r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 222

Time: 9 - 18 February 2004

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

Ministry of the Environment
National Environmental Research Institute
Frederiksborgvej 399
DK-4000 Roskilde
Denmark
Tel.: +45 4630 1200 ◇ Fax: +45 4630 1114
www.neri.dk

Data Sheet

Title:	Monitoring Cruise with r/v Gunnar Thorson in the Sound, the Kattegat, the Skagerrak, the North Sea, the Belt Sea and the Arkona Sea
Subtitle:	Cruise no. 222, 9-18 February 2004
Author: Department:	Gunni Ærtebjerg Department of Marine Ecology
Serial title:	Monitoring Cruise Report
Publisher:	National Environmental Research Institute© Ministry of the Environment
Week/year of publication:	14/2004
Please quote:	Ærtebjerg, G. 2004: Monitoring Cruise with r/v Gunnar Thorson in the Sound, the Kattegat, the Skagerrak, the North Sea, the Belt Sea and the Arkona Sea. Cruise no. 222, 9-18 February 2004. National Environmental Research Institute, Denmark. Monitoring Cruise Report. Reproduction permitted only when quoting is evident.
Keywords:	Marine, monitoring, hydrography, eutrophication
ISSN (electronic): (Only published electronically)	1600-1656 http://www.dmu.dk/1_om_dmu/2_afdelinger/3_hav/CruiseReports/index.htm
Number of pages:	15
	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 Frederiksborgvej 399 P.O. Box 358 DK-4000 Roskilde Tel. +45 4630 1200 Fax +45 4630 1114 E-mail: dmu@dmu.dk www.neri.dk

Monitoring cruise with r/v Gunnar Thorson in the Sound, the Kattegat, the Skagerrak, the North Sea, the Belt Sea and the Arkona Sea, 9-18 February 2004 – Cruise no. 222

Report: Gunni Ærtebjerg

Cruise leader: Gunni Ærtebjerg/Kjeld Sauerberg
Participants:
9-18/2: Kjeld Sauerberg, Jan Damgaard, Dorete Jensen
9-15/2: Gunni Ærtebjerg, Lars Renvald, Peter Kofoed, Jens Larsen
9-10/2: Thyge Dyrnesli, Danish Fishery Research Institute

Summary

The Jutland Coastal Current (JCC) with lower salinity and temperature and high nutrient concentrations, especially nitrate, was as usual evident but rather narrow along the Danish North Sea and Skagerrak coasts. The JCC also influenced the northern Kattegat north of Læsø with nitrate concentrations up to 13-14 µmol/l at salinities of 32-33. The JCC could not be traced south of Læsø and had thus not entered the Kattegat bottom water. In the Arkona Sea the bottom water salinity was as high as 20.2 due to an inflow from the Sound prior to the cruise. In the Kattegat, the Sound and the Belt Sea the temperature was above long-term mean, the stratification was relatively weak for the season, and generally the bottom water salinity was lower than normal, except in the Belt Sea.

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 38 µmol/l), decreasing to the north and west. Close to Hanstholm and Hirtshals and in the northernmost Kattegat nitrate concentrations of 10-15 µmol/l were observed in JCC water. Except for the northernmost Kattegat, the nitrate and DIN concentrations were relatively low in the rest of the Kattegat, the Sound, the Belt Sea and the Arkona Sea, probably due to decreased washout from land, and in the Great Belt partly due to a beginning phytoplankton spring bloom. Phosphate and silicate concentrations were about normal.

The DIN/DIP ratio varied from 25-35 in the German Bight to <10 at the north-western North Sea stations and central Skagerrak stations. In the Kattegat and the Belt Sea the DIN/DIP ratio was rather close to the Redfield ratio of 16 for phytoplankton uptake, as it varied from about 8 in the Arkona Sea to 18 in the northern Kattegat.

The phytoplankton spring bloom had not yet started in the North Sea, the Skagerrak, the Kattegat, the Sound and the Arkona Sea, and the chlorophyll concentrations were generally low. However, the bloom had just started in parts of the Belt Sea, especially at the border to the south-western Kattegat where a chlorophyll maximum of 4.5 µg/l was observed in the surface.

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 concentration of 5.2 ml/l was observed in 150-175 m depth. In the Kattegat, the Sound and the Belt Sea the lowest oxygen concentration of 5.7 ml/l was found in the Sound. Compared to February last year, the minimum oxygen concentrations this year were generally higher. Last year the concentrations were unusually low, while the concentrations this year were about normal for February.

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 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 Skagerrak, the 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 sediment was sampled for monitoring of macrozoobenthos (3 stations), contaminants (8 stations), radioactivity (2 stations) and pigments (12 stations).

Meteorology

Characteristics of the weather conditions since the last cruise in November 2003 are given in *table 1*. The winter 2003-2004 (December-February) was generally mild and wet. In spite of slightly below normal temperature in January, the average winter temperature was 1.3°C and the precipitation 29% above normal, with the highest precipitation in January. The last half of December was dominated by rather strong wind from southwest and west. However, both in January and especially in February the wind force was generally lower than normal.

Table 1 *Deviations in monthly mean temperature and precipitation in November 2003 to February 2004 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. 03	+1.9	-32	4.9	SE-S-SW
Dec. 03	+2.3	+8	5.7	SW-W
Jan. 04	-0.4	+72	4.9	SE-S
Feb. 04	+2.1	+3	4.8	SW-W

The North Sea and the Skagerrak

Hydrography

The Jutland Coastal Current (JCC) with lower salinity and temperature was as usual evident but rather narrow along the Danish North Sea and Skagerrak coasts. West of the JCC the surface salinity was 34.0-34.8 (St. 1023-1026, 1071-1074, 1043-1046, 1054-1056, 1063-1064, 1085), and a tongue of high saline surface water (34.4-34.8) was observed in the central Skagerrak (St. 1102-1104, 1130-1133). Along the coast the salinity increased from 29.2-29.5 in the German Bight (St. 1059, 1080, 1086) to 32.1 at Hanstholm (St. 1019) and 32.4 at Hirtshals (St. 1013) (*figure 2*). The surface temperature ranged from 3.2-3.8°C at the coast-near stations in the German Bight (St. 1059, 1080, 1086) to 6.0-6.5°C at the westernmost stations in the North Sea (St. 1024-1026, 1072-1074, 1045-1046, 1055-1056, 1063-1064, 1085) and in the central Skagerrak (St. 1104, 1131-1133) (*figure 3*).

Nutrients

In the North Sea the winter nutrient concentrations, except for 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 relatively well-mixed water masses in the eastern North Sea. However, the nitrate-silicate relation shows that probably at least two different freshwater sources are involved (*figure 4*). The River Rhine has a lower NO_3/SiO_3 ratio than the River Elbe (Lars Rydberg, pers. com.). The cluster of observations with relatively low nitrate (2.7-14 µmol/l) and silicate (3.5-5.7 µmol/l) concentrations might mainly be influenced by the river Rhine, while the rest of the observations are probably mainly influenced by the freshwater supply via the Elbe estuary.

Table 2 *Linear regression analyses of salinity and concentrations of nutrients at the 35 stations in the North Sea 12-14 February 2004. 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.*

Nutrient	**Slope**	**Intercept**	**34.5 psu**	**R^2**
Nitrate	-4.78	171	6.05	0.84
Nitrite	-0.23	8.35	0.49	0.42
Ammonium	-1.28	44.7	0.64	0.79
DIN	-6.28	224	7.18	0.93
TN	-8.58	312	16.10	0.93
DIP	-0.15	5.75	0.52	0.69
TP	-0.24	8.82	0.70	0.72
Silicate	-3.56	126	3.51	0.91

Due to the relation to the salinity, the nutrient concentrations were highest in the south-eastern German Bight, decreasing to the north and west (*figures 5, 6, 7 and 8*). In the Skagerrak about 15 µmol/l nitrate was observed in the JCC at Hanstholm (St. 1019) and 14 µmol/l at Hirtshals (St. 1013) (*figure 5*).

The DIN/DIP ratio varied from 5-15 in the central North Sea water to 25-35 at the coast-near stations in the JCC (*figure 9*).

Oxygen and chlorophyll-*a*

The minimum oxygen concentrations were about saturation level at all stations in the North Sea. At the deepest stations in the Skagerrak the lowest oxygen concentration of 5.2 ml/l (79-80%) was observed in 150-175 m depth at the central stations 1006 and 1106.

The mean chlorophyll-*a* concentration in the surface layer (0-10 m) varied from <0.5 µg/l in the central Skagerrak (St. 1135) and at the westernmost stations in the North Sea (St. 1025-1026, 1073, 1046, 1056, 1064) to 1.5-2.7 µg/l at the coast-near stations in the German Bight (St. 1042, 1059, 1080, 1086) (*figure 10*). The phytoplankton spring bloom had not yet started.

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

Hydrography

The surface temperature (1 m depth) varied from 1.7°C in the eastern Kattegat (St. 905) to 3.2°C in the Læsø Rende (St. 403) (*figure 3*). The bottom water temperature ranged from 3.0-3.2°C in the southern Belt Sea and western Arkona Sea (St. 449, 450, 952, 954, M2, N3) to 5.5-6.5°C in the Sound and south-eastern Kattegat (St. 431, 418, 921, 922) (*figure 11a*).

The surface salinity was relatively high in the Arkona Sea and ranged from 8.1-8.6 in this area (St. 441, 444, 449) to 29.4 in the north-western Kattegat (St. 1009) (*figure 2*). The bottom water salinity at stratified stations ranged from 17.0-17.5 at Gedser Rev (St. 449, 954) and as high as 20.2 in the deep Arkona Basin (St. 444) to 33.0-33.8 in the eastern and northern Kattegat (St. 403, 413, 418, 905, 1001, 1008) (*figure 11b*). The salinity stratification was relatively weak for the season in the Sound and the Kattegat, but stronger in the Belt Sea.

Compared to long-term monthly means (Lightship observations 1931-1960) for February, the temperature during the present cruise was higher than normal in the whole water column, except in the central eastern Kattegat bottom water. Generally the bottom water salinity was lower than normal, except in parts of the Belt Sea.

Prior to and at the first day of the cruise an inflow towards the Baltic Sea took place, and the surface salinity in the Sound reached 20.9. At the end of the cruise an outflow from the Baltic had established creating relatively low surface salinity in the Belt Sea.

Nutrients

The JCC influenced the northern-most Kattegat with DIN concentrations of 10-15 µmol/l (salinity 32-33) in the surface east of Skagen (St. 1002, 1005) and in an intermediate layer at 15-30 m depth along the Swedish coast from Göteborg to Marstrand (St. 1001, 1004). However, the JCC water could not be traced south of Læsø, and had thus not entered the Kattegat bottom water further south. In the Læsø Rende (St. 403) the surface nitrate concentration was 11.5 µmol/l but the salinity 27.6. Thus this was not JJC water, but perhaps outflow from the Limfjorden. Likewise, the surface nitrate concentration along the Swedish coast (St. 1001-1004) was 9.8-10.4 µmol/l at salinities of 28-30, which may be due to influence from the Göta River. With the exception of the area north of Læsø, the nitrate concentration was relatively low in the Kattegat, the Sound, the Belt Sea and the Arkona Sea (*figure 5* and *12a*). The relatively low surface nitrate concentration might partly be due to a decreased washout of nitrate from land, and in the northern Great Belt partly to a beginning phytoplankton spring bloom.

Also rather high concentrations of nitrite (>1 µmol/l) and ammonium (>2 µmol/l) were found in the northernmost Kattegat (*figure 12b* and *12c*), but otherwise the DIN concentration was relatively low in all other areas (*figure 6 and 13a*). The phosphate concentration was about normal with the highest concentrations (>0.8 µmol/l) in the bottom water of the Kattegat and the Great Belt (*figure 7* and *13b*). The DIN/DIP ratio was rather close to the Redfield ratio for phytoplankton uptake, as it varied from about 8 to 18 in the whole area (*figure 9* and *13c*). The concentration of silicate was highest (>14 µmol/l) in the southern Belt Sea and the Arkona Sea bottom water (*figures 8* and *14a*).

Chlorophyll-*a*

The phytoplankton spring bloom was about to start in parts of the Belt Sea. The mean chlorophyll concentration in the uppermost 10 m varied from 4.2 µg/l at the border between the south-western Kattegat and the northern Belt Sea, and 1.7-2.4 µg/l in the Great Belt and the southern Belt Sea, to <1 µg/l in the Arkona Sea and the eastern Kattegat (*figure 10* and *15*).

Oxygen

The lowest oxygen concentrations of 5.7-5.8 ml/l (79-81% saturation) were observed in the Sound (St. 431) and east of Anholt (St. 413). In the southern Kattegat and the northern Great Belt the minimum concentrations were 6.1-6.5 ml/l (85-90%) (*figure 14b*). Compared to February last year, the minimum oxygen concentrations this year were generally higher and about normal for the season.

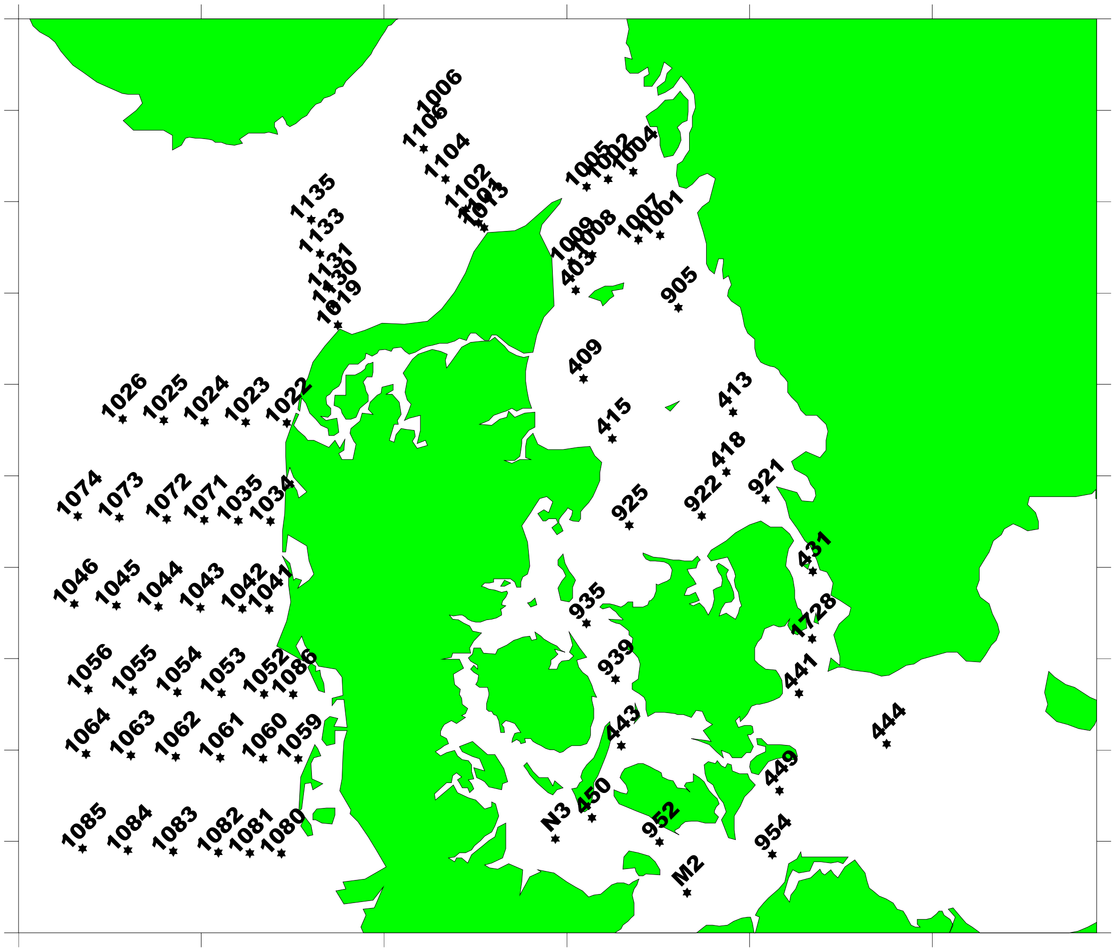

Figure 1 *Stations of the monitoring cruise with r/v Gunnar Thorson 9-18 February 2004 in the Sound, the Kattegat, the Skagerrak, the North Sea, the Belt Sea and the Arkona Sea. Gunnar Thorson cruise no. 222.*

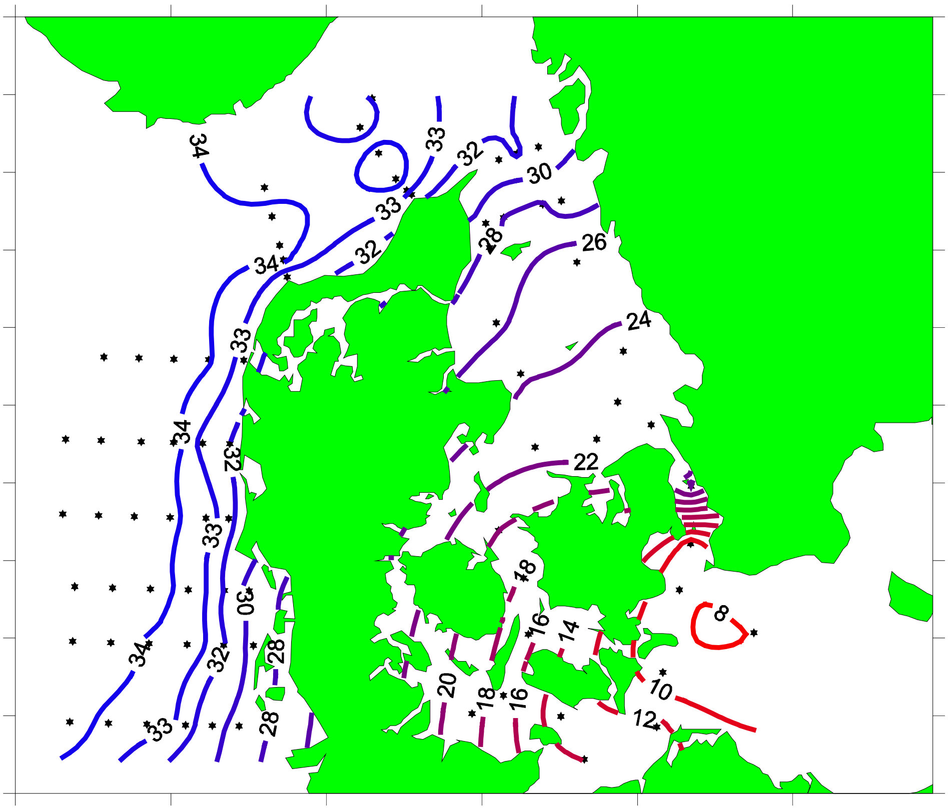

Figure 2 *Interpolated distribution of surface salinity (mean 0-10 m depth).*
Note: The lines in the Little Belt area are interpolation artefacts. There are no stations.

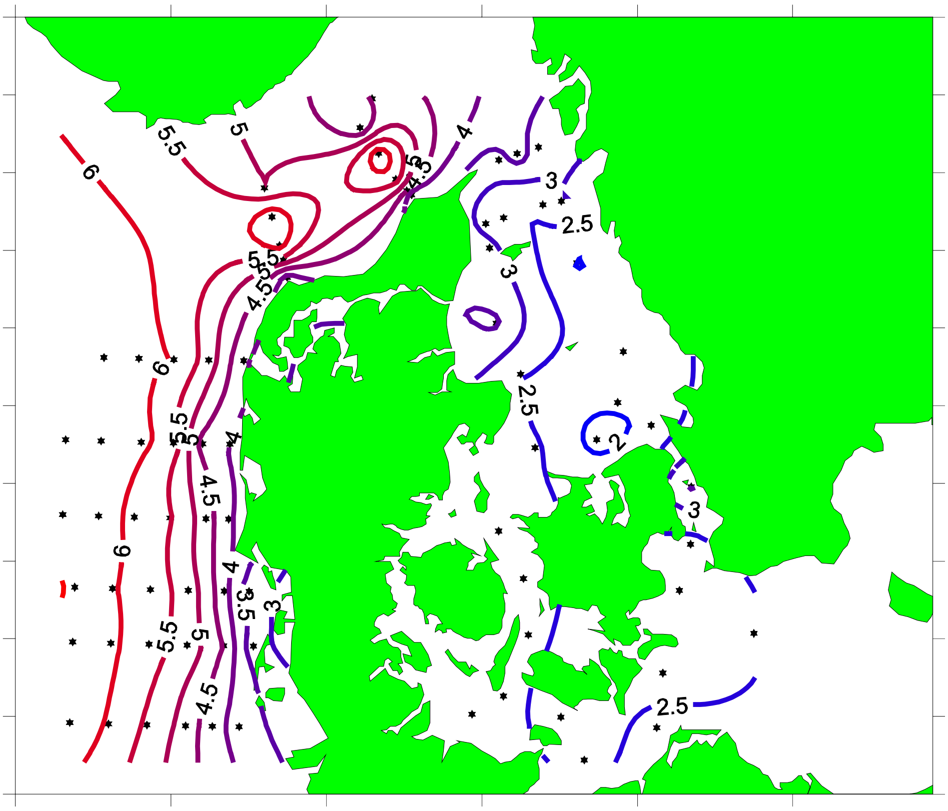

Figure 3 *Interpolated distribution of surface temperature (mean 0-10 m depth).*

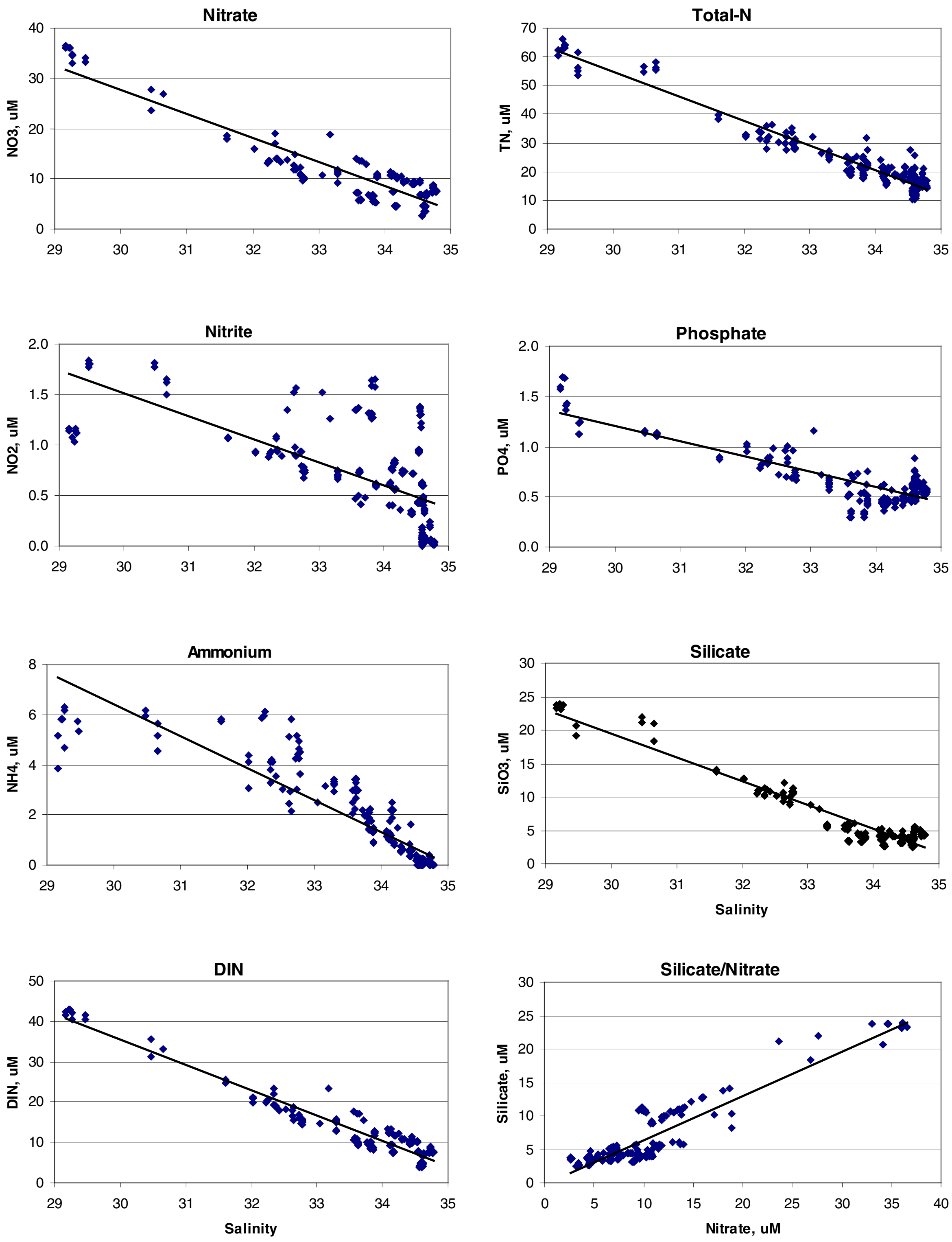

Figure 4 *Correlations between salinity and nutrient concentrations and between nitrate and silicate at the 35 stations in the North Sea 12-14 February 2004.*

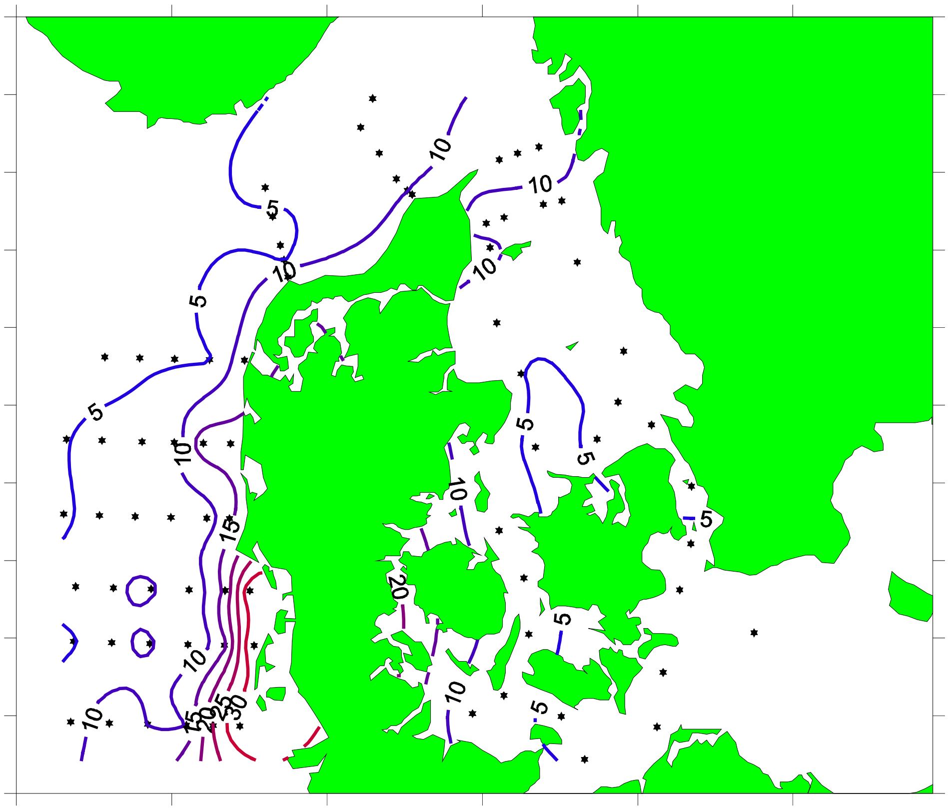

Figure 5 *Interpolated distribution of surface nitrate concentrations (mean 0-10 m depth). Note: The lines in the Little Belt area are interpolation artefacts. There are no stations.*

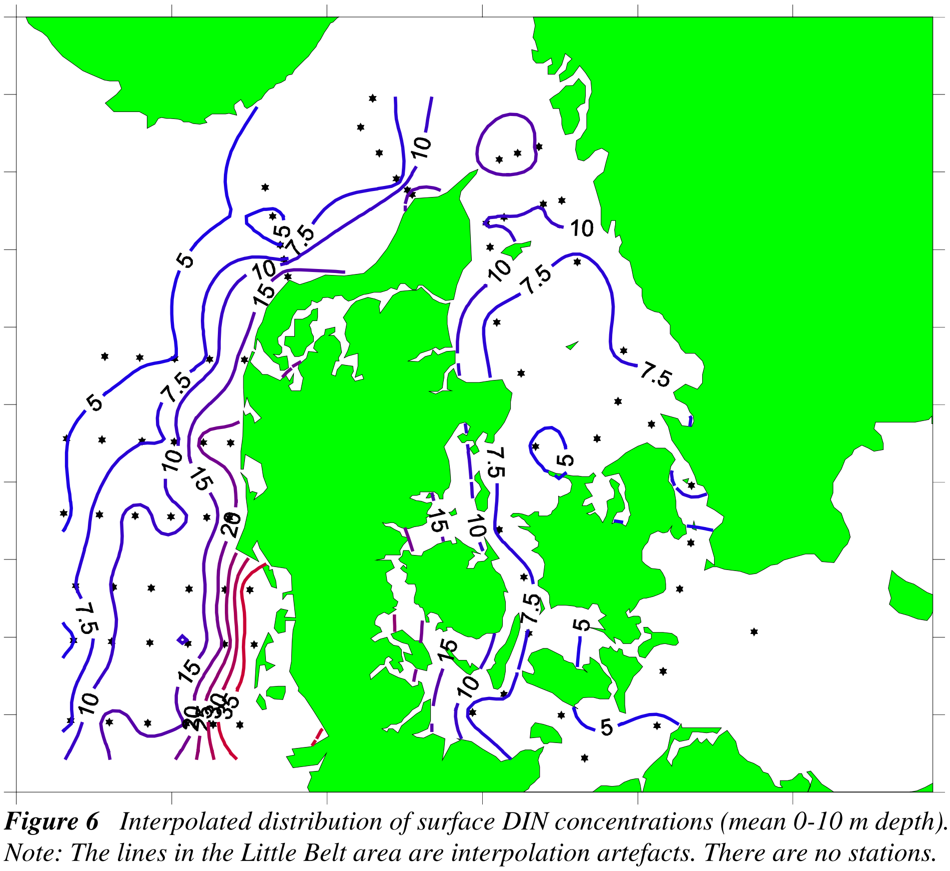

Figure 6 *Interpolated distribution of surface DIN concentrations (mean 0-10 m depth). Note: The lines in the Little Belt area are interpolation artefacts. There are no stations.*

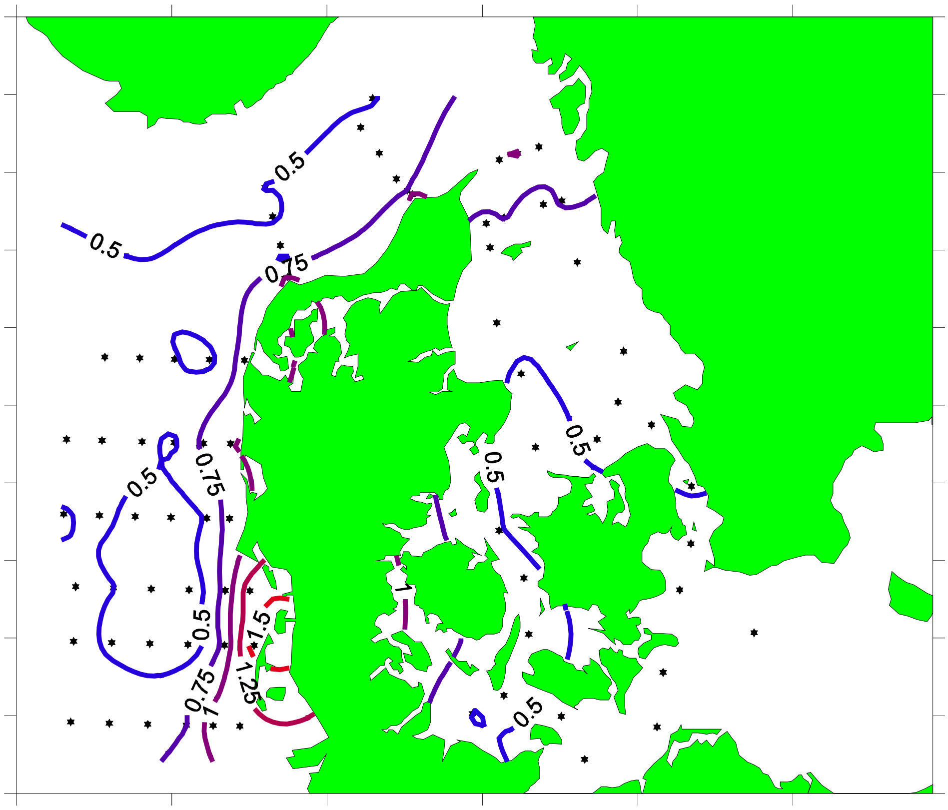

Figure 7 Interpolated distribution of surface phosphate concentrations (mean 0-10 m depth). *Note: The lines in the Little Belt area are interpolation artefacts. There are no stations.*

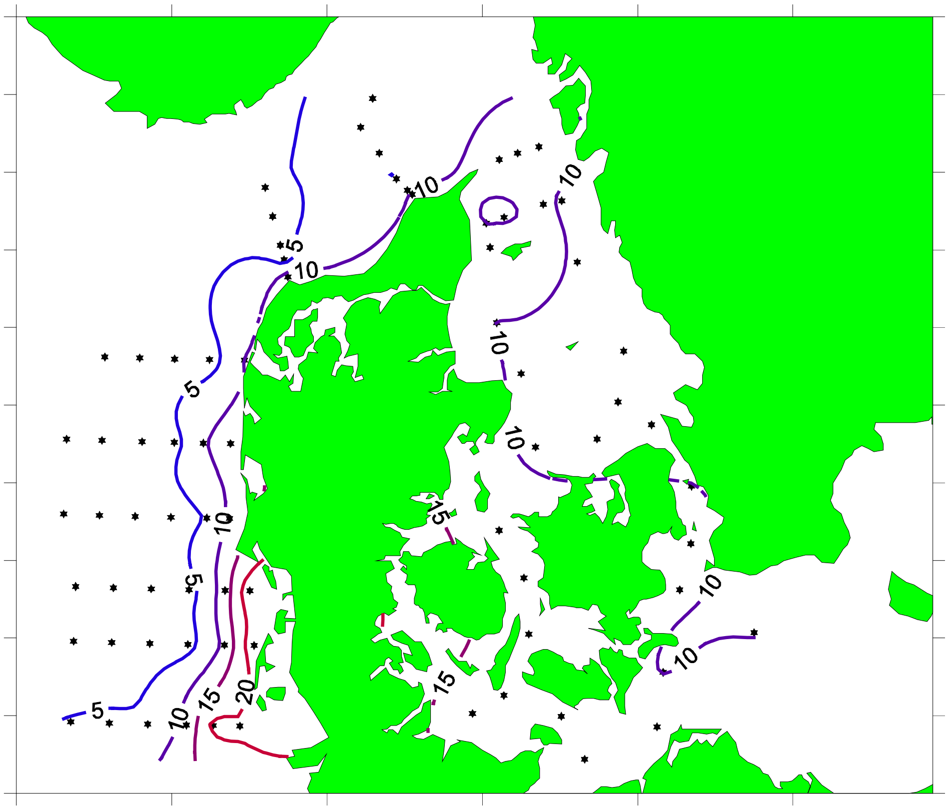

Figure 8 Interpolated distribution of surface silicate concentrations (mean 0-10 m depth). *Note: The lines in the Little Belt area are interpolation artefacts. There are no stations.*

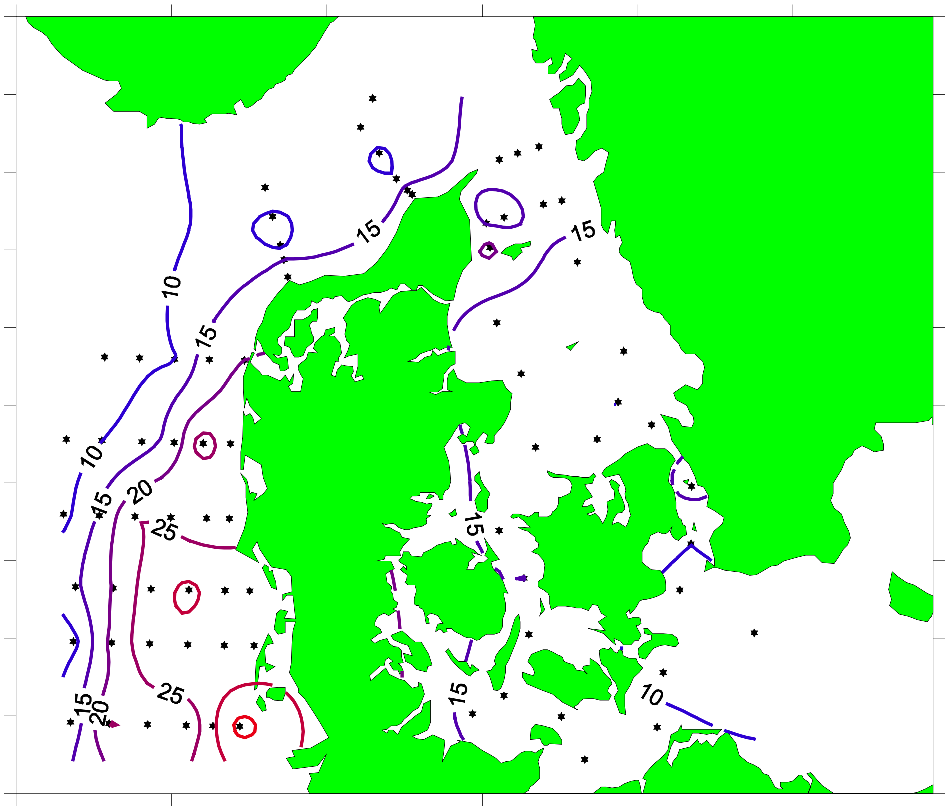

Figure 9 *Interpolated distribution of surface DIN:DIP ratio (mean 0-10 m depth). Note: The lines in the Little Belt area are interpolation artefacts. There are no stations.*

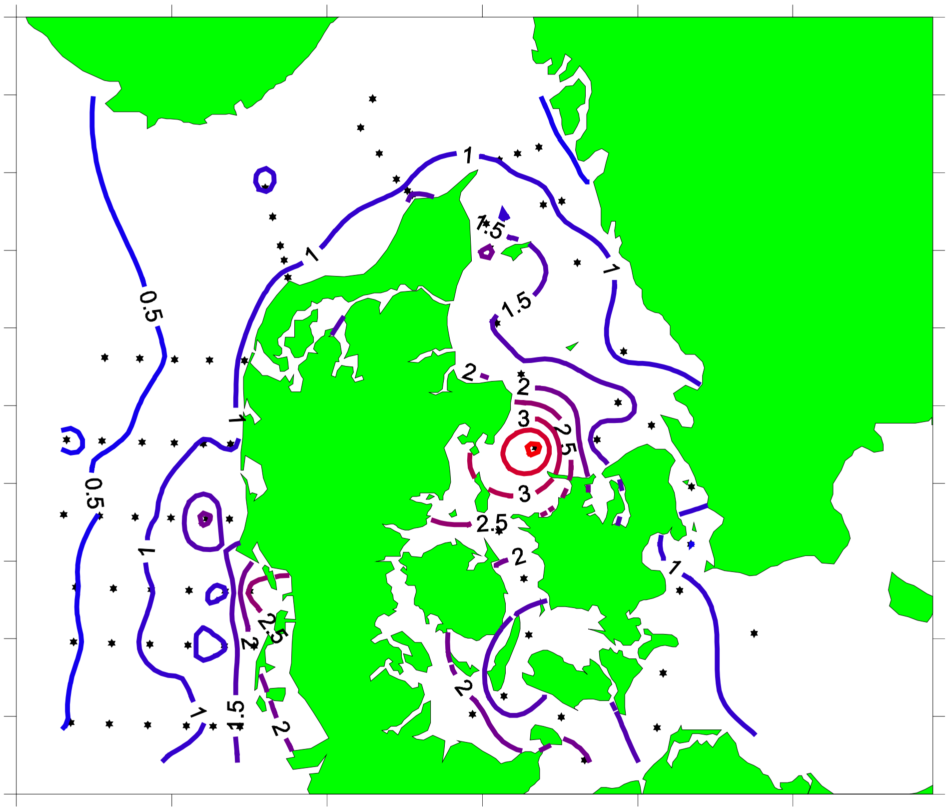

Figure 10 *Interpolated distribution of surface chlorophyll-a concentrations (mean 0-10 m depth). Note: The lines in the Little Belt area are interpolation artefacts. There are no stations.*

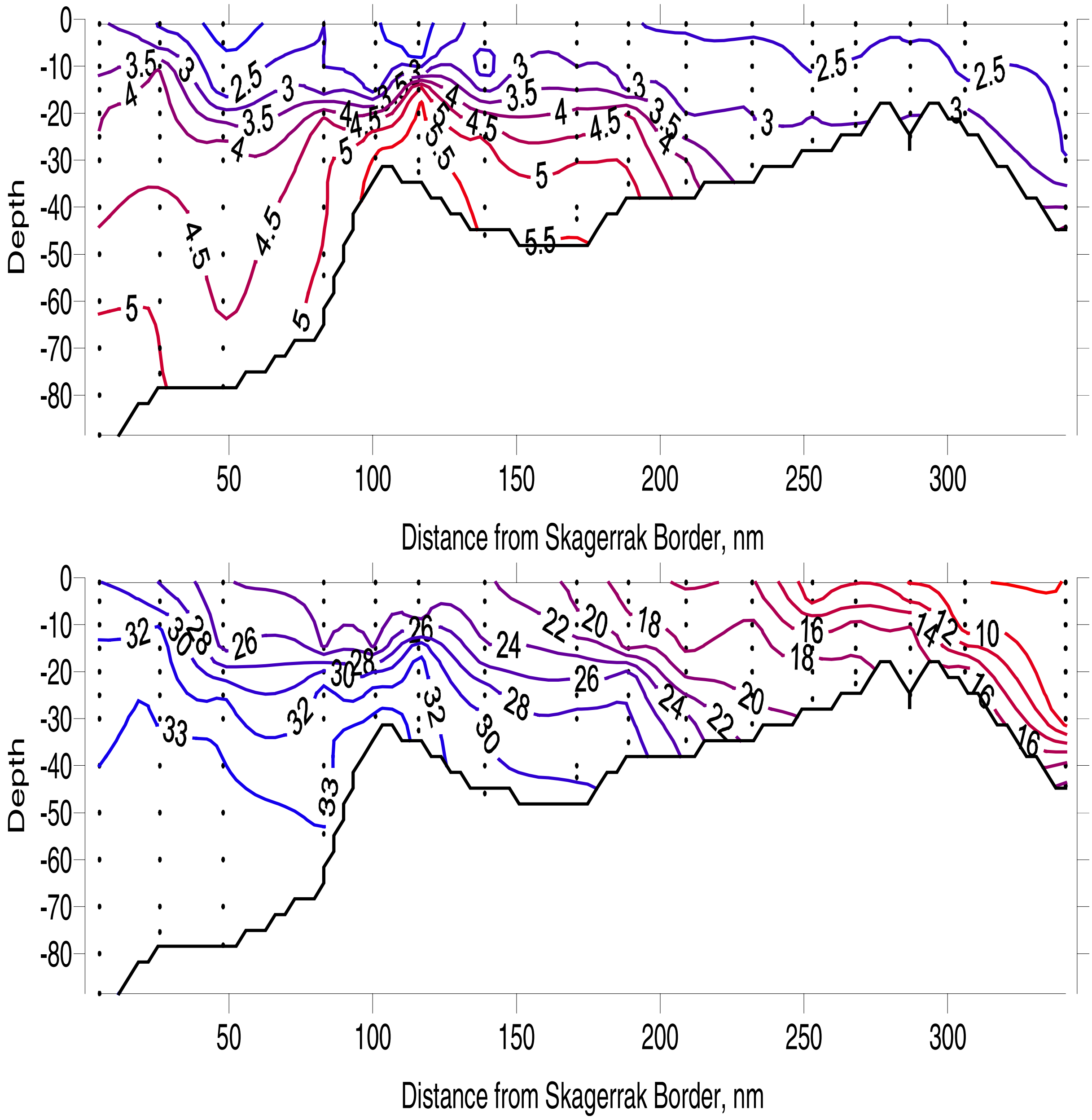

Figure 11 *Temperature (top) and salinity (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.*

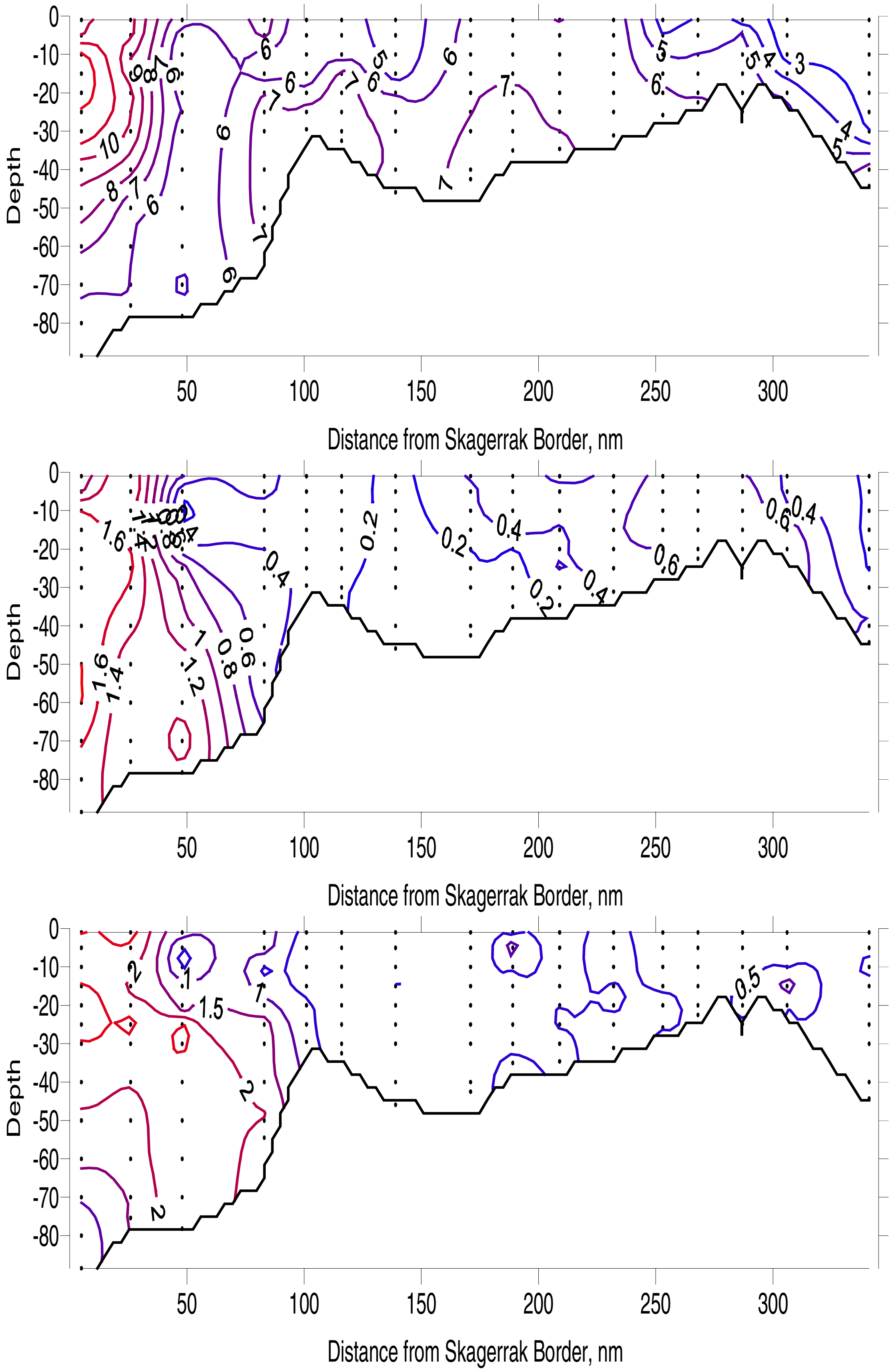

Figure 12 *Nitrate (top), nitrite (mid) and ammonium (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.*

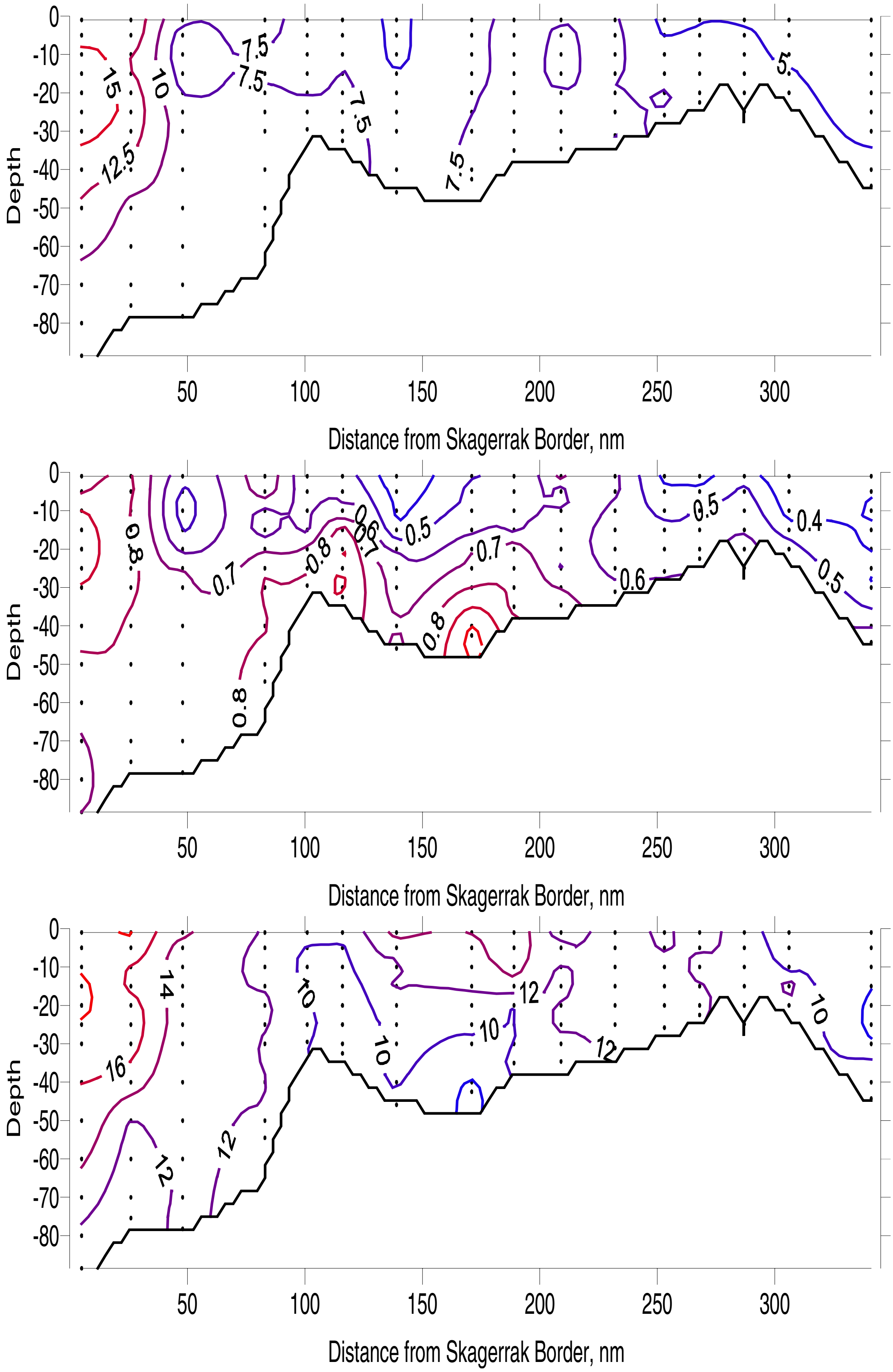

Figure 13 *DIN (top), phosphate (mid) and DIN/DIP ratio (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.*

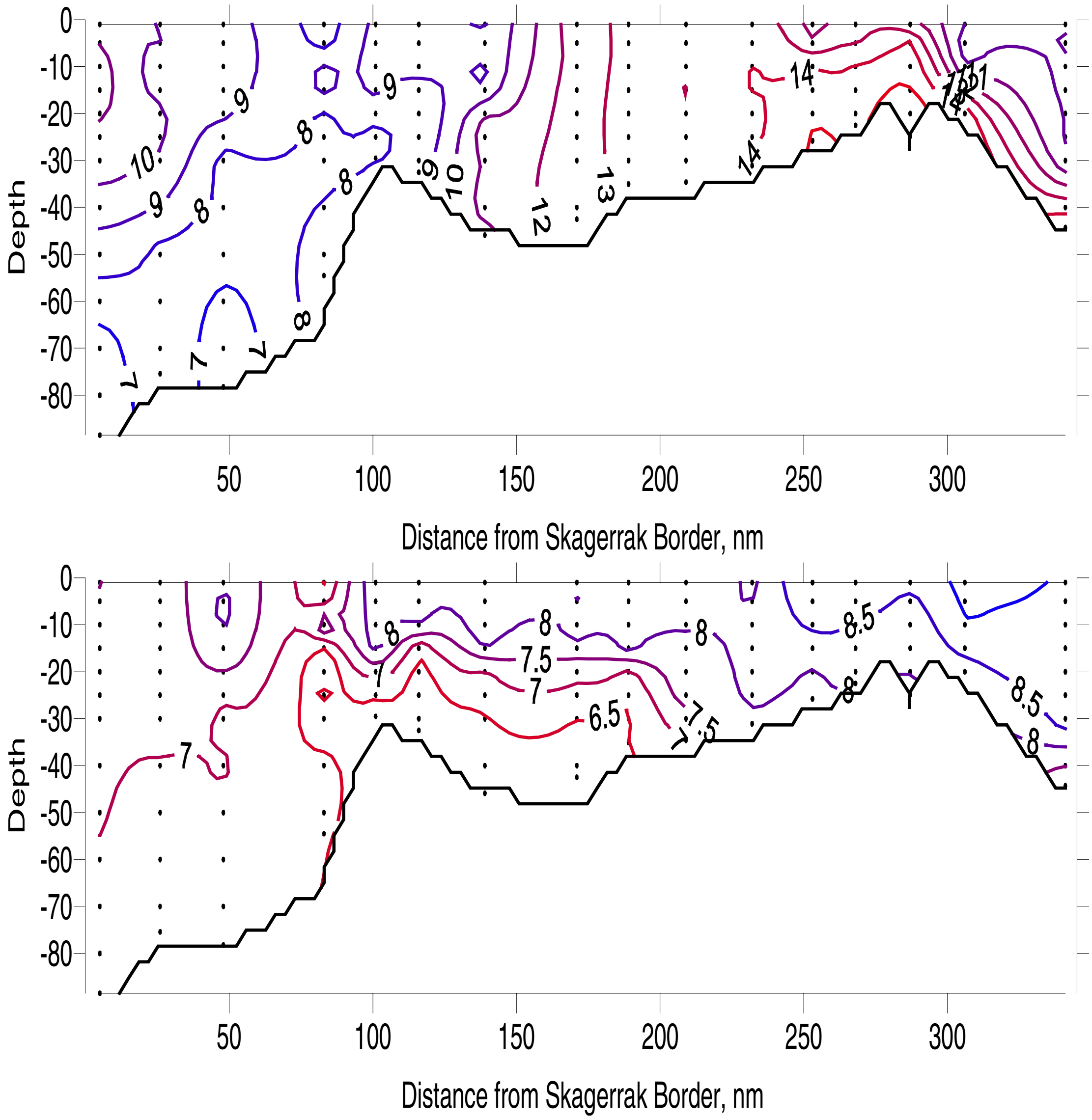

Figure 14 *Silicate (top) and oxygen (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.*

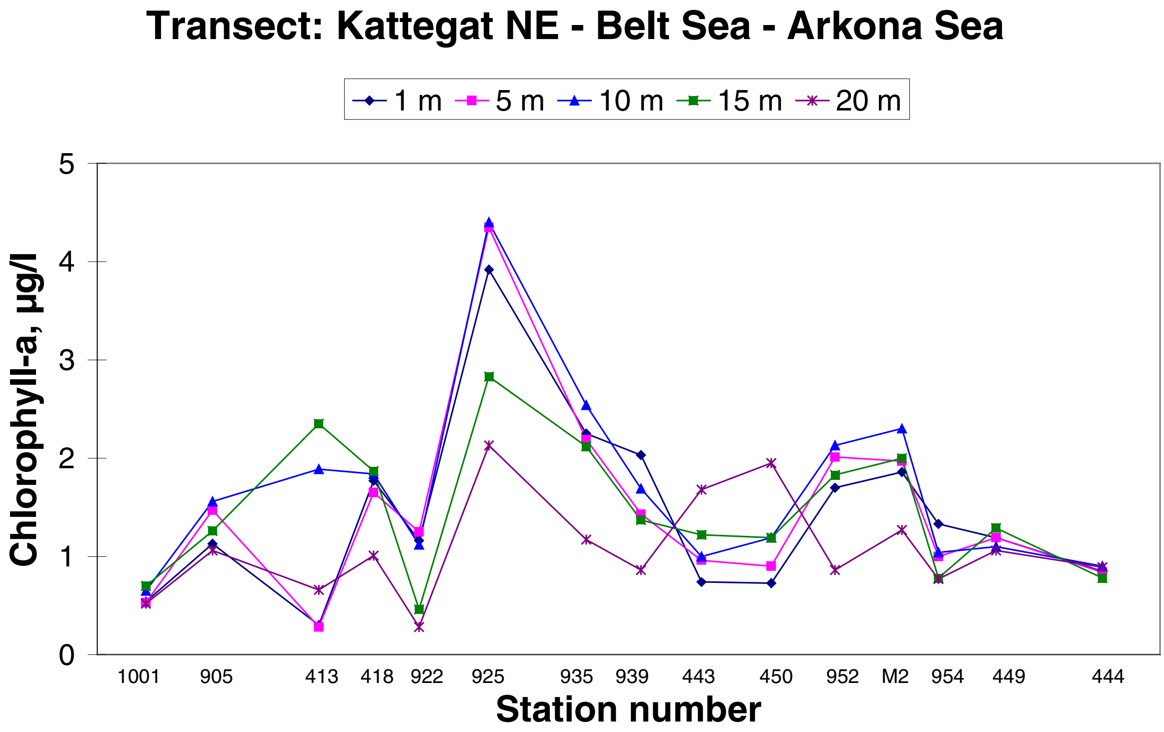

Figure 15 *Chlorophyl-a at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.*