



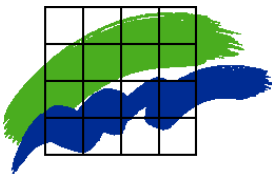
r/v Gunnar Thorson

# Monitoring Cruise Report

**Cruise no.: 226**

**Time: 18 - 22 October 2004**

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



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

## Data Sheet

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

Subtitle: Cruise no. 226, 18-22 October 2004

Author: Gunni Ærtebjerg  
Department: Department of Marine Ecology

Serial title: Monitoring Cruise Report

Publisher: National Environmental Research Institute<sup>©</sup>  
Ministry of the Environment

Week/year of publication: 51/2004

Please quote: Ærtebjerg, G. 2004: Monitoring Cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Cruise no. 226, 18-22 October 2004. National Environmental Research Institute, Denmark. Monitoring Cruise Report.

Reproduction permitted only when quoting is evident.

Keywords: Marine, monitoring, hydrography, eutrophication

ISSN (electronic): 1600-1656  
(Only published electronically) <http://www.dmu.dk/Vand/Havmiljø/Togtrapper/>

Number of pages: 9

*The numbers of the Monitoring Cruises may not be successive, as the numbers also include other types of cruises.*

Published by: National Environmental Research Institute  
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.neri.dk](http://www.neri.dk)

# **Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat, 18-22 October 2004 Cruise no. 226**

**Report:** Gunni Ærtebjerg

**Cruise leader:** Kjeld Sauerberg

**Participants:** Dorete Jensen & Hanne Ferdinand, NERI; Thomas Vinkel-Jørgensen (trainee)

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

## **Summary**

Since September the oxygen concentrations had increased significantly, except in the Sound and southernmost Kattegat. The lowest oxygen concentrations of 2.5-2.6 ml/l (42-44% saturation) were observed in the central and northern Sound and south-western Kattegat, where oxygen depletion (<2.8 ml/l) still persisted. Compared to October last year, the minimum oxygen concentrations this year were higher, except in the southern Belt Sea. Also compared to mean for October in the 1980s, the minimum oxygen concentrations this year were higher, except in the Sound.

In the surface layer the temperature was 0.7-1.1 °C lower than long-term monthly mean for October. Also the surface salinity was generally lower than average in the Kattegat and the Belt Sea. In the Kattegat bottom water both the temperature and the salinity were generally higher than long-term means, while in the Belt Sea they were both lower than normal.

In the surface layer the nitrate concentration was still below 1 µmol/l, except for 1.3 µmol/l in the Sound. Ammonium concentrations of 0.2-1.0 µmol/l were present in all surface waters, and even higher concentrations (1.3-2.2 µmol/l) were observed at the Drogden Sill, in the Fehmarn Belt and the north-western Kattegat. Phosphate concentrations above 0.1 µmol/l were present in surface waters in all areas, and up to 0.5-0.6 µmol/l were observed in the central Great Belt and at the Darss Sill. The silicate concentration was below 1 µmol/l in the surface of the eastern Kattegat, but higher than 10 µmol/l in the Sound, Belt Sea and Arkona Sea.

In the bottom layer nitrate concentrations of 9-10 µmol/l were observed in the Sound and in the highly saline (35.2) Skagerrak water in the north-eastern Kattegat. High ammonium concentrations of 3.0-4.2 µmol/l were found at the bottom in the Fehmarn Belt. The highest concentrations of phosphate (1.2-1.5 µmol/l) and silicate (20-30 µmol/l) in the bottom waters were observed in the Sound, south-western Kattegat and southern Great Belt.

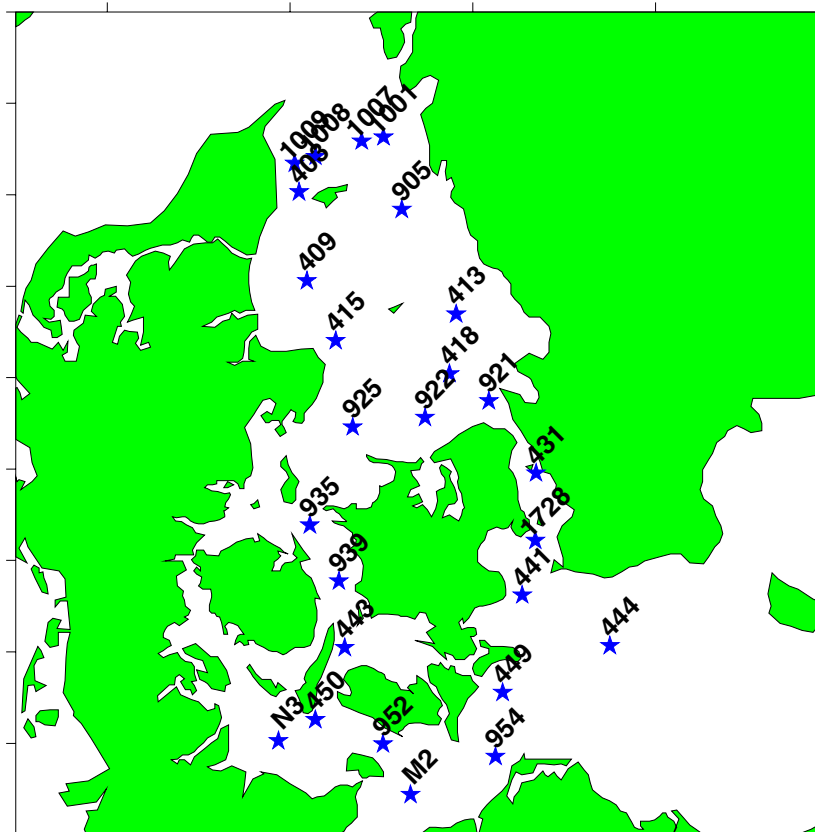
The chlorophyll-*a* was quite evenly distributed in the surface layer with the highest concentrations of 3.4-4.3 µg/l in the south-eastern Kattegat and Mecklenburg Bight. The lowest mean concentration of 0.8 µg/l was observed in the north-western Kattegat (Læsø Rende).

## 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 for the Baltic Sea area (the Arkona Sea, the Sound, the Belt Sea, the Kattegat), and the OSPARCOM monitoring programme 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 stations of the cruise are shown in *figure 1*.



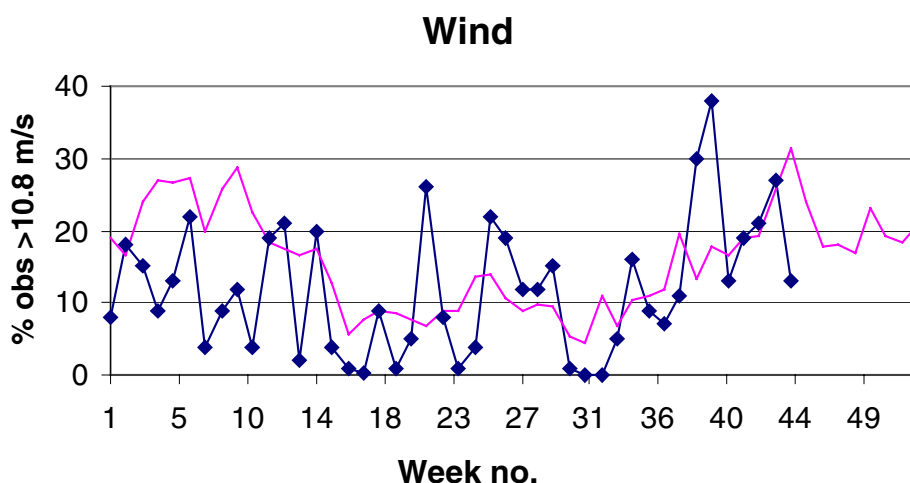
*Figure 1* Stations of the monitoring cruise with r/v Gunnar Thorson 18-22 October 2004 in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Gunnar Thorson cruise no. 226.

## Meteorology

Characteristics of the weather conditions during October 2004 are given in *table 1*. October was relatively warm and wet. The dominating wind directions were from south-east and south-west, and the average wind force was relatively high. The frequency of wind exceeding gale force (*figure 2*) was about normal and relatively high in the first 3 weeks of October (weeks 41-43), but low at the end of the month (week 44).

*Table 1* Deviations in monthly mean temperature and precipitation in October 2004 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
October	+0.5	+41	5.3	SE--SW



**Figure 2** Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2004 (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 10.7 and 11.5 °C in the whole area. The bottom near temperature ranged from 8.2-9.8 °C in the north-eastern Kattegat (St. 1001, 1007) and up to 14.2-14.8 °C in the Sound and southern Kattegat (St. 418, 431, 921, 922, 925) (*figure 3*).

The surface salinity ranged from 8.4-8.7 in the Arkona Sea (St. 441, 444, 449) to 25.2-26.2 in the northern Kattegat (St.1007, 1008, 1009). The bottom water salinity ranged from 16.5-19.3 in the Arkona Sea (St. 444, 449, 954) to 34.9-35.2 in the north-eastern Kattegat (St. 905, 1001, 1007) (*figure 3*). The salinity stratification was relatively strong for the season, except in the central Great Belt.

Compared to long-term monthly means (Lightship observations 1931-1960) for October the surface temperature was 0.7-1.1 °C below average. In the Kattegat the bottom water temperature was 0.3-2.1 °C higher than normal, while in the Belt Sea the bottom water temperature generally was 0.4 °C below normal. The surface salinity in the Kattegat and Belt Sea was 1.3-4.7 below average. The bottom water salinity in the Kattegat was generally 0.3-1.3 above normal, while in the Belt Sea it was lower than average.

## Nutrients

The nitrate concentration in the surface layer was still low (0.0-0.9 µmol/l), only in the Sound (St. 431, 921) the concentration reached 1.2-1.3 µmol/l. In the bottom water relatively high nitrate concentrations of 9-10 µmol/l were observed in the central and northern Sound (St.431, 921) and in the highly saline (35.2) Skagerrak bottom water in the north-eastern Kattegat (St. 1001) (*figure 4a*).

Nitrite concentrations of >0.5 µmol/l were only observed in at 25-30 m depth at the northern entrance to the Belt Sea (St. 925) (*figure 4b*). Ammonium concentrations of 0.2-1.0 µmol/l were observed in the surface in most areas. Even higher ammonium concentrations (1.3-2.2 µmol/l) were observed at the surface at the Drogden Sill (St. 1728), in the Fehmarn Belt (St. 450, 952) and in the north-western Kattegat (St. 403, 1009). In the bottom water the highest concentrations of ammonium (3.0-4.2 µmol/l) were observed in the Fehmarn Belt (St. 450, 952) (*figure 4c*).

Phosphate concentrations higher than 0.1  $\mu\text{mol/l}$  were present in the surface water in all areas, and in the central Great Belt (St. 935, 939) and at Gedser Rev (St. 954) 0.5-0.6  $\mu\text{mol/l}$  were observed. In the bottom water phosphate concentrations of 1.2-1.5  $\mu\text{mol/l}$  were observed in the central and northern Sound (St. 431, 921), in the south-western Kattegat (St. 925) and highest in the southern Great Belt (St.450) (*figure 5a*). Silicate concentrations below 1  $\mu\text{mol/l}$  were observed in the surface layer in the eastern Kattegat (St. 418, 905, 1001, 1007). However, in the Belt Sea, the Arkona Sea and the central Sound the surface concentrations were more than 10  $\mu\text{mol/l}$ . High silicate concentrations (20-31  $\mu\text{mol/l}$ ) were observed in the bottom water in the Sound (St. 431, 921), the Arkona Sea (St. 444), the southern Belt Sea (St. 450, 952, M2) and the south-western Kattegat (St. 925) (*figure 5b*).

### **Chlorophyll-*a***

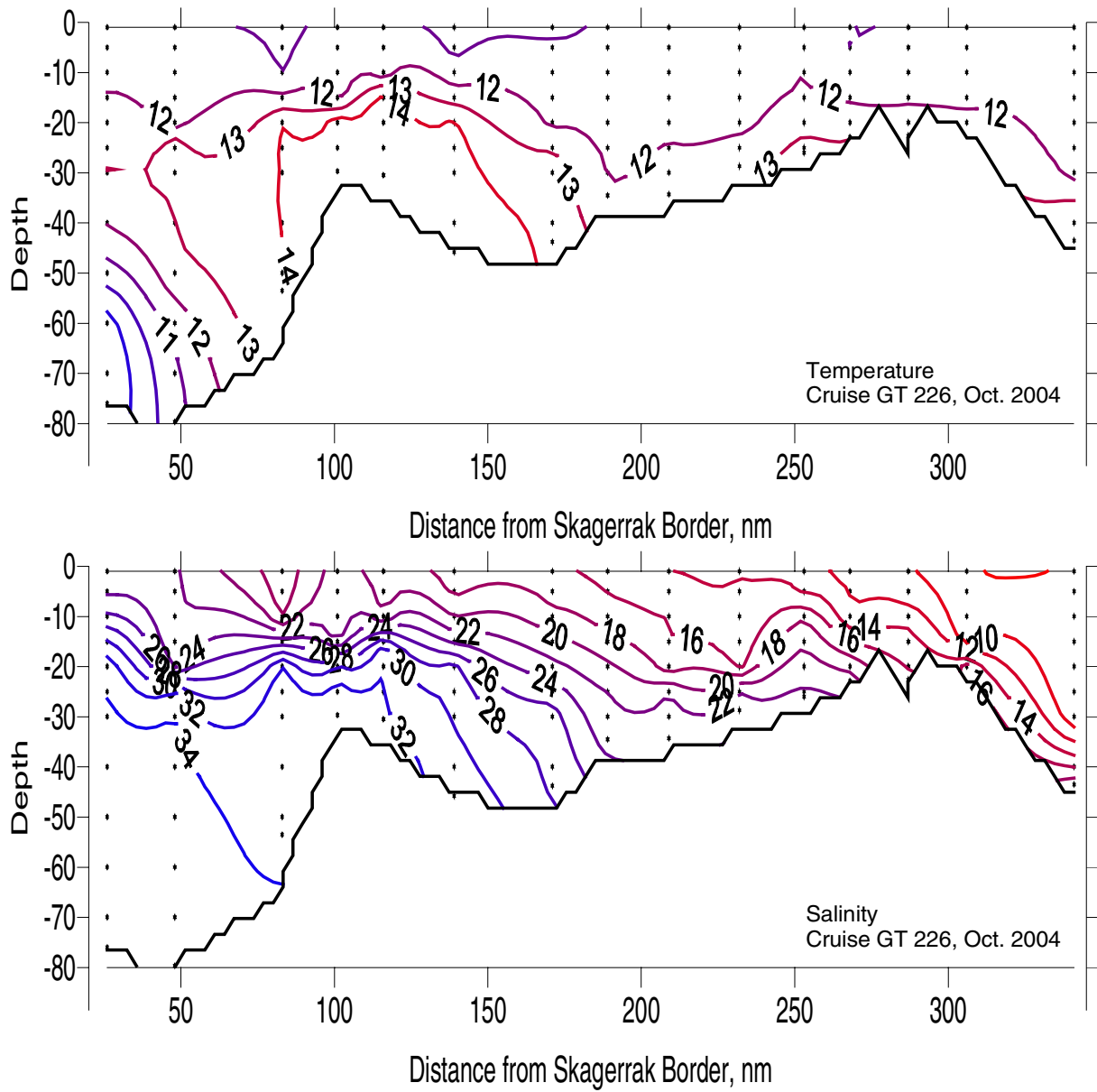
The chlorophyll-*a* was quite evenly distributed in the surface layer with the highest concentrations of 3.4-4.3  $\mu\text{g/l}$  in the south-eastern Kattegat (St. 413, 922) and Mecklenburg Bight (St. M2). The lowest mean concentration of 0.8  $\mu\text{g/l}$  in the uppermost 10 m was observed in Læsø Rende (St. 403). In the Sound, Great Belt and Fehmarn Belt the surface mean concentrations were 1.2-2.0  $\mu\text{g/l}$  (*figure 6*).

### **Oxygen**

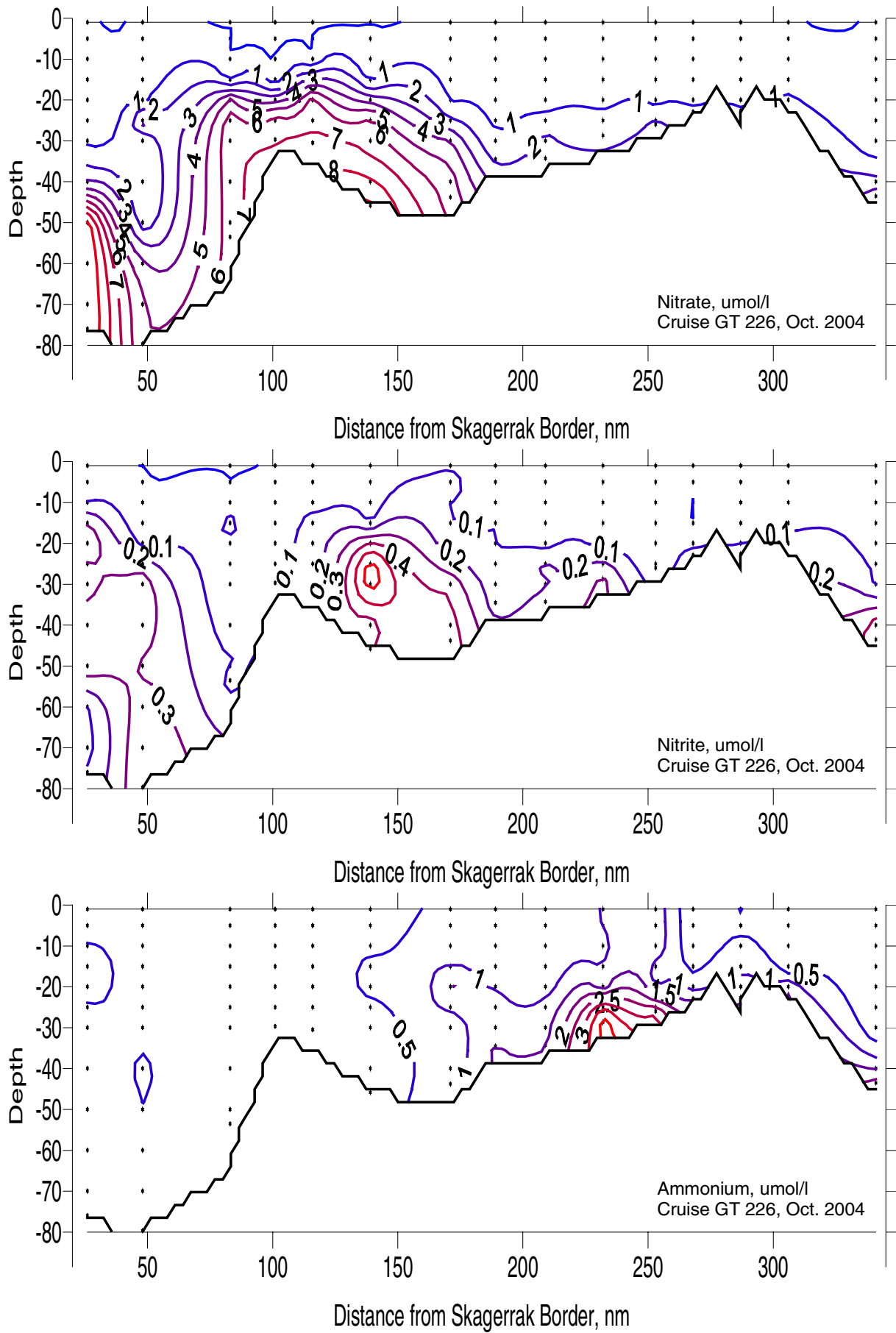
Since September the oxygen concentration had increased significantly in most areas, except in the Sound and southernmost Kattegat. The lowest oxygen concentrations of 2.5-2.6 ml/l (42-44% saturation) were observed in the Sound (St. 431, 921) and south-western Kattegat (St. 925). In the Belt Sea the minimum concentrations varied from 3.8 ml/l to 5.7 ml/l (62-87%) and had increased 0.2-3.7 ml/l during the last month (*figure 7*).

Compared to October last year, the minimum oxygen concentrations this year were higher, except in the southern Belt Sea. Also compared to mean for October in the 1980s, the minimum oxygen concentrations this year were higher, except in the Sound.

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. Oxygen depletion occurred in the Sound (St. 431, 921) and the south-western Kattegat (St. 925). In *figure 8* is shown the stations visited by the Danish counties, NERI, SMHI and Swedish coastal authorities within the first 3 weeks of October 2004, and where oxygen depletion or severe oxygen depletion was observed.

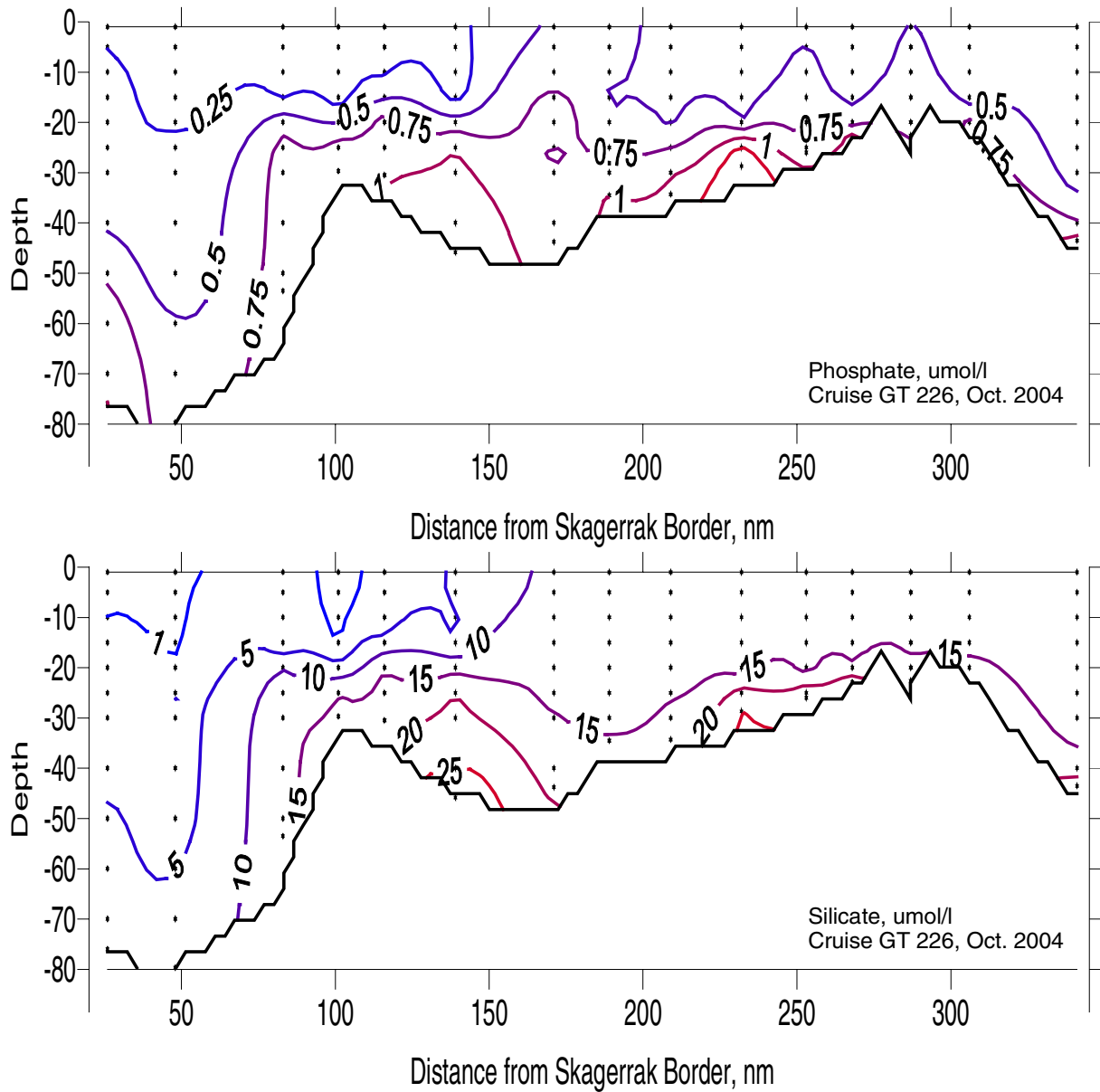


**Figure 3** Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



**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

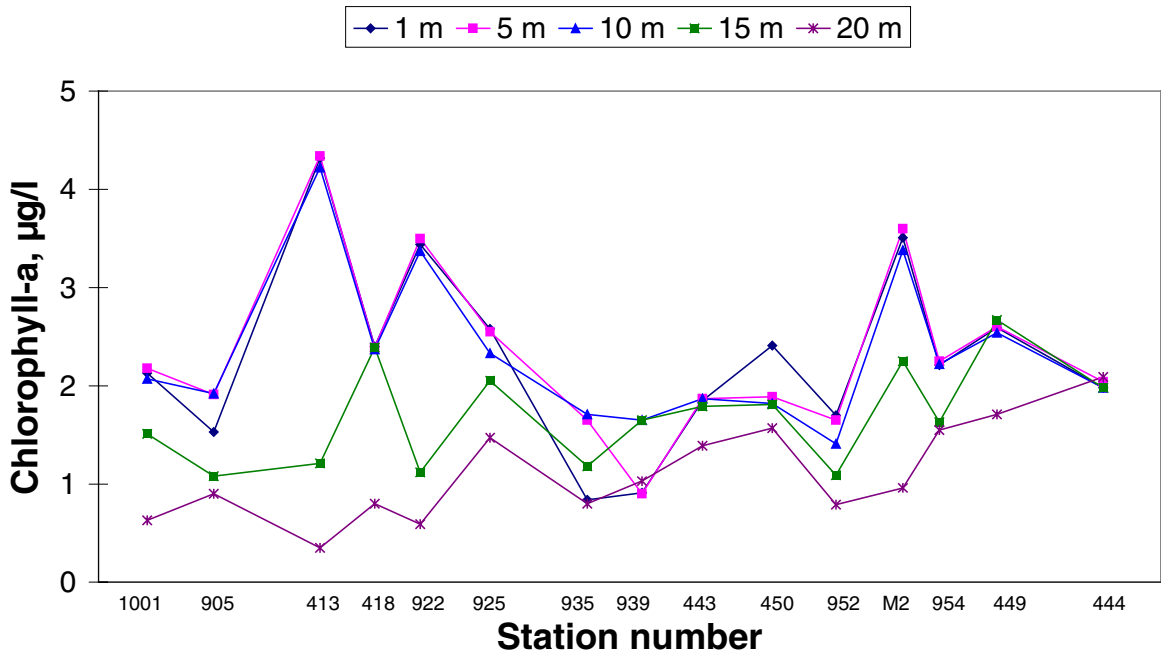


Figure 6 Chlorophyll-a at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

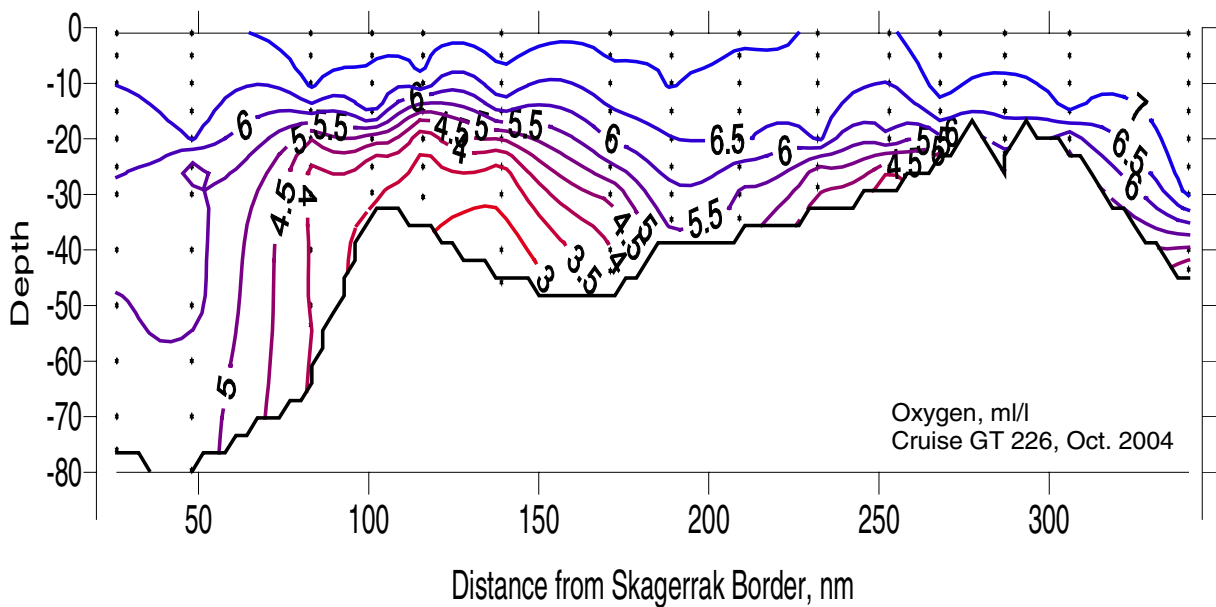
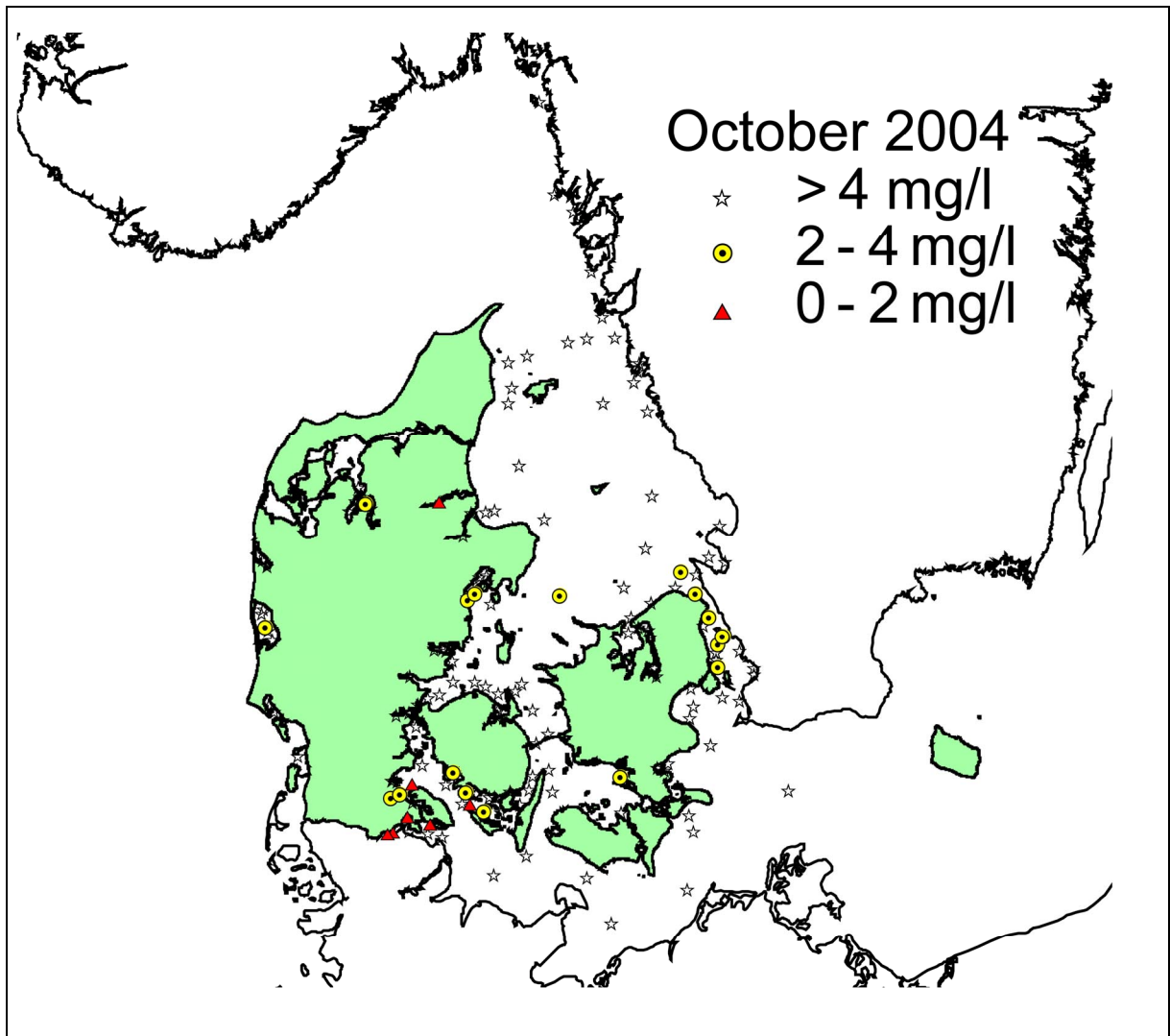


Figure 7 Oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



**Figure 8** Stations visited by the Danish counties, NERI, SMHI and Swedish coastal authorities within the first 3 weeks of October 2004, and where oxygen depletion (<4.0 mg/l) and severe oxygen depletion (<2.0 mg/l) was observed.