



r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 194

Time: 8 - 11 November 1999

**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 November 1999. Cruise no. 194

Report: Gunni Ærtebjerg

Cruise leader: Jan Damgaard.

Participants: Dorete Jensen, Hanne Ferdinand, Peter Kofoed, Britta Pedersen (8-9/11), Ole Jensen (8/11)

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

Summary

Compared to long term monthly mean (1931-1960) for November the temperature during this cruise was 0-2°C higher, both in the surface and the bottom water. The surface salinity was in the Kattegat and Fehmarn Belt generally lower, while the bottom water salinity all over was higher than long term mean.

Nitrate was present ($>0.2 \mu\text{M}$) in the surface layer only in the Sound and Great Belt. Except in the eastern Kattegat traces of phosphate ($>0.05 \mu\text{M}$) were observed all over in the surface layer. Also silicon ($>1 \mu\text{M}$) was found in the surface water, except in the northern and eastern Kattegat.

The mean chlorophyll-*a* concentration in the uppermost 15 m was relatively high and ranged from 2.0 $\mu\text{g/l}$ in the Sound to 10.4 $\mu\text{g/l}$ in the south-western Kattegat. The highest concentration of 20.2 $\mu\text{g/l}$ was found in a narrow sub-surface layer at 10 m depth in the south-western Kattegat. Otherwise, the chlorophyll was fairly evenly distributed in the uppermost 10 m and lower at 15 and 20 m depth.

Since the cruise in October the minimum oxygen concentrations had increased, except in the northern and western Kattegat, Great Belt and the Gedser Rev area. The lowest oxygen concentration of 2.5 ml/l (42% saturation) was observed in the Sound. In the southern-most Kattegat and the Great Belt the minimum concentrations were 3.1-3.9 ml/l (52-61%). Also at Gedser Rev the minimum oxygen concentration was still relatively low (3.4 ml/l, 52%).

Compared to November last year the minimum oxygen concentrations this year were lower in the Sound, southern-most Kattegat and Fehmarn Belt. Compared to mean for November in the 1980s, except for the Arkona Sea, the minimum oxygen concentrations this year were generally lower, especially in the Belt Sea.

Oxygen depletion is in Denmark defined as 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 during the cruise still present in the Sound.

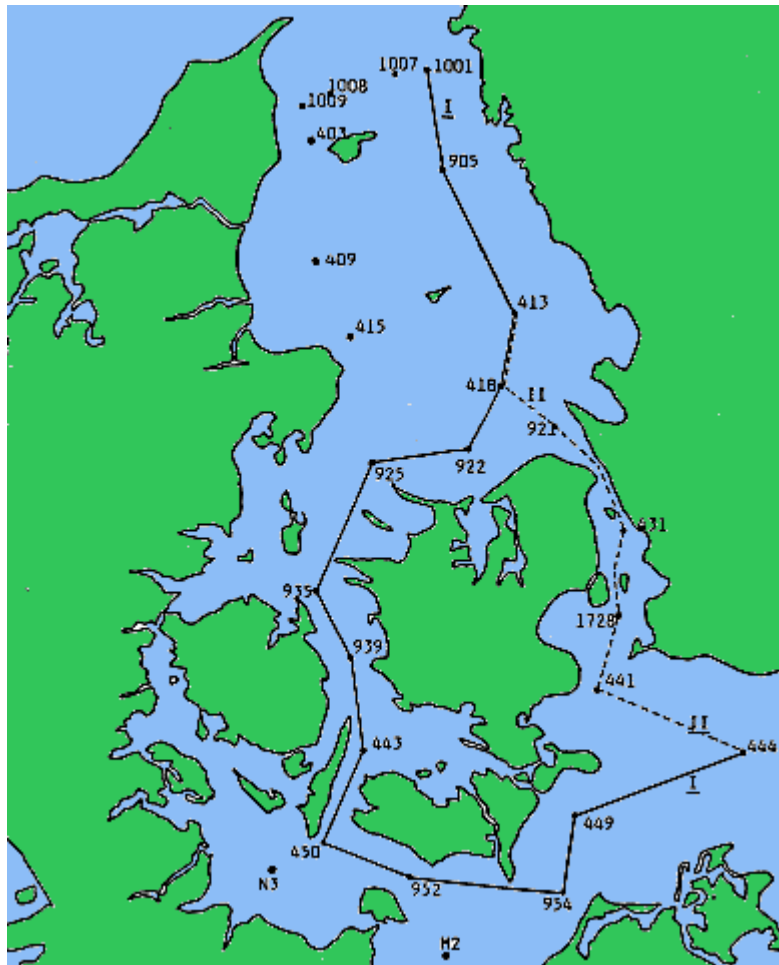


Figure 1. Monitoring cruise with r/v Gunnar Thorson 8-11 November 1999. Cruise no. 194. The 2 lines I and II show the transects used in the following figures:
 Transect I: Kattegat NE - E - S - Great Belt - Fehmarn Belt - Arkona Sea
 Transect II: Kattegat SE - The Sound - Arkona Sea.

General

The main objective of the cruise was to monitor the oxygen situation in the open Danish waters, but also to map the hydrographic situation and the spatial variations in the concentrations of nutrients and chlorophyll.

Meteorology

Relatively strong wind from south, south-west and west prevailed in the beginning of October changing from the middle of October to north-east, east and south-east. The monthly mean temperature for October was 0.3°C above long term mean (1961-90) and the precipitation was about 10% above normal. The first week of November the wind turned back to south and south-west, while the second week (during the cruise) was rather calm (Danish Meteorological Institute).

Hydrography

The surface temperature (1 m depth) had decreased 2-5°C since the cruise in October, and ranged from 8.6-8.8°C in the south-eastern Kattegat (St. 418, 922) to 10.2°C in the western Kattegat (St.409) (Fig. 2).

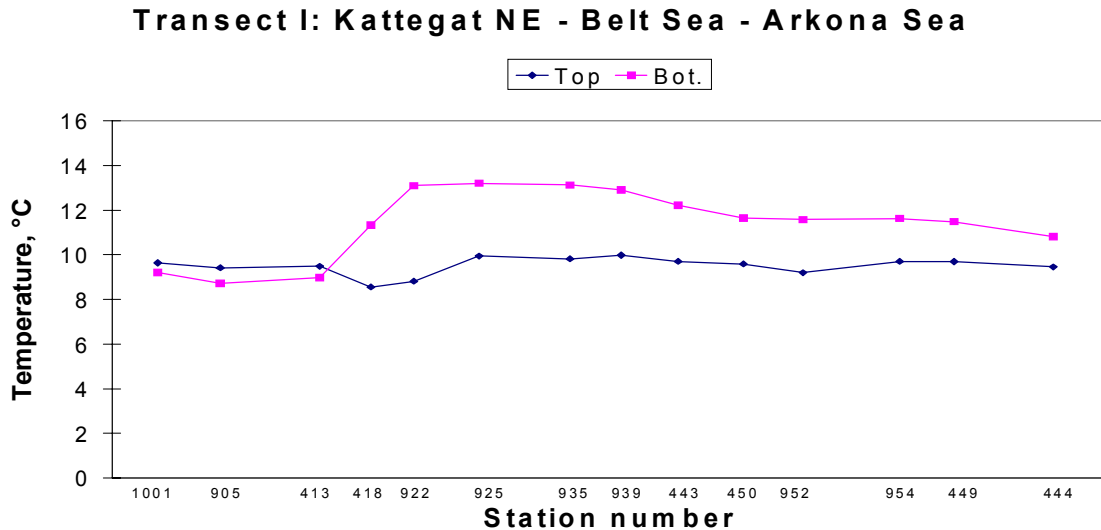


Figure 2. Surface (1 m) and near bottom temperature along transect I (see figure 1).

The bottom water temperature had also decreased, except in the Sound and southern-most Kattegat (St. 431, 921, 922, 925), and ranged from 8.7-9.2°C in the eastern Kattegat (St.413, 905, 1001) to 13.1-13.2 in the Sound, southern-most Kattegat and northern Great Belt (St. 431, 922, 925, 935) (Fig. 2). The temperature difference between surface and bottom was 0.5-4°C, generally with the bottom water warmer than the surface water, except in the north-eastern Kattegat (St. 413, 905, 1001). At these stations a warmer (10-13.6°C) intermediate water layer (25-34.2 psu) was situated between colder surface and bottom near water layers.

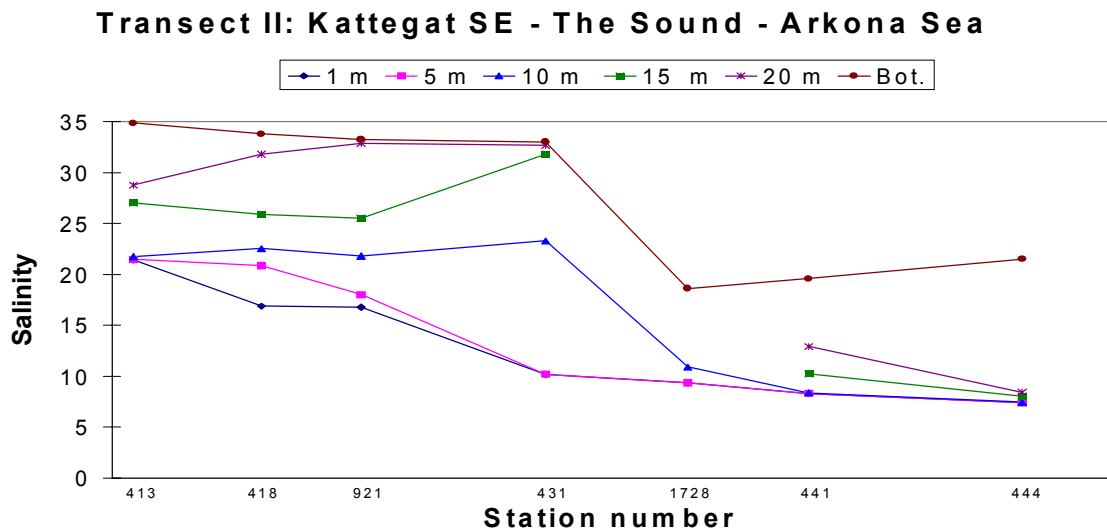
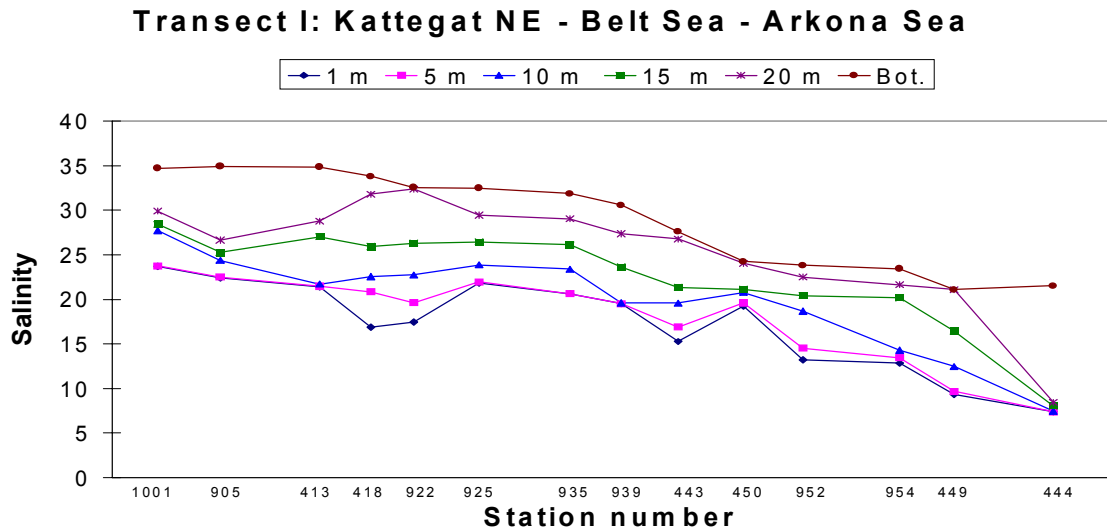


Figure 3. Salinity in 1 m, 5 m, 10 m, 15 m, 20 m depth and near bottom along the transects I and II (see figure 1).

The surface salinity had since October decreased significantly, except in the south-western Kattegat (St. 415, 925), and ranged from 7.4-9.3 in the Arkona Sea (St. 441, 444, 449) to 25.2 in the north-western Kattegat (St. 1008, 1009). The bottom water salinity ranged from 19.6-21.5 in the Arkona Sea (St. 441, 444, 449), showing inflow of saline bottom water to the Baltic Sea, to 34.7-34.9 in the eastern Kattegat (St. 413, 905, 1001) (Fig. 3). The salinity stratification had increased again since October. The strongest stratification of 22.8 psu was observed in the Sound, 12.5-16.9 psu in the eastern Kattegat and 14.1 psu in the central Arkona Sea. The halocline was in the eastern Kattegat situated between 15 and 20 m depth. In the Belt Sea the salinity gradually increased with depth (Fig. 3).

Compared to long term monthly mean (1931-1960) for November the temperature during this cruise was 0-2°C higher, both in the surface and the bottom water. The surface salinity was in the Kattegat and Fehmarn Belt generally lower, while the bottom water salinity all over was higher than long term mean.

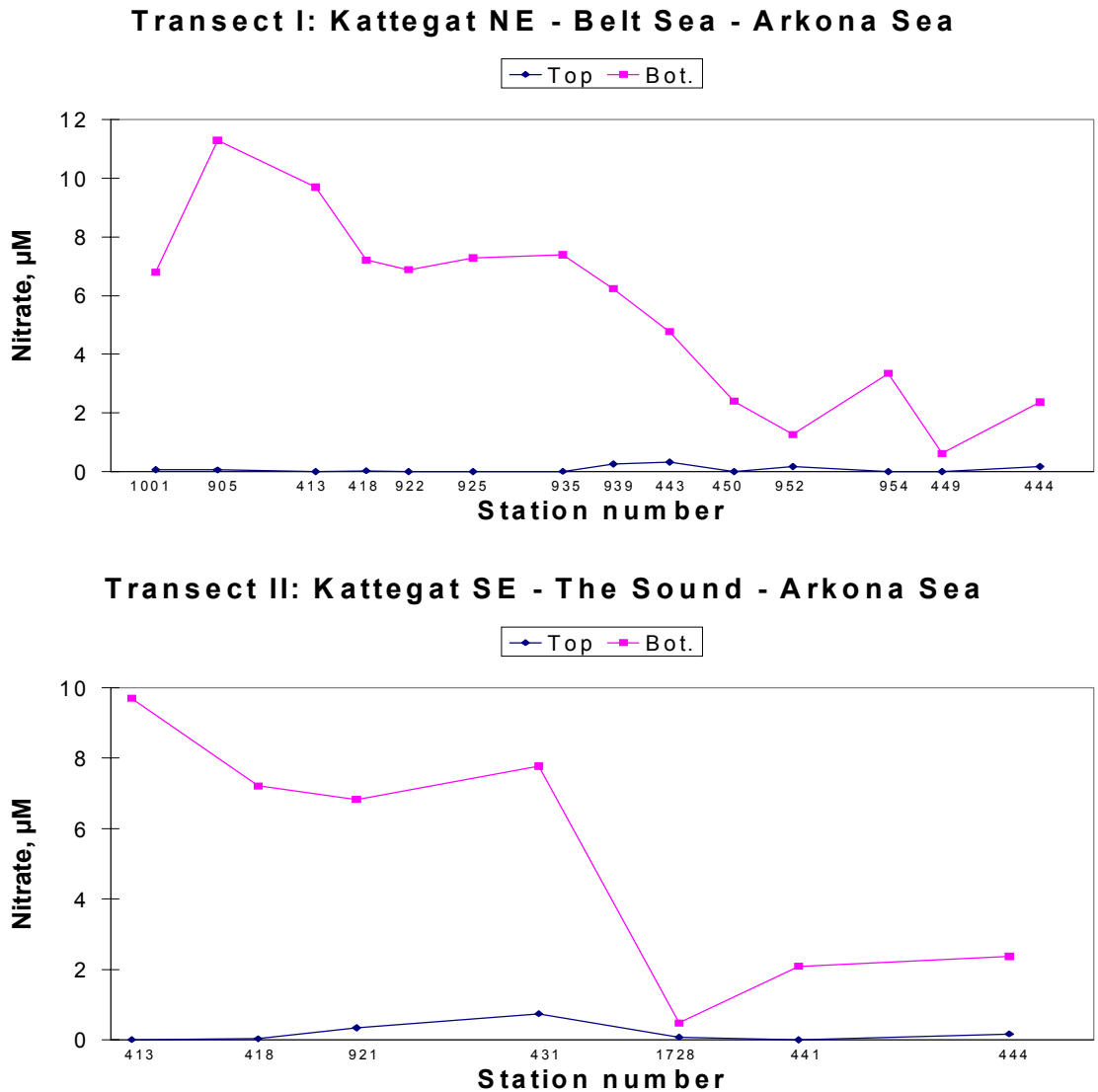


Figure 4. Surface and near bottom concentrations of nitrate along the transects I and II.

Nutrients

In spite of the intensive mixing of water masses in the beginning of October traces of nitrate ($>0.2 \mu\text{M}$) were only found in the surface layer in the Sound and central Great Belt. Close to the bottom the nitrate concentrations were high ($>8 \mu\text{M}$) in the eastern Kattegat (St. 413, 905), and relatively high ($>6 \mu\text{M}$) in the Sound, southern Kattegat and northern Great Belt (Fig. 4).

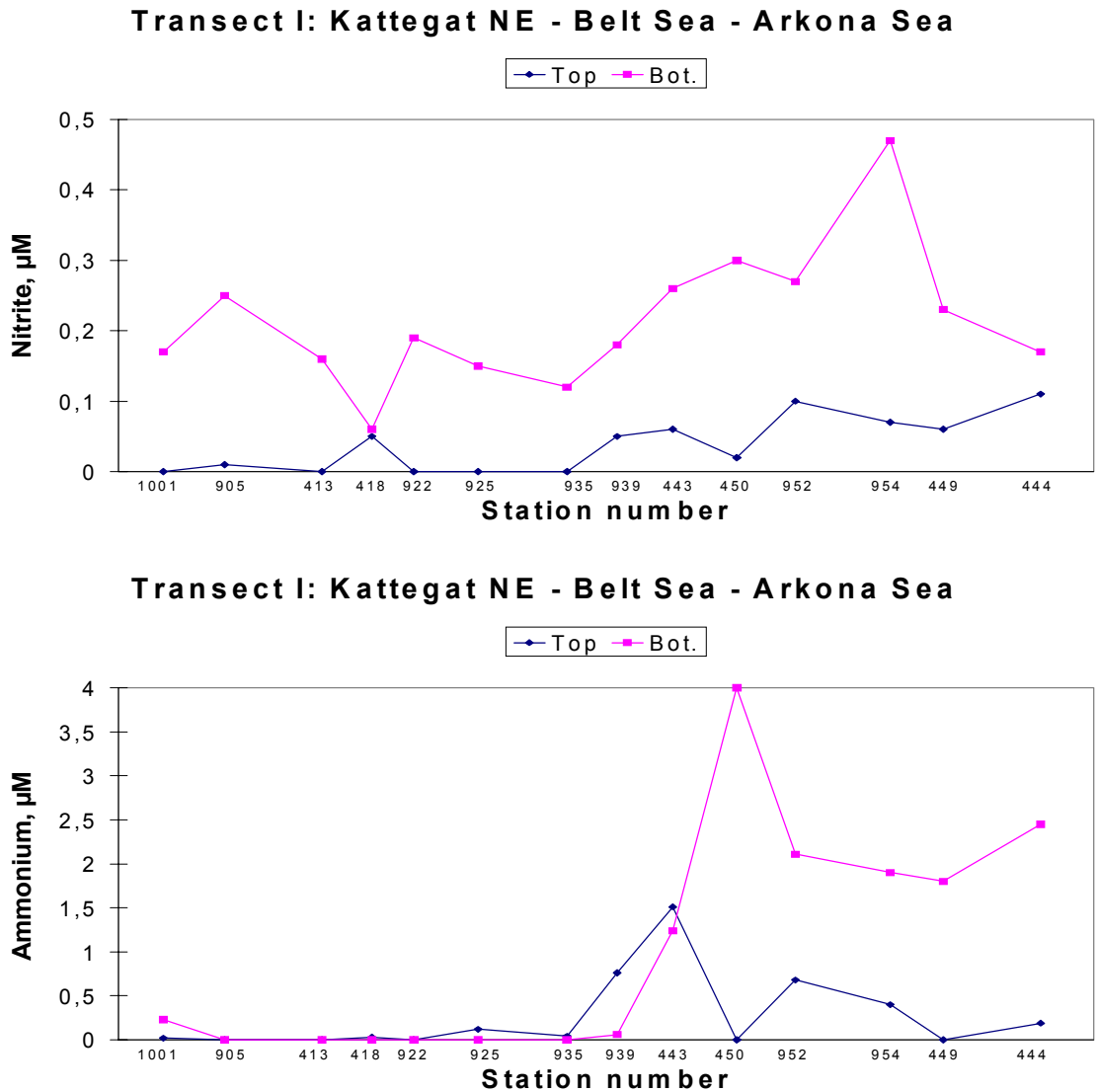


Figure 5. Surface and near bottom concentrations of nitrite and ammonium along transect I.

In the surface nitrite ($>0.1 \mu\text{M}$) was present in the Sound and central Arkona Sea (St. 431, 1728, 444). Ammonium ($>0.5 \mu\text{M}$) was present in Laesoe Rende, the Sound, southern Great Belt and Fehmarn Belt (St. 403, 431, 939, 443, 952). In the bottom water nitrite ($>0.2 \mu\text{M}$) was present in the north-western Kattegat (St. 403, 1009), the Sound (St. 431) and southern Belt Sea (St. 443, 450, 952, 954, 449). Ammonium ($>1 \mu\text{M}$) was observed in the southern Belt Sea and Arkona Sea (St.443, 450, 952, 954, 449, 444, 441, 1728) (Fig. 5).

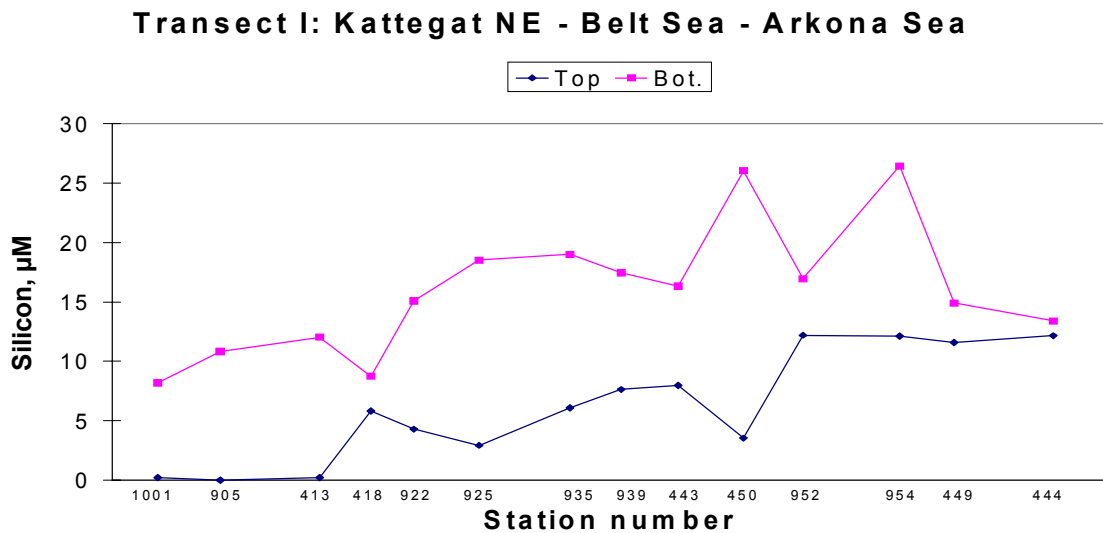
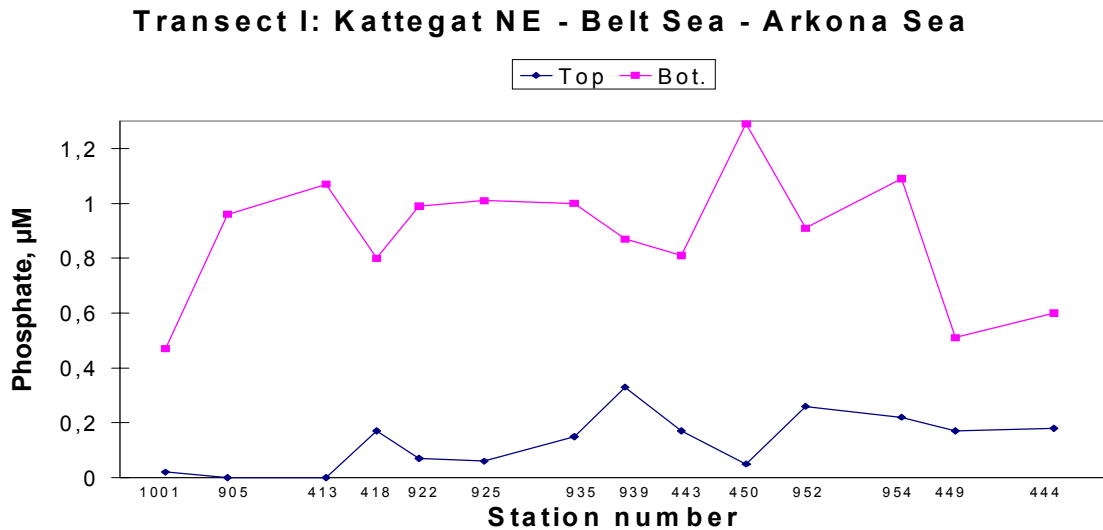
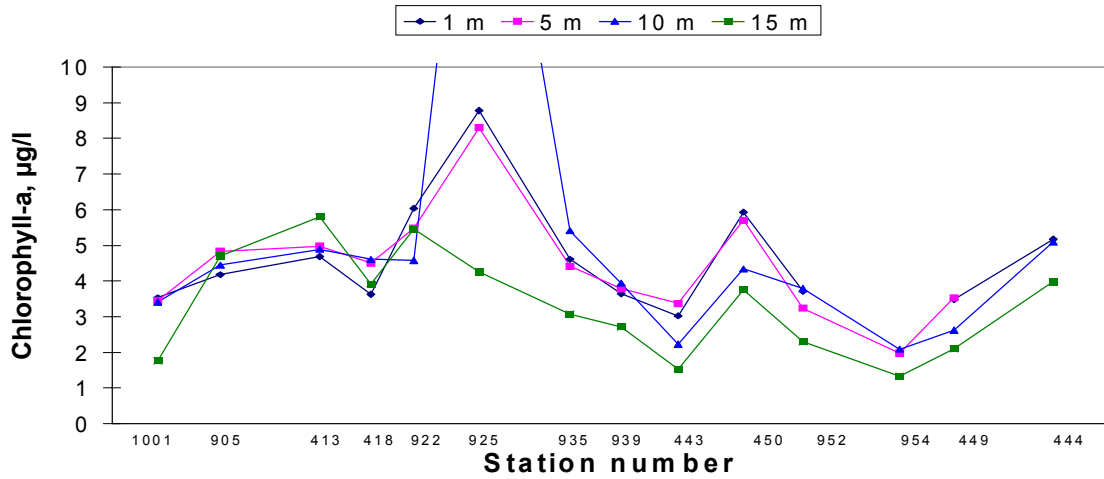


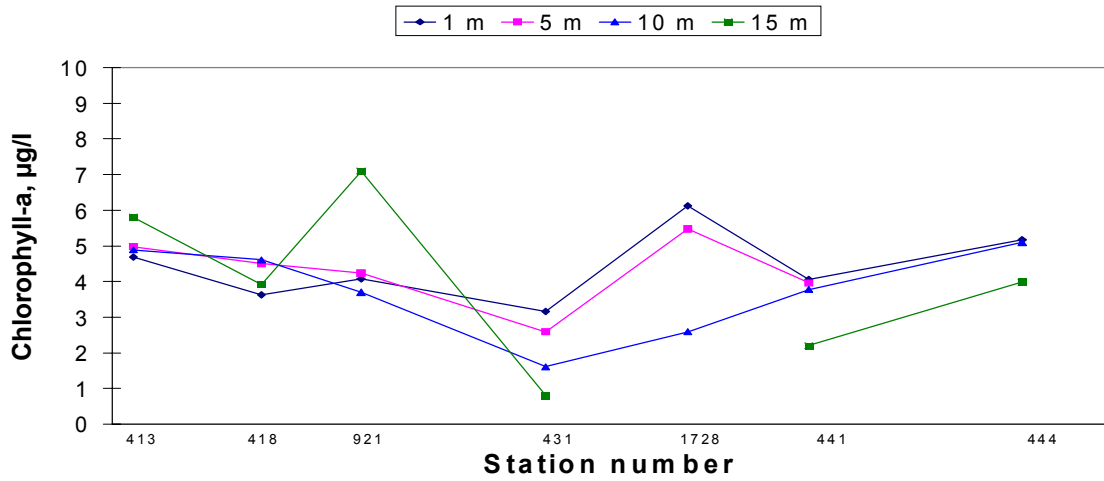
Figure 6. Surface and near bottom concentrations of phosphate and silicon along transect I.

Except in the eastern Kattegat traces of phosphate ($>0.05 \mu\text{M}$) were present in the surface water all over, with the lowest concentrations in the Kattegat and the highest in the Sound and Belt Sea. Also silicon ($>1 \mu\text{M}$) was observed in the surface water, except in the northern and eastern Kattegat. More than $12 \mu\text{M}$ were found in the surface in the Sound and Arkona Sea. In the bottom water phosphate concentrations above $0.8 \mu\text{M}$ were observed, except in the northern Kattegat and the Arkona Sea, while silicon concentrations between 8 and $26 \mu\text{M}$ were found at all stations (Fig. 6).

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

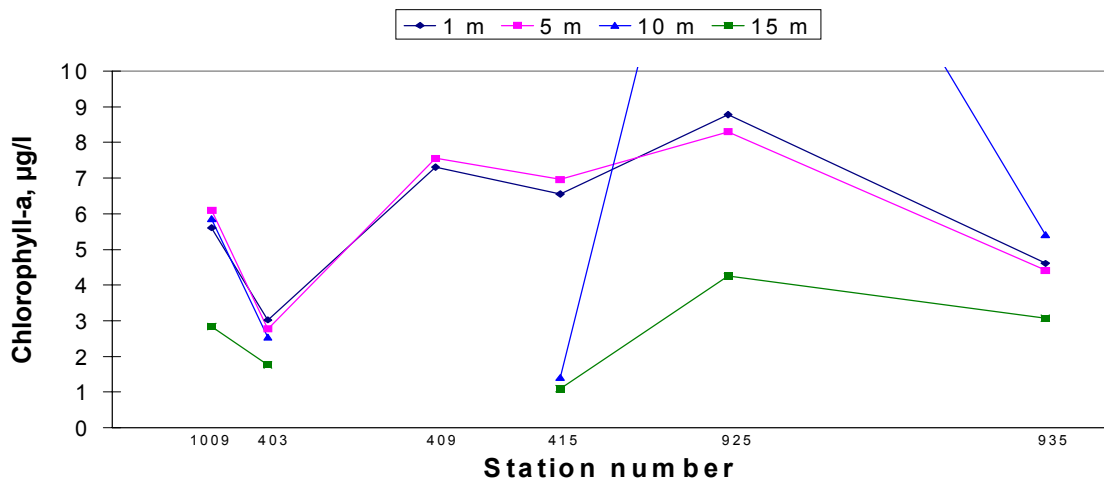


Figure 7. Chlorophyll-*a* concentrations in 1 m, 5 m, 10 m and 15 m depths along the transects I, II and III (see figure 1).

Chlorophyll-*a*

The mean chlorophyll-*a* concentration in the uppermost 15 m was relatively high for the time of the year and ranged from 2.0 µg/l in the Sound (St. 431) to 10.4 µg/l in the south-western Kattegat (St. 925). The highest concentration of 20.2 µg/l was found in a narrow sub-surface layer at 10 m depth at the last mentioned station. Otherwise, the chlorophyll was fairly evenly distributed in the uppermost 10 m, and somewhat lower at 15 and 20 m depth. (Fig. 7).

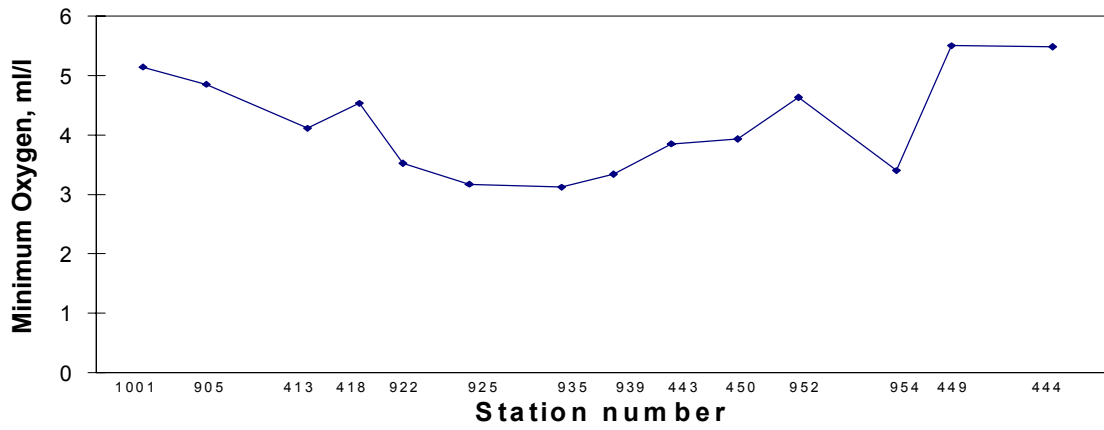
Oxygen

Since the cruise in October the minimum oxygen concentrations had increased, except in the northern and western Kattegat (St. 403, 409, 1007, 1008, 1009), Great Belt (St. 450, 939) and the Gedser Rev area (St. 449, 954). The lowest oxygen concentrations of 2.5 ml/l (42% saturation) was observed in the Sound (St. 431). In the southern-most Kattegat and the Great Belt the minimum concentrations were 3.1-3.9 ml/l (52-61%) (St. 921, 922, 925, 935, 939, 443, 450). Also at Gedser Rev (St. 954) the minimum oxygen concentration was still relatively low (3.4 ml/l, 52%) (Fig. 8).

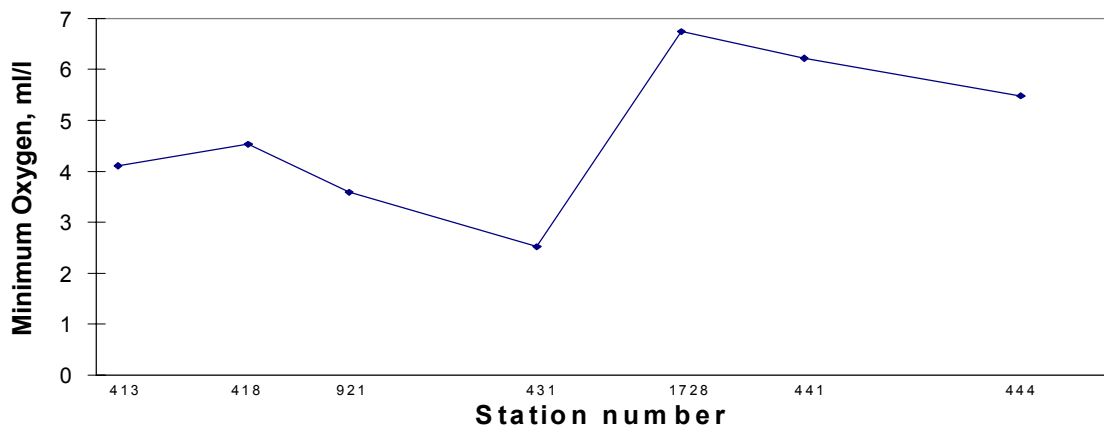
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Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

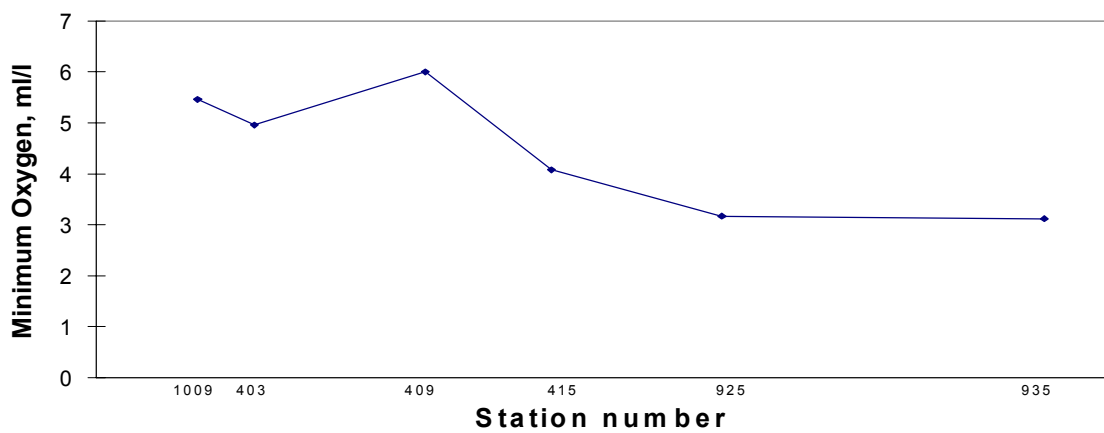


Figure 8. Minimum oxygen concentrations along the transects I, II and III. (see figure 1).