r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 199

Time: 9 - 13 October 2000

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, 9-13 October 2000. Cruise no. 199.

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

The salinity stratification of the water column was unusually strong due to brackish Baltic Sea water at the surface, and inflow of salt bottom water from the north, even into the Arkona Basin. The water temperature was about 12-13°C in all water masses and 0.4-1.6°C higher than normal for the season. The surface salinity was lower and the bottom water salinity higher than long-term means for October.

Phosphate and silicate were present all over in the surface water as also at least traces of nitrate in most areas. High concentrations of ammonium, phosphate and silicate were observed in the bottom water in the area east of Falster with low oxygen concentrations.

The mean chlorophyll concentration in the uppermost 10 m varied between 1.7 µg/l in the south-eastern Kattegat to 3.7-4.8 µg/l in Kiel Bight and Fehmarn Belt. The chlorophyll was highest and homogeneously distributed in the uppermost 5 m of the water column, and very low in the water below the halocline.

Since the cruise in September, the minimum oxygen concentration had increased in all areas, except east of Falster. The lowest oxygen concentration of 0.4-0.7 ml/l (6-11% saturation) was observed in that area. In the central Sound, Great Belt and Fehmarn Belt the minimum oxygen concentrations were 2.0-2.6 ml/l (33-43%), and in Kiel Bight 2.9 ml/l (45%).

Compared to October last year the minimum oxygen concentrations this year are lower in the central Sound, Great Belt and Arkona Sea. Compared to mean for October in the 1980s, the concentrations this year are also lower in the northern Kattegat and southern Belt 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 serious oxygen depletion occurred east of Falster, and oxygen depletion still occurred in the central Sound, all Great Belt and Fehmarn Belt.

Figure 9 shows the stations visited by Danish counties and NERI within the first three weeks of October 2000, and where oxygen depletion or serious oxygen depletion was observed. The severity and area coverage of oxygen depletion this autumn in the Sound, southern Kattegat and Belt Sea is the worst case seen during the last 10 years. The minimum oxygen concentrations observed in the deeper parts of the Great Belt at the end of September and beginning of October are the lowest recorded from this area. Hydrogen sulphide, death of bottom fauna and demersal fish, has been recorded in a number of areas, although systematic investigations of such effects have not been performed.

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 OSPAR 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

In September the mean temperature was 0.4°C above long-term mean, while the precipitation and number of sun-hours were normal. The mean wind was relatively low and came from east and south-east. The first three weeks of October, including the time of the cruise, were characterised by southerly (south-east to south-west) and occasionally strong wind.

Hydrography

The surface temperature (1 m depth) varied from 12.1-12.4°C in the south-eastern Kattegat (St. 921, 922) to 13.2-13.9°C in the Arkona Sea (St. 441, 444, 449). The bottom water temperature ranged from 10.8-11.3°C in the north-eastern Kattegat (St. 905, 1001) to 13.4-14.3°C in the north-western Kattegat (St. 403, 1007, 1008, 1009). Thus, the water temperature was about the same in all water masses (*Figure 2*).

The surface salinity ranged from 7.9-8.3 in the Arkona Sea (St. 441, 444, 449) to only 21.8-22.3 in the north-eastern Kattegat (St.1008, 1009). The bottom water salinity ranged from as high as 18.8-21.0 in the Arkona Sea (St. 441, 444, 449) to 34.0-35.0 in the eastern Kattegat (St. 413, 418, 905, 1001) (*Figure 3*). Inflow of saline bottom water from the north even to the Arkona Sea was evident. The surface salinity was still low due to outflow from the Baltic Sea, and the salinity stratification was strong (9.5-22.9 psu), except in the shallow western Kattegat. The halocline was situated unusually high in the water column (between 5 and 10 m depth) in the Sound, southern Kattegat and Great Belt.

Compared to long-term monthly mean (Lightship observations 1931-1960) for October, the temperature was in the whole water column 0.4-1.6°C higher than normal. Generally, the salinity at the surface during the present cruise was 2.2-8.5 psu lower than normal, but at the bottom 0-8 psu higher than normal.

Nutrients

In the surface layer traces of nitrate were observed in most areas, especially 0.1-0.5 µmol/l was found in the Sound, southern Kattegat and Great Belt. In the bottom water the highest nitrate concentrations (3.8-6.6 µmol/l) were observed in the same areas and also in the north-eastern Kattegat (St. 1001) (*Figure 4*).

Also nitrite was present (0.01-0.2 µmol/l) in the surface in the western and southern Kattegat, the Sound and Great Belt. In the bottom water 0.2-1.2 µmol/l was present in most areas (*Figure 5a*). Ammonium was present in the surface only in the central Sound and central Great Belt (St. 431, 939). High concentrations (0.3-2.3 µmol/l) were observed in the bottom water in the southern Belt Sea and Arkona Sea (*Figure 5b*).

Phosphate and silicate were present in the surface water in all areas. In the bottom water especially high phosphate (1.6-1.9 µmol/l) and silicate (54-55 µmol/l) concentrations were observed at the bottom in the area with low oxygen concentrations east of Gedser Rev (St. 954, 449) (*Figures 6a and 6b*).

Chlorophyll-*a*

The mean chlorophyll concentration in the uppermost 10 m varied between 1.7 µg/l in the south-eastern Kattegat (St. 921) to 3.7-4.8 µg/l in Kiel Bight and Fehmarn Belt (St. N3, 952). The chlorophyll was highest and homogeneously distributed in the uppermost 5 m of the water column, and very low in the water below the halocline in the Sound, southern Kattegat and Great Belt (*Figure 7*).

Oxygen

Since the cruise in September, the minimum oxygen concentration had increased in all areas, except east of Gedser Rev (St. 954, 449). The lowest oxygen concentration of 0.4-0.7 ml/l (6-11% saturation) was observed at these two stations. In the central Sound, Great Belt and Fehmarn Belt (St. 431, 925, 935, 939, 443, 450, 952, M2) the minimum oxygen concentration was 2.0-2.6 ml/l (33-43%), and in Kiel Bight (St. N3) 2.9 ml/l (45%) (*Figure 8*).

Compared to October last year, the minimum oxygen concentrations this year are lower in the central Sound, Great Belt and Arkona Sea (St. 431, 925, 935, 939, 443, 449, 444, 441). Compared to mean for October in the 1980s, the minimum oxygen concentrations this year are also lower in the northern Kattegat and southern Belt 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 serious oxygen depletion occurred east of Gedser Rev (St. 954, 449), and oxygen depletion still occurred in the central Sound, all Great Belt and Fehmarn Belt (St. 431, 925, 935, 939, 443, 450, 952, M2).

In *Figure 9* is shown the stations visited by Danish counties and NERI within the first three weeks of October 2000, and where oxygen depletion or serious oxygen depletion was observed. The severity and area coverage of oxygen depletion this autumn in the Sound, southern Kattegat and Belt Sea is the worst case seen during the last 10 years. The minimum oxygen concentrations observed in the deeper parts of the Great Belt at the end of September and beginning of October are the lowest recorded from this area. Hydrogen sulphide, death of bottom fauna and demersal fish, has been recorded in a number of areas, although systematic investigations of such effects have not been performed.

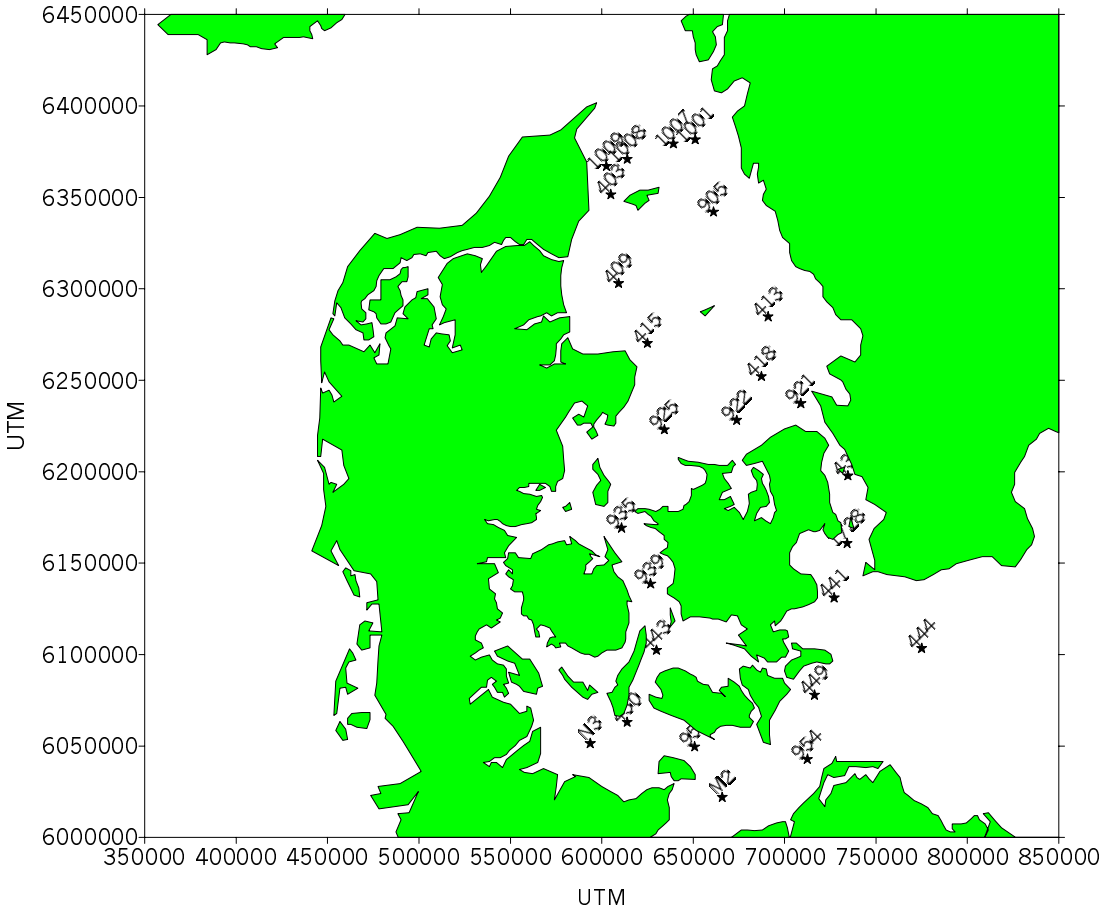


Figure 1. Stations of the monitoring cruise with r/v Gunnar Thorson 9-13 October 2000 in the Sound, the Kattegat, the Belt Sea and the Arkona Sea. Gunnar Thorson cruise no. 199.

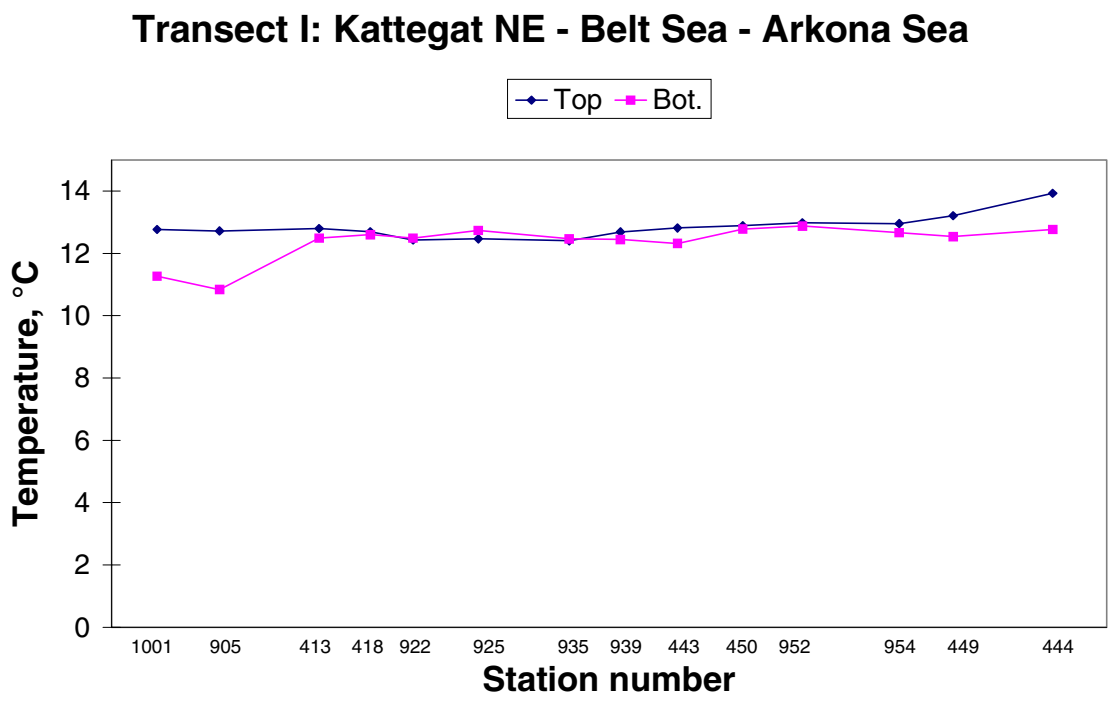
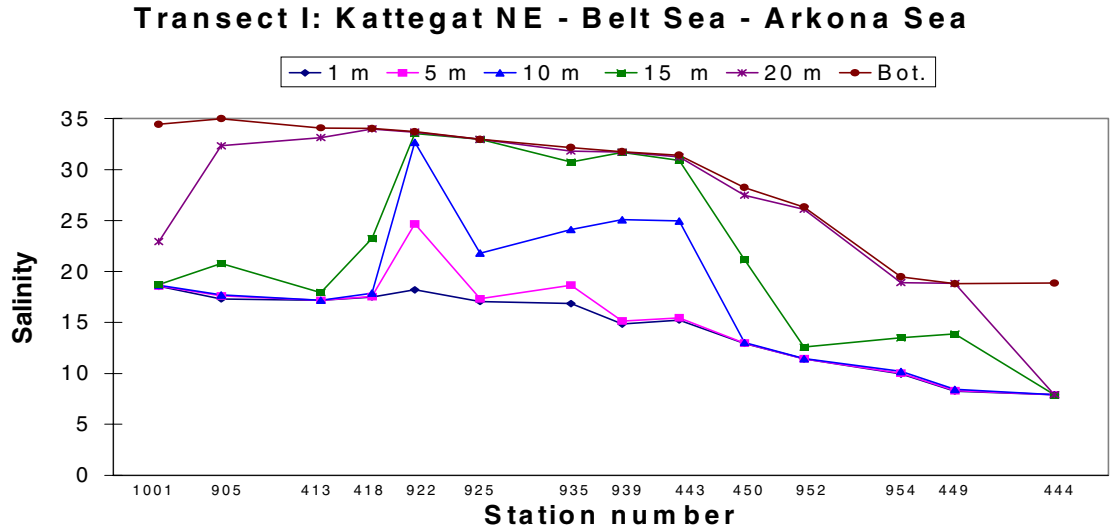
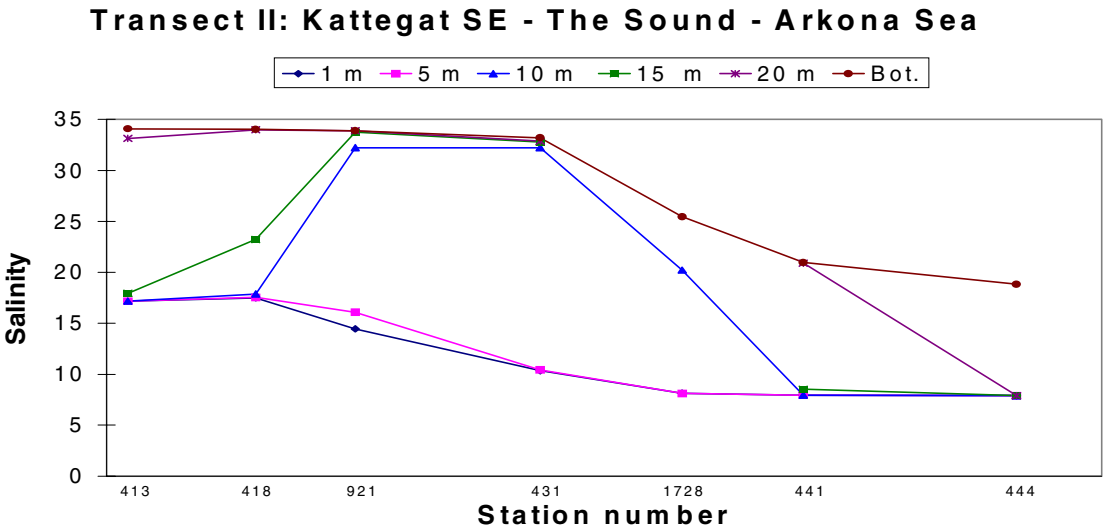


Figure 2. Surface and near bottom temperature along transect I from the north-eastern Kattegat through the Belt Sea to the Arkona Sea.





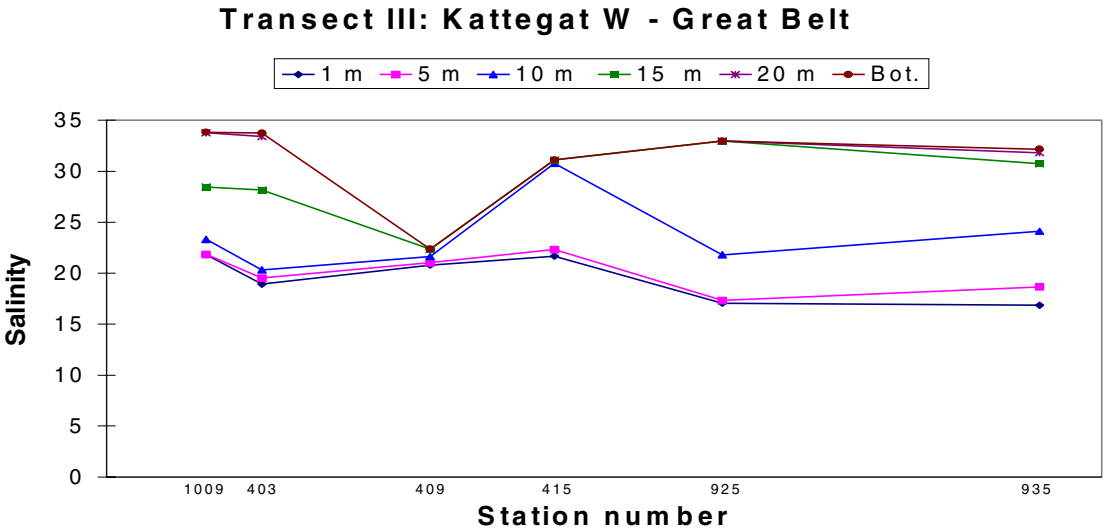


Figure 3. Salinity in 1 m, 5 m, 10 m, 15 m, 20 m depth and near bottom along transect I, II and III from the Kattegat through the Belt Sea and the Sound to the Arkona Sea and in the western Kattegat to the Great Belt, respectively.

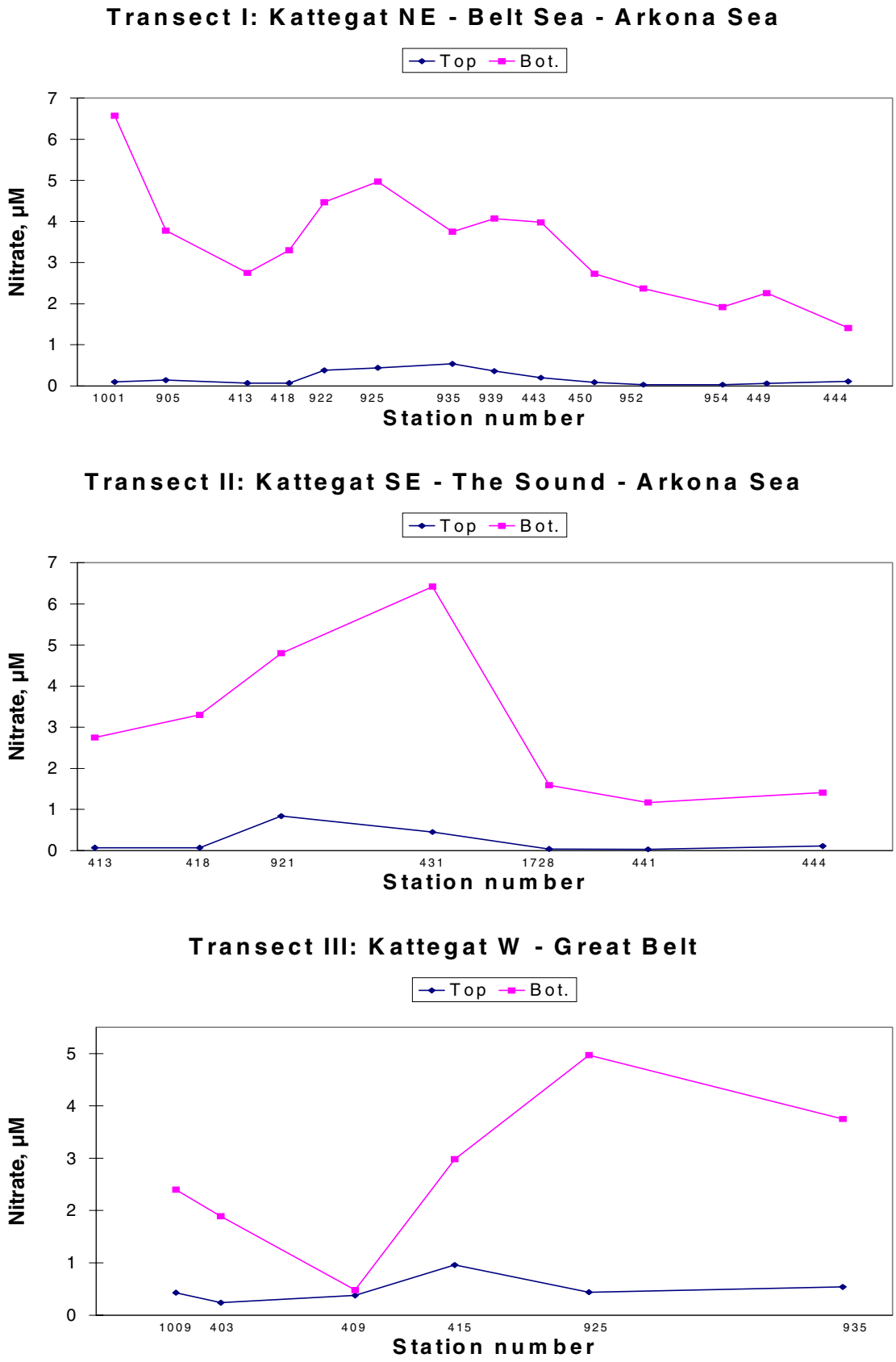
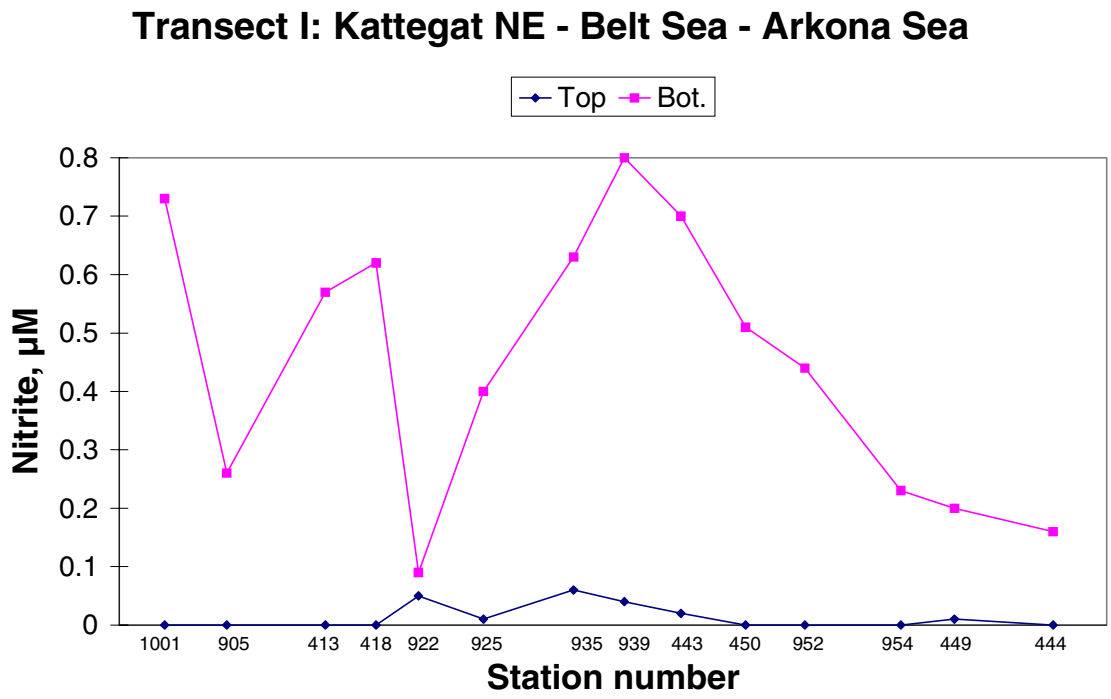


Figure 4. Surface and near bottom concentrations of nitrate along transect I, II and III.



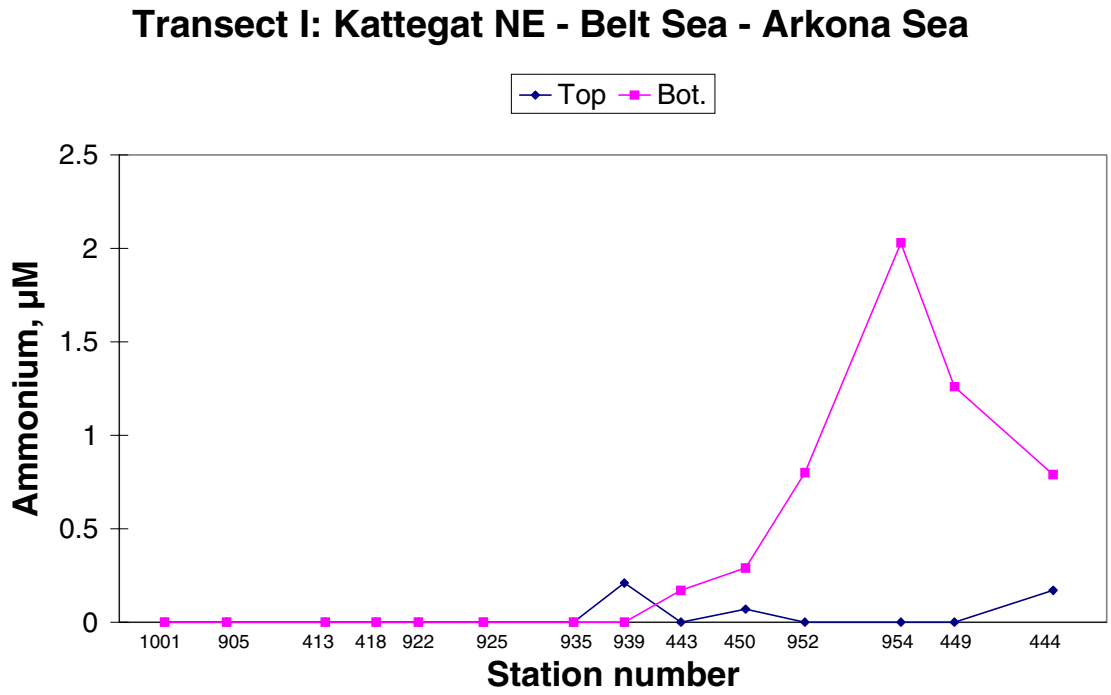


Figure 5. Surface and near bottom concentrations of nitrite and ammonium along transect I.

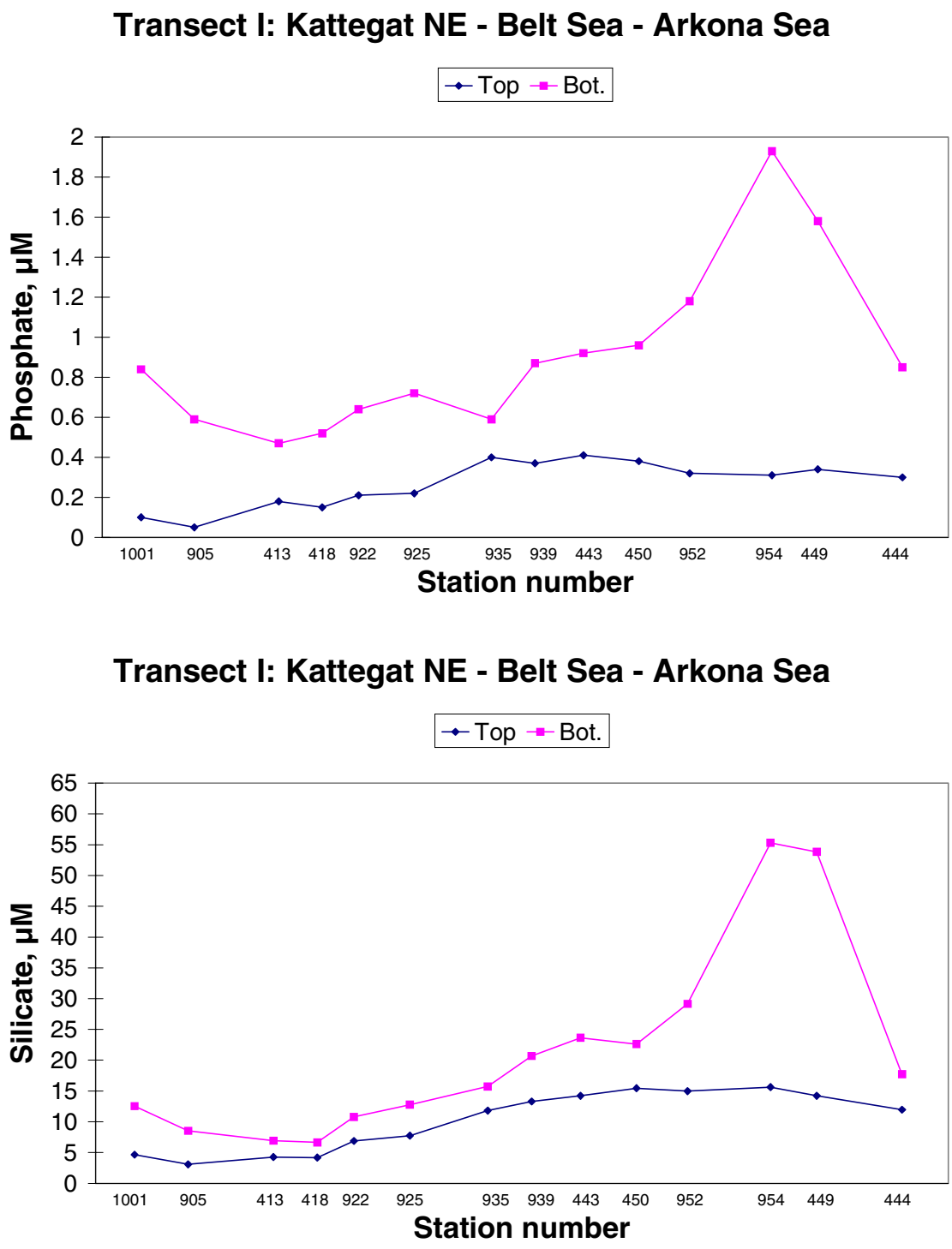


Figure 6. Surface and near bottom concentrations of phosphate and silicate along transect I.

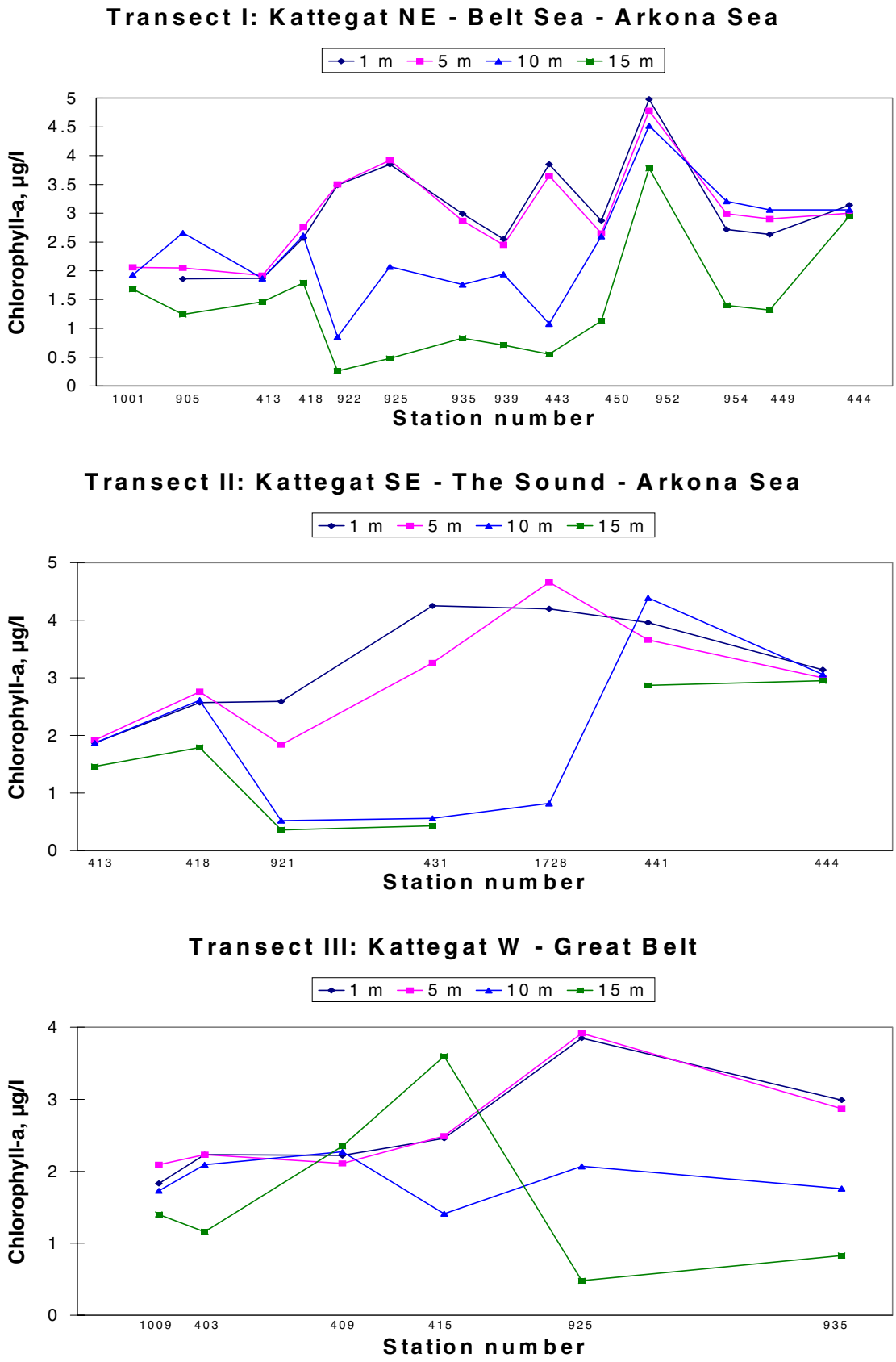


Figure 7. Chlorophyll-*a* concentrations in 1 m, 5 m, 10 m and 15 m depths along transect I, II and III.

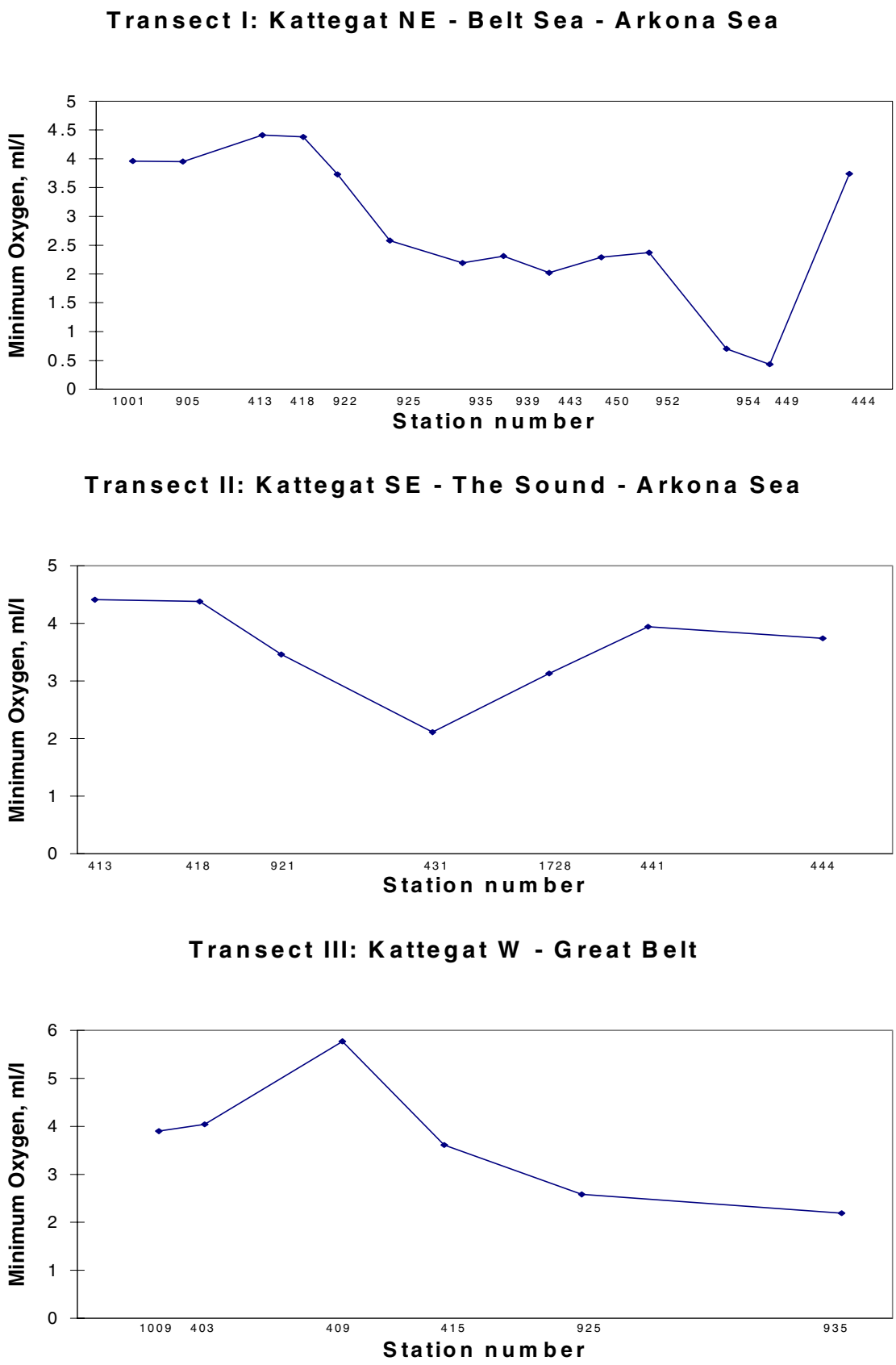


Figure 8. Minimum oxygen concentrations along transect I, II and III.

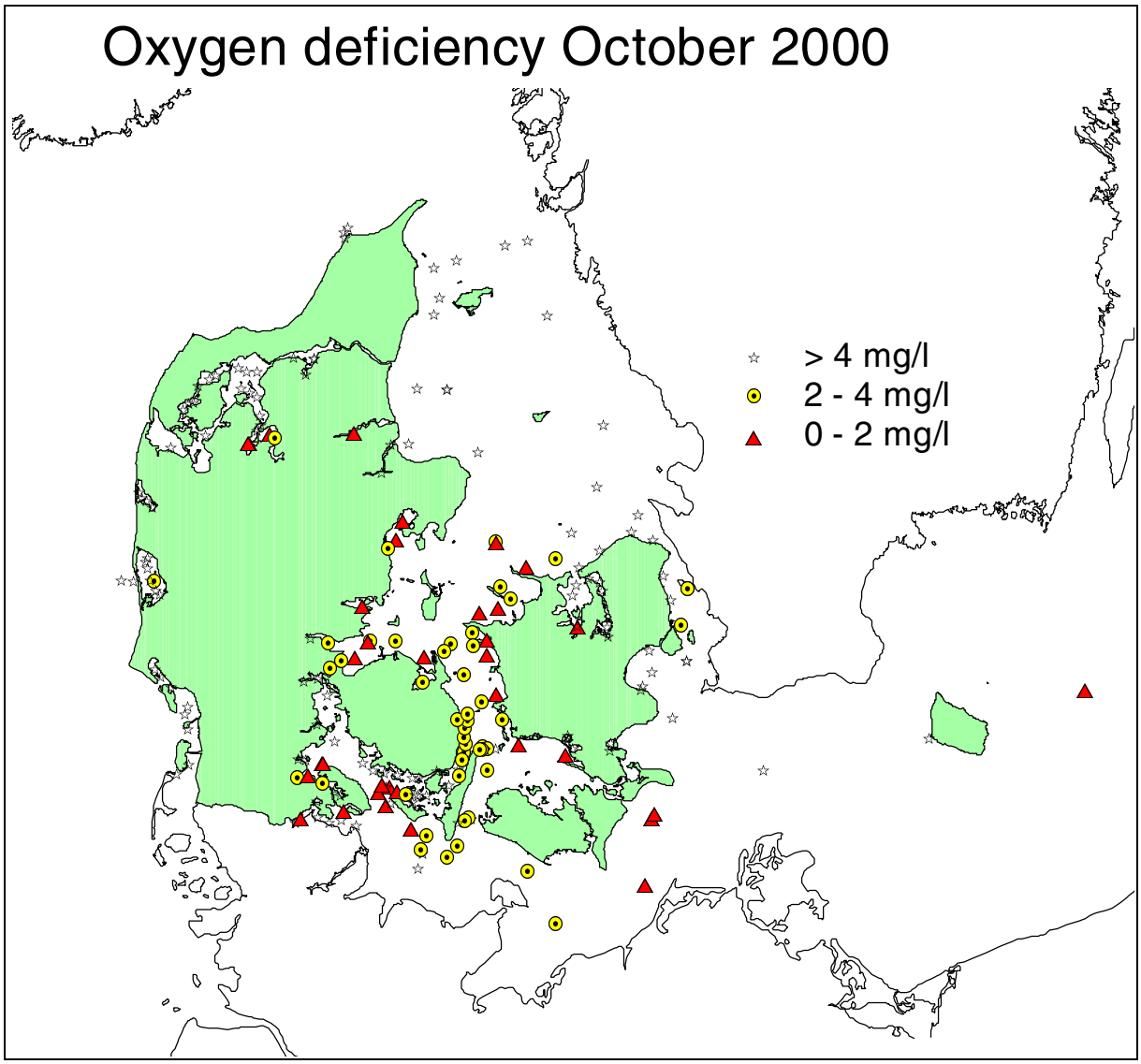


Figure 9. Stations visited by Danish counties and NERI within the first three weeks of October 2000, and where oxygen depletion (<4 mg/l) and serious oxygen depletion (<2 mg/l) was observed.