



r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 193

Time: 11 - 15 October 1999

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

Ministry of Environment and Energy
National Environmental Research Institute
Frederiksborgvej 399
DK-4000 Roskilde
Denmark
Tel.: +45 4630 1200 Fax: +45 4630 1114
www.dmu.dk

Data Sheet

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Author: Gunni Ærtebjerg
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Frederiksborgvej 399
P.O. Box 358
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Tel. +45 4630 1200
Fax +45 4630 1114
E-mail: dmu@dmu.dk
www.dmu.dk

Monitoring cruise with r/v Gunnar Thorson in the Sound, Kattegat, Belt Sea and Arkona Sea, 11-15 October 1999. Cruise no. 193.

Report: Gunni Ærtebjerg

Cruise leader: Jan Damgaard.

Participants: Dorete Jensen, Hanne Ferdinand, Peter Kofoed, Mette Petersen (trainee), Gry Christensen (trainee)

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

Summary

After an extremely warm and rather calm September strong wind from south to west in the first half of October significantly changed the hydrographic situation. Compared to long term monthly mean (1931-1960) for October both the temperature and salinity in the whole water column was higher, due to inflow of highly saline water from the Skagerrak to the Kattegat and mixing of the water column.

Nutrients were mixed from the bottom layer to the surface, and even nitrate was present in the surface water in the Sound and Belt Sea. This supported an autumn phytoplankton bloom in most areas. The highest mean chlorophyll concentrations (7.8-10.8 µg/l) in the upper 15 m were found in the southern Belt Sea.

The oxygen situation had improved significantly, except in the Sound and south-western Kattegat. The lowest oxygen concentrations of 1.9-2.1 ml/l (30-32%) were observed in the Sound. In the southern Kattegat the minimum concentrations were 2.7-3.2 ml/l (45-56%), and in the Kiel Bight and Mecklenburg Bight 2.6-3.2 ml/l. In the Great Belt the minimum concentration increased from 2.9 ml/l (48%) in the north to 5.7 ml/l (91%) in the south.

Compared to October last year the minimum oxygen concentrations this year were lower in the southern and eastern Kattegat, northern Great Belt and central Arkona Sea. Compared to mean for October in the 1980s, when oxygen depletion often occurred, the minimum oxygen concentrations this year were lower in the Sound, north-eastern Kattegat and in the northern to central Great Belt.

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 observed in the Sound, south-western Kattegat and Kiel Bight. Serious oxygen depletion was no longer observed in the areas investigated.

In figure 9 are shown the stations visited by Danish counties and NERI within the first three weeks of October 1999, and where oxygen depletion or serious oxygen depletion was observed.

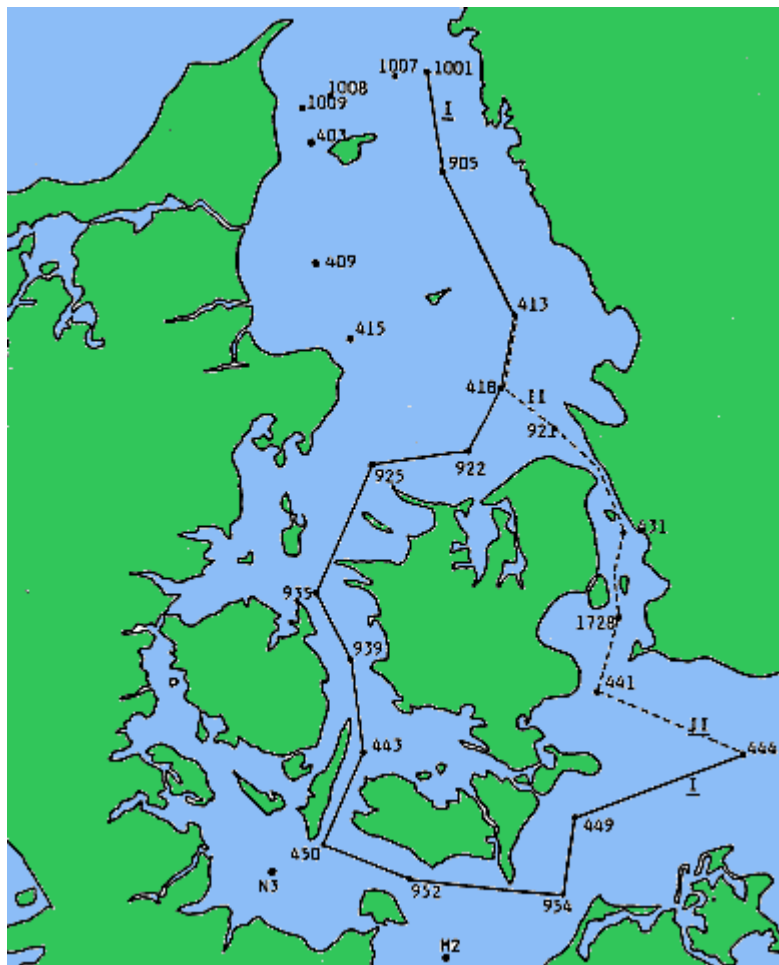


Figure 1. Monitoring cruise with r/v Gunnar Thorson 11-15 October 1999. Cruise no. 193.
The 2 lines I and II show the transects used in the following figures:
Transect I: Kattegat NE - E - S - Great Belt - Fehmarn Belt - Arkona Sea
Transect II: Kattegat SE - The Sound - Arkona Sea.

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

After an extremely warm and rather calm September the weather changed, and relatively strong winds from south, south-west and west prevailed in the beginning of October and during the cruise (Danish Meteorological Institute).

Hydrography

The surface temperature (1 m depth) had decreased 2-5°C since the cruise in September, and ranged from 12.6-12.8°C in the Sound (St.431, 921) to above 14°C in the northern Kattegat (Fig. 2).

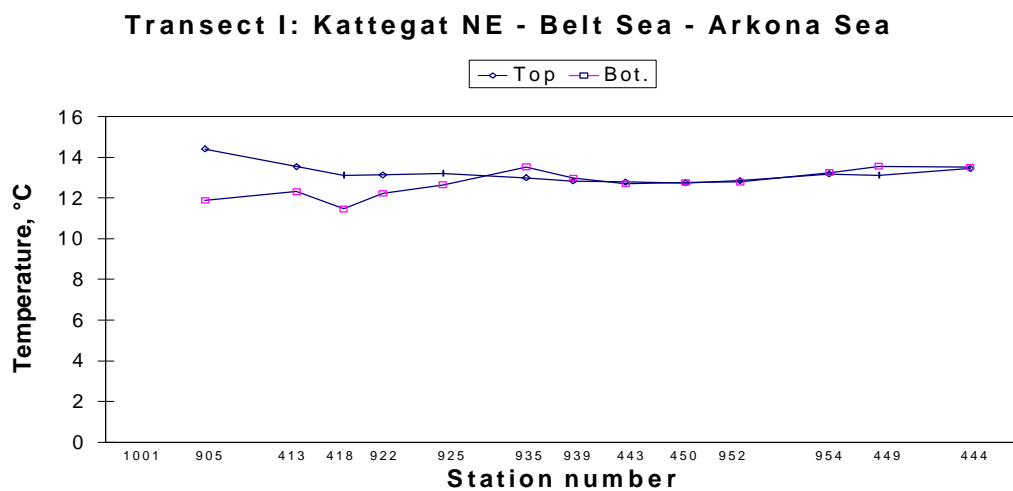


Figure 2. Surface (1 m) and near bottom temperature along transect I (see figure 1).

The bottom water temperature had generally increased, except in the shallow western Kattegat and western Arkona Sea (St. 409, 441), and ranged from 8.0-9.9°C in the Sound (St.431, 921) to above 14 in the north-western Kattegat (St. 403) (Fig. 2). The temperature difference between surface and bottom was 0-4°C, generally with the bottom water warmer than the surface water, except in the Sound, southern and eastern Kattegat.

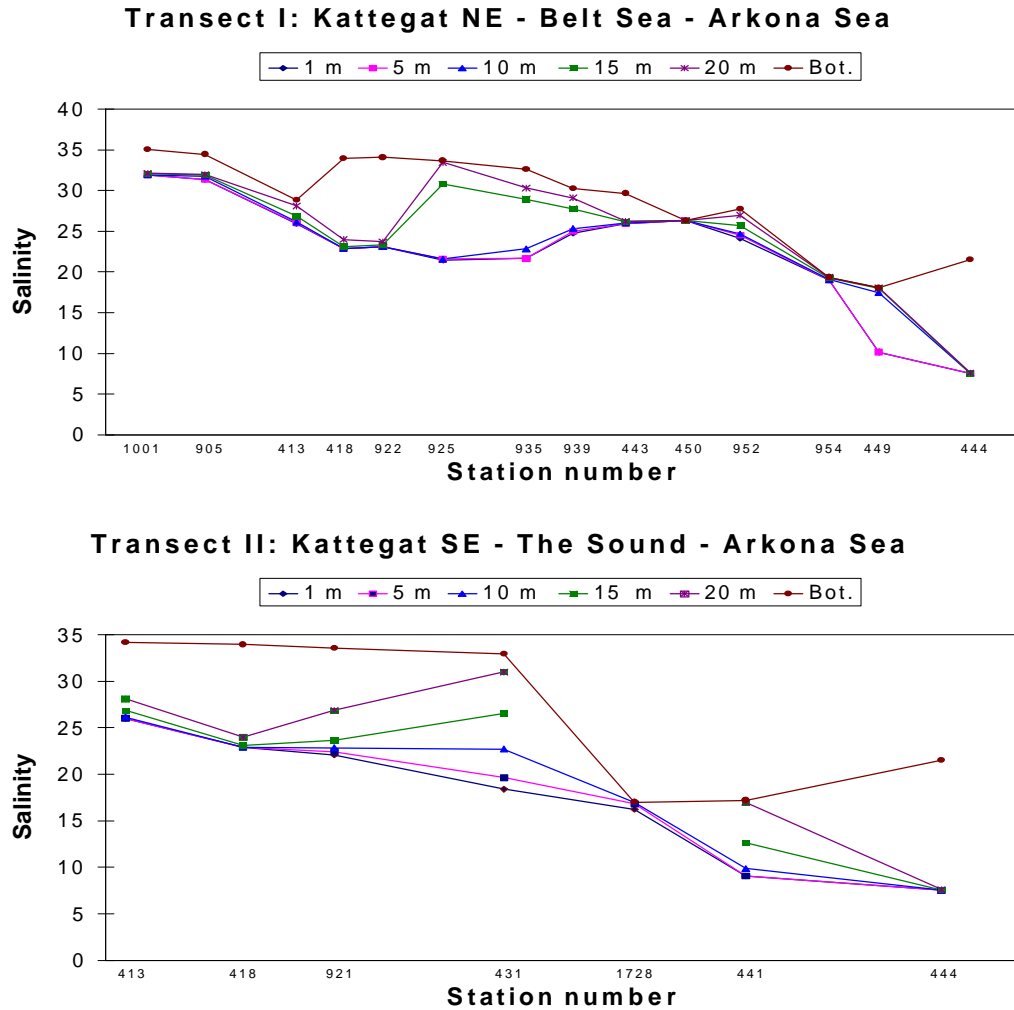


Figure 3. Salinity in 1 m, 5 m, 10 m, 15 m, 20 m depth and near bottom along the transects I and II (see figure 1).

The surface salinity had since September increased significantly, except in the shallow western Kattegat (St. 409, 415), and ranged from 7.5-10.1 in the Arkona Sea (St. 441, 444, 449) to 31.9-32.8 in the northern Kattegat. The bottom water salinity ranged from 17.2-21.5 in the Arkona Sea (St. 441, 444, 449, 954) to 34.5-35.0 in the north-eastern Kattegat (St. 905, 1001) (Fig. 3). The salinity stratification had decreased significantly and was absent in the north-western Kattegat (St. 403, 1007, 1008, 1009), southern Great Belt (St. 450) and at Gedser Rev (St. 449, 954). The strongest stratification (10.5-14.5 psu) was observed in the Sound, southern Kattegat and central Arkona Sea. The halocline was situated deeper than 20 m depth in the Kattegat, and between 10 and 15 m depth in the Great Belt. In the Sound and Fehmarn Belt the salinity gradually increased with depth (Fig. 3).

Compared to long term monthly mean (1931-1960) for October both the temperature and salinity during this cruise was higher due to inflow from the Skagerrak and mixing of the water column, except for lower bottom water salinity east of Anholt in the eastern Kattegat.

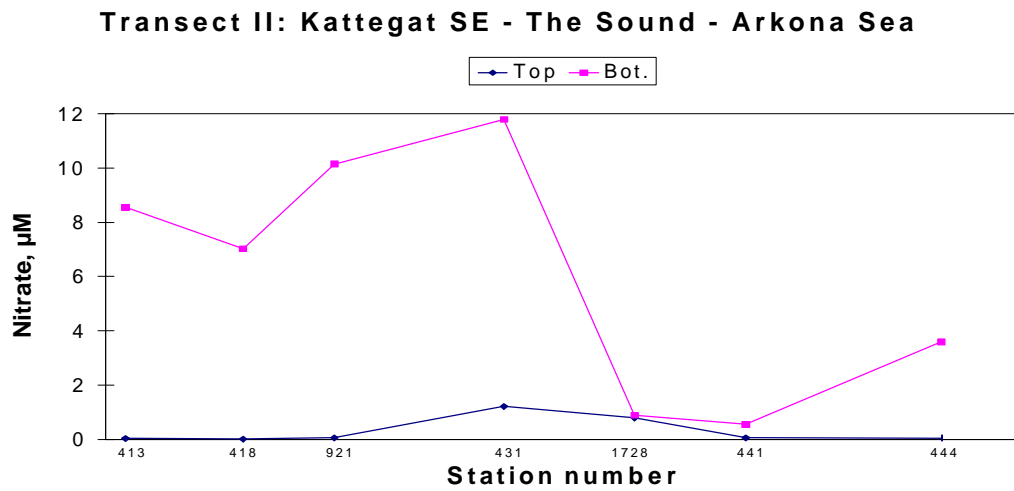
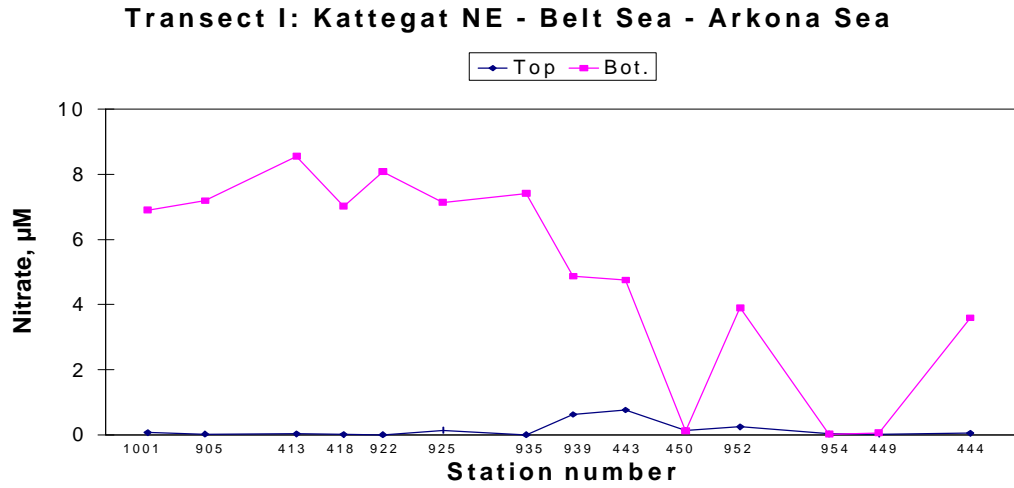


Figure 4. Surface and near bottom concentrations of nitrate along the transects I and II.

Nutrients

Nitrate, nitrite and partly ammonium was present in the surface layer in the Sound, Belt Sea and western Kattegat due to mixing with nutrient rich bottom water. Close to the bottom the nitrate concentrations were high (>10 µmol/l) in the Sound, and relatively high (>6 µmol/l) in the deeper parts of the Kattegat (Fig. 4 and 5).

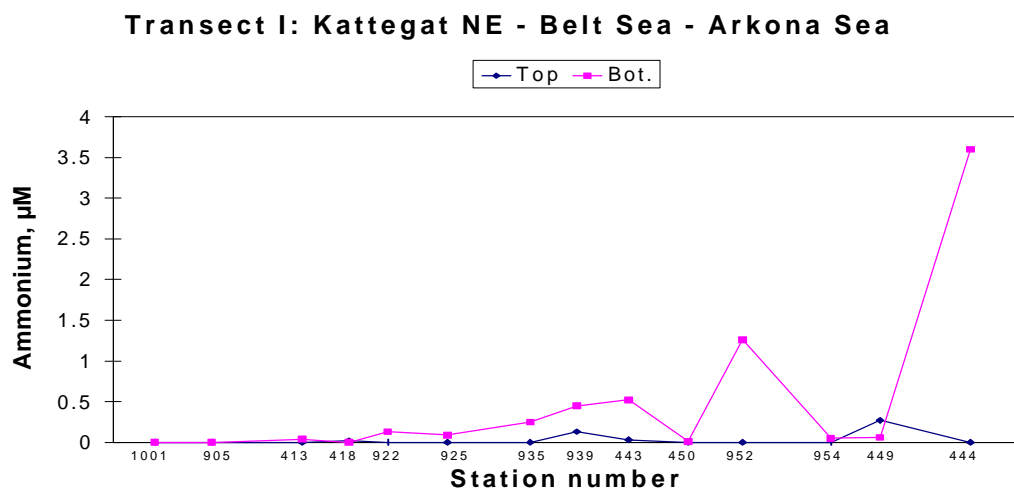
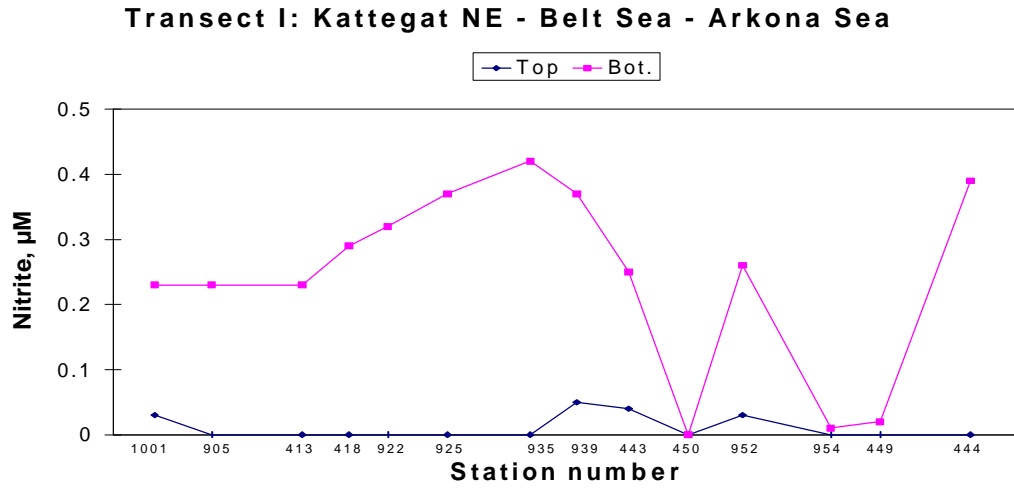
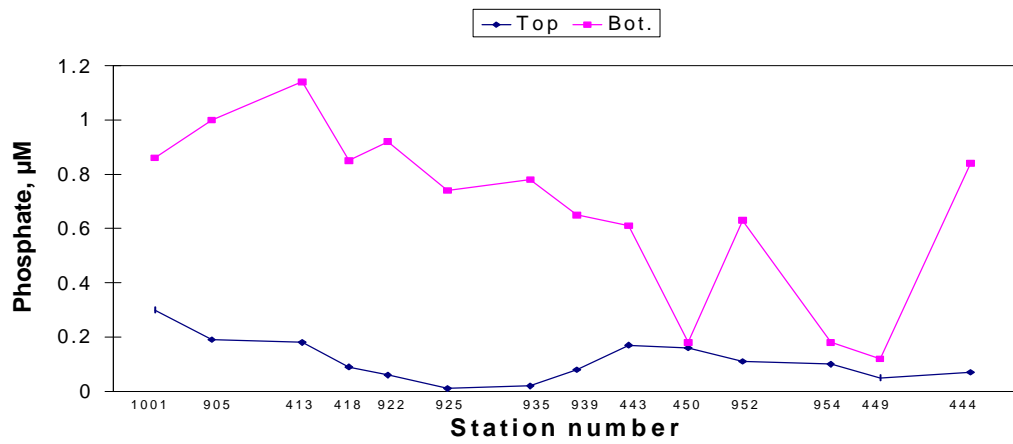


Figure 5. Surface and near bottom concentrations of nitrite and ammonium along transect I.

In the bottom water relatively high concentrations of nitrite ($>0.2 \mu\text{mol/l}$) were found in most areas, except where the water column was well mixed, that is in the north-western Kattegat (St. 403, 1007, 1008, 1009), southern Great Belt (St. 450) and the Gedser Rev area (St. 449, 954). High concentrations of ammonium were observed in the Sound, Fehmarn Belt and especially in the central Arkona Sea (Fig. 5).

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect I: Kattegat NE - Belt Sea - Arkona Sea

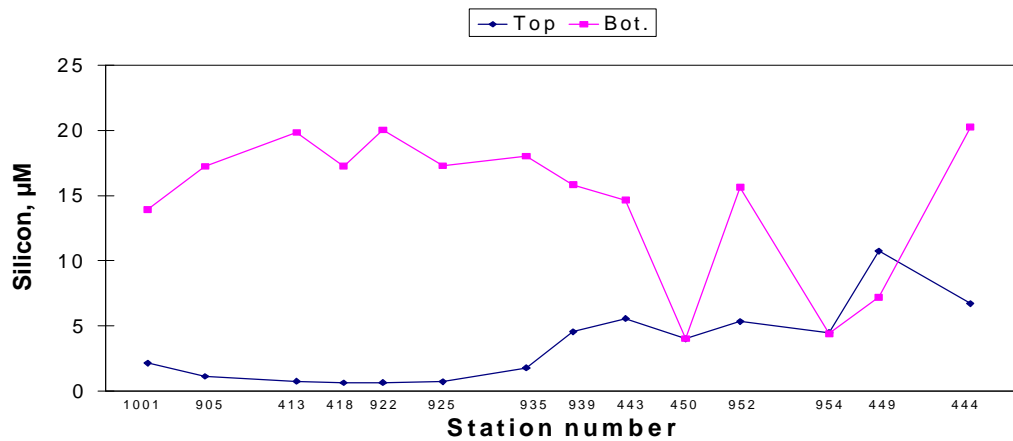


Figure 6. Surface and near bottom concentrations of phosphate and silicon along transect I.

Phosphate and silicon were present in the surface water in all areas with the lowest concentrations in the southern Kattegat. In the bottom water the phosphate and silicon concentrations were relatively high, except where the water column was well mixed (Fig. 6).

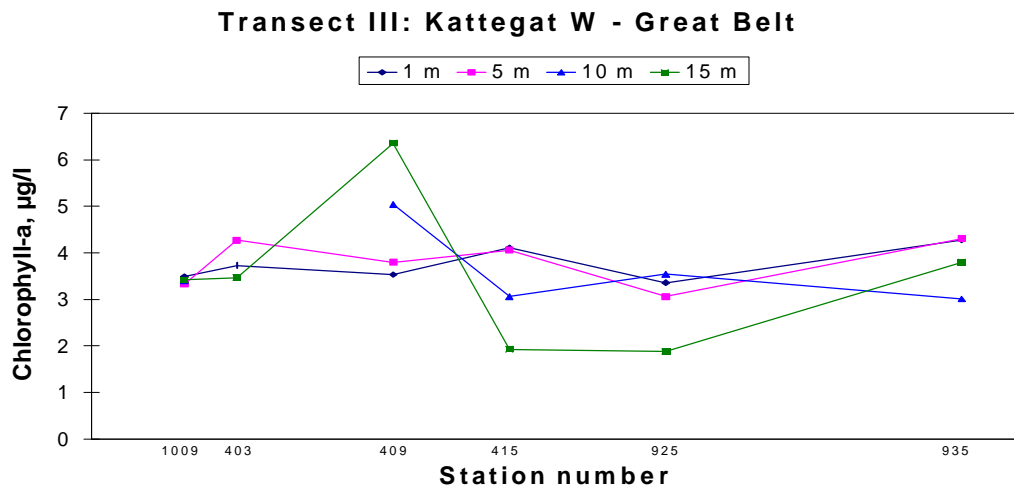
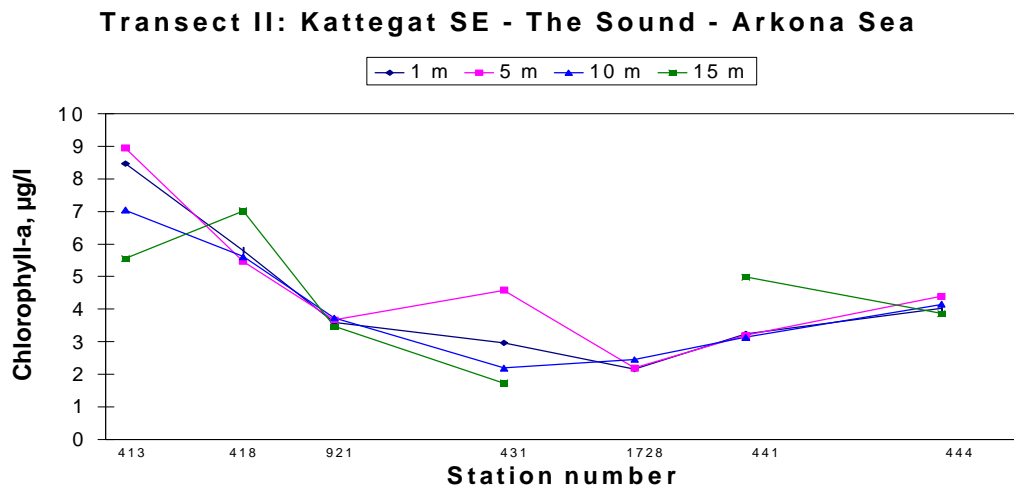
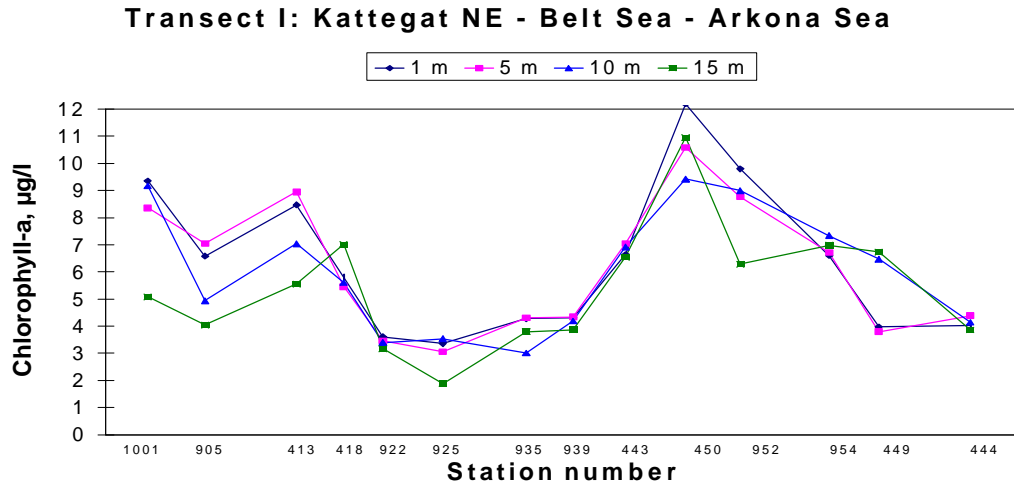


Figure 7. Chlorophyll-*a* concentrations in 1 m, 5 m, 10 m and 15 m depths along the transects I, II and III (see figure 1).

Chlorophyll-*a*

The mean chlorophyll-*a* concentration in the uppermost 15 m was highest (6.9-10.8 µg/l) in the southern Belt Sea (St. 450, 952, 954, M2) and north-eastern Kattegat (St. 1001, 8.0 µg/l). In the other areas the mean concentrations varied from 2.3-2.9 µg/l in the Sound (St. 431, 921) to 5.7-7.5 µg/l in the eastern Kattegat (St. 418, 413, 905). The chlorophyll was relatively evenly distributed in the uppermost 15 m, except in the western Kattegat (St. 409), where the highest concentration of 6,4 µg/l was found at 13 m depth close to the bottom. The generally high concentrations indicate the presence of an autumn phytoplankton bloom (Fig. 7).

Oxygen

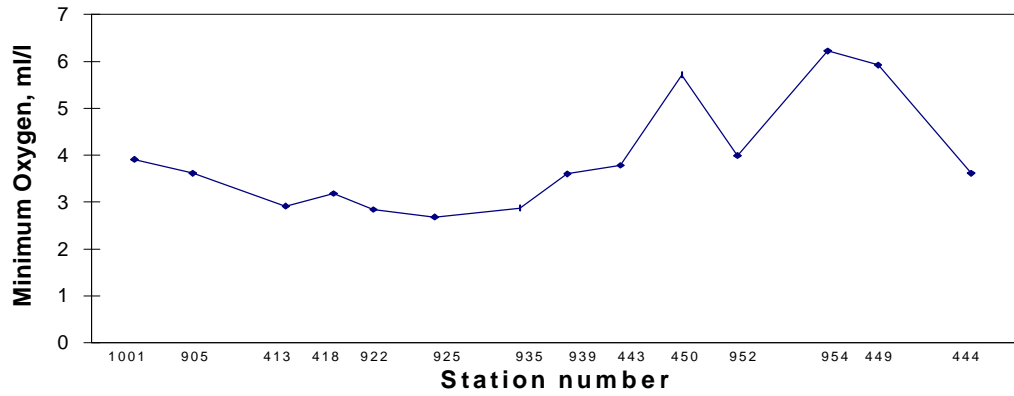
Since the cruise in September the minimum oxygen concentrations had increased, except in the Sound (St. 431) and south-western Kattegat (St. 415, 925). The lowest oxygen concentrations of 1.9-2.1 ml/l (30-32% saturation) were observed in the Sound (St. 431, 921). In the southern Kattegat the minimum concentrations were 2.7-3.2 ml/l (45-56%) (St. 413, 415, 418, 922, 925), and in the Kiel Bight and Mecklenburg Bight 2.6-3.2 ml/l (St. N3, M2). In the Great Belt the minimum concentration increased from 2.9 ml/l (48%) in the north (St. 935) to 5.7 ml/l (91%) in the south (St. 450) (Fig. 8).

Compared to October last year the minimum oxygen concentrations this year were lower in the southern and eastern Kattegat, northern Great Belt and central Arkona Sea. Compared to mean for October in the 1980s, when oxygen depletion often occurred, the minimum oxygen concentrations this year were lower in the Sound, north-eastern Kattegat and in the northern to central Great Belt.

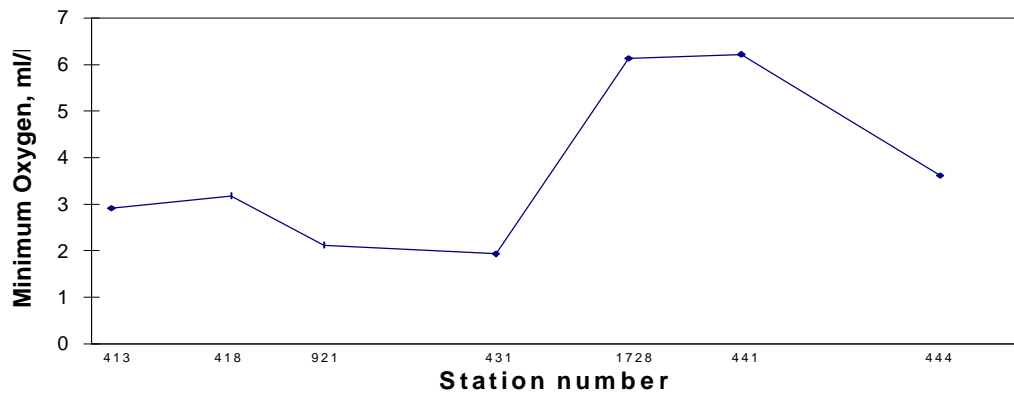
Oxygen depletion is in Denmark defined as below 2.8 ml/l (4 mg/l), and serious oxygen depletion as below 1.4 ml/l (2 mg/l). From these definitions oxygen depletion was during the cruise observed in the Sound (St. 431, 921), south-western Kattegat (St. 925) and Kiel Bight (St. N3). Serious oxygen depletion was no longer observed in the areas investigated.

In figure 9 are shown the stations visited by Danish counties and NERI within the first three weeks of October 1999, and where oxygen depletion or serious oxygen depletion was observed.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

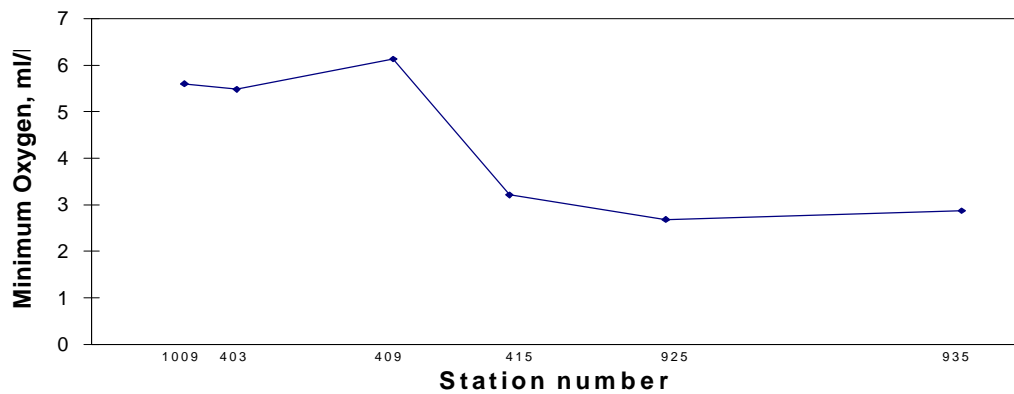
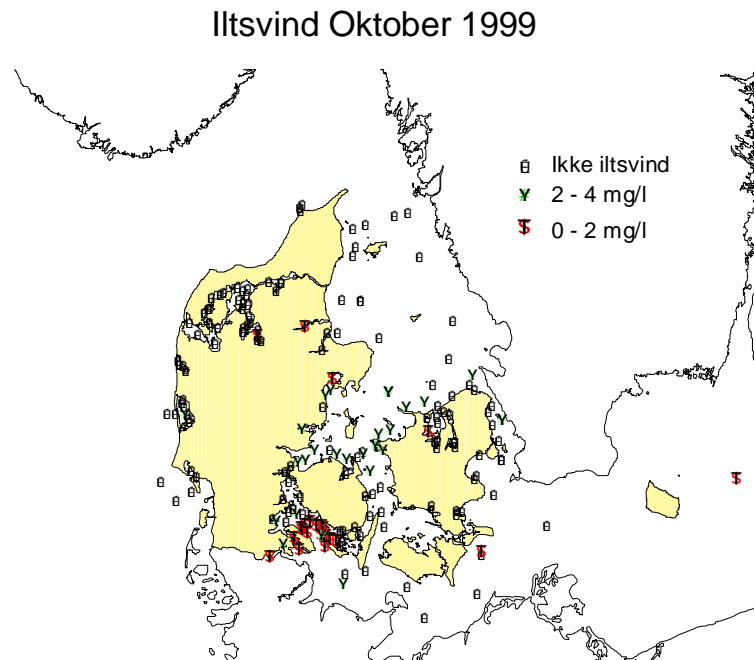


Figure 8. Minimum oxygen concentrations along the transects I, II and III. (see figure 1).

Figure 9. Stations visited by Danish counties and NERI within the first three weeks of October 1999, and where oxygen depletion (<4 mg/l) and serious oxygen depletion (<2 mg/l) were observed.



Kortet er udarbejdet af DMU på grundlag af data fra amterne og DMU