



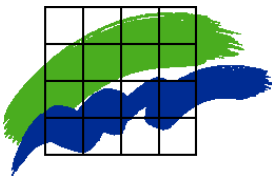
r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 227

Time: 15 - 20 November 2004

**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, 15-20 November 2004

Cruise no. 227

Report: Gunni Ærtebjerg

Cruise leader: Kjeld Sauerberg

Participants: Dorete Jensen, Hanne Ferdinand (NERI); Lars Lund-Hansen, Marie Louise Udesen Theut (Aarhus University)

15-18 Nov.: Jørgen Hansen, Alf Josefson, Troels M. Petersen, Anders Jonsson (NERI)

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

Summary

Since October the oxygen concentration had increased significantly in most areas. The lowest oxygen concentration of 3.5 ml/l (58% saturation) was observed in the central and northern Sound. In the Arkona Sea the minimum concentration was 4.1 ml/l (61%), and in the Mecklenburg Bight and northern Great Belt 4.2-4.3 ml/l (64-70%). Oxygen depletion (<2.8 ml/l = 4 mg/l) was not observed at the cruise, and generally the minimum oxygen concentrations were higher than at the same time last year.

In the surface layer the temperature in the Belt Sea was 0.8-1.1° C higher than long-term monthly mean for November, and in the southern Kattegat the bottom water temperature was 1.1° C above average. The surface salinity was higher than average in all areas, especially in the Belt Sea, where the stratification was very weak due to mixing of the water column.

In the surface layer the nitrate concentration was still below 1 µmol/l, except in the Sound, central Great Belt and Fehmarn Belt, where concentrations of 1.5-3.1 µmol/l were observed. In the southern Kattegat also the surface concentrations of both phosphate and silicate were quite low, 0.2-0.3 µmol/l and <1 µmol/l, respectively.

In the bottom layer the highest nitrate concentration of 8.5 µmol/l was observed in the Sound. The highest concentrations of both nitrite (0.9 µmol/l), ammonium (2.8 µmol/l), phosphate (1.3-1.5 µmol/l) and silicate (30-34 µmol/l) were found at the bottom in the Mecklenburg Bight, and with exception of nitrite also at the bottom in the central Arkona Sea.

The chlorophyll-*a* concentration was relatively high and quite evenly distributed in the surface layer with the highest concentrations of 5.0 and 6.4 µg/l observed east of Anholt and in the Kiel Bight, respectively. In the southern Kattegat, central Great Belt and Mecklenburg Bight the mean concentrations were 3.1-4.0 µg/l.

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 monitoring stations of the cruise are shown in *figure 1*. The cruise was prolonged one day due to special investigations in the southern Little Belt of bottom fauna distribution in relation to the depth of the hydrogensulfide front in the sediments. The western and northern Kattegat was not covered on this cruise due to stormy weather and technical problems.

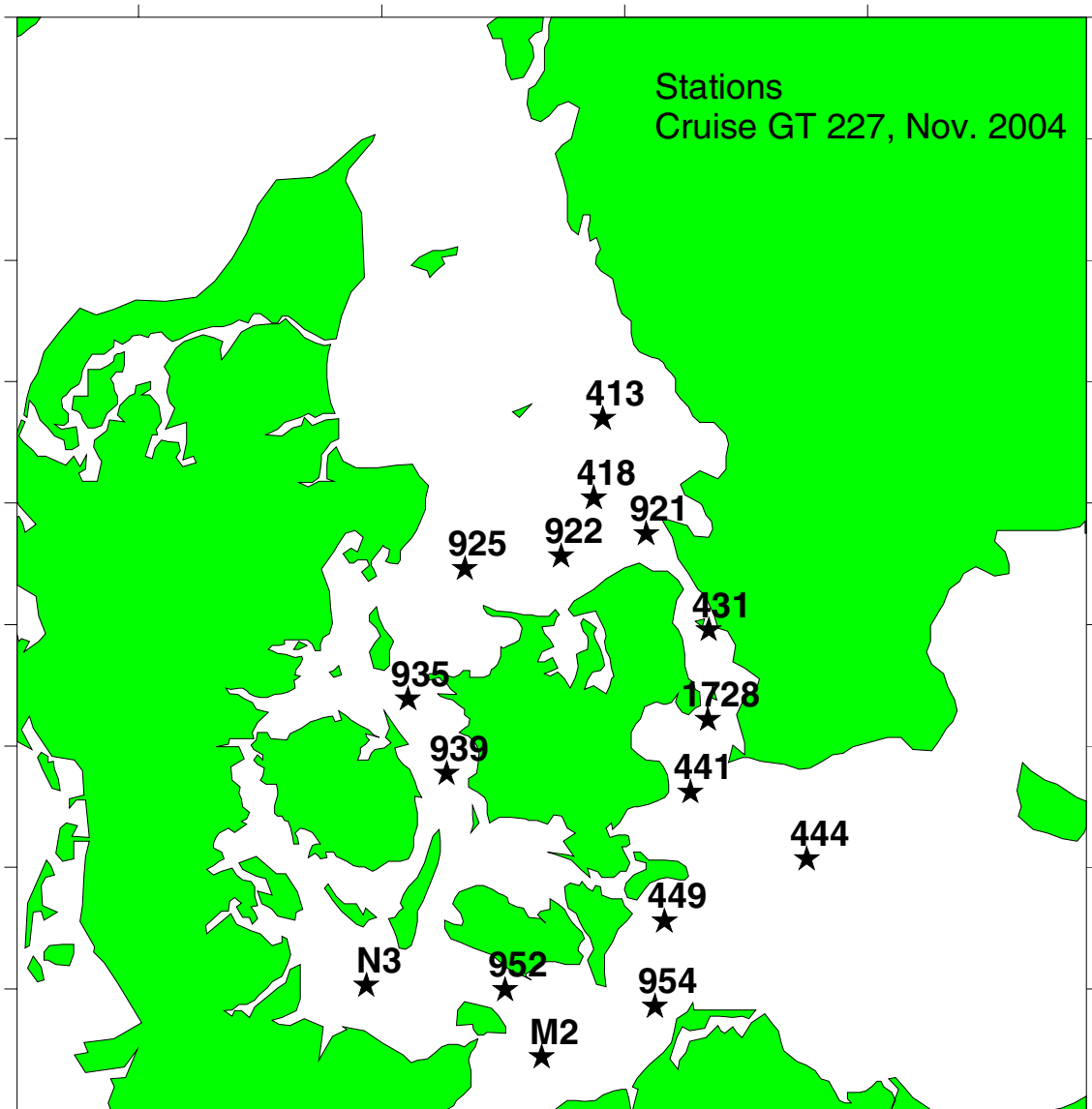


Figure 1. Stations of the monitoring cruise with r/v Gunnar Thorson 15-20 November 2004 in the Sound, the Arkona Sea, the Belt Sea and the southern Kattegat. Gunnar Thorson cruise no. 227.

Meteorology

Characteristics of the weather conditions during November 2004 are given in *table 1*. November was relatively warm and dry. The dominating wind directions were from south-west and west, and the average wind force was about normal. The frequency of wind exceeding gale force (*figure 2*) was relatively high in the second and third week of November (weeks 46-47), including the time of the cruise.

Table 1. Deviations in monthly mean temperature and precipitation in November 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
November	+0.7	-29	4.9	SW-W

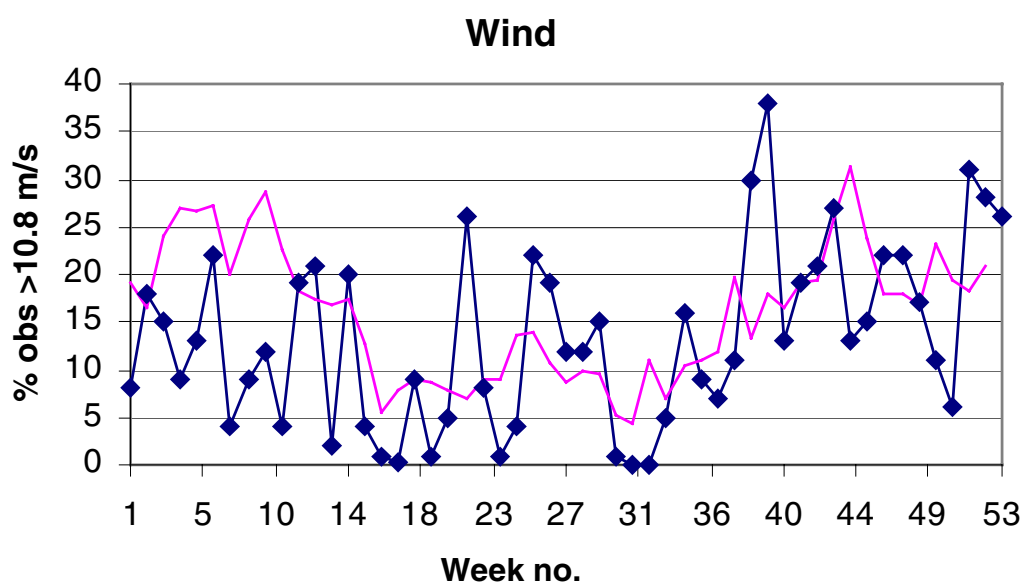


Figure 2. Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2004 (connected points) compared to mean for the period 1994-2002 (thin line). Based on data from the Danish Meteorological Institute.

Hydrography

The surface temperature (1 m depth) varied between 7.4 and 9.4° C with the lowest temperature in the southern Kattegat (St. 418) and the highest in the Fehmarn Belt (St. 952). The bottom near temperature ranged from 9.3-9.8° C in the southern Belt Sea (St. 954, 952, N3) and up to 12.1-12.8° C in the Sound, southern Kattegat, northern Belt Sea and central Arkona Sea (*figure 3*).

The surface salinity ranged from 8.6 in the central Arkona Sea (St. 444) to 22.5-23.5 in the Sound and southern Kattegat. The bottom water salinity ranged from 15.5-15.8 in the Mecklenburg Bight (St. M2, 954) to 33.6-33.8 in the south-eastern Kattegat (St. 413, 418, 921, 922) (*figure 3*). The salinity stratification was weak in Belt Sea.

Compared to long-term monthly means (Lightship observations 1931-1960) for November the surface temperature was 0.8-1.1° C above average in the Belt Sea. In the southern Kattegat the bottom water temperature was 1.1° C higher than normal, while in the Belt Sea the bottom water temperature generally was about normal. The surface salinity was higher than average, especially in the Belt Sea. The bottom water salinity was generally 1.1 above normal in the south-western Kattegat, but 1.8 below normal in the Fehmarn Belt.

Nutrients

The nitrate concentration in the surface layer was still low (0.1-1.0 $\mu\text{mol/l}$). Only in the Sound (St. 431, 1728), the Great Belt (St. 935, 939) and the Fehmarn Belt (St. 952) the nitrate concentrations reached 1.5-3.1 $\mu\text{mol/l}$. In the bottom water the highest nitrate concentration of 8.5 $\mu\text{mol/l}$ was observed in the central Sound (St.431) (*figure 4a*). Relatively high nitrite concentrations of 0.9 $\mu\text{mol/l}$ and ammonium concentrations of 2.8 $\mu\text{mol/l}$ were only observed at the bottom in Mecklenburg Bight (St. M2) (*figure 4b and 4c*).

Relatively low phosphate concentrations of 0.2-0.3 $\mu\text{mol/l}$ were observed in the surface water in the southern Kattegat (St. 413, 318, 921, 922, 925). The highest phosphate concentrations of 1.3-1.5 $\mu\text{mol/l}$ were observed in the bottom water of the Mecklenburg Bight and the central Arkona Sea (St. M2, 444) (*figure 5a*). Also the highest silicate concentrations of 30-34 $\mu\text{mol/l}$ were found at the bottom in the Mecklenburg Bight and the central Arkona Sea. For the season unusually low silicate concentrations (<1 $\mu\text{mol/l}$) were observed in the surface layer in the southern Kattegat (St. 413, 418, 921, 922, 925) (*figure 5b*).

Chlorophyll-*a*

The chlorophyll-*a* concentration was relatively high and quite evenly distributed in the surface layer. The highest mean concentrations in the uppermost 10 m of 5.0 and 6.4 $\mu\text{g/l}$ were observed east of Anholt (St. 413) and in the Kiel Bight (St. N3), respectively. In the southern Kattegat, central Great Belt and Mecklenburg Bight the mean concentrations were 3.1-4.0 $\mu\text{g/l}$ (*figure 6*).

Oxygen

Since October the oxygen concentration had increased significantly in most areas, except in the central Great Belt, Mecklenburg Bight and Arkona Sea. The lowest oxygen concentration of 3.5 ml/l (58% saturation) was observed in the Sound (St. 431, 921). In the Arkona Sea the minimum concentration was 4.1 ml/l (61%) (St. 444), and in the Mecklenburg Bight and northern Great Belt 4.2-4.3 ml/l (64-70%) (*figure 7*).

Compared to November last year, the minimum oxygen concentrations this year were higher, except in the Arkona Sea. Also compared to mean for November in the 1980's, the minimum oxygen concentrations this year were higher, except in the northern Sound 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 oxygen depletion was not observed at the cruise. *Figure 8* shows the stations visited by the Danish counties, NERI, SMHI and Swedish coastal authorities within the first 3 weeks of November 2004, and where oxygen depletion or severe oxygen depletion was observed.

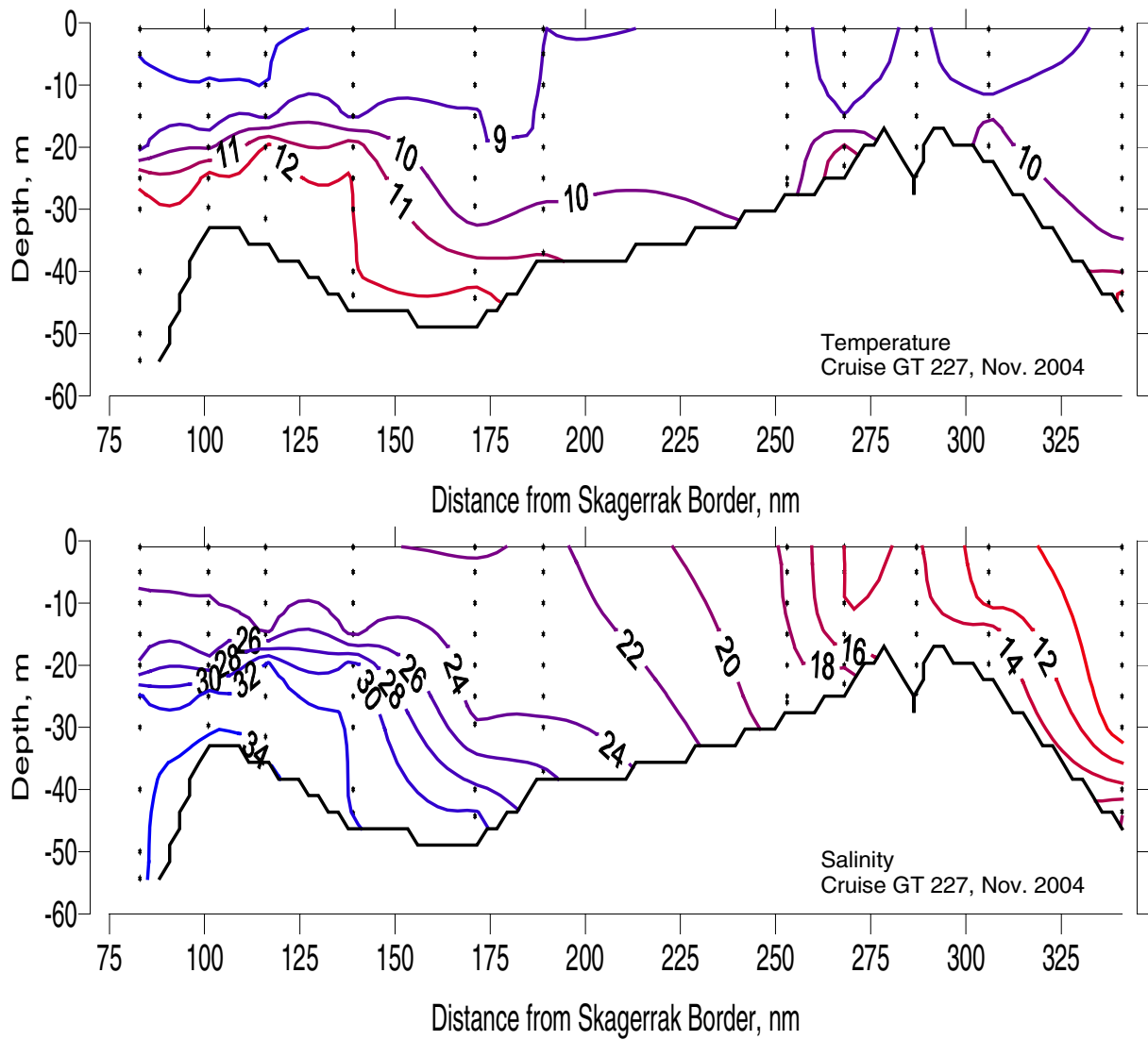


Figure 3. Temperature (top) and salinity (below) distribution in a transect from the eastern Kattegat (east of Anholt) through the Great Belt and Fehmarn Belt to the Arkona Sea.

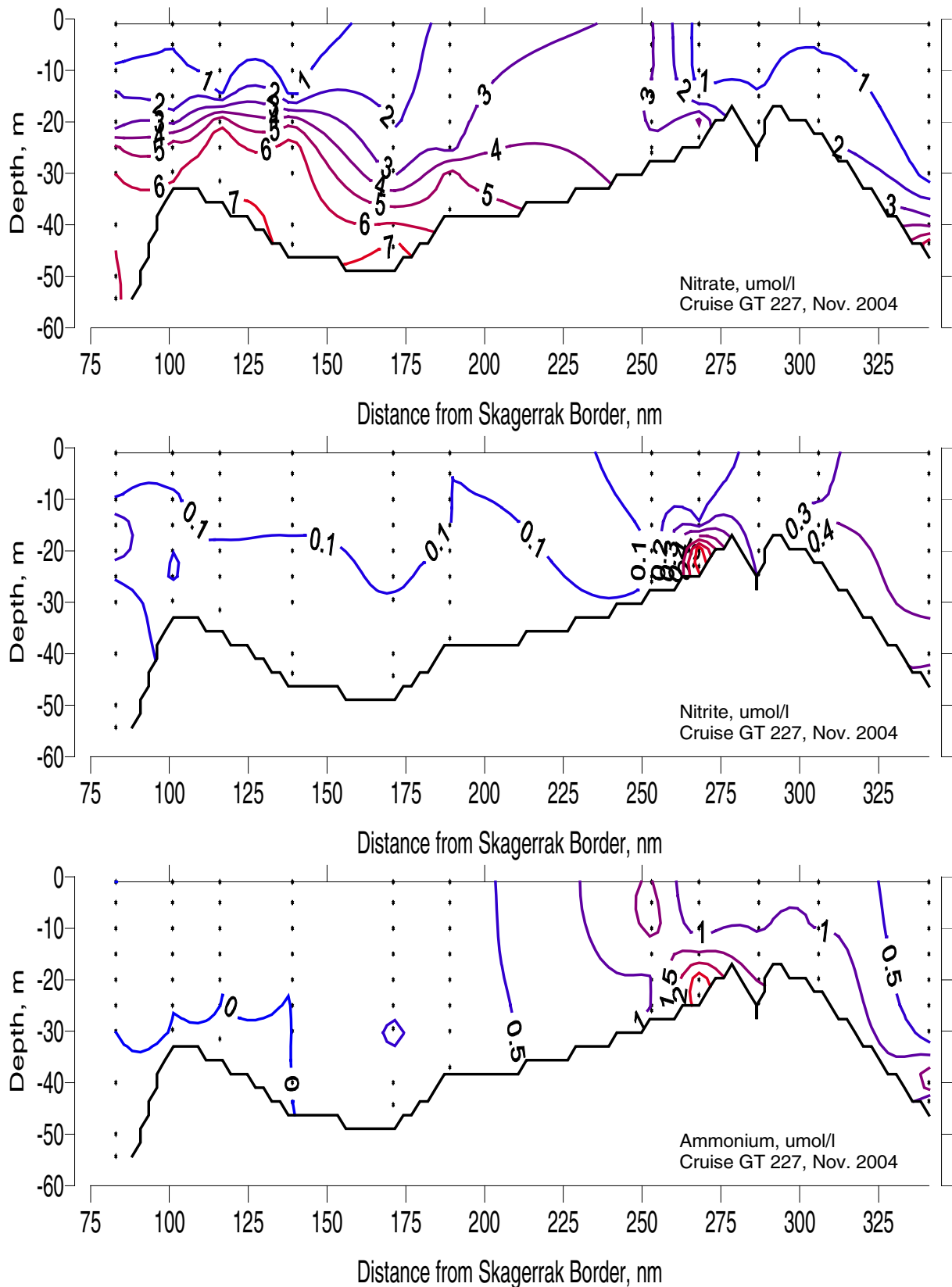


Figure 4. Nitrate (top), nitrite (middle) and ammonium (bottom) distribution in a transect from the eastern Kattegat (east of Anholt) through the Great Belt and Fehmarn Belt to the Arkona Sea.

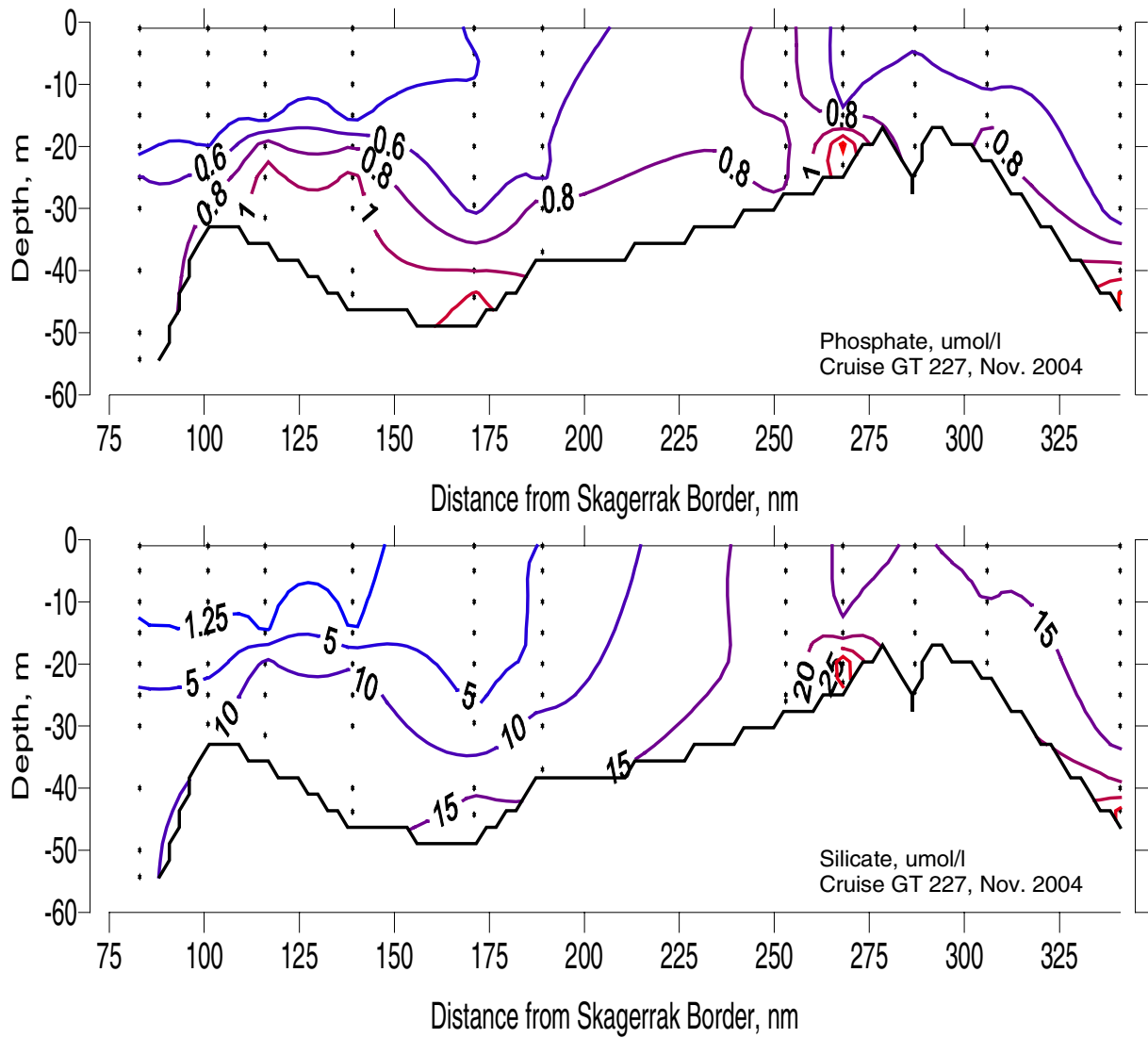


Figure 5. Phosphate (top) and silicate (bottom) distribution in a transect from the eastern Kattegat (east of Anholt) through the Great Belt and Fehmarn Belt to the Arkona Sea.

Transect: Kattegat NE - Belt Sea - Arkona Sea

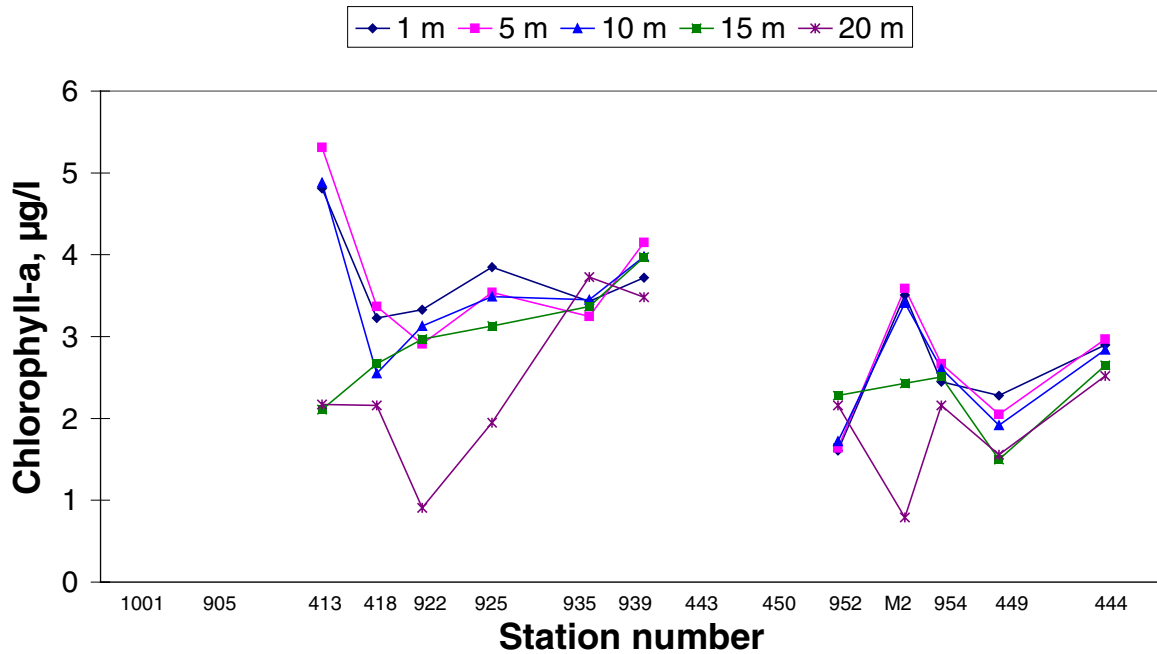


Figure 6. Chlorophyll-*a* at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the eastern Kattegat (east of Anholt) through the Great Belt and Fehmarn Belt to the Arkona Sea.

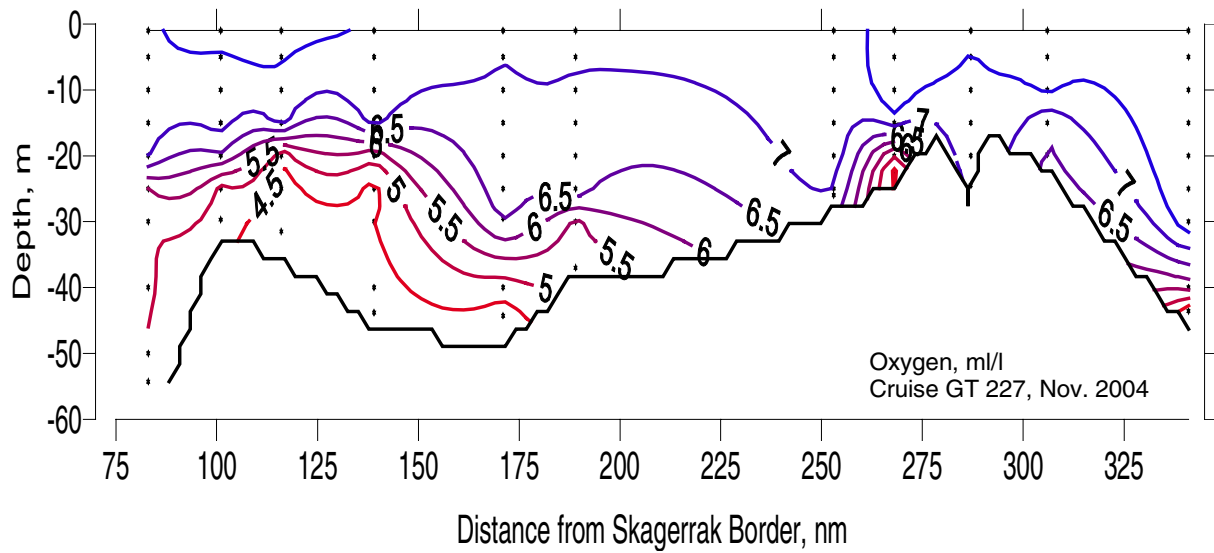


Figure 7. Oxygen distribution in a transect from the eastern Kattegat (east of Anholt) through the Great Belt and Fehmarn Belt to the Arkona Sea.

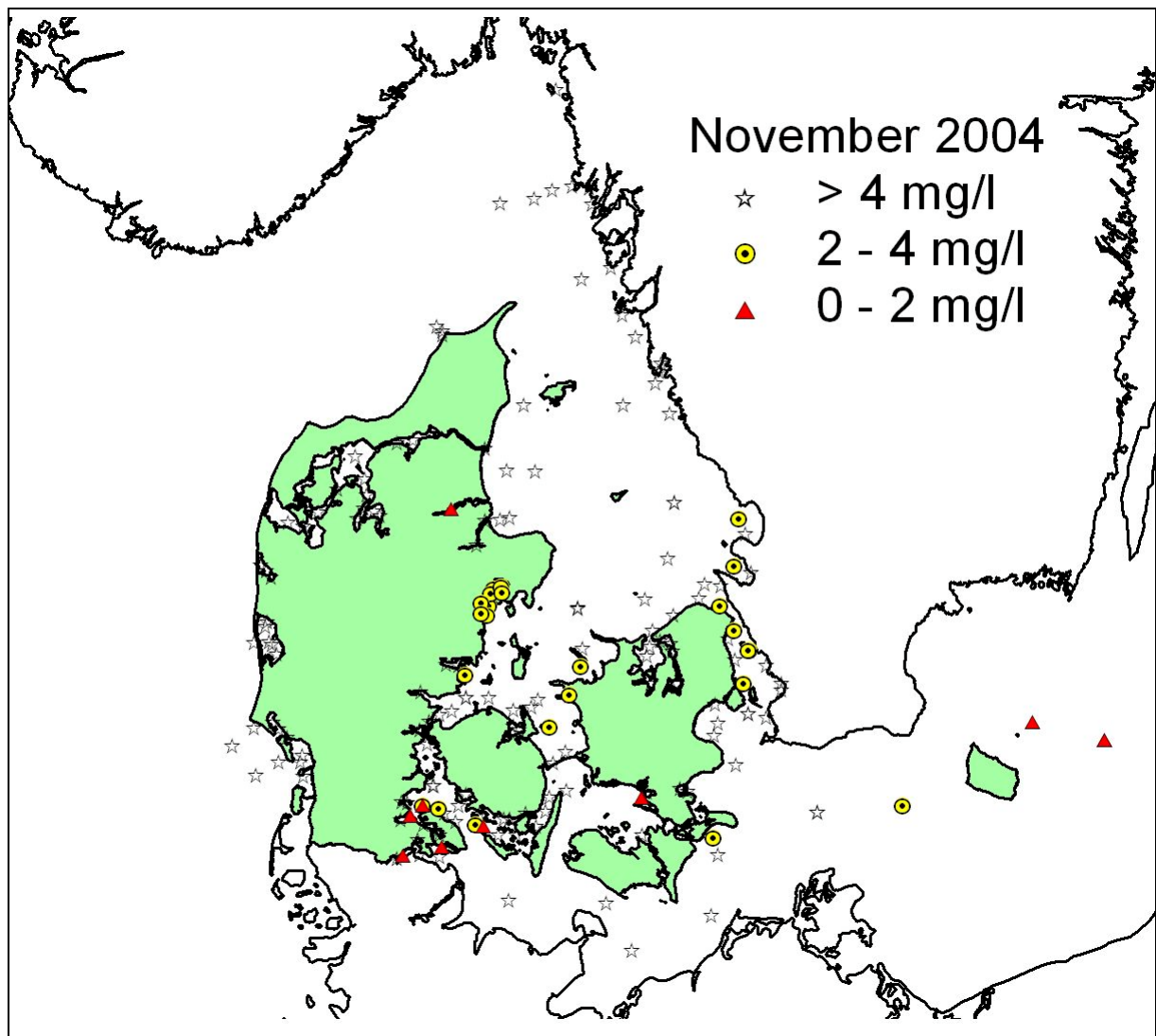


Figure 8. Stations visited by the Danish counties, NERI, SMHI and Swedish coastal authorities within the first 3 weeks of November 2004, and where oxygen depletion (<4.0 mg/l) and severe oxygen depletion (<2.0 mg/l) was observed.