r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 207

Time: 4 - 14 February 2002

Area: The Sound, Kattegat, Skagerrak, North Sea, 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, Skagerrak, North Sea, Belt Sea and Arkona Sea, 4-14 February 2002 - Cruise no. 207

Report: Gunni Ærtebjerg

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Summary

Due to the prevailing westerly wind the Jutland Coastal Current (JCC) with lower salinity and temperature and high nutrient concentrations, especially nitrate, was narrow along all the Danish North Sea and Skagerrak coast. The JCC also influenced the northern Kattegat north of Læsø with nitrate concentrations up to 17 µmol/l, but was not observed further south in the Kattegat.

In the North Sea the nutrient concentrations, except nitrite, as usual varied inversely to the salinity. Due to this the nutrient concentrations were generally highest in the south-eastern German Bight (nitrate up to 57 µmol/l), decreasing to the north and west. The nitrate concentrations in the Kattegat and Belt Sea were relatively high compared to the 1980s, probably due to a high runoff during the winter.

The DIN/DIP ratio varied from 46-67 in the German Bight and about 30 in the JCC to 6-9 at the north-western North Sea stations. In the Kattegat and Belt Sea the DIN/DIP ratio was rather close to the Redfield ratio of 16 for phytoplankton uptake, as it varied from about 12 in the Arkona Sea to 16 in the northern Kattegat.

The mean chlorophyll-*a* concentration in the surface layer (0-10 m) varied from 0.5-1.0 µg/l outside the JCC, both in the North Sea and central Skagerrak, to 3.3-3.4 µg/l at the coast-near stations in the German Bight, the later probably due to re-suspension. In the Kattegat and Belt Sea the mean chlorophyll concentration was highest (2.6 µg/l) at Gedser Rev, and above 1.5 µg/l in Kiel Bight, Mecklenburg Bight and Læsø Rende. The phytoplankton spring bloom had not yet started, but seemed just about to begin in the Gedser Rev area.

The minimum oxygen concentrations were about saturation level at all stations in the North Sea. At the deepest station in the central Skagerrak the lowest oxygen concentrations of 3.4-4.0 ml/l were observed in 200-500 m depth. In the Kattegat and Belt Sea the lowest oxygen concentrations of 6.1-6.4 ml/l were observed in the south-eastern Kattegat and central Great Belt. Compared to mean for February in the 1980's the minimum oxygen concentrations this year were generally higher, except for slightly lower concentrations in the Great Belt and southern Belt Sea.

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, Skagerrak, North Sea). The main scope of the cruise was to monitor the winter nutrient levels, but also the hydrography and the concentrations of oxygen and chlorophyll-*a*. The stations of the cruise are shown in *figure 1*. Also integrated phytoplankton and zooplankton samples were collected at 4 stations, and macrozoobenthos was sampled at 3 stations. Sediment samples for monitoring of radioactivity were sampled at 2 stations. Besides the monitoring measurements, sediments for pigment analyses were sampled at 8 stations, and *Laminaria spp.* collected at one locality.

Meteorology

Characteristics of the weather conditions since the last cruise in the beginning of November 2001 are given in *table 1*. The winter 2001-2002 (December-February) was in spite of a cold December on average 2°C above normal. After a dry November the precipitation increased through the winter to a new record in February and was on average 60% above normal. The wind was strong from mid January and in February, mainly from south-west and west.

Table 1. Deviations in monthly mean temperature and precipitation in November 2001 to February 2002 in Denmark compared to long term monthly means 1961-90, monthly mean wind speed and dominating wind directions (based on data from the Danish Meteorological Institute).

Month	Temperature deviation °C	Precipitation % deviation	Mean wind speed m/s	Dominating wind direction
Nov. 01	+0.5	-25	5.5	SW-W-NW
Dec. 01	-1.0	+8	4.5	Changing
Jan. 02	+2.9	+54	6.1	S-SW-W
Feb. 02	+4.2	+187	7.0	SW-W

North Sea and Skagerrak

Hydrography

The Jutland Coastal Current (JCC) with lower salinity and temperature was evident but relatively narrow along the Danish North Sea and Skagerrak coast. Northwest of the JCC the surface salinity was high, 34.3-34.8 (St. 1024-1027, 1073-1074), and a tongue of high saline surface water (34.3-34.7) was observed in the central Skagerrak (St. 1104, 1131-1135). Along the coast the salinity increased from 25.9-28.3 in the German Bight to 29.9 at Hanstholm, 30.8 at Hirtshals and 32.0 at Skagen (*figure 2*). The surface temperature was unusually high for the season and ranged from 5.1°C at the coast-near stations (St. 1059, 1086) in the German Bight to 7.2°C at the north-western stations in the North Sea (St. 1025-1026, 1074) and 6.3-6.9°C in the central Skagerrak (St. 1102-1104, 1130-1133) (*figure 3*).

Nutrients
In the North Sea the nutrient concentrations, except nitrite, as usual varied inversely to the salinity (*figure 4*). The results of linear regressions are shown in *table 2*. All regressions, except for nitrite, are highly significant, indicating well-mixed water masses in the eastern North Sea, although ammonium, DIP and TP correlations to salinity are lower than for nitrate, DIN, TN and silicate due to bio-geochemical processes.

Table 2. Linear regression analyses of salinity and concentrations of nutrients at the 32 stations in the North Sea 6-9 February 2002. The intercept gives the estimated mean concentrations in fresh water entering the south-eastern North Sea. 34.5 psu gives the estimated concentrations in central North Sea water. Unit = µmol/l. n = number of samples.

Nutrient	Slope	Intercept	34.5 psu	n	R^2
Nitrate	-7.1	252	5.3	207	0.95
Nitrite	-0.01	0.56	0.1	207	0.04
Ammonium	-0.47	16.0	0	207	0.75
DIN	-7.6	268	4.8	207	0.94
TN	-10.6	376	11.7	206	0.97
DIP	-0.10	3.91	0.43	207	0.70
TP	-0.24	9.21	0.82	206	0.74
Silicate	-4.8	168	3.1	207	0.90

Due to the relation to the salinity the nutrient concentrations were generally highest in the south-eastern German Bight, decreasing to the north and west (*figures 5, 6, 7, 8, 9 and 10*). In the Skagerrak as much as 33.8 µmol/l nitrate was observed in the JCC at Hanstholm (St. 1019) and 26.1-28.5 µmol/l at Hirtshals (St. 1013, 1101) (*figure 5*).

The DIN/DIP ratio varied from 46-67 in the German Bight and about 30 in the JCC to 6-9 at the north-western North Sea stations (*figure 11*).

Oxygen and chlorophyll-*a*
The minimum oxygen concentrations were about saturation level at all stations in the North Sea. At the deepest station in the Skagerrak the lowest oxygen concentrations of 3.4-4.0 ml/l (50-59%) were observed in 200-500 m depth at the central station 1006 (M6).

The mean chlorophyll-*a* concentration in the surface layer (0-10 m) varied from 0.5-1.0 µg/l outside the JCC, both in the North Sea and central Skagerrak, to 3.3-3.4 µg/l at the coast-near stations in the German Bight, probably due to re-suspension (*figure 12*). Spring bloom was not initiated.

Kattegat, Sound, Belt Sea and Arkona Sea

Hydrography
The surface temperature (1 m depth) was high for the season and varied from 3.5-3.6°C in the Arkona Sea (St. 441, 444) to 5.1-5.3°C in the Great Belt (St. 450, 443, 939, 935) (*figure 3*). The bottom water temperature ranged from 4.2-5.0°C in the Arkona Sea and southern Belt Sea (St. 441, 444, 952, 954, N3, M2) to 6.1-6.3°C in the south-eastern Kattegat (St. 921, 922) (*figure 13a*).

The surface salinity was high for the season and ranged from 8.6-9.1 in the Arkona Sea (St. 441, 444) to 30.7-31.8 in the north-eastern Kattegat (St. 1007, 1008) (*figure 2*). The bottom water salinity ranged from 15.6-16.7 in the Arkona Sea (St. 441, 444, 954) to 33.1-33.4 in the eastern Kattegat (St. 433, 905, 921, 922) (*figure 13b*). The salinity stratification was relatively weak for the season with a maximum of 12 psu in the Sound.

Compared to long term monthly means (Lightship observations 1931-1960) for February the water temperature during the present cruise was higher, both in the surface (2.5-3.7°C) and in the bottom water (0-2.8°C). The salinity was generally higher than normal, except for lower than normal bottom water salinity in Kattegat.

Nutrients
The JCC influenced the northern Kattegat with nitrate and DIN concentrations of 10-18 µmol/l north of Læsø. But south of this inflow from the JCC could not be traced (*figure 5, 14a* and *15a*). However, in the rest of the Kattegat, Belt Sea and Arkona Sea the nitrate and DIN concentrations were relatively high, probably due to a high runoff (*figure 14a* and *15a*).

Rather high concentrations of nitrite (>0.5 µmol/l) and ammonium (>1 µmol/l) were found in the southern Belt Sea (*figure 14b* and *14c*). Also the concentration of silicate was highest in the Belt Sea (*figures 10 and 16a*), while the phosphate concentration was highest (>0.7 µmol/l) in the Kattegat bottom water (*figure 8 and 15b*).

The DIN/DIP ratio was rather close to the Redfield ratio for phytoplankton uptake, as it varied from about 12 in the Arkona Sea to 16 in the northern Kattegat, but up to 28 in the JCC water north of Læsø (*figure 11* and *15c*).

Chlorophyll-*a*
The mean chlorophyll concentration in the uppermost 10 m was highest (2.6 µg/l) at Gedser Rev (St. 954), and above 1.5 µg/l in Kiel Bight, Mecklenburg Bight and Læsø Rende (*figure 12*). The chlorophyll was relatively homogeneously distributed in the uppermost 10-15 m (*figure 16b*). The phytoplankton spring bloom had not yet started, but seemed just about to begin in the Gedser Rev area.

Oxygen
The lowest oxygen concentrations of 6.1-6.4 ml/l (88-91% saturation) were observed in the south-eastern Kattegat and central Great Belt (*figure 16c*). Compared to mean for February in the 1980’s the minimum oxygen concentrations this year were generally higher, except for slightly lower concentrations in the Great Belt and southern Belt Sea.

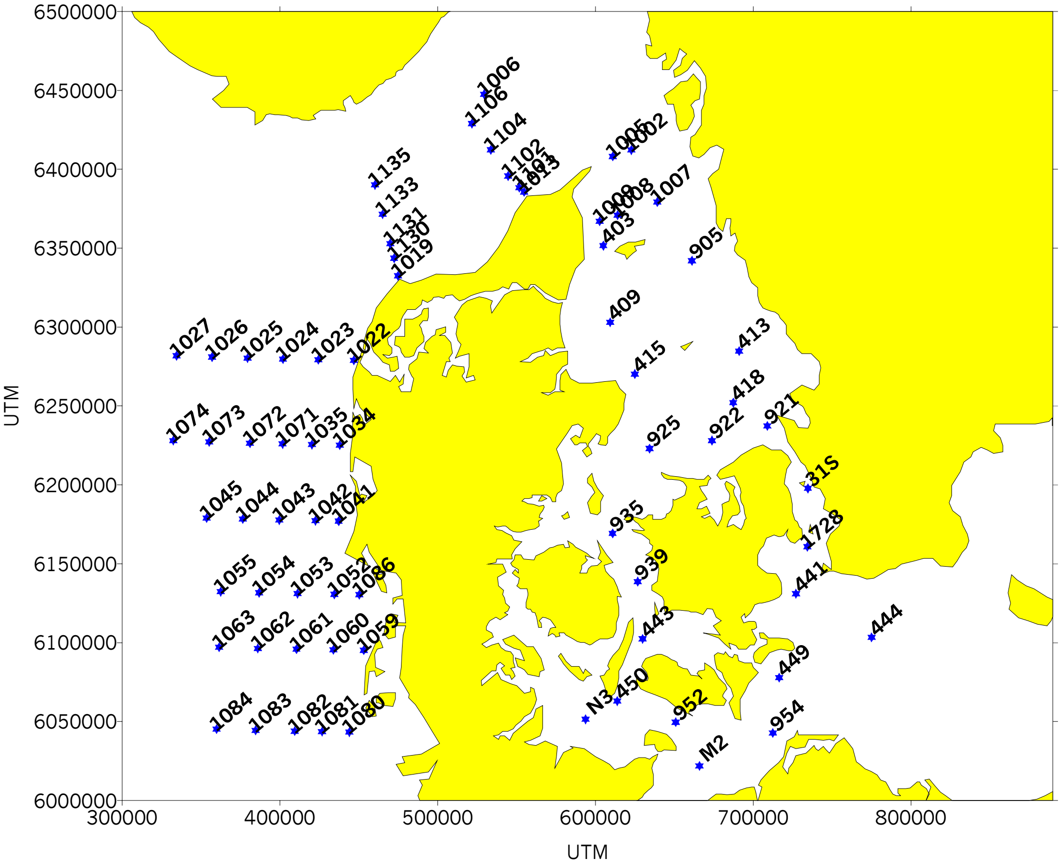

Figure 1 Stations of the monitoring cruise with r/v Gunnar Thorson 4-14 February 2002 in the Sound, Kattegat, Skagerrak, North Sea, Belt Sea and Arkona Sea. Gunnar Thorson cruise no. 207.

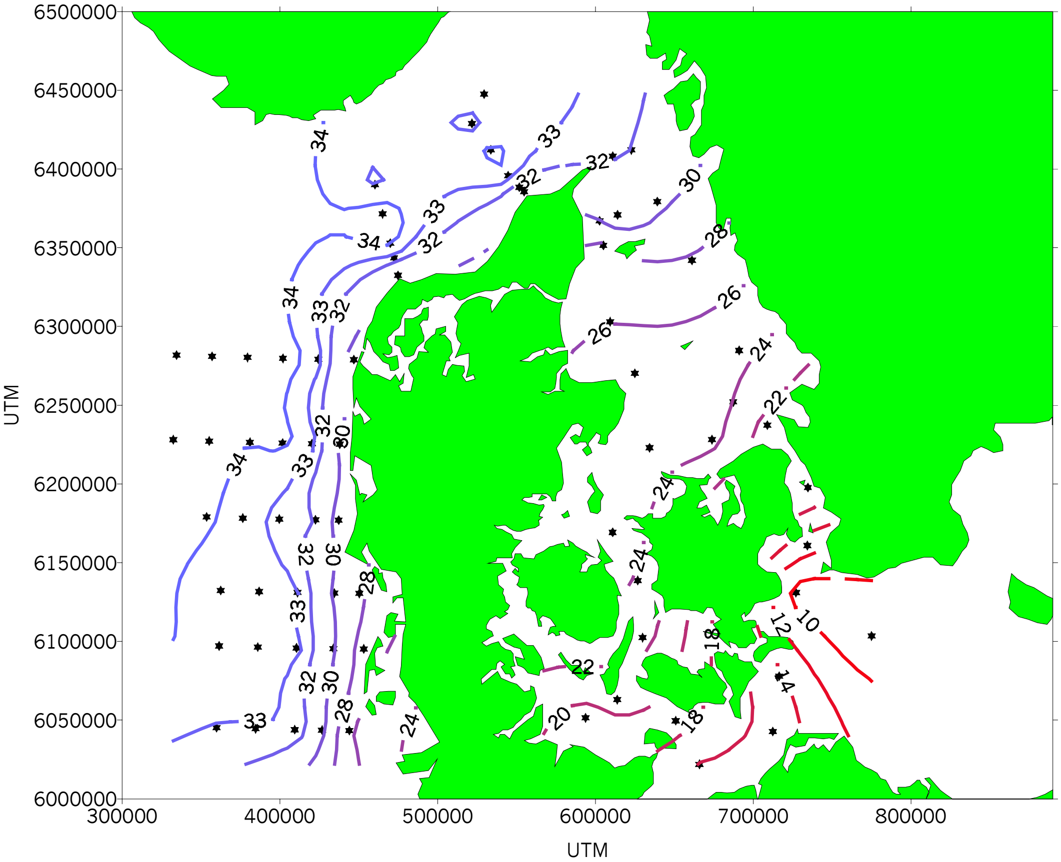

Figure 2 Interpolated distribution of surface salinity (mean 1, 5 and 10 m depth).

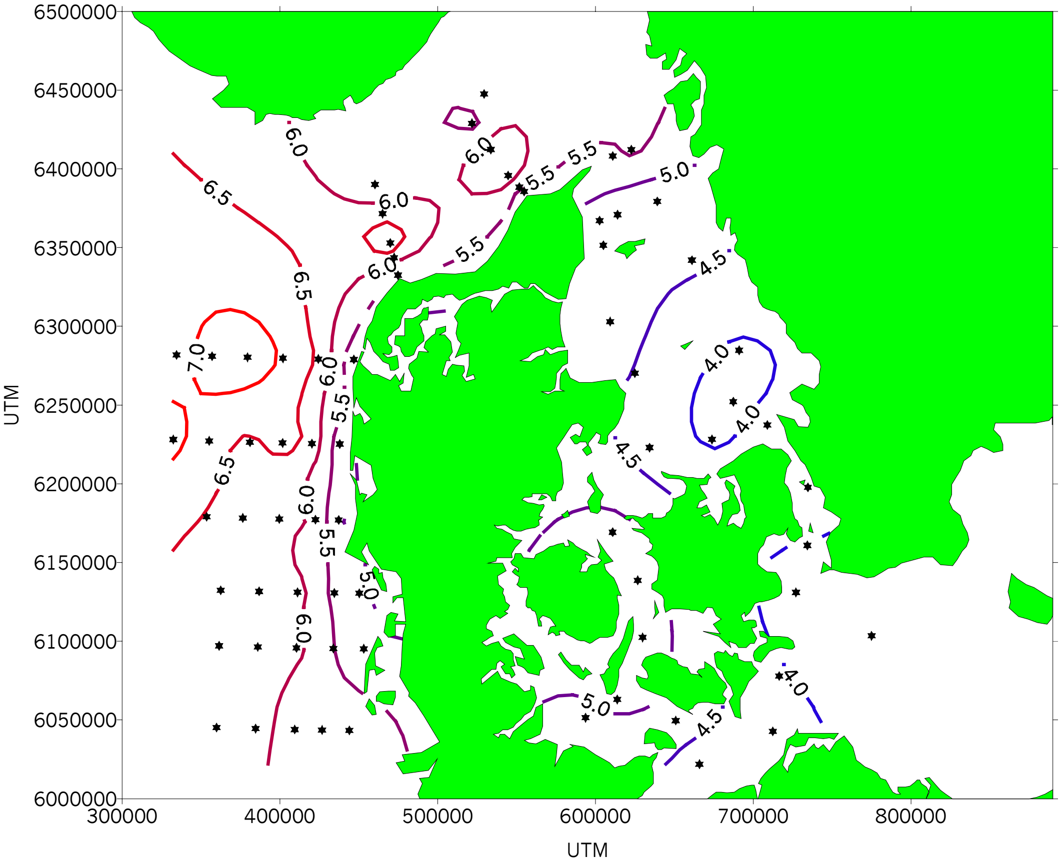

Figure 3 Interpolated distribution of surface temperature (mean 1, 5 and 10 m depth).

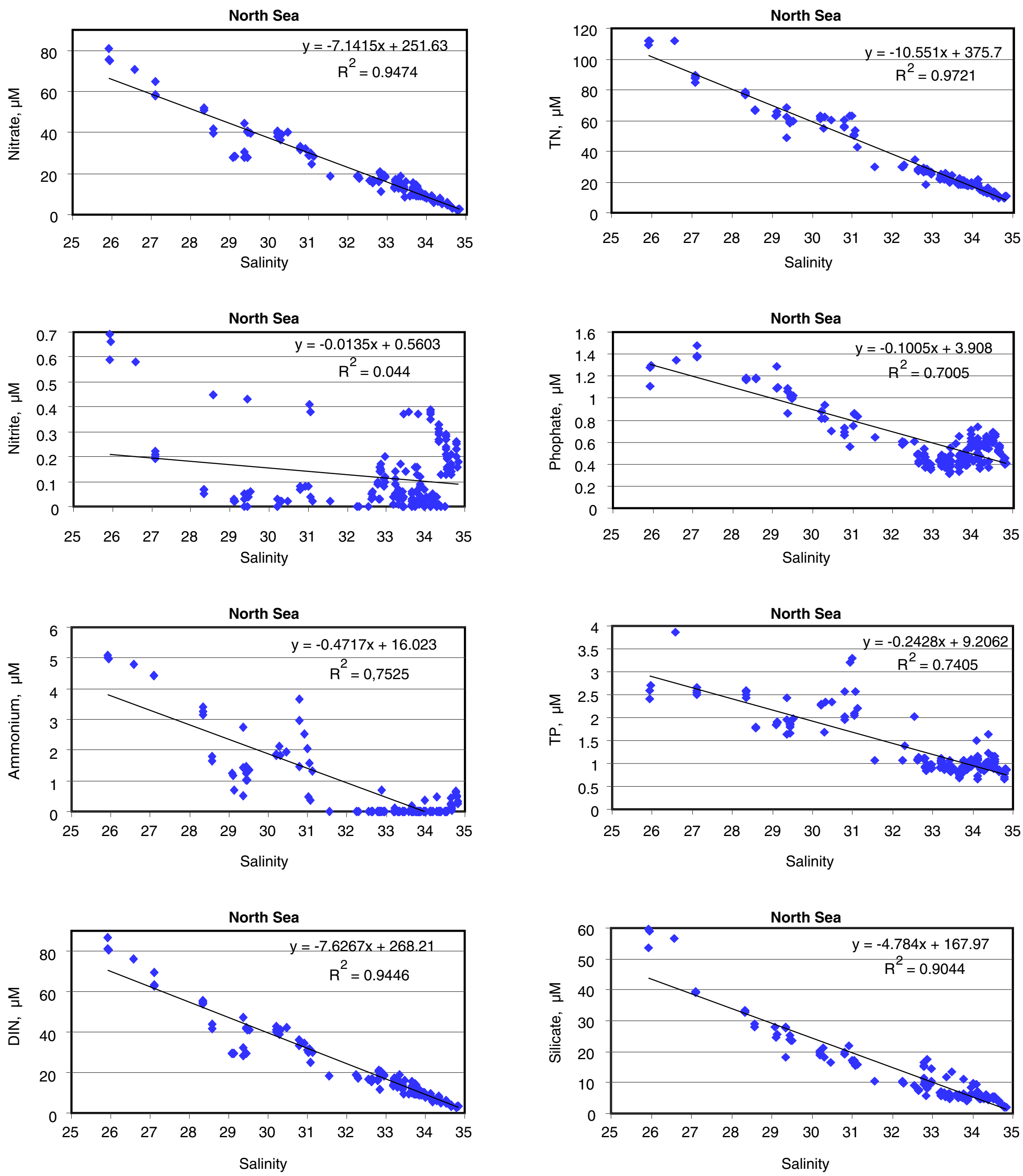

Figure 4 Correlations between salinity and nutrient concentrations at the 32 stations in the North Sea 6-9 February 2002.

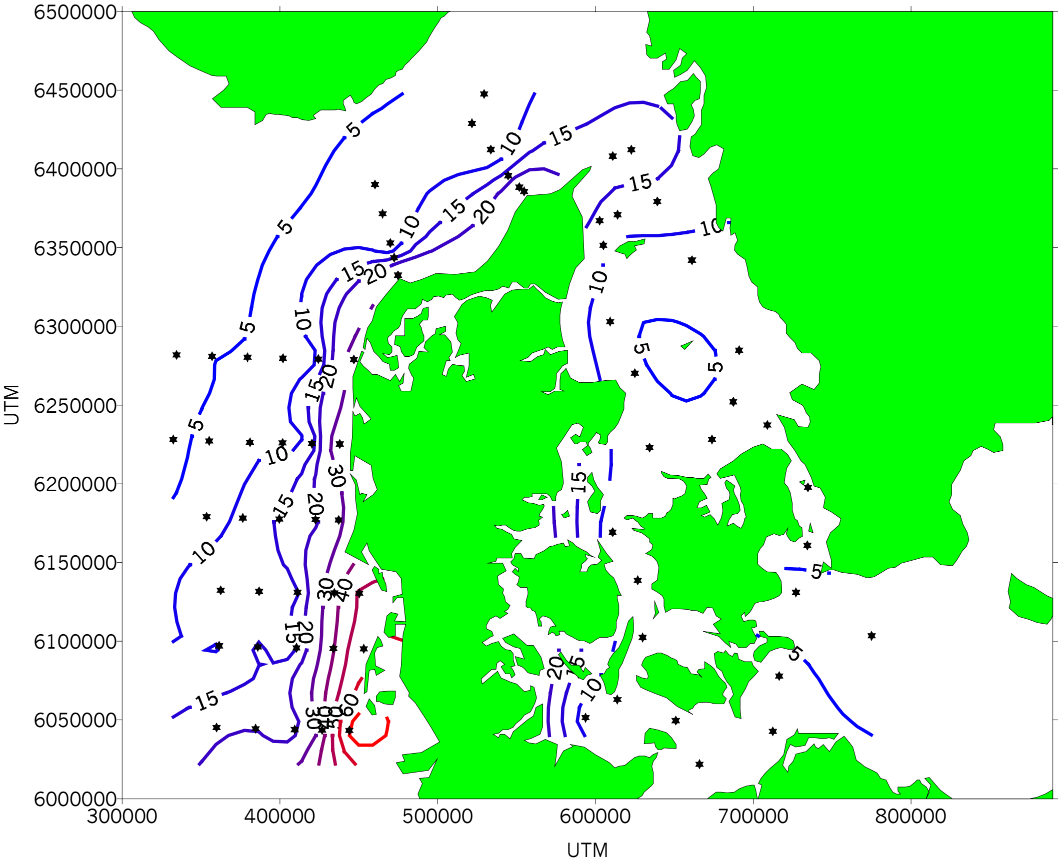

Figure 5 Interpolated distribution of surface nitrate concentrations (mean 1, 5 and 10 m depth).

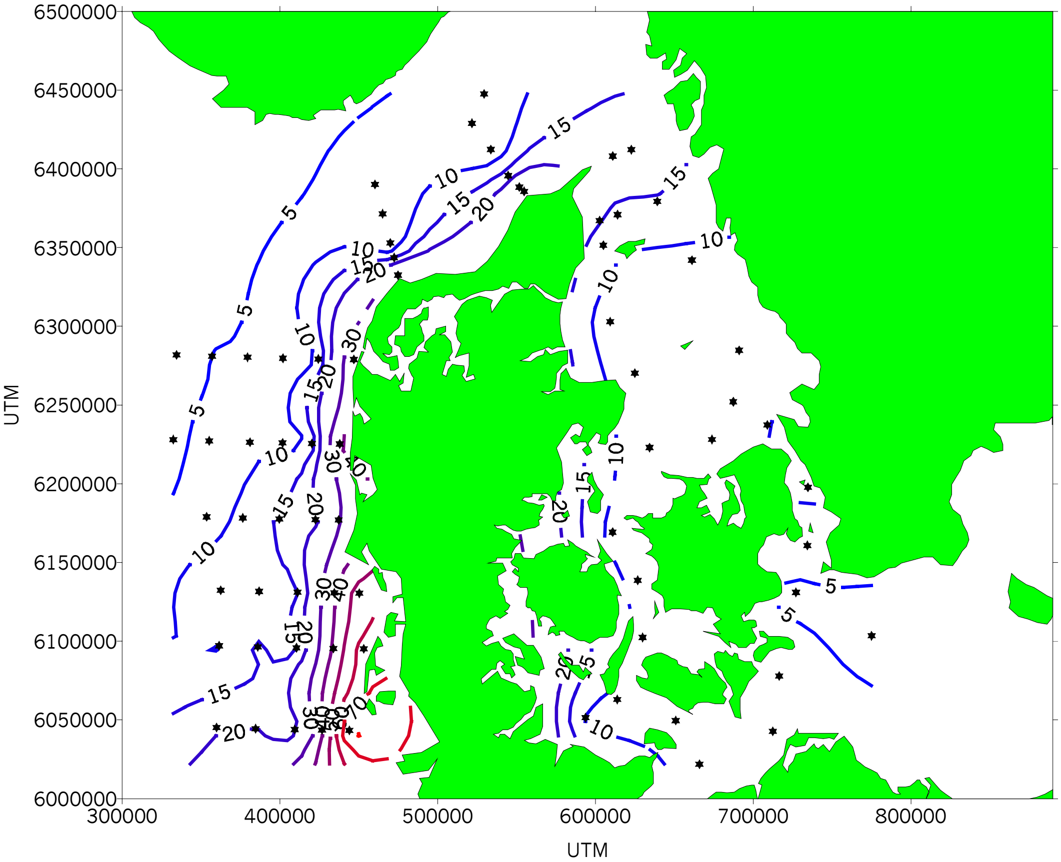

Figure 6 Interpolated distribution of surface DIN concentrations (mean 1, 5 and 10 m depth).

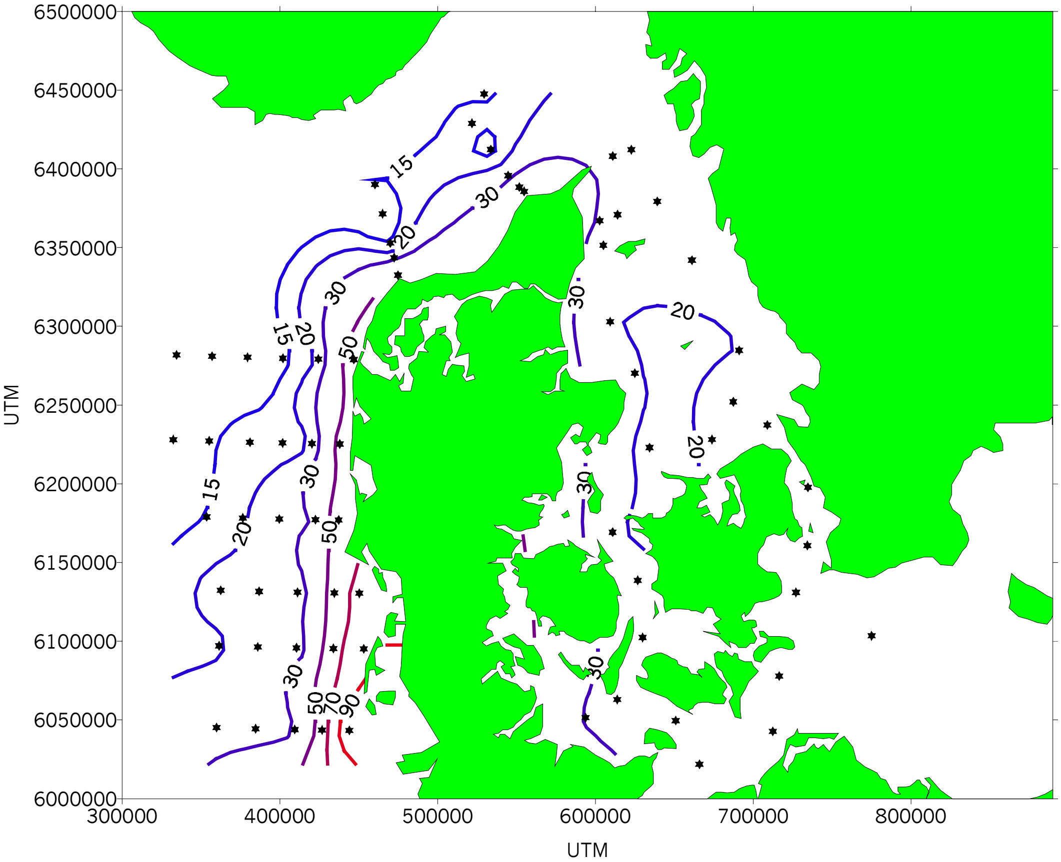

Figure 7 Interpolated distribution of surface Total-N (mean 1, 5 and 10 m depth).

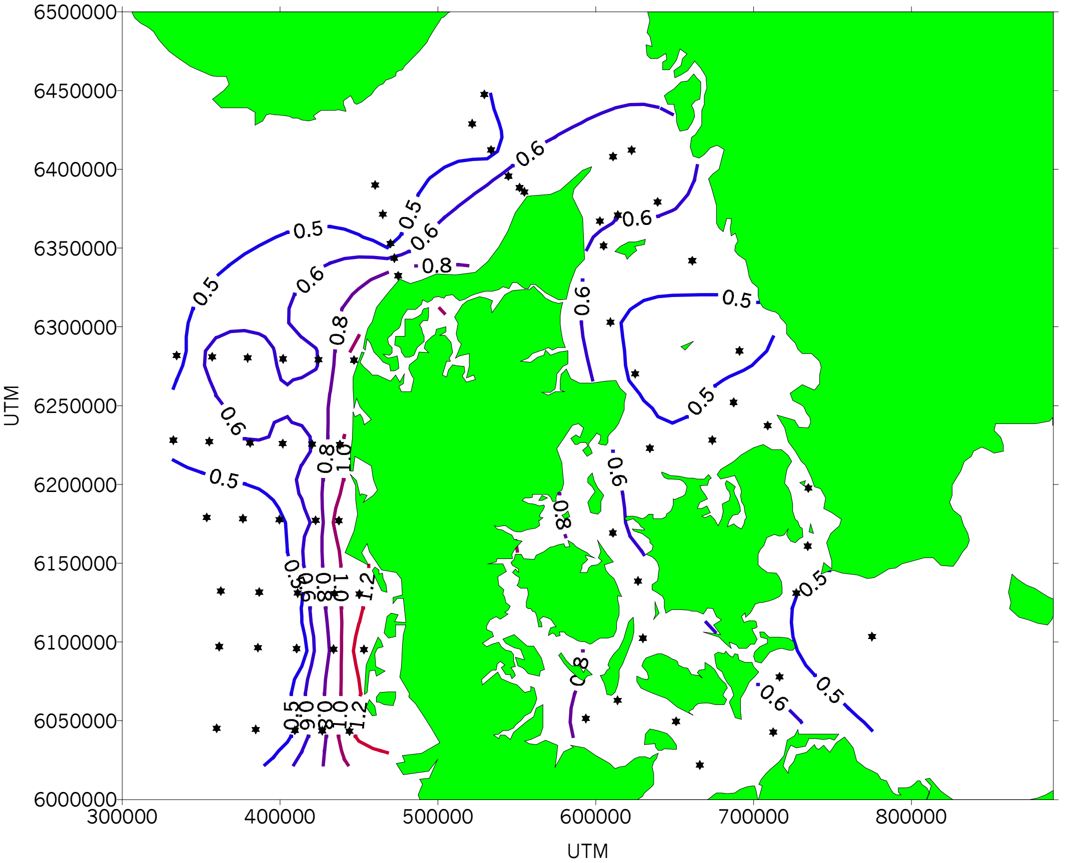

Figure 8 Interpolated distribution of surface phosphate concentrations (mean 1, 5 and 10 m depth).

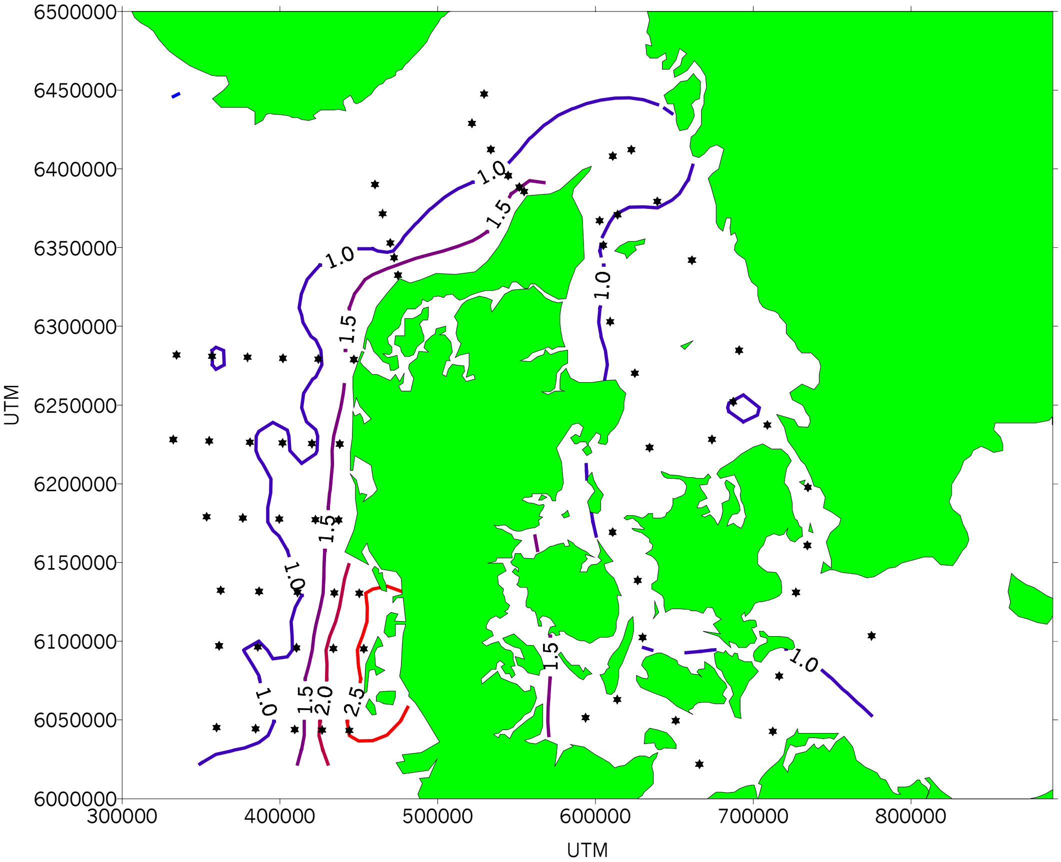

Figure 9 Interpolated distribution of surface Total-P concentrations (mean 1, 5 and 10 m depth).

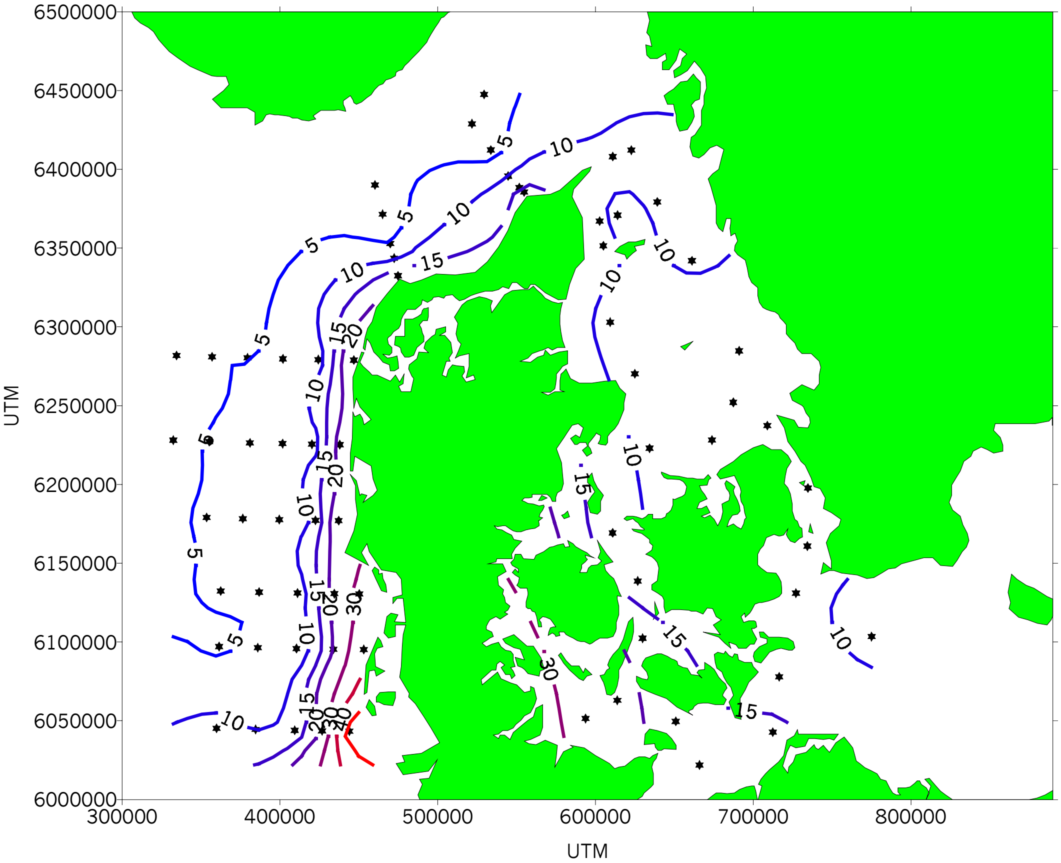

Figure 10 Interpolated distribution of surface silicate concentrations (mean 1, 5 and 10 m depth).

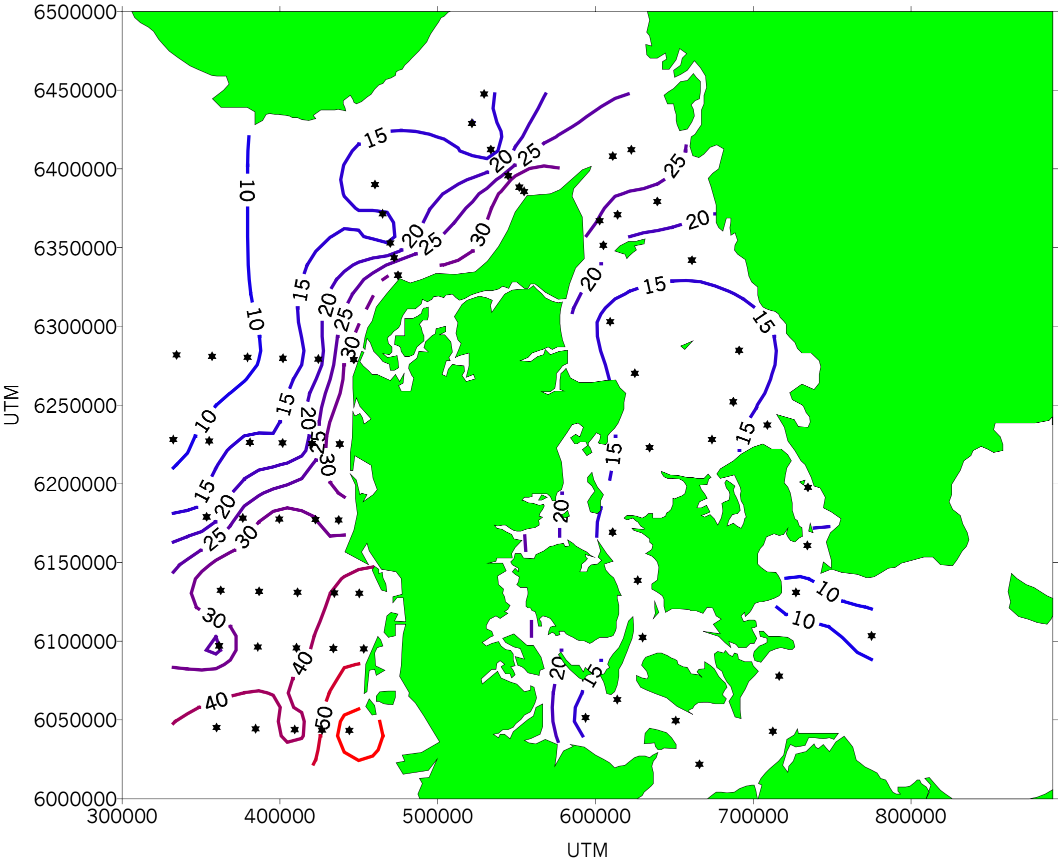

Figure 11 Interpolated distribution of surface (0-10 m) DIN/DIP ratio.

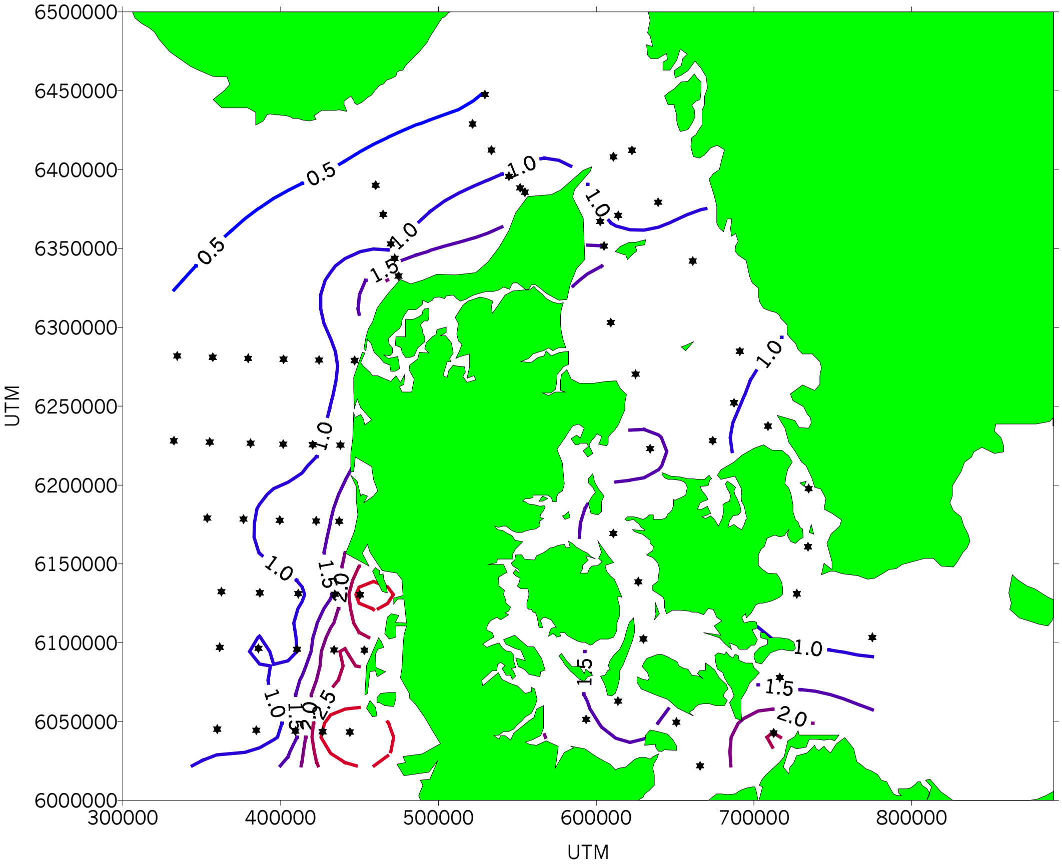

Figure 12 Interpolated distribution of surface chlorophyll-*a* concentrations (mean 1, 5 and 10 m depth).

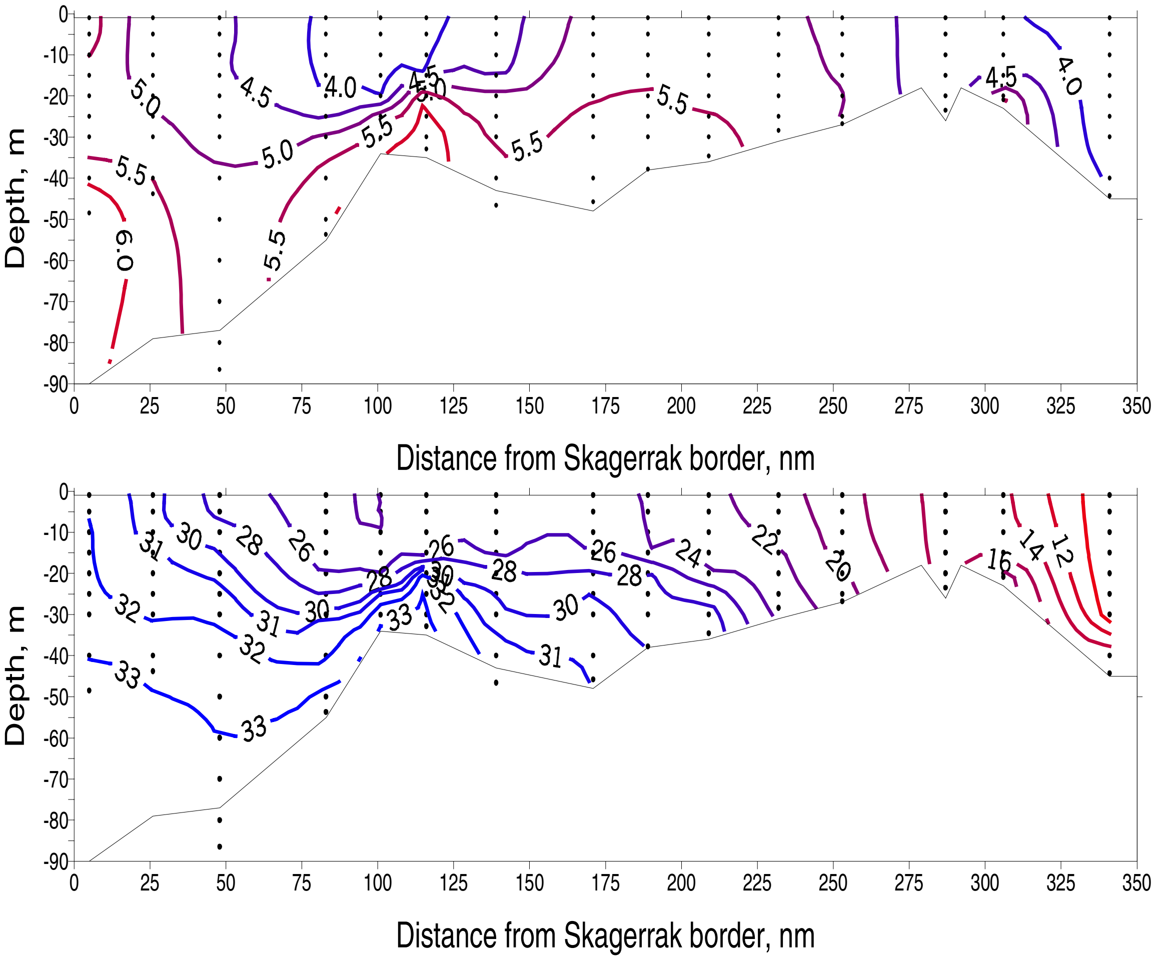

Figure 13 Temperature and salinity distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

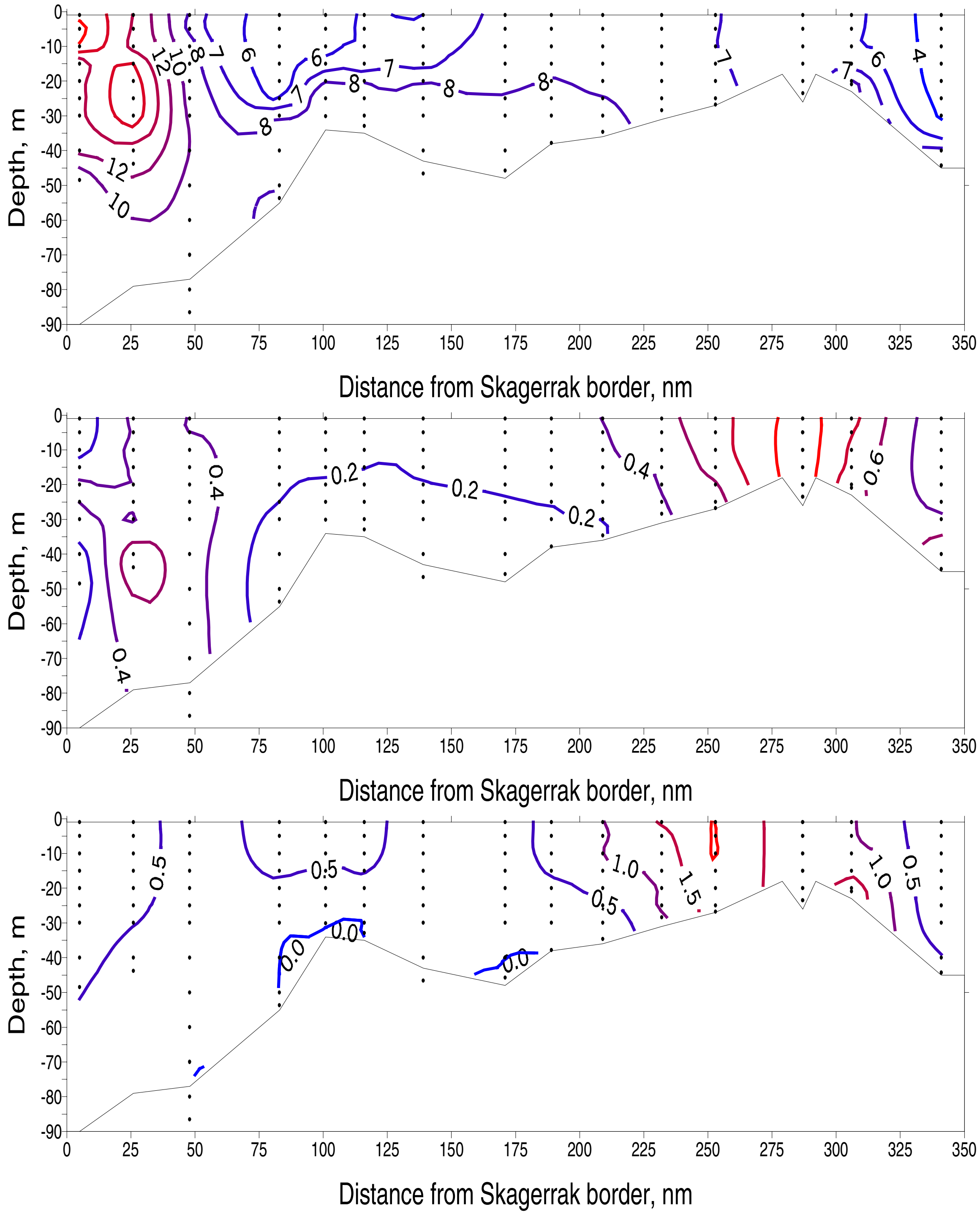

Figure 14 Nitrate, nitrite and ammonium distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

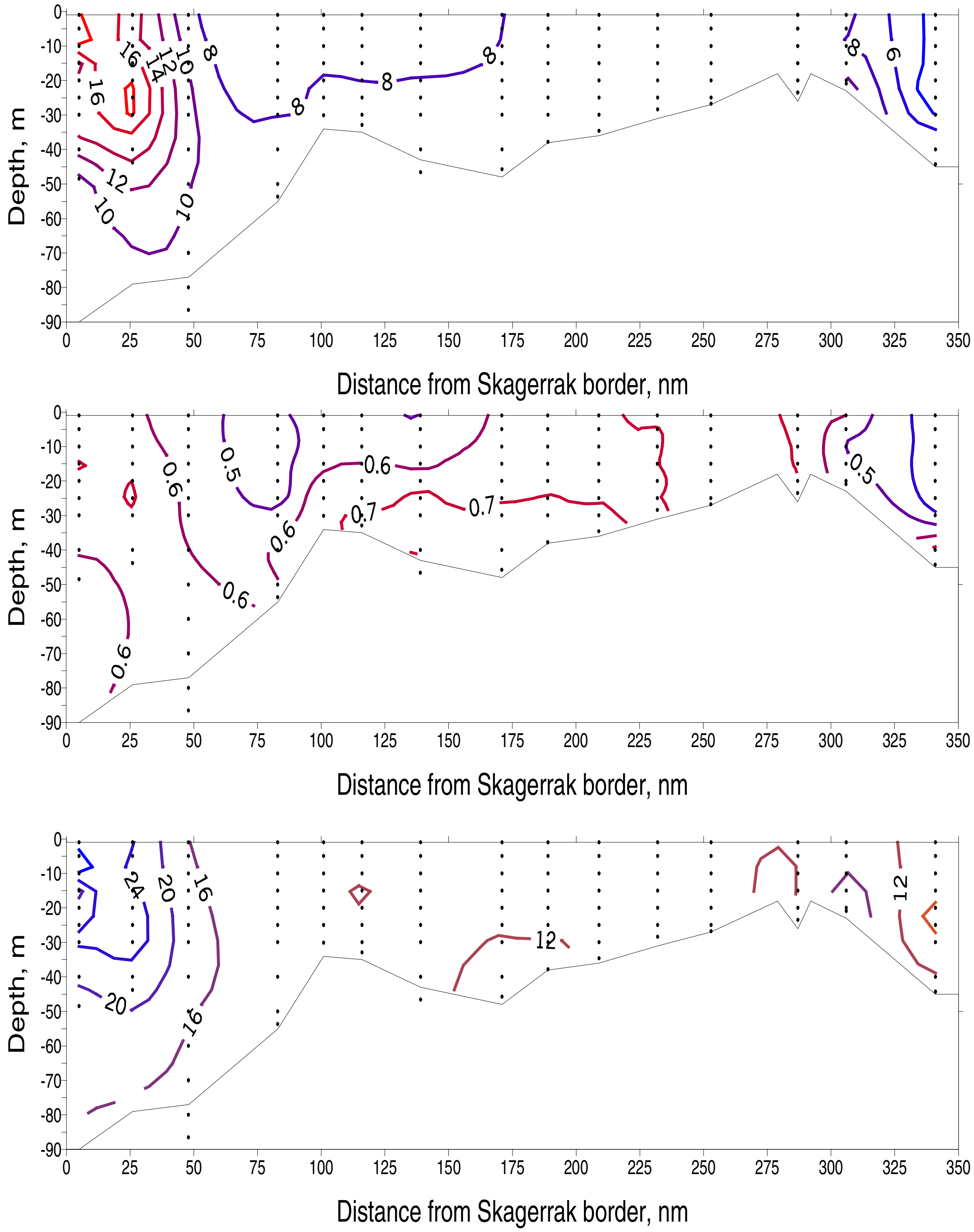

Figure 15 DIN, phosphate and DIN/DIP ratio distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

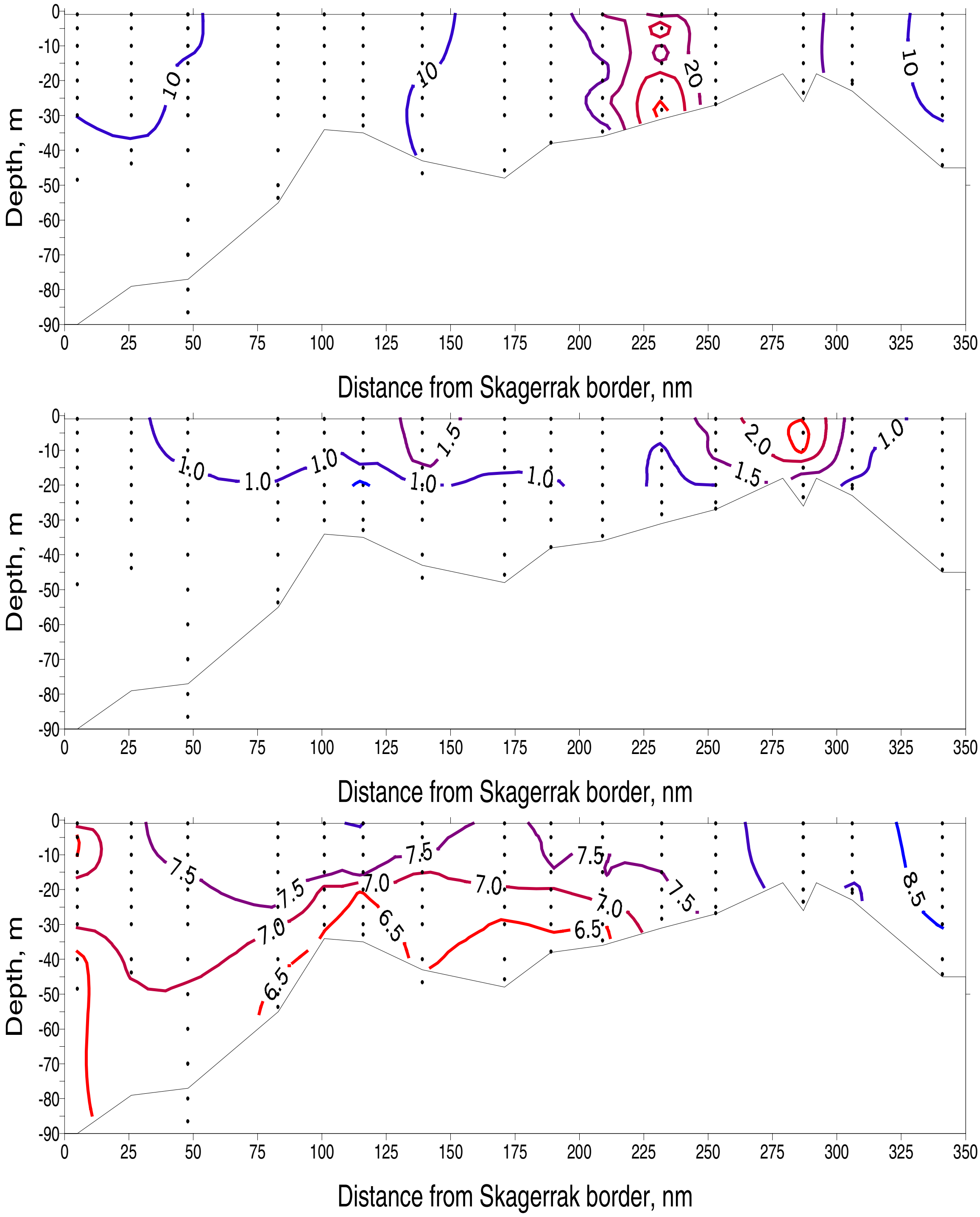

Figure 16 Silicate, chlorophyll-a and oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.