



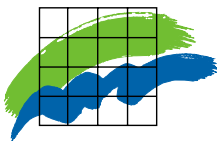
r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 204

Time: 10 - 14 September 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, 10-14 September 2001.

Cruise no. 204.

Report: Gunni Ærtebjerg

Cruise leader: Jan Damgaard

Participants: Lars Renvald, Hanne Ferdinand, Dorete Jensen, Claus Heinrich (technician trainee).

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

Summary

The salinity stratification was strong in the Sound, southern Kattegat and northern Great Belt, but weak in the southern Belt Sea due to intense mixing since the cruise in August. Compared to long term monthly means the temperature was 0.2-2.8°C higher than normal, except for lower bottom water temperature east of Anholt. Generally, the salinity was higher than normal, except in Aalborg Bight and in the bottom water of the central and southern Great Belt and southern Belt Sea.

In the surface traces of nitrate were observed only in the Fehmarn Belt – Gedser Rev area. Phosphate was generally not present in the surface water in Kattegat, but only in the Sound, Belt Sea and Arkona Sea. The mean chlorophyll concentration in the uppermost 10 m varied from 1.3-2.1 µg/l in most of Kattegat to 4.6 µg/l in the north-western Kattegat and 7.4 µg/l in Mecklenburg Bight. The chlorophyll was generally homogeneously distributed in the uppermost 15 m.

Since the cruise in August the minimum oxygen concentration had decreased, except in the southern Belt Sea and Gedser Rev area. In the Sound, southern Kattegat and Arkona Sea the decrease was as high as 2.0-2.8 ml/l. The lowest oxygen concentration of 0.7 ml/l was found in the central Arkona Sea. In the Sound, southern Kattegat and northern Great Belt 2.2-2.8 ml/l was observed. In the southern Belt Sea and Gedser Rev area the minimum oxygen concentration had increased to 3.3-5.9 ml/l.

The reason for the large decrease in oxygen concentration, especially in the Sound and southern Kattegat, is believed to be the bloom of cyanobacteria in July in the Arkona Sea, southern Belt Sea, Sound and south-eastern Kattegat. In the beginning of August shortly after the bloom chlorophyll concentrations of 6-10 µg/l and 2-6 µg/l were observed in the bottom water in the Sound and south-eastern Kattegat, respectively.

Compared to September last year, when wide spread oxygen depletion occurred, the minimum oxygen concentration this year is higher, except in the northern Kattegat.

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 central Arkona Sea, and oxygen depletion occurred in the Sound and southern 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 September 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 September including during the cruise wind of varying speed from westerly directions prevailed. The last two weeks of the month the wind came from easterly directions.

Hydrography

The surface temperature (1 m depth) varied between 15.1 and 16.4°C in the whole area investigated. The bottom water temperature ranged from 7.9-10.8°C in the eastern Kattegat (St. 1001, 905, 413, 418, 921) to 14.4-15.0°C in the north-western Kattegat (St. 403, 1007, 1008, 1009) and 15.4°C at Gedser Rev (St. 954) (*figure 2*).

The surface salinity ranged from 7.6-9.7 in the Arkona Sea (St. 441, 444, 449) to 29.5-30.4 in the north-eastern Kattegat (St. 1001, 1007). The bottom water salinity ranged from 15.9 at Gedser Rev (St. 954, 449) to 34.0-34.6 in the north-eastern Kattegat (St. 905, 1001) (*figure 3*). The salinity stratification was strong (10.3-19.5 psu) in the Sound, southern Kattegat and northern Great Belt.

Compared to long term monthly means (Lightship observations 1931-1960) for September the temperature was in the whole water column 0.2-2.8°C higher than normal, except for 1.8°C lower bottom water temperature east of Anholt (St. 413). Generally, the salinity during the present cruise was higher than normal, except in Aalborg Bight (St. 409) and in the bottom water of the central and southern Great Belt and southern Belt Sea.

Nutrients

In the surface traces of nitrate (0.2-0.3 µmol/l) were observed only in the Fehmarn Belt – Gedser Rev area (St. 952, 954, 449). Also in the bottom water the nitrate concentrations were generally very low, except in the northern Kattegat (St. 403, 1009, 1001, 905, 413) and deeper Arkona Sea (St. 444) (*figure 4*).

Nitrite concentrations in the surface were very low, but somewhat higher at the bottom, especially in the northern Kattegat (*figure 5a*). Ammonium was present in the surface in the Sound, Belt Sea and Arkona Sea areas, and in high concentrations (2.0-5.9 µmol/l) in the bottom water in the north-eastern Kattegat, Fehmarn Belt and central Arkona Sea (*figure 5b*).

Phosphate was generally not present in the surface water in Kattegat, but only in the Sound, Belt Sea and Arkona Sea (0.1-0.4 $\mu\text{mol/l}$). In the bottom water above 1.0 $\mu\text{mol/l}$ phosphate was observed in Fehmarn Belt and Arkona Sea (*figure 6a*). Silicate above 1 $\mu\text{mol/l}$ was present in the whole water column in all areas (*figure 6b*).

Chlorophyll-a

The mean chlorophyll concentration in the uppermost 10 m varied from 1.3-2.1 $\mu\text{g/l}$ in most of Kattegat to 4.6 $\mu\text{g/l}$ in the north-western Kattegat (St. 1009) and 7.4 $\mu\text{g/l}$ in Mecklenburg Bight (St. M2). The chlorophyll was generally homogeneously distributed in the uppermost 15 m of the water column, except in the north-western Kattegat, southern Belt Sea and Arkona Sea. A significant subsurface maximum of 7.5-9.1 $\mu\text{g/l}$ was observed in the north-western Kattegat (St. 1009) in 7.5-15 m depth. In the southern Great Belt (St. 443) 8.0 $\mu\text{g/l}$ and in Mecklenburg Bight (St. M2) 8.7 $\mu\text{g/l}$ was observed at the surface (*figure 7*).

Oxygen

Since the cruise in August the minimum oxygen concentration had decreased, except in the southern Belt Sea and Gedser Rev area. In the Sound, southern Kattegat and Arkona Sea the decrease was as high as 2.0-2.8 ml/l. The lowest oxygen concentration of 0.7 ml/l was found in the central Arkona Sea (St. 444). In the Sound, southern Kattegat and northern Great Belt 2.2-2.8 ml/l was observed. In the southern Belt Sea and Gedser Rev area the minimum oxygen concentration had increased to 3.3-5.9 ml/l (*figure 8*).

The reason for the large decrease in oxygen concentration, especially in the Sound and southern Kattegat, is believed to be the bloom of cyanobacteria in July in the Arkona Sea, southern Belt Sea, Sound and south-eastern Kattegat. In the beginning of August, shortly after the bloom, chlorophyll concentrations of 6-10 $\mu\text{g/l}$ and 2-6 $\mu\text{g/l}$ were observed in the bottom water in the Sound and south-eastern Kattegat, respectively.

Compared to September last year, when wide spread oxygen depletion occurred, the minimum oxygen concentrations this year are higher, except in the northern Kattegat.

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 central Arkona Sea, and oxygen depletion occurred in the Sound and southern 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 September 2001, and where oxygen depletion or serious oxygen depletion was observed.

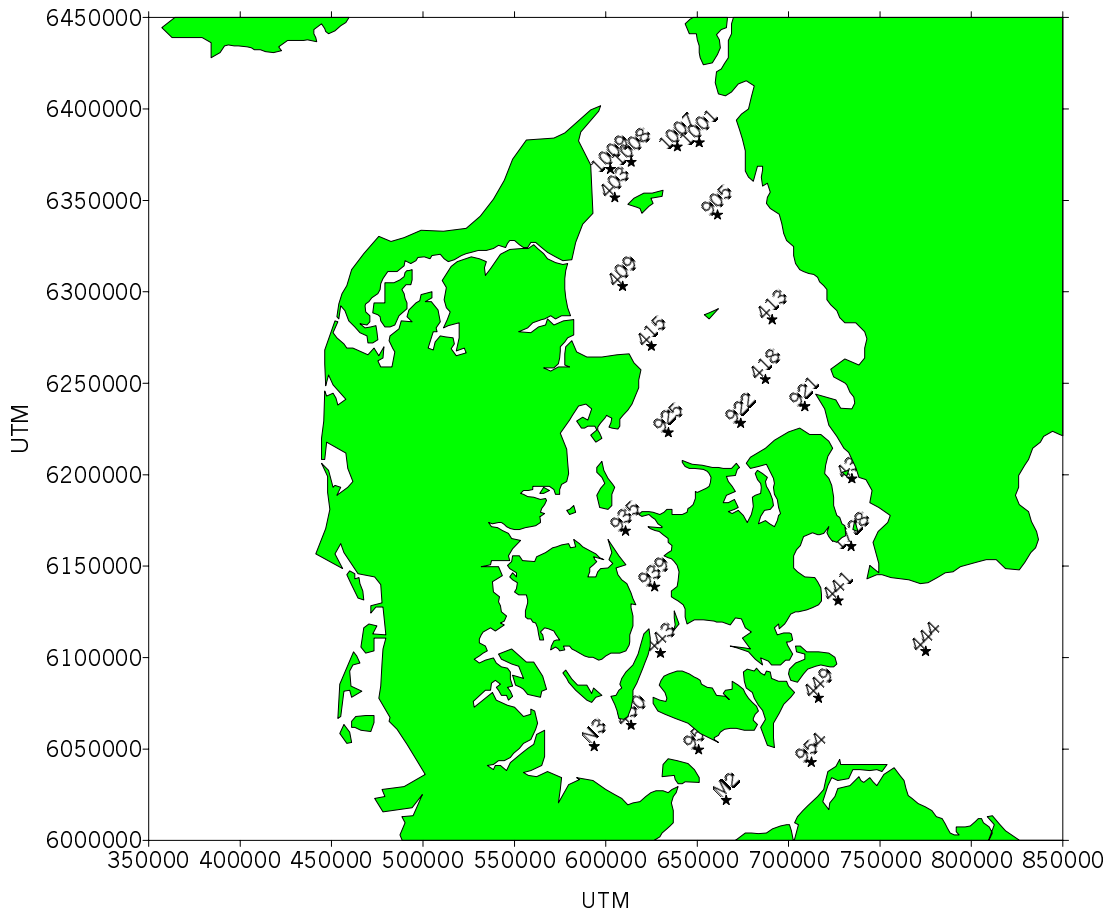


Figure 1. Stations of the monitoring cruise with r/v Gunnar Thorson 10-14 September 2001 in the Sound, Kattgat, Belt Sea and Arkona Sea. Gunnar Thorson cruise no. 204.

Transect I: Kattgat NE - Belt Sea - Arkona Sea

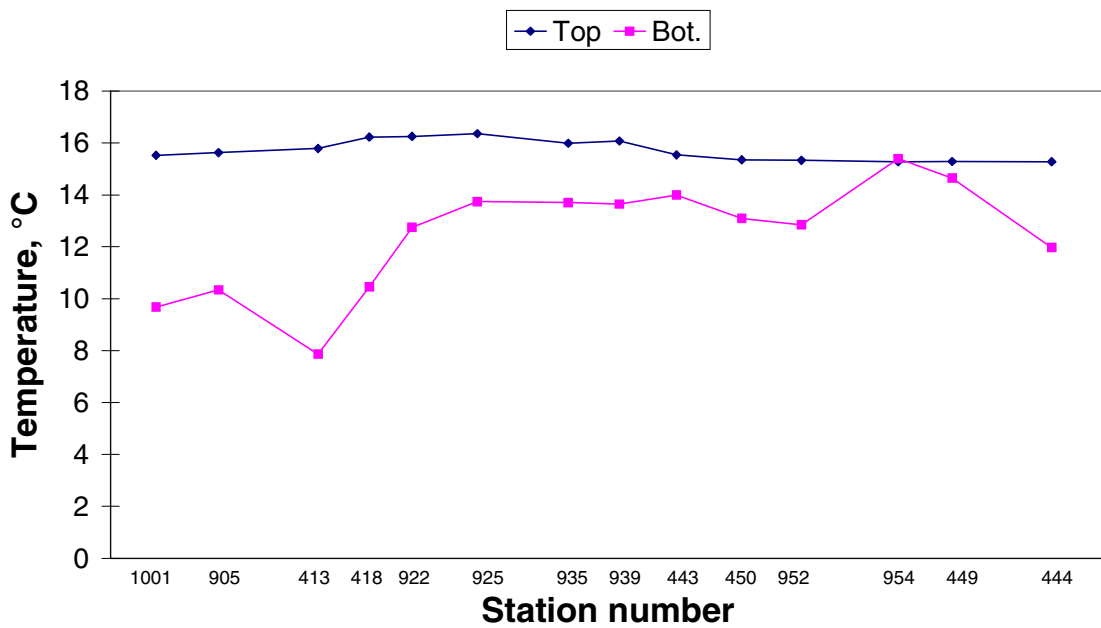
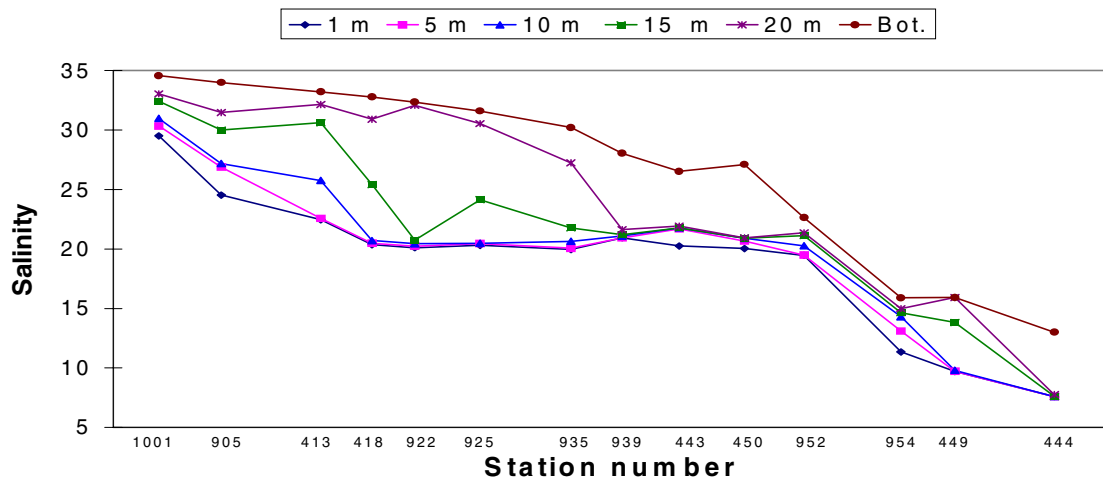
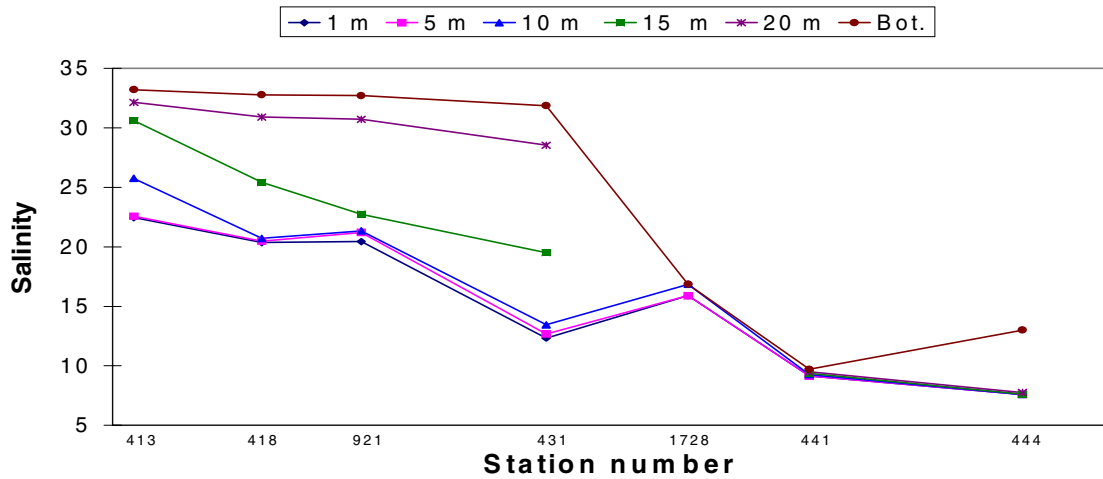


Figure 2. Surface and near bottom temperature along transect I from the north-eastern Kattgat through the Belt Sea to the Arkona Sea.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

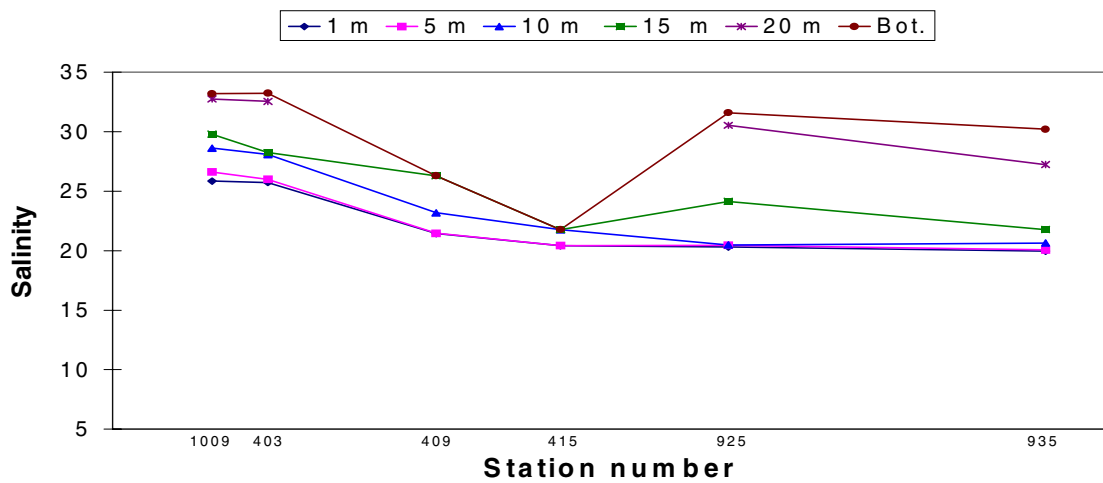
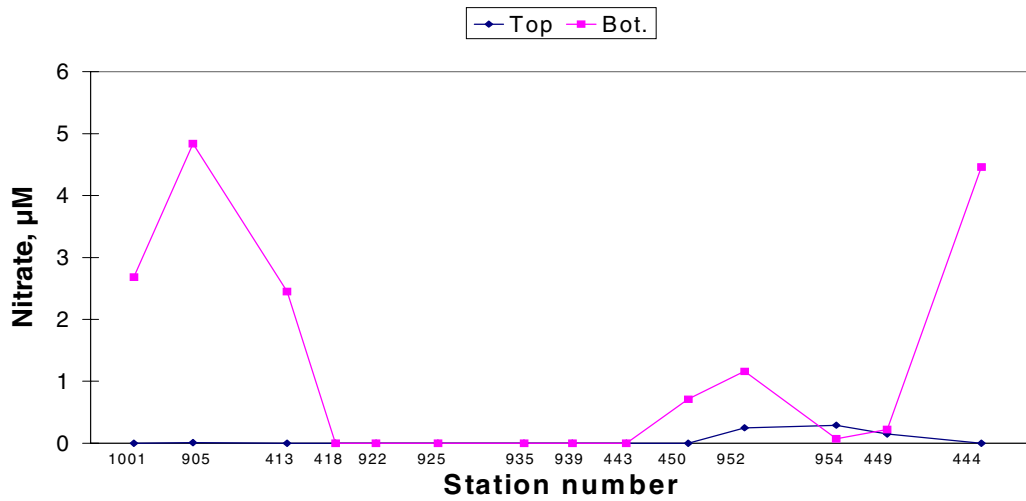
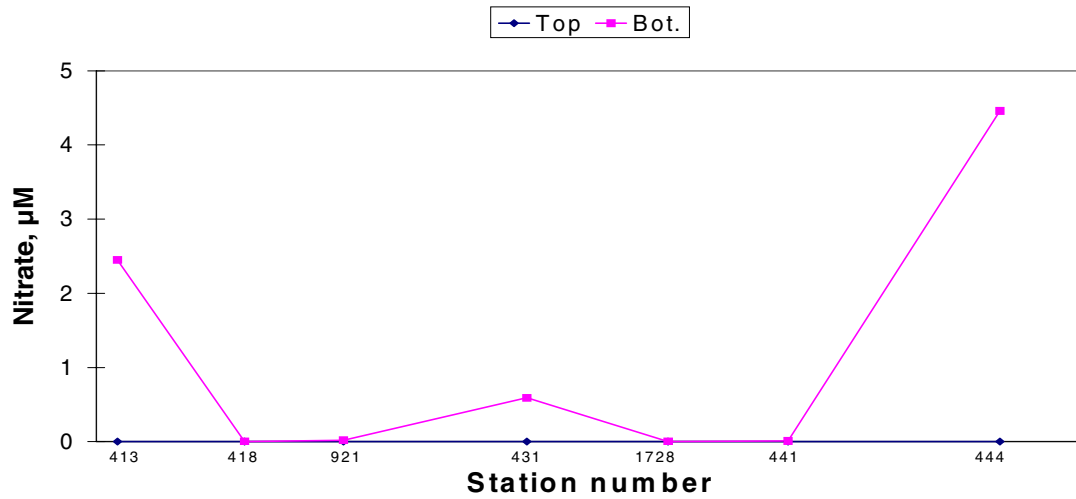


Figure 3. Salinity in 1 m, 5 m, 10 m, 15 m, 20 m depth and near bottom along transect I, II and III from the Kattegat through the Belt Sea and Sound to the Arkona Sea and in the western Kattegat to the Great Belt, respectively.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

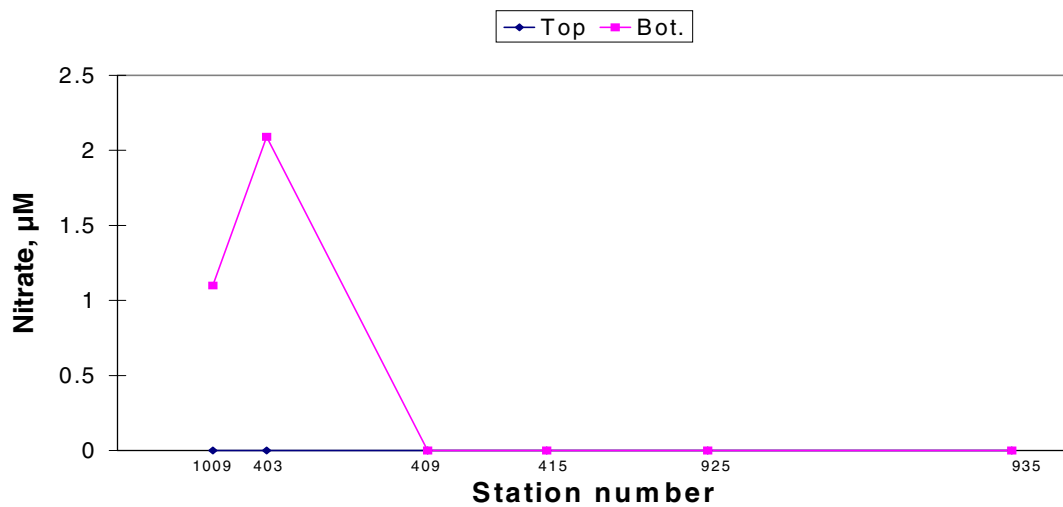
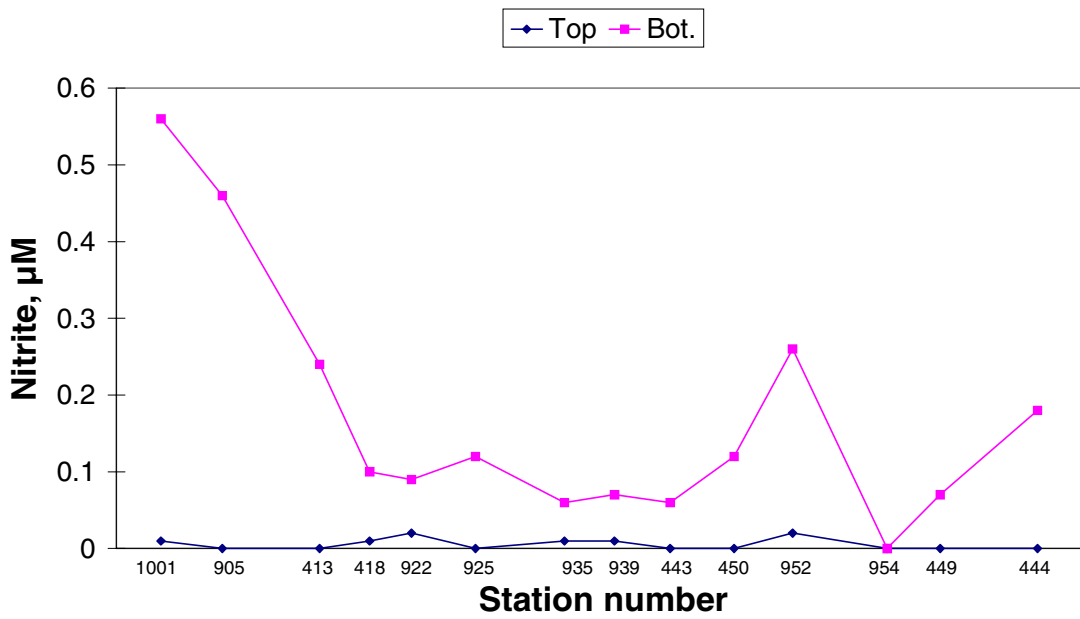


Figure 4. Surface and near bottom concentrations of nitrate along transect I, II and III

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect I: Kattegat NE - Belt Sea - Arkona Sea

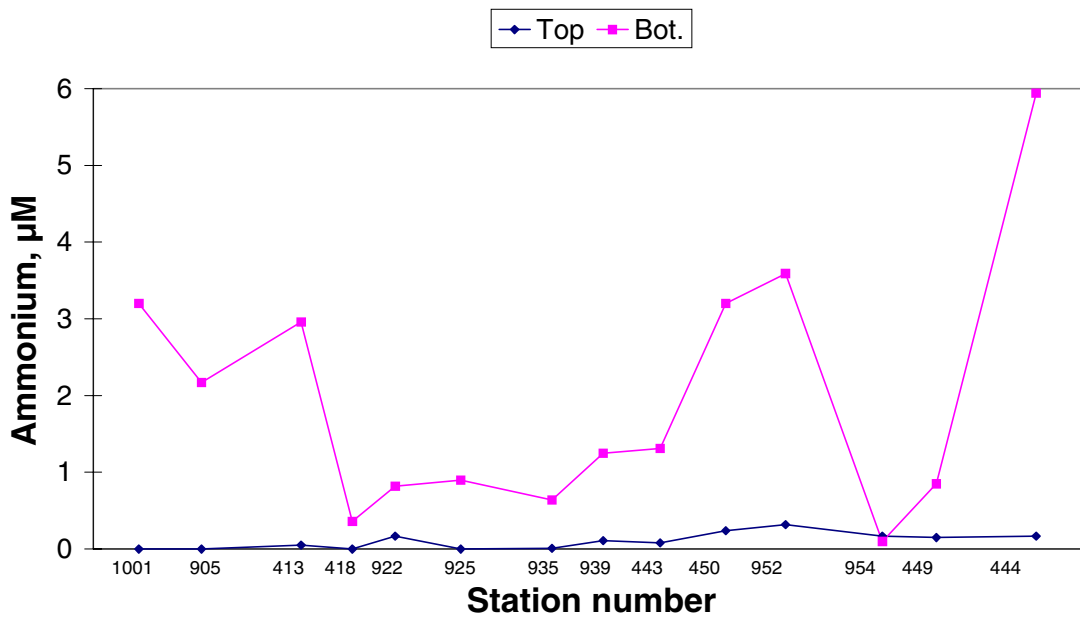
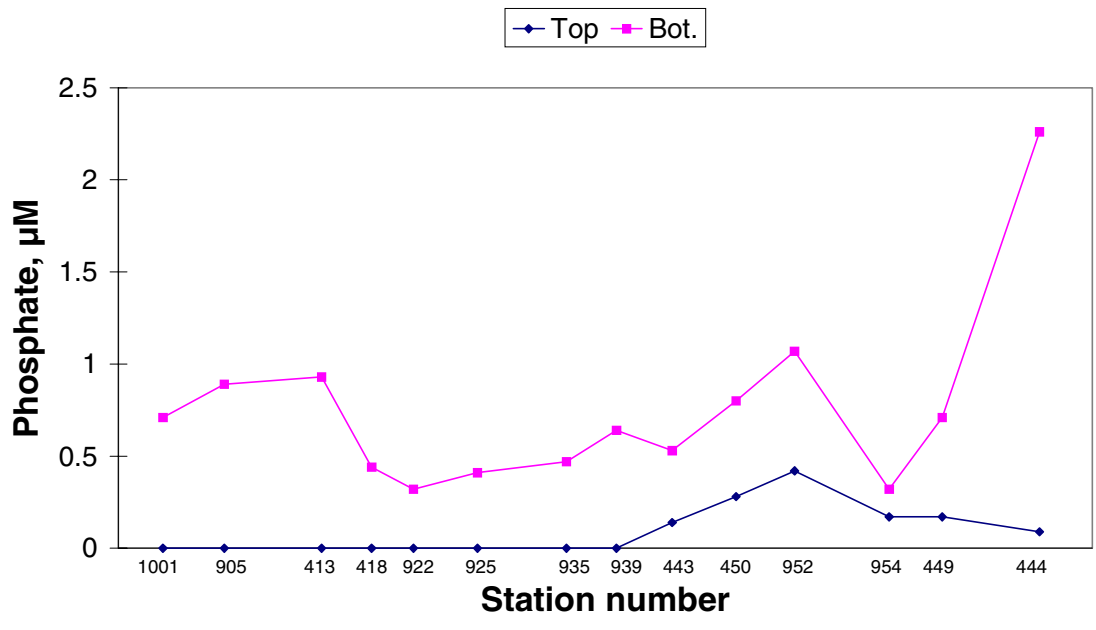


Figure 5. Surface and near bottom concentrations of nitrite and ammonium along transect I.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect I: Kattegat NE - Belt Sea - Arkona Sea

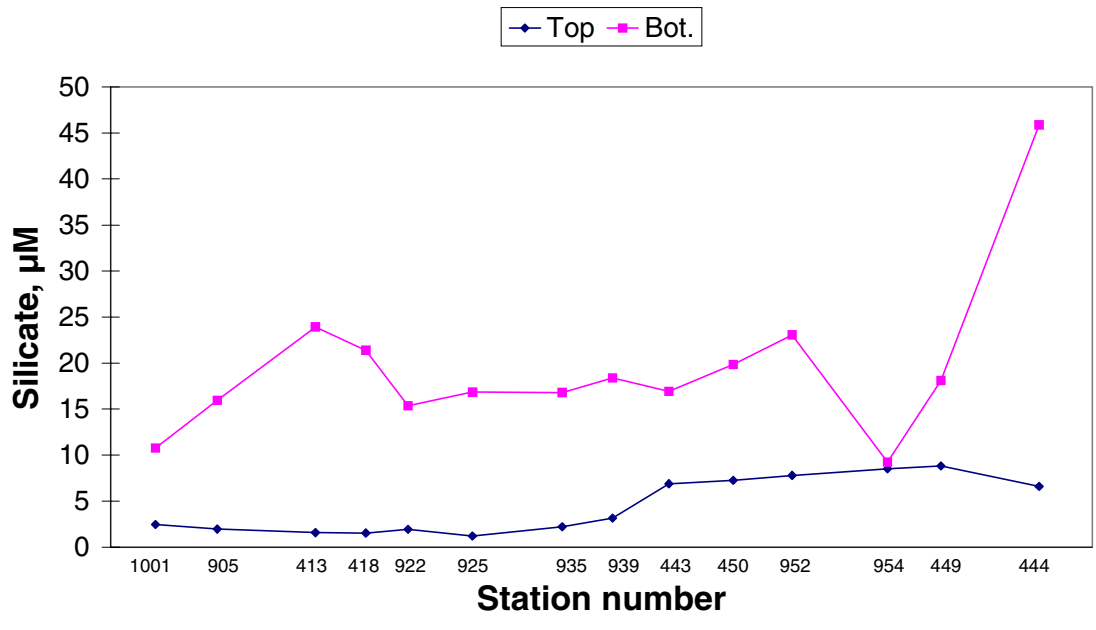
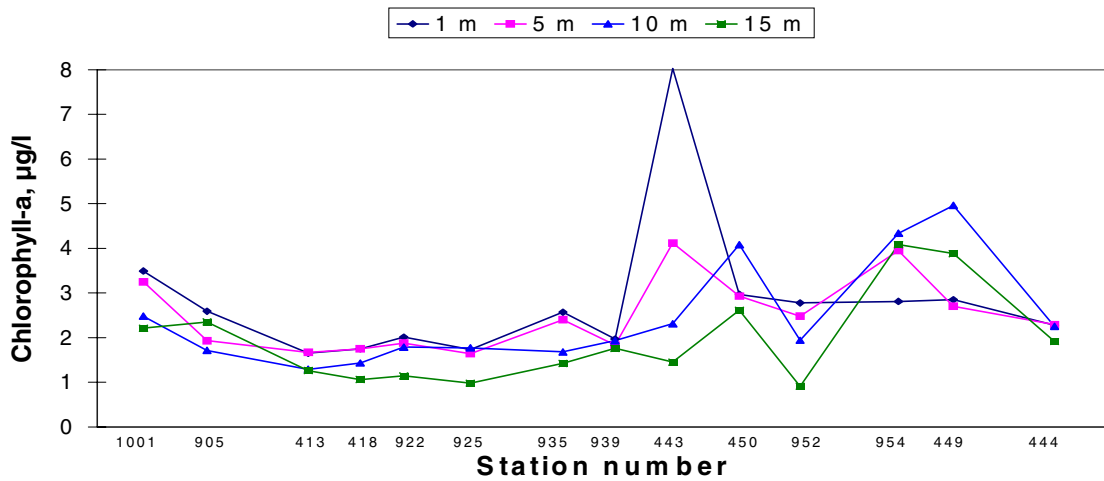
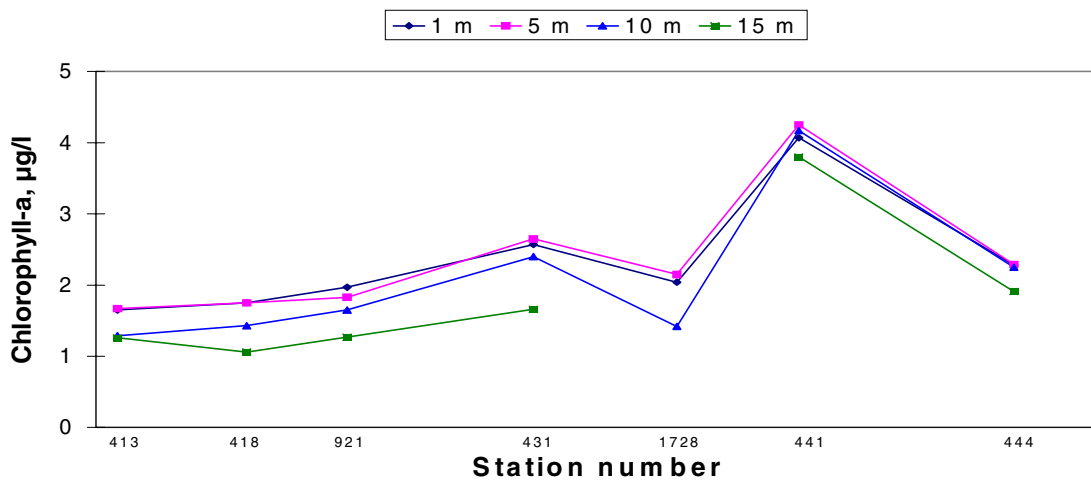


Figure 6. Surface and near bottom concentrations of phosphate and silicate along transect I.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

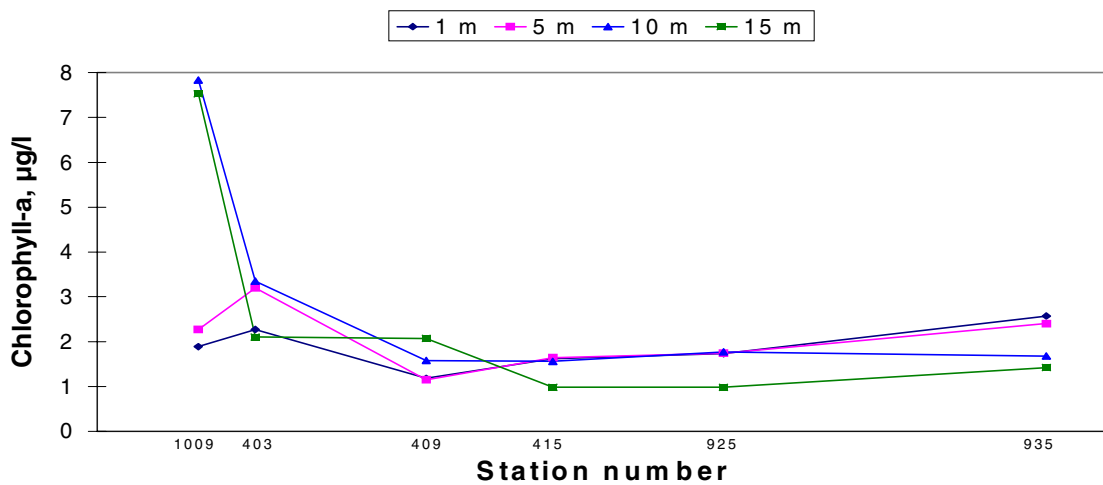
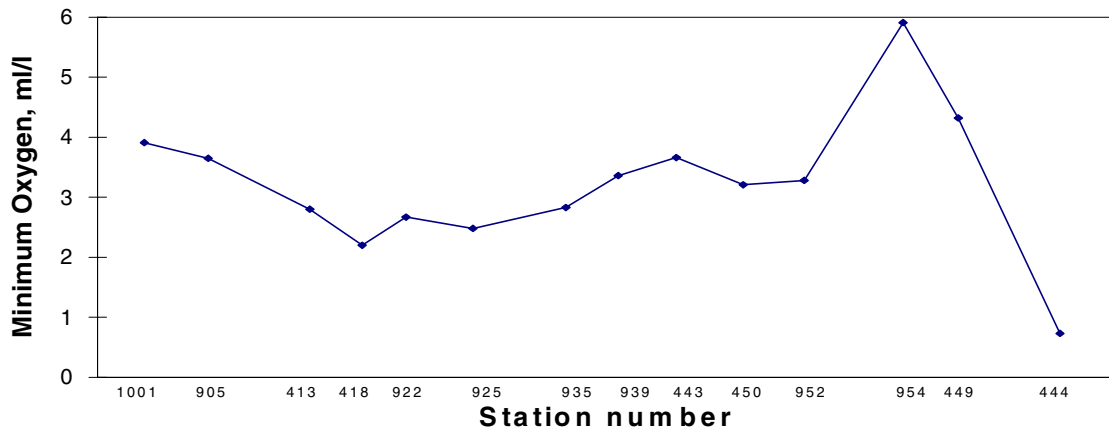
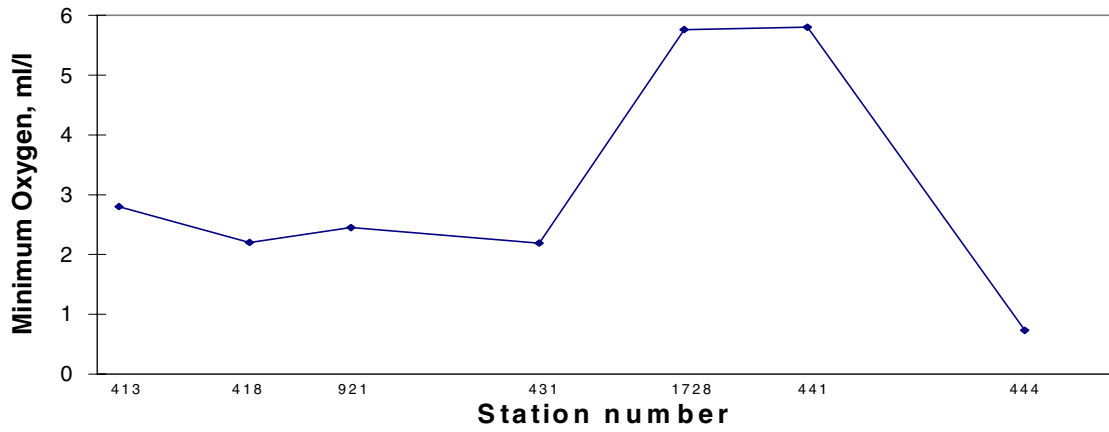


Figure 7. Chlorophyll-a concentrations in 1 m, 5 m, 10 m and 15 m depths along transect I, II and III.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

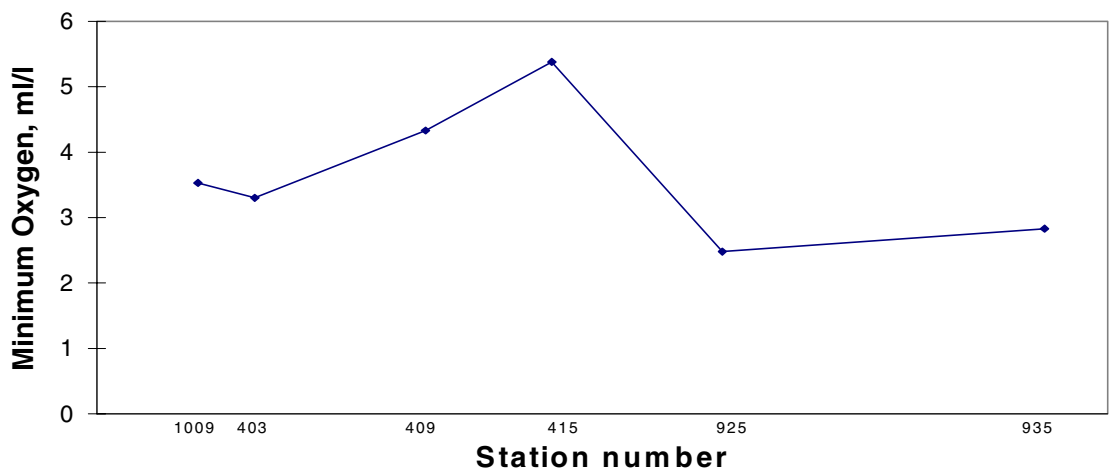


Figure 8. Minimum oxygen concentrations along transect I, II and III.

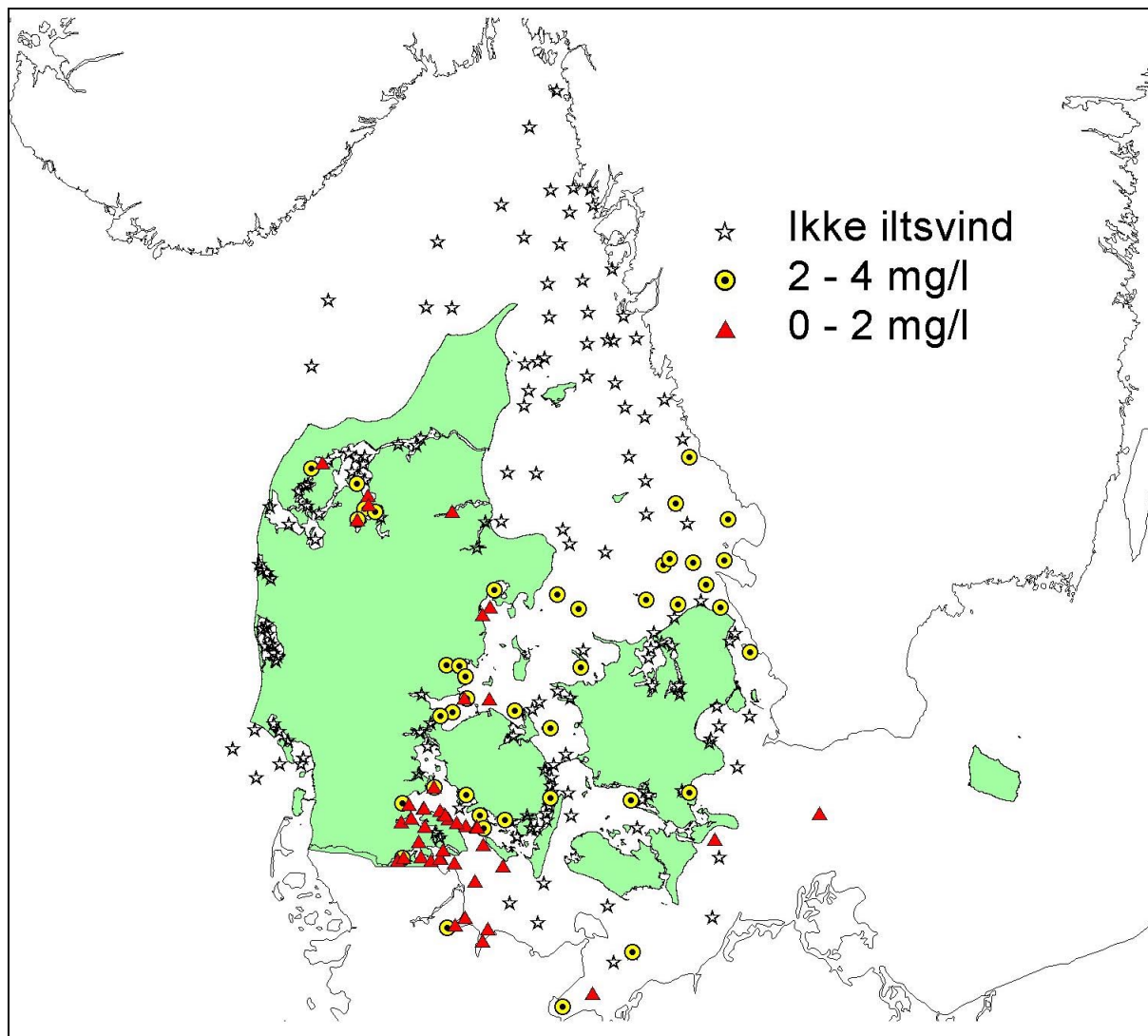


Figure 9. Stations visited by Danish counties, NERI, SMHI and Landesamt für Natur und Umwelt, Schleswig-Holstein, within the first three weeks of September 2001, and where oxygen depletion (<4 mg/l) and serious oxygen depletion (<2 mg/l) was observed.