



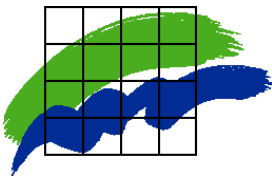
r/v Gunnar Thorson

# Monitoring Cruise Report

**Cruise no.: 221**

**Time: 10 - 14 November 2003**

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



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## Data Sheet

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

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# Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat, 10-14 November 2003 Cruise no. 221

**Report:** Gunni Ærtebjerg  
**Cruise leader:** Kjeld Sauerberg  
**Participants:** Peter Kofoed, Hanne Ferdinand, Jeanette Blidorf (NERI)  
Peter Hansen, Maria Grundahl Noppenau (Trainees)

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

## Summary

Oxygen depletion (<2.8 ml/l) still occurred in the northern Great Belt, and also in the southern Great Belt; the minimum oxygen concentration was quite low (2.9-3.0 ml/l, 45-47% saturation). In the Great Belt, the Fehmarn Belt and the Mecklenburg Bight the minimum oxygen concentrations were lower than at the same time last year, and in all areas except the Sound and the Arkona Sea lower than averages for November in the 1980's.

The surface temperature was about average for the season, while the bottom water temperature was 0.6-3.2°C higher than normal. The surface salinity was much lower than average (2.5-6.1 psu), except in the Aalborg Bight, while the bottom water salinity was generally higher than normal. The southern Belt Sea bottom water deviated from this pattern with temperature and salinity lower than normal. Generally, the stratification was relatively strong for the season, especially in the Great Belt.

The hydrography witnesses to dominating calm weather and southerly wind conditions, surface outflow from the Baltic Sea, and rather stagnant bottom water. The autumn renewal of the bottom water with oxygen rich Skagerrak water had not yet taken place.

In the surface layer the nitrate concentration was still quite low (0.1-1.0 µmol/l) in most areas, except in the western Kattegat. Ammonium concentrations of 0.2-1 µmol/l were observed in the surface in most areas. Phosphate concentrations of 0.1-0.6 µmol/l and silicate concentrations above 3 µmol/l and up to 11 µmol/l were present in the surface water in all areas.

In the bottom water the highest concentrations of nitrate (7-10 µmol/l), phosphate (1.0-2.0 µmol/l) and silicate (25-30 µmol/l) were observed in the Great Belt, that is in the area with the lowest oxygen concentration. The highest concentrations of ammonium (2.0-3.5 µmol/l) and nitrite (>0.8 µmol/l) were found in the southern Belt Sea and the Mecklenburg Bight, respectively.

The chlorophyll-*a* was quite evenly distributed in the surface layer where the concentrations in the uppermost 10 m varied between 1.2 and 2.8 µg/l with the lowest concentrations in the Sound and the Mecklenburg Bight.

## 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 OSPARCOM 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*.



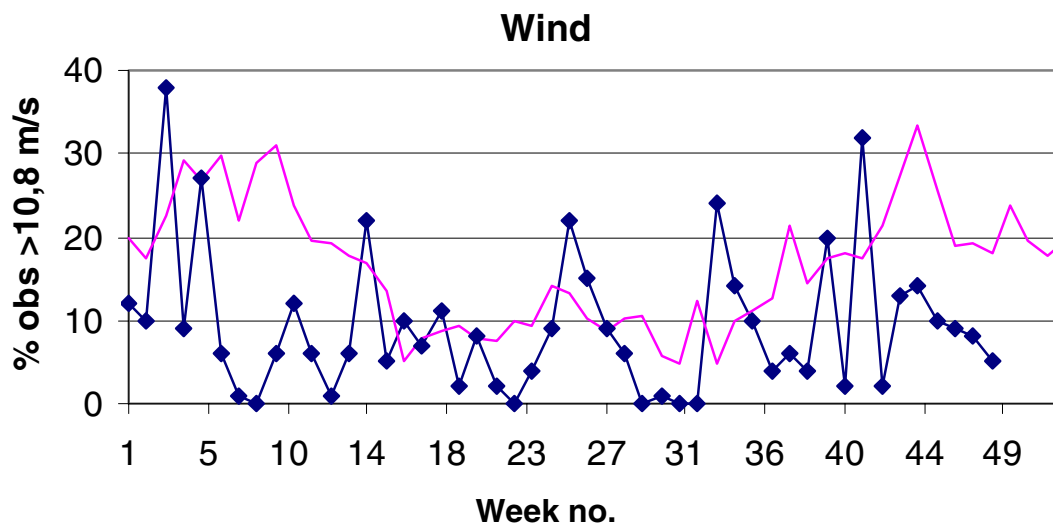
*Figure 1.* Stations of the monitoring cruise with r/v Gunnar Thorson 10-14 November 2003 in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Gunnar Thorson cruise no. 221.

## Meteorology

Characteristics of the weather conditions during November 2003 are given in *table 1*. November was warm with a mean temperature of 6.6°C, which was actually higher than in October (6.5°C). The precipitation was well below average. The dominating wind directions were southerly (SE-S-SW 68% of the time). The frequency of wind exceeding gale force (*figure 2*) was low in November (weeks 45-48).

**Table 1.** Deviations in monthly mean temperature and precipitation in November 2003 in Denmark compared to long-term monthly means 1961-90, monthly mean wind force and dominating wind directions (based on data from the Danish Meteorological Institute).

Month	Temperature deviation °C	Precipitation % deviation	Mean wind force m/s	Dominating wind direction
November	+1.9	-32	4.9	SE-S-SW



**Figure 2.** Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2003 (connected points) compared to mean for the period 1994-2002 (thin line). Based on data from the Danish Meteorological Institute.

## Hydrography

The surface temperature (1 m depth) had since the cruise in October further decreased 2.1-4.9°C, and now varied between 7.4 and 9.8°C in the whole area, highest in the western Kattegat, the southern Belt Sea and the Arkona Sea and lowest in the south-eastern Kattegat and the Sound. Also the bottom water temperature had decreased 0.5-4.0°C in all areas, except for a small increase in the south-eastern Kattegat and the Sound. The bottom near temperature ranged from 9.3-9.8°C in the Arkona Sea (St. 441, 444) and the north-eastern Kattegat (St. 905, 1001), to 12.4-13.0°C in the Great Belt and the Mecklenburg Bight (St. 925, 935, 939, 443, M2). However, warmer water masses (11.0-13.6°C) were observed as an intermediate layer in the eastern Kattegat (St. 1007, 1001, 905, 413) (*figure 3*).

The surface salinity ranged from 8.2-9.9 in the Arkona Sea (St. 441, 444, 449, 954) and the Sound (St. 431, 1728) to 24.6 in the north-western Kattegat (St. 1008, 1009) and 25.7 in Aalborg Bight (St. 409). The bottom water salinity ranged from 13.8-13.9 in the Arkona Sea (St. 441, 444) to 34.1-34.75 in the northern Kattegat (St. 413, 905, 1001, 1007, 1008, 1009, 403) (*figure 3*). The salinity stratification was relatively strong for the season, especially in the Great Belt.

Compared to long-term monthly means (Lightship observations 1931-1960) for November the surface temperature was about average, while the near bottom temperature was 0.6-3.2°C higher than normal, except in the southern Belt Sea. The surface salinity was during the present cruise much lower than average (2.5-6.1 psu), except in the Aalborg Bight. The bottom near salinity was generally higher than normal, except in the southern Belt Sea.

## Nutrients

The nitrate concentration in the surface layer was still quite low (0.1-1.0  $\mu\text{mol/l}$ ) in most areas, only in the western Kattegat (St. 403, 409, 415, 1009) the concentrations reached 2-3  $\mu\text{mol/l}$ . In the bottom water high nitrate concentrations of 7-10  $\mu\text{mol/l}$  were only observed in the Great Belt (St. 935, 939, 443, 450) (*figure 4a*).

High nitrite concentrations  $>0.8 \mu\text{mol/l}$  were only observed in the bottom water in the Mecklenburg Bight (St. M2) (*figure 4b*). In the surface layer ammonium concentrations of 0.2-1  $\mu\text{mol/l}$  were observed in most areas. The highest ammonium concentrations (2.0-3.5  $\mu\text{mol/l}$ ) were found in the bottom water in the southern Belt Sea (*figure 4c*).

Phosphate concentrations of 0.1-0.6  $\mu\text{mol/l}$  were present in the surface water in all areas, lowest in the south-eastern Kattegat and highest in the western Kattegat. In the bottom water phosphate concentrations of 1.0-2.0  $\mu\text{mol/l}$  were only observed in the Great Belt (*figure 5a*). Silicate concentrations above 3  $\mu\text{mol/l}$  and up to 11  $\mu\text{mol/l}$  were present in the surface water in all areas. High concentrations (25-30  $\mu\text{mol/l}$ ) were observed in the bottom water in the Great Belt (St. 935, 939, 450) (*figure 5b*).

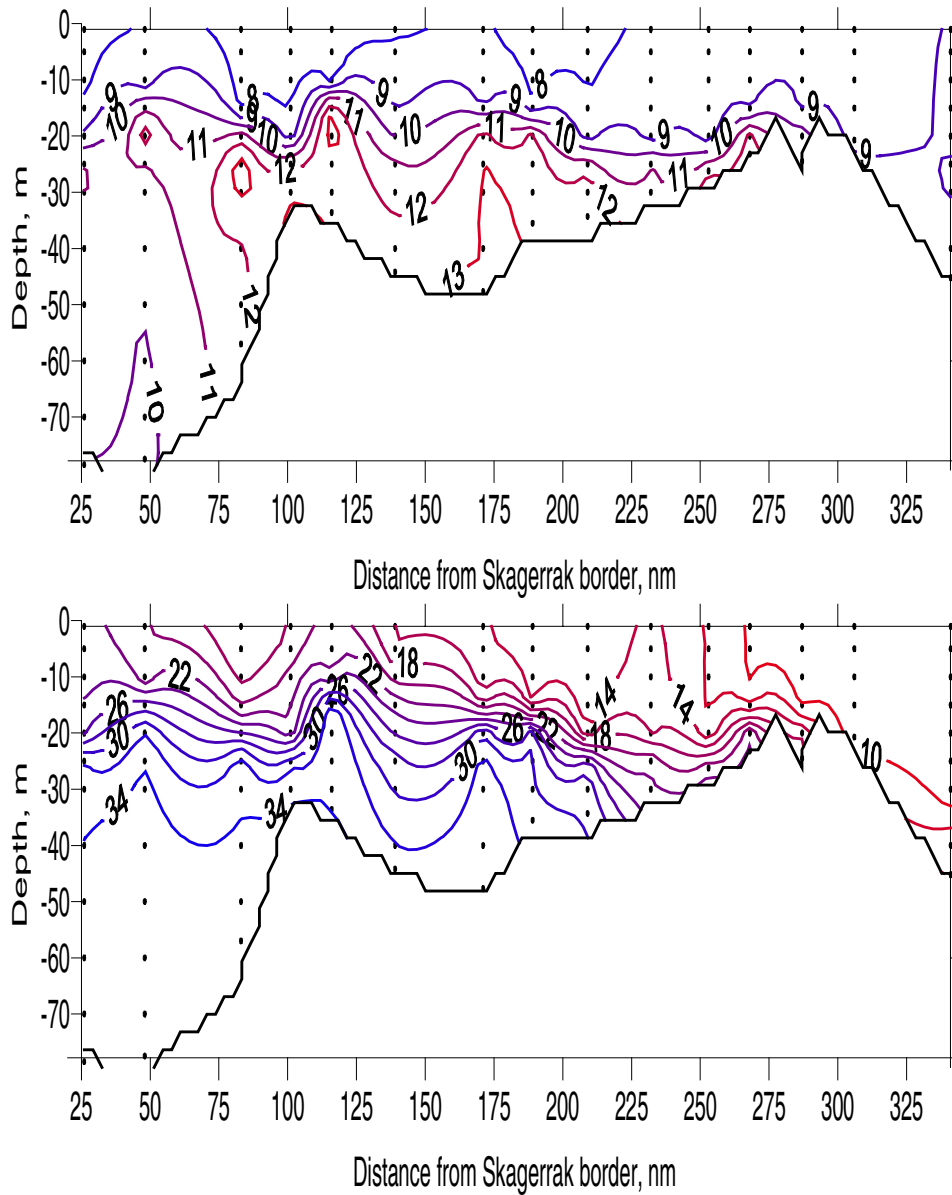
## Chlorophyll-*a*

The chlorophyll-*a* was quite evenly distributed in the surface layer where the concentrations in the uppermost 10 m varied between 1.2 and 2.8  $\mu\text{g/l}$  with the lowest concentrations in the Sound (St. 431, 921) and Mecklenburg Bight (St. M2). Below the pycnocline the chlorophyll-*a* concentrations were generally low (0.2-0.9  $\mu\text{g/l}$ ) in the Kattegat, the Sound, the Mecklenburg Bight and the northern Great Belt. However, in the Fehmarn Belt and the Arkona Sea the concentrations were quite even down to 20 m depth (*figure 6*).

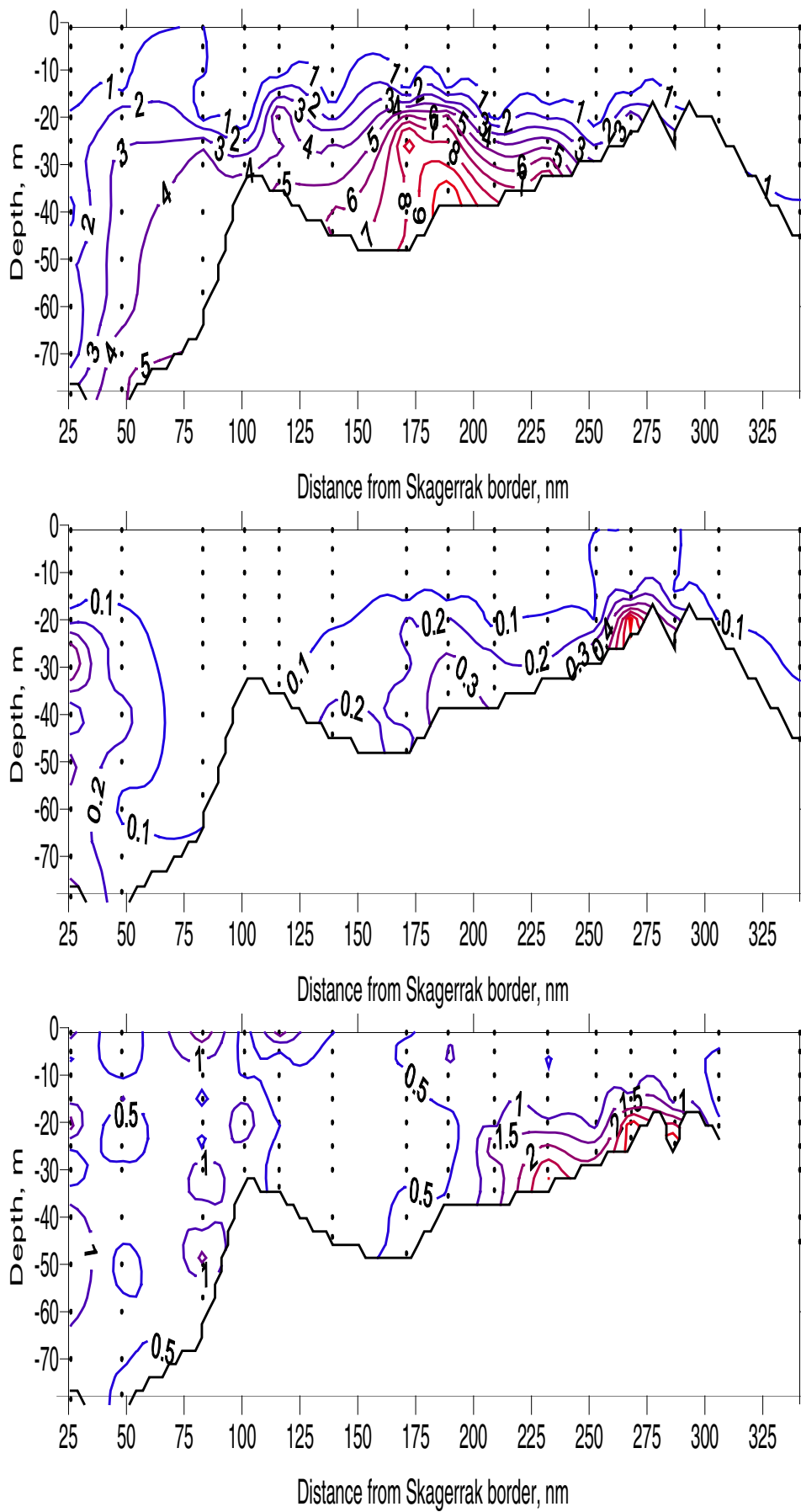
## Oxygen

Since October the minimum oxygen concentrations had generally increased in all areas, except in the southern Great Belt, the Fehmarn Belt and the Mecklenburg Bight (St. 443, 450, 952, M2). The lowest oxygen concentration of 2.1 ml/l (35% saturation) was observed in the northern Great Belt (St. 925, 935). In the southern Great Belt (St. 939, 443, 450) the minimum concentrations were 2.8-3.0 ml/l (45-47%) (*figure 7*). Compared to November last year, the minimum oxygen concentrations this year are generally higher in the Kattegat, the Sound and the Arkona Sea, but in the Great Belt, the Fehmarn Belt and the Mecklenburg Bight the concentrations are lower than at the same time last year. Compared to mean for November in the 1980s, the minimum oxygen concentrations this year are generally lower, except in the Sound and Arkona Sea.

In Denmark oxygen depletion is defined as minimum oxygen concentrations below 2.8 ml/l (4 mg/l), and severe oxygen depletion as below 1.4 ml/l (2 mg/l). From these definitions oxygen depletion was still present in the northern Great Belt (St. 925, 935, 939).

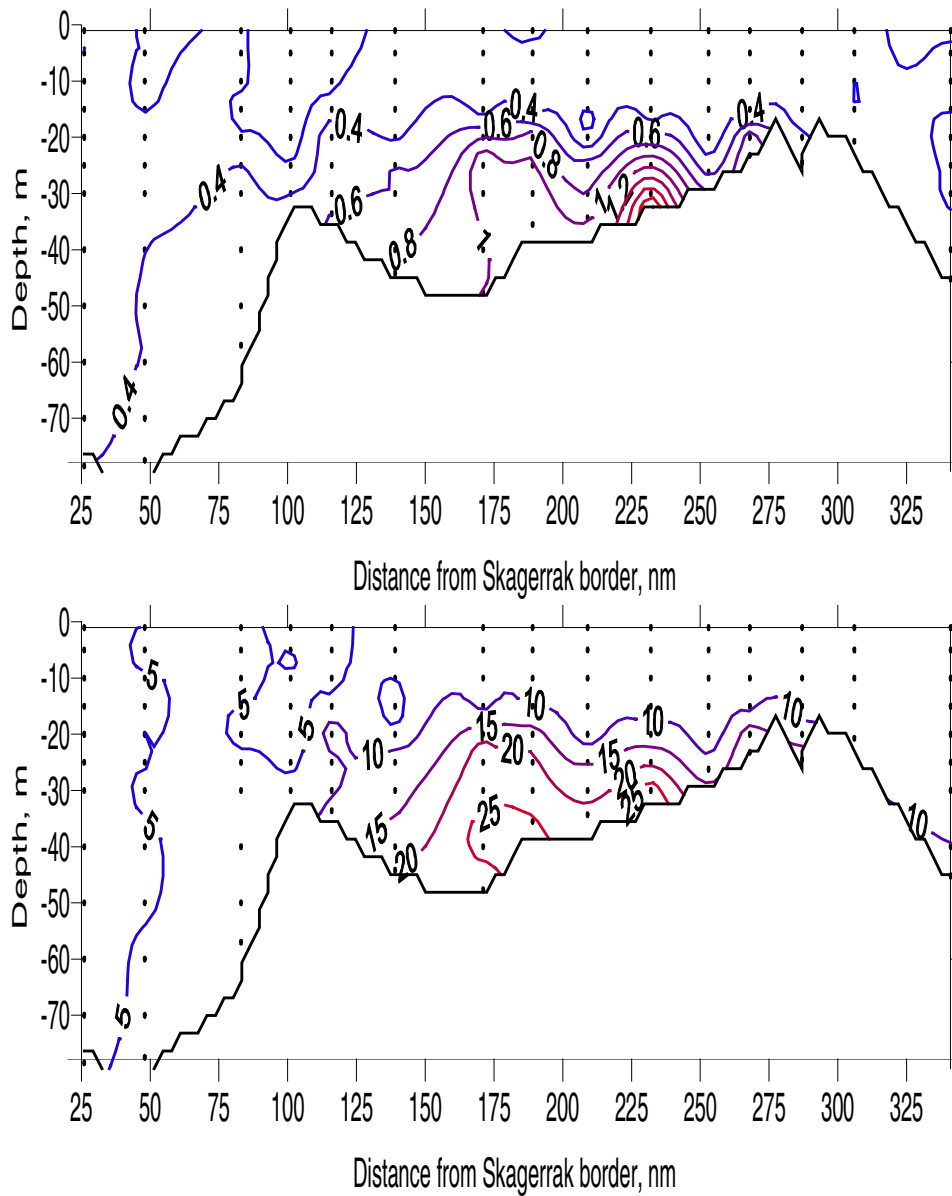


**Figure 3.** Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



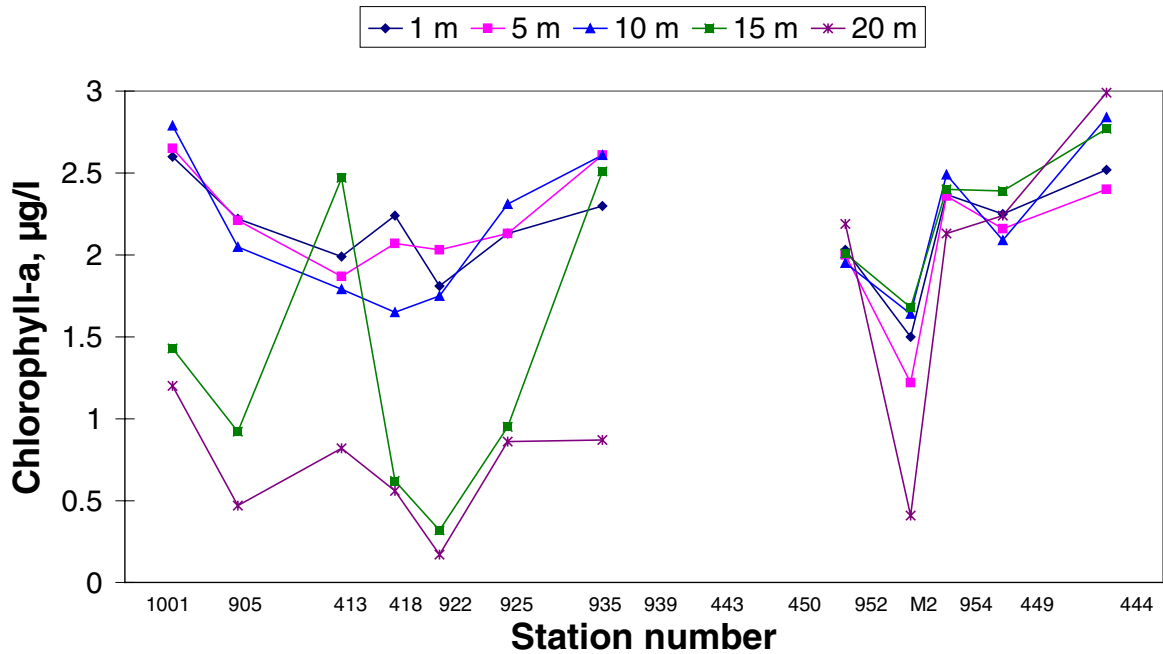
**Figure 4.** Nitrate (top), nitrite (middle) and ammonium (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



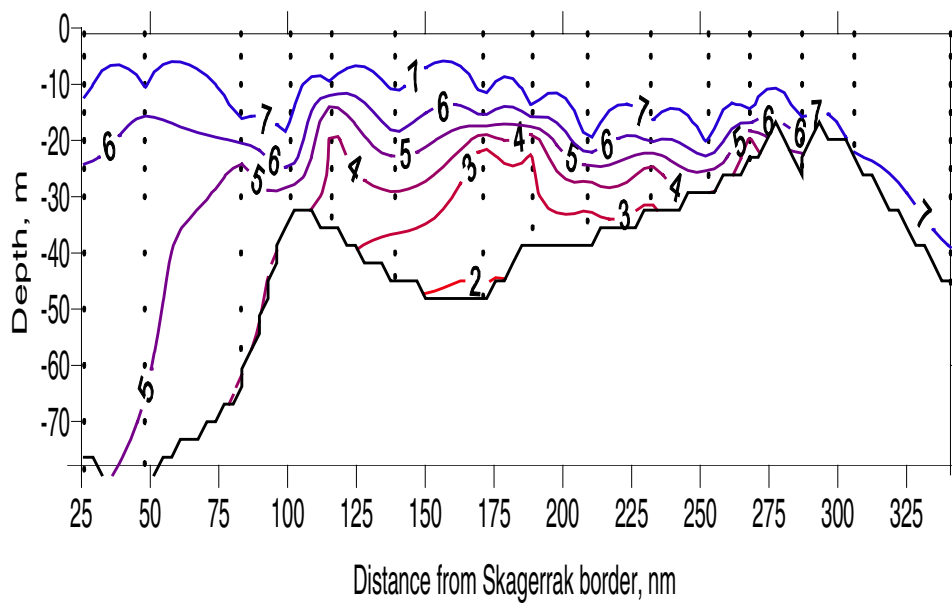


**Figure 5.** Phosphate (top) and silicate (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

### Transect: Kattegat NE - Belt Sea - Arkona Sea



**Figure 6.** Chlorophyll-*a* at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.



**Figure 7.** Oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.