



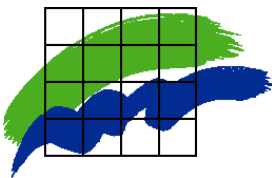
r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 230

Time: 15 - 19 August 2005

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



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Data Sheet

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Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat, 15-19 August 2005

Cruise no. 230

Report: Gunni Ærtebjerg
Cruise leader: Kjeld Sauerberg
Participants: Dorete Jensen, Hanne Ferdinand

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

Summary

Very high phosphate concentrations for the season were observed in the surface water in the Arkona Sea and in the water flowing from the Baltic Sea into the Danish straits. The phosphate concentration in the surface of the central Arkona Sea was about 0.7 $\mu\text{mol/l}$, decreasing to 0.2-0.3 $\mu\text{mol/l}$ in the Great Belt and 0.1 $\mu\text{mol/l}$ in the south-western Kattegat. In the central Sound the surface phosphate concentration was 0.65 $\mu\text{mol/l}$, decreasing to 0.35 $\mu\text{mol/l}$ at Kullen. In the Kattegat the surface phosphate concentration was below 0.1 $\mu\text{mol/l}$.

Nitrate was practically absent from the surface water, except for 0.1 $\mu\text{mol/l}$ in the Great Belt. Silicate was below 1 $\mu\text{mol/l}$ in most of the Kattegat surface water, but relatively high in the Sound, Arkona Sea and Belt Sea.

In the Great Belt a distinctive subsurface chlorophyll maximum was observed with concentrations of 3.0-4.8 $\mu\text{g/l}$. In other areas the subsurface maximum was less pronounced, and the chlorophyll concentration about normal for the season.

Severe oxygen depletion (< 1.4 ml/l) was observed in the Fehmarn Belt and Mecklenburg Bight (0.5-0.9 ml/l, 8-13% saturation), and oxygen depletion (< 2.8 ml/l) was found in the Kiel Bight and central Arkona Sea (2.1-2.6 ml/l, 33-37%). In the Sound the minimum oxygen concentration was 2.9 ml/l (43%). At the rest of the deeper stations of the cruise the minimum oxygen saturation was 50-70%.

In the oxygen depleted bottom water high concentrations of phosphate (1.3-1.6 $\mu\text{mol/l}$), ammonium (2.8-3.7 $\mu\text{mol/l}$) and silicate (45-54 $\mu\text{mol/l}$) were observed, e.g. in the Fehmarn Belt, Mecklenburg Bight and Kiel Bight. In the Arkona Sea the corresponding bottom water concentrations were a little lower. However, the highest ammonium concentration (3.7-4.7 $\mu\text{mol/l}$) was observed at the bottom of the central Sound.

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*. The northernmost Kattegat was not covered on this cruise due to technical problems.

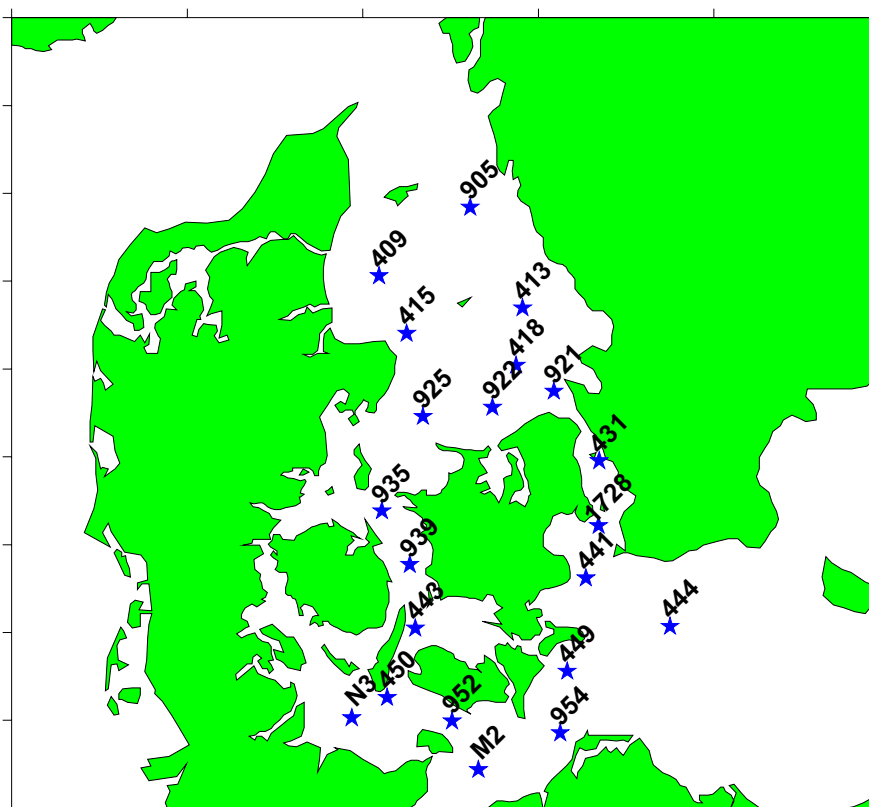


Figure 1 Stations of the monitoring cruise with r/v Gunnar Thorson 15-19 August 2005 in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Gunnar Thorson cruise no. 230.

Meteorology

Characteristics of the weather conditions from March to August 2005 are given in *table 1*. April and July were relatively warm, while the temperature in the other months was about or a little below normal. The precipitation was high in May and July, but low in April and August, and the accumulated precipitation in the period January-August was about normal. March and April were dominated by easterly wind, while May to August was dominated by wind from west and southwest. The frequency of wind exceeding gale force (*figure 2*) was generally low in the whole period March-August, except for stronger wind in the beginning of June (weeks 22-23) and the second week of August (week 32).

Table 1 Deviations in monthly mean temperature and precipitation in the months March-August 2005 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
March	-0.6	9	4.8	E
April	+2.0	-29	4.7	E
May	0	+27	4.5	SW-W
June	-0.4	-4	4.6	W
July	+1.6	+45	3.8	W
August	-0.3	-24	4.3	SW-W

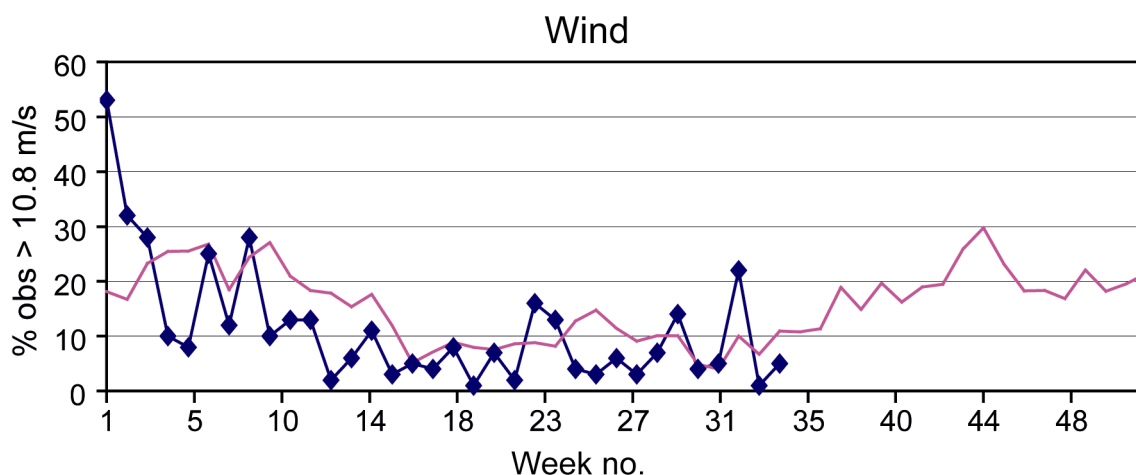


Figure 2 Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2005 (connected points) compared to mean for the period 1994-2004 (thin line). Based on data from the Danish Meteorological Institute.

Hydrography

The surface temperature (1 m depth) varied from 11-13° C in the Arkona Sea (St. 441-444) to 18° C in the southern Kattegat (St. 413, 418, 922). The bottom near temperature ranged from 6.0° C east of Anholt (St. 413) to 10.2-12.9° C in the Belt Sea, and 14.3° C east of Falster (*figure 3*).

The surface salinity ranged from 7.7-8.2 in the Arkona Sea (St. 441, 444, 449) to 20.1-20.7 in the central Kattegat (St. 409, 413, 415, 905, 925). The bottom water salinity ranged from 16-17 in the Arkona Sea (St. 444, 449) to 33.6-34.0 in the eastern Kattegat (St. 413, 905) (*figure 3*). The salinity stratification was a little below average for the season, except in the western Kattegat.

Compared to long-term monthly means (Lightship observations 1931-1960) for August the surface temperature was 0.7° C below average in the Belt Sea, but in other areas about normal. In the eastern Kattegat and the Belt Sea the bottom water temperature was 0.7-1.4° C lower than normal. The surface salinity was higher than average, especially in the Belt Sea. The bottom water salinity was 2.2-2.8 above normal in the western Kattegat and the Great Belt, but 0.8 below normal in the Fehmarn Belt.

Nutrients

The nitrate concentration in the surface layer was low (0.0-0.1 µmol/l), with the highest concentrations observed in the Great Belt and east of Stevns (St. 441). In the bottom water the highest nitrate concentration of 7.7-8.7 µmol/l was observed in the eastern Kattegat (St. 413, 905) and in the Fehmarn Belt (St. 952, 8.5 µmol/l) (*figure 4a*). The highest nitrite concentration of 0.3 µmol/l was observed at the bottom in the Arkona Sea and at Gedser Rev (St. 444, 954). The highest ammonium

concentrations of 3.7-4.7 $\mu\text{mol/l}$ were observed at the bottom in the Sound (St. 431). In the southern Belt Sea ammonium concentrations of 2.4-3.7 $\mu\text{mol/l}$ were found (*figure 4b and 4c*).

Very high phosphate concentrations for the season were observed in the surface water in the Arkona Sea and the water flowing into the Danish straits from the Baltic Sea. The phosphate concentration in the surface of the central Arkona Sea (St. 444) was about 0.7 $\mu\text{mol/l}$, decreasing to 0.2-0.3 $\mu\text{mol/l}$ in the Great Belt and 0.1 $\mu\text{mol/l}$ in the south-western Kattegat (St. 925). In the central Sound (St. 431) the surface phosphate concentration was 0.65 $\mu\text{mol/l}$, decreasing to 0.35 $\mu\text{mol/l}$ at Kullen (St. 921). In the Kattegat the surface phosphate concentration was below 0.1 $\mu\text{mol/l}$ (*figure 5a*). In the bottom water the highest phosphate concentrations of 1.3-1.6 $\mu\text{mol/l}$ were observed in the southern Belt Sea (St. 952, M2, N3) and the Arkona Sea (St. 444). Also the highest silicate concentrations of 50-54 $\mu\text{mol/l}$ were found at the bottom in the Fehmarn Belt, Mecklenburg Bight and Kiel Bight (St. 952, M2, N3) (*figure 5b*).

Chlorophyll-a

In the Great Belt a distinctive subsurface chlorophyll maximum was observed. In the northern Great Belt (St. 925, 935, 939) the maximum (3.5-4.8 $\mu\text{g/l}$) was observed in 15-20 m depths. In the southern Great Belt (St. 443, 450) the maximum (3.0-4.1 $\mu\text{g/l}$) was distributed in most of the water column from 5 m to 15-20 m depth. In other areas the subsurface maximum was less pronounced, and the chlorophyll concentration about normal for the season (*figure 6*).

Oxygen

The lowest oxygen concentrations of 0.5-0.9 ml/l (8-13% saturation) were observed in the Fehmarn Belt and Mecklenburg Bight (St. 952, M2). In the Kiel Bight (St. N3) the oxygen minimum concentration was 2.1 ml/l (33%), in the Arkona Sea (St. 444) 2.6 ml/l (37%) and in the Sound (St. 431) 2.9 ml/l (43%). At the rest of the deeper stations of the cruise the oxygen minimum saturation was 50-70% (*figure 7*).

Compared to mean for August in the 1980s, the minimum oxygen concentrations this year were higher, except in the Fehmarn Belt and the Arkona Sea.

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 observed in the Fehmarn Belt and Mecklenburg Bight and oxygen depletion in the Kiel Bight and Arkona Sea. *Figure 8* shows the stations visited by the Danish counties, NERI, SMHI and Swedish coastal authorities within the first 3 weeks of August 2005, and where oxygen depletion or severe oxygen depletion was observed.

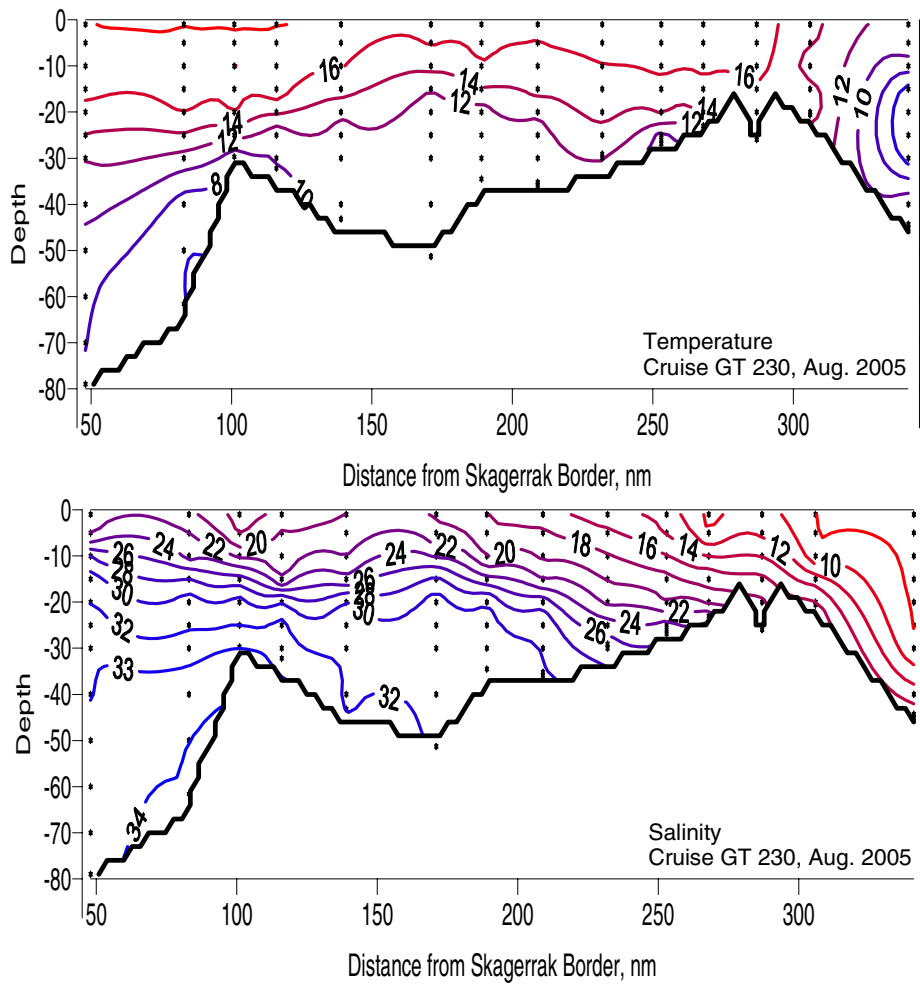


Figure 3 Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

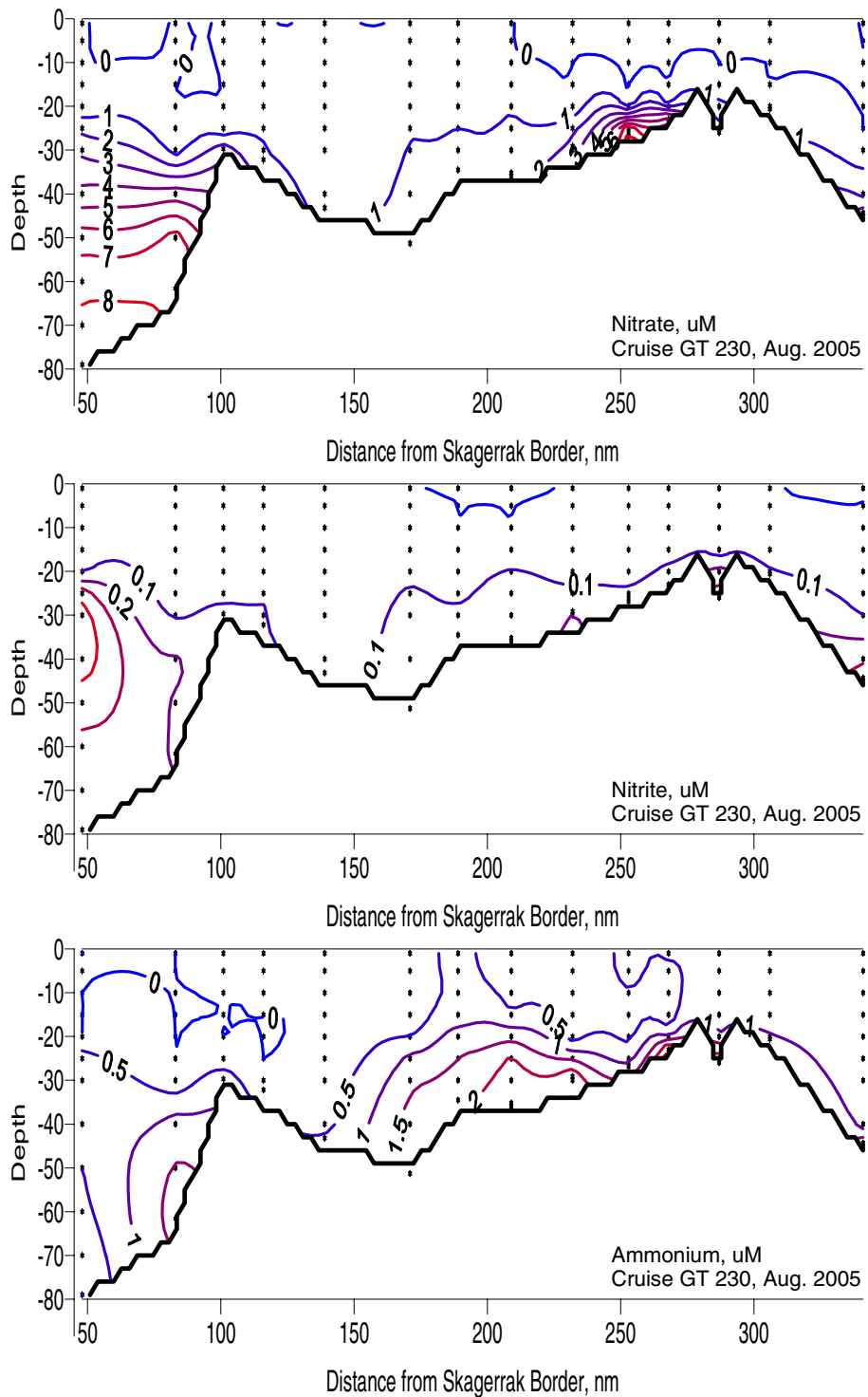


Figure 4 Nitrate (top), nitrite (middle) and ammonium (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

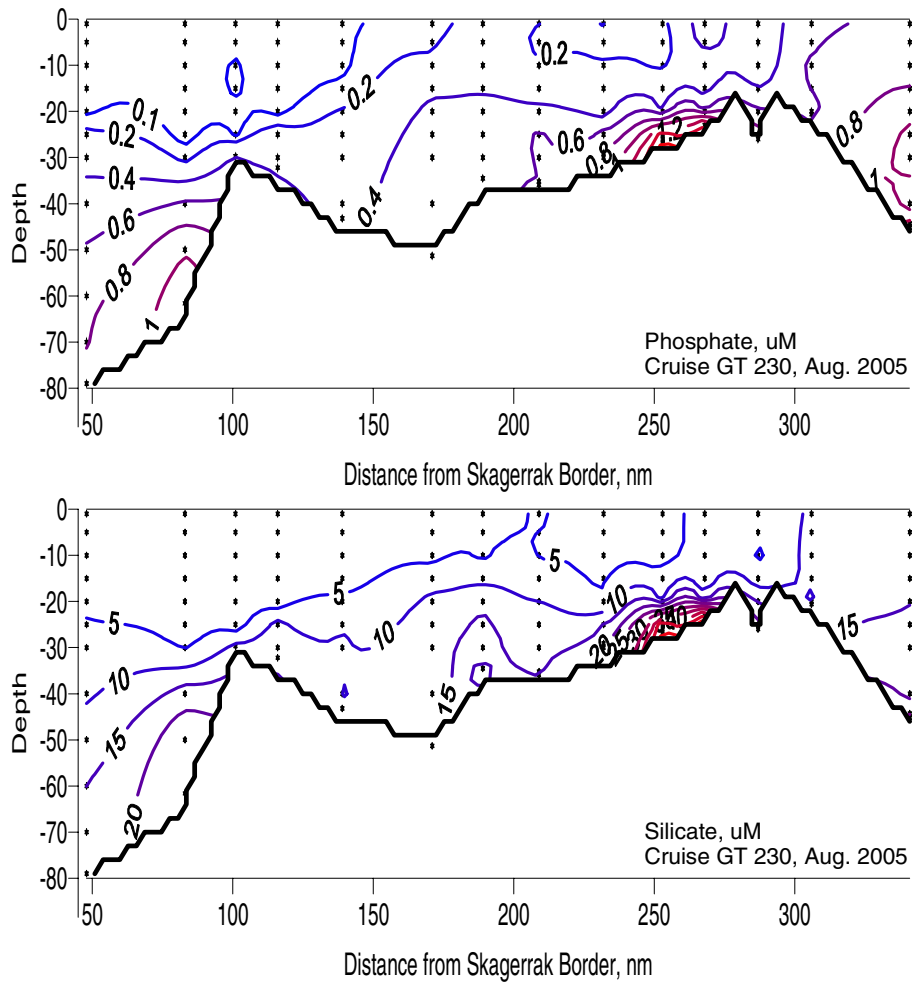


Figure 5 Phosphate (top) and silicate (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

Transect: Kattegat NE - Belt Sea - Arkona Sea

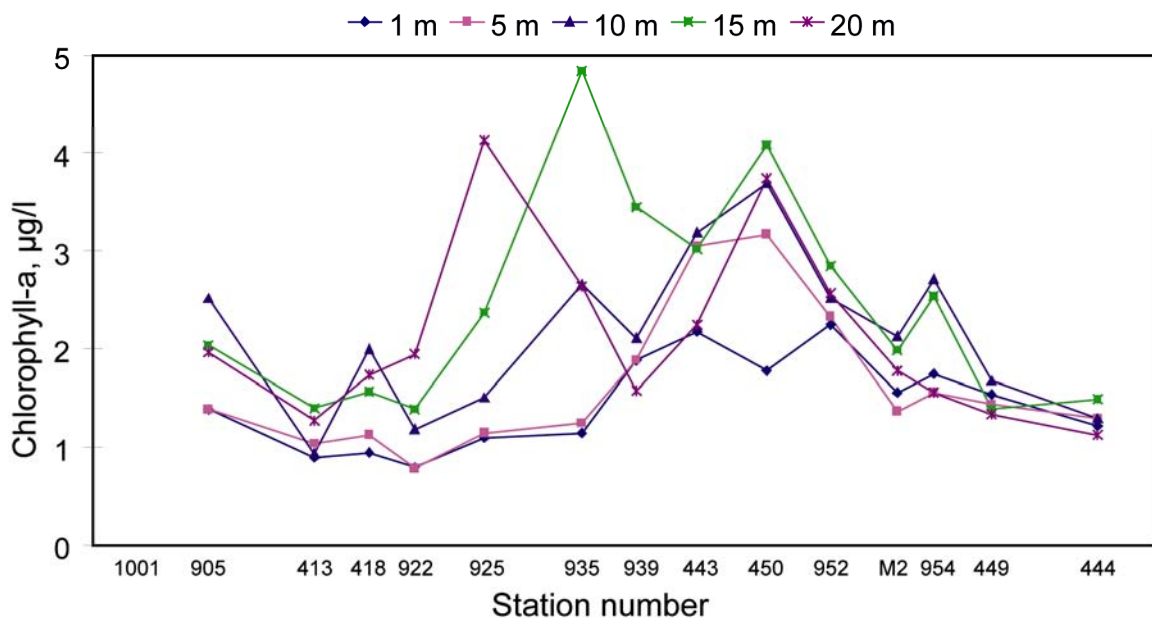


Figure 6 Chlorophyll-a at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

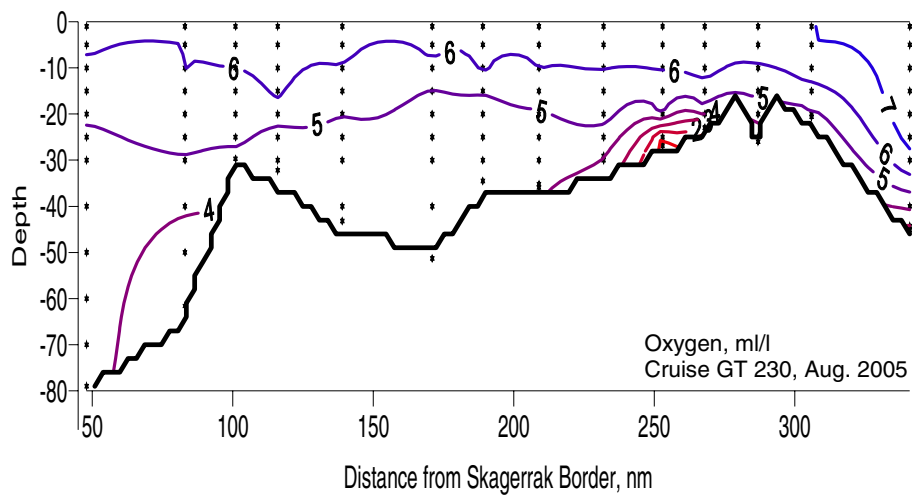


Figure 7 Oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

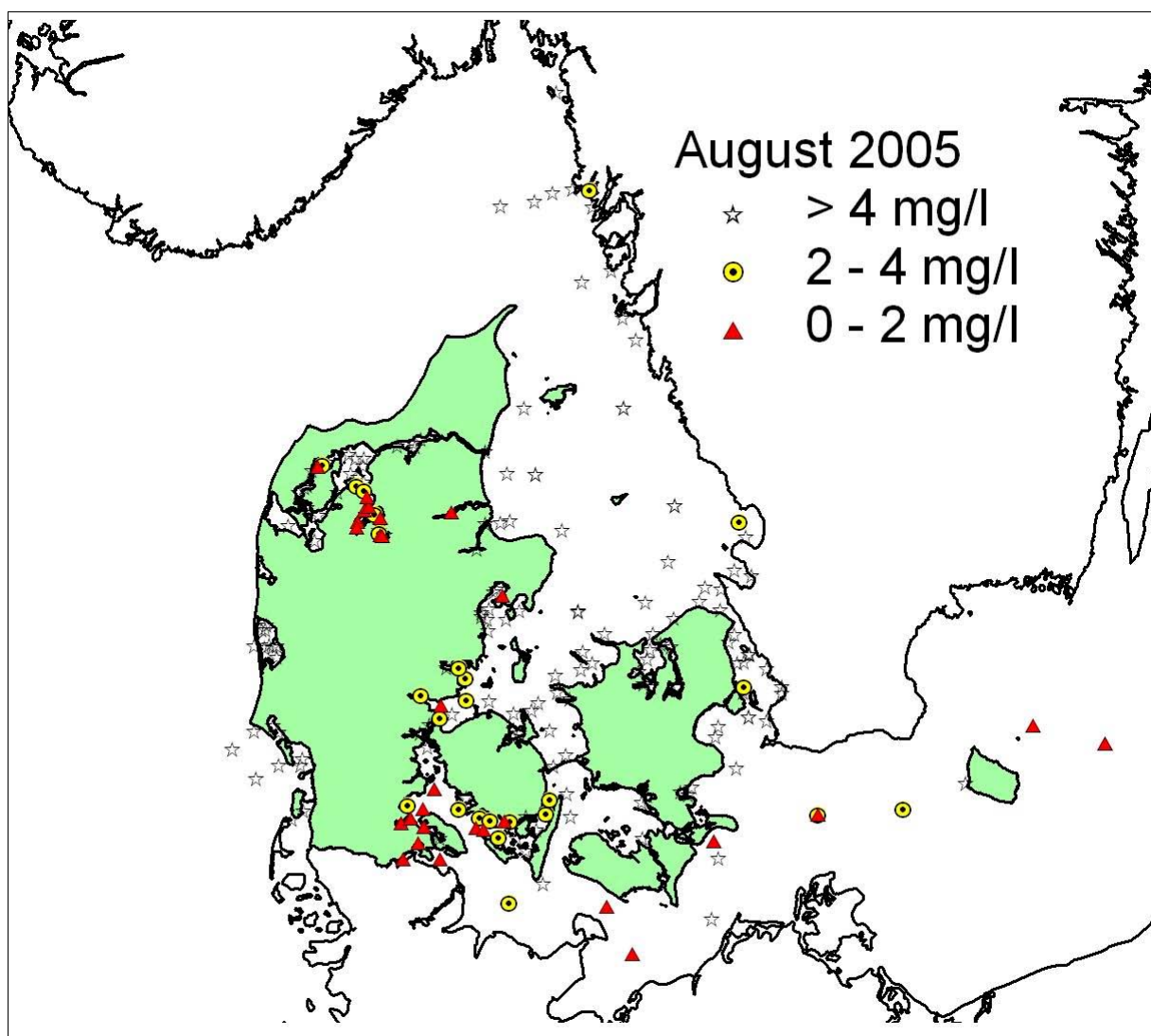


Figure 8 Stations visited by the Danish counties, NERI, SMHI and Swedish coastal authorities within the first 3 weeks of August 2005, and where oxygen depletion (< 4.0 mg/l) and severe oxygen depletion (< 2.0 mg/l) was observed.