



r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 200

Time: 6 - 9 November 2000

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

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Data Sheet

Title: Monitoring Cruise with r/v Gunnar Thorson in the Arkona Sea, the Belt Sea, the Kattegat and the Sound

Subtitle: Cruise no. 200, 6-9 November 2000

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Serial title: Monitoring Cruise Report

Publisher: Ministry of Environment and Energy
National Environmental Research Institute[©]

Week/year of publication: 49/2000

Please quote: Ærtebjerg, G. (2000): Monitoring Cruise with r/v Gunnar Thorson in the Arkona Sea, the Belt Sea, the Kattegat and the Sound. Cruise no. 200, 6-9 November 2000. National Environmental Research Institute, Denmark. Monitoring Cruise Report.

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Keywords: Marine, monitoring, hydrography, eutrophication

ISSN (electronic): 1600-1656
(Only published electronically) http://www.dmu.dk/1_om_dmu/2_afdelinger/3_hav/CruiseReports/index.htm

Number of pages: 10

The numbers of the Monitoring Cruises may not be successive, as the numbers also include other types of cruises.

Published by: National Environmental Research Institute
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DK-4000 Roskilde

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Monitoring cruise with r/v Gunnar Thorson in the Arkona Sea, the Belt Sea, the Kattegat and the Sound, 6-9 November 2000.

Cruise no. 200.

Report: Gunni Ærtebjerg

Cruise leader: Jan Damgaard

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

Summary

Since the last cruise in mid October, the surface salinity had increased, the bottom water salinity decreased and the salinity stratification declined in all areas, except in the central Sound, showing that a significant mixing and exchange of water masses had taken place. The halocline was situated unusually deep (>20 m depth) in the southern Belt Sea due to a gale from southeast. Compared to long term monthly mean (Lightship observations 1931-1960) for November the temperature was in the whole water column 0.8-2.5°C higher than normal, and the salinity was higher than normal in the whole water column in the Belt Sea, but lower than normal in the eastern Kattegat.

Nutrients had been mixed into the surface layer, and a phytoplankton autumn bloom was present in most areas. Due to the bloom the surface nitrate concentration was still low (<0.2 µmol/l) in the eastern Kattegat, Fehmarn Belt and the central Arkona Sea, as also the silicate concentration (0.3-0.6 µmol/l) in the eastern Kattegat.

The mean chlorophyll-a concentration in the uppermost 10 m varied between 1.2-1.8 µg/l in the Sound to 5.1-5.4 µg/l in Kiel Bight and Fehmarn Belt. The chlorophyll was either rather homogeneously distributed in the uppermost 10-15 m of the water column or highest at the surface, except for a subsurface maximum of 4.3 µg/l in 13.5 m depth at the northern entrance to the Sound.

Since the cruise in October the minimum oxygen concentration had increased in all areas, except in the south-eastern Kattegat. The lowest oxygen concentration of 2.4 ml/l (39% saturation) was observed in the central Sound, where the oxygen concentration was 2.4-2.5 ml/l in the whole water column from 20 m depth to the bottom in 51 m depth. In the Great Belt the minimum concentration had increased 1.6-2.8 ml/l to 4.2-4.8 ml/l (68-76%). In the south-eastern Kattegat the minimum concentration was 3.5-4.4 ml/l (58-74%).

Compared to November last year the minimum oxygen concentrations this year are now higher, except in the northern Kattegat. Compared to mean for November in the 1980s, the minimum oxygen concentrations this year are lower in the Sound, south-eastern Kattegat and from the central Great Belt to Fehmarn Belt.

In Denmark oxygen depletion is defined as minimum oxygen concentrations below 2.8 ml/l (4 mg/l). From this definition oxygen depletion still occurred on 9 November in a 30 m high water column in the Sound.

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 (the Arkona Sea, the Sound, the Belt Sea, the Kattegat), and the OSPAR monitoring programme for the Greater North Sea (the 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 October the mean temperature was 1.8°C above long-term mean, while the precipitation was 26% above normal and the number of sun-hours 10% below normal. The mean wind came from southern directions (SE-SW). The first two weeks of November, including the time of the cruise, were also characterised by southerly and occasionally strong wind.

Hydrography

The surface temperature (1 m depth) was about the same in all areas and varied only from 10.0°C in the central Great Belt (St. 939) to 11.3°C in the central Arkona Sea (St. 444) and 11.4°C in the northern Kattegat (St. 1007). The bottom water temperature ranged from 10.6°C at Gedser Rev (St. 954) to 13.0-13.4°C in the south-eastern Kattegat (St. 413, 418, 922). Thus, the bottom water temperature was 0-3°C higher than at the surface (*figure 2*).

The surface salinity ranged from 8.0-9.8 in the Arkona Sea (St. 441, 444) to 28.9-30.4 in the northern Kattegat (St. 1007, 1008, 1009). The bottom water salinity ranged from 14.7 at Gedser Rev (St. 954) and 14.9-16.3 in the Arkona Sea (St. 441, 444, 449) to 34.3 in the north-eastern Kattegat (St. 1001) (*figure 3*). Since the last cruise in mid October the surface salinity had increased and the bottom water salinity decreased in all areas, except in the central Sound (St. 431), showing that a significant mixing and exchange of water masses had taken place. Thus the salinity stratification had decreased, except in the Sound where the difference between surface and bottom was 23 psu. The halocline was situated unusually deep (>20 m depth) in the southern Belt Sea (St. 450, 952, M2).

Compared to long-term monthly mean (Lightship observations 1931-1960) for November the temperature was in the whole water column 0.8-2.5°C higher than normal. The salinity during the present cruise was higher than normal in the whole water column in the Belt Sea, but lower than normal in the eastern Kattegat.

Nutrients

Close to the surface the nitrate concentration was still low (<0.2 µmol/l) in the eastern Kattegat (St. 905, 413, 418), Fehmarn Belt (St. 952) and the central Arkona Sea (St. 444), but 0.5-1.0 µmol/l in most other areas. In the bottom water the highest nitrate concentration (8.5 µmol/l) was observed in the central Sound (St. 431) (*figure 4*).

No nitrite was present in the surface in the eastern Kattegat (St. 413, 418), while 0.3-0.5 µmol/l was observed in the northern Kattegat (St. 1007, 1008, 1009) and 0.2 µmol/l in the Sound (St. 921, 431) and the Arkona Sea (St. 444, 449, 954). In the bottom water 0.4-0.7 µmol/l was present in the northern Kattegat (St. 905, 1001, 1007, 1008, 1009) (*figure 5a*). Ammonium was observed in the surface in relatively high concentrations (1.0-1.4 µmol/l) in the Sound and Gedser Rev area (St. 921, 431, 954,

449). High concentrations (1.0-1.7 $\mu\text{mol/l}$) were also observed in the bottom water in the Arkona Sea (St. 1728, 441, 444, 449) and Fehmarn Belt area (St. 450, 952, 954) (*figure 5b*).

Phosphate was present in the surface water in all areas, in the Sound and the Belt Sea up to 0.5-0.6 $\mu\text{mol/l}$, while the silicate concentration was still low (0.3-0.6 $\mu\text{mol/l}$) in the eastern Kattegat (St. 413, 418, 905). In the bottom water the highest phosphate (1.3 $\mu\text{mol/l}$) and silicate (22.1 $\mu\text{mol/l}$) concentrations were observed at the bottom in the central Sound together with low oxygen concentrations (St. 431) (*figures 6a and 6b*).

Chlorophyll-*a*

The mean chlorophyll concentration in the uppermost 10 m varied between 1.2-1.8 $\mu\text{g/l}$ in the Sound (St. 431, 921) to 5.1-5.4 $\mu\text{g/l}$ in Kiel Bight and Fehmarn Belt (St. N3, 952). The chlorophyll was either rather homogeneously distributed in the uppermost 10-15 m of the water column or highest at the surface, except for a subsurface maximum of 4.3 $\mu\text{g/l}$ in 13.5 m depth at the northern entrance to the Sound (St. 921) (*figure 7*).

Oxygen

Since the cruise in October the minimum oxygen concentration had increased in all areas, except in the south-eastern Kattegat (St. 413, 418, 921). The lowest oxygen concentration of 2.4 ml/l (39% saturation) was observed in the central Sound (St. 431), where the oxygen concentration was 2.4-2.5 ml/l in the whole water column from 20 m depth to the bottom in 51 m depth (*figure 8*). In the Great Belt (St. 925, 935, 939, 443) the minimum concentration had increased 1.6-2.8 ml/l to 4.2-4.8 ml/l (68-76%). In the south-eastern Kattegat (St. 413, 418, 922, 921) the minimum concentration was 3.5-4.4 ml/l (58-74%).

Compared to November last year the minimum oxygen concentrations this year are now higher, except in the northern Kattegat (St. 403, 1007, 1008, 1009). Compared to mean for November in the 1980s the minimum oxygen concentrations this year are lower in the Sound, south-eastern Kattegat and from the central Great Belt to Fehmarn Belt.

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 still occurred on 9 November in a 30 m high water column in the Sound (St. 431).

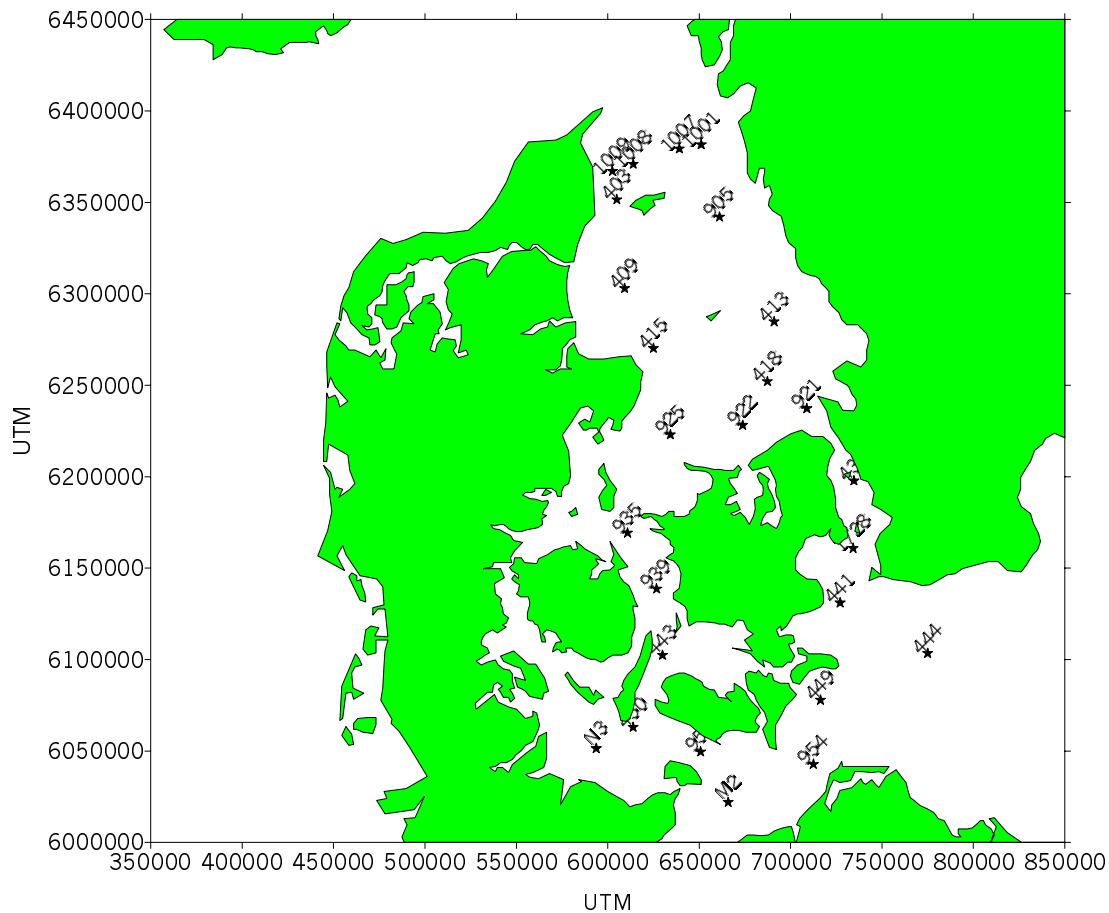


Figure 1. Stations of the monitoring cruise with r/v Gunnar Thorson 6-10 November 2000 in the Sound, the Kattegat, the Belt Sea and the Arkona Sea. Gunnar Thorson cruise no. 200.

Transect I: Kattegat NE - Belt Sea - Arkona Sea

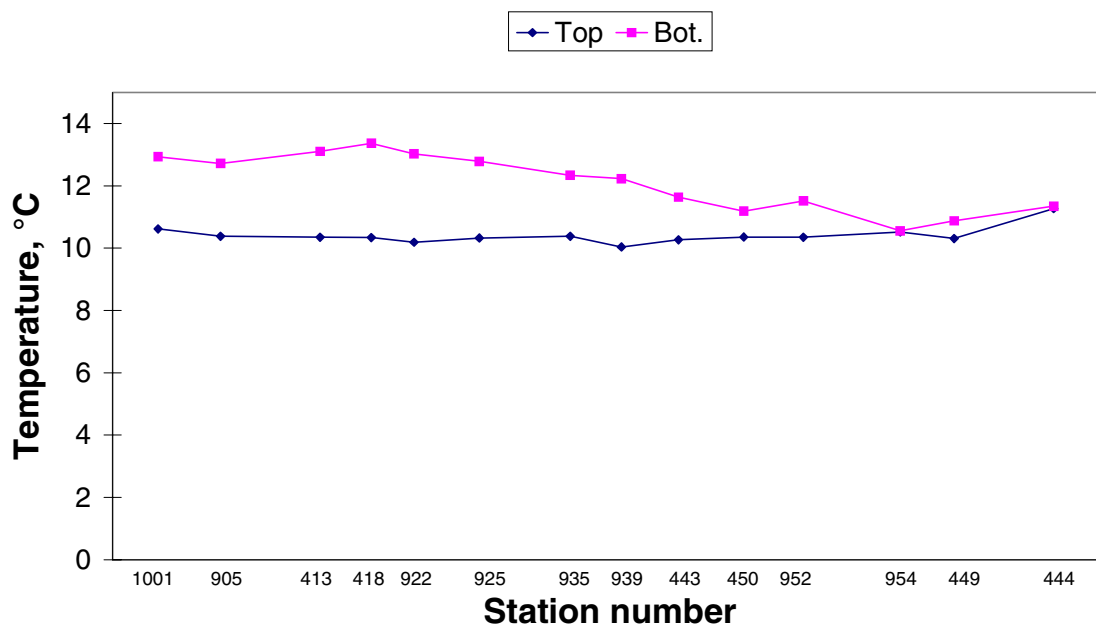
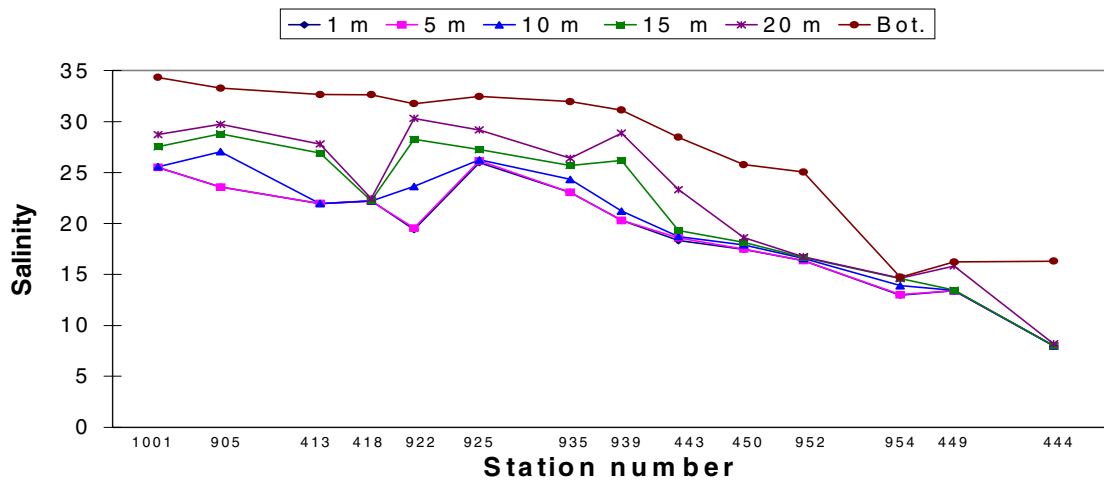
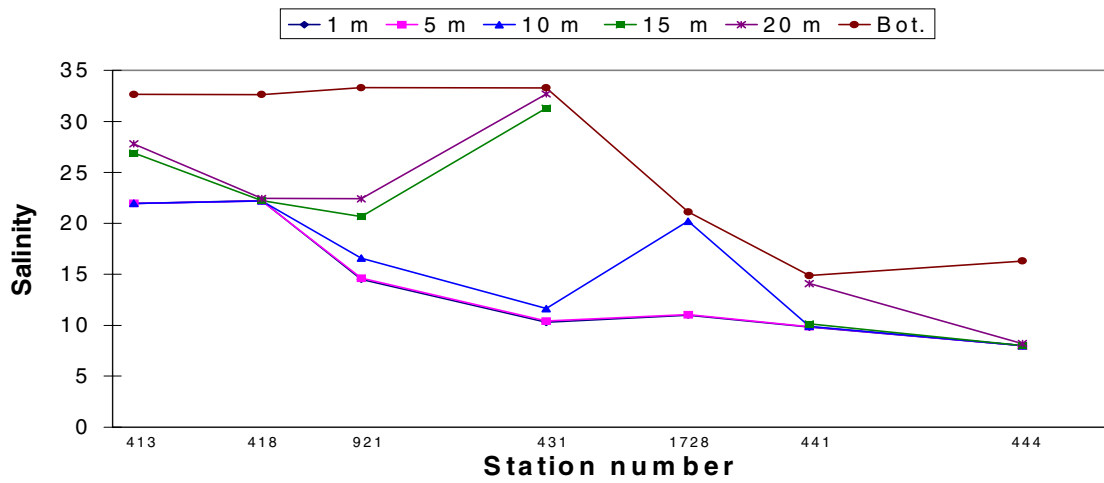


Figure 2. Surface and near bottom temperature along transect I from the north-eastern Kattegat through the Belt Sea to the Arkona Sea.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

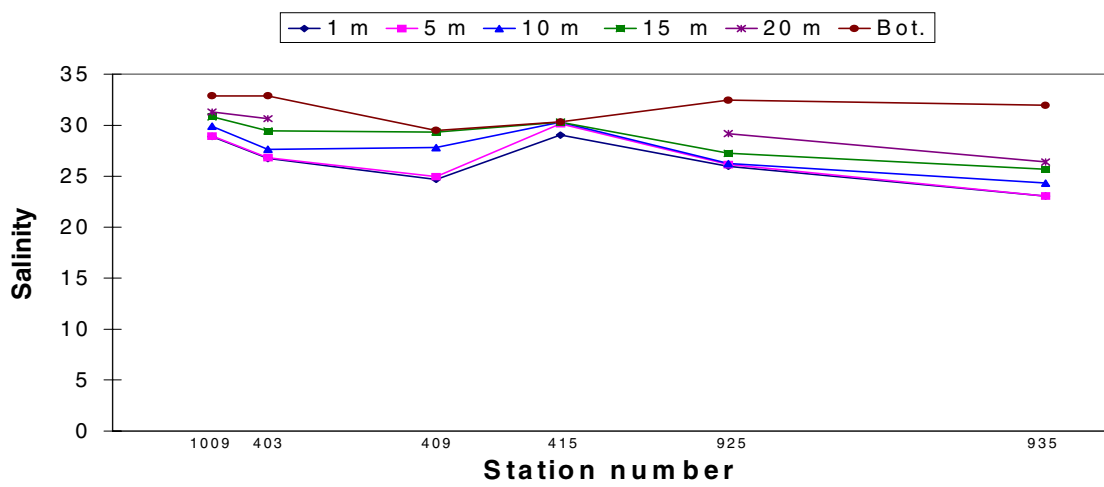
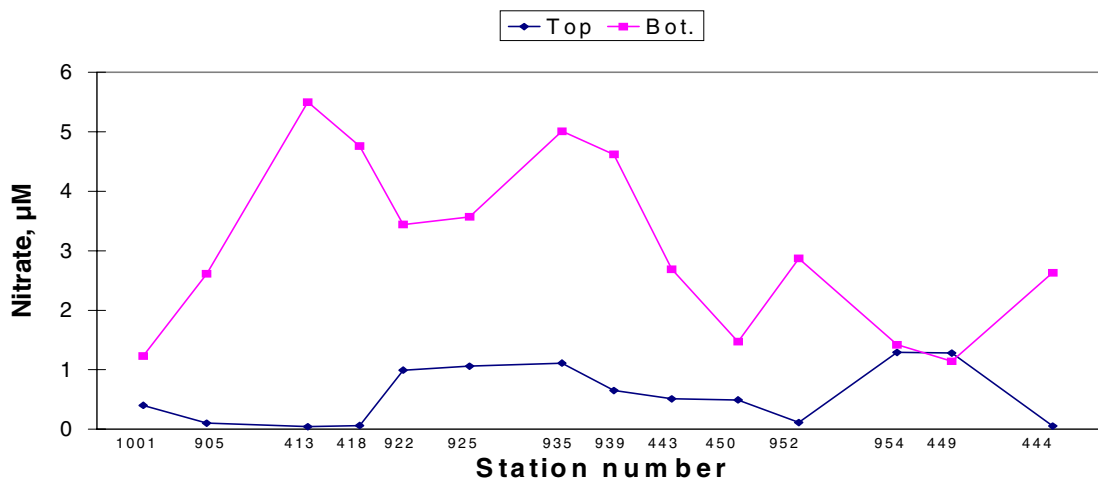
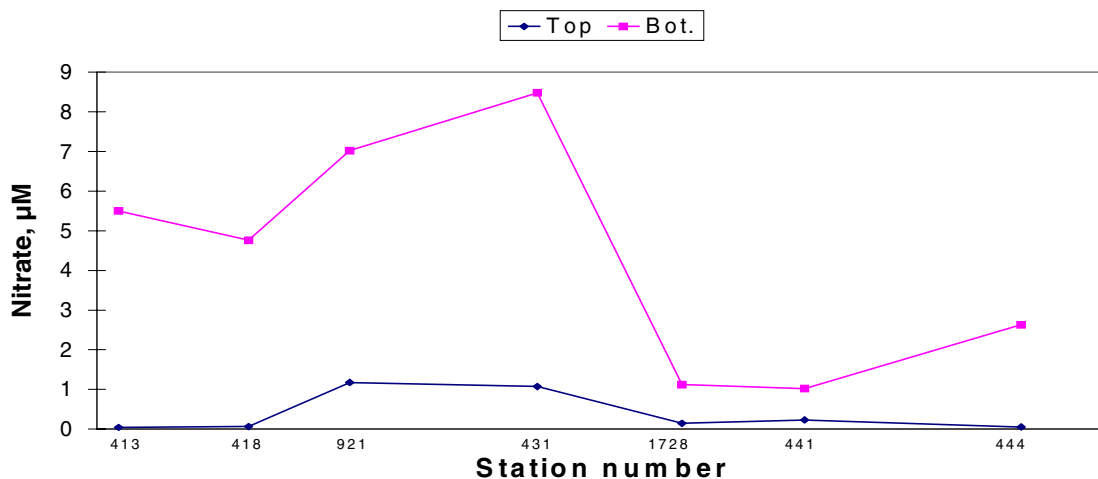


Figure 3. Salinity in 1 m, 5 m, 10 m, 15 m, 20 m depth and near bottom along transect I, II and III from the Kattegat through the Belt Sea and the Sound to the Arkona Sea and in the western Kattegat to the Great Belt, respectively.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

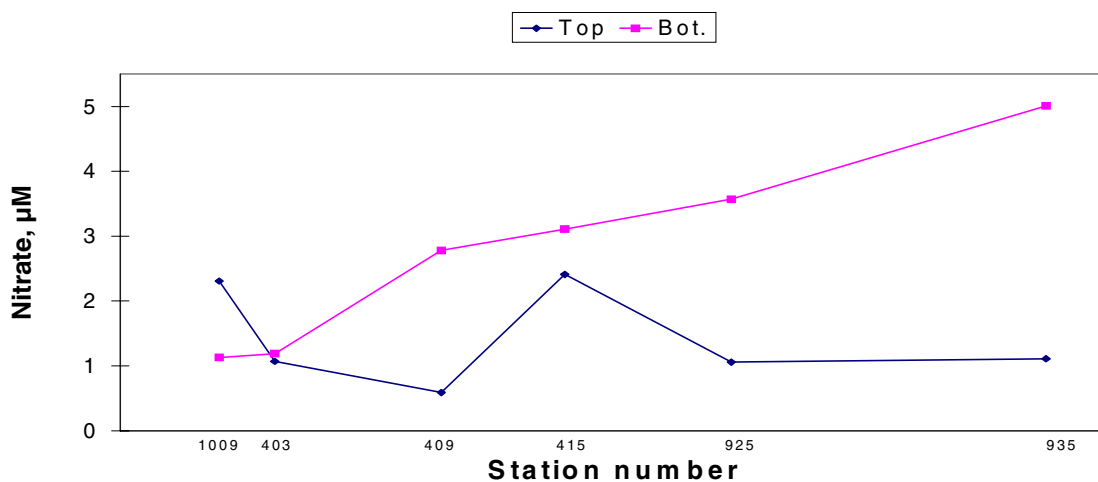
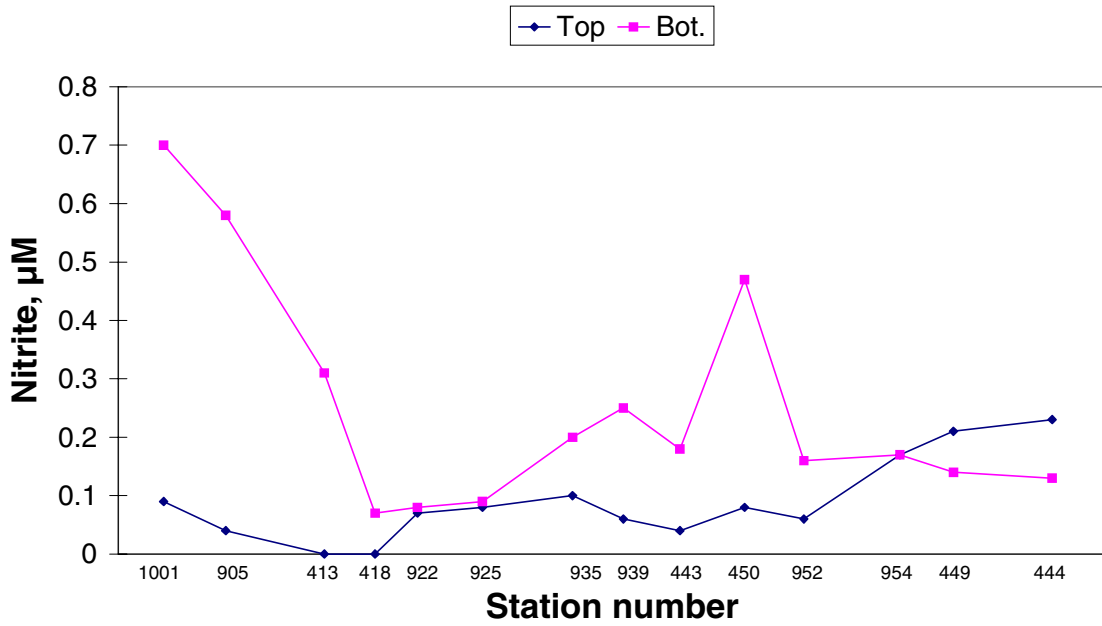


Figure 4. Surface and near bottom concentrations of nitrate along transect I, II and III.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect I: Kattegat NE - Belt Sea - Arkona Sea

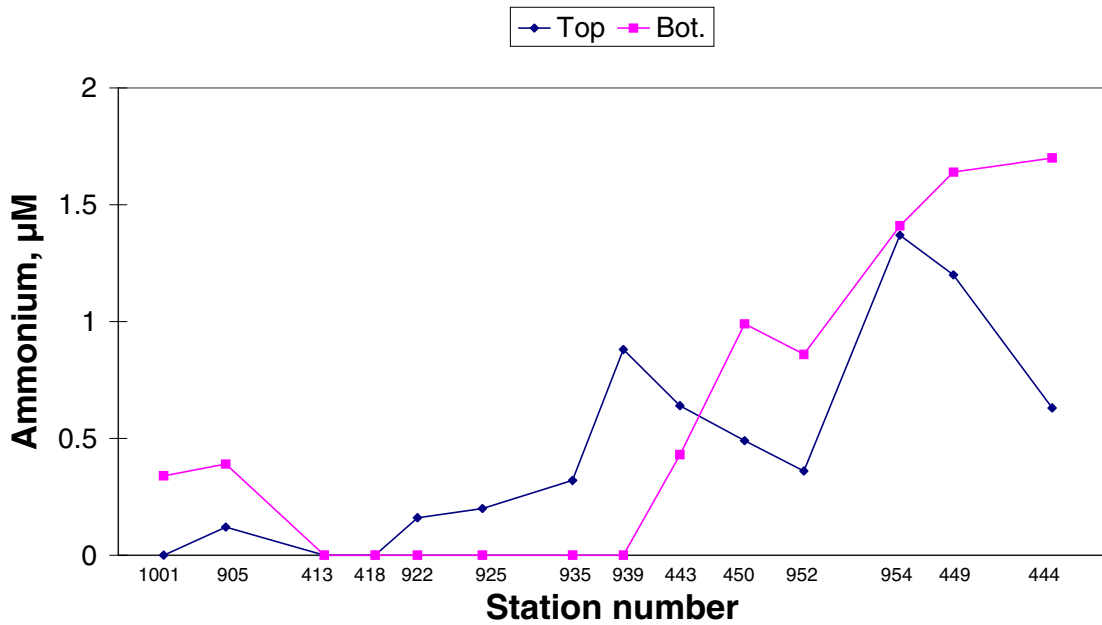
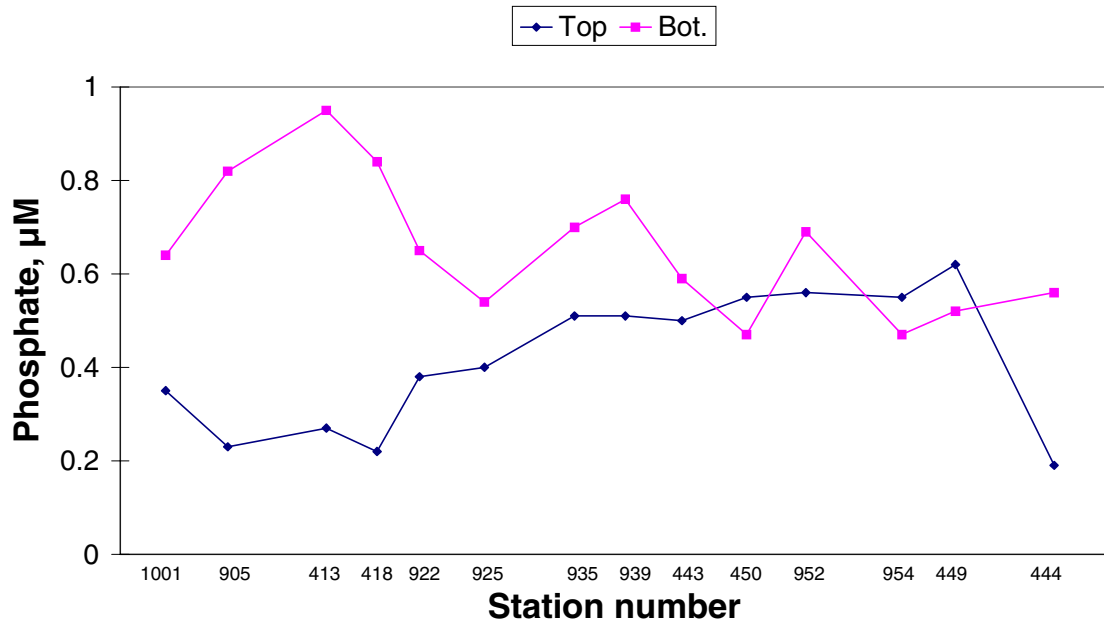


Figure 5. Surface and near bottom concentrations of nitrite and ammonium along transect I.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect I: Kattegat NE - Belt Sea - Arkona Sea

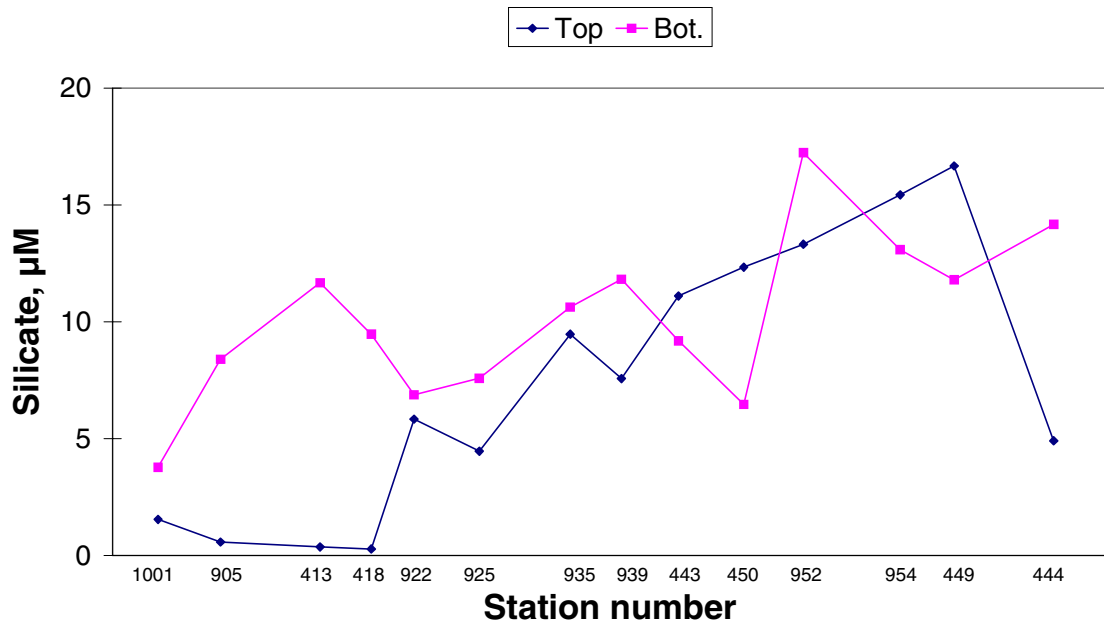
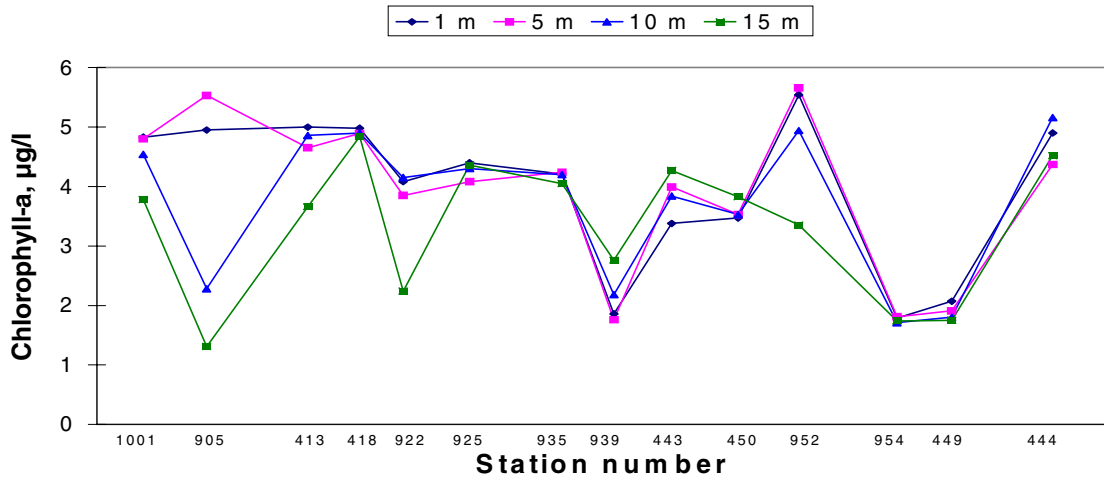
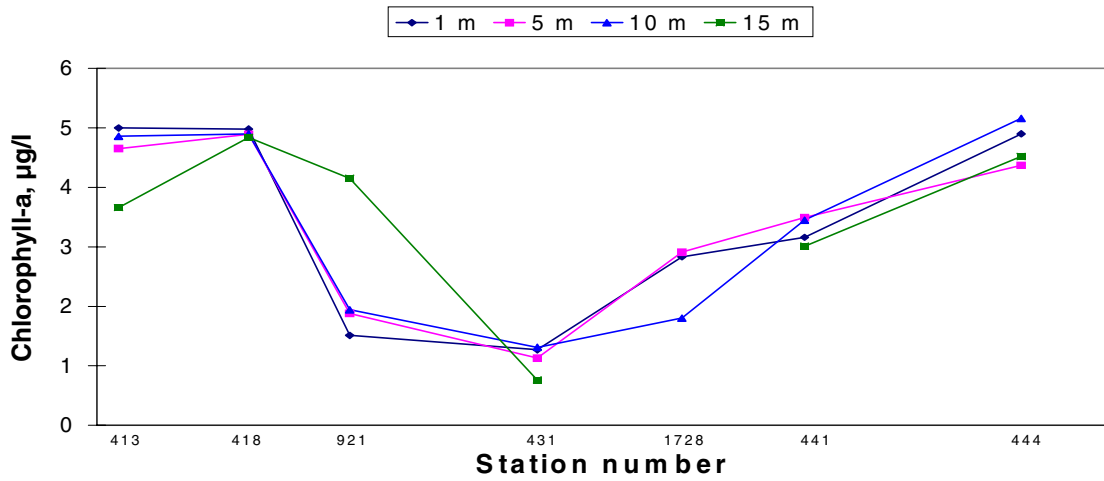


Figure 6. Surface and near bottom concentrations of phosphate and silicate along transect I.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

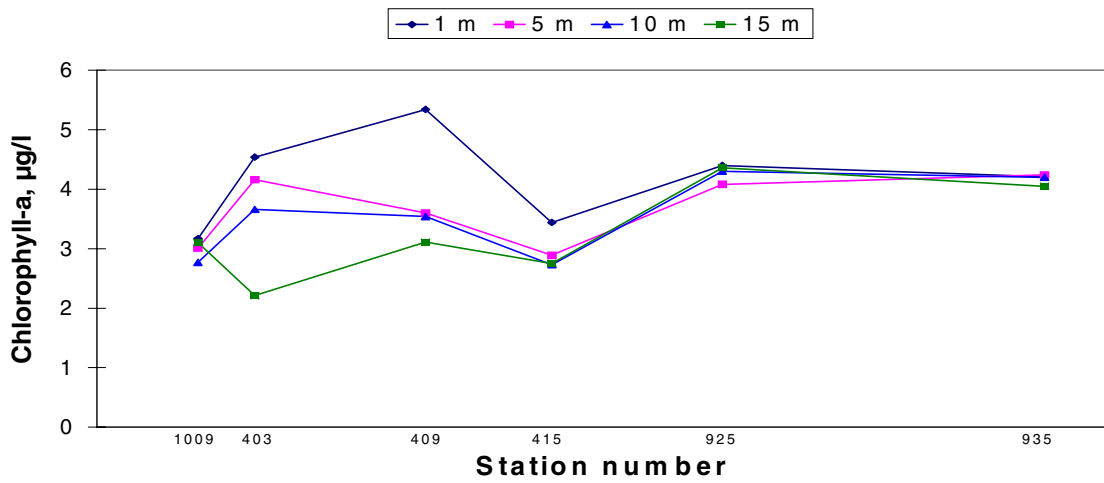
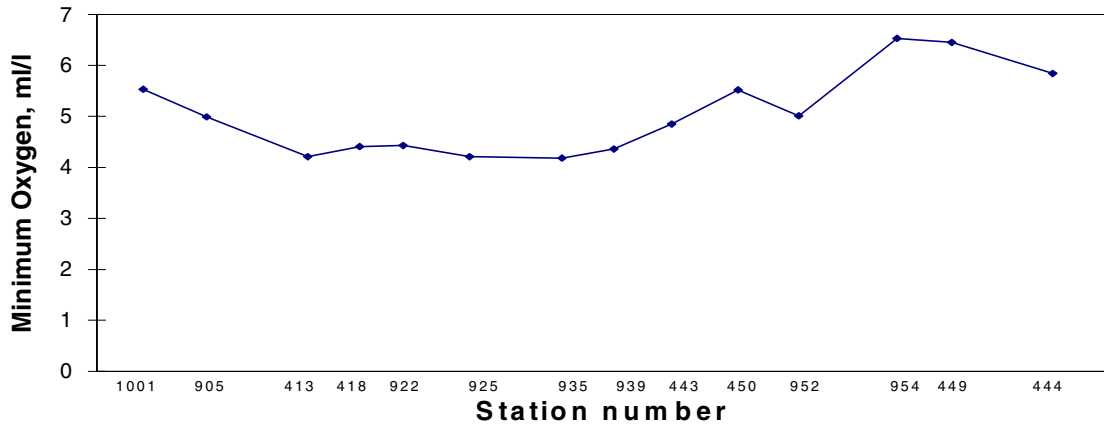
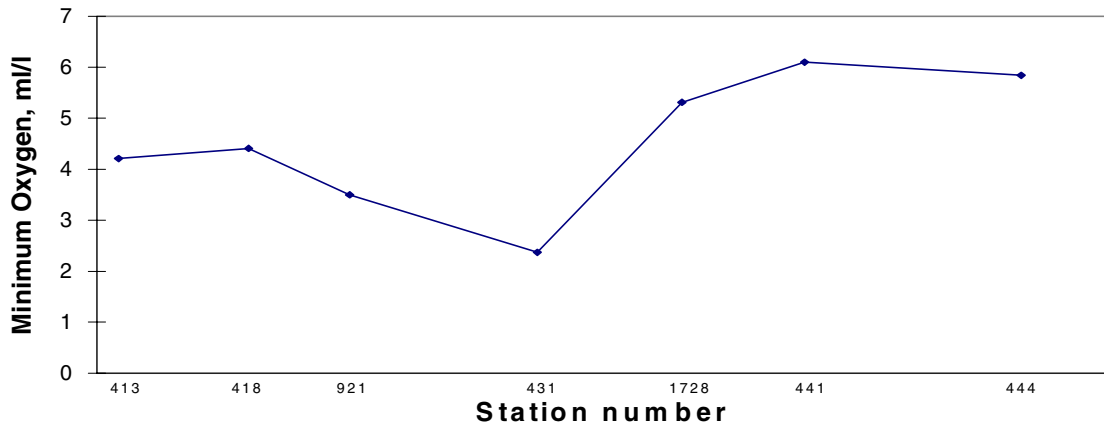


Figure 7. Chlorophyll-a concentrations in 1 m, 5 m, 10 m and 15 m depths along transect I, II and III.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

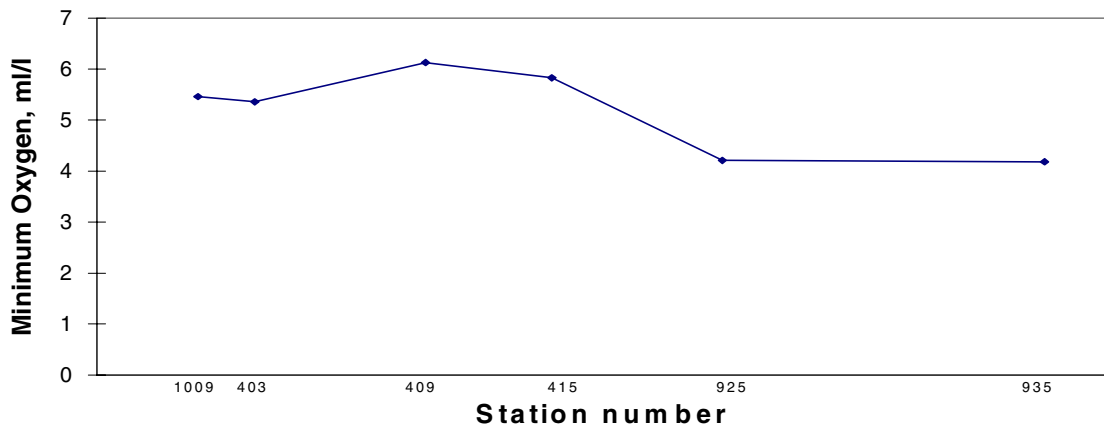


Figure 8. Minimum oxygen concentrations along transect I, II and III.