r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: GT 240

Time: 29 January - 2 February 2007

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

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Data sheet

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Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat, 29 January - 2 February 2007. Cruise no. GT 240

Report: Gunni Ærtebjerg

Cruise leader: Kjeld Sauerberg
Participants: Dorete Jensen, Berit Langkilde Møller, Lars Renvald, Colin Stedmon, Christopher Osburn;
Jørgen Hansen, Jørgen Bendtsen (from Korsør to Frederikshavn)

Summary

The windy and warm weather prevailing during November 2006 to January 2007 had mixed the water masses well, so the stratification was unusually weak for the season and nearly absent in the Belt Sea and southern Kattegat. Due to the intensive mixing, the surface salinity was higher, and the bottom water salinity lower than normal in all areas, and the oxygen concentration was close to saturation in the whole water column, except for 93-97% saturation in the bottom water in the north-eastern Kattegat and the central Arkona Sea. The surface temperature was 2.8-3.8° C higher than average, and the bottom water temperature generally 1.5-3.0° C above average.

In the southern Great Belt and Fehmarn Belt the nitrate was evenly distributed in the water column, and showed higher concentrations (7.1-7.6 µmol/l) than both north and east of the area. This was probably due to an intensive freshwater runoff. The high nitrate concentration in the surface of Læsø Rende (12.9-13.4 µmol/l) might also originate from runoff and outflow from the estuaries Limfjorden, Mariager Fjord and/or Randers Fjord.

The highest concentrations of both ammonium, nitrite, phosphate and silicate were observed in the water column of the southern Belt Sea and southern Great Belt as well as in the bottom water of the Arkona Sea. Some of this might, as the nitrate, originate from the runoff, but at least ammonium seemed mainly to originate from the sediments.

The chlorophyll concentrations were relatively low (mean 0-10 m: 0.4-1.8 µg/l) with the highest concentrations observed in the southern Belt Sea. It was rather homogenously distributed in the surface layer. The concentration was normal for the season before the actual onset of the phytoplankton spring bloom.

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 NOVANA, the HELCOM monitoring programme (COMBINE) for the Baltic Sea area (the Arkona Sea, the Sound, the Belt Sea, the Kattegat), and the OSPARCOM monitoring programme (JAMP) for the Greater North Sea (the Kattegat). The main scope of the cruise was to monitor the winter nutrient concentrations, but also the hydrography and the concentrations of oxygen and chlorophyll *a*. Macrozoobenthos was sampled at 3 stations, sediments were sampled at 10 stations for measurements of chlorophyll before the phytoplankton spring bloom, and at 3 stations for monitoring of radioactivity. The monitoring stations of the cruise are shown in *figure 1*. Besides the monitoring measurements, special investigations were performed on DOM and respiration in the water.

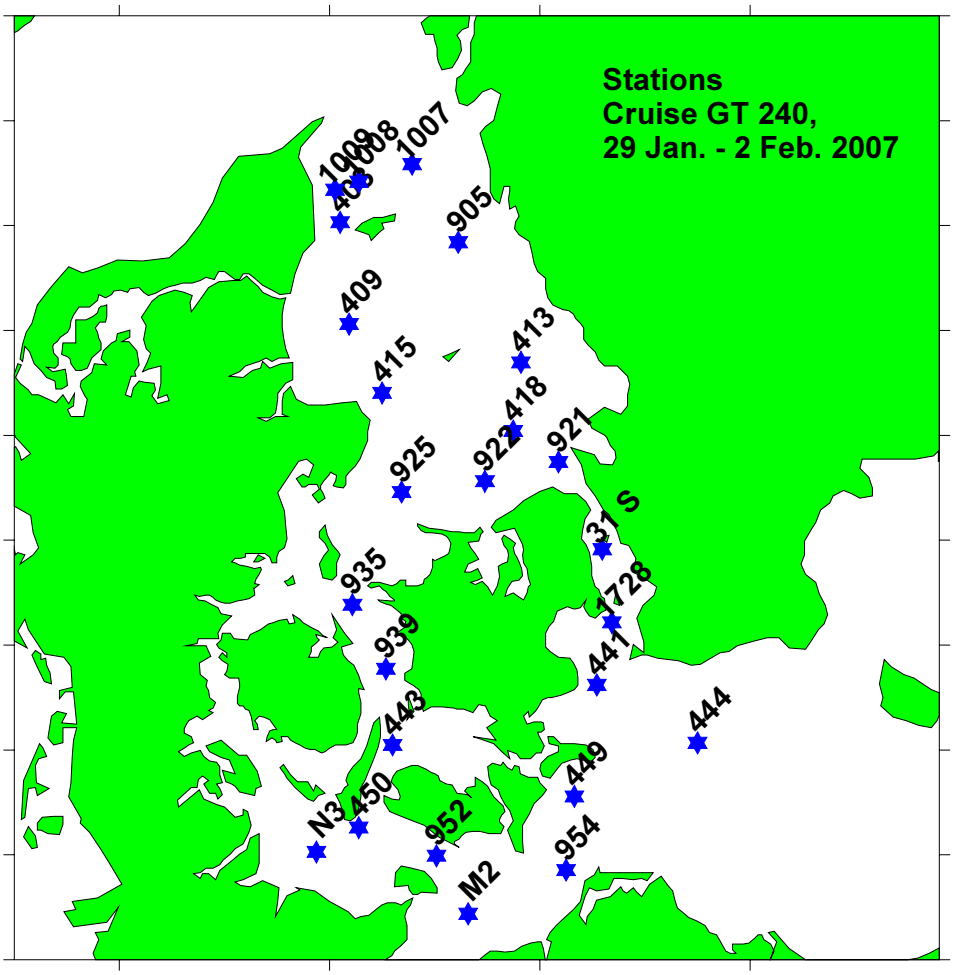

Figure 1 Stations of the monitoring cruise with r/v Gunnar Thorson 29 January – 2 February 2007 in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Gunnar Thorson cruise no. GT 240.

Meteorology

Characteristics of the weather conditions in November 2006 to January 2007 are given in *table 1*. As July, September and October, all 3 months from November 2006 to January 2007 were also record warm. The precipitation in December to January was 94% above normal. Winds from southwest and west prevailed in all 3 months, and were especially strong in the beginning of November (weeks 44 and 45, *figure 2*), first half of December (weeks 49 and 50), and the middle of January (weeks 2 and 3) as well as during the cruise.

Table1 Deviations in monthly mean temperature and precipitation in November 2006 to January 2007 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 2006	+3.4	+4	5.9	S-SW-W
December 2006	+5.4	+77	6.4	SW-W
January 2007	+5.0	+116	7.6	SW-W

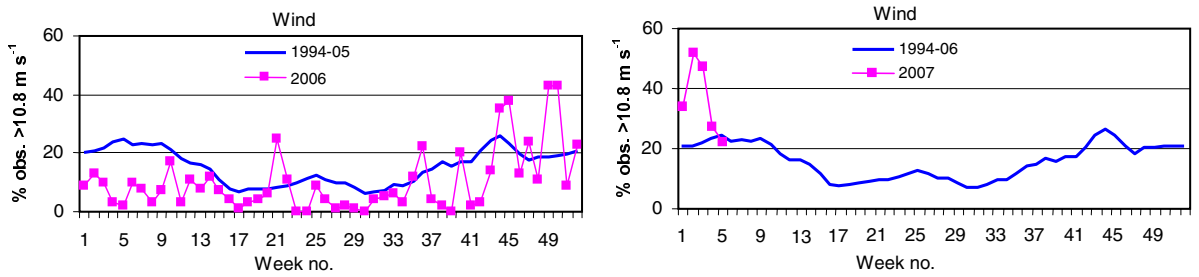

Figure 2 Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2006 and January 2007(connected points) compared to 3-weeks running mean for the period 1994-2005/06 (blue line). Based on data from the Danish Meteorological Institute.

Hydrography

The surface temperature (1 m's depth) varied from 4.3° C at the Drogden Sill (St. 1728) to 6.4° C in the northern Kattegat (St. 1008). The bottom near temperature ranged from 4.6-4.9° C in the Great Belt (St. 443, 925, 935, 939) to 7.3-7.6° C in the eastern Kattegat (St. 413, 905, 1007). The temperature stratification was less than 1° C, except in the eastern Kattegat (St. 413, 905, 1007) and the Arkona Sea (St. 444, 449), generally with the bottom water a little warmer than the surface water (*figure 3*).

The surface salinity ranged from 8.9 in the central Arkona Sea (St. 444) and 10.6-12.2 in the western Arkona Sea and the Sound (St. 441, 449, 954, 1728, 31 S) to 30.6-32.8 in the north-western Kattegat (St. 403, 1008, 1009). The bottom water salinity ranged from 13.8-17.6 in the Arkona Sea (St. 441, 444, 449, 954) to 33.4-34.3 in the northern Kattegat (St. 905, 1007, 1008, 1009) (*figure 3*).

Compared to long-term monthly means (Lightship observations 1931-1960) for January the surface temperature was 2.8-3.8° C higher than average, and the bottom water temperature generally 1.5-3.0° C above average in all areas, except in the bottom water of the south-western Kattegat. The surface salinity was higher than average, and the bottom water salinity was lower than normal in all areas. The salinity stratification was unusually weak for the season in all areas, and nearly absent in the Belt Sea and southern Kattegat (*figure 3*).

Nutrients

The nitrate concentration in the surface layer was as usual lowest (3.1-5.0 µmol/l) in the Arkona Sea (St. 441, 444, 449, 954, 1728), but also in the southern Kattegat and northern Great Belt (St. 418, 922, 925, 935) the concentration was relatively low (*figure 4a*). The highest surface concentration was found in the Læsø Rende (St. 403: 12.9-13.4 µmol/l) and northern Kattegat (St. 1007, 1008, 1009: 8.8-10.2 µmol/l). The high nitrate concentration in the Læsø Rende might originate from the estuaries Limfjorden, Mariager Fjord and/or Randers Fjord. In the southern Great Belt and Fehmarn Belt the nitrate was evenly distributed in the water column with higher concentration (7.1-7.6 µmol/l) than both north and east of the area, probably due to an intensive freshwater runoff to the area. Otherwise the highest bottom water nitrate concentration of 9.6-10.6 µmol/l was found in the northern Kattegat (St. 403, 905, 1007, 1008, 1009).

Relatively high concentrations of ammonium (1.0-2.2 µmol/l) and nitrite (0.5-0.7 µmol/l) for the season were present in the Fehmarn Belt and southern and central Great Belt (St. 443, 450, 952, 939, M2). While nitrite was rather evenly distributed in the water column (*figure 4b*), the ammonium was highest in the bottom water, especially at the southern entrance to the Great Belt (St. 450) (*figure 4c*).

The phosphate concentration in the surface layer was lowest (0.3-0.4 µmol/l) in the southern Kattegat and northern Great Belt (St. 413, 418, 922, 925, 935) and highest both in the surface and bottom waters (0.72-0.84 µmol/l) in the Arkona Sea and southern Belt Sea (*figure 5a*). Also the highest silicate concentrations of 13.8-15.2 µmol/l were found in the bottom water of the Arkona Sea (St. 441, 444, 449, 954) and the whole water column of the southern Belt Sea (St. 443, 450, N3, 952, M2) (*figure 5b*).

Chlorophyll *a*

The highest mean chlorophyll concentration in the uppermost 10 m of 1.6-1.8 µg/l was observed in the southern Belt Sea (St. 443, 450, 952, M2, N3). The lowest concentration of 0.4-1.0 µg/l was found in the Sound and Kattegat, except for 1.4 µg/l observed in the Læsø Rende (St. 403). In the Great Belt (St. 925, 935, 939) the concentration was 1.3-1.5 µg/l, and in the Arkona Sea (St. 441, 444, 449, 954) 1.1-1.5 µg/l (*figure 6*). The chlorophyll concentrations were relatively homogenous distributed in the surface layer and normal for the season before the actual onset of the phytoplankton spring bloom.

Oxygen

The lowest oxygen concentrations of 6.3-6.9 ml/l (93-98% saturation) were observed in the eastern and northern Kattegat (St. 413, 905, 1007, 1008, 1009) in the relatively warm bottom water (*figure 7*). Also in the bottom water of the central Arkona Sea the saturation was only 94%. Otherwise the water was generally saturated with oxygen in the whole water column in all areas.

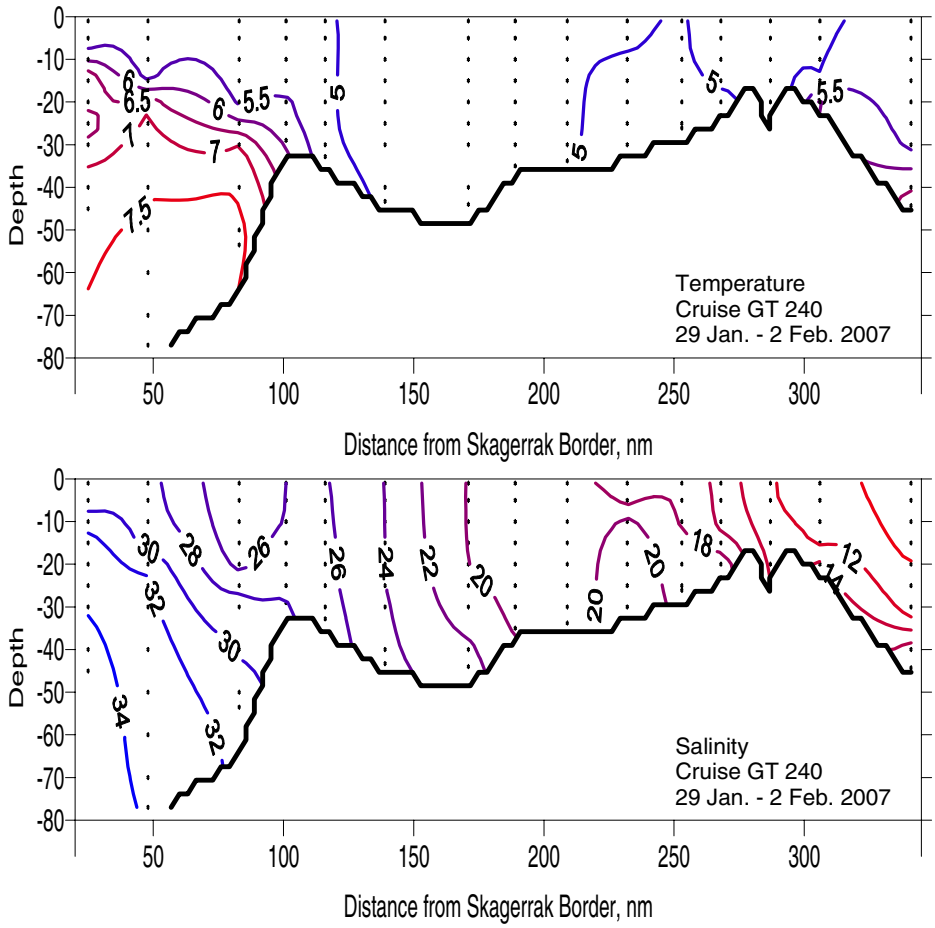

Figure 3 Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

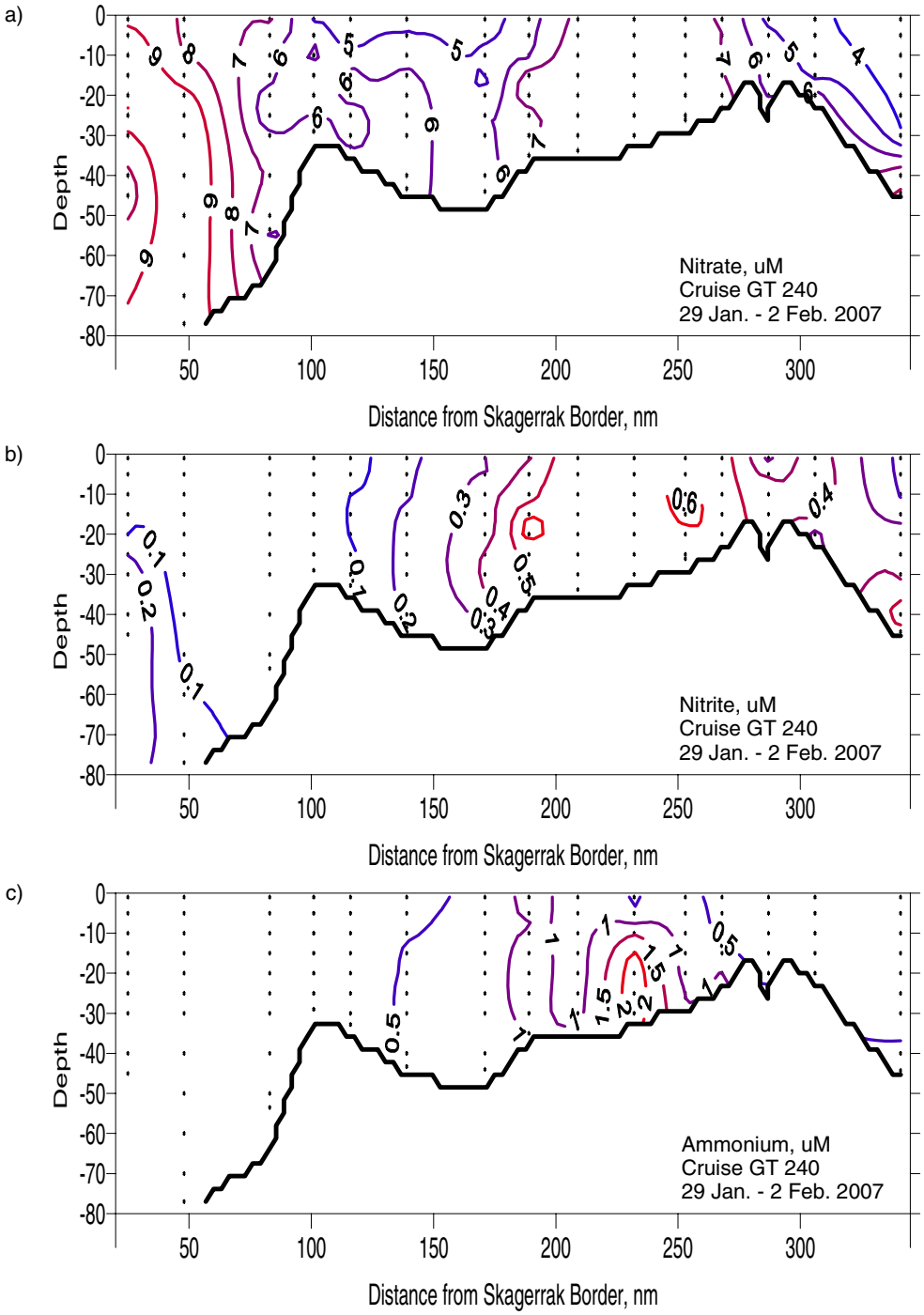

Figure 4 Nitrate (a), nitrite (b) and ammonium (c) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

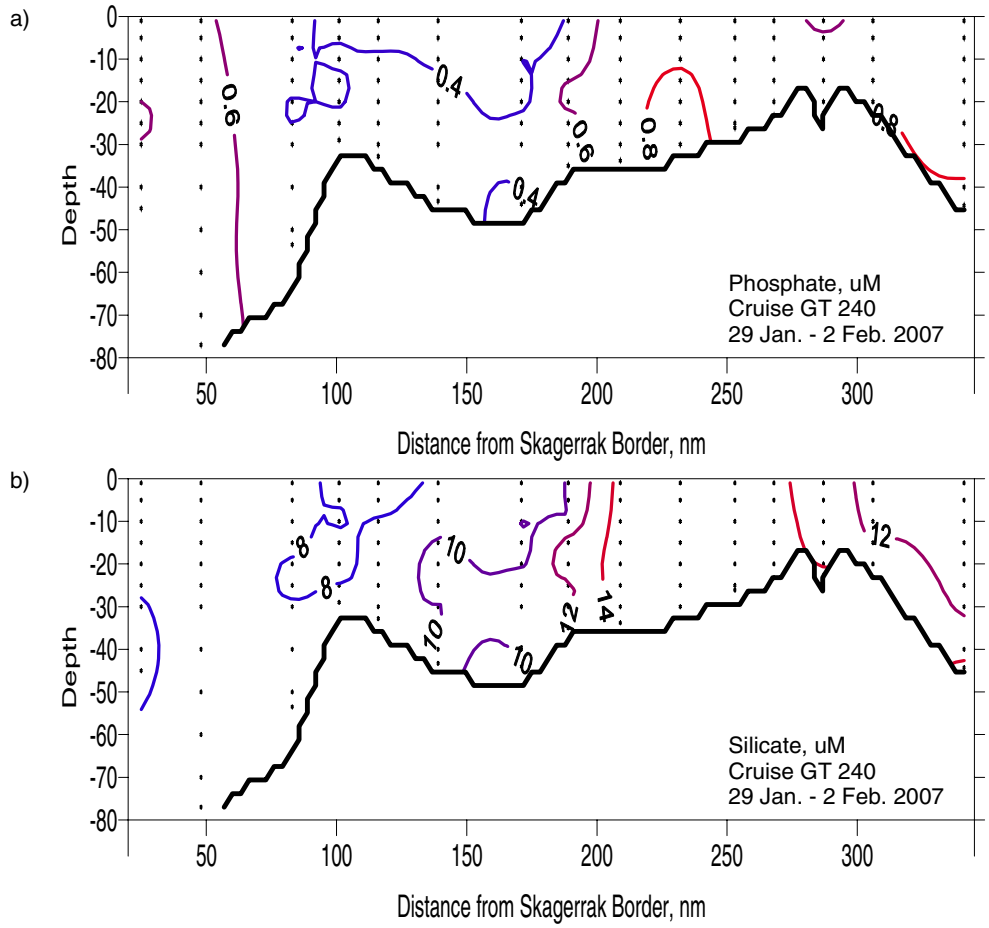

Figure 5 Phosphate (a) and silicate (b) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

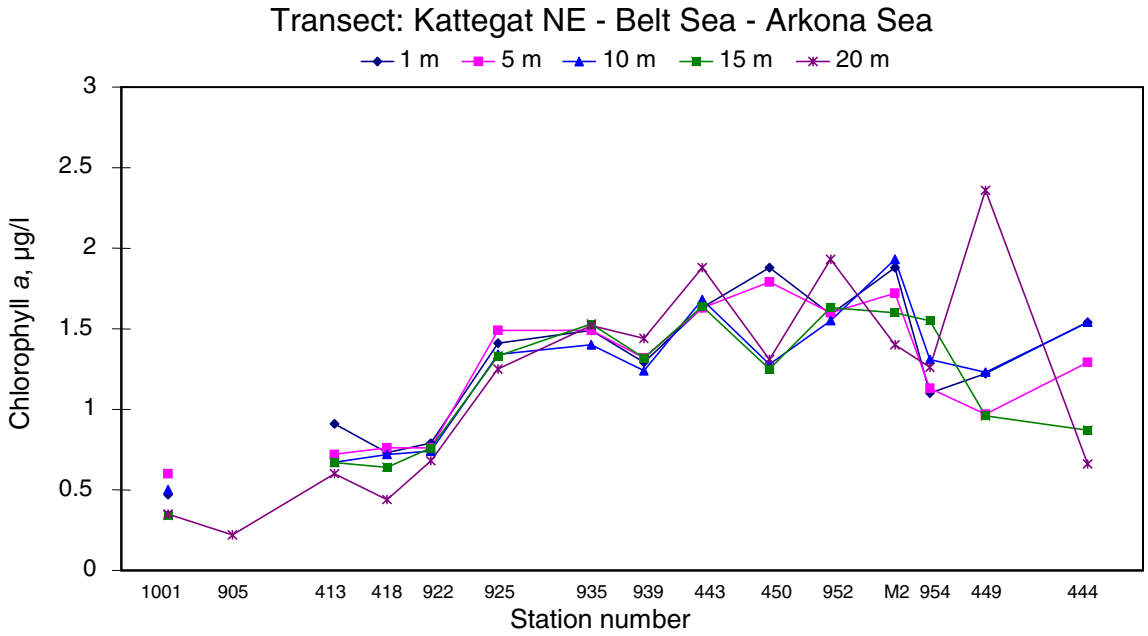

Figure 6 Chlorophyll *a* at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

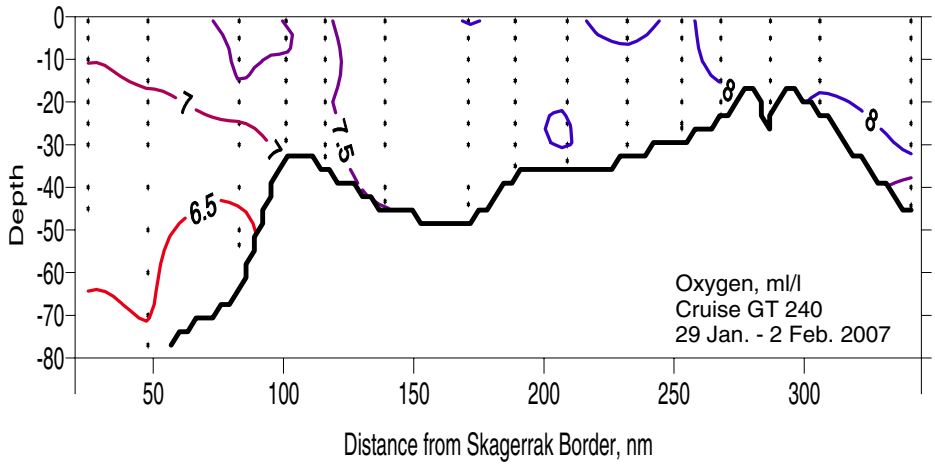

Figure 7 Oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.