



r/v Gunnar Thorson

Monitoring Cruise Report

Cruise no.: 198

Time: 11 - 14 September 2000

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

Ministry of Environment and Energy
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, Kattegat, Belt Sea and Arkona Sea

Subtitle: Cruise no. 198, 11-14 September 2000

Author: Gunni Ærtebjerg
Department: Department of Marine Ecology

Serial title: Monitoring Cruise Report

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

Week/year of publication: 41/2000

Please quote: Ærtebjerg, G. (2000): Monitoring Cruise with r/v Gunnar Thorson in the Sound, Kattegat, Belt Sea and Arkona Sea. Cruise no. 198, 11-14 September 2000. 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: 12

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, Kattegat, Belt Sea and Arkona Sea, 11-14 September 2000.

Cruise no. 198.

Report: Gunni Ærtebjerg

Cruise leader: Kjeld Sauerberg

Participants: Lars Renvald, Hanne Ferdinand, Peter Kofoed, Charlotte Andersen (student), Claus Jacobsen (technician trainee), Steffen Sørensen (trainee)

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

Summary

The salinity stratification of the water column was strong in all investigated areas due to outflow of brackish surface water from the Baltic Sea. Generally, the water temperature was lower and the bottom water salinity higher than long-term means for September.

In the surface only traces of nitrate and nitrite were observed, while about 0.5 $\mu\text{mol/l}$ ammonium was found in most areas. Phosphate and silicate were present in the surface; however, in the north-eastern Kattegat only in low concentrations. Relatively high concentrations of ammonium, phosphate and silicate were present in the bottom water in the areas with low oxygen concentrations; that is the south-eastern Kattegat, southern Belt Sea and Arkona Sea.

The mean chlorophyll concentration in the uppermost 10 m varied between 1.2 $\mu\text{g/l}$ in the Sound to 3.7 $\mu\text{g/l}$ in the Fehmarn Belt. The chlorophyll was relatively homogeneously distributed in the uppermost 10 m of the water column. Significant subsurface maximum was only observed close to the bottom in the shallow western Kattegat (3.3 $\mu\text{g/l}$) and Kiel Bight (5.4 $\mu\text{g/l}$).

Since the cruise in August the minimum oxygen concentration had decreased in all investigated areas. The lowest oxygen concentration of 0.3 ml/l (4% saturation) was observed in the central Arkona Sea. In the Fehmarn Belt, Mecklenburg Bight and Gedser Rev area the minimum oxygen concentration was only 0.5-0.9 ml/l (8-13%), and in Kiel Bight 1.1 ml/l. In the Sound and southern Kattegat 1.2-1.7 ml/l (18-26%) was observed and in the Great Belt the concentration was 1.7-2.2 ml/l (28-35%). Even in the shallow western Kattegat the oxygen concentration at the bottom was only 3.1 ml/l (52%).

Compared to September last year and to mean for September in the 1980's the minimum oxygen concentrations this year are lower, except in the north-eastern Kattegat. The concentrations in the Great Belt are probably the lowest ever recorded at these stations.

In Denmark oxygen depletion is defined as minimum oxygen concentrations below 2.8 ml/l (4 mg/l), and serious oxygen depletion as below 1.4 ml/l (2 mg/l). From these definitions serious oxygen depletion occurred in the Sound, southern Kattegat, Kiel Bight, Fehmarn Belt, Mecklenburg Bight, Gedser Rev area and central Arkona Sea, and oxygen depletion occurred in the south-eastern Kattegat and all Great Belt. In *figure 9* is shown the stations visited by Danish counties and NERI within the first three weeks of September 2000, and where oxygen depletion or serious oxygen depletion was observed.

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). 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*.

Meteorology

The first two weeks of September were characterised by weak wind mainly from western directions. During the cruise and the following week rather strong wind from east and south-east was dominating.

Hydrography

The surface temperature (1 m depth) varied from 14.2-14.9°C in the Kattegat to 15.9-16.5°C in the southern Belt Sea (St. N3, 450, 952, M2, 954). The bottom water temperature ranged from 9.1-10.0°C in the south-eastern Kattegat, the Sound and central Arkona Sea (St. 413, 921, 922, 431, 444) to 13.2-13.3°C in the northern Kattegat (St. 403, 1007, 1008, 1009) and 14.5-15.0°C in the shallow western Kattegat (St. 409, 415). The bottom water was generally 0.8-5.7°C colder than the surface water (*figure 2*).

The surface salinity ranged from 7.8-9.7 in the Arkona Sea (St. 441, 444, 449) to only 23.3-24.6 in the northern Kattegat (St. 1001, 1007, 1008). The bottom water salinity ranged from 14.7-16.4 in the Arkona Sea (St. 441, 444, 449) to 34.7 in the north-eastern Kattegat (St. 905, 1001) (*figure 3*). The salinity stratification was strong (10.3-19.2 psu) in most areas. Even in the Arkona Sea and shallow western Kattegat the stratification was 6.1-8.8 psu.

Compared to long term monthly means (Lightship observations 1931-1960) for September the temperature was in the whole water column 0-1.0°C lower than normal, except for 0.2-0.7°C higher surface temperatures in the Belt Sea (St. 939, 952, 954). Generally, the salinity at the surface during the present cruise was 1.4-5.5 psu lower than normal, but at the bottom 0-3 psu higher than normal, except for 0.9-2.5 psu higher surface salinity in the Belt Sea (St. 939, 952, 954) and 1.1 psu lower bottom water salinity in Fehmarn Belt (St. 952).

Nutrients

In the surface traces of nitrate (0.1-0.2 µmol/l) were observed in the south-eastern Kattegat (St. 418, 921), southern Belt Sea (St. 450, N3, 952, M2, 954) and Arkona Sea (St. 449, 441, 444). In the bottom water the highest nitrate concentrations (4.4-5.6 µmol/l) were observed in the Arkona Sea (St. 444) and east of Anholt (St. 413) (*figure 4*). Nearly no nitrate (0.1-0.3 µmol/l) was present at the bottom in the Great Belt (St. 925, 935, 939, 443).

Nitrite concentrations in the surface were very low, but somewhat higher at the bottom, especially in the north-eastern Kattegat (*figure 5a*). Ammonium was present in the surface in most areas, and in high concentrations (2.0-3.8 $\mu\text{mol/l}$) in the bottom water in the south-eastern Kattegat, Great Belt, Fehmarn Belt and central Arkona Sea (*figure 5b*).

Phosphate and silicate were present in the surface water, although the concentrations were low in the north-western Kattegat. High phosphate (0.7-1.3 $\mu\text{mol/l}$) and silicate (22-60 $\mu\text{mol/l}$) concentrations were observed at the bottom in the south-eastern Kattegat, the Sound, Belt Sea and Arkona Sea (*figures 6a and 6b*).

Chlorophyll-*a*

The mean chlorophyll concentration in the uppermost 10 m varied between 1.2 $\mu\text{g/l}$ in the Sound (St. 1728, 431, 921) to 3.7 $\mu\text{g/l}$ in the Fehmarn Belt (St. 952) and 2.9-3.4 $\mu\text{g/l}$ in the Great Belt and southern Belt Sea (St. 939, 443, 450, N3, M2). The chlorophyll was relatively homogeneously distributed in the uppermost 10 m of the water column. Significant subsurface maximum was only observed close to the bottom in the shallow western Kattegat (3.3 $\mu\text{g/l}$; St. 409, 415) and Kiel Bight (5.4 $\mu\text{g/l}$; St. N3) (*figure 7*).

Oxygen

Since the cruise in August the minimum oxygen concentration had decreased in all investigated areas. The lowest oxygen concentration of 0.3 ml/l (4% saturation) was observed in the central Arkona Sea (St. 444). In the Fehmarn Belt, Mecklenburg Bight and Gedser Rev area (St. 952, M2, 954) the minimum oxygen concentration was only 0.5-0.9 ml/l (8-13%), and in Kiel Bight 1.1 ml/l. In the Sound and southern Kattegat 1.2-1.7 ml/l (18-26%) was observed, and in the Great Belt (St. 925, 935, 939, 443, 450) the minimum concentration was 1.7-2.2 ml/l (28-35%). Even in the shallow western Kattegat (St. 409, 415) the oxygen concentration at the bottom was only 3.1 ml/l (52%) (*figure 8*).

Compared to September last year and to mean for September in the 1980's the minimum oxygen concentrations this year are lower, except in the north-eastern Kattegat. The concentrations in the Great Belt are probably the lowest ever recorded at these stations.

In Denmark oxygen depletion is defined as minimum oxygen concentrations below 2.8 ml/l (4 mg/l), and serious oxygen depletion as below 1.4 ml/l (2 mg/l). From these definitions serious oxygen depletion occurred in the Sound, southern Kattegat, Kiel Bight, Fehmarn Belt, Mecklenburg Bight, Gedser Rev area and central Arkona Sea, and oxygen depletion occurred in the south-eastern Kattegat and all Great Belt. In *figure 9* is shown the stations visited by Danish counties and NERI within the first three weeks of September 2000, and where oxygen depletion or serious oxygen depletion was observed.

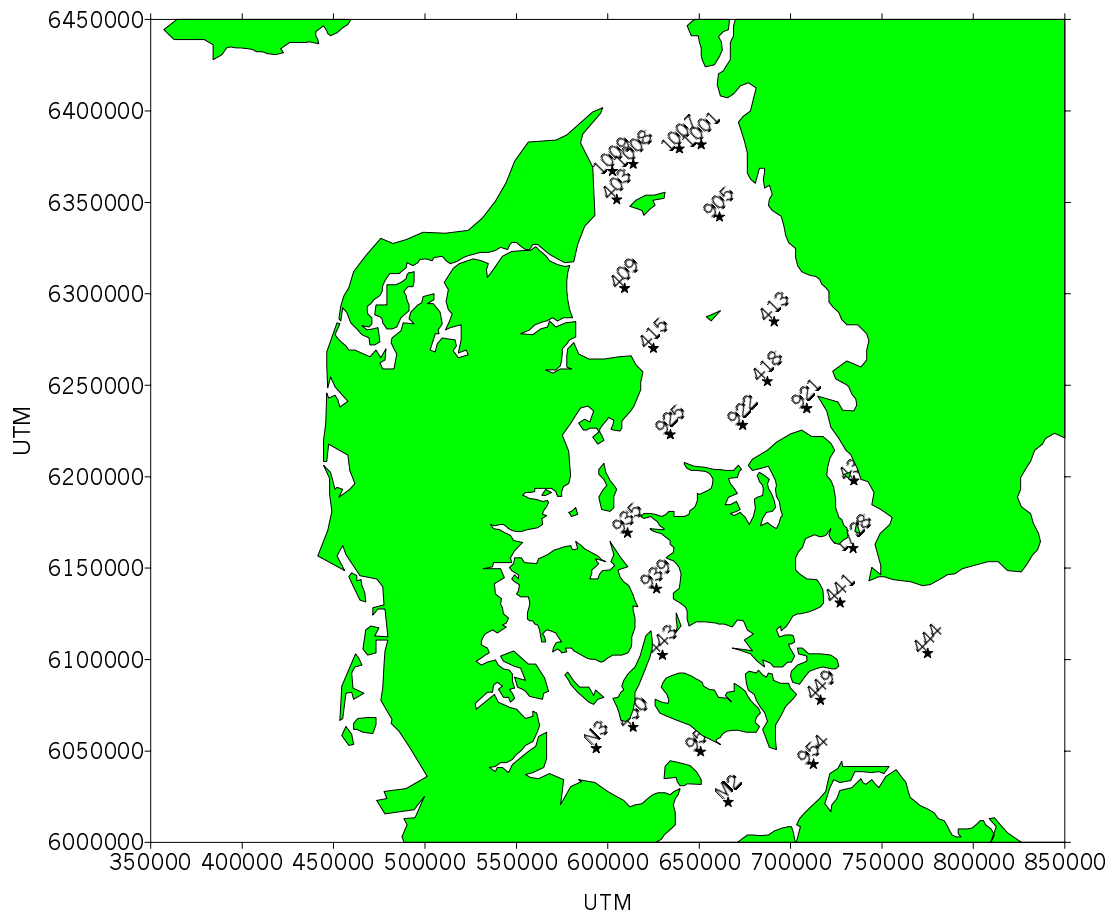


Figure 1. Stations of the monitoring cruise with r/v Gunnar Thorson 11-14 September 2000 in the Sound, Kattegat, Belt Sea and Arkona Sea. Gunnar Thorson cruise no. 198.

Transect I: Kattegat NE - Belt Sea - Arkona Sea

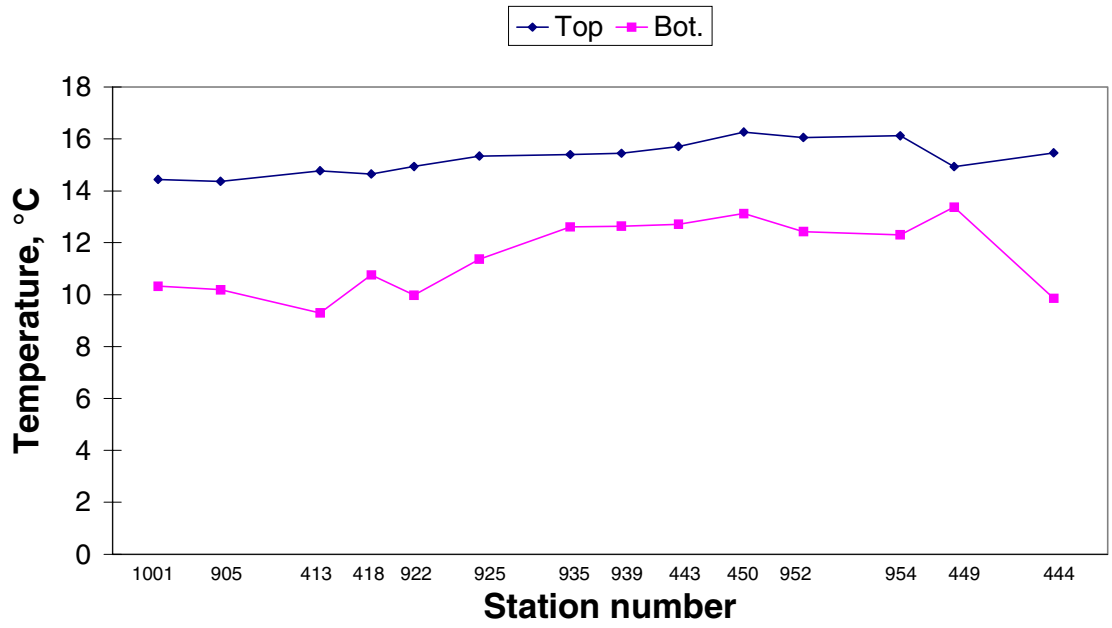
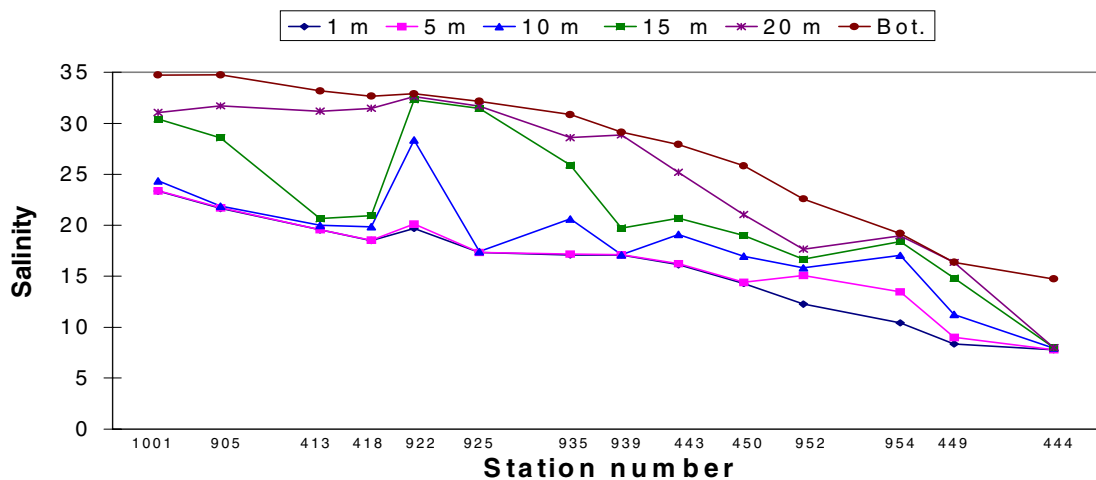
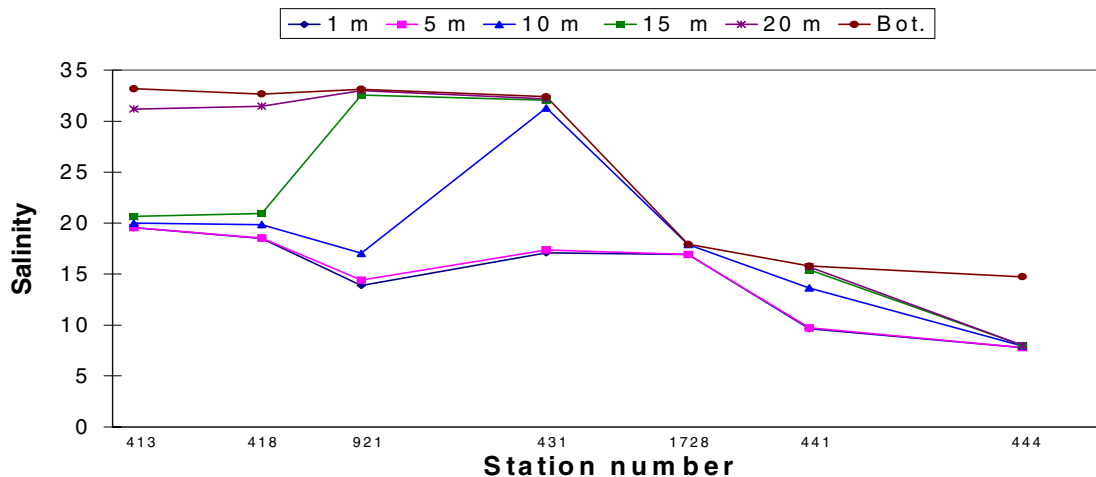


Figure 2. Surface and near bottom temperature along transect I from the north-eastern Kattegat through the Belt Sea to the Arkona Sea.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

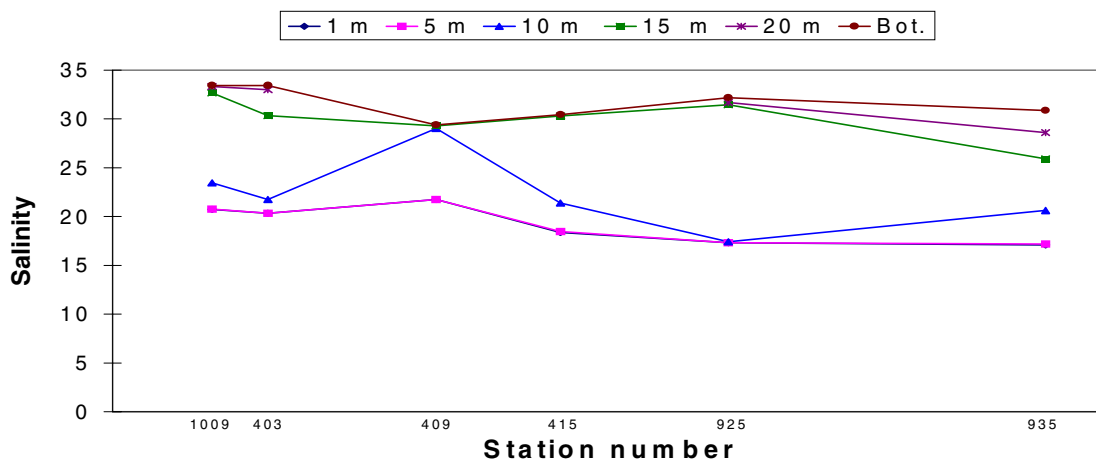
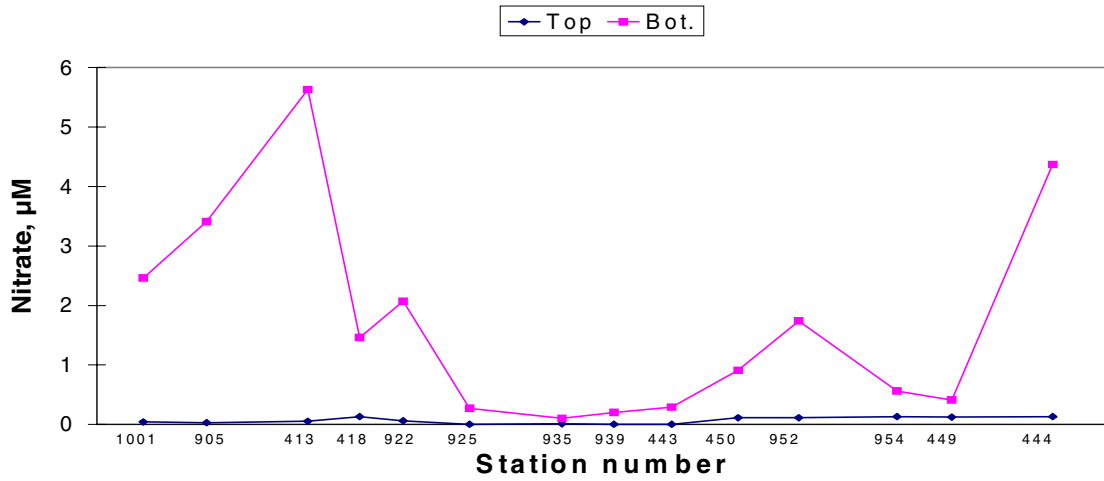
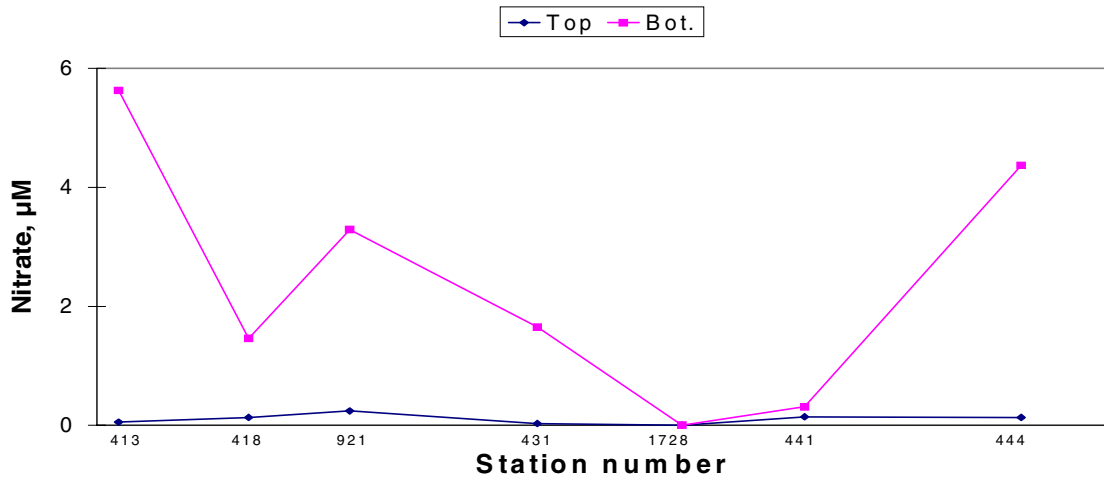


Figure 3. Salinity in 1 m, 5 m, 10 m, 15 m, 20 m depth and near bottom along transect I, II and III from the Kattegat through the Belt Sea and Sound to the Arkona Sea and in the western Kattegat to the Great Belt, respectively.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

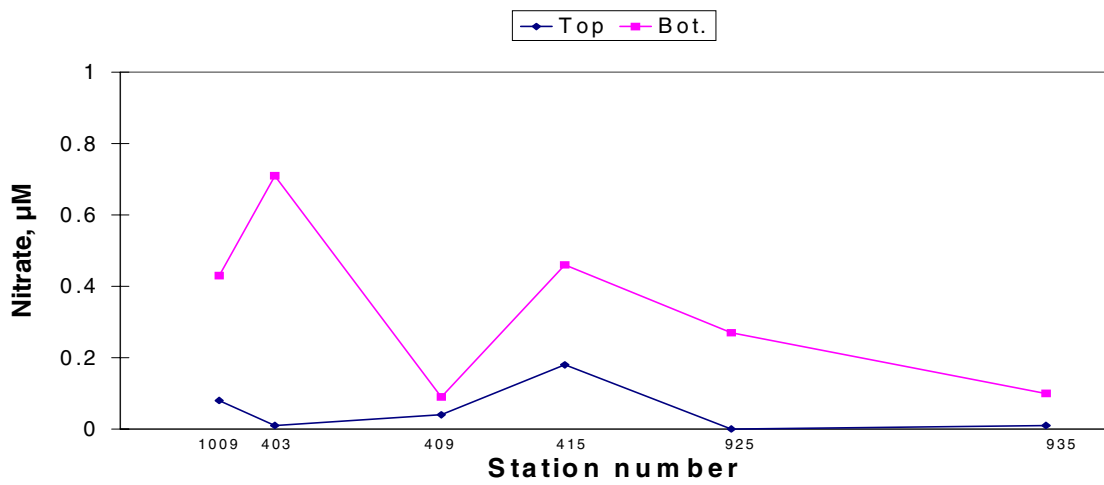
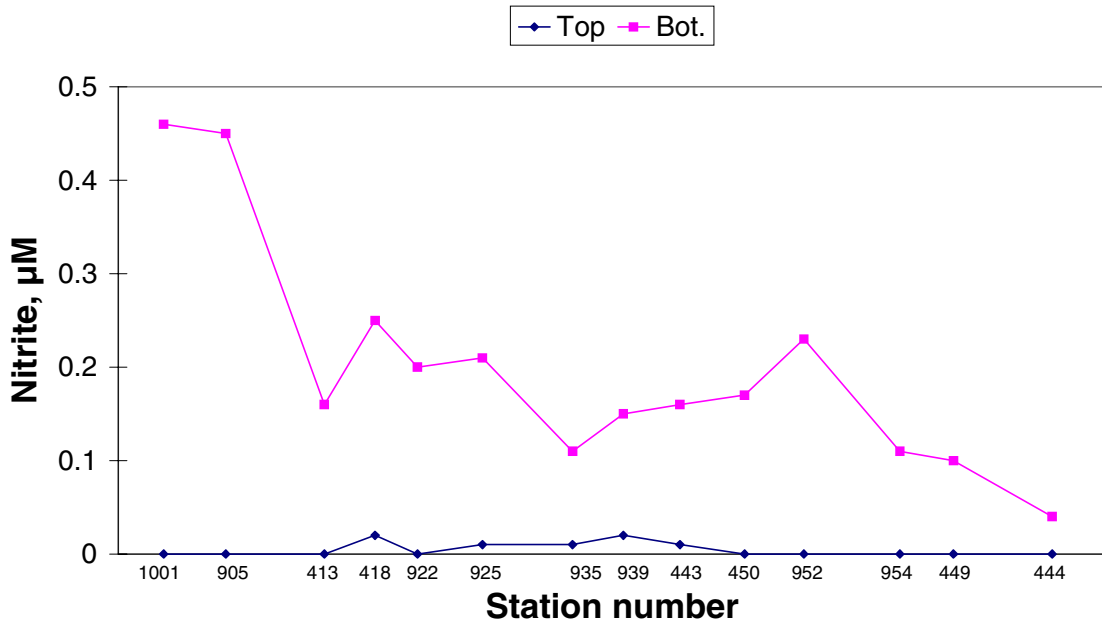


Figure 4. Surface and near bottom concentrations of nitrate along transect I, II and III

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect I: Kattegat NE - Belt Sea - Arkona Sea

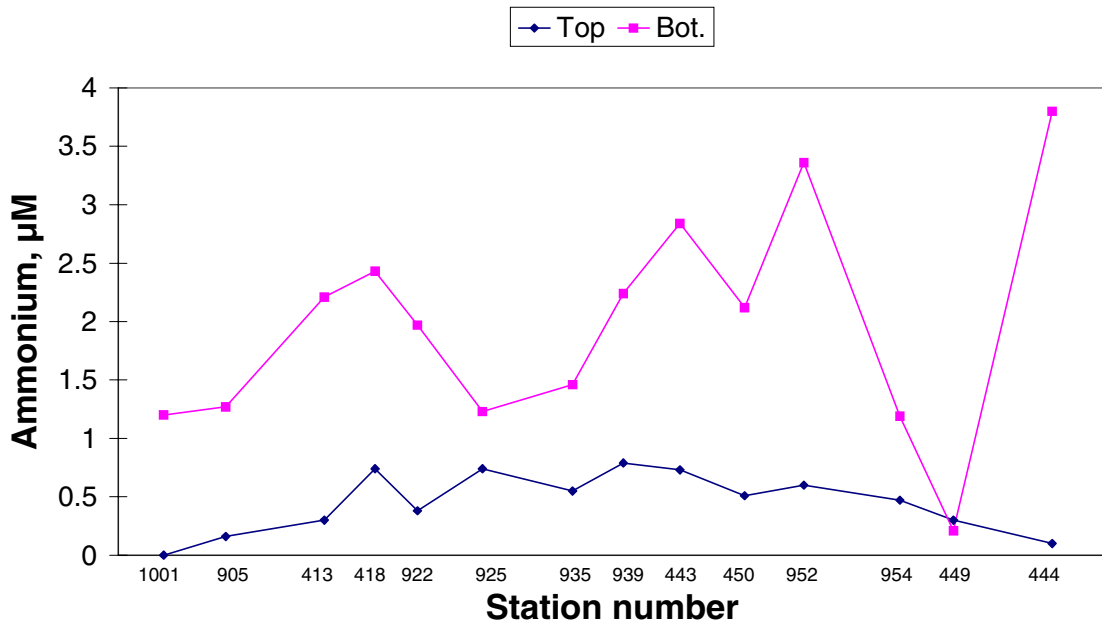
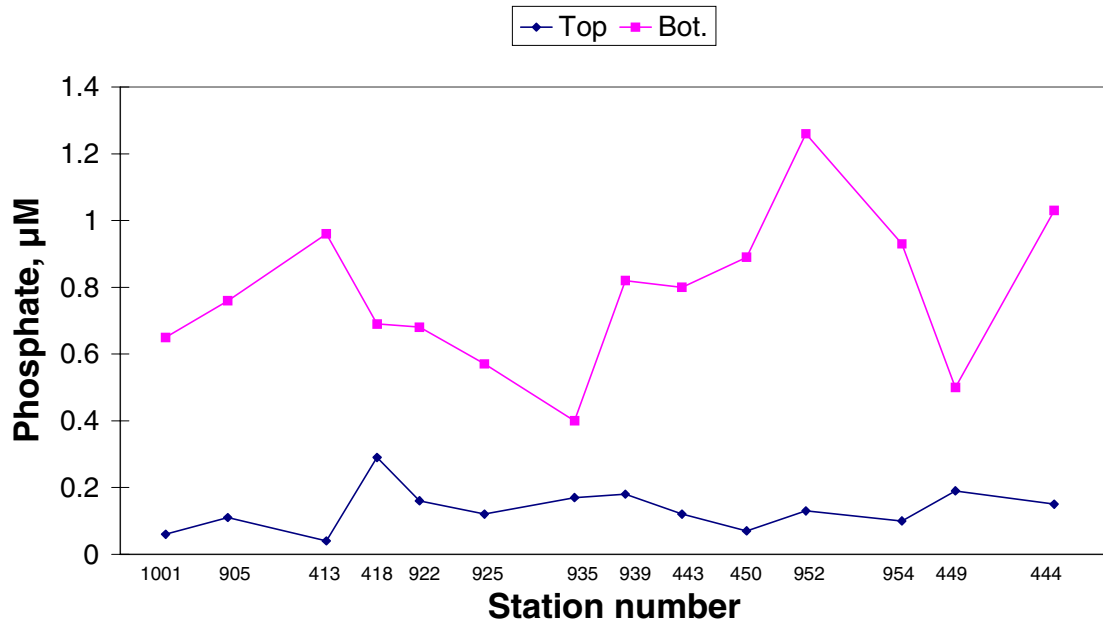


Figure 5. Surface and near bottom concentrations of nitrite and ammonium along transect I.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect I: Kattegat NE - Belt Sea - Arkona Sea

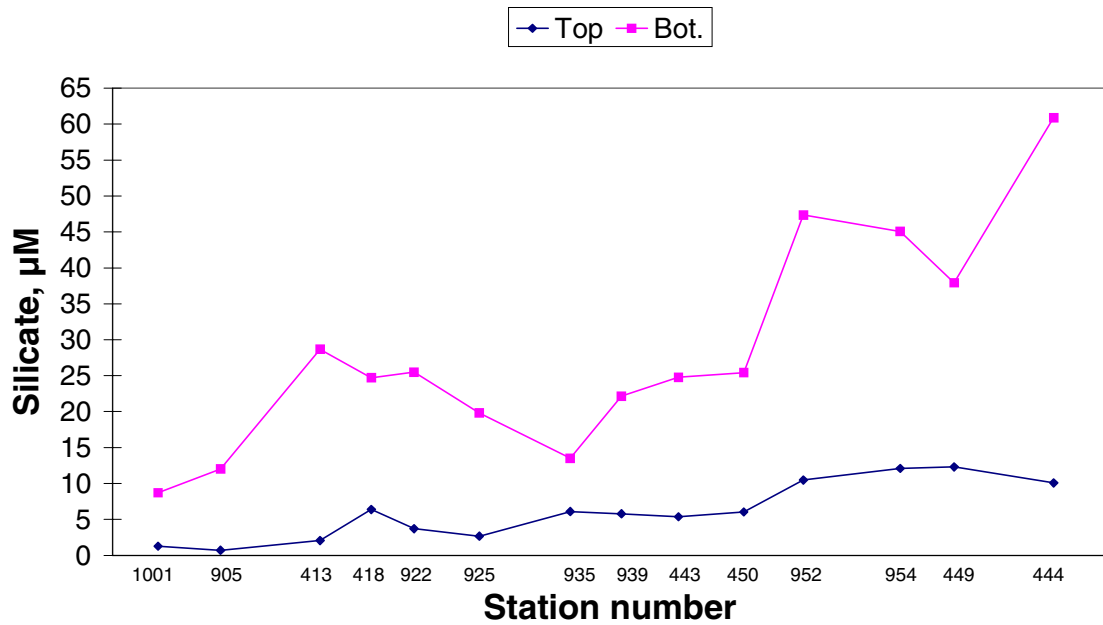
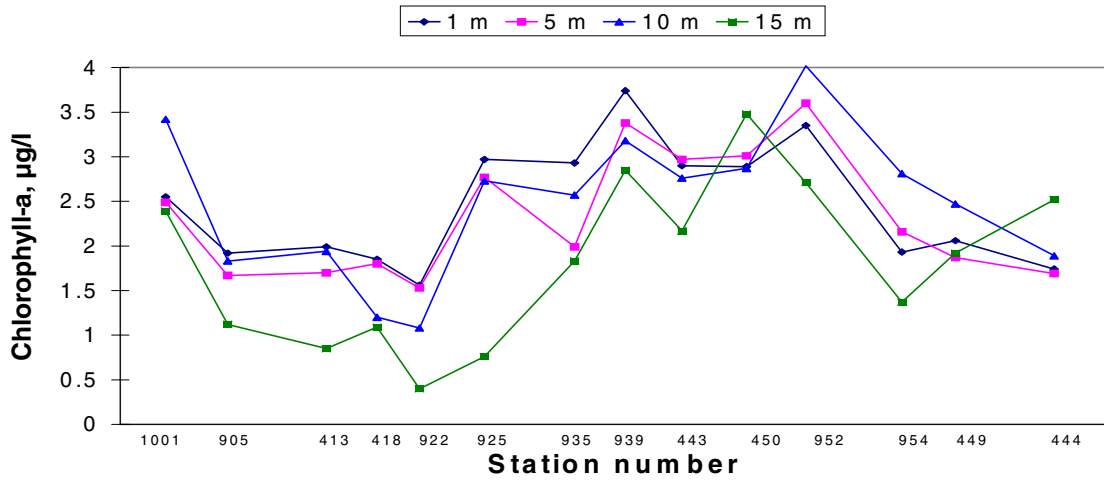
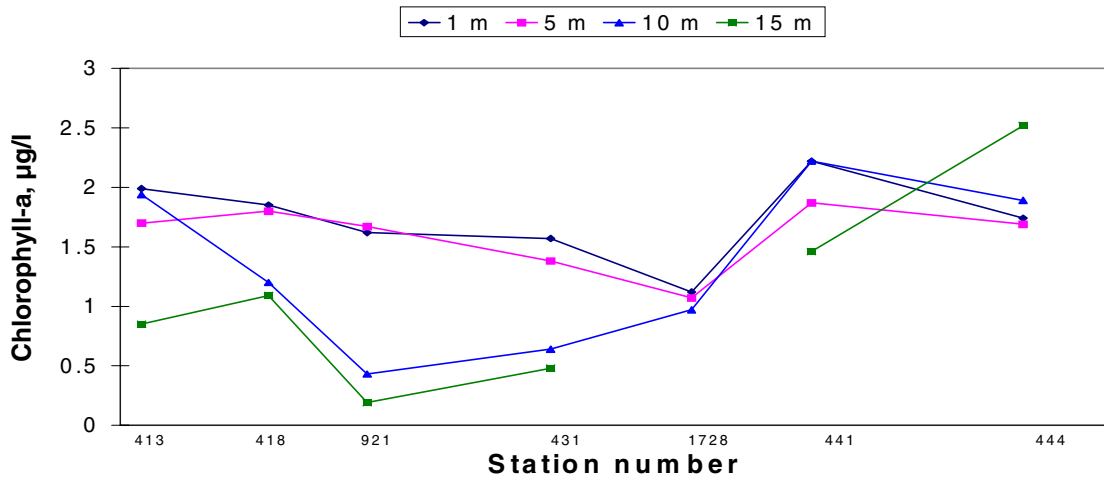


Figure 6. Surface and near bottom concentrations of phosphate and silicate along transect I.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

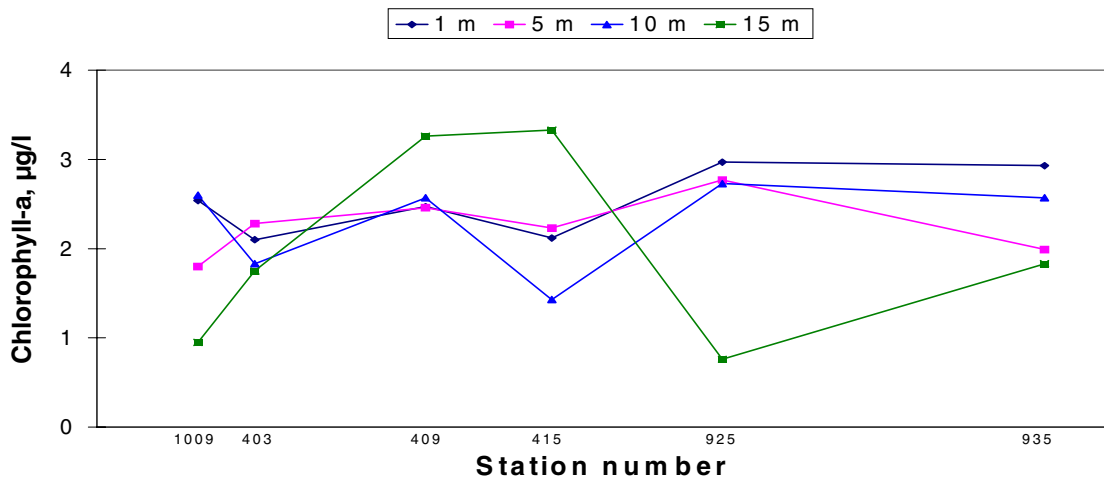
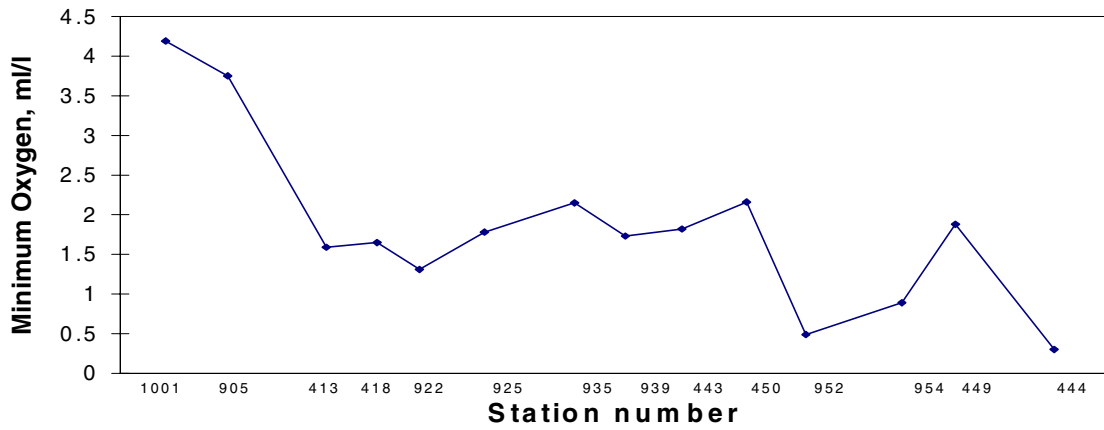
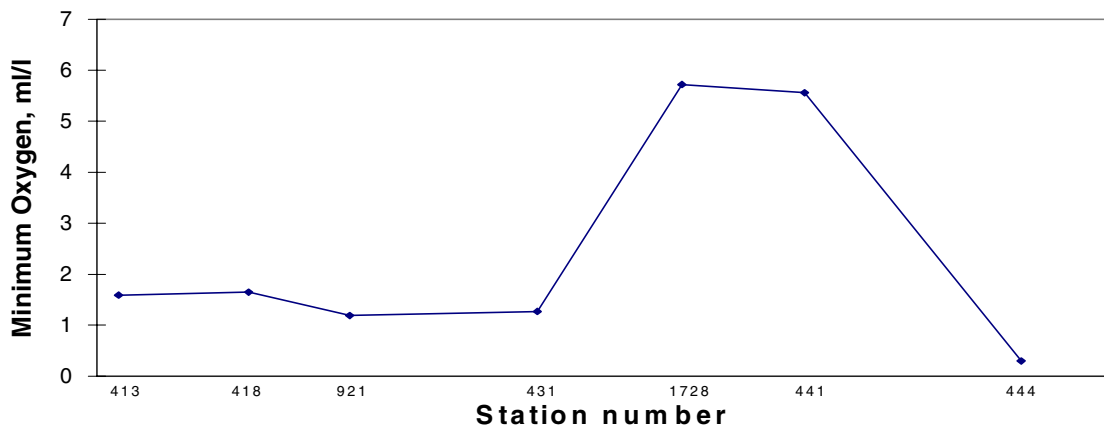


Figure 7. Chlorophyll-a concentrations in 1 m, 5 m, 10 m and 15 m depths along transect I, II and III.

Transect I: Kattegat NE - Belt Sea - Arkona Sea



Transect II: Kattegat SE - The Sound - Arkona Sea



Transect III: Kattegat W - Great Belt

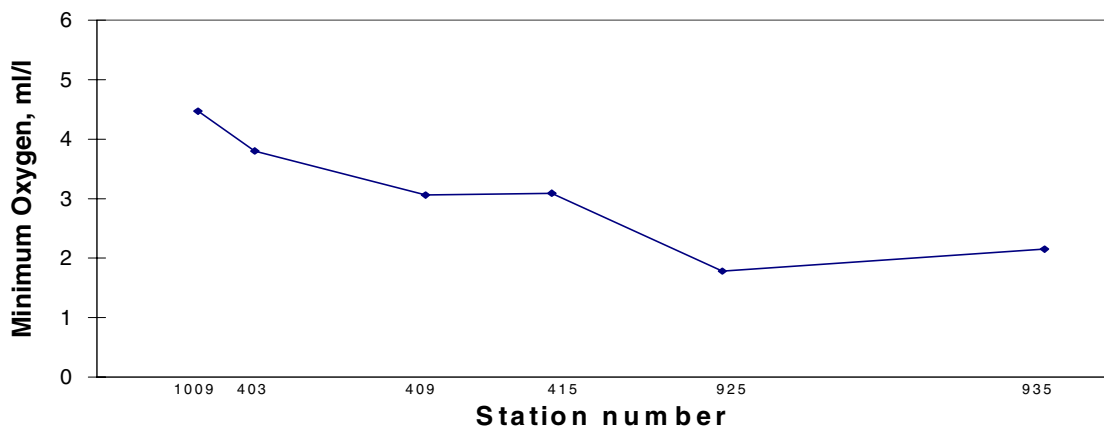


Figure 8. Minimum oxygen concentrations along transect I, II and III.

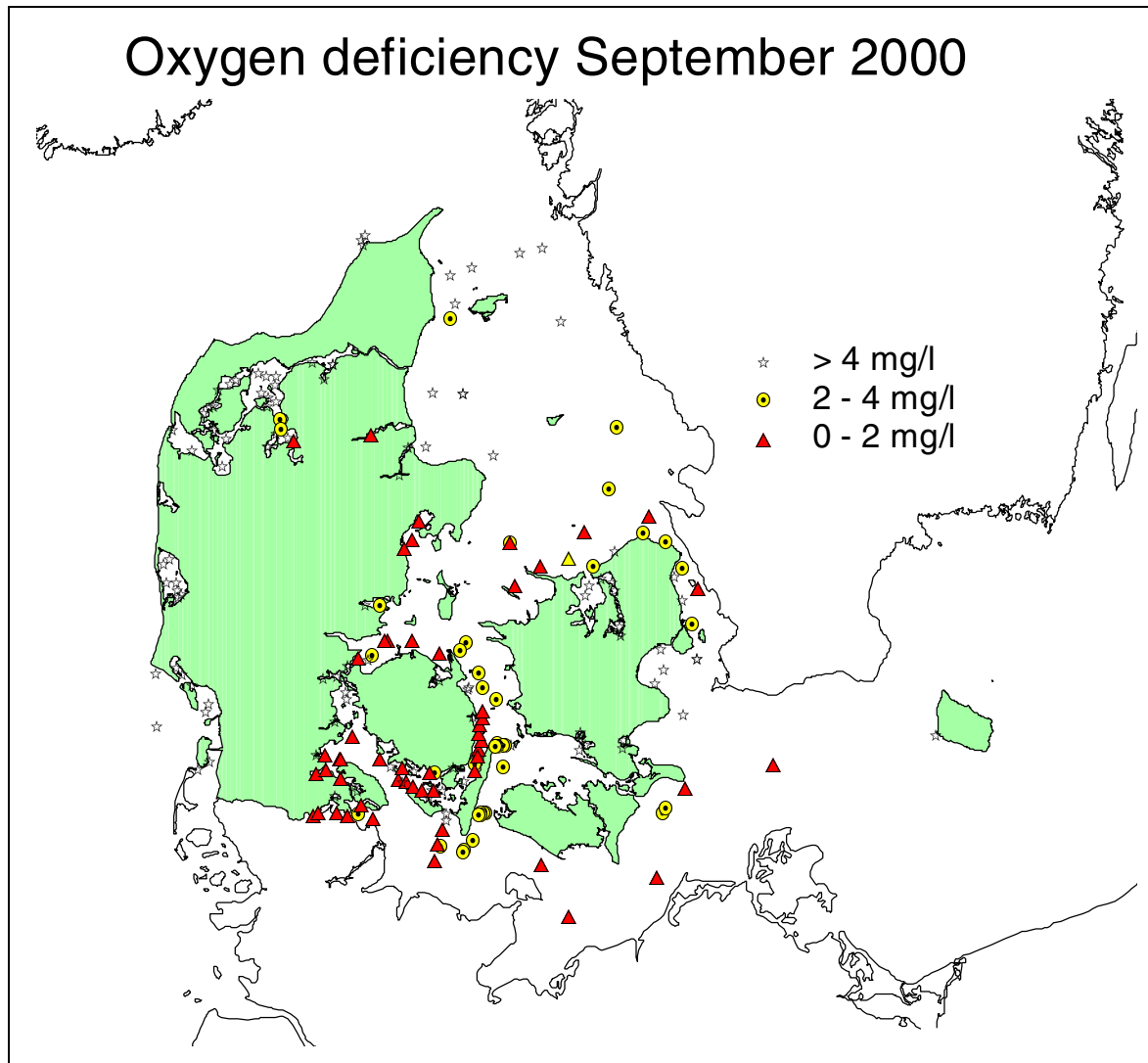


Figure 9. Stations visited by Danish counties and NERI within the first three weeks of September 2000, and where oxygen depletion (<4 mg/l) and serious oxygen depletion (<2 mg/l) was observed.