



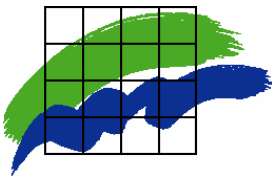
r/v Gunnar Thorson

# Monitoring Cruise Report

**Cruise no.: GT 242**

**Time: 20 - 23 August 2007**

**Area: The Sound, the Arkona Sea,  
the Belt Sea and the Kattegat**



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## Data sheet

Title: Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat

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# **Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat, 20-23 August 2007.**

## **Cruise no. GT 242**

**Report:** Gunni Ærtebjerg

**Cruise leader:** Kjeld Sauerberg

**Participants:** Dorete Jensen, Lars Renvald, Peter Kofoed (NERI)  
Sif Emilie Schrøder (trainee)

This report is based on preliminary data, which might later be corrected. Citation permitted only when quoting is evident.

### **Summary**

The first 8 months of 2007 were warmer than average for the period 1961-90, especially the period January-April, and they were very rain full, especially the periods January-February and May-July. Gales occurred regularly. During the cruise the surface water temperature was less than 1° C, and the bottom water temperature up to 2.5° C, above average for the season. The surface salinity was lower than average due to outflow from the Baltic Sea, which made the stratification stronger than average for the season.

In the surface layer practically no nitrogen nutrients were present in any area (DIN <0.5 µmol/l). The phosphate concentrations were very low (<0.1-0.0 µmol/l) in the eastern Kattegat, somewhat higher (0.1-0.2 µmol/l) in the western Kattegat, and very high for the season (0.25-0.6 µmol/l) in the Sound and Belt Sea. Surface silicate concentrations were low (0.6-1.2 µmol/l) only in the north-eastern Kattegat, but higher (1.6-3.7 µmol/l) in the rest of the Kattegat and about 10 µmol/l in the Sound, Belt Sea and Arkona Sea.

In the bottom water unusually high nitrate concentrations (11.0-11.7 µmol/l) occurred in the south-eastern Kattegat, while the concentrations in the Belt Sea were relatively low. In the bottom water the highest concentrations of nitrite, ammonium, phosphate and silicate were observed in the southern Belt Sea, phosphate and silicate also in the central Arkona Sea, and ammonium and silicate also in the southern Great Belt.

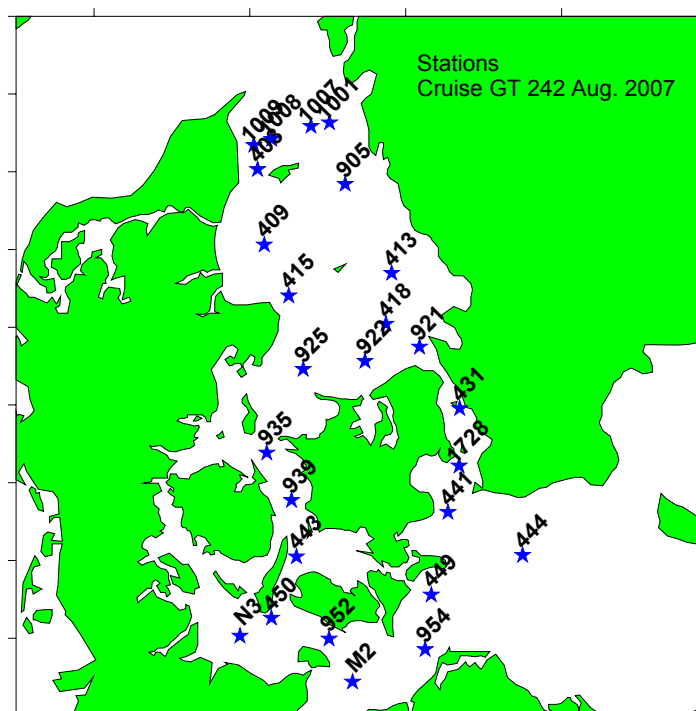
Oxygen concentrations below 2 ml/l (23-30% saturation) were observed in the central Arkona Sea, central Sound and Fehmarn Belt. Minimum oxygen concentrations below 3 ml/l were found in the southern Kattegat, Great Belt and southern Belt Sea including Kiel Bight and Mecklenburg Bight. In Denmark oxygen depletion is defined as minimum oxygen concentrations below 2.8 ml/l (4 mg/l), and severe oxygen depletion as below 1.4 ml/l (2 mg/l). From these definitions severe oxygen depletion was not observed at the cruise, while oxygen depletion was found in the central Arkona Sea, the central Sound, Fehmarn Belt, central and southern Great Belt and south-eastern Kattegat.

## General

The objectives of the cruise were:

- to determine the actual situation in the open Danish waters
- to trace the influence of land-based discharges of nutrients
- to establish reference data for the local monitoring in coastal areas
- to continue time series for trend monitoring.

The cruise is part of the Danish nation-wide monitoring programme NOVANA, the HELCOM monitoring programme (COMBINE) for the Baltic Sea area (the Arkona Sea, the Sound, the Belt Sea, the Kattegat), and the OSPARCOM monitoring programme (JAMP) for the Greater North Sea (the Kattegat). The main scope of the cruise was to monitor the oxygen situation, but also the hydrography and the concentrations of nutrients and chlorophyll *a*. The monitoring stations of the cruise are shown in *figure 1*. Besides the monitoring measurements, special investigations were performed on DOM.



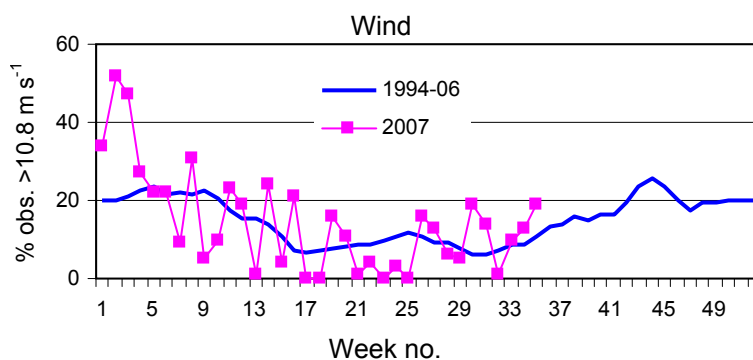
**Figure 1** Stations of the monitoring cruise with r/v Gunnar Thorson 20-23 August 2007 in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Gunnar Thorson cruise no. GT 242.

## Meteorology

Characteristics of the weather conditions in January to August 2007 are given in *table 1*. All 8 months had mean temperatures above long-term averages (1961-90). Especially the period January to April was exceptionally warm. The accumulated precipitation over the 8 months was 54% above average. Especially the months January, February, May, June and July were very wet. Westerly winds dominated in all months, except in February and in parts of March and June, when easterly winds prevailed. January was very windy, and periods with gales have occurred throughout the year, except for a longer calm period from mid May to late June (weeks 21-25, *figure 2*).

**Table 1** Deviations in monthly mean temperature and precipitation in January to August 2007 in Denmark compared to long-term monthly means 1961-90, monthly mean wind force and dominating wind directions (based on data from the Danish Meteorological Institute).

Month	Temperature deviation ° C	Precipitation % deviation	Mean wind force m/s	Dominating wind direction
January	+5.0	+116	7.6	SW-W
February	+2.2	+113	5.8	E-SE
March	+4.1	-4	5.6	NE-E---SW-W
April	+3.6	-76	5.0	SW-W-NW
May	+0.7	+50	4.3	SW-W
June	+1.8	+124	3.7	NE-E---SW-W
July	+0.1	+92	4.9	SW-W
August	+1.1	-6	4.6	SW-W-NW



**Figure 2** Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in January-August 2007 (connected points) compared to 3-weeks running mean for the period 1994-2006 (blue line). Based on data from the Danish Meteorological Institute.

## Hydrography

The surface temperature (1 m's depth) varied from 15.9-16.9° C in the Mecklenburg Bight, Fehmarn Belt, Gedser Rev and east of Falster (St. M2, 952, 954, 449) to 18.3-18.7° C in the eastern Kattegat (St. 1001, 905, 413, 418, 921, 922) and Kiel Bight (St. N3). The bottom near temperature ranged from 8.5-9.8° C in the south-eastern Kattegat and the Sound (St. 413, 418, 921, 431) to 14.7-14.9° C in the northern Kattegat and Læsø Rende (St. 1007, 1009, 403) and 15.4-15.5° C in the shallow western Kattegat. The temperature stratification was up to 9.4-10.0° C in the south-eastern Kattegat (St. 413, 418, 921) (*figure 3*).

The surface salinity ranged from 7.7-8.4 in the Arkona Sea and the Sound (St. 444, 449, 441, 1728, 431) to only 19.1-21.7 in the northern Kattegat (St. 403, 1001, 1007, 1008, 1009). The bottom water salinity ranged from 14.4-14.5 in the Arkona Sea (St. 444, 449) to 34.6-34.7 in the north-eastern Kattegat (St. 905, 1001) (*figure 3*).

Compared to long-term monthly means (Lightship observations 1931-1960) for August the surface temperature was 0.0-0.9° C higher than average. The bottom water temperature was generally 0.7-2.5° C above average. However, in the bottom water of the central eastern Kattegat the bottom water temperature was 1.3° C lower than normal. The surface salinity was 0.8-4.9 lower than average, while the bottom water salinity was lower than normal in the southern Belt Sea but about average in other areas. The salinity stratification was stronger than usual for the season in all areas, except in the Gedser Rev area (*figure 3*).

## Nutrients

As normal for the season nitrogen nutrients were practically absent from the surface layer with a DIN concentration less than 0.5  $\mu\text{mol/l}$  in all areas. The nitrate concentration in the bottom layer was unusual high (11.0-11.7  $\mu\text{mol/l}$ ) in the south-eastern Kattegat (St. 413, 418), but relatively low in the Belt Sea (*figure 4a*). Nitrite concentrations above 0.5  $\mu\text{mol/l}$  were observed in the bottom water in the southern Belt Sea (St. 954, M2, 952), Læsø Rende (St. 403) and the north-eastern Kattegat (St. 1001) (*figure 4b*). High concentrations of ammonium (2.6-5.6  $\mu\text{mol/l}$ ) were present in the Fehmarn Belt and Great Belt (St. 952, 450, 443, 939, 935) (*figure 4c*).

The phosphate concentrations in the surface layer were very low (<0.1-0.0  $\mu\text{mol/l}$ ) in the eastern Kattegat (St. 1001, 1007, 905, 413, 418, 921, 922), and Kiel Bight (St. N3). In the western Kattegat the surface concentrations were 0.1-0.2  $\mu\text{mol/l}$ . In contrast, high phosphate concentrations (0.25-0.6  $\mu\text{mol/l}$ ) were present in the surface layer in the Sound and Belt Sea with the highest concentrations in the Fehmarn Belt and Mecklenburg Bight (*figure 5a*). The highest bottom water phosphate concentrations (1.6-1.9  $\mu\text{mol/l}$ ) were observed in the central Arkona Sea and the southern Belt Sea (St. 444, 952).

The lowest surface concentrations of silicate (0.6-1.2  $\mu\text{mol/l}$ ) were observed in the north-eastern Kattegat (St. 1001, 1007, 905). In the rest of the Kattegat the surface concentrations ranged from 1.6 to 3.7  $\mu\text{mol/l}$ . In the Sound, Belt Sea and Arkona Sea the surface concentrations were about 10  $\mu\text{mol/l}$  (7-13  $\mu\text{mol/l}$ ), except for only 4.4  $\mu\text{mol/l}$  in Kiel Bight. Bottom water silicate concentrations above 30  $\mu\text{mol/l}$  were found in the Sound, Arkona Sea, southern Belt Sea, southern Great Belt and east of Anholt (St. 431, 444, 952, 450, 939, 413) (*figure 5b*).

## Chlorophyll a

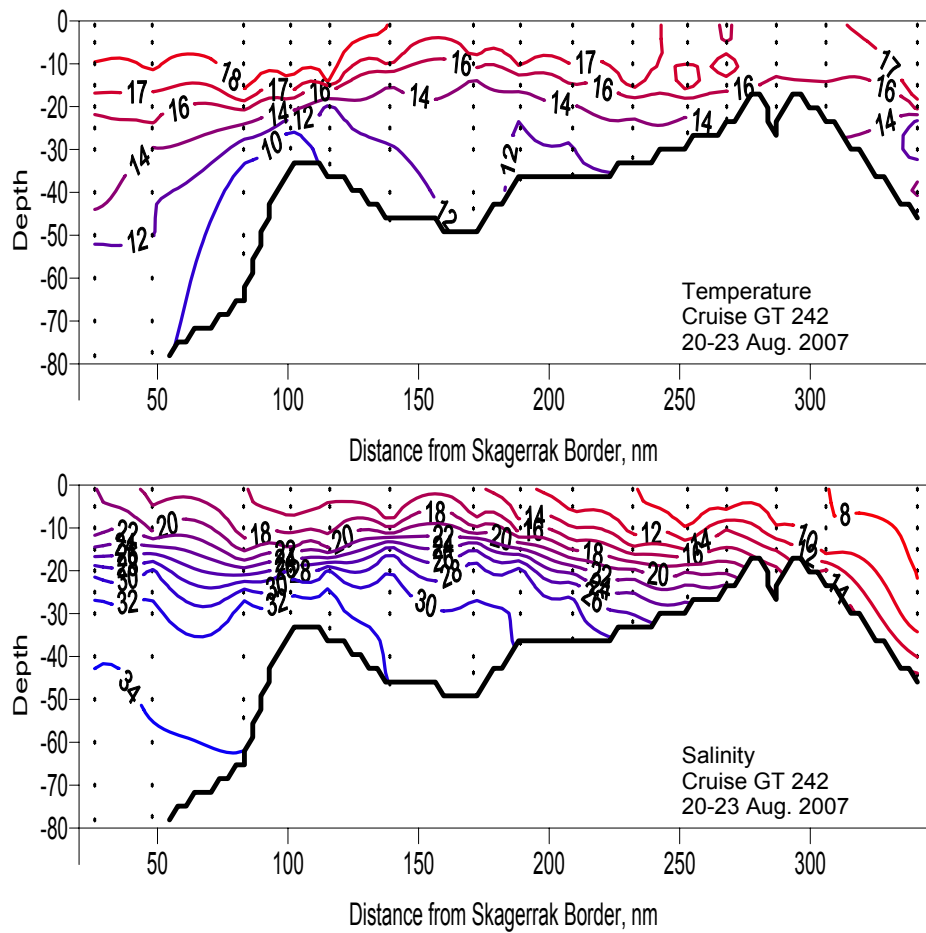
The highest mean chlorophyll concentrations in the uppermost 10 m of 3.0-3.6  $\mu\text{g/l}$  were observed in the Great Belt and Kiel Bight (St. 925, 935, 939, 443, 450, N3) and the central Arkona Sea (St. 444; 3.9  $\mu\text{g/l}$ ). In the Sound and the Kattegat the mean concentrations ranged from 1.8 to 2.4  $\mu\text{g/l}$ . In the Kattegat and Great Belt the highest concentrations were observed in the uppermost 5 to 10 m. In the southern Belt Sea a subsurface maximum occurred at 10-15 m depth (*figure 6*).

## Oxygen

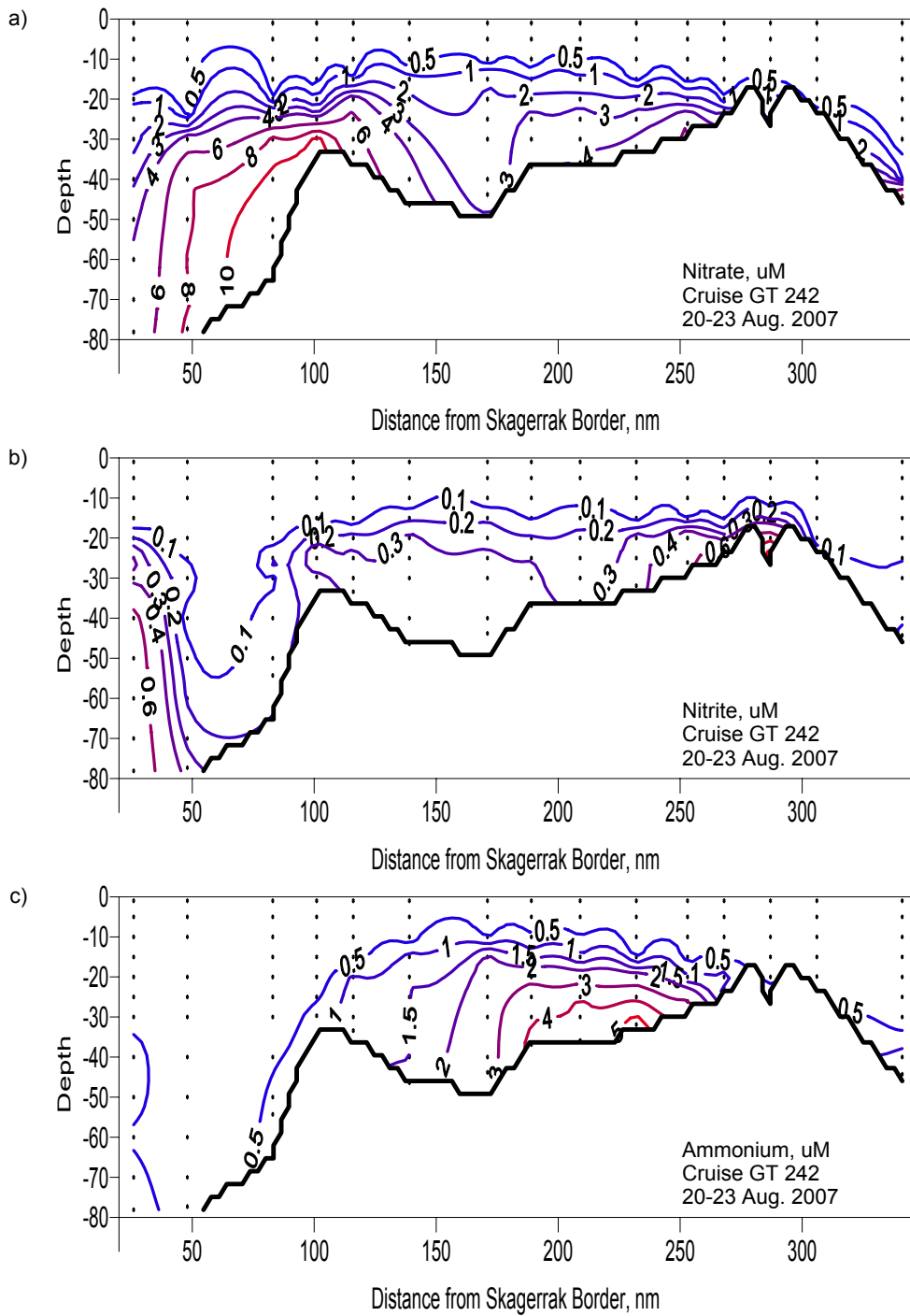
Oxygen concentrations below 2 ml/l (23-30% saturation) were observed in the central Arkona Sea (St. 444), central Sound (St. 431) and in the Fehmarn Belt (St. 952). Minimum oxygen concentrations below 3.1 ml/l were found in the southern Kattegat, Great Belt and southern Belt Sea including Kiel Bight and Mecklenburg Bight (*figure 7*).

Compared to mean for August last year, the minimum oxygen concentrations this year were generally lower, except in the Gedser Rev area (St. 954, 449) and Læsø Rende (St. 403).

In Denmark oxygen depletion is defined as minimum oxygen concentrations below 2.8 ml/l (4 mg/l), and severe oxygen depletion as below 1.4 ml/l (2 mg/l). From these definitions severe oxygen depletion was not observed at the cruise, while oxygen depletion was found in the central Arkona Sea, the central Sound, Fehmarn Belt, central and southern Great Belt and south-eastern Kattegat. *Figure 8* shows the stations visited by the Danish environmental centres, NERI, SMHI and Swedish coastal authorities within the first 3 weeks of August 2007, and where oxygen depletion or severe oxygen depletion was observed.

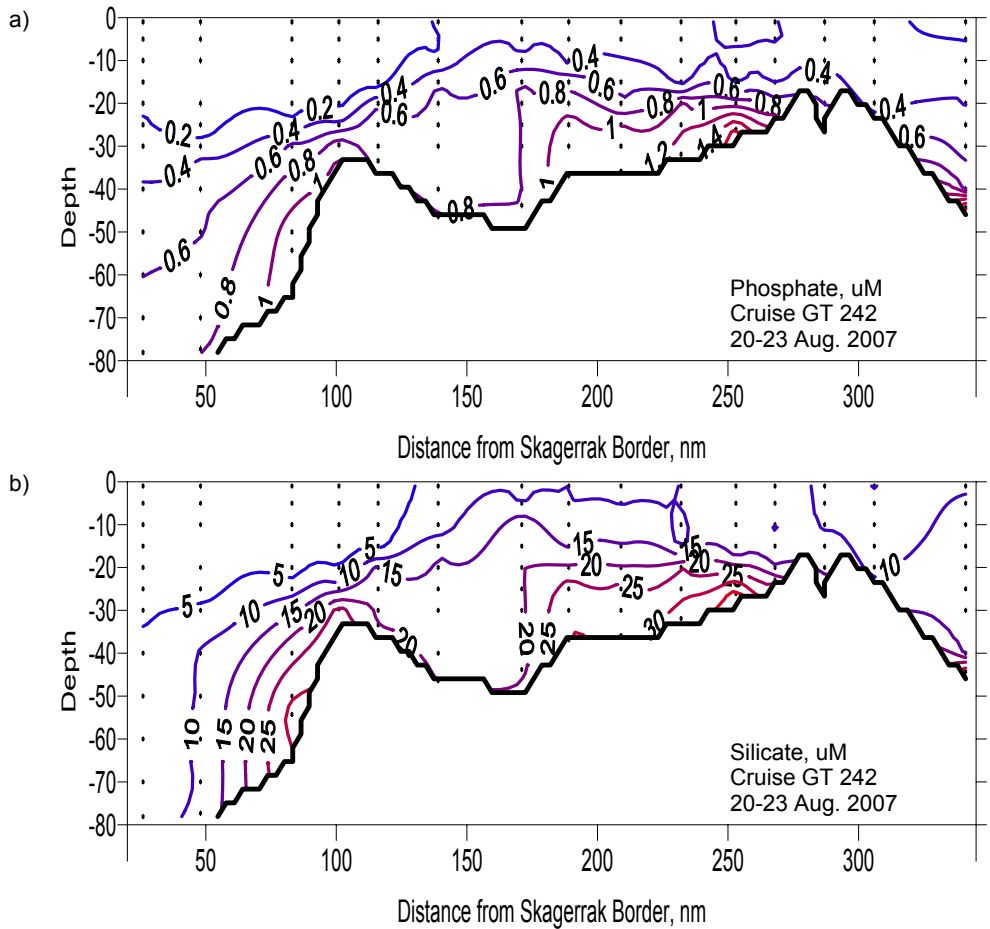


**Figure 3** Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

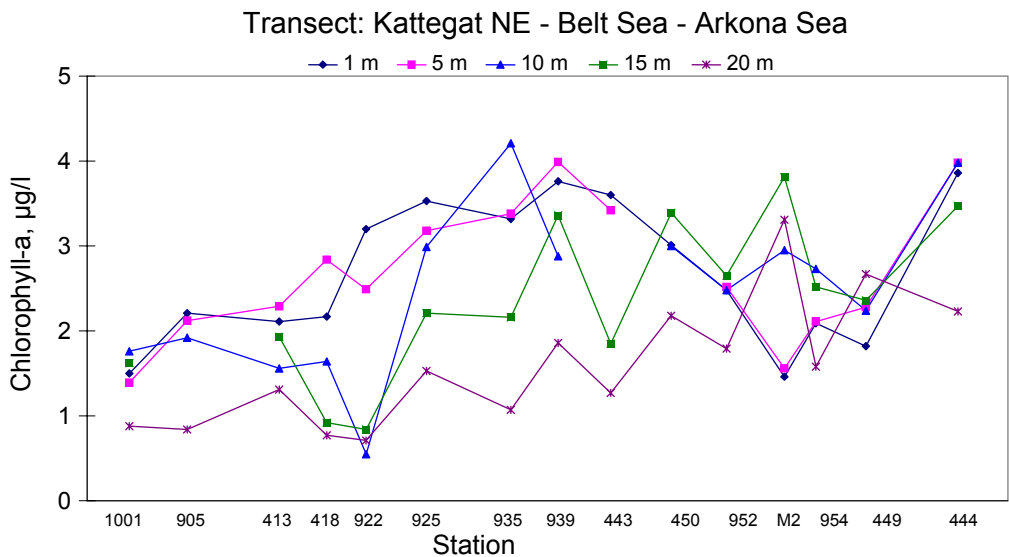


**Figure 4** Nitrate (a), nitrite (b) and ammonium (c) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

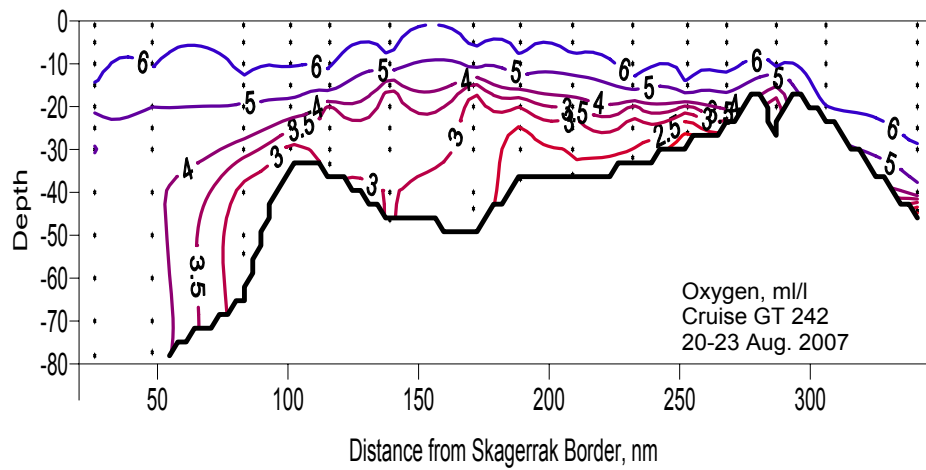




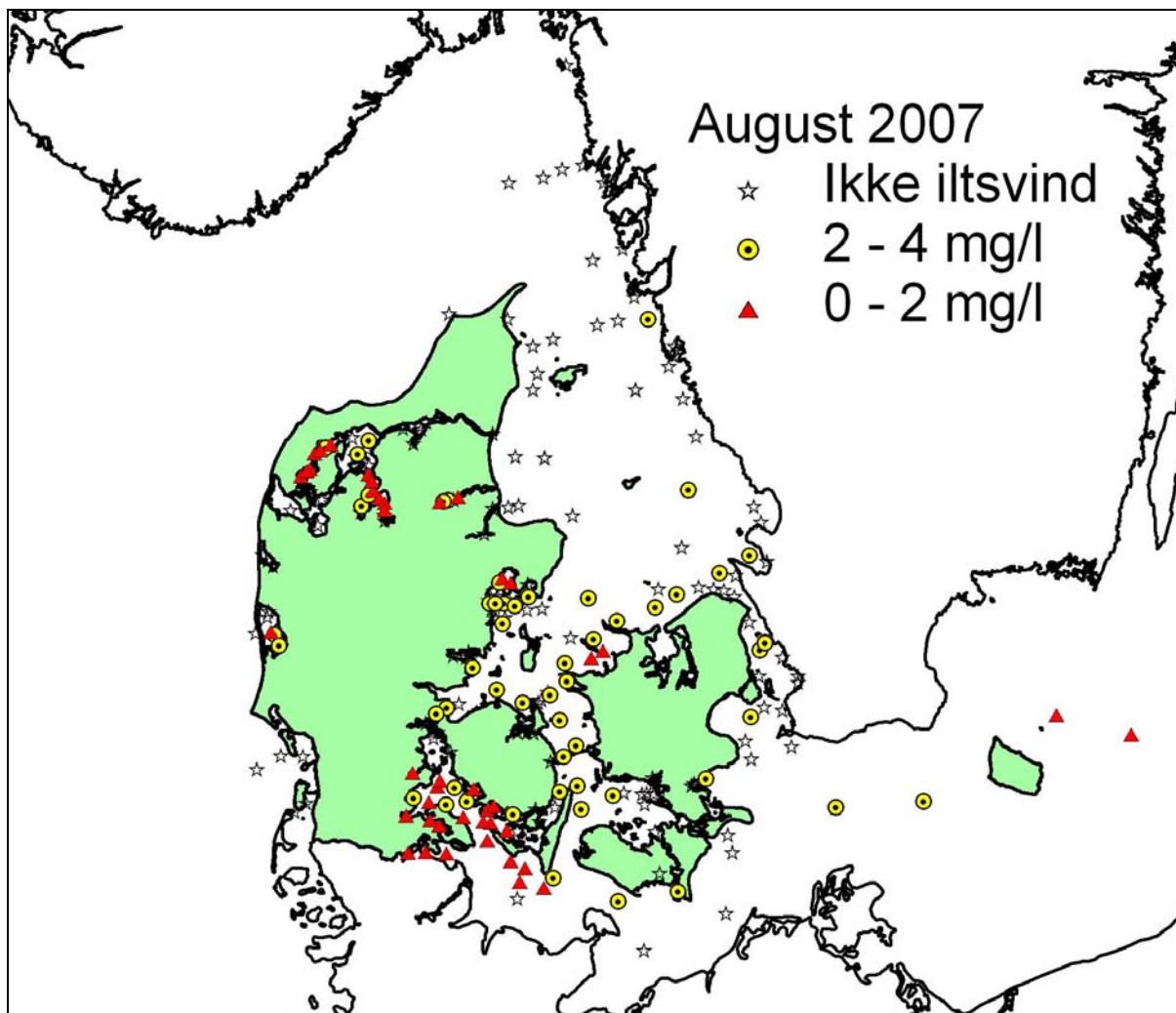
**Figure 5** Phosphate (a) and silicate (b) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



**Figure 6** Chlorophyll a at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



**Figure 7** Oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



**Figure 8** Stations visited by the Danish regional Environmental Centres, NERI, SMHI and Swedish coastal authorities within the period 1-24 August 2007, and where oxygen depletion (<4 mg/l) and severe oxygen depletion (<2 mg/l) was observed.