r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 205

Time: 8 - 11 October 2001

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

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Data Sheet

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Monitoring cruise with r/v Gunnar Thorson in the Sound, Kattegat, Belt Sea and Arkona Sea, 8-11 October 2001. Cruise no. 205.

Report: Gunni Ærtebjerg

Cruise leader: Jan Damgaard
Participants: Kjeld Sauerberg, Peter Kofoed, Dorete Jensen, Jesper Rasmussen (technician trainee), Tore Hansen (student).

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

Summary
Strong south-western winds at the beginning of October caused an inflow of cold, high saline and relatively oxygen rich deep water from Skagerrak to the Kattegat bottom water. Salinity of 34-35 was observed in all eastern Kattegat as far south as the entrance to the Sound. This caused higher than normal bottom water salinity in all areas investigated, and lower than normal bottom water temperature in the eastern Kattegat. At the same time the surface salinity was generally lower than normal, resulting in for the season unusually strong stratification.

The inflow lifted up the original oxygen poor Kattegat bottom water and pressed it into the Sound and Belt Sea. In the south-eastern Kattegat and the Sound the lowest oxygen concentrations were now observed in 20-30 m depth, not at the bottom. The dynamics had also brought nutrients to the surface and triggered an autumn diatom bloom in most areas, but in Mecklenburg Bight dinoflagellates (*Ceratim sp.* and *Prorocentrum micans*) dominated. However, nitrate was still not present in the surface water, while phosphate was present in all areas. Silicate was low in the Kattegat surface water, but present in the other areas.

Since the cruise in September the minimum oxygen concentration had increased 0.7-1.9 ml/l, in all Kattagat, but decreased 0.9-4.1 in the Belt Sea. In the area Fehmarn Belt, Mecklenburg Bight, Gedser Rev to east of Falster the minimum oxygen concentration was 1.0-2.8 ml/l (16-43%), lowest in the Fehmarn Belt. In the Sound 2.0 ml/l (30%) was observed, and in the Great Belt the oxygen concentrations were 1.9-3.0 ml/l (30-49%), lowest in the north and highest in the south.

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 serious oxygen depletion occurred in the Fehmarn Belt, and oxygen depletion occurred in the Sound, Great Belt and the Mecklenburg Bight – Gedser Rev area. Oxygen depletion was no longer observed in the Kattegat. In *figure 9* is shown the stations visited by Danish counties, NERI, SMHI and Landesamt für Natur und Umwelt, Schleswig-Holstein, within the first three weeks of October 2001, and where oxygen depletion or serious oxygen depletion was observed.

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*. The stations of the cruise are shown in *figure 1*.

Meteorology
The first two weeks of October including during the cruise wind of varying speed from south-west prevailed.

Hydrography
The surface temperature (1 m depth) varied between 12.8 and 13.9°C in the whole area investigated. The bottom water temperature ranged from 7.6-8.8°C in the north-eastern Kattegat (St. 1001, 905, 413) to 14.0°C in the southern Great Belt (St. 450) (*figure 2*).

The surface salinity ranged from 7.5-8.0 in the Arkona Sea (St. 441, 444, 449, 954) to 26.4-31.7 in the northern Kattegat (St. 1001, 1007, 1009). The bottom water salinity ranged from 18.5 in the Arkona Sea (St. 444, 449) to 34.0-34.96 in all eastern Kattegat as far south as the entrance to the Sound (St. 921, 922, 418, 413, 905, 1001) (*figure 3*). The salinity stratification was unusually strong for the season in all areas.

Compared to long term monthly means (Lightship observations 1931-1960) for October the temperature was in the whole water column higher than normal, except for lower bottom water temperature in the eastern Kattegat. Generally, the surface salinity during the present cruise was lower than normal and the bottom water salinity higher than normal.

Nutrients
In the surface nitrate (1.5 µmol/l) was observed only in the shallow western Kattegat (St. 409). In the bottom water the nitrate concentrations were relatively high in the Kattegat and Sound, decreasing through the Belt Sea and very low in the Arkona Sea (*figure 4*).

Generally nitrite and ammonium concentrations in the surface were low. At the bottom relatively high concentrations were observed in the Sound and Belt Sea (*figure 5*).

Phosphate was present in the surface water in all areas, while silicate concentrations were low only in the Kattegat. In the bottom water high concentrations of phosphate and silicate were observed in the Fehmarn Belt – Gedser Rev area (*figure 6*).

Chlorophyll-*a* and phytoplankton
The mean chlorophyll concentration in the uppermost 10 m (2.0-5.5 µg/l) was relatively high and an autumn bloom was going on in most areas with the lowest concentrations in the south-eastern Kattegat and the highest in the Great Belt and northern Kattegat (*figure 7*).

Samples from Kattegat East (St. 413), Kiel Bight (St. N3), Mecklenburg Bight (St. M2) and Arkona Sea (St. 444) showed domination of diatoms, except in Mecklenburg Bight where dinoflagellates (*Ceratim tripos, C. fusus* and *Prorocentrum micans*) dominated. The dominating diatoms in Kattegat East and Kiel Bight were *Pseudonitzschia sp.* and *Proboscia alata*, and in the Arkona Sea large centric diatoms.

Oxygen
Since the cruise in September the minimum oxygen concentration had increased 0.7-1.9 ml/l, in all Kattegat, but decreased 0.9-4.1 in the Belt Sea. The lowest oxygen concentration of 1.0 ml/l (16%) was found in the Fehmarn Belt (St. 952). In the area Fehmarn Belt, Mecklenburg Bight, Gedser Rev to east of Falster (St. 952, M 2, 954, 449) the minimum oxygen concentration was 1.0-2.8 ml/l (16-43%). In the Sound 2.0 ml/l (30%) was observed. In the Great Belt the oxygen concentrations were 1.9-3.0 ml/l (30-49%), lowest in the north (St. 935) and highest in the south (St 450) (*figure 8*).

The reason for the changes in oxygen concentrations is an inflow of cold, high saline and relatively oxygen rich deep water from Skagerrak to the Kattegat bottom water. This has lifted up the original oxygen poor bottom water and pressed it into the Sound and Belt Sea. In the south-eastern Kattegat and the Sound the lowest oxygen concentrations were observed in 20-30 m depth, not at the bottom.

Compared to October last year, the minimum oxygen concentrations this year do not differ much, except for higher concentrations in the western Arkona Sea.

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 no longer present in the Kattegat, serious oxygen depletion occurred in the Fehmarn Belt, and oxygen depletion occurred in the Sound, Great Belt and the Mecklenburg Bight – Gedser Rev area. In *figure 9* is shown the stations visited by Danish counties, NERI, SMHI and Landesamt für Natur und Umwelt, Schleswig-Holstein, within the first three weeks of October 2001, and where oxygen depletion or serious oxygen depletion was observed.

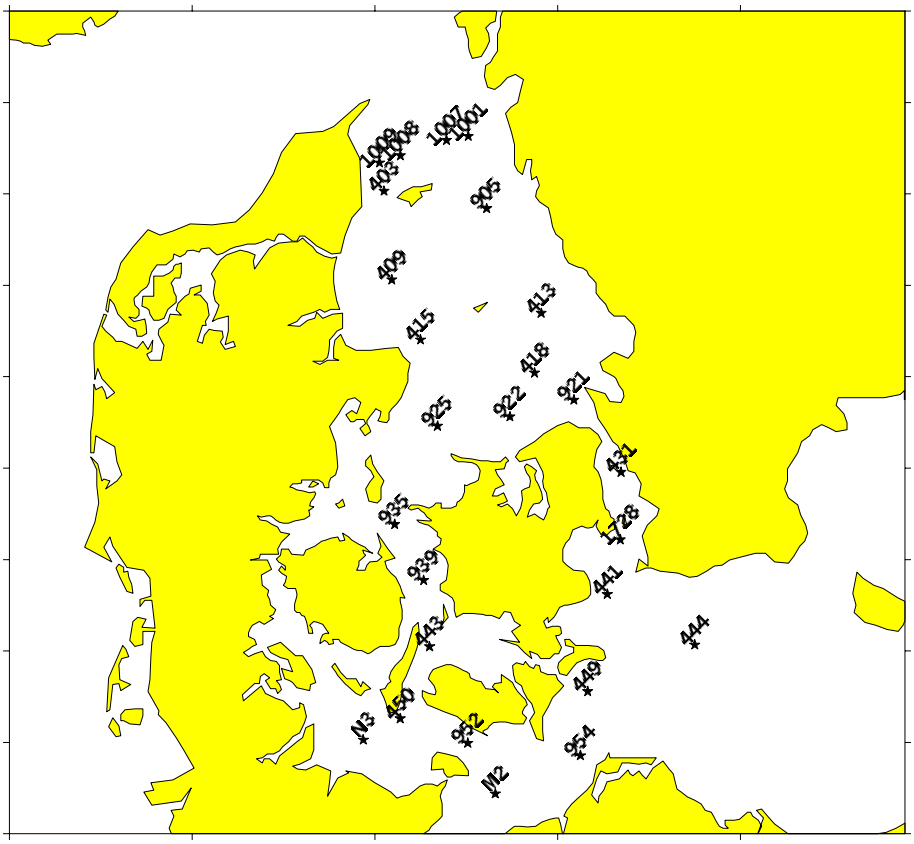

Figure 1. Stations of the monitoring cruise with r/v Gunnar Thorson 8-11 October 2001 in the Sound, Kattegat, Belt Sea and Arkona Sea. Gunnar Thorson cruise no. 205.

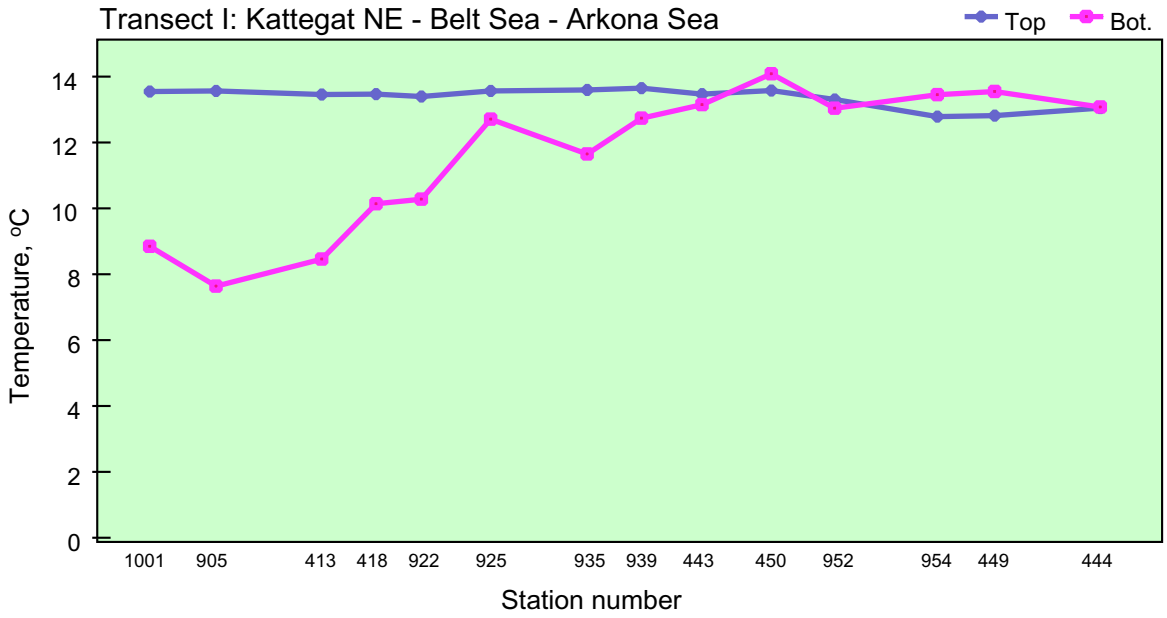

Figure 2. Surface and near bottom temperature along transect I from the north-eastern Kattegat through the Belt Sea to the Arkona Sea.

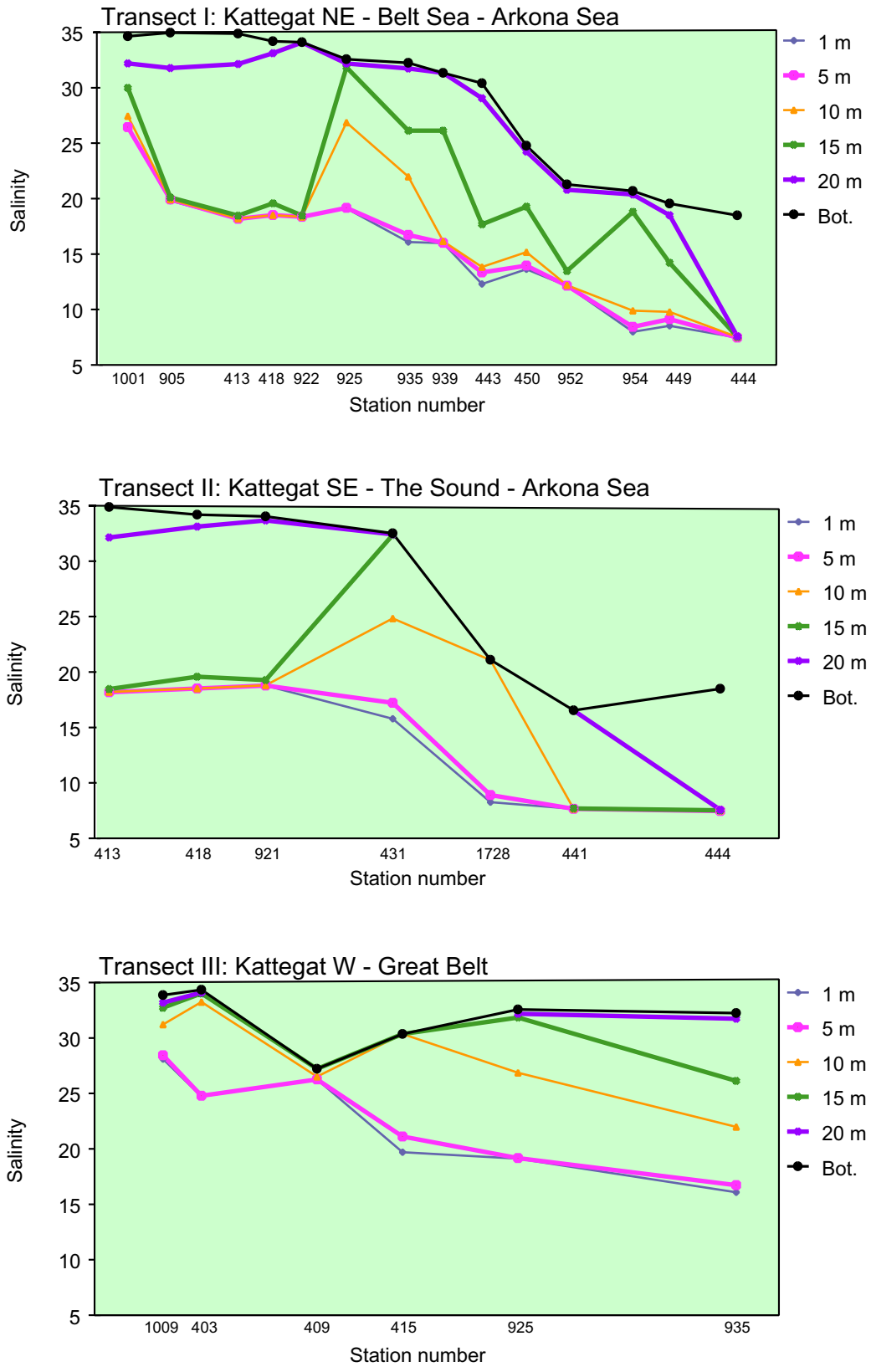

Figure 3. Salinity in 1 m, 5 m, 10 m, 15 m, 20 m depth and near bottom along transect I, II and III from the Kattegat through the Belt Sea and Sound to the Arkona Sea and in the western Kattegat to the Great Belt, respectively.

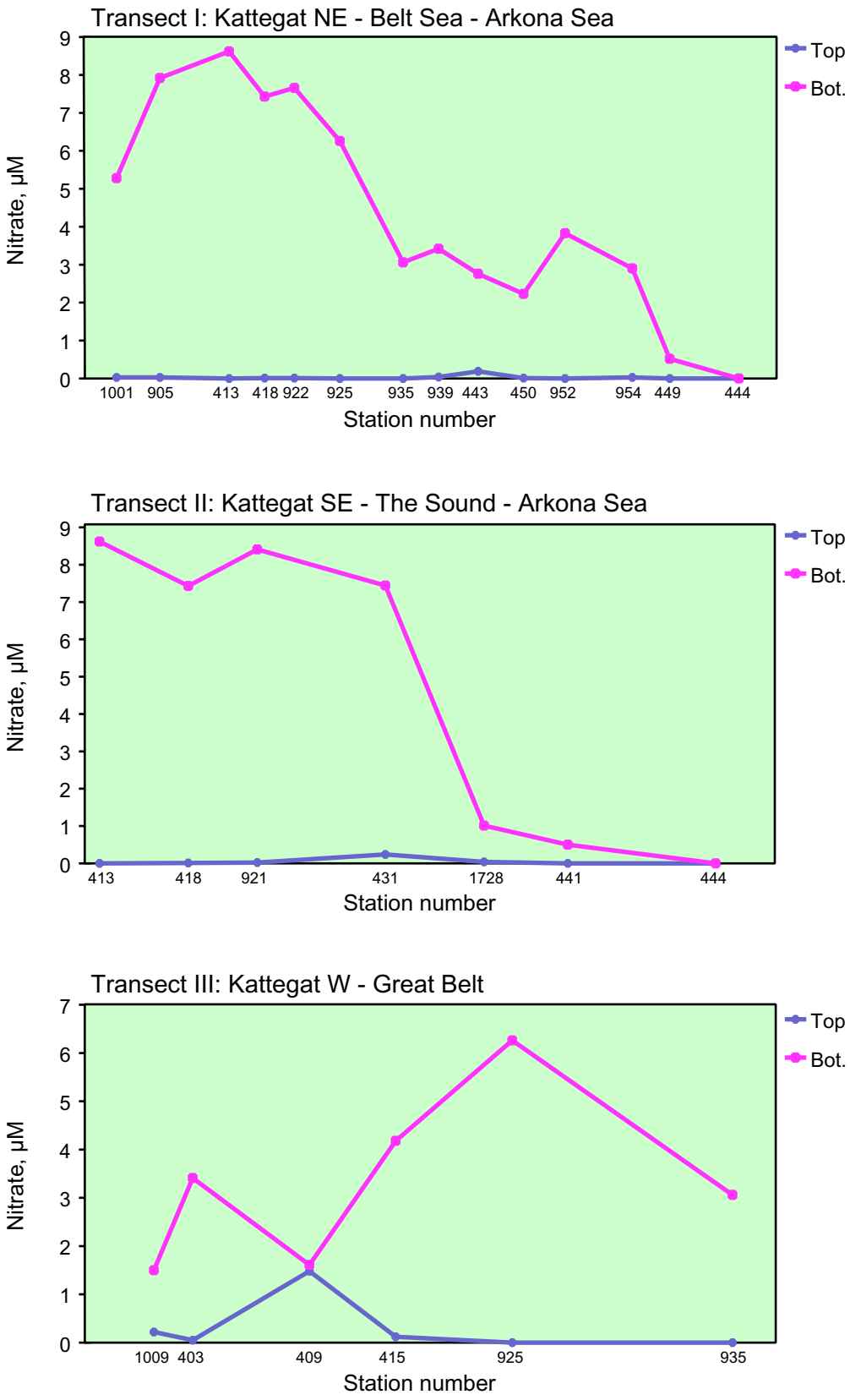

Figure 4. Surface and near bottom concentrations of nitrate along transect I, II and III.

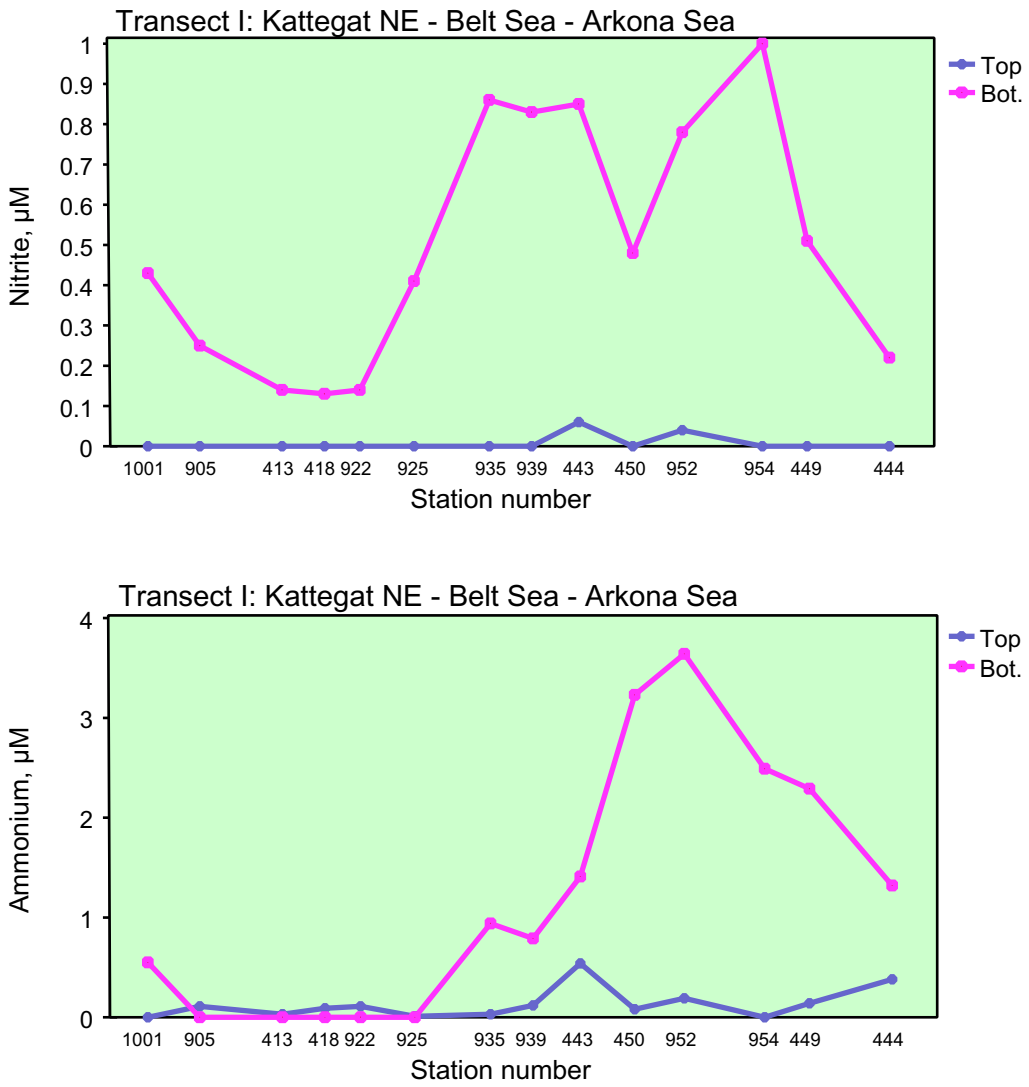

Figure 5. Surface and near bottom concentrations of nitrite and ammonium along transect I.

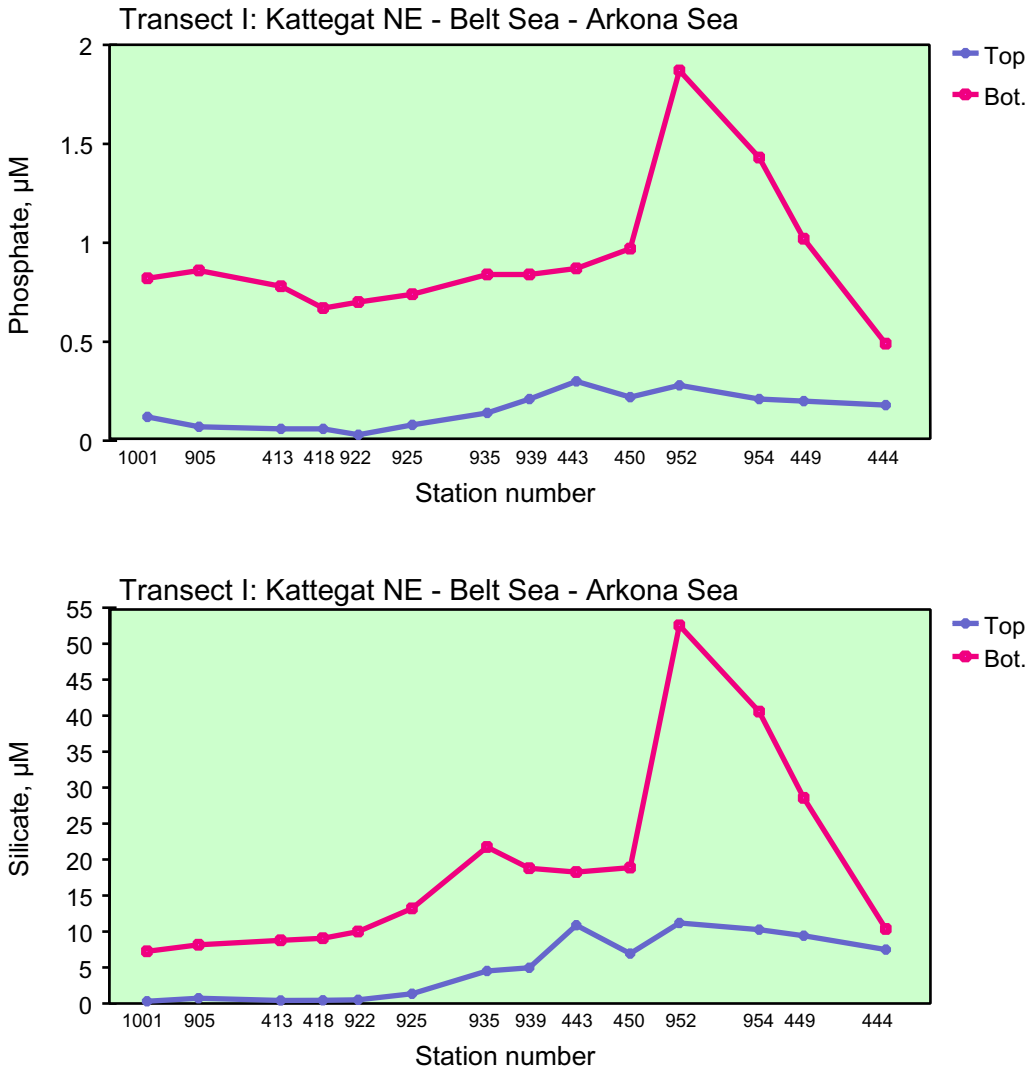

Figure 6. Surface and near bottom concentrations of phosphate and silicate along transect I.

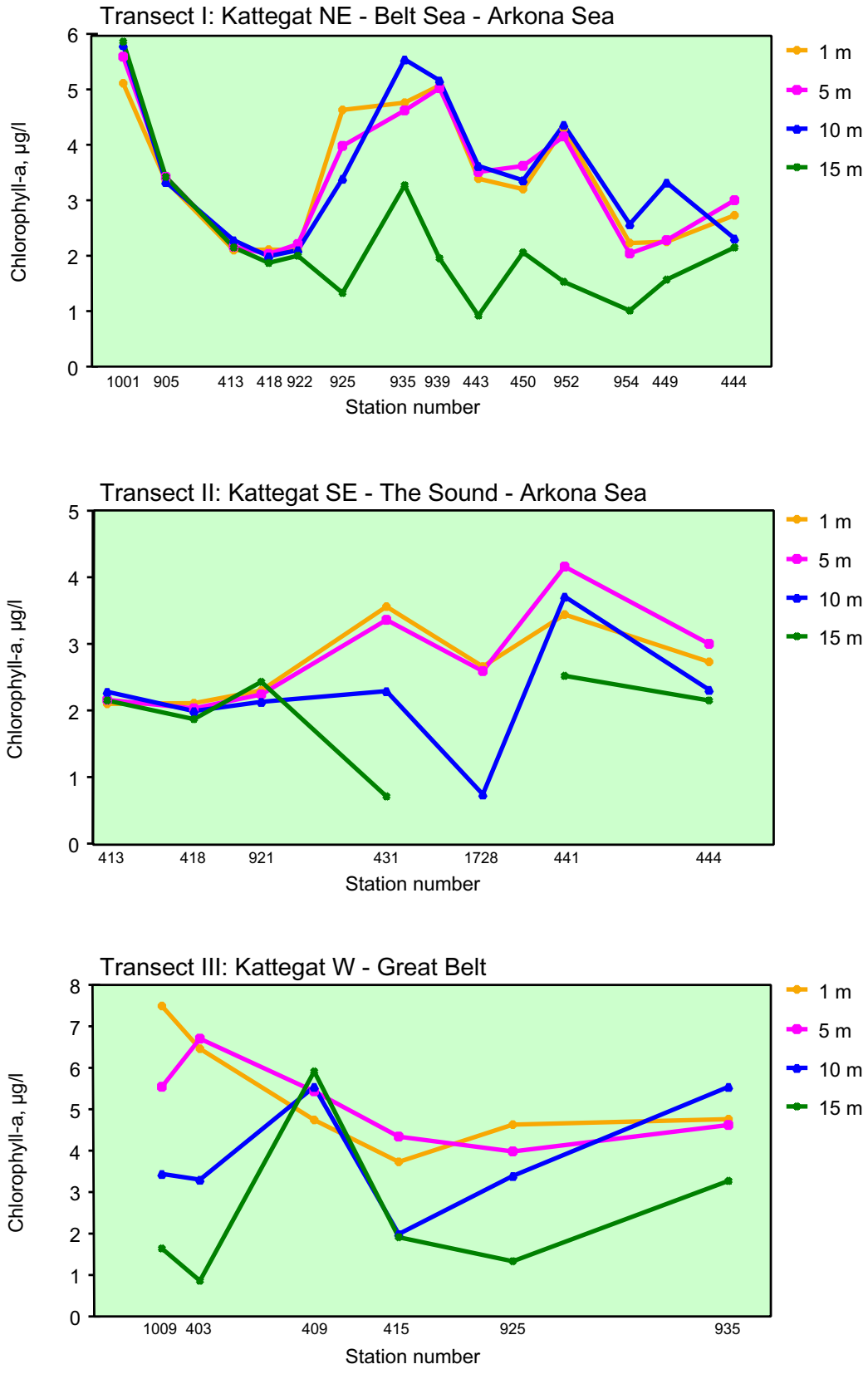

Figure 7. Chlorophyll-*a* concentrations in 1 m, 5 m, 10 m and 15 m depths along transect I, II and III.

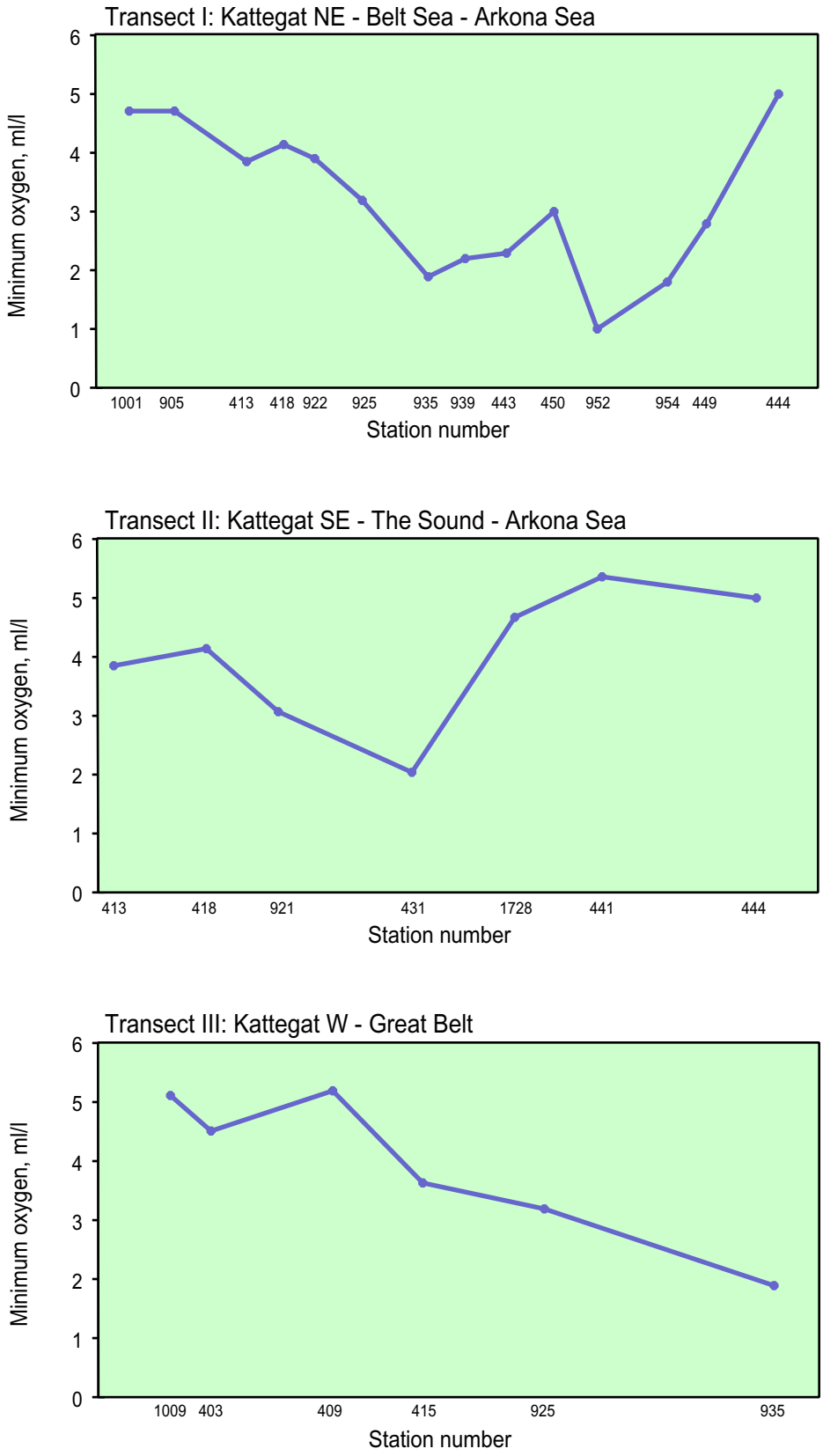

Figure 8. Minimum oxygen concentrations along transect I, II and III.

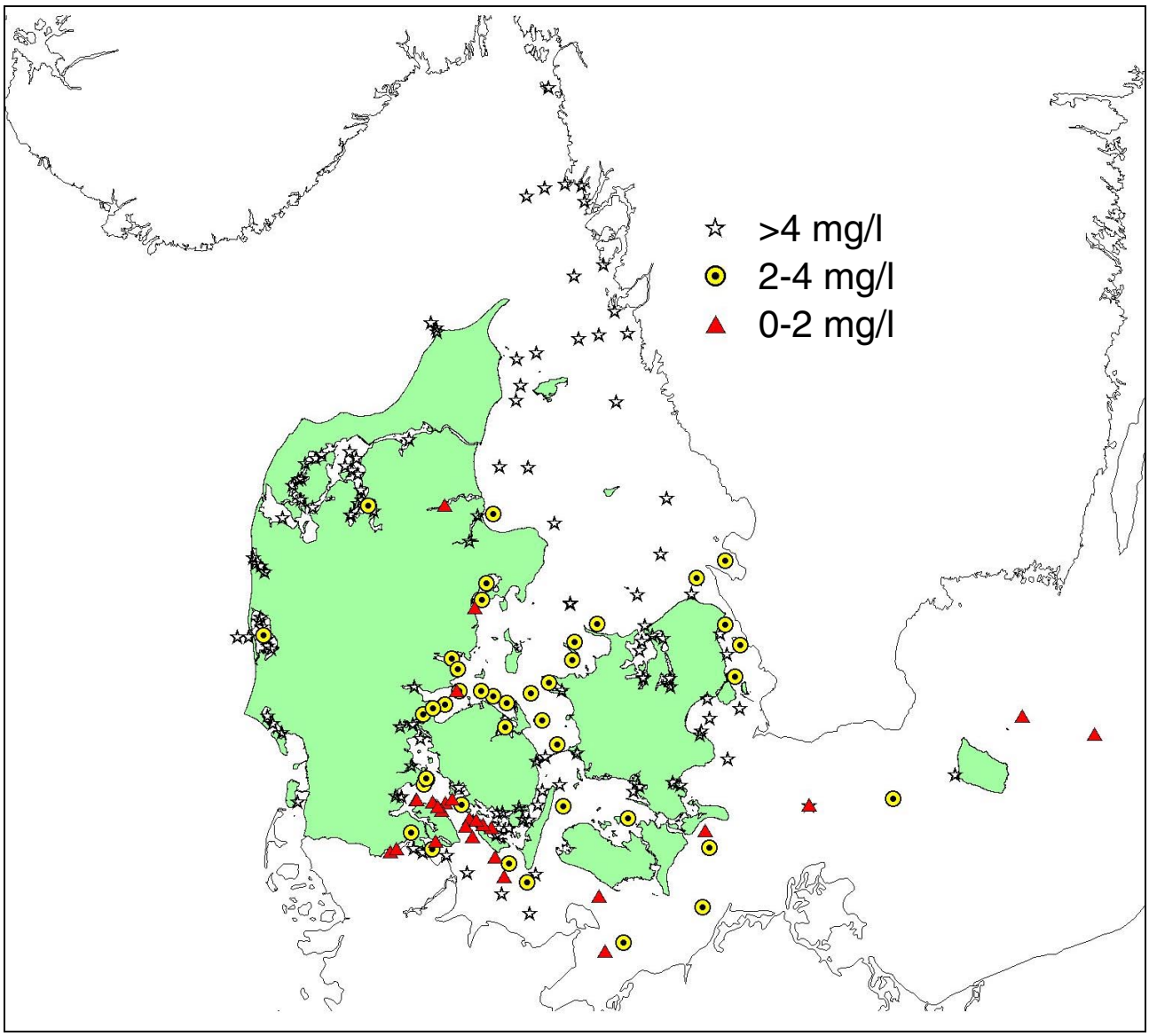

Figure 9. Stations visited by Danish counties, NERI, SMHI and Landesamt für Natur und Umwelt, Schleswig-Holstein, within the first three weeks of October 2001, and where oxygen depletion (<4 mg/l) and serious oxygen depletion (<2 mg/l) was observed.