



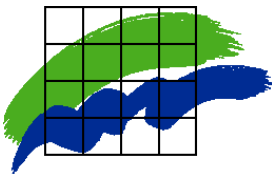
r/v Gunnar Thorson

# Monitoring Cruise Report

**Cruise no.: 217**

**Time: 18 - 22 August 2003**

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



Ministry of the Environment  
National Environmental Research Institute  
Frederiksborgvej 399  
DK-4000 Roskilde  
Denmark  
Tel.: +45 4630 1200 ♦ Fax: +45 4630 1114  
[www.dmu.dk](http://www.dmu.dk) ♦ [dmu@dmu.dk](mailto:dmu@dmu.dk)

## Data Sheet

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Author: Gunni Ærtebjerg  
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Frederiksborgvej 399  
P.O. Box 358  
DK-4000 Roskilde

Tel. +45 4630 1200  
Fax +45 4630 1114  
E-mail: [dmu@dmu.dk](mailto:dmu@dmu.dk)  
[www.dmu.dk](http://www.dmu.dk)

# Monitoring cruise with r/v Gunnar Thorson in the Sound, the Kattegat, the Belt Sea and the Arkona Sea, 18-22 August 2003 – Cruise no. 217

**Report:** Gunni Ærtebjerg

**Cruise leader:** Dorete Jensen

**Participants:** Hanne Ferdinand, Gitte Jacobsen, Peter Kofoed (NERI).  
18/8: Gunni Ærtebjerg, Martin Larsen (NERI), Jesper Theilgaard,  
Peter Sidsgård (DR TV-A)

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

## Summary

The minimum oxygen concentrations in August this year were significantly higher than at the same time last year, except in the north-eastern Kattegat. The lowest oxygen concentration observed was 1.1 ml/l (17% saturation) in the Mecklenburg Bight. In the south-eastern Kattegat and the Sound the minimum concentrations were 2.3-3.0 ml/l (33-46%), and in the Fehmarn Belt and Arkona Sea 2.6 ml/l (40-42%).

In week 34 (18-22 August) the actual area distribution of oxygen deficiency (<4 mg/l) and severe oxygen deficiency (<2 mg/l) in the Kattegat, the Sound and the Belt Sea with associated estuaries, but excluding the Arkona Basin, was only about 1/5 of the distribution at the same time last year. The geographical distribution of oxygen deficiency generally resembled that of 2001, which can be thought to represent an average distribution of oxygen deficiency. The area afflicted by oxygen deficiency was larger in the first half of August 2003, but strong westerly winds in the middle of the month improved the oxygen conditions at some localities (e.g. the Limfjord, Aarhus Bight and north of Funen). A report on oxygen deficiency in July and August 2003 is available at: <http://iltrapport.dmu.dk> (in Danish with an English summary).

At the cruise both the salinity and the temperature generally were higher than normal in the whole water column due to the warm weather in July and August and the strong wind in mid August. The wind accomplished an inflow to the Arkona Sea, where the bottom water salinity reached 20.

In the surface layer generally no inorganic nitrogen nutrients were present, while traces of phosphate, and silicate concentrations of 1-7  $\mu\text{mol/l}$ , were present in the surface water in most areas, except in the north-eastern Kattegat. In the bottom water nitrate concentrations above 6  $\mu\text{mol/l}$  were observed only in the eastern Kattegat. In the Sound and Belt Sea the nitrate concentration in the bottom water was unusually low. Very high ammonium concentrations (6.0-8.8  $\mu\text{mol/l}$ ) were observed in the bottom water in the Great Belt and especially in the Fehmarn Belt and Mecklenburg Bight. High silicate and phosphate concentrations were observed in the bottom water in the Fehmarn Belt and Arkona Sea.

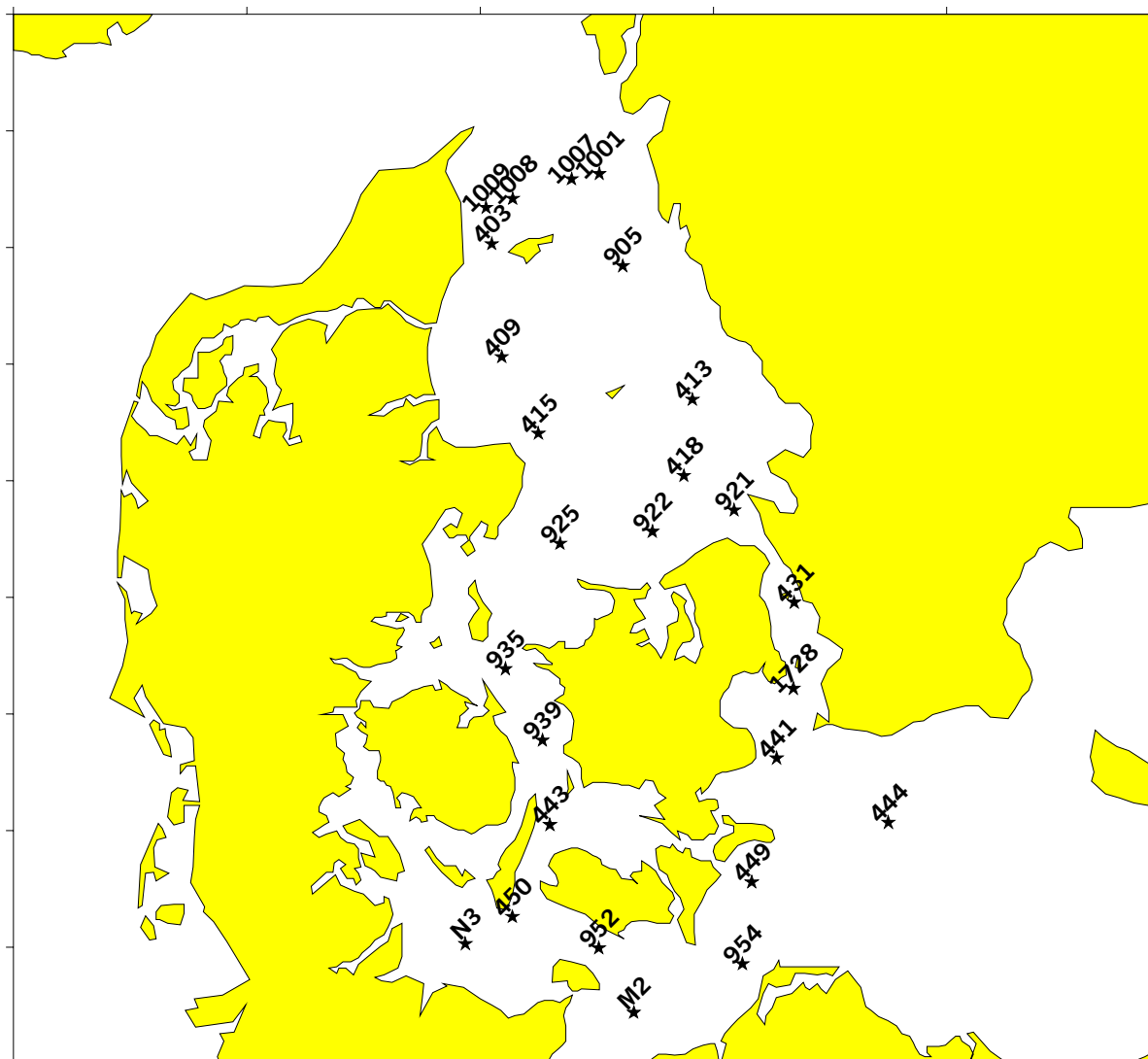
The chlorophyll-a concentration was relatively low (<1.5  $\mu\text{g/l}$ ) in most of the Kattegat. However, in the south-western Kattegat and northern Great Belt a pronounced subsurface maximum (3.4-6.8  $\mu\text{g/l}$ ) was present in 15-17 m depth. In the Fehmarn Belt the highest concentrations (3.0-3.6  $\mu\text{g/l}$ ) were observed in the surface layer.

## 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 NOVA 2003, the HELCOM monitoring programme for the Baltic Sea area (Arkona Sea, Sound, Belt Sea, Kattegat), and the OSPARCOM monitoring programme for the Greater North Sea (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*. Bottom fauna was sampled at 4 stations. The stations of the cruise are shown in *figure 1*.



**Figure 1.** Stations of the monitoring cruise with r/v Gunnar Thorson 18-22 August 2003 in the Sound, Kattegat, Belt Sea and Arkona Sea. Gunnar Thorson cruise no. 217.

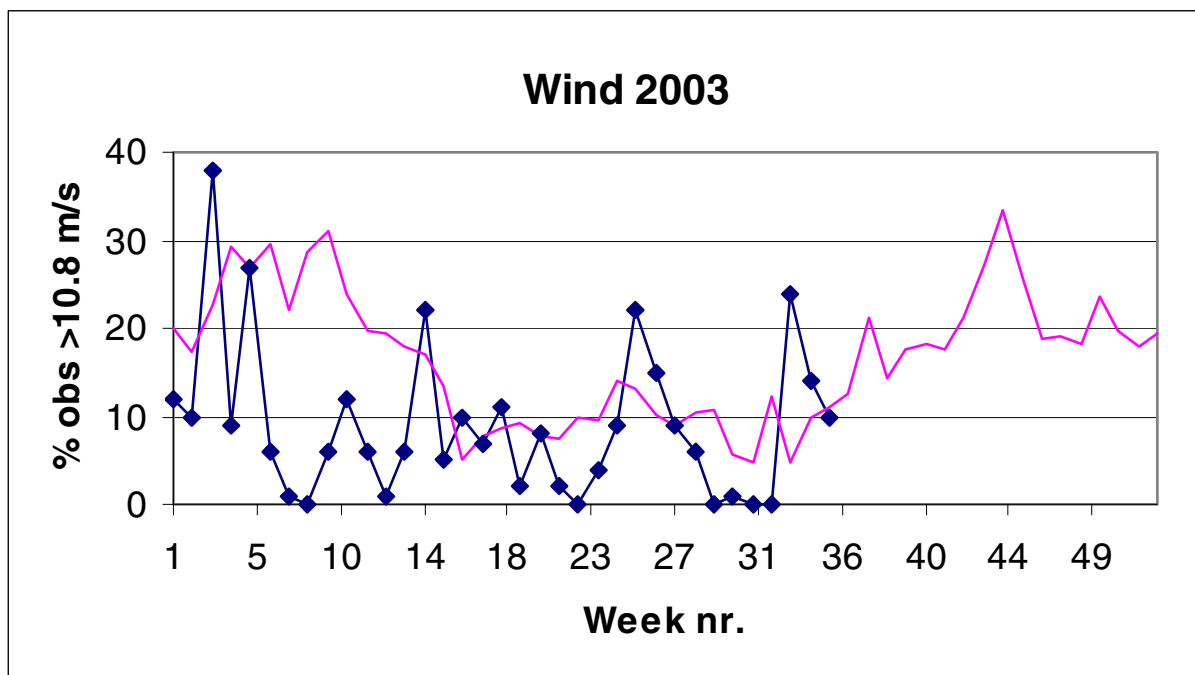
## Meteorology

Characteristics of the weather conditions during 2003 are given in *table 1*. The first quarter (January-March) was relatively cold and unusually dry, while the following months and especially July and August were warmer than normal. High precipitation from the end of April through May and June caught up with the precipitation deficit. In July the precipitation was relatively normal, while August

was dry. The wind did not deviate significantly from normal in January. However, the frequency of strong wind events has since February generally been low (*figure 2*), except for a few short periods with strong wind at the beginning of April, last half of June and mid August (weeks 14, 25-26 and 33-34). Especially from mid July to mid August (weeks 29-32) the wind activity was unusually low.

**Table 1.** Deviations in monthly mean temperature and precipitation in January to August 2003 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	+0.2	-16	5.6	SW-W
February	-1.2	-68	3.8	E-SE-S
March	-1.3	-67	4.6	SE—SW-W
April	+1.4	+41	5.3	N-NE-E
May	+0.6	+54	4.3	E-SE-S-SW-W
June	+1.5	+45	5.4	SW-W
July	+2.5	+9	3.8	Shifting
August	+2.0	-39	4.2	S-SW-W



**Figure 2.** Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2003 (connected points) compared to mean for the period 1994-2002 (thin line). Based on data from the Danish Meteorological Institute.

## Hydrography

The surface temperature (1 m depth) varied between 18.3°C in the Arkona Sea to 20.5°C in the southern Kattegat. However, at Stevns (St. 441) the surface temperature was only 14.8°C due to upwelling of cold water. The bottom water temperature ranged from 6.9-7.9°C in the south-eastern Kattegat (St. 413, 418, 921, 922) to 15.6-16.3°C in the western Kattegat (St. 409, 403, 1009) and 17.5°C in the Kiel Bight (St. N3) (*figure 3*).

The surface salinity ranged from 7.8-8.9 in the Arkona Sea (St. 441, 444, 449) to 27.4-28.7 in the northern Kattegat (St. 1007, 1008, 1009). The bottom water salinity ranged from 20.4-20.9 in the Arkona Sea (St. 444, 449) to 34.1-34.75 in the north-eastern Kattegat (St. 1001, 1007) (*figure 3*). The

salinity stratification was relatively normal for the season, except for the strong stratification in the Arkona Sea due to unusually salt water at the bottom.

Compared to long term monthly means (Lightship observations 1931-1960) for August the surface temperature was 1.6-2.6°C and the bottom water temperature 0.1-2.9°C higher than normal. The surface salinity during the present cruise was generally 0.2-4.3 higher than normal, except for 0.4-1.1 lower than normal east of Anholt and in the western Kattegat. The bottom water salinity was higher than normal, except in the Fehmarn Belt (St. 952).

## Nutrients

In the surface layer generally no inorganic nitrogen nutrients were present (*figure 4*). In the bottom water nitrate concentrations above 6 µmol/l were observed only in the eastern Kattegat (St. 413, 905, 1001, 1007). In the Sound and Belt Sea the nitrate concentration in the bottom water was unusually low (*figure 4a*).

Relatively high nitrite concentrations (0.8-0.9 µmol/l) were observed at 40-50 m depth in the north-eastern Kattegat (St. 905, 1001) (*figure 4b*). Very high ammonium concentrations (6.0-8.8 µmol/l) were observed in the bottom water in the Great Belt and especially in the Fehmarn Belt and Mecklenburg Bight (St. 450, 952, M2, 954) (*figure 4c*).

Traces of phosphate were present in the surface water in most areas, except in the north-eastern Kattegat. The highest concentrations were observed in the western Kattegat, the Sound, southern Belt Sea and Arkona Sea (0.11-0.18 µmol/l). In the bottom water phosphate above 1.0 µmol/l was observed east of Anholt, in the Fehmarn Belt and the Arkona Sea (*figure 5a*). Silicate concentrations above 1 µmol/l and up to 7 µmol/l were present in the surface water in all areas, except the eastern Kattegat. High concentrations (>25 µmol/l) were observed in the bottom water in the eastern Kattegat, Fehmarn Belt and Arkona Sea (*figure 5b*).

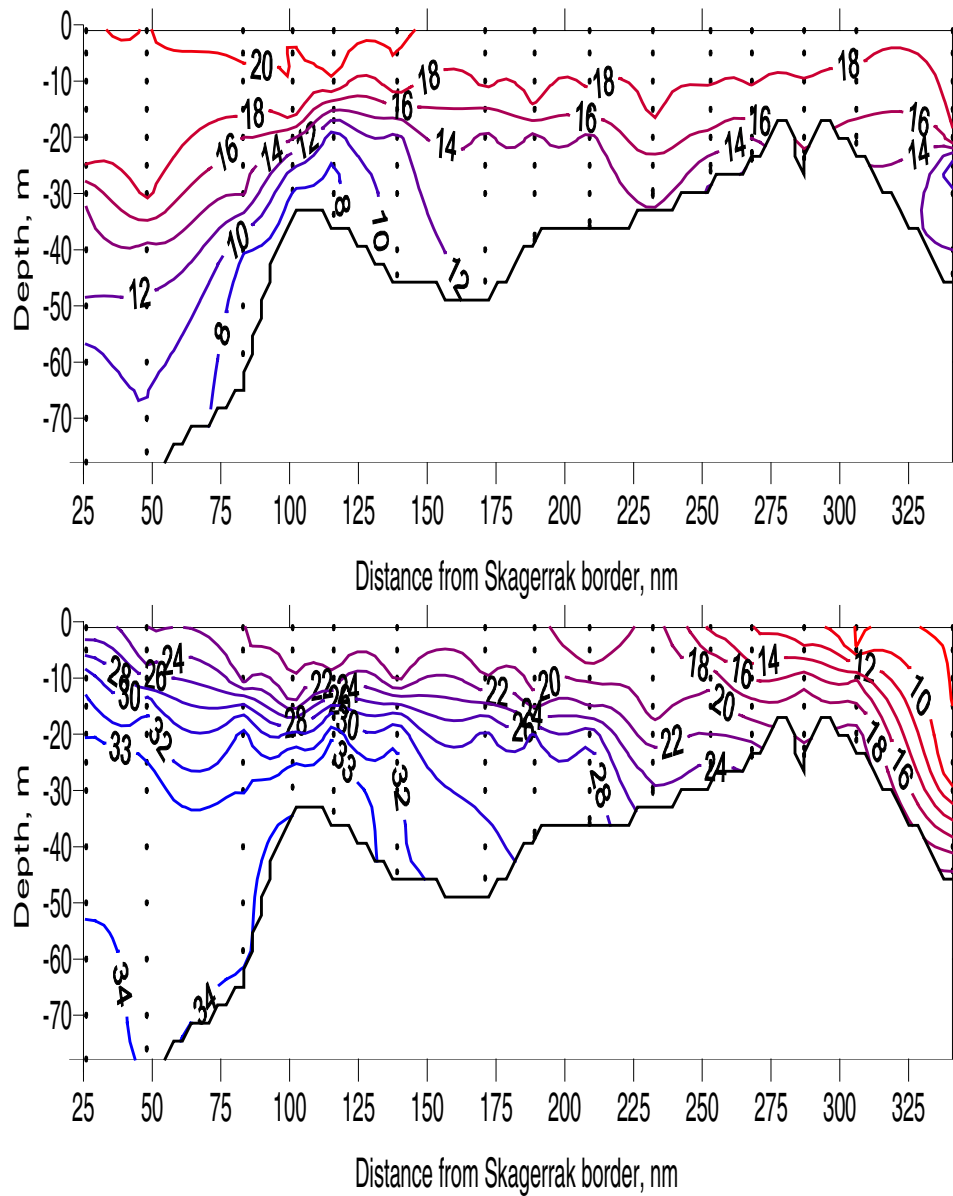
## Chlorophyll-a

The chlorophyll-a concentration was relatively low (<1.5 µg/l) in most of the Kattegat (*figure 6*). However, in the south-western Kattegat and northern Great Belt (St. 922, 925, 935) a pronounced subsurface maximum (3.4-6.8 µg/l) was present in 15-17 m depth. In the Fehmarn Belt the highest concentrations (3.0-3.6 µg/l) were observed in the surface layer (*figure 6*).

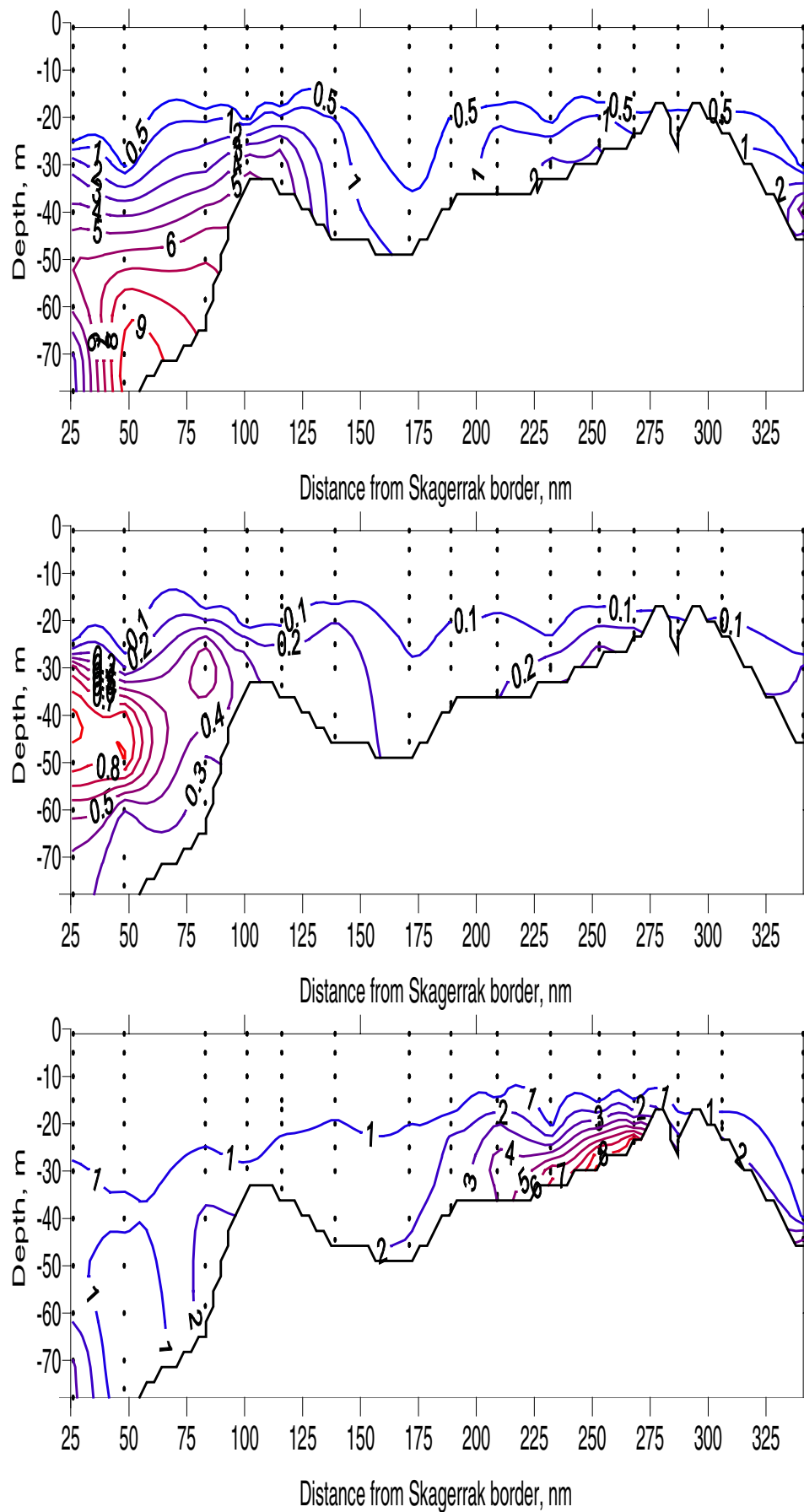
## Oxygen

The minimum oxygen concentrations in August this year was significantly higher than at the same time last year, except in the north-eastern Kattegat (St. 905, 1001, 1007). The lowest oxygen concentration observed was 1.1 ml/l (17% saturation) in the Mecklenburg Bight (St. M2) (*figure 5c*). In the south-eastern Kattegat and the Sound (St. 413, 921, 922, 431) the minimum concentrations were 2.3-3.0 ml/l (33-46%). In the Fehmarn Belt and Arkona Sea (St. 450, 952, 444) the minimum concentration was 2.6 ml/l (40-42%). Compared to mean for August in the 1980s the minimum oxygen concentrations in the Kattegat were generally lower, but in the rest of the areas investigated equal to or higher than in the 1980s.

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 oxygen depletion was observed in the south-eastern Kattegat (St. 413, 922), the Fehmarn Belt (St. 450, 952) and the Arkona Sea (St. 444). Severe oxygen depletion occurred in the Mecklenburg Bight (St. M2). In *figure 7* is shown the stations visited by the Danish counties, NERI, SMHI and Swedish and German coastal authorities within the first three weeks of August 2003, and where oxygen depletion or severe oxygen depletion was observed.

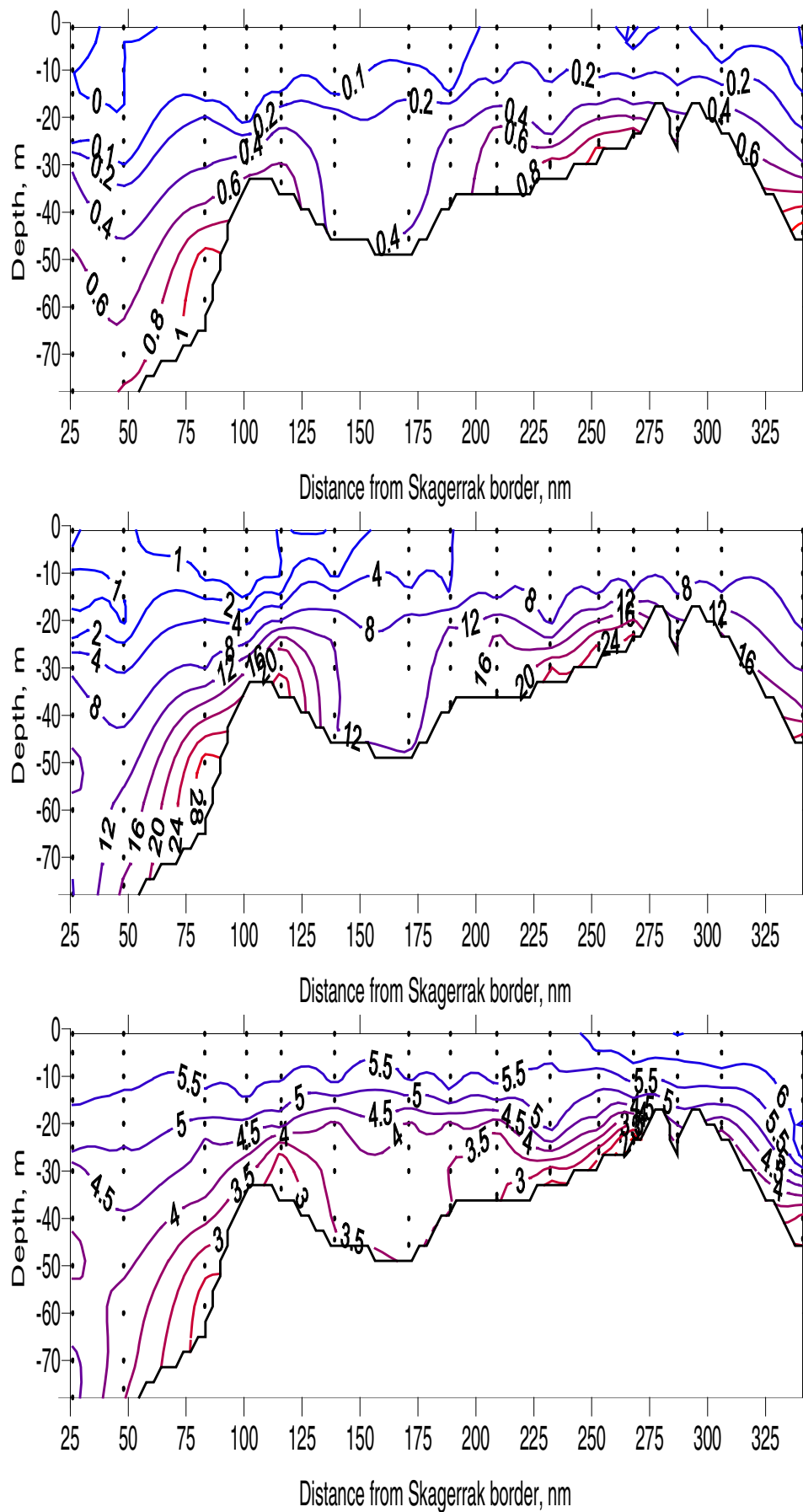


**Figure 3.** Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

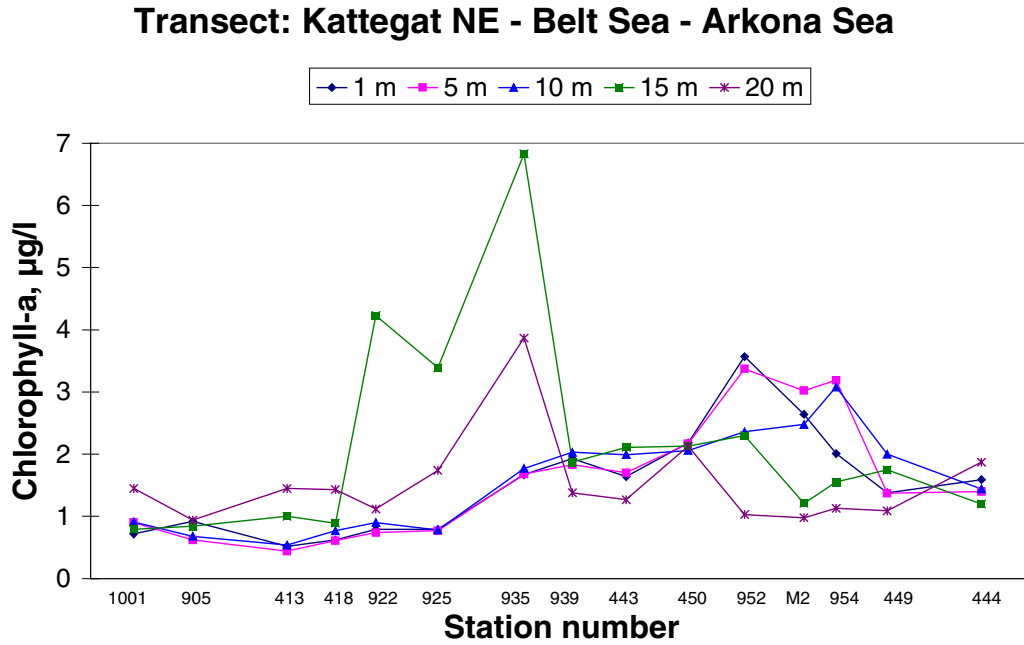


**Figure 4.** Nitrate (top), nitrite (mid) and ammonium (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

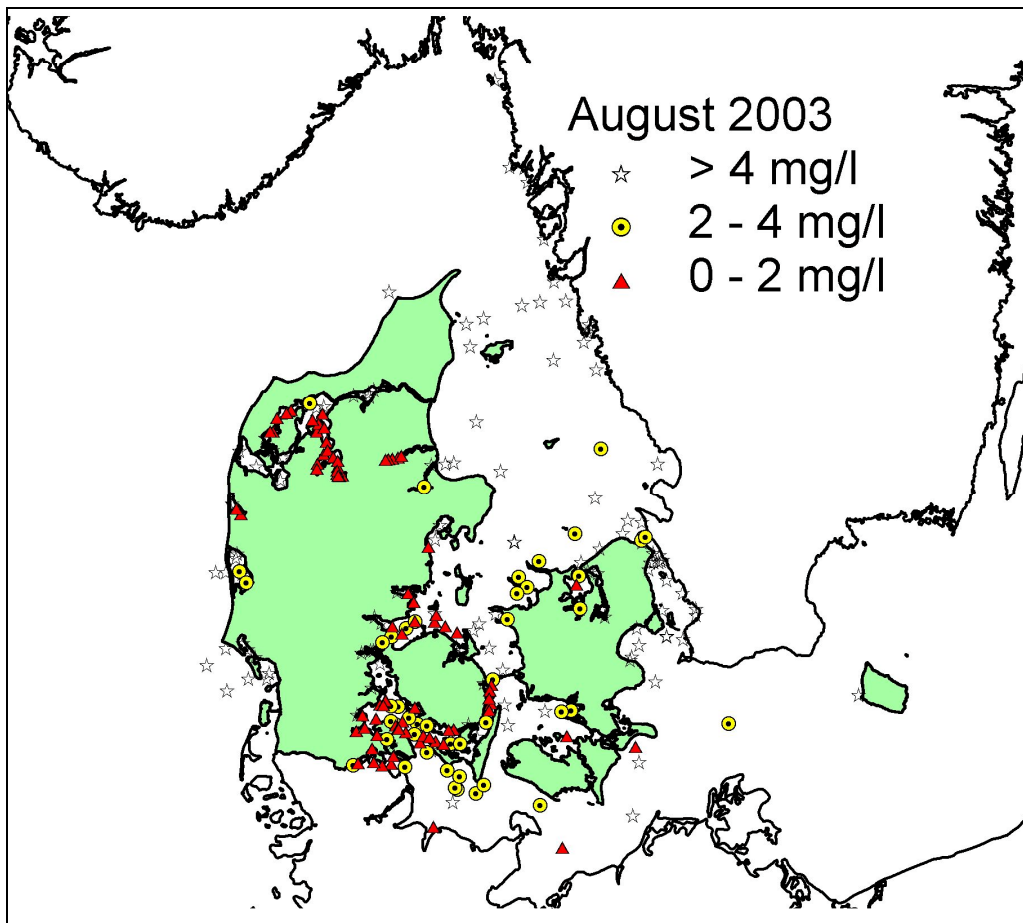




**Figure 5.** Phosphate (top), silicate (mid) and oxygen (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



**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.** Stations visited by the Danish counties, NERI, SMHI and Swedish and German coastal authorities within the first three weeks of August 2003, and where oxygen depletion (<4 mg/l) and severe oxygen depletion (<2 mg/l) was observed.