PRELIMINARY HYDROLOGICAL RESULTS OF THE "SPANISH NAMIBIAN ENVIRONMENTAL CRUISE" SURVEY, SNEC-II

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INTRODUCTION

A second joint South African-Spanish cruise (SNEC-II) on environmental studies was undertaken during April off Namibia on board the R/V "AFRICANA". The spatial distribution of the stations was similar to the SNEC-I cruise, with latitudinal transects almost perpendicular to the shoreline. The main difference was that the northern boundary of the area studied was extended to reach the Kunene River (17°15' S), in order to study the features of the front between the Benguela system and the Angola current. The station grid (figure 1) consisted of four "main" transects at 26°, 23°, 20° and 17°30' S, reaching from the coast to 135 miles offshore, with two shorter transects between each two. The hydrographic data and methodology used are described in Gutiérrez et al. (1986). The present paper contains a summary of the general hydrological features encountered.

RESULTS

Horizontal distribution

The temperature distribution at the surface and at a depth of 100 m (Figures 2 and 3) can be divided into two discrete areas, north and south of 21° S. The coldest temperatures recorded during the cruise, under 13 °C, were found in the southern area near Lüderitz, 30 miles offshore. Relatively low temperatures were also found north of Cape Frio, on the shelf, and a strong surface temperature gradient was detected approximately 65 miles offshore. The salinity distribution shows a similar pattern (Figure 4), i.e., low values near Lüderitz and relatively low close to the coast in the north off Cape Frio. A strong transversal salinity gradient was found between 21° and 27° S, indicating that the southern limit of the influence of Angolan water lies in this area. According to Shannon (1985), this influence is maximum in summer and early autumn. Assuming that the southern boundary of the Angolan water coincides with the 35.5 isohaline (O'Toole 1988), this boundary was at 22° S during the present cruise.

Oxygen content at the surface (Figure 5) was found to be under 4.5 ml/l at all stations in the coastal area, with values of 2-3 ml/l in the upwelled cells. The highest coastal concentrations were found north of Walvis Bay, in the same area that Estrada et al. (in press) found the highest chlorophyll values (over 10 mg/m²). The highest overall oxygen concentrations recorded during the cruise were registered in this same region, 35 miles offshore.

A high content of surface nitrate was found in the Lüderitz upwelling area (Figure 6), and even higher values were recorded in...
coastal waters north of Mossel Point. A strong horizontal gradient was detected 55 miles offshore at 19° S, the low offshore values being associated with strong stratification. The coastal zone near Walvis Bay (22°-25° S) also showed nitrate depletion (under 2 µM/l), associated with high chlorophyll and oxygen concentrations.

Vertical distribution

Only the more relevant vertical distributions of temperature, salinity, sigma-t, oxygen and nitrates are considered.

In the first cross section, off Lüderitz (Figure 7), coastal waters were found to be upwelled and offshore waters stratified, with a thermocline at a depth of between 30 and 50 m. Upwelling was found to be weaker and further inshore in the second and third sections (Figures 8 and 9), the offshore waters being more stratified northwards. In the fourth cross section (Figure 10), a strong surface temperature gradient was observed approximately 60 miles offshore (3 °C in a twenty-mile distance). Offshore waters were strongly stratified, with a thermocline at depths of between 40 and 60 m, coastal upwelling being confirmed by high surface nitrate concentrations (Figure 6).

Throughout the area surveyed, nitrate concentrations (Figure 11) below the thermocline were always higher than 10 µM/l, and dropped abruptly to lower values above it.

The location of the oxygen-deficient area (concentrations of under 2 ml/l) is shown in Figure 12. A deep layer - between 150 and 500 m - of low oxygen values (under 1 ml/l) was observed in the northern cross section. This layer was found over the shelf near 20° E; over the slope, however, it was thinner, extending from 208 to 300 m. Off Walvis Bay, a 200-m layer, between 200 and 400 m, was recorded up to 75 miles offshore, while on the southern transect (26° S), a thin layer was observed over the shelf area only.

DISCUSSION

Upwelling was found to be more or less intense in the coastal waters of the entire survey area.

The northern area (north of 21° S) was characterised by an upwelling zone north of Cape Frio, and weak coastal upwelling in the rest of the coastal area, with some relatively intense cells (Station 39). The front between warm oceanic waters and relatively cold upwelled water was acute in the Cape Frio upwelling area, and more subdued towards the south. This front coincided with high chlorophyll concentrations (Estrada et al., 1987). The upwelled waters extended south in the upper layer, their course being well defined by surface isohalines. A strong transversal salinity gradient between 21° and 23° S was indicative of the frontal zone between Angola current-influenced and Benguela current-influenced waters; the Angolan water was found to have penetrated particularly far south on this survey. A detailed study on the intrusion of Angolan water is in preparation by Boyd et al. (Boyd, pers. comm.). The situation seems to be in some ways similar to the 1984 event, when warm, saline Angolan water penetrated exceptionally far south, severely restricting the productive upwelling area (Boyd et al. 1985). In any case, the temperatures recorded in 1986 were not as high, and nutrient depletion less severe (Boyd, pers. comm.). Similar conditions were recorded by O’Toole (1980) in March-April 1974, but the temperatures recorded during that survey in the inshore Cape Frio area were cooler.

The southern region was characterised by water from the Lüderitz upwelling zone, and by upwelled waters from different depths all along the coast, advected by the Benguela current. The offshore limit of the upwelled water seemed to be about 75 miles from the coast.

REFERENCES


FIG. 1. Track of SNEC-II cruise, showing Transects I, II, III and IV
FIG. 2. Surface isotherms (°C)
FIG. 3. Isotherms (°C) at 100 m
FIG. 4. Surface isohalines
FIG. 5. Surface oxygen concentrations (ml/l)
FIG. 6. Surface nitrate concentrations (μM/L)
FIG. 7. Vertical distribution at Transect I, a) Temperature (°C), b) Salinity, and c) Sigma-t
FIG. 8. Vertical distribution at Transect II, a) Temperature (° C), b) Salinity, and c) Sigma-t
FIG. 9. Vertical distribution at Transect III, a) Temperature (°C), b) Salinity, and c) Sigma-t
FIG. 10. Vertical distribution at Transect IV, a) Temperature (°C), b) Salinity, and c) Sigma-t
FIG. 11. Vertical nitrate concentration ([NO₃⁻]), a) Transect I, b) Transect II
FIG. 11 (cont'd). Vertical nitrate concentration (µM/l),
c) Transect III, d) Transect IV
FIG. 12. Vertical oxygen concentration (ml/l). a) Transect I, b) Transect II
FIG. 12 (cont'd). Vertical oxygen concentration (ml/l),
c) Transect III, d) Transect IV