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International Council for the
Exploration of the Sea

C.M. 1993/C:54
Hydrography Committee

Results of Oceanographic Investigations in the northeast Atlantic in Spring, 1993.

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Abstract

A total of 65 stations were visited in northeast Atlantic waters west of Ireland and Britain by the Russian research vessel "Professor Marti" between 16th and 30th April, 1993. Temperature and salinity profiles were recorded to a maximum depth of 1000 m. The concentration of oxygen, phosphate and nitrite was measured in samples taken at up to 11 discrete depths at each station. Continuous measurements of near surface *in vivo* chlorophyll fluorescence and salinity were made along the cruise track. Evidence for the onset of pycnocline development was found at nearly all stations. Dissolved oxygen data suggested that the phytoplankton spring bloom was close to its maximum, and phosphate data implied that the bloom was not fully developed. A thermohaline front separating Irish coastal water from oceanic water was observed at approximately 11° W. Surface chlorophyll fluorescence showed a minimum at the front increasing both seaward and towards the coast.

Introduction

Joint Russian-Irish investigations have been carried in each spring since 1989 in waters to the north and west of Ireland (Titov et al., 1992). The area is characterised by thermohaline fronts separating Irish and Scottish coastal waters from oceanic water further offshore. Certain characteristics of the Irish Shelf front derived from satellite imagery have been presented by Cracknell and Huang (1988) and Huang et al. (1991). Details of the front, however, are still not fully understood. This paper presents a description of the front together with other hydrographic and hydrochemical data from the entire survey area.

Materials and Methods

Sampling was carried out between 16th-30th April 1993 on board the Russian research vessel "Professor Marti". The study area lies between 52° and 61° N and between longitude $03^{\circ}30'$ and $15^{\circ}30'W$ and the stations visited are shown in Figure 1. At each station temperature and salinity profiles were obtained from surface to bottom or surface to 1000 m, depending on water column depth, using a Neil Brown Mk.III rosette CTD system. Water samples were taken with 1.5 l General Oceanics water sampling bottles. Depths sampled were 0, 20, 50, 100, 200, 300, 400, 500, 600, 800 and 1000 m. Where waters were shallower, depth intervals between samples were correspondingly smaller. Samples were analysed for dissolved oxygen, phosphate and nitrite using methods described by Grasshoff (1976). Measurements of near surface *in vivo* chlorophyll fluorescence were made using a Turner Designs Model 10 fluorometer linked to a continuous flow seawater system. Outflow from the fluorometer ran into a constant level reservoir into which was placed a salinity probe (WTW LF191). Data from both instruments were logged into a host micro-computer.

Results

During the study period the meteorological situation consisted of west and southwest anticyclonic winds with speeds of 7-10 m/s predominating. Near the end of April an anticyclonic condition prevailed over the observation grid with wind speeds of 4-7 m/s resulting. Atmospheric pressure during the cruise was higher than normal.

Using the temperature and salinity data the geostrophic circulation of the surface layer (0-500 dbar) was calculated and the results are shown in Figure 2. A similar circulation pattern was noted in 1991 and 1992, but the circulation was stronger than in previous years. Two strong anticyclonic circulation cells were found to the northwest and southwest of Ireland. No closed circulation was observed in the Porcupine Bank as had been observed in 1991.

The surface temperature and salinity recorded during the survey are shown in Figure 3. Temperatures ranged from 8.25 to $10.92^{\circ}C$ and salinity ranged from 34.90 to 35.45 psu. Generally the distributions are similar to those found in 1992 although the temperatures were $0.1-0.2^{\circ}C$ higher in 1993. The temperatures of deeper water were the same in 1993 as in 1992. To the west of Ireland salinities were the same in 1993 as in 1992, but nearer the coast values were typically 0.1 psu lower than in 1992. A tongue of fresher water appeared to have advected west from the Scottish coastal region. The surface salinity of waters to the west of the Outer Hebrides was 0.02 - 0.09 psu lower in 1993 than in 1992. Frontal areas were observed to the west of Ireland and north and northwest of Scotland.

Stratification was present at virtually all stations with a pycnocline at approximately 20 m. The density gradient across the pycnocline was 0.06-0.09 $\sigma\text{-t}$.

The Irish Shelf Front (Huang et al., 1991) was observed along the 140 m isobath as had

been noted previously (Boytssov et al., 1991; Titov et al., 1992) at approximately 11°W. Using data from a cross-frontal transect at 53°N the temperature gradient was 0.7°C and the salinity gradient was 0.35 psu which persisted to the bottom of the water column (Figure 4a and 4b). A plot of continuous near-surface salinity clearly shows the frontal position as 11°15'W. at this latitude (Figure 5a). A corresponding plot of near-surface fluorescence shows a minimum at the front with levels increasing to on either side. This is probably due to differences in water column stability characteristics, and hence state of bloom development, at the front compared with that of the water column on either side.

Figure 6 shows the distribution of dissolved oxygen and phosphate in the surface waters during the study. Oxygen saturation exceeded 103% over most of the area with the highest levels >125% in coastal waters to the southwest of Ireland and north of Scotland. In general the absolute values increased from 6.2 to 6.9 ml.l⁻¹ from south to north. Maximum concentrations reached 7.8-8.4 ml.l⁻¹ in the same area as maximum saturation levels. Lowest levels of oxygen were observed in the path of the north Atlantic Current to the northwest of the study area. Phosphate concentrations ranged from 0.5-0.9 µM.l⁻¹ over most of the study area. Concentrations <0.2 µM.l⁻¹ were observed in the zones of maximum oxygen saturation. This was undoubtedly due to the uptake of nutrients by phytoplankton during the spring phytoplankton bloom. The concentration of nitrites was 0.1-0.3 µM.l⁻¹ with maximum levels at depths of 50-100 m. A maximum of >0.4 µM.l⁻¹ occurred in the near-bottom layer of the inshore zone, most likely due to recent decomposition of organic material.

Oxygen saturation of 100% was observed at approximately 50-75 m. This was a typical over the entire region and the depth probably reflects the bottom of the euphotic zone. At greater depths lower oxygen and maximum phosphate concentrations were observed. Within the two anticyclonic areas identified in Figure 2, lowest oxygen levels at either 50 or 100 m were observed compared with similar depths at other stations suggesting that deeper water may have uplifted to depths shallower than 100 m and could indicate upwelling. This was most noticeable at stations 39 and 76.

The nutrient and oxygen data obtained during this survey suggests that the spring bloom was well developed particularly in the nearshore waters southwest of Ireland and to the north of Scotland. A similar situation was observed in 1990 (Boytssov et al., 1991). This contrasts with the situation in both 1991 and 1992 (Titov et al., 1992) when the water columns were well-mixed and there was little evidence of the spring bloom. A comparison of surface dissolved oxygen levels with those obtained in 1992 (Titov *et al.*, 1992) shows that, although waters to the west of Scotland were not sampled in 1992, the difference between years for the area to the southwest of Ireland is quite marked. It should also be noted that it was only at this location that any indication of phytoplanktonic activity was observed in 1992 (Titov et al., 1992). Surface phosphate concentrations were lower in 1993 than in 1992. Levels were, however, similar to those found in 1991 and 1990 (Boystov et al., 1991).

Conclusions

Temperature and salinity characteristics of the water column over the entire study area suggested that seasonal pycnocline development had started. This was in contrast to the situation in 1991 and 1992 when the water column was well mixed. As a result, oxygen and nutrient data indicated that the spring phytoplankton bloom was underway, particularly in coastal areas to the southwest of Ireland and north of Scotland. Thermohaline fronts were found separating Irish and Scottish coastal waters from oceanic water further offshore.

Acknowledgements

The authors wish to thank the master and crew of the R/V "Professor Marti" and in particular the senior scientist S.V. Belikov.

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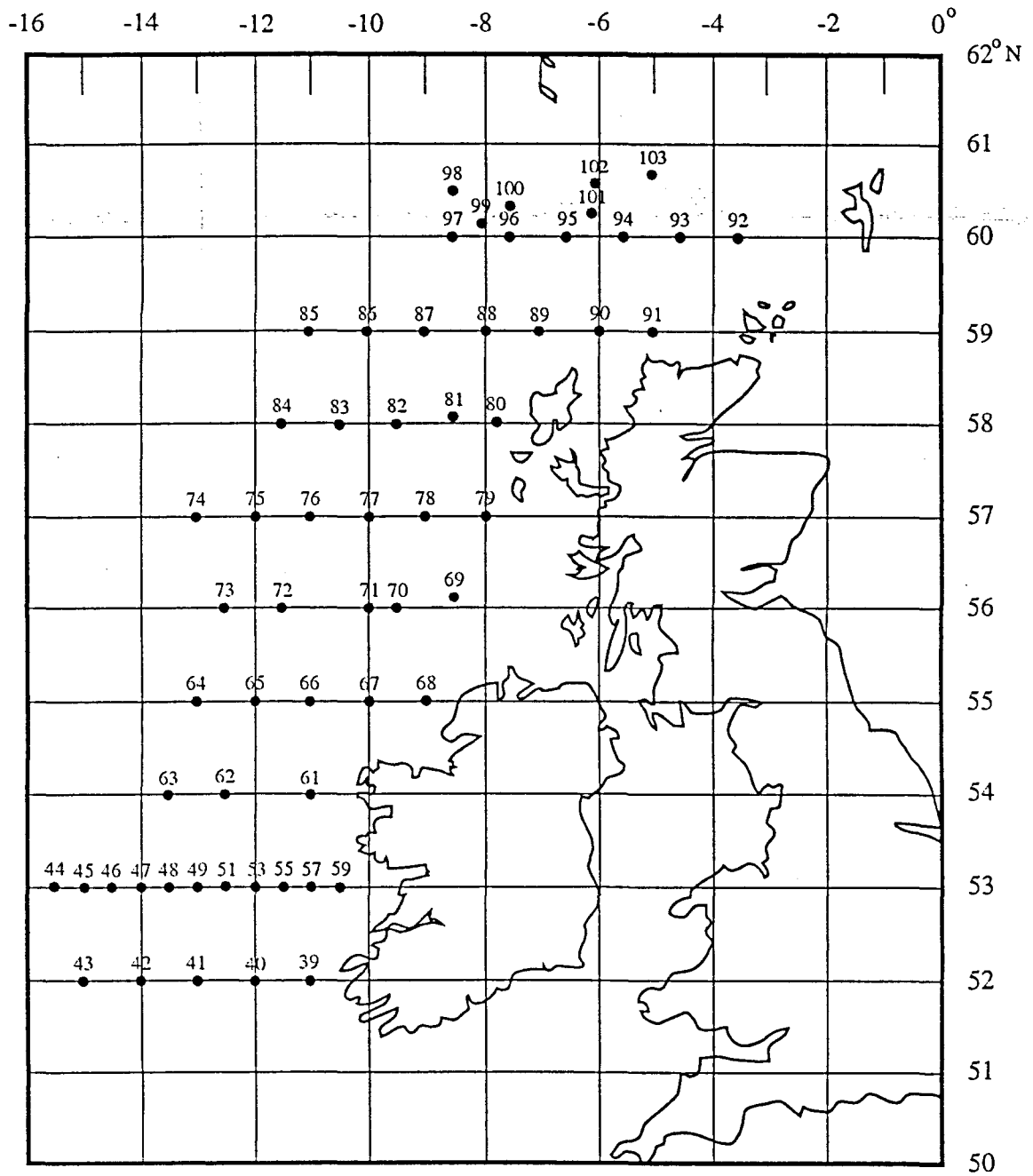


Figure 1. Oceanographic station positions, "Professor Marti" cruise, 16th-30th April, 1993.

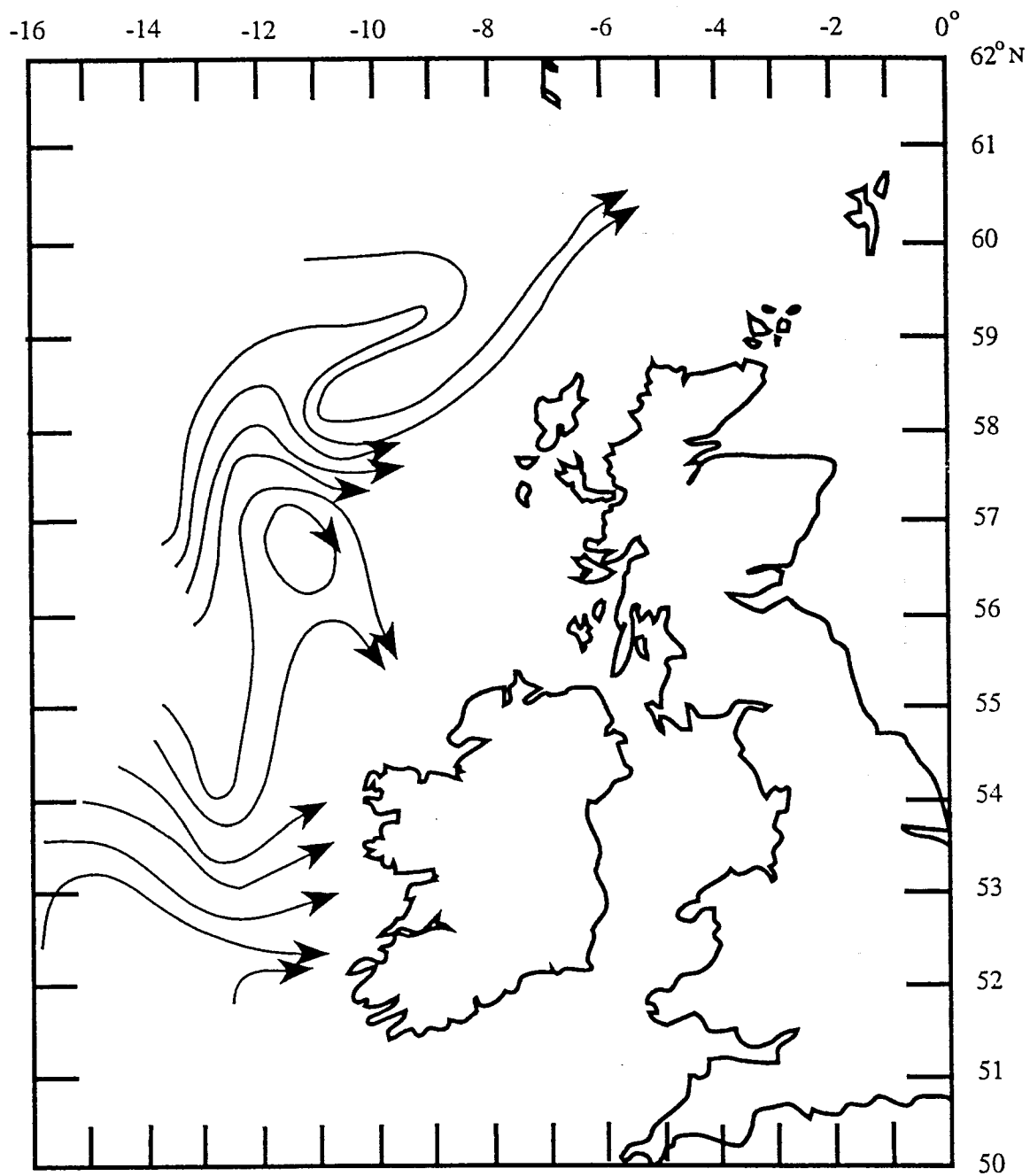


Figure 2. Geostrophic circulation for the surface layer (0-500 dbar).

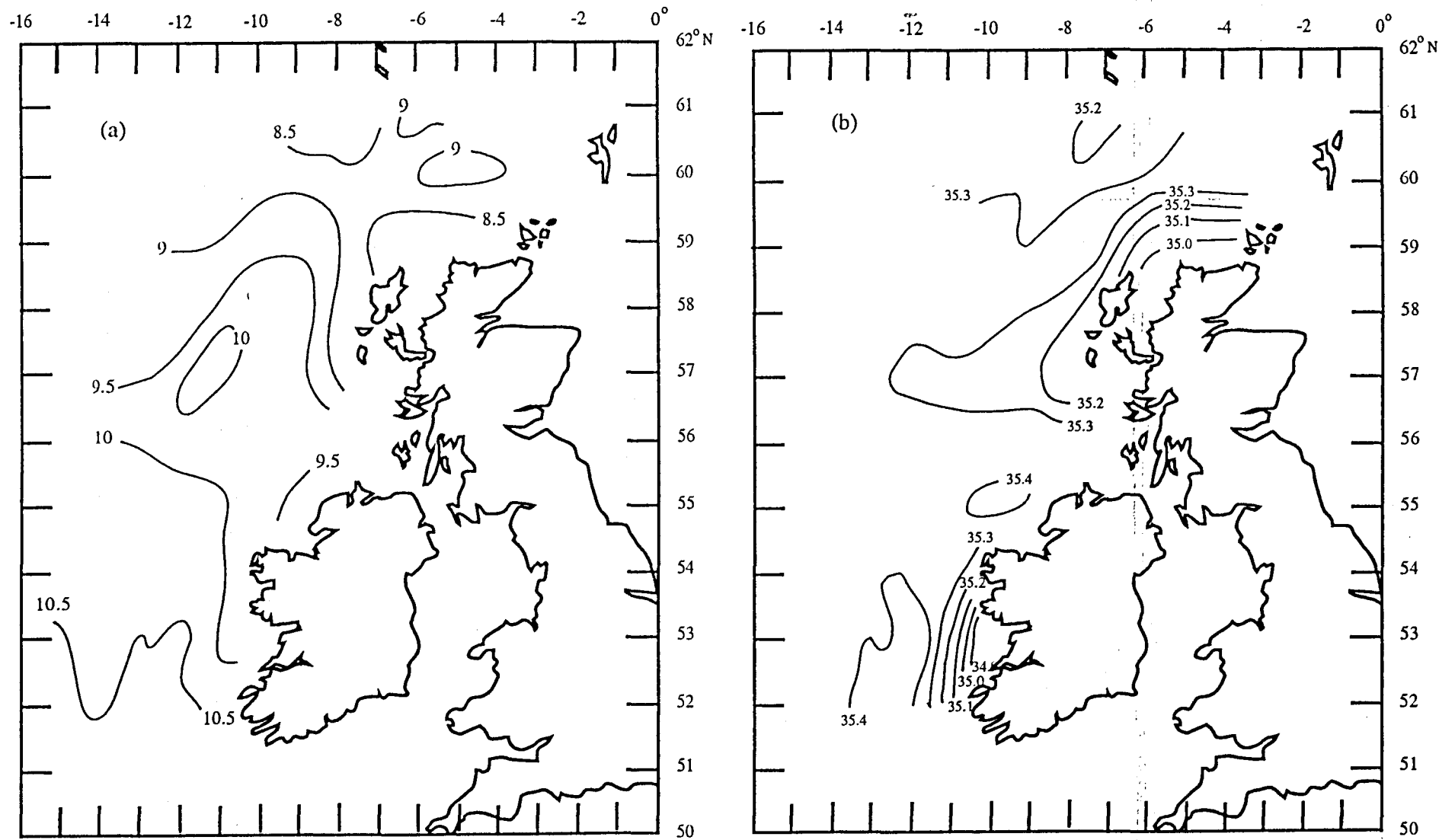


Figure 3. a) Surface temperature (C) and b) Surface salinity, 16th-30th April, 1993.

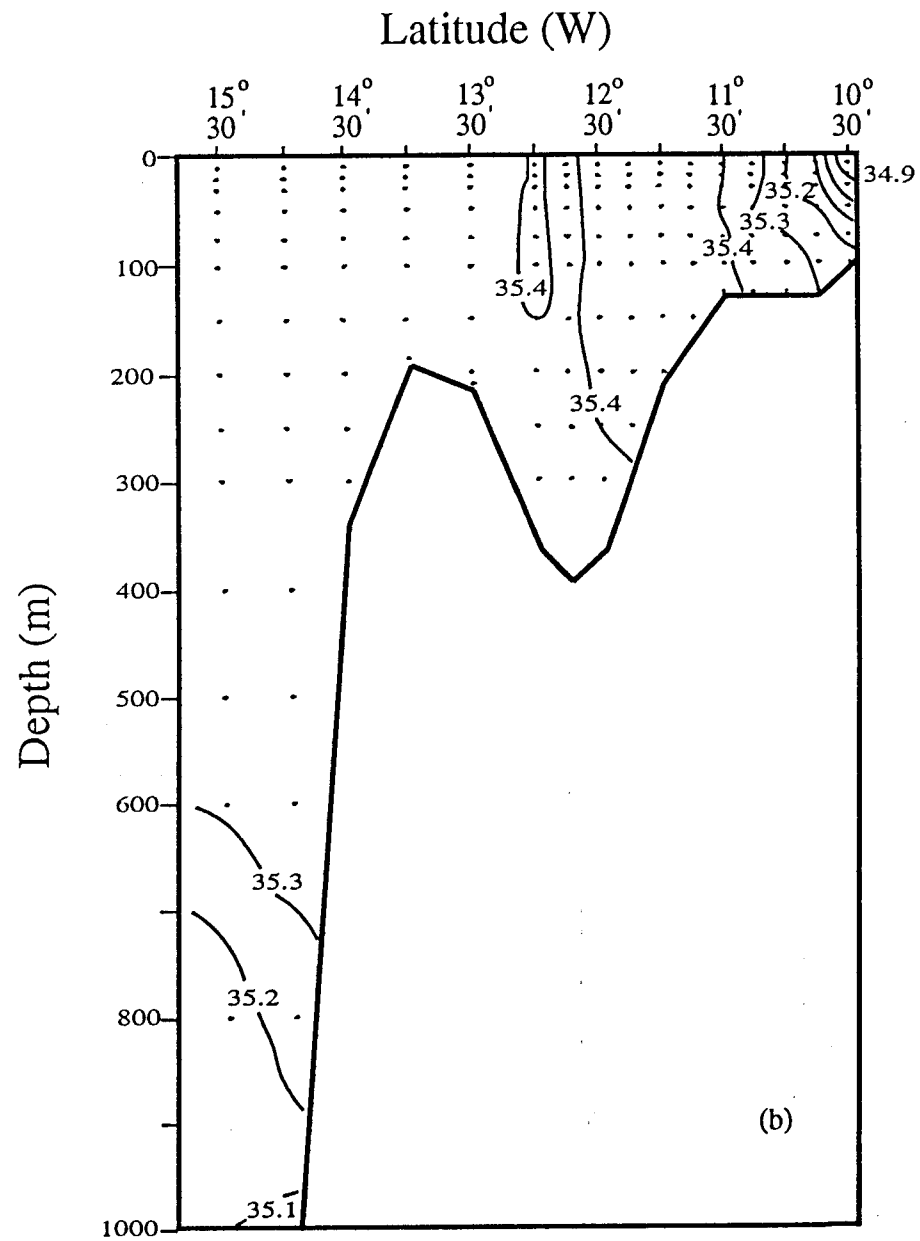
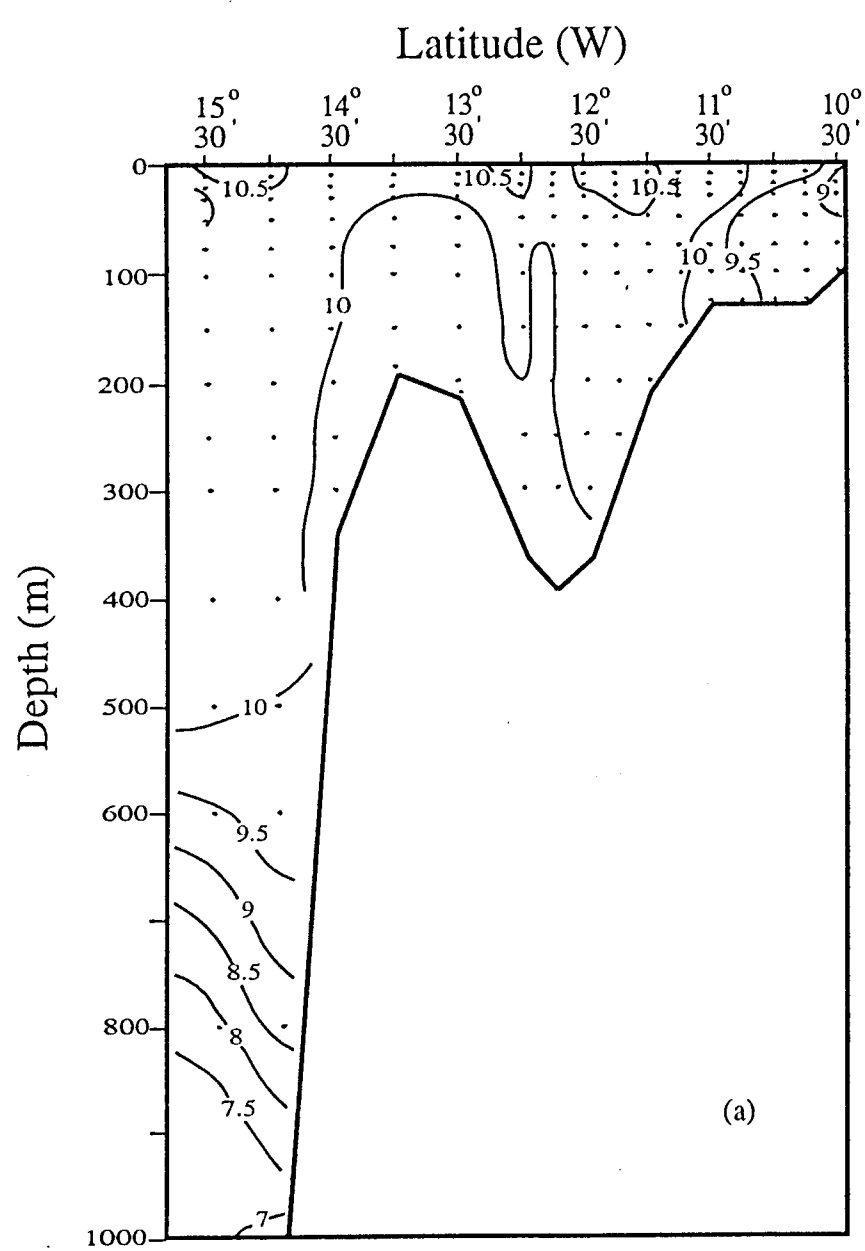


Figure 4. a) Isotherms (C) and b) Isohalines along the transect of stations at 53°00'N; 14th April, 1993.

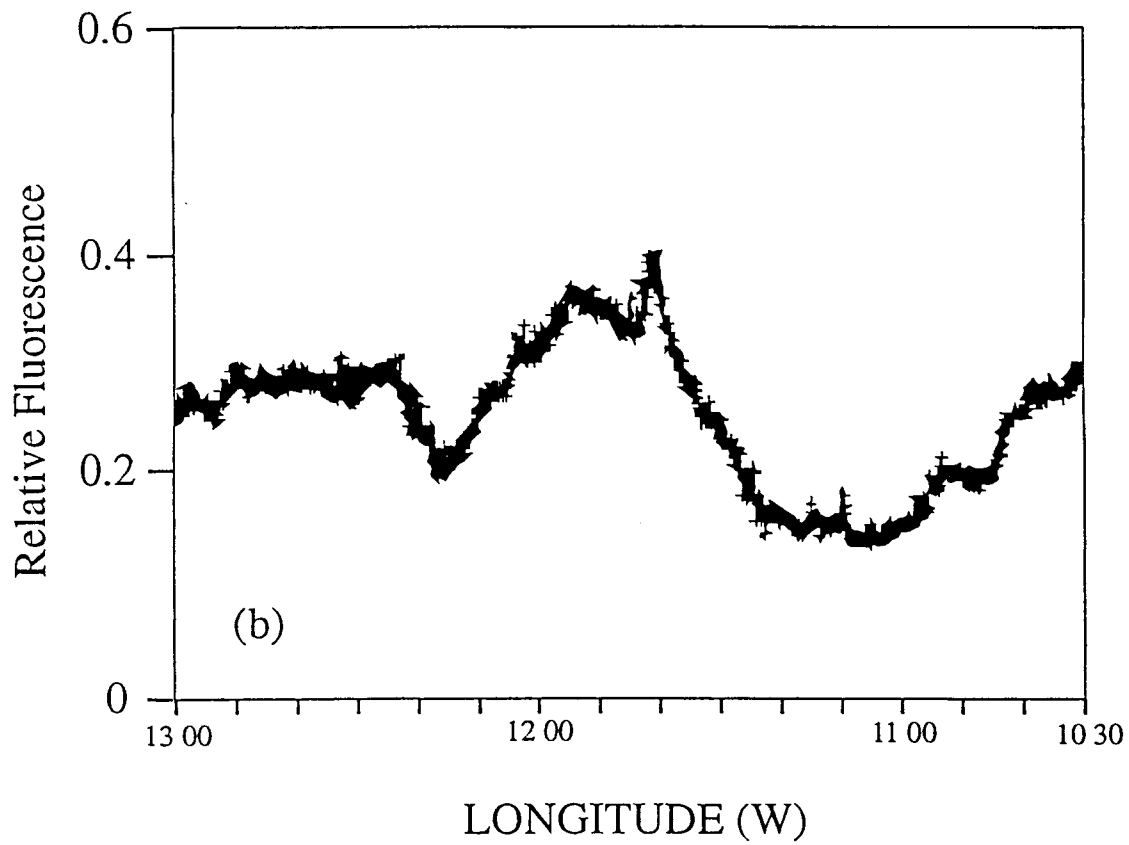
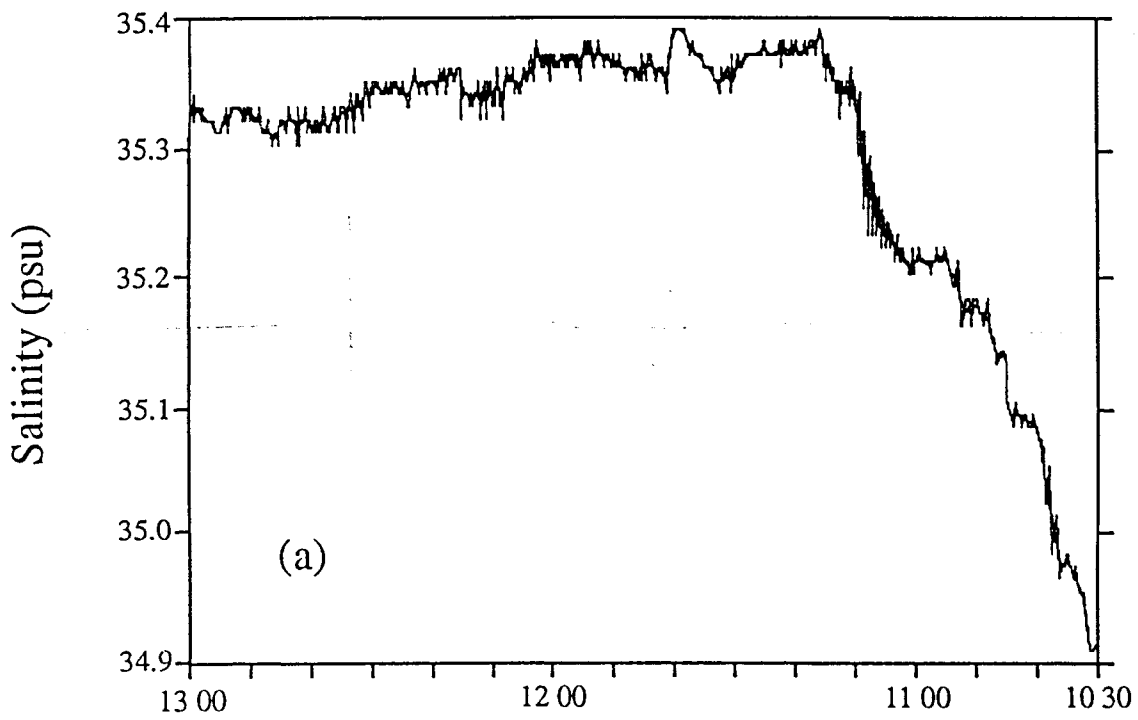


Figure 5. Near surface a) salinity and b) fluorescence along 53 00'N; 14th April, 1993.

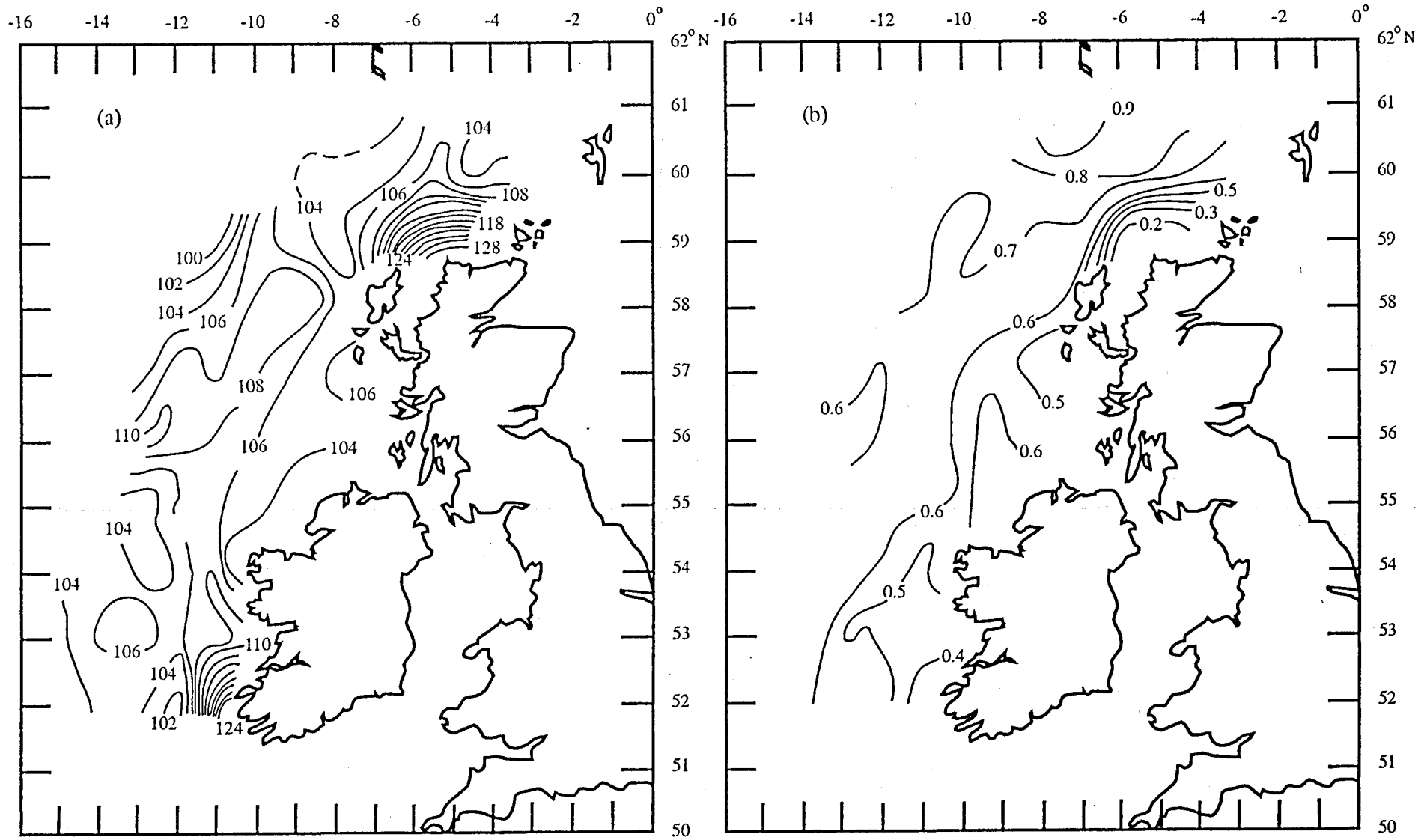


Figure 6. a) Dissolved oxygen, percent saturation, and b) Phosphate (uM) in surface waters, 16th-30th April, 1993.