SMHI

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Annual report 2014

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1. Exceptional events

- A major inflow to the Baltic took place at the end of the year.
- Higher than normal sea surface temperatures for most of the year.
- Low surface salinities in the Eastern Gotland Basin.
- Elevated levels of phosphate and silicate in parts of the Baltic Proper.

Meteorological conditions

2014 was the warmest year in Sweden since measurements began around 1860. In general the precipitation was higher than normal in the southern part of the country but below normal in the northern part.

The winter 2013/14 was the warmest since 2008. Warm weather also dominated during March and April. An unusually cold start and a very warm end resulted in a rather normal mean monthly temperature in May**.** June was the only month with temperatures below normal in most parts of the country. The warm and dry weather returned in July and for the northwestern part of Sweden it was the warmest July on record. August started with very warm weather but later in the month the weather turned much more unsettled, with some very heavy precipitation events. September was warm, dry and very sunny. October was also warm and in most parts of the country very wet. Warm weather also dominated in November. The year ended with a rather warm December despite a cold period around Christmas.

The ice season 2013/2014

The ice season 2013/2014 was mild with a maximum ice extent of 93 000 km^2 reached on February 7. The ice began to form in mid-November, about a week later than normal, but due to a mild and windy start of the winter it was not until late January that the Bay of Bothnia was completely ice covered. The mild weather conditions in February, and the following months, shortened the ice season somewhat and around May 14 the Bay of Bothnia was ice-free, about a week earlier than normal.

2. Hydrological conditions

Discharge

On several occasions during the year, high and/or very high flows took place, especially in connection with torrential rain in August. However, in some places unusually low water flows were recorded. The spring flood came earlier than normal, and by the end of April it was over in Svealand, except for the mountain regions and in parts of Norrland. Warmer weather during the second half of May led to increased snow melting and the flows increased. In the mountain region of Lappland and in the unregulated northern rivers the flows were slightly higher than during a normal spring runoff. The summer of 2014 was hot and much of the water evaporated from the ground. The eastern Svealand and southeastern Norrland had only little rainfall in the summer which made the water flows very low. In parts of the country a lot of rain fell during autumn. Especially Bohuslän and Dalsland had much rain in October and the flows in many rivers were very high.

Hydrographic conditions

Sea water levels

The winter 2014 began with high water levels which were followed by a long period of water levels below normal, due to a high pressure weather conditions with northeasterly winds. The year ended with rising water levels associated with the largest saltwater inflow to the Baltic Sea for many years. The lowest water level was measured in Skanör (-120 cm) and the highest water level was measured in Kalix (+109 cm). The long period of low water levels in the Baltic Sea created favorable conditions for an inflow of new salt-rich water to the Baltic Sea. In early December, a large saltwater intrusion into the Baltic Sea began, the largest since 1993, and the water level at Stockholm, which reflects the average volume in the Baltic Sea well, rose from about -40 to +50 cm.

Inflows to the Baltic

Some small inflows during winter and autumn, and a massive inflow in December led to the oxygenation of the deep waters of the southern Baltic. This year summed inflow to the Baltic Sea was 323 km³ and the summed outflow was 625 km³. The average for inflows and outflows during the period 1977-2014 is 309 km³ respectively 610 km³. Both inward and outward flow into the Baltic Sea in 2014 was thus slightly larger than normal. In January and February there were two smaller inflows of 30 km³ and 20 km³ through the Sound. After the summer another two smaller inflows occurred. A continued high pressure dominating autumn with large outflows from the Baltic which lowered the overall water level in the Baltic, and in the beginning of December the water level was about 40 cm below normal in the Baltic Proper. The low water level in the Baltic Sea together several low-pressure passages and sheer southwesterly winds now created very good conditions for a larger inflow. A major salt water inflow was a fact, and between the 2nd and 24th of December about 70 km³ flowed in through the Sound, and in January 2015 another 30 km³ entered. An estimated total inflow of 250-300 km³ has entered through the Sound and Belts for these two periods**.**

The inflow during the month of December was larger than the inflow winter 2003/2004. It belongs to one of the five strongest inflows since the end of the 1800s. The inflow is likely to improve the oxygen situation in the Baltic Sea considerably, even though the water was slightly warmer than normal for the season, and then also less oxygen-rich. The salinity of the inflowing water was also slightly lower than during the inflow the winter of 1993.

a. Skagerrak, Kattegat and the Sound

Surface water temperatures in Skagerrak and Kattegat were above normal for most of the year, except for during the first months when it was well below normal. These low temperatures were linked to very low surface salinities, due to an outflow of Baltic water. Otherwise, surface salinities were normal in both Skagerrak and Kattegat for the rest of the year.
All nutrients showed normal concentrations throughout the year, with the only exception that silicate was enhanced during the first months, due to the outflow mentioned above. The lowest oxygen concentration in the bottom water was measured in the end of September, at the station W Landskrona, in the Sound, 2.55 ml/l. In the open Skagerrak there is normally no shortage of oxygen in the deep water. The lowest value in 2014 was found at the station Släggö, in the mouth of the Gullmar fjord, where concentrations fell to 2.01 ml/l in the beginning of September, corresponding to a saturation of 30%.

Spring bloom was ongoing at the coastal station N14 in the Kattegat during the end of February with many species of diatoms in large quantities. The situation was more or less the same at the Skagerrak coastal stations.
In April and May, a few harmful species were observed above their warning limits at several stations in the Kattegat and Skagerrak. High concentrations of chlorophyll was found at many stations in May. The high concentrations were partly caused by what is thought to be a naked stadium of the flagellate *Dictyocha speculum*, which may be harmful for fish, but the phytoplankton samples were also unusually diverse for May. Several species of the potentially toxic genus *Alexandrium* were observed over the warning limit (200 cells/l) in April and May. The highest cell count was 26000 per liter. The toxins that *Alexandrium* spp produce may accumulate in filtrating blue mussels which then become poisonous to humans. The toxins were also detected in blue mussels from mussel farms in Bohuslän which could not be harvested.
During the period June to August chlorophyll concentrations were low but within the range of normal for the season. The phytoplankton samples were rather rich of species during the autumn months and a chlorophyll peak was observed in November in southern Kattegat. In December the chlorophyll concentrations were around normal or low at most stations. The biodiversity was unusually high and the dinoflagellate genus *Ceratium* was abundant.
During autumn a naked stadium of the flagellate *Dictyocha* was found, the cells were however larger than those observed in May.

b. Baltic Proper

Surface water temperature was above normal for the main part of the year, especially during summer, when it was about 4.5 degrees higher than mean for the season. Salinity in the surface layer was normal, except in the Eastern Gotland Basin where it was clearly below mean throughout the year.

The concentrations of inorganic nitrogen were at typical levels throughout the year in the whole area. In the Arkona- and Bornholm Basins, Hanö Bight as well as in the southeastern parts of the Baltic Proper, phosphate and silicate also showed normal levels the whole year. In the Eastern Gotland Basin silicate showed enhanced values and in the Western Gotland Basin and in the Northern Baltic Proper both silicate and phosphate were clearly above mean concentrations throughout the whole year.

In early 2014 (February and March) two inflows occurred through the Sound of about 20 - 30 km^3. In July and August these inflows had reached the central parts of the Eastern Gotland Basin and the bottom water was oxygenated, which has not occurred since April 2007. However, the oxygen situation quickly deteriorated and already in September anoxia was again present. The inflow was not strong enough to reach the northern or western parts of the Baltic Proper. In August and October two inflows, each of about 25 km^3, were recorded that improved the oxygen situation in the Arkona Basin and later in November also improved the situation in the Bornholm Basin. In the Western Gotland Basin the stagnation continues. Since, most likely, no inflows have reached the Western Gotland Basin, hypoxia and anoxia are now found at shallow depths. In December hypoxia was found from ~65 meters depth and anoxia from ~75 meters depth.

During December, the storm Alexander passed over the Baltic region. This storm resulted in high sea levels in southern Kattegat, and from the 2^{nd} to the 24^{nd} of December an inflow, trough the Sound, of approximately 70 km^3 took place. A total of approximately 200 km^3, including the Belts, is estimated to have entered the Baltic Sea. But the effect of this inflow is uncertain since the temperature of the water is much higher than normal.

Preliminary results for 2014, after the autumn oxygen survey but before the major inflow in December, showed that anoxic conditions affected around 17% of the bottom areas in the Baltic Proper, including the Gulf of Finland and the Gulf of Riga and approximately 27% suffer from hypoxia. The inflows that occurred in the beginning of 2014 did result in renewal of bottom water in the Eastern Gotland basin during July and August. This has not occurred since 2007. However, the oxygen concentration dropped fast and in September anoxic conditions were again present, until December.

In the Arkona basin the spring bloom occurred during the beginning of March. In the Bornholm basin and further north and east, the bloom started later which is normal for these areas. High levels of chlorophyll in the Bornholm deep, Gotland deep and Kalmar sound were mainly caused by the summer occurrence of cyanobacteria. A minor autumn bloom was observed at most stations with high chlorophyll concentrations and phytoplankton samples dominated by diatoms and colonies of small cyanobacteria.

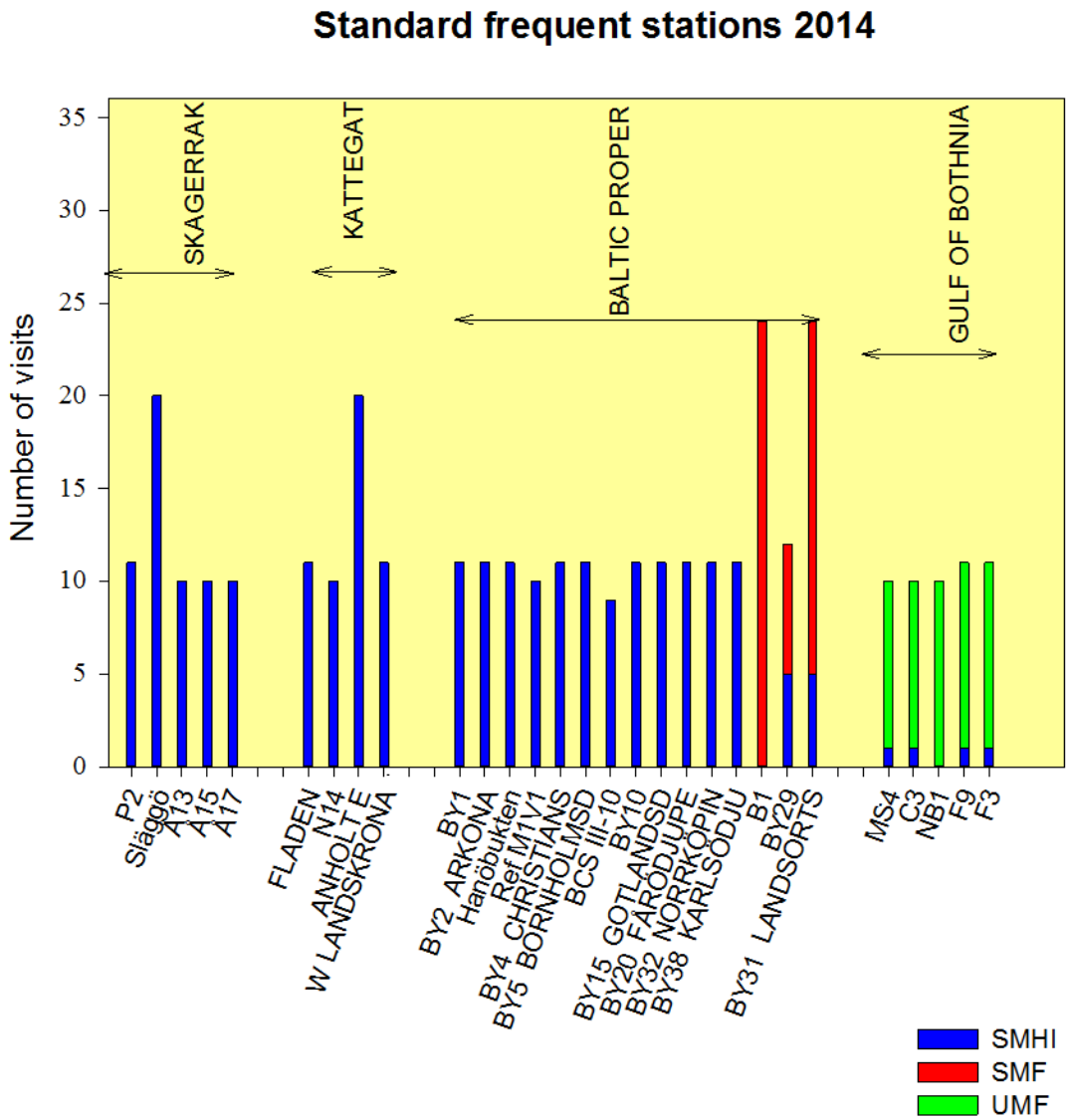
Cyanobacteria

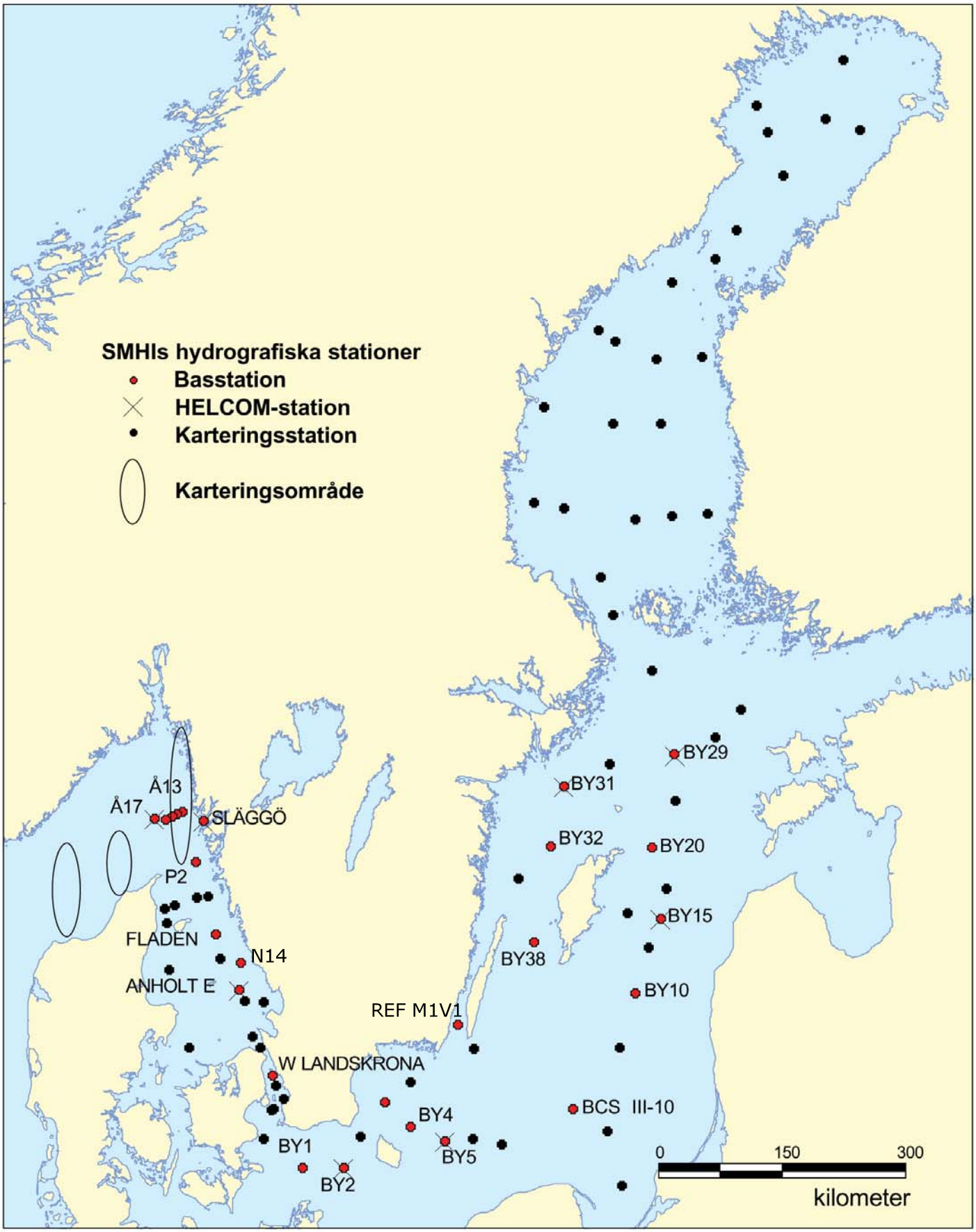
In 2014, surface blooms of cyanobacteria were observed continuously for over five weeks, from July 4 to August 10. Although the major bloom started comparably late and had a lesser than average spatial extent, the northern part of the Eastern Gotland Basin and the adjacent Northern Baltic Proper had intensive blooms during the entire period above. The normalized duration of the bloom was among the highest recorded but the normalized extent among the lowest.

The warm and sunny weather in July was favorable for the formation of surface blooms in the Baltic Sea region. However, the blooms started late and lasted only until early August. In all, the densest blooms were observed west to northwest of the islands Saaremaa and Hiumaa. The first subsurface blooms of cyanobacteria were observed in the Bornholm Basin already around June 10. Persistent winds for the next two weeks however meant that surface blooms did not form until early July. The blooms in the southern half of the Baltic Proper were not long-lived, instead one week into July dense blooms formed in the eastern part of the Northern Baltic Proper and the northern half of the Eastern Gotland Basin.

Although minor blooms continued in the south, it was the northern half of the Baltic Proper that housed the major part of the cyanobacteria blooms for the rest of the summer. Into August, the blooms were concentrated to the eastern part of the Northern Baltic Proper with little left in other areas. On August 11, the summer warmth gave way for a cooler, low-pressure dominated weather period continuing towards the end of the month. This ended the cyanobacteria bloom season of 2014 in the Baltic Sea.

Number of visits at standard frequent stations




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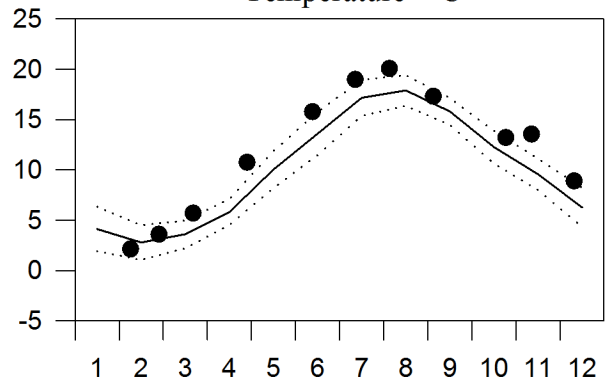
N14
ANHOLT E
W LANDSKRONA
BY1
BY2
BY4
BY5
REF M1V1
BY38
BY29
BY31
BY32
BY20
BY15
BY10
BCS III-10
0
150
300
kilometer

STATION P2 SURFACE WATER

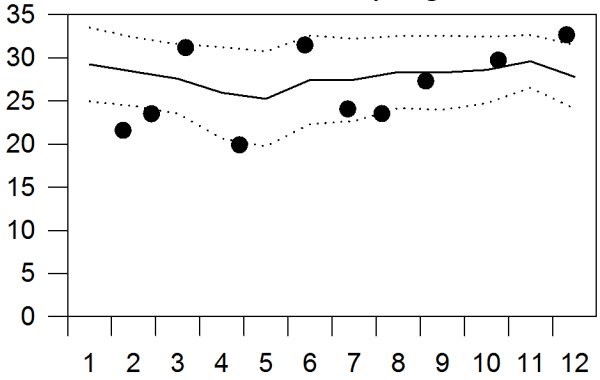
Annual Cycles

Mean 1996-2010 ····· St.Dev. ● 2014

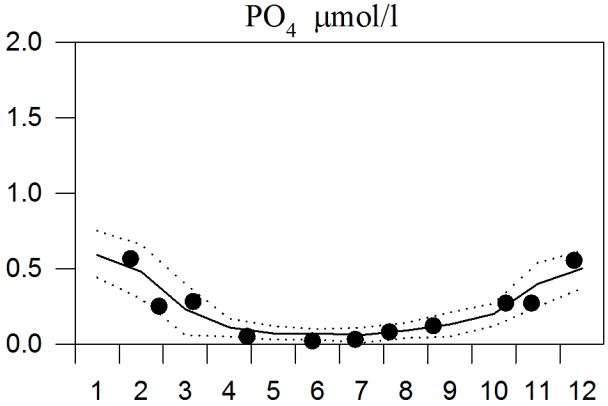
Temperature °C



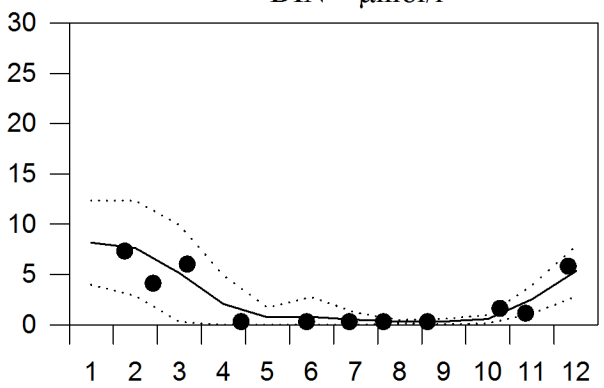
Salinity psu



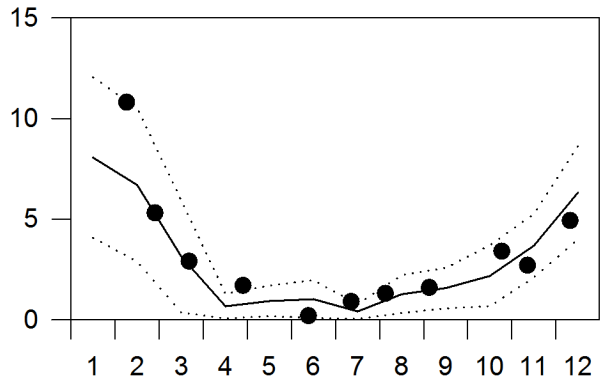
PO_4 µmol/l



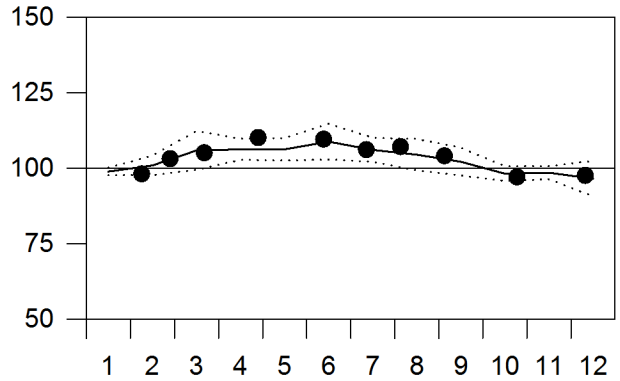
DIN µmol/l



SiO_3 µmol/l

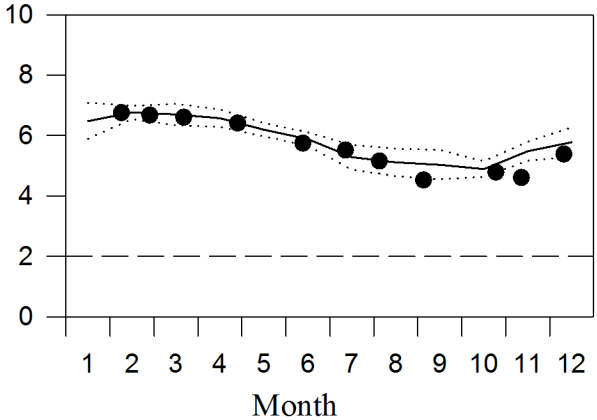


O_2 saturation %



OXYGEN IN BOTTOM WATER (depth >75m)

O_2 ml/l



O_2 ml/l