r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 209

Time: 19 - 22 August 2002

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

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Data Sheet

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Monitoring cruise with r/v Gunnar Thorson in the Sound, the Kattegat, the Belt Sea and the Arkona Sea, 19-22 August 2002.
Cruise no. 209.

Report: Gunni Ærtebjerg

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

Summary
For the season unusually low oxygen concentrations were observed in the bottom water in about all areas investigated. The lowest concentrations observed were 0.5 ml/l in the Arkona Sea, 0.7 ml/l in Fehmarn Belt and Mecklenburg Bight and 0.9 ml/l in Ålborg Bight. In the Sound and central Great Belt the minimum concentration was 1.3-1.8 ml/l. This is probably the lowest concentration ever measured in the open Great Belt at this time of the year. Also in the southern and western Kattegat the minimum oxygen concentration was unusually low (1.8-2.9 ml/l).

In Denmark oxygen depletion is defined as minimum oxygen concentrations below 2.8 ml/l, and serious oxygen depletion as below 1.4 ml/l. In *figure 7* is shown the stations visited by Danish and Swedish authorities within the first three weeks of August 2002, and where oxygen depletion or serious oxygen depletion was observed.

The reason for the widespread and serious oxygen depletion for the season is believed to be due to a large load of nutrients during winter and calm wind during spring and summer. Due to a more than doubled precipitation in January-February the runoff was unusually high in the period January-March. The large load came just before and during the phytoplankton springbloom, giving rise to large and long lasting blooms, which after sedimentation has increased the oxygen consumption at the bottom. High precipitation in June and July has supplied further nutrients to the systems. During spring and summer the frequency of strong wind events has generally been low, and the wind has often come from eastern directions which lower the bottom water exchange in the Kattegat, the Sound and the Belt Sea. However, the wind force has in periods been strong enough to mix the water column in most shallow estuaries and coastal areas.

Deemed from the present unusually low oxygen concentrations in the Kattegat, the Sound, the Belt Sea and the western Baltic Sea there is a risk during the next couple of months for development of even very serious oxygen depletion at a level comparable to the worst situations in the 1980s with extensive death of bottom fauna. Only strong gales from west can prevent the oxygen depletion to develop further.

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 (the Arkona Sea, the Sound, the Belt Sea, the 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*. The stations of the cruise are shown in *figure 1*.

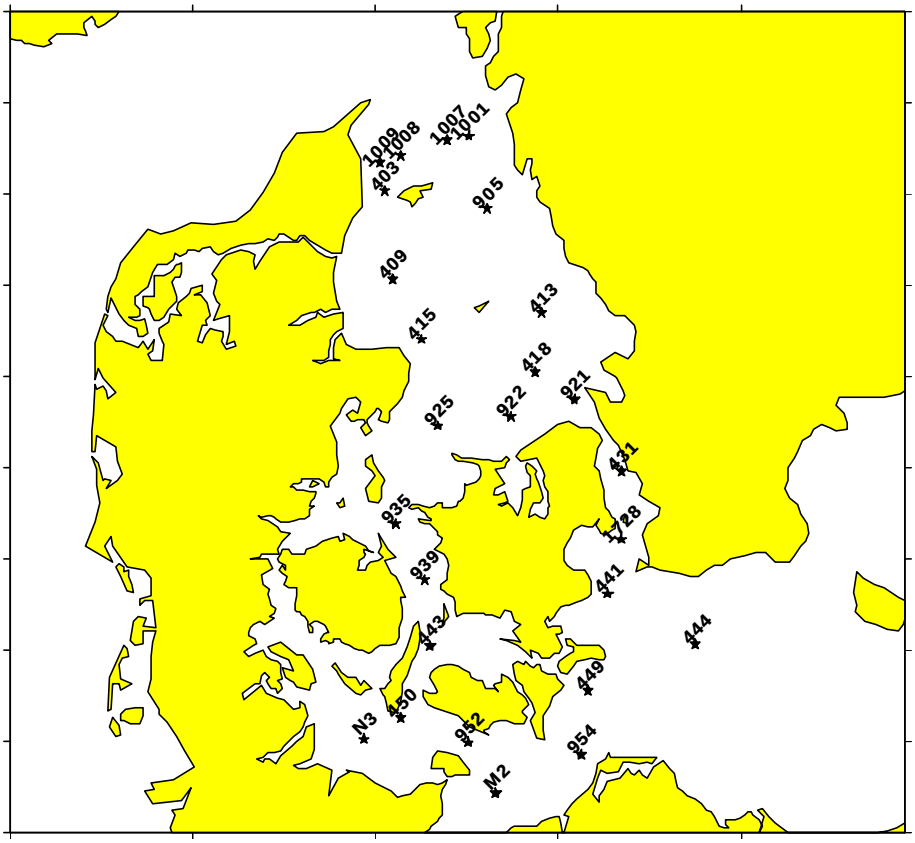

Figure 1. Stations of the monitoring cruise with r/v Gunnar Thorson 19-22 August 2002 in the Sound, the Kattegat, the Belt Sea and the Arkona Sea. Gunnar Thorson cruise no. 209.

Meteorology

Characteristics of the weather conditions during 2002 are given in *table 1*. As the winter also the spring (March-May) and summer (June-August) were warmer than normal. January and especially February were very wet, while the spring was relatively dry (87% of normal). The precipitation in June and July was 76% above normal, but August was close to normal. The monthly mean wind force did not deviate significantly from normal during spring and summer. However, the frequency of strong wind events has since March generally been low (*figure 2*), except for a few short periods with strong wind at the beginning and end of June and at the end of July (weeks 23, 26 and 30).

Table 1. Deviations in monthly mean temperature and precipitation in January to August 2002 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	+2.9	+54	6.1	S-SW-W
February	+4.2	+187	7.0	SW-W
March	+2.1	-17	5.7	S-SW-W
April	+1.5	-20	4.4	NE-E-SE-S
May	+2.0	-4	4.3	NE-E-SE-S--SW-W
June	+1.3	+82	5.1	SW-W
July	+1.5	+71	4.2	S-SW-W
August	+3,9	+6		

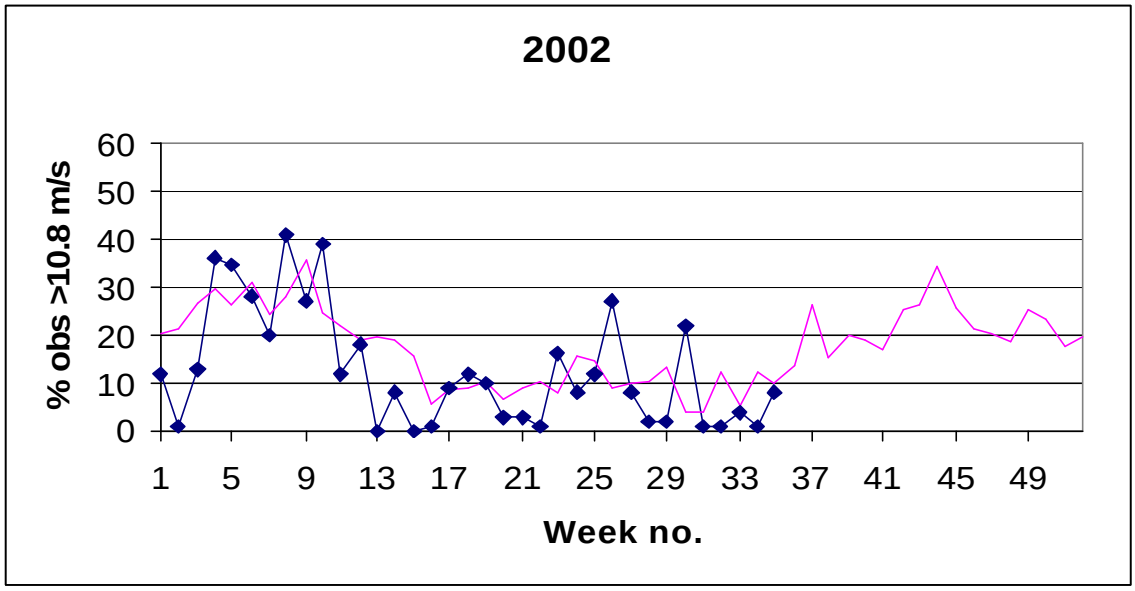

Figure 2. Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2002 (connected points) compared to mean for the period 1994-2000 (thin line). Based on data from the Danish Meteorological Institute.

Hydrography

The surface temperature (1 m depth) varied between 19.0 and 21.6°C in the whole area investigated. The bottom water temperature ranged from 7.6-9.8°C in the eastern Kattegat (St. 1001, 905, 413, 418, 921, 922) and the Sound (St. 431) to 11.2-13.7°C at the rest of the stations, except for 15.3°C in Ålborg Bight (St. 409) and 19.5°C at Stevns (St. 441) (*figure 3*).

The surface salinity ranged from 7.3-8.1 in the Arkona Sea and the Sound (St. 441, 444, 449, 1728, 431) to only 18.1-19.1 in the north-western and western Kattegat (St. 1008, 1009, 403, 409). The bottom water salinity ranged from 14.8-15.4 in the Arkona Sea (St. 441, 444) to 34.0-34.9 in the north-eastern Kattegat (St. 905, 1001, 1007) (*figure 3*). The salinity stratification was unusually strong (7.2-24.6 psu) in all areas (strongest in the Sound), even in the shallow Ålborg Bight (8.7 psu) and western Arkona Sea (7.2-8.0 psu).

Compared to long-term monthly means (Lightship observations 1931-1960) for August the surface temperature was 2-3°C higher than normal. The bottom water temperature was in the Kattegat 0-1°C lower, but in the Great Belt and Fehmarn Belt 1-1.5°C higher than normal. The surface salinity during the present cruise was 0.7-7.5 psu lower than normal, while the bottom water salinity generally was higher than normal, except in 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, 418) and the Arkona Sea (St. 444). In the Sound and the Belt Sea the nitrate concentration in the bottom water was unusually low (*figure 4a*).

Relatively high nitrite concentrations were observed at 30-40 m depth in the north-eastern Kattegat and in the bottom water in the southern Belt Sea (*figure 4b*). High ammonium concentrations (>3 µmol/l) were found in the bottom water in the Great Belt and especially in Fehmarn Belt (*figure 4c*).

Traces of phosphate was present in the surface water in all areas, lowest in the eastern and southern Kattegat (0.01-0.04 µmol/l), and higher in the Sound, the Arkona Sea and central Great Belt (0.10-0.16 µmol/l). In the bottom water above 1.0 µmol/l phosphate was observed in Fehmarn Belt and the Arkona Sea (*figure 5a*). Silicate concentrations above 1 µmol/l and up to 10 µmol/l were present in the surface water in all areas, lowest in the Kattegat. High concentrations (>30 µmol/l) were observed in the bottom water, especially in the eastern Kattegat, Fehmarn Belt and the Arkona Sea (*figure 5b*).

Chlorophyll-*a*

The chlorophyll-a concentration was relatively low, generally 0.7-2 µg/l, except for 3-4 µg/l in the surface of the Arkona Sea. In the Kattegat, the Sound and the Belt Sea the highest concentrations were observed at 10 to 15 m depth (*figure 6*).

Oxygen

For the season unusually low oxygen concentrations were observed in the bottom water in about all areas (*figure 5c*). The lowest concentrations observed were 0.5 ml/l in the Arkona Sea (St. 444), 0.7 ml/l in Fehmarn Belt and Mecklenburg Bight (St. 952, M2) and 0.9 ml/l in Ålborg Bight (St. 409). In the Sound (St. 431, 921) and central Great Belt (St. 443, 935, 939) the minimum concentration was 1.3-1.8 ml/l. This is probably the lowest concentration ever measured in the open Great Belt at this time of the year. Also in the southern and western Kattegat the minimum oxygen concentration was unusually low (1.8-2.9 ml/l).

In Denmark oxygen depletion is defined as minimum oxygen concentrations below 2.8 ml/l (4 mg/l), and serious oxygen depletion as below 1.4 ml/l (2 mg/l). From these definitions oxygen depletion was observed in all areas, except the north-eastern Kattegat and shallow parts of the Arkona Sea, and serious oxygen depletion occurred in the central Arkona Sea, the Sound, the Great Belt and Ålborg Bight. *Figure 7* shows the stations visited by Danish counties, NERI, SMHI and Swedish coastal authorities within the first three weeks of August 2002, and where oxygen depletion or serious oxygen depletion was observed.

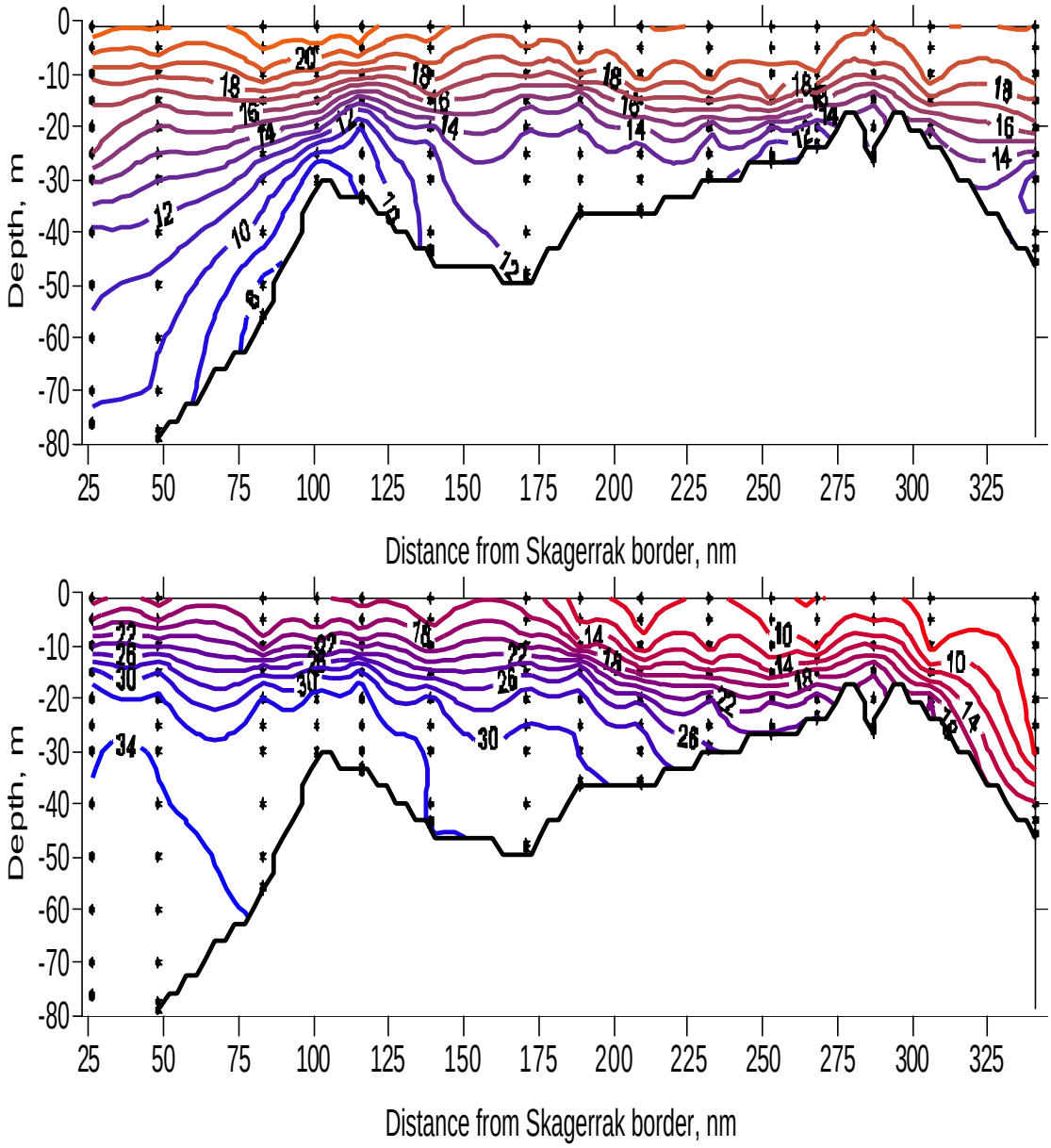

Figure 3. Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

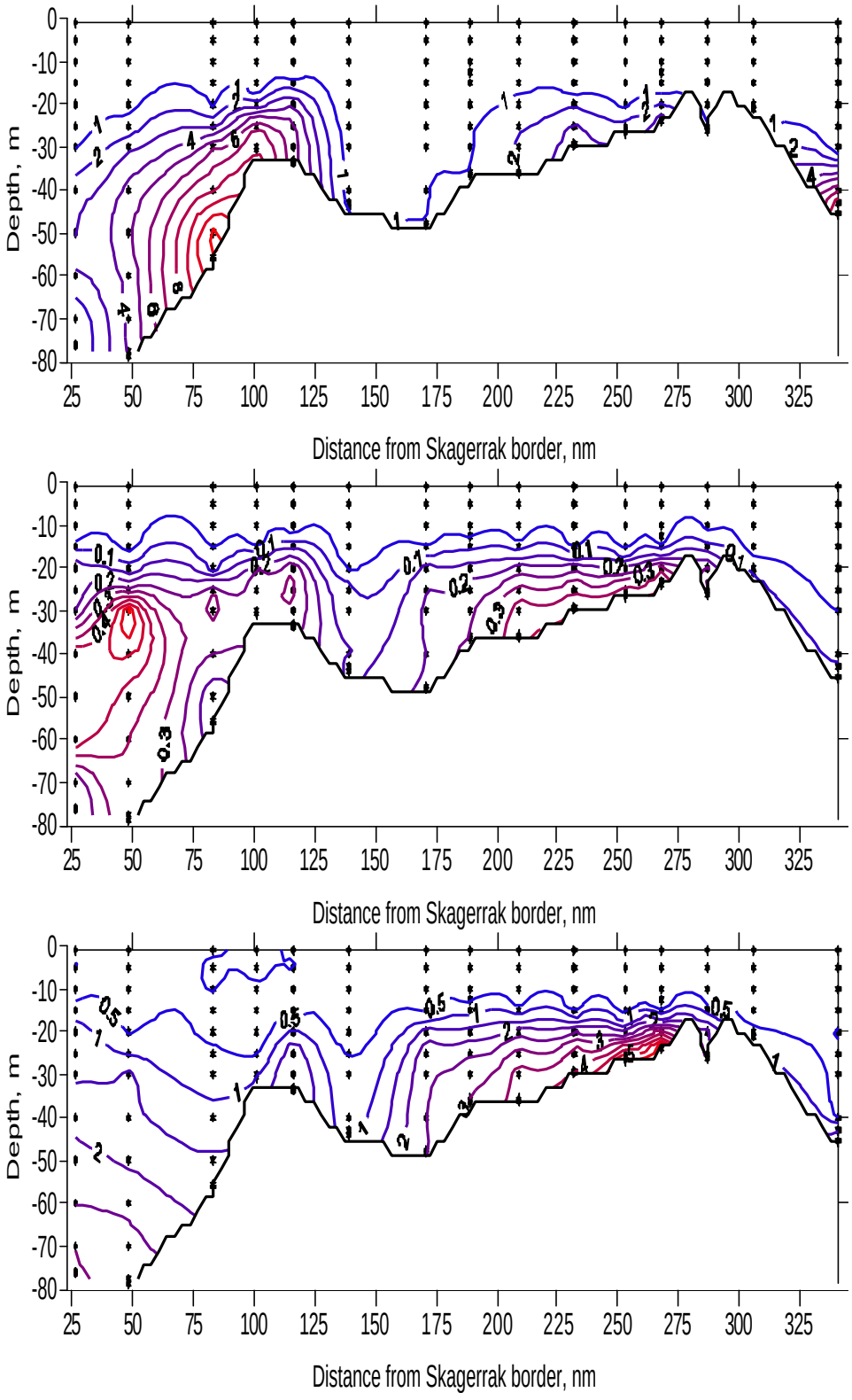

Figure 4. Nitrate (top), nitrite (mid) and ammonium (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

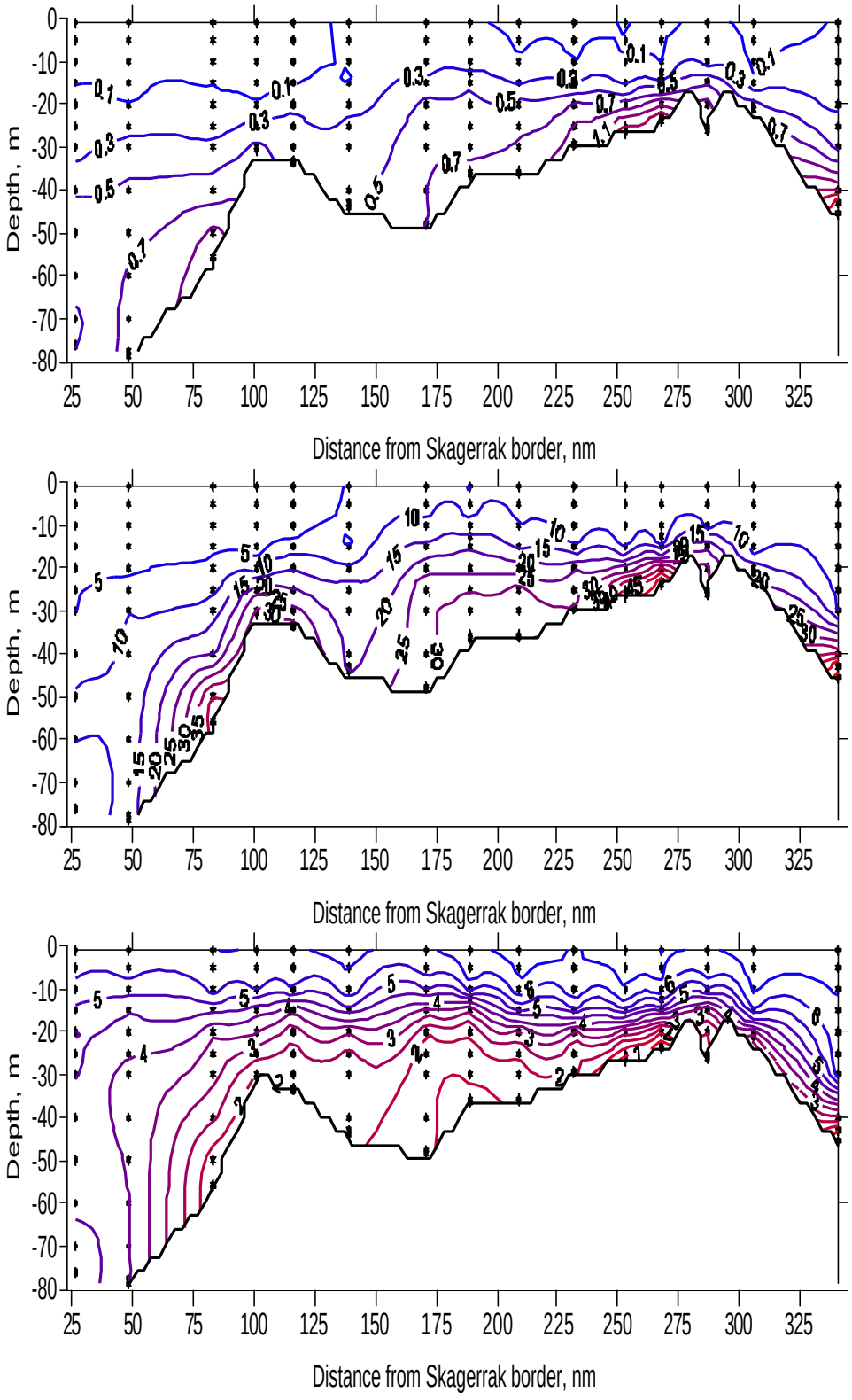

Figure 5. Phosphate (top), silicate (mid) and oxygen (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

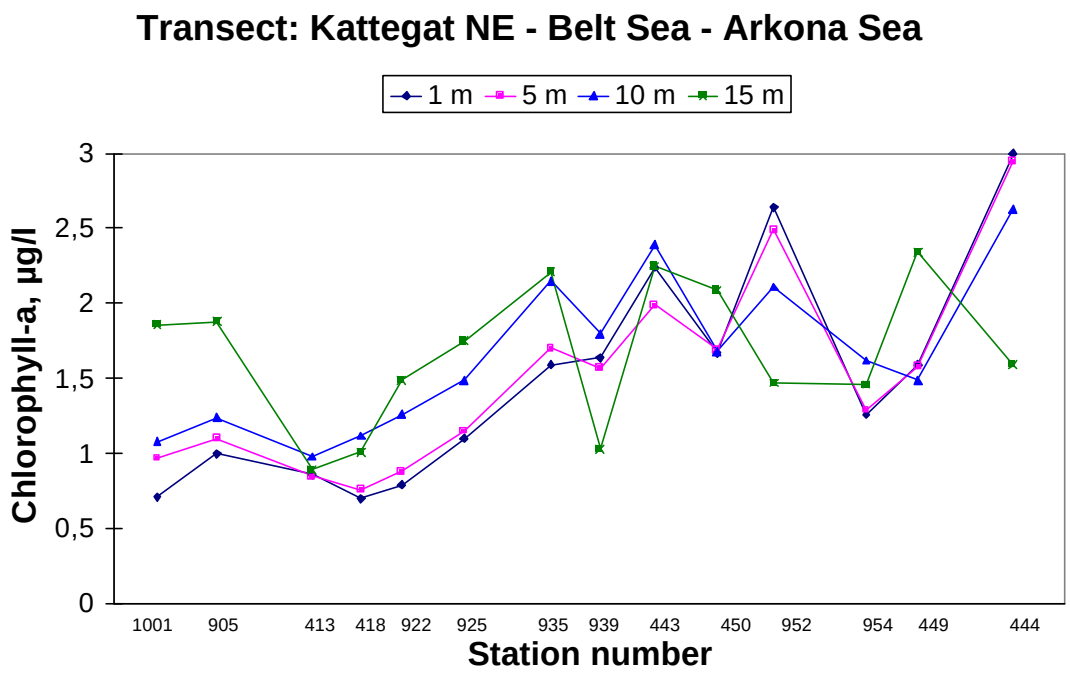

Figure 6. Chlorophyl-a at 1 m, 5 m, 10 m and 15 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

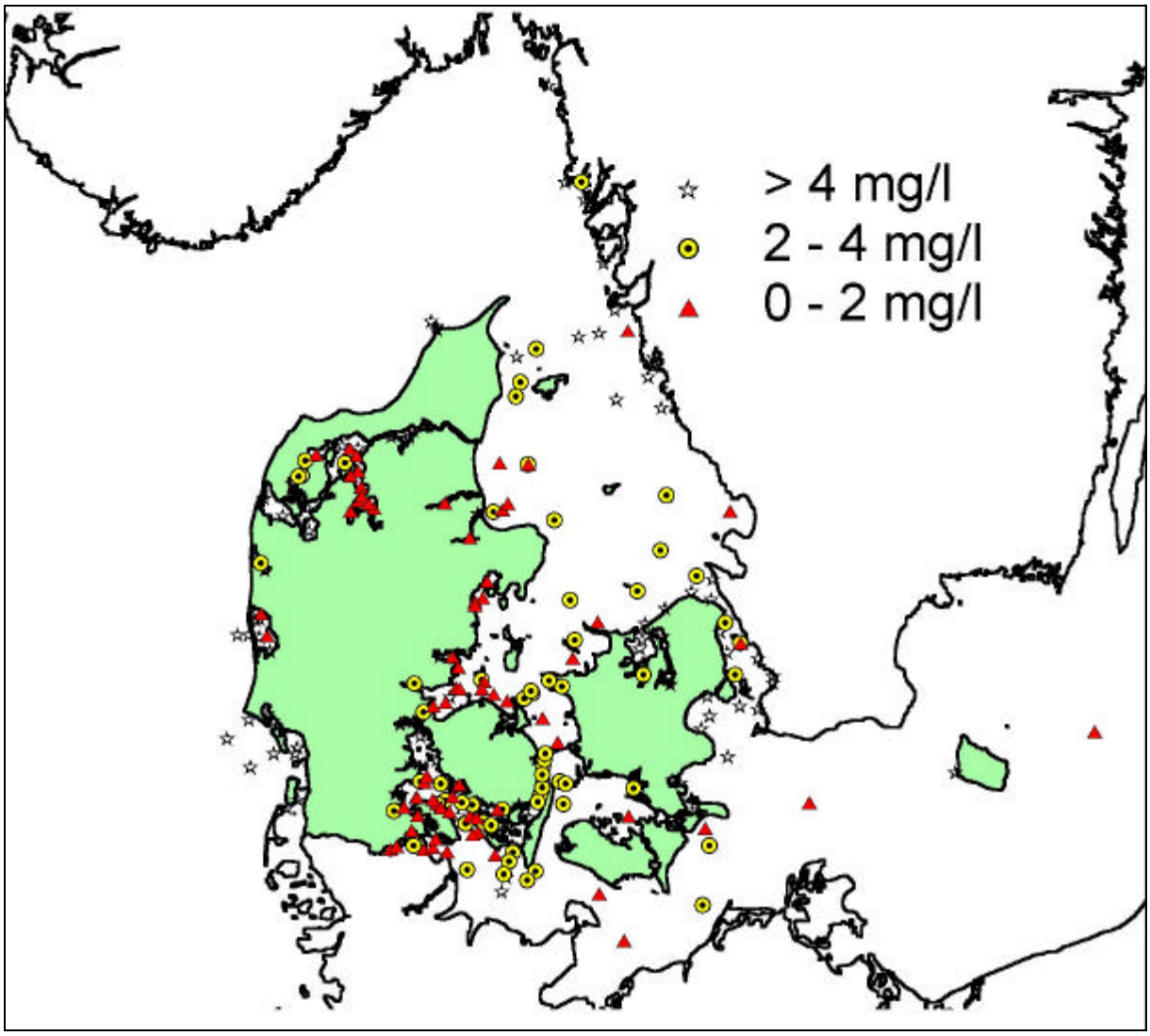

Figure 7. Stations visited by Danish counties, NERI, SMHI and Swedish coastal authorities within the first three weeks of August 2002, and where oxygen depletion (<4 mg/l) and serious oxygen depletion (<2 mg/l) was observed.