



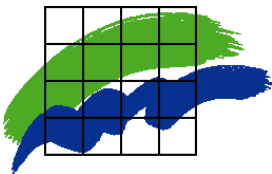
r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 212

Time: 11 - 15 November 2002

**Area: The Sound, the Kattegat,
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.dmu.dk

Data Sheet

Title: Monitoring Cruise with r/v Gunnar Thorson in the Sound, the Kattegat, the Belt Sea and the Arkona Sea

Subtitle: Cruise no. 212, 11-15 November 2002

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: 50/2002

Please quote: Ærtebjerg, G. 2002: Monitoring Cruise with r/v Gunnar Thorson in the Sound, the Kattegat, the Belt Sea and the Arkona Sea. Cruise no. 212, 11-15 November 2002. 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/1_om_dmu/2_afdelinger/3_hav/CruiseReports/index.htm

Number of pages: 9

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 Kattegat, the Belt Sea and the Arkona Sea, 11-15 November 2002 – Cruise no. 212

Report: Gunni Ærtebjerg

Cruise leader: Kjeld Sauerberg

Participants: Jan Damgaard, Hanne Ferdinand, Peter Kofoed, (NERI).

Lars Lund-Hansen, Henning Mogensen (Århus University)

11/11-02: Gunni Ærtebjerg, Jens Chr. Pedersen, Kirsten Rydahl (NERI) and 5 journalists from the Danish Radio News

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

Summary

The following summary is based not only on the present cruise, but also on oxygen measurements made by the Danish counties, SMHI and Swedish coastal authorities. The report on oxygen deficiency is published at the address: <http://iltrapport.dmu.dk>

The exceptionally strong, long-lasting and widespread oxygen deficiency in the Kattegat, the Sound, the Belt Sea and the western Baltic Sea during summer and autumn 2002 is now greatly reduced. This is due to more windy and colder weather during October and November causing mixing and exchange of the oxygen depleted bottom water masses. However, widespread severe oxygen depletion was still present in the southern Little Belt, Flensborg Fjord and the Ærø Basin in the archipelago south of Funen, and hydrogen sulphide was still present in the bottom waters north of the island of Als and in the Ærø Basin. However, also the oxygen conditions in these waters had progressively improved during the last month. In the southern Kattegat, the Sound and the northern Belt Sea the oxygen concentration in the bottom water was still low for the season, even though oxygen depletion was no longer apparent.

The mixing of nutrient rich bottom water into the surface water had created an unusually large autumn bloom of phytoplankton in the Kattegat and especially in the southern Belt Sea, which after sedimentation might delay the re-oxygenation of the bottom water.

The oxygen depletion in the Danish waters in 2002 will be remembered for the dramatic events with dead fish and bottom fauna washed ashore several places along the Jutland east coast at the beginning of October. However, the oxygen deficiency leaves behind other serious trails not visible from the surface in the form of reduced or extinct bottom fauna communities, which will take several years without severe oxygen depletion to re-establish. The feeding resources for demersal fish and wintering diving ducks are reduced in these areas, and the function of the benthic ecosystem is changed.

The Danish counties and NERI are intensively working at mapping the severity and extent of the damage caused by oxygen deficiency to the benthic fauna. Preliminary results from a few investigated areas show up to 100% reduction in the abundance of the bottom fauna in different areas. Large reductions are seen in areas exposed to severe and long-lasting oxygen deficiency, as seen in the southern Little Belt and Flensborg Fjord, where the fauna is extinct at depths greater than 17-20 m. Contrary, in areas only shortly exposed to less severe oxygen deficiency no visible damages to the bottom fauna are observed (e.g. along the coasts of North Zealand).

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 (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*. Bottom fauna was sampled in the Sound (St. 31S) and eastern Kattegat (St. 413).

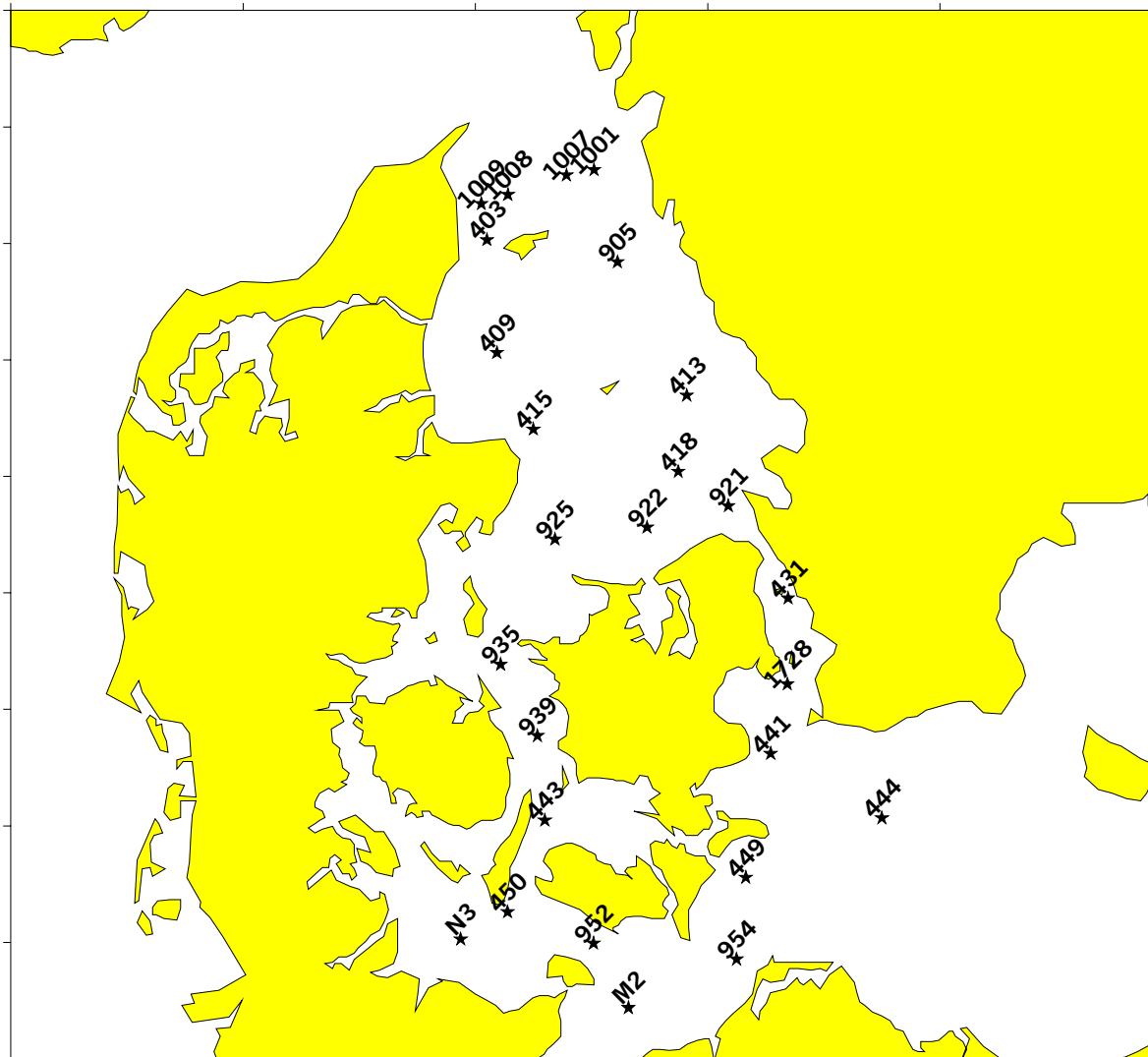


Figure 1 Stations of the monitoring cruise with *r/v Gunnar Thorson* 11-15 November 2002 in the Sound, the Kattegat, the Belt Sea and the Arkona Sea. *Gunnar Thorson* cruise no. 212.

Meteorology

Characteristics of the weather conditions in November 2002 are given in *table 1*. The month was a little colder and wetter than normal. The monthly mean wind force was low for the season. The frequency of observations of gale force was very low during all of November (weeks 45-48, *figure 2*), and the domination of easterly wind directions is quit unusual for the month.

Table 1 Deviations in monthly mean temperature and precipitation in November 2002 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 directions
November	-0.5	+10	4.7	E-SE

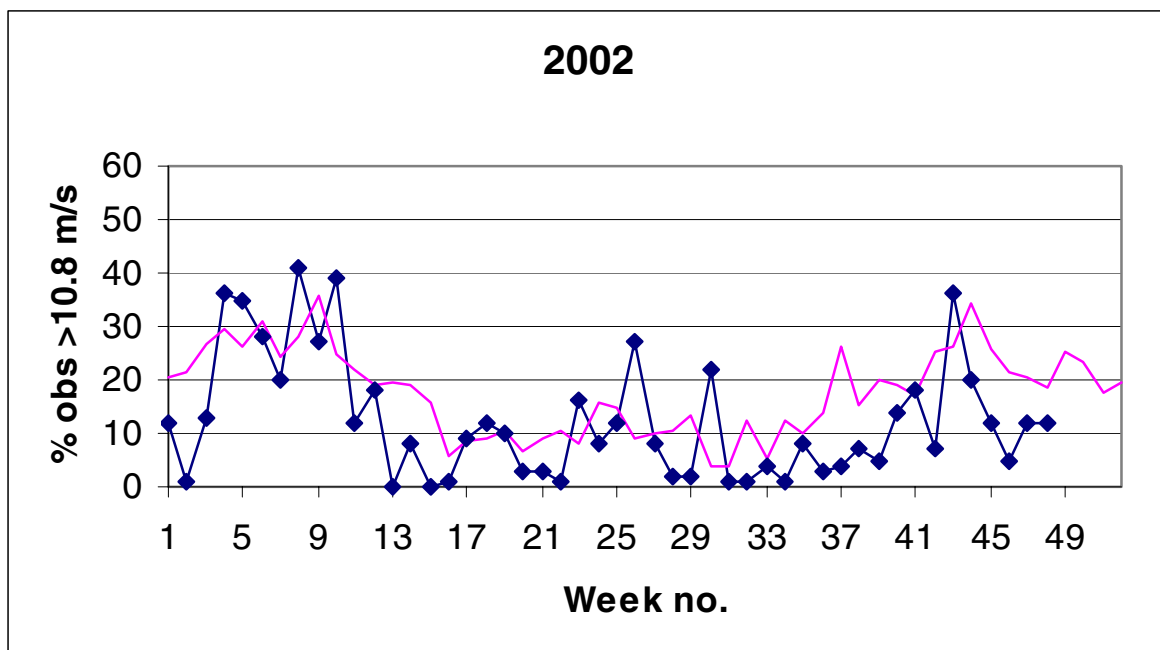


Figure 2 Frequency per week of observations of wind forces above 10.8 m/s (above gale force) in 2002 (connected points) compared to mean for the period 1994-2000 (thin line). Based on data from the Danish Meteorological Institute.

Hydrography

The surface temperature (1 m depth) varied from 6-7.4°C in most areas to 8-9°C in the Arkona Sea (St. 954, 441, 444, 449). The bottom water temperature ranged from 8.6-9.7°C in the eastern and northern Kattegat to 10.5-11.8°C in the Sound, the southern Kattegat and the northern Belt Sea (St. 431, 921, 922, 418, 415, 925, 935, 939) (*figure 3*).

The surface salinity ranged from 7.9-9.0 in the Arkona Sea (St. 1728, 441, 444, 449) to 26.5-28.3 in the northern Kattegat (St. 1001, 1007, 1008, 1009, 403). The bottom water salinity ranged from 10.1-15.5 in the western Arkona Sea (St. 441, 449, 954), and 21.7 in the deep Arkona Sea (St. 444), due to a smaller inflow from the Sound, to 34.1-34.7 in the eastern and northern Kattegat (St. 418, 413, 905, 1001, 1008) (*figure 3*). Thus, since the cruise in October the salinity had decreased and the temperature increased in the bottom water in the north-eastern Kattegat. The salinity stratification has since October decreased significantly, and was >10 only in the Sound, the eastern Kattegat, the central Great Belt and the central Arkona Sea (St. 431, 921, 418, 413, 935, 939, 444).

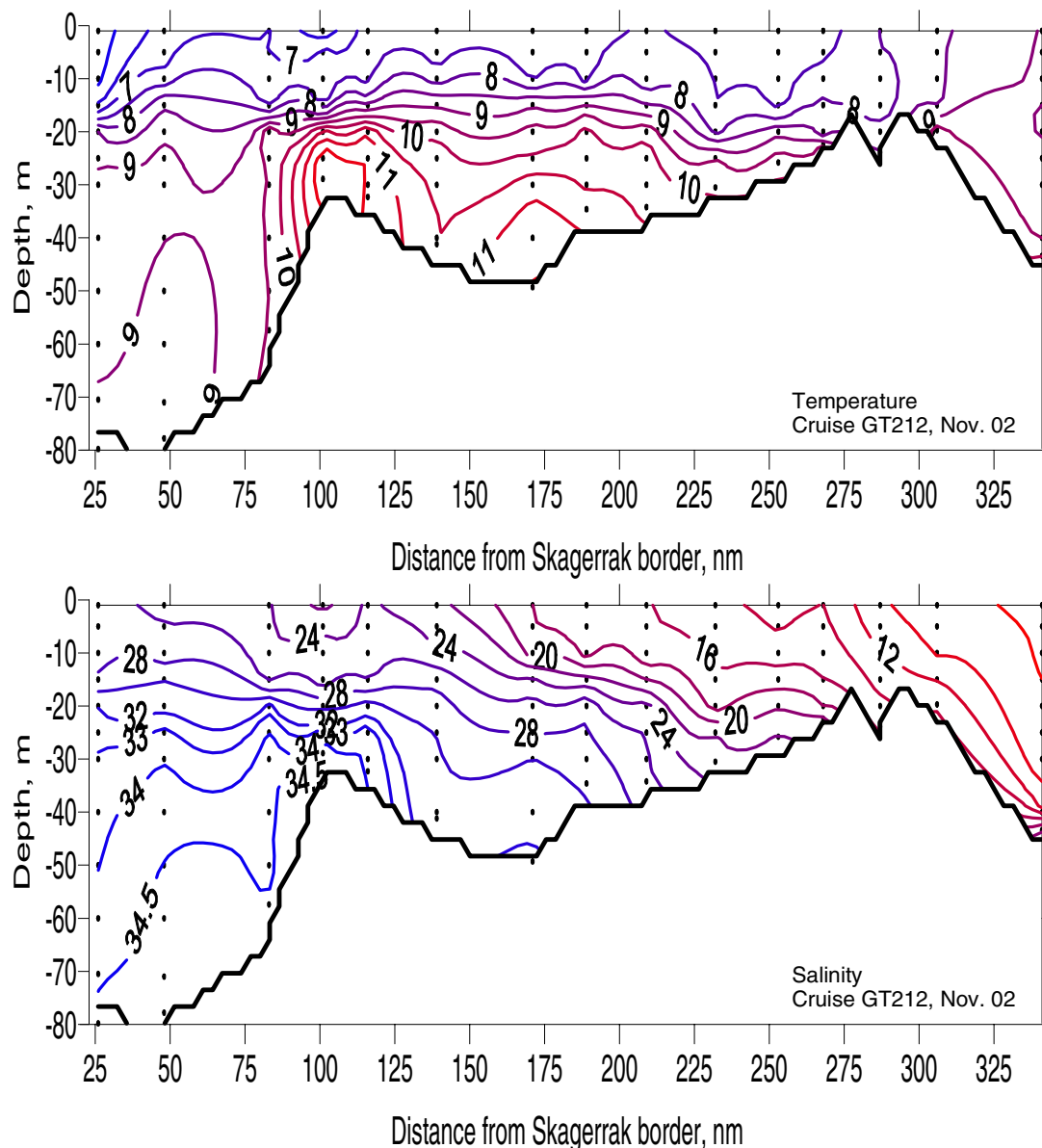


Figure 3 Temperature (top) and salinity (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

Compared to long-term monthly means (Lightship observations 1931-1960) for November, the temperature was about 1°C lower than normal in all areas and in the whole water column. The salinity was during the present cruise higher than normal both in the surface layer and the bottom layer in most areas, except for the southern Belt Sea where the salinity was lower than normal.

Nutrients

In the surface layer the nitrate concentration was still below 0.5 $\mu\text{mol/l}$ in the eastern Kattegat, the southern Belt Sea and the central Arkona Sea (figure 4). In the bottom water high nitrate concentrations (9.0-11.5 $\mu\text{mol/l}$), corresponding to the concentrations seen in the North Atlantic bottom water observed in the north-eastern Kattegat one month before, were now observed in the eastern Kattegat (St. 905, 413, 418, 921, 922) and the Sound (St. 431). In the Great Belt the bottom water nitrate concentration was above 6 $\mu\text{mol/l}$ (figure 4).

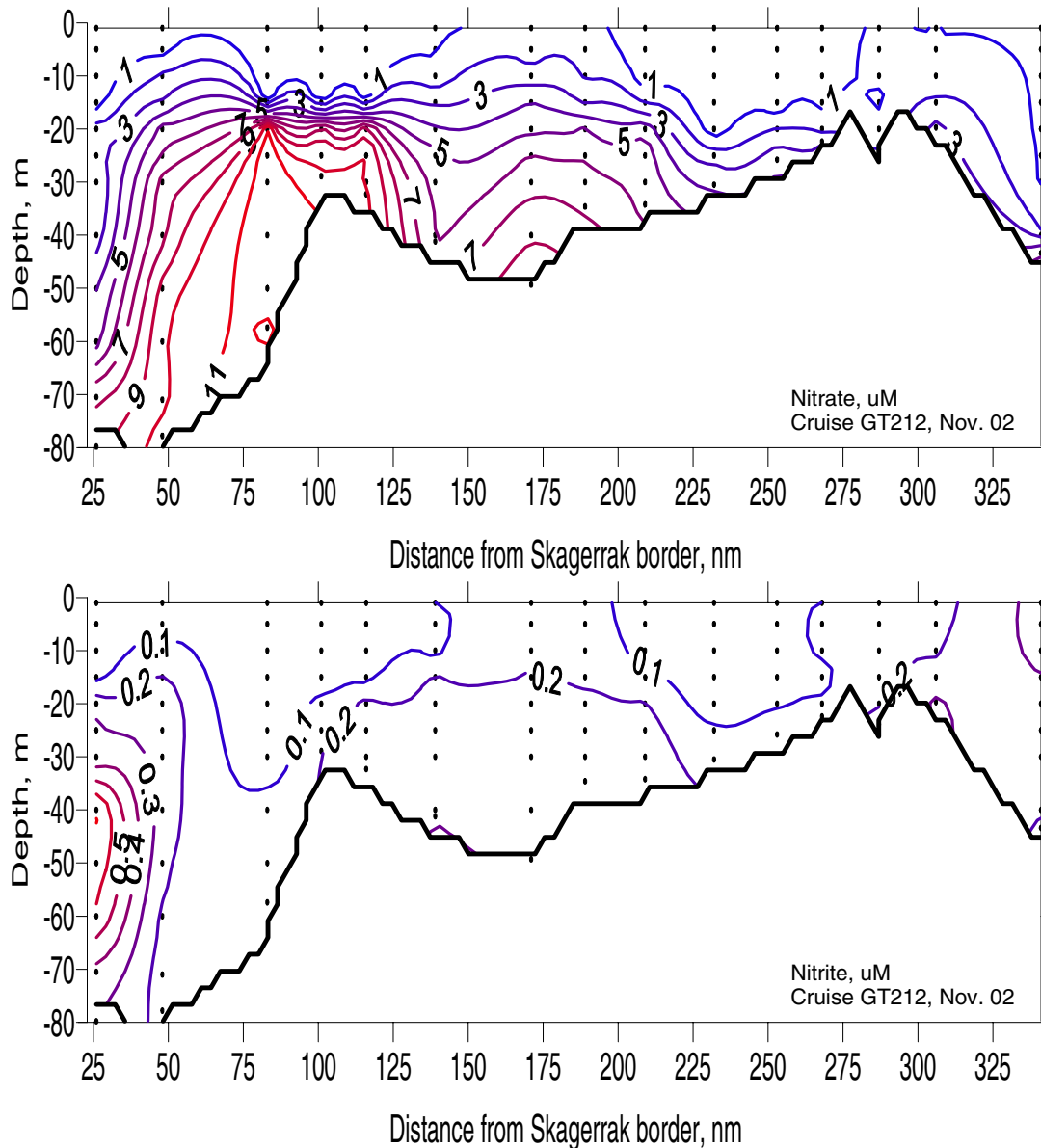


Figure 4 Nitrate (top) and nitrite (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

Relatively high nitrite concentrations (0.5-0.7 $\mu\text{mol/l}$) were observed at 40-60 m depth in the north-eastern Kattegat (St. 1001). Otherwise the nitrite concentrations were about normal (*figure 4*). Phosphate and silicate were present in the surface water in all areas, lowest in the north-eastern Kattegat (*figure 5*).

The extremely high ammonium, phosphate and silicate concentrations found in the oxygen depleted bottom water of the southern Belt Sea in October were significantly reduced. During the present cruise the highest ammonium concentrations (1.5-3.1 $\mu\text{mol/l}$) were observed in the bottom water of the southern Great Belt, Fehmarn Belt, Mecklenburg Bight and the Arkona Sea (St. 939, 443, 450, 952, M2, 954, 449, 444). Phosphate concentrations were highest (>1.2 $\mu\text{mol/l}$) in the eastern Kattegat bottom water (St. 905, 413), and the silicate concentrations highest (>20 $\mu\text{mol/l}$) in the southern Great Belt bottom water (St. 443) (*figure 5*).

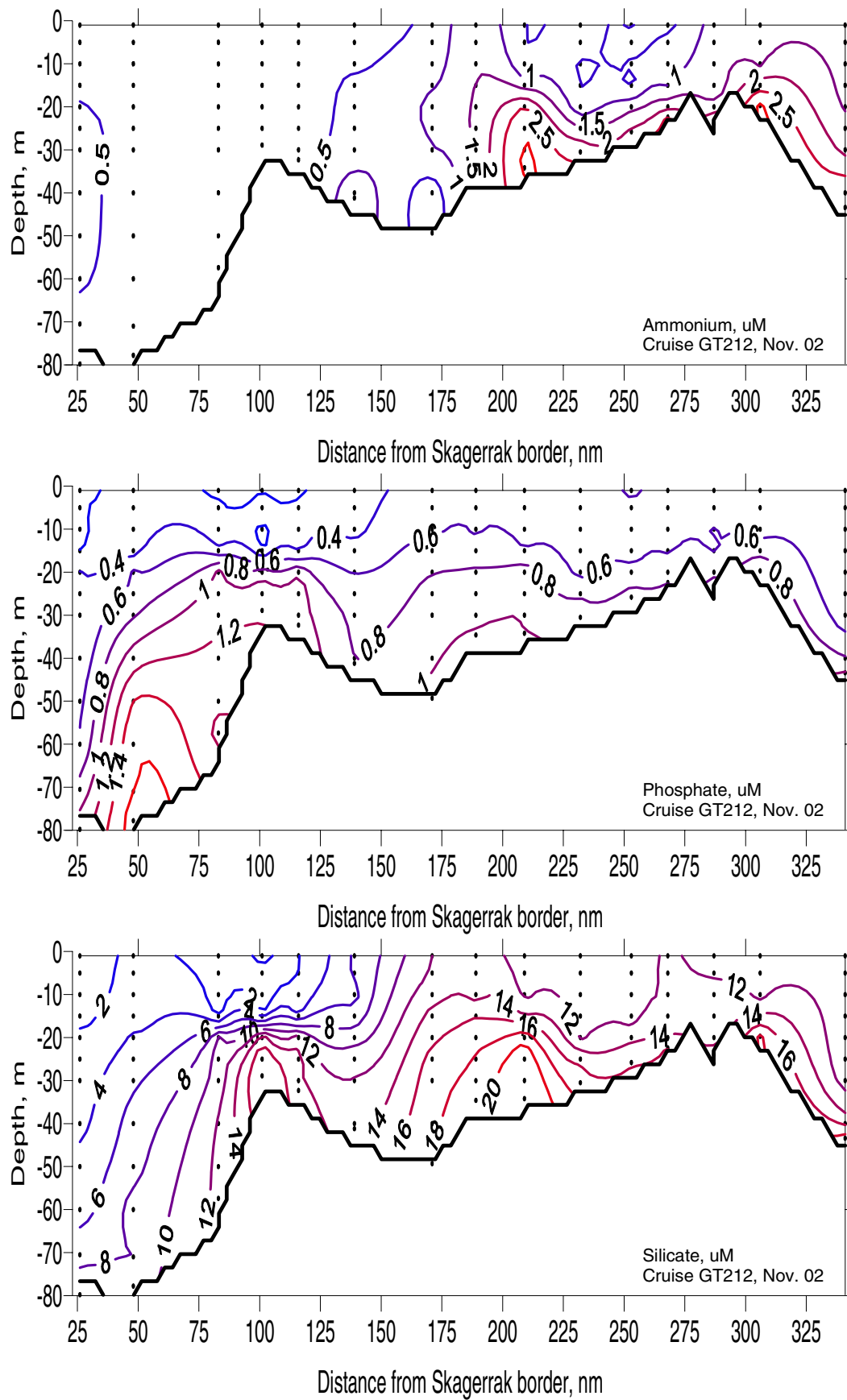


Figure 5 Ammonium (top), phosphate (mid) and silicate (bottom) distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

Chlorophyll-*a* and phytoplankton

In most areas the mean chlorophyll-*a* concentration in the uppermost 10 m was unusually high for the season. The lowest mean concentrations (0.8-4.2 µg/l) were found in the Sound, the Arkona Sea and the southern Kattegat. In the northern Kattegat the mean concentration was 5.8-7.9 µg/l, and in the Belt Sea generally 5.8-11.7 µg/l – highest in the southern Belt Sea. The chlorophyll-*a* concentration was relatively homogeneously distributed in the uppermost 15 m (figure 6).

Transect: Kattegat NE - Belt Sea - Arkona Sea

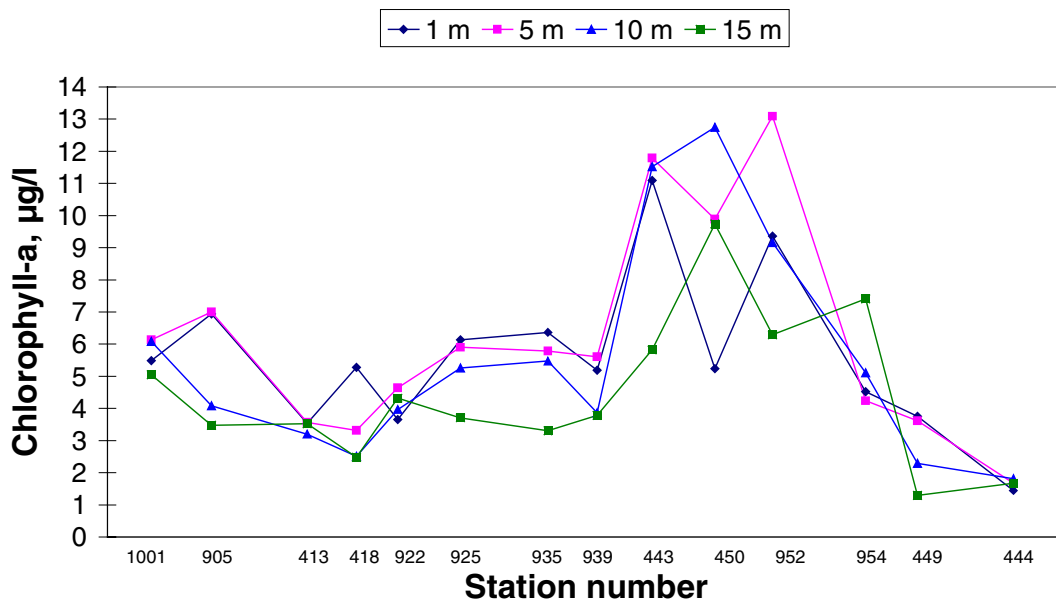


Figure 6 Chlorophyll-*a* at 1 m, 5 m, 10 m and 15 m depth in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

In the Kattegat (St. 413) the phytoplankton was dominated by diatoms (*Rhizosolenia setigera*, *Guinardia flaccida*, *Coscinodiscus* sp., *Pseudo-nitzschia* sp./spp., *Thalassiosira* sp.), and the dinoflagellates *Ceratium tripos*, *C. fusus* and *C. lineatus*. The high phytoplankton biomass in the southern Belt Sea (St. N3, M2) was dominated by the dinoflagellates *Cerartaulina pelagica*, *Ceratium tripos*, and *C. fusus*. In the central Arkona Sea (St. 444), the phytoplankton was dominated by centric diatoms, *Chaetoceros* sp., *Ceratium tripos* and lots of tintinids.

Oxygen

Since the cruise in October, the minimum oxygen concentration has increased in all areas. The lowest concentration of 2.9 ml/l was observed in the Sound (St. 431). Minimum oxygen concentrations of 3.0-3.7 ml/l were observed in the southern Kattegat and northern Great Belt (St. 921, 922, 418, 415, 925, 935, 939) (*figure 7*). Compared to November last year, the minimum oxygen concentrations this year are lower, except in the eastern Kattegat and the Arkona Sea. Compared to mean for November in the 1980s, when oxygen depletion often occurred during autumn, the minimum concentrations this year are lower, except in the Arkona Sea.

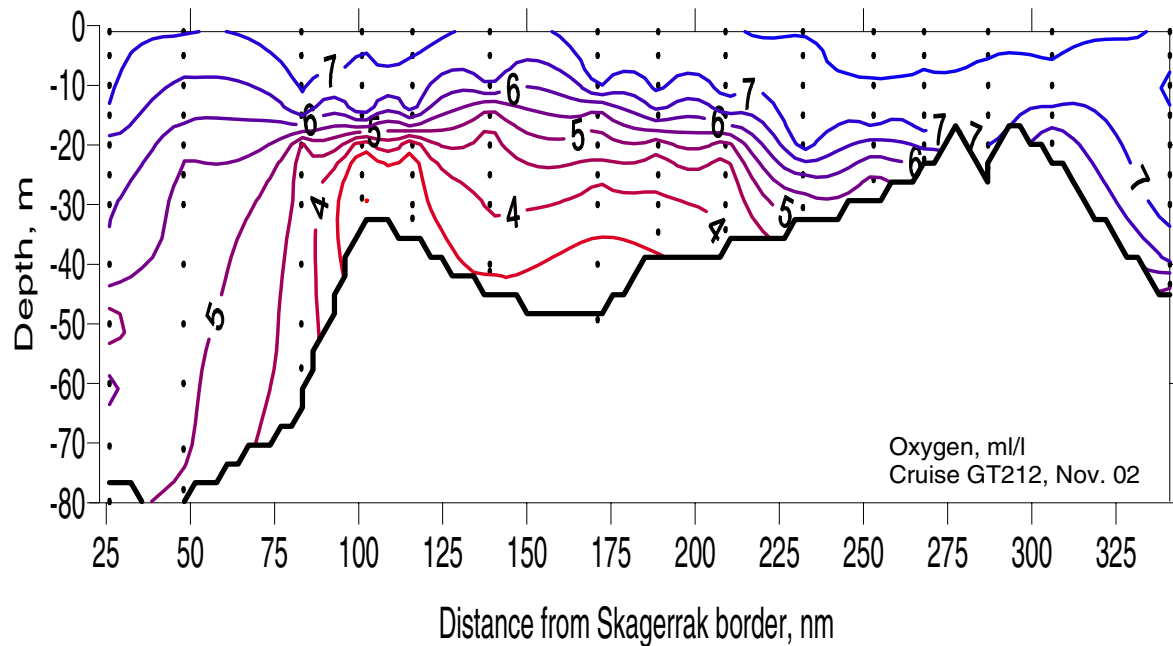


Figure 7 Oxygen distribution in a transect from the north-eastern Kattegat through the Great Belt and Fehmarn Belt to the Arkona Sea.

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 no longer occurred at the stations visited. *Figure 8* shows the stations visited by Danish counties, NERI, SMHI and Swedish coastal authorities within the first three weeks of November 2002, and where oxygen depletion or severe oxygen depletion was observed.

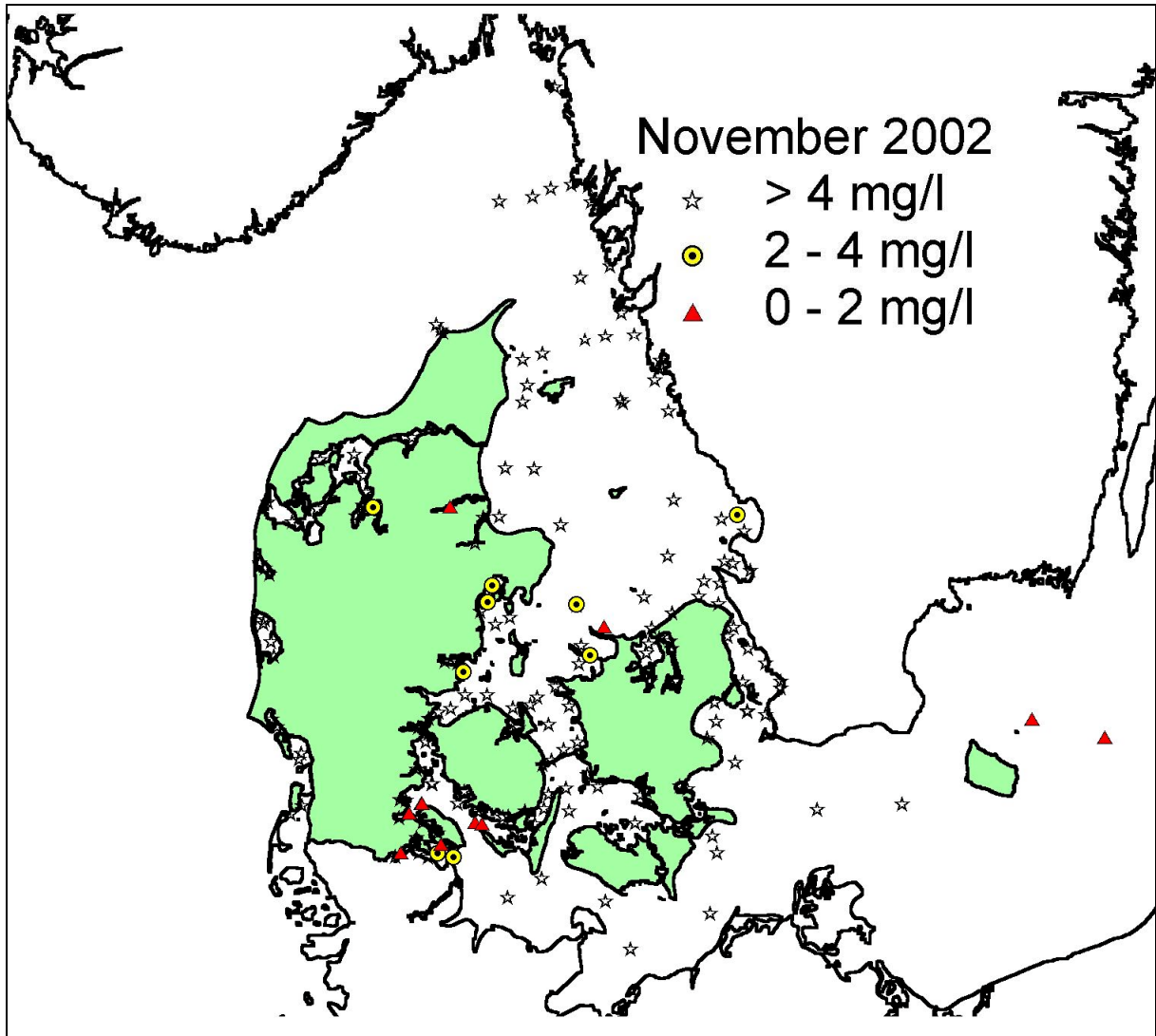


Figure 8 Stations visited by Danish counties, NERI, SMHI and Swedish coastal authorities within the first three weeks of November 2002, and where oxygen depletion (<4 mg/l) and severe oxygen depletion (<2 mg/l) was observed.