Lars Andersson

Annual report 2011

Annual Report 2011

Table of content

Exceptional events 2011

- Oxygen conditions were extremely bad in the deep water of the central and northern Baltic Proper.
- A large inflow to the Baltic took place at the end of the year.

Summary of the state of the environment

2011 was warmer than normal in the whole of Sweden, also the main part of the country had more precipitation than normal. The most extreme weather conditions occurred in the northern part, where 2011 was one of the warmest and wettest years ever recorded. The year began with a mild January followed by a cold February. This fact, together with a very cold December 2010, made the winter 2010/2011, the coldest since the 1980s, at least in parts of Götaland and the northernmost Sweden. The cold winter was followed by a warm spring, especially April was in many places the warmest ever recorded. The summer was warm and very wet, with a lot of thunder. The warm weather continued during autumn, which in the northern part of Sweden was the warmest so far recorded. The year ended with stormy weather, but it was also mild and dry.

The ice season 2010/2011 can be classified as severe. Despite the mild January, the cold December 2010 and cold February 2011 was enough to cause an extensive ice cover. The maximum ice extent occurred in the end of February when about 300 000 square kilometres of the Baltic Sea was covered. This is the largest areal extension since 1987. The ice started to melt in March and during April the rest of the ice disappeared quickly.

Fresh water drainage to the Skagerrak was higher than normal in April, well below mean in May and much higher than normal during the whole summer, from June to September. Run off to the Kattegat had two peaks, one in January and one in February. As in Skagerrak, the fresh water supply was well below mean in May and higher than normal, from June to October, in September three times normal values.
Freshwater supply to the Baltic Proper was above normal during the period from January to Mars and also well above normal during late summer, from July to October. During these periods the run-off was about twice as high as normal.
The Bothnian Sea and Bothnian Bay shared the same pattern of freshwater supply. Run-off had a strong peek already in April but was much lower than normal in May. During autumn, September to October, freshwater supply was twice normal values.

Hydrography and hydrochemistry

A large inflow, about 50 km^3, of oxygen rich water with high salinity, from the Kattegat to the Baltic, took place trough Öresund from mid-November to mid-December. Beside this some minor inflows also took place during the year, three of about 20 km^3, in February, March and September and three of about 10 km^3, in May, August and October, respectively. The effect of the smaller inflows could be seen in the Arkona Basin and in parts of the Bornholm Basin, but they were not large enough to affect conditions further into the Baltic Sea. The effect of the large inflow could also be seen in the southern parts during the end of the year. The total volume of this inflow, including the Danish Belts, was probably 150 km^3, but the inflow did not reach further into the central Baltic until 2012.

Skagerrak, Kattegat and the Sound

Surface temperature in Skagerrak was lower than normal during February and March, above mean in July, August and December, otherwise normal throughout the year. In the Kattegat, surface water temperature showed the same pattern.
In Skagerrak the concentrations of phosphate and inorganic nitrogen were normal throughout the year but silicate showed enhanced values during the last months. Also in Kattegat, phosphate and inorganic nitrogen were at normal levels but here silicate was elevated throughout the whole year.
The lowest oxygen concentration in the bottom water was measured during October in the central part of the Sound, 2.10 ml/l, corresponding to a saturation of 35%. In the open Kattegat, the lowest concentration was 2.85 ml/l, equivalent to a saturation of 49%,

measured at the station Anholt E, also in October.
In the open Skagerrak there is normally no shortage of oxygen in the deep water. The lowest value in 2011 was found at the station Släggö, in the mouth of the Gullmar fjord, where concentrations fell to 2.39 ml/l in August.

The diatom spring bloom in the Kattegat and Skagerrak areas occurred in February. No off shore expedition was performed in February why spring bloom data is missing from the national stations except from Släggö which is sampled with the coastal sampling program in addition to the national program. The fish toxic genus *Pseudochattonella* caused elevated chlorophyll concentrations in the Kattegat in March.

There was no diatom bloom in the Kattegat and the Skagerrak during autumn 2011. High chlorophyll concentrations in October-November were caused by an extensive bloom, in both time and space, by the nontoxic dinoflagellate *Ceratium*. During the same period many people reported that the water along the coast was brownish, which is typical during *Ceratium* blooms.

The National Food Agency has warning limits for a number of potentially toxic phytoplankton that may cause mussels to become toxic. Some of these species were observed above their limits from August to December at several stations. Consequently mussels were toxic during the same period with diarrhea toxins above the limits for harvesting. The dinoflagellate genus *Dinophysis* produces diarrhea toxins and *Dinophysis acuta*, the most potent among them, was observed above its warning limit during autumn.

Baltic Proper

Surface water temperatures were at normal levels during the main part of the year, excluding the first months when they were slightly lower in the whole area.
The nutrients, phosphate and silicate showed elevated levels during the first months as well as during the end of the year, while concentrations in other respects remained at normal levels, with one exception. During March extremely high concentrations of inorganic nitrogen was measured in the Arkona Basin. The spring bloom occurred in late March/early April and thereafter nitrogen concentrations remained below the detection limit until October.

Hydrogen sulphide was present in the bottom water of the Bornholm Basin and the Hanö Bight from late summer till the end of the year. It was also measured, for the first time since the 1980s, in the bottom water at the station BCS III-10 in the southeastern area, in October. Otherwise hydrogen sulphide was found in the deep water in the central and northern parts of the Baltic Proper.
Low oxygen levels (<2ml/l) were measured in the Arkona Basin during summer and in the south-eastern Baltic Proper throughout the year.
The oxygen situation in the deep water of the Baltic Proper continues to be very serious. About one fifth (~19%) of the bottom area in the Baltic Proper is affected by anoxia

(oxygen free, with toxic hydrogen sulphide present) corresponding to ~11% of the water volume. Acute oxygen deficiency, with concentrations <2ml/l, affects about 30% of the bottom area, or about 21% of the volume. This is the largest affected volume and area recorded since regular the measurements started in the 1960s. In November/December a large inflow occurred which affected the Arkona Basin and some effects could also be seen in the Bornholm Basin. This inflow will probably affect the more central parts of the Baltic Proper during 2012.

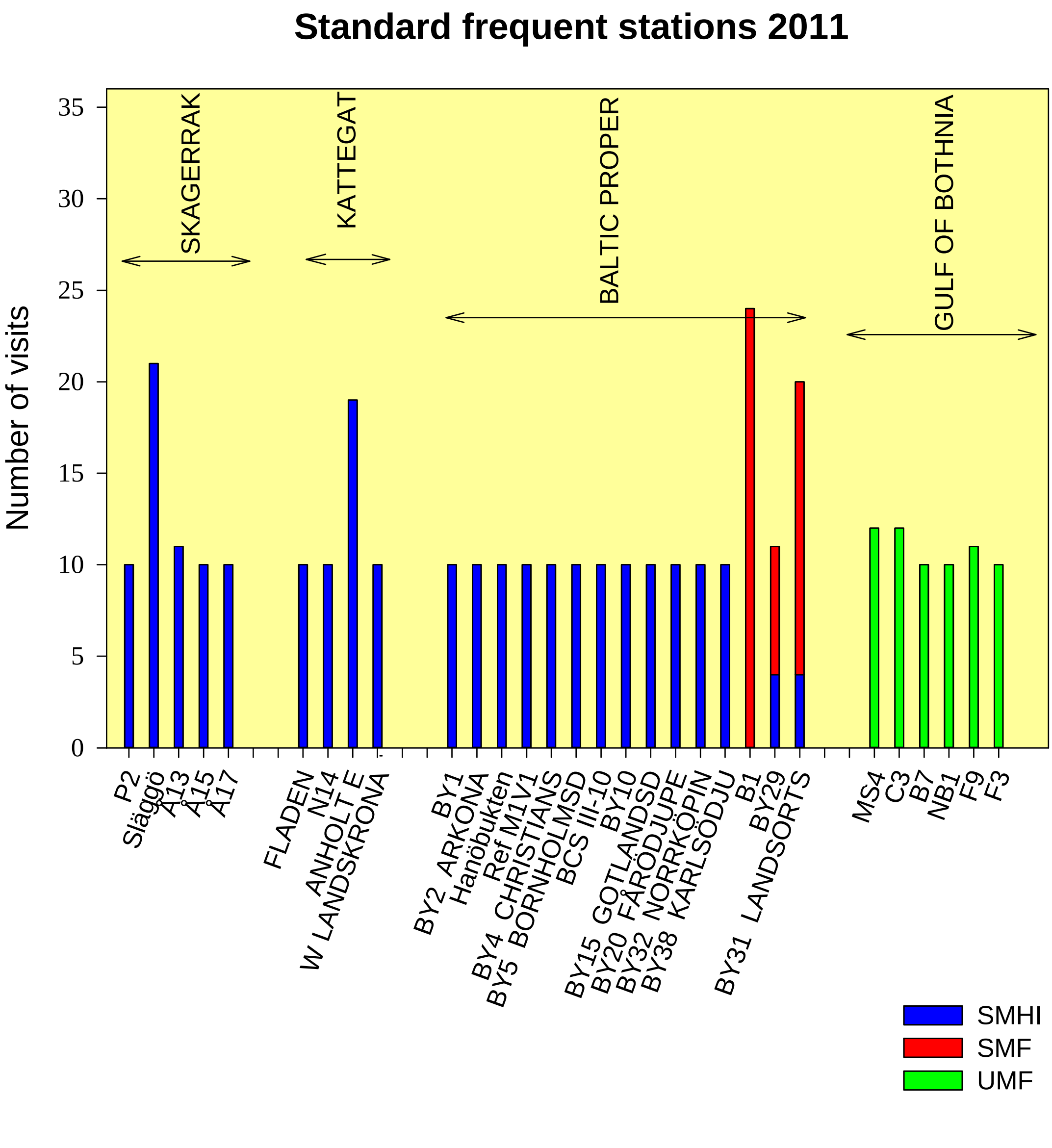
The sampling in April revealed an on-going diatom bloom in the southern Baltic, obvious both from the chlorophyll values as well as from the phytoplankton analysis results from the station BY2 in the Arkona basin amongst others. Usually spring bloom first starts in the Southern Baltic, evolving later northwards and finally takes place in the Bothnian Bay. 2011 was not an exception, as spring bloom was recorded in the beginning of April in the Southern parts of the Baltic Proper, and in the end of April in the Bothnian Bay.

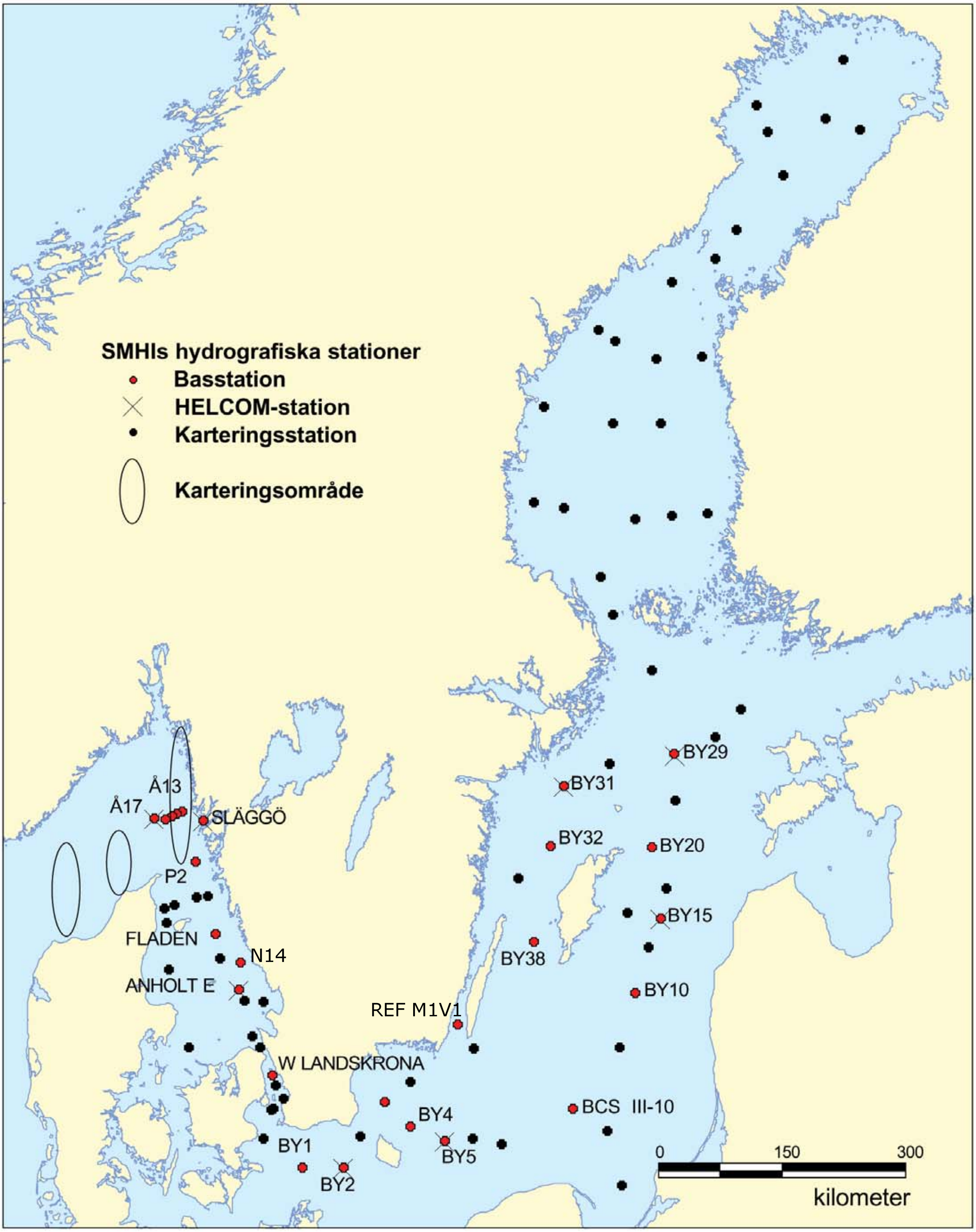
The summer cyanobacteria bloom was prolonged

During summer, surface accumulations of cyanobacteria were observed for more than two months, from June 29th to September 5th. Extensive accumulations were observed for 30 days from July 7th, but no really massive accumulations were present this year. In the Bothnian Sea, blooms normally occur only in August, but this year the bloom period started already in July.

Gulf of Bothnia

Number of visits at standard frequent stations



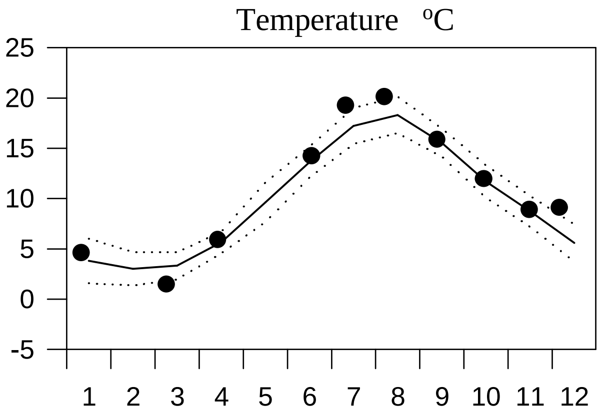


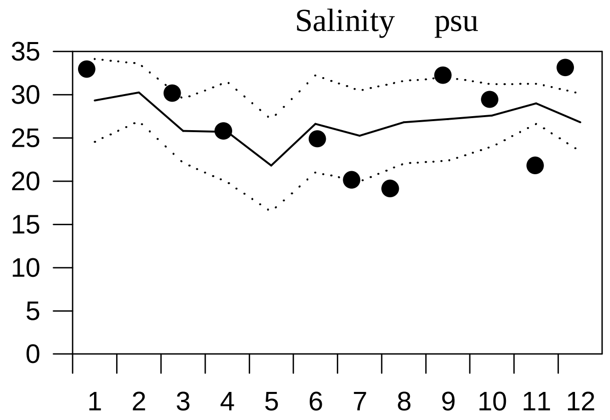
SMHIs hydrografiska stationer
Basstation
HELCOM-station
Karteringsstation
Karteringsområde
Å13
Å17
SLÄGGÖ
P2
FLADEN
N14
ANHOLT E
REF M1V1
W LANDSKRONA
BY1
BY2
BY4
BY5
BCS III-10
BY10
BY15
BY20
BY29
BY31
BY32
BY38
0
150
300
kilometer

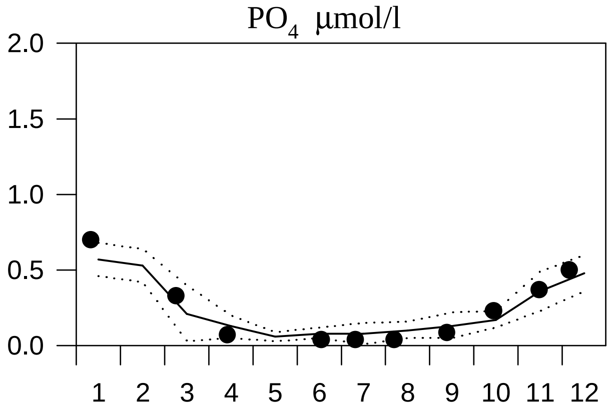
STATION P2 SURFACE WATER

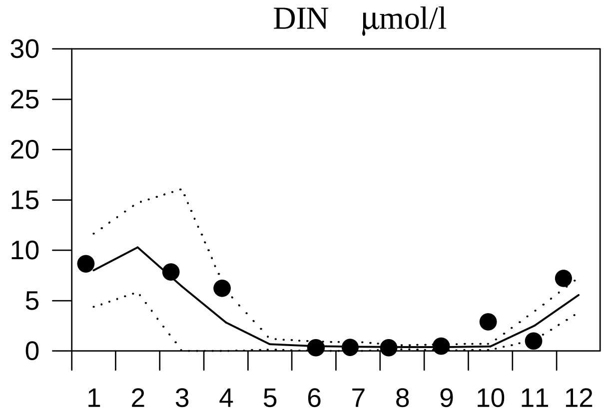
Annual Cycles

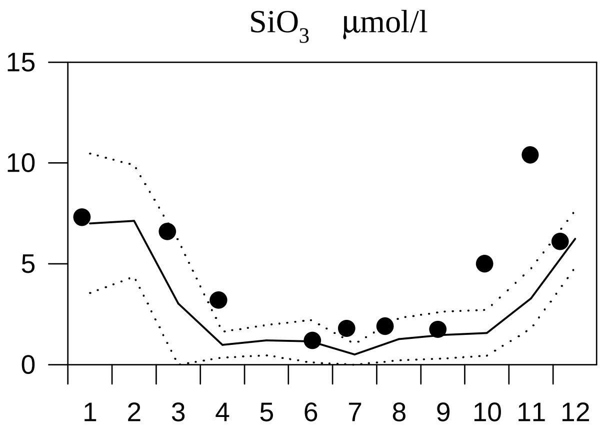
Mean 1995-2004 ······ St.Dev. ● 2011

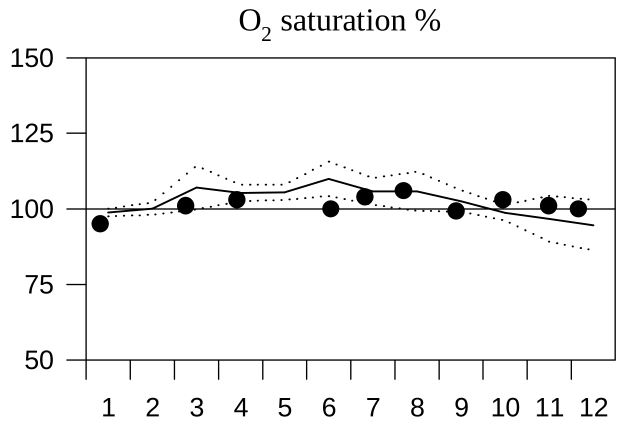




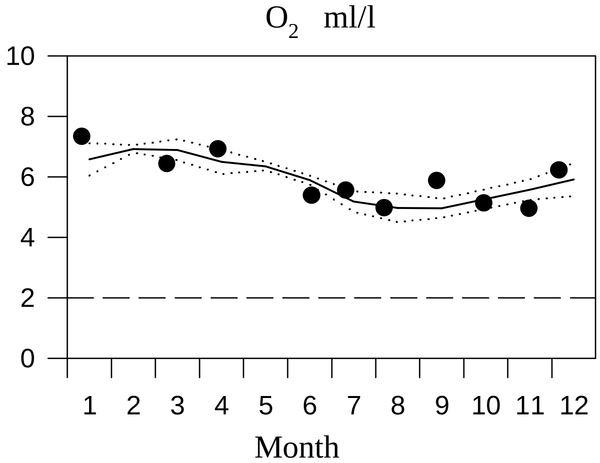


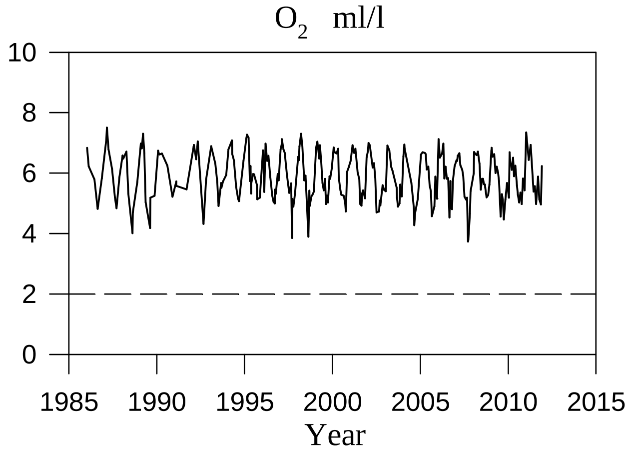




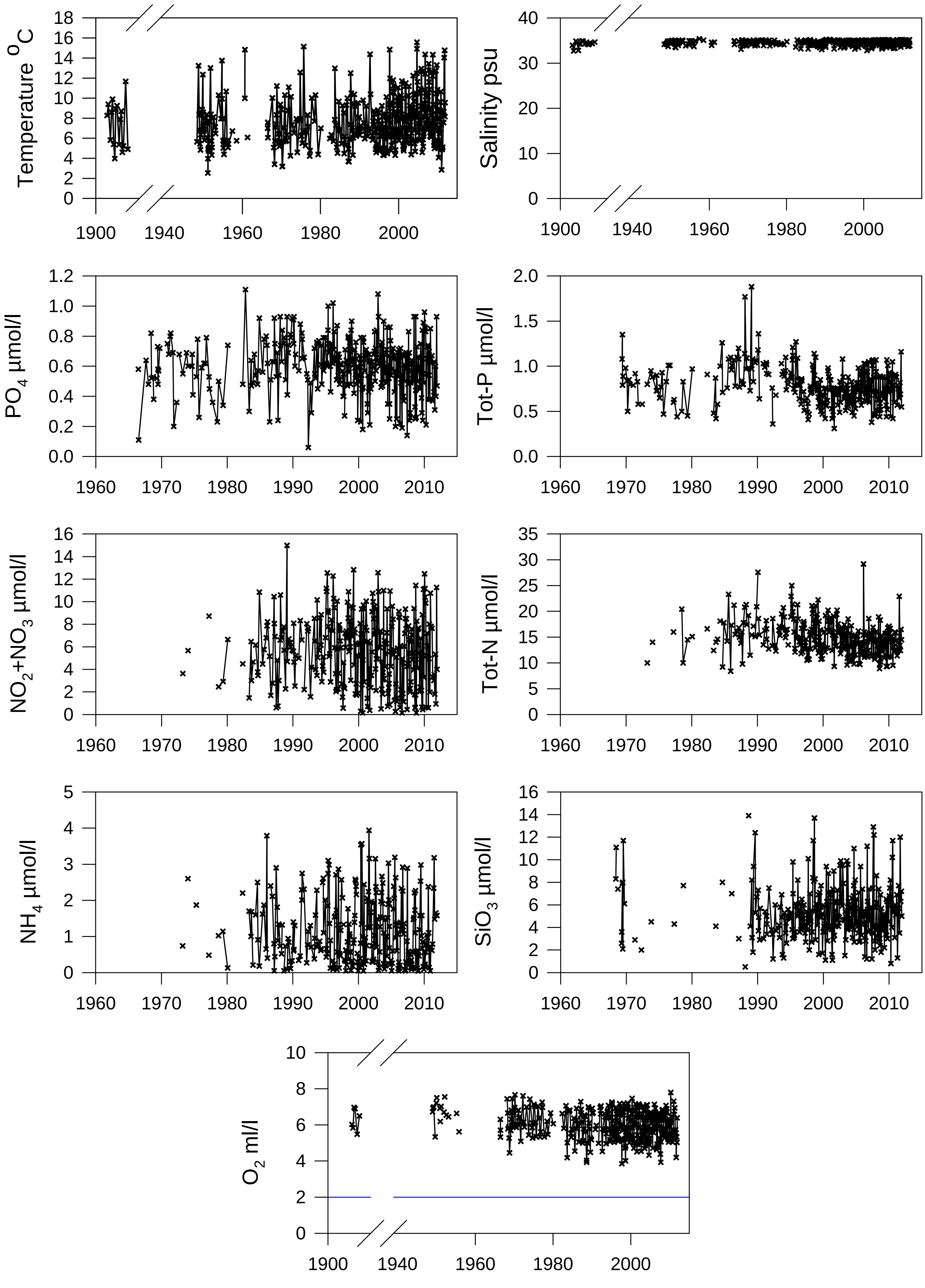


OXYGEN IN BOTTOM WATER





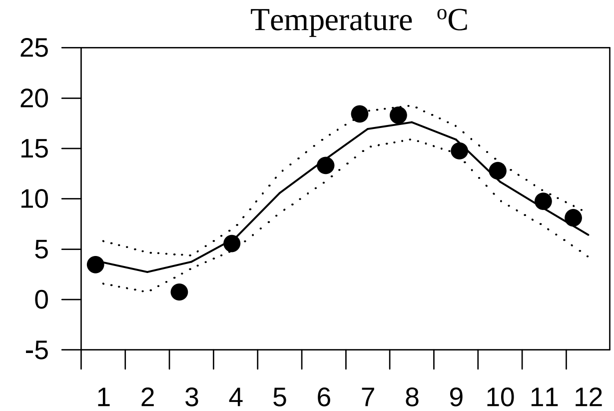
STATION P2 DEEP WATER (75m)

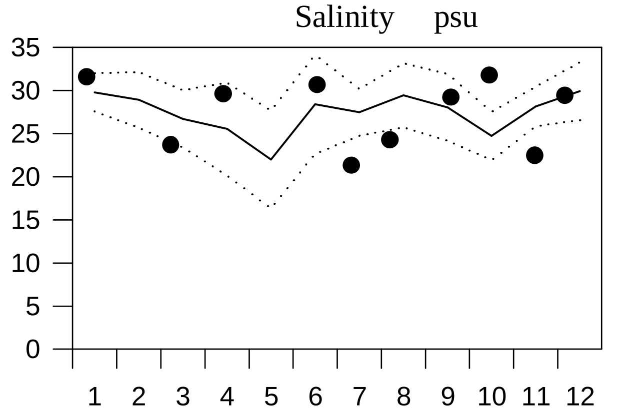


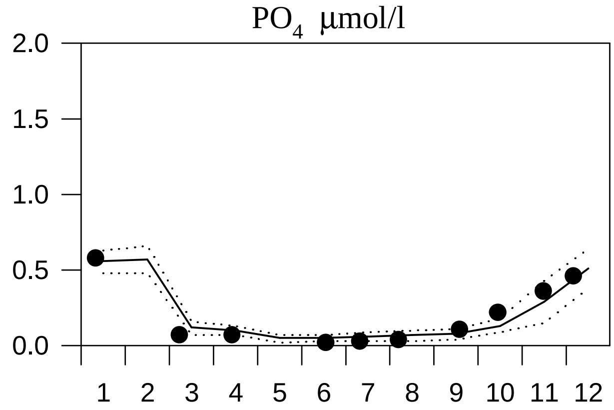
STATION Å13 SURFACE WATER

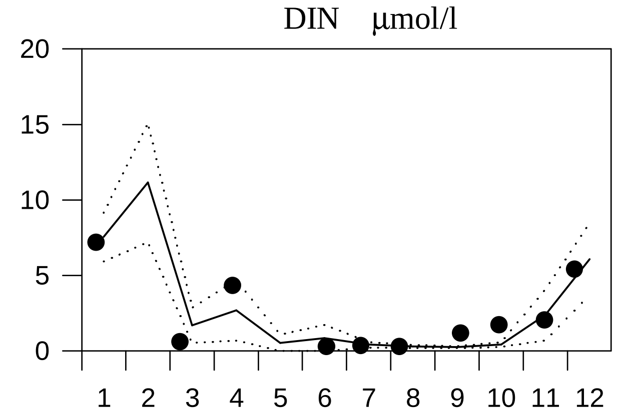
Annual Cycles

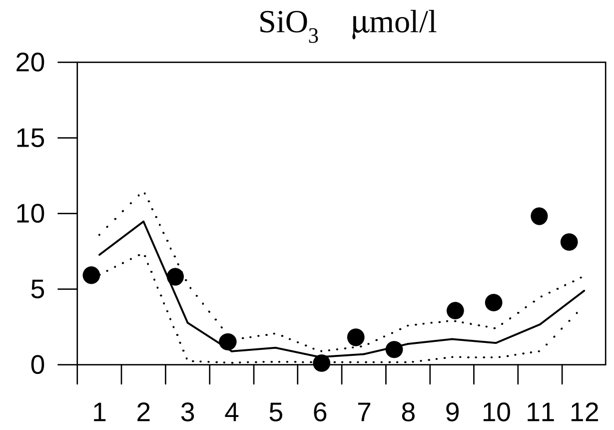
Mean 1995-2004 St.Dev. ● 2011

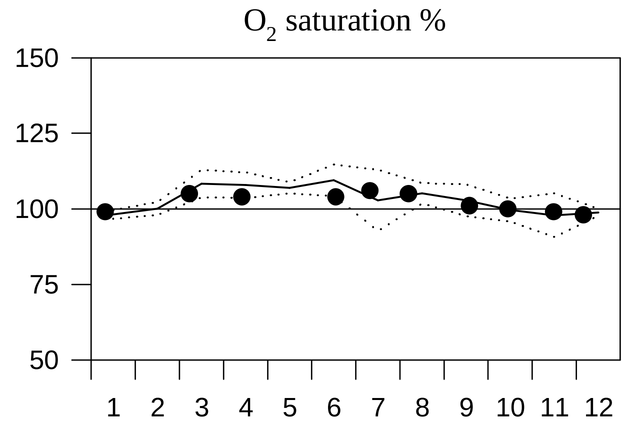




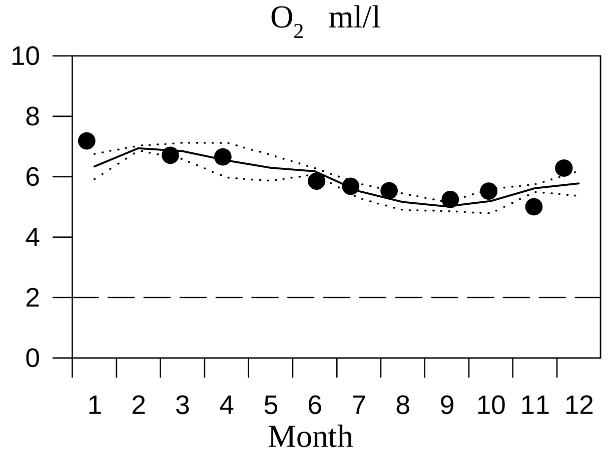


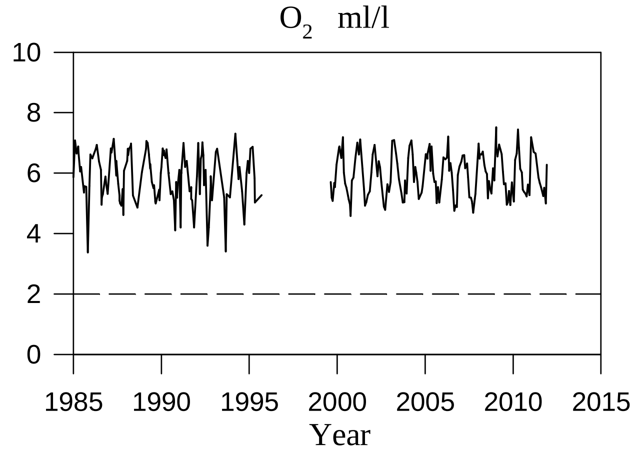




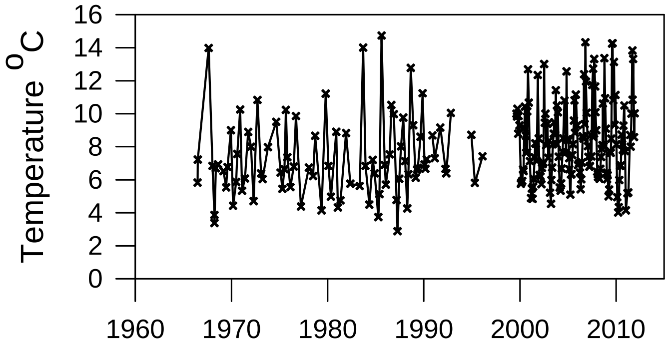


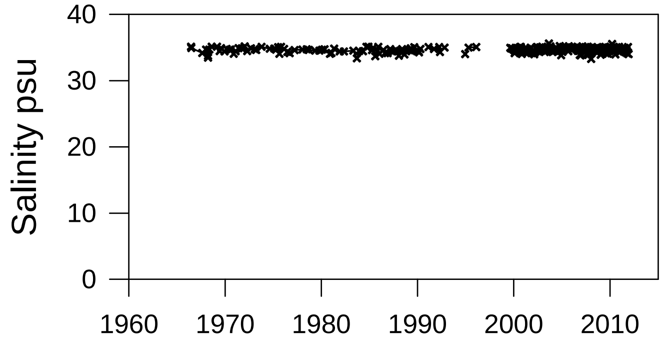
OXYGEN IN BOTTOM WATER

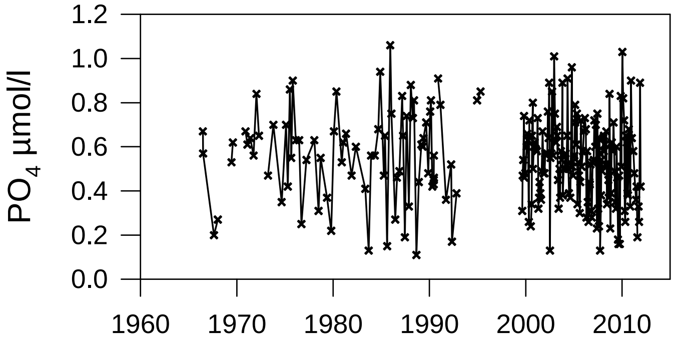


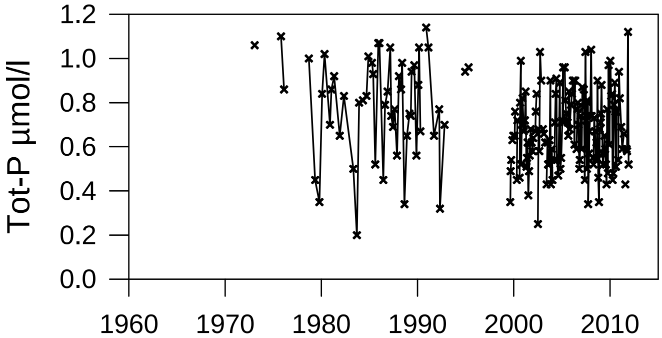


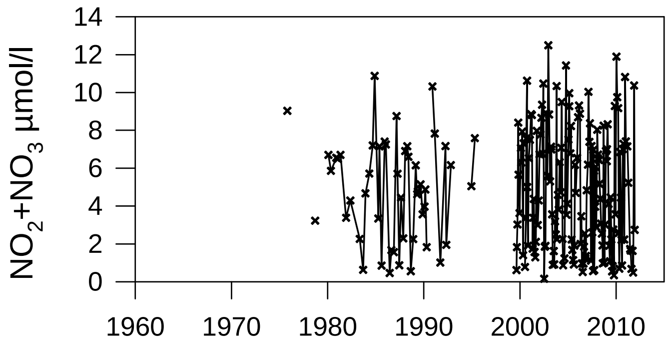
STATION Å13 DEEP WATER (75m)

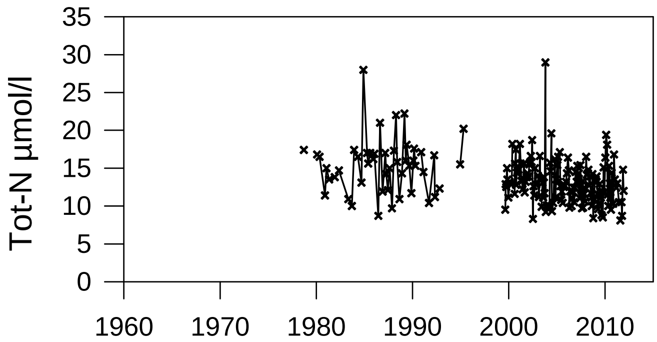


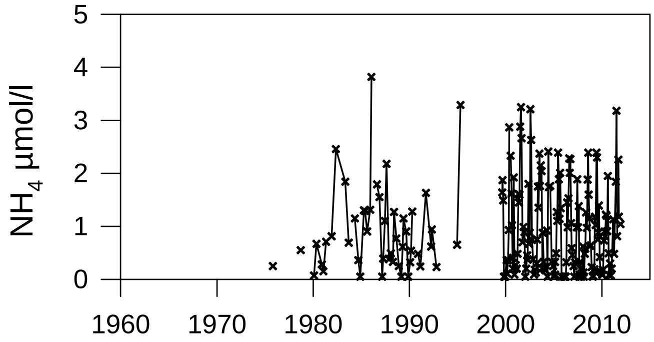


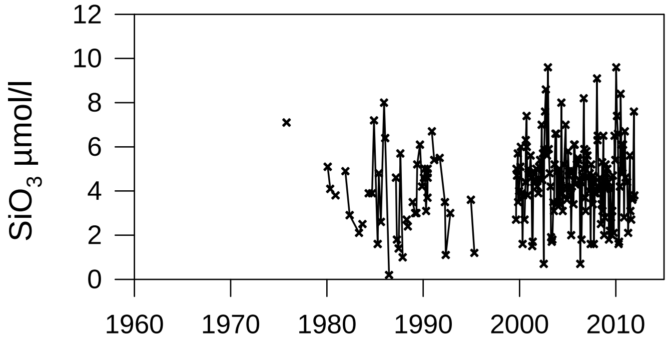


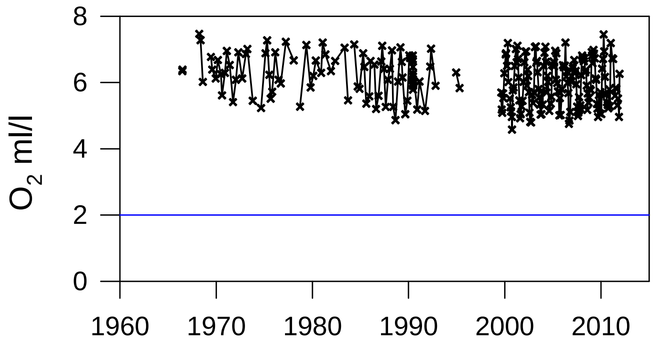








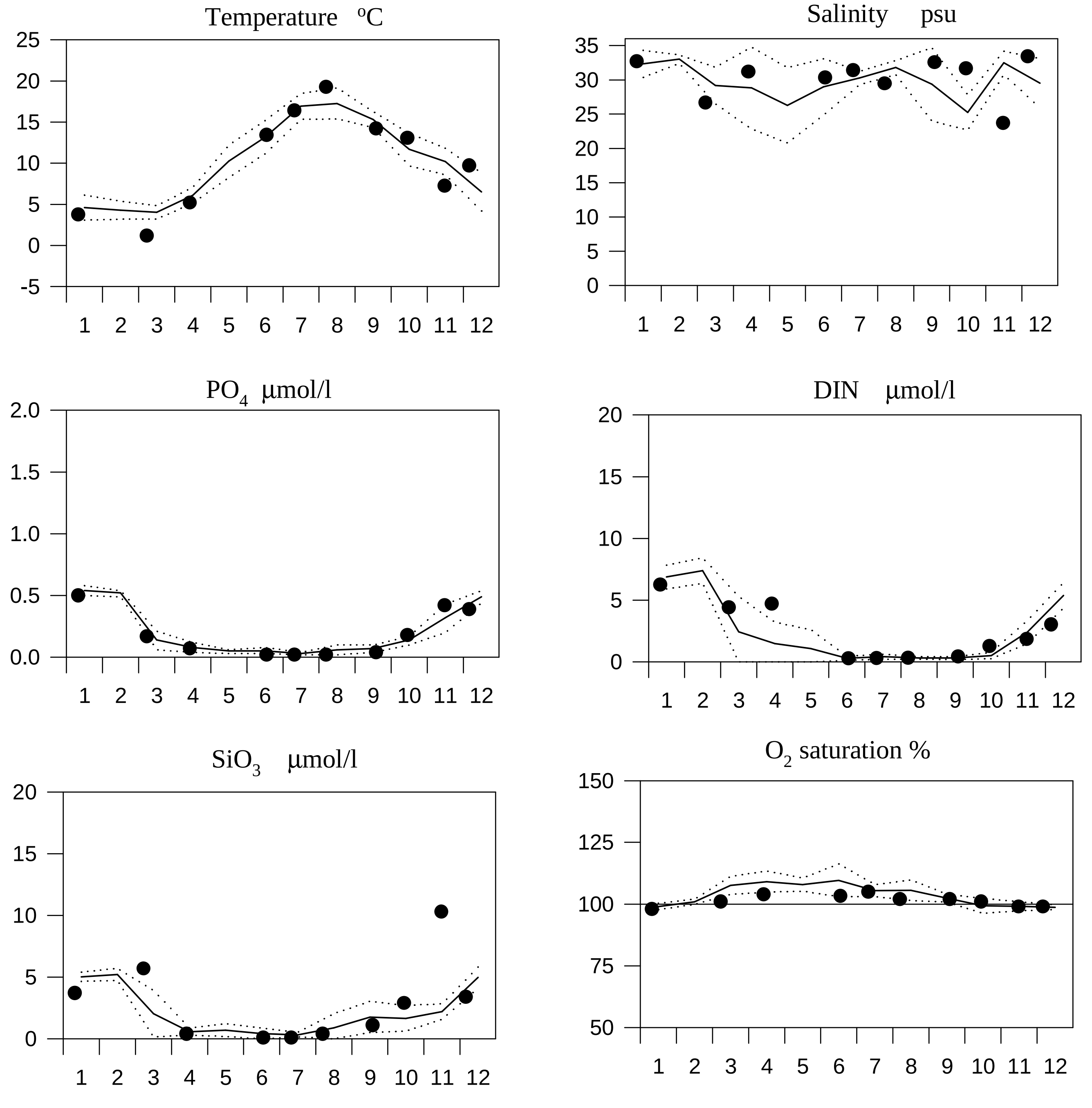




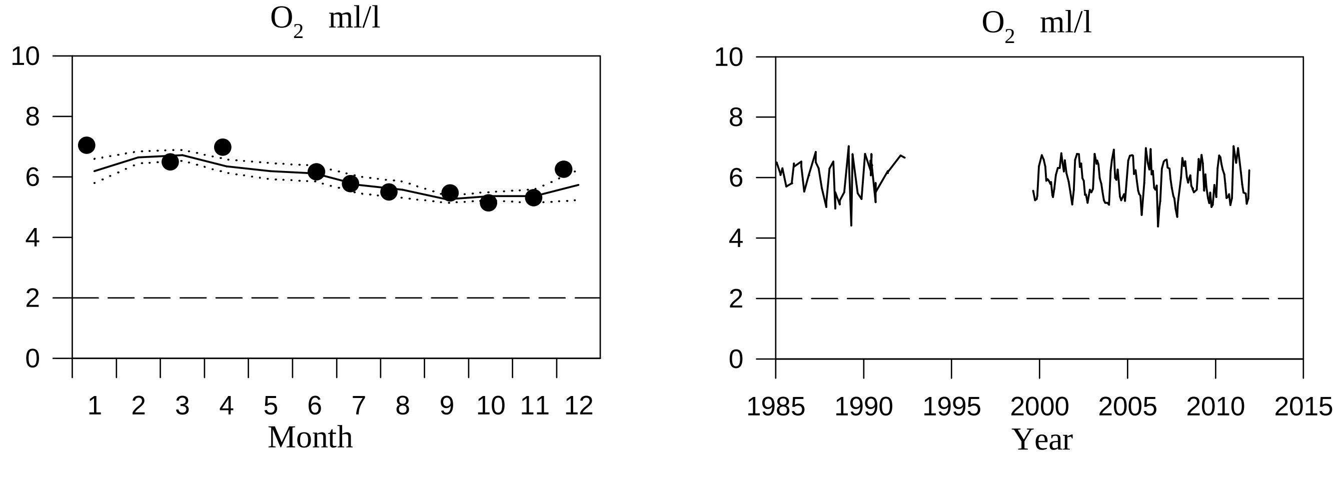
STATION Å15 SURFACE WATER

Annual Cycles

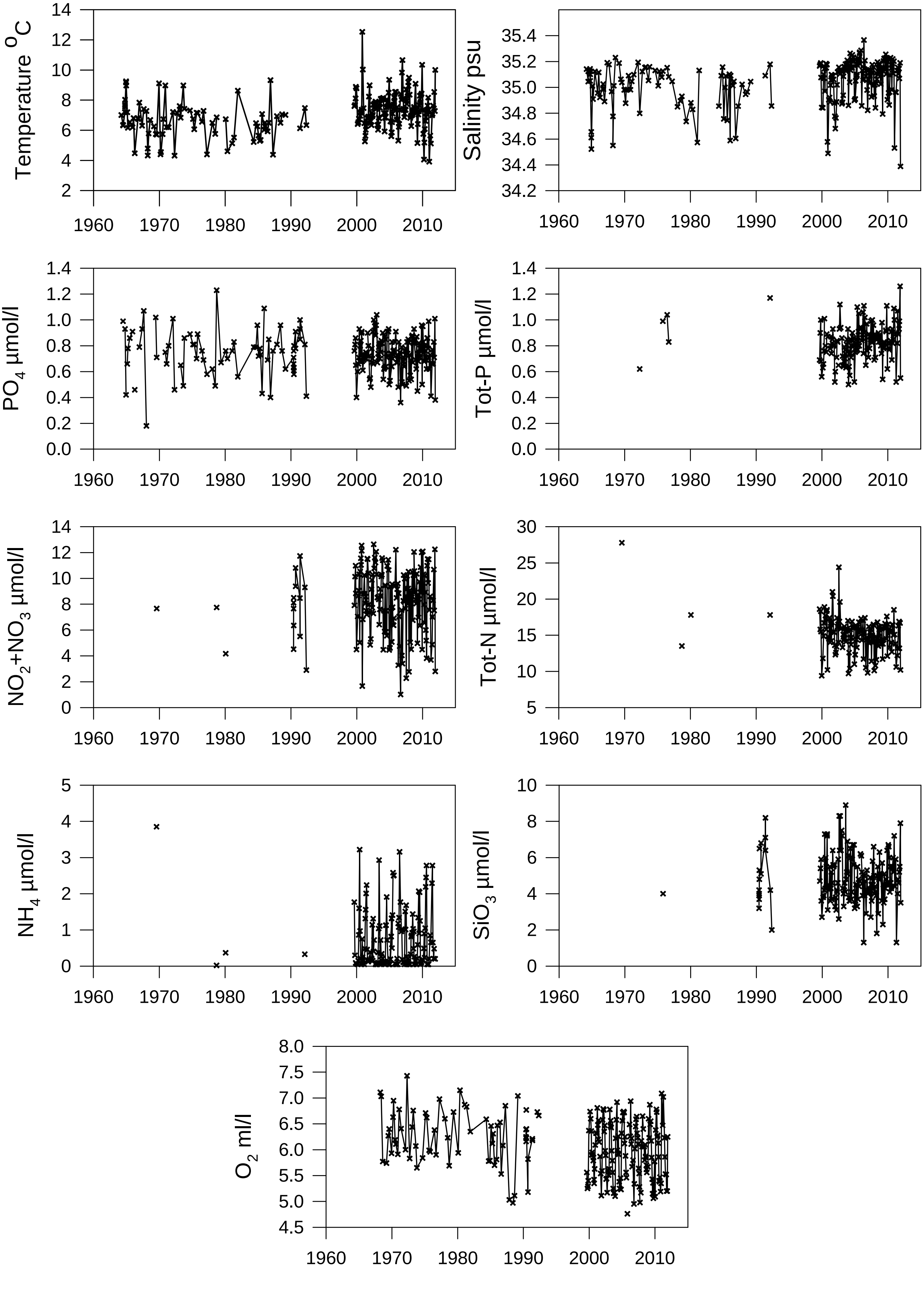
Mean 1995-2004 St.Dev. 2011



OXYGEN IN BOTTOM WATER



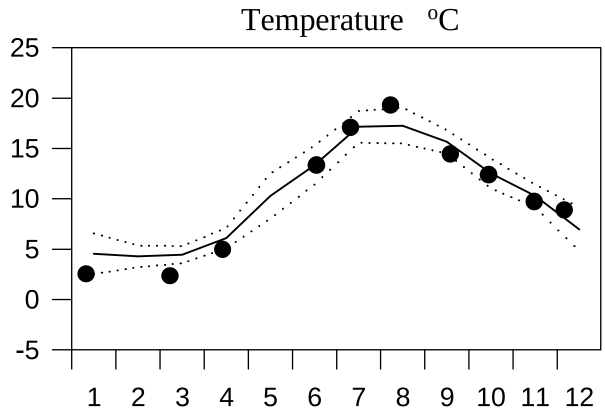
STATION Å15 DEEP WATER (125m)

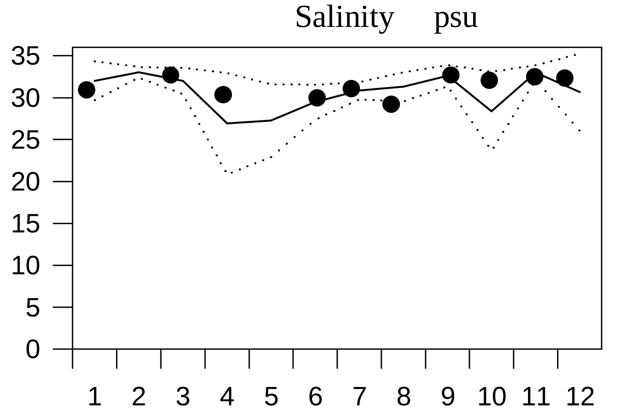


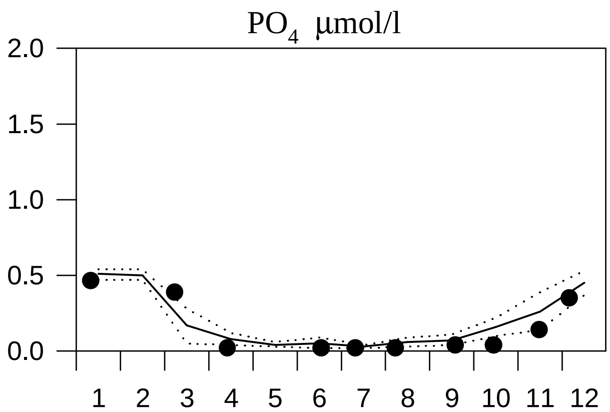
STATION Å17 SURFACE WATER

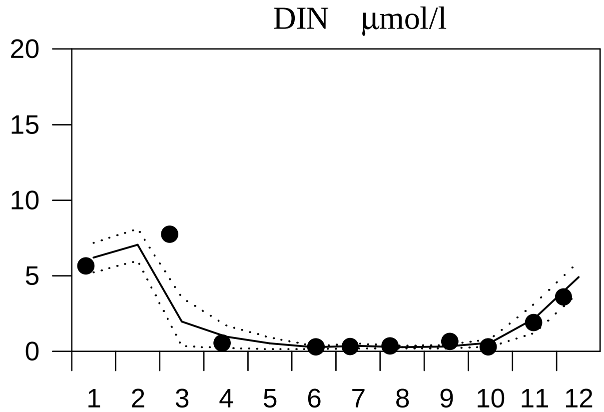
Annual Cycles

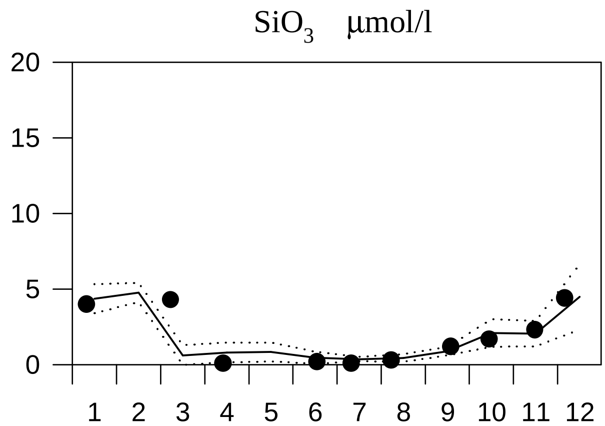
Mean 1995-2004 St.Dev. 2011

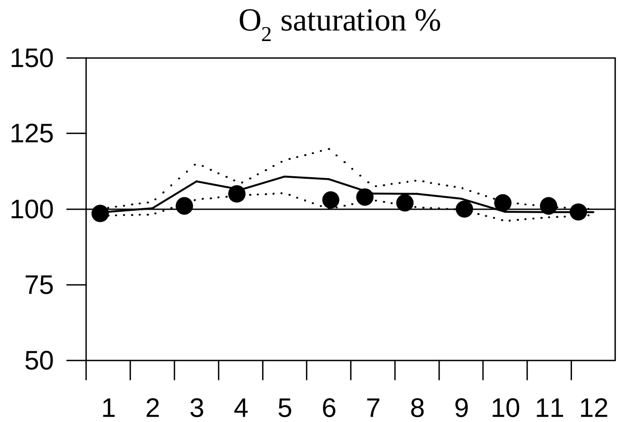




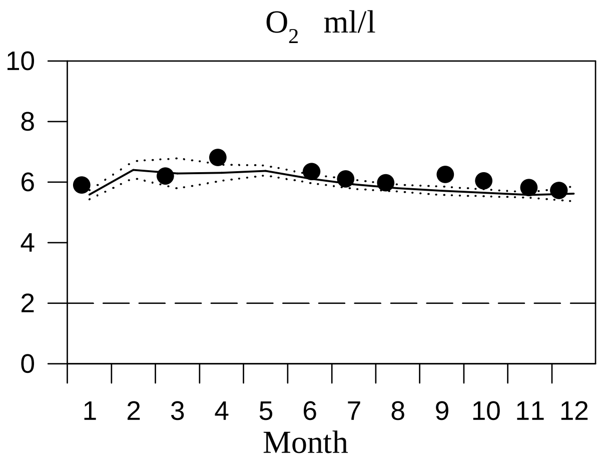


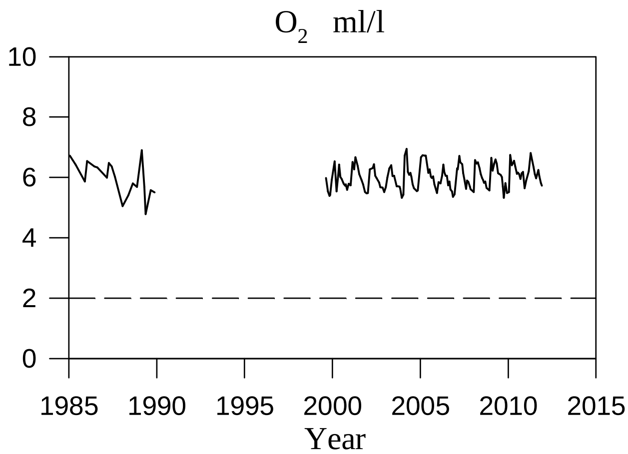




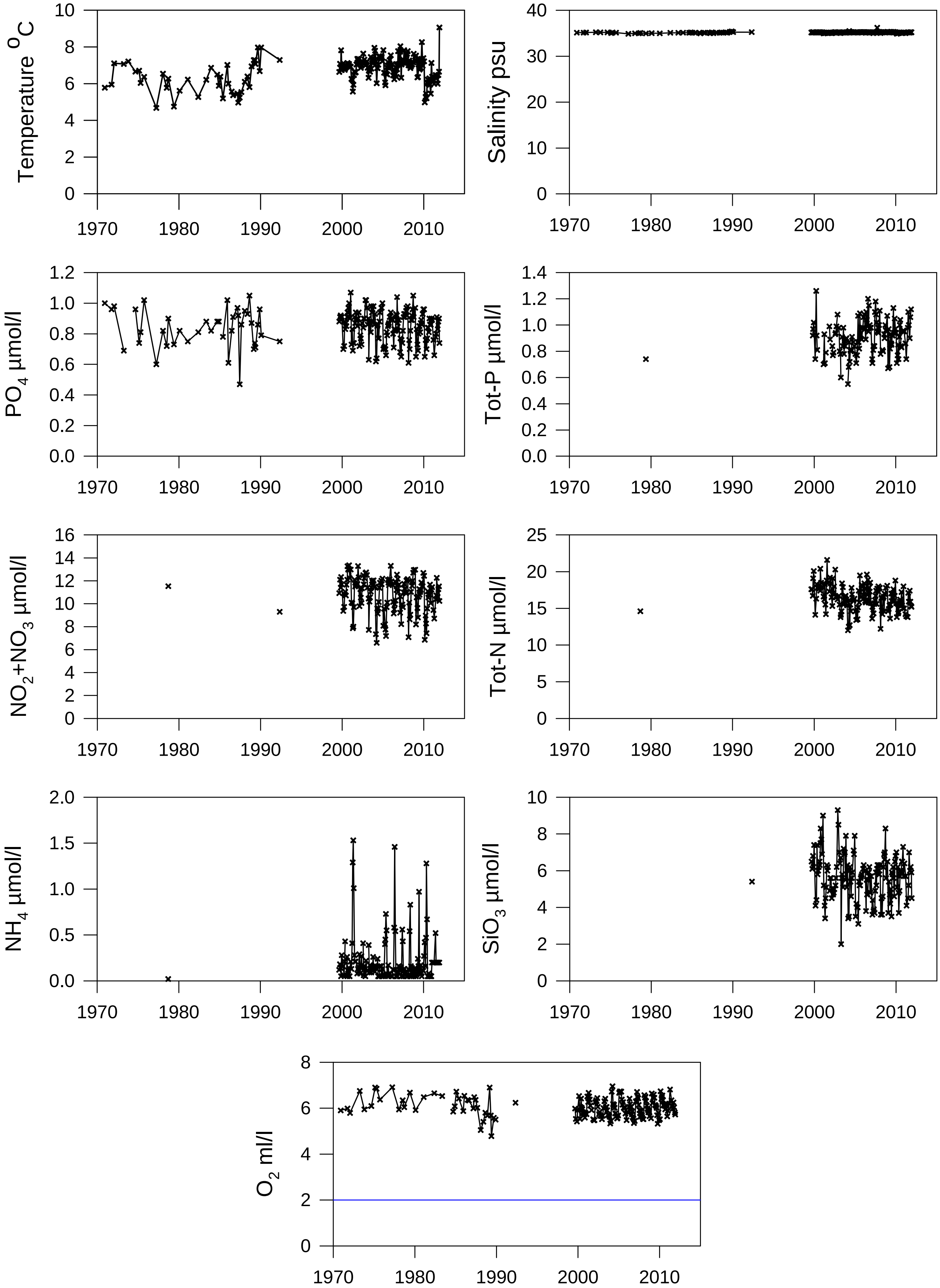


OXYGEN IN BOTTOM WATER





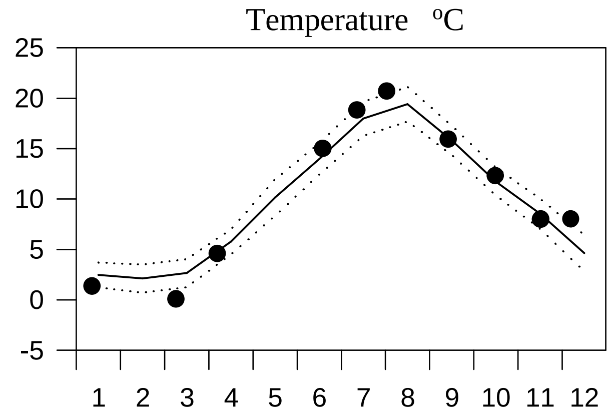
STATION Å17 DEEP WATER (300m)

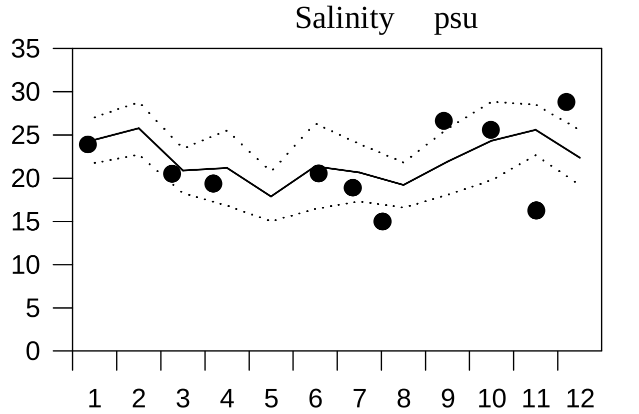


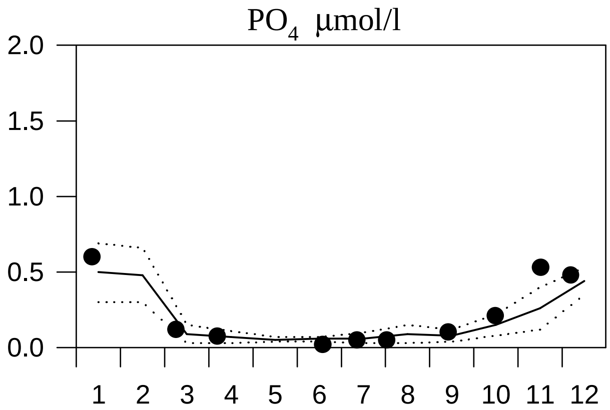
STATION FLADEN SURFACE WATER

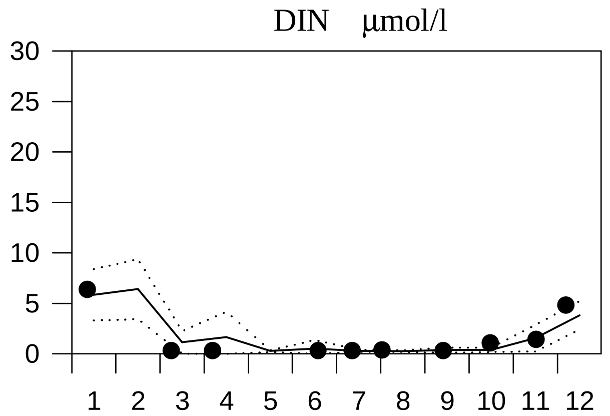
Annual Cycles

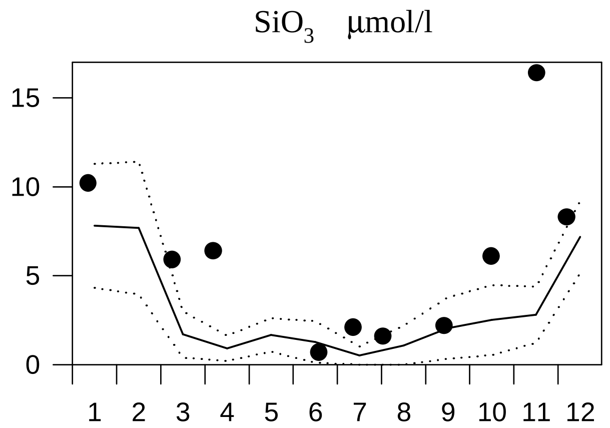
Mean 1995-2004 St.Dev. 2011

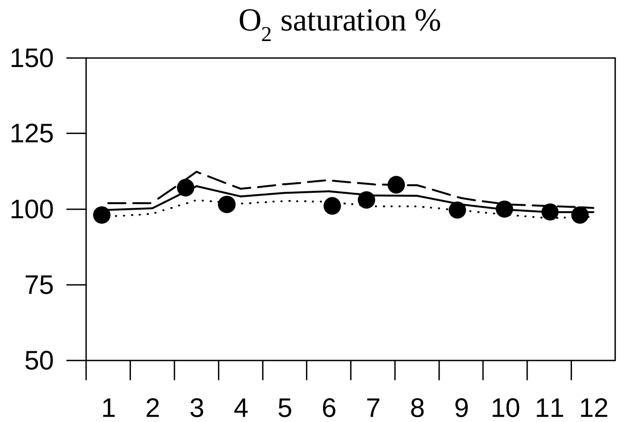




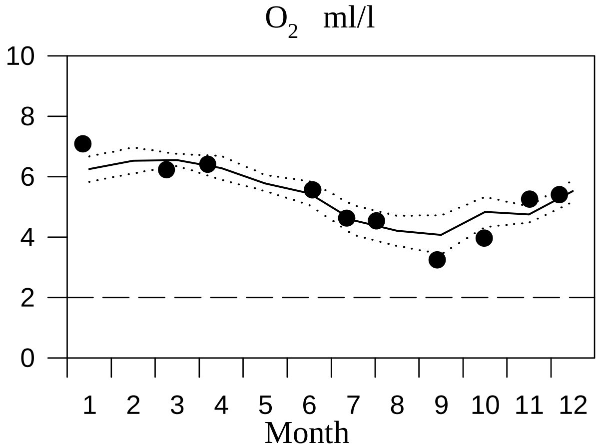


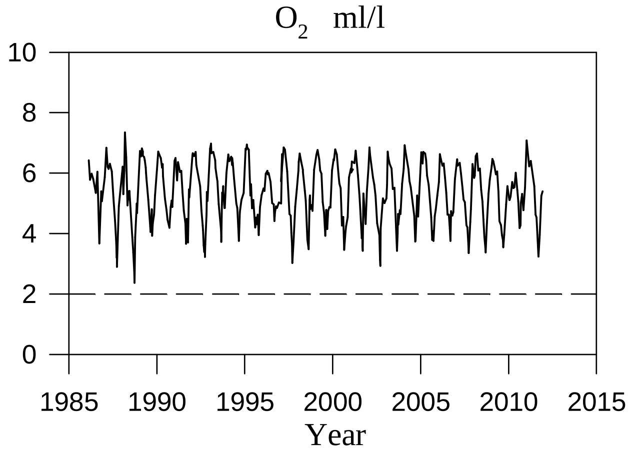




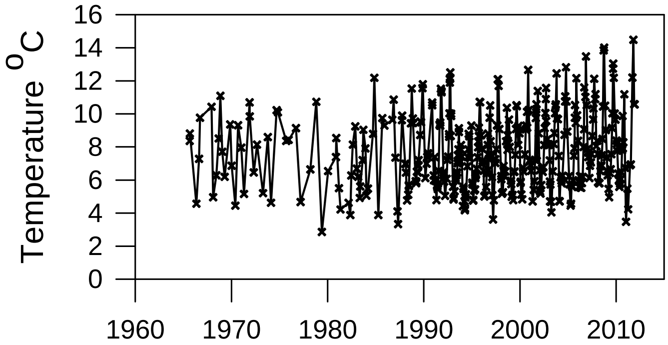


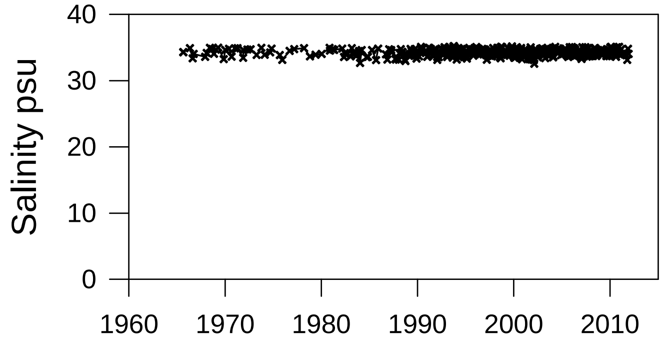
OXYGEN IN BOTTOM WATER

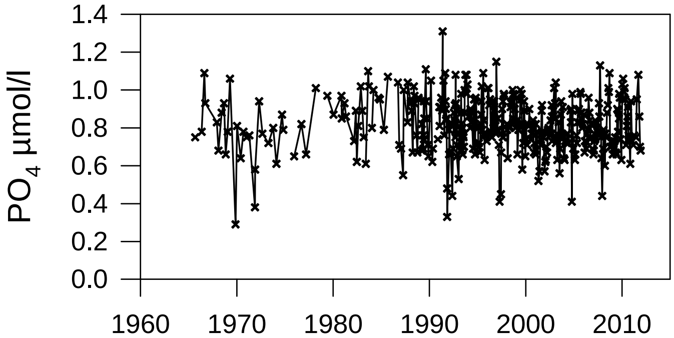


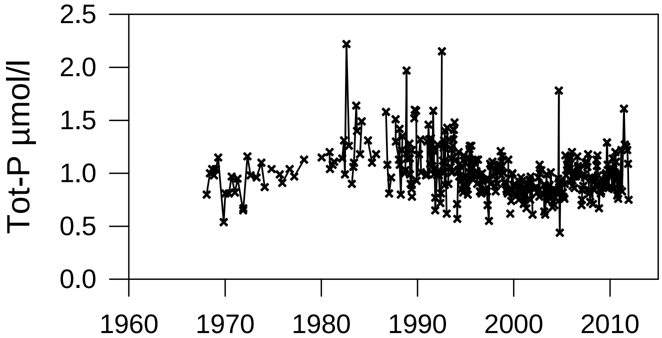


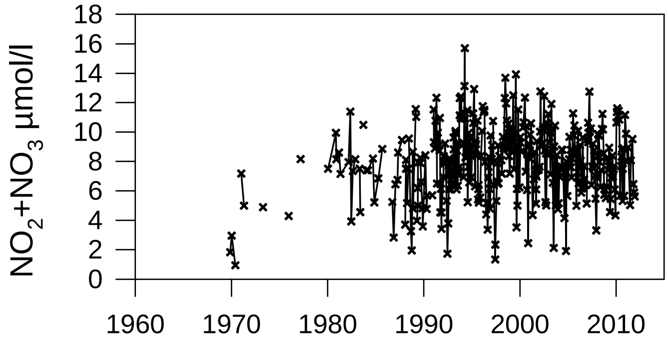
STATION FLADEN DEEP WATER (70m)

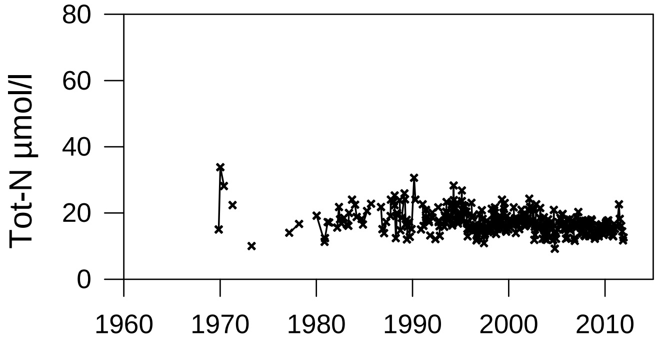


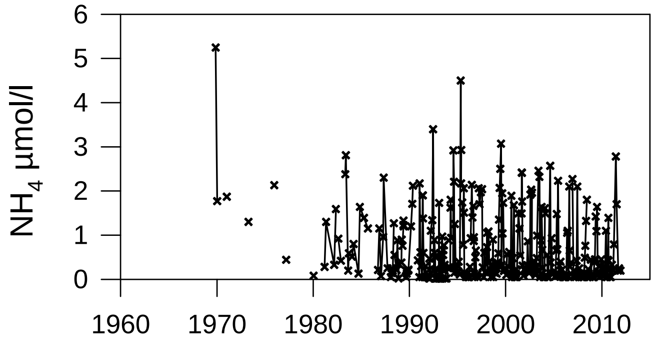


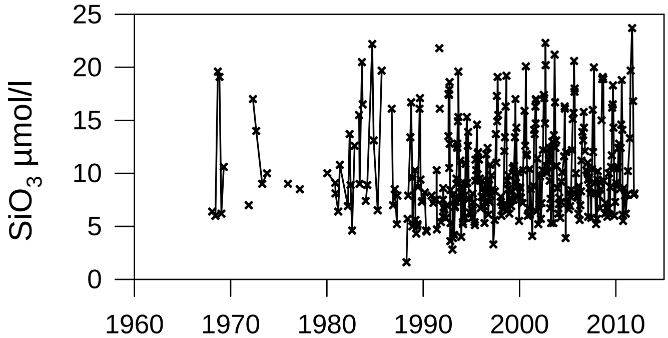


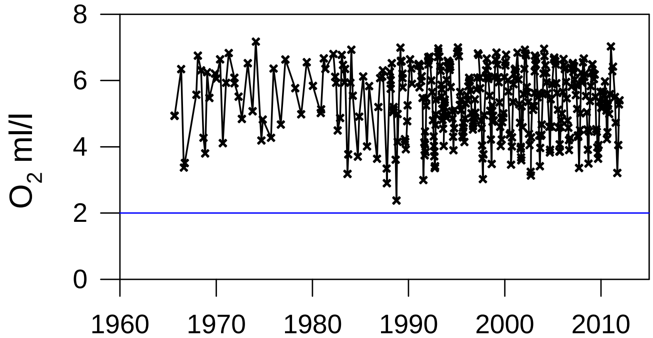






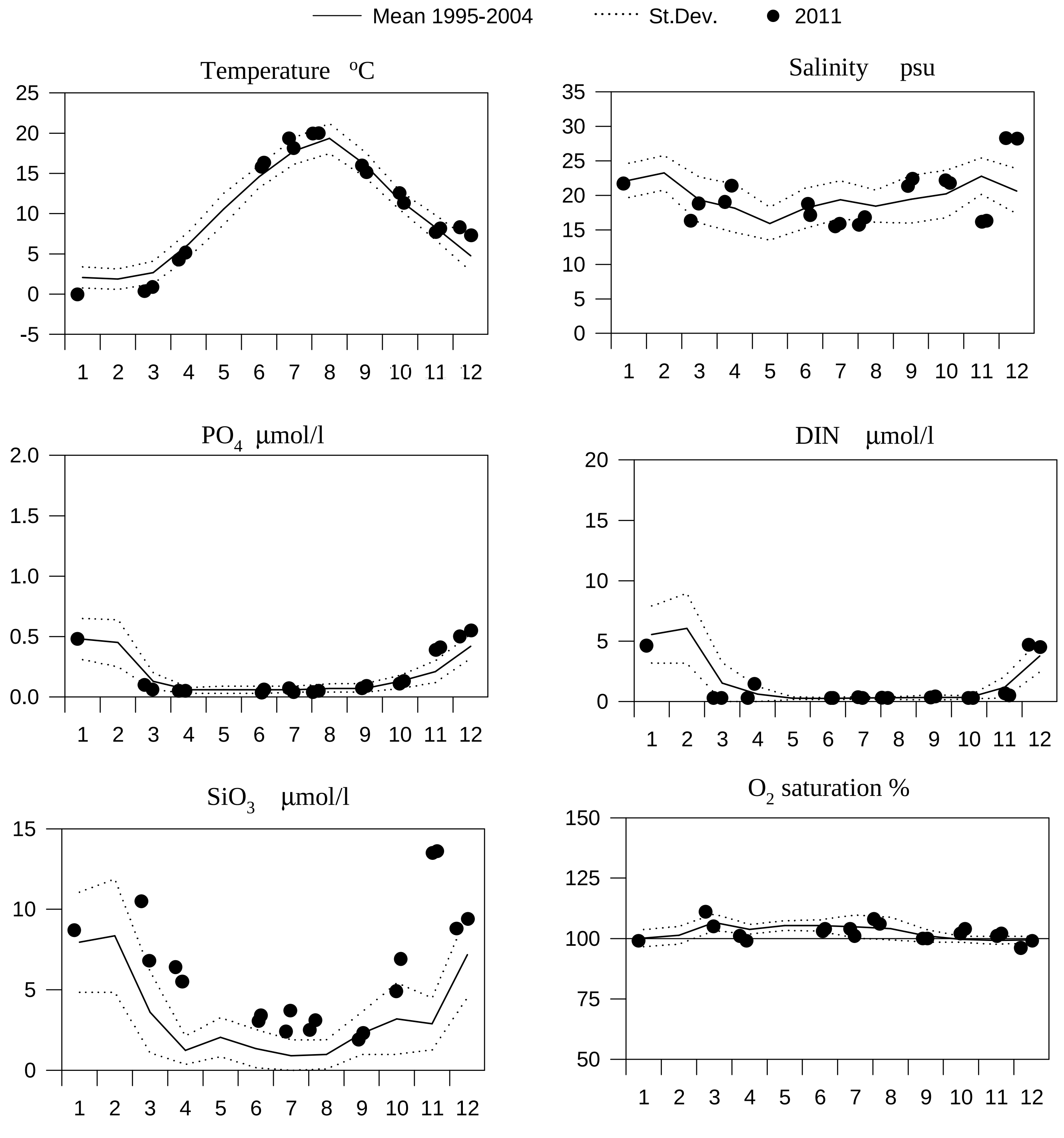




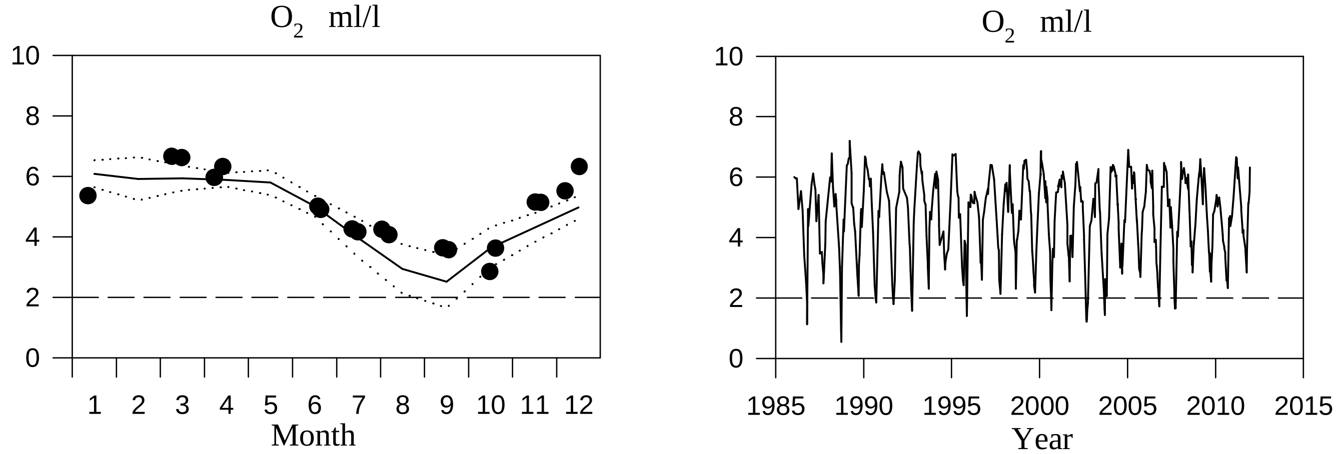


STATION ANHOLT E SURFACE WATER

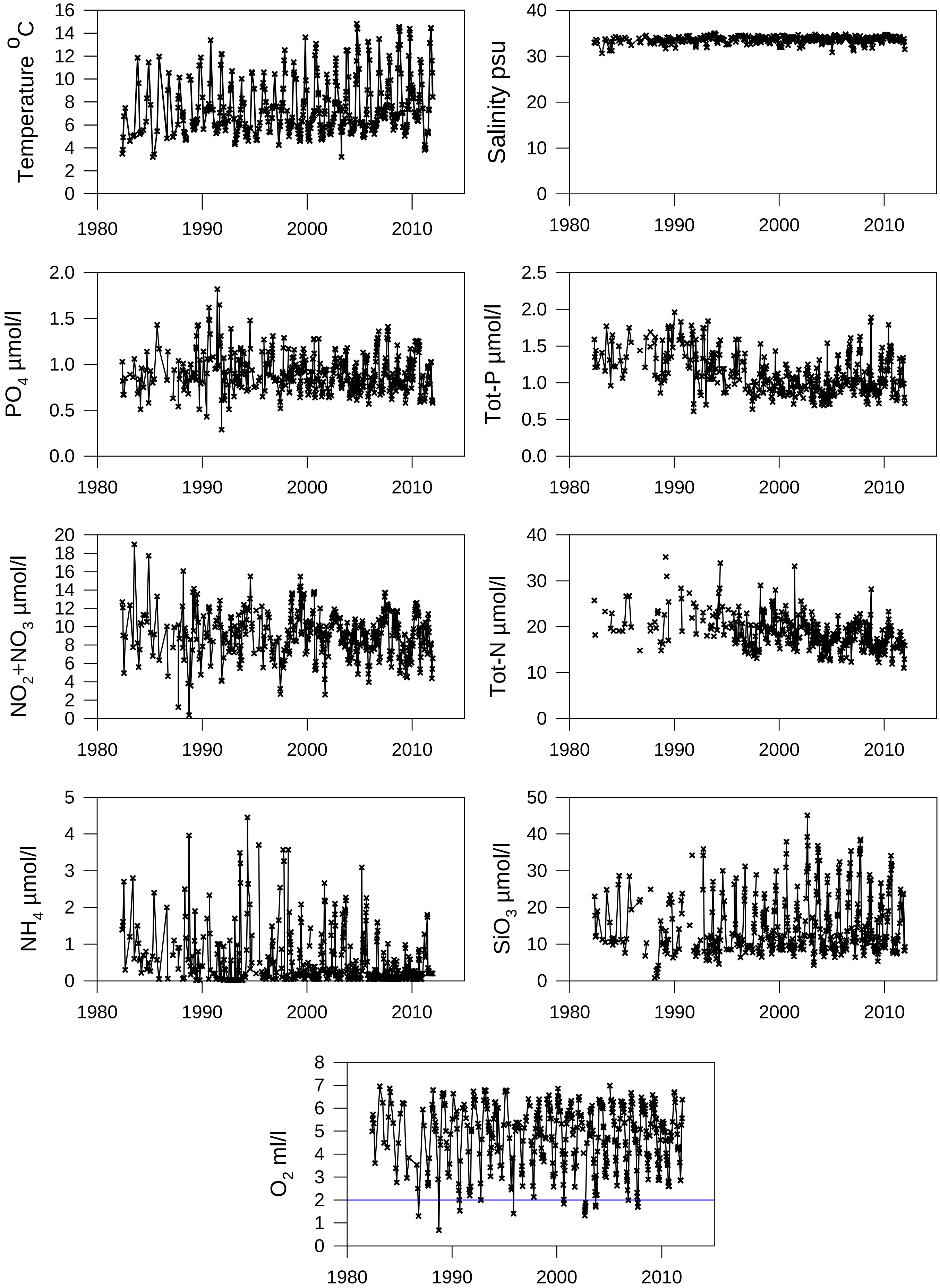
Annual Cycles



OXYGEN IN BOTTOM WATER



STATION ANHOLT-E DEEP WATER (50m)

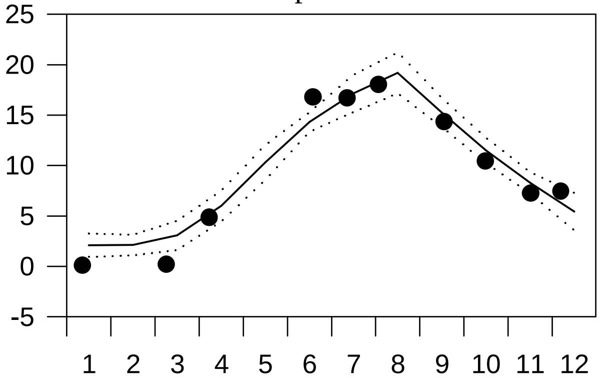


STATION W LANDSKRONA SURFACE WATER

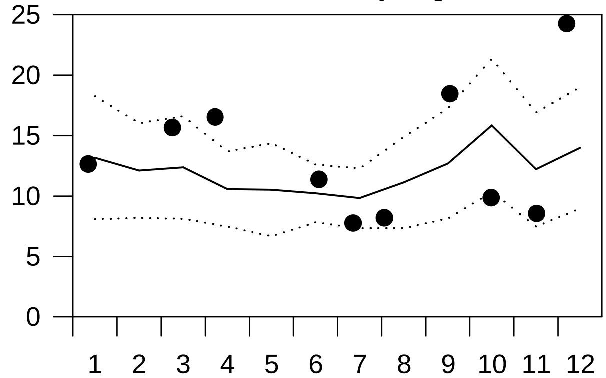
Annual Cycles

Mean 1995-2004 · St.Dev. · 2011

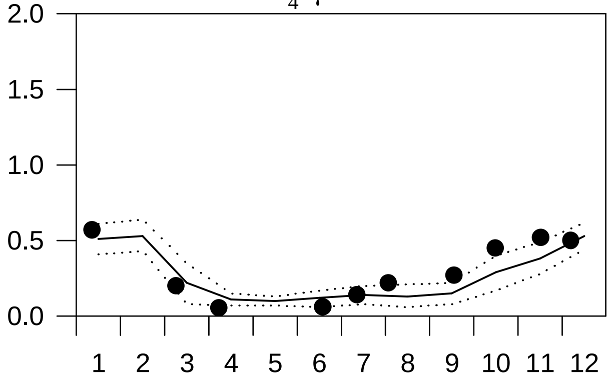
Temperature °C



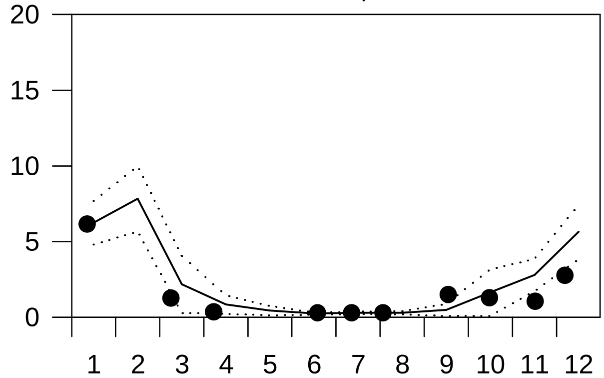
Salinity psu



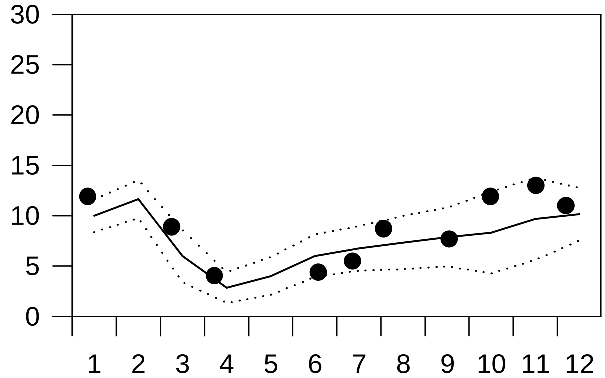
PO_4 µmol/l



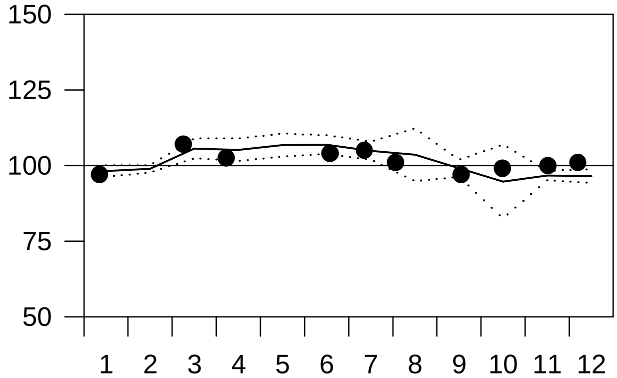
DIN µmol/l



SiO_3 µmol/l

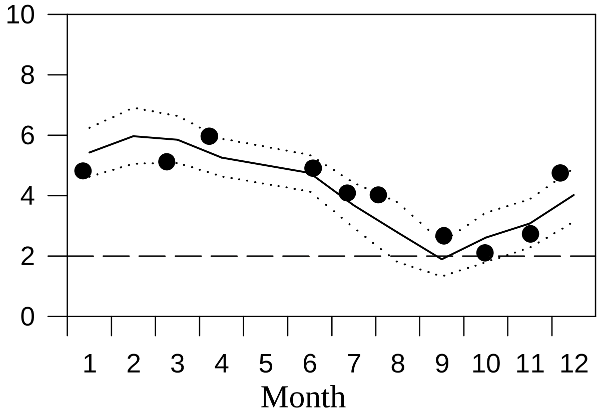


O_2 saturation %

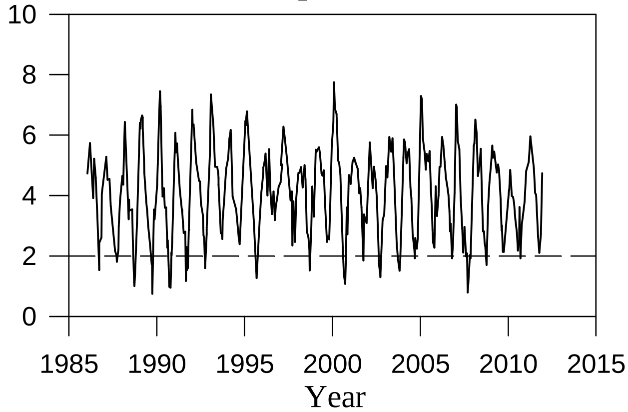


OXYGEN IN BOTTOM WATER

O_2 ml/l

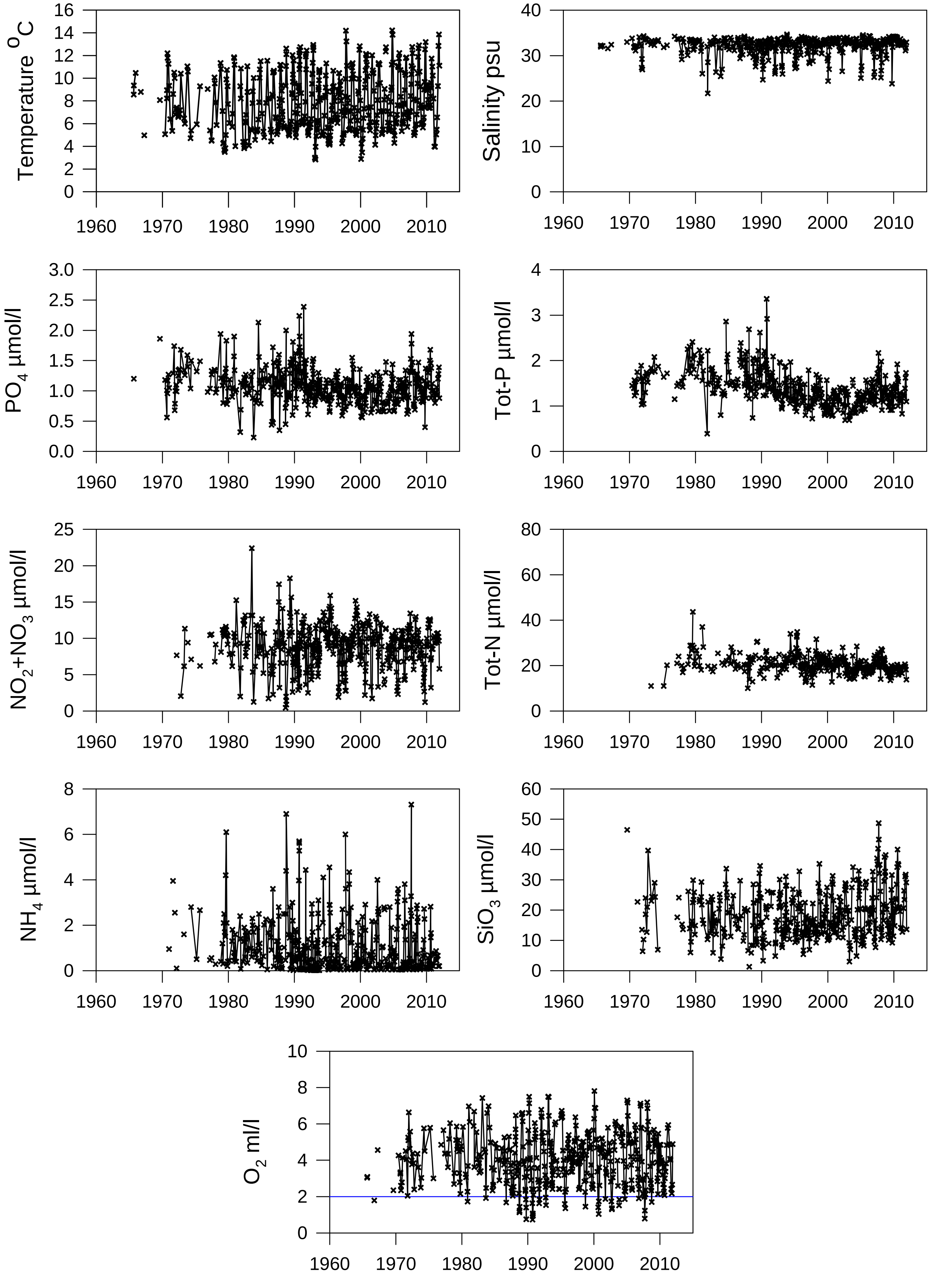


O_2 ml/l



SMHI

STATION W LANDSKRONA DEEP WATER (40m)

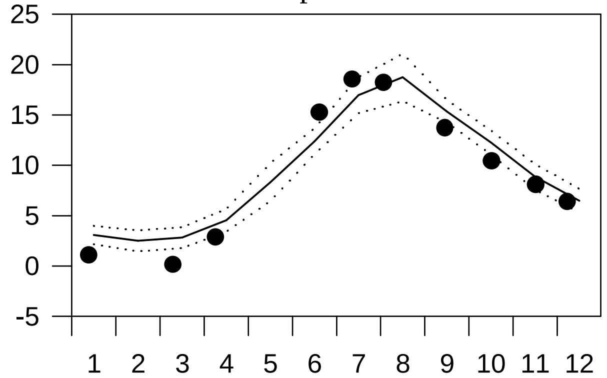


STATION BY1 SURFACE WATER

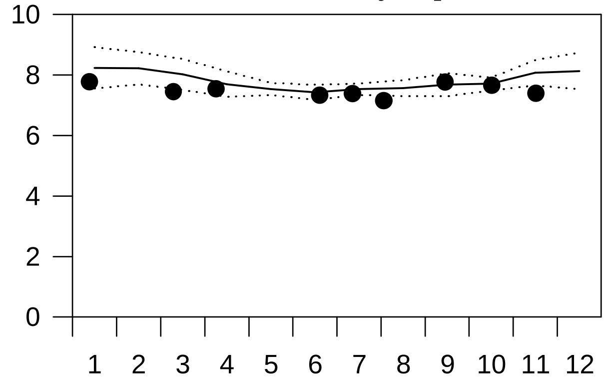
Annual Cycles

Mean 1995-2004 St.Dev. 2011

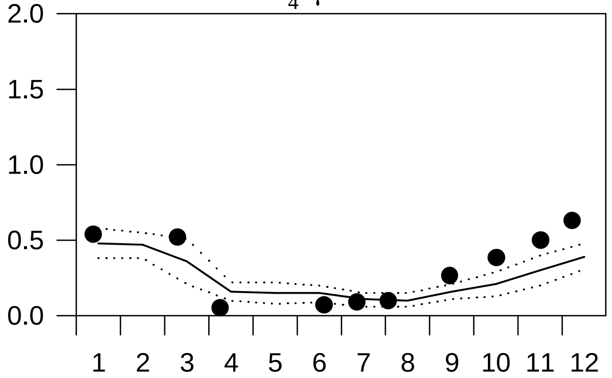
Temperature ^{o}C



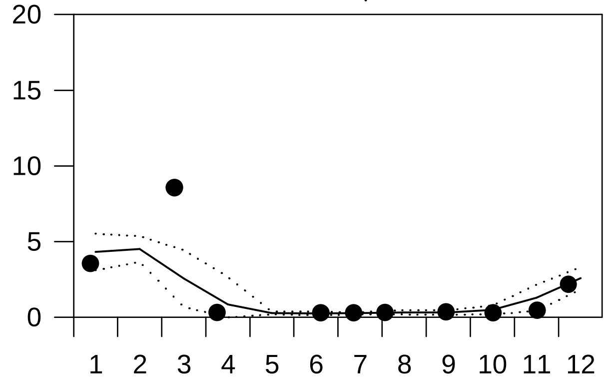
Salinity psu



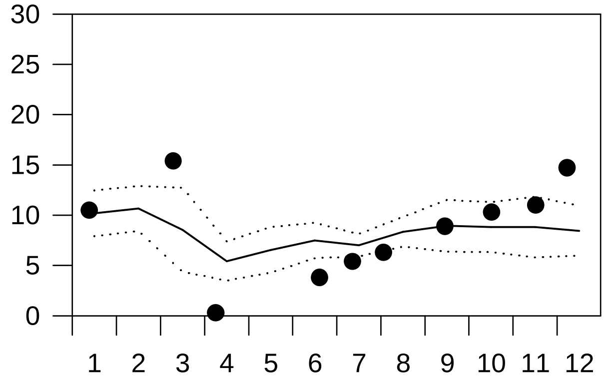
PO_4 µmol/l



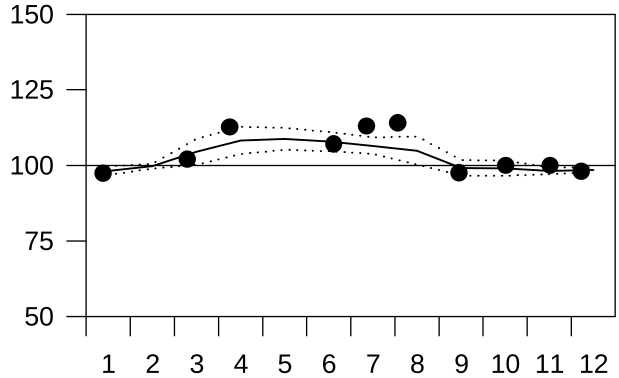
DIN µmol/l



SiO_3 µmol/l

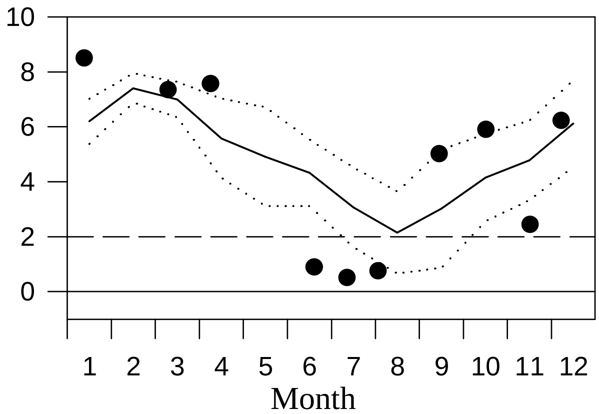


O_2 saturation %

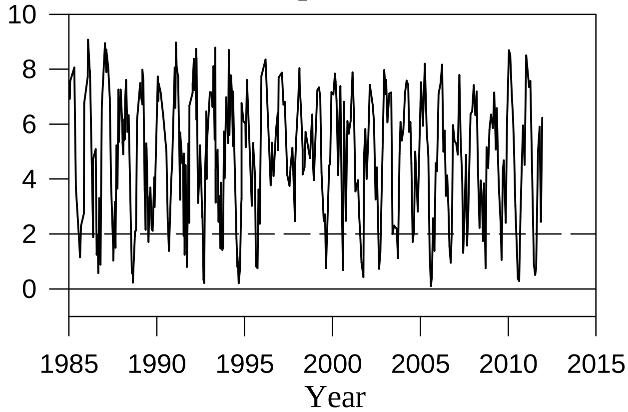


OXYGEN IN BOTTOM WATER

O_2 ml/l

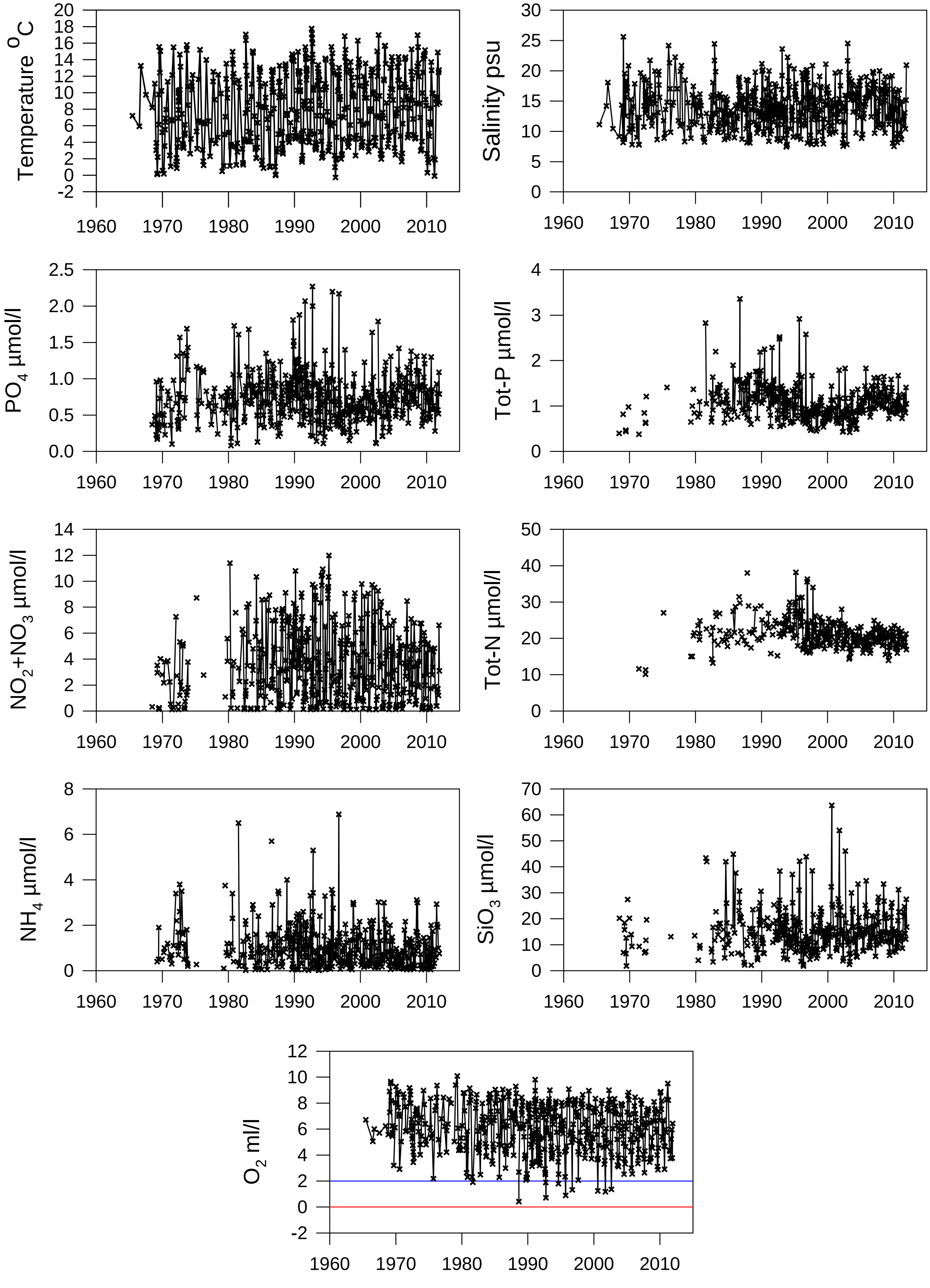


O_2 ml/l



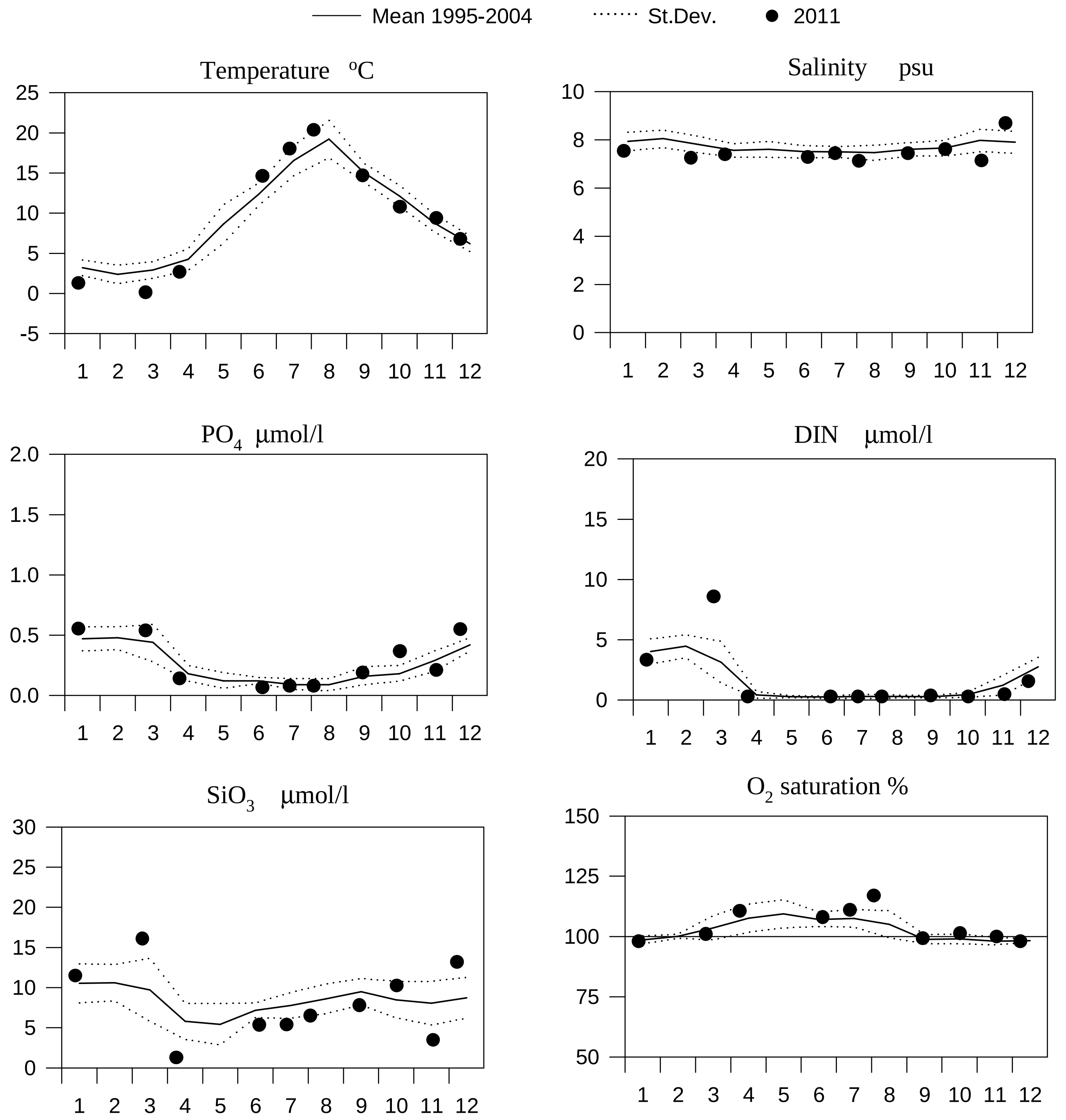
SMHI

STATION BY1 DEEP WATER (40m)

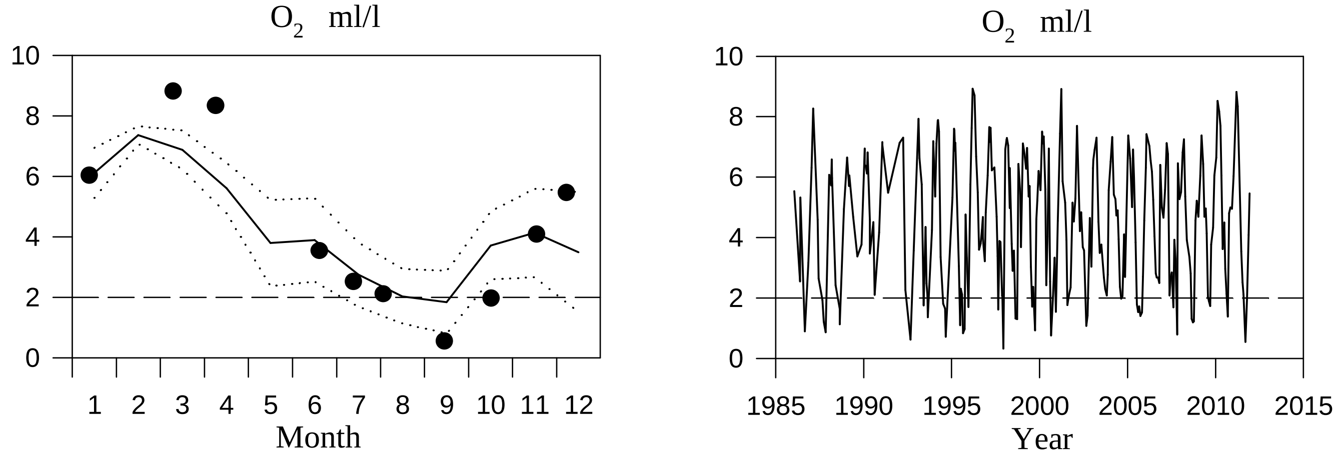


STATION BY2 SURFACE WATER

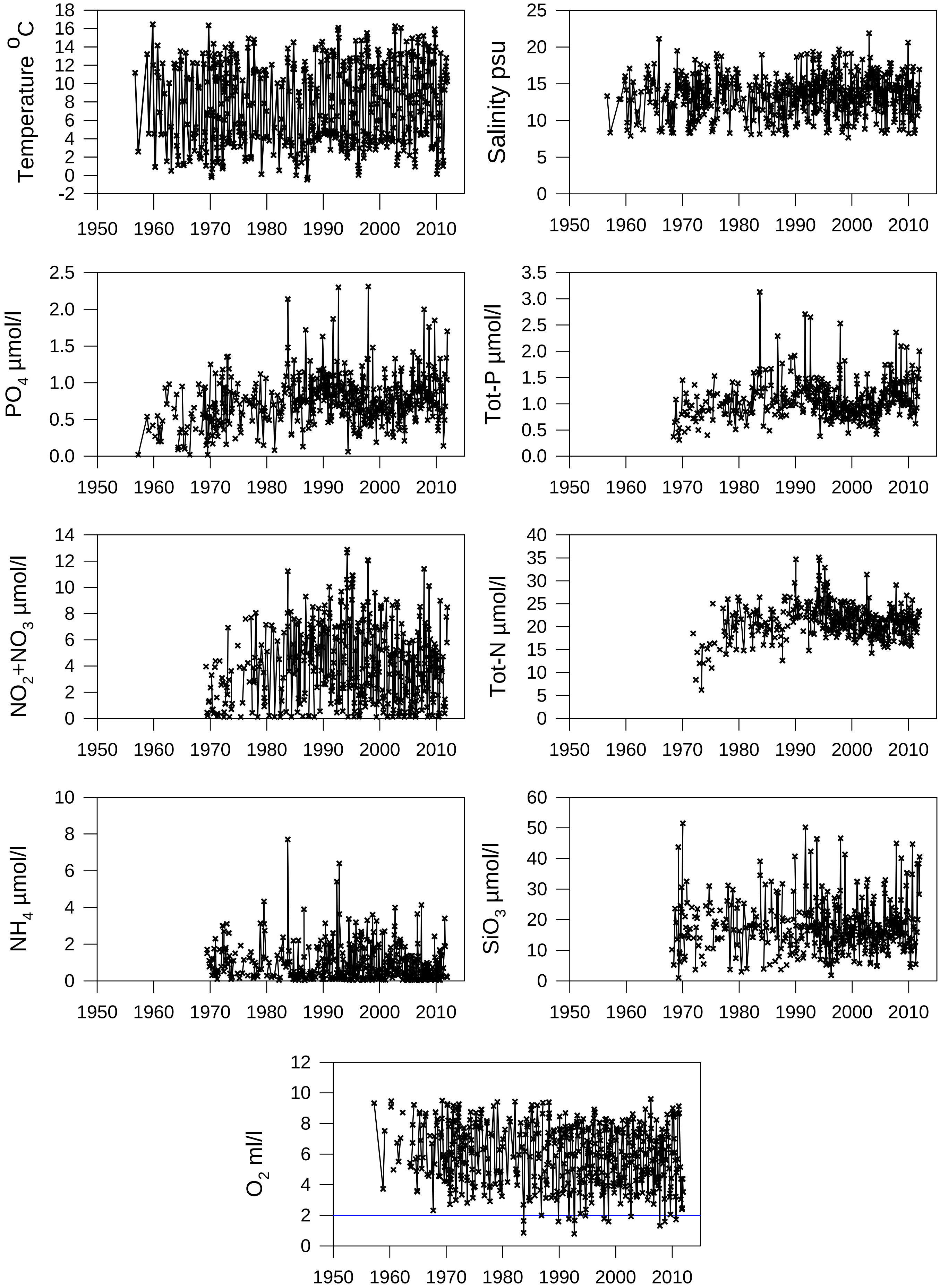
Annual Cycles



OXYGEN IN BOTTOM WATER



STATION BY2 DEEP WATER (40m)

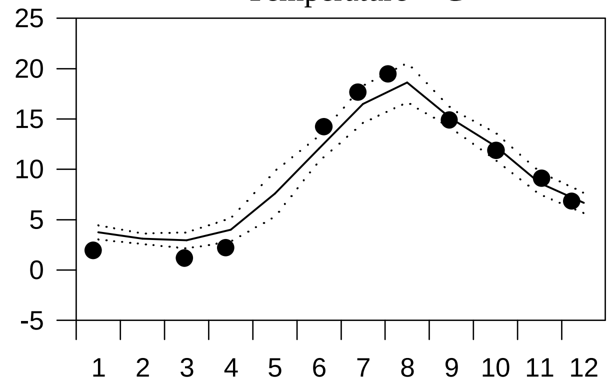


STATION BY4 SURFACE WATER

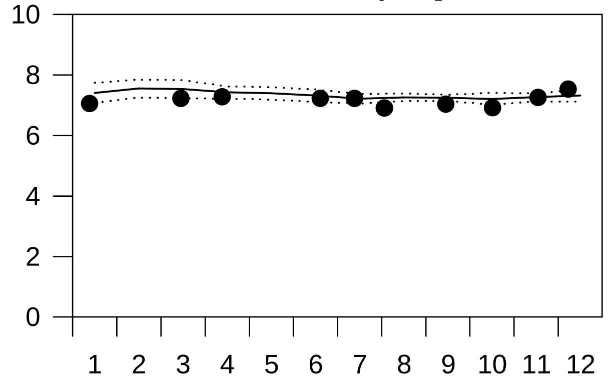
Annual Cycles

Mean 1995-2004 St.Dev. ● 2011

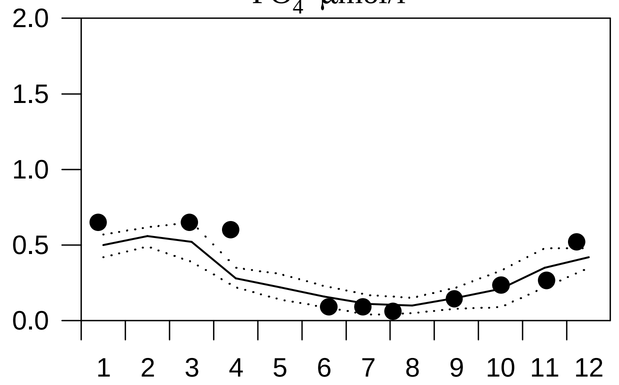
Temperature °C



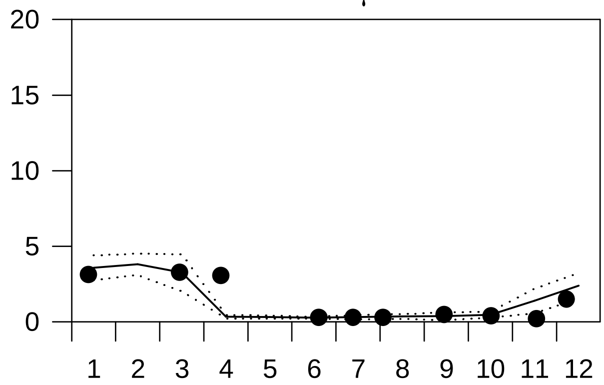
Salinity psu



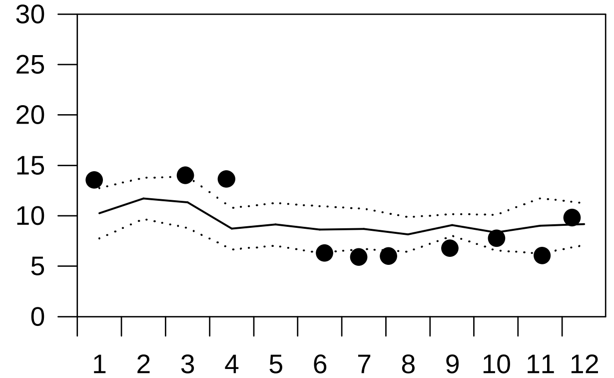
PO_4 µmol/l



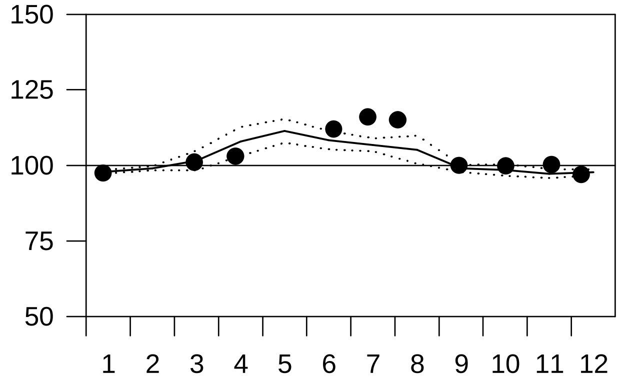
DIN µmol/l



SiO_3 µmol/l

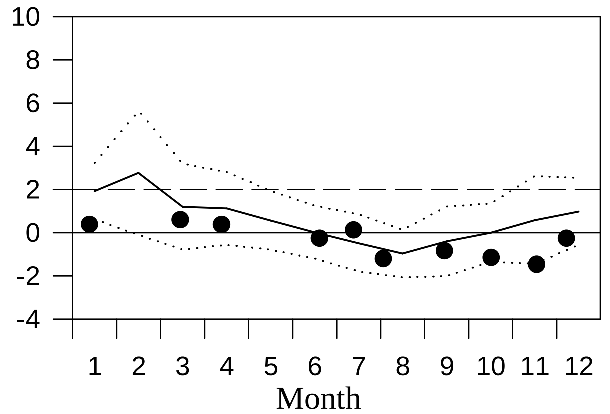


O_2 saturation %

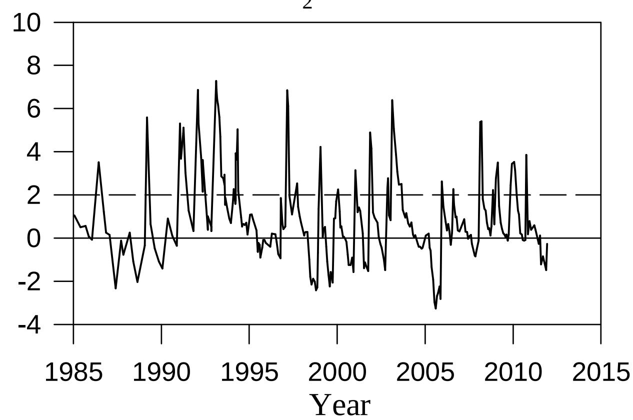


OXYGEN IN BOTTOM WATER

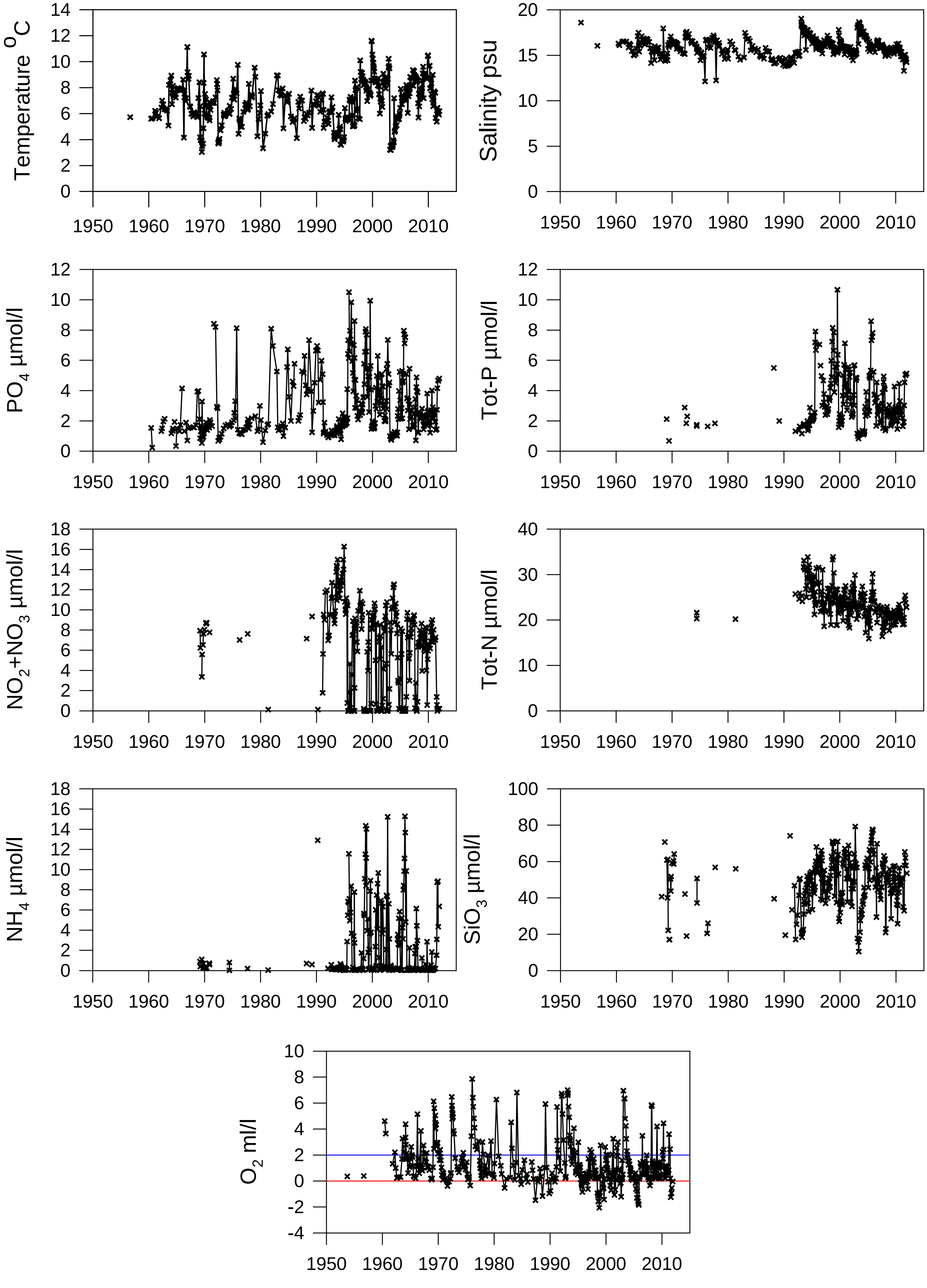
O_2 ml/l



O_2 ml/l



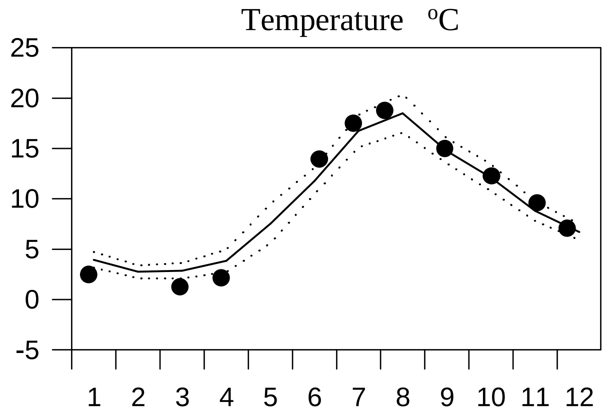
STATION BY4 DEEP WATER (80m)

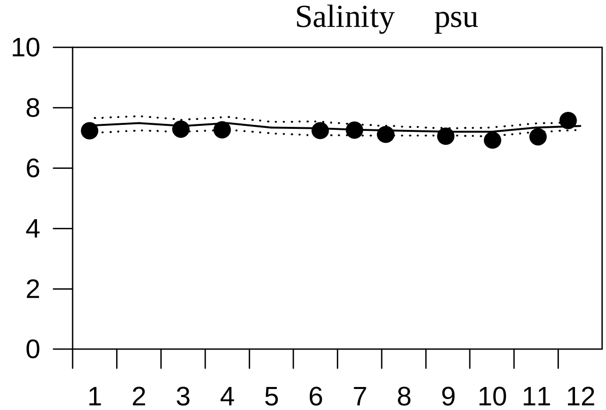


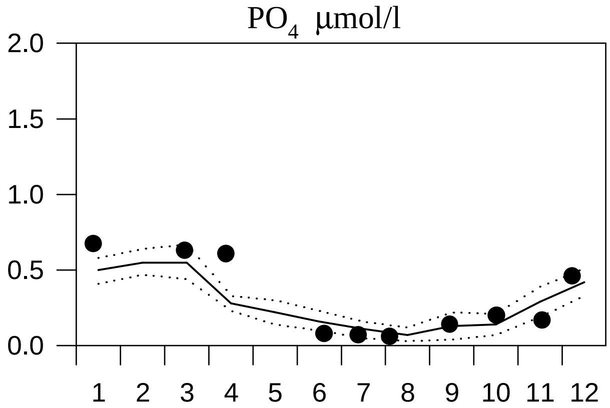
STATION BY5 SURFACE WATER

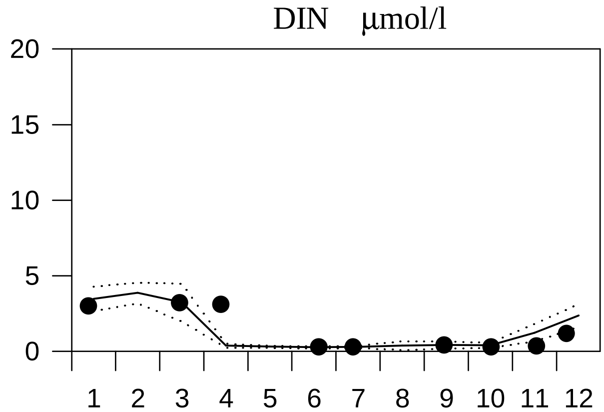
Annual Cycles

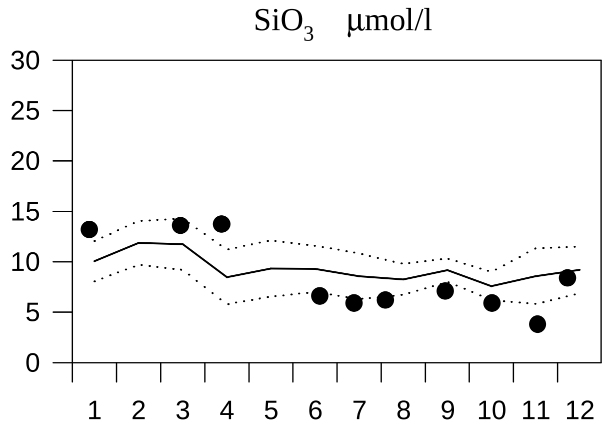
Mean 1995-2004 · St.Dev. · 2011

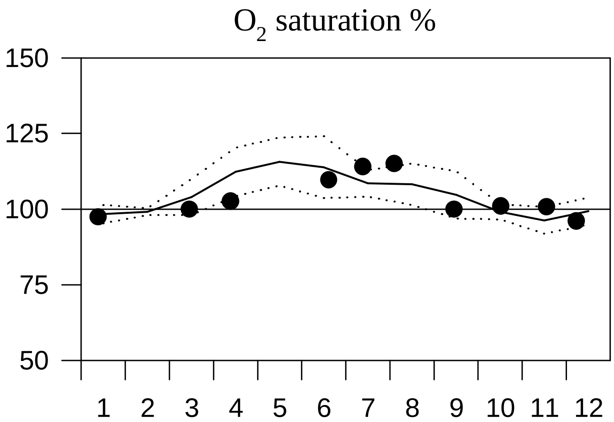




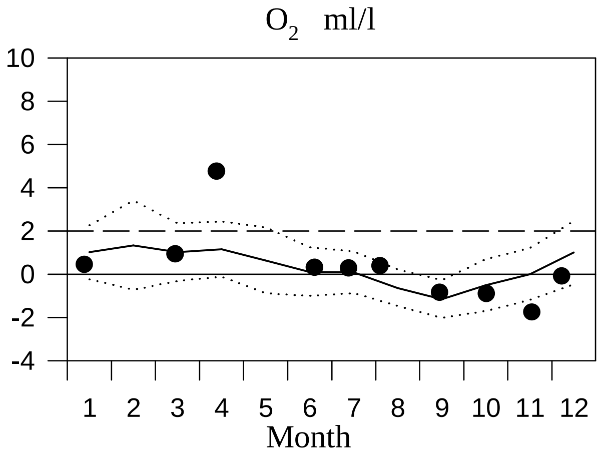


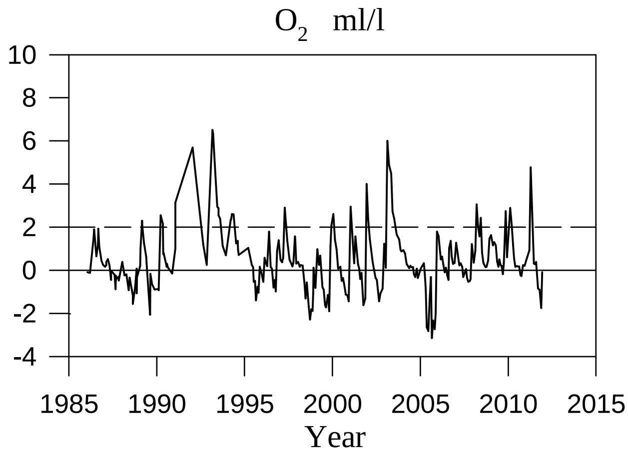




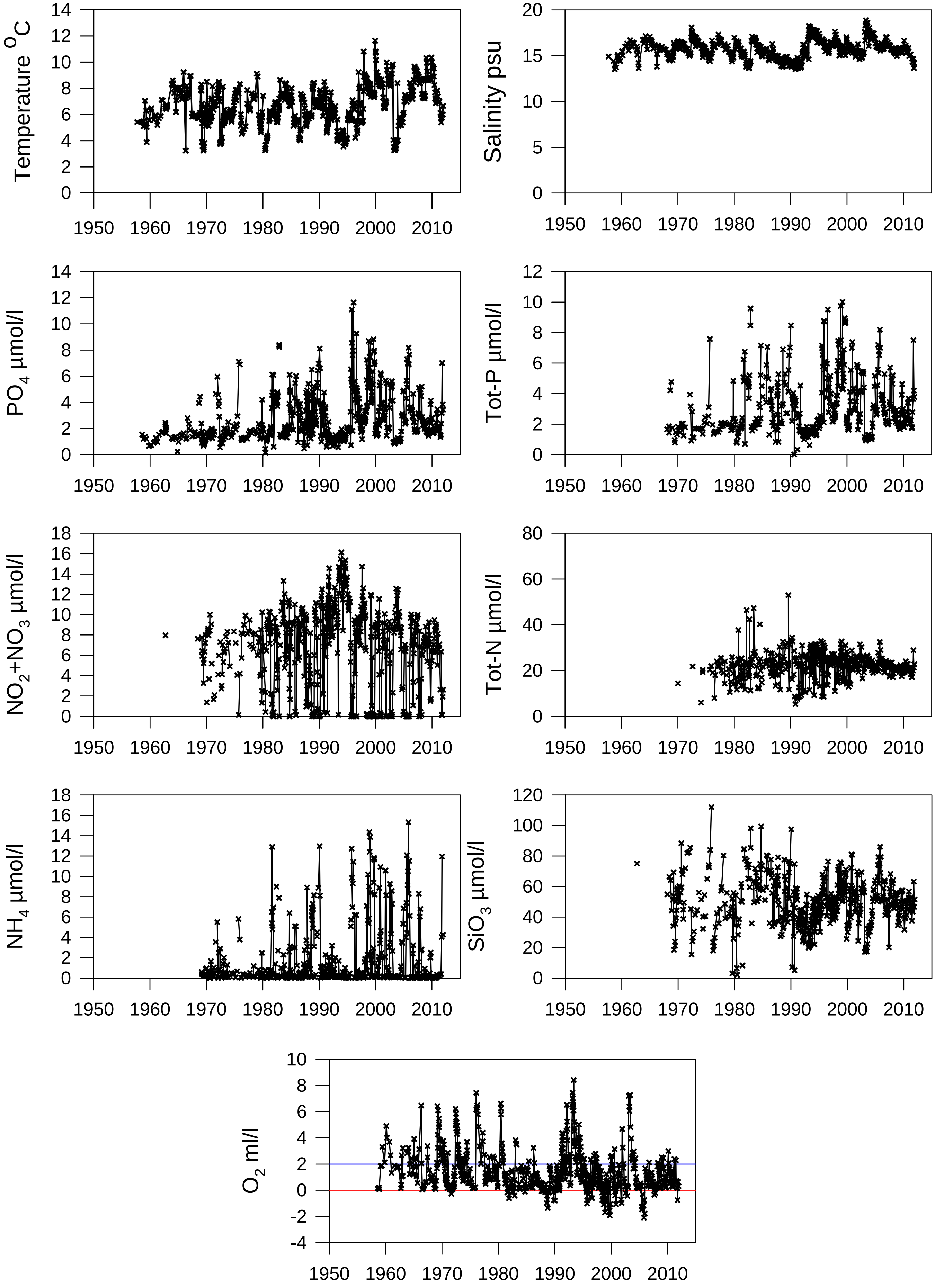


OXYGEN IN BOTTOM WATER





STATION BY5 DEEP WATER (80m)

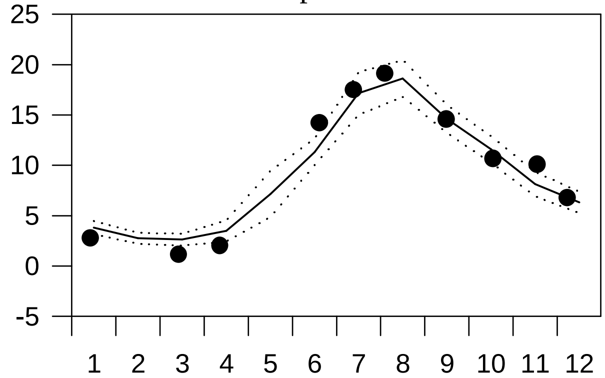


STATION BCS III-10 SURFACE WATER

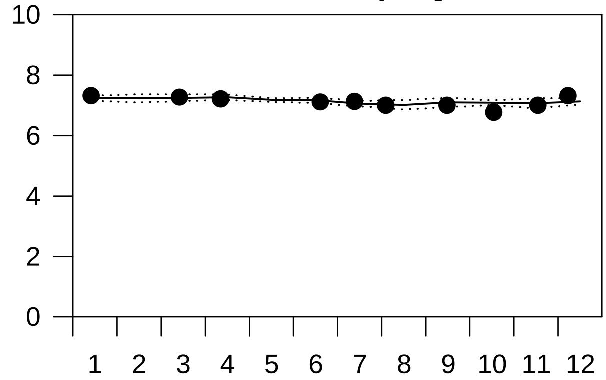
Annual Cycles

—— Mean 1995-2004 ······ St.Dev. ● 2011

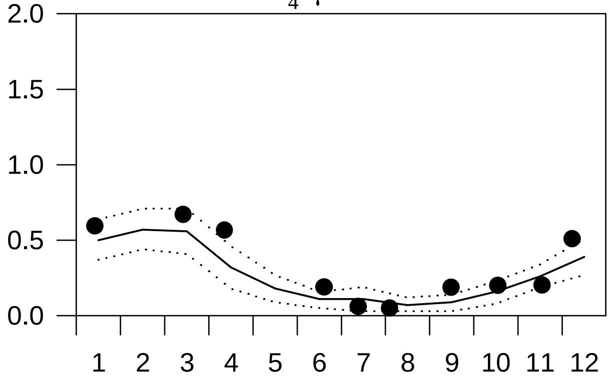
Temperature °C



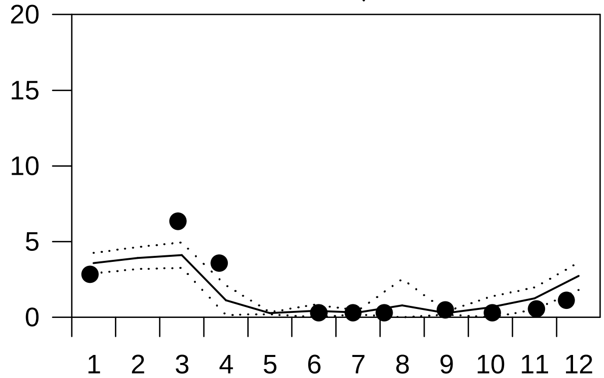
Salinity psu



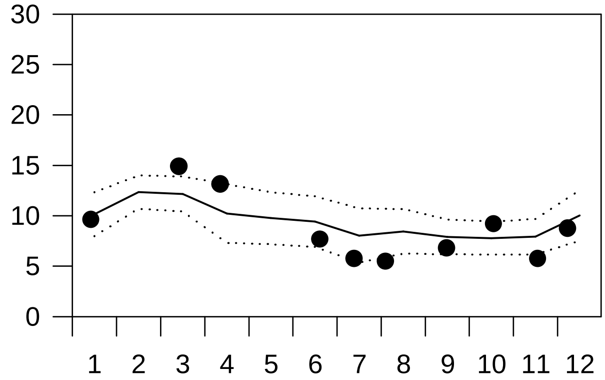
PO_4 µmol/l



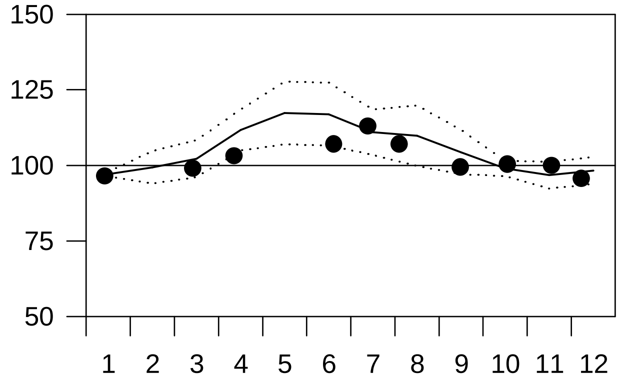
DIN µmol/l



SiO_3 µmol/l

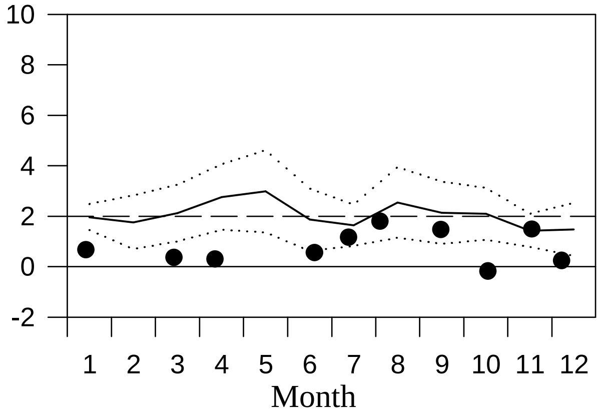


O_2 saturation %

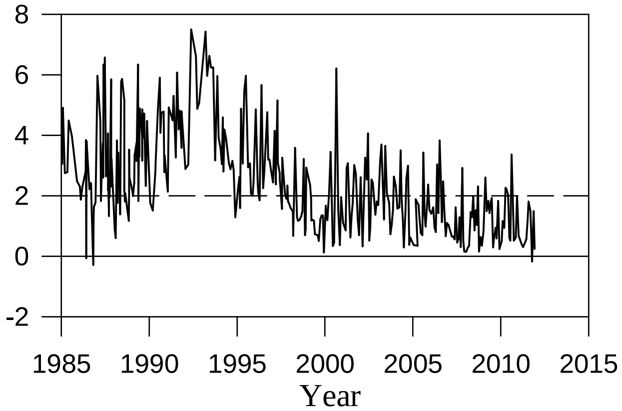


OXYGEN IN BOTTOM WATER

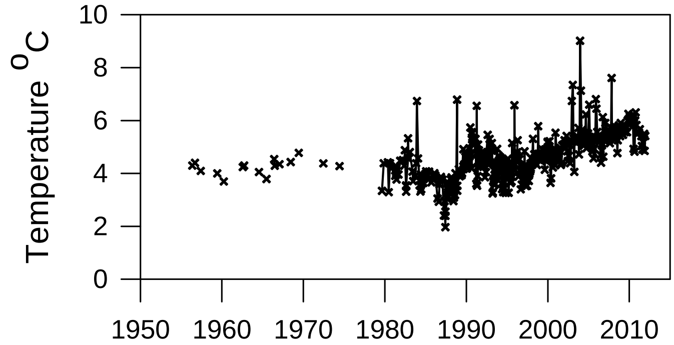
O_2 ml/l

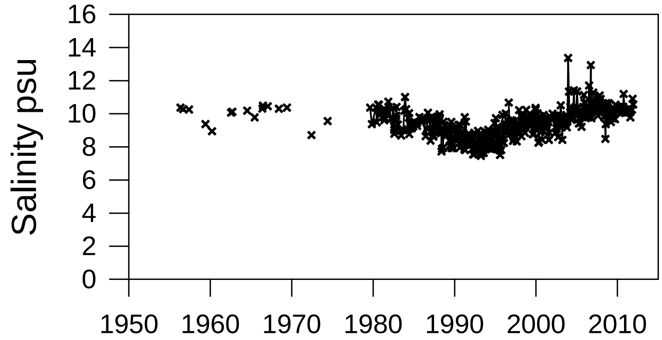


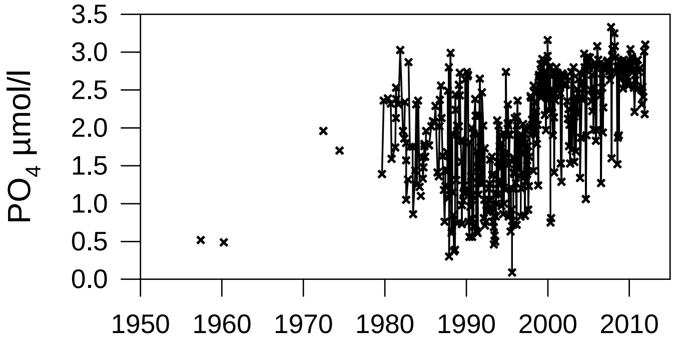
O_2 ml/l

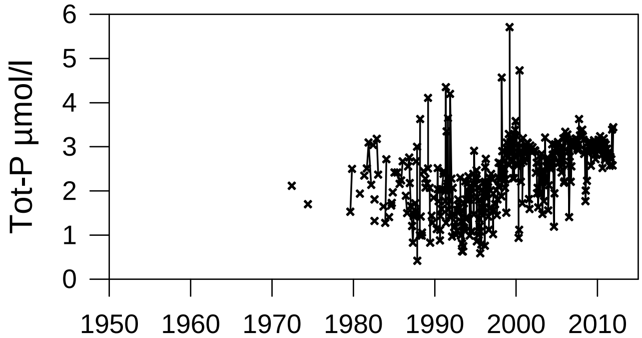


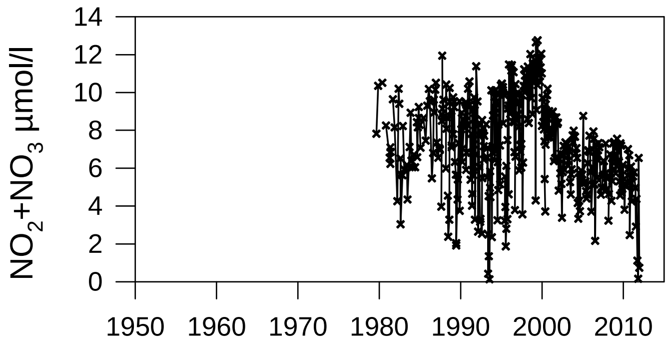
STATION BCS III-10 DEEP WATER (80m)

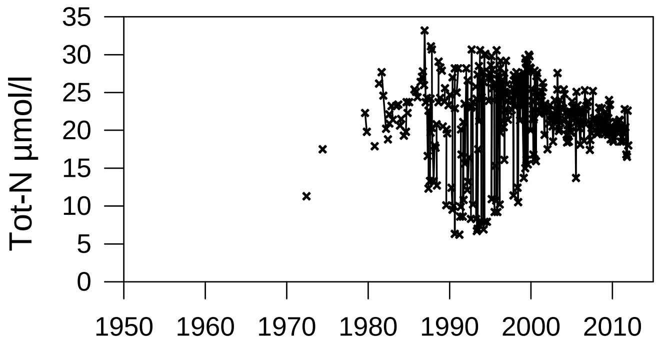


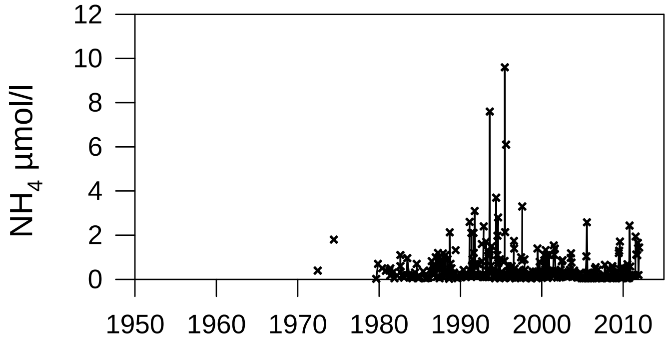


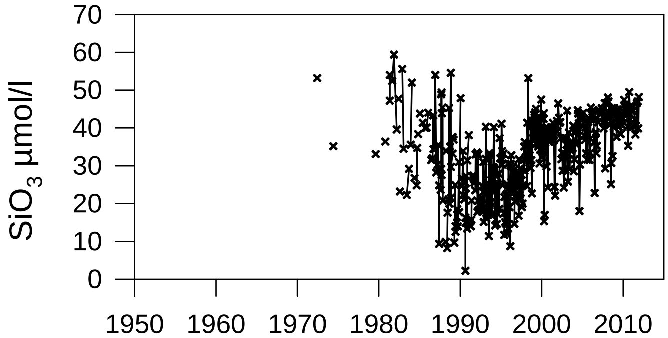


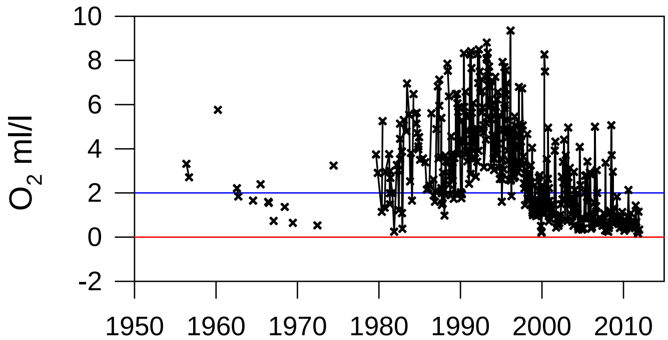










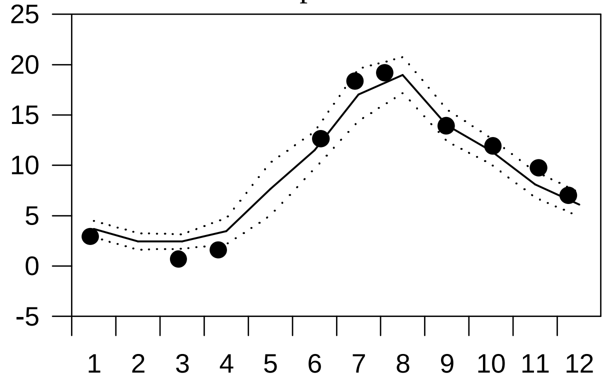


STATION BY10 SURFACE WATER

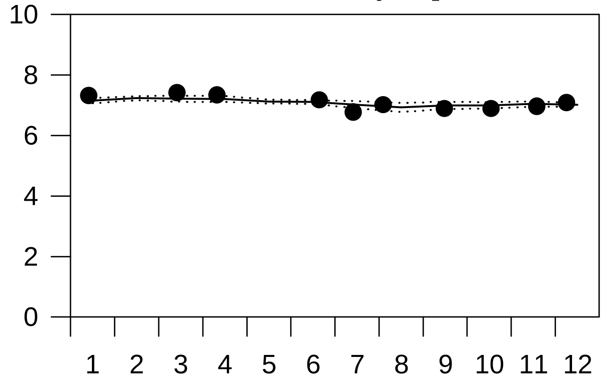
Annual Cycles

Mean 1995-2004 · St.Dev. · 2011

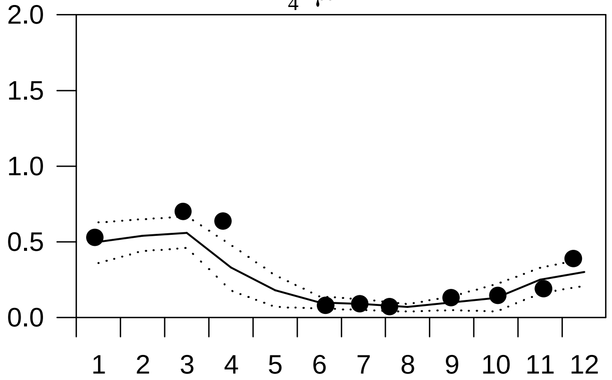
Temperature °C



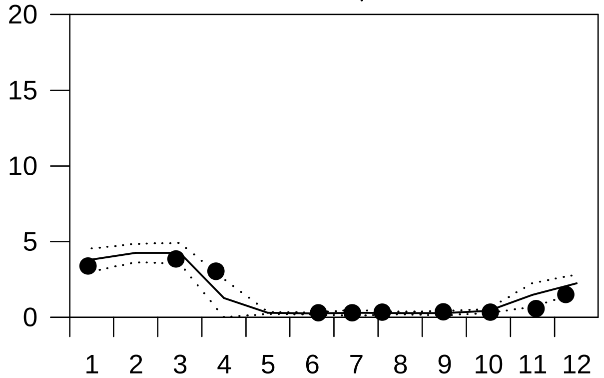
Salinity psu



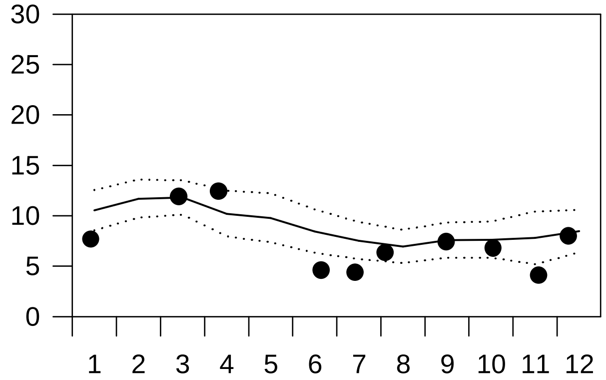
PO_4 µmol/l



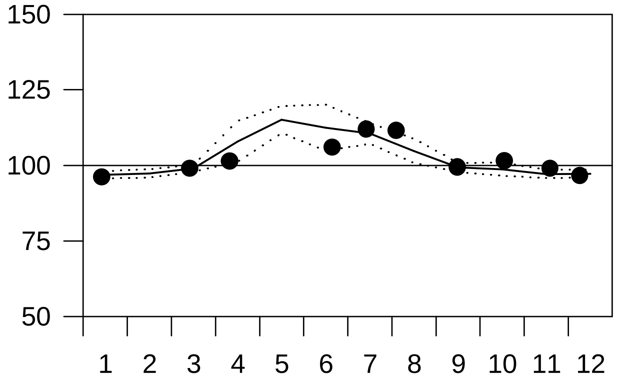
DIN µmol/l



SiO_3 µmol/l

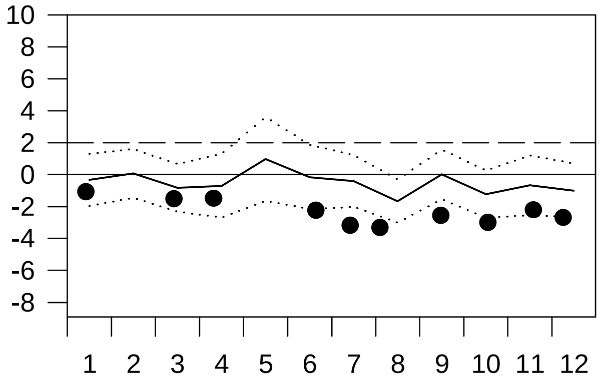


O_2 saturation %

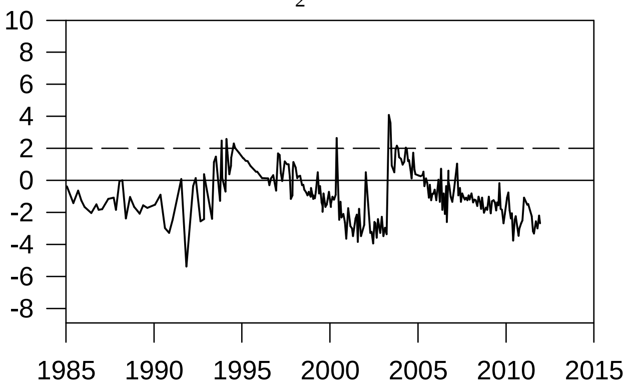


OXYGEN IN BOTTOM WATER

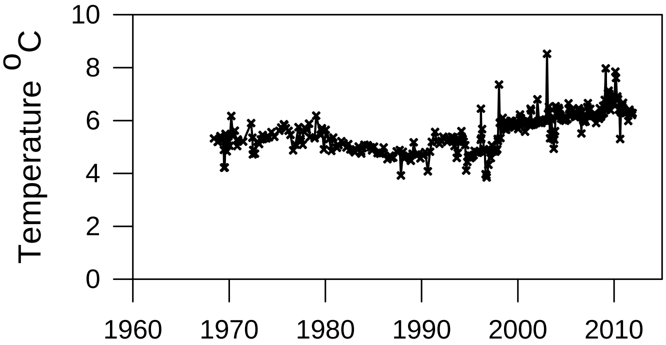
O_2 ml/l

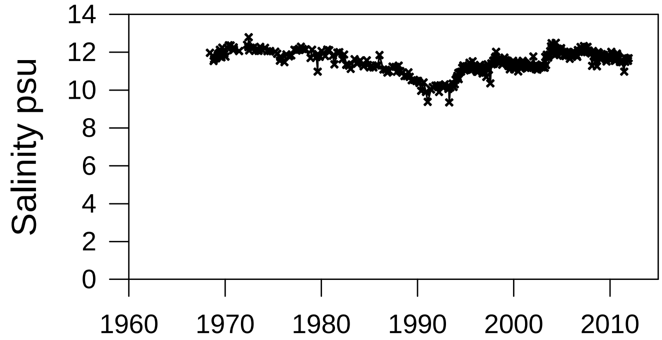


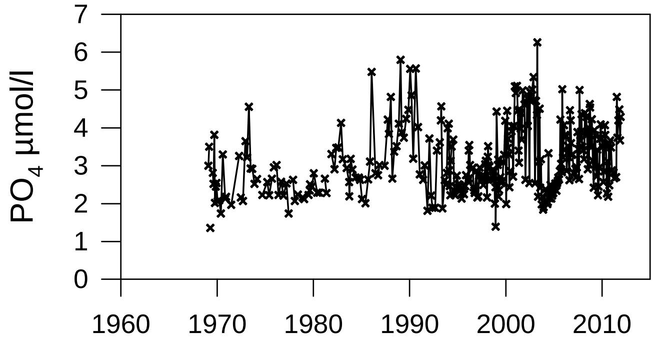
O_2 ml/l

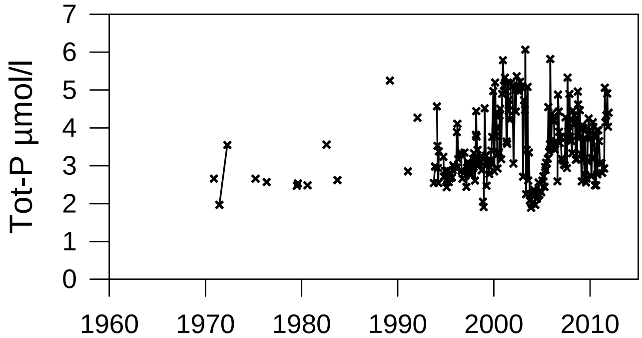


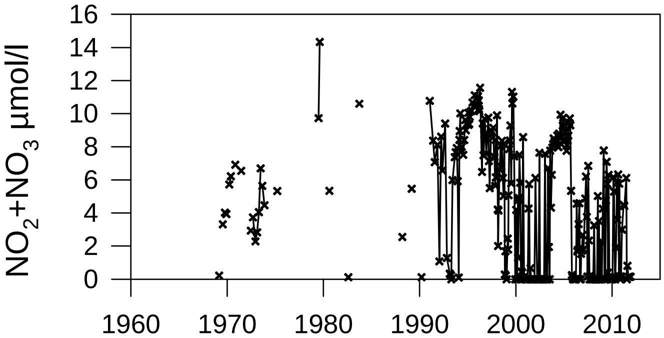
STATION BY10 DEEP WATER (125m)

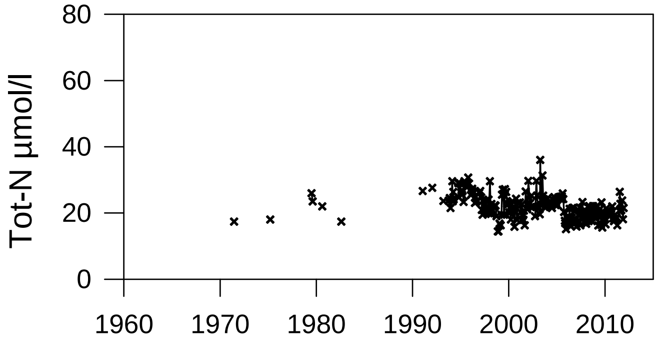


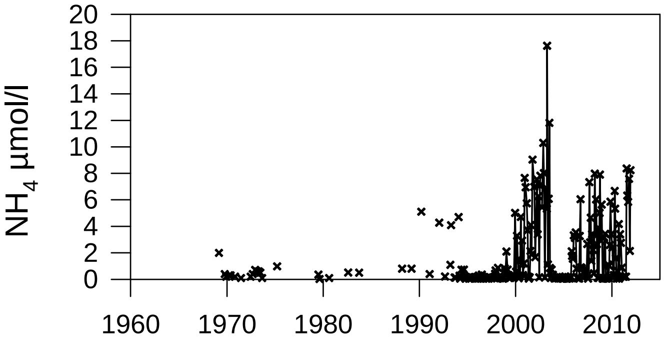


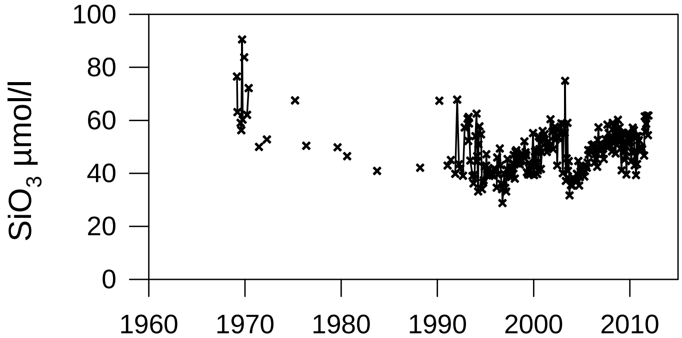


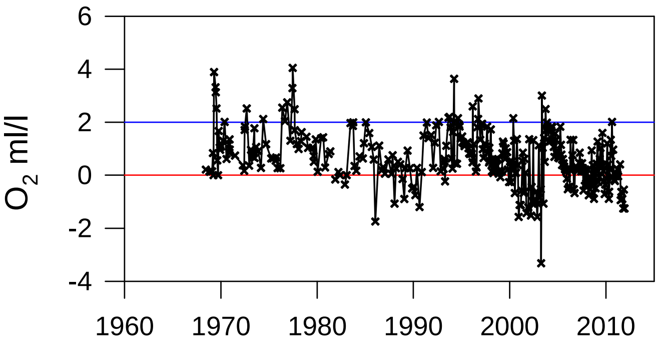








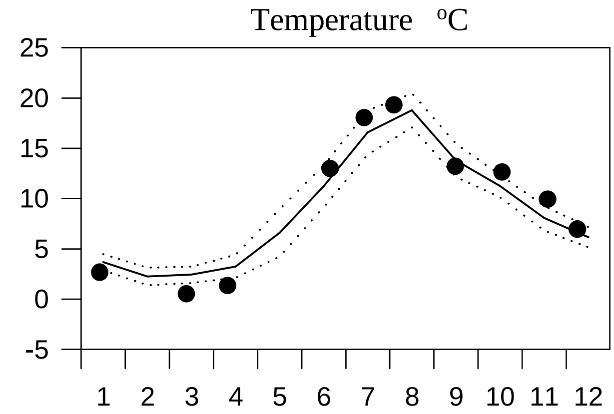


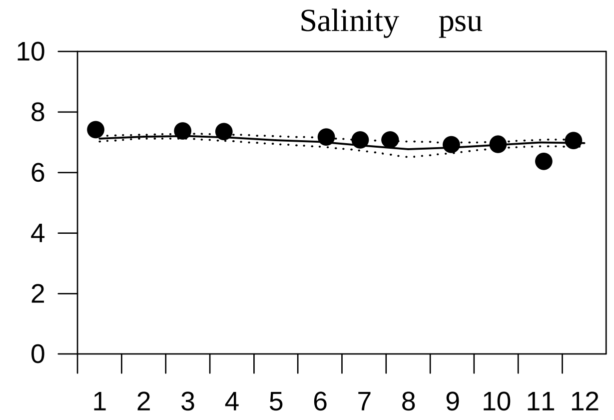


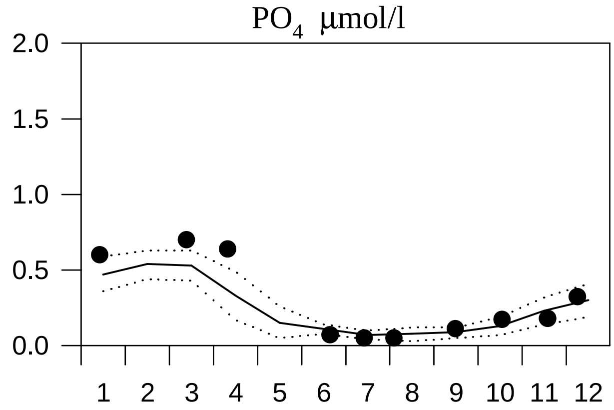
STATION BY15 SURFACE WATER

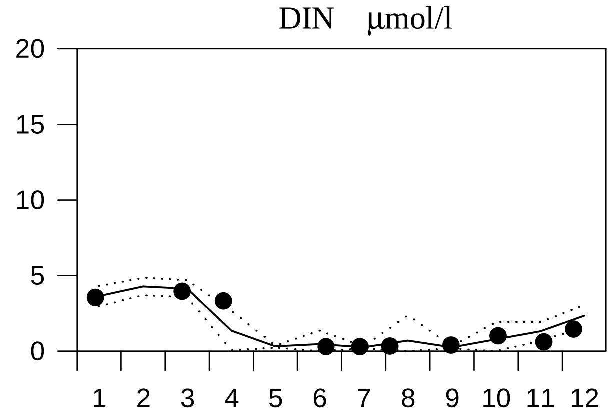
Annual Cycles

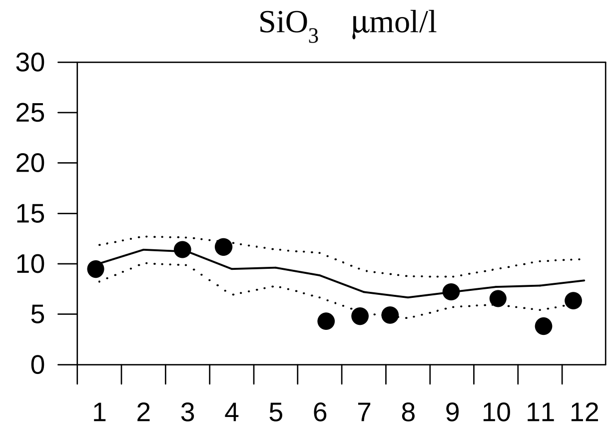
Mean 1995-2004 St.Dev. 2011

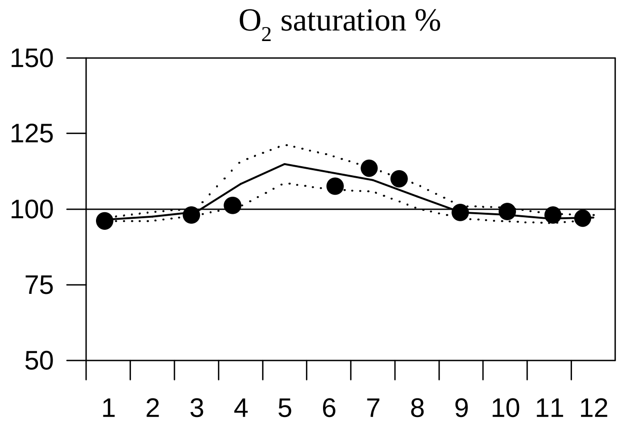




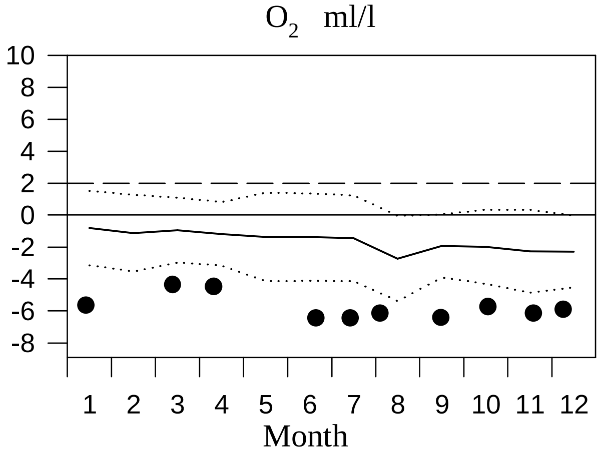


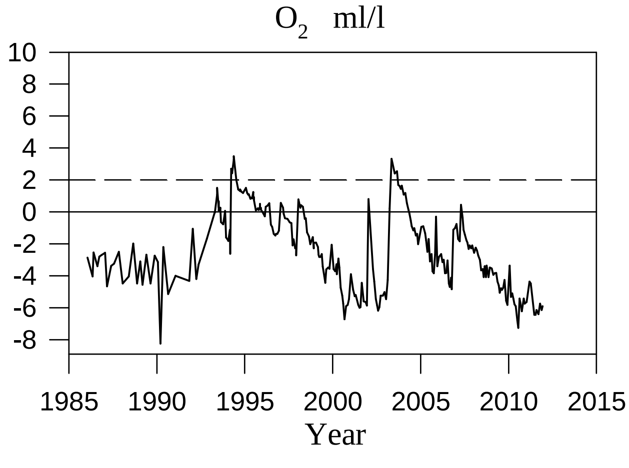




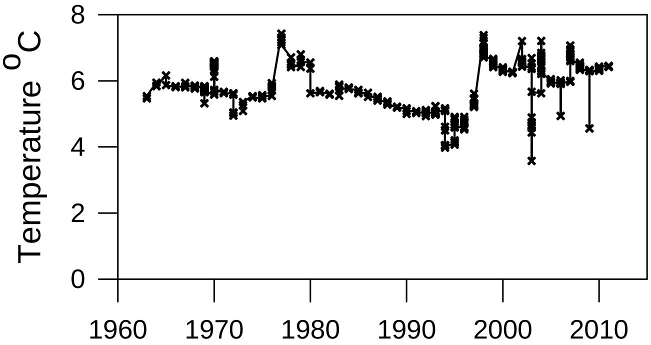


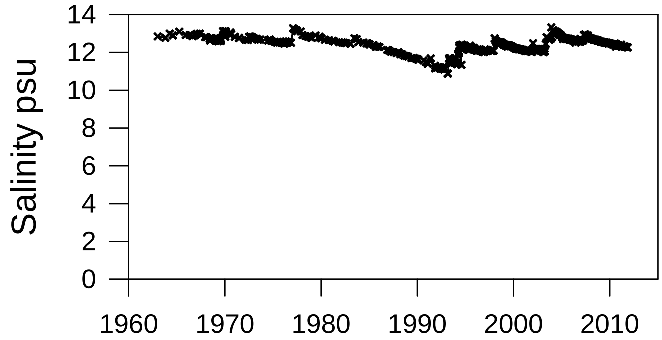
OXYGEN IN BOTTOM WATER

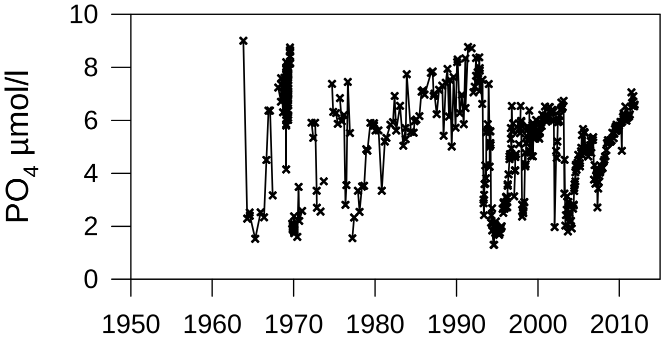


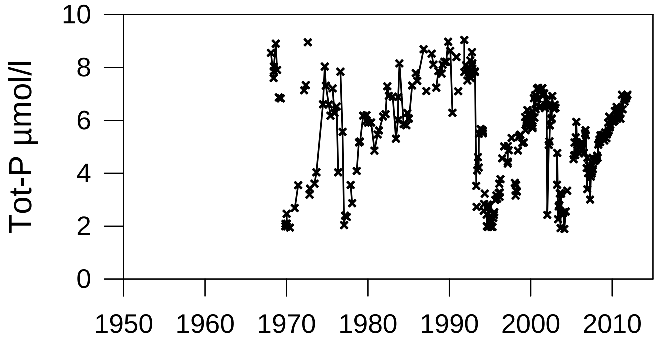


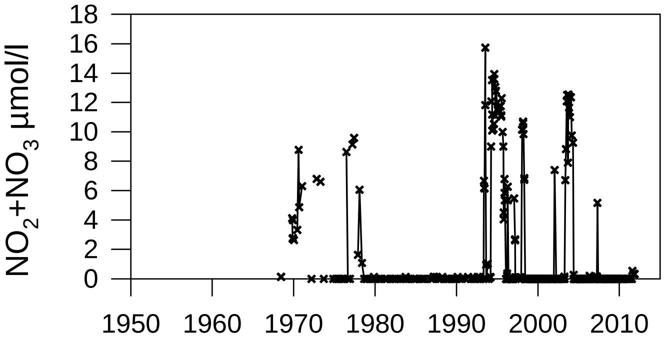
STATION BY15 DEEP WATER (240m)

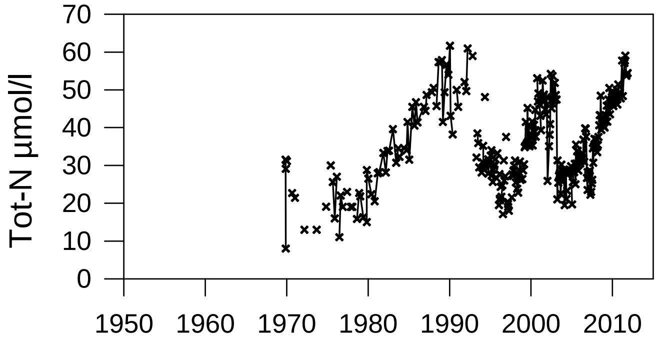


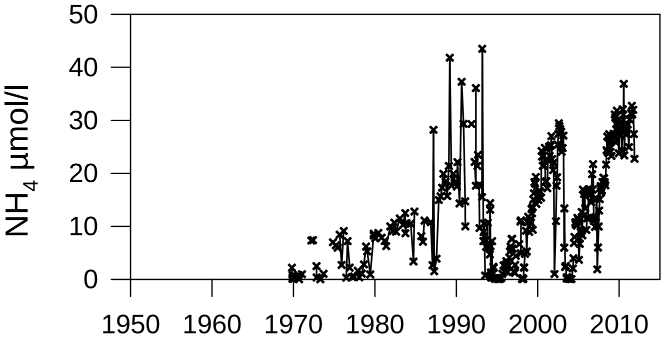


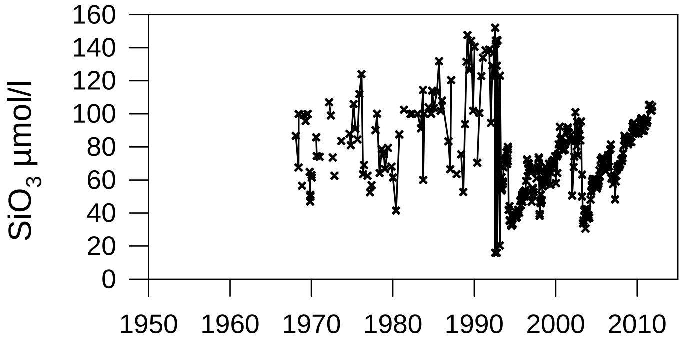


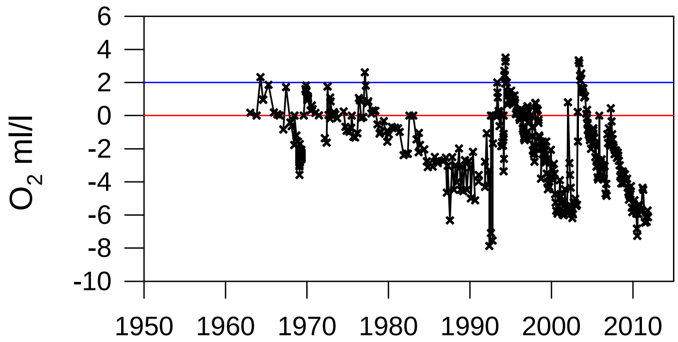






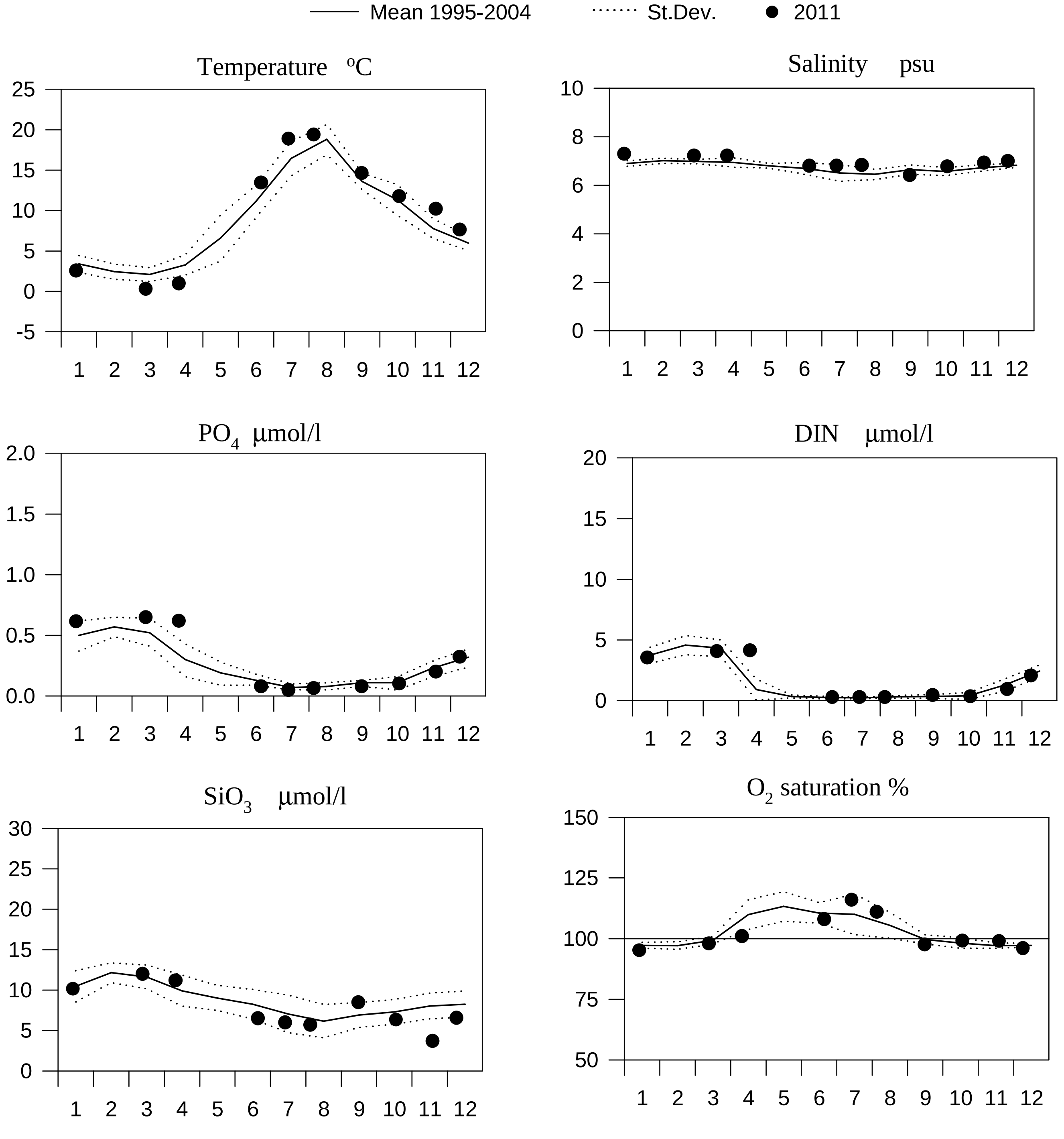




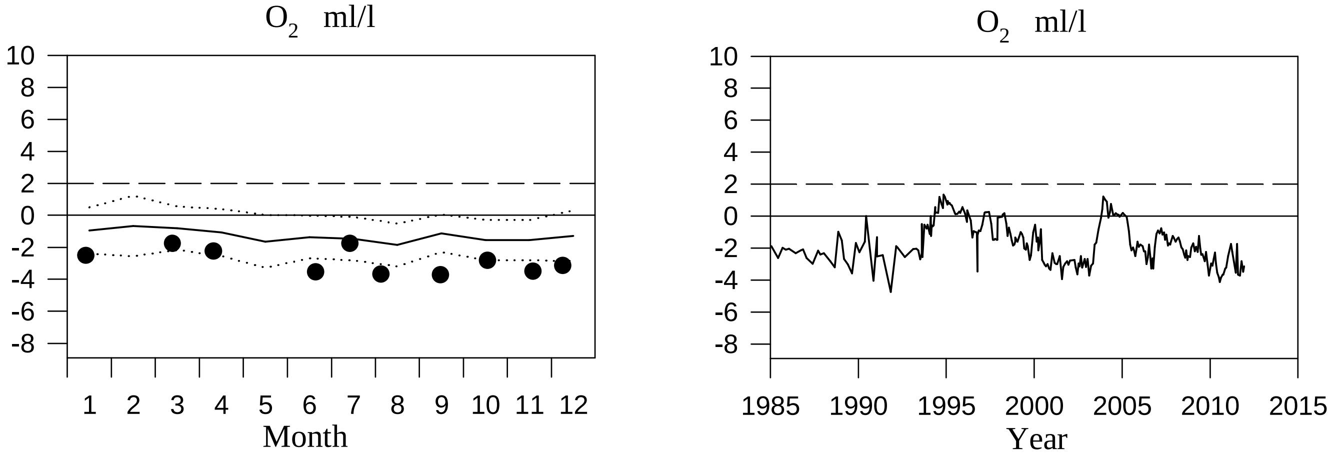


STATION BY20 SURFACE WATER

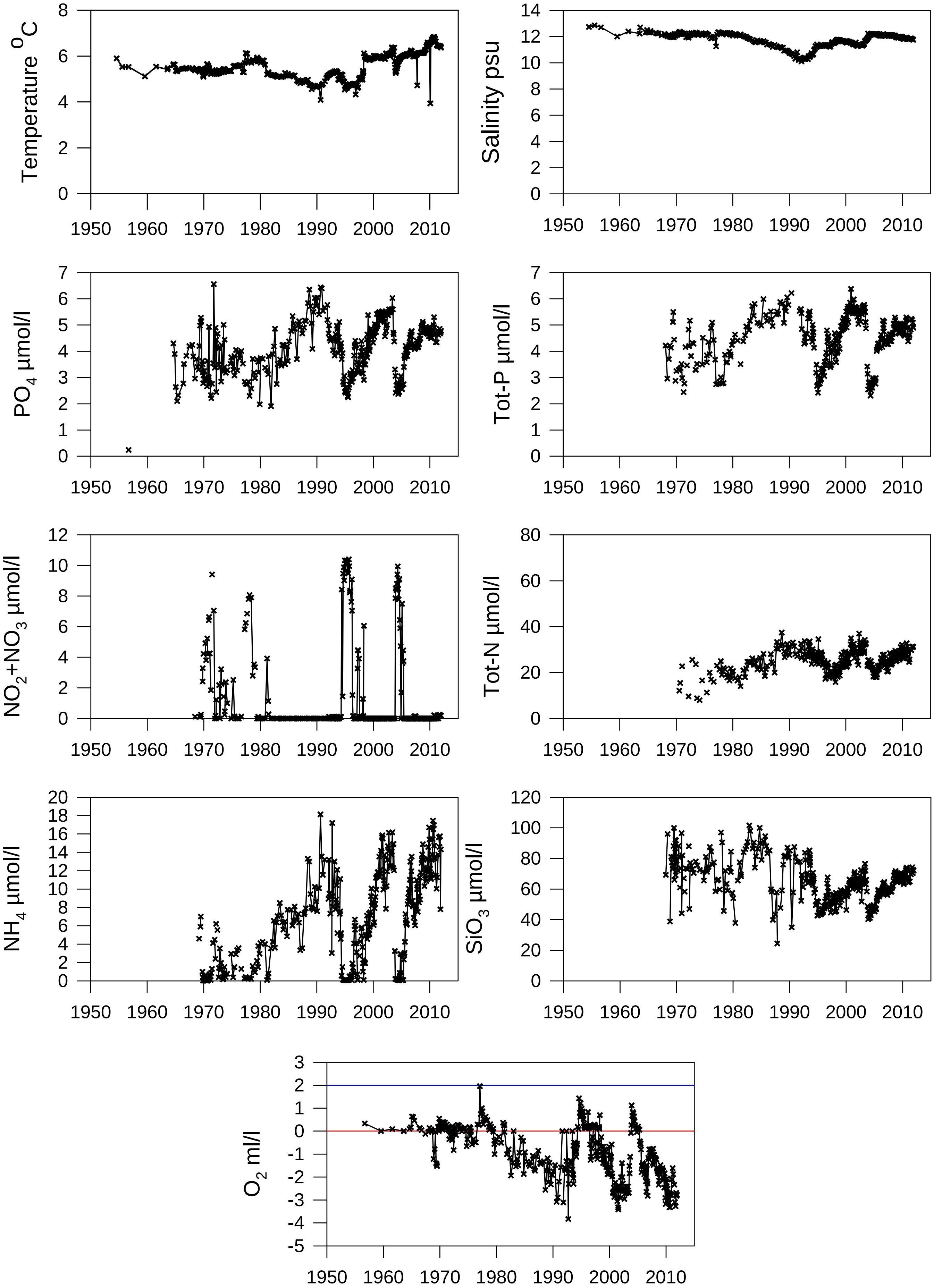
Annual Cycles



OXYGEN IN BOTTOM WATER

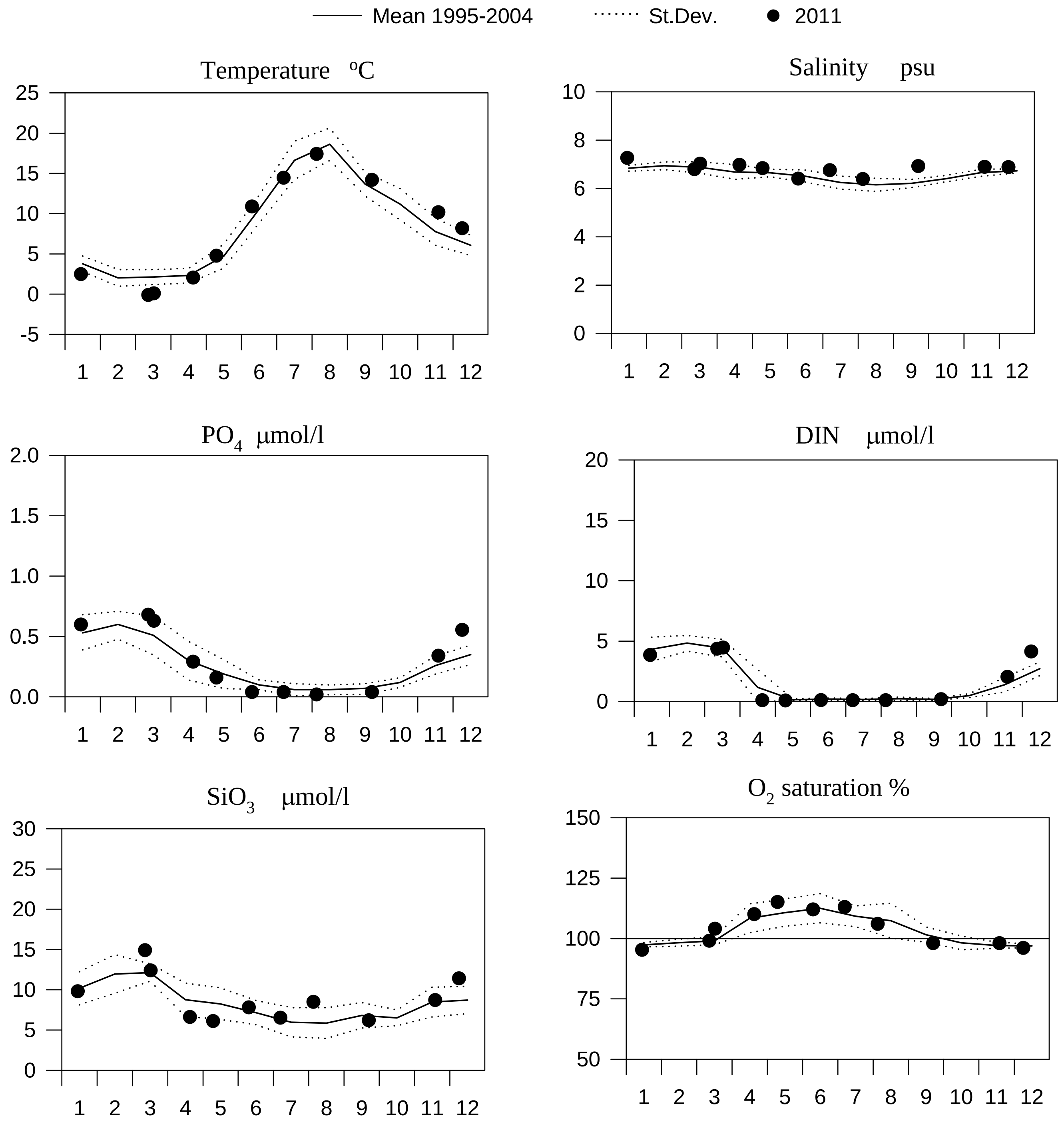


STATION BY20 DEEP WATER (175m)

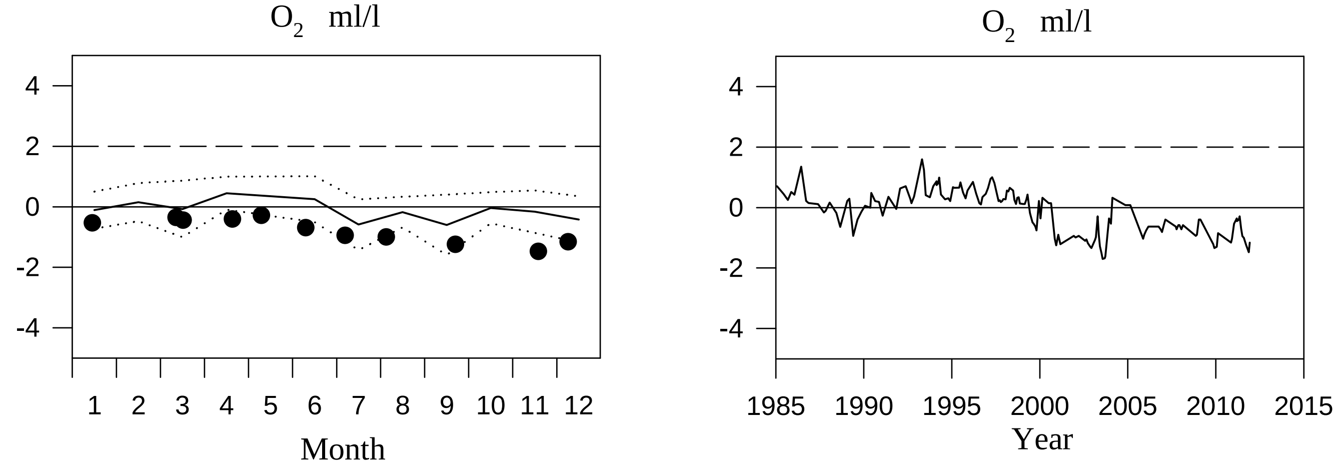


STATION BY29 SURFACE WATER

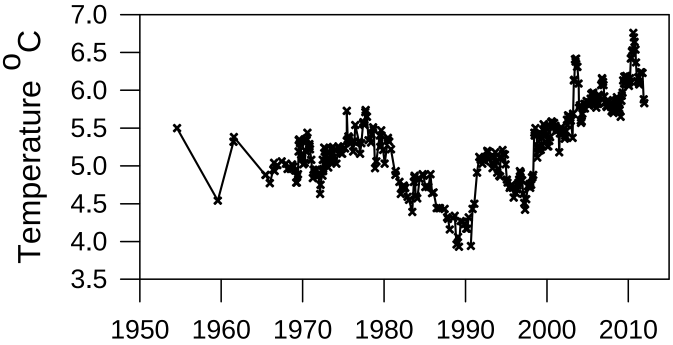
Annual Cycles

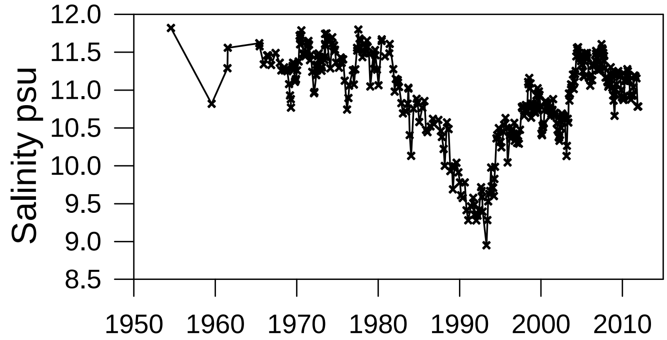


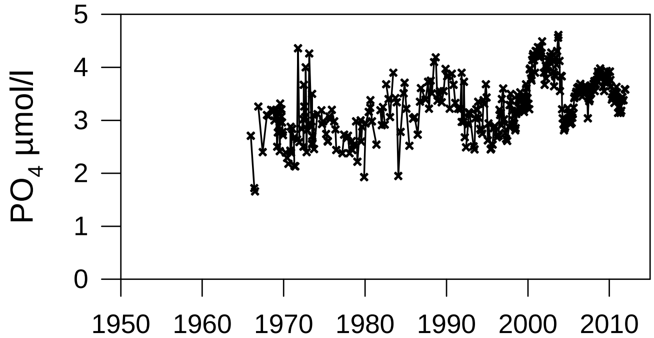
OXYGEN IN BOTTOM WATER

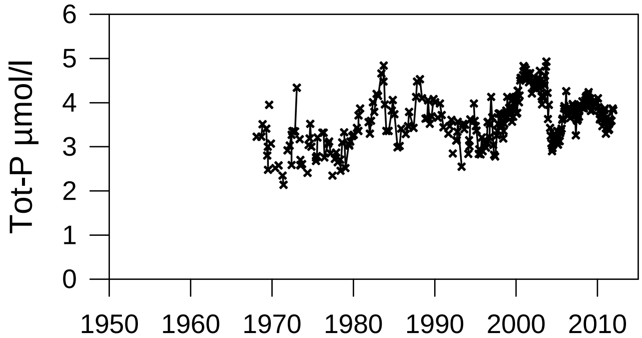


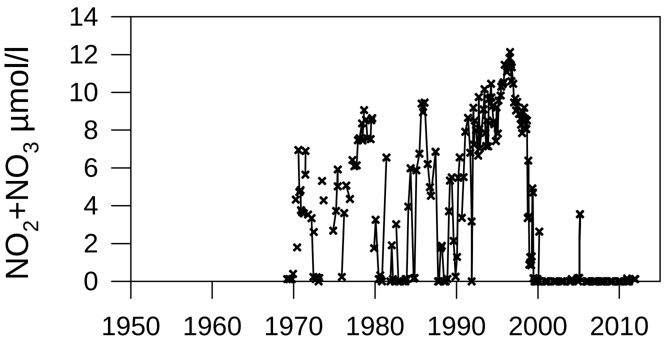
STATION BY29 DEEP WATER (150m)

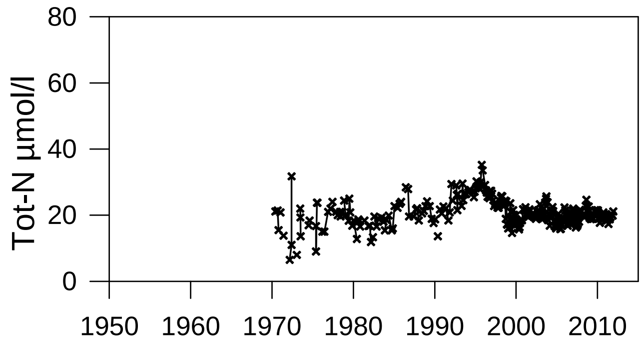


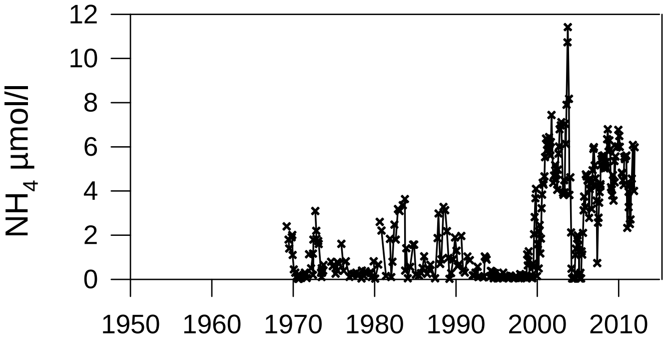


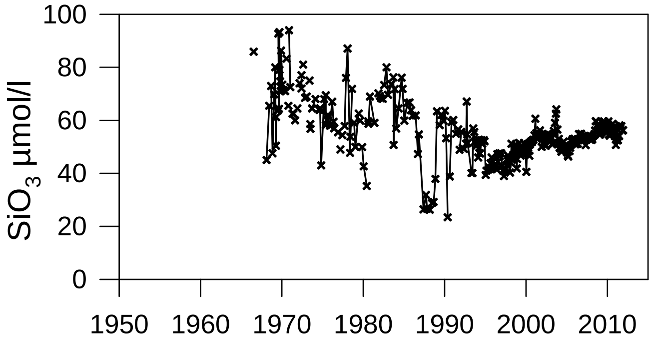


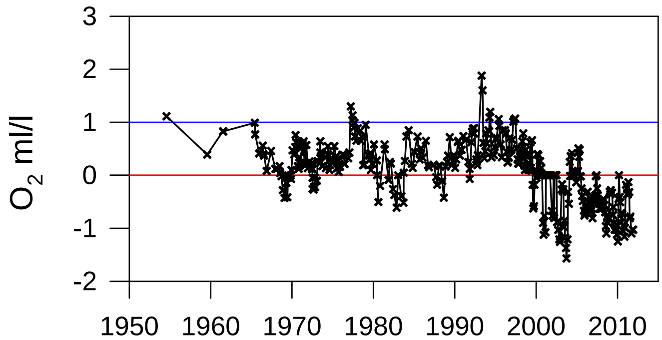










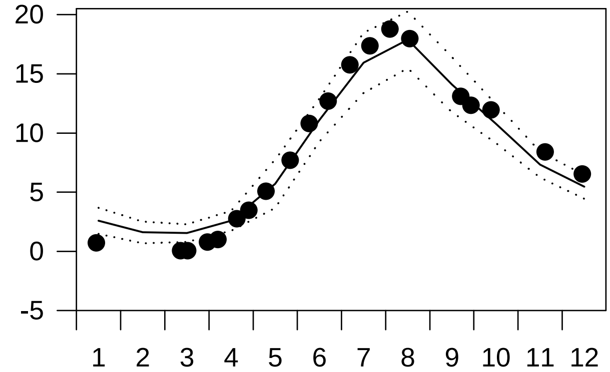


STATION BY31 SURFACE WATER

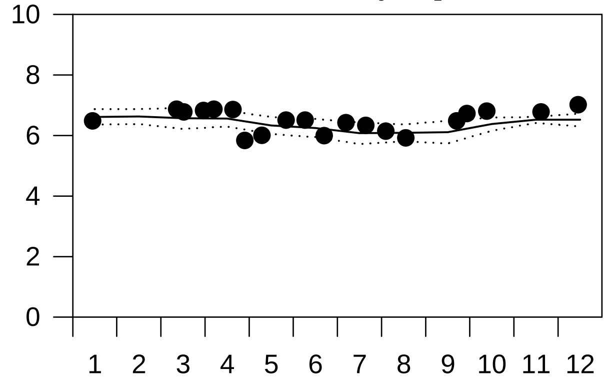
Annual Cycles

Mean 1995-2004 St.Dev. 2011

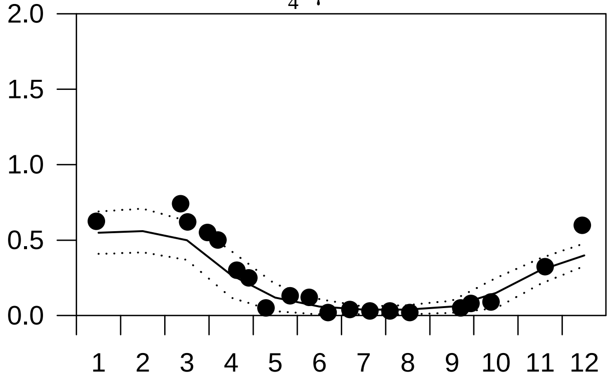
Temperature ^{o}C



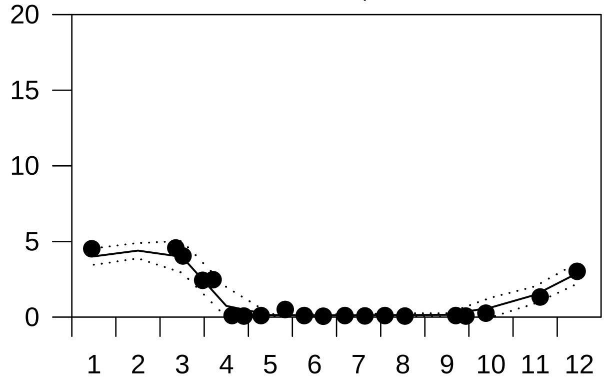
Salinity psu



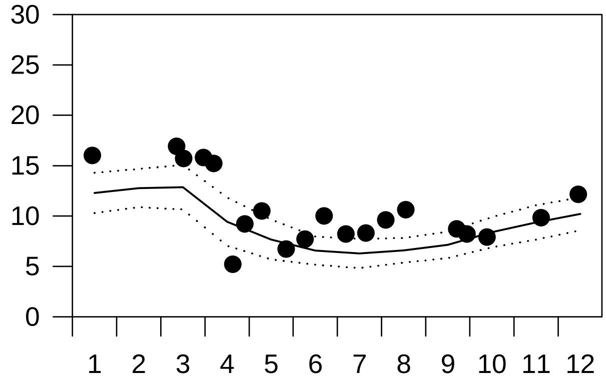
PO_4 µmol/l



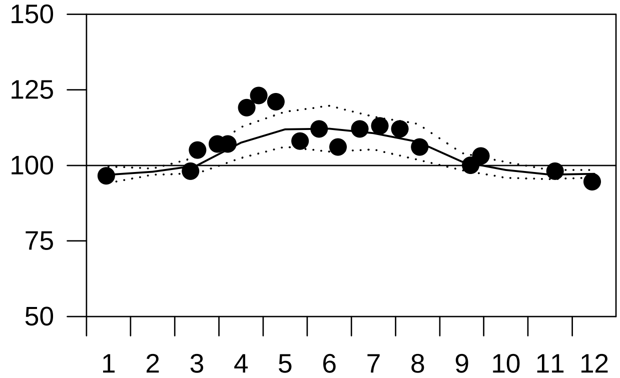
DIN µmol/l



SiO_3 µmol/l

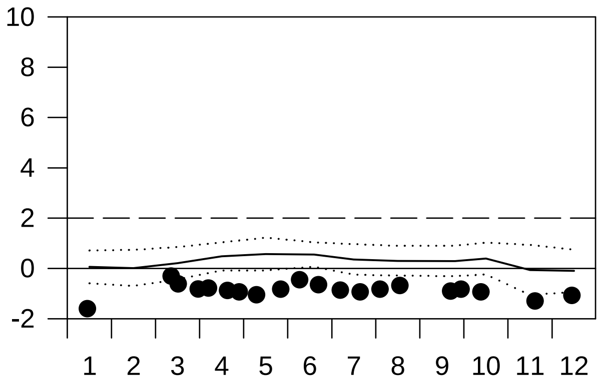


O_2 saturation %

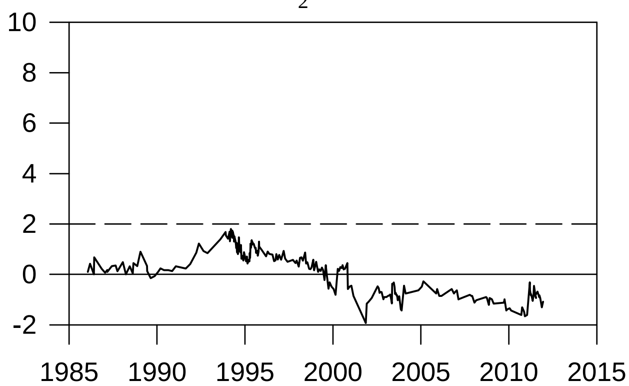


OXYGEN IN BOTTOM WATER

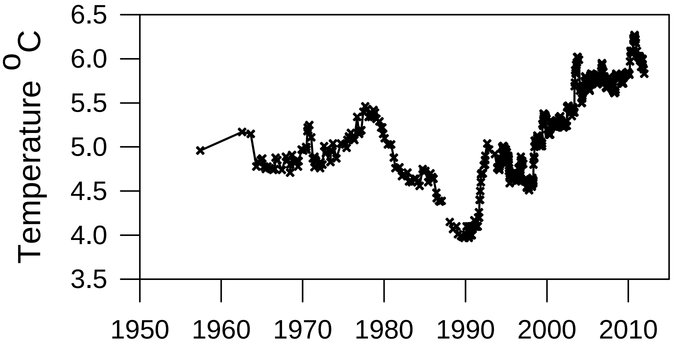
O_2 ml/l

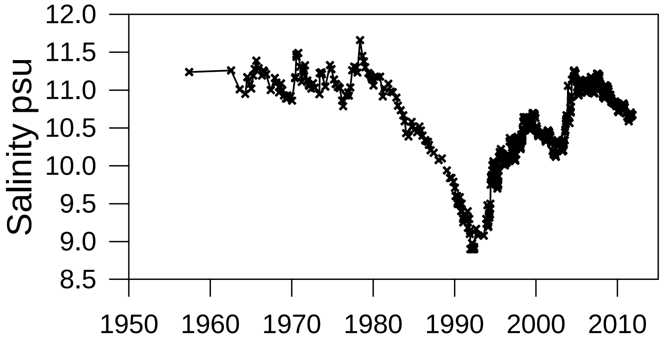


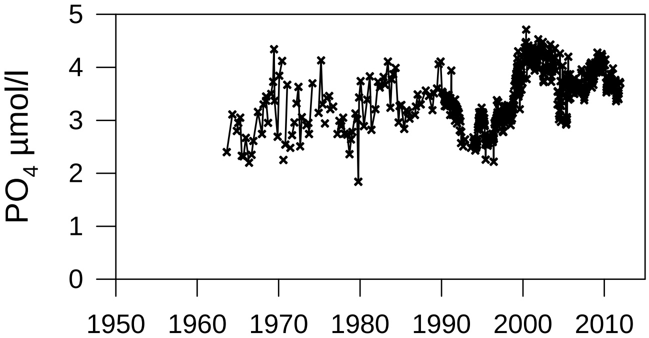
O_2 ml/l

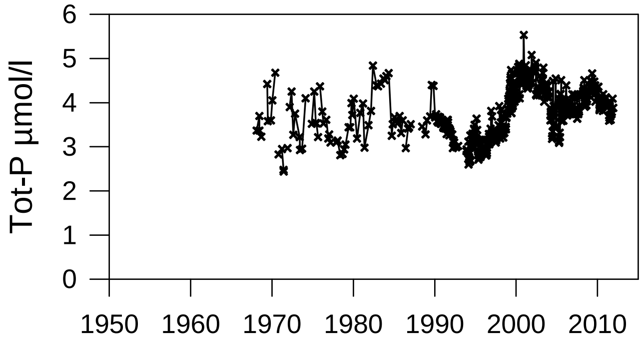


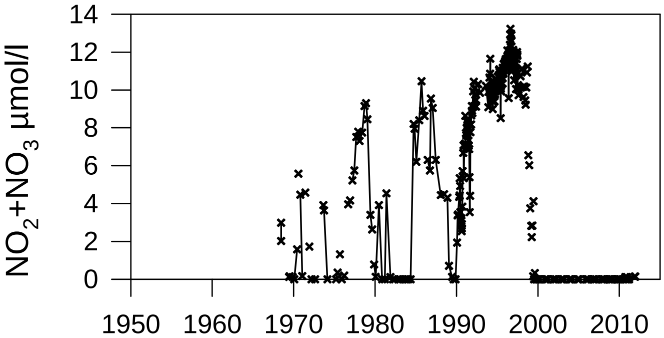
STATION BY31 DEEP WATER (440m)

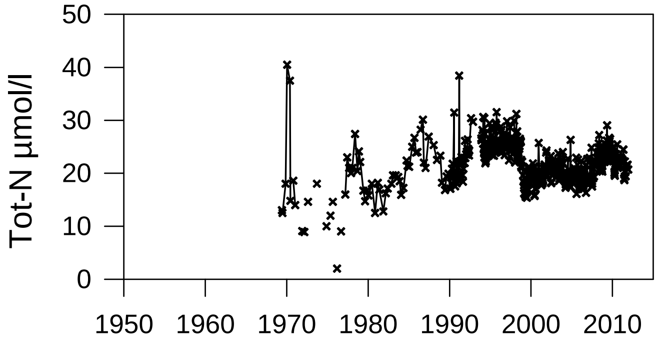


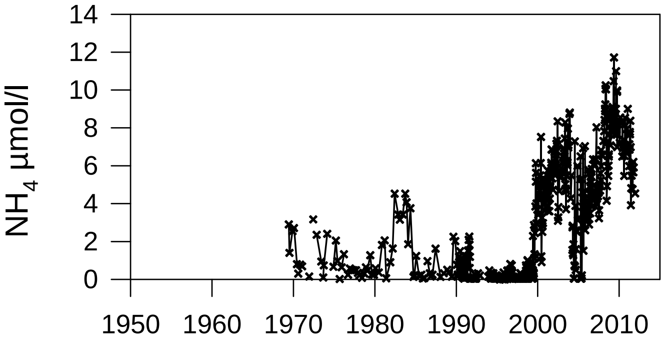


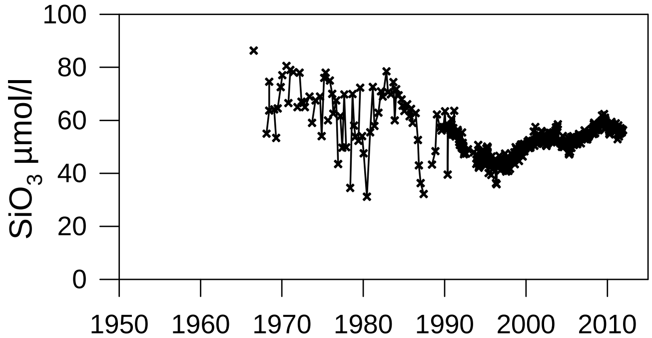


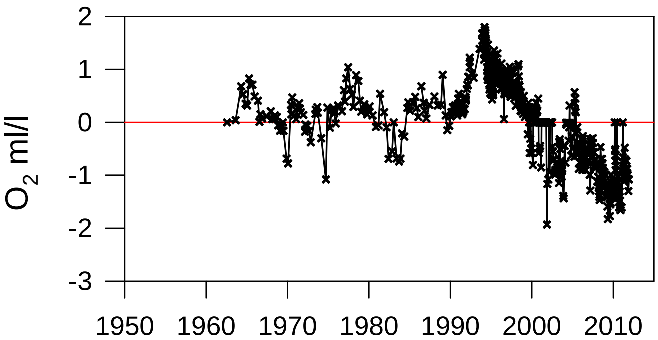






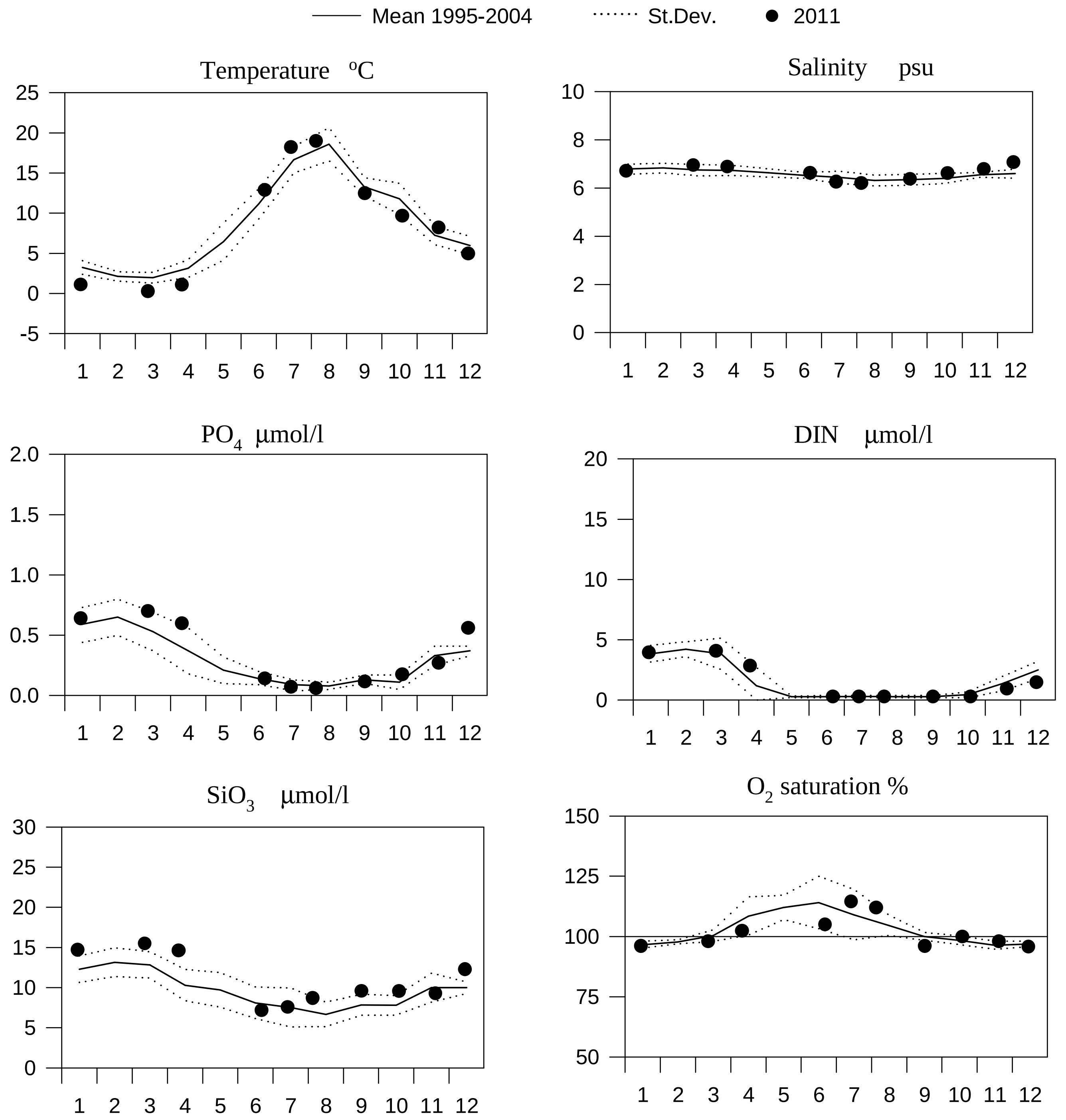




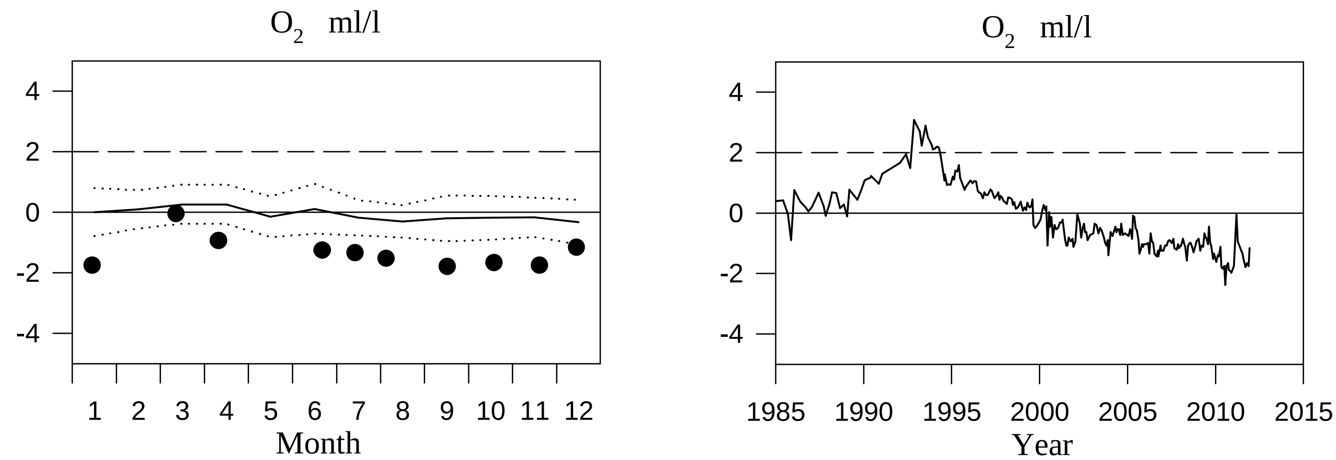


STATION BY32 SURFACE WATER

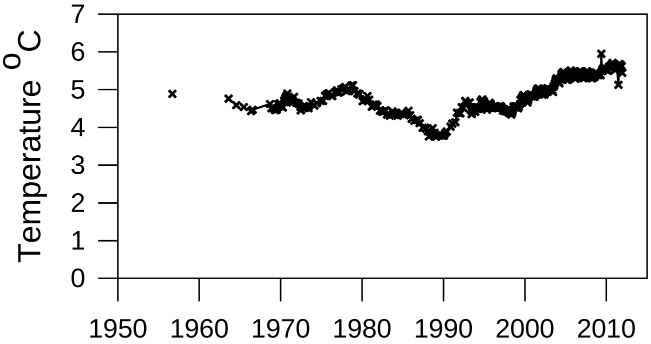
Annual Cycles

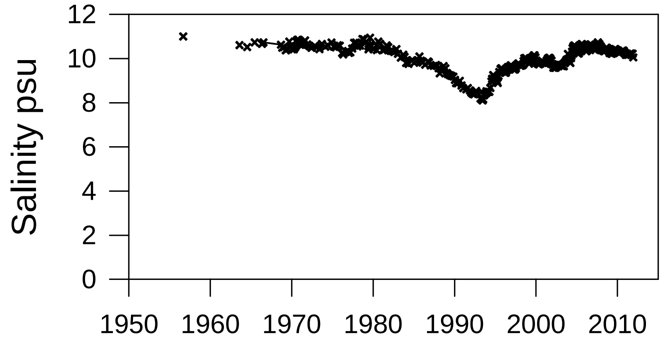


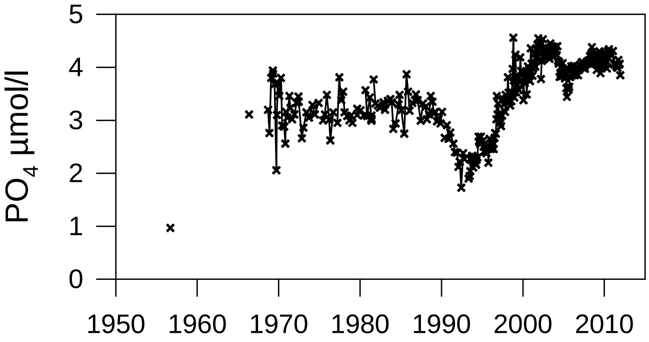
OXYGEN IN BOTTOM WATER

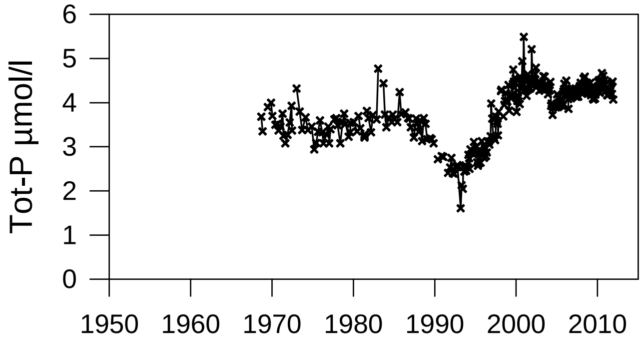


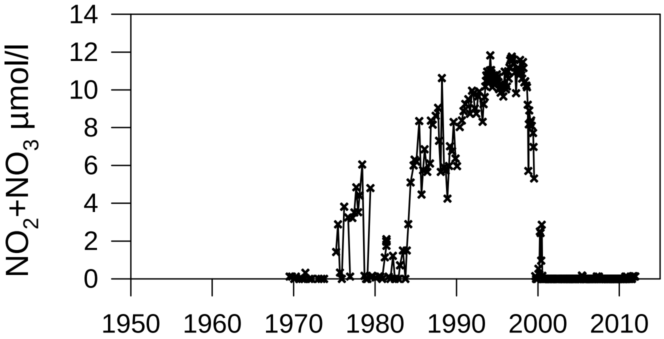
STATION BY32 DEEP WATER (175m)

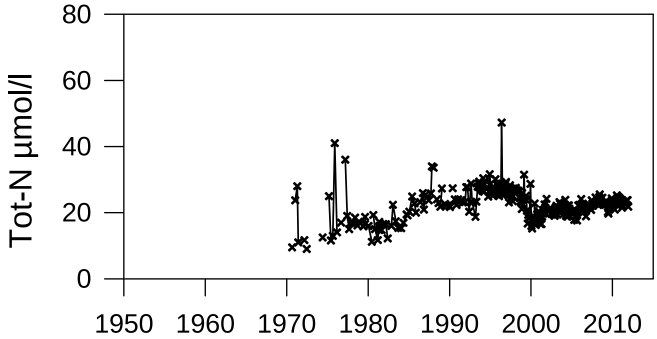


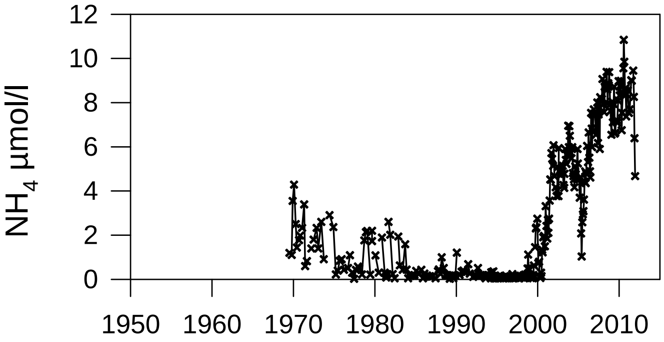


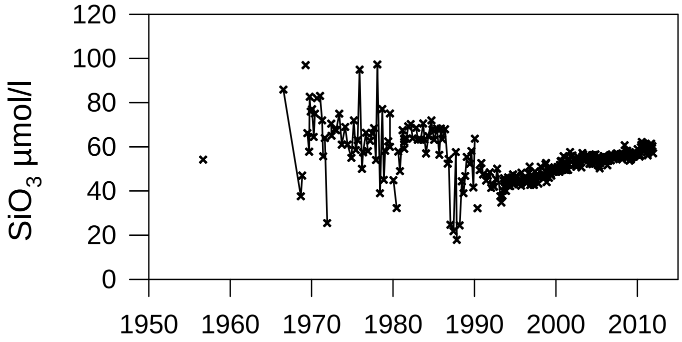


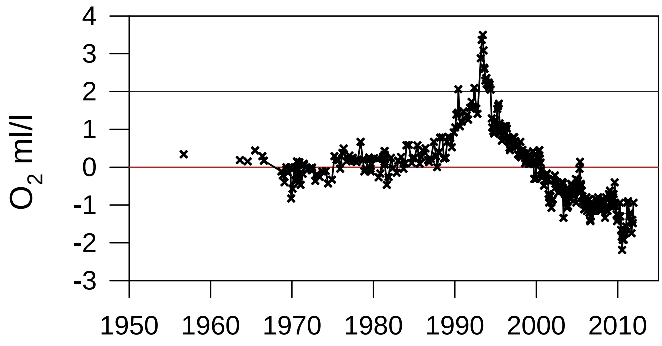








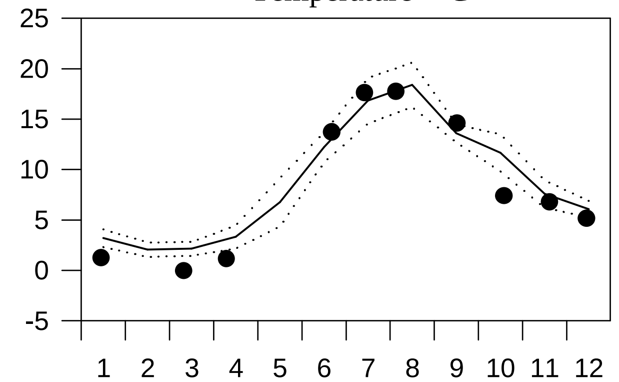


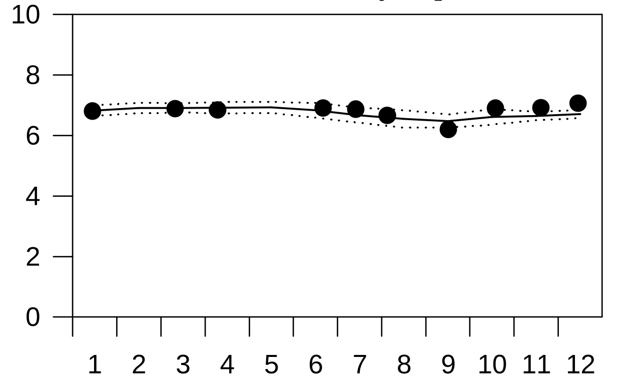


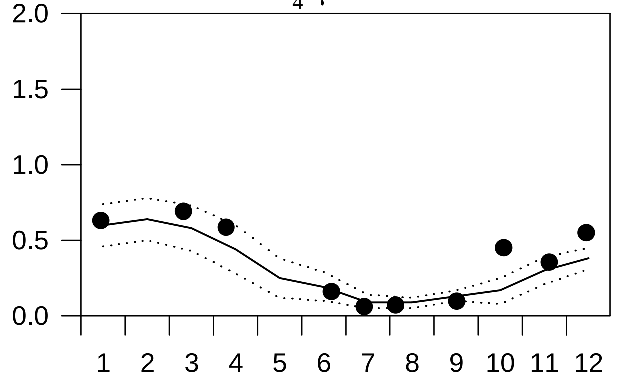
STATION BY38 SURFACE WATER

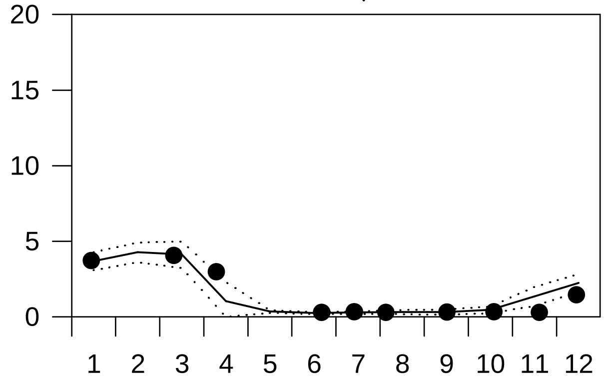
Annual Cycles

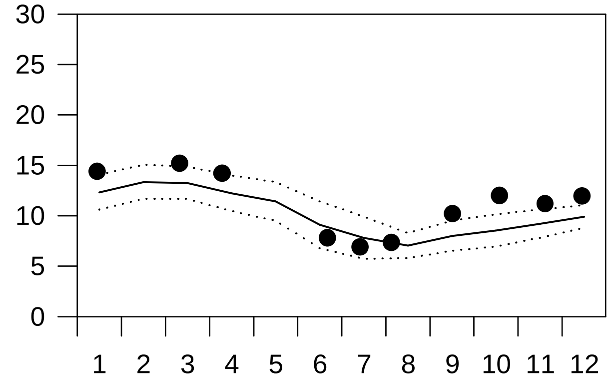
—— Mean 1995-2004 ······ St.Dev. ● 2011

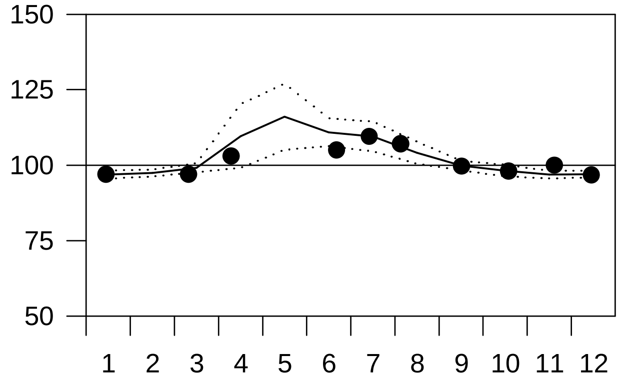




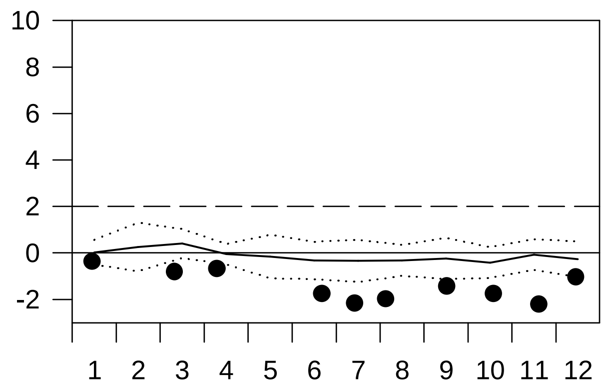


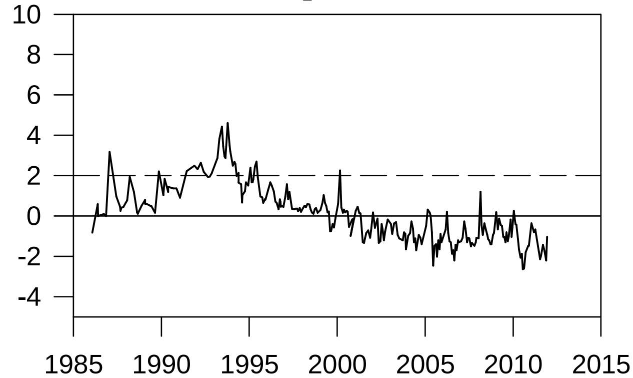




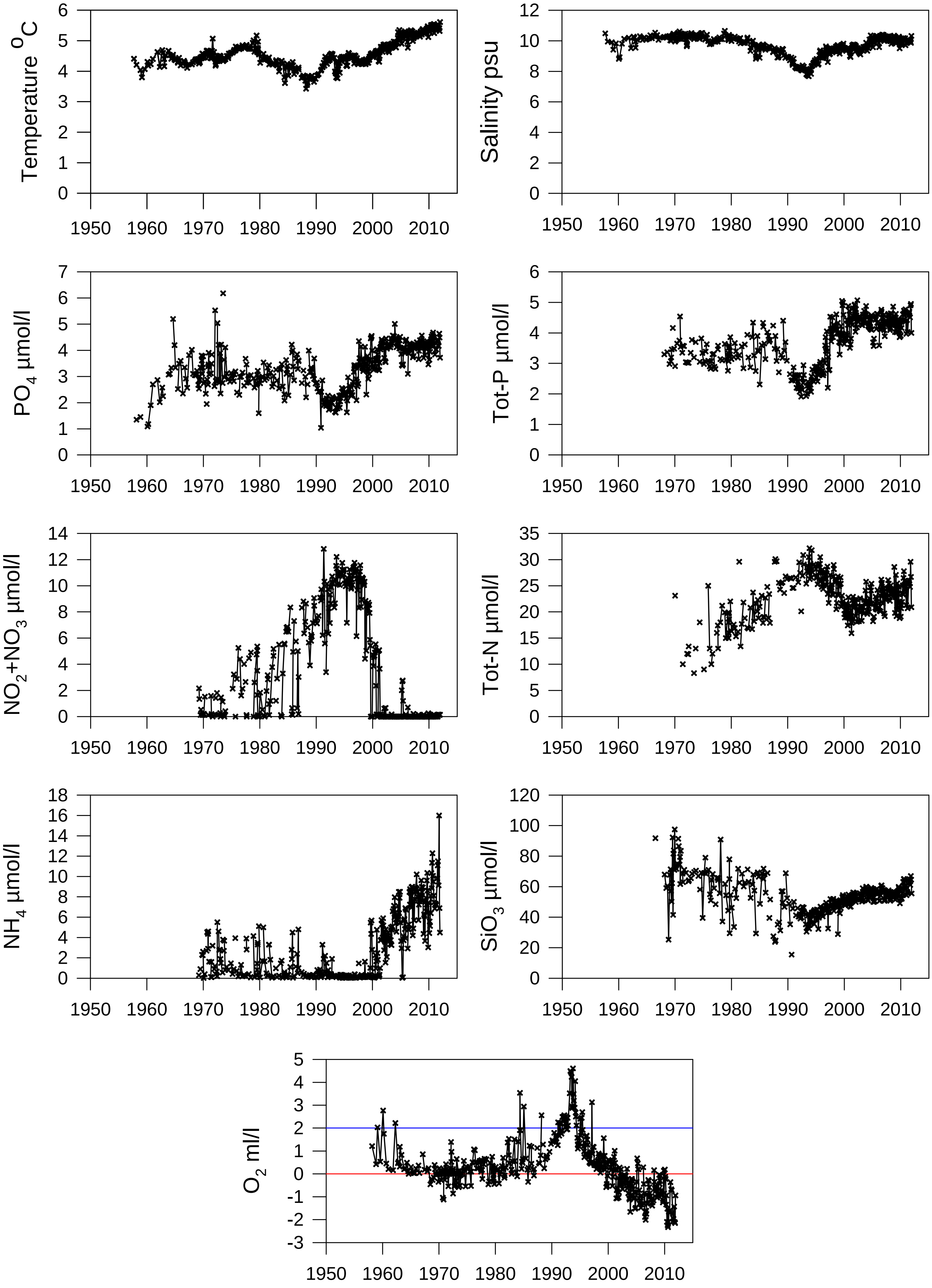


OXYGEN IN BOTTOM WATER



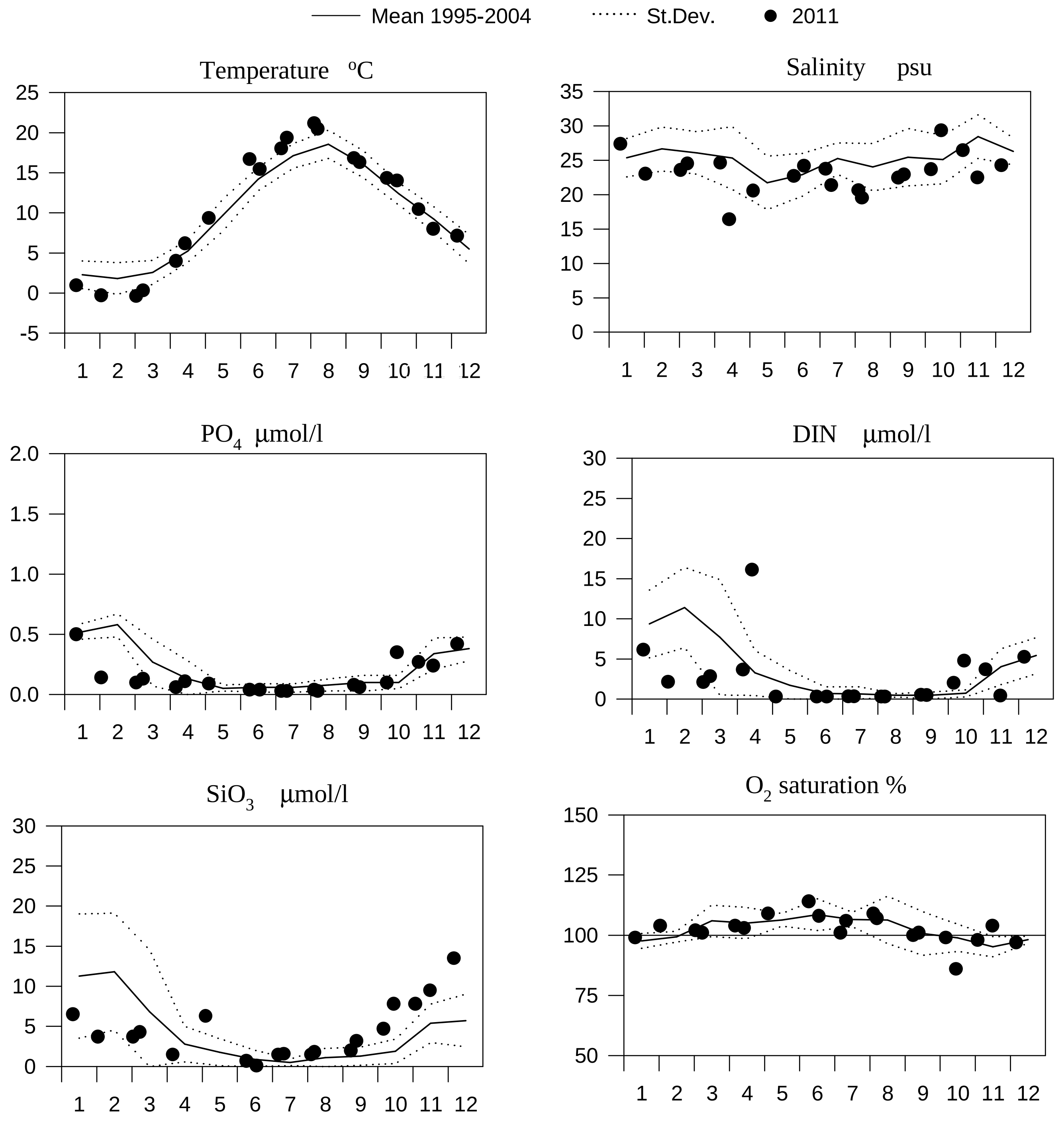


STATION BY38 DEEP WATER (100m)

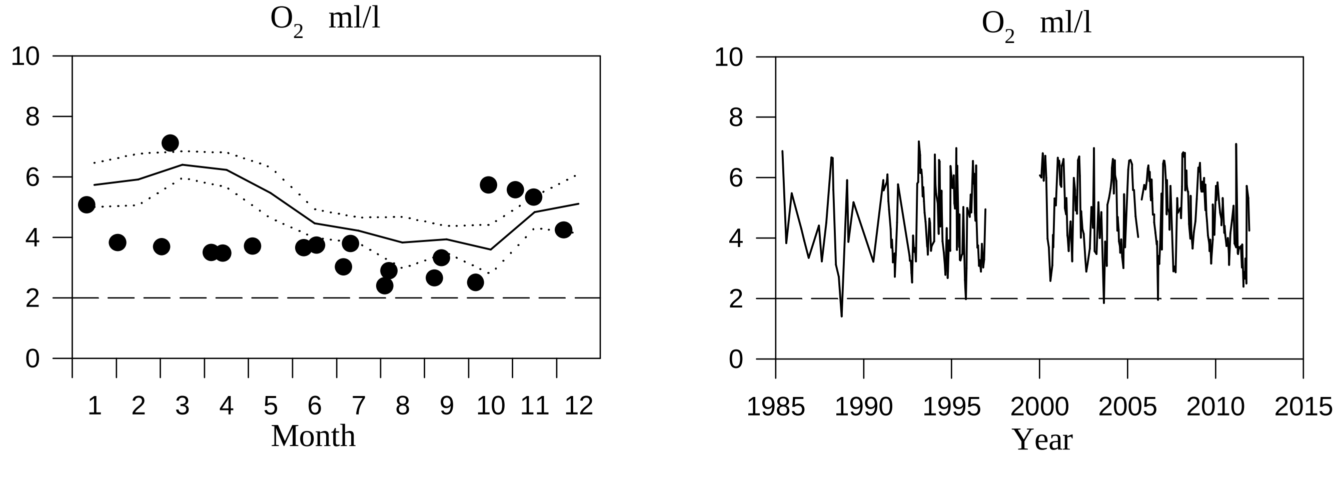


STATION SLÄGGÖ SURFACE WATER

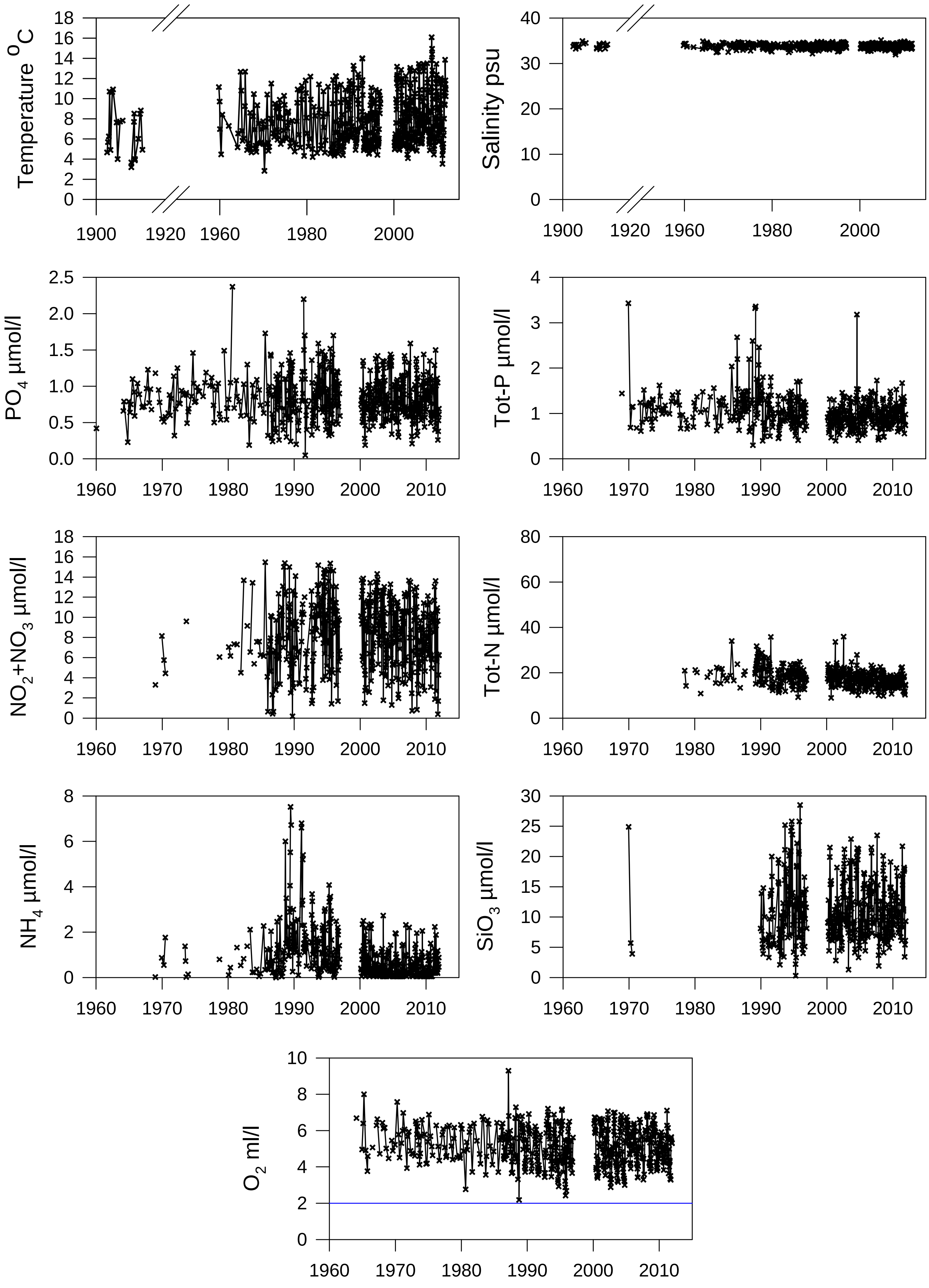
Annual Cycles



OXYGEN IN BOTTOM WATER

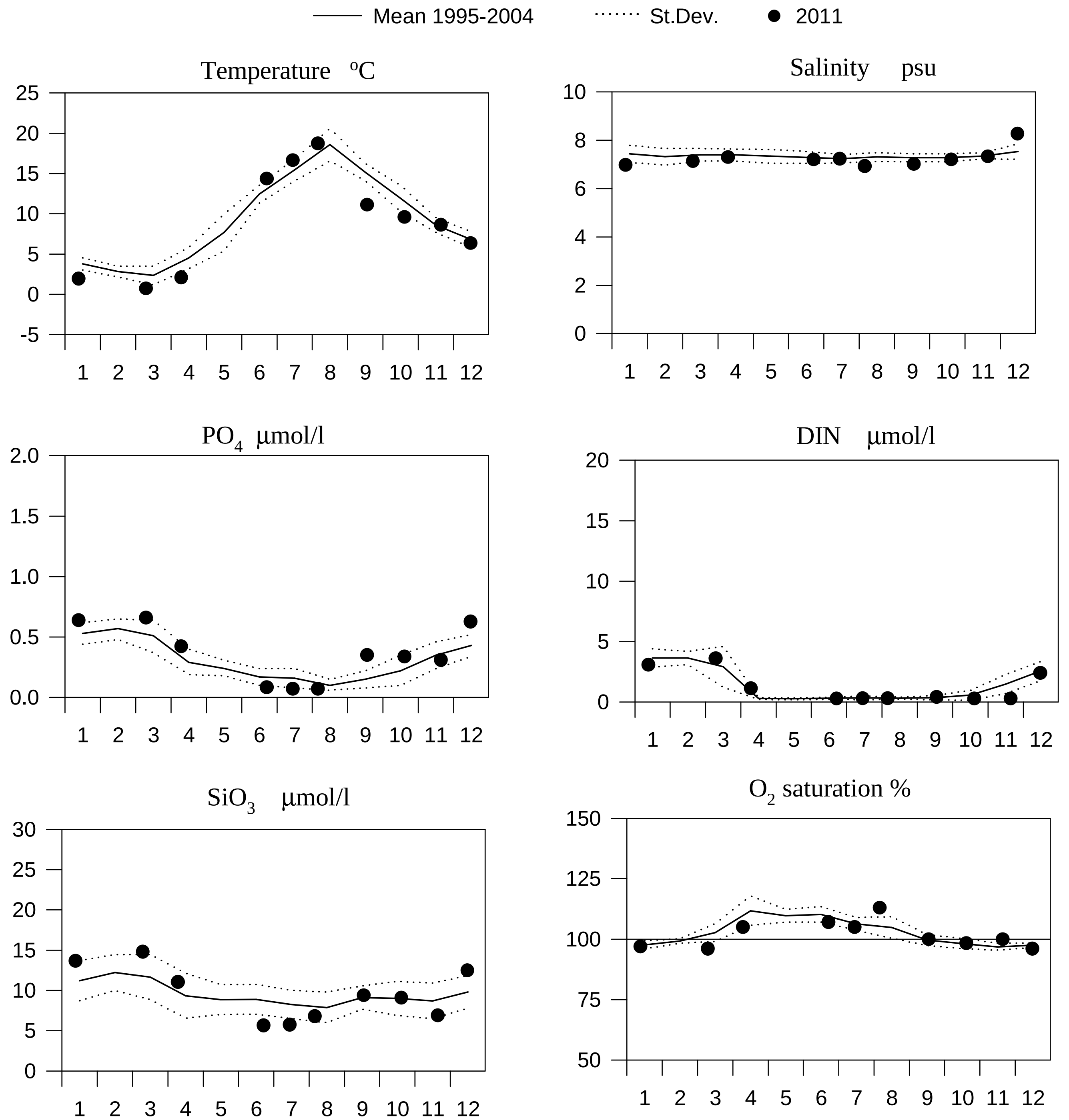


STATION SLÄGGÖ DEEP WATER (50m)

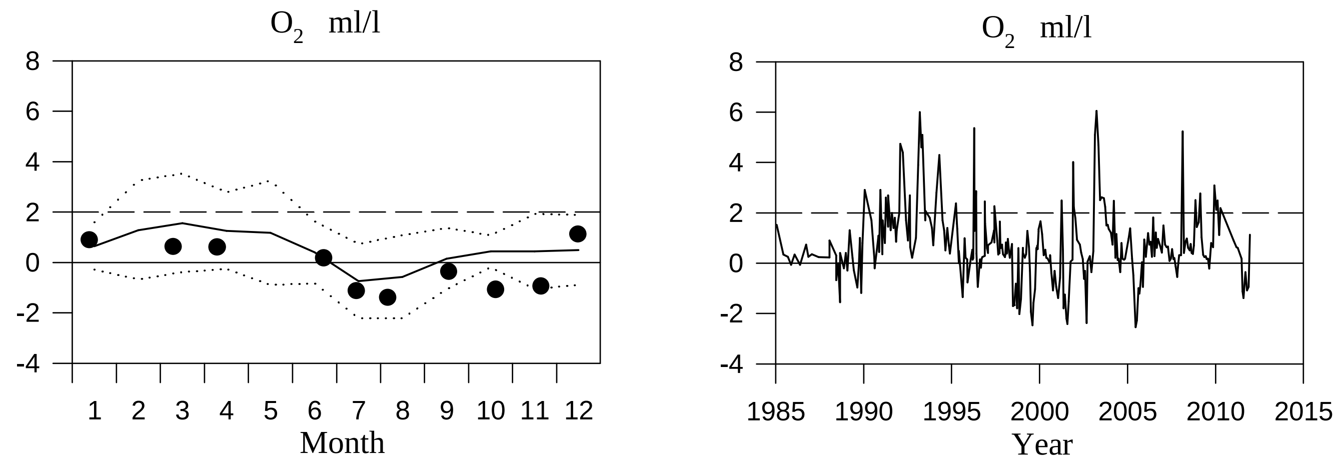


STATION HANÖBUKTEN SURFACE WATER

Annual Cycles



OXYGEN IN BOTTOM WATER



STATION HANÖBUKTEN DEEP WATER (70m)