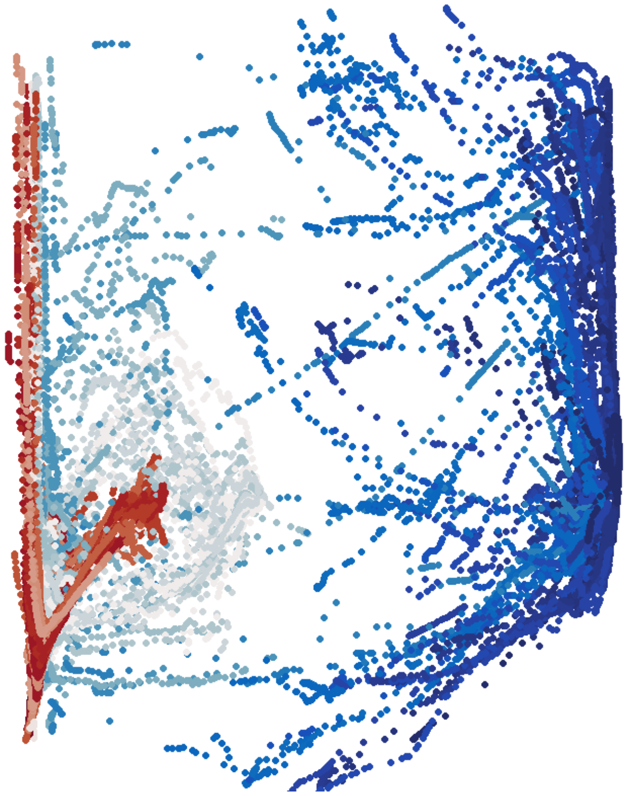
REPORT OCEANOGRAPHY No. 64 2018



The Swedish National Marine Monitoring Programme 2017

Hydrography

Nutrients

Phytoplankton

Karin Wesslander, Lena Viktorsson and Ann-Turi Skjevik

Front.
The image illustrates a T-S diagram made by all SMHI’s CTD-observations during 2017.

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Summary

This report presents the main results of the Swedish national marine monitoring programme of the pelagic during 2017. The monitoring data of hydrography, nutrients and phytoplankton are analysed for the seas surrounding Sweden: Skagerrak, Kattegat, The Sound, Baltic Proper, Bothnian Sea and Bothnian Bay. The monitoring is carried out by SMHI (Swedish Meteorological and Hydrological Institute), SU (Stockholm University) and UMF (Umeå Marine Sciences Centre) and the monitoring programme is co-funded by SwAM (Swedish Agency for Marine and Water Management), SMHI, SU and UMF. Data is collected, analysed and reported with support from Swedish environmental monitoring and commissioned by SwaM.

The Baltic current along the Swedish west coast implies large variations in surface salinity and the unusually large outflow of brackish water from the Baltic Sea in 2017 was reflected as low surface salinity in Skagerrak and Kattegat in the beginning of the year. There were no major deep water inflows to the Baltic Sea during 2017 but a few inflows of minor magnitude. These minor inflows only temporarily improved the oxygen condition in the Bornholm Basin and in the southern part of the Eastern Gotland Basin.

The salinity below the halocline was above normal in the Gotland Basins and in the Northern Baltic Proper, and also in the surface layer in the Eastern Gotland Basin for almost the whole year.

In Skagerrak and Kattegat, surface concentrations of phosphate and dissolved inorganic nitrogen were normal while dissolved silica concentrations were elevated especially in spring. In the Baltic Sea, the concentration of silicate in the surface water was elevated in all basins. According to the estimated total content of silicate there has been an increase in silica content in the Baltic Sea since the early 1990’s. Surface concentrations of phosphate were above normal in the Gotland basins and the Northern Baltic Proper while inorganic nitrogen content was above normal in parts of the Arkona and Bornholm basins. During spring and summer, the inorganic nitrogen was consumed at greater depths than usual in the Baltic Proper. In particular concentrations of phosphate and dissolved silica were generally lower than normal in the bottom layer.

Instead of diatoms, the flagellate genus *Pseudochattonella*, which is potentially toxic to fish, bloomed in the Kattegat and Skagerrak areas in February – April. During autumn there was a prolonged diatom bloom though. In the Baltic Sea spring bloom occurred in April. The cyanobacteria bloom began in May already with *Aphanizomenon flos-aquae*. During June and July all three of the filamentous cyanobacteria, *A. flos-aquae, Dolichospermum lemmermannii* and the potentially harmful *Nodularia spumigena* were found in the phytoplankton samples in various amounts.

In the Bothnian Sea, the sea surface temperature during summer was lower than normal and the oxygen conditions in the bottom layer was not critical but still below normal levels.

Sammanfattning

Den här rapporten sammanfattar de huvudsakliga resultaten av det svenska nationella marina övervakningsprogrammet av pelagialen under 2017. Resultat från mätningar av hydrografi, näringsämnen och växtplankton diskuteras för haven runt Sverige; Skagerrak, Kattegatt, Öresund, Egentliga Östersjön, Bottenhavet och Bottenviken. Övervakningen utförs av SMHI (Sveriges meteorologiska och hydrologiska institut), SU (Stockholms Universitet) och UMF (Umeå marina forskningscentrum) och övervakningsprogrammet samfinansieras av HaV (Havs- och vattenmyndigheten), SMHI, SU and UMF. Data är insamlade, analyserade och rapporterade med stöd från svensk miljöövervakning och på uppdrag HaV.

Den Baltiska strömmen längs Västkusten medför stora fluktuationer av salthalten i ytan och det ovanligt höga utflödet med bräckt vatten från Östersjön under 2017 avspeglades som låg ytsalthalt i Skagerrak och Kattegatt i början av året. Det var inga stora djupvatteninflöden till Östersjön under 2017 men ett par av mindre storlek. Dessa mindre inflöden förbättrade syreförhållanden endast temporärt i Bornholmsbassängen och i södra delen av Östra Gotlandsbassängen.

Salthalten under haloklinen var högre än normalt i Gotlandsbassängerna och i Norra Egentliga Östersjön samt även i ytlagret i Östra Gotlandsbassängen.

Koncentrationen av fosfat och oorganiskt kväve i Skagerrak och Kattegatts ytvatten var normal medan silikatkoncentrationen var hög, speciellt under våren. I Östersjöns ytvatten var det höga nivåer av silikat i alla bassänger. Enligt det uppskattade totala innehållet av kisel i Östersjön har det pågått en ökning av kisel sedan början av 90-talet. Koncentrationen av fosfat i ytvattnet var över normal i Gotlandsbassängerna och Norra Egentliga Östersjön medan koncentrationen av oorganiskt kväve var mer än normalt i Arkona- och Bornholmsbassängen. Under vår och sommar var det djup där det oorganiska kvävet tar slut i Egentliga Östersjön större än normalt. I djupvattenlagret var det lägre koncentrationer än normalt av särskilt fosfat och silikat.

I stället för de sedvanliga kiselalgerna var det det för fisk skadliga flagellatsläktet *Pseudochattonella* som blommade på Västkusten i februari till april. Under hösten förekom däremot en utdragen kiselalgsblomning. I Östersjön förekom vårblomningen i april. Cyanobakterieblomningen startade redan i maj med *Aphanizomenon flos-aquae*. Under juni och juli fanns alla tre av de filamentösa cyanobakterierna, *A. flos-aquae*, *Dolichospermum lemmermannii* och den potentiellt skadliga *Nodularia spumigena*, i växtplanktonproverna i varierande mängd.

I Bottenhavet var ytvattentemperaturen lägre än normalt och koncentrationen av syre var under normala nivåer, men ändå högre än kritiska.

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1 Introduction

The purpose of the national marine monitoring programme of the pelagic is to document the status and changes in the marine environment through a selection of parameters. In Sweden there are national environmental goals, EU legislation and commitments to the sea conventions OSPAR and HELCOM to consider. The Swedish agency for marine and water management (SwAM) is responsible for the marine monitoring programme of the pelagic and there are three institutes that implement the monitoring; Swedish Meteorological and Hydrological institute (SMHI), Stockholm University (SU) and Umeå Marine Sciences Centre (UMF). The monitoring program is co-funded by SwAM, SMHI, SU and UMF. Sampling and laboratory analyses are carried out according to Swedish guidelines as well as the HELCOM COMBINE manual[1].

This report is written by SMHI as a part of the SMHI monitoring contract with SwAM for the year 2017. The report summarizes and presents data from the national marine monitoring of the pelagic with the aim to describe the general environmental conditions in Swedish waters the past year and show deviations from the normal situation. All data that are used in the report is quality controlled, open access and available at the national data host (SMHI). To download the data visit https://sharkweb.smhi.se or http://sharkdata.se/about/. An exception is the data collected by Finnish Environment Institute (SYKE) for SMHI in January 2017 in the Gulf of Bothnia, these data are not yet available at the data host but it will be as soon as possible.

The main parameters discussed in this report are salinity, temperature, oxygen, dissolved inorganic phosphorus, dissolved inorganic nitrogen, dissolved silica and phytoplankton. The data are presented in Appendix I as seasonal cycles of the surface water (0-10 m). In Appendix II longer time series for surface waters (0-10 m) and bottom waters of the above parameters as well as total phosphorus, total nitrogen and chlorophyll is also presented. Content of total and inorganic nutrients is calculated for all basins in the Baltic Proper as well as the Bothnian Sea and the Bothnian Bay and is presented in Appendix III. Vertical sections of CTD-observations of salinity, temperature, oxygen and density from Skagerrak to the Western Gotland Basin are presented in Appendix IV. Other parameters also included in the marine monitoring program are Secchi depth, zooplankton, humus, primary production, pH and alkalinity but these are not presented here.

1.1 The monitoring programme

Performance in 2017 and description of the current programme

The pelagic marine monitoring programme in Sweden consists of 32 standard stations distributed in the seas surrounding Sweden, red dots in Figure 2. The visiting frequency is monthly at most standard stations and six of the standard stations (Släggö, Anholt E, Ref M1V1, B1, BY31 and B7+NB1/B3) are visited every other week. The pool of winter nutrients and oxygen during autumn is mapped once per year at additional stations, purple in dots Figure 2. The visiting frequency on the standard stations during 2017 is presented in Figure 1.

[1] Link to HELCOM Combine manual

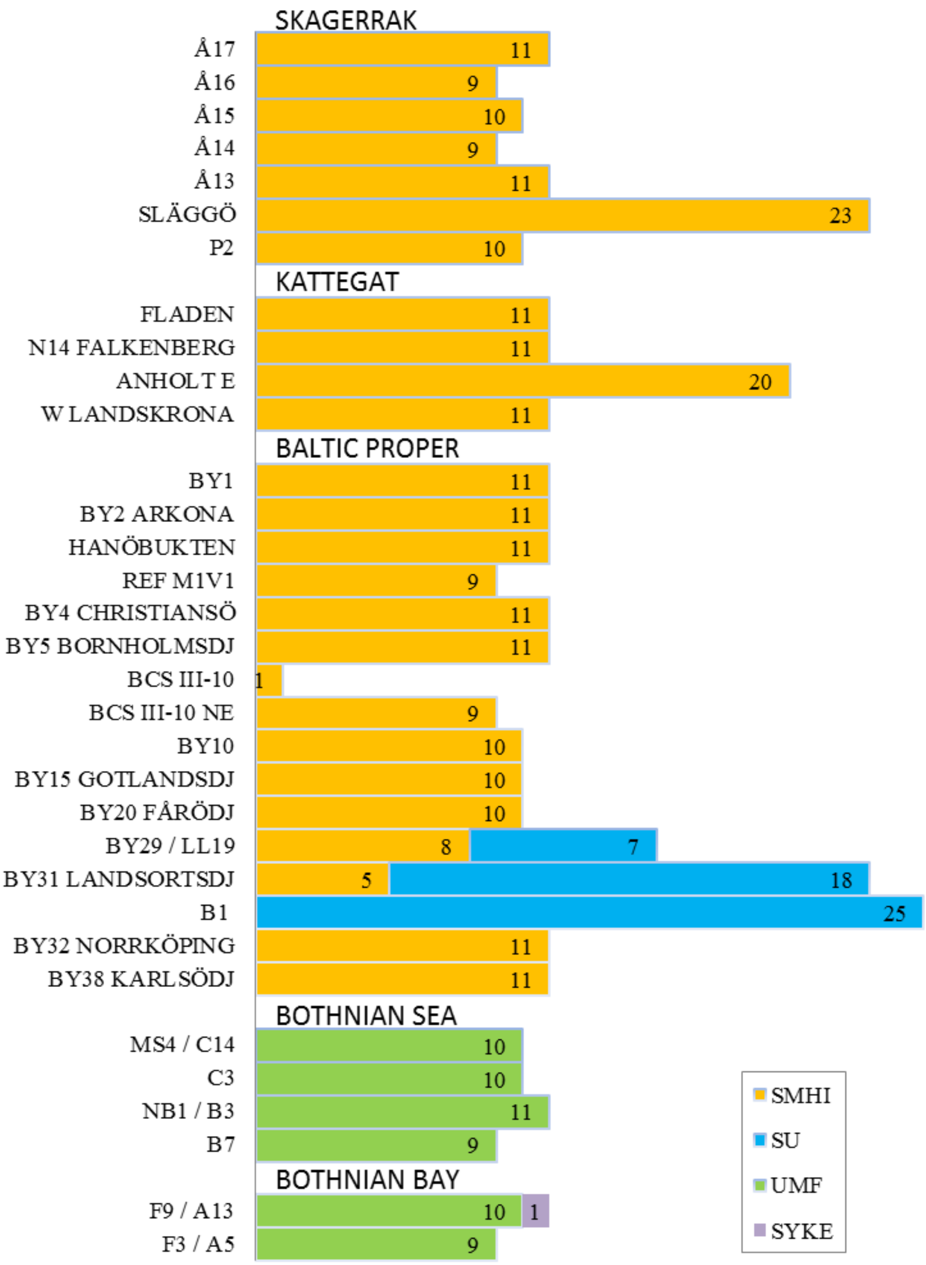

Figure 1. Stations sampled 2017, number of visits and sampling institute. The station Släggö was visited 11 times by SMHI and 12 times by Börjessons and SMHI made all analyses.

Note that the station BCS III-10 in the southern part of the Eastern Gotland Basin was replaced by a station slightly to the northeast of the standard station in 2017. The station was moved outside the Polish EEZ because it was not possible for SMHI to meet the requirements that followed with the permission to sample inside the Polish EEZ. This also affected a few of the nutrient winter mapping stations.

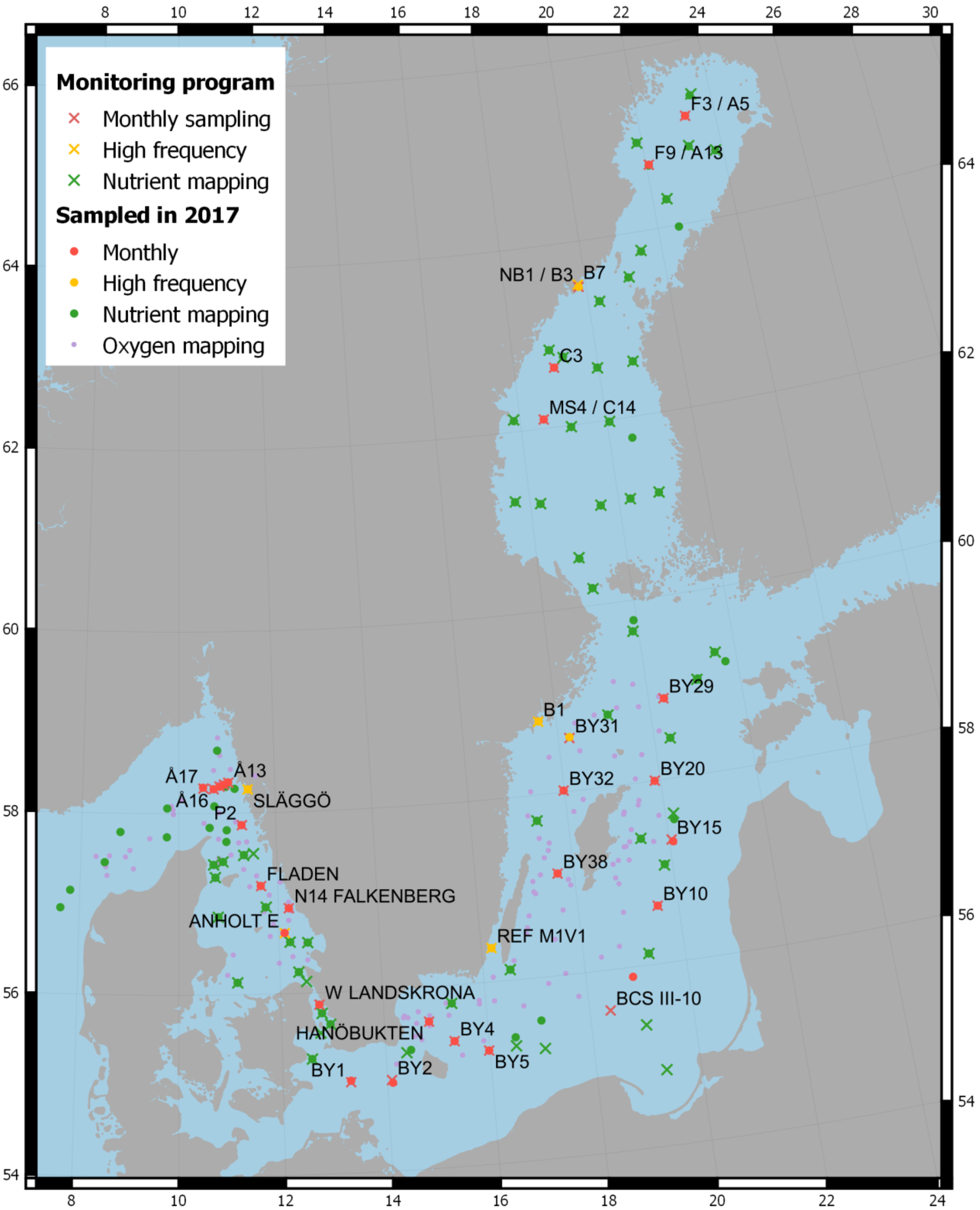

Figure 2. Map of the Swedish monitoring programme of the pelagic. Crosses show stations included in the programme and dots show stations sampled in 2017. Red are standard stations, yellow high frequency stations, green nutrient mapping and purple oxygen mapping

Sweden has, since 2014, contracted the Finnish research vessel R/V Aranda for SMHI's monitoring purpose in the open sea. As an extension of this cooperation SMHI has sampled Finnish monitoring stations in the Gulf of Finland on the way out from Helsinki with R/V Aranda and SYKE has sampled Swedish winter mapping stations in the Gulf of Bothnia on their winter cruise with R/V Aranda. SMHI has also sampled BY29 a few times for SYKE and because this station is also a standard station in the Swedish monitoring programme these data are included in this report. In August 2017, R/V Aranda was brought to the shipyard to be renovated and modernised and was not available for the rest of the year. The SMHI cruises were instead made with the Finnish cargo ships Meri and Aura (Figure

3). These ships are not constructed for research so the sampling work and analyses were made from specially designed laboratory containers placed on deck. This led to difficulties to sample all stations on cruises in September-December due to various malfunctions of the containers. Also the cruise in August had to be cancelled to allow for moving equipment from R/V Aranda to the containers.

Figure 3. The monitoring containers on the deck on Aura.

Släggö in Skagerrak was also visited by Börjessons with the ship R/V Sensor in addition to the monthly visits by SMHI to accomplish the high frequency sampling. The samples taken with R/V Sensor were analysed at the SMHI laboratory.

Stockholm University has used M/S Fyrbyggaren and at some occasions R/V Electra for sampling at the open sea stations BY31 and BY29. The smaller vessel R/V Limanda and R/V Electra (in conditions with sea ice) were used for sampling at B1. Umeå Marine Science Center has used R/V Lotty, KBV181 and R/V Botnica for their sampling.

History of the monitoring program

The current Swedish open sea monitoring programme has been in place since 1994, with only smaller changes. The focus of the current programme is eutrophication and oxygen deficiency and has been since the end of the 1970’s. The programme has historically had a large focus on fishery hydrography, while plankton and chlorophyll has been added in the later years. The data from the Swedish open sea monitoring are used widely in research as well as management. The data are among other purposes used for trend analysis, modelling, climate studies and assessments for EU directives such as the Water Framework Directive 2000/60/EC (WFD)[2] and the Marine Strategy Framework Directive 2008/56/EC (MSFD)[3].

In 1991 SMHI published an investigation of the Swedish monitoring programme, its station network and sampling frequency (Rahm et al 1991[4]). In 1992 an international panel was formed to make an evaluation of the Swedish monitoring programme and this panel recommended that the changes suggested by SMHI (SNV Report 4170[5]) should be made and the new monitoring programme was fully implemented in 1994. This led to a large change of the monitoring programme, mainly in the frequency of expeditions. It was decided to have a number of stations with monthly sampling in all sea areas and a few stations with high frequency monitoring (twice a month). The main aim of the high frequency stations is to better monitor changes in biological parameters that change rapidly, especially during spring and summer.

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[2] Link to WFD
[3] Link to MSFD
[4] Rahm L., Sjöberg B., Håkansson B., Andersson L., Fogelqvist E., 1991. *Utredning om Optimering av utsjö-monitoringprogrammet vid SMHI.*
[5] Report / Swedish Environmental Protection Agency, ISSN: 0282-7298 ; 4170, 1993. *Swedish National Marine Monitoring Programme, Report of an Evaluation Panel.* Stored at the library of SwAM.

In addition to the monthly and high frequency stations, a denser network of stations was set up to map winter nutrient pools. The winter nutrient pool determines how large the phytoplankton production in spring and summer can become. Winter nutrient mapping is normally done in Skagerrak and Kattegat in January, in the Baltic Proper in February and in the Gulf of Bothnia it has been mostly in December. In the Kattegat and the Baltic Proper, where oxygen deficiency had been documented during parts of the year, an autumn mapping of oxygen was also started. For the oxygen mapping there are no fixed stations, instead stations vary from year to year and the sampling is generally performed in combination with a trawling cruise. The aim with this is to monitor the part of the year with the most severe oxygen deficiency, with focus on the deep water.

The first oceanographic measurements in Swedish waters were done on the initiative of Gustav Ekman who in 1877 initiated a mapping of all Swedish seas with the warships HMS Alfhild and HMS Gustav af Klint. The data from this first mapping were not analysed until 1901 by Otto Petterson. Otto Petterson was the permanent secretary of the Hydrographic-biologic commission 1901-1930 and the initiator of the formation of the International Council for the Exploration of the Sea (ICES). In 1948 the Hydrographic-biologic commission became the National board of fisheries (Fiskeristyrelsen) with the main aim to explain what controlled the variations in herring stocks. The first Swedish research vessel R/V Skagerrak I was used and the measurements were mainly salinity, temperature and oxygen. Stations were sampled 1-2 cruises per year and after a few years alkalinity and pH were added to the measurements. In the 1950's the frequency of cruises increased and from 1958 the Swedish monitoring became part of an internationally coordinated sampling effort. During the 1960's nutrients entered the picture, first phosphorus then nitrogen and finally silica. However, the frequency was still variable between years, in some periods measurements were only done during summer and in others only in spring. This makes it difficult to create homogenous time series with data from this period, to for example make a trend analysis. In the deep basins of the Baltic Sea conditions are more stable than in the surface waters and for these areas data are easier to use for long time series analysis. Although the frequency still varied between 1-3 times per year the network of stations was roughly the same as today. At the end of the 1960's the monitoring became more structured, Skagerrak and the fjords were visited 4 times per year, Kattegat and the Sound five times per year, the Baltic Proper four times per year and the Bothnian Bay two times per year. Sampling was both oceanographic and biologic, including bottom fauna sampling.

1969-1970 was the international Baltic Year and this is when many of the stations were named BY. In 1978 the Programme for Environmental Control (Programmet för Miljökontroll PMK) was started and the following year HELCOM started its Baltic Monitoring Programme (BMP). The Swedish commitment in BMP 1979 included nutrients, oxygen, salinity and temperature and all countries around the Baltic Sea shared their data with each other. The programme continued until 1993 when it was revised as described above.

2 Weather situation 2017 in short

According to NASA, the year 2017 was globally the second warmest year after 2016. This was however not reflected as any heat records in Sweden.

Several low pressure systems passed the region in January and they resulted in windy weather, high waves and high sea levels. New high sea level records were observed in the Baltic Sea at Oskarshamn (+116 cm), Simrishamn (+120 cm), Skanör (+154 cm) and Klagshamn (+146 cm) and a new record in significant wave height was observed at Knolls grund north of Öland (5.3 meters).

In February, temperatures dropped and the Bothnian Bay and the northern parts of the Bothnian Sea got covered with ice. The maximum ice extent occurred on 12th of February and overall the ice season was classified as mild.

March started off with a cold high pressure system from the east and ends with low pressures. The ice cover still grew in the northern parts of the Baltic Sea while the sea surface temperature started to increase in the south.

Weather was cold in April but the ice cover started to break and the sea surface started to warm up. In May warm winds were blowing from the south and the ice melting accelerated and the surface layer continued to warm in the south.

The summer was chilly and windy and several low pressures caused high sea levels and this pattern continued towards the autumn. A high pressure system was established in September and the sea levels became lower in the Baltic Sea.

In the end of year, in November and December, repetitive low pressures caused high sea levels and pushed water in to the Baltic Sea.

3 Oceanographic conditions

The development of the monitored parameters during 2017 is discussed in this section. Annual cycles of the surface water, 0-10 m, vertical sections from Skagerrak to the Western Gotland Basin and time series are presented in Appendices I-IV. In the text, we often refer to a normal condition or value and by this we mean the average +/- one standard deviation for the period 2001-2015. There is also extra material, as vertical figures for each station, in the cruise reports available at SMHI publications.

The Swedish seas have large variations in especially salinity, which gives the seas their different characteristics (Figure 4). The Skagerrak on the west coast has almost open ocean salinities, with lower salinities closer to the coast due to the Baltic current bringing the outflowing Baltic water northward (blue colours in Figure 4). The Baltic Proper has typical fjordlike hydrography with a strong stratification separating the deep waters from the surface waters (grey to red colours in Figure 4). This makes the Baltic Proper naturally sensitive to increases in nutrient input leading to oxygen deficiency. The Bothnian Sea is the freshest sea in Swedish waters (not included in Figure 4) and is still an oligotrophic sea with lower nutrient concentrations than the Baltic Proper.

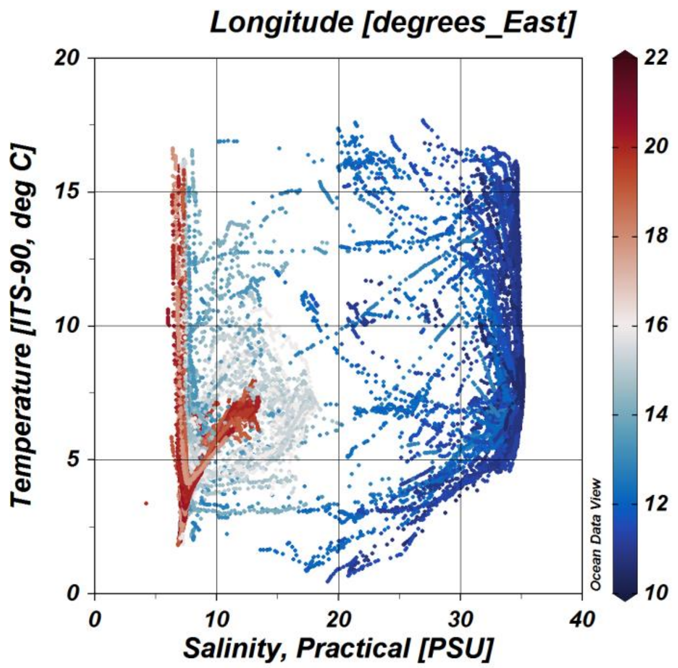


Figure 4. T-S diagram of all CTD-observations made by SMHI in the Swedish national marine monitoring programme of the pelagic 2017. The Gulf of Bothnia is not represented in this diagram. The colours are related to the longitude.

3.1 Skagerrak, Kattegat and the Sound

Temperature & Salinity

The windy weather in January led to a well-mixed surface water layer along the west coast of Sweden. The surface layer in Skagerrak was well-mixed down to 30 meters and the water was a little warmer and saltier than normal for this time of the year. The sea surface temperature in Skagerrak was about 6°C. In Kattegat, the surface layer was well-mixed down to 10 meters and the temperature was lower, around 4°C. There was a strong stratification in the Sound at 10 meters with relatively low salinity in the surface layer, 10.5 psu, and 28 psu in the bottom layer. The sea surface temperature is statistically lowest in February on the west coast and this was also the case in 2017. In the middle of February water temperature had dropped to 1-2°C along the entire west coast with the lowest temperatures near the coast. In Skagerrak, the surface layer was colder than normal down to 10 meters. It was also less saline than normal in the surface layer, which reflects that the outflow from the Baltic Sea was unusually high in January and February 2017. In the outermost Skagerrak the surface salinity was 25 psu in February compared with 33 psu in January. The Baltic current carrying outflowing water from the Baltic Sea has its path along the Swedish west coast due to the earth's rotation and the width and volume transport varies over time.

Winter had come to its end in March and the temperature in the surface layer started to increase at the west coast. The salinity varied along the coast and had risen to normal in the Skagerrak but was still low in Kattegat. During spring, a thermocline began to develop due to the increased temperature and it became most pronounced in the outermost Skagerrak. Even though July was somewhat colder than normal the thermocline was strongest that month and the warm surface layer was 5-10 meter thick. The salinity-related stratification, the halocline, was found at around 20 meters depth. Higher surface salinity than normal, about 19 psu, was observed in the Sound in June and salinities in this range is often related to salt water inflow to the Baltic Sea. However, there was no inflow event observed at the same time but a smaller inflow occurred a couple of days before. Smaller inflows have the tendency to be mixed in the Arkona Basin and then some of the water again flows out through the Sound.

The sea surface temperature increased from 3-5°C in March to 15-17°C in July with temperatures in Kattegat becoming higher than in Skagerrak. The SMHI cruise in August was unfortunately cancelled but the surface layer is usually warmest in August. However, according to the observations from the buoy at Väderöarna, August was not much warmer than July in 2017. In September summer was fading and the thermocline started to break up.

The autumn in Sweden was warmer than normal and this was also reflected at some occasions in Skagerrak and Kattegat. The sea surface temperature decreased steadily throughout the autumn and in December it had reached 7°C in Skagerrak and 6°C in Kattegat, which is normal for the season.

The salinity in the surface layer varies a lot with the Baltic current while the salinity in the deeper water below 20 meters is less variable. Temperature is also less variable in the deep water but it still varies more than the salinity. The deep water in Kattegat was for example warmer than normal on several stations during the year.

Nutrients

In particular dissolved inorganic nitrogen (DIN) and silicate but also phosphate was lower than normal in the entire water column in both Skagerrak and Kattegat in January. These low concentrations of nutrients were also observed in December 2016. All of the nutrients normally reach their maximum levels in the surface water during winter and during 2017 the highest concentrations were generally observed in February. Along the west coast, the concentration of phosphate was about 0.4 µmol/l and DIN was 4.5 µmol/l while silicate varied from 14 µmol/l in The Sound to 7 µmol/l in the outer Skagerrak. The winter concentrations of nutrients were normal for the season.

When the spring bloom sets off, all nutrients rapidly decrease and this was observed in March at all stations. High levels of nutrients were still observed during the first visit in March at Släggö (March 7) but at the second visit (March 12) there had been a remarkable decrease. Silicate decreased quickly especially in outer Skagerrak which reflects the bloom of diatoms. The concentration of DIN was almost everywhere totally consumed down to 10-15 meters in March while there were still some phosphate and plenty of silicate left. Nutrients continued to decrease during spring and summer and in April most of the phosphate was also depleted. The maximum depth of the layer with exhausted dissolved inorganic nitrogen varied in the area. At station P2 in Skagerrak the DIN pool was already emptied down to 75 meters in May while at Anholt in Kattegat nitrogen was still present below 25 meters in June. The decrease of nutrients in the Sound was observed one month later, in April, indicating a later start of the spring bloom.

During spring, silicate was above normal levels but a decrease in June/July was probably a consequence of the relatively large diatoms that often bloom in summer, as it did this year as well. The levels of phosphate and dissolved inorganic nitrogen were mainly normal in the surface water over the year. However, the concentration of dissolved inorganic nitrogen in the bottom layer was lower than normal at many stations.

The break-up of the thermocline started to bring back nutrients to the surface layer in September. The nutrients decreased again in October-November because of an autumn bloom. In December, nutrient concentrations in the surface water were high and normal.

The surface pool of winter nutrients in Skagerrak and Kattegat was mapped in January 2017 (Figure 5). The concentration of nutrients varied a lot in the Kattegat surface layer while it was more homogenous in Skagerrak.

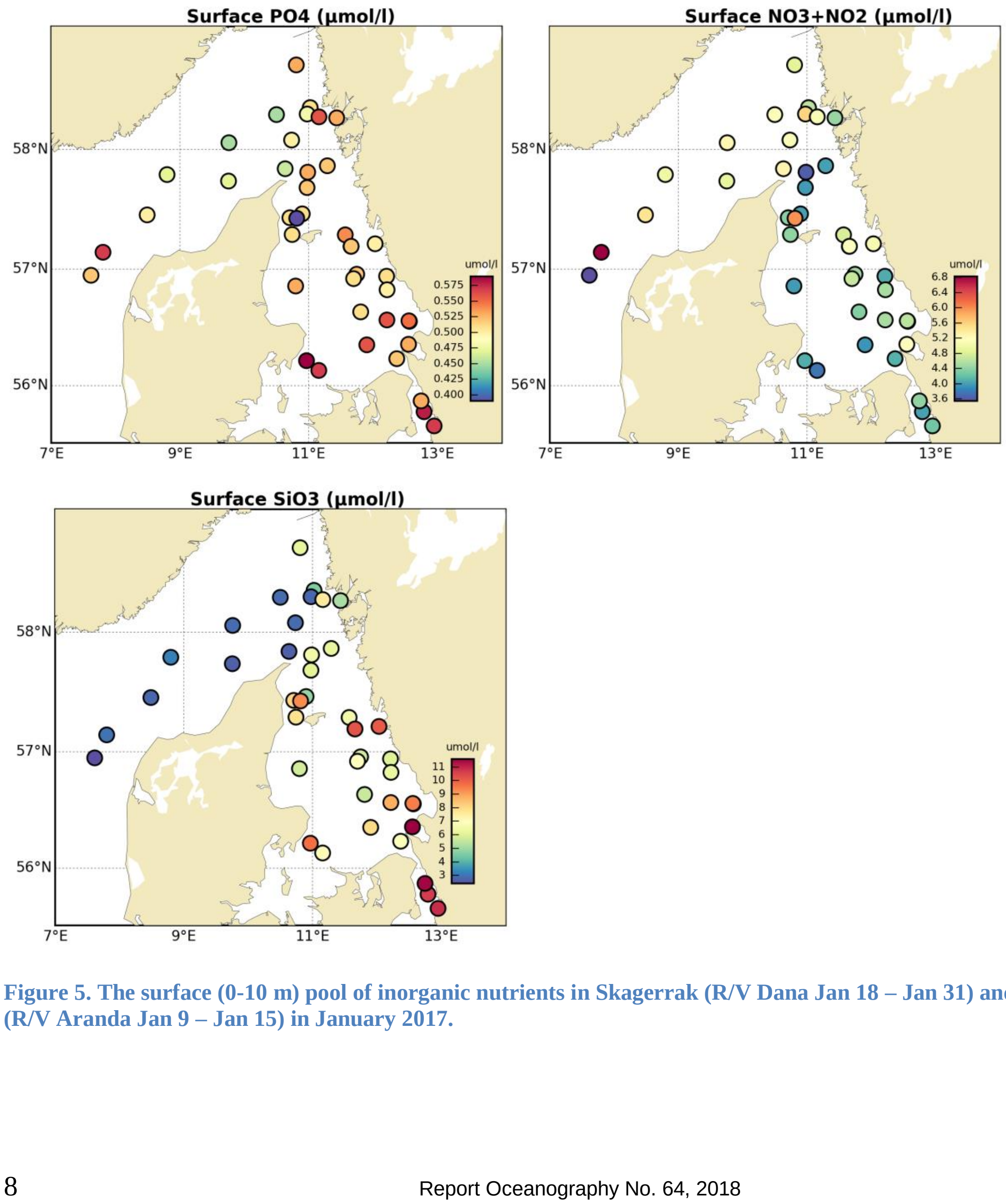


Figure 5. The surface (0-10 m) pool of inorganic nutrients in Skagerrak (R/V Dana Jan 18 – Jan 31) and Kattegat (R/V Aranda Jan 9 – Jan 15) in January 2017.

Phytoplankton

The flagellate genus *Pseudochattonella*, which is potentially toxic to fish, was observed in phytoplankton samples from the Kattegat and Skagerrak areas in February. The genus was found with high cell numbers at most stations throughout April, and even caused a chlorophyll fluorescence maximum in May at West Landskrona. *Pseudochattonella* spp. hence bloomed for a long period of time and the observations suggest that the diatom bloom which normally occurs in February-March was outcompeted. The small diatom *Phaeodactylum tricornutum* bloomed at most of the Kattegat and Skagerrak stations in May. This diatom seldom occurs in large numbers and is known to thrive in rock pools. At Å17 (open Skagerrak) *Pseudochattonella* spp. was found in very low numbers and the early diatom spring bloom was larger than at the other stations and *Phaeodactylum tricornutum* was absent in May. Despite the high cell numbers of *Pseudochattonella* spp. there have been no reports of fish death.

Typical summer species were present in moderate amounts in July. In September the conditions seem to have been perfect for diatom blooms, especially at Släggö at the Skagerrak coast where the diversity was very high. At Släggö there were also high numbers of the naked stage of the flagellate genus *Dictyocha* which has a cross or star shaped skeleton (depending on species) when in its “dressed” stage. In the naked stage *Dictyocha* spp. is potentially harmful for fish. The naked stage of *Dictyocha* spp. as well as the potentially toxic diatom *Pseudo-nitzschia* spp. were present in the Kattegat and Skagerrak areas in October. Generally speaking, the diatom diversity was high as late as in November.

Oxygen condition in the bottom water

The oxygen concentration in the bottom water reached its minimum values in September-October. There is never a deficit in oxygen in outer Skagerrak due to natural conditions. There are generally lower oxygen concentrations in Kattegat but during 2017 the oxygen condition was well above critical values in the open sea. The lowest concentrations of oxygen were observed in the Sound, 2.2 ml/l, in October. The concentration of oxygen at the coastal station Släggö was lower than normal in September, 2.4 ml/l, but in October the concentration had risen to 5.3 ml/l that instead was above normal.

3.2 The Baltic Proper

Temperature & Salinity

In the open sea areas of the Baltic Proper, the sea surface temperature varied between 3.5-5.7°C in January, with the lowest temperatures in the western and northern parts. It was colder at the coastal stations Ref M1V1 (2.9°C) and at B1 (1.7°C).

The Arkona Basin is a very dynamic area where the incoming salty water through the Sound and the Belt Seas meets the brackish Baltic Sea water. The water is mixed and depending on the properties the water is either flushed back out in Kattegat or it propagates further into the Baltic Sea. In January, the surface layer was well mixed down to 30 meters in the Arkona Basin and this stratification then continuously deepened towards 65 meters in the Eastern Gotland Basin and the Northern Baltic Proper. In the Western Gotland Basin the well mixed layer was observed at 50 meters.

The surface temperature continued to decrease during the winter and the coldest temperature in the open sea was observed in the Northern Baltic Proper in February (2°C). The coldest coastal station was B1 in February (1.3°C). The temperature in the Eastern Gotland Basin was 3.1°C in March, which was the coldest observation for this area.

Spring arrived in April to the Baltic Proper and the surface water started to warm up and in May the beginning of a weak thermocline was observed at 10-15 meters. Below the warmed surface water the colder winter water remained and below that, under the halocline, the temperature increased again to 5-6°C. The surface water continued to be warmed up throughout the summer until November when it was chilled and well mixed down to the halocline again.

The SMHI cruise in August was unfortunately cancelled and this is usually the warmest month. The highest temperature during the SMHI cruise in early July was observed in the Western Gotland Basin with 16.5°C. When Stockholm University visited the same area in late July the temperature had increased to 18.3°C but during their August cruise the temperature had fallen to 17.2°C. The surface water was generally colder than normal during the summer in the Arkona-, Bornholm-, Eastern Gotland- and northern parts of Western Gotland Basin.

The salinity below the halocline was above normal in the Gotland Basins and in the Northern Baltic Proper, and also in the surface layer in the Eastern Gotland Basin for almost the whole year.

The halocline in the Baltic Proper is rather stable because of the large difference in density between the surface and bottom layer. Fluctuations of the halocline position can depend on the circulation and incoming salty water that refills the bottom layer and lifts up the halocline. This might be the reason to what happened in the central Eastern Gotland Basin when the halocline depth shifted from 60 meters in July to 50 meters in September (Figure 6). The salinity increased from 8 to 9.4 psu and the dissolved oxygen decreased from 5.2 to 0.4 ml/l. There was however no major inflows during 2017 and this shift was probably an effect of the minor inflows in December 2016, February 2017 and during summer 2017 pushing older bottom water further in to the Baltic Proper.

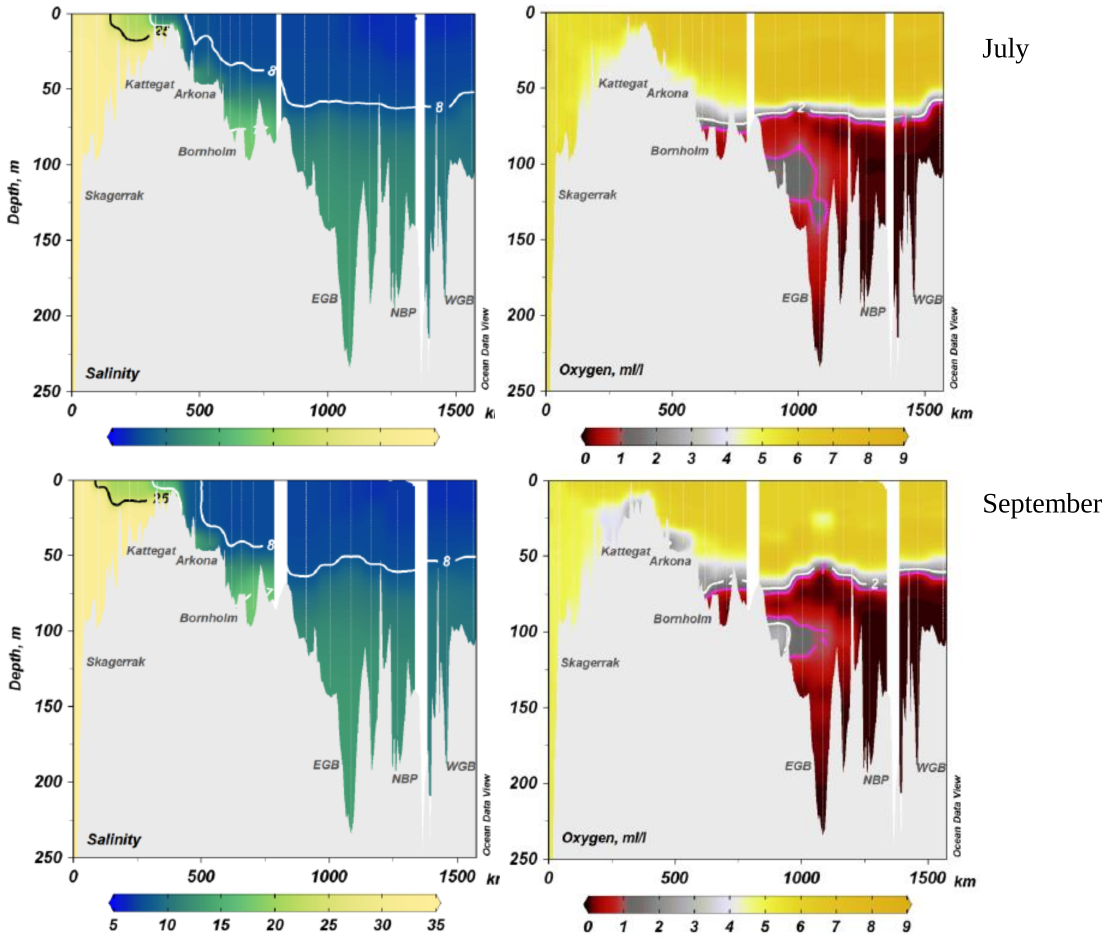


Figure 6. Transect showing salinity (left column) and oxygen (right column) from Skagerrak to the Western Gotland Basin. Top row shows the data from the cruise in July with a halocline at 60 m depths in the Eastern Gotland Basin and the bottoms row shows data from the September cruise when the halocline was shallower and about 50 m.

Nutrients

At most stations, the maximum concentration of nutrients in the surface water, occurred in February. Phosphate and silicate increased from the Arkona Basin in the south to the Northern Baltic Proper while dissolved inorganic nitrogen instead decreased from Arkona towards the Northern Baltic Proper. Phosphate varied from 0.7 µmol/l in the Arkona Basin to 1.0 µmol/l in the Western Gotland Basin, dissolved inorganic nitrogen from 3.6 µmol/l in the northern areas to 7.5 µmol/l in the Arkona Basin and silicate varied from 14 µmol/l in the Arkona Basin to 20 µmol/l in the northern parts.

In February, there was a peak in nutrients in the surface water in the Arkona Basin, for example the dissolved inorganic nitrogen changed from 4 µmol/l in January to 7.5 µmol/l in February in the surface layer (0-30 meters). In February the concentration decreased at 40 meters and then increased again near the bottom at 45 meters. The water mass near the bottom was probably related to an earlier smaller inflow in December 2016 since the inflow in February was after this peak. The change in the surface water may instead be related to the prevailing weather situation with high north easterly winds. However, the concentrations were back to normal in March and this event illustrates just how dynamic the Arkona Basin is.

Nutrient levels were still high in March, but in April the nutrients started to decrease and DIN was quickly consumed in the surface water and the spring bloom was ongoing in the entire area. The spring bloom in the Baltic Proper hence started 1-2 months later than in Skagerrak and Kattegat. In April the dissolved inorganic nitrogen was consumed in the whole water column in Arkona Basin, down to 30-40 meters in Bornholm Basin, 30-50 meters in Eastern and Western Gotland Basins and Northern Baltic Proper. The station BY31 in the Western Gotland Basin is monitored with higher frequency and it can there be seen how DIN rapidly decreased from March 21, when levels still were high, to March 27, when the consumption was observed near the surface, and one week later when inorganic nitrogen was consumed down to 30 meters.

During the summer season, DIN was consumed down to 70-80 meters in the Eastern and Western Gotland basins and the Northern Baltic Proper, which is deeper than normal (Figure 7). Usually DIN is consumed down to about 50 meters in this area. The reason for the consumption of DIN in or below the halocline is most likely due to denitrification processes that take place in or close to oxyclines. To determine if denitrification was the cause for the unusually low DIN concentrations down to 80 m higher vertical resolution and very careful sampling of the individual dissolved inorganic nitrogen species is needed. However, the monitoring programme with monthly measurements and a depth resolution limited to 10-20 meters cannot give a full explanation to events like these. The dissolved inorganic nitrogen had again increased in all basins in November and December.

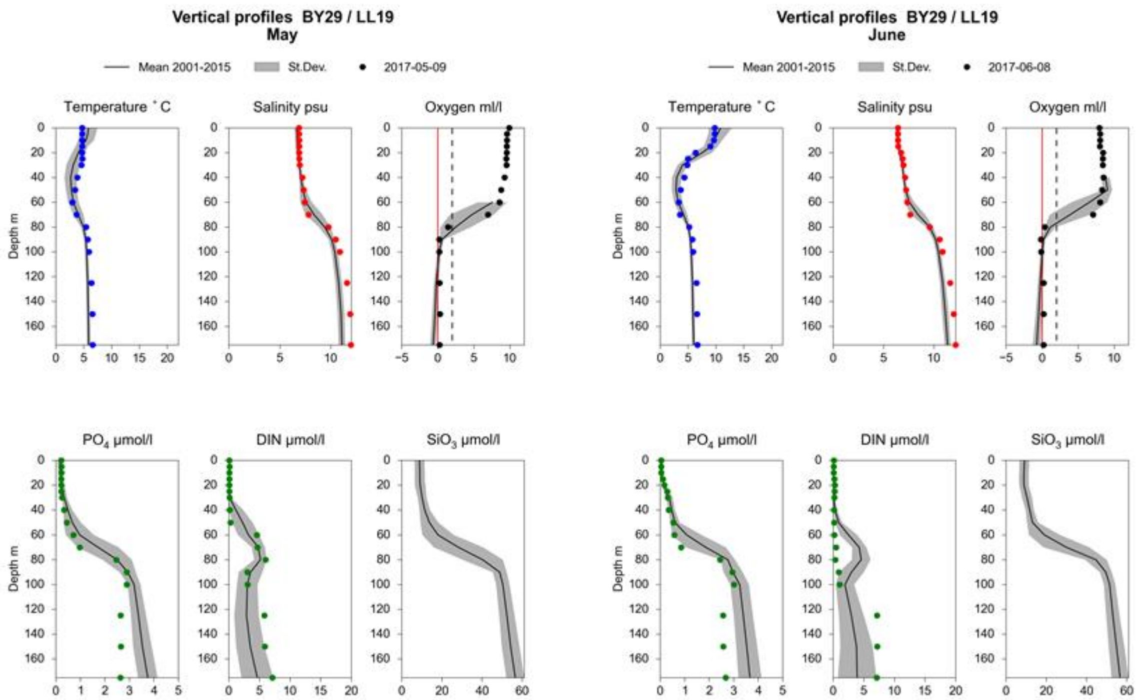


Figure 7. Profiles of temperature, salinity, oxygen, phosphate, dissolved inorganic nitrogen (DIN) and silicate at BY29 in the Northern Baltic Proper in May (left) and June (right). Note how DIN is almost entirely consumed down to 80 m in June (bottom row middle).

When DIN was consumed in April there was still phosphate left in the surface layer and this is beneficial for the nitrogen-fixing cyanobacteria. However, the concentration of phosphate was eventually consumed during the summer months June and July in the Eastern and Western Gotland Basins and Northern Baltic Proper, which coincides with the most intense period with cyanobacteria blooms. Phosphate was never totally consumed in the Arkona and Bornholm basins.

Surface concentrations of phosphate were above normal in the Eastern and Western Gotland basins and the Northern Baltic Proper while the DIN concentration was above normal in parts of the Arkona and Bornholm basins. Silicate was above normal in all basins and in all seasons and was never depleted (see also Appendix III). The nutrients in the bottom layer, particularly phosphate and silicate, were generally lower than normal.

The surface pool of winter nutrients in the Baltic Proper was mapped in February 2017 (Figure 8). Noticeable is that both phosphate and silicate increased significantly from Arkona Basin to the Northern Baltic Proper and further more to the Western Gotland Basin.

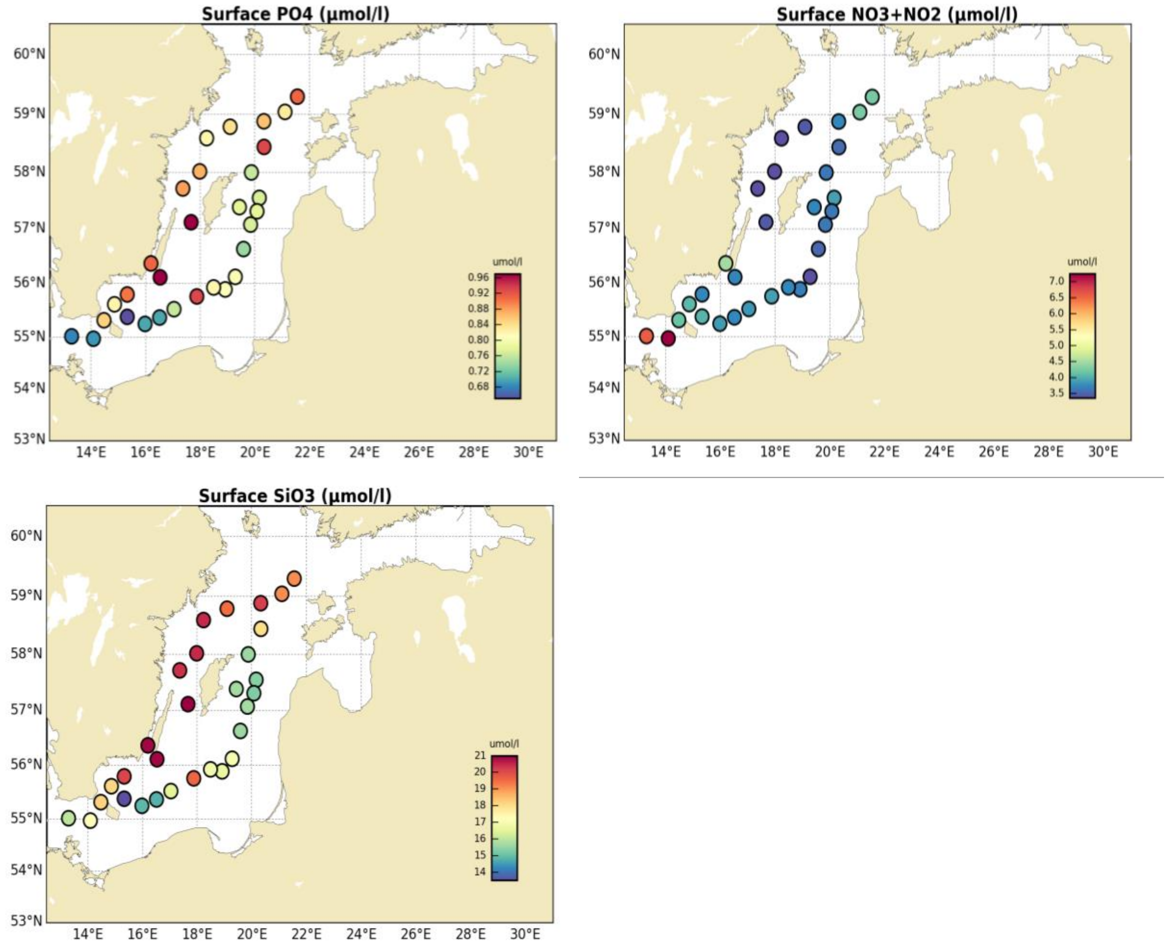


Figure 8. The surface (0-10 m) pool of inorganic nutrients in the Baltic Proper in February 2017.

Phytoplankton

There was very little activity in the plankton community during January and February, which is normal for this period of the year. However, there were elevated amounts of the filamentous cyanobacteria *Aphanizomenon flos-aquae* at station BY38 in the Western Gotland Basin in February. In March relatively high numbers of cells and elevated chlorophyll concentrations indicated that the spring bloom had started in the Arkona and Bornholm basins. The bloom of the harmful flagellate genus *Pseudochattonella* in the Skagerrak and the Kattegat had spread into the Arkona Basin and was found at station BY1 at 35 meters depth in April. The *Pseudochattonella* spp. at BY1 was revealed by a chlorophyll fluorescence peak. Corresponding chlorophyll fluorescence peaks in the rest of the Baltic Sea were caused by the spring bloom in different stages and did not relate to *Pseudochattonella* spp.

Already in May the amount of cyanobacteria was large at most of the stations in the Baltic Proper. It was exclusively *Aphanizomenon flos-aquae* that was found, which is the species that normally is seen first when the temperature is at the lower end of the scale that the filamentuos summer species tolerate. *A. flos-aquae* dominated the cyanobacteria also in June, but then with a varying degree of the potentially harmful species *Nodularia spumigena* and *Dolichospermum lemmermannii* also present in the samples. In June there were also some relatively high maxima in chlorophyll fluorescence, these were caused by species from the potentially harmful group Prymnesiales, among others. In July the amount of cyanobacteria was large and all three filamentous species were found. *Nodularia spumigena* was found in greatest abundance in the south-eastern (station BSC III-10) part of the Baltic Proper and at station Hanöbukten but was more or less abundant also at all of the other stations. During the autumn the amount of algae decreased and small species and colonies of pico cyanobacteria dominated the samples.

Oxygen condition in the bottom water

The total outflow from the Baltic Sea through the Sound during 2017 was 736 km^3, which is 100 km^3 larger than normal when compared to the time period 1977-2016. There were no major inflows through the Sound that reached the deep basins but several minor inflows. The two largest of these, occurred in February and October and they brought approximately 20 km^3 each. There was also, as normal for the season, a couple of small inflows during summer. The inflows during 2017 only temporally improved the oxygen situation in the Bornholm Basin and the southern part of Eastern Gotland Basin. The small inflow (~20 km^3) in December 2016 together with the one in February reached at least station BY10 in the Eastern Gotland Basin, observed as increased oxygen levels below the halocline.

The Arkona Basin is dynamic and shallow and oxygen conditions are therefore usually good, the oxygen concentration was only below 2 ml/l in September during 2017. The Bornholm Basin is deeper and the bottom layer is often stagnant. The effect of the smaller inflows in the beginning of the year diminished after April and during the rest of the year the oxygen concentrations stayed below 1 ml/l from 70-80 meters. The oxygen condition in the Eastern Gotland Basin and the Northern Baltic Proper was still better than it was before the major inflow in 2014 but oxygen levels were rather low, < 2 ml/l below 70-80 meters. At the Gotland Deep there was hydrogen sulphide below 200 meters and occasionally at Fårö Deep below 175 meter, even though concentrations still were low. The concentrations of oxygen in the northern parts of the Western Gotland Basin were < 2 ml/l below 60-70 meters and anoxic condition with hydrogen sulphide present was observed below 70-100 meters. In the southern parts, at station BY38, conditions were worse and anoxia occurred already below 60-80 meters. There were still high concentrations of hydrogen sulphide in the Western Gotland Basin.

For a more detailed description of the oxygen conditions in the Baltic Proper see Hansson et al (2017)[6].

3.3 Bothnian Bay and Bothnian Sea

Temperature & Salinity

The sea surface temperature dropped to -0.1°C in the Bothnian Bay in January and to 1.15°C in the Bothnian Sea in February and the ice cover reached its maximum in the middle of February. From May, the temperature started to rise and the maximum temperature was observed in August, 16.2°C in the Bothnian Sea and 14°C in the Bothnian Bay. The summer was colder than normal in both basins.

The sea surface salinity in the Bothnian Bay varied between 2.1-2.9 psu and in the Bothnian Sea the variation was 4.7-5.3 psu. Despite the normally low variability salinity was lower than normal in the Bothnian Bay during winter.

The water column in the Bothnian Bay was almost totally mixed during winter and then a weak stratification was established at 40-60 meters. An annual cycle in the bottom water temperature was also observed. In the Bothnian Sea on the other hand, the water column was only mixed down to the stabile stratification at about 80 meters at station C3 and 40 meters at MS4/C14. The variability in salinity was low and the stratification in both basins was mainly driven by the temperature. In summer a thermocline was developed at about 10 meters in both basins. This warm layer extended down to 40 meters in October at station C3 in the Bothnian Sea, which is unusual.

Nutrients

Inorganic nutrients were only sampled during winter in the open sea. Because of the mixed water column in the Bothnian Bay there were only small changes in nutrient concentrations between the surface and the bottom layer. Concentrations of phosphate in the Bothnian Bay were a bit above normal and about 0.08 µmol/l. Bothnian Bay has naturally very low concentrations of inorganic phosphorus because the phosphate binds with iron that is supplied via rivers to complex in the

[6] Hansson M., Viktorsson L., Andersson L., SMHI Rapport RO 63, 2017. *Oxygen Survey in the Baltic Sea 2017 - Extent of Anoxia and Hypoxia, 1960-2017*

sediment, a process that only works in oxic condition. The concentration of phosphate in the Bothnian Sea is higher and in 2017 it was also above normal and around 0.5 µmol/l.

Winter concentrations of inorganic nitrogen in the surface water were about 7 µmol/l in the Bothnian Bay and 4 µmol/l in the Bothnain Sea, which is normal for the season. The concentration of silicate was just like in the Baltic Proper above normal, about 43 µmol/l in the Bothnian Bay and 25 µmol/l in the Bothnian Sea.

All nutrients in the Bothnian Sea increased below the pycnocline and in particular phosphate but also silicate was above normal in the bottom water.

The oxygen saturation increased in April-May that indicates biological production.

The pool of winter nutrients in the Gulf of Bothnia was mapped in January by SYKE. Since these data are not yet available at the data host no figures are shown in this report.

Phytoplankton

Phytoplankton data from the Gulf of Bothnia is not presented in this report.

Oxygen condition in the bottom water

The bottom layer in the Bothnian Bay is well oxygenated and there is no oxygen deficiency. This depends on the weak stratification and on the good ventilation between the surface and the bottom layer. The concentration of oxygen during summer is actually lower than in the deep water because warm water dissolves less oxygen than cold water.

In the Bothnian Sea the bottom layer is less ventilated than in the Bothnian Bay and oxygen decreases below the pycnocline. The concentration of oxygen in the bottom layer was about 5 ml/l with a decrease during autumn. The lowest concentrations were observed in September and October with 4.2 ml/l and 4.5 ml/l, which is lower than normal. The decrease of oxygen in the bottom layer is due to both increased temperature as well as consumption.

3.4 Long time series

Although the main focus of this report is the results from 2017 we also present data in the form of longer time series of two kinds. In Appendix II time series from all the stations currently included in the monthly sampling programme are shown from 1960-2017. No statistical trend analysis has been done, but the figures give an overview of the development of the monitoring programme as well as providing a quick way to observe the main changes in nutrients, oxygen, temperature and salinity over time in each of the basins.

In Appendix III the basin content of nutrients was calculated from the same data set that was used for the time series presented in Appendix II. The resulting time series of basin content of nutrients shows large scale changes of nutrient content as well as variability between the basins. Starting in the south with the Arkona and Bornholm basins, a jump in the content of both inorganic and total phosphorus is seen between 2004 and 2005. This is most likely an effect of higher concentrations in the surface waters which could be a consequence of the inflow in the winter 2003-2004 that lifted phosphorus rich water from the deep basins in the Baltic Proper to surface waters. However, it should be noted that the total phosphorus method at the SMHI laboratory was changed at the same time which makes the changes in total phosphorus more difficult to connect to changes due to the inflow.

In the rest of the Baltic Proper the phosphorus content increased from 1994 until around 2000 when it starts to level out. The last 2-3 years show a tendency towards decreasing phosphorus content in the Eastern Gotland Basin, but it is still too early to determine if it is a persistent or temporary decline. The nitrogen content trend is opposite, with a decrease in content from 1994 to the beginning of the 21st century. The drop in dissolved inorganic nitrogen is most drastic in the Western Gotland Basin for the sub-basins around stations BY31 and BY32. The decrease in nitrogen content is most likely due to decreased loading of nitrogen from land while the absence of a decrease in phosphorus is generally connected to internal recycling of phosphate from sediments and decreased burial capacity of phosphorus in anoxic sediments[7]. With continued efforts to keep phosphorus loading lower than during the end of the 20th century phosphorus content could also decrease with time.

Dissolved silica shows an increase from 1994 and seems to continue in the same direction. The increase is most pronounced in the Eastern Gotland Basin. The cause of this increase is not evident. We speculate that it could be connected to the increase in area of anoxic bottoms since dissolved silica also adsorb to iron oxides in oxic sediments and thus has less adsorption sites under anoxic conditions. Another reason for the increase in dissolved silica could be changes in the phytoplankton community, less species that form silica shells would cause a lower uptake and consequential burial of silica. However, none of these hypotheses are fully investigated and we hope that more in depth studies of the cause for the increase in dissolved silica will be made.

In the Gulf of Bothnia there is less data for this analysis. In the Bothnian Sea there seems to be an increase in winter phosphate as well as an increase in total phosphorus over all seasons. This could be due to the import of phosphorus from the high phosphorus content in the Baltic Proper. Also there is an indication of increasing content of dissolved silica in the Bothnian Sea.

When comparing the content between the basins the most striking pattern is the difference in dissolved inorganic nitrogen and phosphate content between the Eastern Gotland Basin and the Bothnian Bay. These two areas are similar in size and dissolved inorganic nitrogen content, but the Eastern Gotland Basin contains nearly twice the amount of phosphorus in comparison to the Bothnian Sea.

[7] Viktorsson L., Ekeroth N., Nilsson M., Kononets M., Hall POJ. *Phosphorus recycling in sediments of the central Baltic Sea.* 2013. Biogeosciences 10 (6), 3901-3916.

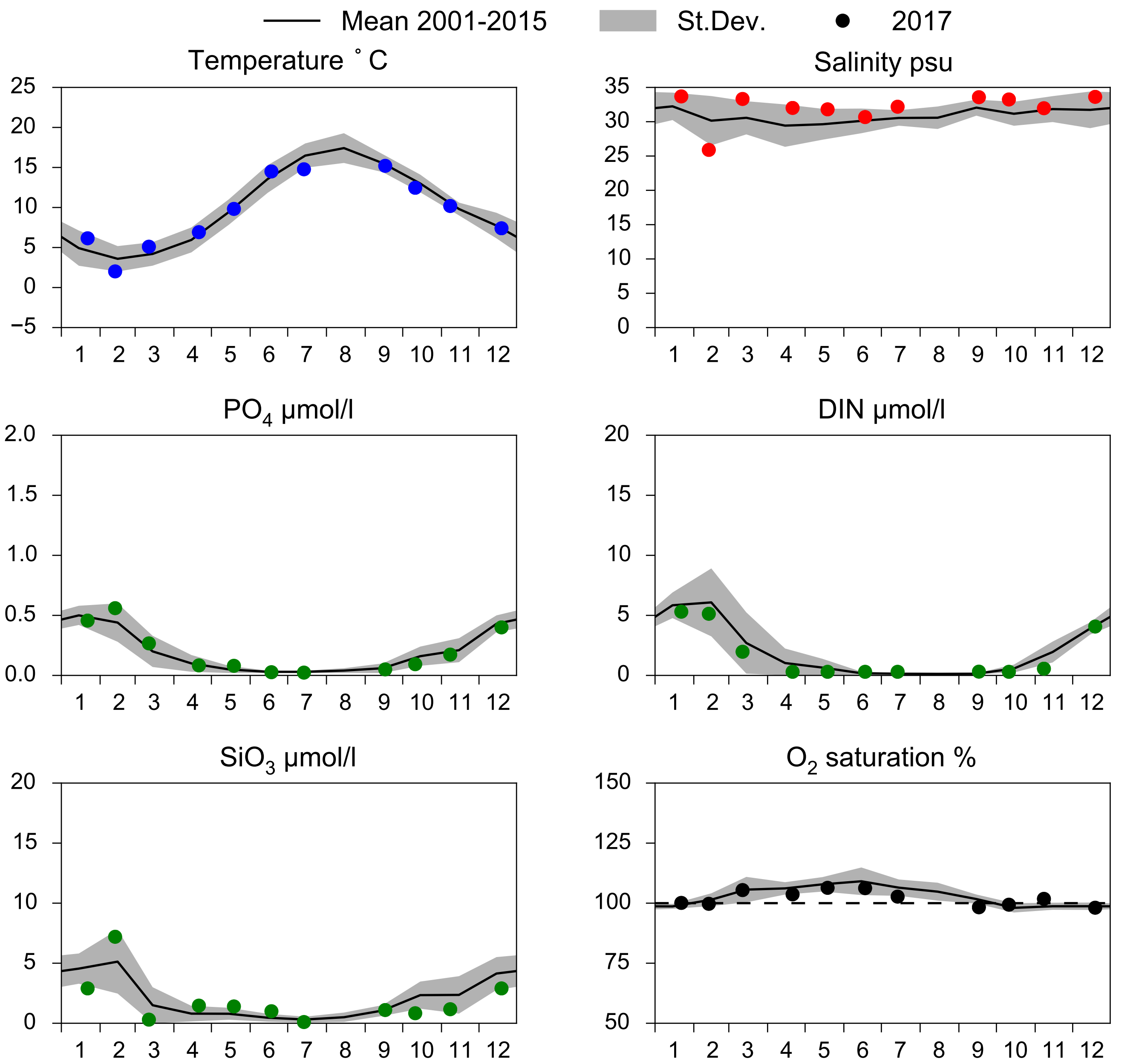
Appendix I

Seasonal cycles from all monthly and high frequency stations sampled 2017.

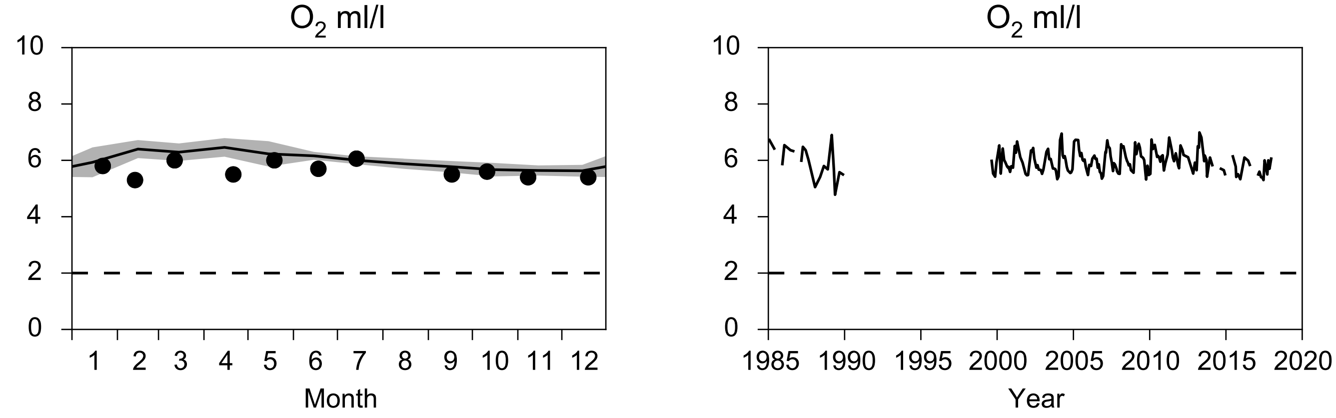
Surface water (0-10 m), including comparison to mean and standard deviation at each station for the period 2001-2015. Included parameters; salinity, temperature, dissolved oxygen (including hydrogen sulphide as negative oxygen), oxygen saturation, phosphate, dissolved inorganic nitrogen (DIN, sum of ammonium, nitrate and nitrite) and dissolved silica.

STATION Å17 SURFACE WATER (0-10 m)

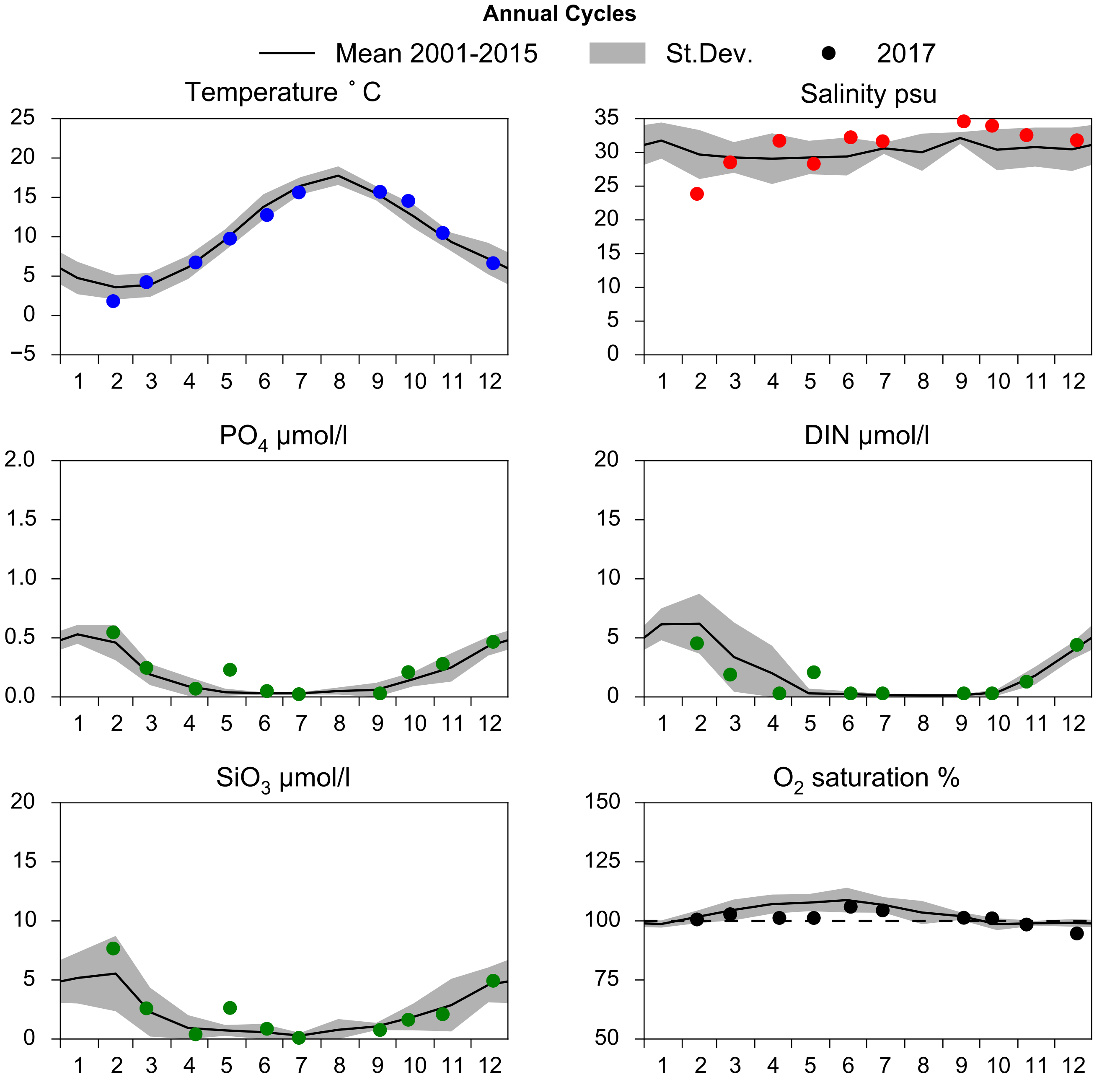
Annual Cycles



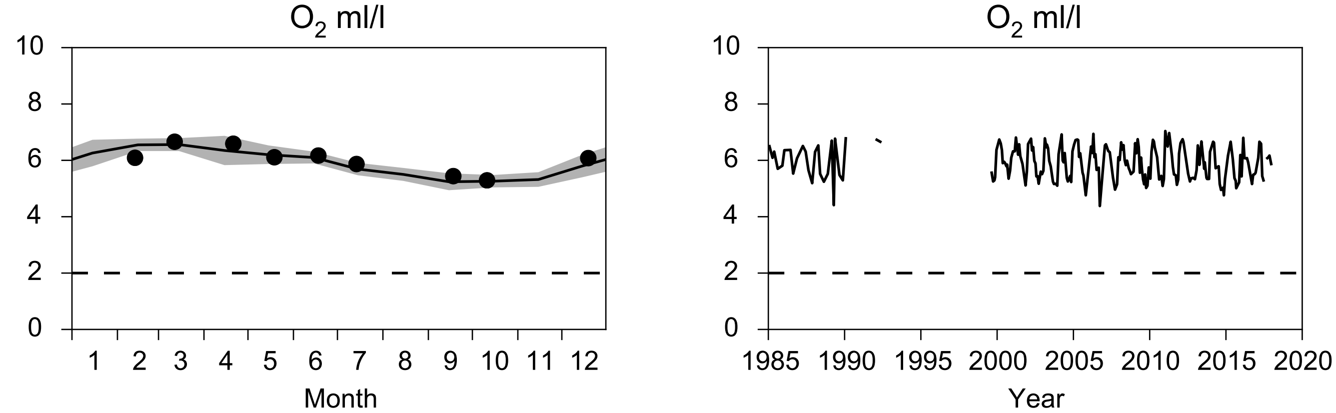
OXYGEN IN BOTTOM WATER (depth >= 300 m)



STATION Å15 SURFACE WATER (0-10 m)

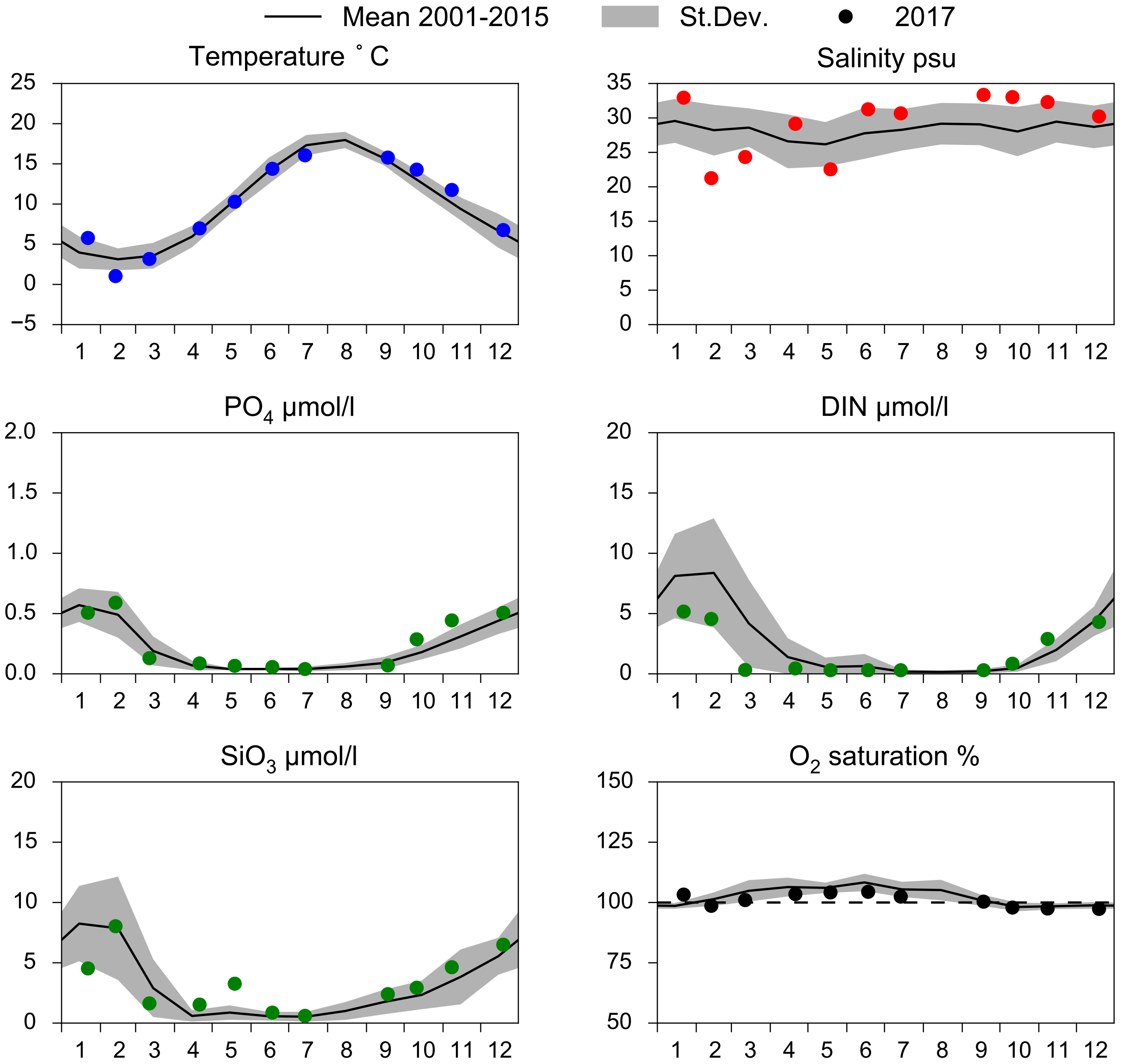


OXYGEN IN BOTTOM WATER (depth >= 125 m)

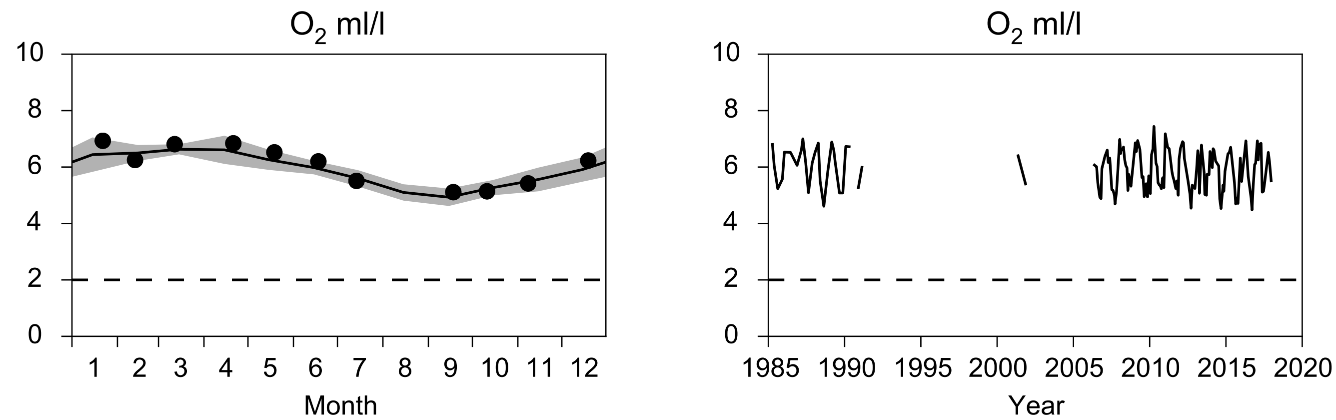


STATION Å13 SURFACE WATER (0-10 m)

Annual Cycles

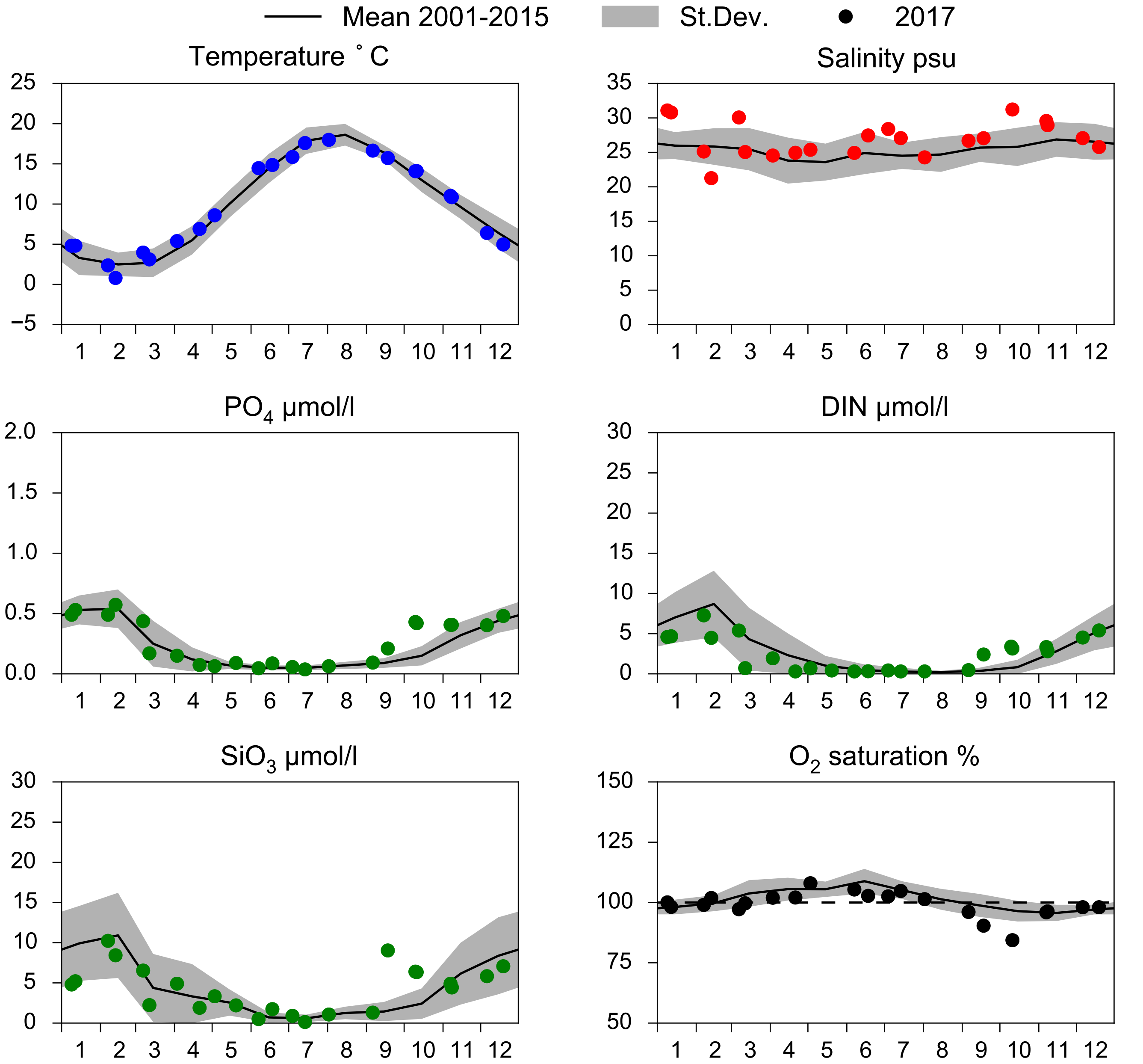


OXYGEN IN BOTTOM WATER (depth >= 80 m)

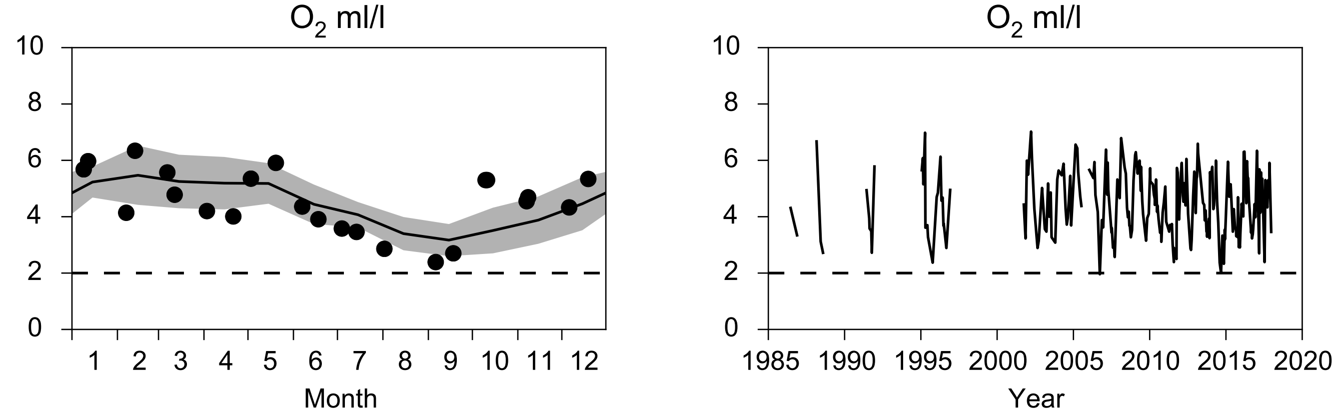


STATION SLÄGGÖ SURFACE WATER (0-10 m)

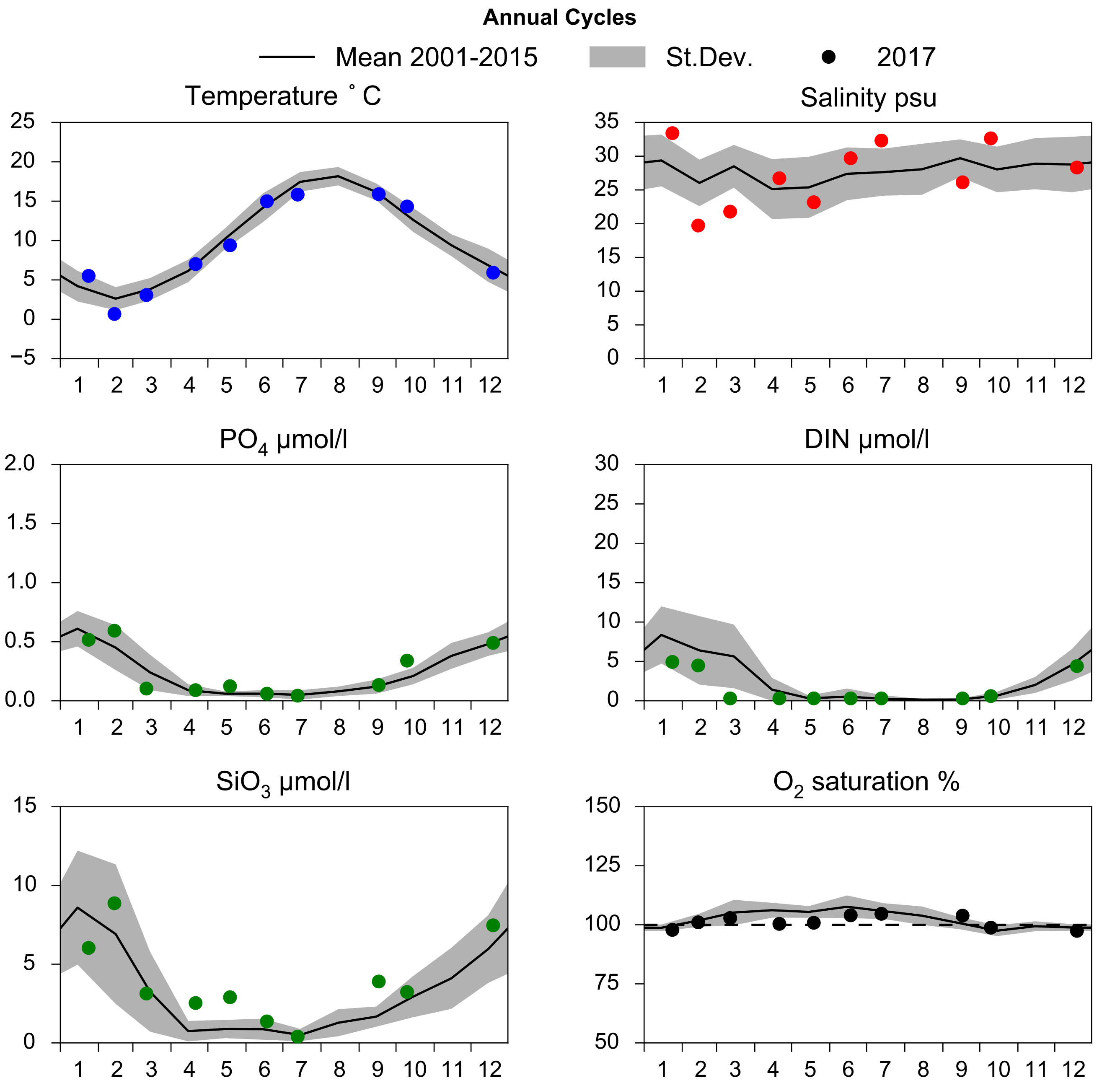
Annual Cycles



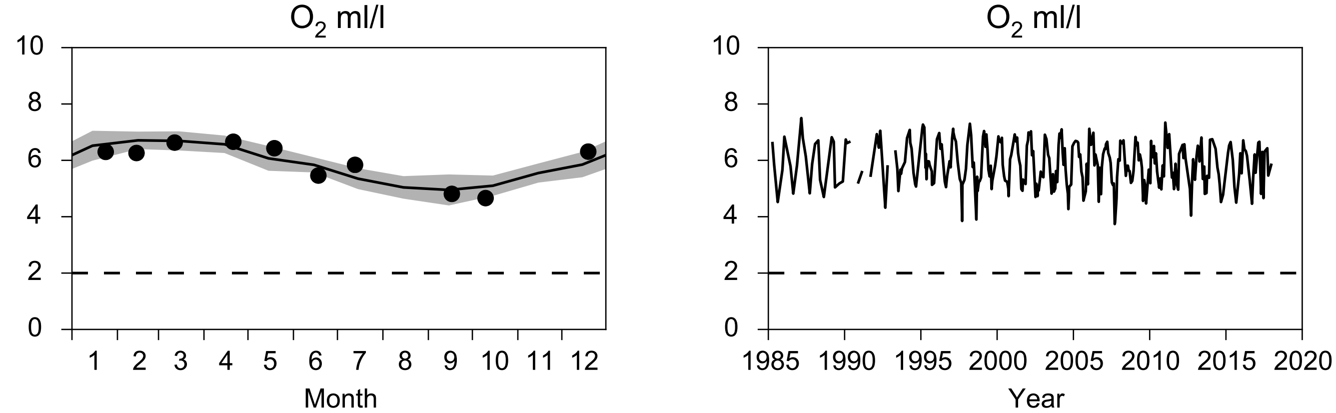
OXYGEN IN BOTTOM WATER (depth >= 64 m)



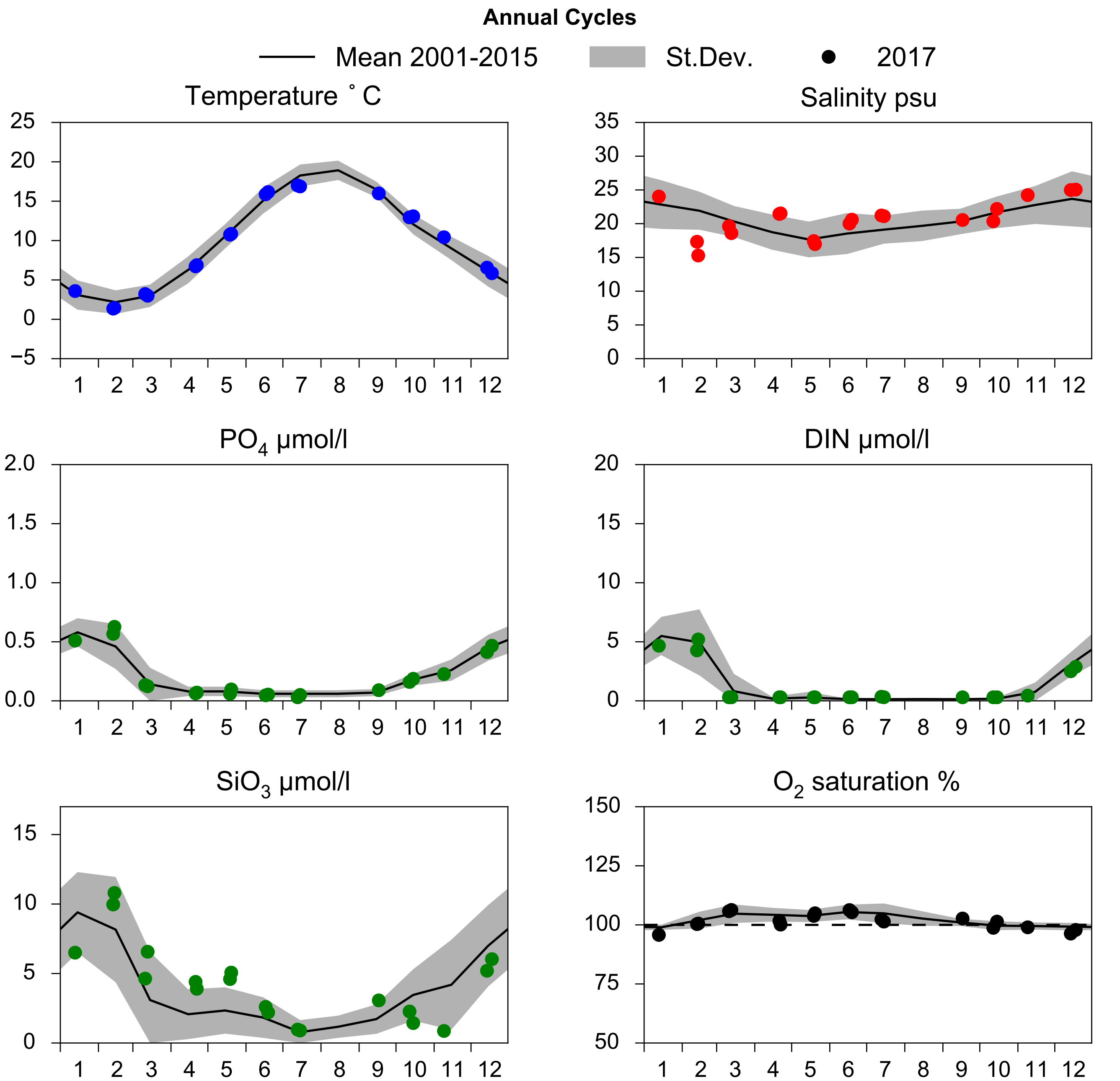
STATION P2 SURFACE WATER (0-10 m)



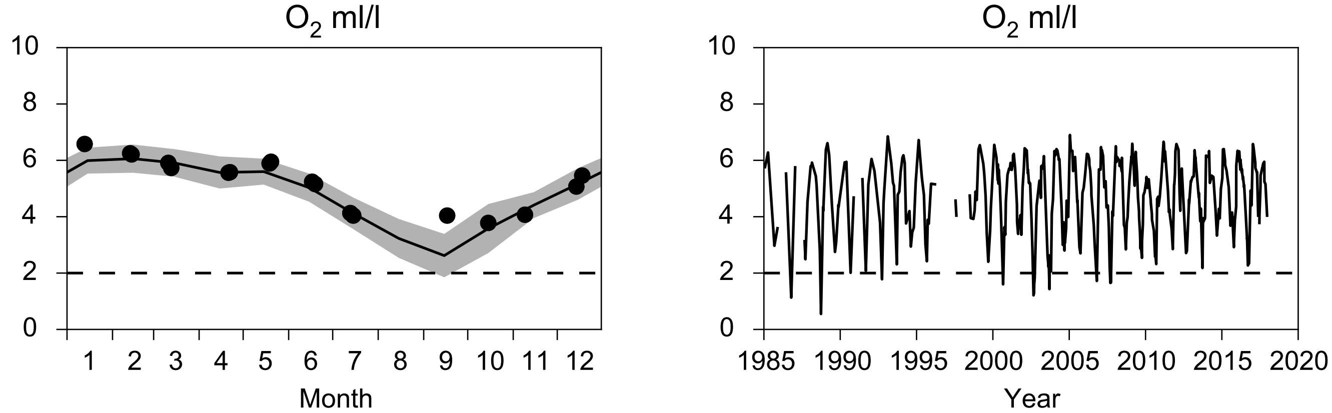
OXYGEN IN BOTTOM WATER (depth >= 75 m)



STATION ANHOLT E SURFACE WATER (0-10 m)

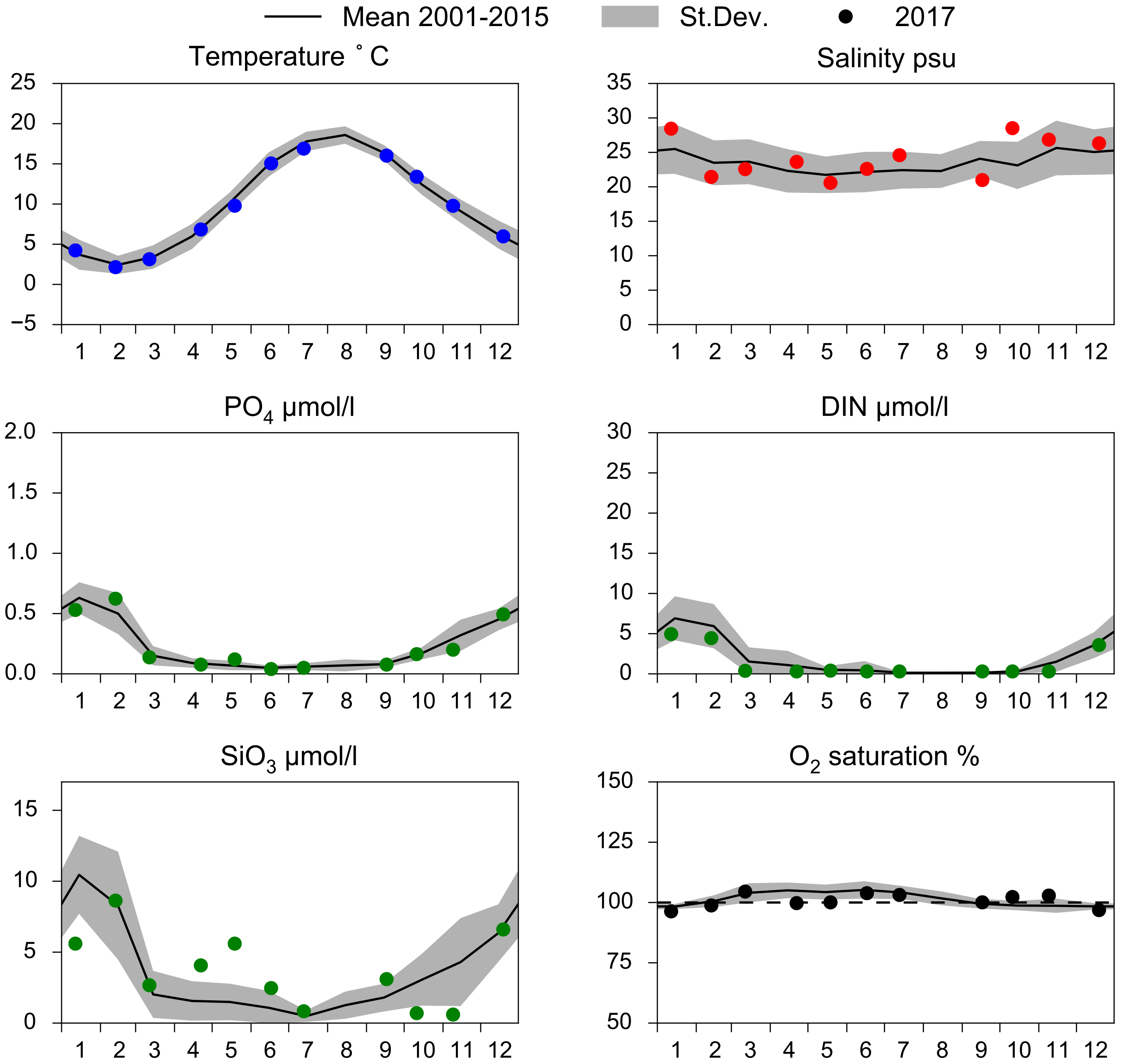


OXYGEN IN BOTTOM WATER (depth >= 52 m)

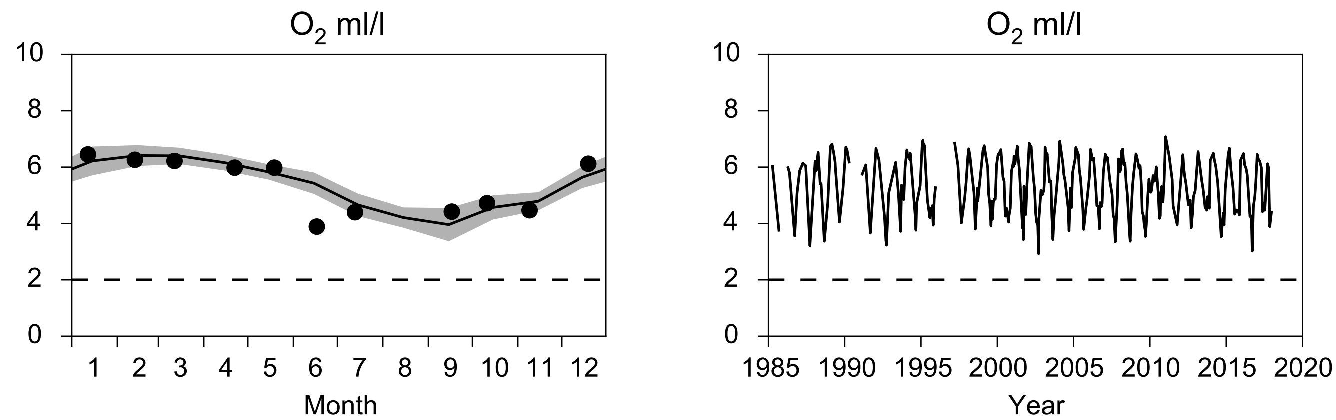


STATION FLADEN SURFACE WATER (0-10 m)

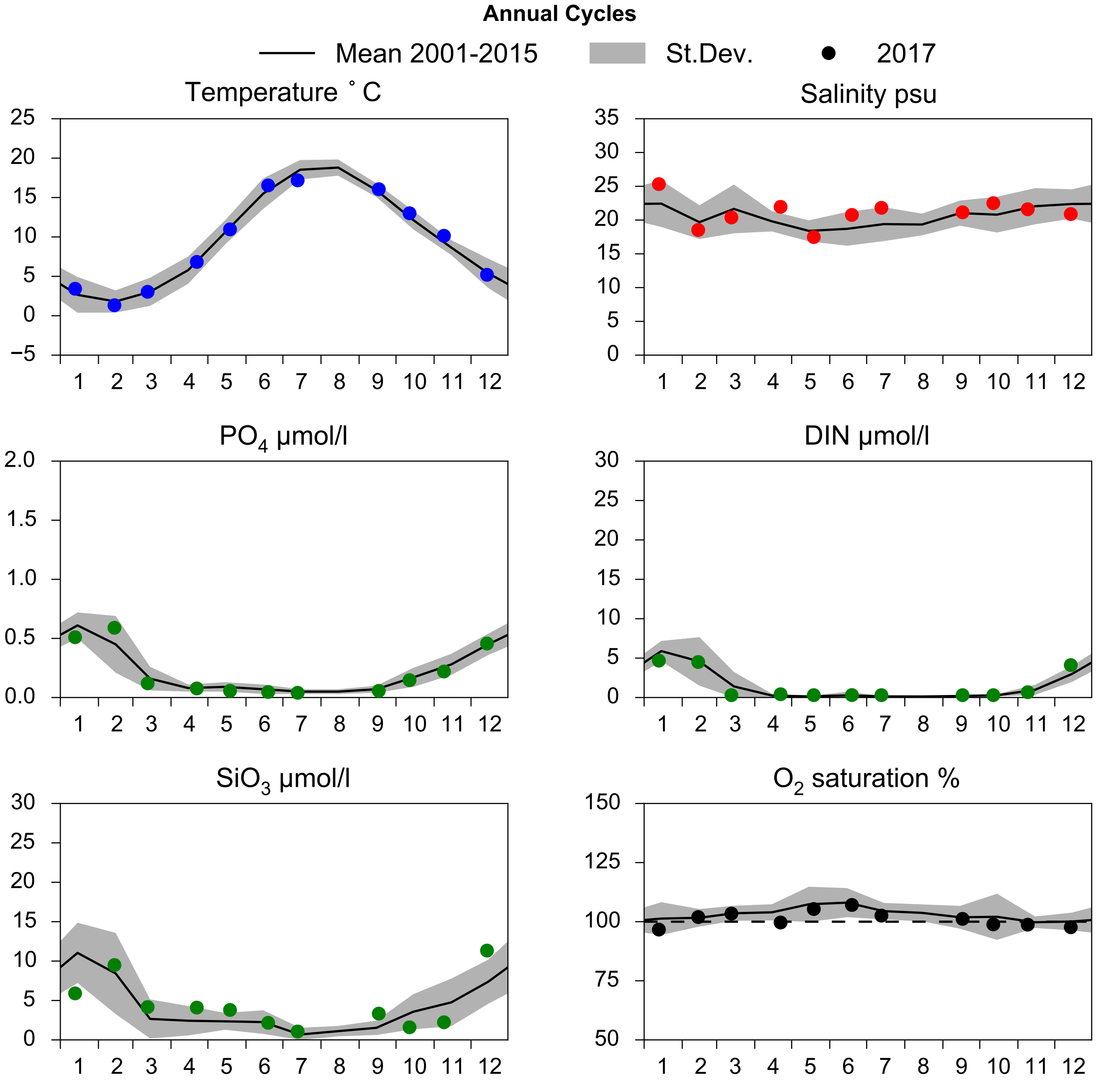
Annual Cycles



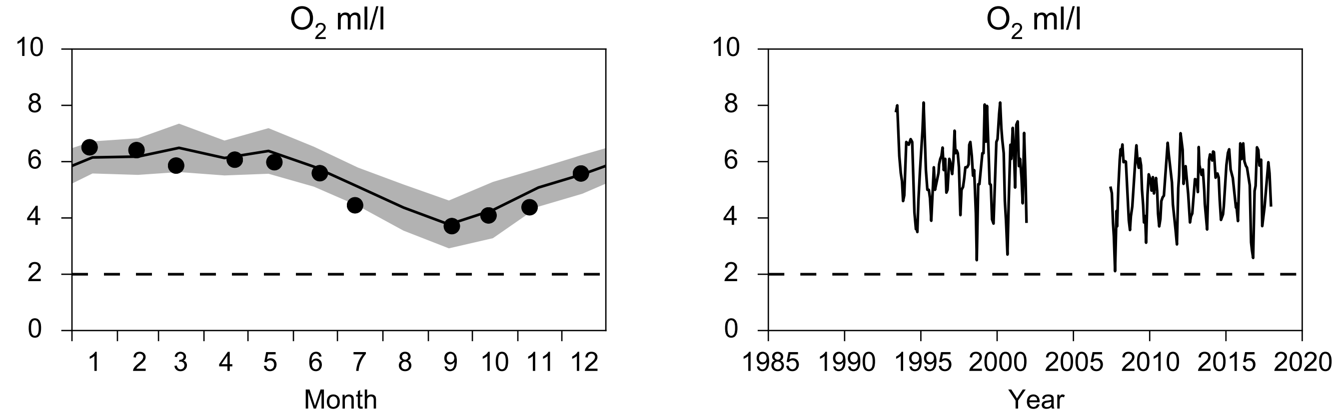
OXYGEN IN BOTTOM WATER (depth >= 74 m)



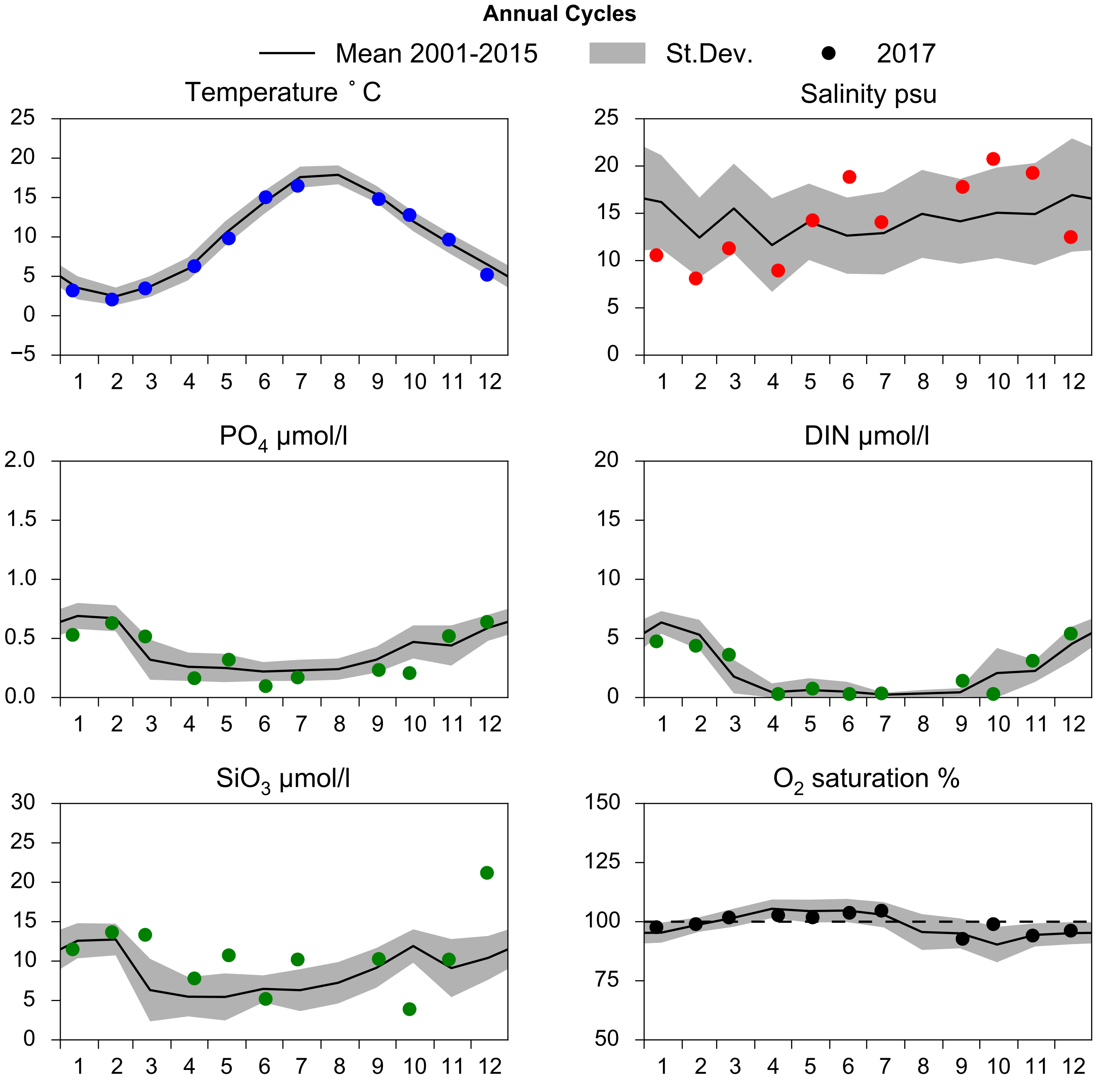
STATION N14 FALKENBERG SURFACE WATER (0-10 m)



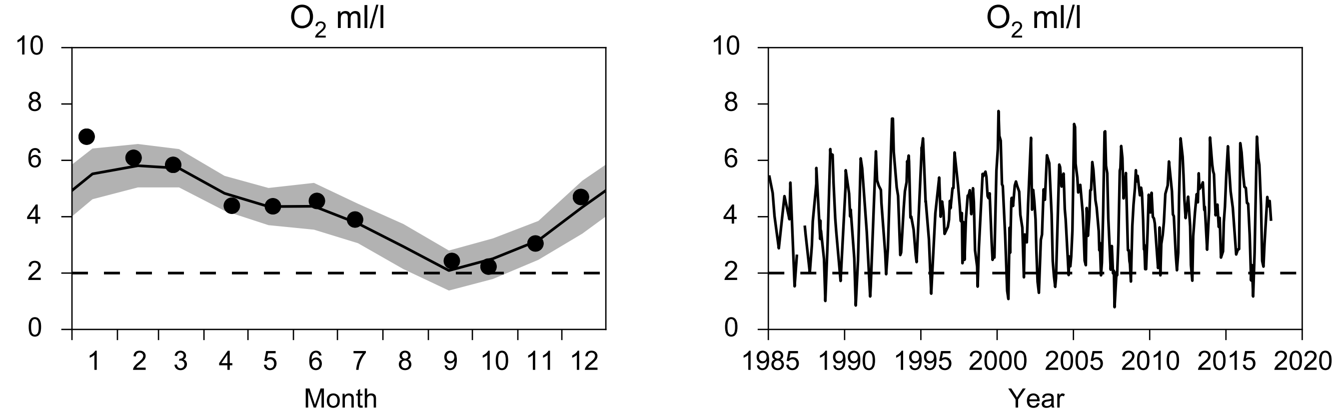
OXYGEN IN BOTTOM WATER (depth >= 25 m)



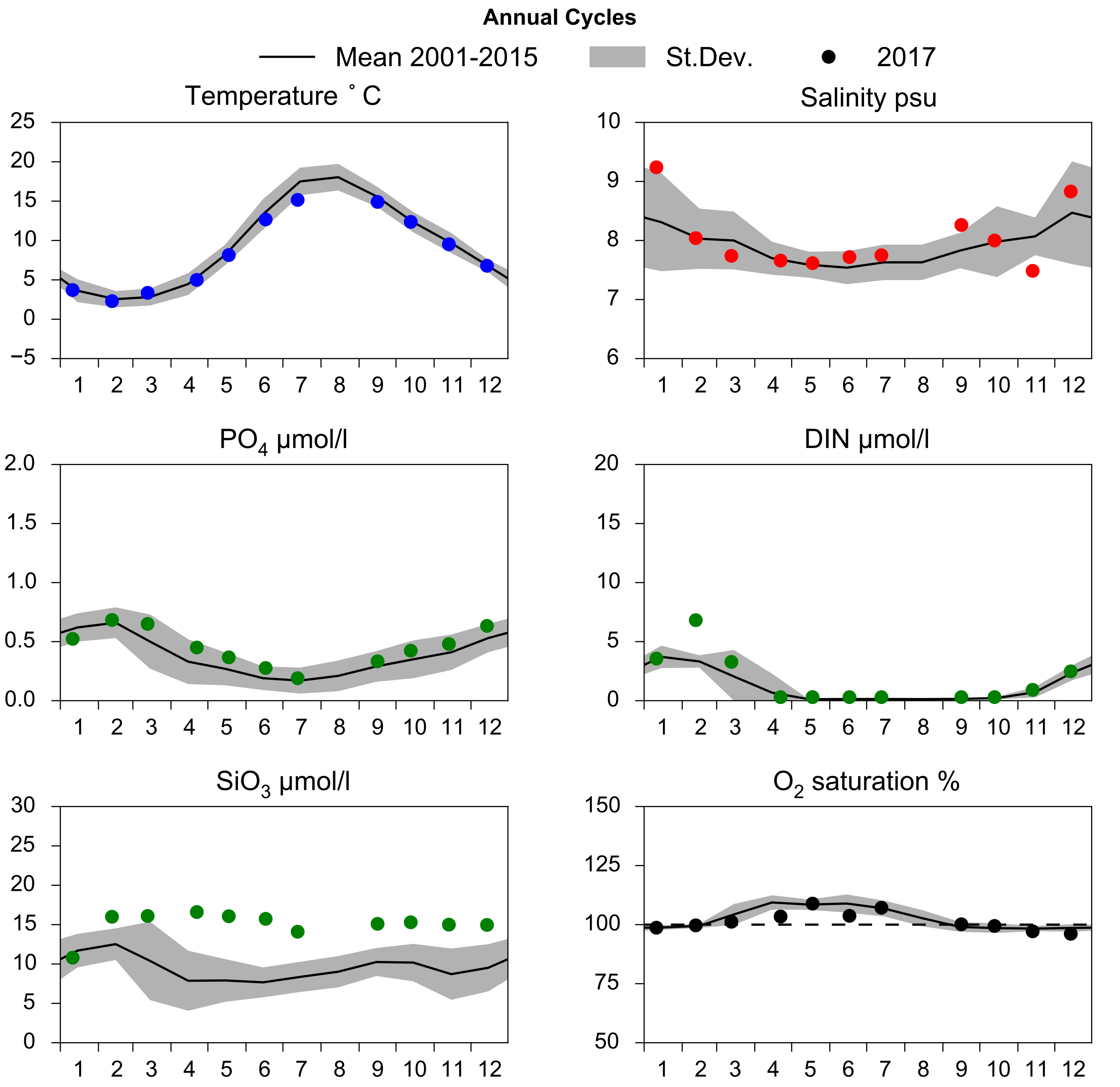
STATION W LANDSKRONA SURFACE WATER (0-10 m)



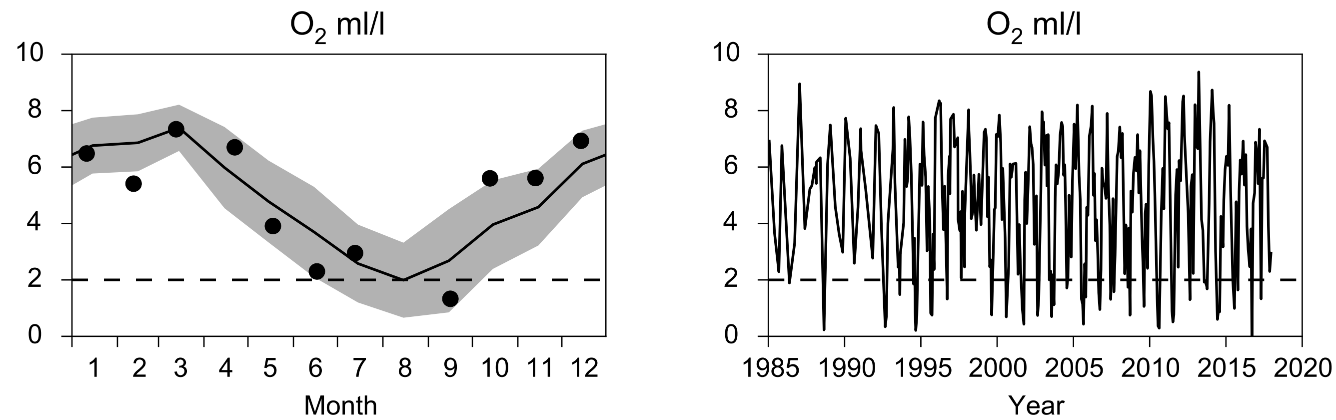
OXYGEN IN BOTTOM WATER (depth >= 40 m)



STATION BY1 SURFACE WATER (0-10 m)

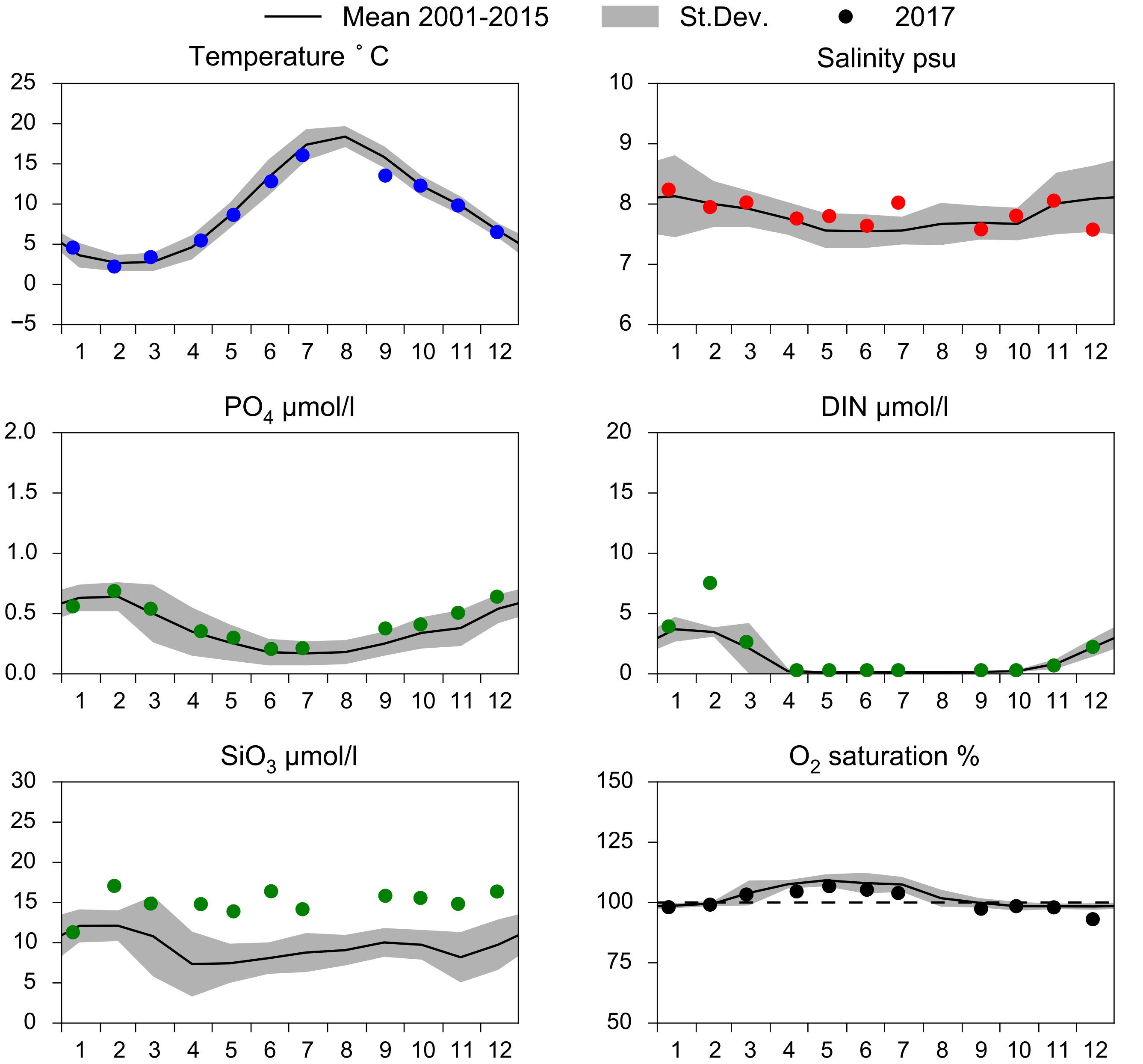


OXYGEN IN BOTTOM WATER (depth >= 40 m)

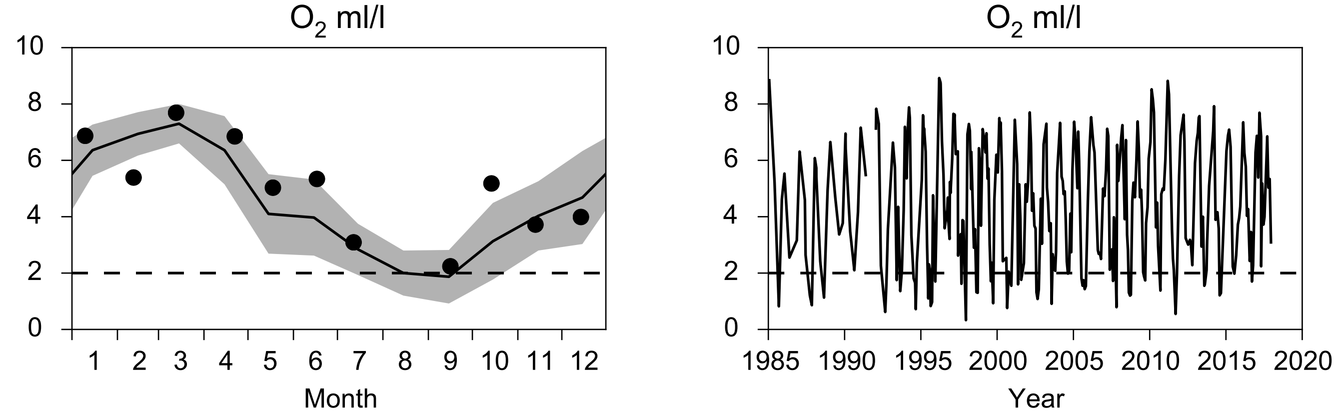


STATION BY2 ARKONA SURFACE WATER (0-10 m)

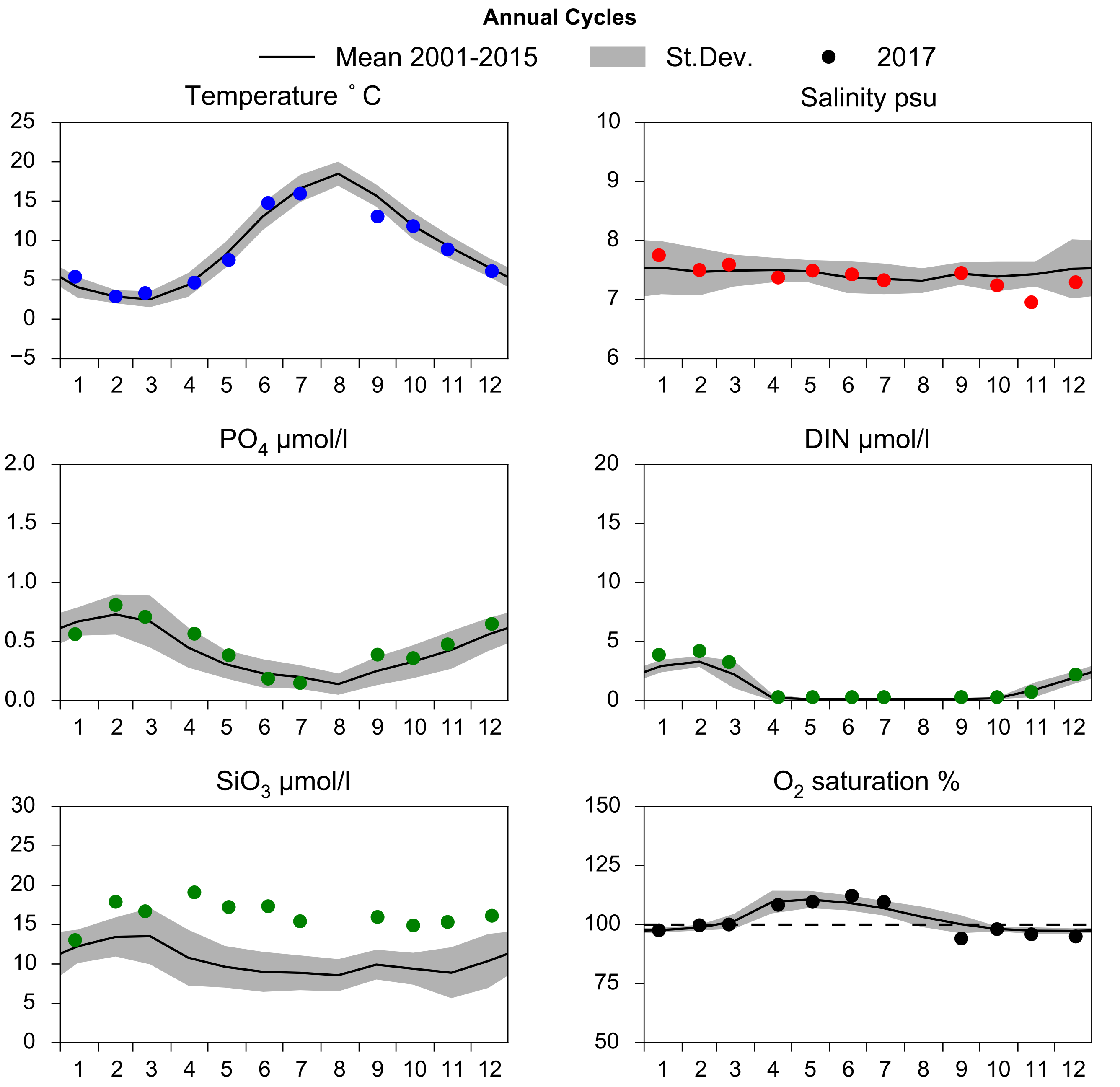
Annual Cycles



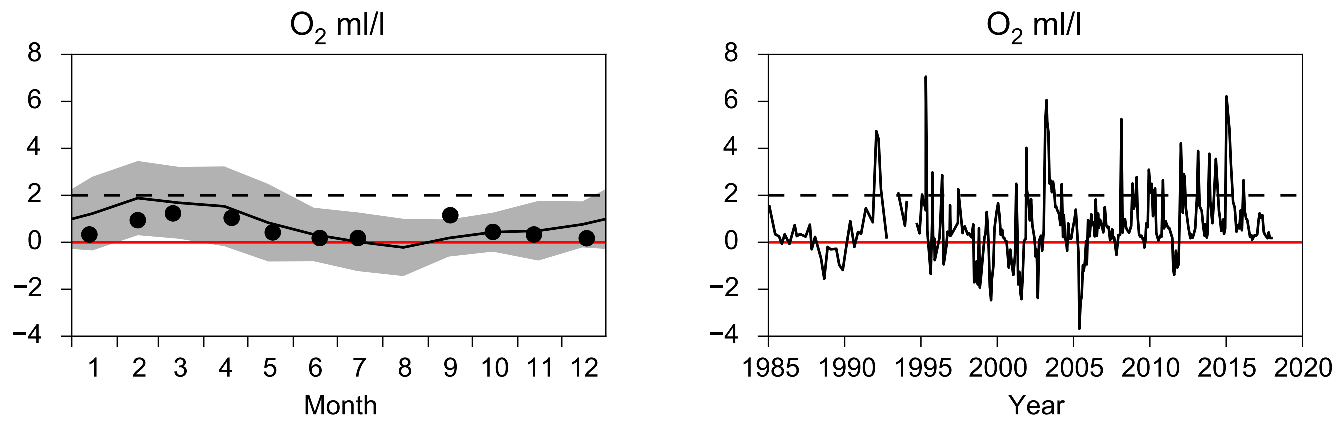
OXYGEN IN BOTTOM WATER (depth >= 40 m)



STATION HANÖBUKTEN SURFACE WATER (0-10 m)

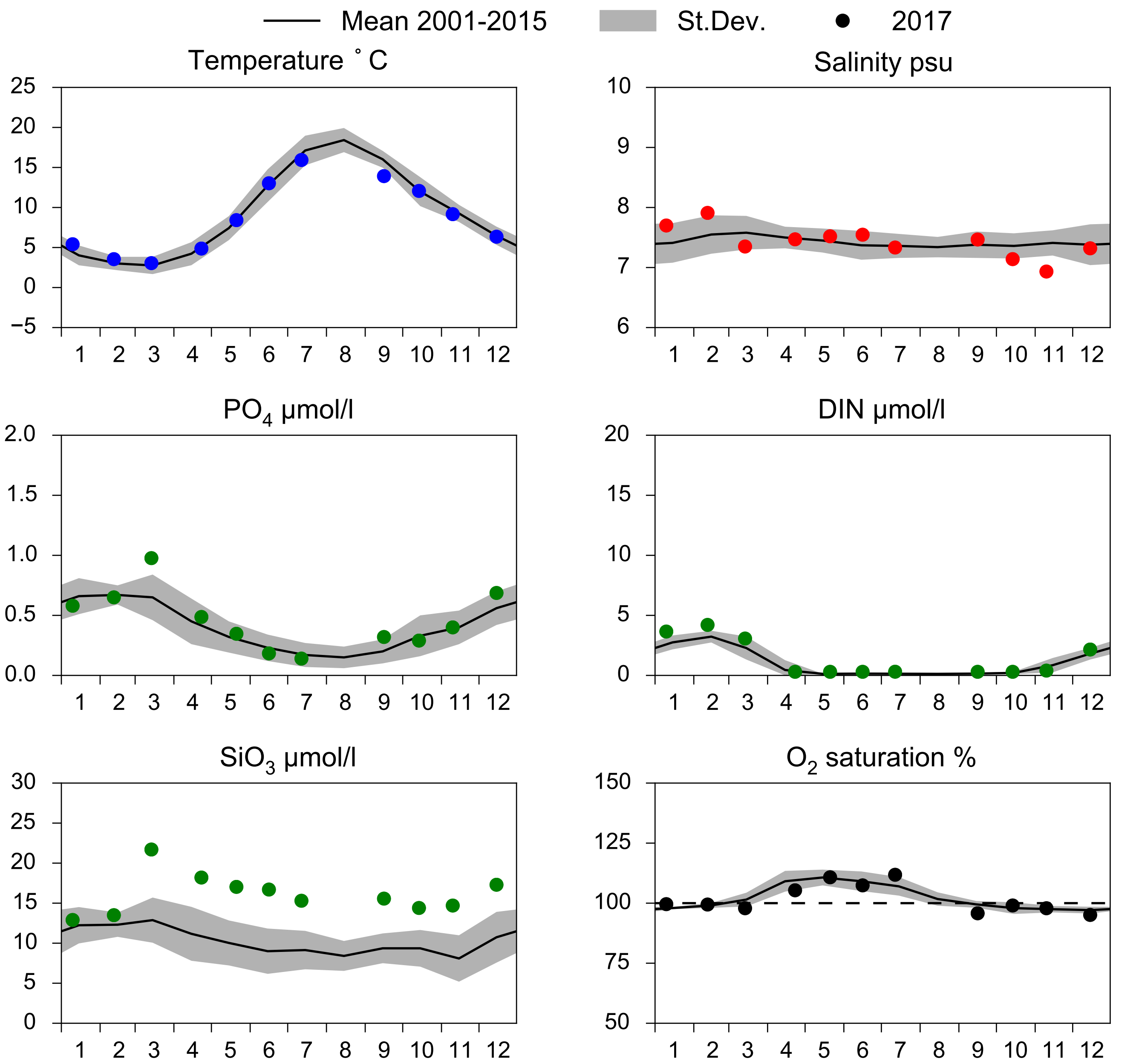


OXYGEN IN BOTTOM WATER (depth >= 70 m)

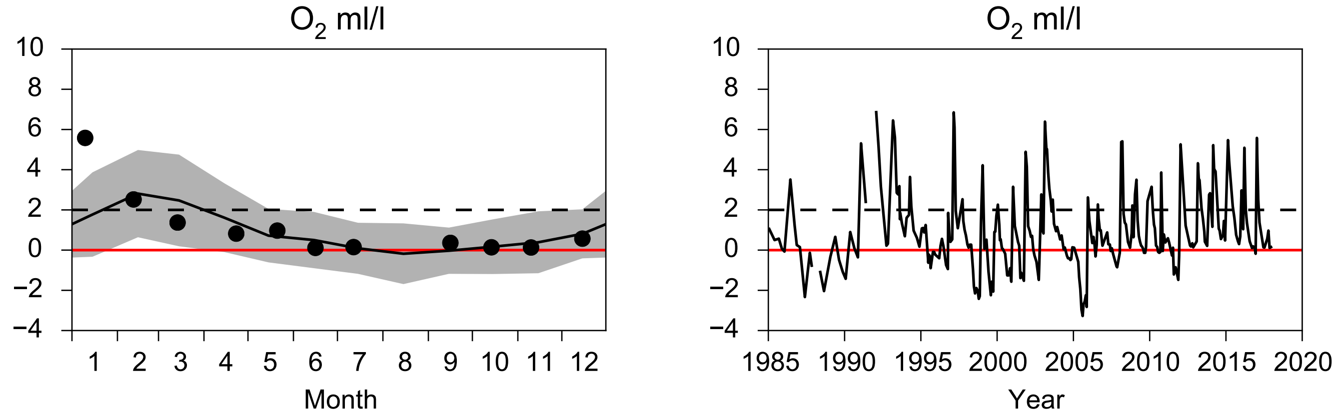


STATION BY4 CHRISTIANSÖ SURFACE WATER (0-10 m)

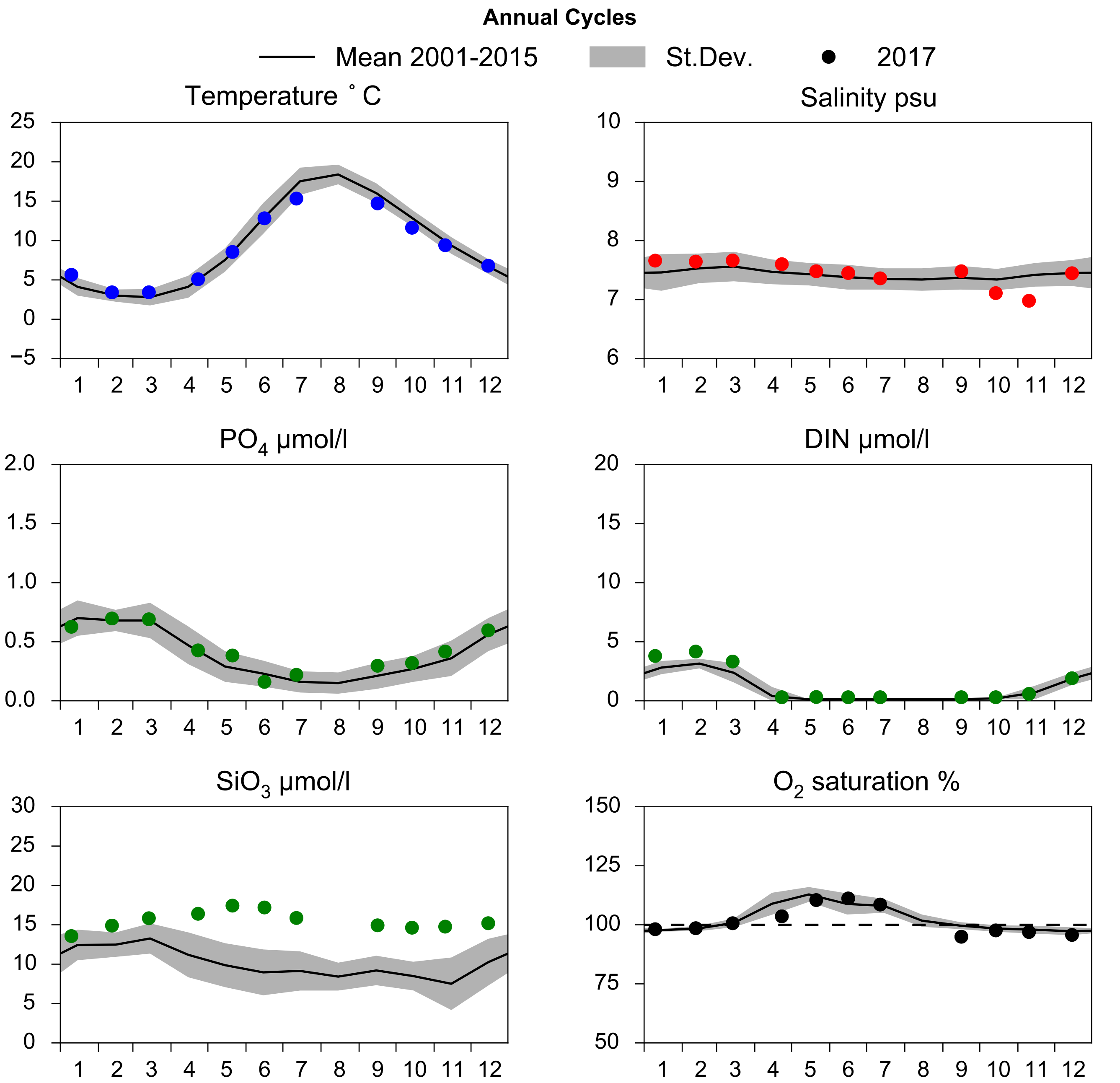
Annual Cycles



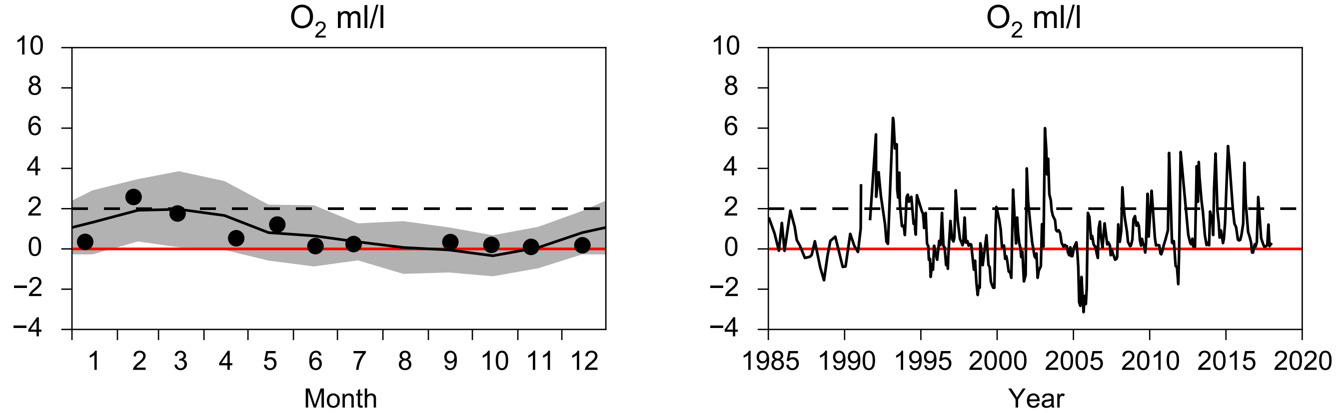
OXYGEN IN BOTTOM WATER (depth >= 80 m)



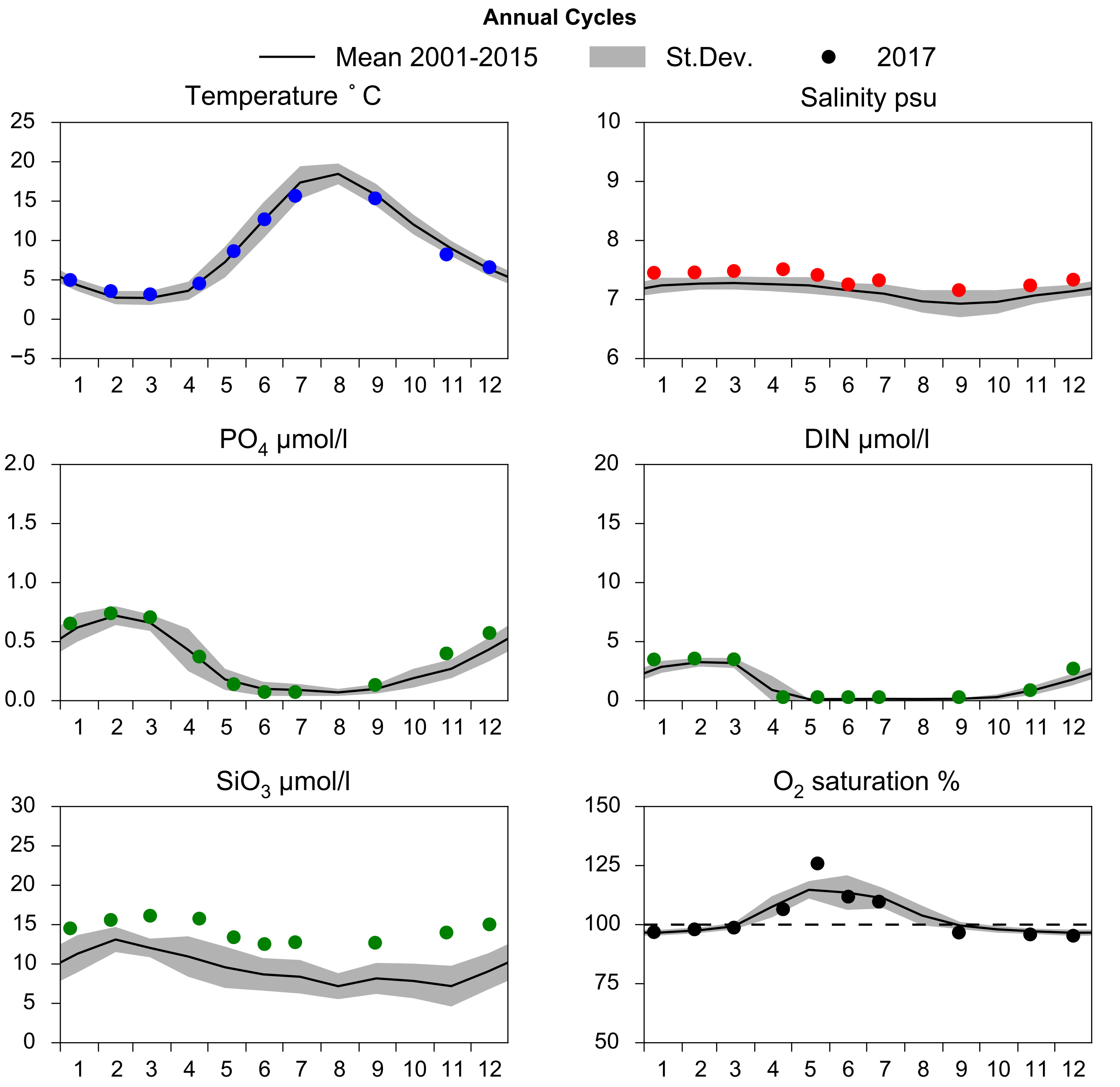
STATION BY5 BORNHOLMSDJ SURFACE WATER (0-10 m)



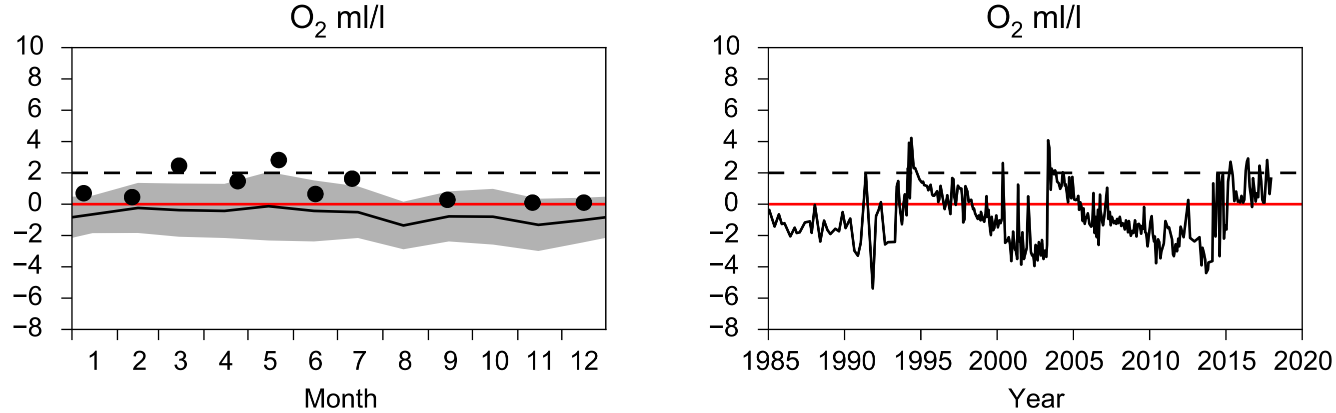
OXYGEN IN BOTTOM WATER (depth >= 80 m)



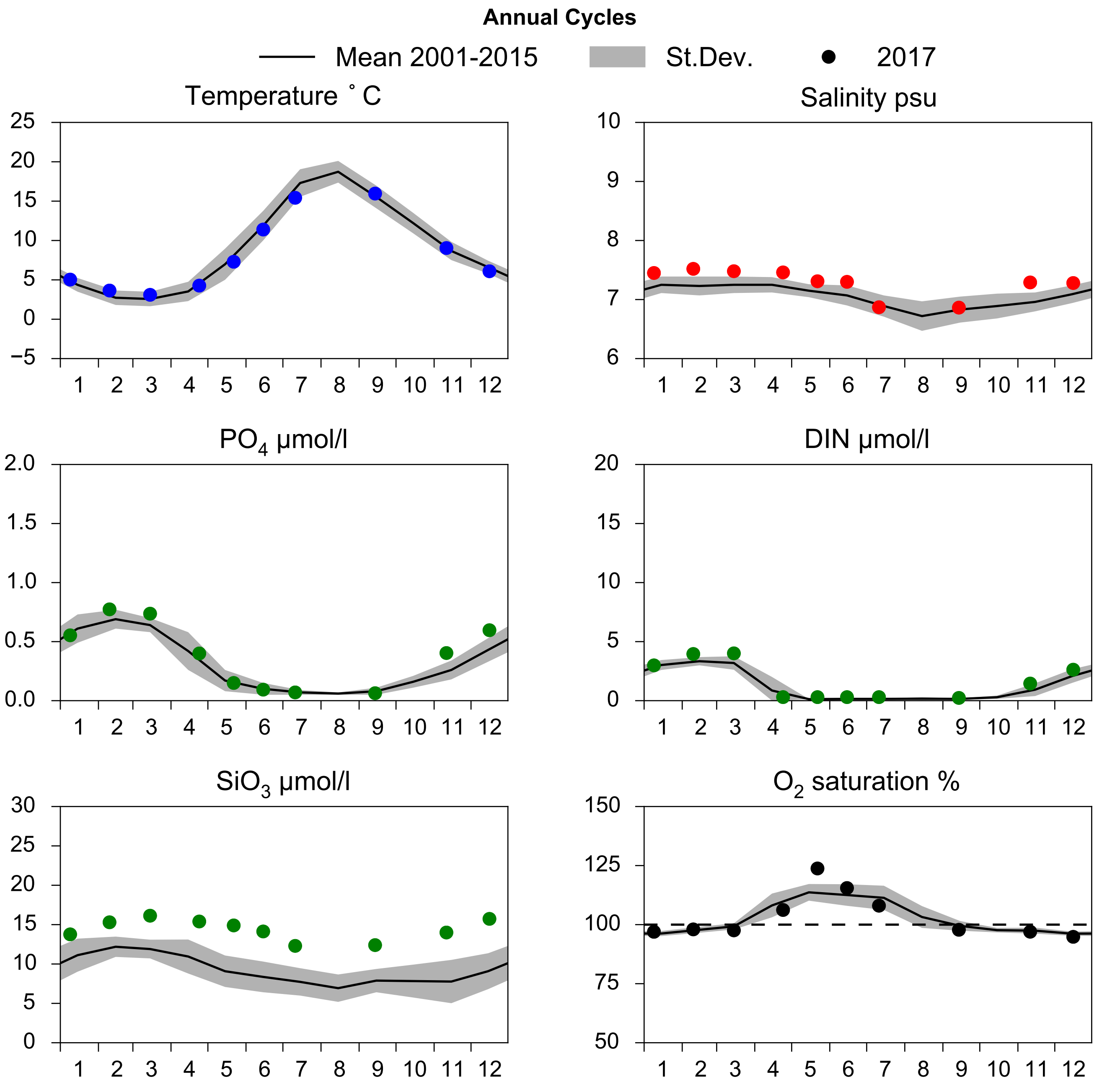
STATION BY10 SURFACE WATER (0-10 m)



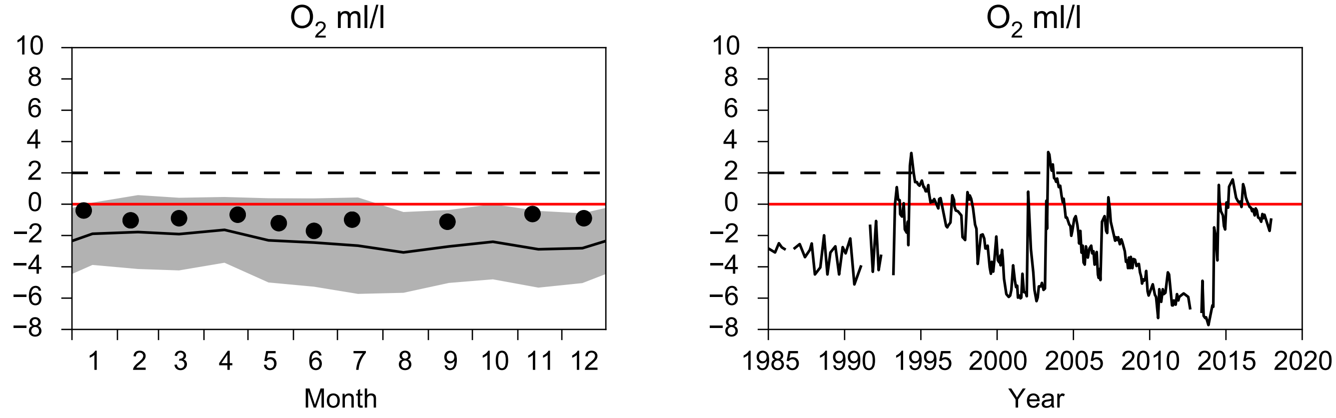
OXYGEN IN BOTTOM WATER (depth >= 125 m)



STATION BY15 GOTLANDSDJ SURFACE WATER (0-10 m)

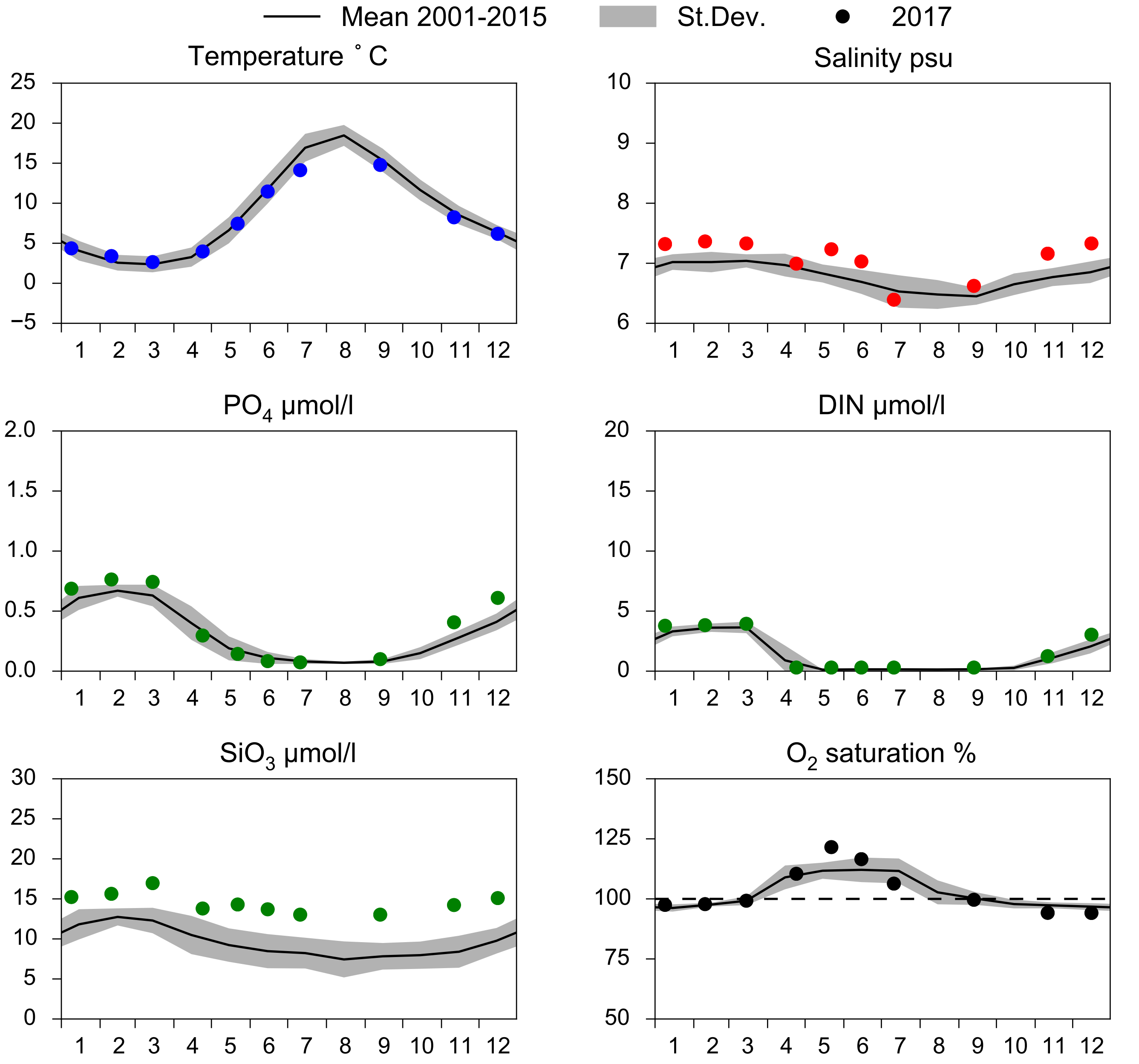


OXYGEN IN BOTTOM WATER (depth >= 225 m)

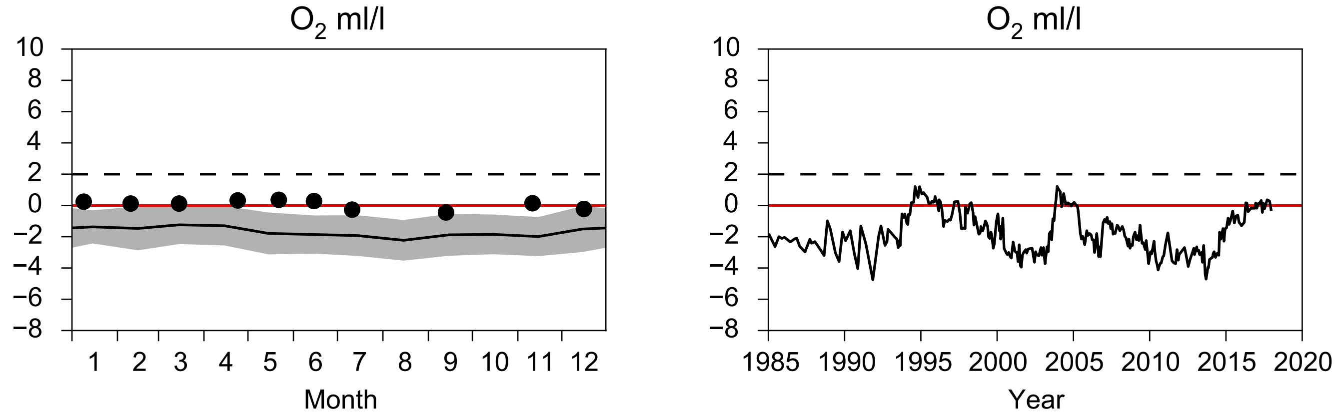


STATION BY20 FÅRÖDJ SURFACE WATER (0-10 m)

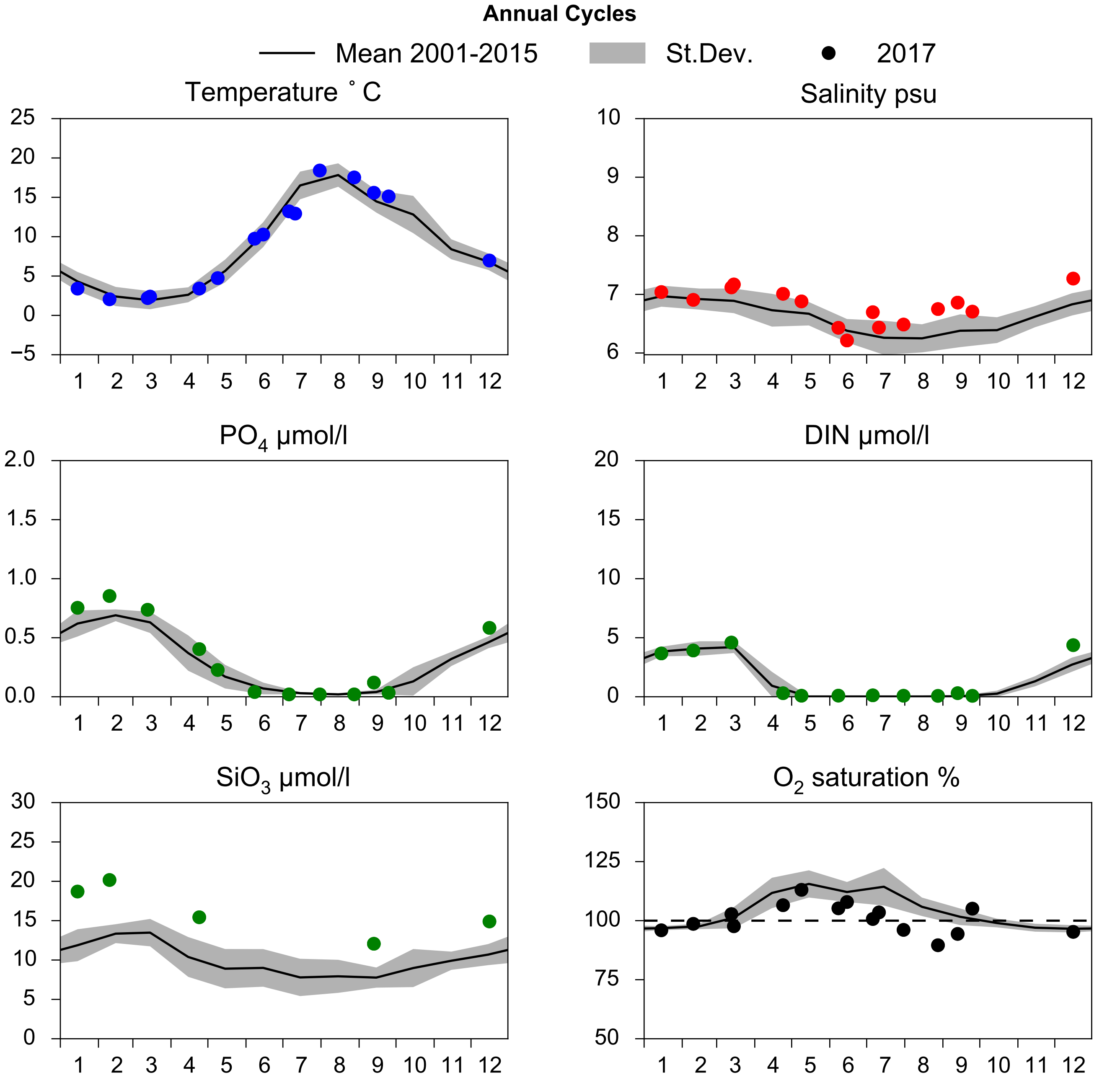
Annual Cycles



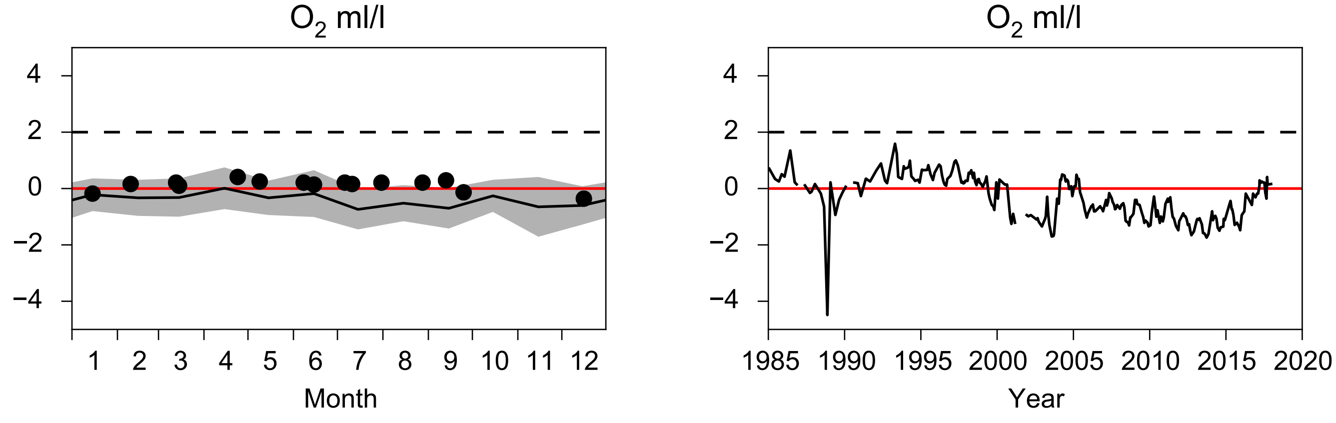
OXYGEN IN BOTTOM WATER (depth >= 175 m)



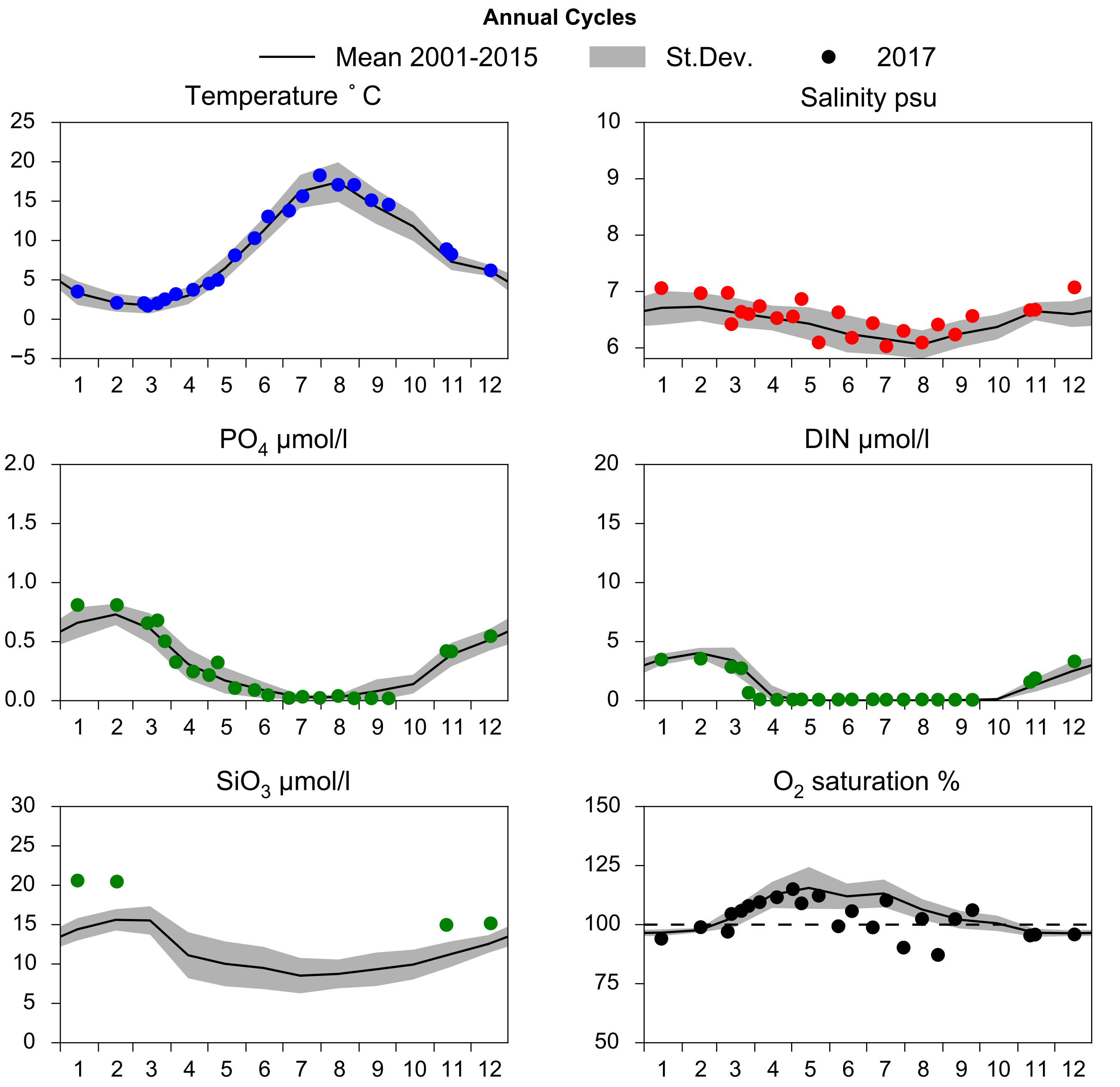
STATION BY29 / LL19 SURFACE WATER (0-10 m)



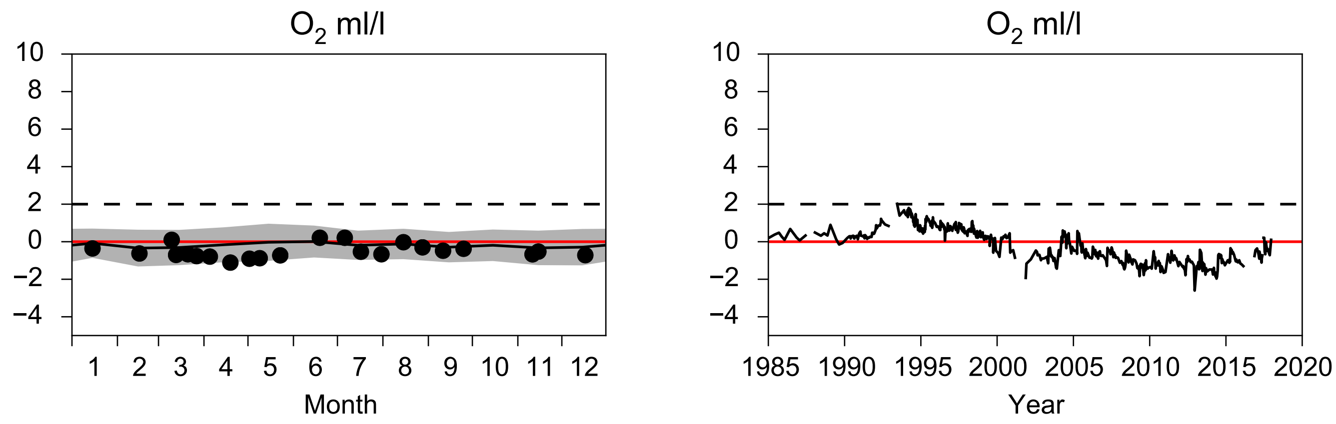
OXYGEN IN BOTTOM WATER (depth >= 150 m)



STATION BY31 LANDSORTSDJ SURFACE WATER (0-10 m)

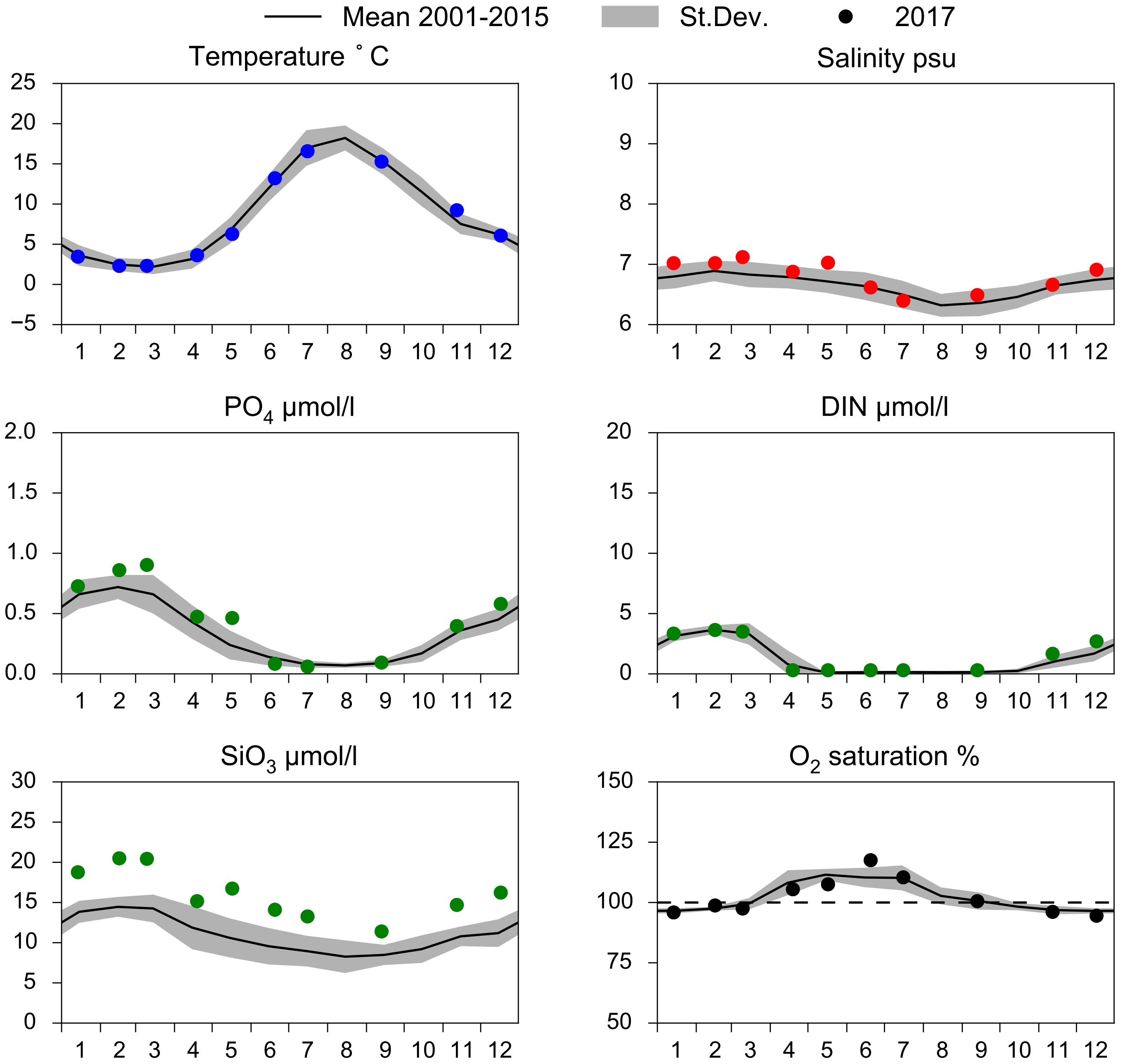


OXYGEN IN BOTTOM WATER (depth >= 425 m)

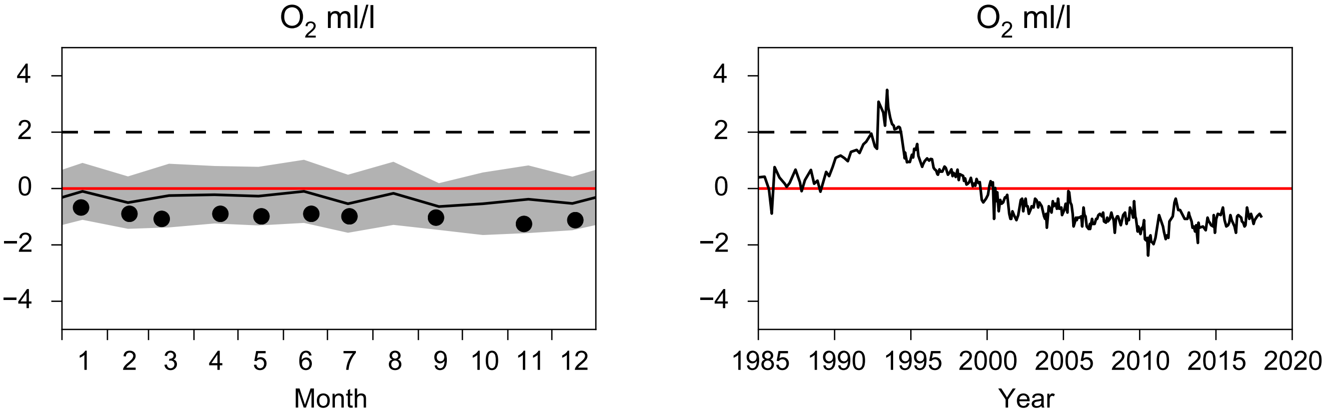


STATION BY32 NORRKÖPINGSDJ SURFACE WATER (0-10 m)

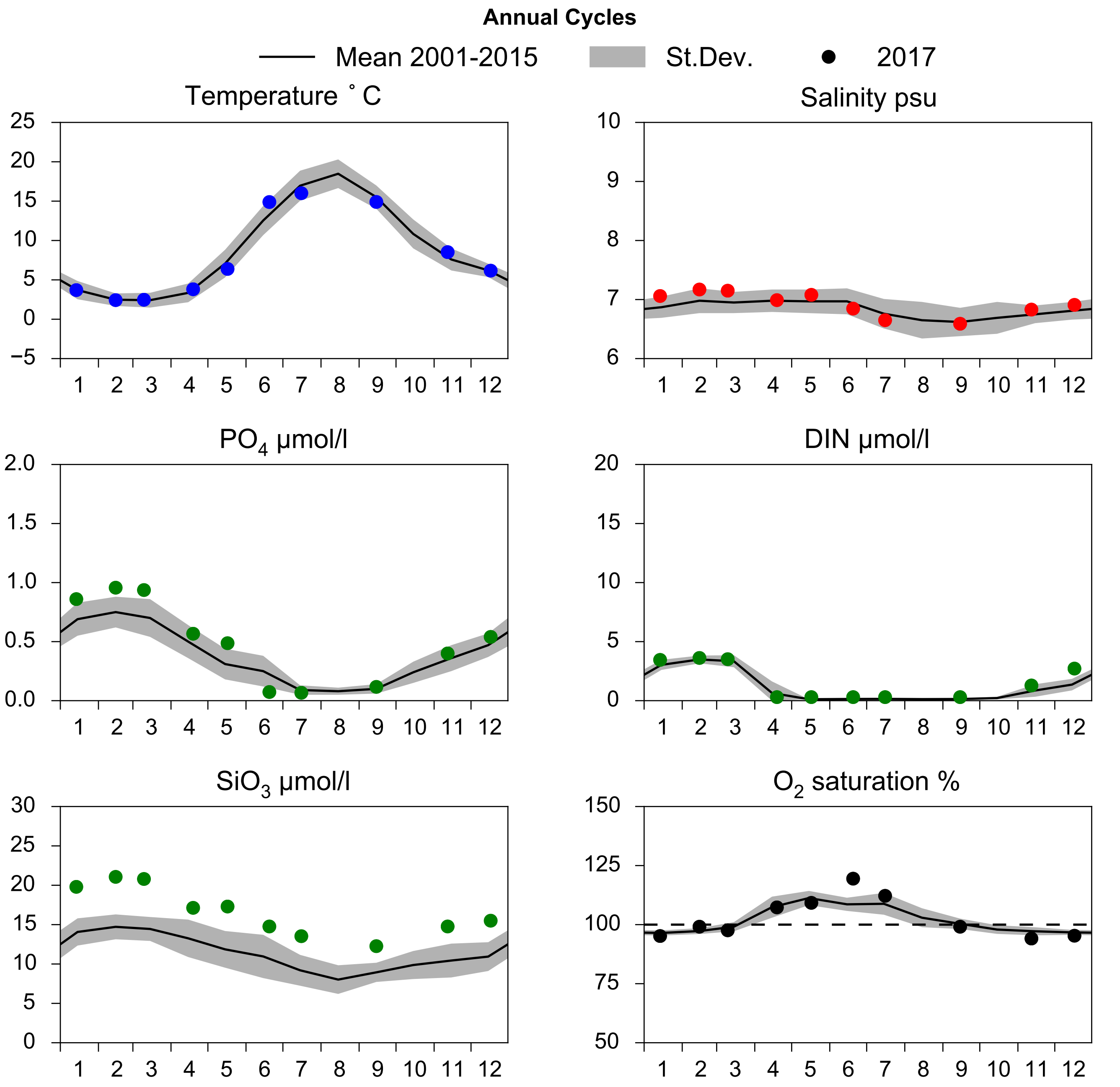
Annual Cycles



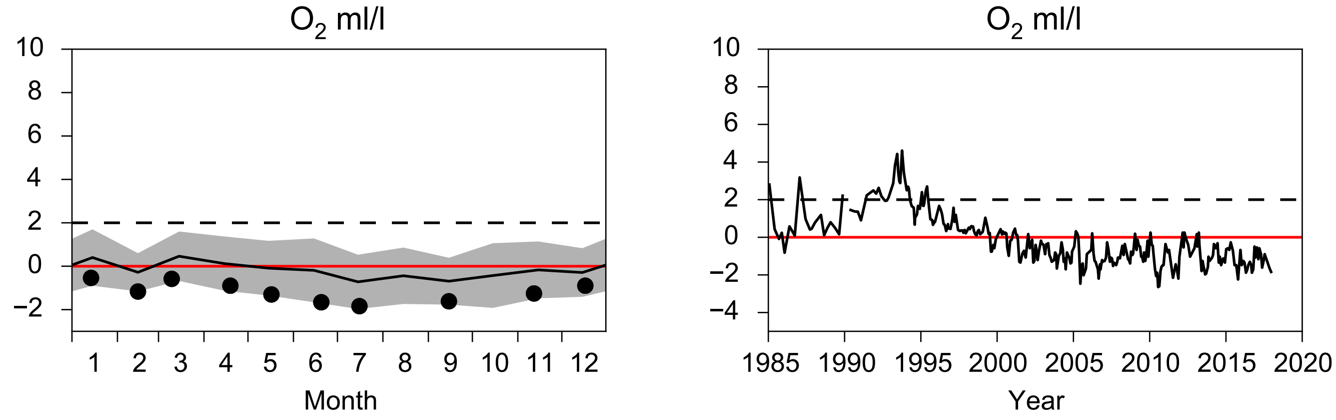
OXYGEN IN BOTTOM WATER (depth >= 175 m)



STATION BY38 KARLSÖDJ SURFACE WATER (0-10 m)

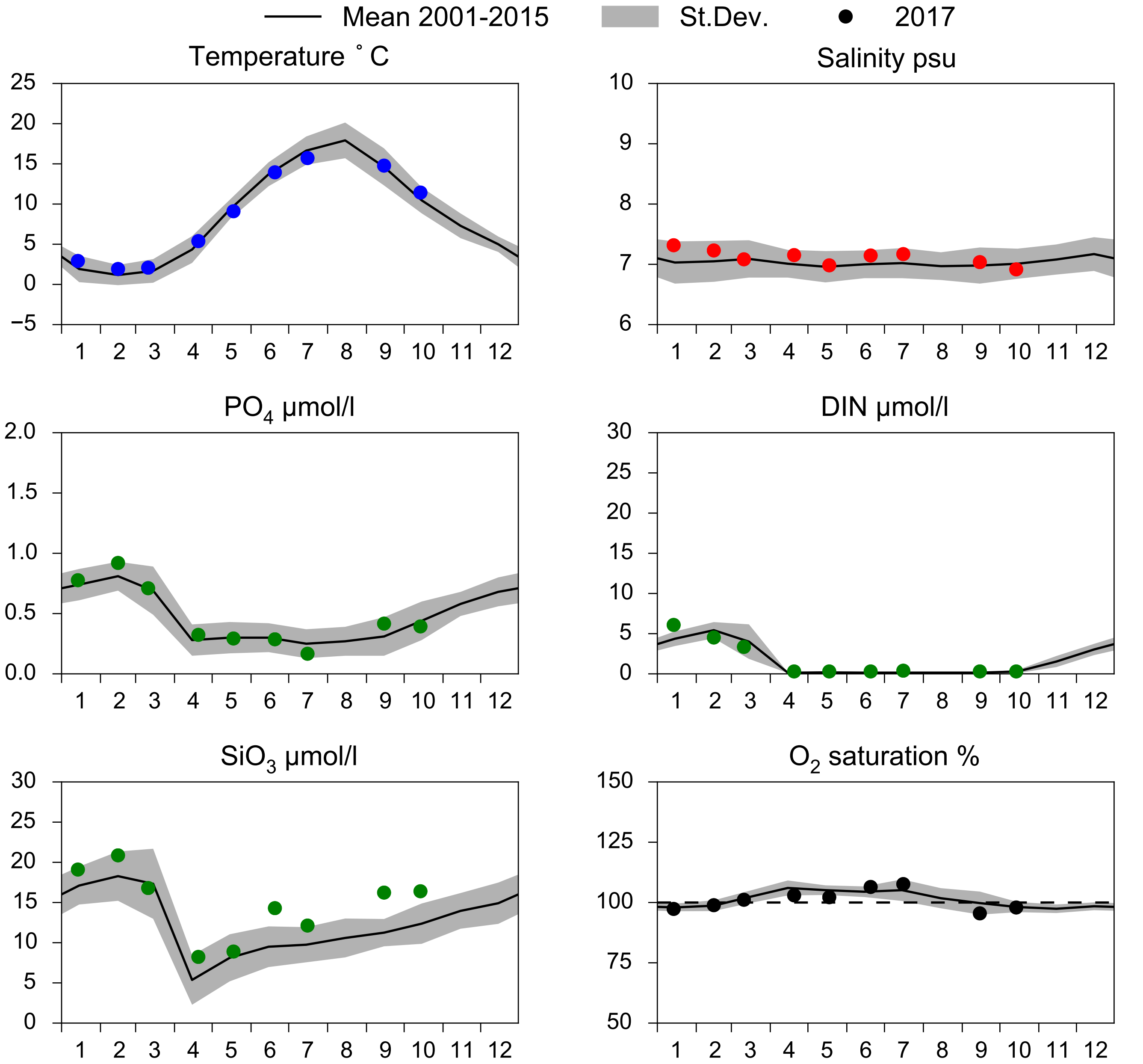


OXYGEN IN BOTTOM WATER (depth >= 100 m)

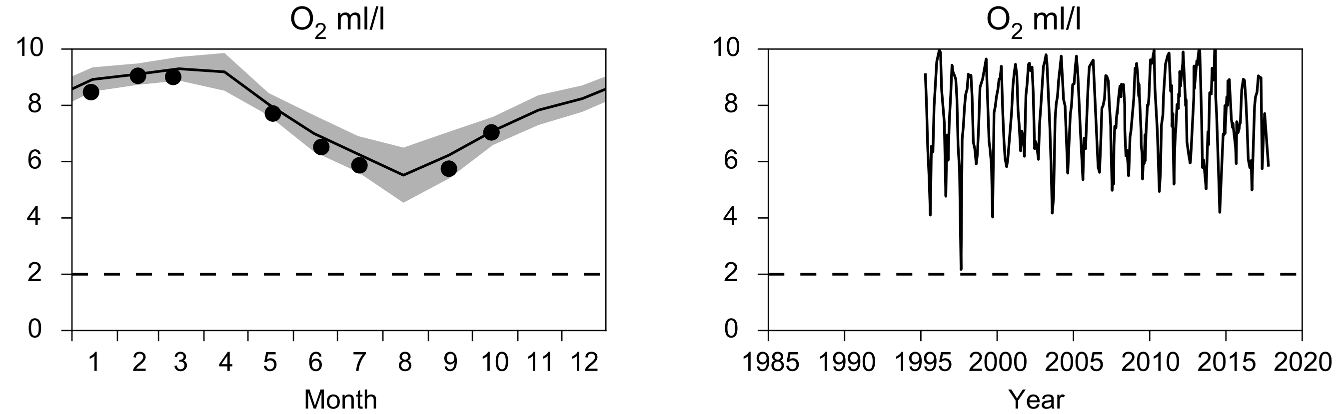


STATION REF M1V1 SURFACE WATER (0-10 m)

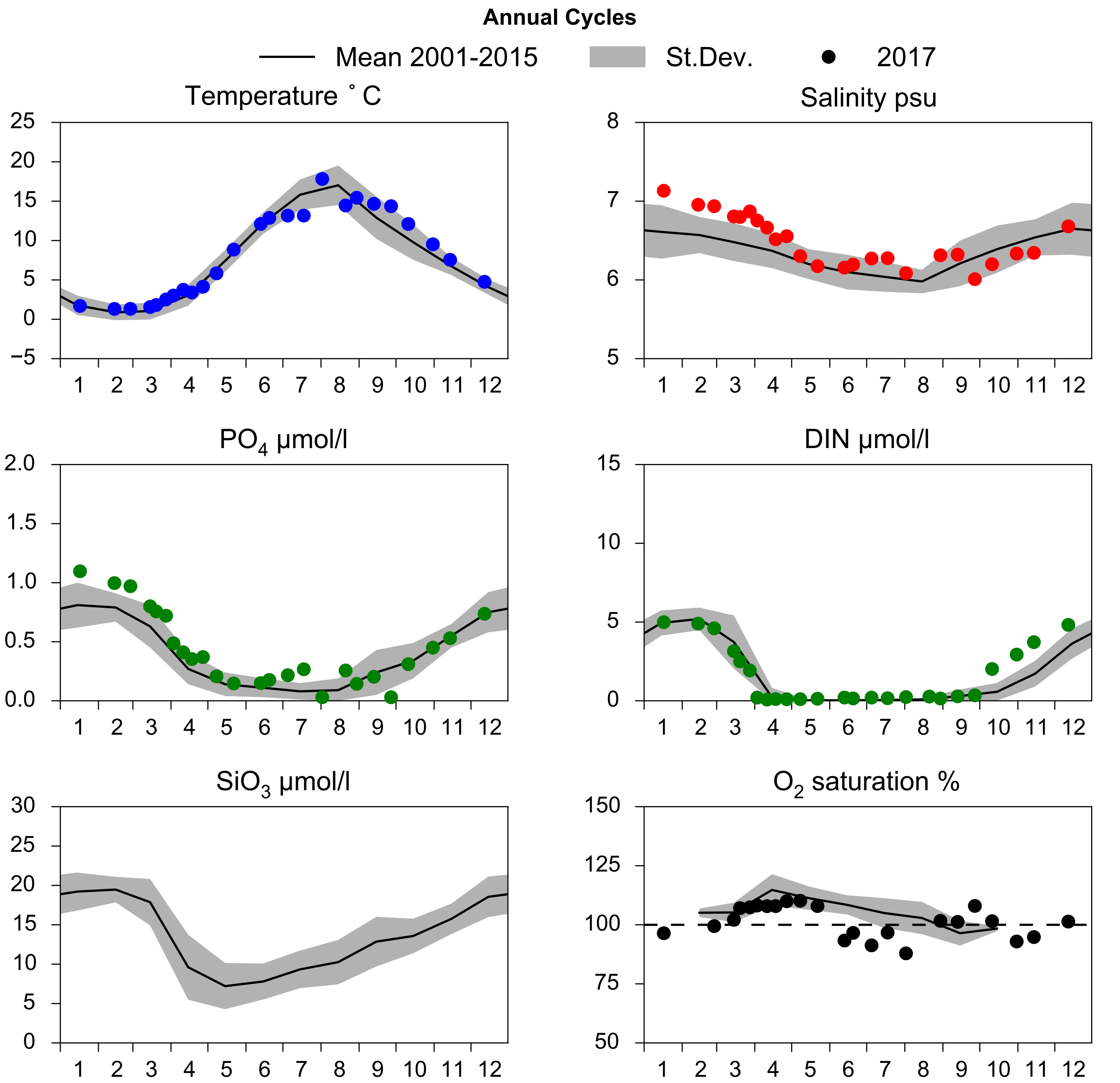
Annual Cycles



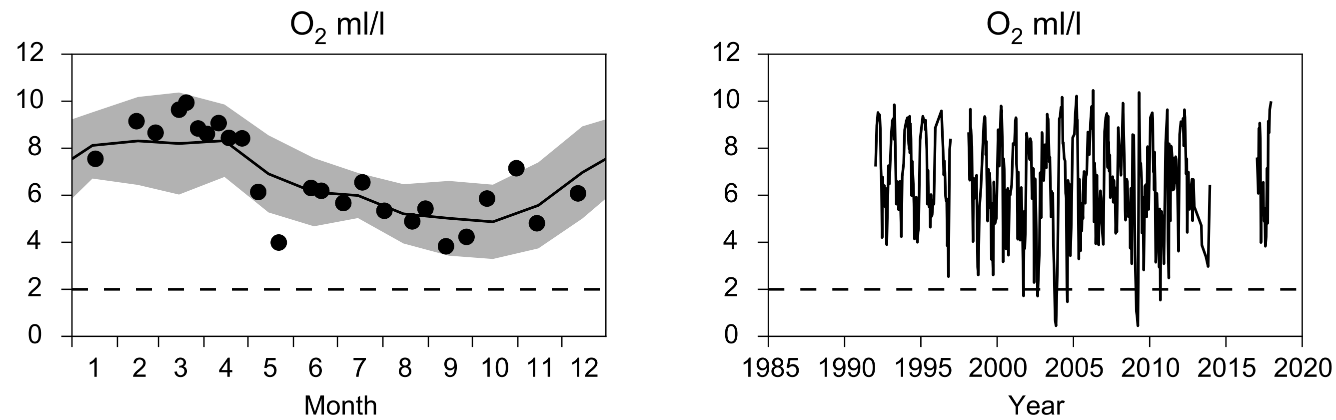
OXYGEN IN BOTTOM WATER (depth >= 17 m)



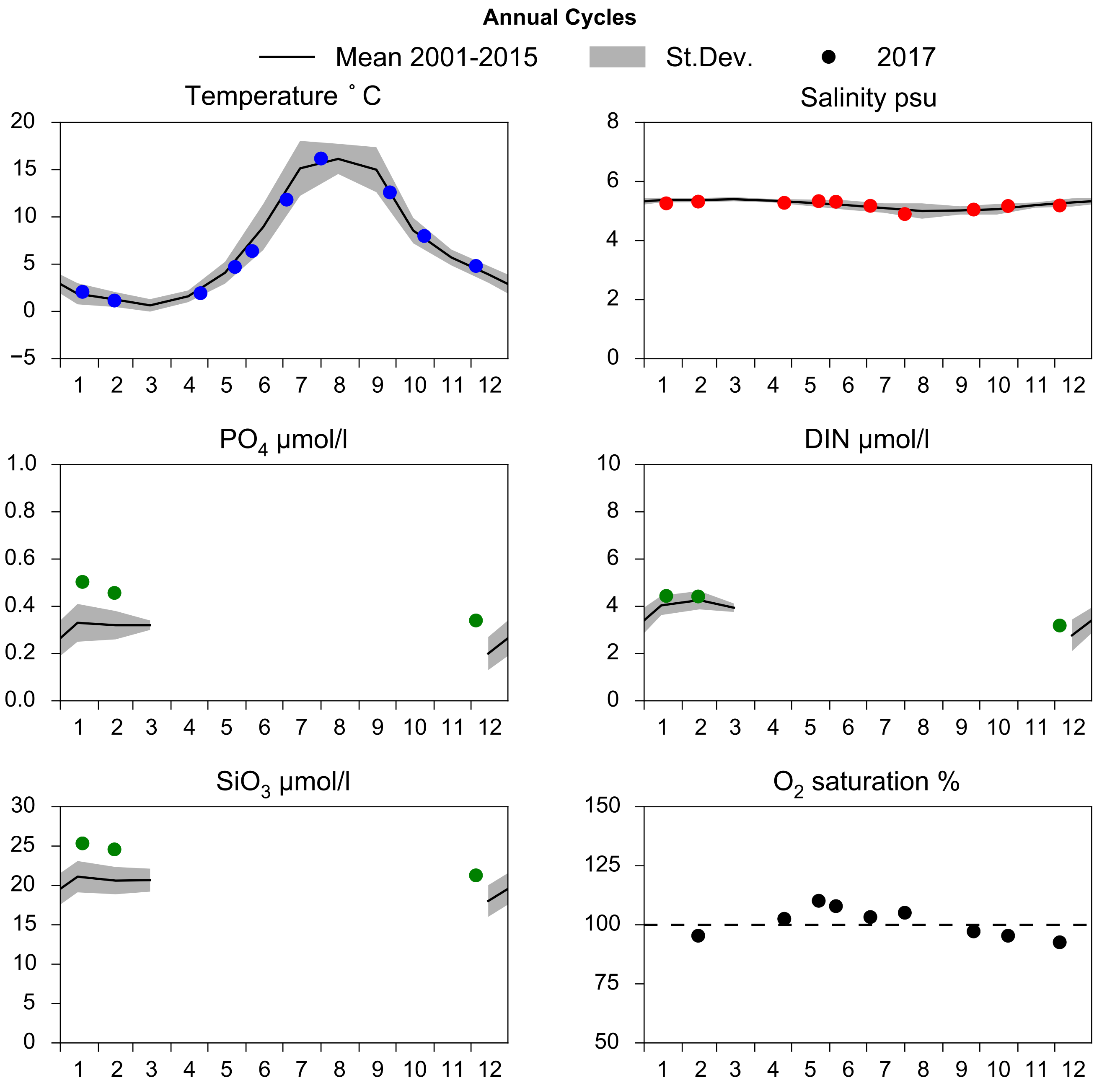
STATION B1 SURFACE WATER (0-10 m)



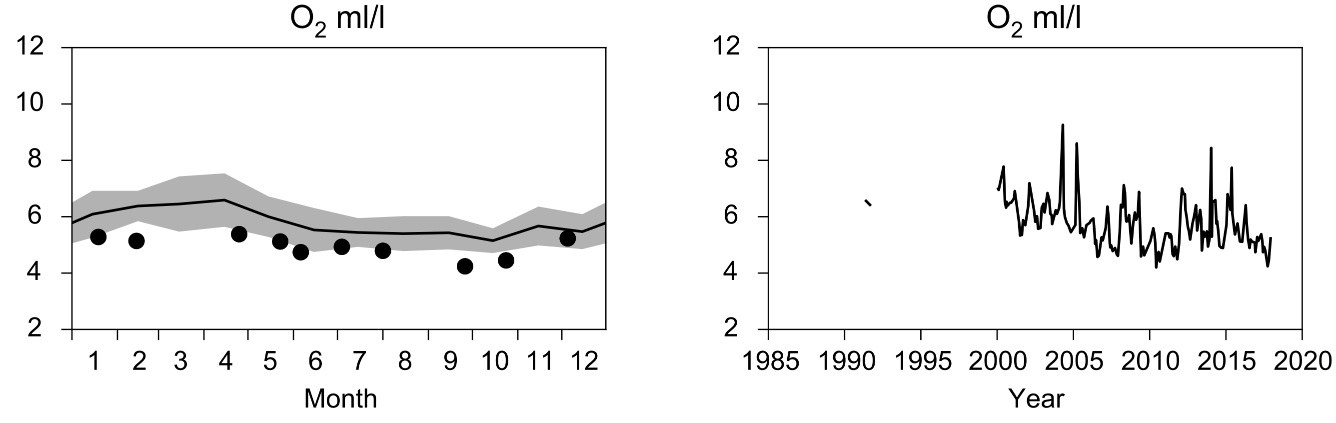
OXYGEN IN BOTTOM WATER (depth >= 40 m)



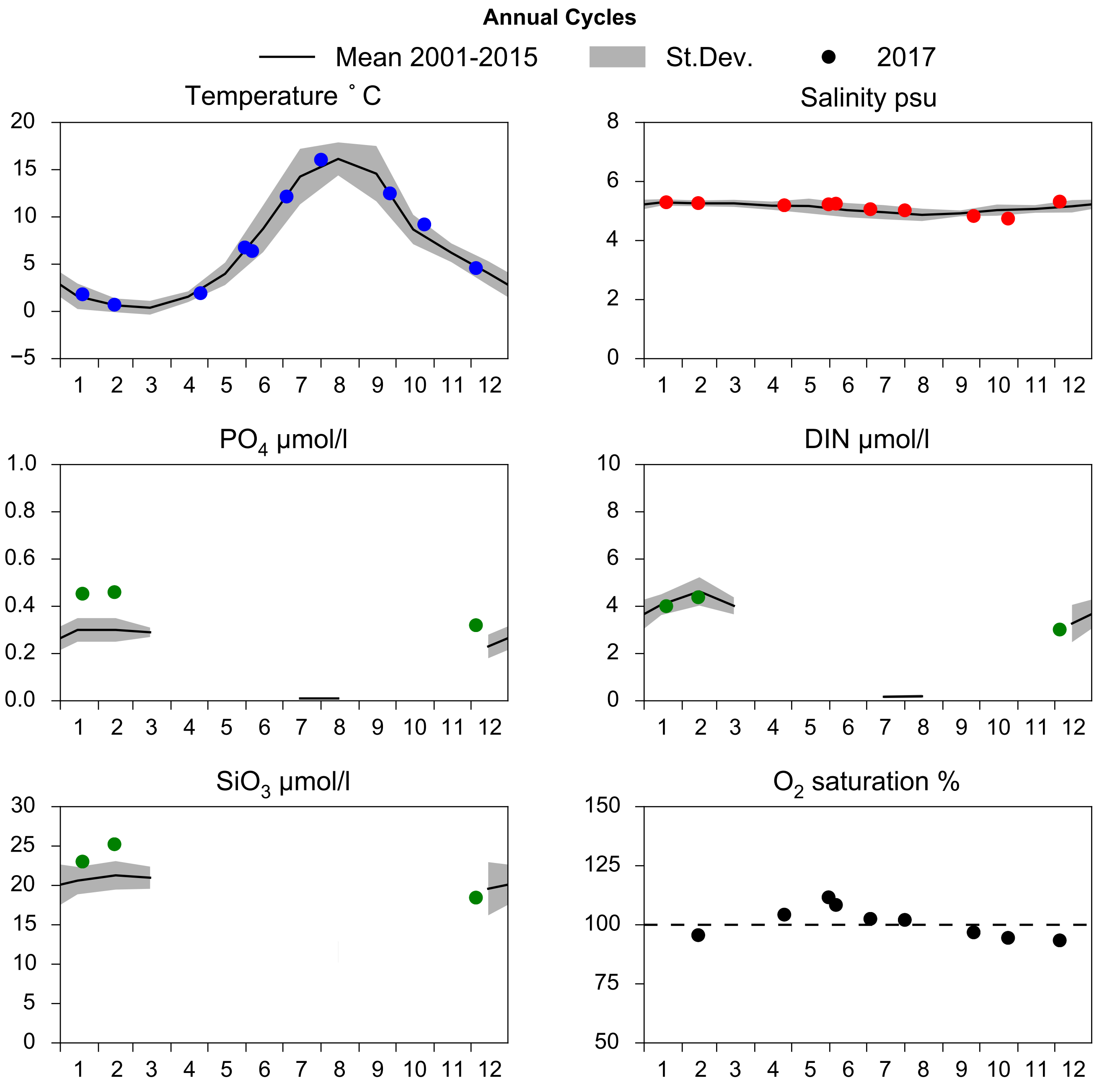
STATION MS4 / C14 SURFACE WATER (0-10 m)



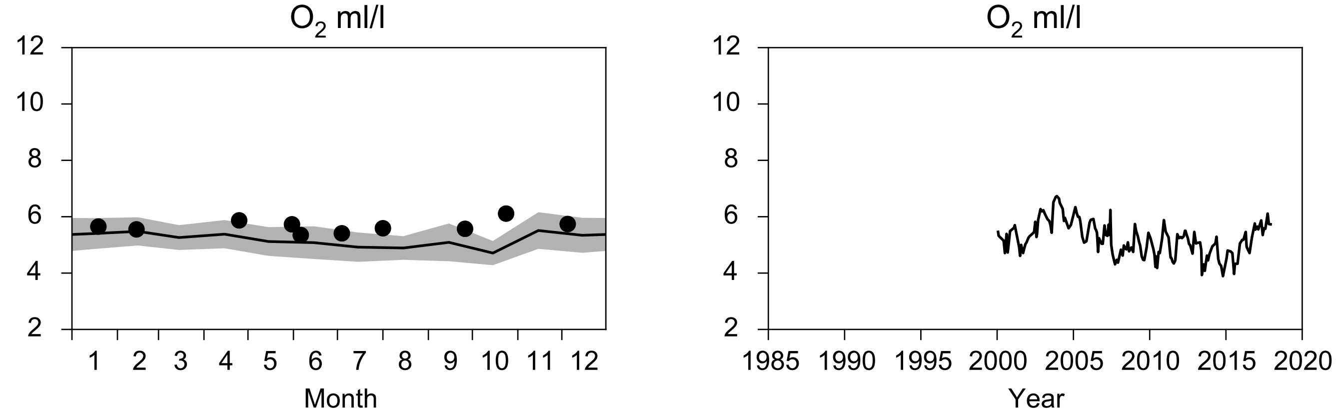
OXYGEN IN BOTTOM WATER (depth >= 80 m)



STATION C3 SURFACE WATER (0-10 m)

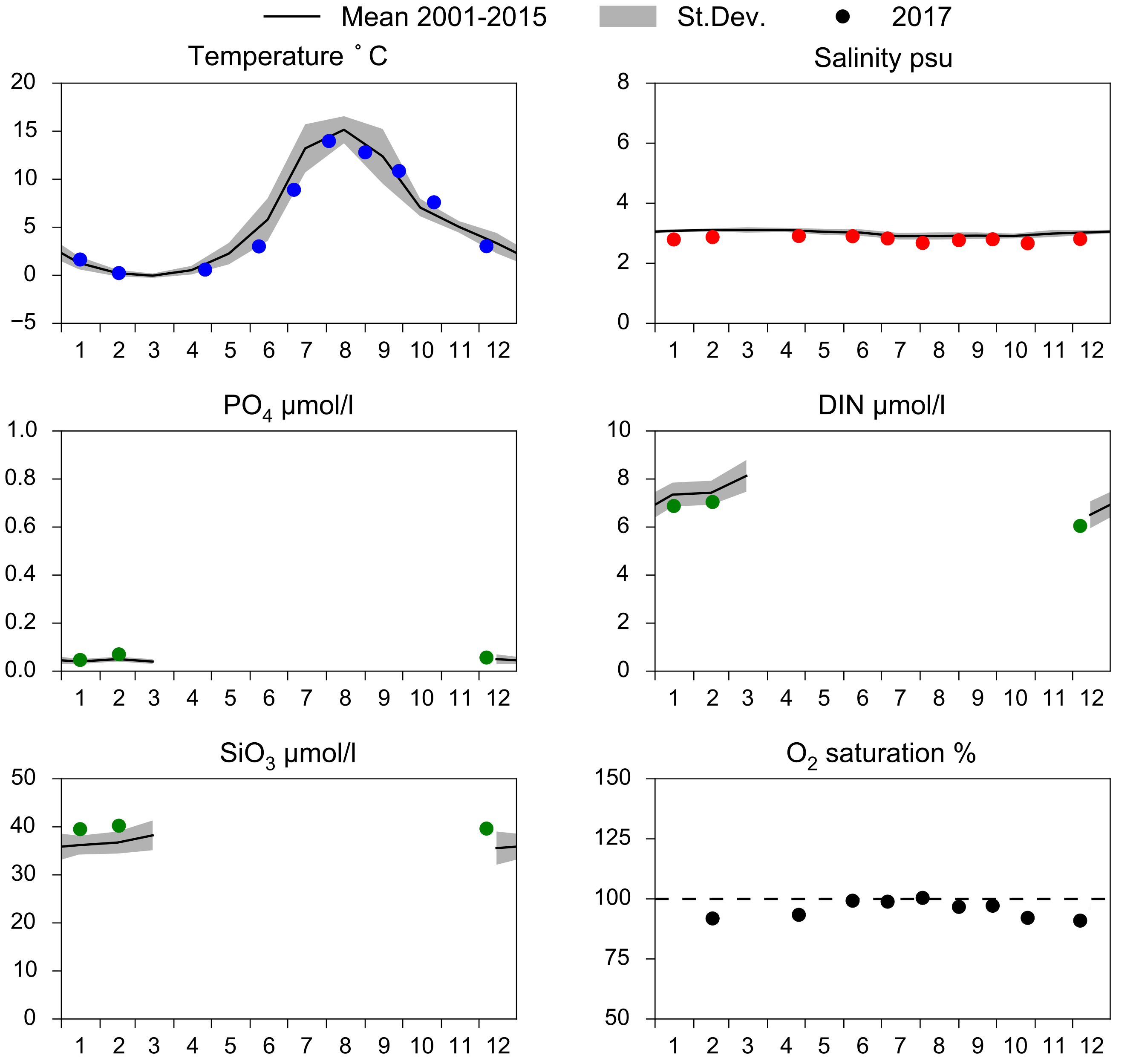


OXYGEN IN BOTTOM WATER (depth >= 184 m)

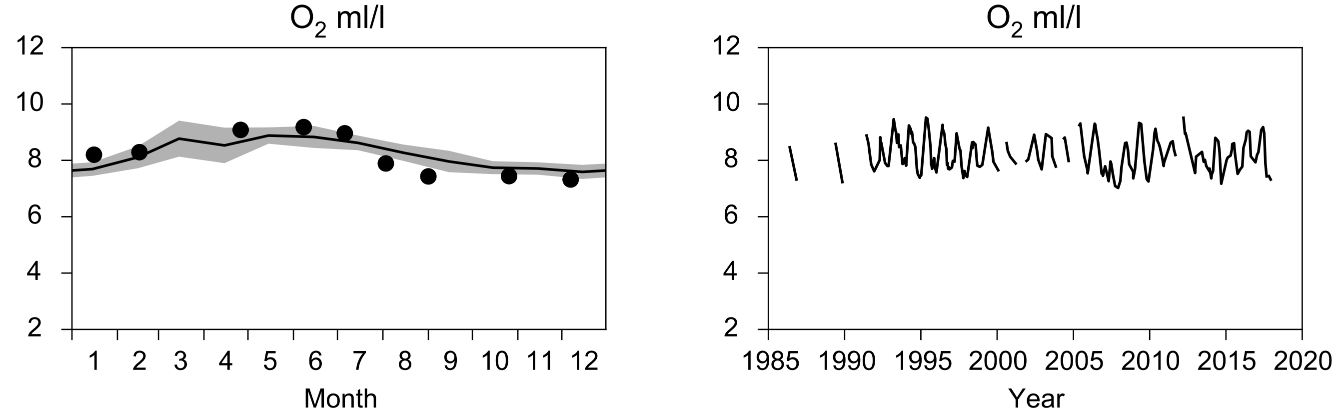


STATION F9 / A13 SURFACE WATER (0-10 m)

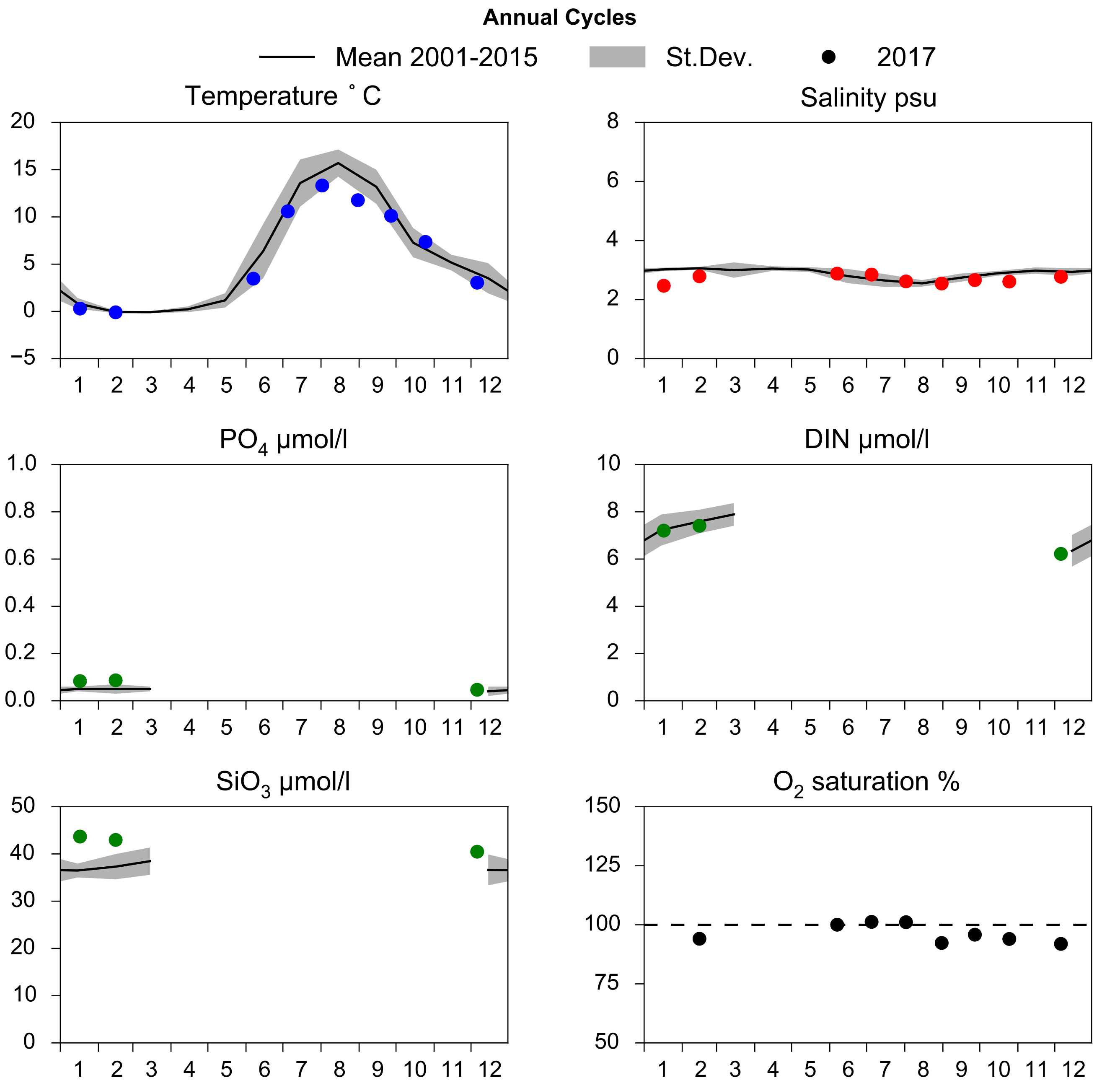
Annual Cycles



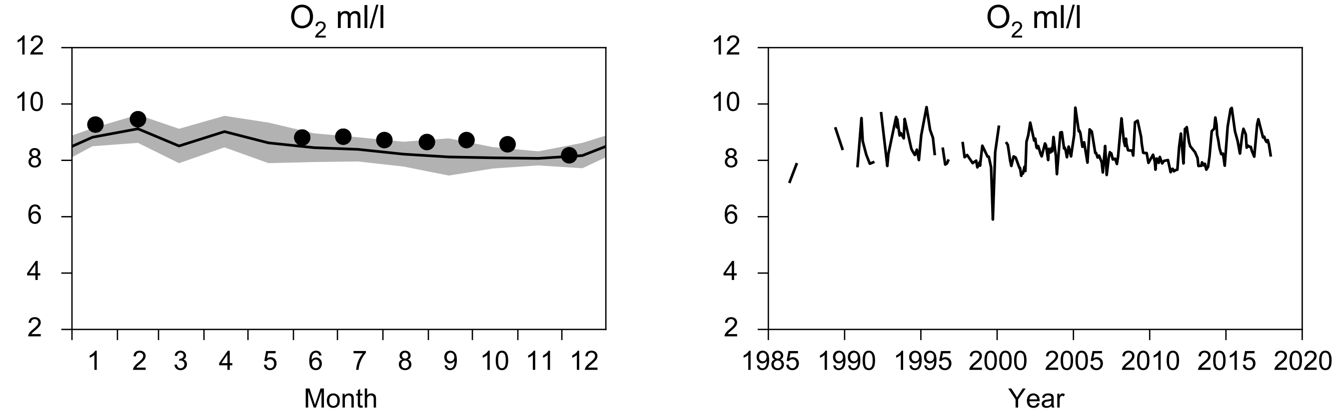
OXYGEN IN BOTTOM WATER (depth >= 120 m)



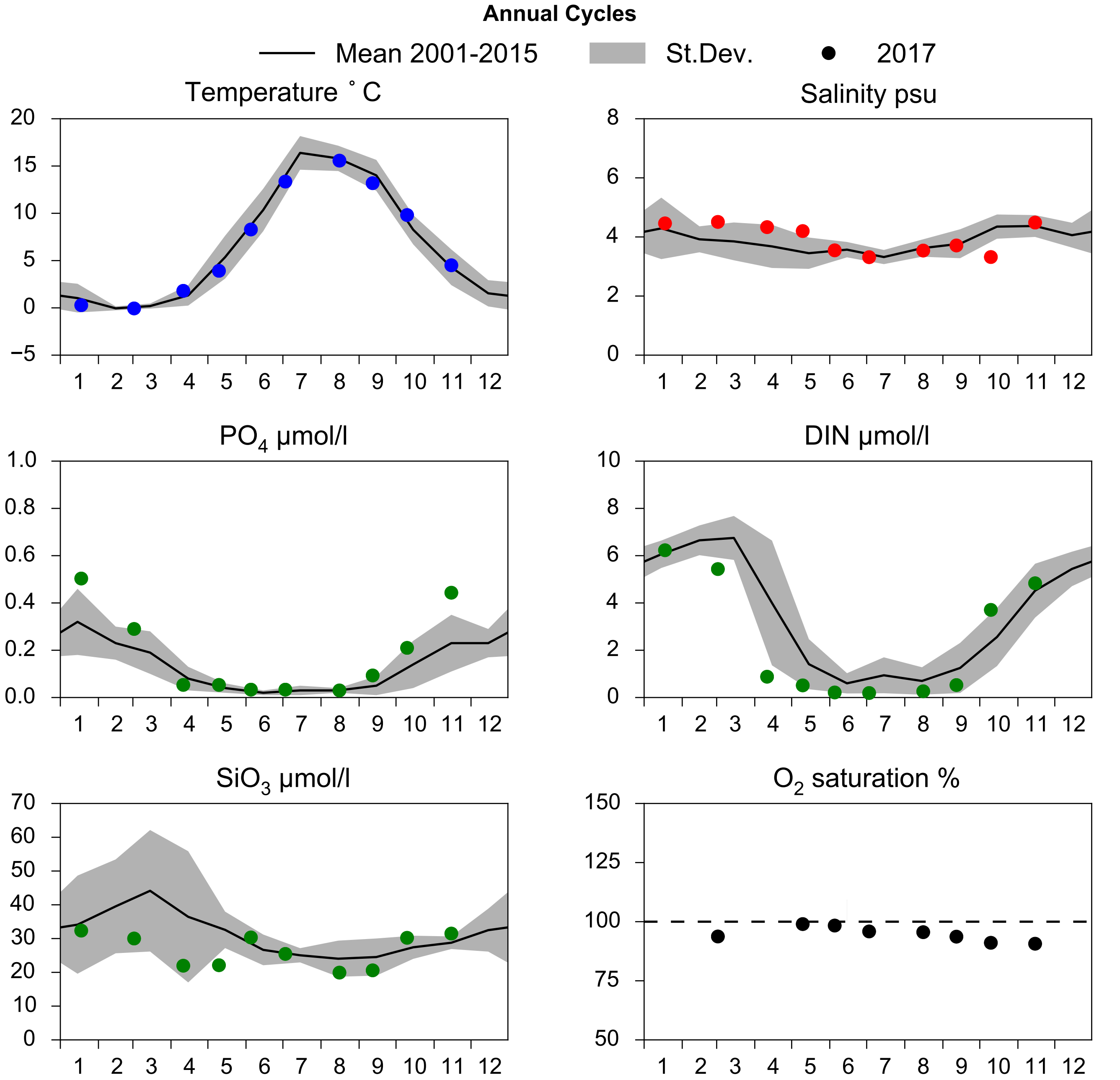
STATION F3 / A5 SURFACE WATER (0-10 m)



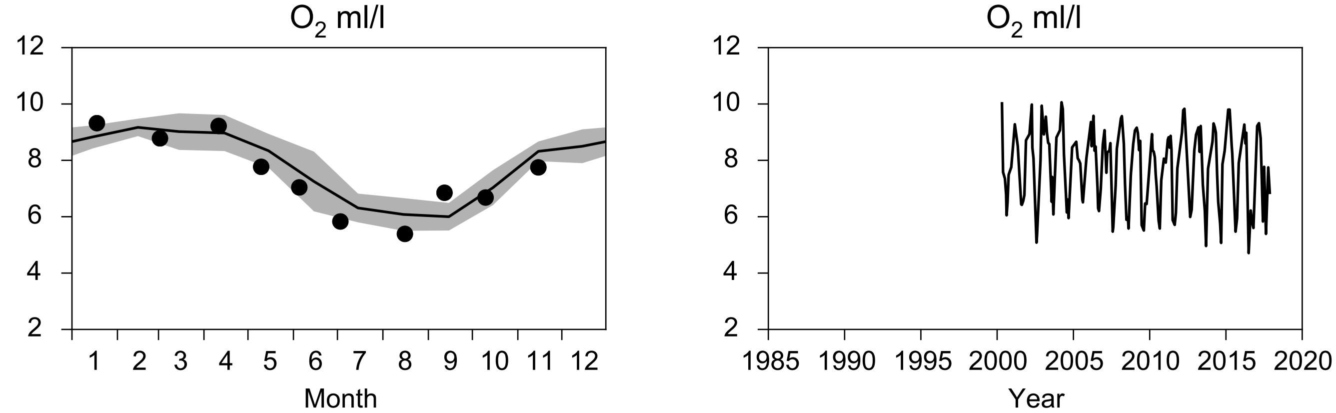
OXYGEN IN BOTTOM WATER (depth >= 80 m)



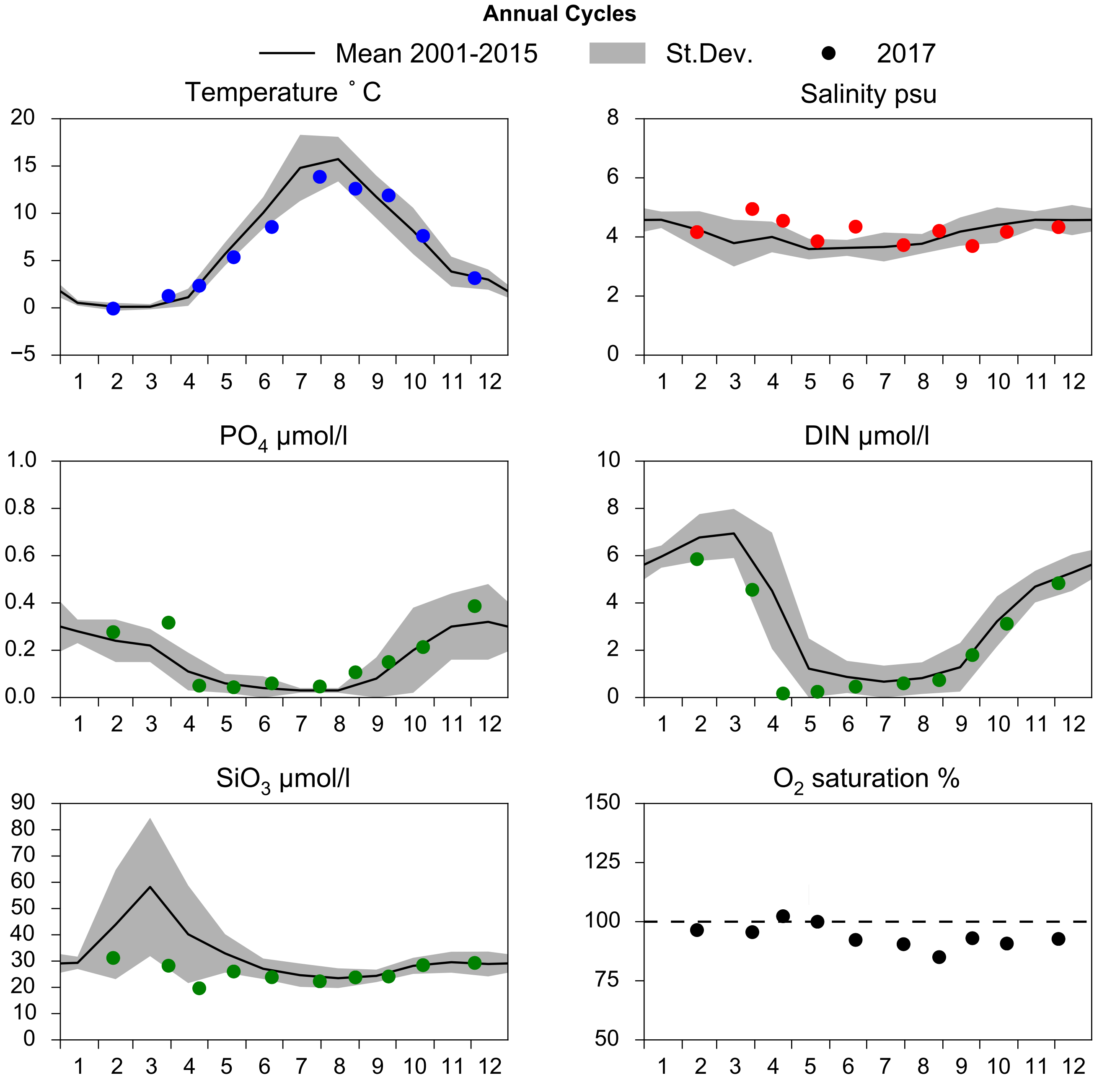
STATION B7 SURFACE WATER (0-10 m)



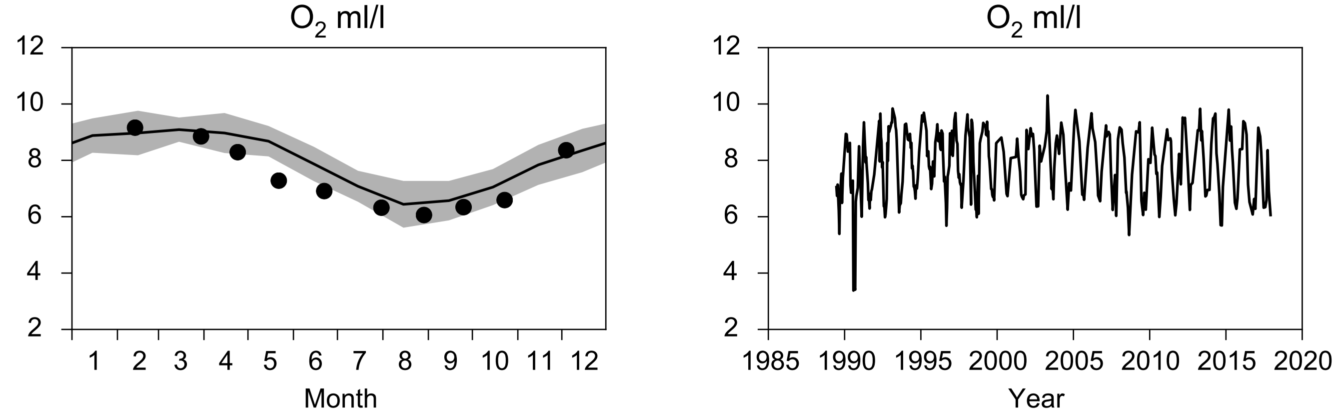
OXYGEN IN BOTTOM WATER (depth >= 20 m)



STATION NB1 / B3 SURFACE WATER (0-10 m)



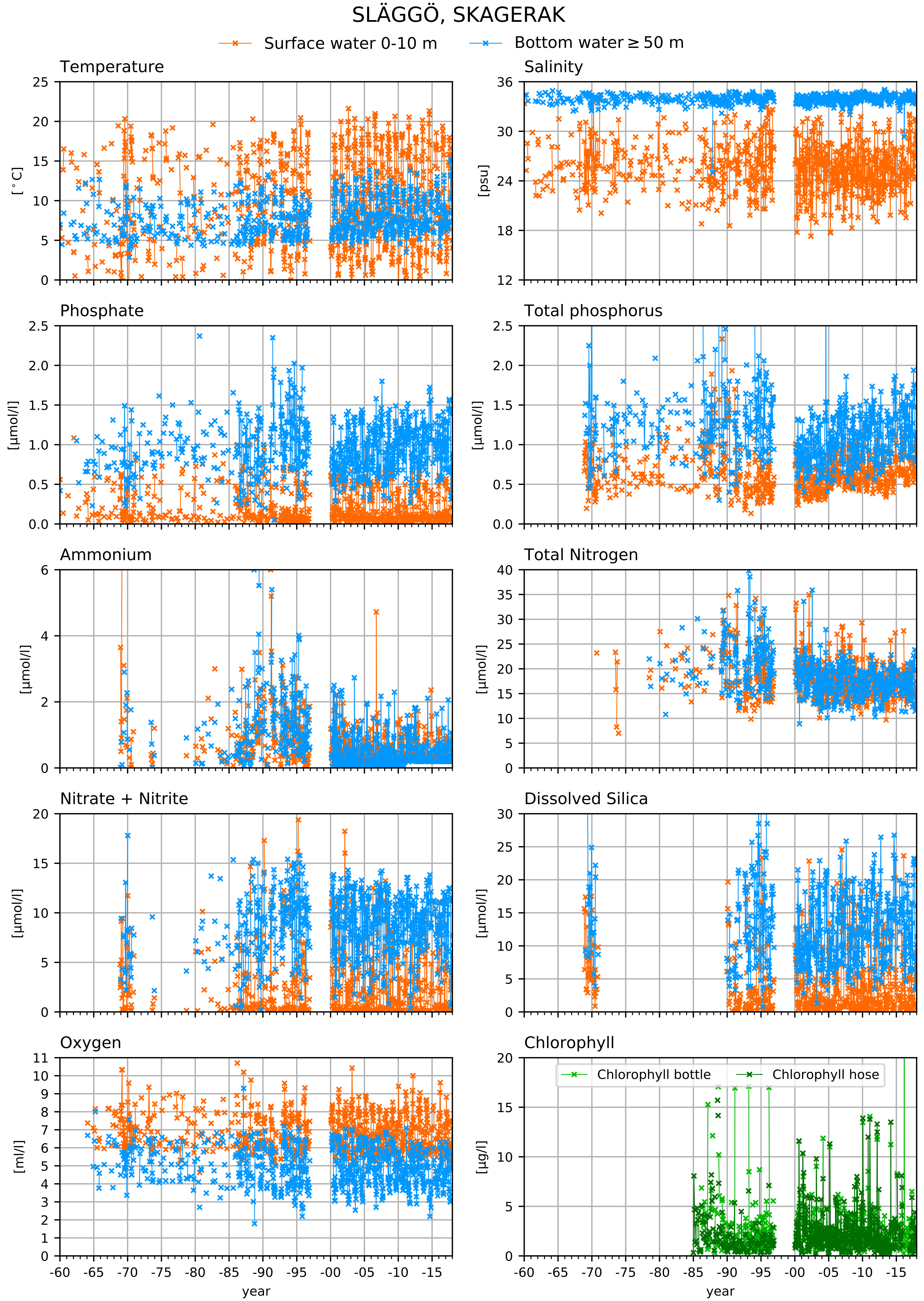
OXYGEN IN BOTTOM WATER (depth >= 20 m)

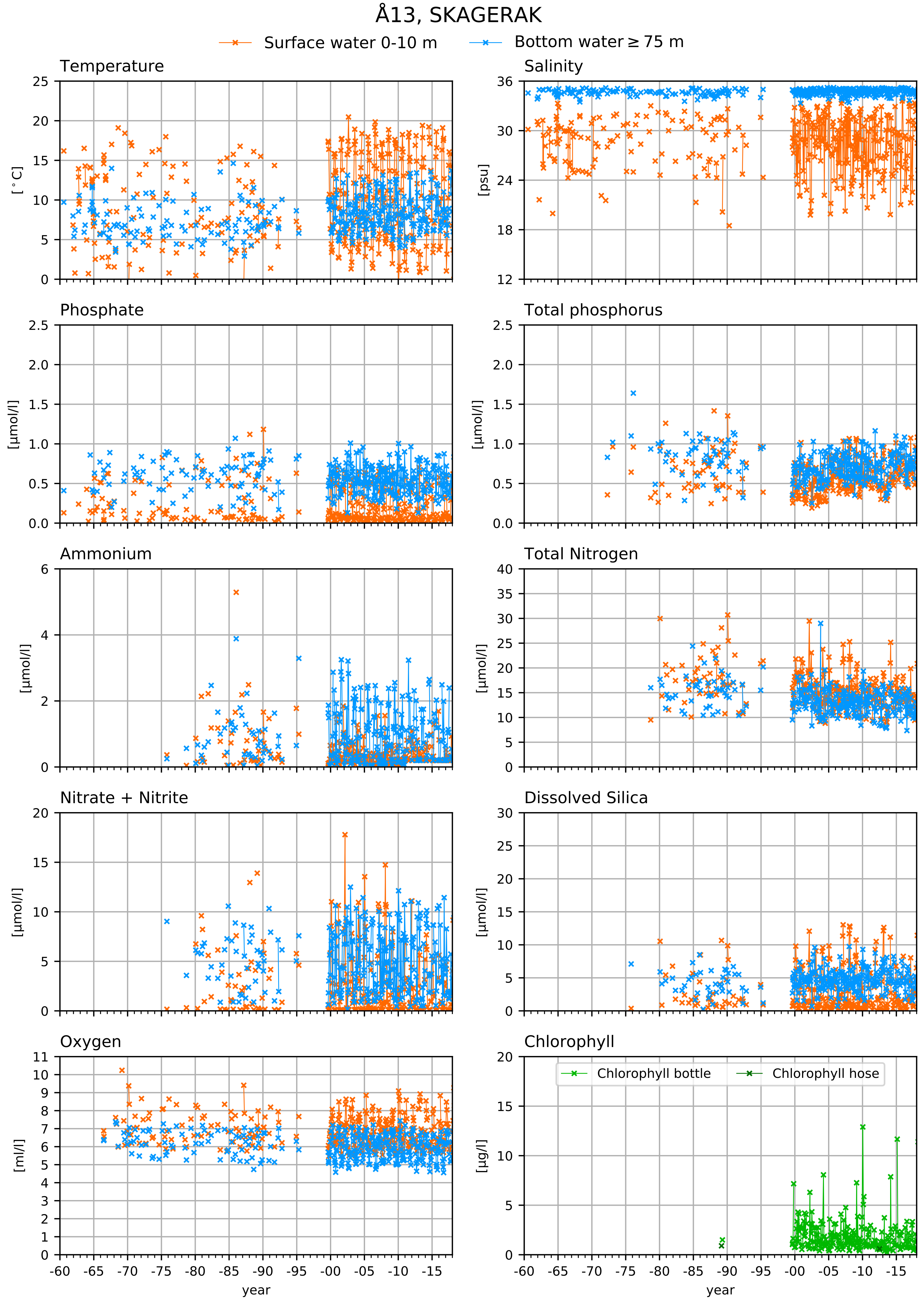


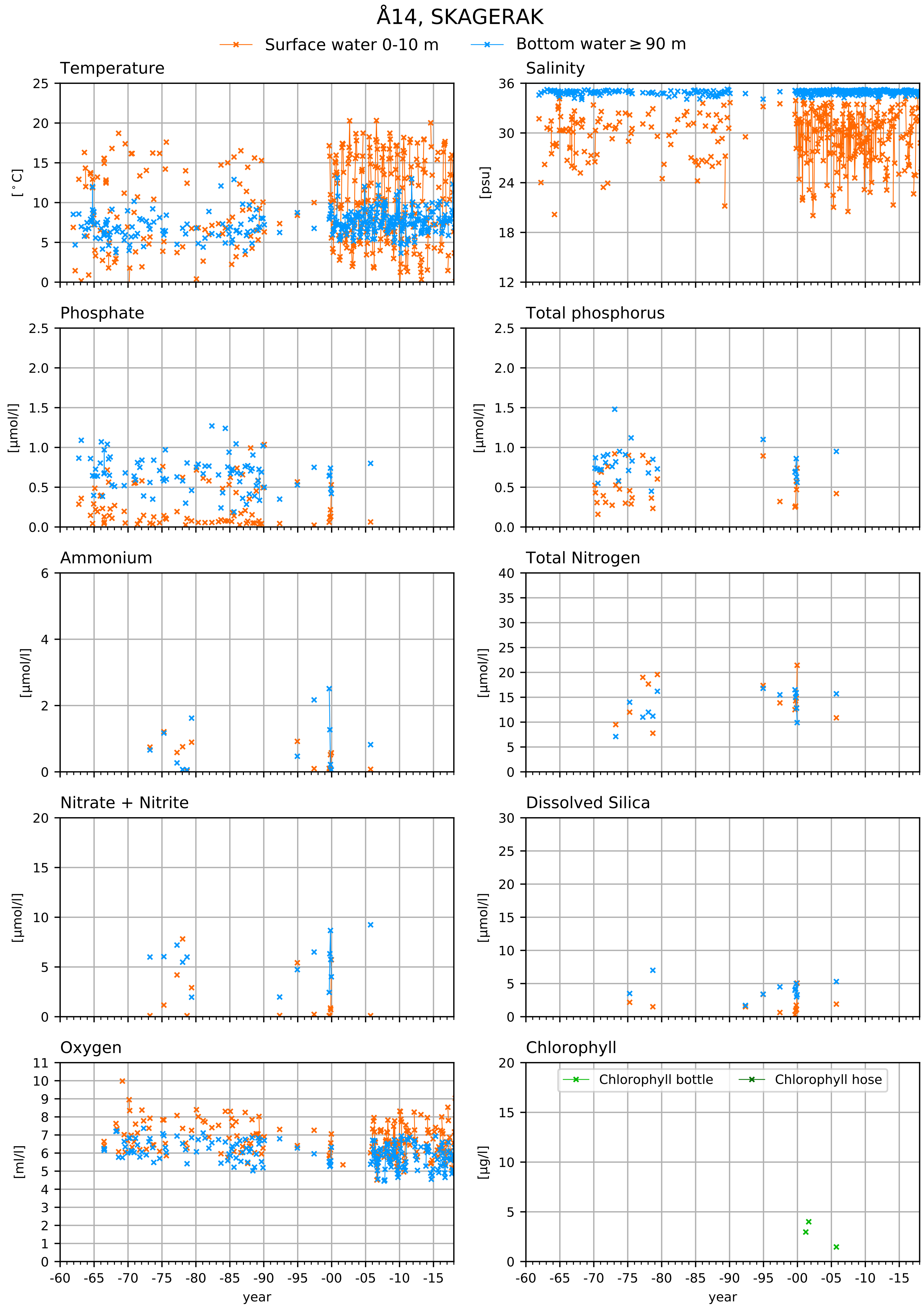
Appendix II

Time series (1960-2017) of surface water (0-10 m) and bottom water (station specific) for all monthly and high frequency stations sampled in 2017.

Included parameters; salinity, temperature, dissolved oxygen (including hydrogen sulphide as negative oxygen), phosphate, total phosphorus, ammonium, sum of nitrate and nitrite, total nitrogen, dissolved silica and chlorophyll (hose sampling and mean from discrete depth 0-10 m). In the plots showing stations BCS III-10 a red line indicates when the stations was temporarily moved north-east of its correct position.

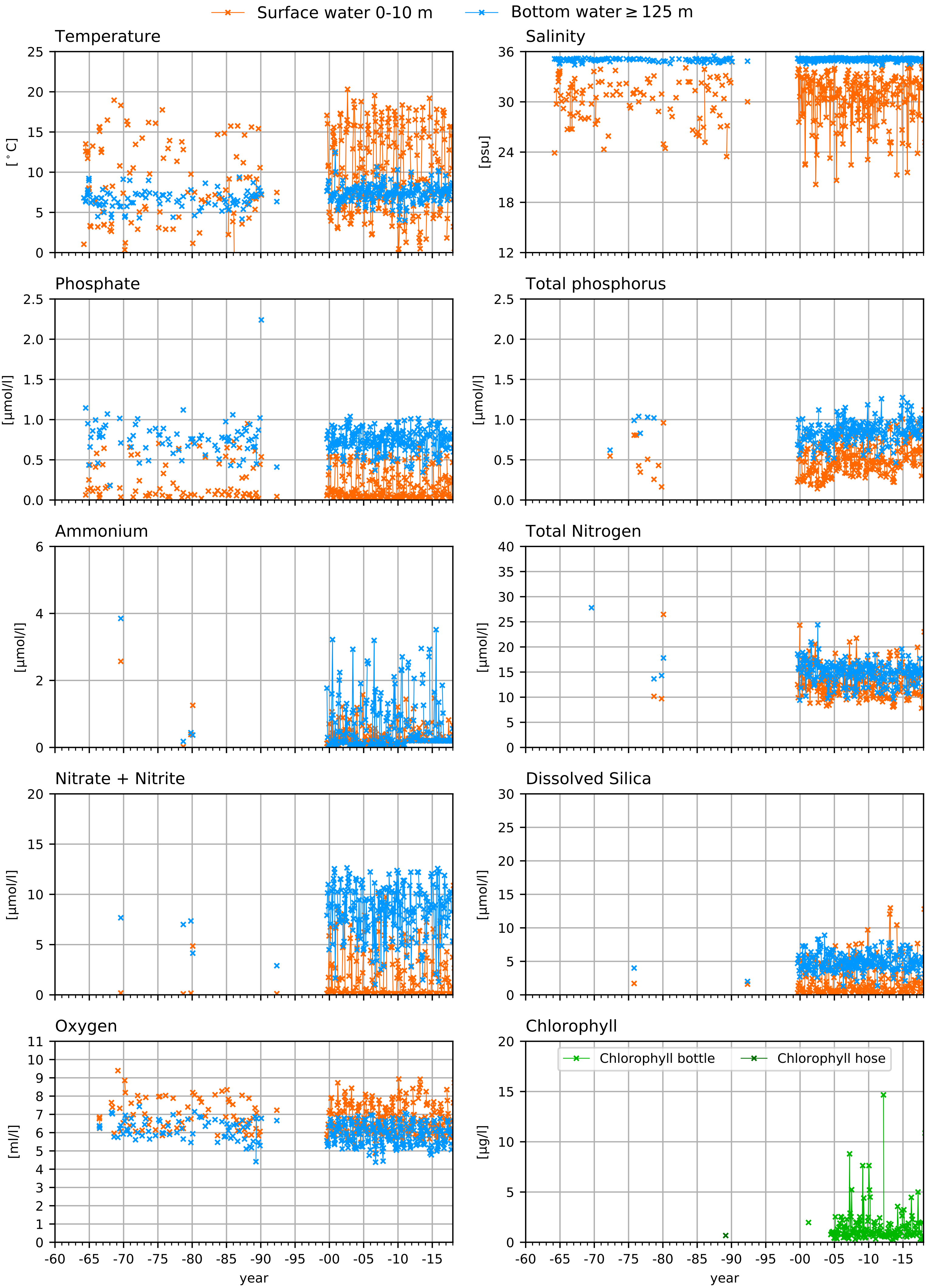

SLÄGGÖ, SKAGERAK
Surface water 0-10 m
Bottom water ≥ 50 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
[µg/l]
Chlorophyll bottle
Chlorophyll hose
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year


Å13, SKAGERAK
Surface water 0-10 m
Bottom water ≥ 75 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
year

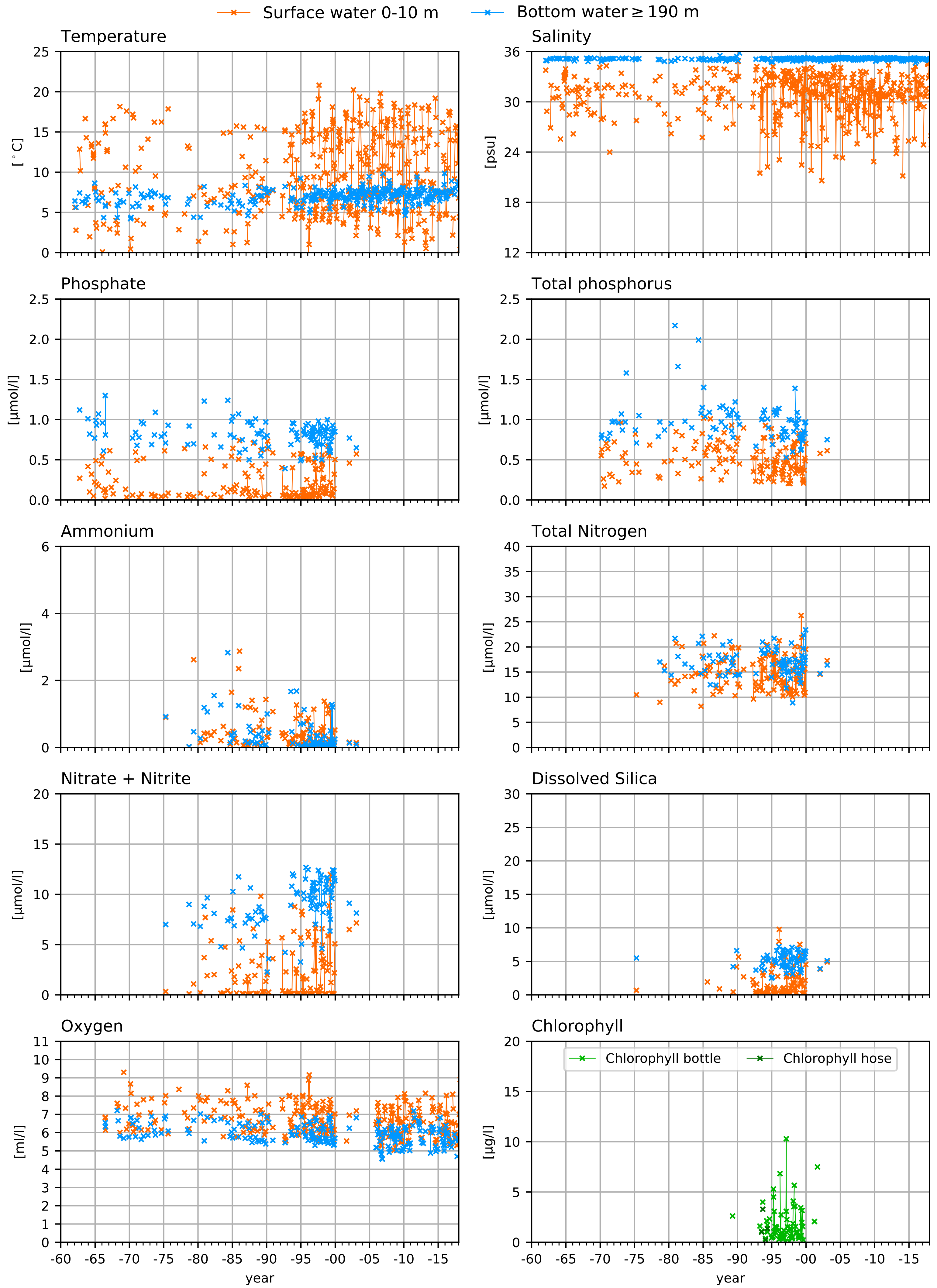


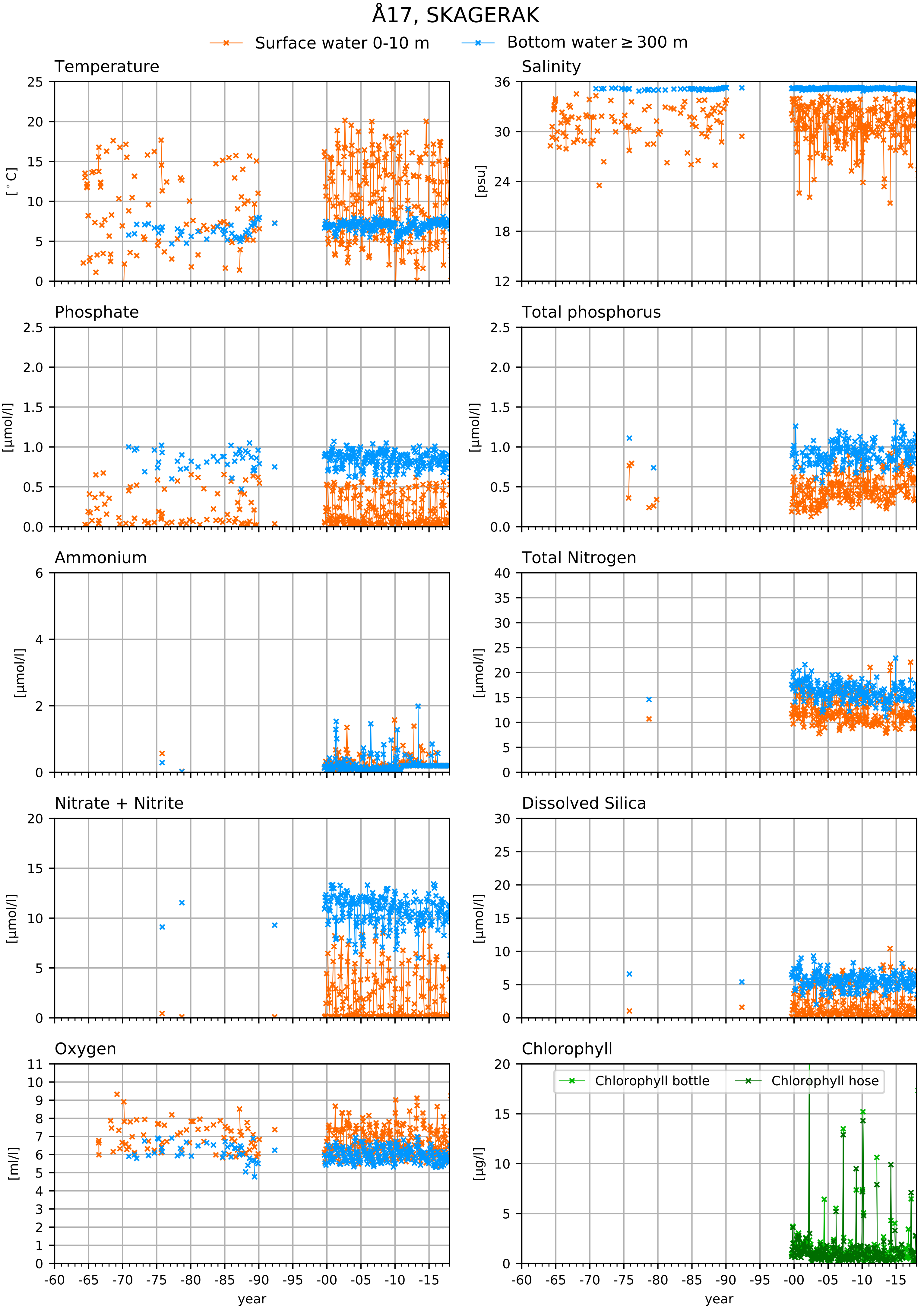
Å14, SKAGERAK
Surface water 0-10 m
Bottom water ≥ 90 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year

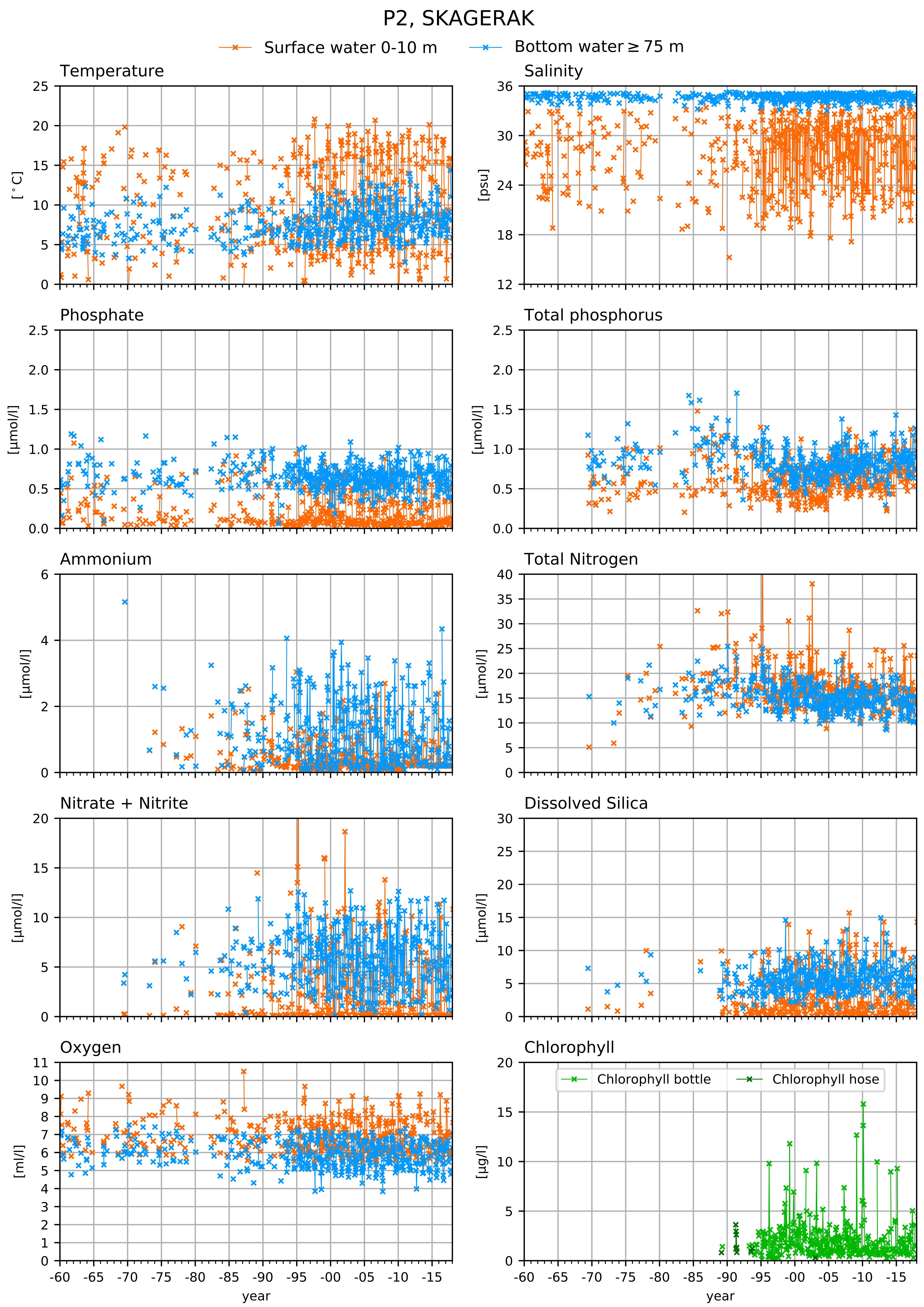
Å15, SKAGERAK

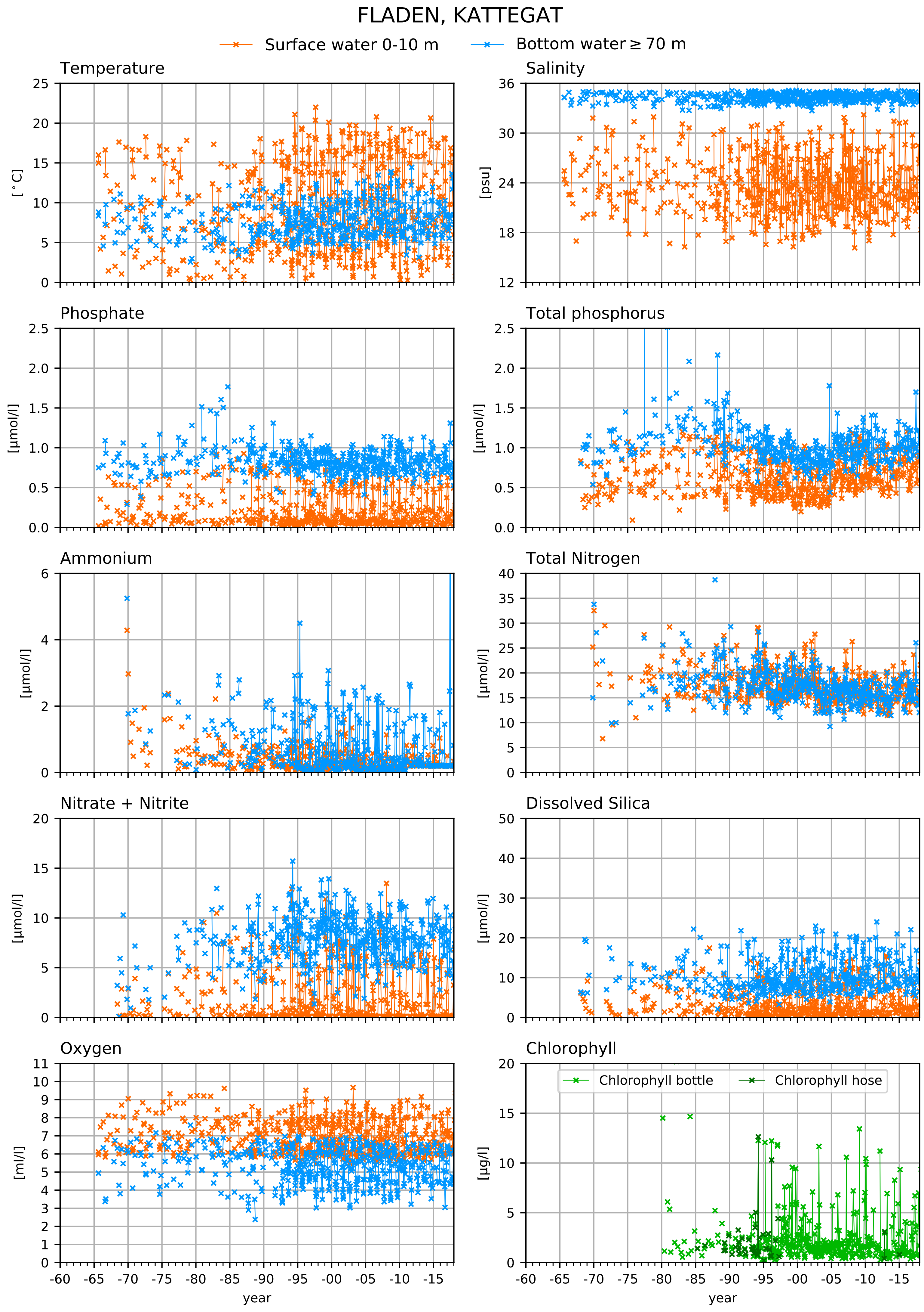


Å16, SKAGERAK

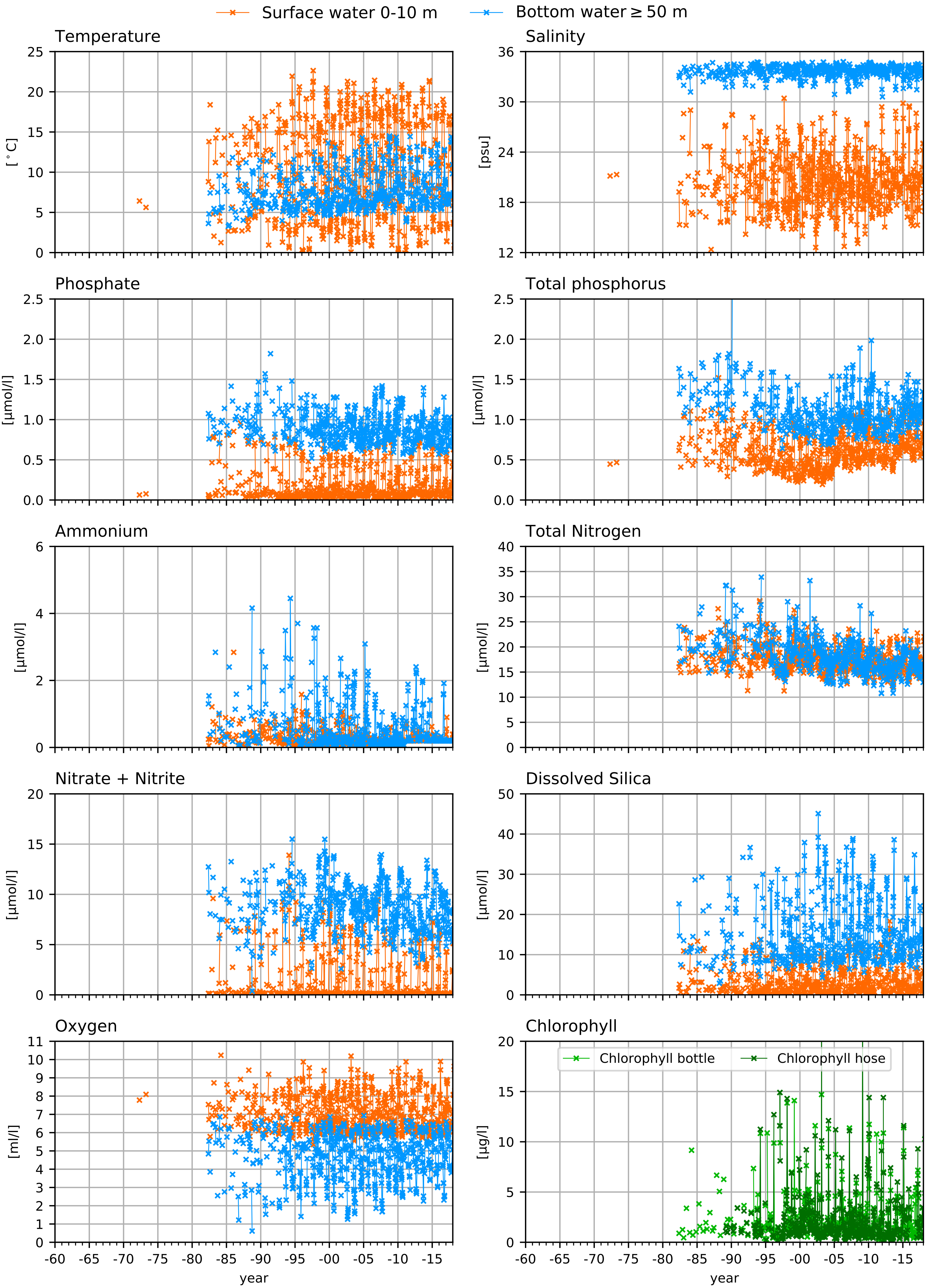


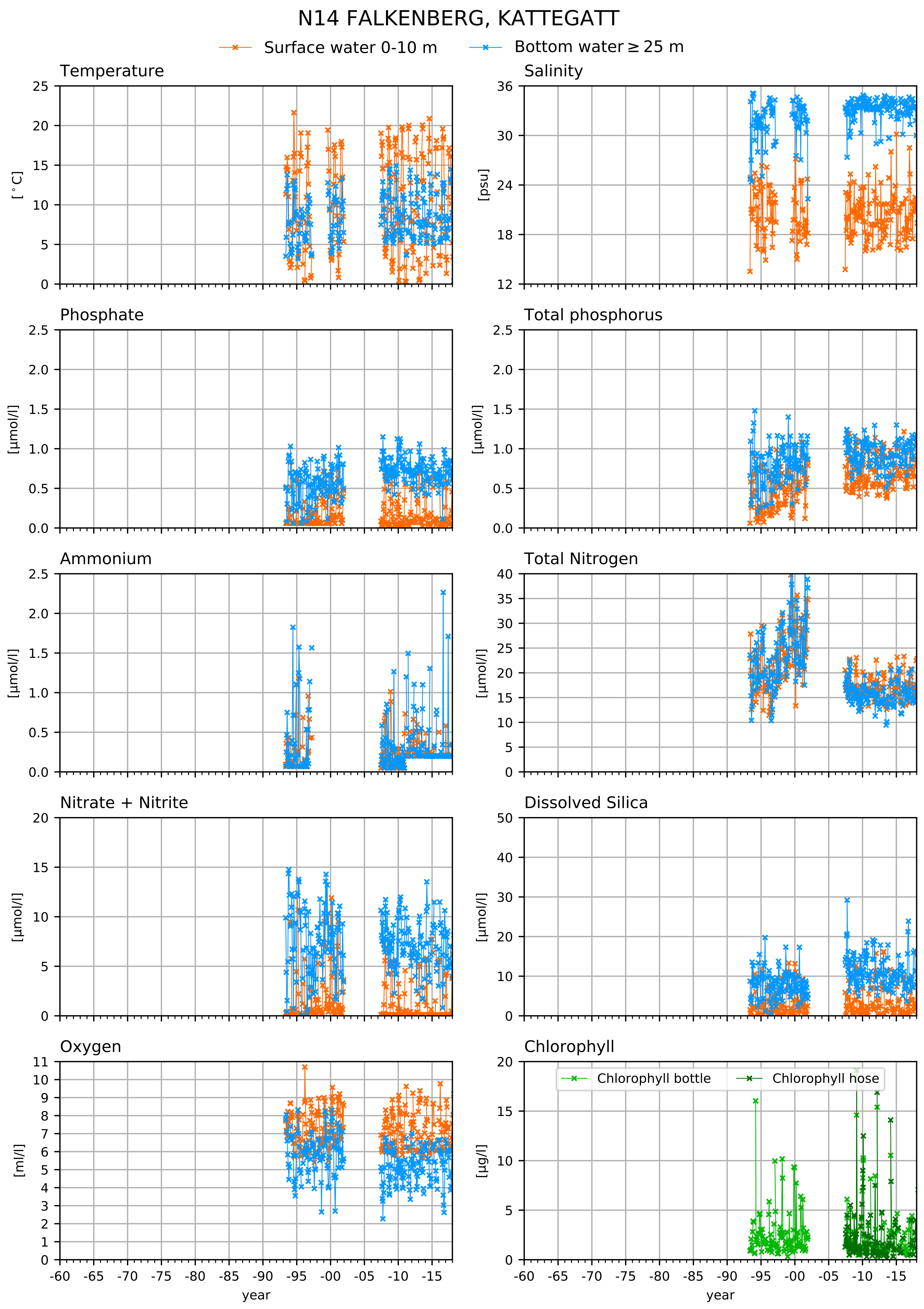

Å17, SKAGERAK
Surface water 0-10 m
Bottom water ≥ 300 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
[µg/l]
Chlorophyll bottle
Chlorophyll hose
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year

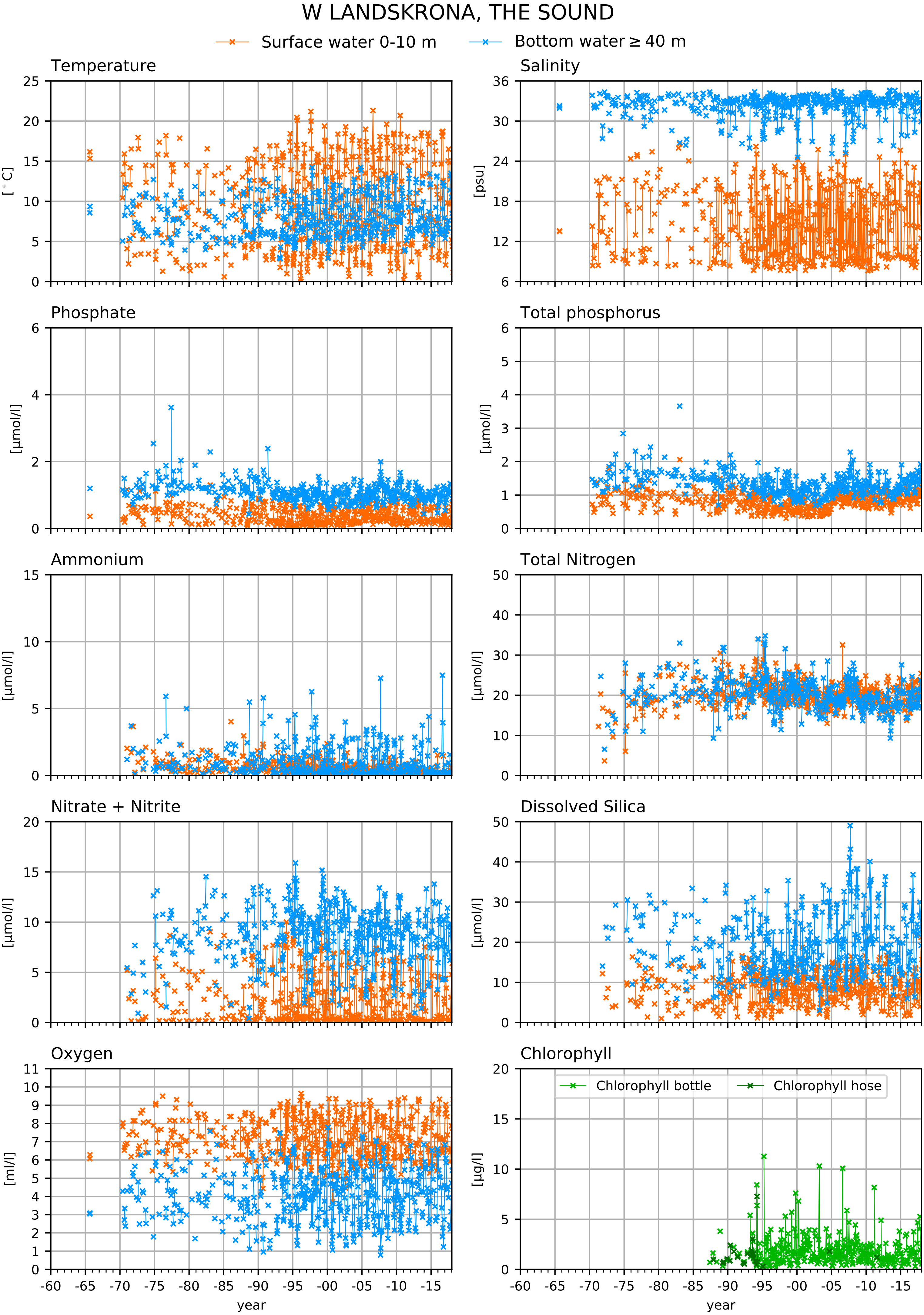

P2, SKAGERAK
Surface water 0-10 m
Bottom water ≥ 75 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
year

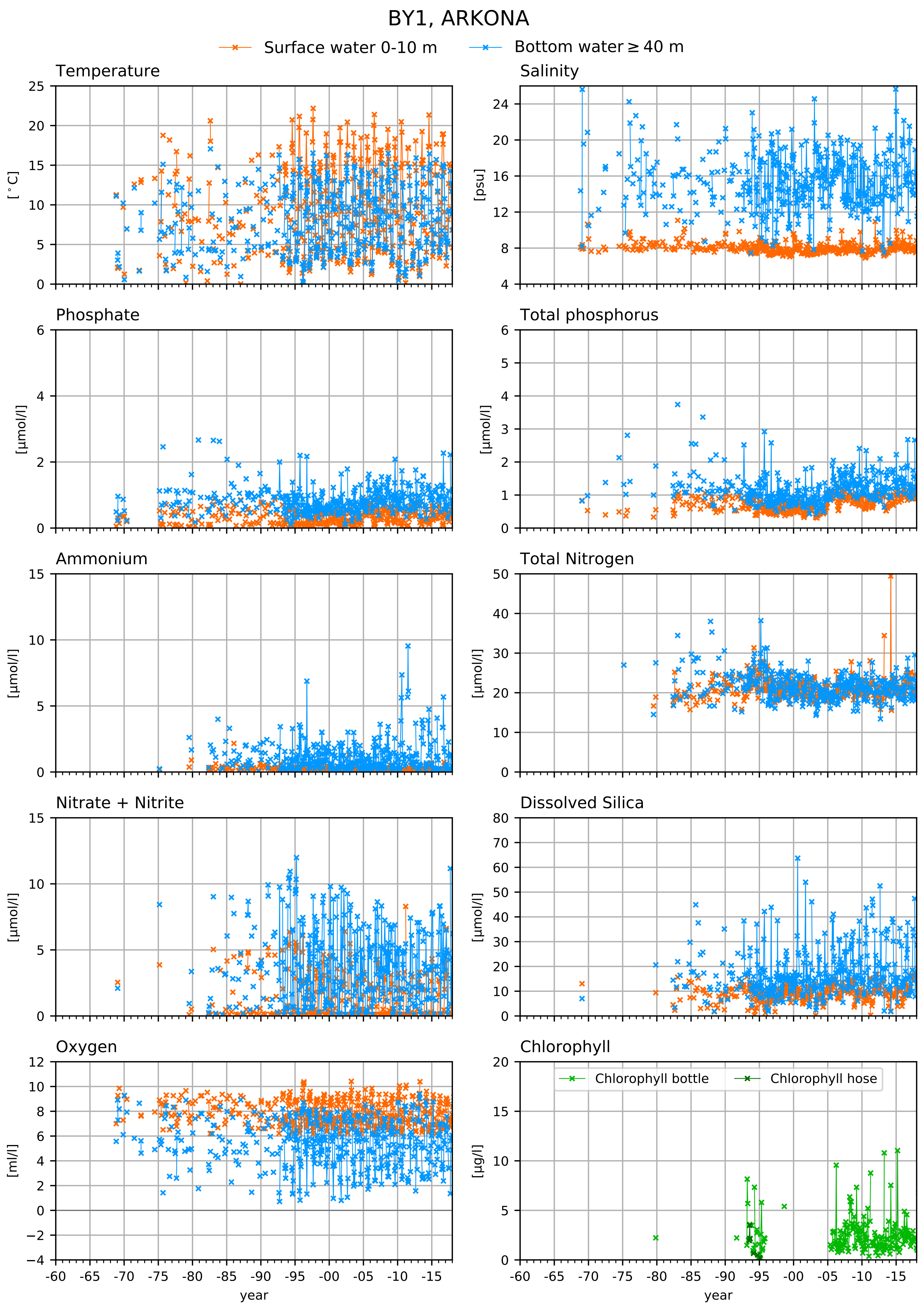

FLADEN, KATTEGAT
Surface water 0-10 m
Bottom water ≥ 70 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15

ANHOLT E, KATTEGAT

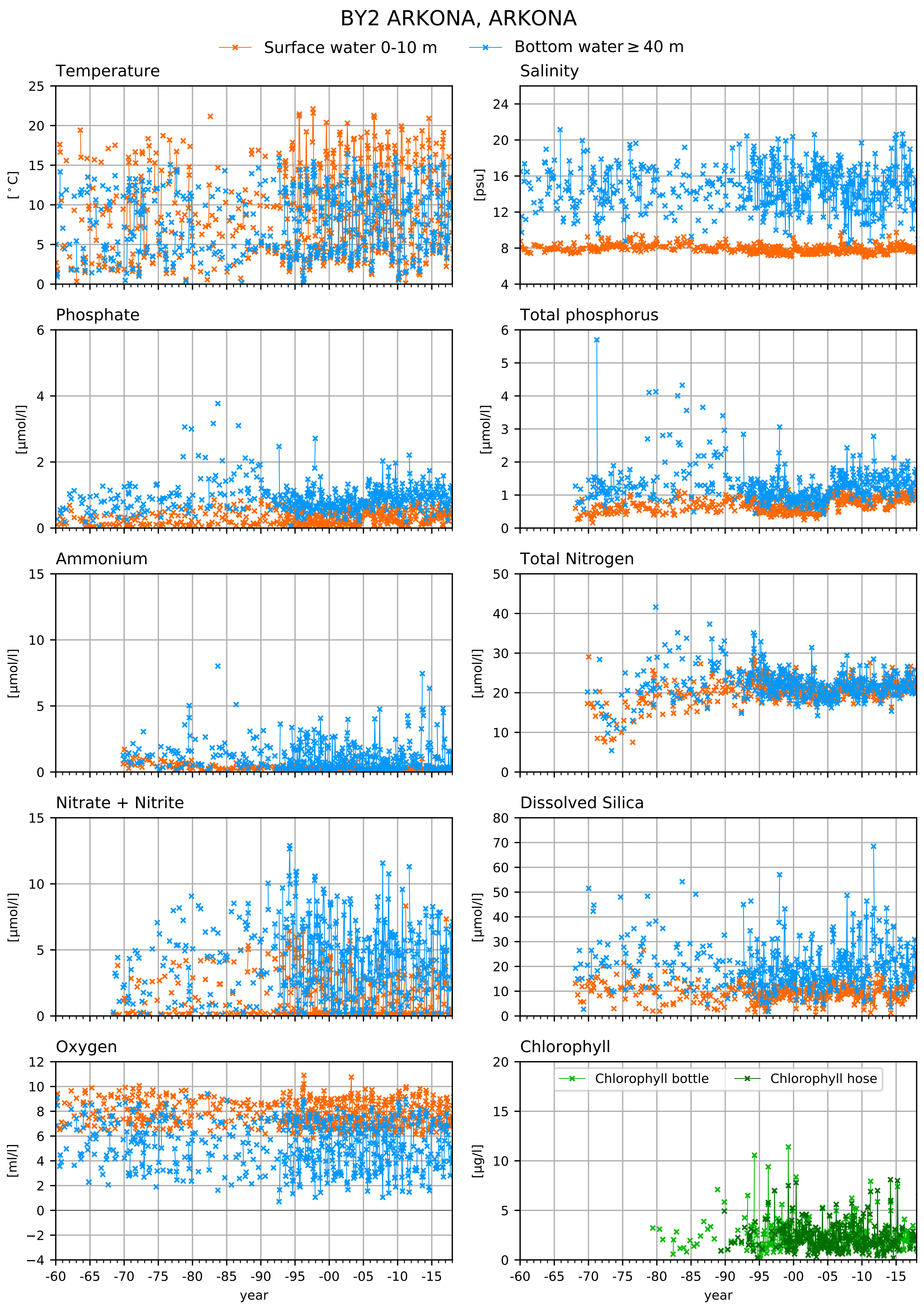



N14 FALKENBERG, KATTEGATT
Surface water 0-10 m
Bottom water ≥ 25 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year

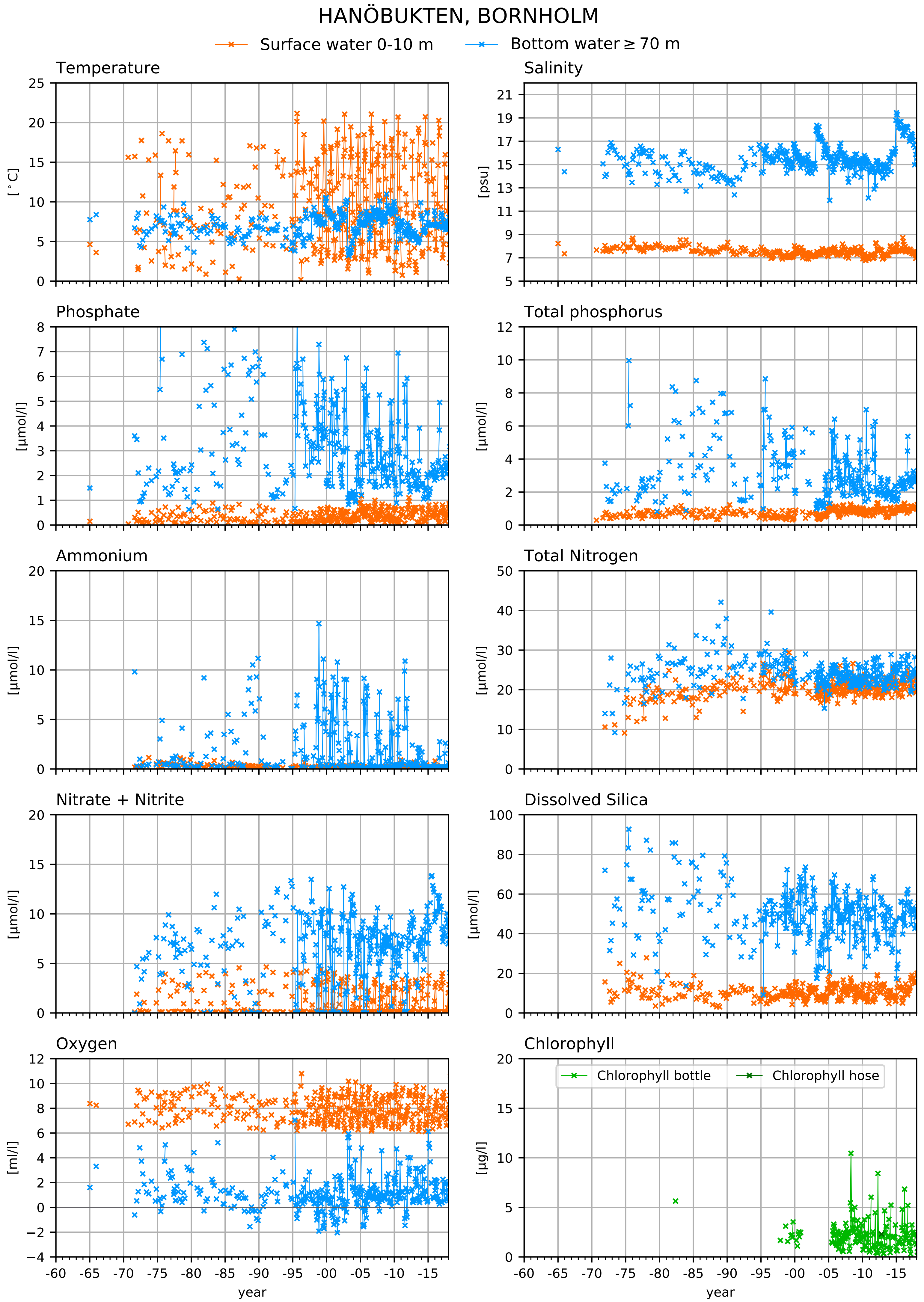

W LANDSKRONA, THE SOUND
Surface water 0-10 m
Bottom water ≥ 40 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year



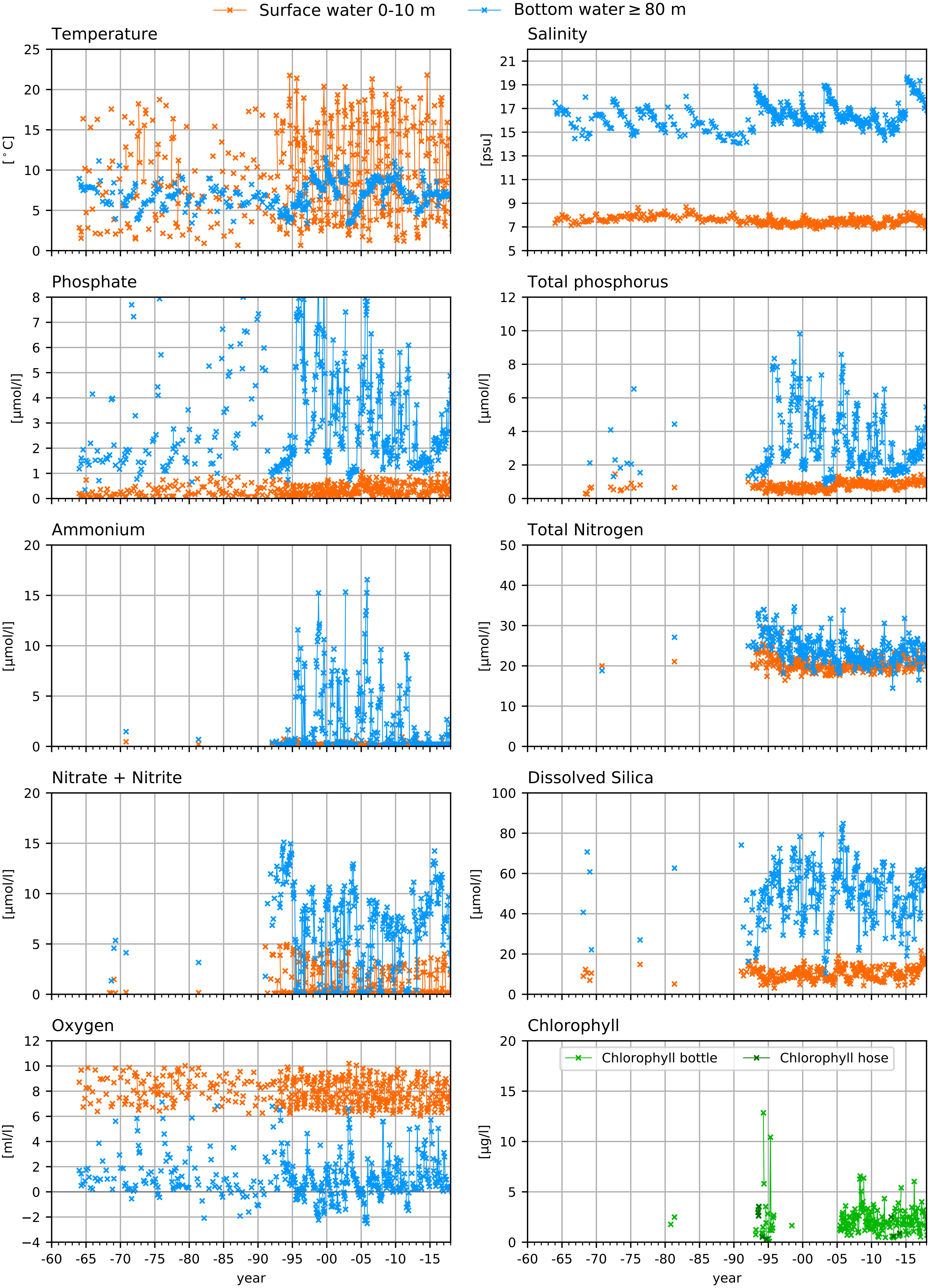
BY1, ARKONA
Surface water 0-10 m
Bottom water ≥ 40 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
year



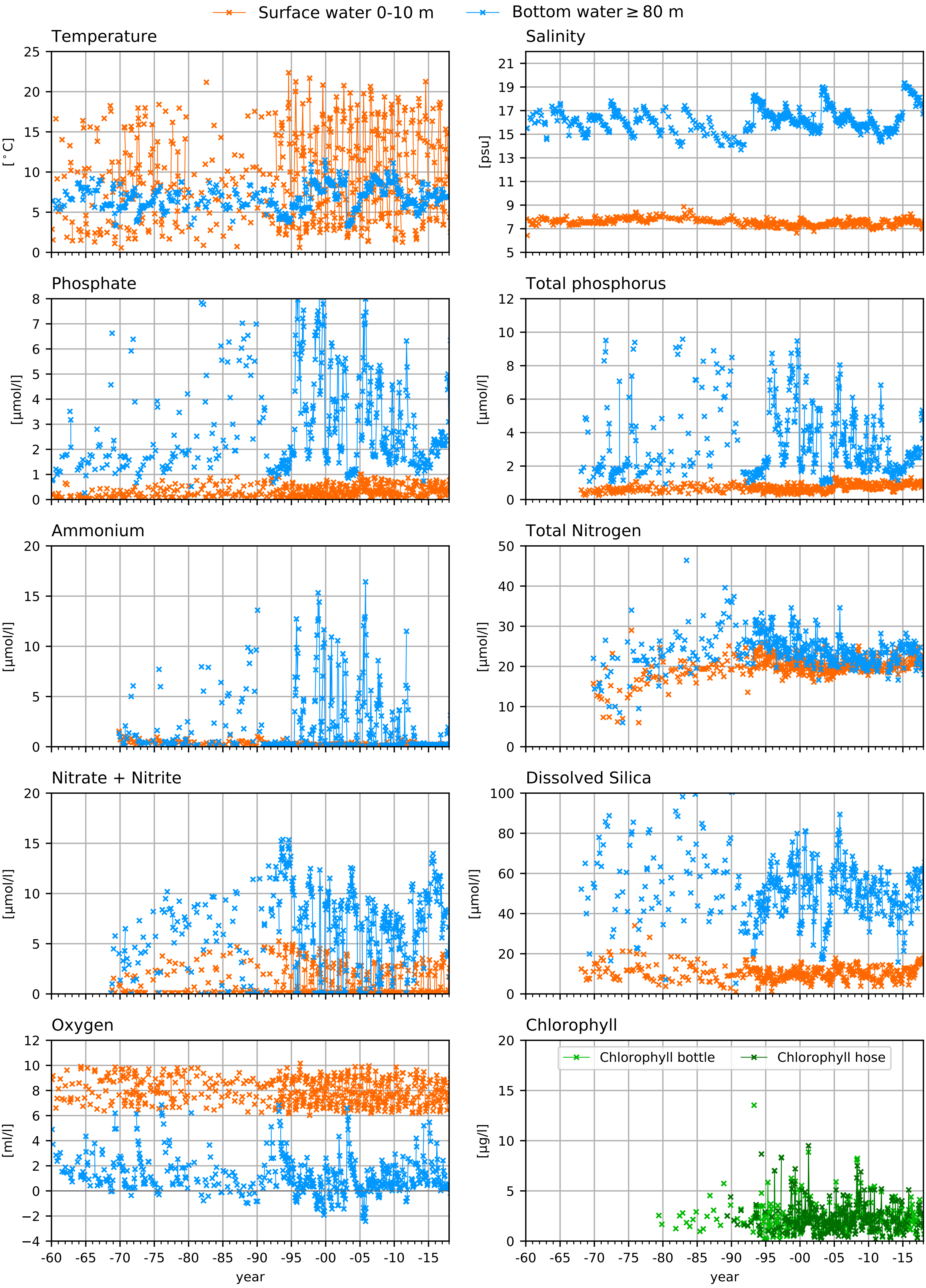
BY2 ARKONA, ARKONA
Surface water 0-10 m
Bottom water ≥ 40 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15

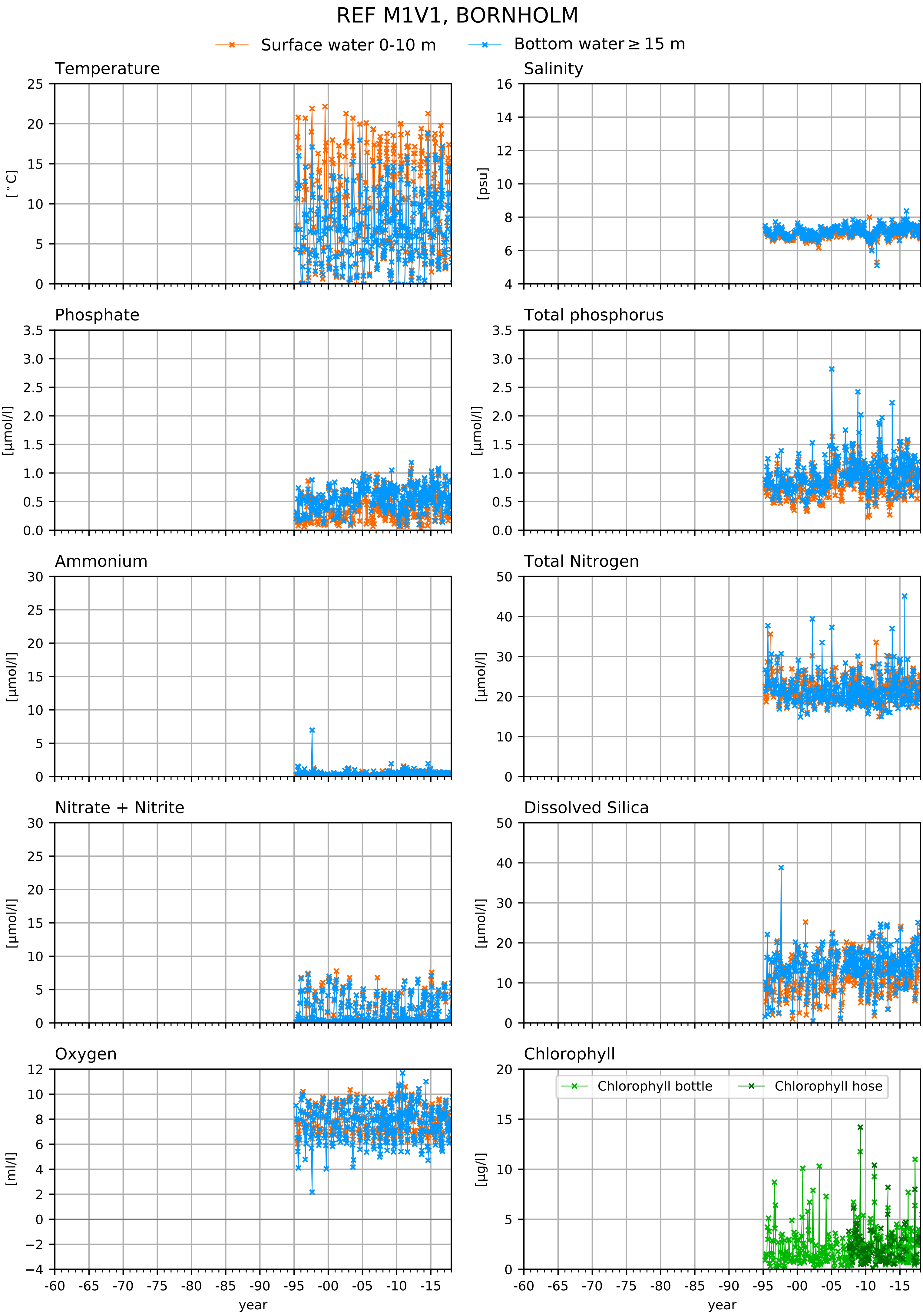

HANÖBUKTEN, BORNHOLM
Surface water 0-10 m
Bottom water ≥ 70 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
[µg/l]
Chlorophyll bottle
Chlorophyll hose
year
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15

BY4 CHRISTIANSÖ, BORNHOLM

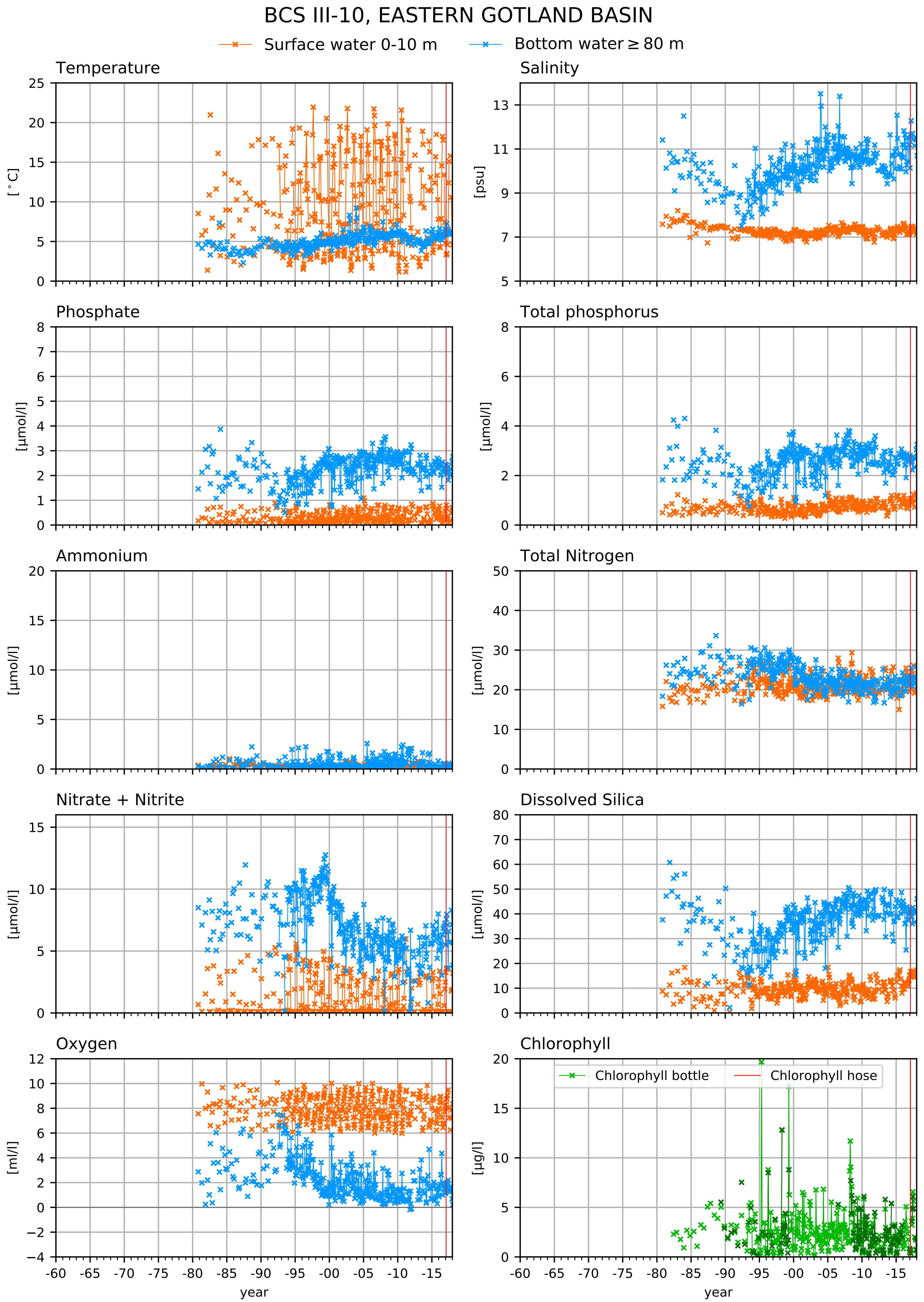


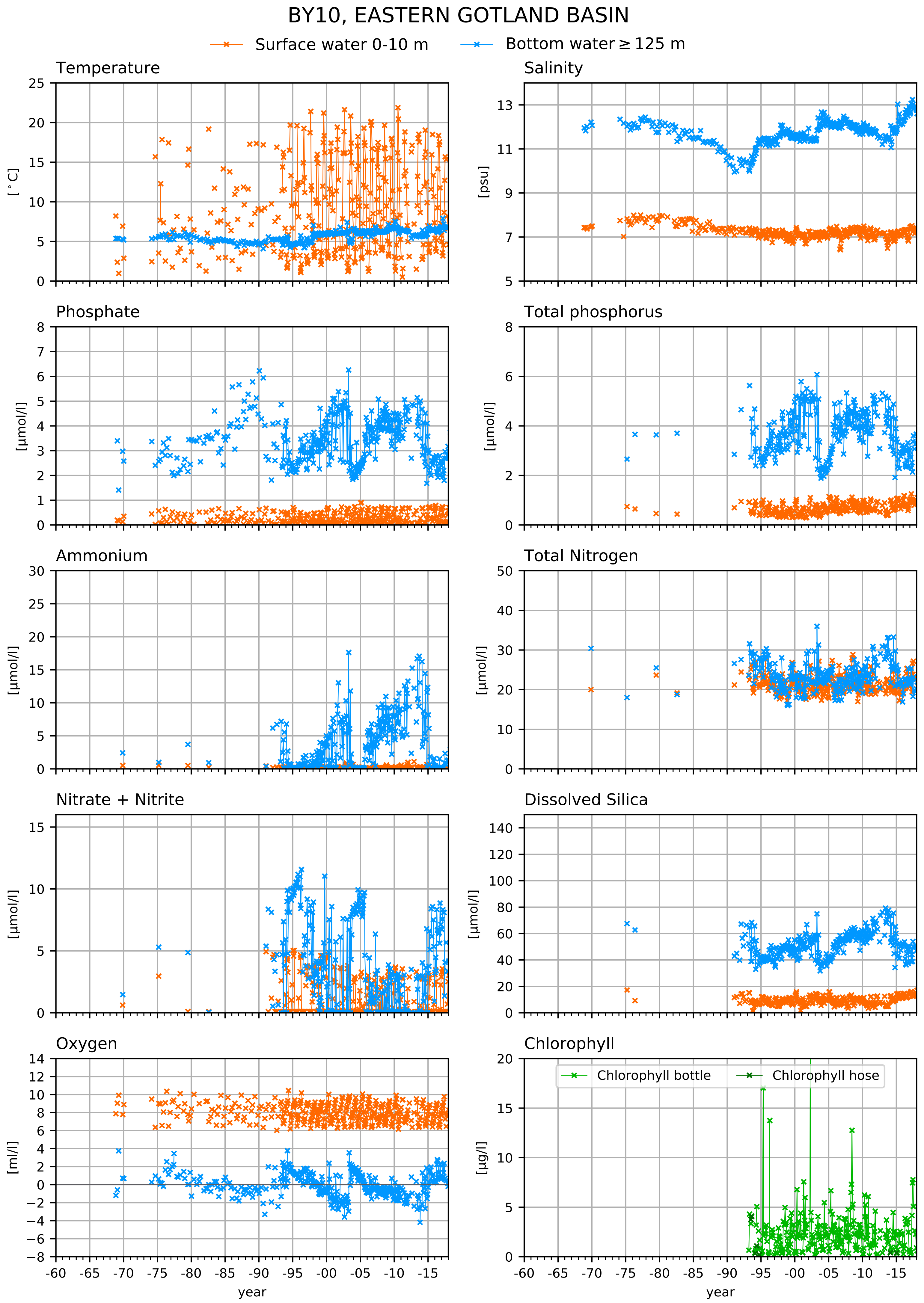
BY5 BORNHOLM DEEP, BORNHOLM



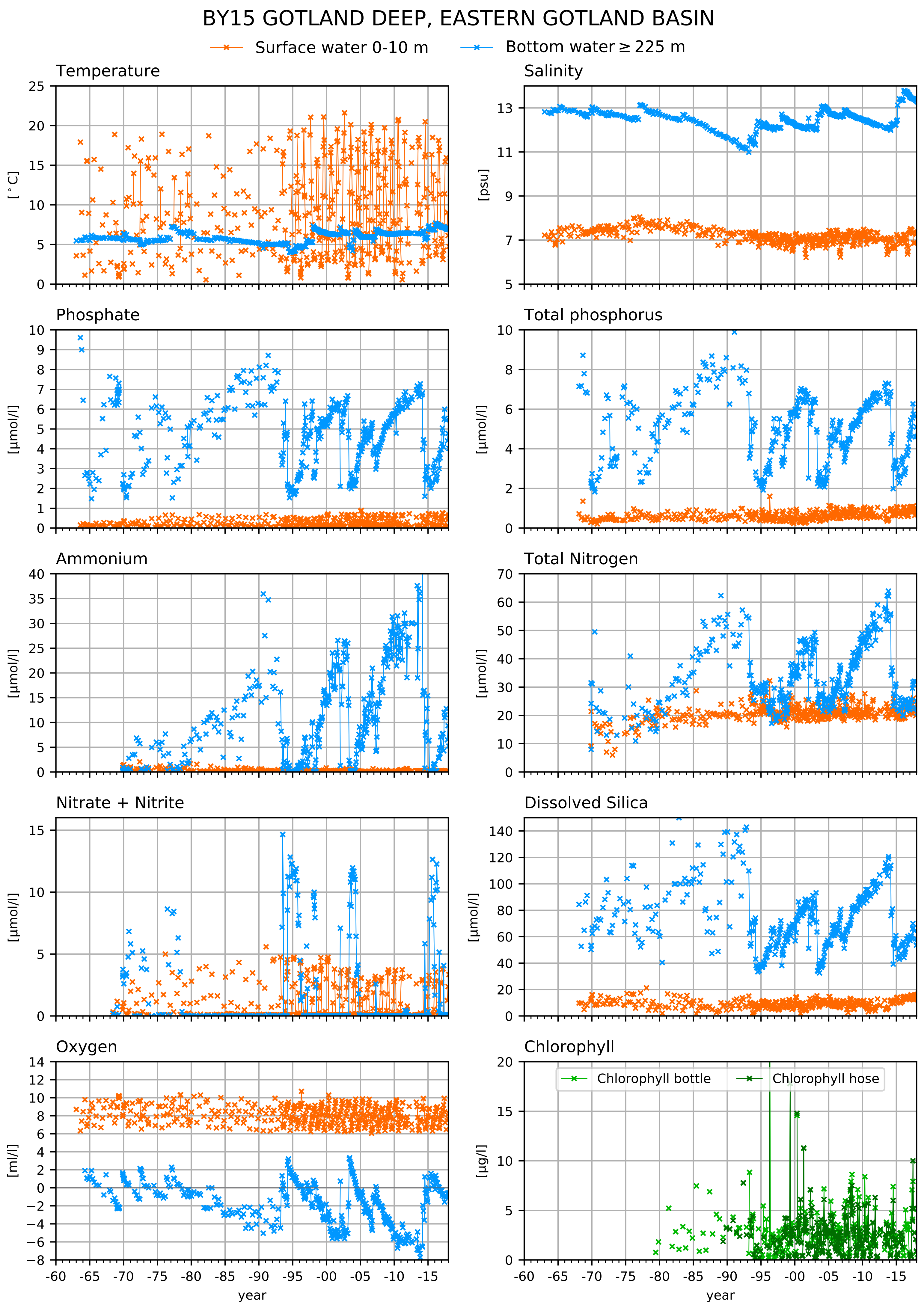


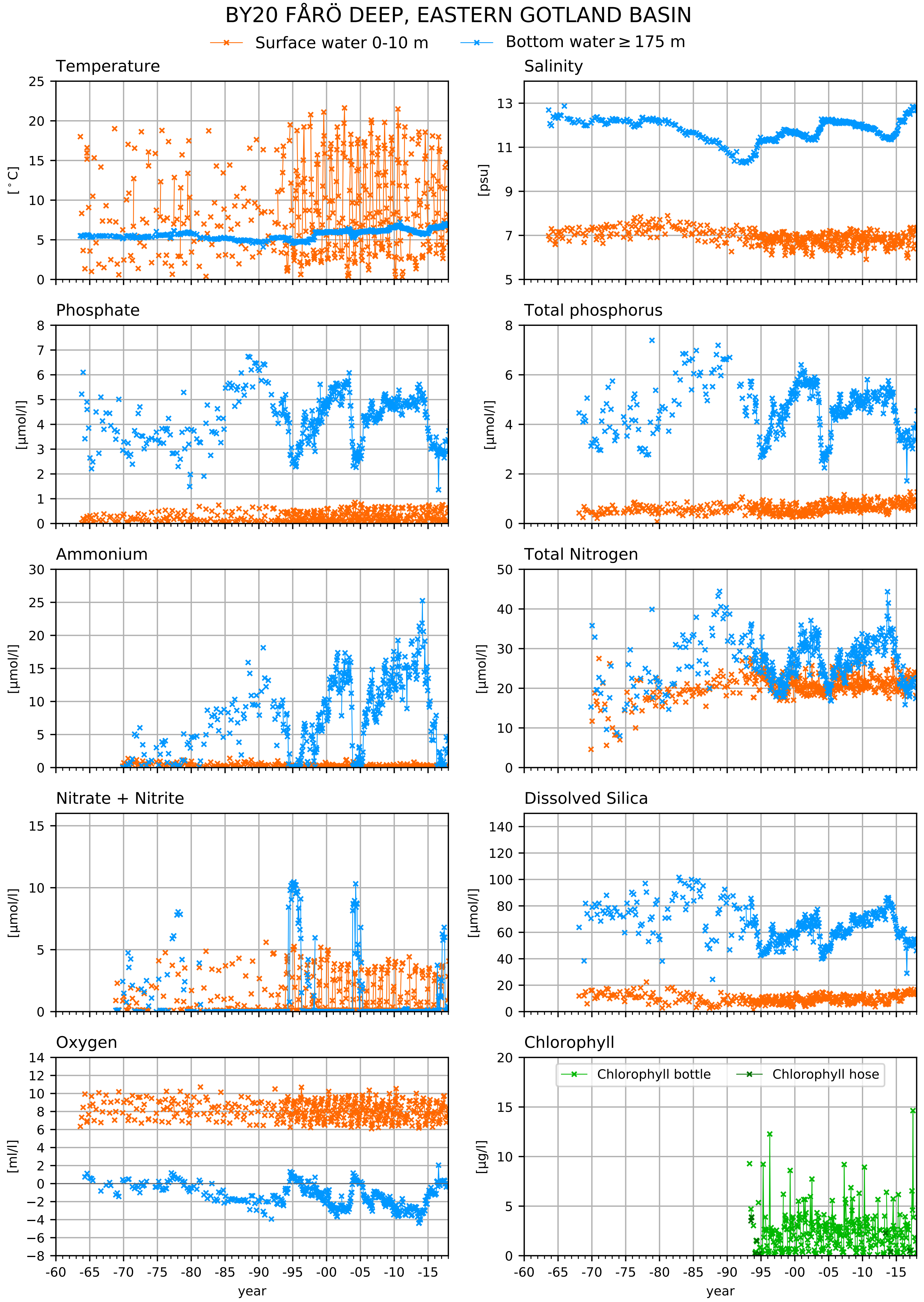
REF M1V1, BORNHOLM
Surface water 0-10 m
Bottom water ≥ 15 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
year

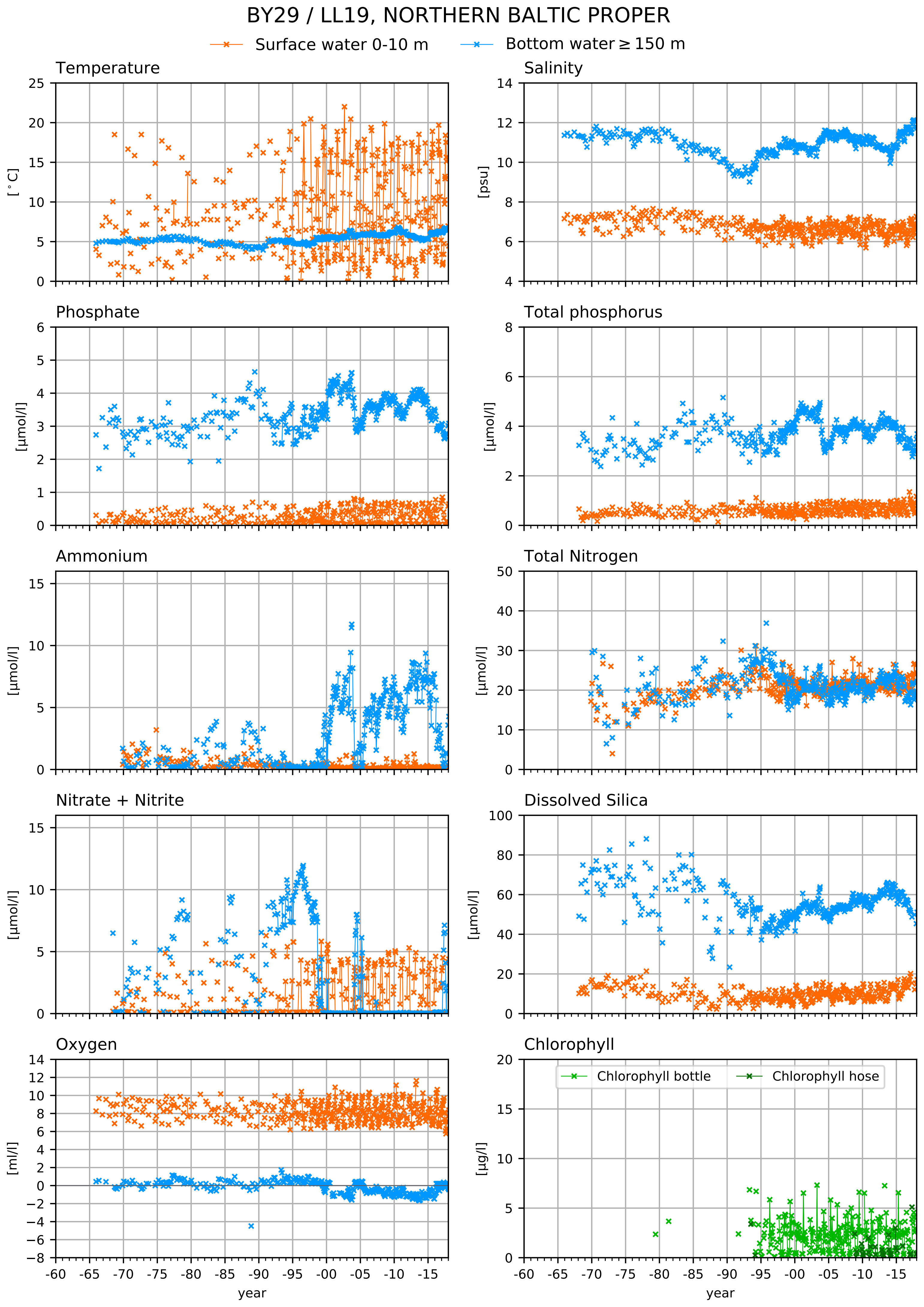

BCS III-10, EASTERN GOTLAND BASIN
Surface water 0-10 m
Bottom water ≥ 80 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year

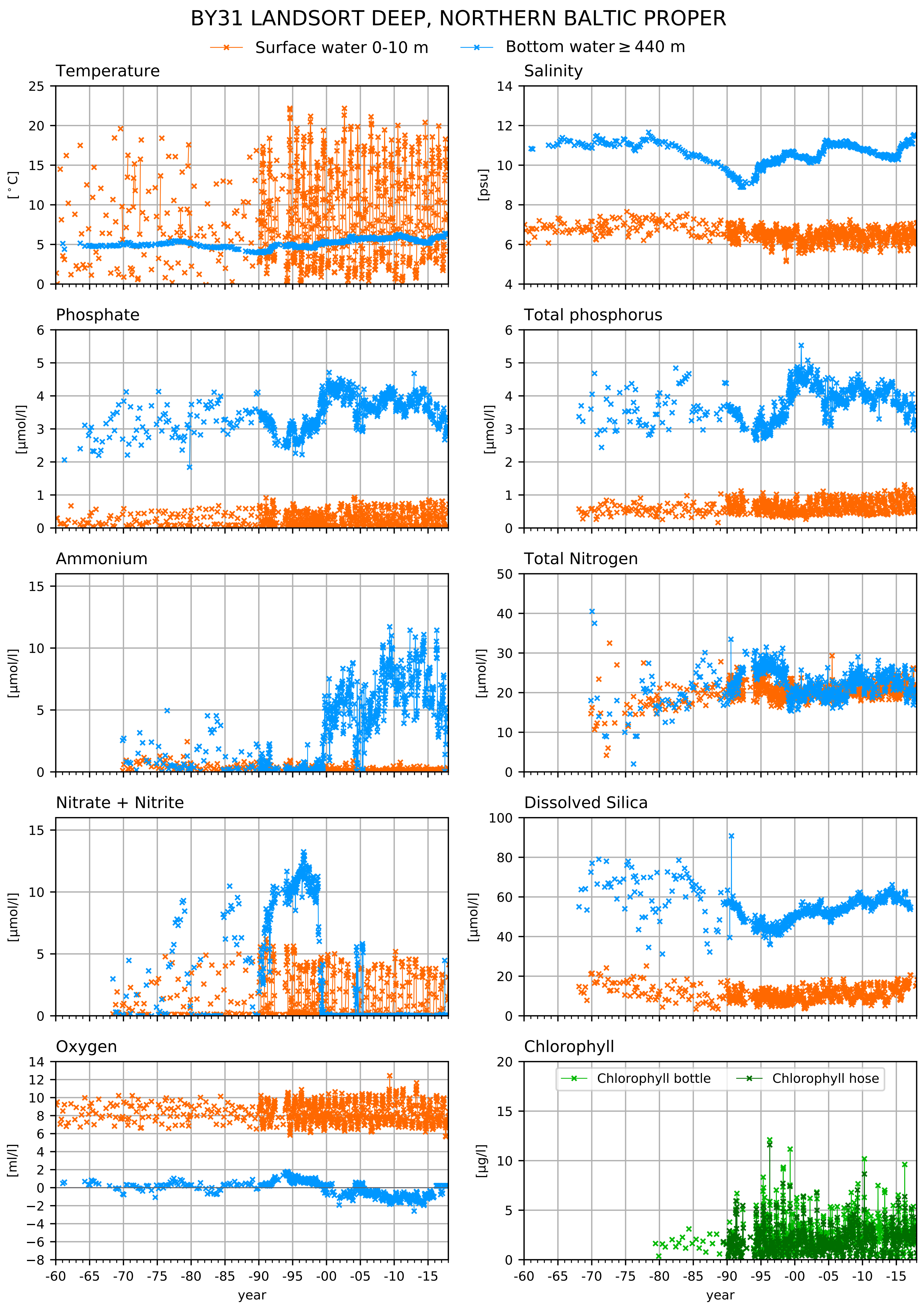


BY10, EASTERN GOTLAND BASIN
Surface water 0-10 m
Bottom water ≥ 125 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15

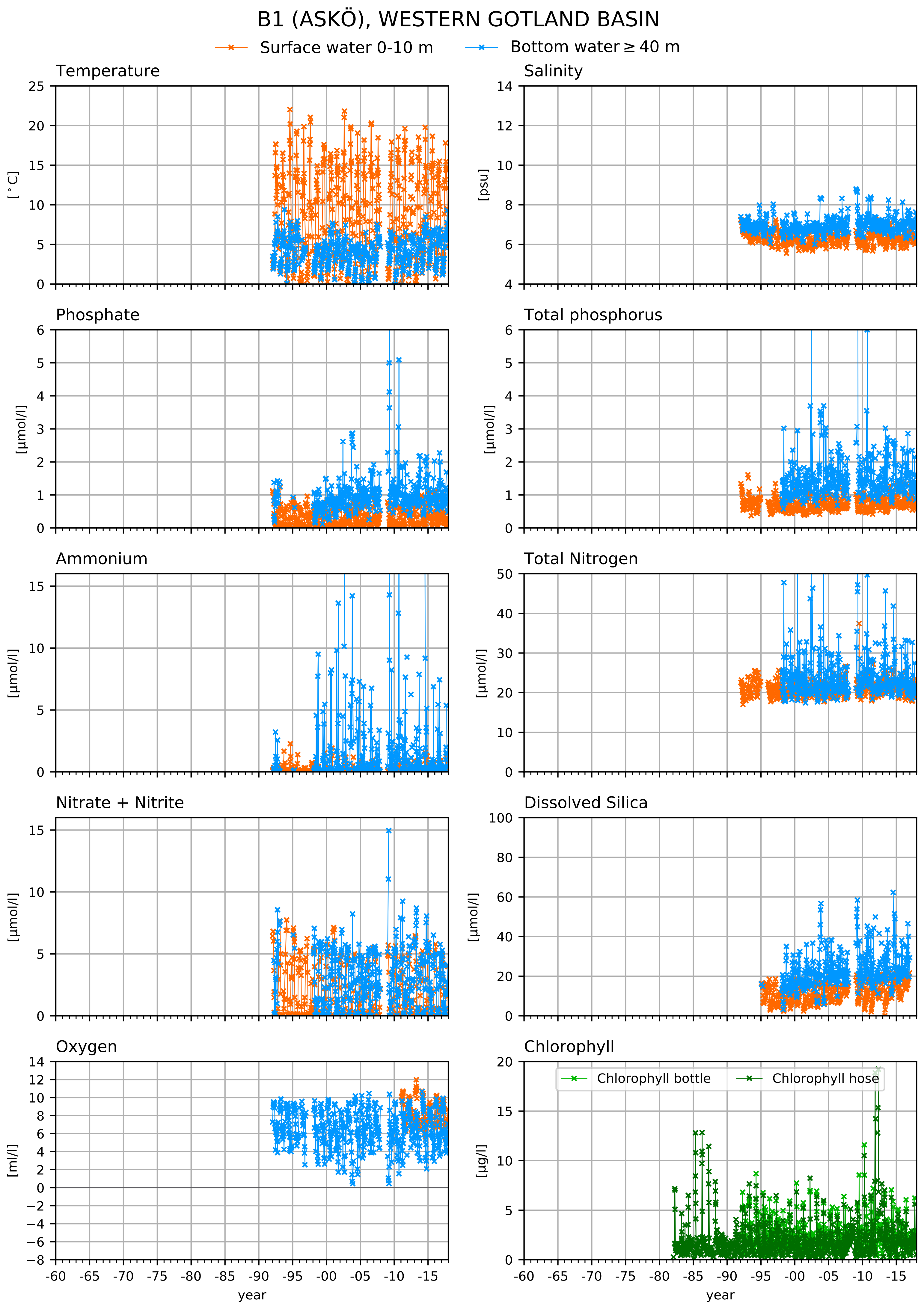

BY15 GOTLAND DEEP, EASTERN GOTLAND BASIN
Surface water 0-10 m
Bottom water ≥ 225 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
[µg/l]
Chlorophyll bottle
Chlorophyll hose
year
year


BY20 FÅRÖ DEEP, EASTERN GOTLAND BASIN
Surface water 0-10 m
Bottom water ≥ 175 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year


BY29 / LL19, NORTHERN BALTIC PROPER
Surface water 0-10 m
Bottom water ≥ 150 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
[µg/l]
Chlorophyll bottle
Chlorophyll hose
year
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15

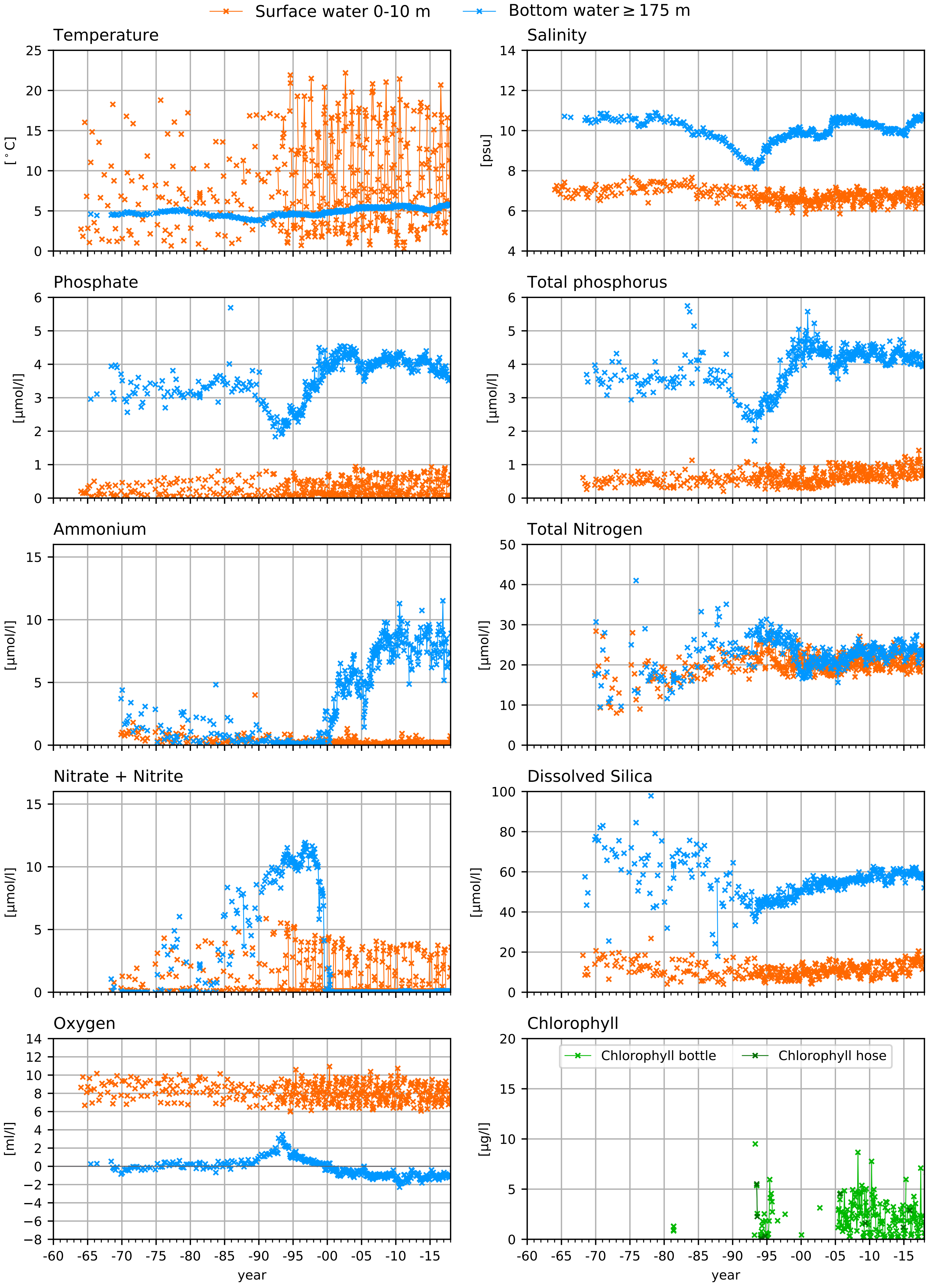


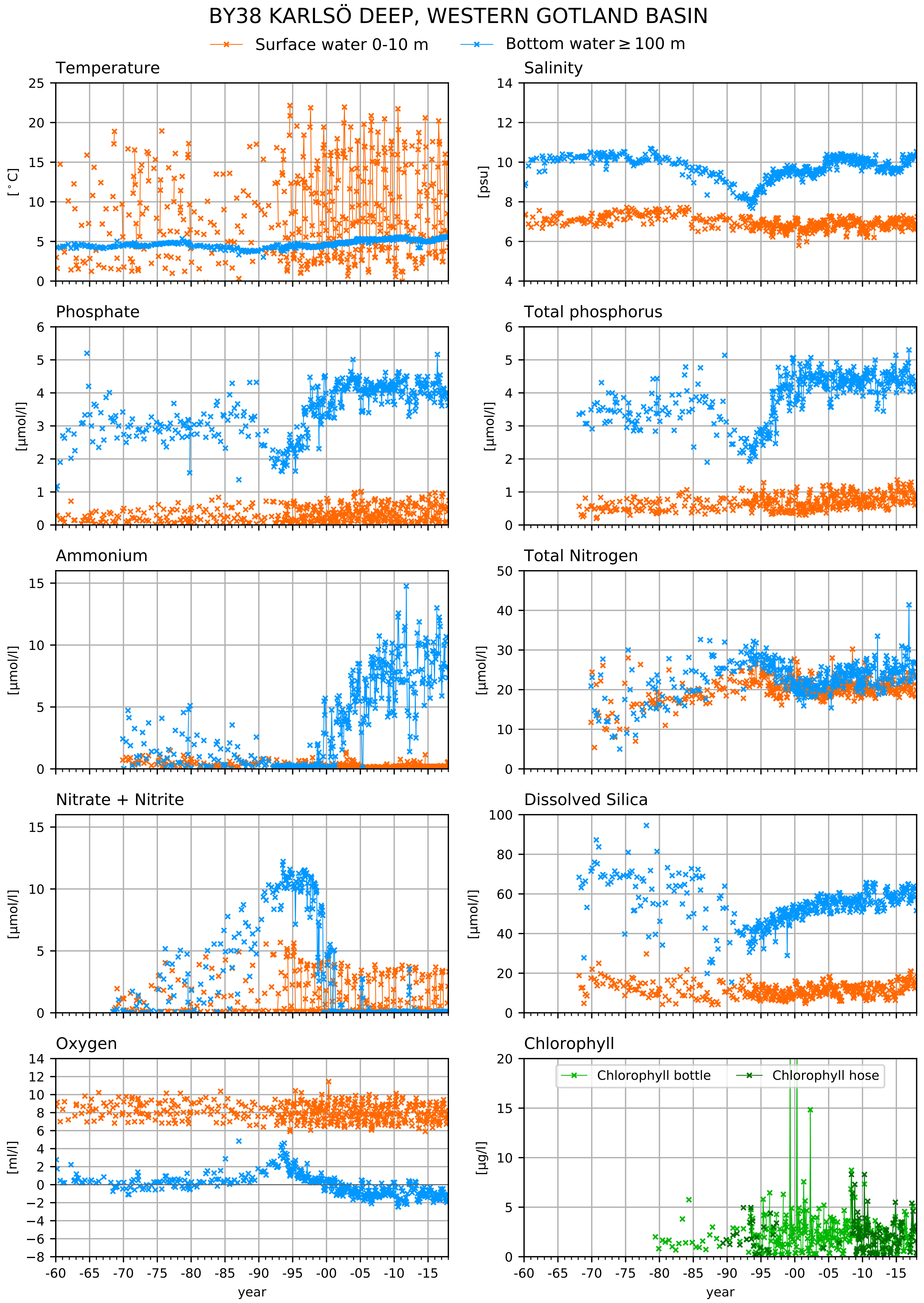
BY31 LANDSORT DEEP, NORTHERN BALTIC PROPER
Surface water 0-10 m
Bottom water ≥ 440 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year



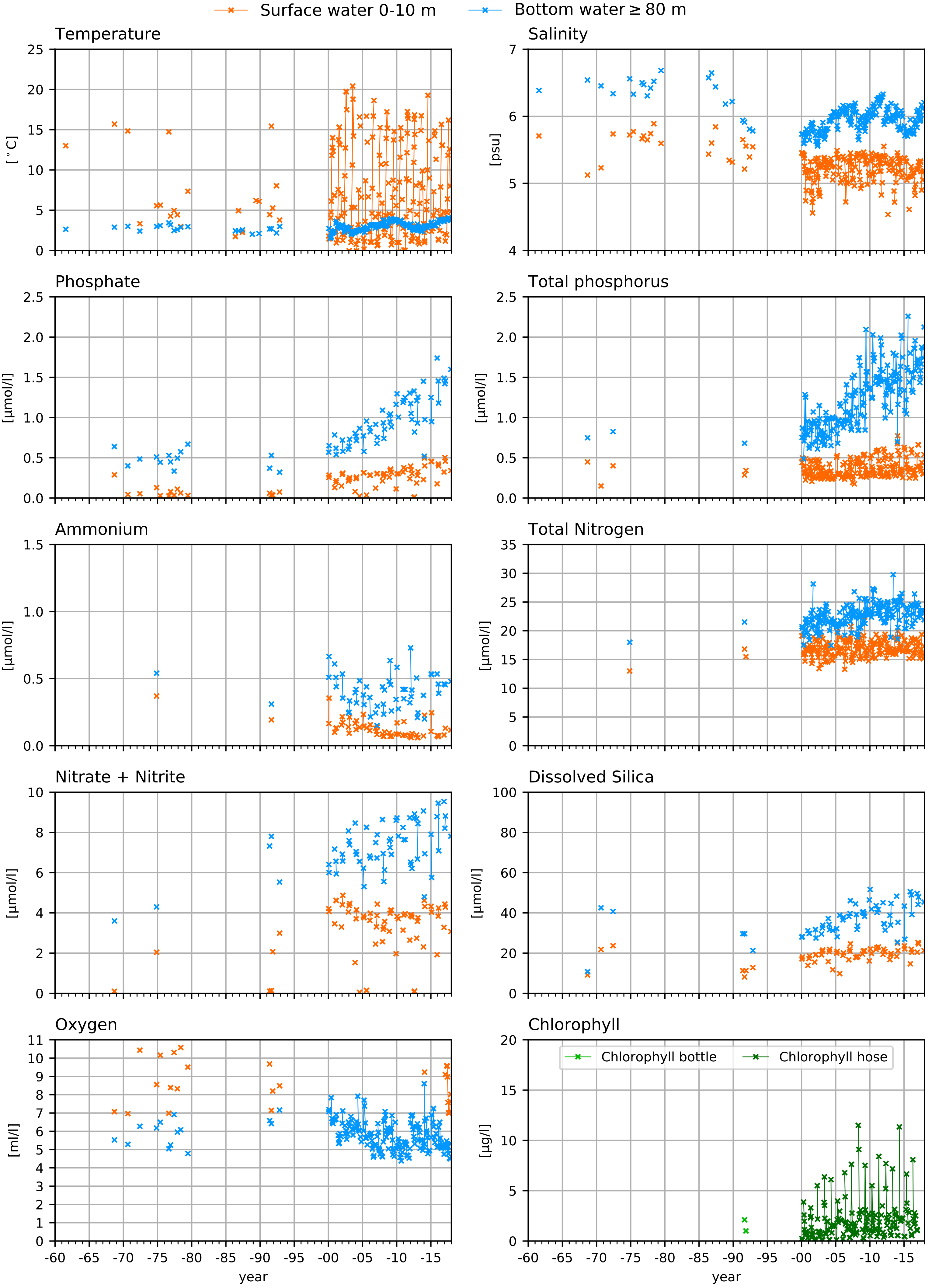
B1 (ASKÖ), WESTERN GOTLAND BASIN
Surface water 0-10 m
Bottom water ≥ 40 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
year

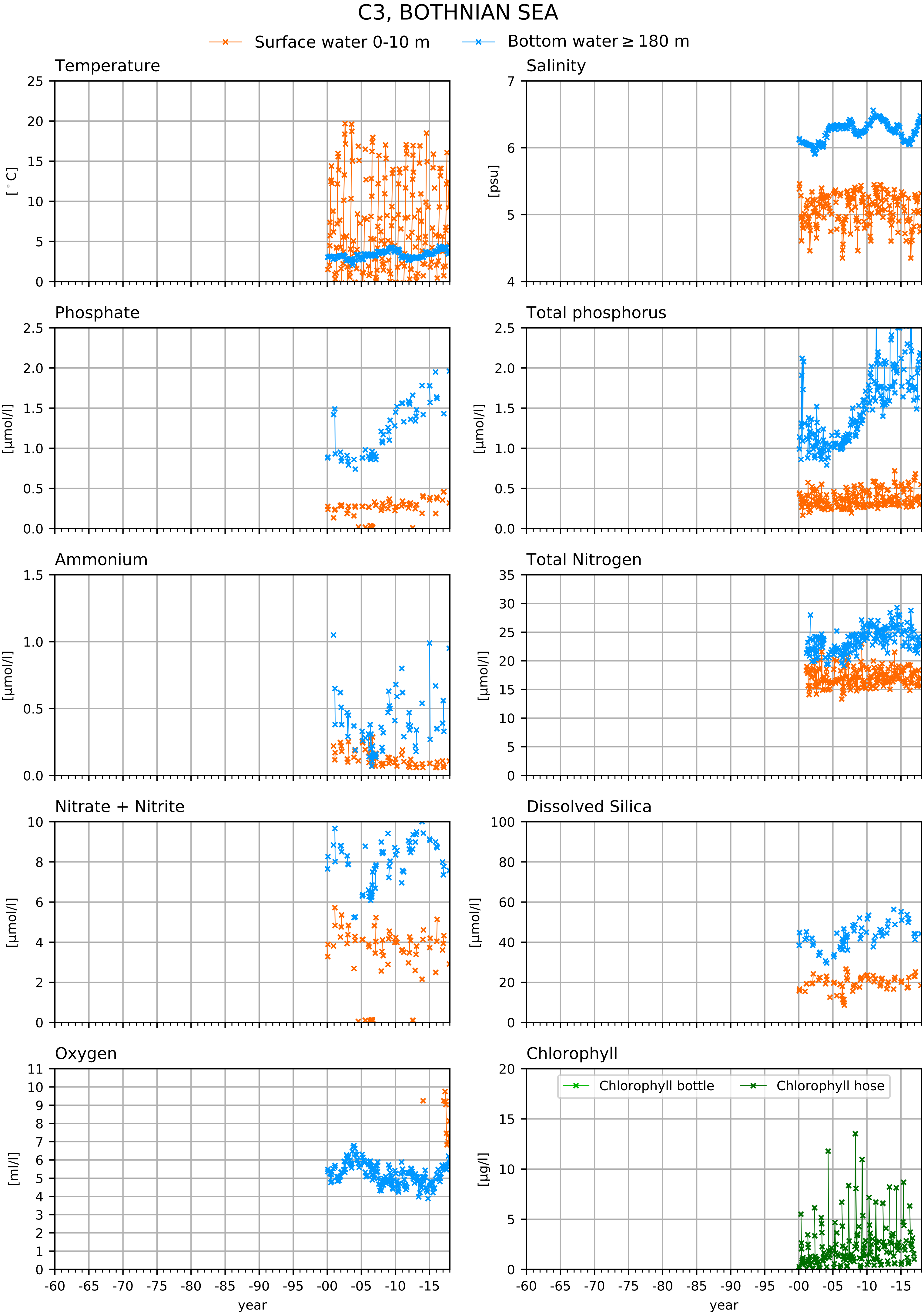
BY32 NORRKÖPING DEEP, WESTERN GOTLAND BASIN

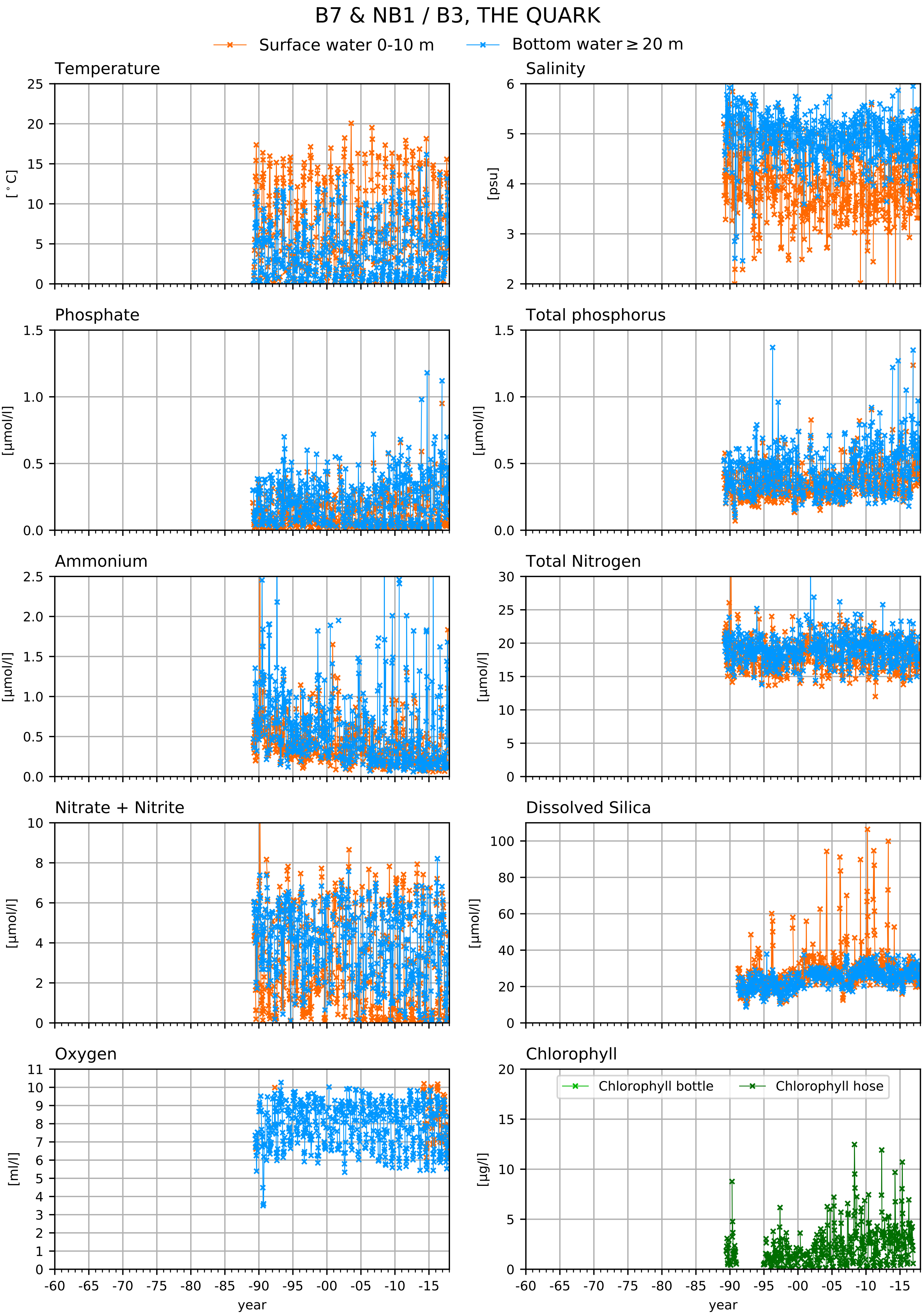



BY38 KARLSÖ DEEP, WESTERN GOTLAND BASIN
Surface water 0-10 m
Bottom water ≥ 100 m
Temperature
[°C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
[µg/l]
Chlorophyll bottle
Chlorophyll hose
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year

MS4 / C14, BOTHNIAN SEA

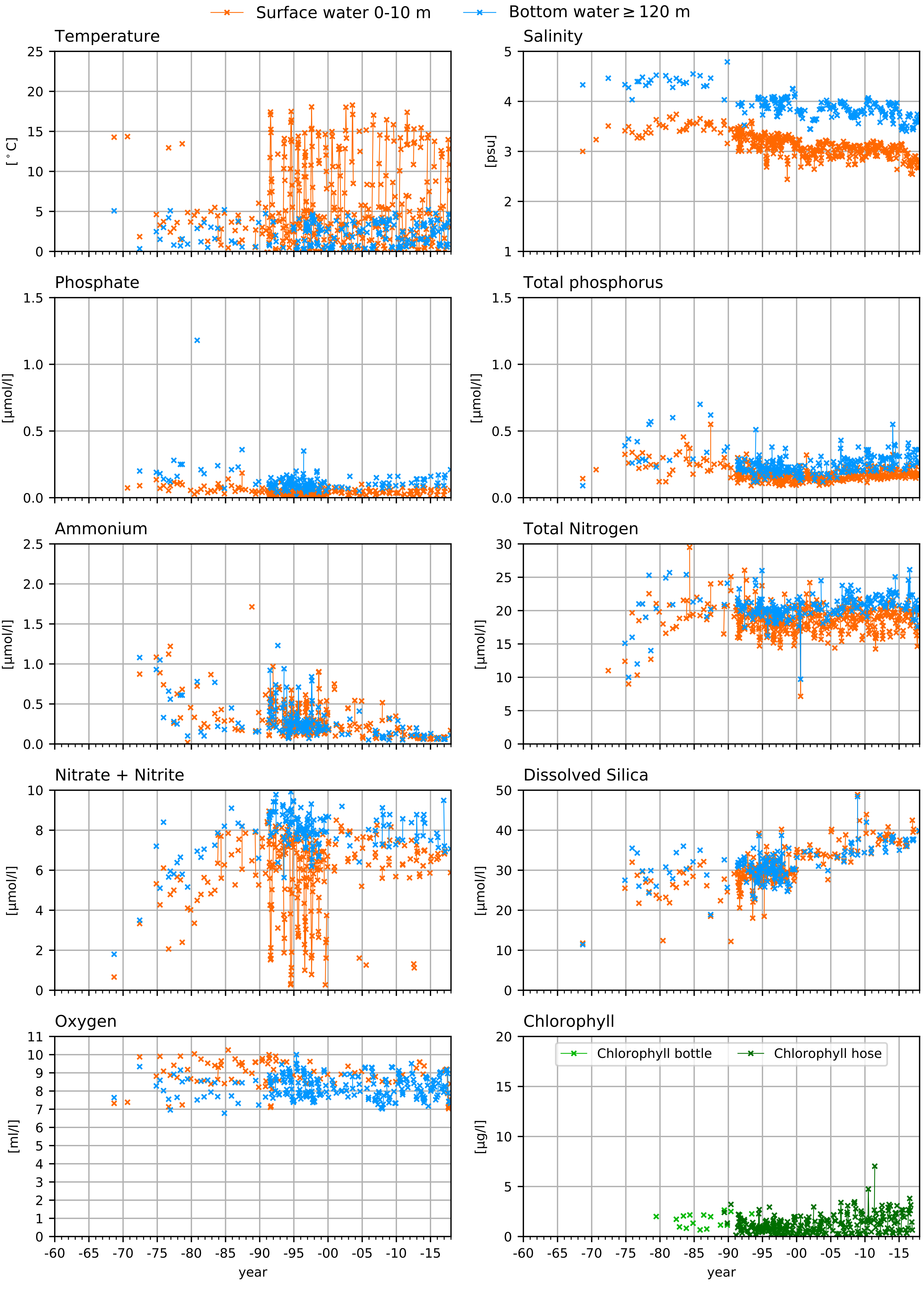



C3, BOTHNIAN SEA
Surface water 0-10 m
Bottom water ≥ 180 m
Temperature
[$^\circ$C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
year
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15

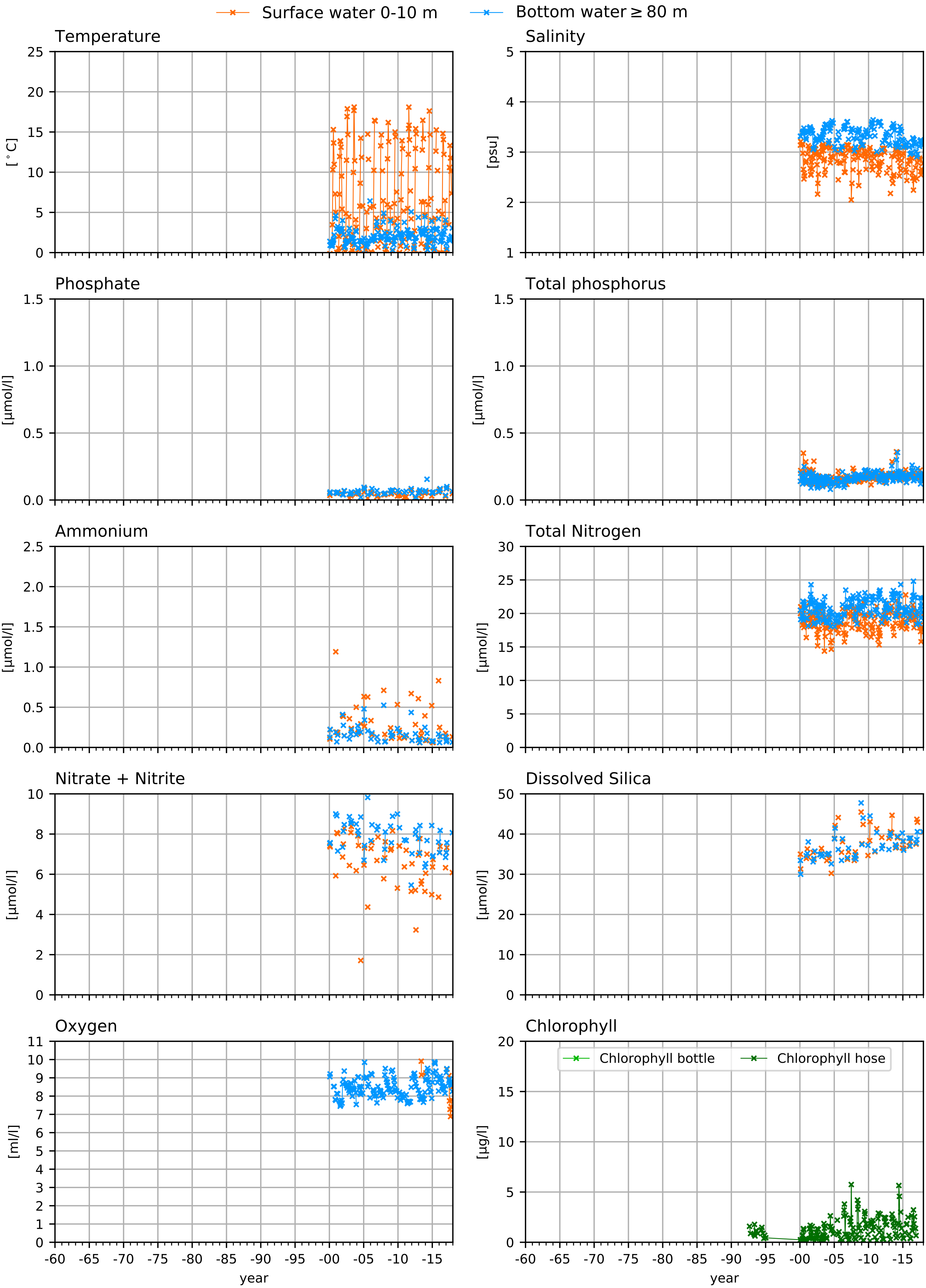


B7 & NB1 / B3, THE QUARK
Surface water 0-10 m
Bottom water ≥ 20 m
Temperature
[° C]
Salinity
[psu]
Phosphate
[µmol/l]
Total phosphorus
[µmol/l]
Ammonium
[µmol/l]
Total Nitrogen
[µmol/l]
Nitrate + Nitrite
[µmol/l]
Dissolved Silica
[µmol/l]
Oxygen
[ml/l]
Chlorophyll
Chlorophyll bottle
Chlorophyll hose
[µg/l]
-60 -65 -70 -75 -80 -85 -90 -95 -00 -05 -10 -15
year

F9 / A13, BOTHNIAN BAY



F3 / A5, BOTHNIAN BAY



Appendix III

Nutrient content per basin in the Baltic Sea and the Gulf of Bothnia

Method

The basin content of nutrients was calculated from the same data set that was used for the time series presented in Appendix II. Each profile was interpolated (linearly) to retrieve concentrations in 1 m depth resolution from each station. Only complete profiles with data in the surface, intermediary and deep waters are used.

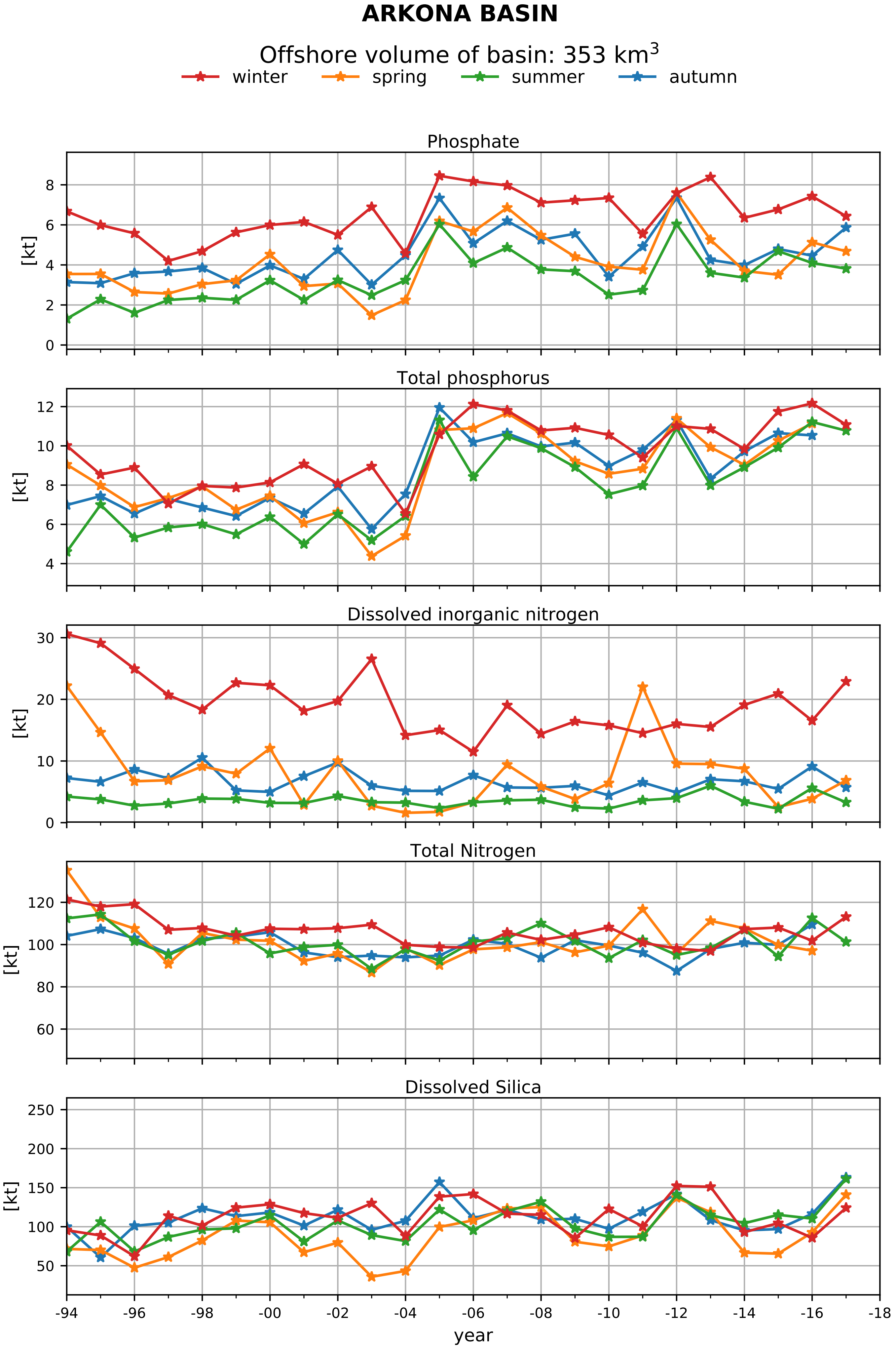
The data is divided into winter, spring, summer and autumn (winter: Dec-Feb, spring: Mar-May, summer: June-Aug, autumn: Sep-Nov). This means that 2017 winter was calculated from data collected in December 2016, January 2017 and February 2017.

For each basin the concentration at each depth is multiplied by the volume of that depth layer, thereby getting the content of each nutrient in that depth layer. All depth layers are then summed to give the content for the whole basin. In Bornholm Basin, Arkona Basin, Bothnian Sea and Bothnian Bay the average concentration of two stations is used for the calculation, assuming little horizontal variations in all depth layers. The Western Gotland Basin and the Eastern Gotland Basin are divided into three and four sub-basins respectively because the horizontal variations, especially in the deep waters are larger here. The sub-basins are chosen based on bathymetry around the monitoring stations. Calculated content is shown both for the sub-basins and the whole basins.

The winter and summer content is shown for all basins on the last page. Note that the difference in content between the basins depends on their difference in size.

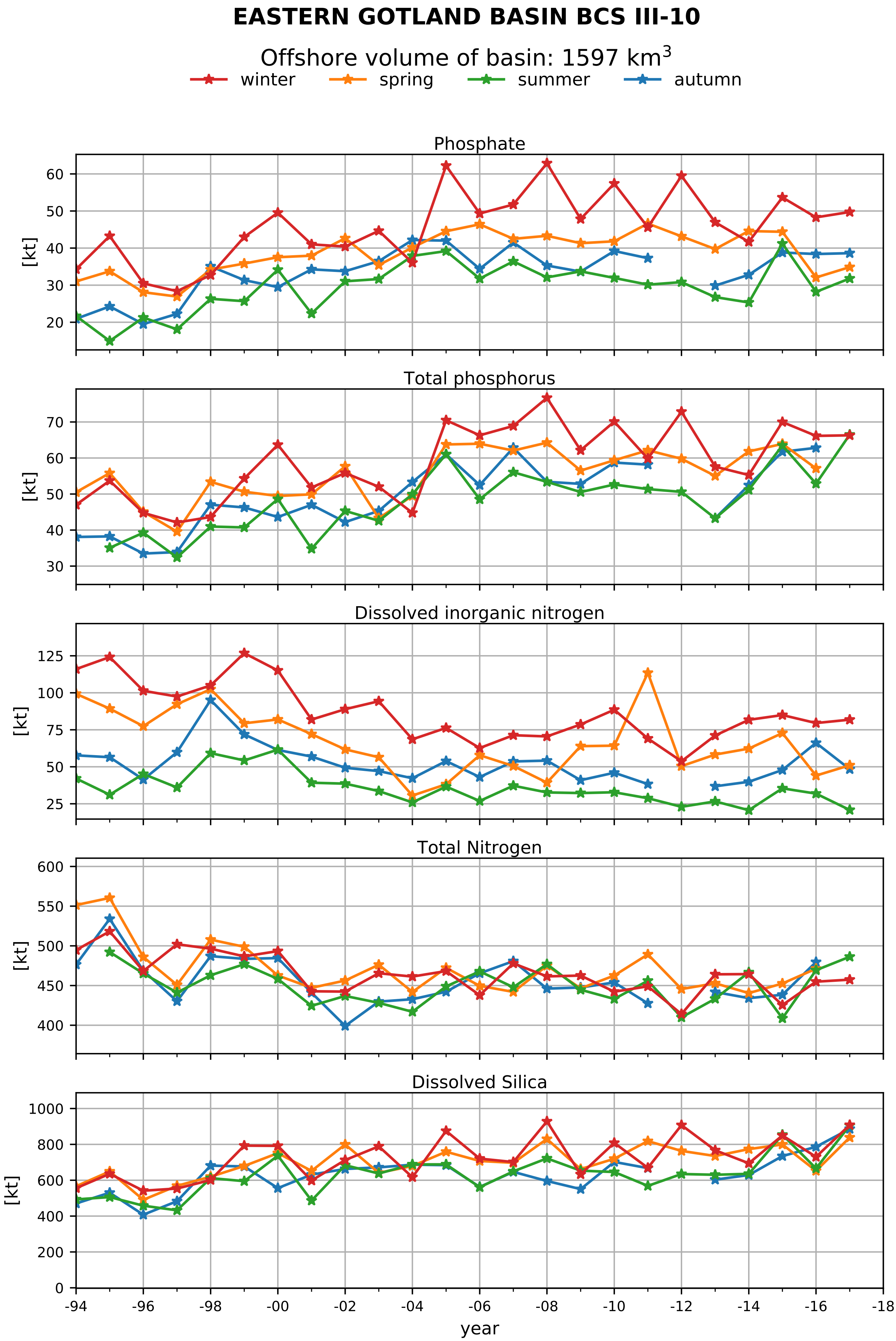
The volume of each depth layer was calculated from the bathymetry dataset iowotopo2 available by IOW at https://www.io-warnemuende.de/topography-of-the-baltic-sea.html and by using the open sea basin subdivision set by HELCOM, (http://maps.helcom.fi/website/mapservice/index.html). The sub-basin divisions where made with GIS-software and lines for these division where drawn with guidance from the bathymetry map. All basin subdivisions used are shown in the first figure of this Appendix (Figure 1).

Figure 1. Basin subdivisions used for calculating hypsography and then basin content of sub-basins. The major basins shown in different colours are the HELCOM basin division revised in 2018. The previous basin division placed the station BY31 in the Northern Baltic Proper. The dashed lines showing the sub-basins were drawn to follow the bathymetry to get a smaller basin that the individual monitoring station better represents.

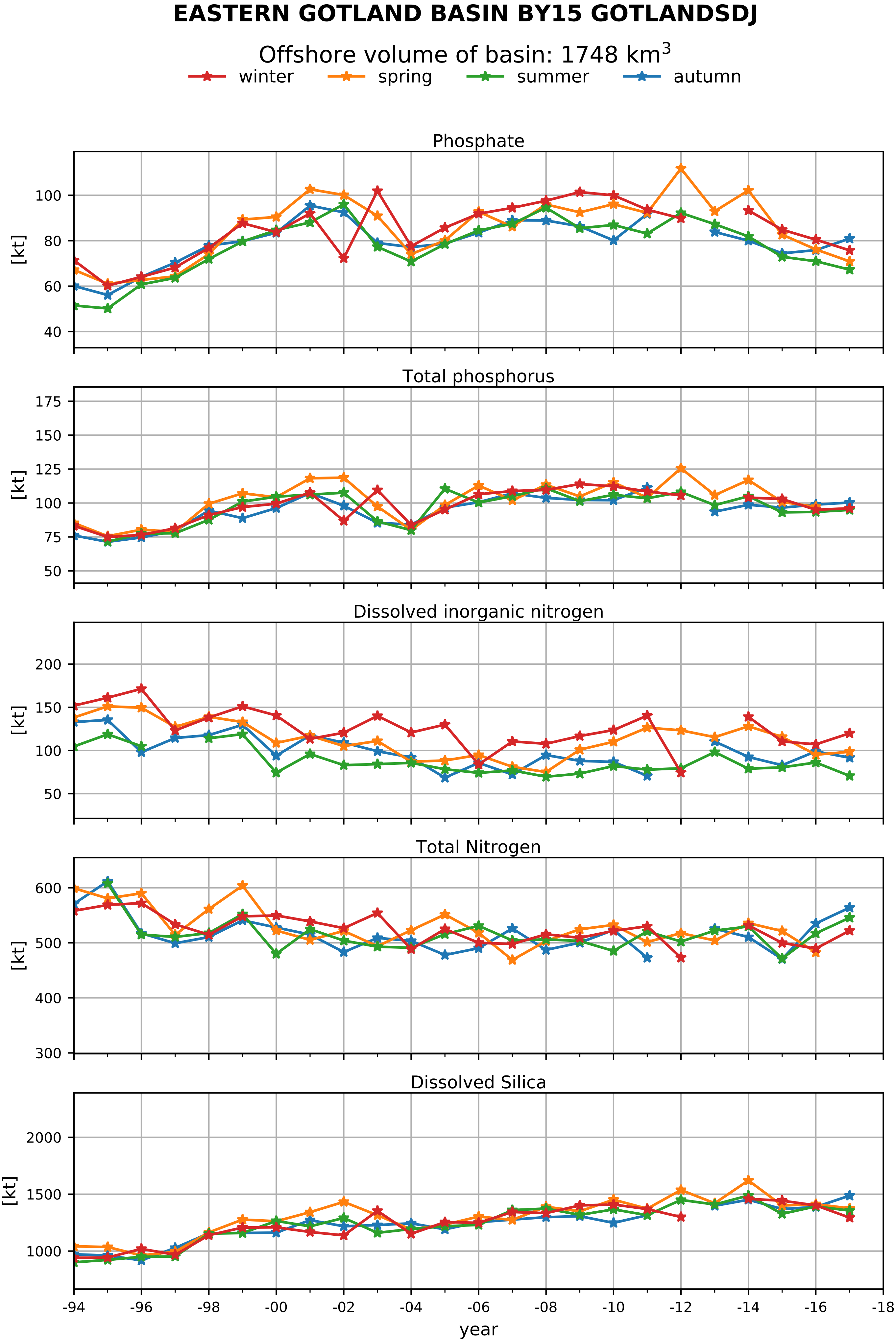


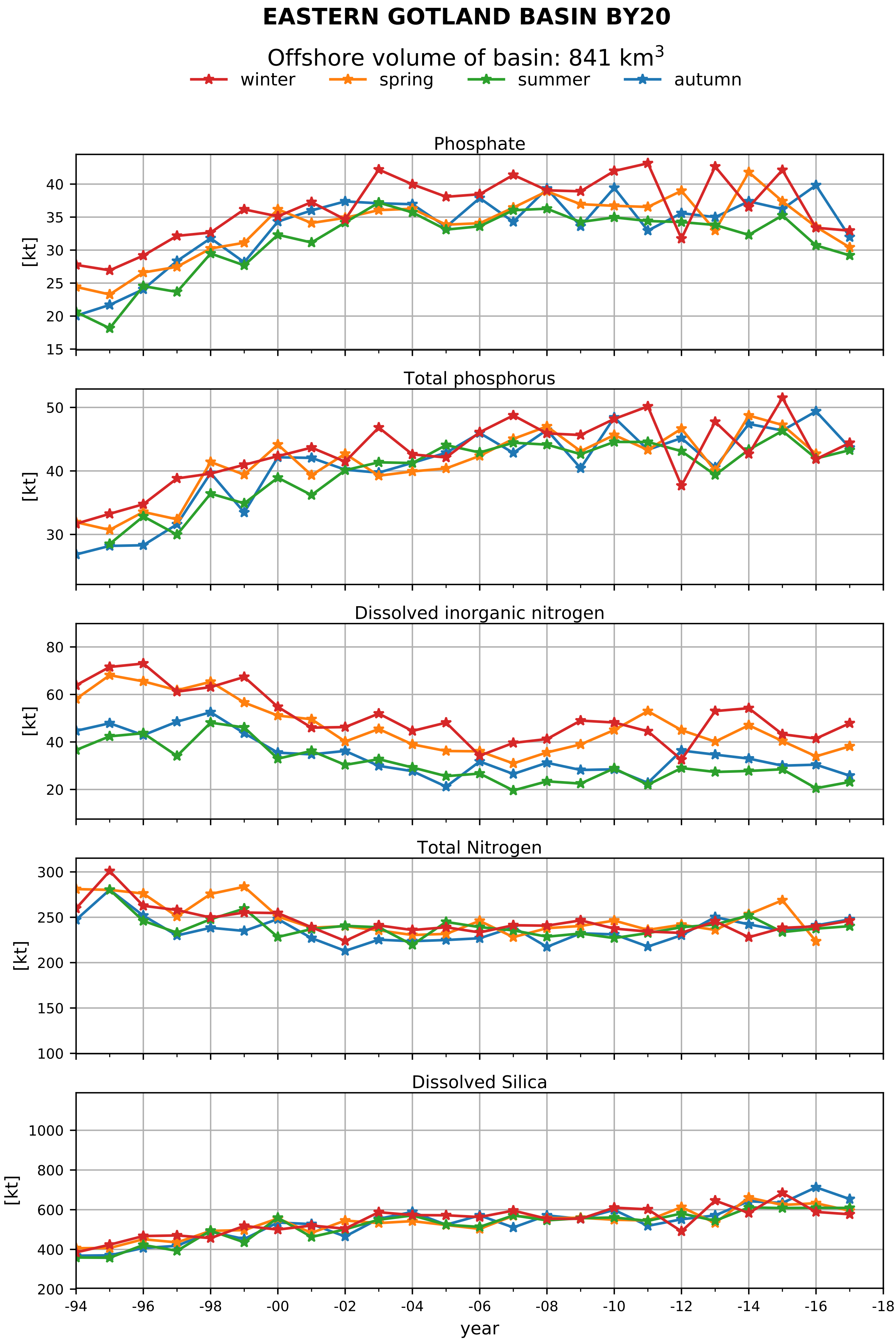
ARKONA BASIN
Offshore volume of basin: 353 km3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18


BORNHOLM BASIN
Offshore volume of basin: 1603 km3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

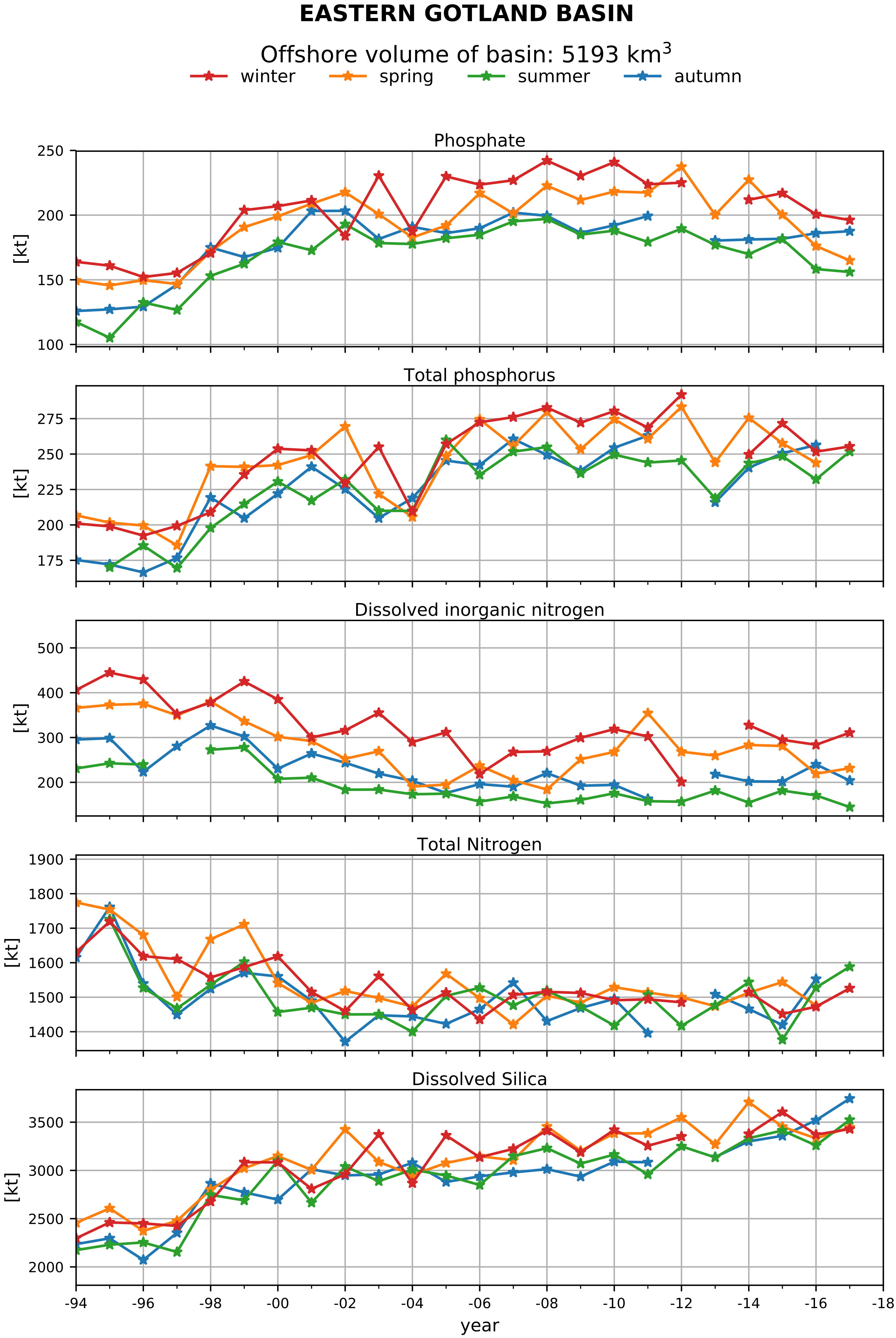

EASTERN GOTLAND BASIN BCS III-10
Offshore volume of basin: 1597 km^3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18


EASTERN GOTLAND BASIN BY10
Offshore volume of basin: 1007 km^3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18


EASTERN GOTLAND BASIN BY15 GOTLANDSDJ
Offshore volume of basin: 1748 km^3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

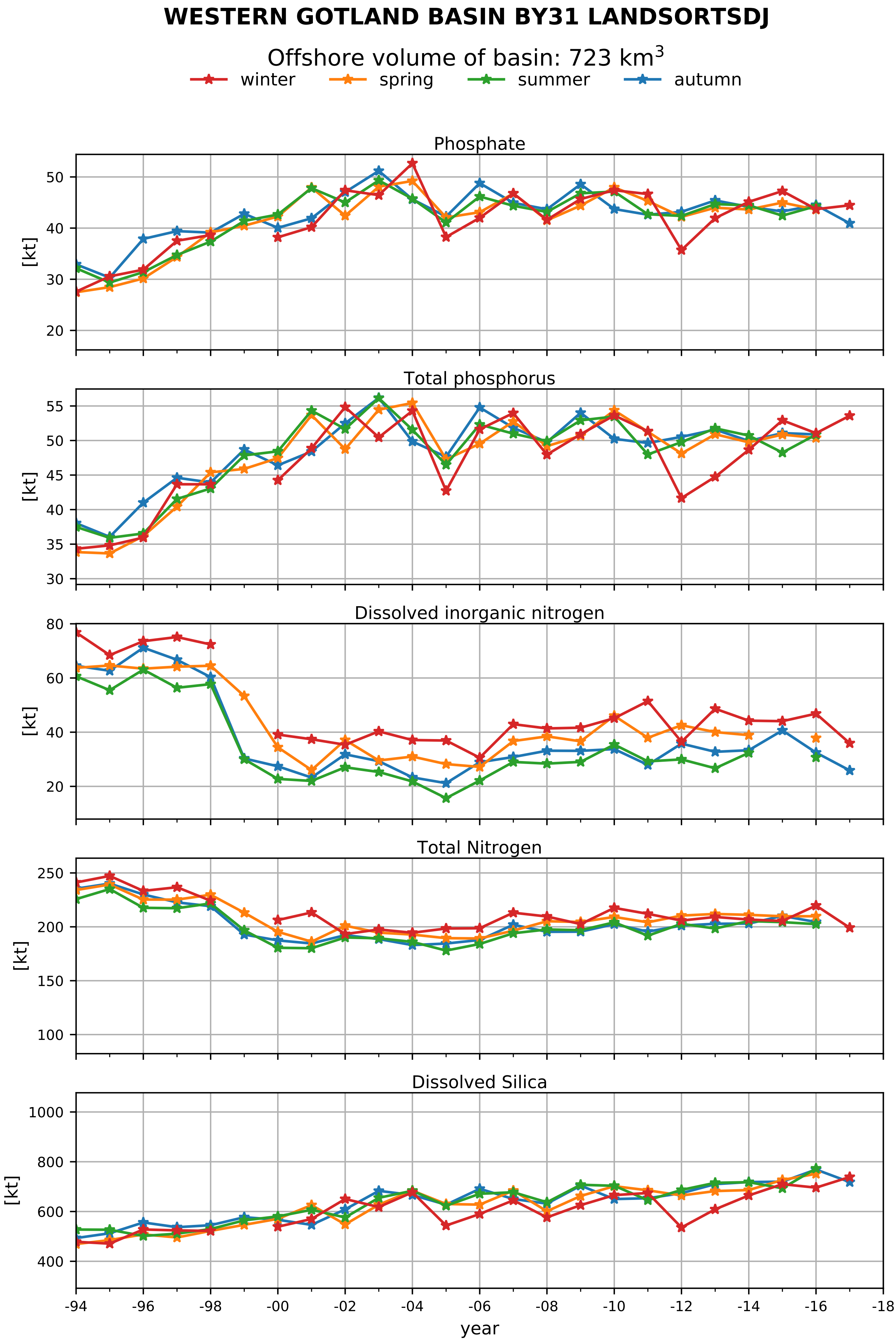


EASTERN GOTLAND BASIN BY20
Offshore volume of basin: 841 km^3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18



EASTERN GOTLAND BASIN
Offshore volume of basin: 5193 km^3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

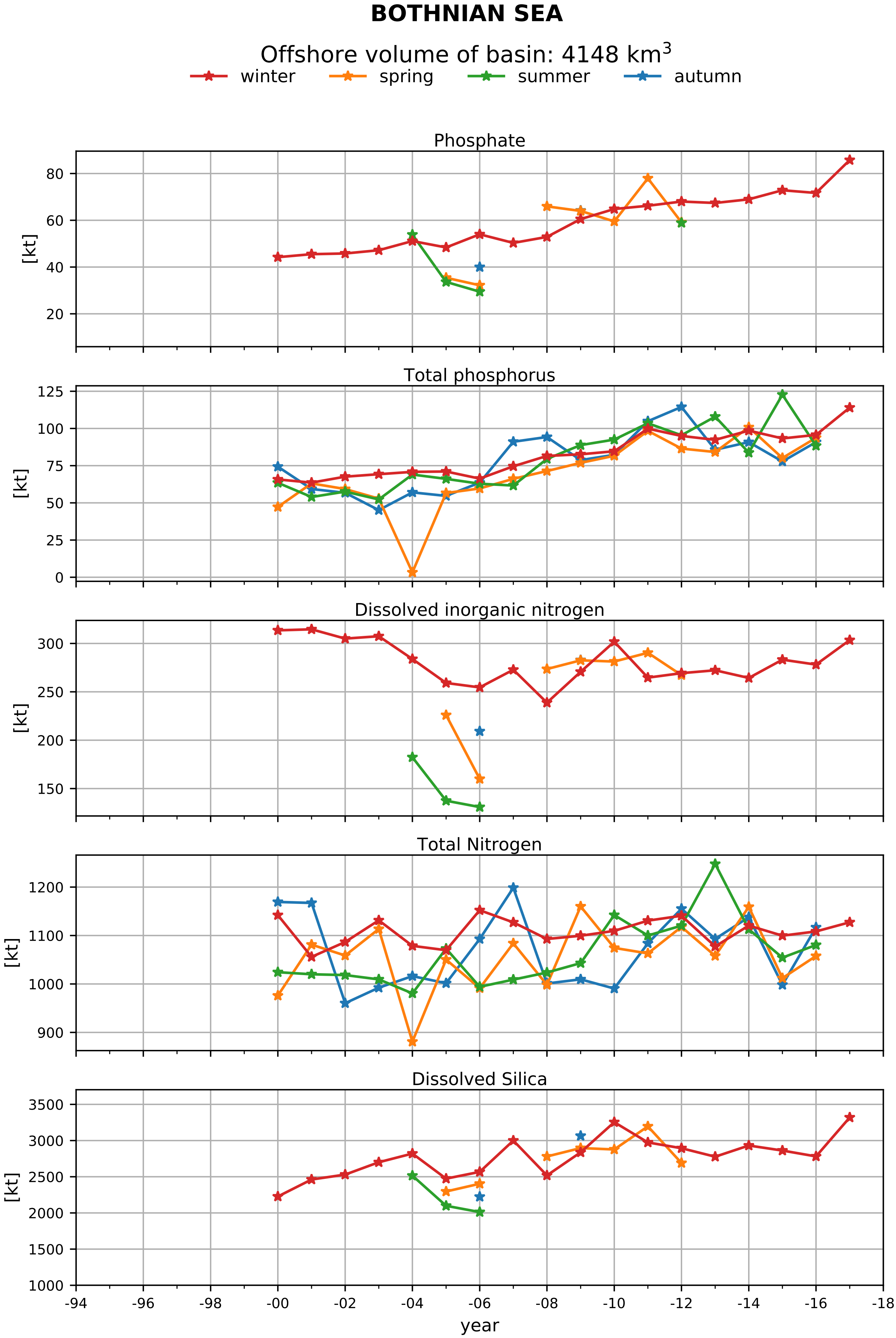

NORTHERN BALTIC PROPER
Offshore volume of basin: 2327 km^3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

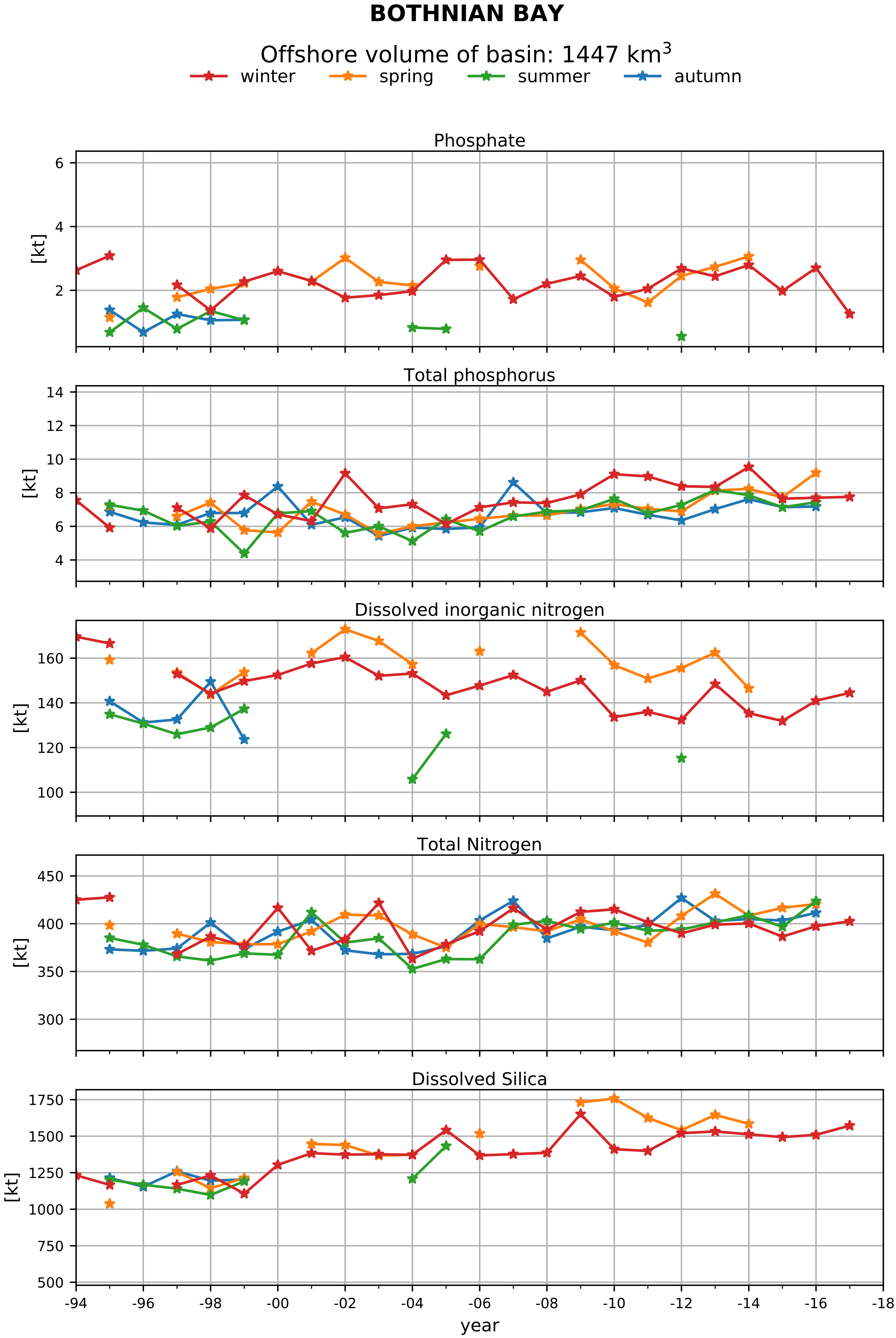

WESTERN GOTLAND BASIN BY31 LANDSORTSDJ
Offshore volume of basin: 723 km3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

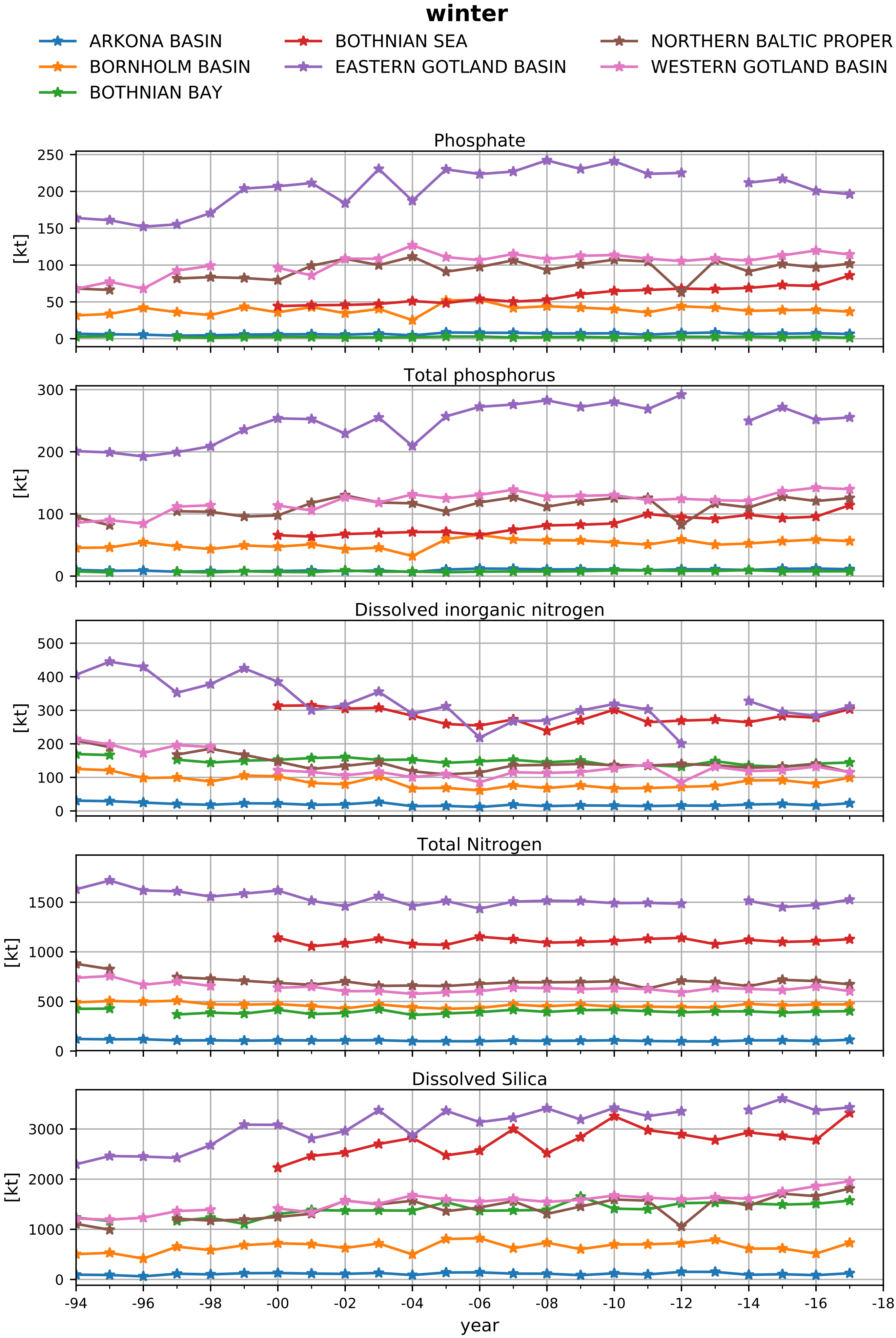

WESTERN GOTLAND BASIN BY32
Offshore volume of basin: 767 km3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

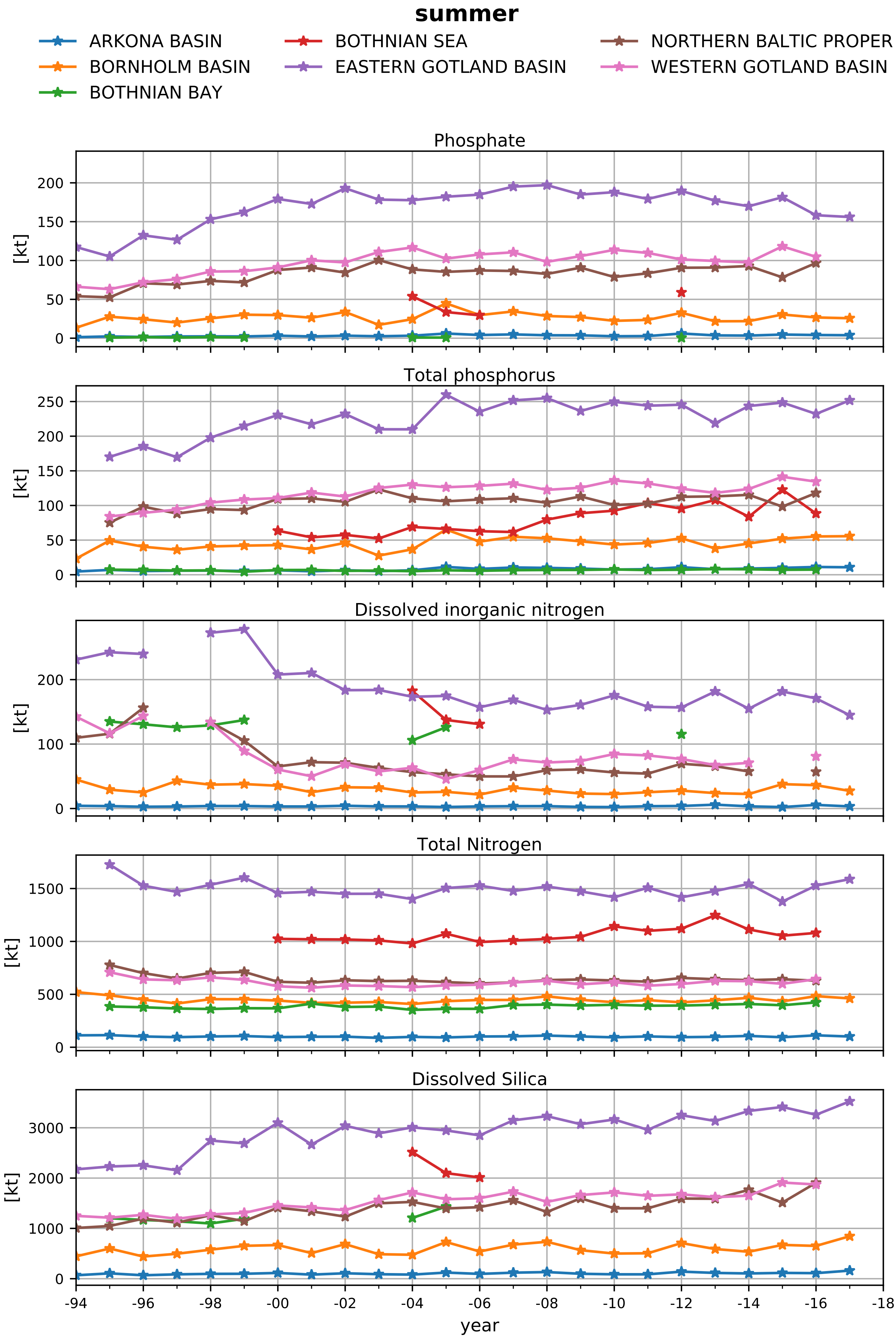

WESTERN GOTLAND BASIN BY38
Offshore volume of basin: 708 km3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

WESTERN GOTLAND BASIN
Offshore volume of basin: 2198 km3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18


BOTHNIAN SEA
Offshore volume of basin: 4148 km3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18


BOTHNIAN BAY
Offshore volume of basin: 1447 km^3
winter
spring
summer
autumn
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18


winter
ARKONA BASIN
BORNHOLM BASIN
BOTHNIAN BAY
BOTHNIAN SEA
EASTERN GOTLAND BASIN
NORTHERN BALTIC PROPER
WESTERN GOTLAND BASIN
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

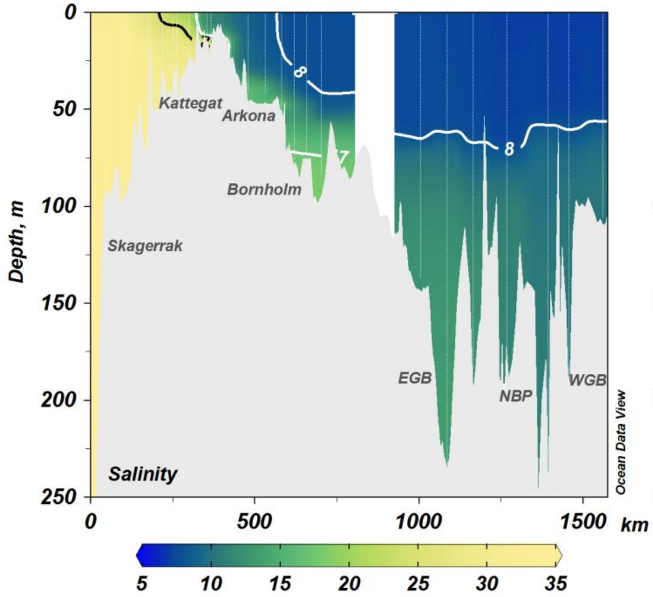

summer
ARKONA BASIN
BORNHOLM BASIN
BOTHNIAN BAY
BOTHNIAN SEA
EASTERN GOTLAND BASIN
NORTHERN BALTIC PROPER
WESTERN GOTLAND BASIN
Phosphate
Total phosphorus
Dissolved inorganic nitrogen
Total Nitrogen
Dissolved Silica
[kt]
year
-94
-96
-98
-00
-02
-04
-06
-08
-10
-12
-14
-16
-18

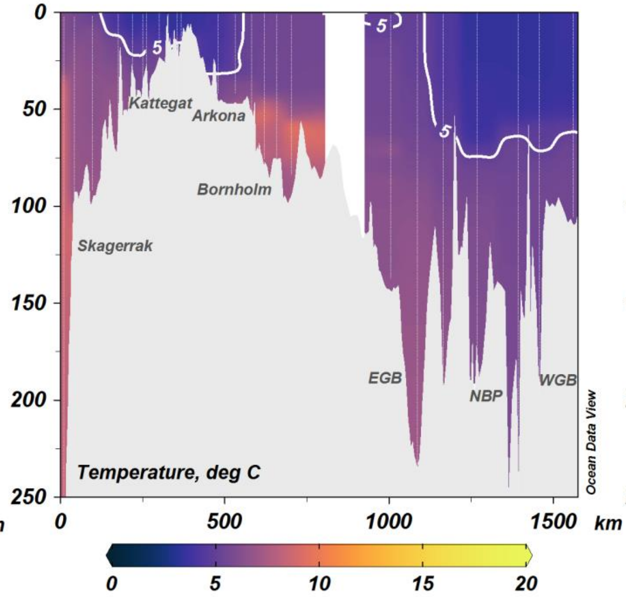
Appendix IV

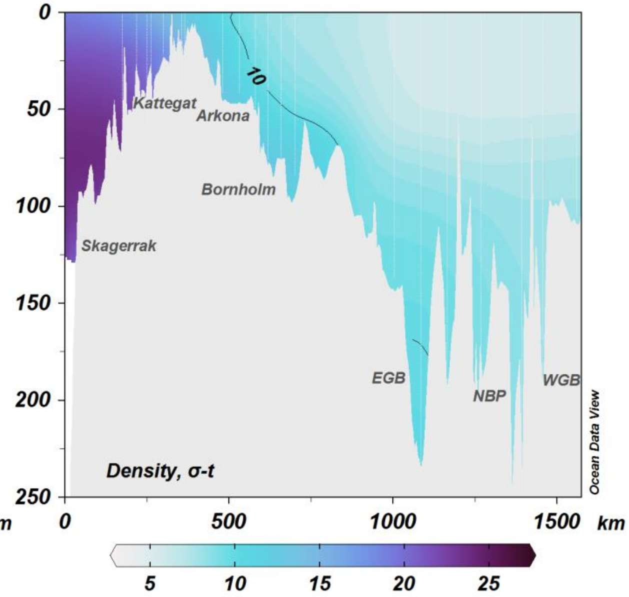
Transects from the Skagerrak to the Western Gotland basin

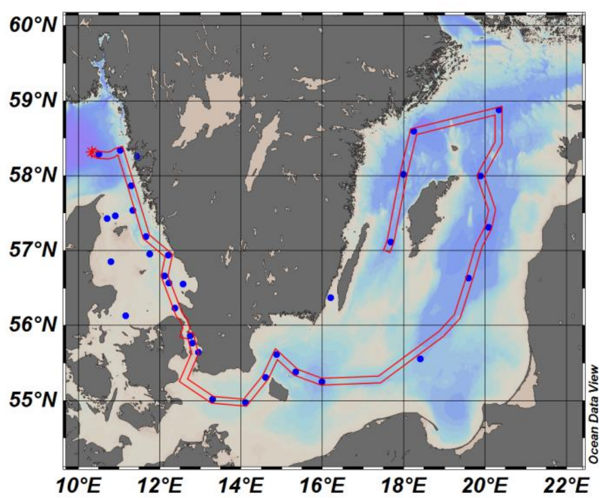
Included parameters; salinity, temperature, density and dissolved oxygen from CTD.

SMHI cruise January
20170108 – 20170115
CTD section



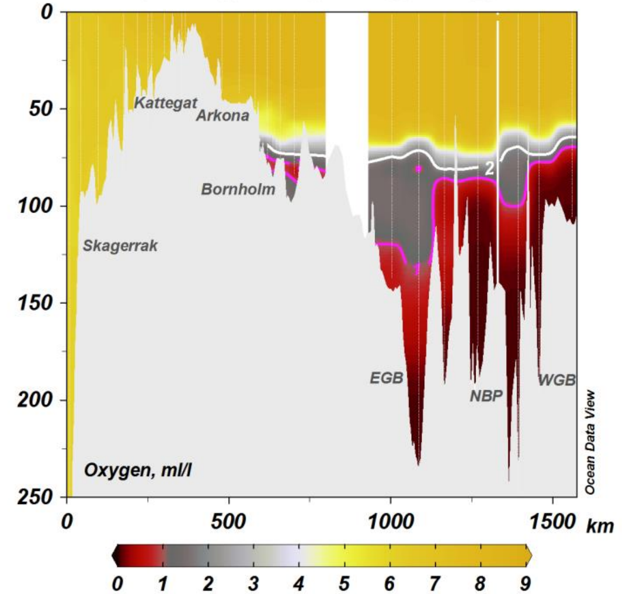




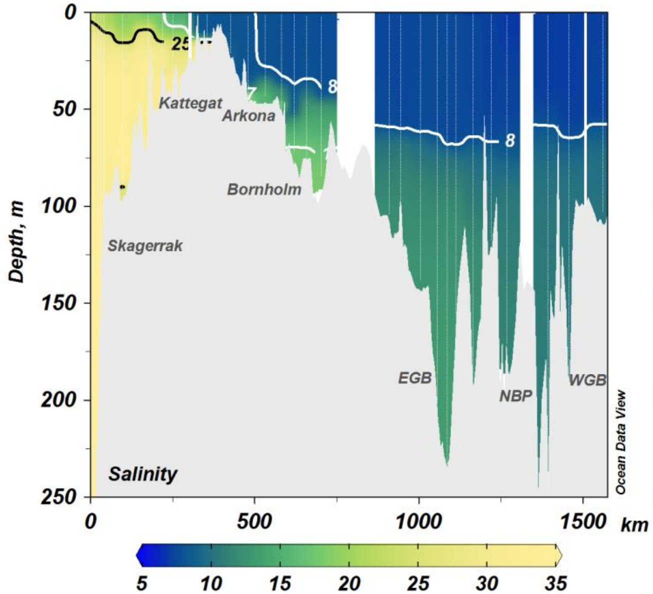


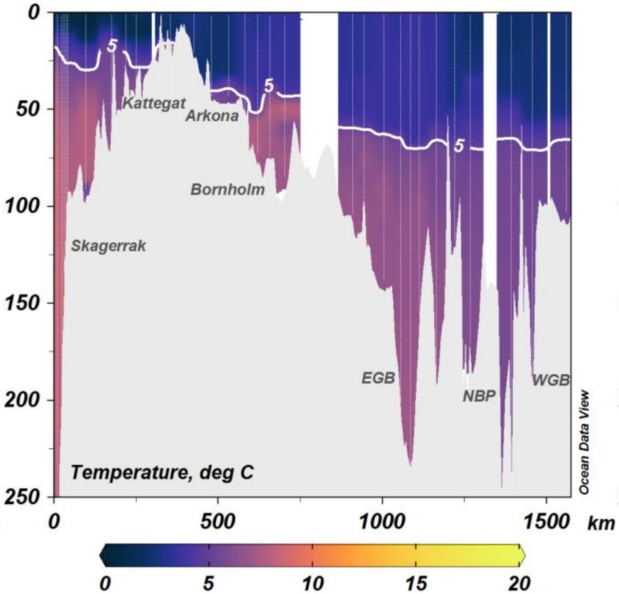
Isolines
Salinity: 6, 8, 17 (white), 25 (black)
Temperature: 5
Oxygen: 1 (pink), 2 (white)
Density: 10

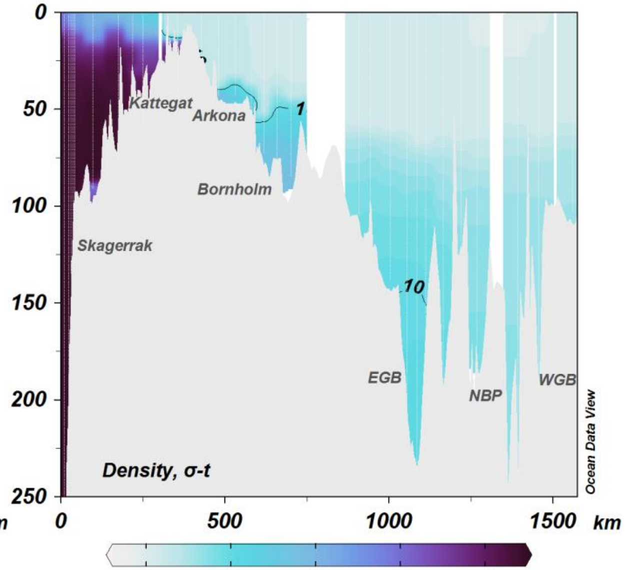
Thin vertical lines are stations

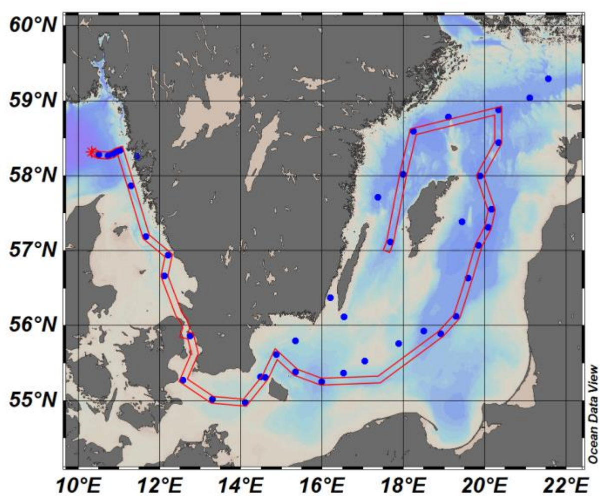


SMHI cruise February
20170209 – 20170217
CTD section



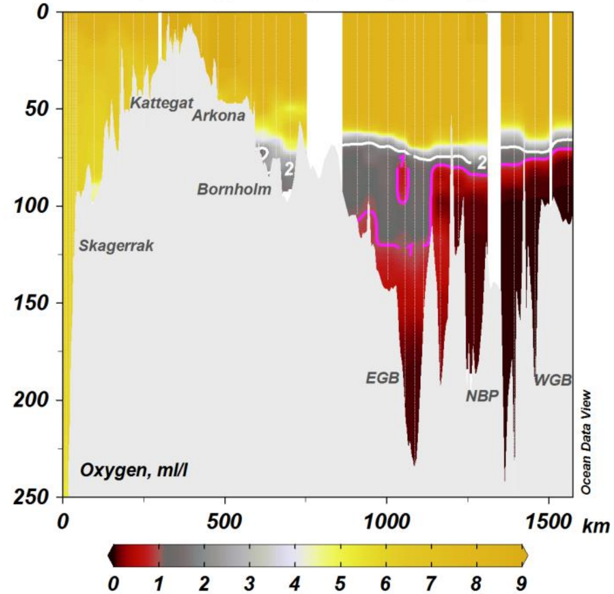




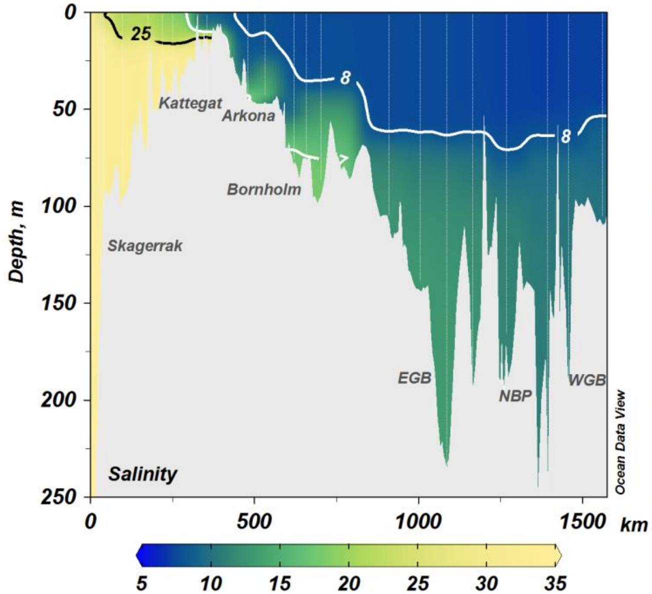


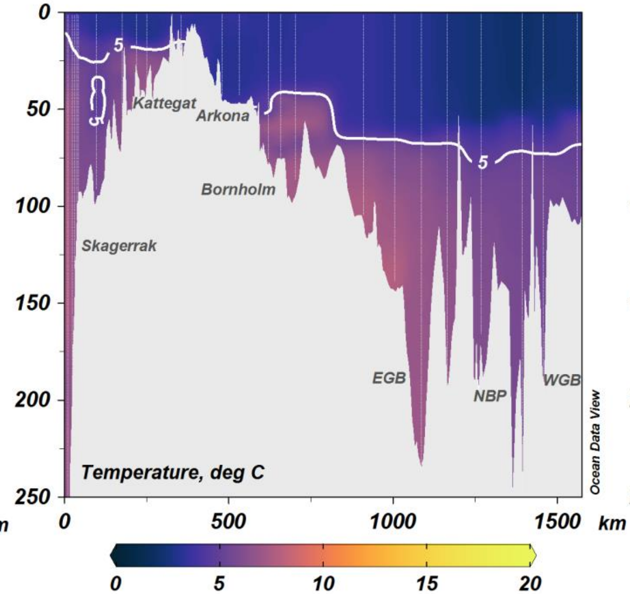
Isolines
Salinity: 6, 8, 17 (white), 25 (black)
Temperature: 5
Oxygen: 1 (pink), 2 (white)
Density: 10

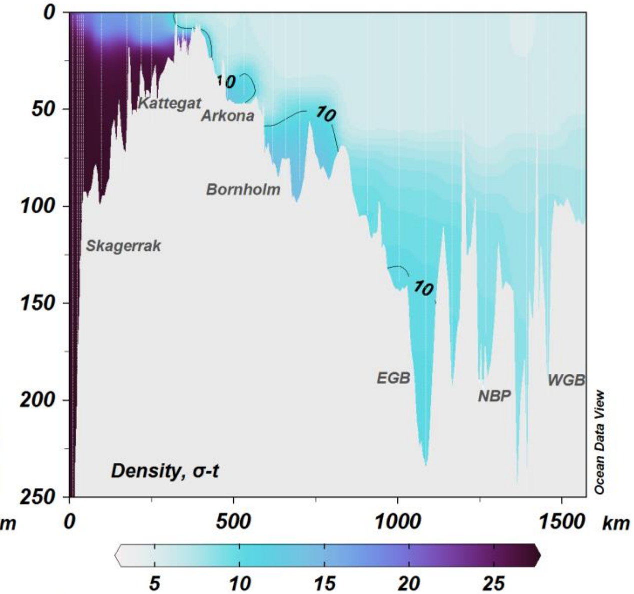
Thin vertical lines are stations

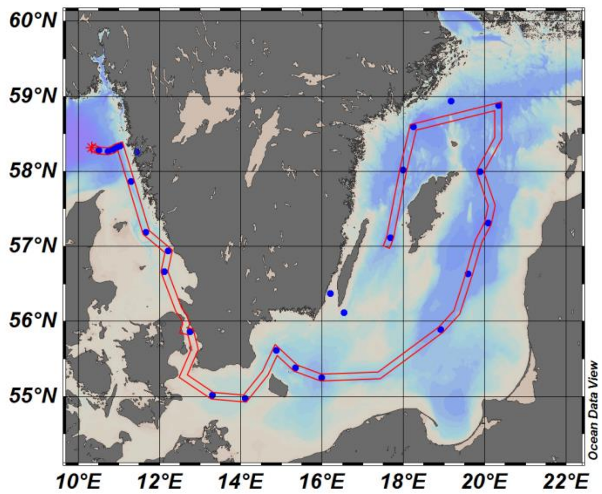


SMHI cruise March
20170309 – 20170316
CTD section



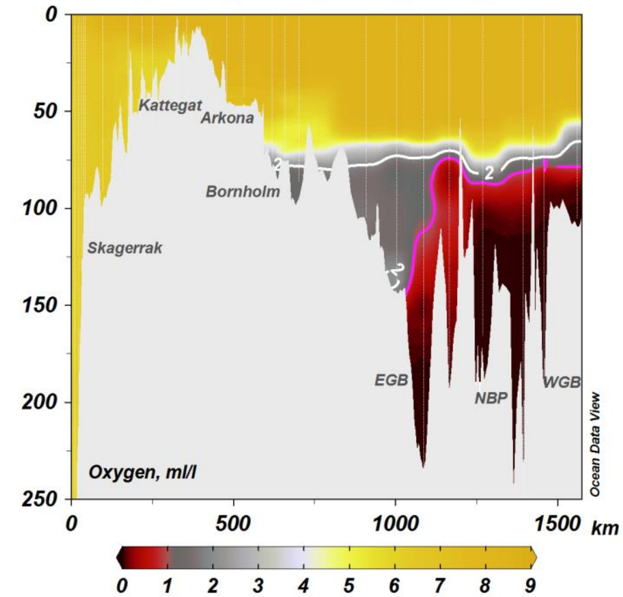




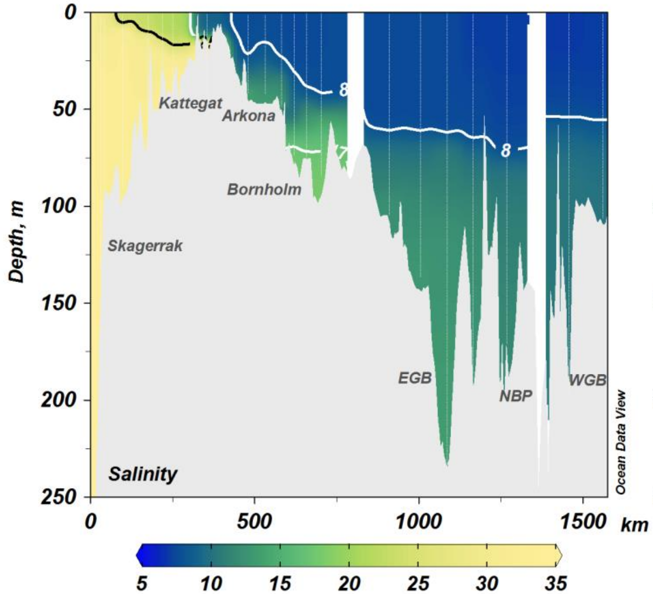


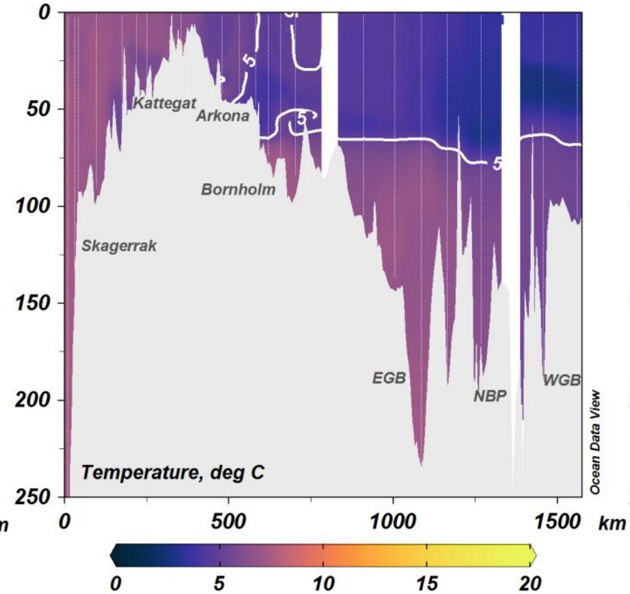
Isolines
Salinity: 6, 8, 17 (white), 25 (black)
Temperature: 5
Oxygen: 1 (pink), 2 (white)
Density: 10

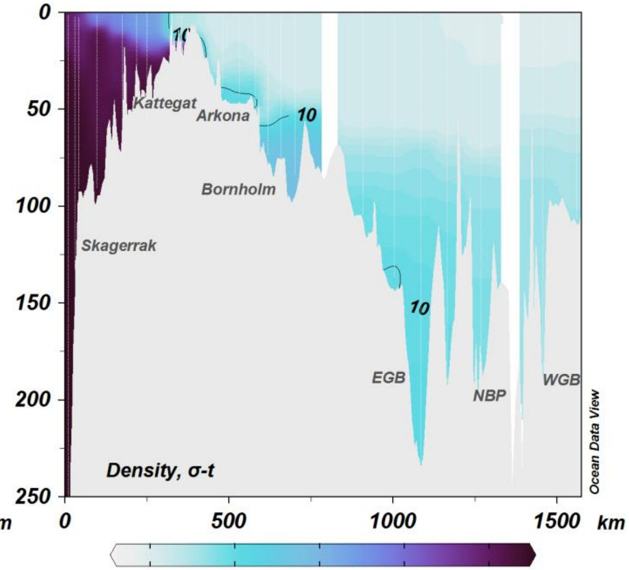
Thin vertical lines are stations

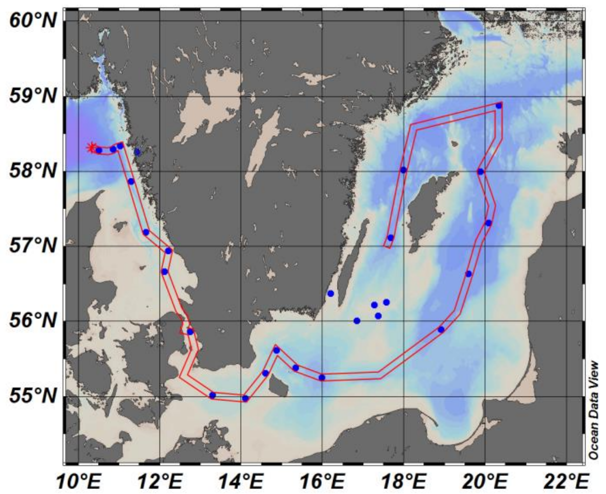


SMHI cruise April
20170418 – 20170425
CTD section









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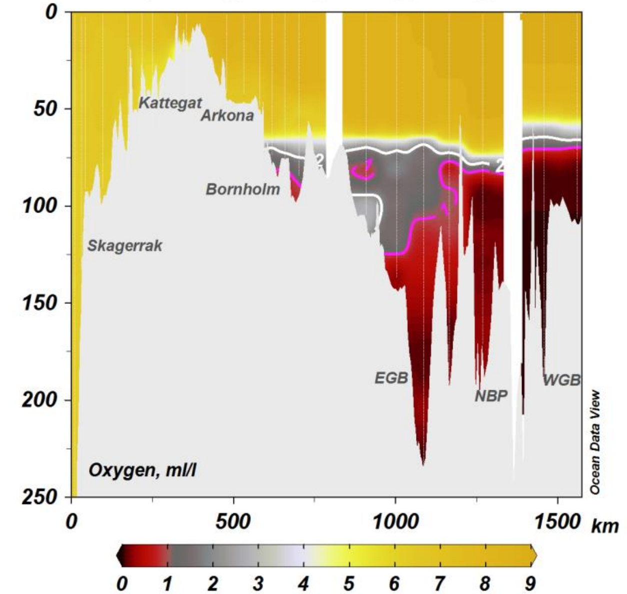
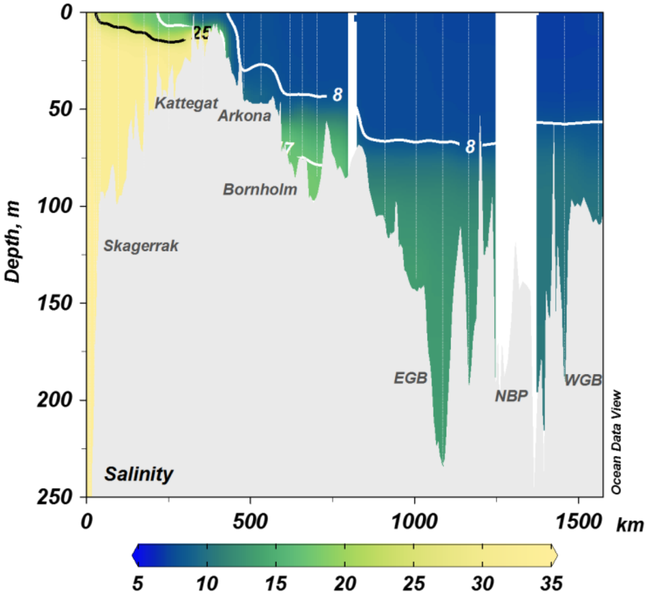
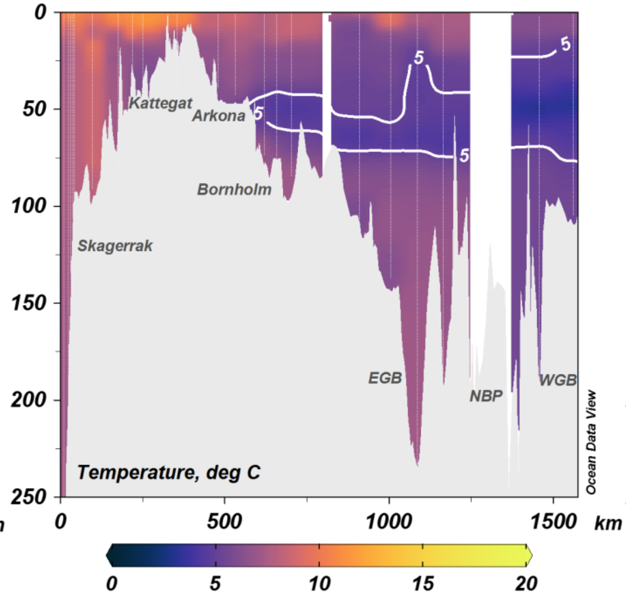
Oxygen: 1 (pink), 2 (white)
Density: 10

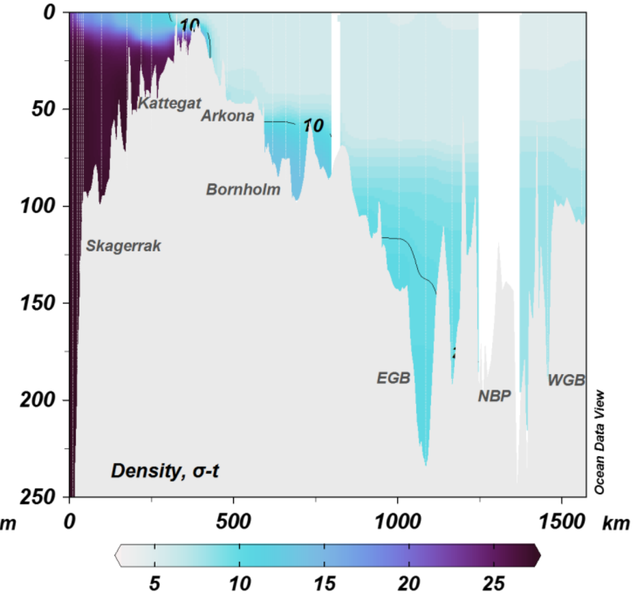
Thin vertical lines are stations

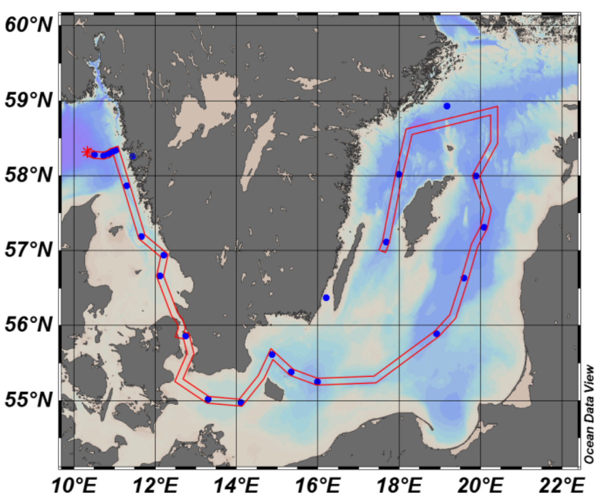


SMHI cruise May
20170516 – 20170523
CTD section









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Density: 10

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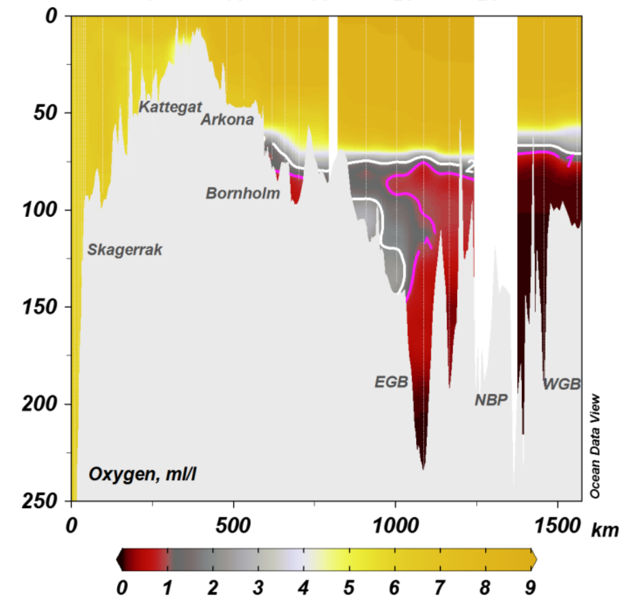
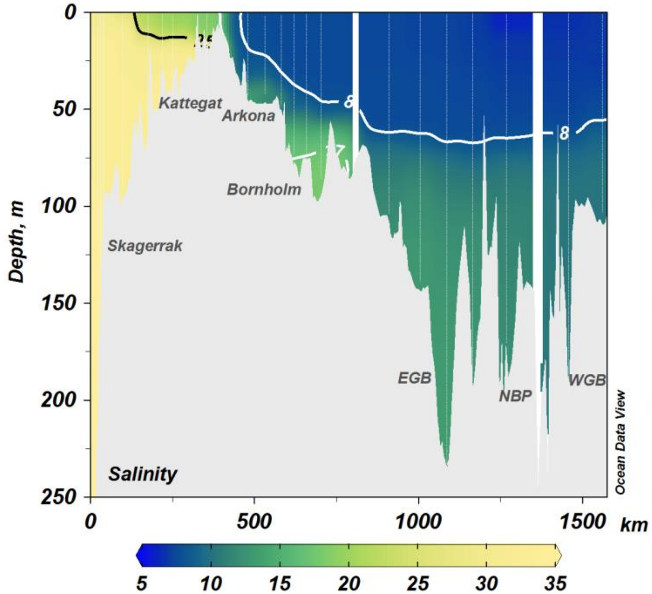
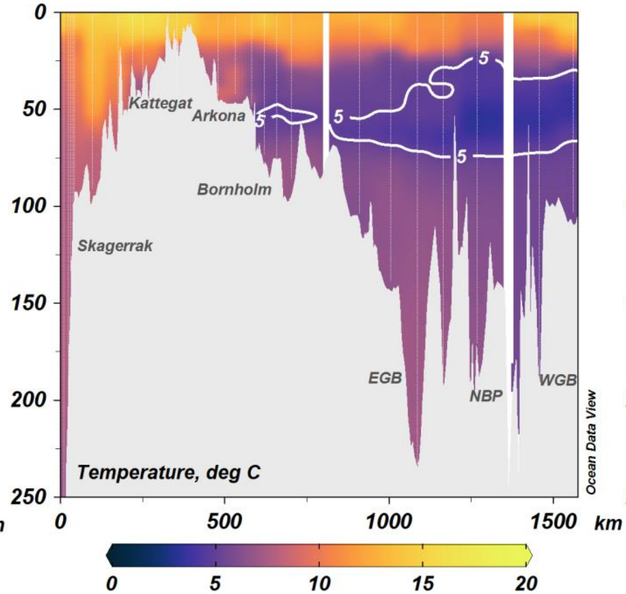
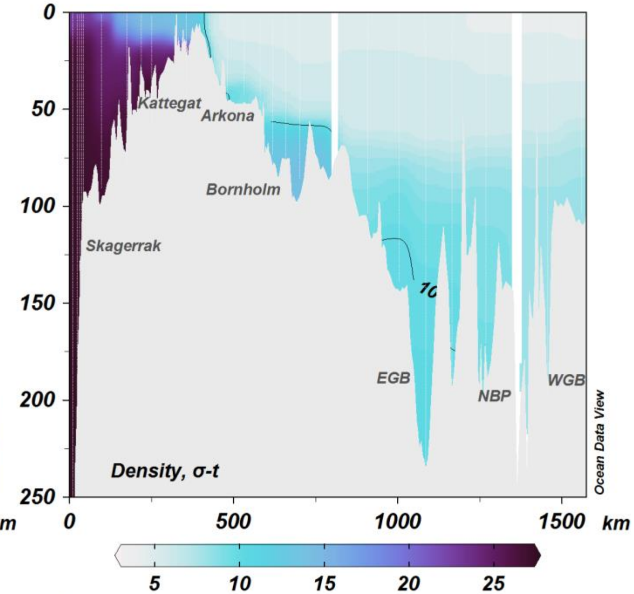
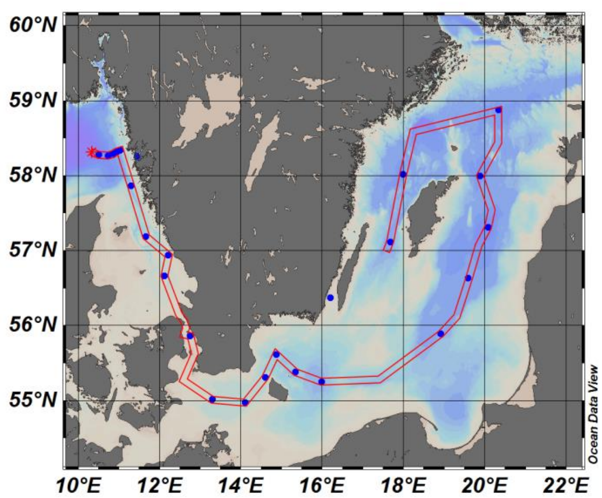


SMHI cruise June
20170614 – 20170621
CTD section









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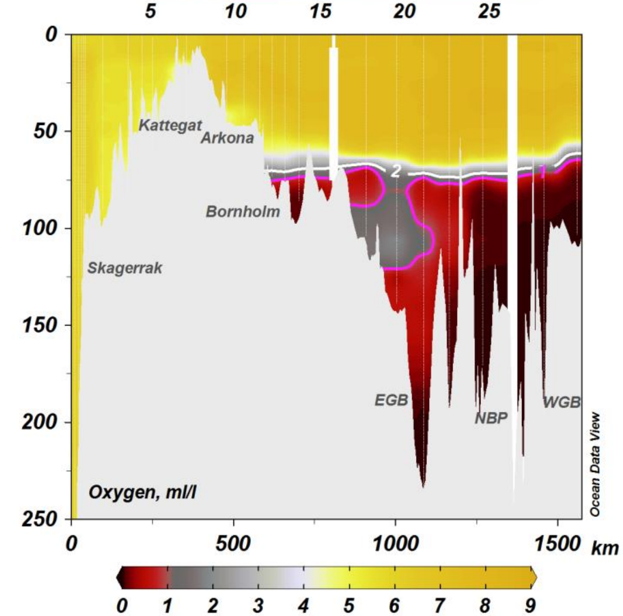
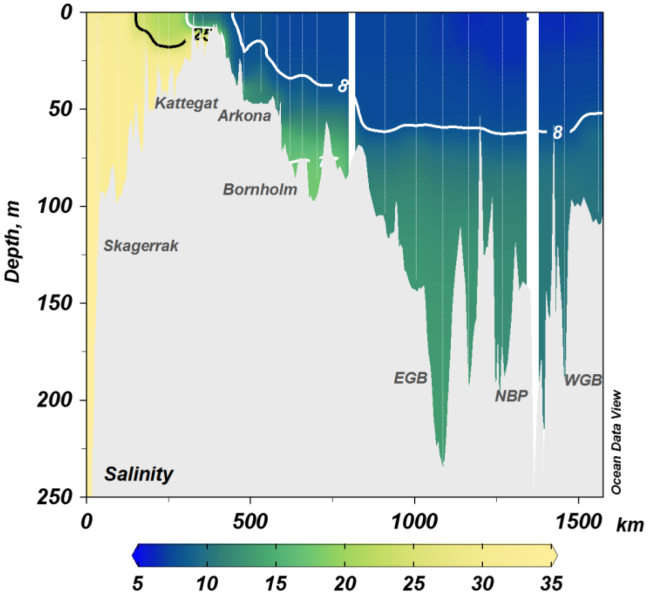
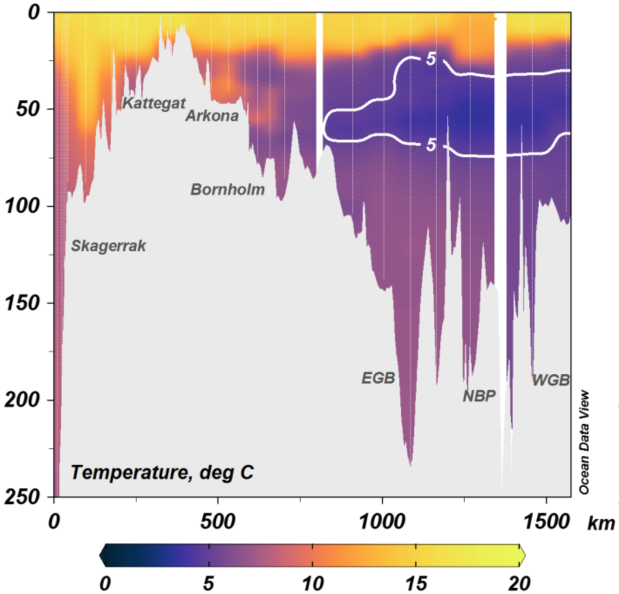
Temperature: 5
Oxygen: 1 (pink), 2 (white)
Density: 10

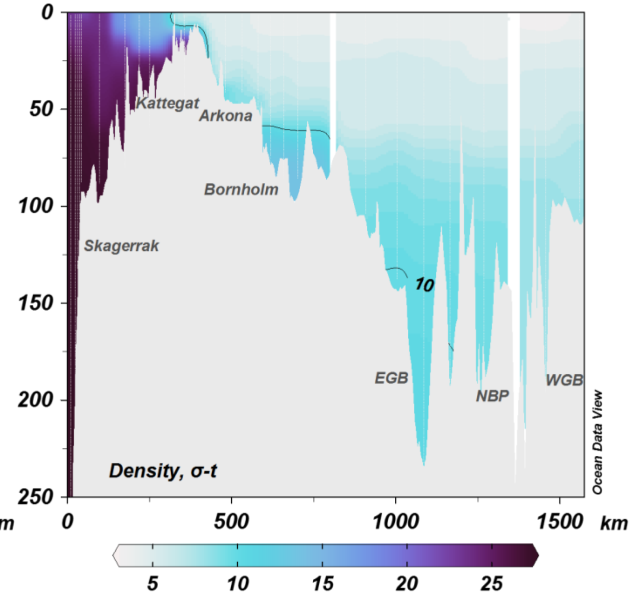
Thin vertical lines are stations

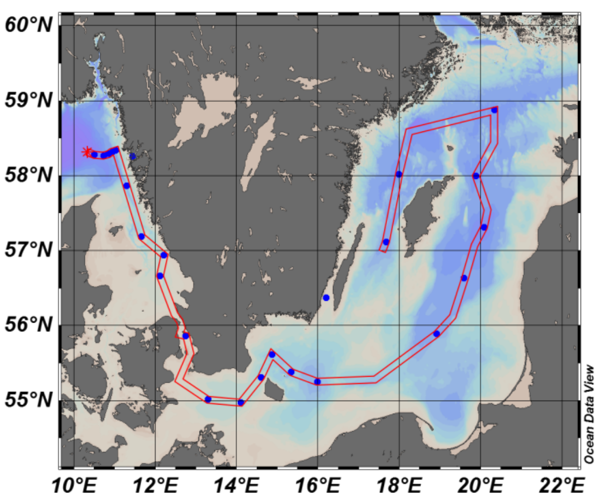


SMHI cruise July
20170710 – 20170717
CTD section









Isolines
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Temperature: 5
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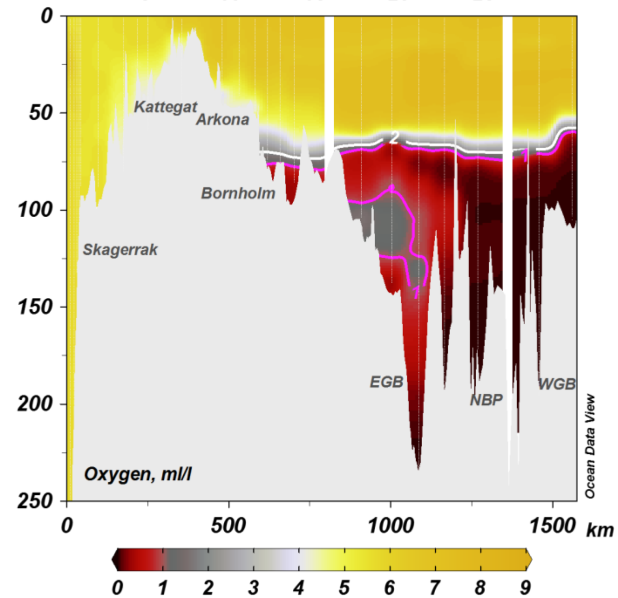
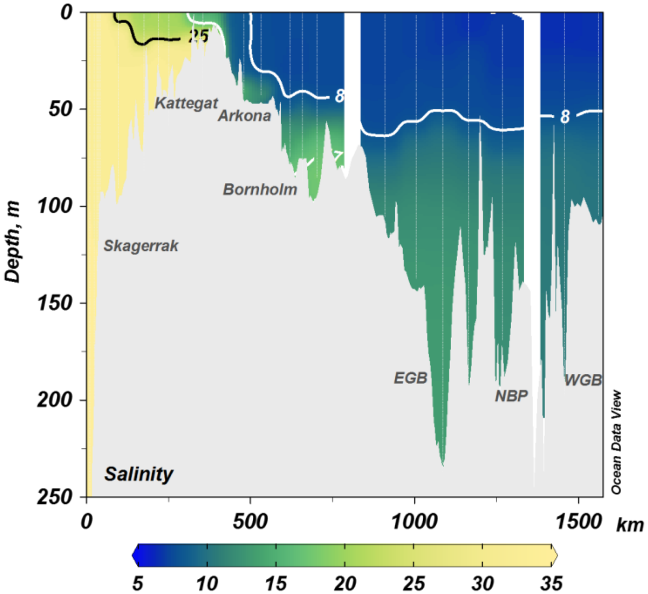
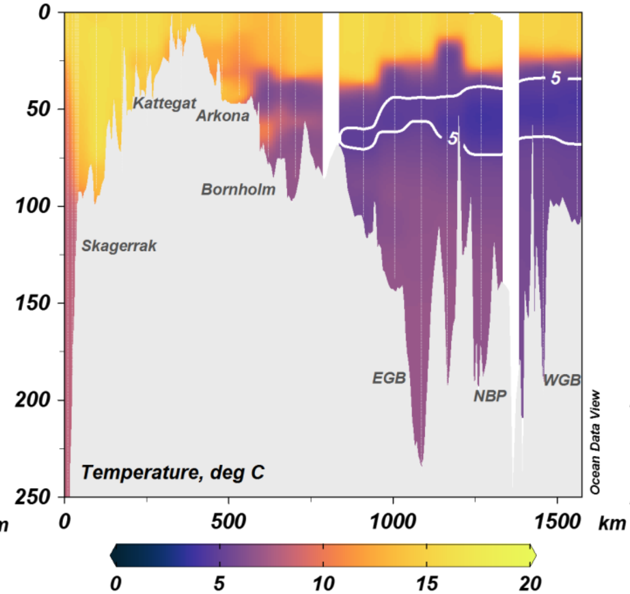
Density: 10

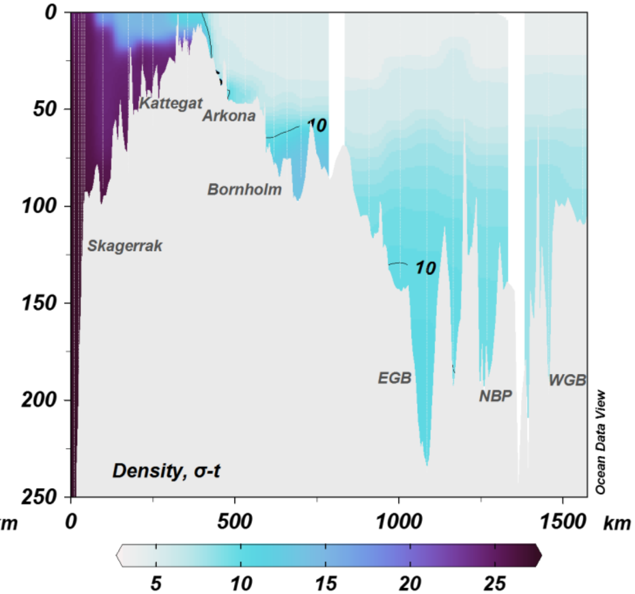
Thin vertical lines are stations

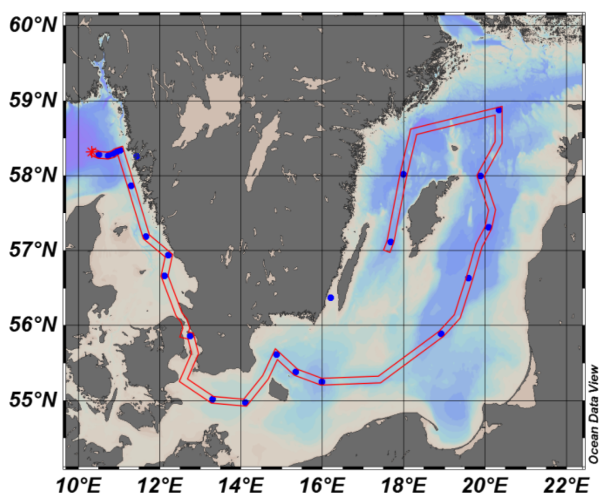


SMHI cruise September
20170912 – 20170918
CTD section









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Density: 10

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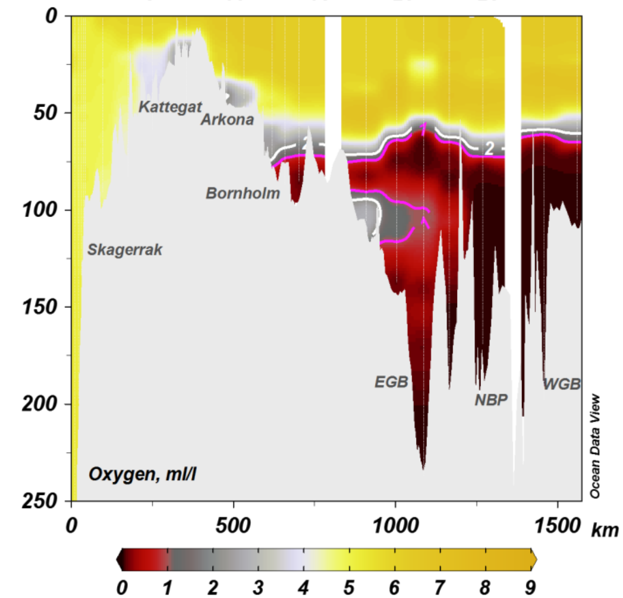
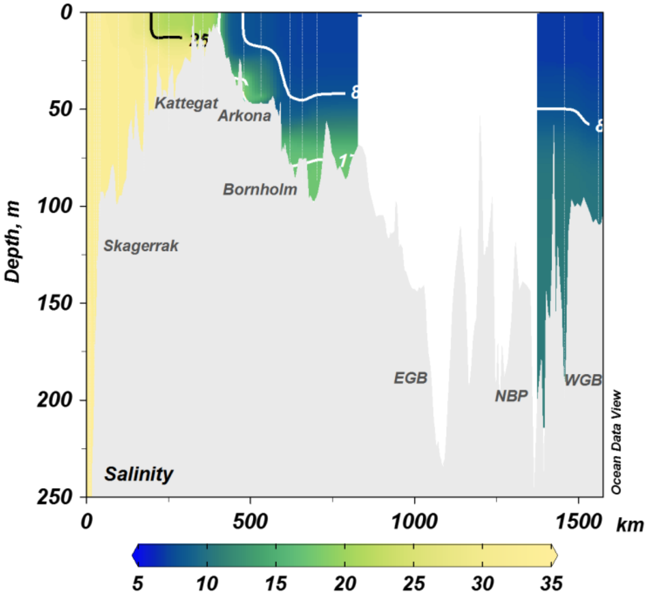
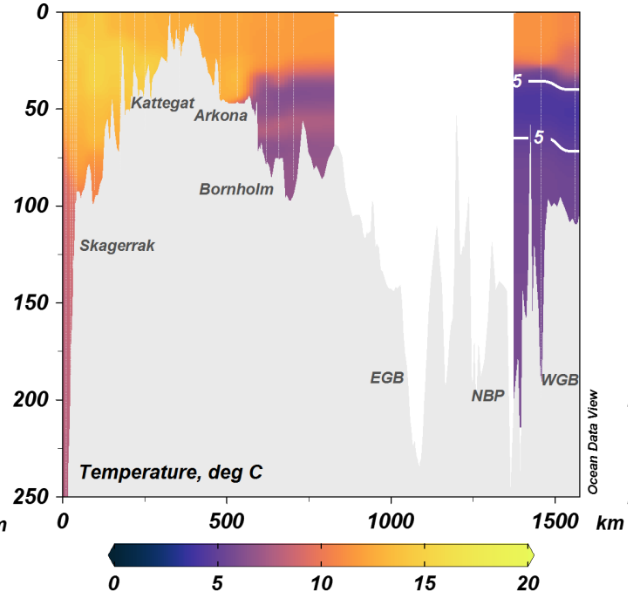
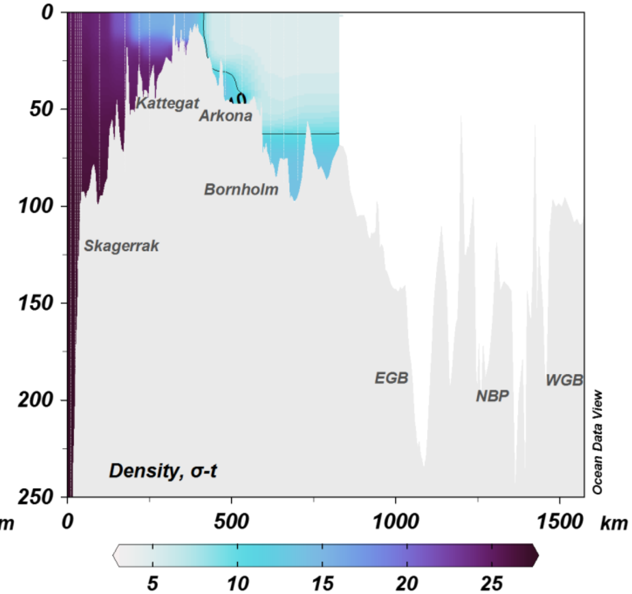
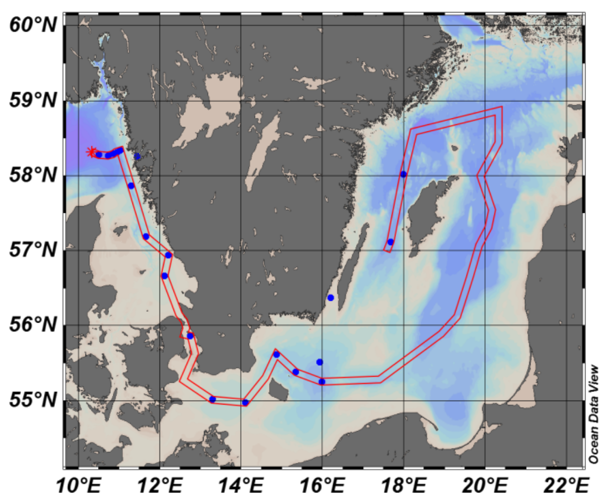


SMHI cruise October
20171010 – 20171016
CTD section









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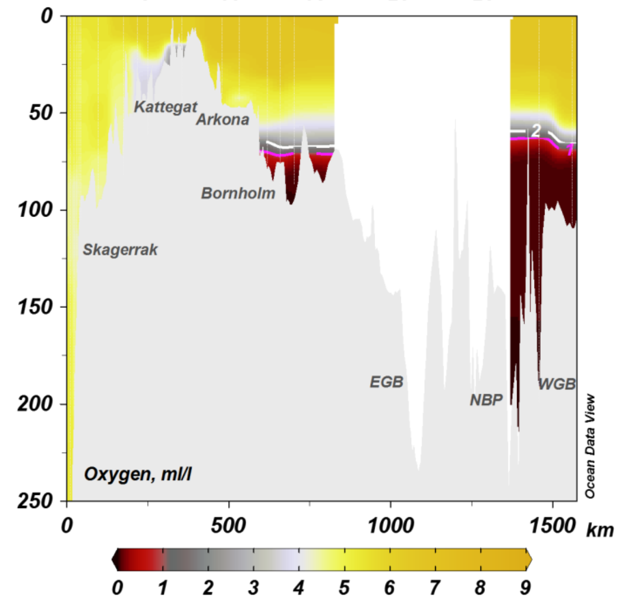
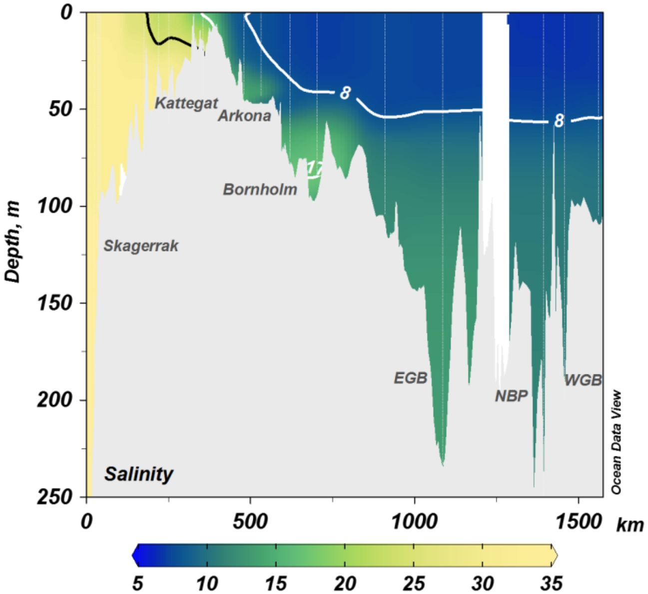
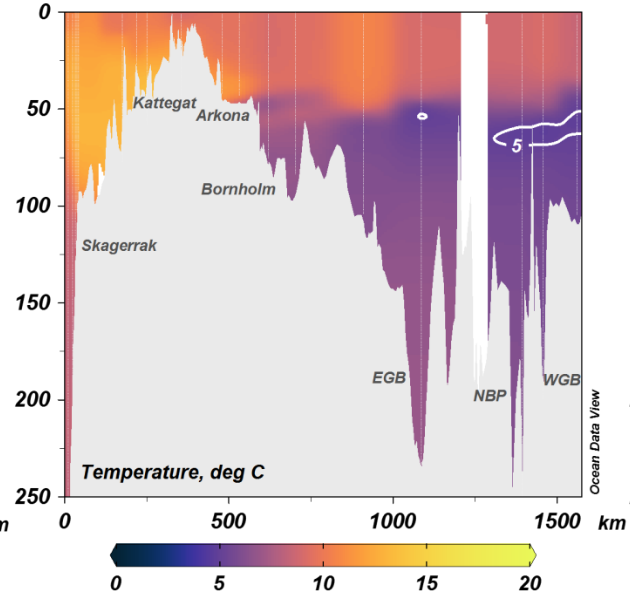
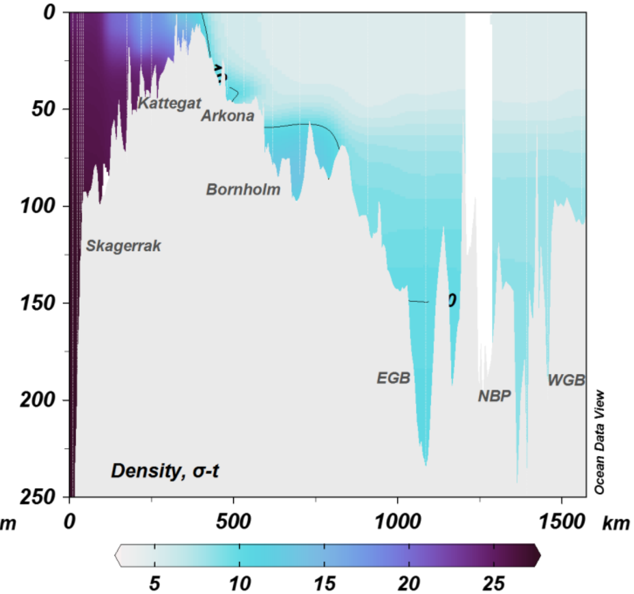
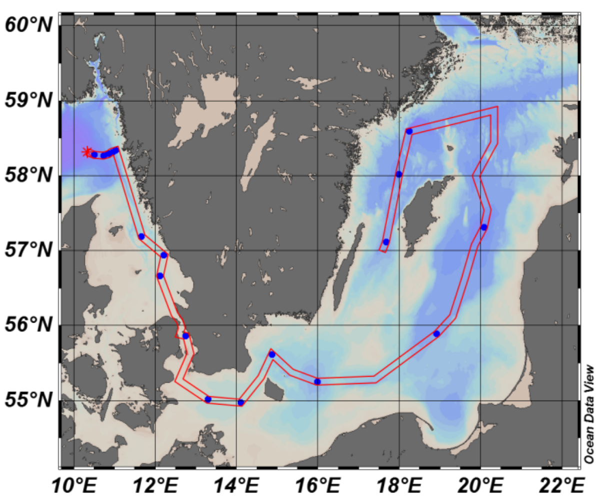


SMHI cruise November
20171107 – 20171114
CTD section









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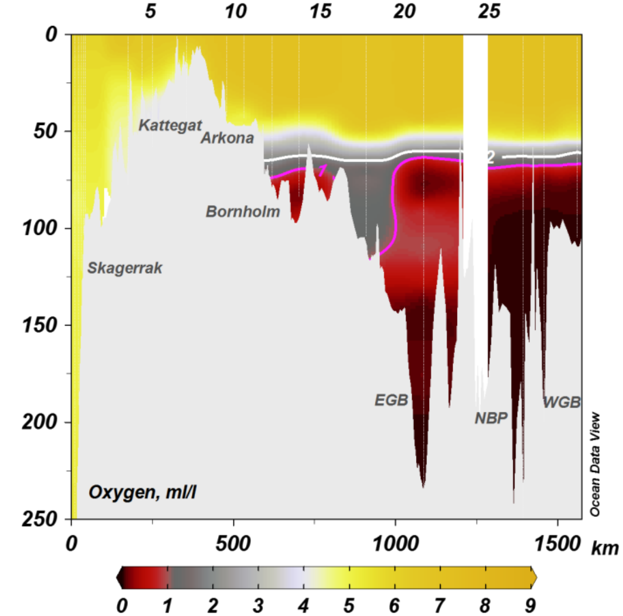
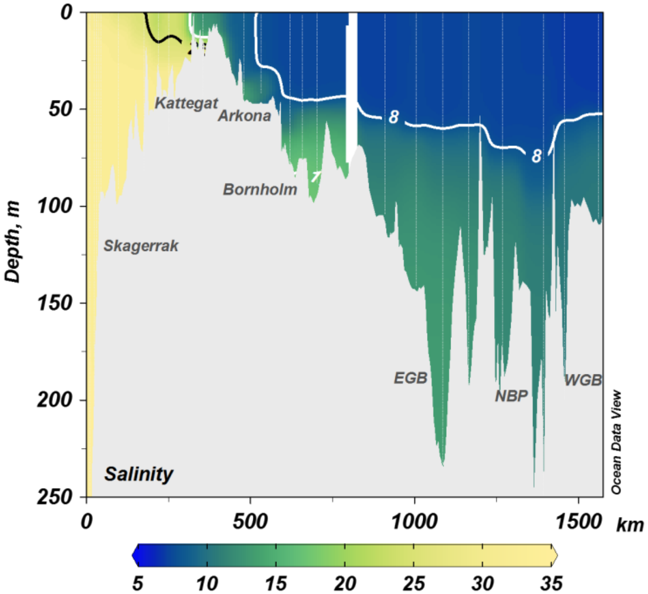
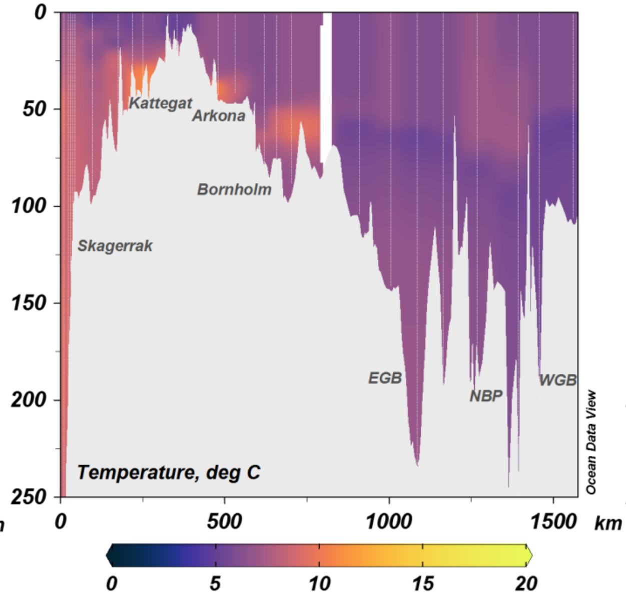
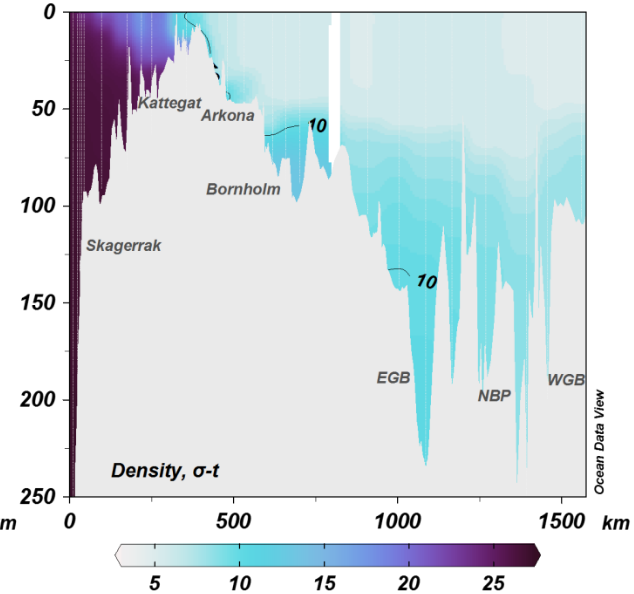
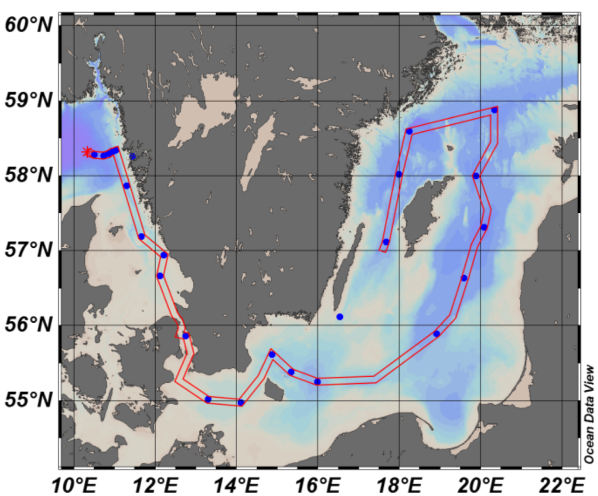


SMHI cruise December
20171213 – 20171220
CTD section









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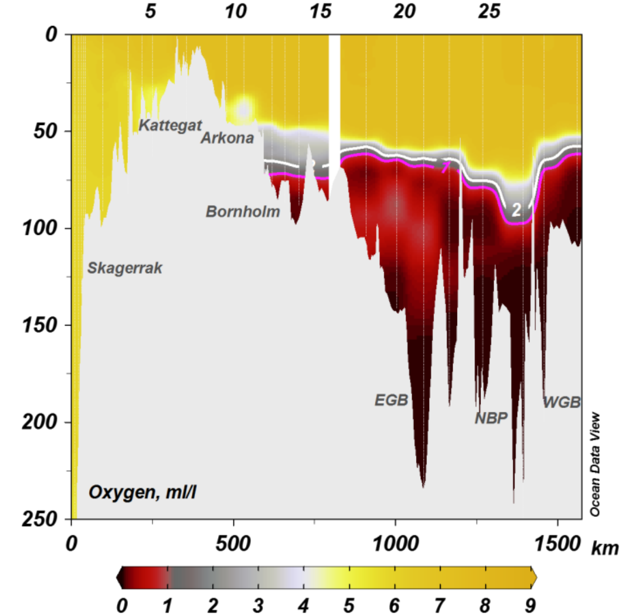

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