



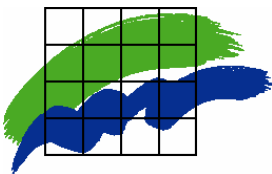
r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 231

Time: 19 - 23 September 2005

**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.neri.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. 231, 19-23 September 2005

Author: Gunni Ærtebjerg
Department: Department of Marine Ecology

Serial title: Monitoring Cruise Report

Publisher: National Environmental Research Institute[©]
Ministry of the Environment

Week/year of publication: 01/2006

Please quote: Ærtebjerg, G. 2006: Monitoring Cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Cruise no. 231, 19-23 September 2005. National Environmental Research Institute, Denmark. Monitoring Cruise Report.

Reproduction permitted only when quoting is evident.

Keywords: Marine, monitoring, hydrography, eutrophication

ISSN (electronic): 1600-1656
(Only published electronically) <http://www.dmu.dk/Vand/Havmiljo/Togtrapperter/>

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.neri.dk

Monitoring cruise with r/v Gunnar Thorson in the Sound, the Arkona Sea, the Belt Sea and the Kattegat, 19-23 September 2005 Cruise no. 231

Report: Gunni Ærtebjerg
Cruise leader: Kjeld Sauerberg
Participants: Dorete Jensen, Hanne Ferdinand

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

Summary

High phosphate concentrations for the season (0.3-0.6 $\mu\text{mol/l}$) were still present in the surface water of the Arkona Sea, the Sound and the southern Belt Sea, brought in with water from the Baltic Proper. Also in the north-western Kattegat (Læsø Rende) high phosphate concentrations (0.4-0.9 $\mu\text{mol/l}$) were observed in the surface water. In the rest of the Kattegat the surface phosphate concentration was ca. 0.1 $\mu\text{mol/l}$.

Nitrate was practically absent from the surface water, except for 0.1-0.3 $\mu\text{mol/l}$ in the north-western Kattegat and at Drogden Sill. The silicate concentration was generally higher than 2 $\mu\text{mol/l}$ in the surface water in all areas, and above 10 $\mu\text{mol/l}$ in the Sound, the Arkona Sea and the southern Belt Sea.

In the Kattegat the mean chlorophyll concentration in the uppermost 15 m was 1.2-1.7 $\mu\text{g/l}$, except in Læsø Rende where 2.5-2.9 $\mu\text{g/l}$ was found. In the Arkona Sea, southern Belt Sea and southern Great Belt 2.2-2.7 $\mu\text{g/l}$ was observed.

Severe oxygen depletion (< 1.4 ml/l) was observed in the Fehmarn Belt and Mecklenburg Bight (0.5-0.6 ml/l, 9% saturation), and oxygen depletion (< 2.8 ml/l) was found in the Arkona Sea (1.4-1.9 ml/l, 21-30%), the Kiel Bight, the Sound and parts of the southern Kattegat (2.5-2.7 ml/l, 39-44%). In all other areas the minimum oxygen concentration was higher than 50% saturation.

In the oxygen depleted bottom water in the southern Belt Sea high concentrations of phosphate (1.3-1.7 $\mu\text{mol/l}$), ammonium (2.6-4.9 $\mu\text{mol/l}$) and silicate (42-71 $\mu\text{mol/l}$) were observed, e.g. in the Fehmarn Belt, Mecklenburg Bight and Kiel Bight. Also in the Arkona Sea bottom water the silicate concentration was high, 44-55 $\mu\text{mol/l}$.

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 oxygen situation, but also the hydrography and the concentrations of nutrients and chlorophyll-*a*. The monitoring stations of the cruise are shown in *figure 1*.

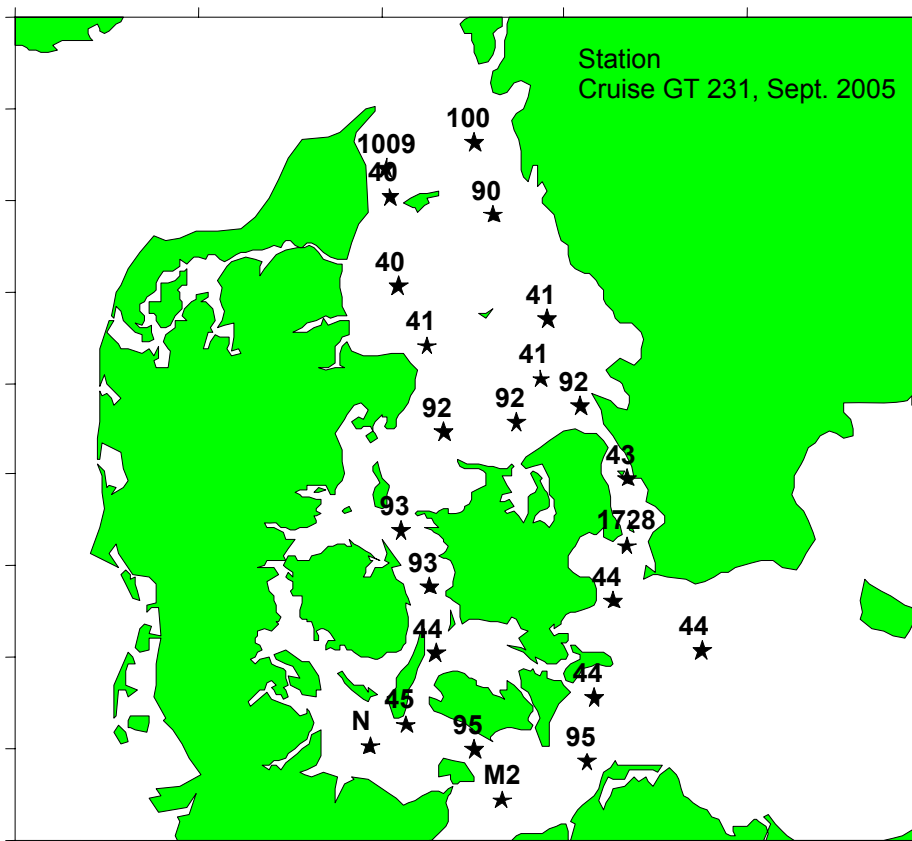


Figure 1 Stations of the monitoring cruise with r/v Gunnar Thorson 19-23 September 2005 in the Sound, the Arkona Sea, the Belt Sea and the Kattegat. Gunnar Thorson cruise no. 231.

Meteorology

Characteristics of the weather conditions in September 2005 are given in *table 1*. September was generally warm, dry and relatively calm with dominating wind from south-west. Only mid September (week no. 37) stronger winds occurred (*figure 2*).

Table 1 Deviations in monthly mean temperature and precipitation in September 2005 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
September	+1.7	-62	4.2	S-SW-W

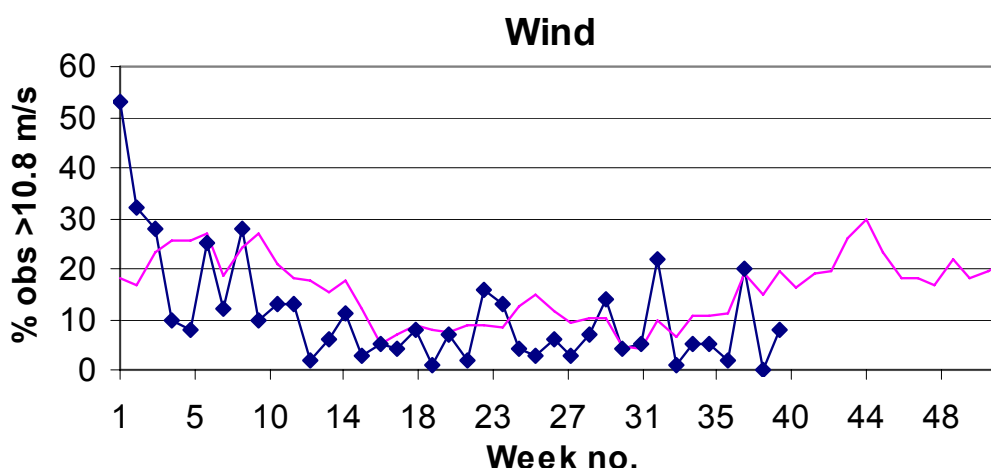


Figure 2 Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2005 (connected points) compared to mean for the period 1994-2004 (thin line). Based on data from the Danish Meteorological Institute.

Hydrography

The surface temperature (1 m depth) varied between 14.6° C and 16.4° C in all areas. The bottom water temperature ranged from 8.8-9.8° C in the eastern Kattegat (St. 905, 413, 921) to 14.1-14.9° C in the north-western Kattegat (St. 403, 1009), central Great Belt (St. 935, 939) and Fehmarn Belt (St. 450, 952) (*figure 3*).

The surface salinity ranged from 7.7-8.3 in the Arkona Sea (St. 441, 444, 449) to 24.0-26.1 in the north-western Kattegat (St. 403, 1009). The bottom water salinity ranged from 15.9-16.9 in the Arkona Sea (St. 441, 444) to 34.3-34.5 in the north-eastern Kattegat (St. 905, 1001) (*figure 3*). The salinity stratification was about average for the season in all areas.

Compared to long-term monthly means (Lightship observations 1931-1960) for September the temperature was generally above average, both in the surface and the bottom layer, except for lower than average temperature in the bottom water of the eastern Kattegat. In the Kattegat the salinity was lower than average in the whole water column, except for higher bottom water salinity in Læsø Rende. Contrary, in the Belt Sea the salinity in the whole water column was higher than average, except for lower bottom water salinity in Fehmarn Belt.

Nutrients

The nitrate concentration in the surface layer was low (0.0-0.2 µmol/l), with the highest concentrations observed in the north-western Kattegat (St. 1009) and at Drogden (St. 1728). In the bottom water the highest nitrate concentration of 7.3-8.3 µmol/l was observed in the eastern Kattegat (St. 413, 905, 1001) (*figure 4a*). The highest nitrite concentration of 0.5-0.8 µmol/l was observed in the bottom water of most of Kattegat and the Sound (*figure 4b*). The highest ammonium concentrations of 2.6-4.9 µmol/l were observed at the bottom in the southern Belt Sea (St. 952, M2, N3). In the Sound 2.7-3.6 µmol/l were found, and in the Great Belt the concentrations at the bottom were 2.1-3.1 µmol/l (*figure 4c*).

High phosphate concentrations for the season were observed in the surface water in the Arkona Sea and the water flowing into the Danish straits from the Baltic Sea. The phosphate concentration in the surface of the Arkona Sea the Sound, southern Belt Sea and southern Great Belt was about 0.3-0.6 µmol/l (*figure 5a*). In the Kattegat the surface phosphate concentration was 0.1-0.15 µmol/l, except in the north-western Kattegat (St. 403, 1009) where 0.4-0.5 µmol/l was observed. In the bottom water the highest phosphate concentrations of 1.3-1.7 µmol/l were observed in the southern Belt Sea (St. 952,

954, M2, N3). Also the highest silicate concentrations of 42-71 $\mu\text{mol/l}$ were found at the bottom in the Fehmarn Belt, Mecklenburg Bight and Kiel Bight (St. 952, 954, M2, N3), as well as in the Arkona Sea (St. 444, 449) (*figure 5b*).

Chlorophyll-*a*

In the Kattegat the mean chlorophyll concentration in the uppermost 15 m was generally low, 1.2-1.7 $\mu\text{g/l}$, except in the Læsø Rende where 2.5-2.9 $\mu\text{g/l}$ were observed. Also in the Arkona Sea (St. 441, 444), southern Belt Sea (St. 450, 952, 954, M2, N3) and southern Great Belt the chlorophyll concentration was relatively high with 2.2-2.7 $\mu\text{g/l}$ (*figure 6*).

Oxygen

The lowest oxygen concentration of 0.5-0.6 ml/l (9% saturation) was observed in the Fehmarn Belt and Mecklenburg Bight (St. 952, M2). In the Arkona Sea and at Gedser Rev (St. 444, 449, 954) the oxygen minimum concentration was 1.4-1.9 ml/l (21-30%). In Kiel Bight (St. N3), the Sound (St. 431, 921) and parts of the southern Kattegat (St. 413, 925) the oxygen minimum concentration was 2.5-2.7 ml/l (39-44%). In all other areas the minimum concentrations were higher than 50% saturation (*figure 7*).

Compared to mean for September last year, the minimum oxygen concentrations this year were generally lower, except in the Great Belt. Compared to September in the 1980s, the minimum oxygen concentrations this year were lower in the southern Belt Sea and the 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 severe oxygen depletion was observed in the Fehmarn Belt and Mecklenburg Bight and oxygen depletion in the Kiel Bight, Arkona Sea, the Sound and parts of the southern Kattegat. *Figure 8* shows the stations visited by the Danish counties, NERI, SMHI and Swedish and German coastal authorities within the first 3 weeks of September 2005, and where oxygen depletion or severe oxygen depletion was observed.

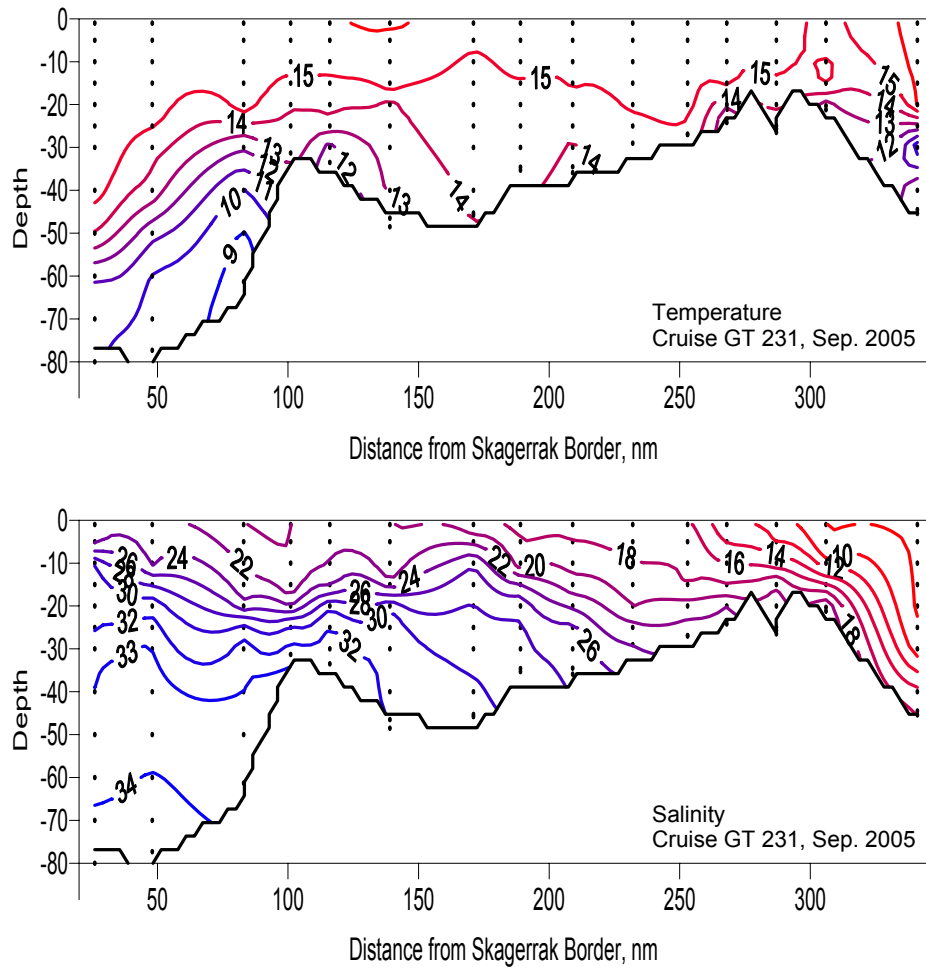


Figure 3 Temperature (top) and salinity (below) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

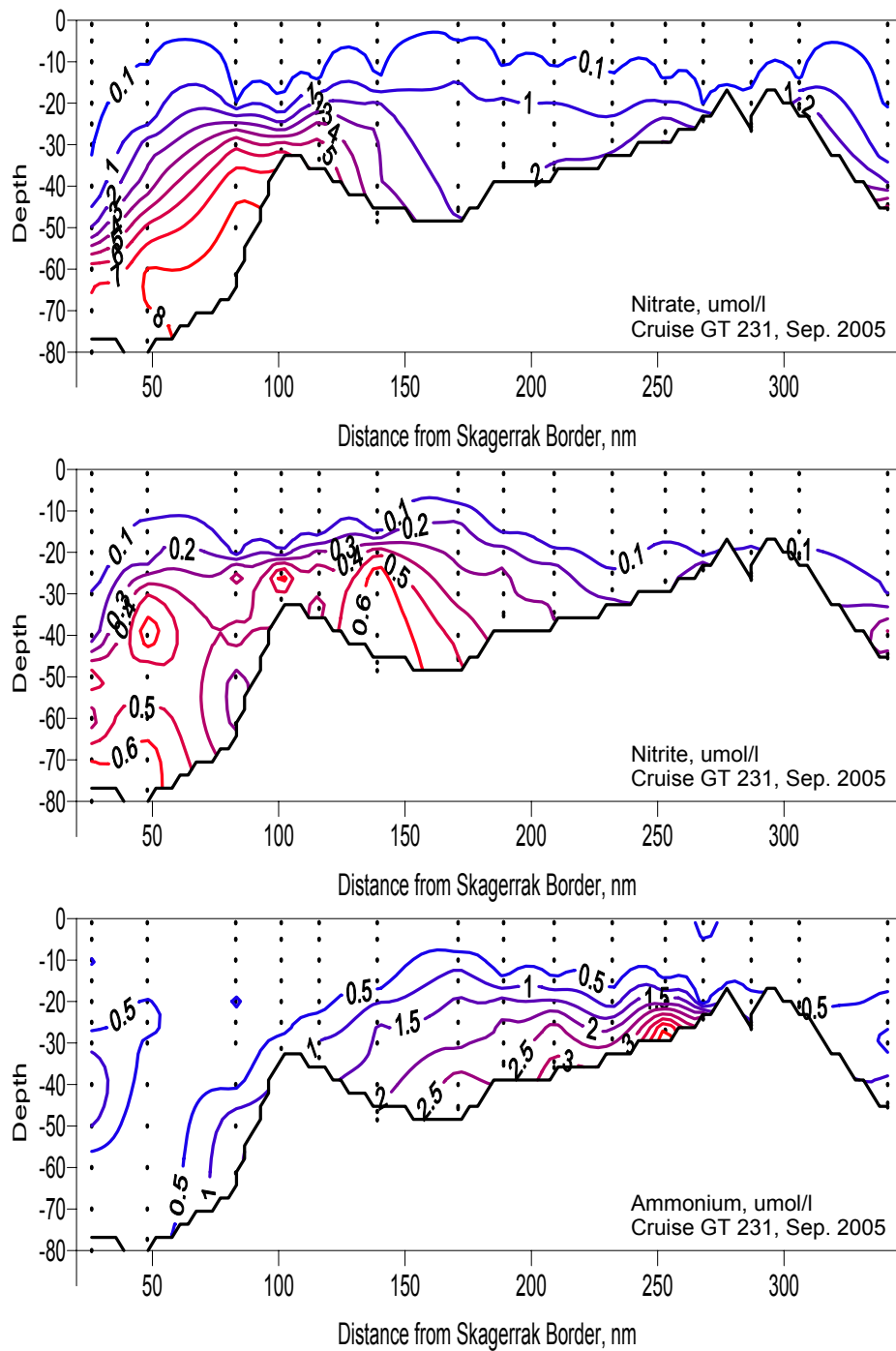


Figure 4 Nitrate (top), nitrite (middle) and ammonium (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

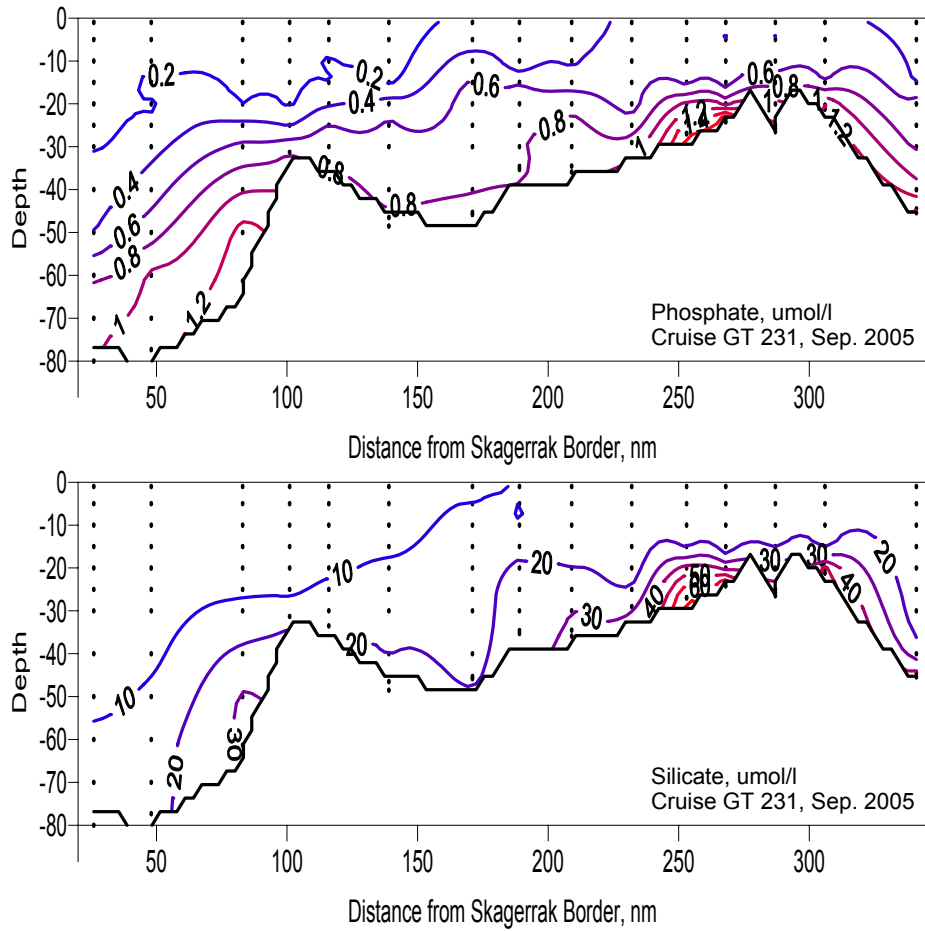


Figure 5 Phosphate (top) and silicate (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

Transect: Kattegat NE - Belt Sea - Arkona Sea

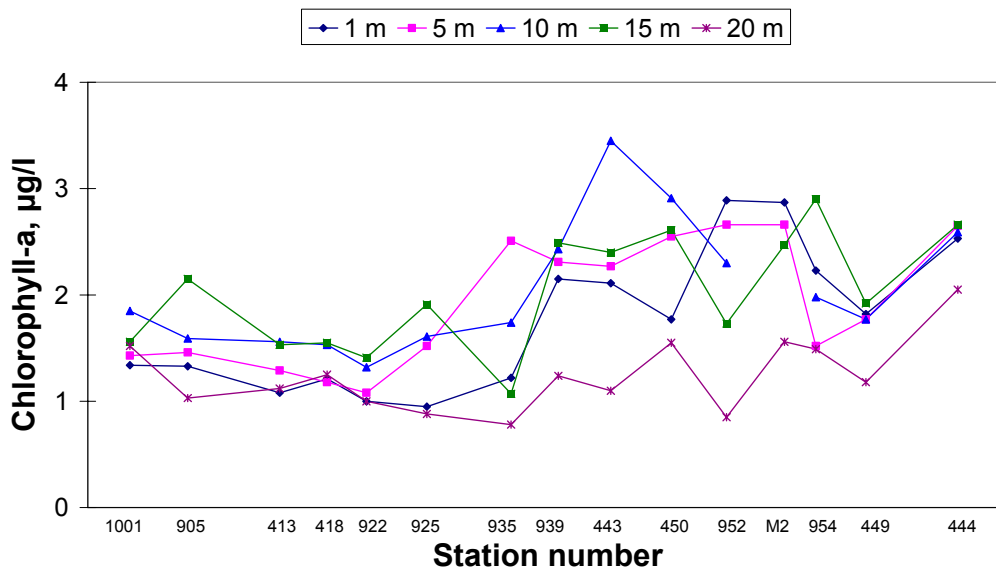


Figure 6 Chlorophyll-a at 1 m, 5 m, 10 m, 15 m and 20 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

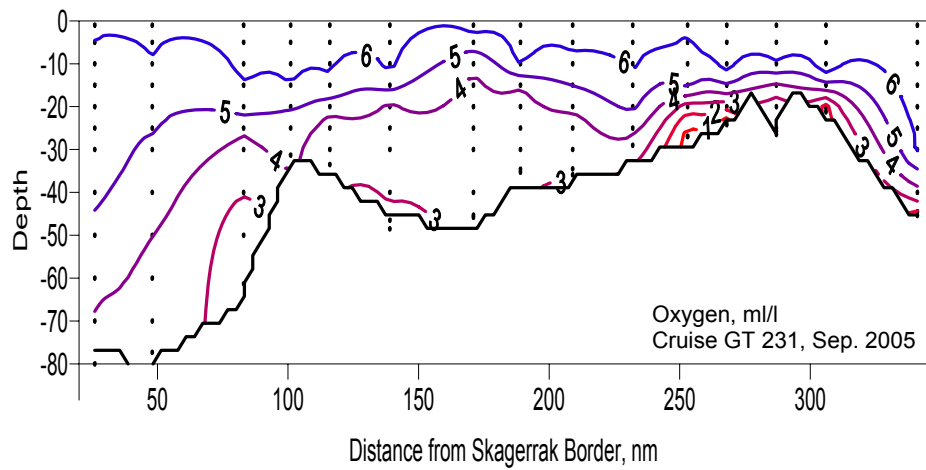


Figure 7 Oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

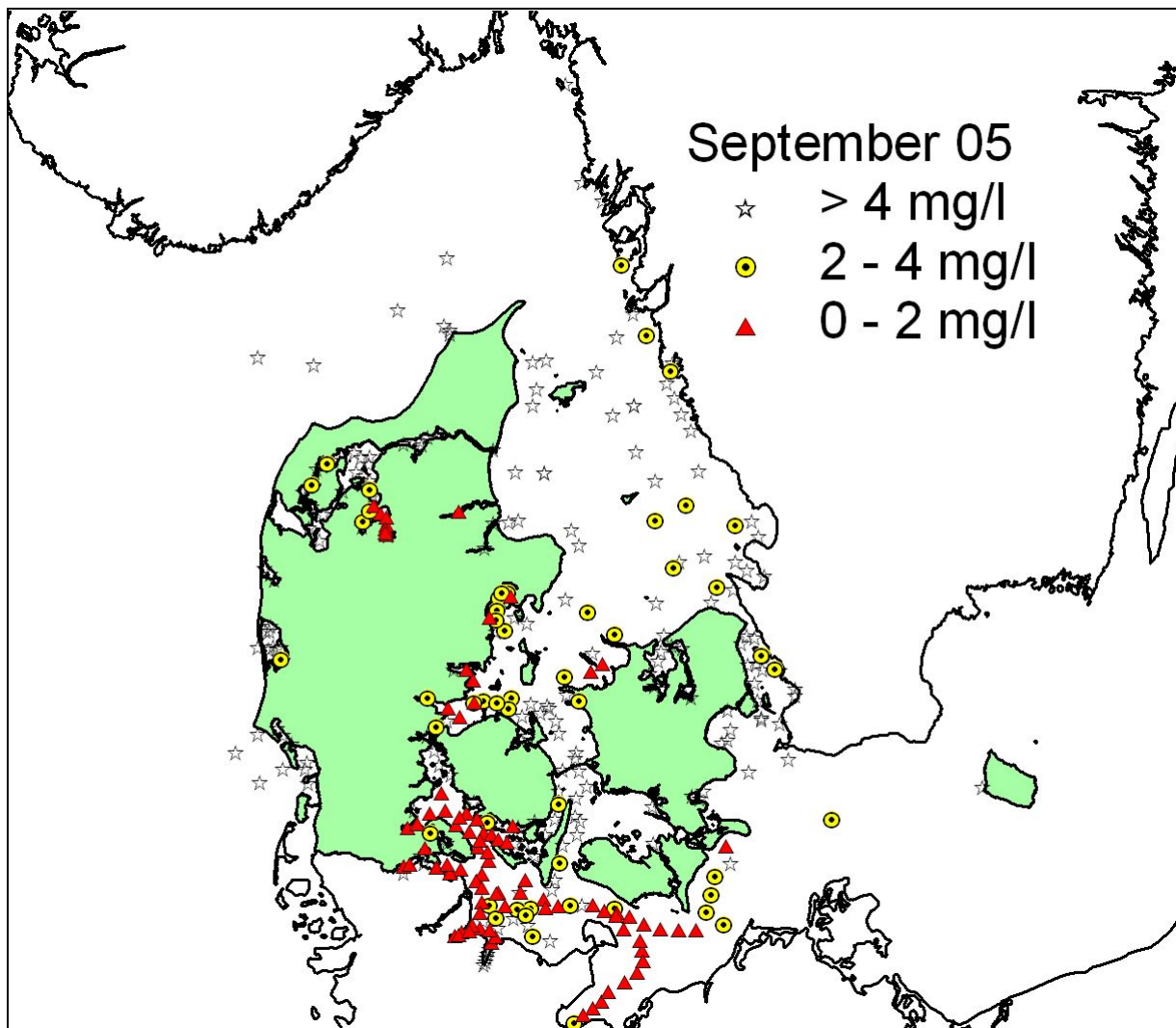


Figure 8 Stations visited by the Danish counties, NERI, SMHI and Swedish and German coastal authorities within the first 3 weeks of September 2005, and where oxygen depletion (< 4.0 mg/l) and severe oxygen depletion (< 2.0 mg/l) was observed.