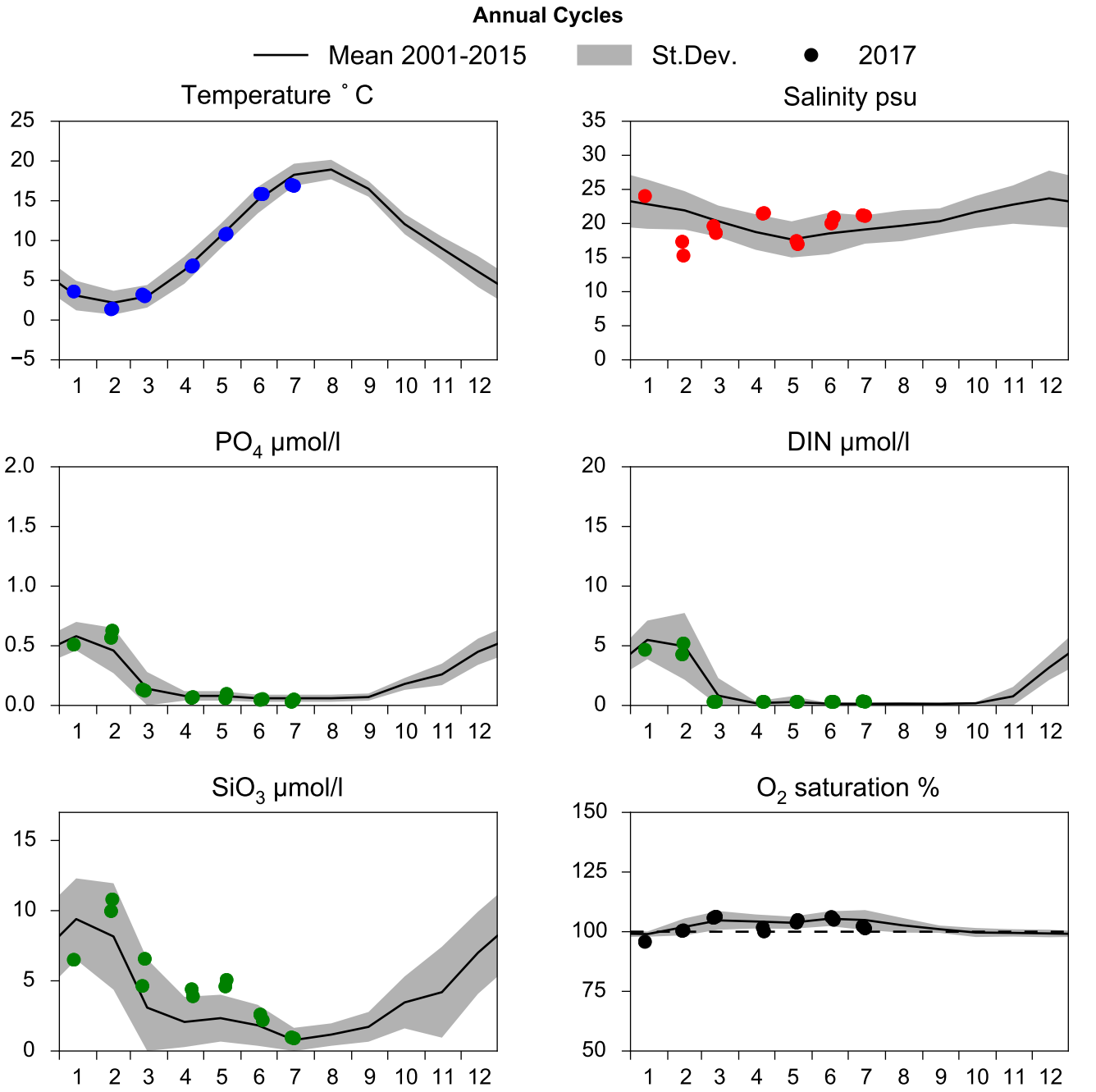
OXYGEN IN BOTTOM WATER (depth >= 40 m)



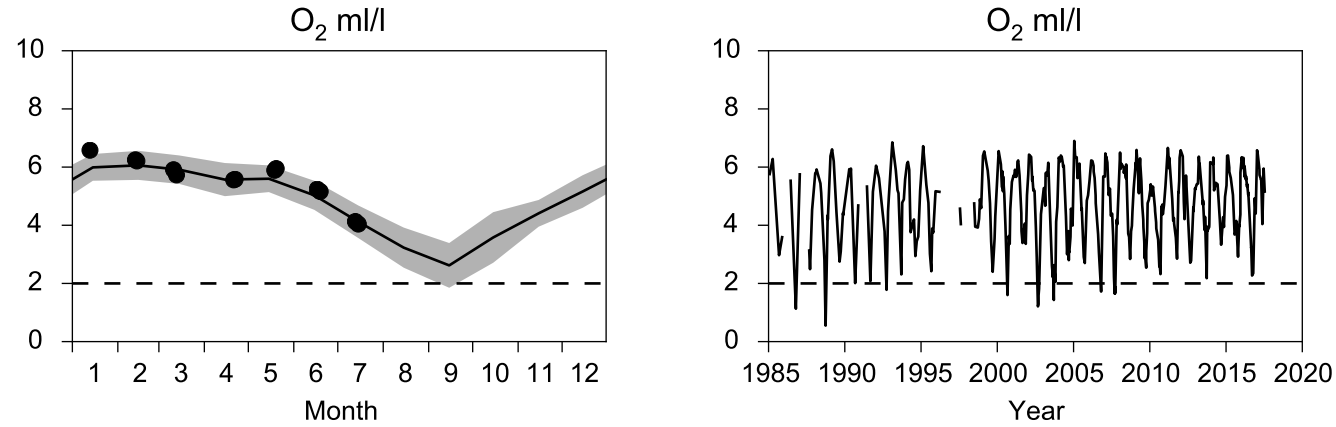
Vertical profiles W LANDSKRONA
July



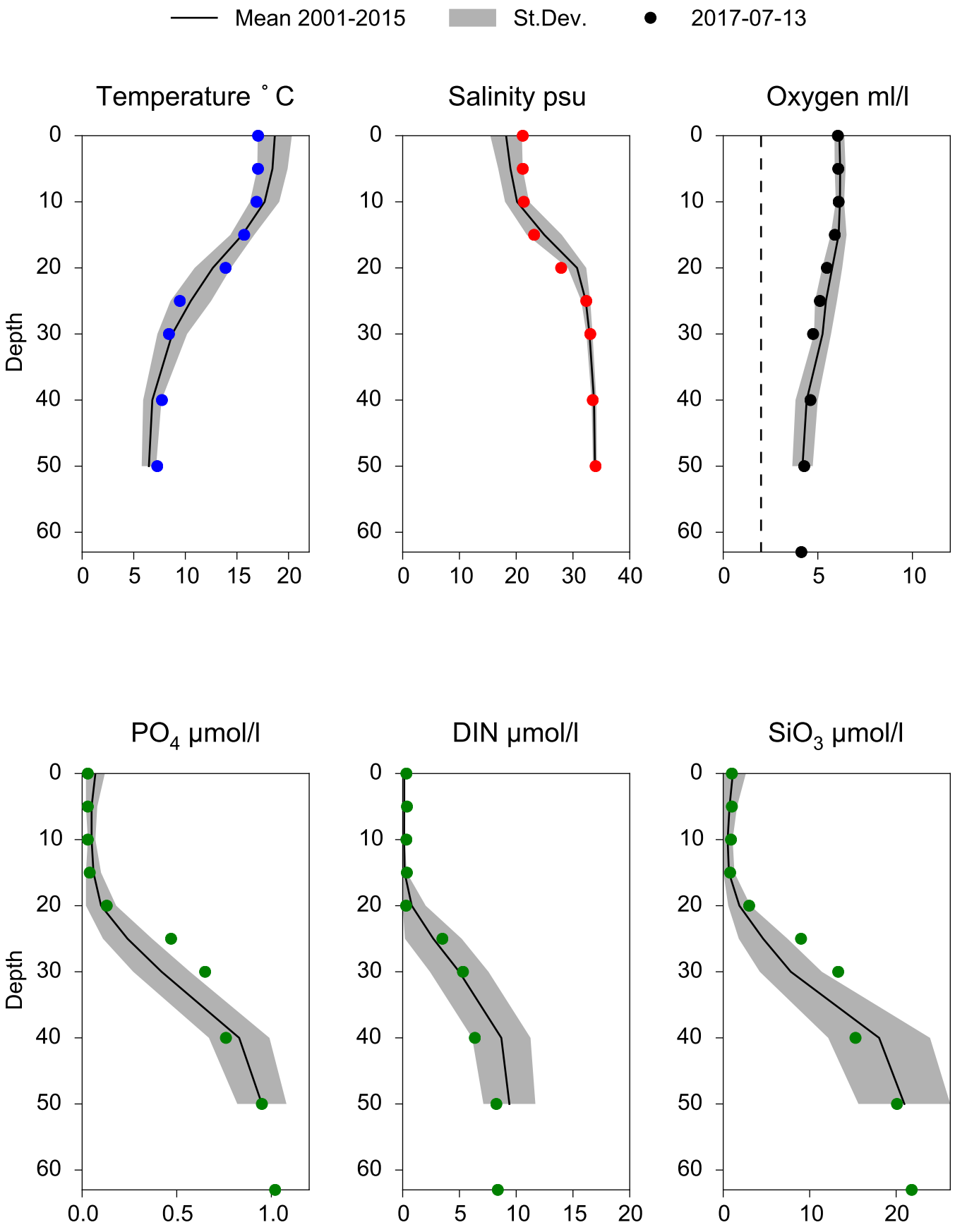
STATION ANHOLT E SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 52 m)

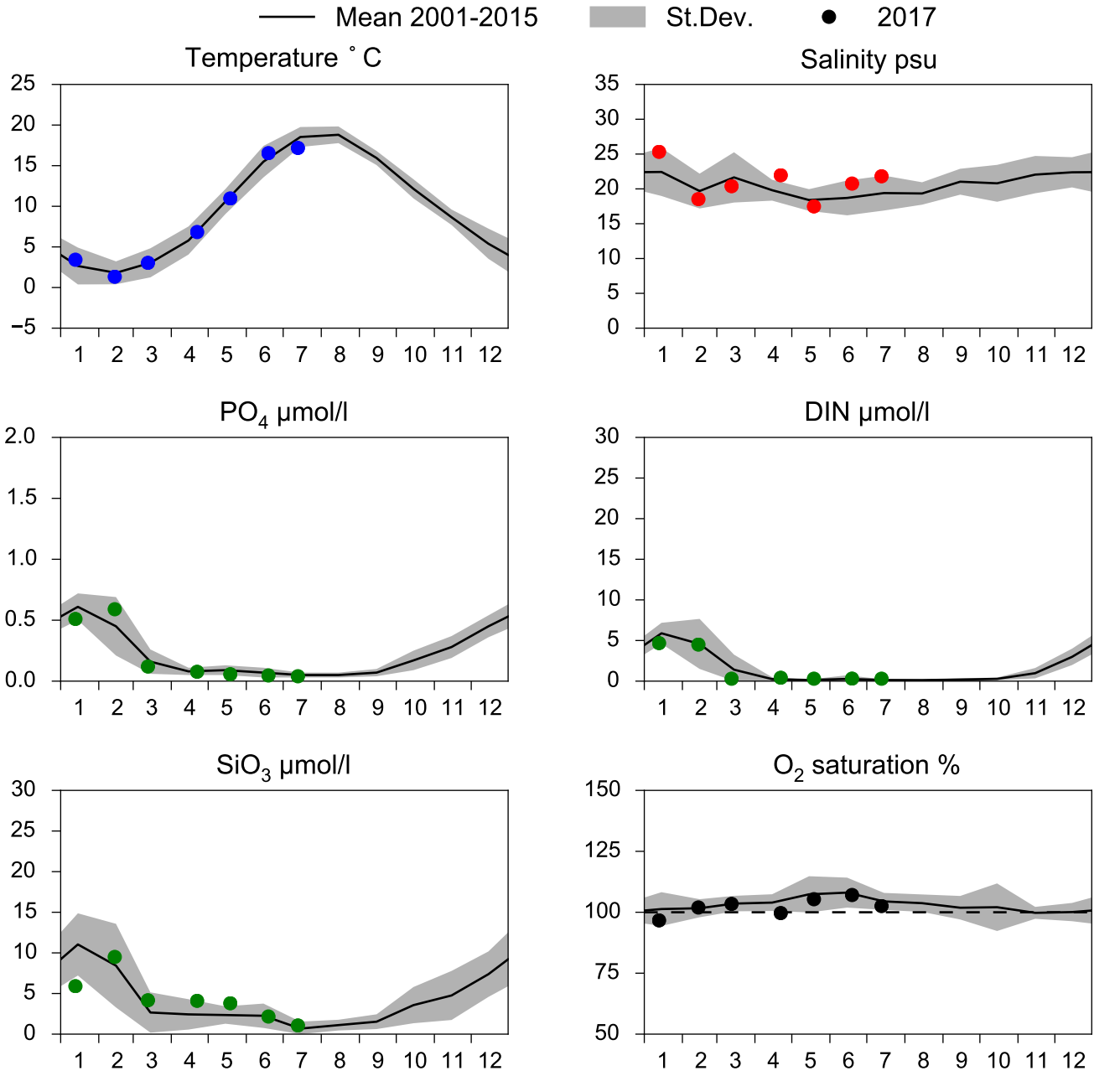


Vertical profiles ANHOLT E
July

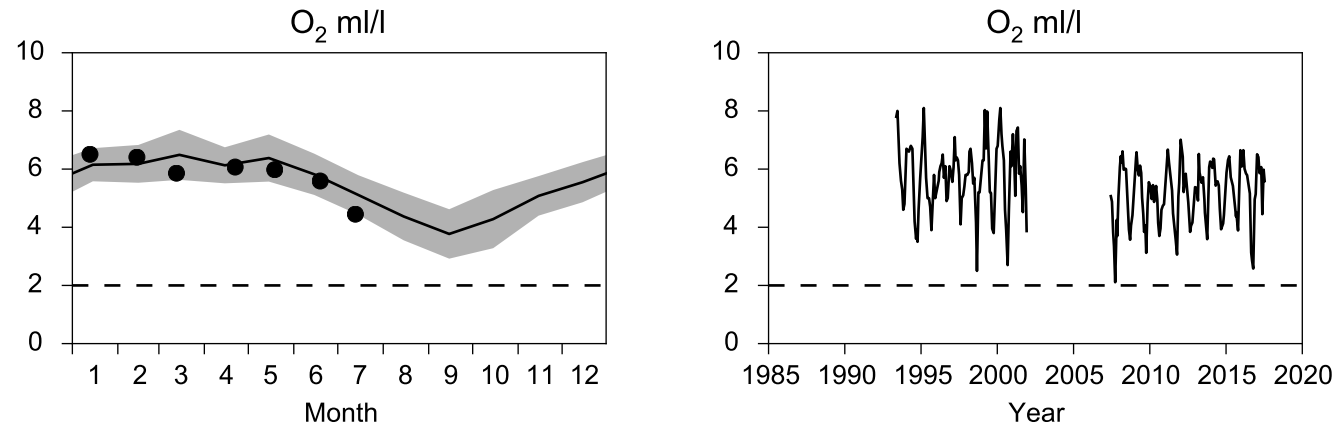


STATION N14 FALKENBERG SURFACE WATER (0-10 m)

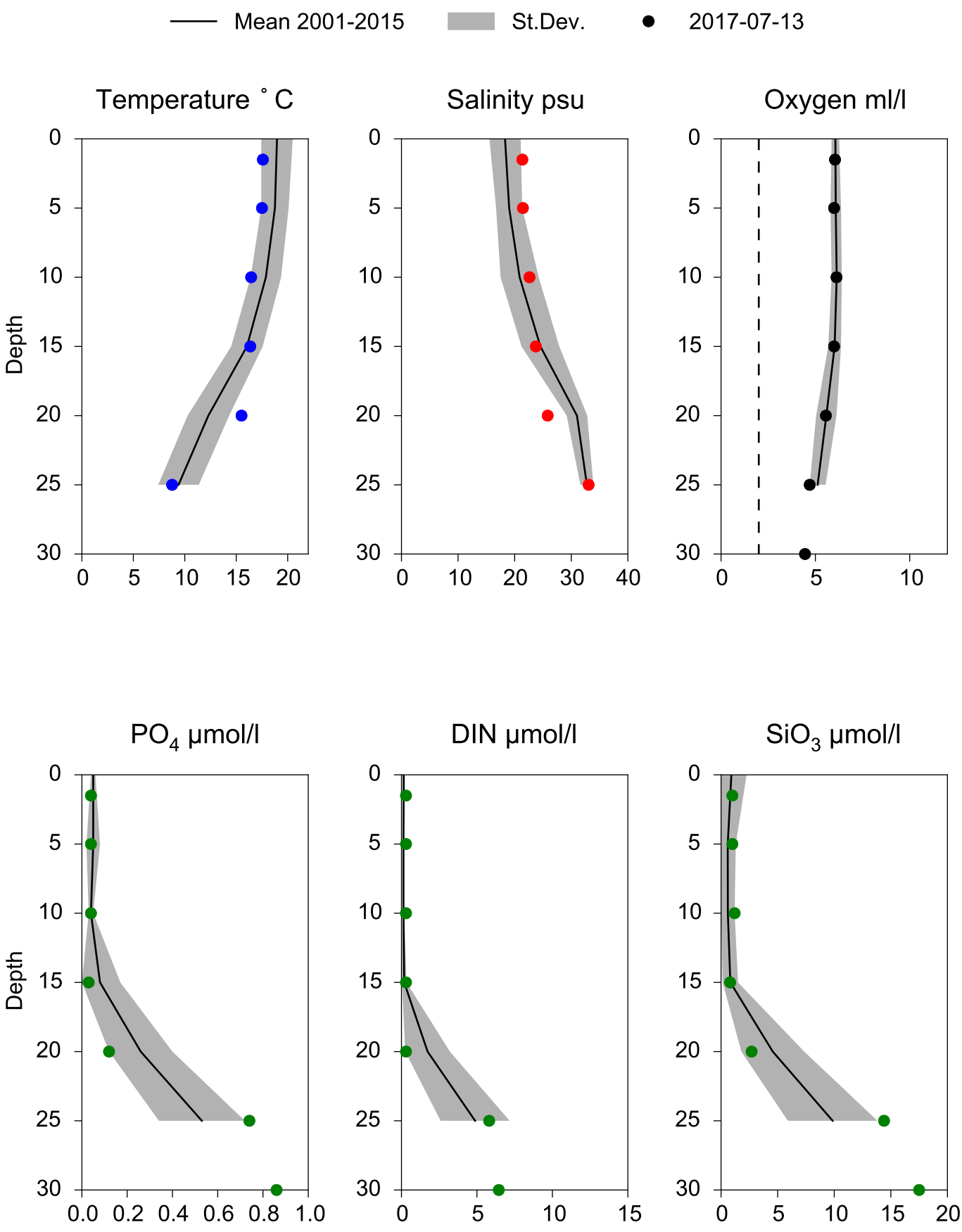
Annual Cycles



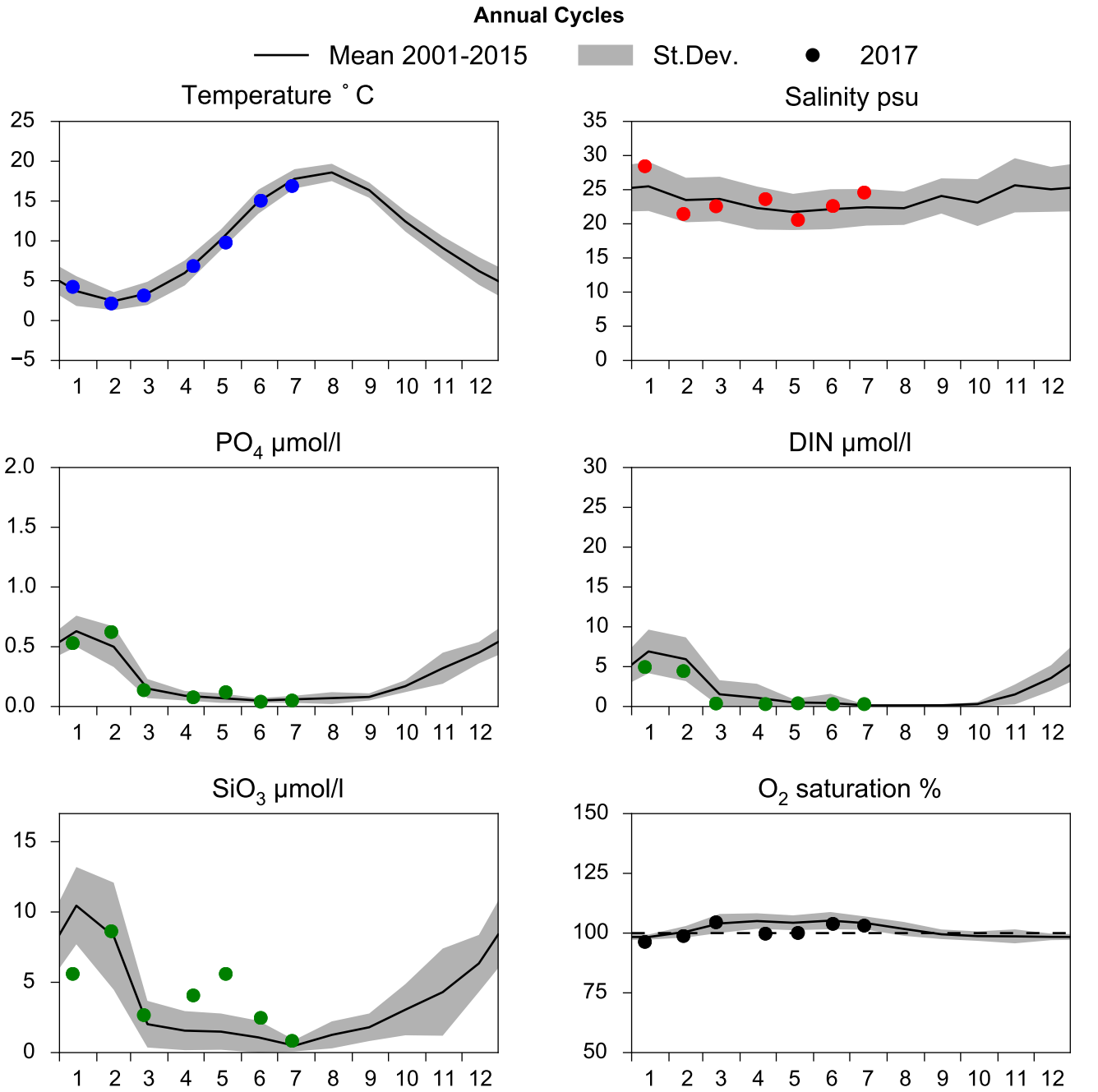
OXYGEN IN BOTTOM WATER (depth >= 25 m)



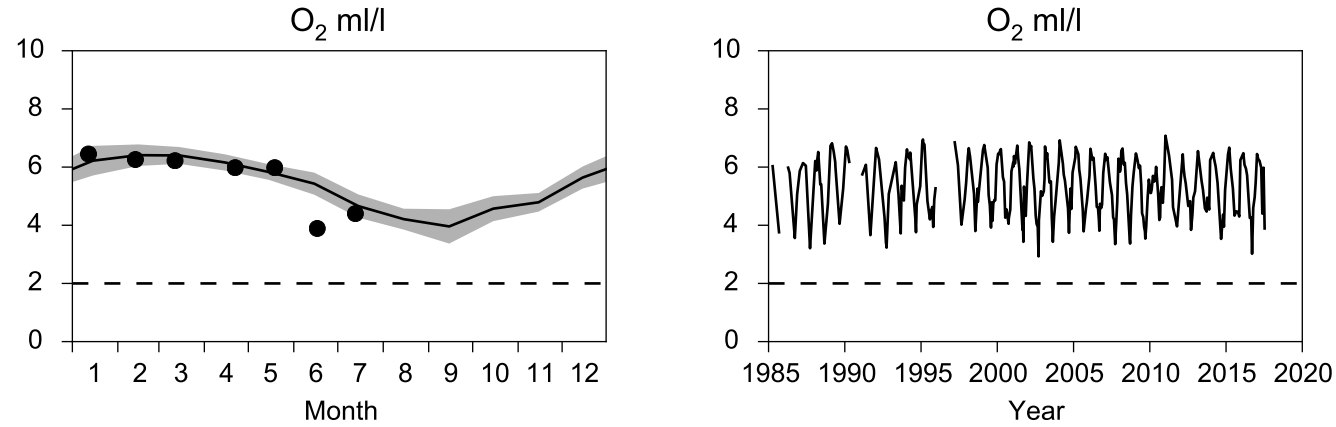
Vertical profiles N14 FALKENBERG
July



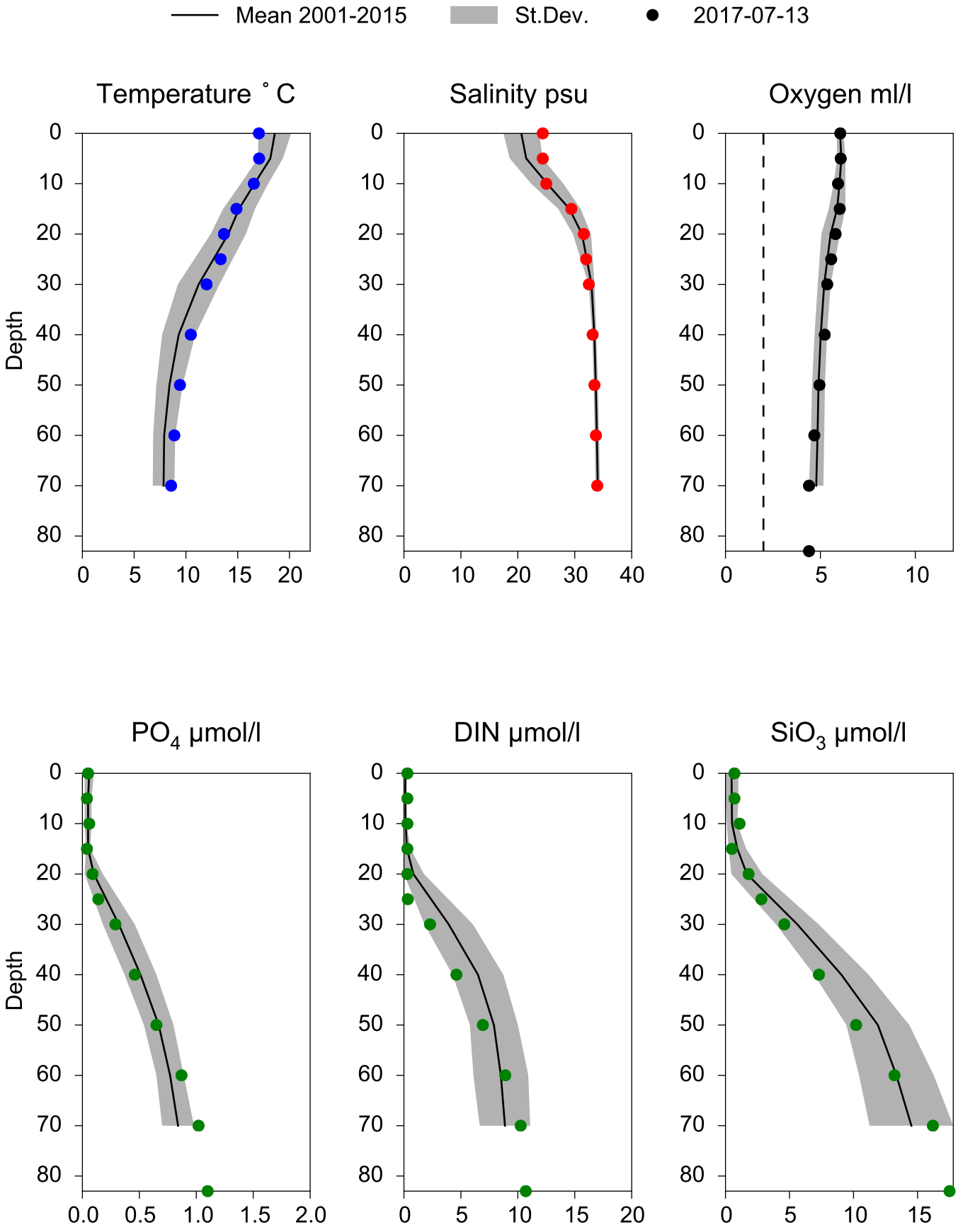
STATION FLADEN SURFACE WATER (0-10 m)



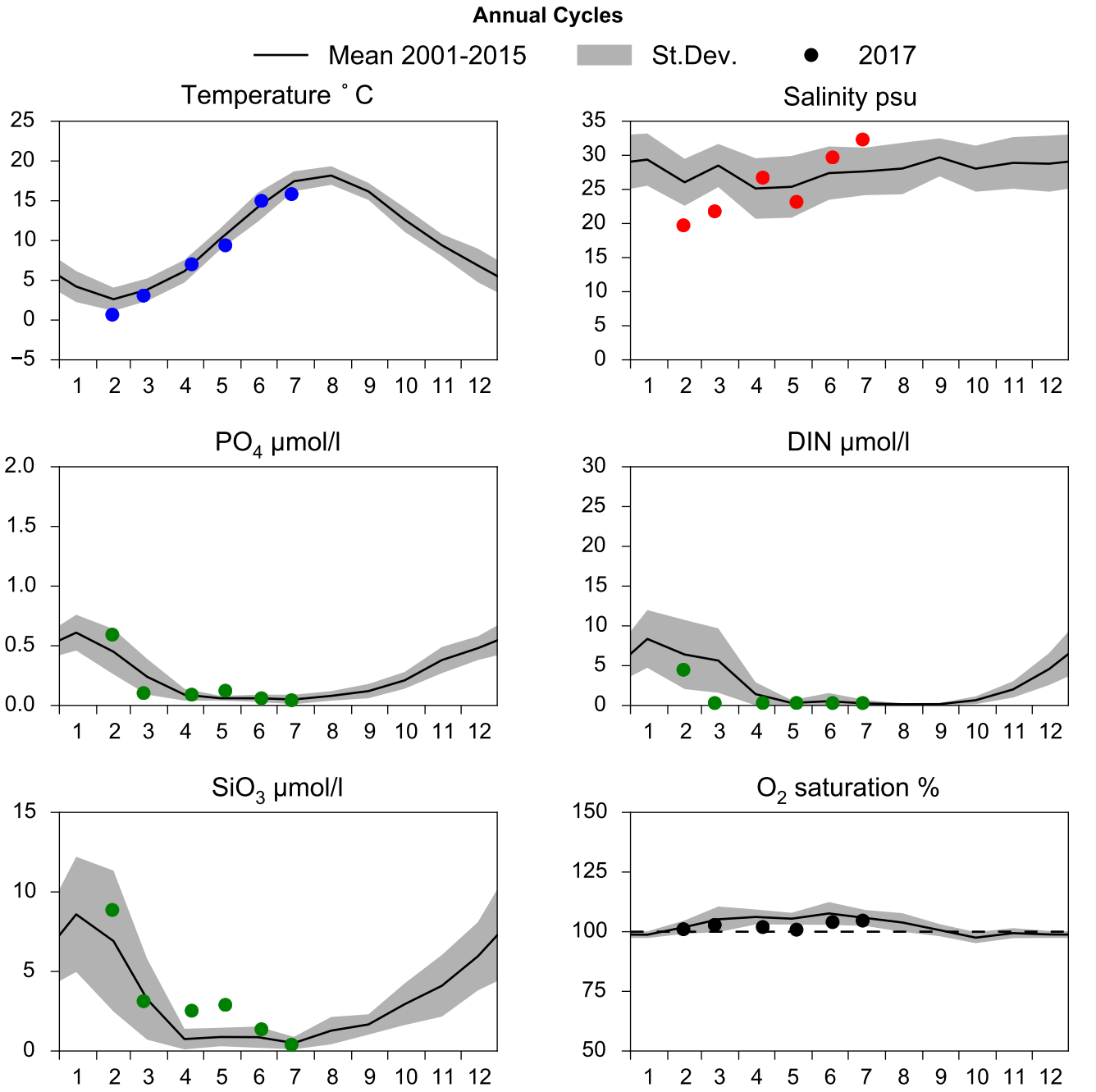
OXYGEN IN BOTTOM WATER (depth >= 74 m)



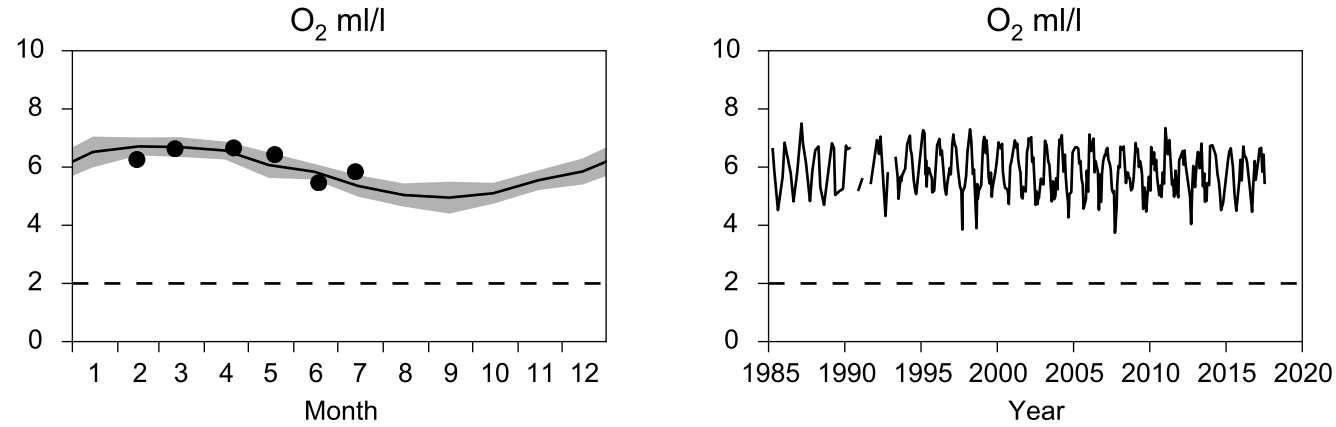
Vertical profiles FLADEN
July



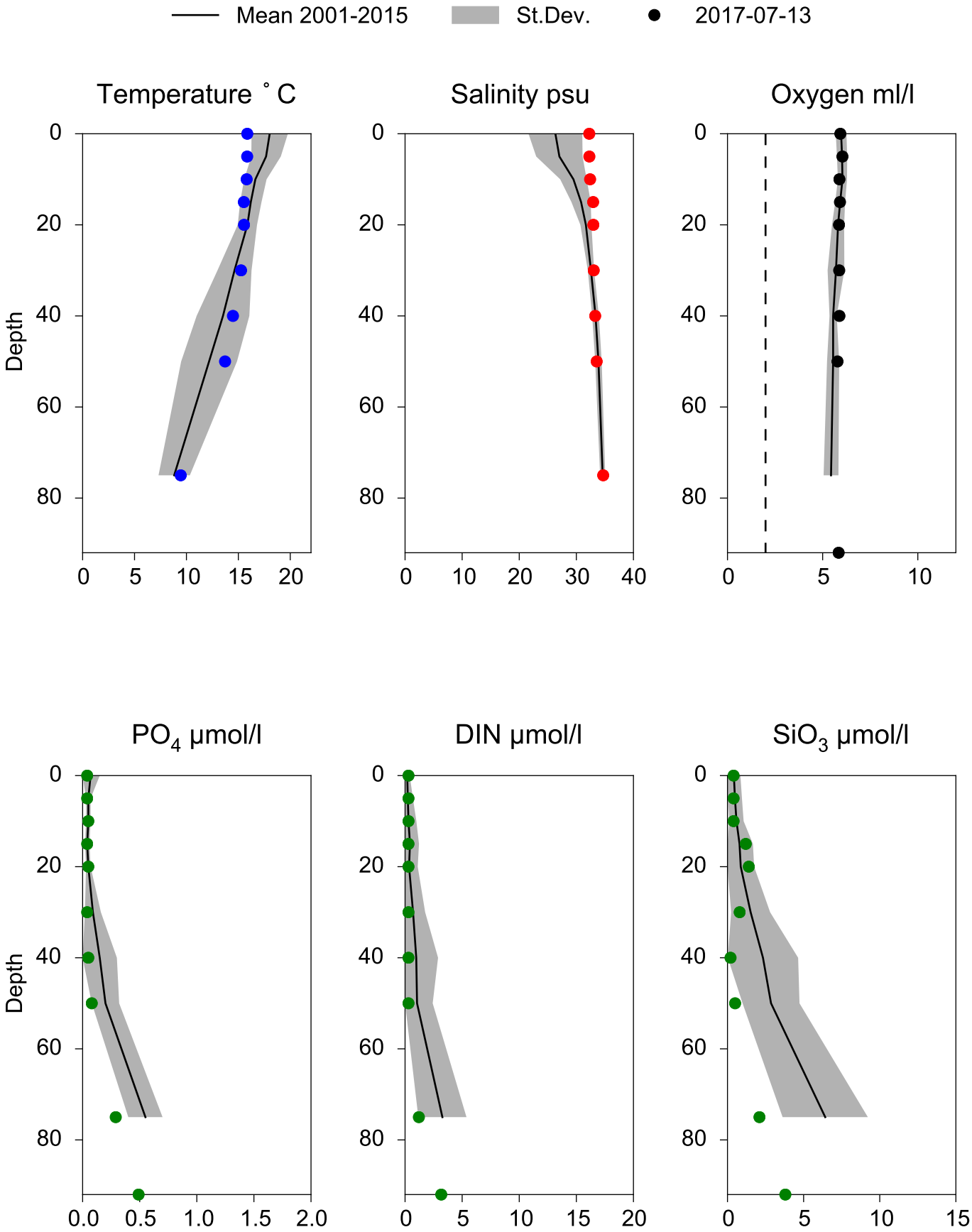
STATION P2 SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 75 m)

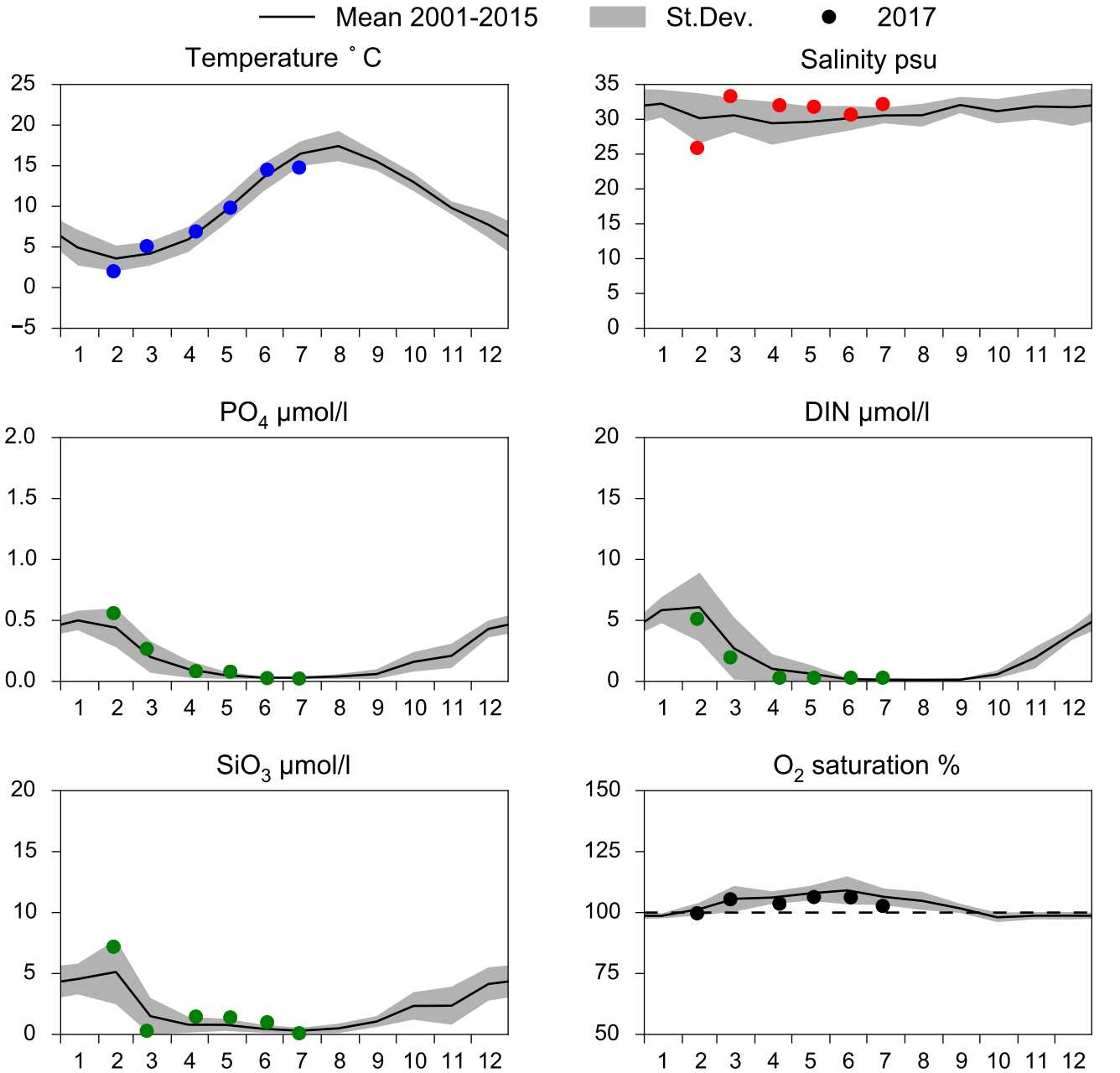


Vertical profiles P2
July

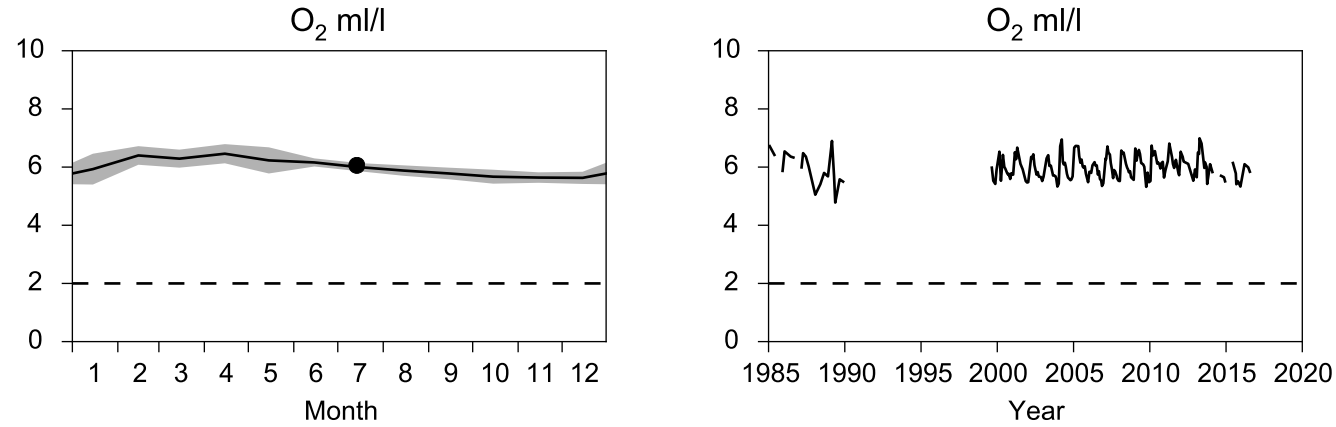


STATION Å17 SURFACE WATER (0-10 m)

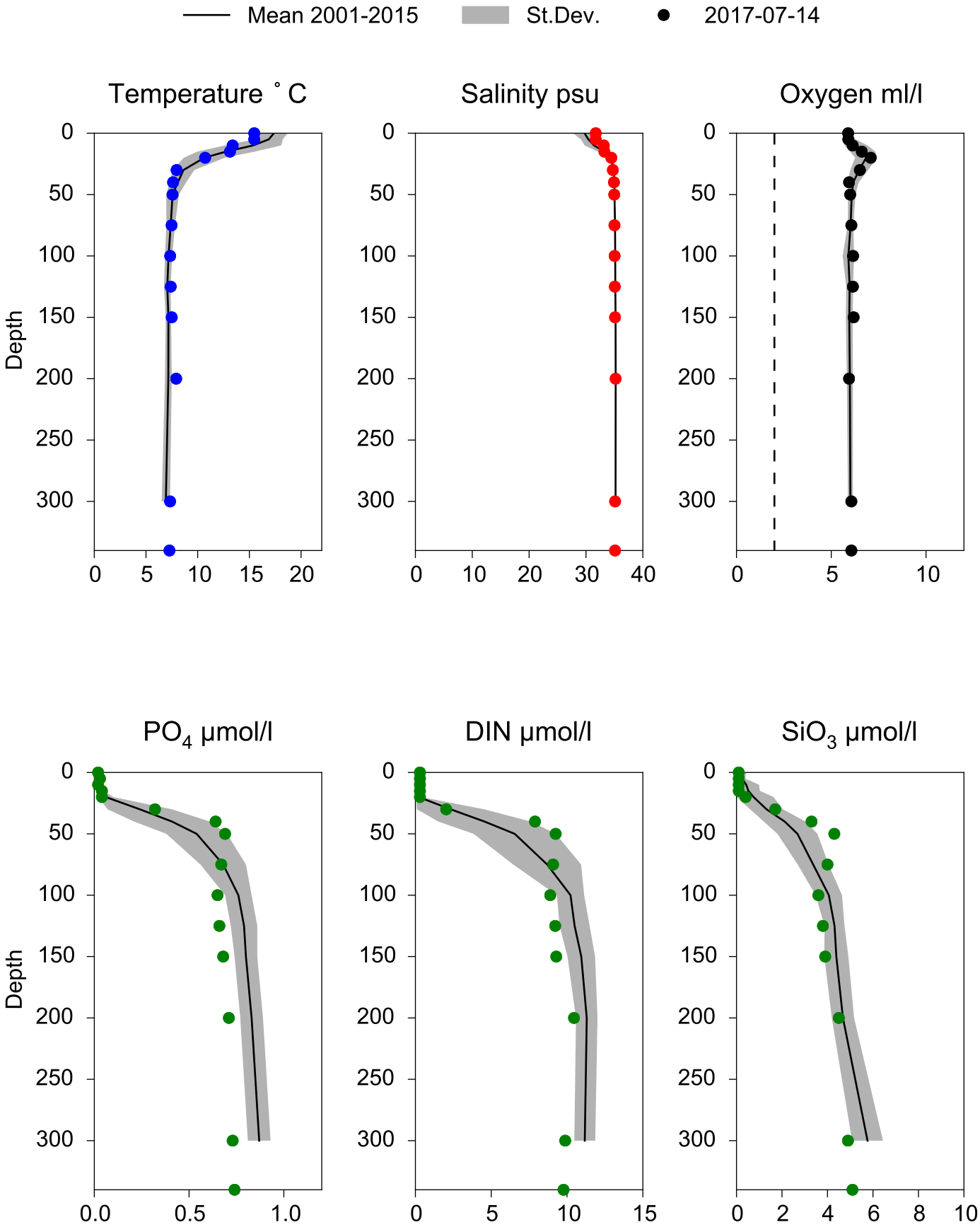
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 300 m)

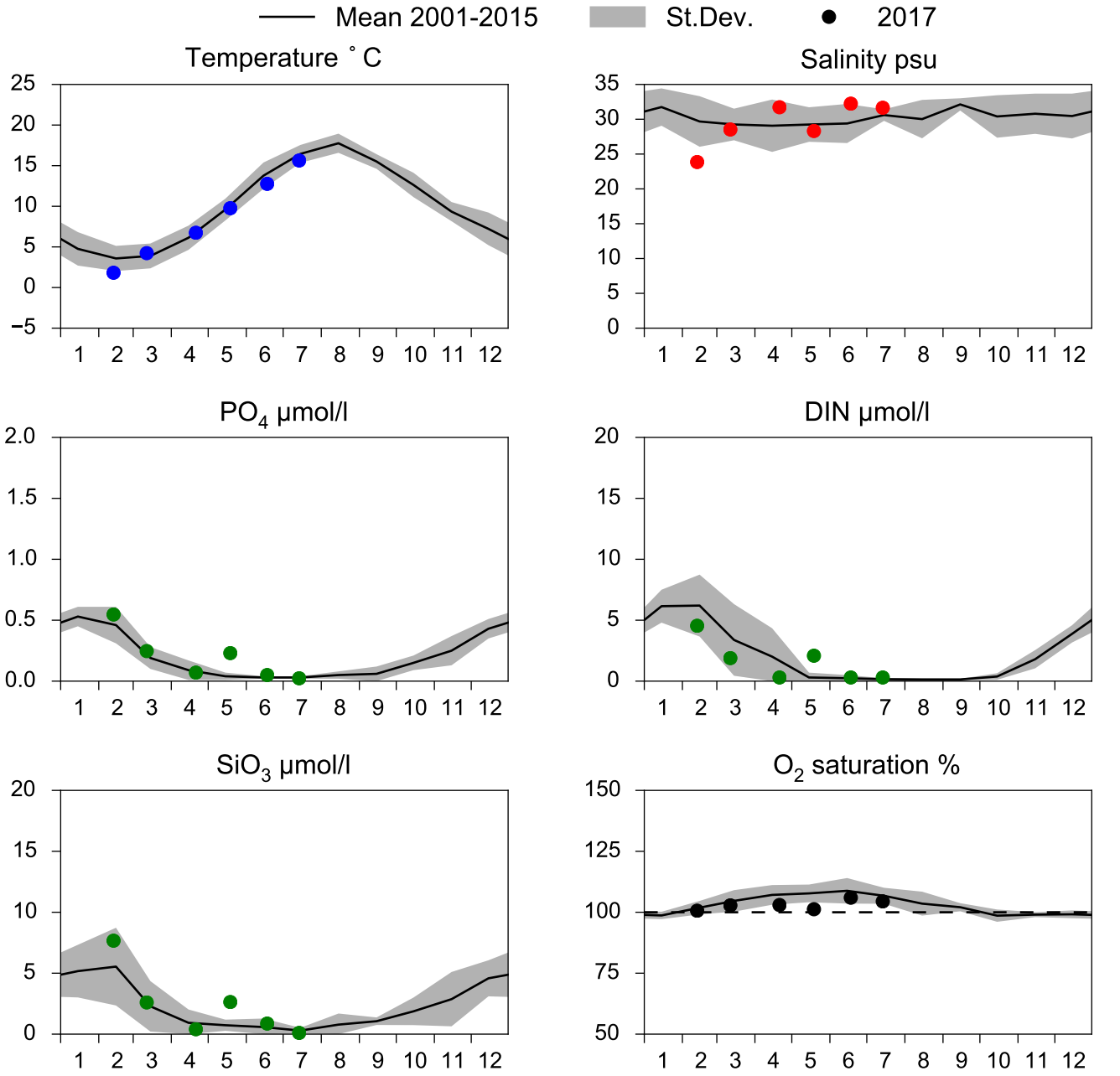


Vertical profiles Å17
July

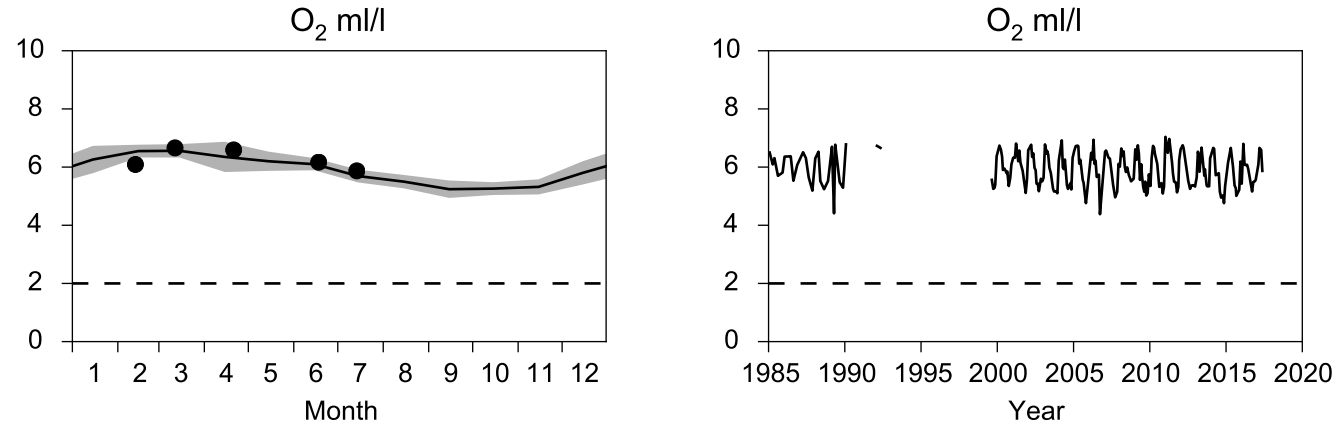


STATION Å15 SURFACE WATER (0-10 m)

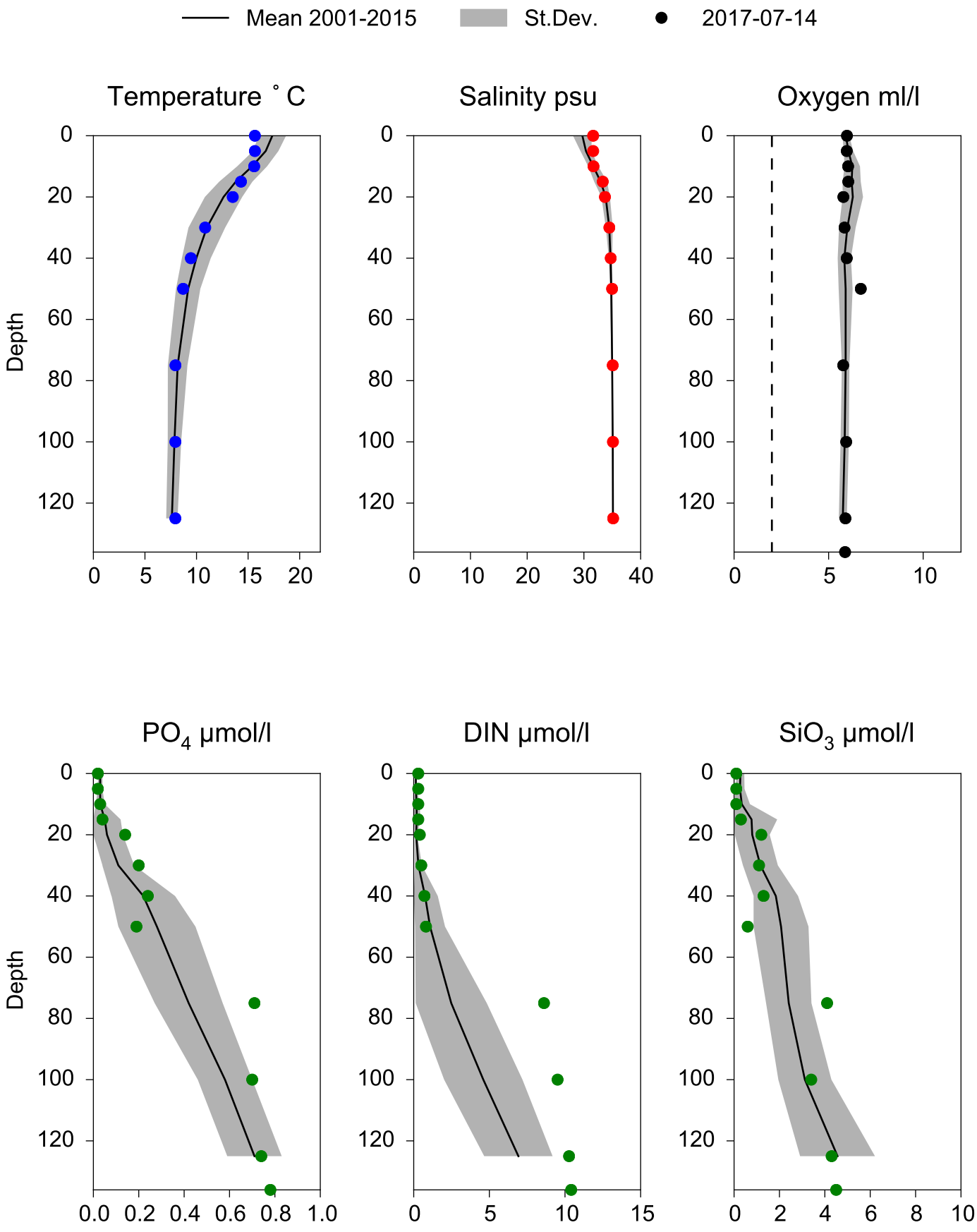
Annual Cycles



OXYGEN IN BOTTOM WATER (depth >= 125 m)

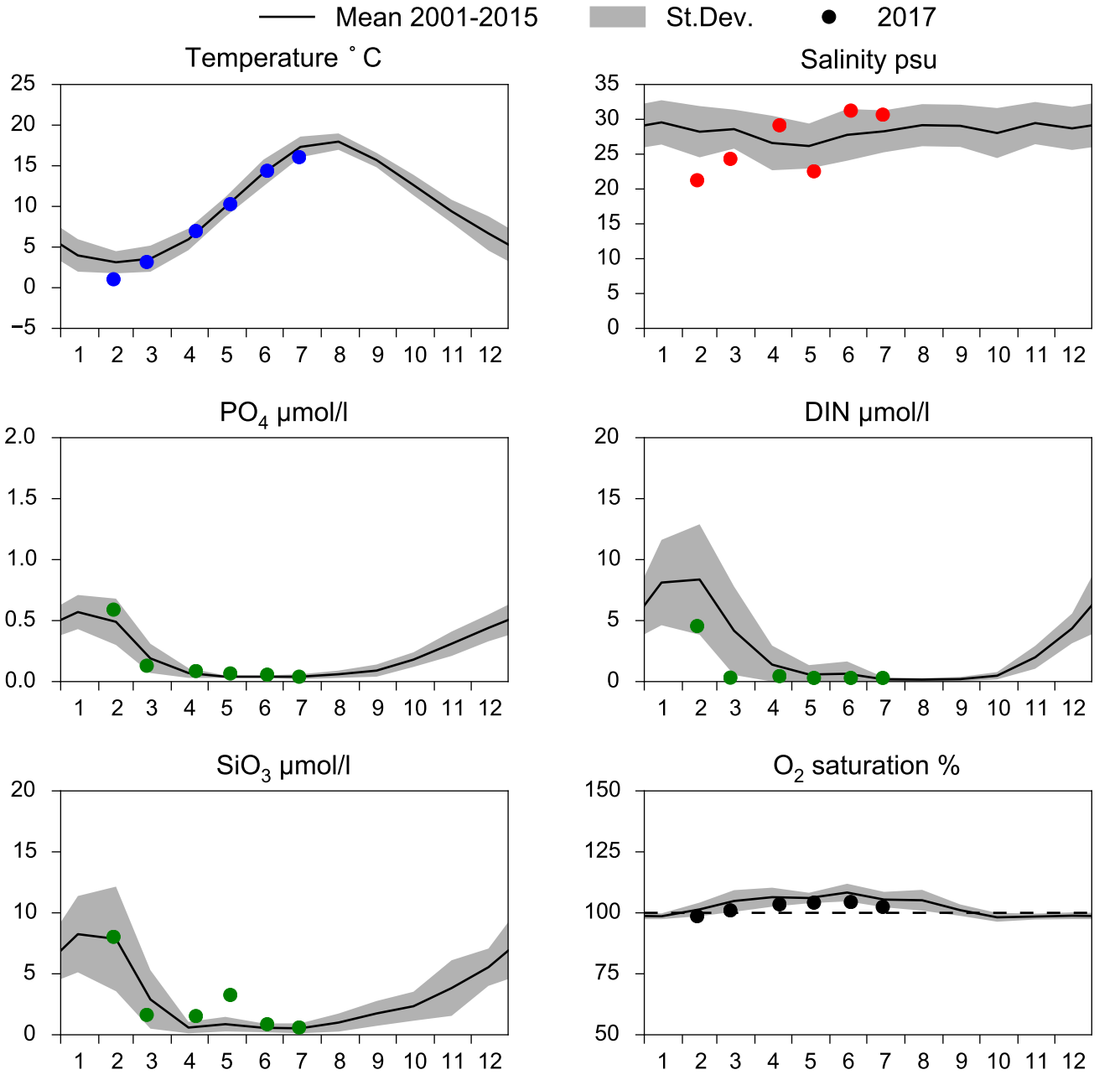


Vertical profiles Å15
July

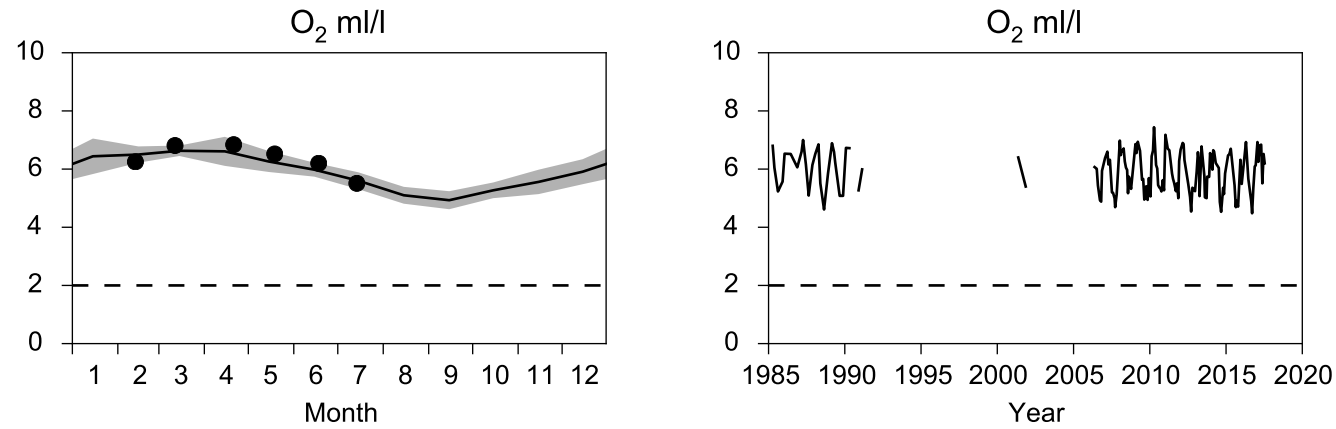


STATION Å13 SURFACE WATER (0-10 m)

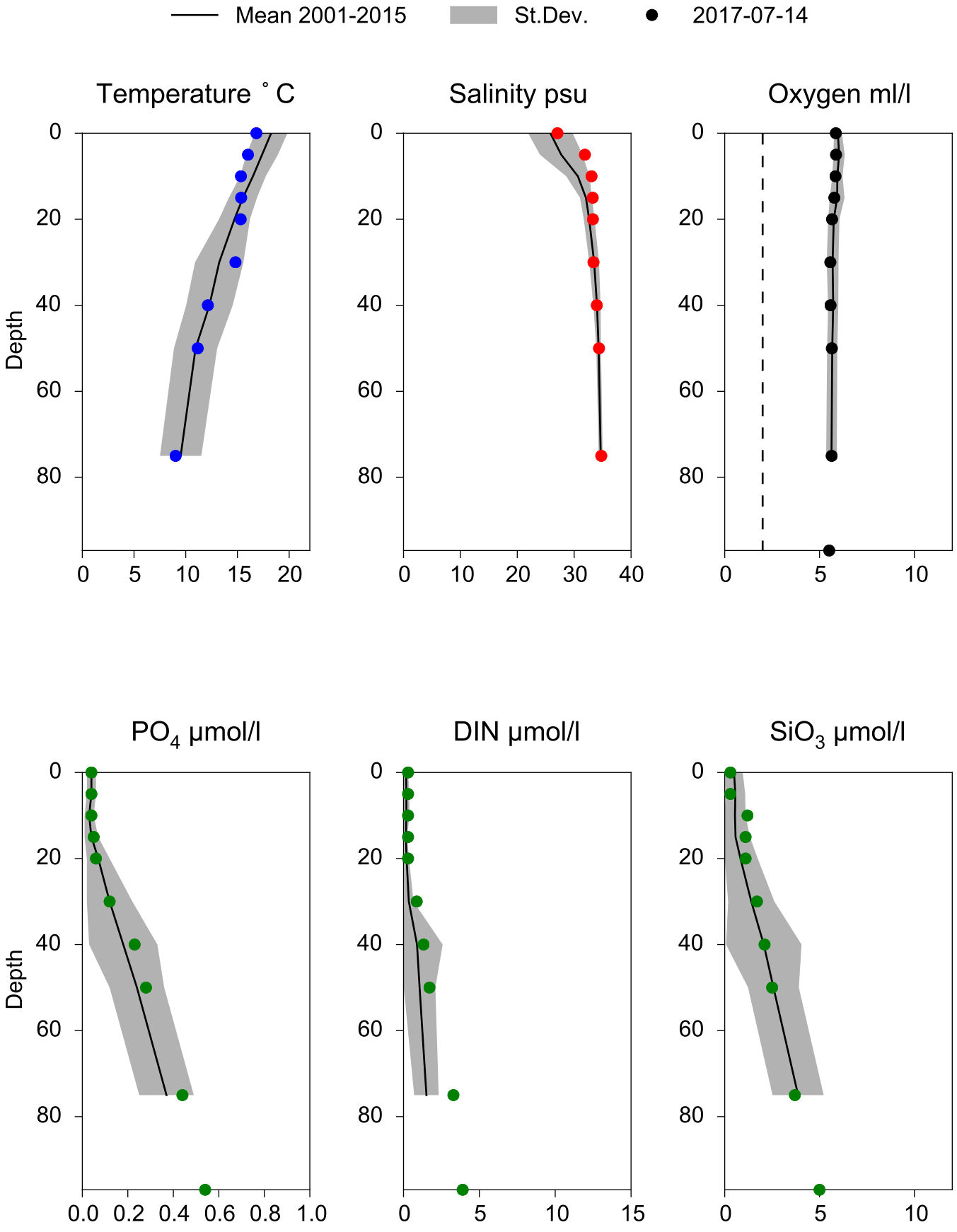
Annual Cycles



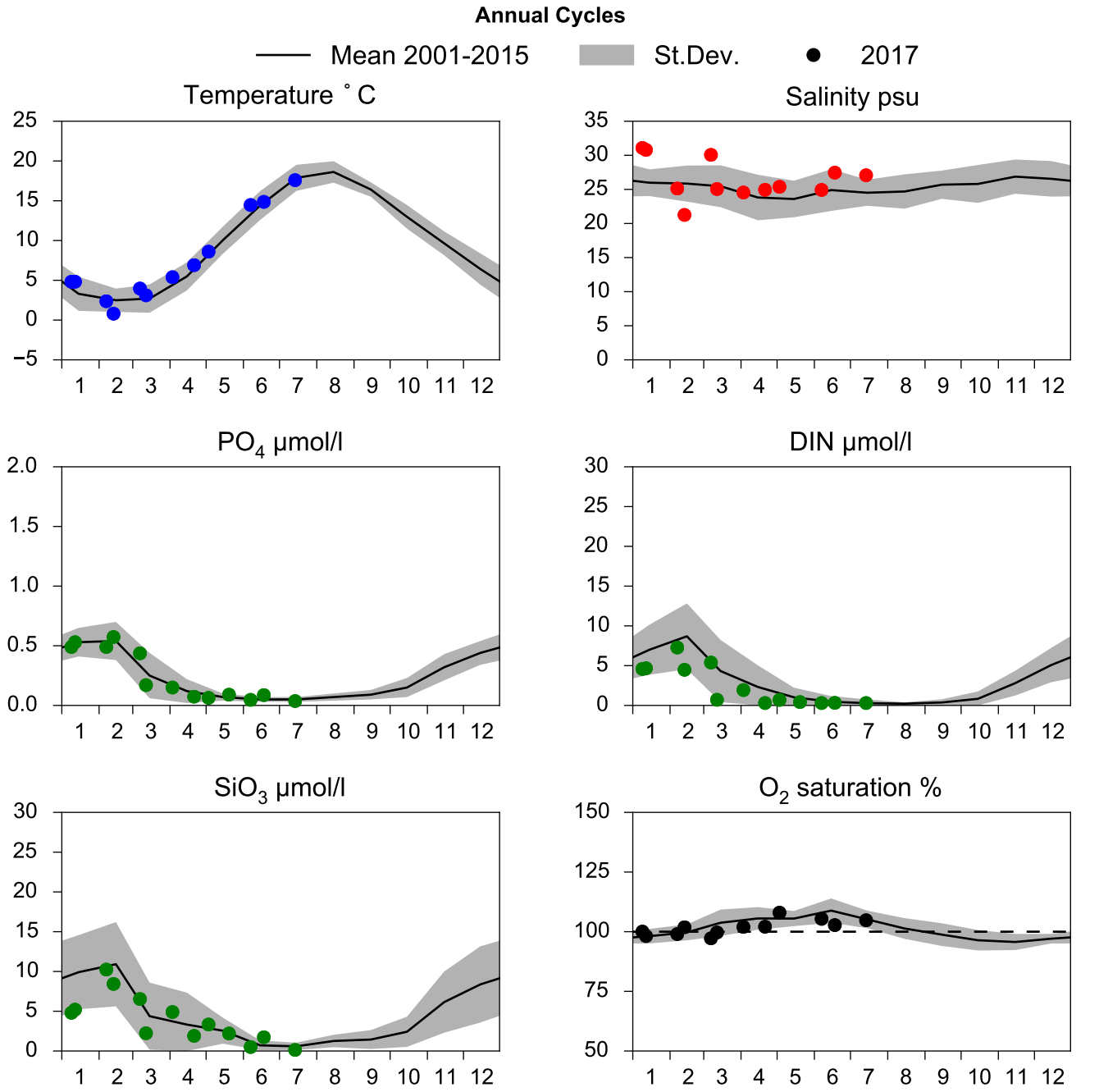
OXYGEN IN BOTTOM WATER (depth >= 80 m)



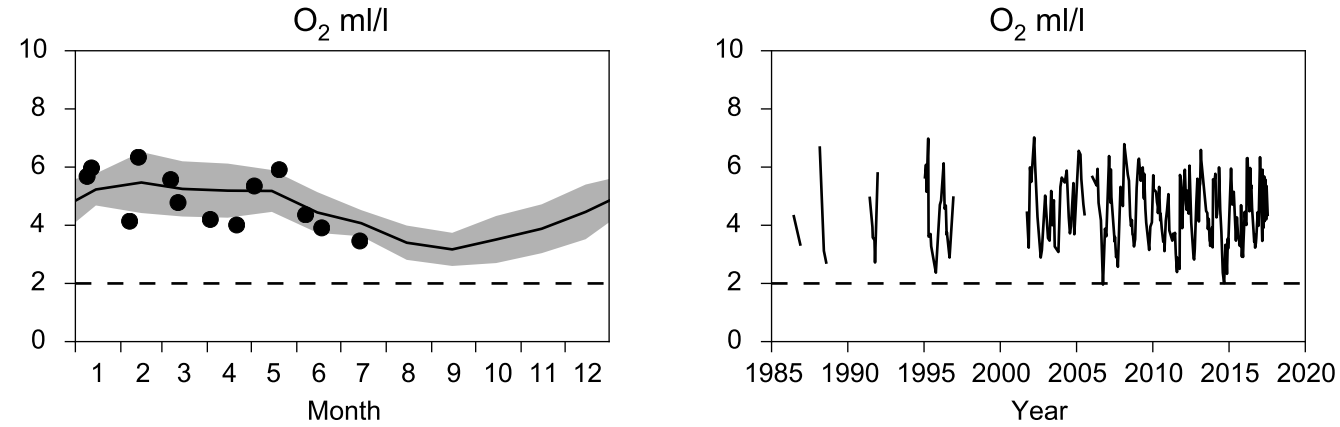
Vertical profiles Å13
July



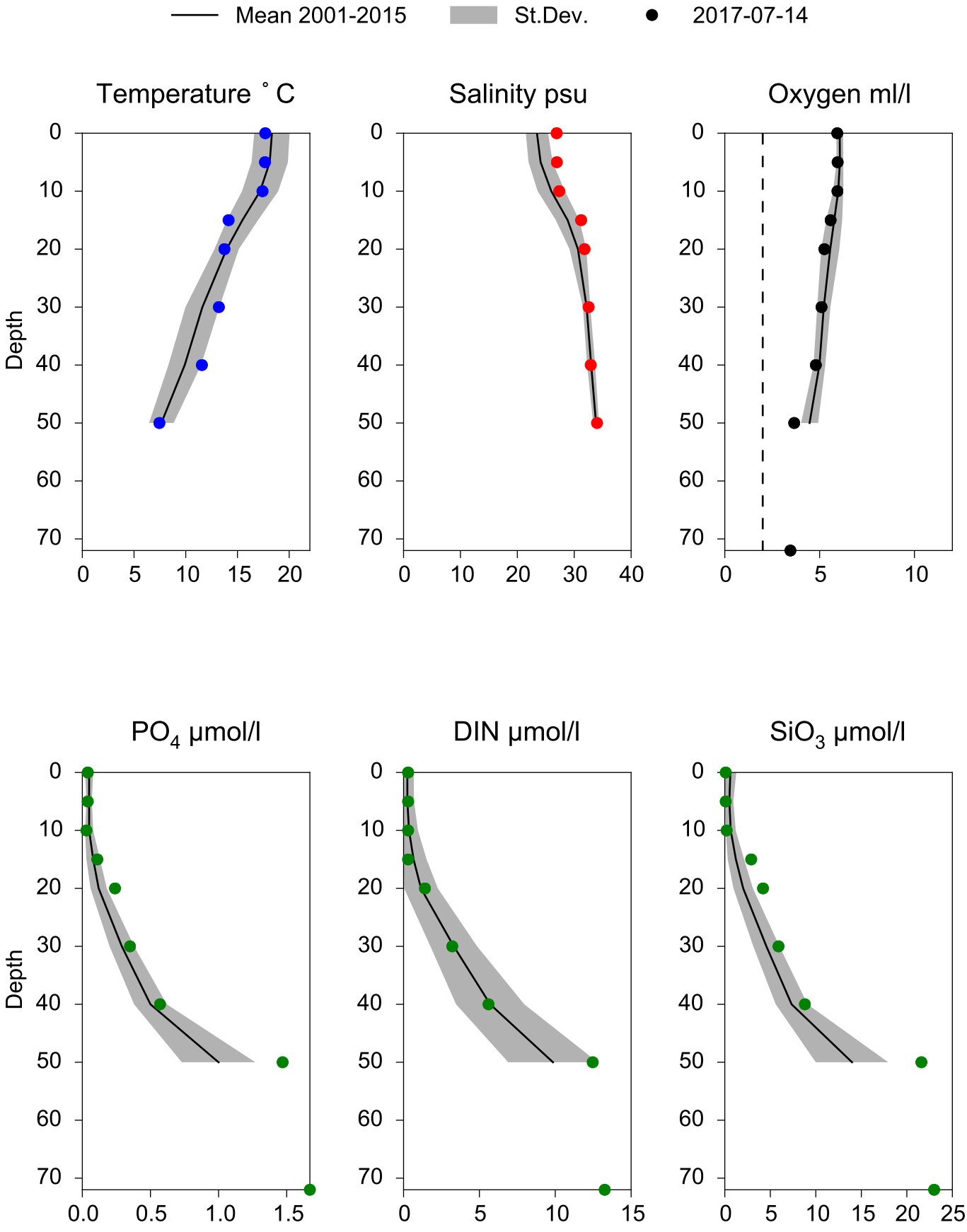
STATION SLÄGGÖ SURFACE WATER (0-10 m)



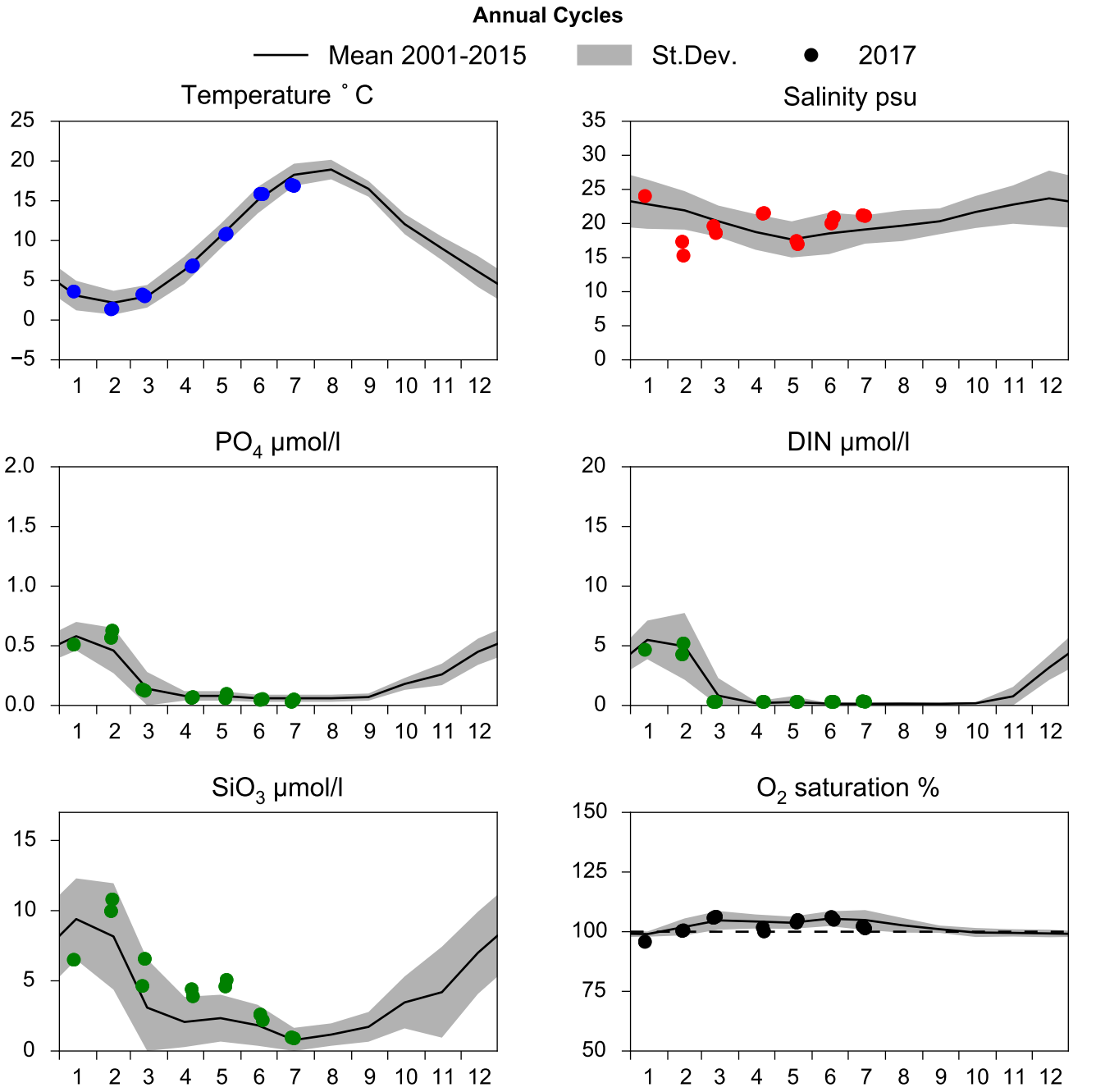
OXYGEN IN BOTTOM WATER (depth >= 64 m)



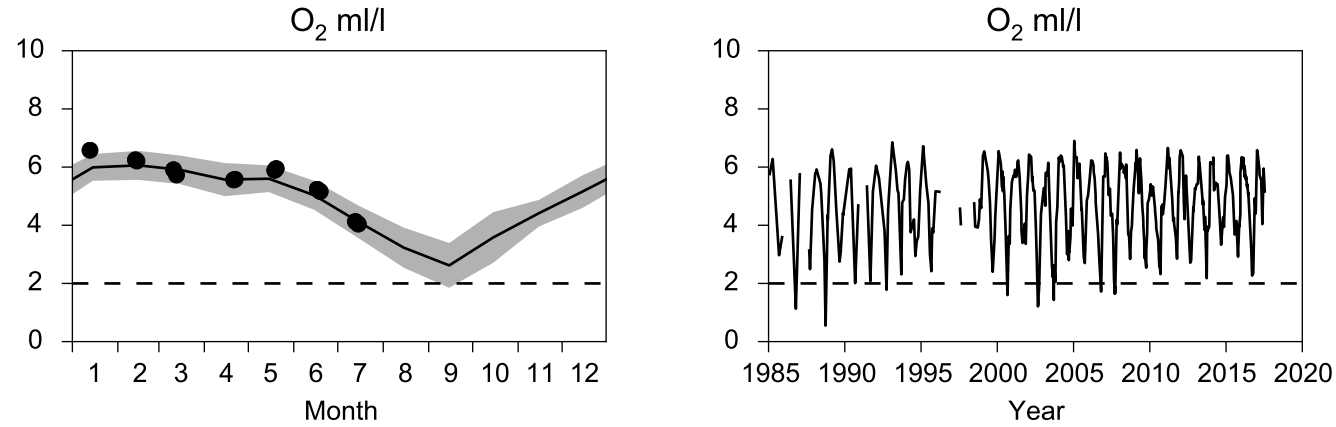
Vertical profiles SLÄGGÖ
July



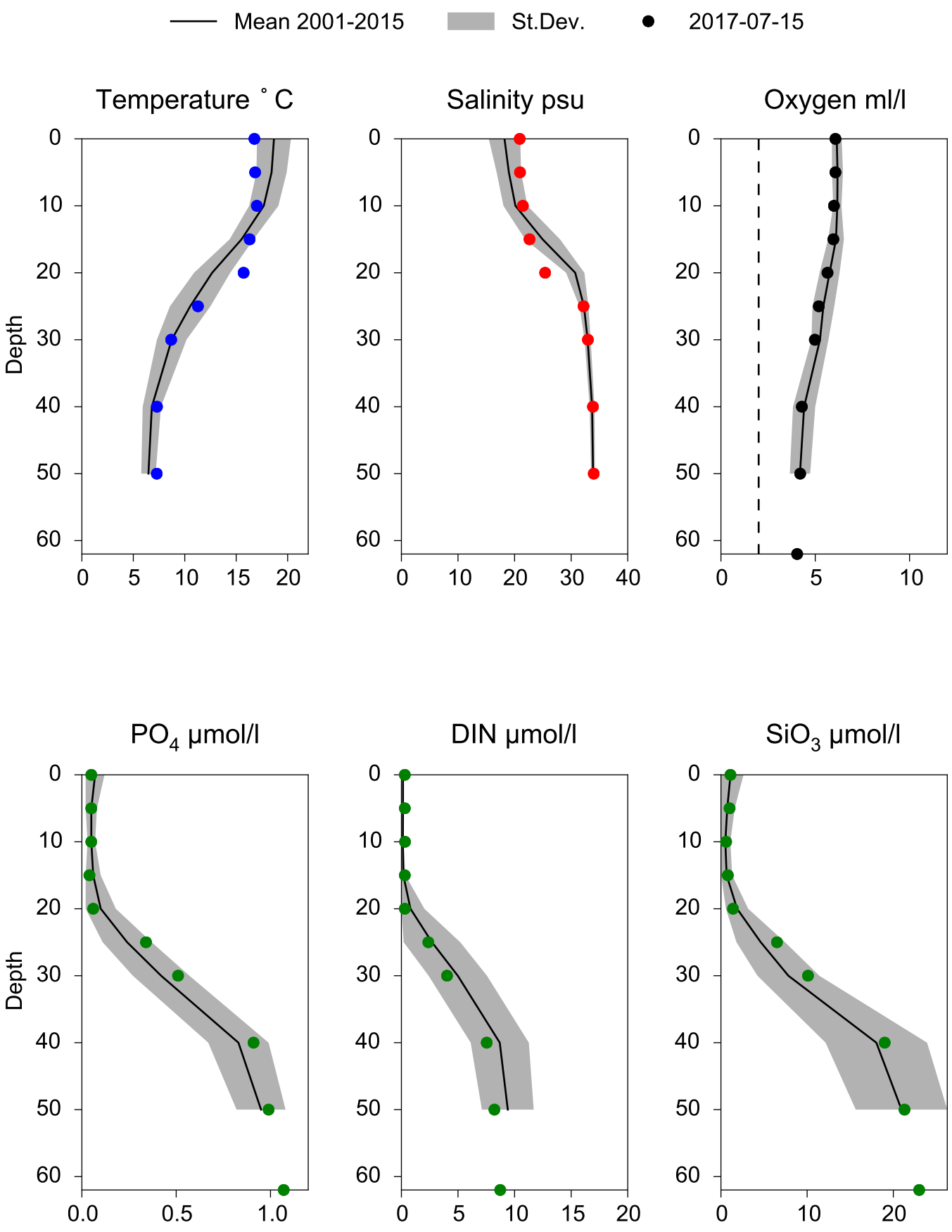
STATION ANHOLT E SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 52 m)

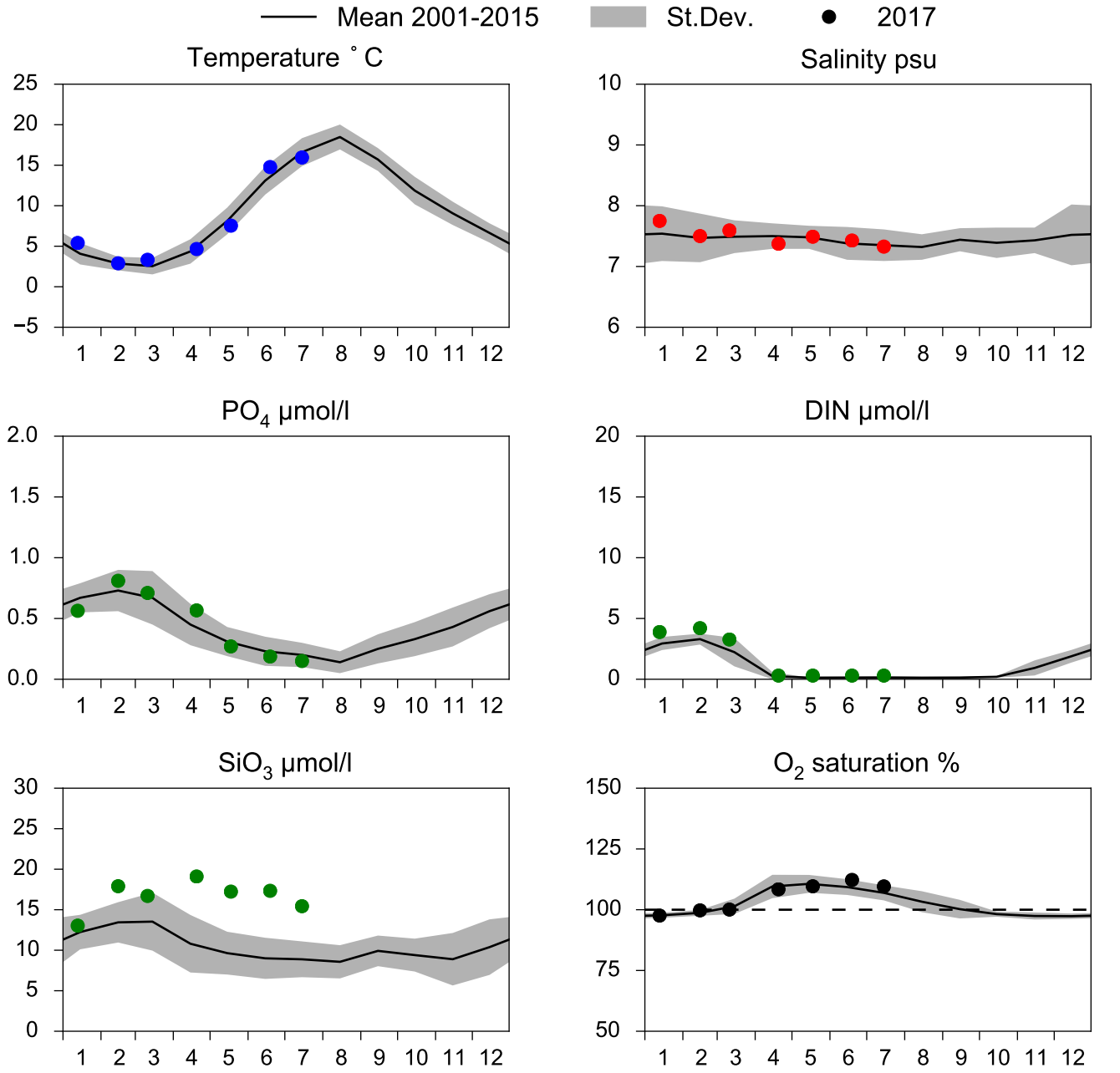


Vertical profiles ANHOLT E
July

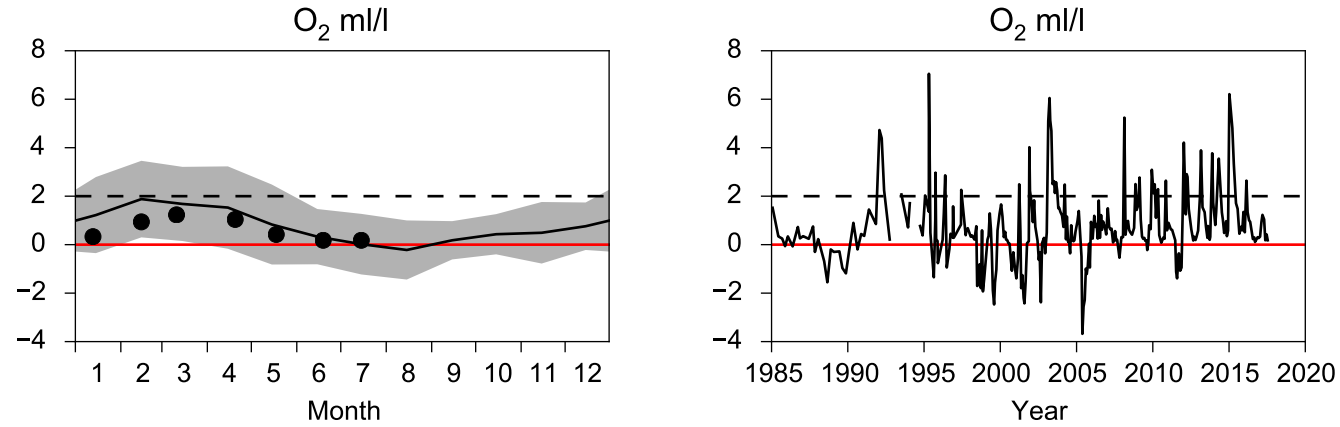


STATION HANÖBUKTEN SURFACE WATER (0-10 m)

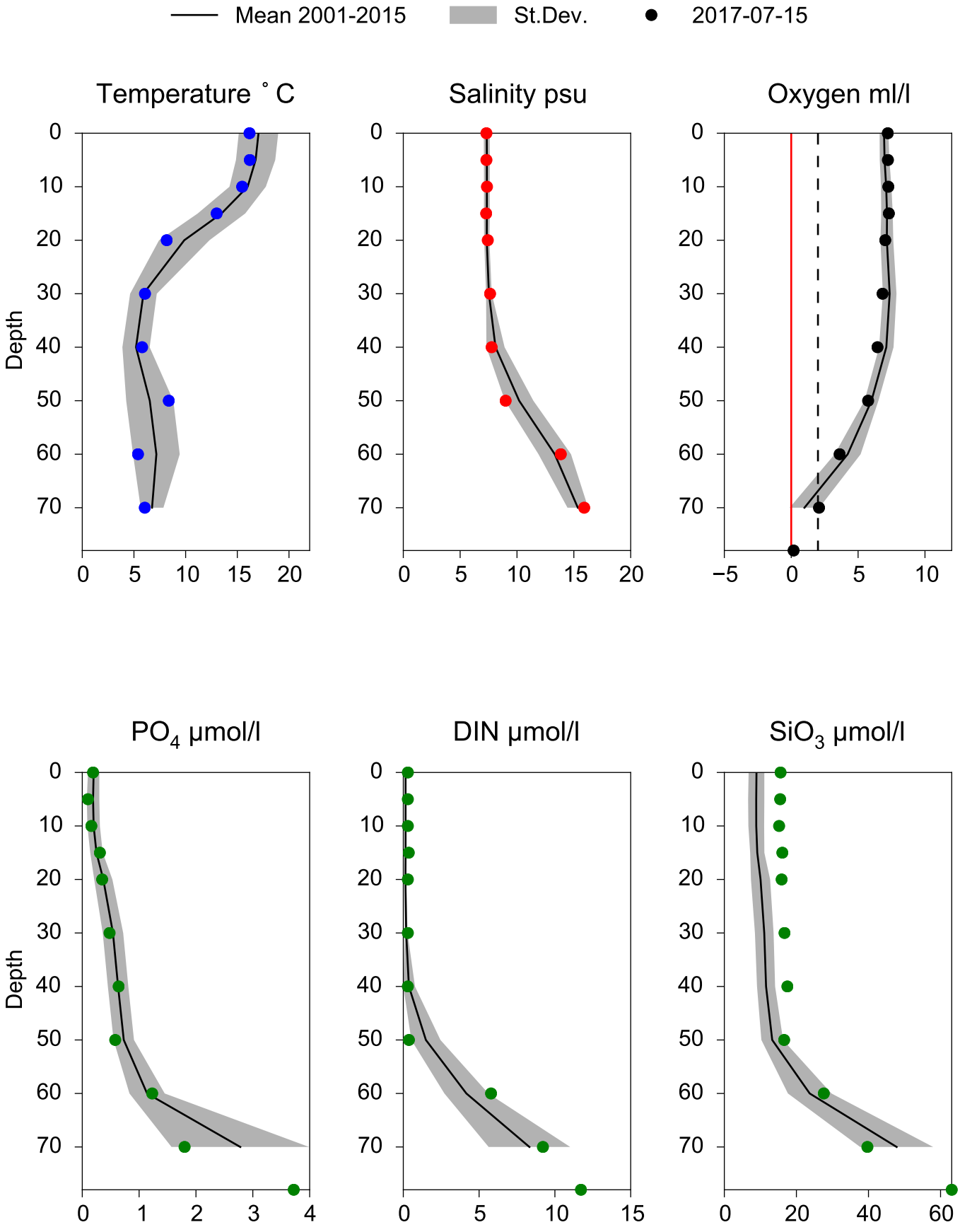
Annual Cycles



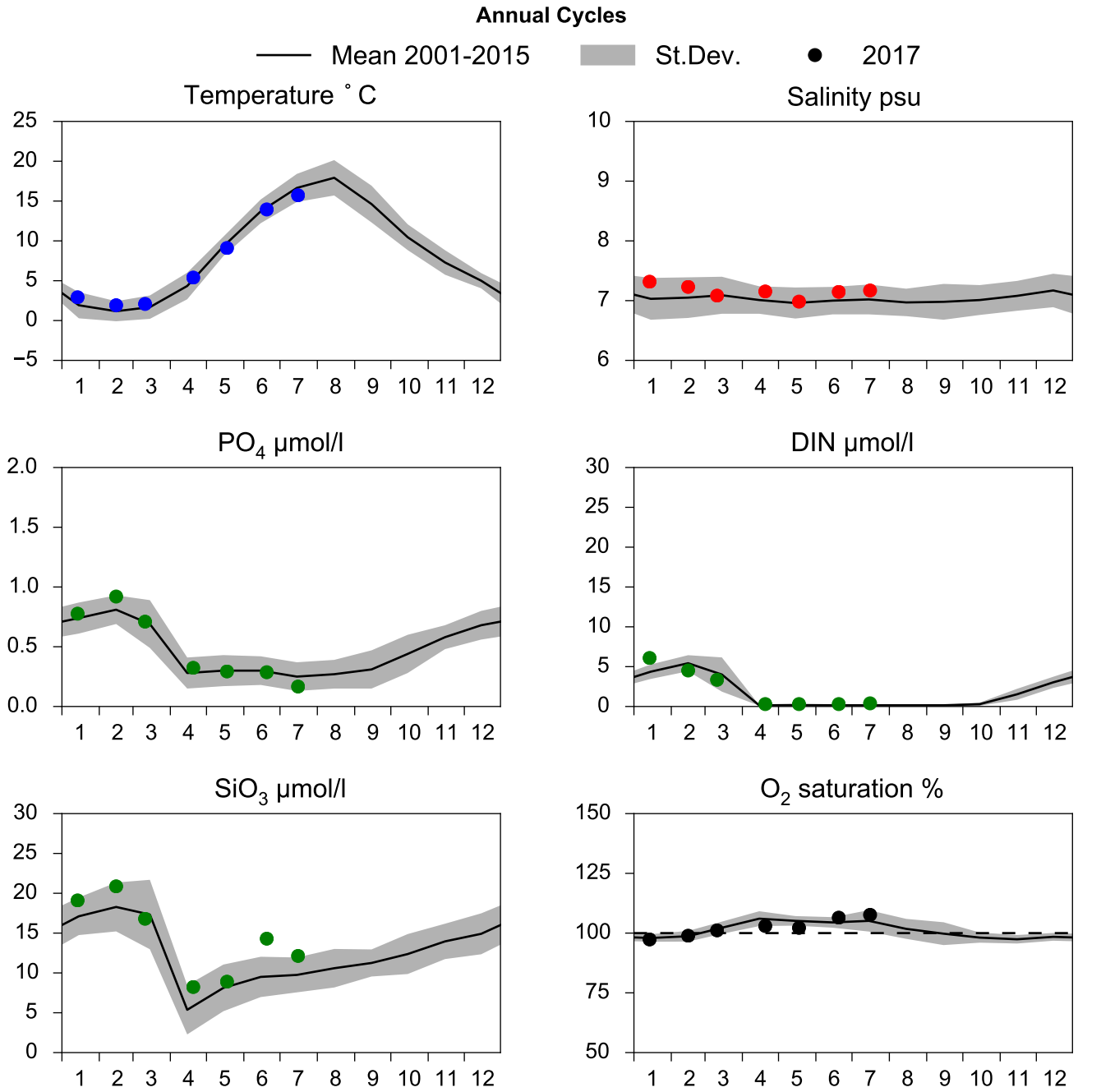
OXYGEN IN BOTTOM WATER (depth >= 70 m)



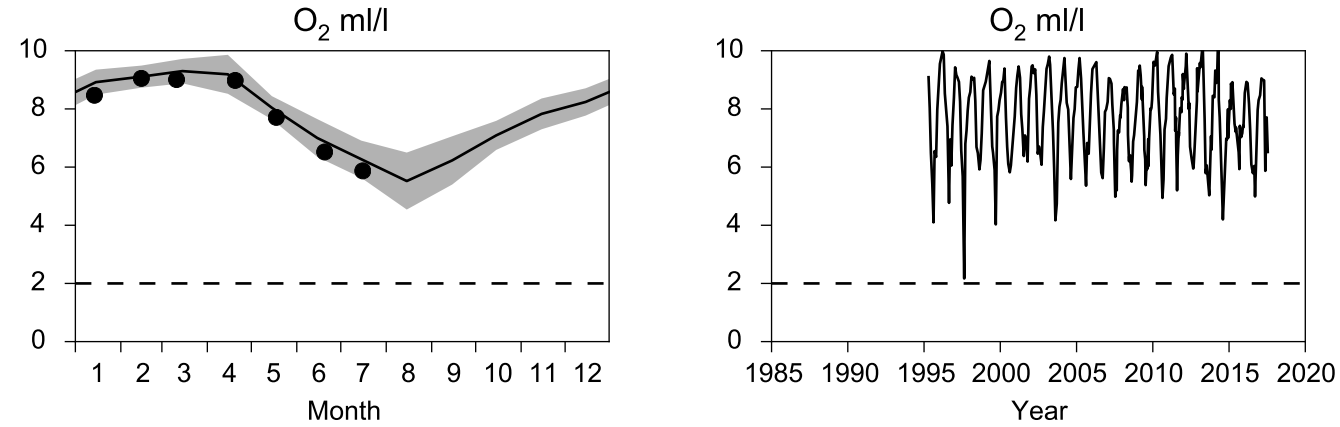
Vertical profiles HANÖBUKTEN
July



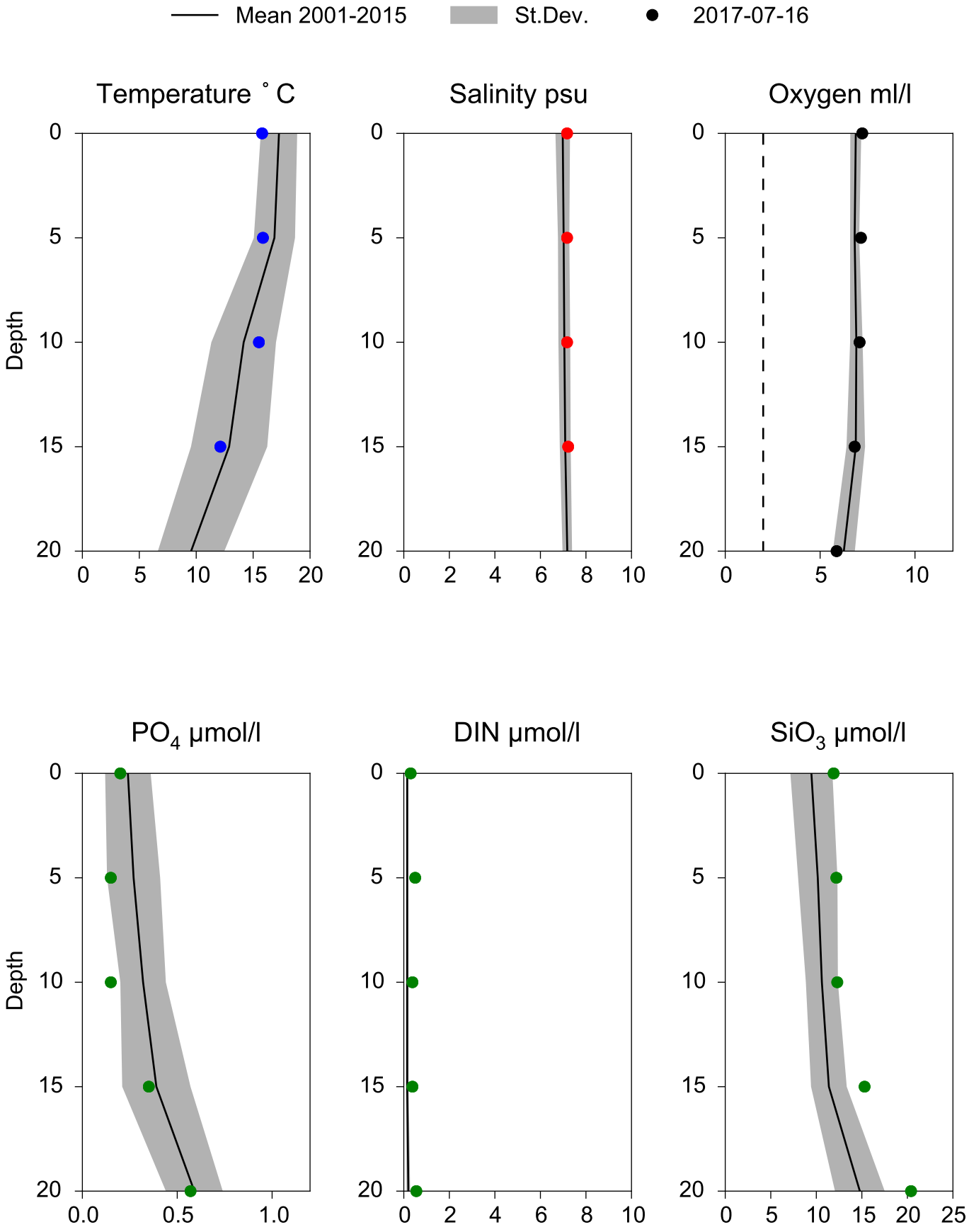
STATION REF M1V1 SURFACE WATER (0-10 m)



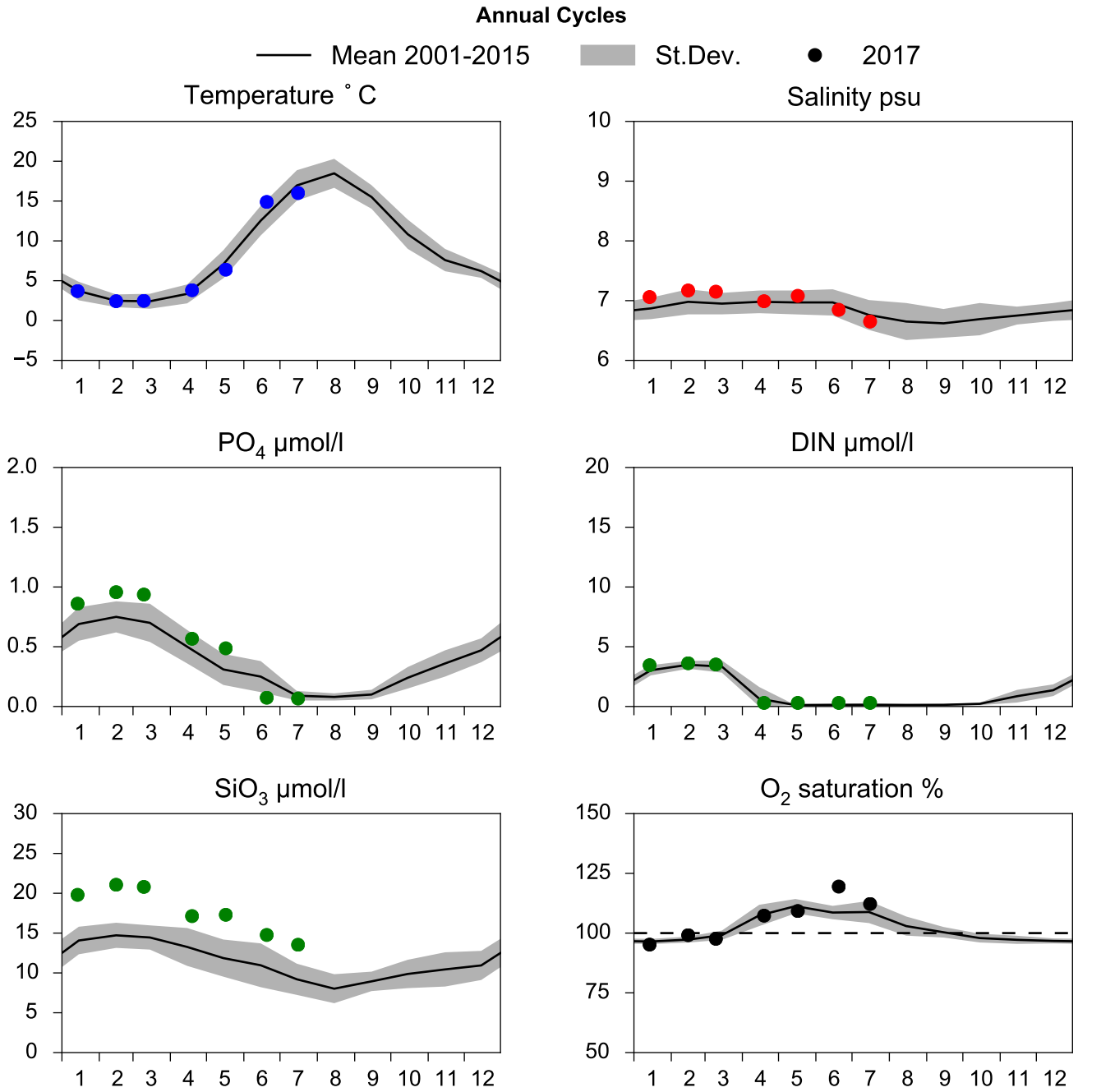
OXYGEN IN BOTTOM WATER (depth >= 17 m)



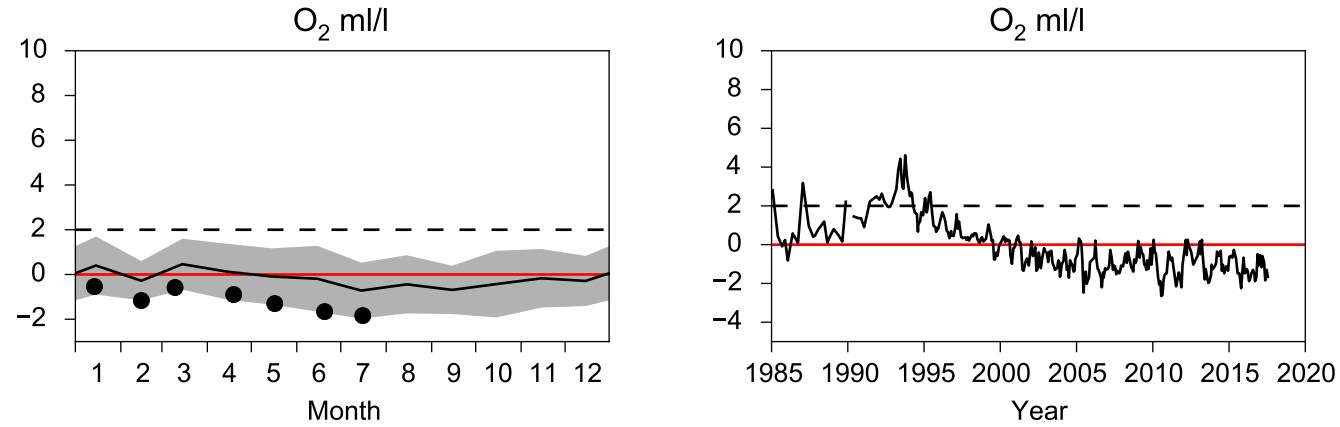
Vertical profiles REF M1V1
July



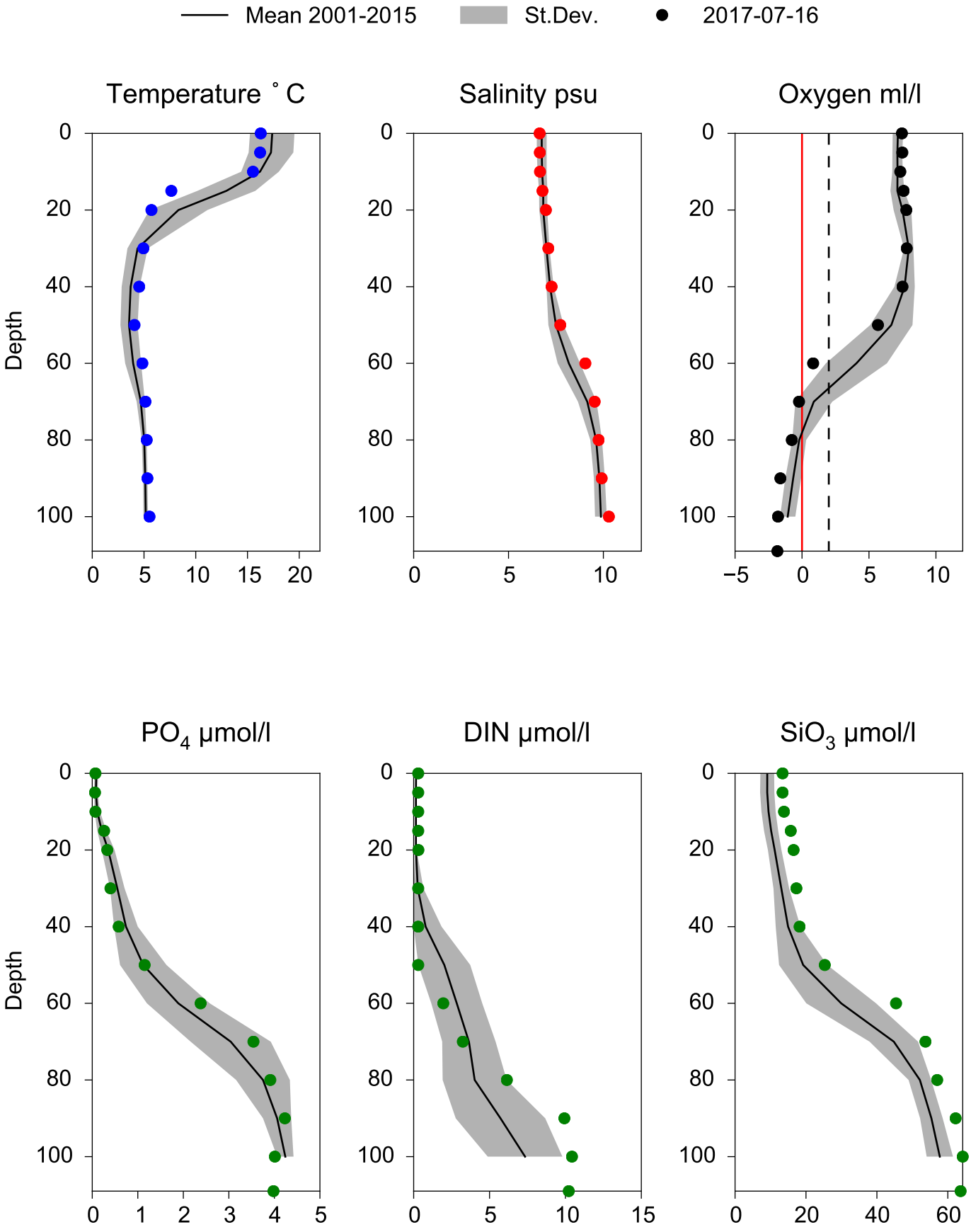
STATION BY38 KARLSÖDJ SURFACE WATER (0-10 m)



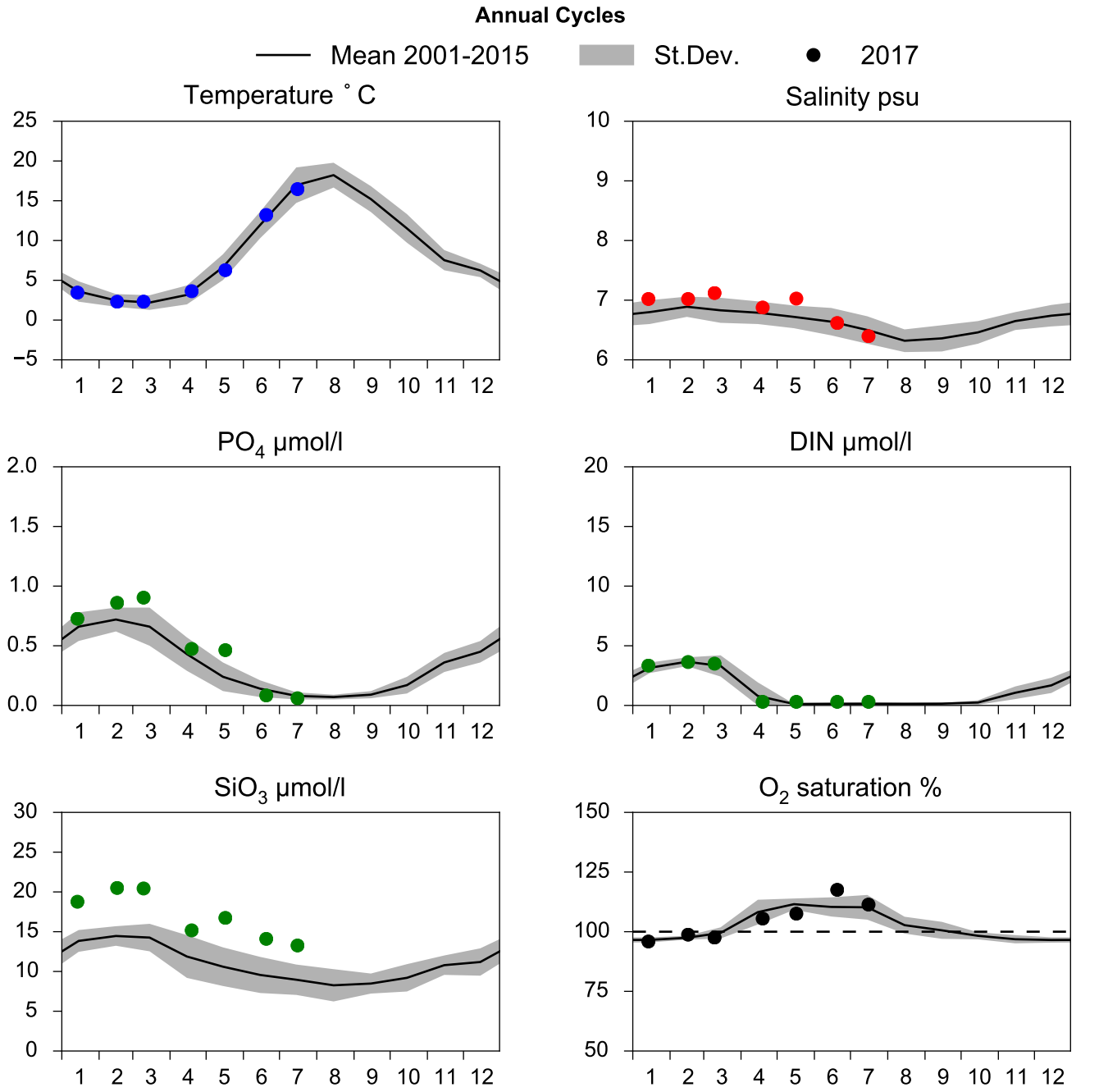
OXYGEN IN BOTTOM WATER (depth >= 100 m)



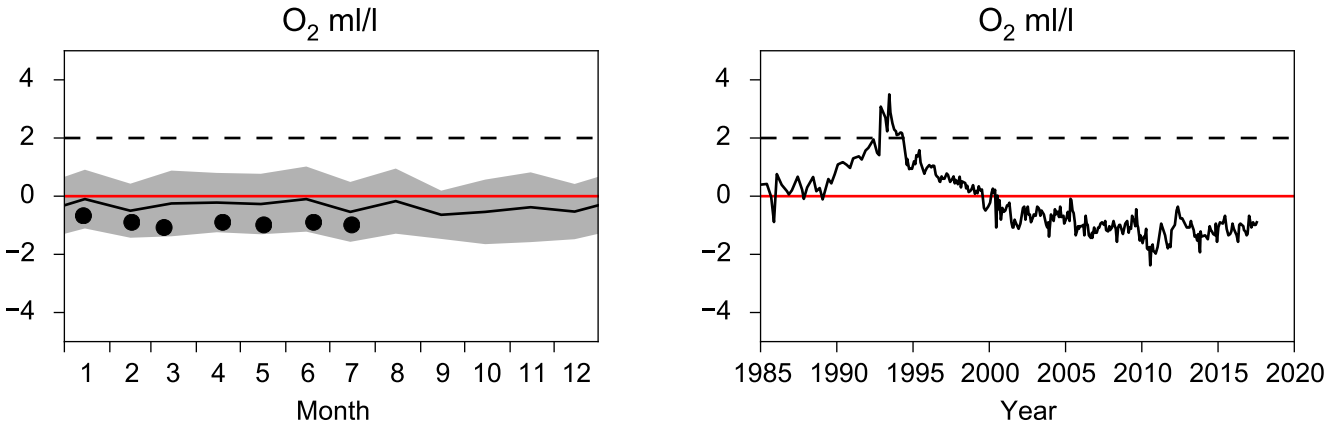
Vertical profiles BY38 KARLSÖDJ
July



STATION BY32 NORRKÖPINGSDJ SURFACE WATER (0-10 m)



OXYGEN IN BOTTOM WATER (depth >= 175 m)



Vertical profiles BY32 NORRKÖPINGSDJ
July