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SHELF OFF ALAGOAS AND SERGIPE (NORTHEASTERN BRAZIL)

1. INTRODUCTION

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RESUMO

Esta primeira parte introdutória dos estudos feitos na plataforma continental de Alagoas e Sergipe fornece dados sôbre a topografia, a temperatura, a salinidade e as possibilidades para a pesca.

(1) A plataforma continental nesta área é estreita, com sua rutura para o talude a uns 50-60m de profundidade. O seu relêvo é bastante plano nas profundidades de 25 a 50 m, existindo em frente ao rio São Francisco um canyon.

(2) As temperaturas superficiais são relativamente constantes. Na foz do rio São Francisco nota-se a influência das águas fluviais relativamente quentes.

(3) As sanilidades são também comuns, porém com diferenças estacionais. Destaca-se a influência dos rios na zona costeira, baixando a salinidade naquela área.

(4) As possibilidades da pesca não são muito promissôras. Apenas na zona costeira do Estado de Sergipe e na área com depósitos de lama na foz do São Francisco existem possibilidades de pesca com redes de arrasto à base comercial.

PRELIMINARY REMARKS

On the iniciative of the Development Organization for Northeastern Brazil (SUDENE), a survey of the continental platform off the coast of the States of Alagoas and Sergipe has been made in three trips in 1965 by the vessel Akaroa. The chief purpose of the survey was an exploration of the possibilities for fishery, but at the same time additional investigations could be made on hydrology and collection of bottom samples.

Plankton was collected at the surface with a normal plankton-net. Water samples for salinity analysis were taken with the Nansen-bottle, measuring at the same time the temperature. Constant echo-sounding provided bottom sections during the whole traject of the three trips. The bottom samples were obtained by dredging.

The situation of the investigated shelf has been presented in figure 1. It extends between the latitudes of 8°55' and 11°20'S, and between the coast and the continental margin. The platform is very narrow in this area, and has a width of about 25 miles. The break occurs at a relatively moderate depth (50-60 m), such that the samples taken below depths are already representative for the continental slope.

The greater part of figure 1 presents the sampling localities; about every 5 miles a station was made. The first trip, from August 6-11, 1965, under the supervision of O. C. da Silva, included the sampling of the stations 106-156. The second trip, from September 2-10, under the supervision of P. A. Coelho and M. Kempf, covered the area with stations 1-106. Being necessary a more detailed investigation of the mouth of the São Francisco river, on the third trip, from December 2-3, under the supervision of M. Kempf, the stations 160-190 were sampled; these stations have been presented in the lower part of figure 1. In this area, the distance between the stations was 2½ miles.

The total of some 200 samples provided a great abundance of material, being studied actually in the Oceanographical Institute of the Federal University of Pernambuco.

TOPOGRAPHY AND CONTINENTAL GEOLOGY

Land

The shelf off Alagoas and Sergipe is bordered by an area

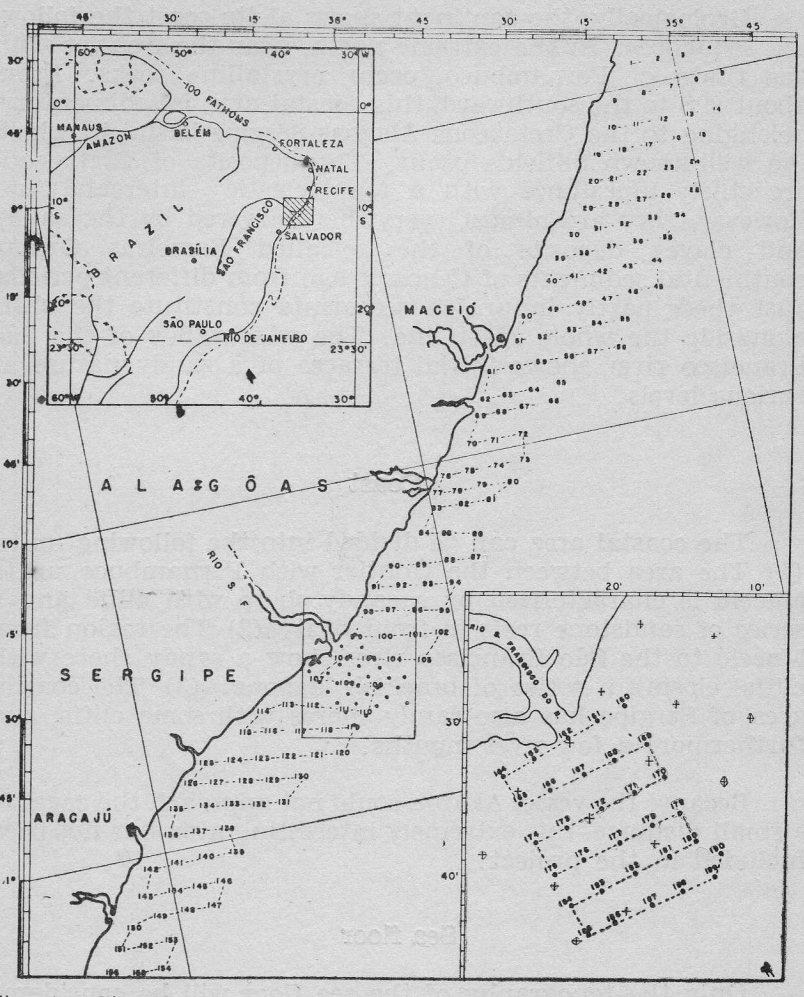

Fig. 1. Situation of the investigated shelf area and sampling localities. Situação da área estudada na plataforma com as estações de amostras.

with a relatively moderate relief. Although the beach shows numerous cliffs, these are never higher than 40 m. So the isohypse of 100 m is to be found at some distance from the coast, varying between 2 and 20 km in Alagoas, and at 30-40 km in Sergipe. This flat area is cut by various rivers of little importance, with exception of the São Francisco, and the Vaza-Barris in the far south. The valley of this first river is wide and shows various terraces.

Geologically, the continent shows at its coast the following sequences. In the extreme north, near the frontier with the State of Pernambuco, occur crystalline rocks. From about 9°S to the southward, this coastal area is sedimentary, belonging to the Cretaceous Alagoas-Sergipe basin, in which the well-known oilfields occur. The deposits of Cretaceous are chiely limestones with a few clastic intercalations. However, they are almost everywhere covered by the sandy and clayey deposits of the so-called Barreiras Group, continental sediments of Cenozoic age from different periods. Just these partly indurated sediments constitute the cliffs alongside the whole coast line. The wide valley of the São Francisco river shows fluvial terraces of a sandy nature at various levels.

Coast

The coastal area can be divided into the following units. (1) The area between the frontier with Pernambuco up to Maceió is characterized by a sandy shore with cliffs and a series of sandstone reefs in front of it. (2) The region from Maceió to the São Francisco river show a sandy shore with cliffs, closing a series of brackish lagoons. (3) The coastal area of Sergipe has also sandy shores with some cliffs, and furthermore a few river mouths.

Because the vessel Akaroa could not approach the coast to a small distance, this extremely interesting area has not been included in the project.

Sea floor

Only the topography of the sea floor will be considered here, its geology being the subject of a separate paper.

Topographically, one can distinguish three parts. The northern part shows a fairly flat area with depths about 25-45 m, extending as far as the mouth of the São Francisco river (fig. 2). Only at a few places some irregularites occur, somewhat higher or lower parts in relation to its surroundings.

The second part is the area where the São Francisco throws its water into the sea. Here, a submarine canyon has been developed. The 50 and 100 m isobaths curve towards the coast, showing neatly the extent of this submarine valley towards the SE.

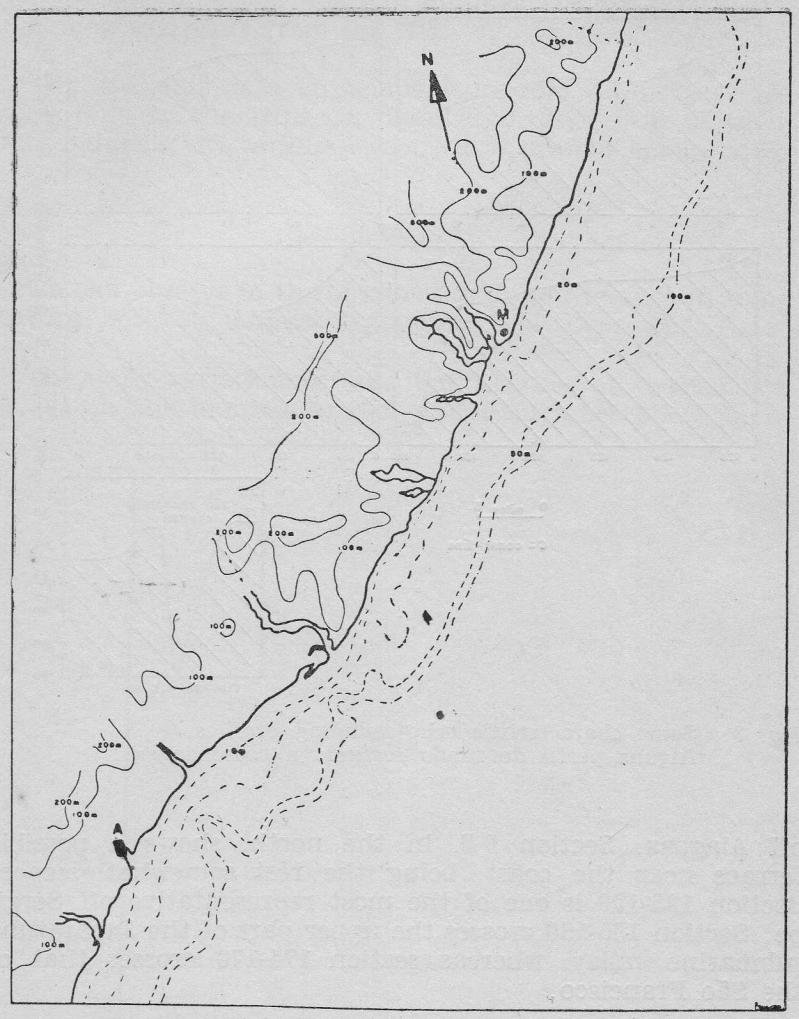

Fig. 2. Topography of the investigated shelf area and the adjacent continent.
Topografia da plataforma estudada e do continente adjacente.

To the soutward, the third part off the coast of Sergipe, the platform is more irregular, interrupted by another small submarine valley in front of the Japaratuba river. Depths of the flattest parts vary between 10 and 50 m.

Some characteristic sections of the shelf bottoms, as determined by the echo-soudings, are represented in figure 3. Section 98-95 is one of the most typical of the platform

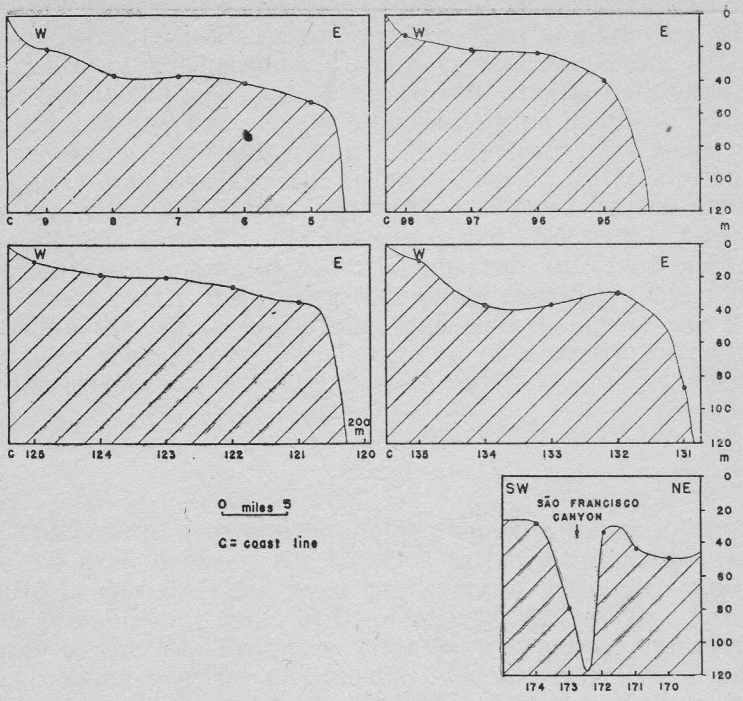

Fig. 3. Some characteristic echo-sounding profiles.
Alguns perfís do fundo segundo a ecosondagem.

off Alagoas. Section 9-5, in the north, shows a possible terrace near the coast, being the rest somewhat deeper. Section 125-120 is one of the most representative off Sergipe. Section 135-130 crosses the upper part of the Japaratuba submarine valley, whereas section 174-170 crosses that of the São Francisco.

OCEANOGRAPHY

Generalities

As to be expected, the investigated area shows during the different seasons changes in temperature, salinity and currents. The borderland has a As-climate in the sense of Köppen's classification, which means a tropical climate with precipitation in winter (May-July). The winds belong to the SE-trade type, and blow almost during the whole year

from the same direction. Only in summer, the dry season, the winds blow generally from the NE.

The available data on temperature and salinity are referring only to the trips. A detailed investigation of their changes during the various seasons is at present being made.

Temperature

On can observe in the obtained data a difference in temperature between August-September and December.

The daily variations of the temperature at the surface (fig. 4) in the months August and September show their

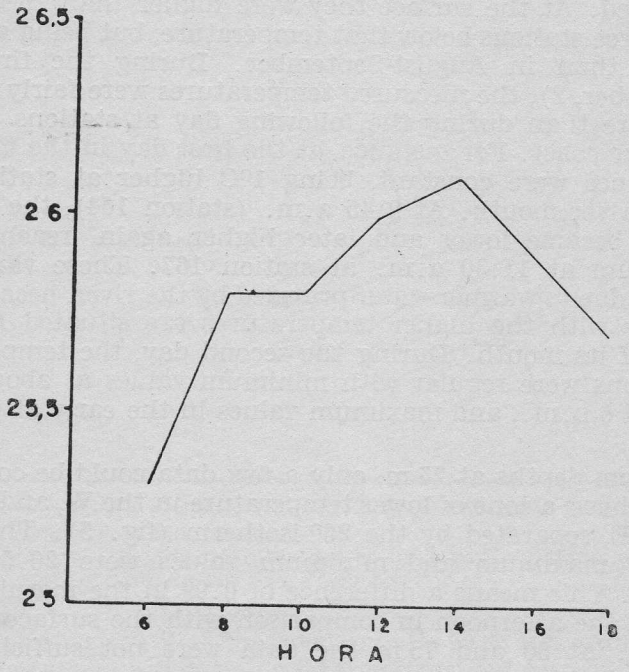

Fig. 4. Daily temperature variation at the surface.
Variação diurna da temperatura na superfície.

maxima at 2:00 p.m., reaching as high as 27°C at station 77; the average is 26.1°. The minima occur at 6:00 a.m. and 6:00 p.m., respectively, with a minimum of 24.5°C at station 97, and an average of 25.3° in August and 25.7° in September. During the day the difference between the maximum and mi-

nimum average was 0.8°C. It has to be emphasized that the stations were only made during day-light (5 a.m. — 7 p.m.).

At a depth of 25 m the temperature showed variations between 25.5° and 26.0°C in the whole investigated area, with exception of some stations near the mouth of the S. Francisco river. These showed averages of 25°C, being thus somewhat lower. At 50 m below the surface the temperature showed the same trend as at 25 m. At 75 m, however, although only a few samples could be taken, the temperatures were obviously lower, showing variations between 22.6° and 25°C.

During the third trip, in December 1965, at the mouth of the São Francisco river, the following temperatures were measured. At the surface they were higher than 26°C, with only three stations below that temperature, but being anyhow higher than in August-September. During the first day (December, 2), the measured temperatures were fairly irregular, more than during the following day at stations farther from the coast. For instance, at the first day in the morning the values were constant, being 1°C higher at station 162 at the river mouth. At 9:45 a.m. (station 164), the temperature became lower and later higher again, reaching its maximum at 11:30 a.m. at station 167. These variations may be due to warmer water provided by the river, because the stations with the higher temperatures are situated just in front of its mouth. During the second day, the temperature variations were regular with minimum values at about 6 a.m. and 6 p.m., and maximum values in the early afternoon.

From depths at 25 m, only a few data could be collected, but it shows a zone of lower temperature in the W, and higher in the E, separated by the 26°-isotherm (fig. 5). Their respective maximum and minimum values were 26.5° and 23.7°C. This means a difference of 0.9° in the morning and 2.0° in the afternoon in comparison with the surface temperatures. At 50 and 75 m the data were not sufficient for interpretation.

Salinity

The isohalines (fig. 6) show clearly the influence of the fresh water of the São Francisco, which lowers the salinity near its mouth to considerable distances. Generally,

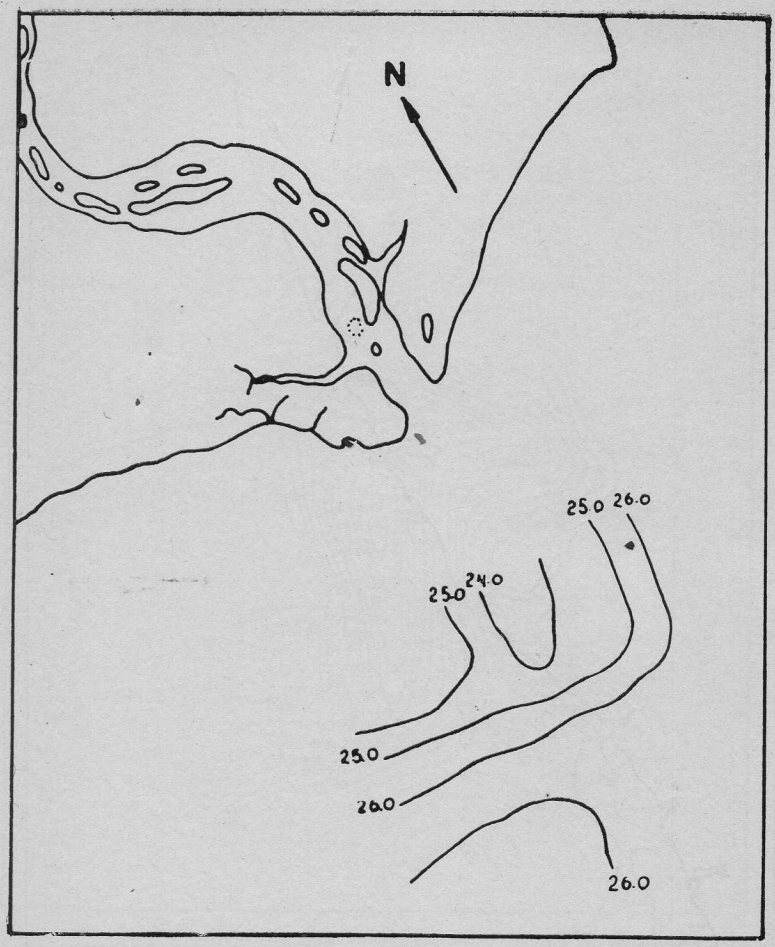

Fig. 5. Temperature distribution at a depth of 25 m near the São Francisco river mouth.
Distribuição da temperatura a uma profundidade de 25 m, perto da foz do rio São Franciso.

the coastal waters S of the river mouth were less saline than those N of it, caused not only by this river, but also by the fact that in the State of Alagoas only small coastal rivers discharge into the ocean. At some sites, the isohaline of $35^{o}/_{oo}$ can be found at a distance of almost 5 miles from the coast. It has still to be studied, whether these features are due to rain or river influence, being seasonal or not. In December, the isohaline of $28^{o}/_{oo}$ at the mouth of the São Francisco lies at some 10 miles from the coast, thus farther than in September. This may be possibly caused by the higher water run-off in

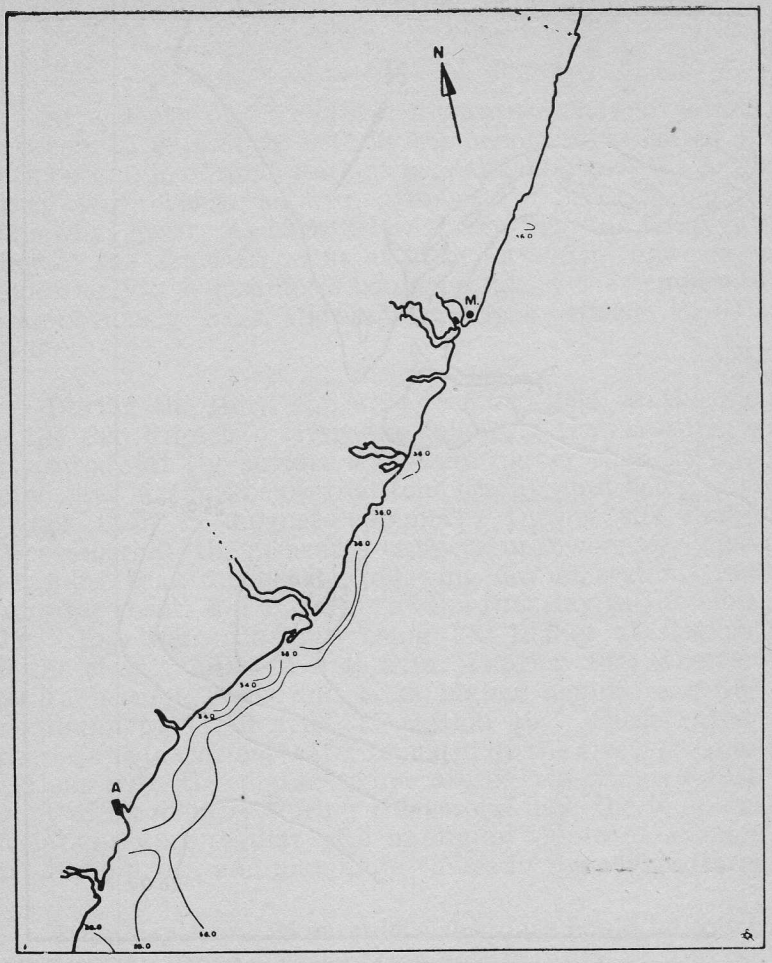

Fig. 6. Surface salinity in august-september 1965.
Salinidade na superfície em agôsto-setembro de 1965.

December, when the dry season at the coast coincides with the rainy season in the upstream area of the river.

At 25 m depth the salinity values are almost constant in the whole area. The only differences occur again in the area of the river influence. The data of 50 and 75 m are again too few for evaluation.

Figure 7 presents the surface salinity in some detail of the São Francisco area, after data obtained in December

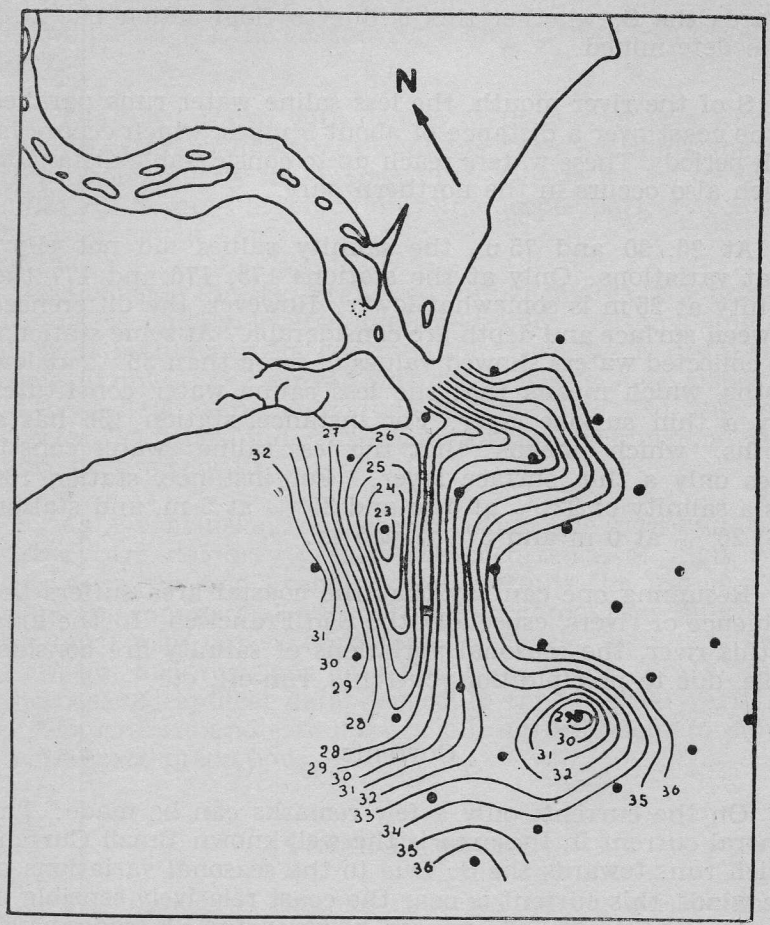

Fig. 7. Surface salinity of the São Francisco area in december 1965. Salinidade na superfície na área do São Francisco em dezembro de 1965.

1965. The distribution is different from that in August--September. The zone with a salinity of less than 35 $^{0}/_{00}$, which extends parallel to the coast to the northward up to more than 15 miles from the river mouth in September, was reduced to only 3 miles in December. The less saline water, in that latter month, was found up to a distance of 14 miles from the coast seaward, which distance was only 5 miles in September. S of the river mouth, at a distance of some 7 miles parallel to the coast, a wedge of high saline water (over 36 $^{0}/_{00}$) causes the deslocation of the less saline water

towards the S; whether this is due to tidal action has still to be determined.

S of the river mouth, the less saline water runs parallel to the coast over a distance of about 5 miles, which occurs in both periods. These waters reach up to considerable distances, which also occurs in the northern part.

At 25, 50 and 75 m, the salinity values did not show great variations. Only at the stations 175, 176 and 177 the salinity at 25 m is somewhat lower. However, the differences between surface and depth are considerable. At some stations, the collected waters showed values of more than $36^0/_{00}$ at low depths, which means that the less saline water constitutes only a thin surface layer. For instance, station 166 has a depths, which means that the less saline water constitutes only a thin surface layer. For instance, station 166 has a salinity of $22^0/_{00}$ at 0 m and $36^0/_{00}$ at 5 m, and station 163, $26^0/_{00}$ at 0 m and $37^0/_{00}$ at 5 m.

Resuming one can say that the coastal area suffers the influence or rivers, especially the São Francisco. In the area of this river, the seasonal variations of salinity are considerable, due to precipitation, currents, run-off, etc.

Currents

On the currents only a few remarks can be made. The general current in the area is the well-known Brazil Current which runs towards the S. Due to the seasonal variations of the winds, this current is near the coast relatively sensible in summer (NE-winds). In winter, however, the SE-trades cause the deslocation of the chief current more towards the open sea, the shelf area suffering a species of counter-current, which has still to be measured.

PRELIMINARY REMARKS ON FISHERY

The chief purpose of the investigation of the shelf area was its possibilities for fishery. Exact data, however, can only be obtained after more detailed studies.

The most important fact, which influences the fishing possibilities, is the nature of the bottom (treated in part 2 of this series of papers). The irregularities of this bottom

do not permit the use of trawls in this area, with exception of two parts: (1) the coastal zone, and (2) the São Francisco area.

The coastal area with depths to 10-15 m, is very narrow, and often interrupted by elevations such as sandstone and coral reefs, chiefly in Alagoas. The zone is wider, up to 3-4 miles, off Sergipe, of which only the deeper part is accessible for commercial ships.

Alongside the São Francisco influence area, the area for fishing is chiefly located on the muddy bottoms and the detritial bottoms in its continuation, covering a distance of some 30 miles. The canyon with its relatively steep slopes has to be evited, being dangerous for the nets. In this area species of fishes and crustaceans of high commercial value have been met with.

As a conclusion, one can say that the possibilities for fishery are not very great. The occurrence of high value species in the São Francisco area permits the use of a few ships for commercial purpose. The organic, especially algal, bottoms may be excellent living places for crustaceans However, investigations have still to be made. Furthermore, the oceanographical data, especially the seasonal variations of temperature and salinity, are still not sufficient to provide more exact predictions.

FINAL REMARKS

The numerous samples collected during this campaign provided so much material, that its study will take several years. The results will be published in the subsequent volumes of this bulletin using as a base this first introductory part.