



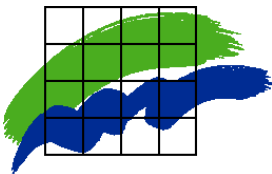
r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 225

Time: 13 - 17 September 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

Data Sheet

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Author: Gunni Ærtebjerg
Department: Department of Marine Ecology

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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
www.neri.dk

Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat, 13-17 September 2004

Cruise no. 225

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

Severe oxygen depletion (<1.4 ml/l) was observed east of Falster (0.8 ml/l; 13%), and oxygen depletion (<2.8 ml/l) occurred in the Sound, the Arkona Basin and the southern Belt Sea (1.8-2.7 ml/l; 29-41%). However, generally the minimum oxygen concentrations were higher than at the same time last year, except in the Kiel Bight and east of Falster. Also compared to September in the 1980's the minimum concentrations this year were generally higher, except in the southern Belt Sea and the Arkona Basin.

The water temperature was both in the surface layer and the bottom layer above long-term average for the season, except for slightly lower bottom water temperature in the central Great Belt. Also the salinity was generally higher than long-term average in the whole water column, except in the north-western Kattegat. Generally, the stratification was about normal for the season.

In the surface layer the nitrate concentration was quite low (0.0-0.9 $\mu\text{mol/l}$), except in the south-western Kattegat and Læsø Rende, where 1.3-1.9 $\mu\text{mol/l}$ were observed. Ammonium concentrations of 0.2-1 $\mu\text{mol/l}$ were observed in the surface in most areas. Phosphate concentrations of 0.1-0.5 $\mu\text{mol/l}$ were present in the surface water in all areas, except the south-eastern Kattegat, while silicate concentrations above 2 $\mu\text{mol/l}$ and up to 14 $\mu\text{mol/l}$ were present in the surface water in all areas.

In the bottom water the highest concentrations of nitrate (7.4-9.1 $\mu\text{mol/l}$), phosphate (1.0-1.1 $\mu\text{mol/l}$) and ammonium (>1.5 $\mu\text{mol/l}$) were observed in the Sound, and for phosphate and ammonium also close to the bottom at a few other stations. High nitrite concentrations (1.3-1.4 $\mu\text{mol/l}$) were only found in an intermediate layer in the eastern Kattegat. High silicate concentrations (20-39 $\mu\text{mol/l}$) were present in the bottom water in the Sound, the Arkona Basin and the southern Belt Sea.

The chlorophyll-*a* was quite evenly distributed in the surface layer where the concentrations in the uppermost 10 m varied between 1.4 in the Sound to 2.5-3.9 $\mu\text{g/l}$ in the Belt Sea, western Kattegat and central Arkona Sea.

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*.

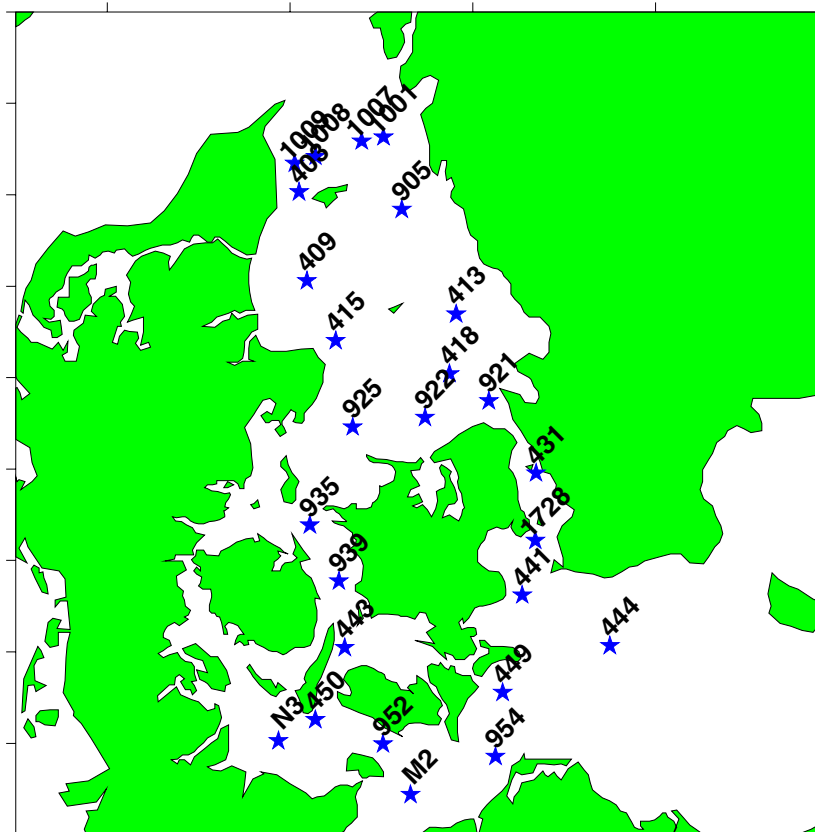


Figure 1 Stations of the monitoring cruise with r/v Gunnar Thorson 13-17 September 2004 in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Gunnar Thorson cruise no. 225.

Meteorology

Characteristics of the weather conditions during July to September 2004 are given in *table 1*. July was cold and relatively wet, while August was warm and rainfall. September was also relatively warm but with normal precipitation. The wind forces were relatively low in July (weeks 28-31) and August (weeks 32-35) (*figure 2*), with dominating wind directions in July from southwest and west, but in August from changing directions. The dominating wind directions in September (weeks 36-40) were southwest and west, and the wind force was relatively high. Especially in mid September (weeks 38-39) westerly gales occurred.

Table 1 Deviations in monthly mean temperature and precipitation in the months July to September 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
July	-0.5	+12	4.1	SW-W
August	+2.2	+61	4.2	Changing
September	+1.0	0	5.1	SW-W

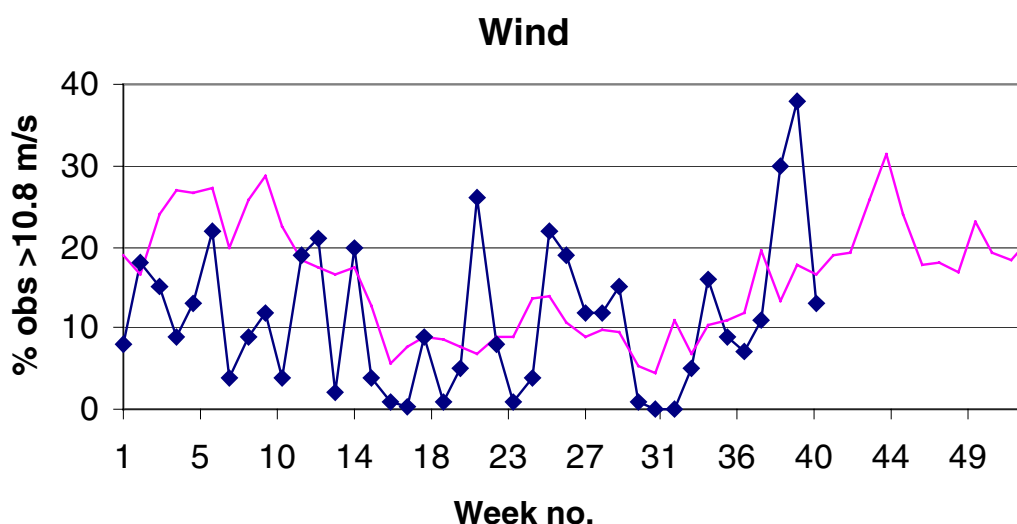


Figure 2 Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2004 (connected points) compared to mean for the period 1994-2002 (thin line). Based on data from the Danish Meteorological Institute.

Hydrography

The surface temperature (1 m depth) varied between 15.0 and 16.8°C in the whole area. The bottom near temperature ranged from 11.2°C in the Sound (St. 431, 921) and up to 16.4°C in the northern Kattegat (St. 1007, 1009). However, colder water masses (9.0-10.4°C) were observed as an intermediate layer in the Arkona Basin (St. 444) at 26-32 m depth (*figure 3*).

The surface salinity ranged from 7.9-8.7 in the Arkona Sea (St. 441, 444, 449) to 31.0-31.2 in the north-western Kattegat (St. 403, 1009). The bottom water salinity ranged from 16.6 in the Arkona Sea (St. 444) to 34.1-34.55 in the north-eastern Kattegat (St. 905, 1001) (*figure 3*). The salinity stratification was normal for the season.

Compared to long-term monthly means for September (Lightship observations 1931-1960) the temperature was above average, both in the surface and the bottom layer, except for slightly lower bottom water temperature in the central Great Belt. Both the surface salinity and the bottom water salinity were during the present cruise higher than average, except in the north-western Kattegat (St. 1009).

Nutrients

The nitrate concentration in the surface layer was low (0.0-0.9 µmol/l) in most areas, only in the south-western Kattegat (St. 415, 925) and Læsø Rende (St. 403) the concentrations reached 1.3-1.9 µmol/l. In the bottom water relatively high nitrate concentrations of 7.4-9.1 µmol/l were only observed in the central and northern Sound (St.431, 921) (*figure 4a*).

High nitrite concentrations of 1.3-1.4 $\mu\text{mol/l}$ were only observed in an intermediate water layer in the eastern Kattegat (St. 413, 905) (*figure 4b*). Ammonium concentrations of 0.2-1 $\mu\text{mol/l}$ were observed in the surface in most areas. High ammonium concentrations $>1.5 \mu\text{mol/l}$ were observed at the Drogden Sill and in the bottom water of the central Sound (St. 1728, 431), in the western Kattegat (St. 409) and the central Great Belt (St. 939) (*figure 4c*).

Phosphate concentrations of 0.1-0.5 $\mu\text{mol/l}$ were present in the surface water in all areas, except the south-eastern Kattegat (St. 418, 922). In the bottom water phosphate concentrations of 1.0-1.1 $\mu\text{mol/l}$ were only observed in the central Sound and close to the bottom at a few stations (431, 444, 921, 935, 1001) (*figure 5a*). Silicate concentrations above 2 $\mu\text{mol/l}$ and up to 14 $\mu\text{mol/l}$ were present in the surface water in all areas. High concentrations (20-39 $\mu\text{mol/l}$) were observed in the bottom water in the Sound (St. 431), the Arkona Sea (St. 444) and the southern Belt Sea (St. M2, N3, 952, 954) (*figure 5b*).

Chlorophyll-*a*

The chlorophyll-*a* was quite evenly distributed in the surface layer. The lowest mean concentration in the uppermost 10 m was observed in the central Sound (1,4 $\mu\text{g/l}$). In the Kattegat the concentrations varied from 1.2-2.0 $\mu\text{g/l}$ in the southern, eastern and northern parts to 3.2 $\mu\text{g/l}$ in the shallow western part. In the Belt Sea the concentrations were relatively high (2.5-3.9 $\mu\text{g/l}$), In the Arkona Sea the concentration varied from 2.3 $\mu\text{g/l}$ at the coastal stations to 3.0 $\mu\text{g/l}$ in the open part.

Oxygen

The lowest oxygen concentration of 0.8 ml/l (13% saturation) was observed east of Falster (St. 449). In the Arkona Basin the minimum concentration was 2.7 ml/l (41%). In the southern Belt Sea, that is the Mecklenburg Bight, Kiel Bight, Fehmarn Belt and the Kadetrenden in the Darss sill (St. M2, N3, 952, 954) the minimum concentrations were 1.8-2.4 ml/l (29-38%) (*figure 7*). In the central Sound 2.6 ml/l (41%) was observed. Compared to September last year, the minimum oxygen concentrations this year were higher, except in Kiel Bight and east of Falster. Compared to mean for September in the 1980s, the minimum oxygen concentrations this year were generally higher, except in the southern Belt Sea and the Arkona Basin.

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 east of Falster (St. 449), and oxygen depletion occurred in the Sound (St. 431), the Arkona Basin (St. 444), and in the southern Belt Sea (St. M2, N3, 952, 954). In *figure 8* is shown the stations visited by the Danish counties, NERI, SMHI and Swedish and German coastal authorities within the first 3 weeks of September 2004, and where oxygen depletion or severe oxygen depletion was observed.

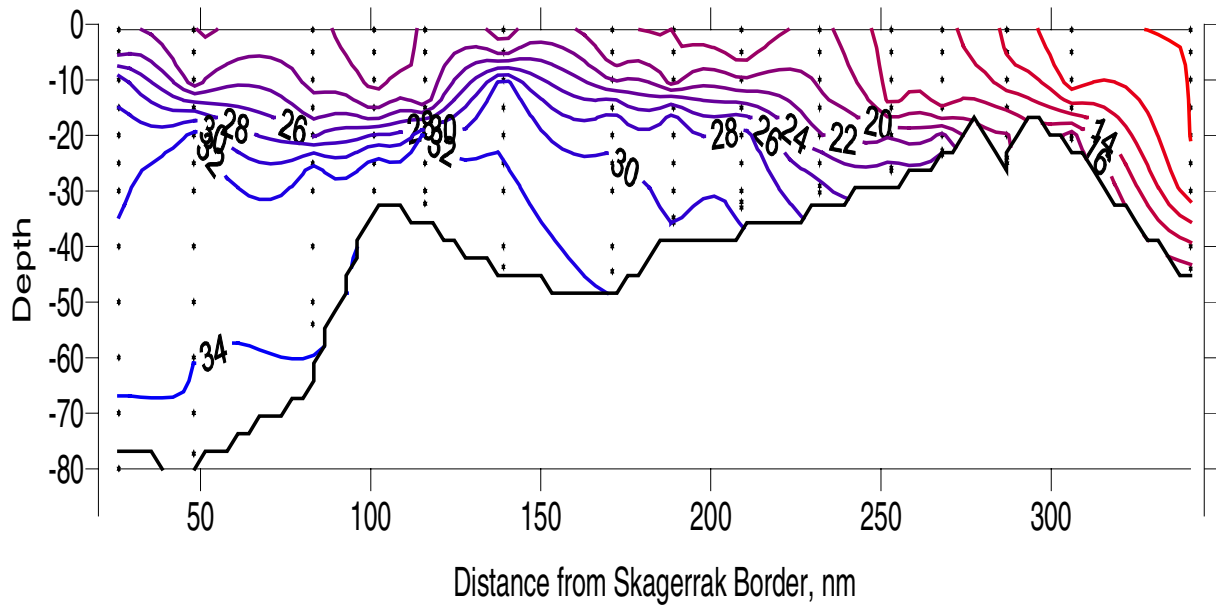
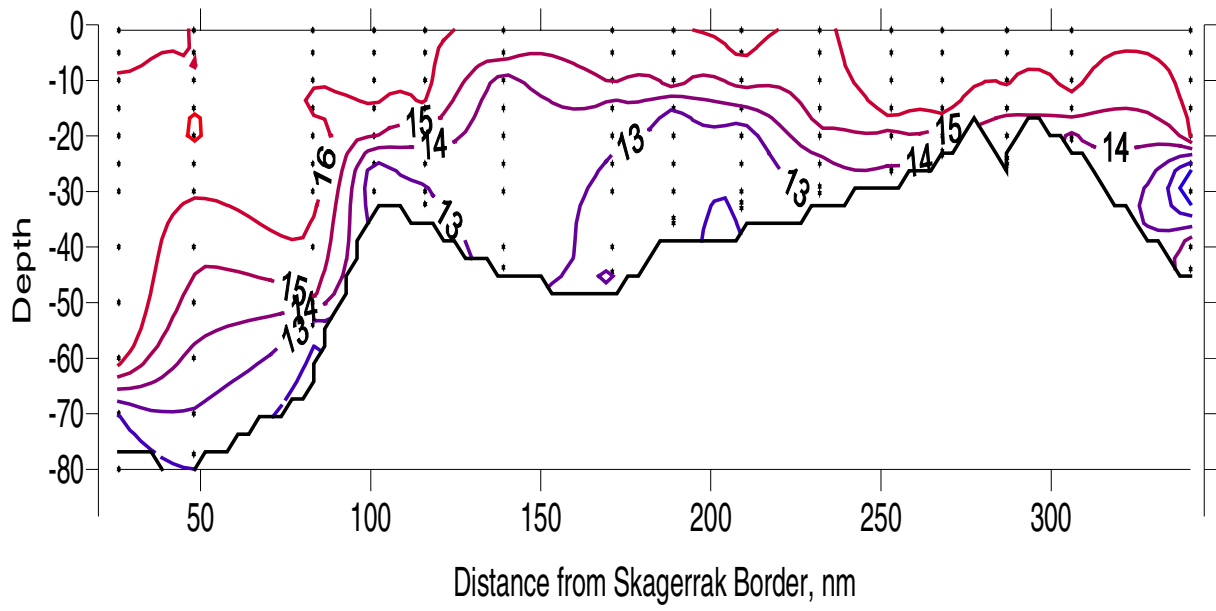


Figure 3 Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

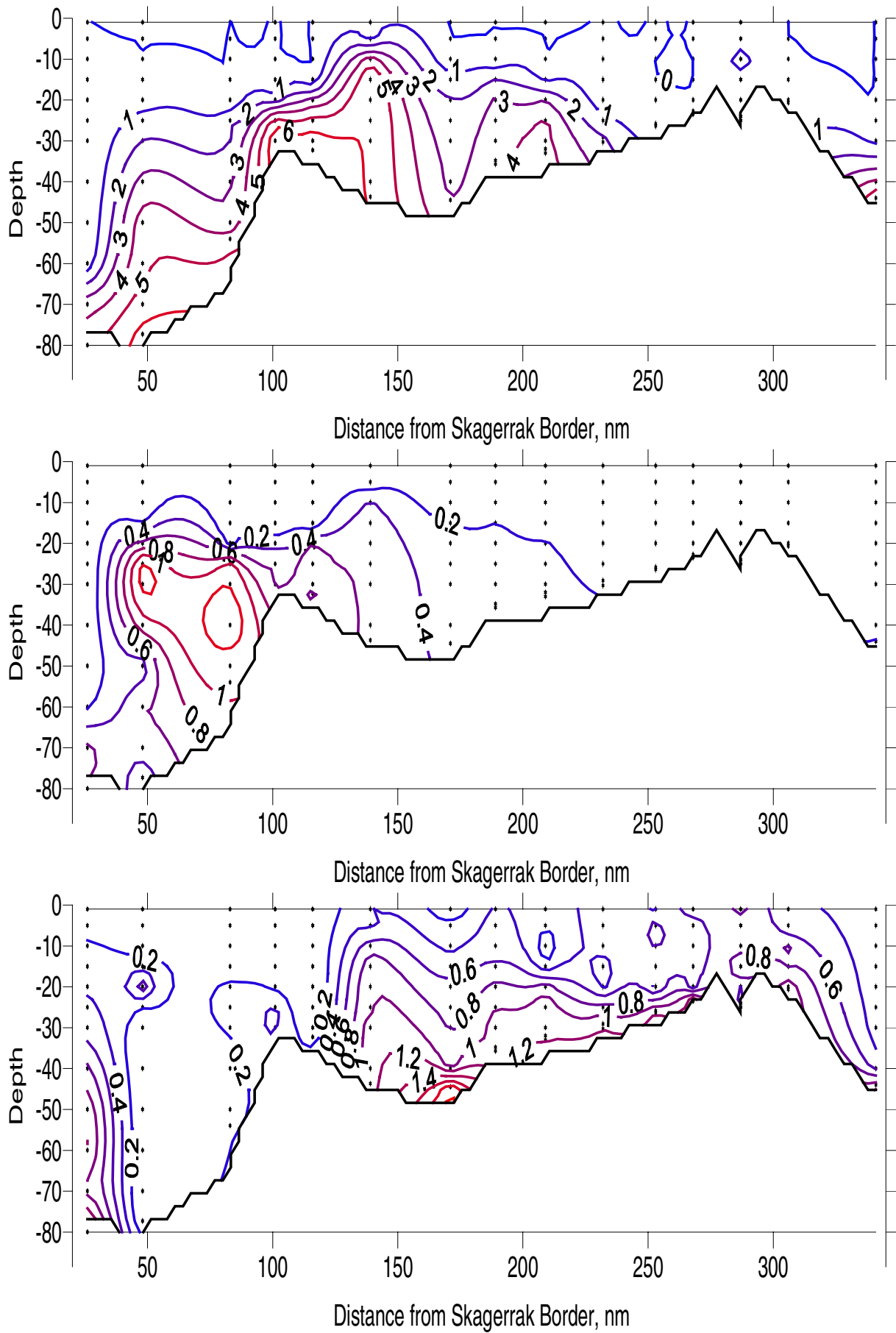


Figure 4 Nitrate (top), nitrite (middle) and ammonium (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

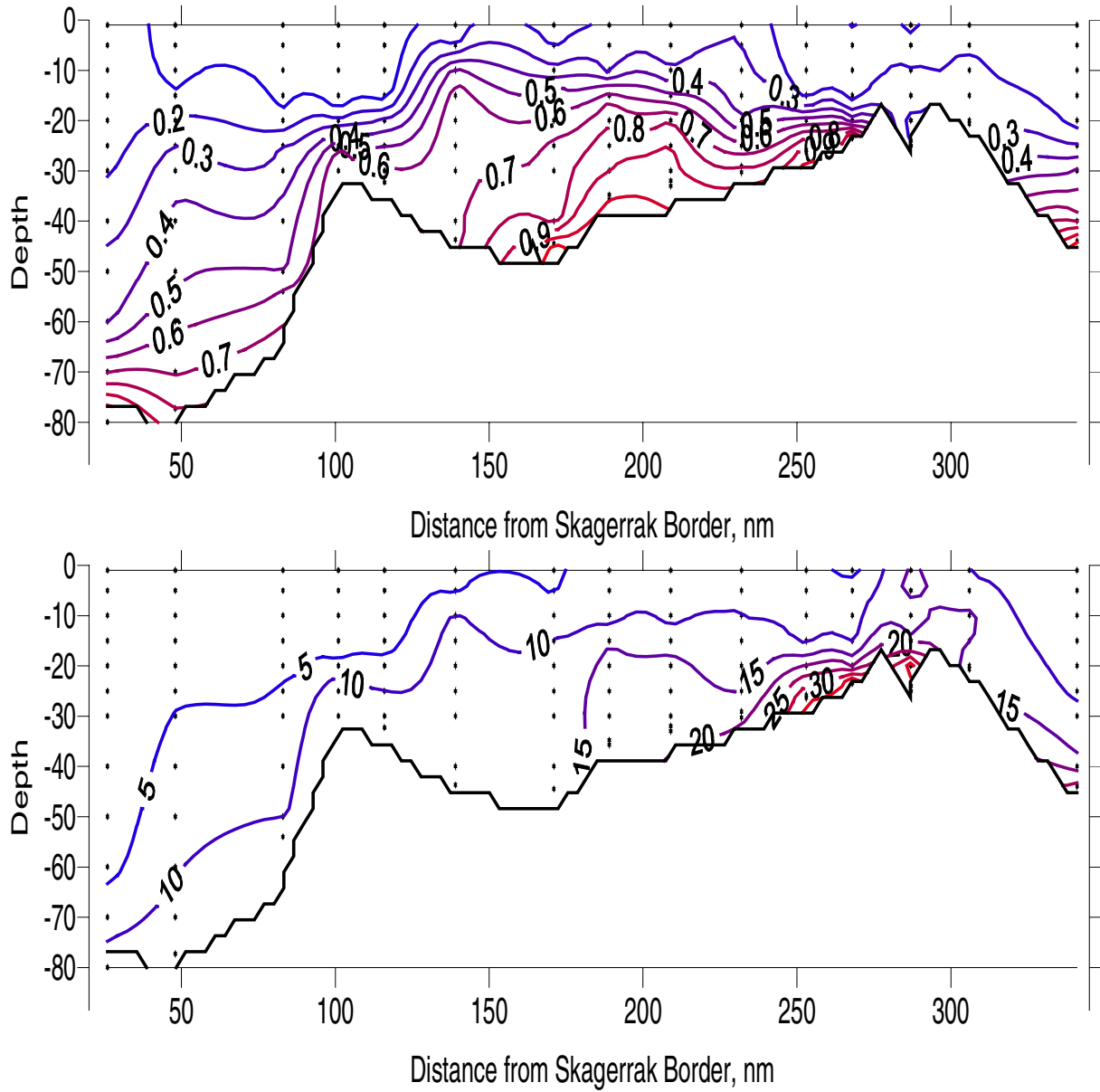


Figure 5 Phosphate (top) and silicate (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

Transect: Kattegat NE - Belt Sea - Arkona Sea

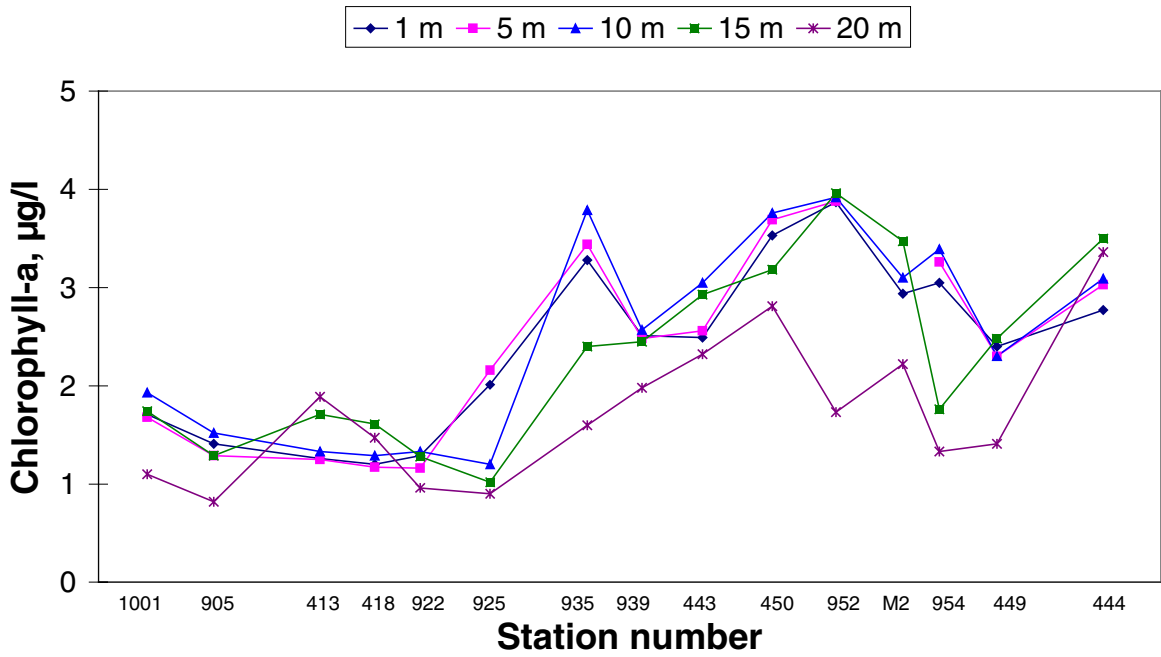


Figure 6 Chlorophyll-a at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

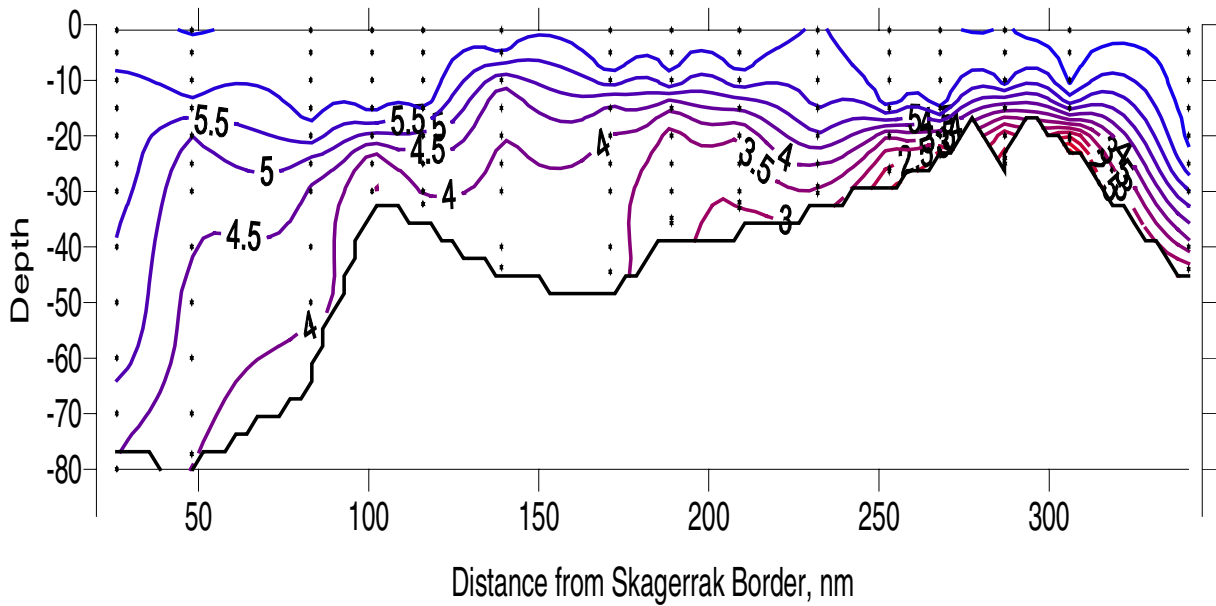


Figure 7 Oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

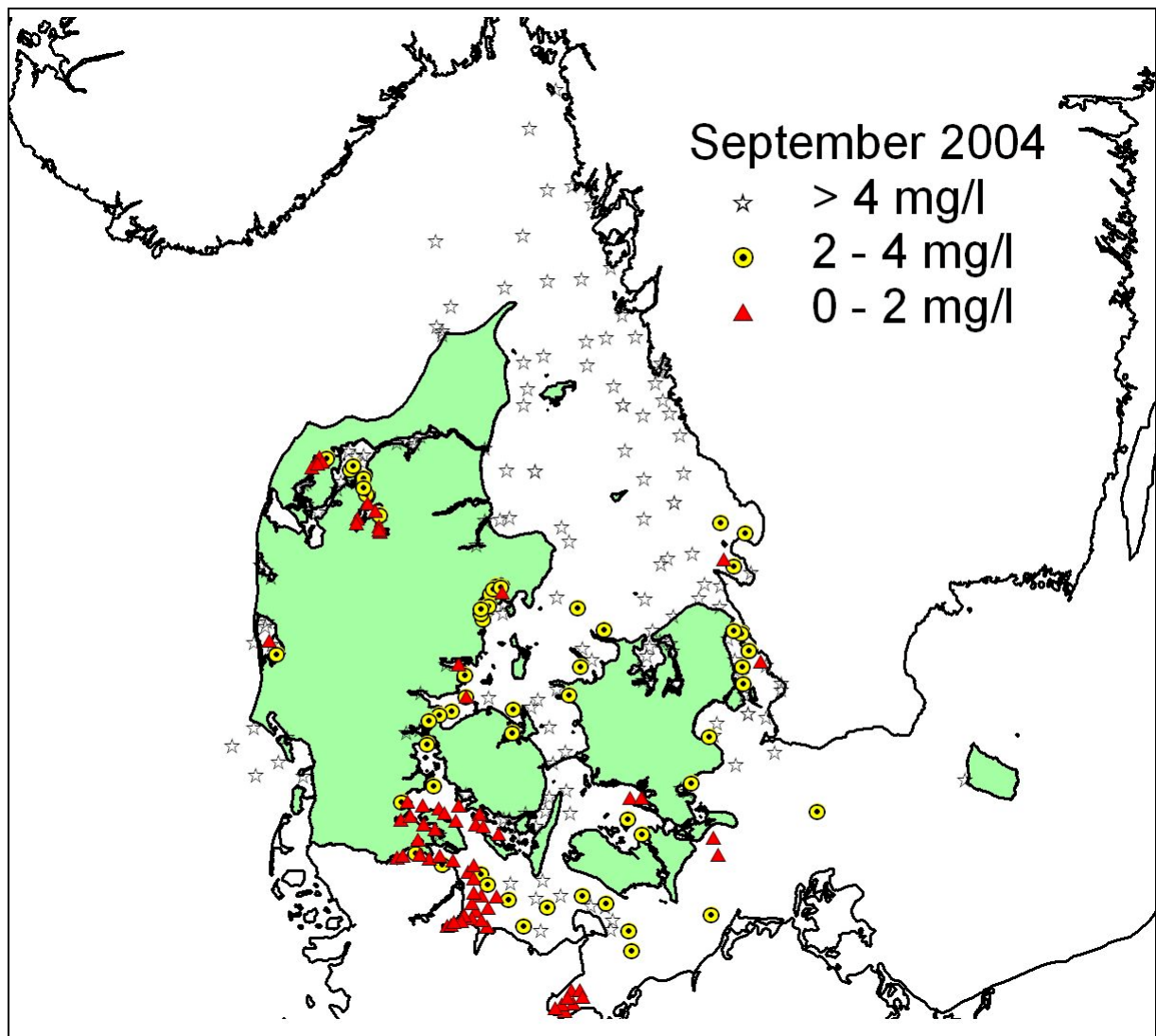


Figure 8 Stations visited by the Danish counties, NERI, SMHI and Swedish and German coastal authorities within the first 3 weeks of September 2004, and where oxygen depletion (<4.0 mg/l) and severe oxygen depletion (<2.0 mg/l) was observed.