r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 219

Time: 13 - 17 October 2003

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

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

Data Sheet

Title:	Monitoring Cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat
Subtitle:	Cruise no. 219, 13-17 October 2003
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:	46/2003
Please quote:	Ærtebjerg, G. 2003: Monitoring Cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Cruise no. 219, 13-17 October 2003. 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:	8
	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.dmu.dk

Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat, 13-17 October 2003 Cruise no. 219

Report: Gunni Ærtebjerg

Cruise leader: Kjeld Sauerberg
Participants: Dorete Jensen, Lars Renvald, Jan Damgaard (NERI)
13 Oct. 2003: Hanne Ferdinand, Martin Larsen, Ingela Dahllöf, Lone Grundahl (NERI).

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

Summary

Due to reduced temperature stratification and strong westerly wind mid October, the minimum oxygen concentrations had generally increased since September, except in the Sound, parts of the southern Kattegat and in the northern Great Belt. Generally the concentrations were higher than at the same time last year, except at 4 stations in the areas mentioned above. However, oxygen deficiency (<2.8 ml/l) was still observed in the southern Kattegat, the Sound and the northern Great Belt, while severe oxygen deficiency (<1.4 ml/l) was only observed in the Sound (1.1 ml/l). Measurements made by Danish counties showed that oxygen deficiency and severe oxygen deficiency also still occurred in the southern Little Belt and Flensborg Fjord. A report on oxygen deficiency in October 2003 is available at: http://iltrapport.dmu.dk (in Danish with an English summary).

The stratification of the water column was unusually weak in the southern Great Belt and southern Belt Sea due to vertical mixing. Also in other areas the stratification was relatively weak for the season, except in the Sound and the Arkona Sea. Warmer water masses (14.5 - 15.4°C) were observed as intermediate layers both in the eastern Kattegat and in the Arkona Sea.

Compared to long-term monthly means (Lightship observations 1931 - 1960) for October, the temperature was 0.2 - 1.5°C higher than normal in the whole water column. During the present cruise the salinity was also generally higher than normal (0.2 - 5.8 psu), except for a little lower than normal in the south-western Kattegat bottom water.

In the surface layer nitrate was now present (0.1 - 1.1 µmol/l) in the Sound, the Great Belt and the Fehmarn Belt with the highest concentrations in the central Great Belt. Phosphate (0.06 - 0.4 µmol/l) and silicate (1 - 10 µmol/l) were also present in the surface water in all areas. In the bottom water the highest concentrations of nitrate, phosphate, nitrite and silicate were observed in the Sound, the southern Kattegat and the northern Great Belt, that is where oxygen deficiency occurred. High ammonium concentrations (2.2 - 2.3 µmol/l) were only observed in the bottom water in the central Arkona Sea.

A strong bloom of *Proboscia alata* and *Ceratium* spp. occurred in the Mecklenburg Bight with a chlorophyll-a concentration of 6.1 - 6.7 µg/l in the upper 15 m, and at 10 m depth in the Kiel Bight. In most other areas the vertical chlorophyll-a distribution was rather homogenous within the upper
15 - 20 m and ranged between 1 and 3 µg/l with the highest concentrations in the surface of the northern Great Belt.

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*.

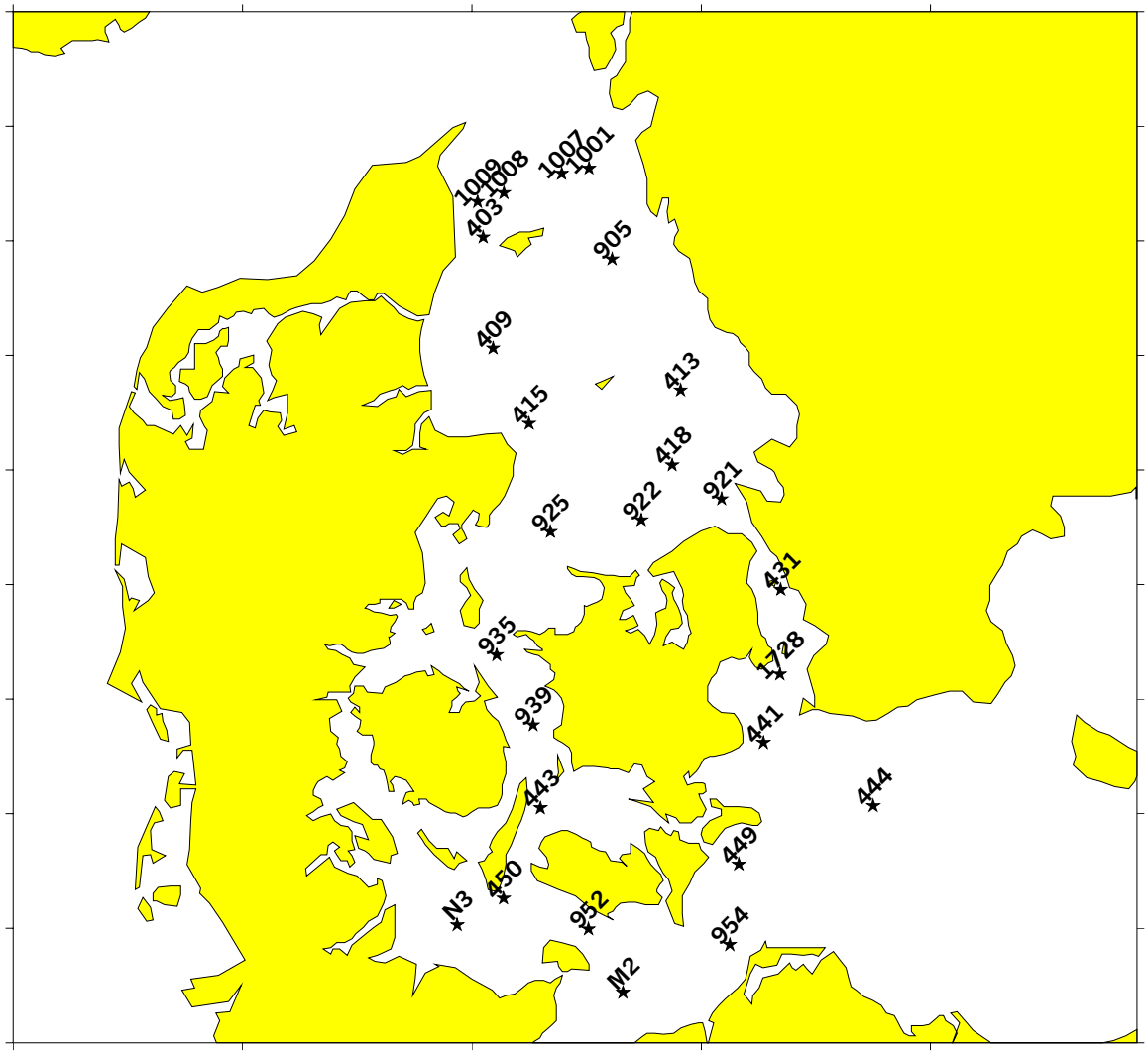

Figure 1. Stations of the monitoring cruise with r/v Gunnar Thorson 13-17 October 2003 in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Gunnar Thorson cruise no. 219.

Meteorology

Characteristics of the weather conditions during October 2003 are given in *Table 1*. October was cold and dry with mean temperature and precipitation well below average. The dominating wind directions were westerly (SW-W-NW 50% of the time) and north-easterly (N-NE-E 35% of the time). The frequency of wind exceeding gale force (*Figure 2*) was low in the first week of October (week 40), but in the following week strong westerly wind occurred. The next two weeks (weeks 42-43) were

dominated by northerly and relatively weak wind, except for a period with strong wind from north-east in the latter week.

Table 1. Deviations in monthly mean temperature and precipitation in October 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
October	-2.6	-34	4.3	SW-W-NW-N-NE-E

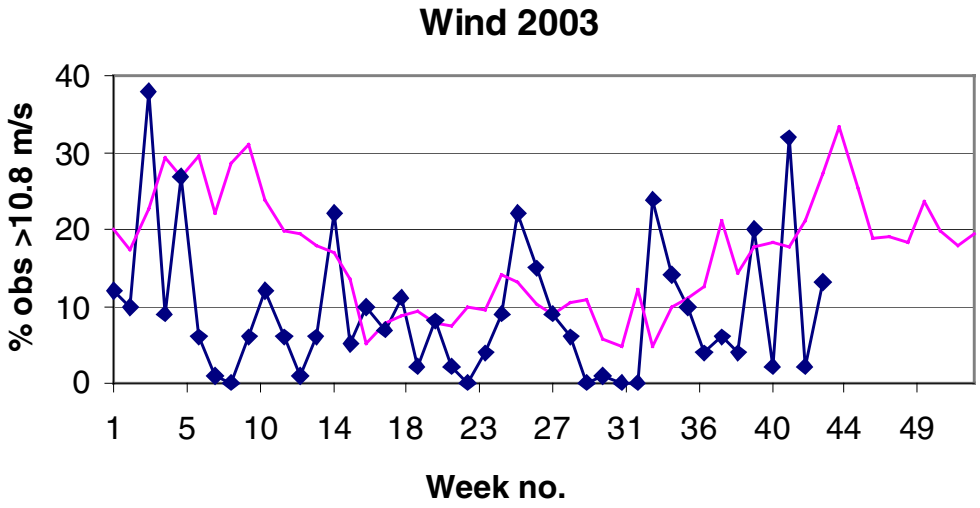

Figure 2. Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2003 (connected points) compared to mean for the period 1994-2002 (thin line). Based on data from the Danish Meteorological Institute.

Hydrography

The surface temperature (1 m depth) had since the cruise in September decreased 2.8 - 5.4°C, and now varied between 10.9 and 13.0°C in the whole area, highest in the southern Belt Sea and the Arkona Sea and lowest in the north-western Kattegat. The bottom water temperature had increased 0,7 - 3.6°C in the eastern and southern Kattegat, but decreased 0.7 - 2.6°C in the southern Belt Sea and the Arkona Sea. The bottom near temperature ranged from 11.4 - 11.8°C in the Sound (St. 431, 921) to 13.5 - 14.0°C in the northern Kattegat. However, warmer water masses (14.5 - 15.4°C) were observed as intermediate layers both in the eastern Kattegat (St. 1007, 905, 413) and in the Arkona Sea (St. 444) (*Figure 3*).

The surface salinity ranged from 8.0 - 9.7 in the Arkona Sea (St. 441, 444, 449) to 28.2 - 31.1 in the northern Kattegat (St. 1001, 1007, 1008, 1009). The bottom water salinity ranged from 18.6 - 19.3 in the Arkona Sea (St. 444, 449) to 34.0-34.7 in the north-eastern Kattegat (St. 905, 1001, 1007) (*Figure 3*). The salinity stratification was relatively weak for the season, especially in the Great Belt.

Compared to long-term monthly means (Lightship observations 1931-1960) for October, the temperature was 0.2 - 1.5°C higher than normal in the whole water column. Also the salinity was during the present cruise generally higher than normal (0.2 - 5.8 psu) in the whole water column, except for 1.3 lower than normal in the south-western Kattegat bottom water (St. 925).

Nutrients

Nitrate was present (0.1 - 1.1 µmol/l) in the surface layer in the Sound, the Great Belt and the Fehmarn Belt with the highest concentrations in the central Great Belt (*Figure 4*). In the bottom water nitrate concentrations were unusually low (<1.5 µmol/l) in the north-western Kattegat (St. 403, 1008, 1009), the Arkona Sea (St. 441, 444, 449) and the southern Belt Sea and southern Great Belt (St. 954, M2, 952, N3, 450, 443). In the Sound (St. 431) 10 µmol/l was observed at the bottom, and 6 - 9 µmol/l was found in the southern Kattegat and northern Great Belt (St. 413, 418, 922, 925, 935, 939) (*Figure 4a*).

Nitrite concentrations >0.6 µmol/l were observed in the bottom water in the Sound (St. 431), the north-eastern (St. 1001, 1007) and southern Kattegat (St. 922, 925, 415) and northern Great Belt (St. 935, 939) (*figure 4b*). Relatively high ammonium concentrations (2.2 - 2.3 µmol/l) were only observed in the bottom water in the Arkona Sea (*Figure 4c*).

Phosphate concentrations of 0.06 - 0.4 µmol/l were present in the surface water in all areas, lowest in the north-western and southern Kattegat. In the bottom water phosphate above 1.0 µmol/l was observed in the Sound, southern Kattegat and northern Great Belt (*Figure 5a*). Silicate concentrations above 1 µmol/l and up to 9 µmol/l were present in the surface water in all areas. High concentrations (>25 µmol/l) were observed in the bottom water in the Sound (St. 431), the southern Kattegat (St. 413, 922, 925) and northern Great Belt (St. 935) (*figure 5b*).

Chlorophyll-*a*

The highest chlorophyll-a concentrations (6.1 - 6.7 µg/l) were observed in the uppermost 15 m in the Mecklenburg Bight (St. M2), at 10 m depths east of Falster (St. 449) and at 10 m depth in the Kiel Bight (St. N3) (*Figure 6*). In Aalborg Bight (St. 409) 3.5 - 4.2 µg/l was found at 10-13 m depth. In the other areas the vertical distribution was rather homogenous within the upper 15 - 20 m and ranged between 1 and 3 µg/l with the highest concentrations in the surface of the northern Great Belt (*Figure 6*). The phytoplankton bloom in the Mecklenburg Bight was dominated by *Proboscia alata* together with large amounts of *Ceratium tripos* and *C. fusus*. In the Kiel Bight *Ceratium fusus*, *C. tripos* and *C. lineatum* dominated together with large amounts of *Proboscia alata*.

Oxygen

Since September the minimum oxygen concentrations have increased in most areas, except in the Sound (St. 431), parts of the southern Kattegat (St. 418, 922, 925) and the northern Great Belt (St. 935). In the southern Great Belt and southern Belt Sea the minimum oxygen concentration has increased to 5.6 - 6.0 ml/l (87 - 93% saturation). The lowest oxygen concentration observed was 1.1 ml/l (17% saturation) in the Sound (St. 431). In the southern Kattegat (St. 413, 418, 922, 925) the minimum concentrations were 1.6 - 2.2 ml/l (26 - 36%), and in the northern Great Belt (St. 935, 939) 2.0 - 2.5 ml/l (34 - 41%) (*Figure 5c*). Compared to October last year, the minimum oxygen concentrations this year are generally higher, except in the Sound, parts of the southern Kattegat and in the central Great Belt (St. 431, 413, 922, 939). Compared to mean for October in the 1980s, the minimum oxygen concentrations this year are also generally higher, except in the Sound, eastern Kattegat and northern Great Belt.

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 observed in the southern Kattegat and northern Great Belt, and severe oxygen depletion was found only in the Sound (St. 431). *Figure 7* shows the stations visited by the Danish counties, NERI, SMHI and Swedish and German coastal authorities within the first three weeks of October 2003, and where oxygen depletion or severe oxygen depletion was observed.

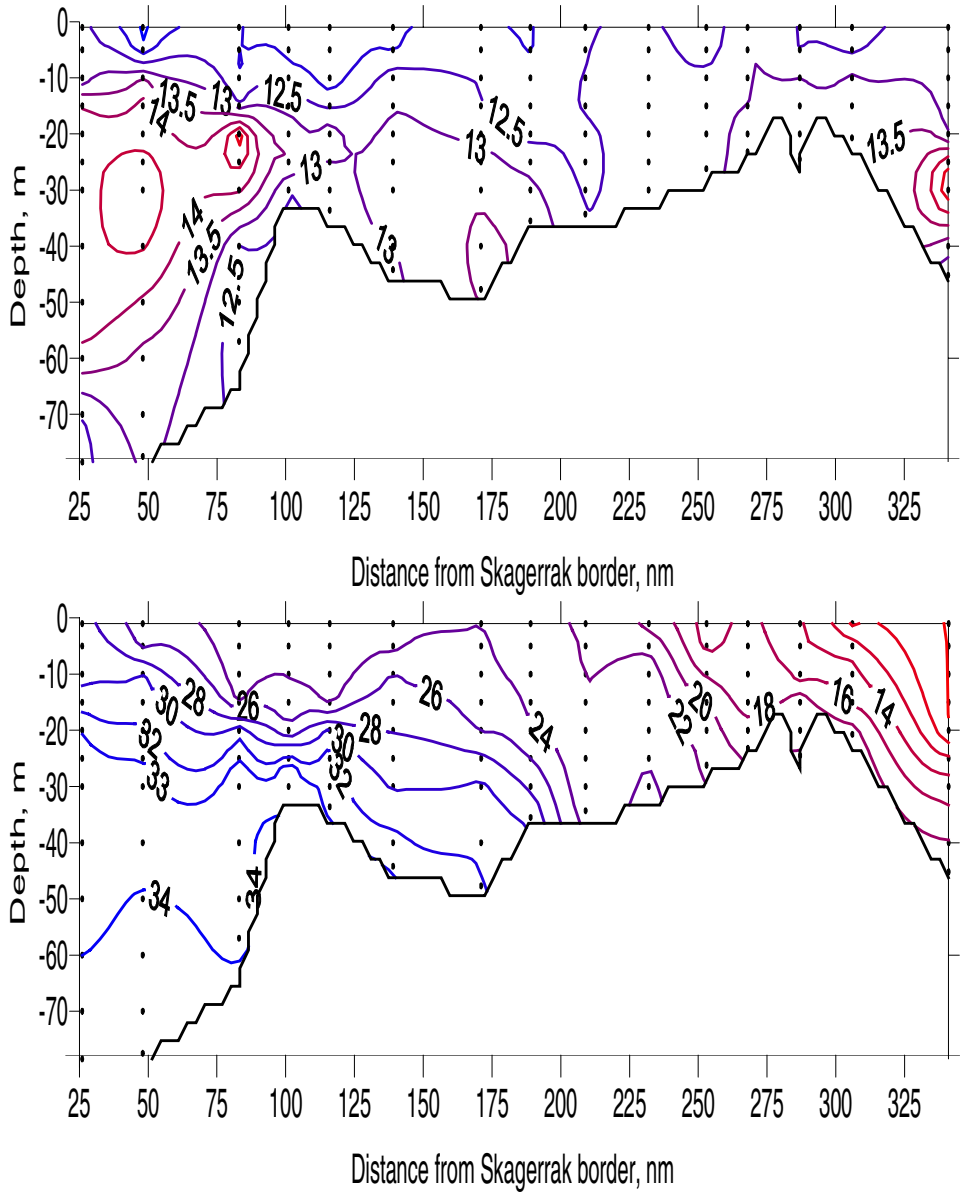

Figure 3. Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

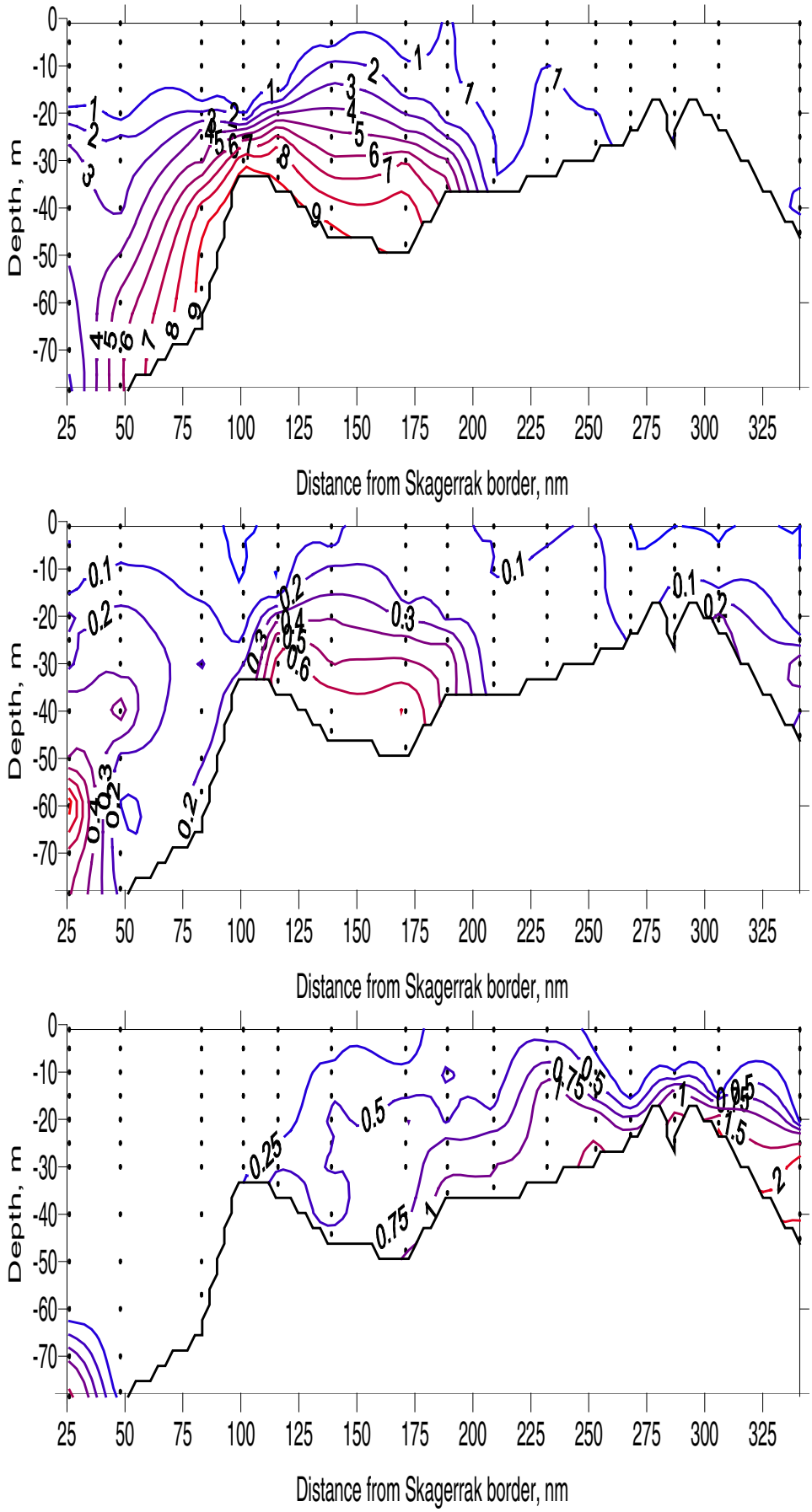

Figure 4. Nitrate (top), nitrite (mid) and ammonium (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

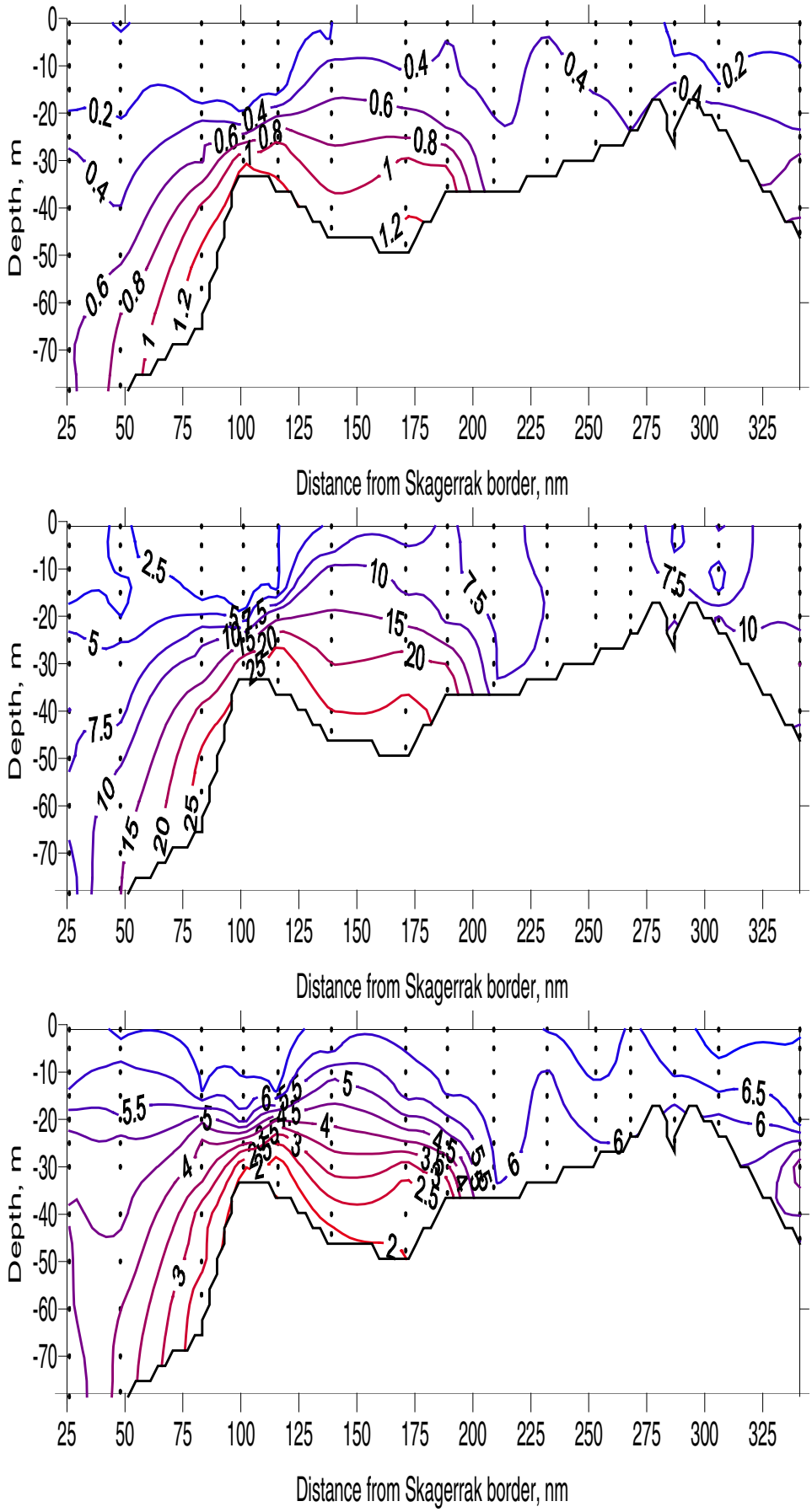

Figure 5. Phosphate (top), silicate (mid) and oxygen (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

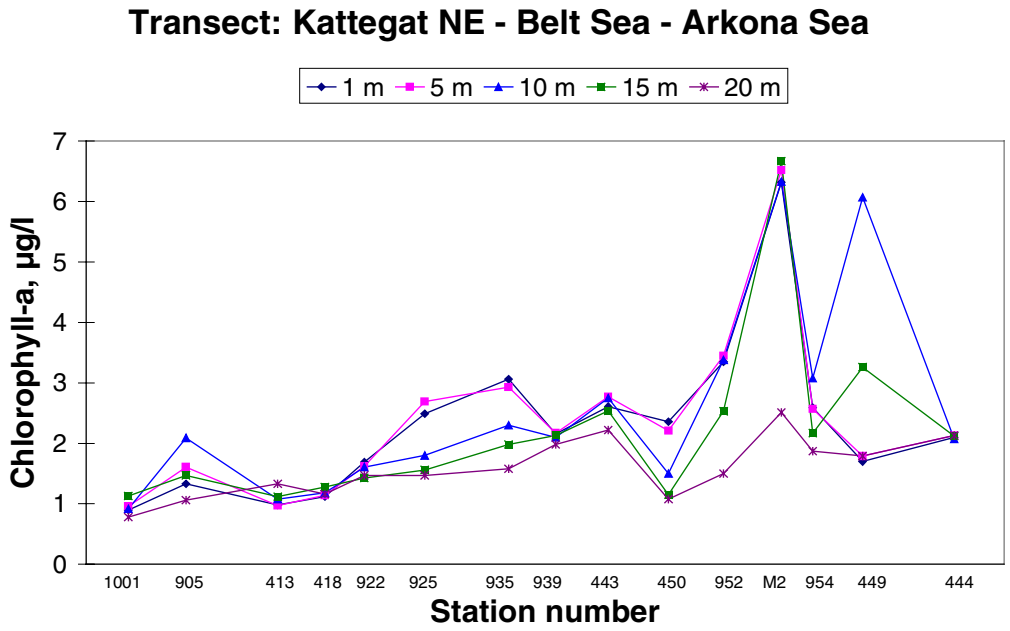

Figure 6. Chlorophyll-a at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

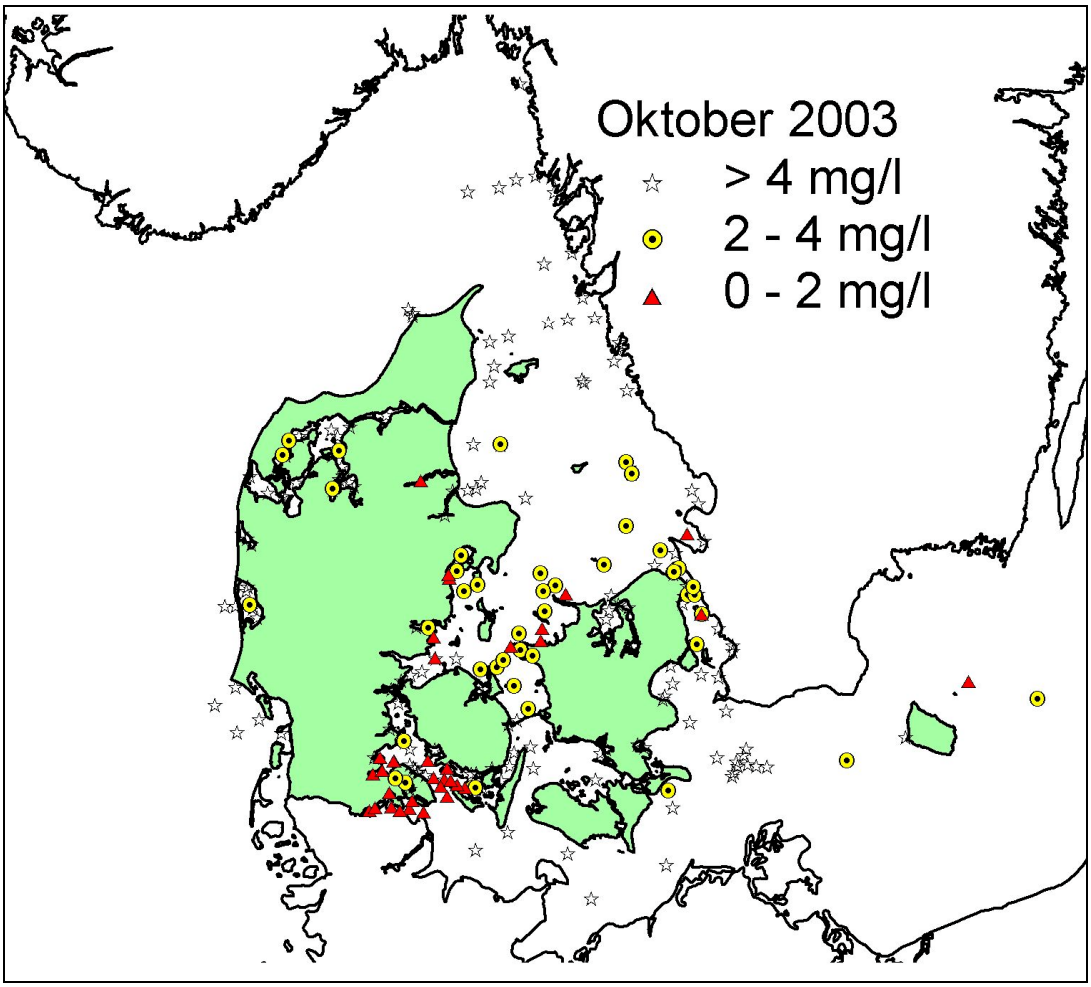

Figure 7. Stations visited by the Danish counties, NERI, SMHI and Swedish and German coastal authorities within the first three weeks of October 2003, and where oxygen depletion (<4 mg/l) and severe oxygen depletion (<2 mg/l) was observed.