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ARABIAN SEA SUB -SURFACE SALINITY MINIMA (ASSM)

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ABSTRACT: This paper presents the results of the study on the Arabian Sea sub-surface salinity minima (ASSM). The data collected under the North Arabian Sea Environment and Ecosystem Research (NASEER) programme and World Ocean Circulation Experiment (WOCE) has been used in the study. Study of the Arabian Sea water masses is most significant in understanding marine productivity and monsoonal reversal features. Analysis of the data shows that the Arabian Sea sub-surface salinity minima (ASSM) can be found between 25.8 to 26.0 Sigma Theta surfaces. ASSM originates from the South and South east . It is inferred from the results that the salt content of the ASSM varies during different seasons. Appreciable mixing of Arabian Sea salinity minima is observed over Murray Ridge.

KEY WORDS: Arabian Sea, Sub-Surface Salinity Minima (ASSM), Water Mass, Sigma-Theta Surface, Core Layer.

INTRODUCTION

The Arabian Sea experiences extreme in atmospheric forcing which lead to the semi-annual seasonal changes (Arshad *et al*, 1995). Monsoonal effect are predominantly felt on the surface layers that leads to the formation of water masses with distinct characteristics.

Banse (1990) indicated the occurrence of salinity minima in North Arabian Sea. Shetye *et al* (1992) identified water mass in the proximity of Saurashtra, India. They proposed that northeast monsoon winds have main control of ASSM development in this region. In the present study Arabian Sea subsurface salinity minima (ASSM) in north western Arabian sea has been discussed. A salinity minima is defined as that point on a Temperature – Salinity (T-S) curve which has a lesser salinity value than the value obtained by the mixing of the water above and below it on the curve. The observation stations were located north of 20°N in North Arabian Sea (Fig. 1). The CTD data was collected in five different months i.e January, March, May, August and December. From CTD data used in this study the sources of the water mass can be inferred and temporal changes in the flow may also be observed.

MATERIAL AND METHODS

The cruises of research programme "North Arabian Sea Environment and Ecosystem Research (NASEER)" were under taken during January, March, May and December in 1992, 93, 94 and 95 respectively along the cruise track shown in Figure.1. WOCE cruise was undertaken during August and covers central and eastern part of north Arabian Sea. The data of different parameters related to physical, biological and chemical oceanography were collected.

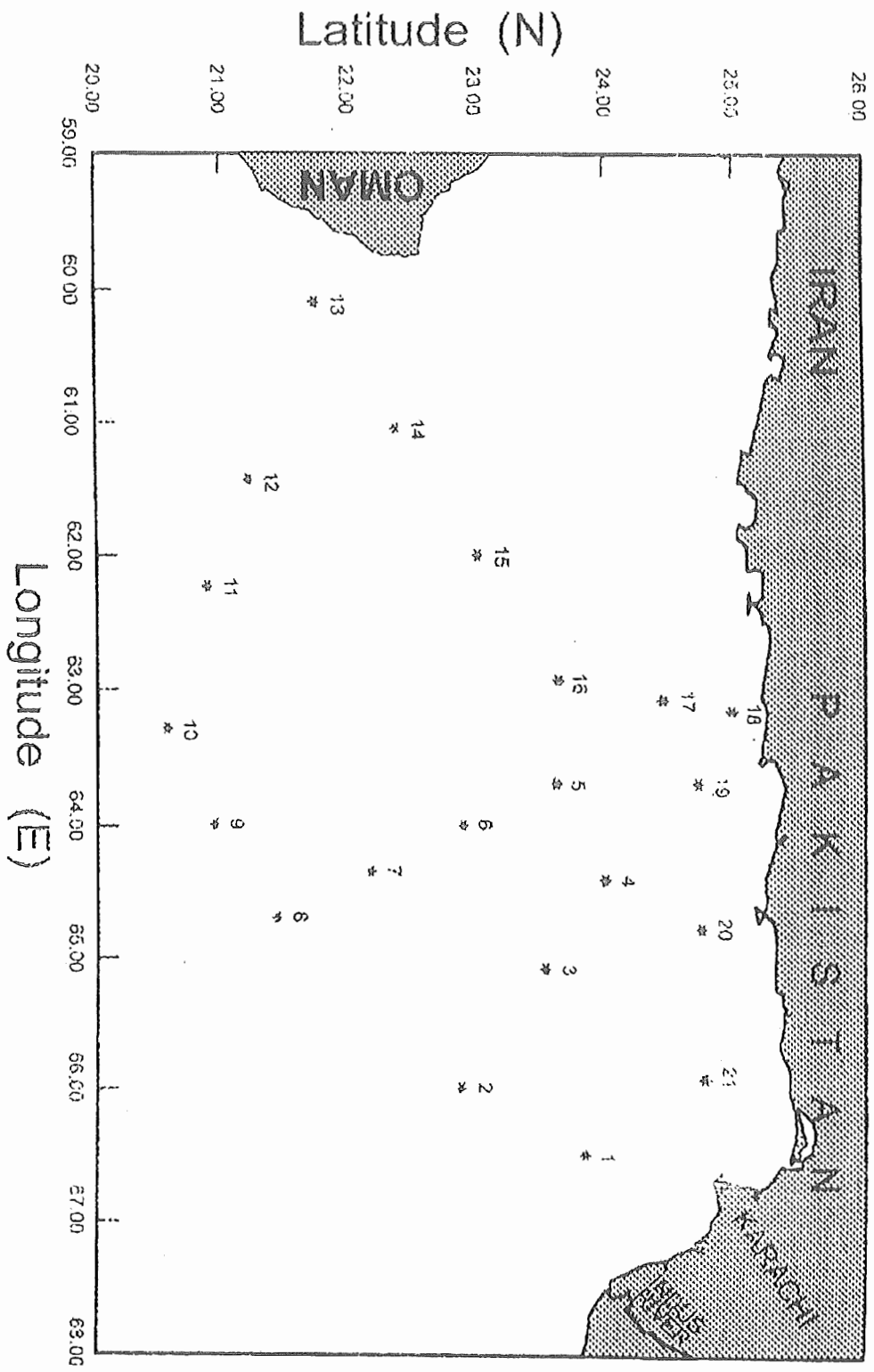

Fig. 1. Stations location map.

Conductivity, temperature, and depth (CTD) measurements (on board M/V Aghyer-S, M/V Mangan and S/V Behr Paima) were made with Sea Bird's SBE 9/11 plus CTD profiler added with 11 bottles General Oceanic Rosette sampler and fitted with reversing protected and unprotected thermometers. M/V Aghyar-S and M/V Magan being cargo vessels were specially converted into research vessels by adding "A" frame with motorised winch supported with wire length digital meter, and an observation platform on port side. During the transect, CTD was lowered at the pre selected stations and data was recorded during the downcast with a sampling frequency of 8 Hz and lowering speed of about 1m/s. The CTD has the accuracies of +-0.01 °C and+- 0.003 PSU for temperature and salinity respectively. Recorded data was retrieved into the computer via RS232 cable.

Since the data is obtained from CTD which has an accuracy of surface salinities depth $\pm$ 1 meter therefore surface water was sampled precisely. The quality of CTD data was checked from the data recorded by water samples on inductive salinometer for salinity values. Some stations of NASEER were Time Series where samples were collected four to five times. The values of theses data were incorporated after treating them as multiple independent samples.

For preparation of charts, core layer method for identification of water masses was employed. A T/S Diagram has been plotted and the core salinity of the Arabian Sea sub surface salinity minima (ASSM) layer was identified. These values have been noted at each station. Contours of the Co-salinity were drawn using standard techniques.

RESULTS AND DISCUSSION

In general the pattern of the Arabian Sea subsurface salinity minima (ASSM) involves the meandering of the 36.0 salinity contour across the Murray Ridge and south of the Gulf of Oman. Influence of bathymetric feature of Murray Ridge in separating the more saline minimum to the north from the lower salinity ASSM to the south has been observed.

The January cruise (Fig. 2) shows more saline ASSM to the south of the Murray Ridge. Salinity values are >36.5 and increase up to 36.9 as it proceeds to the east. The largest salinity gradients in the ASSM core occur between the Murray Ridge and the southern coast of Oman. At stations # 12,13 and 14 near the southern coast of Oman salinity values are 36.61, 36.04 and 36.12 respectively. A fairly uniform high salinity ASSM layer is found in the cyclonic feature between the eastern Murray Ridge and the Makran coast of Pakistan. This can be recognised in SE and SW part of the study area. The density of the ASSM layer in January varies from 25.70-26.10 but on average it is found hover about the 25.90 surface value.

The ASSM distribution in the month of March (Fig. 3) is similar to that of the January. A notable difference in March for a high salinity ASSM layer observed in an anti-cyclone over the eastern Murray Ridge. ASSM layer shows salinity ~ 36.90 in this area. West of 62° E / 22° N longitude salinity ranges between 36.00 to 36.10. Off Makran coast ASSM shows values in similar ranges. Maximum concentration of salt is observed in the east and north as was observed in the month of January (Fig. 2). During March density varies from 25.70 to 26.30 but on average it is found along 25.95 surfaces.

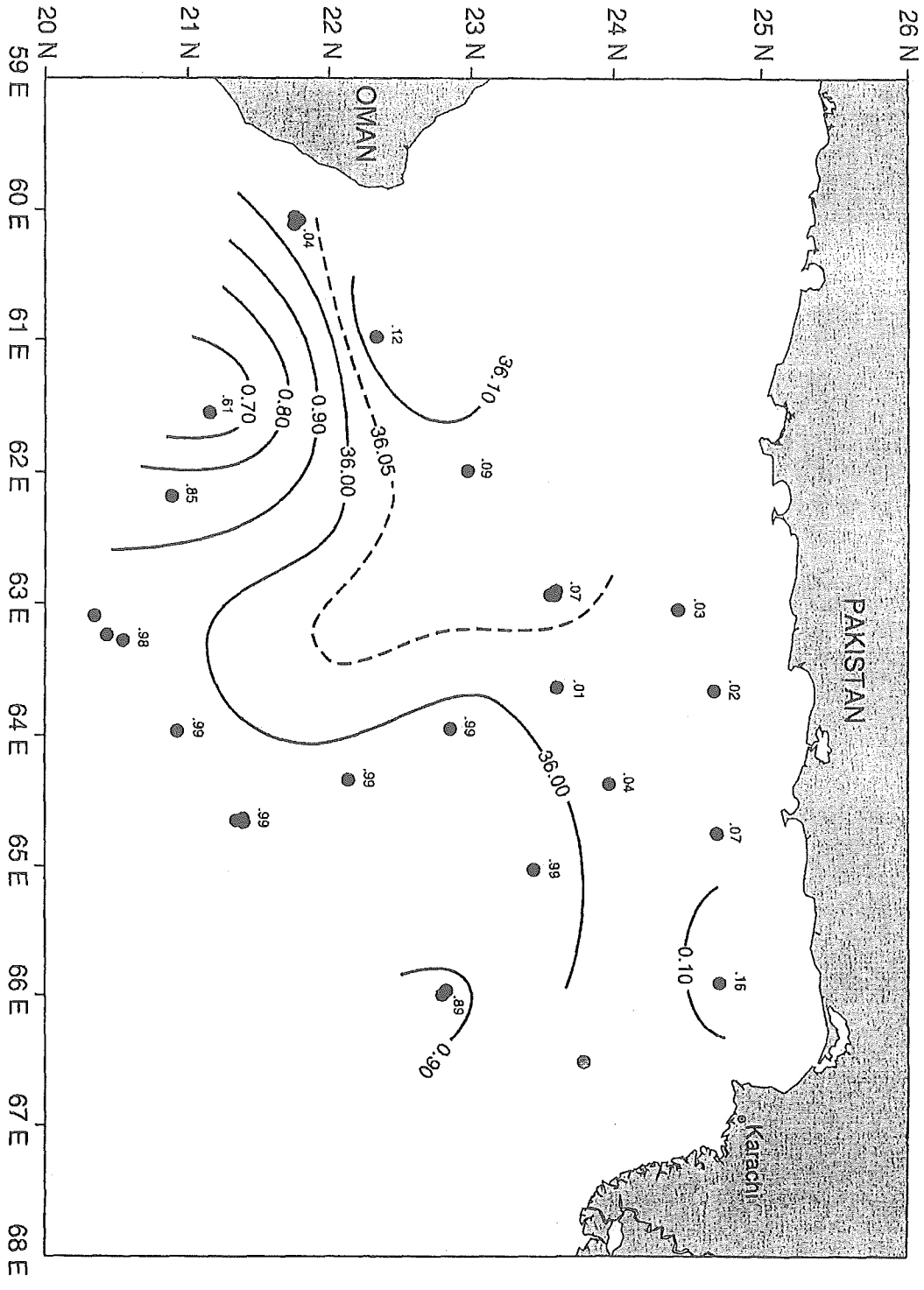

Fig. 2. Co-salinity (PSU) lines during January.

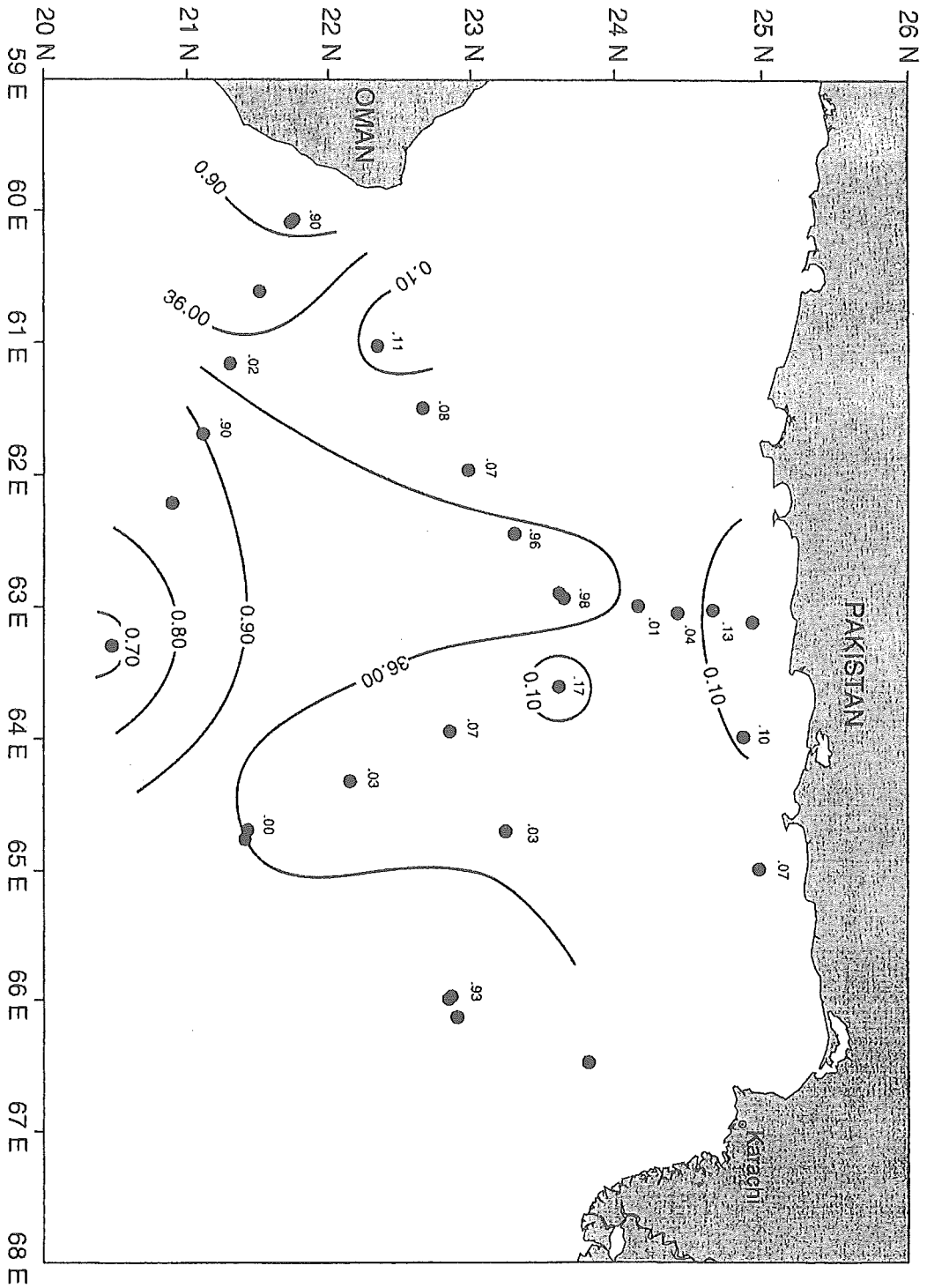

Fig. 3. Co-salinity (PSU) lines during March.

In May (Fig. 4), less saline water (<36.10) appears further to the 24° N and above off Pakistan coast than in January and March. ASSM layer south of 23° N has higher salinity ranges from 36.85 to 36.90. High salinity (36.10) water along 62°E occurs in an anti-cyclonic eddy over the shallow peak of Murray ridge. During May density varies from 25.50-26.10 and on average found along the 25.85 surface and lower density core of ASSM appears at 25.5.

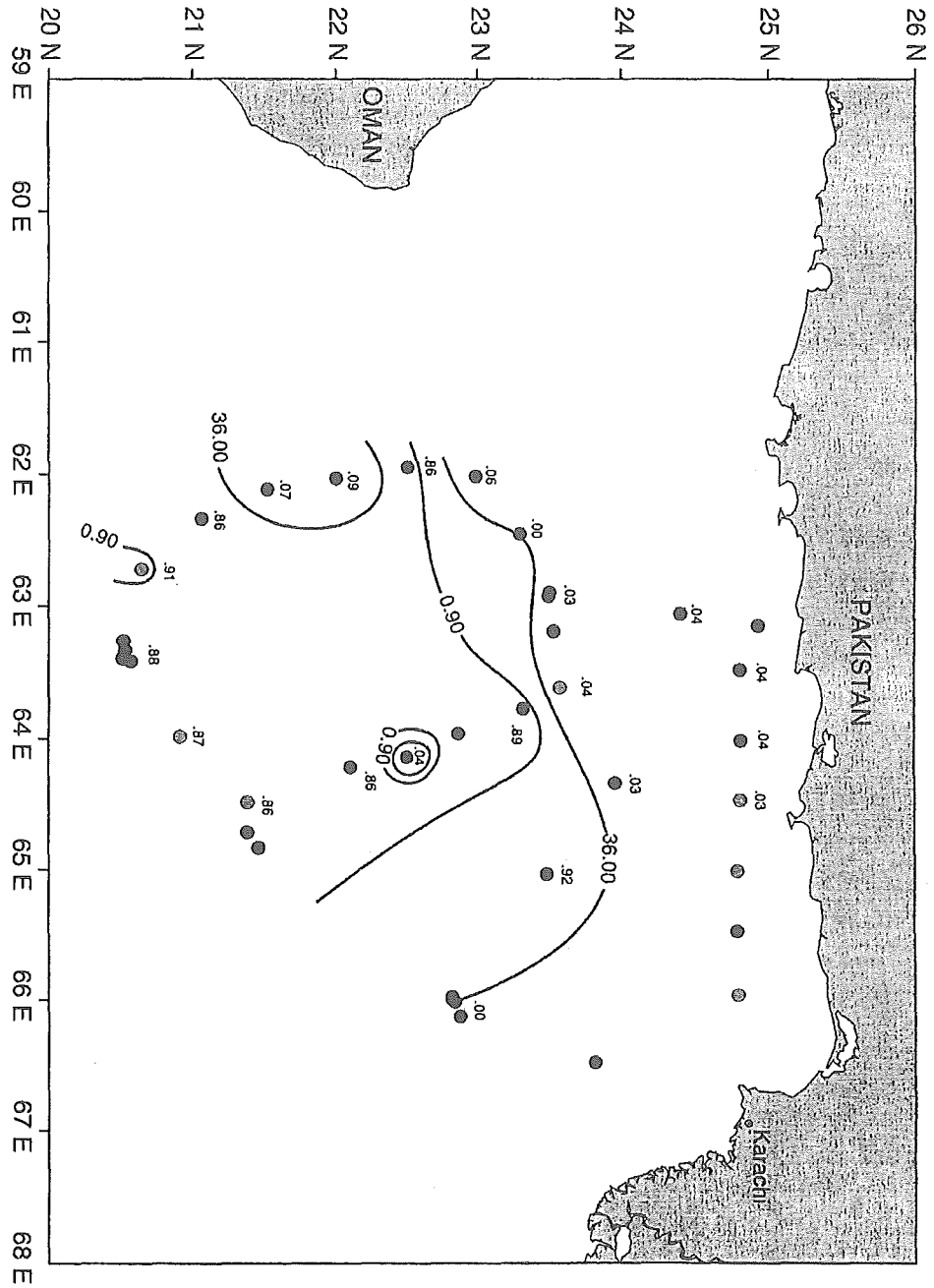

Fig. 4. Co-salinity (PSU) lines during May.

In August (Fig. 5), a tongue of higher concentration of salt (36.00 PSU) in the ASSM extends southward west of 62°E. This is consistent with the pattern seen in the surface salinities and suggests that this water comes from the coast of Pakistan. Also, the concentration of salt increases rapidly north of 22° N to more than 36.20 PSU which is not seen in other months. It suggests more mixing in this area over Murray Ridge. Fresh upwelled water is observed coming from the west with salinity less than 36.00 PSU along the Oman coast. This fresher water is only seen in lenses farther to the east.

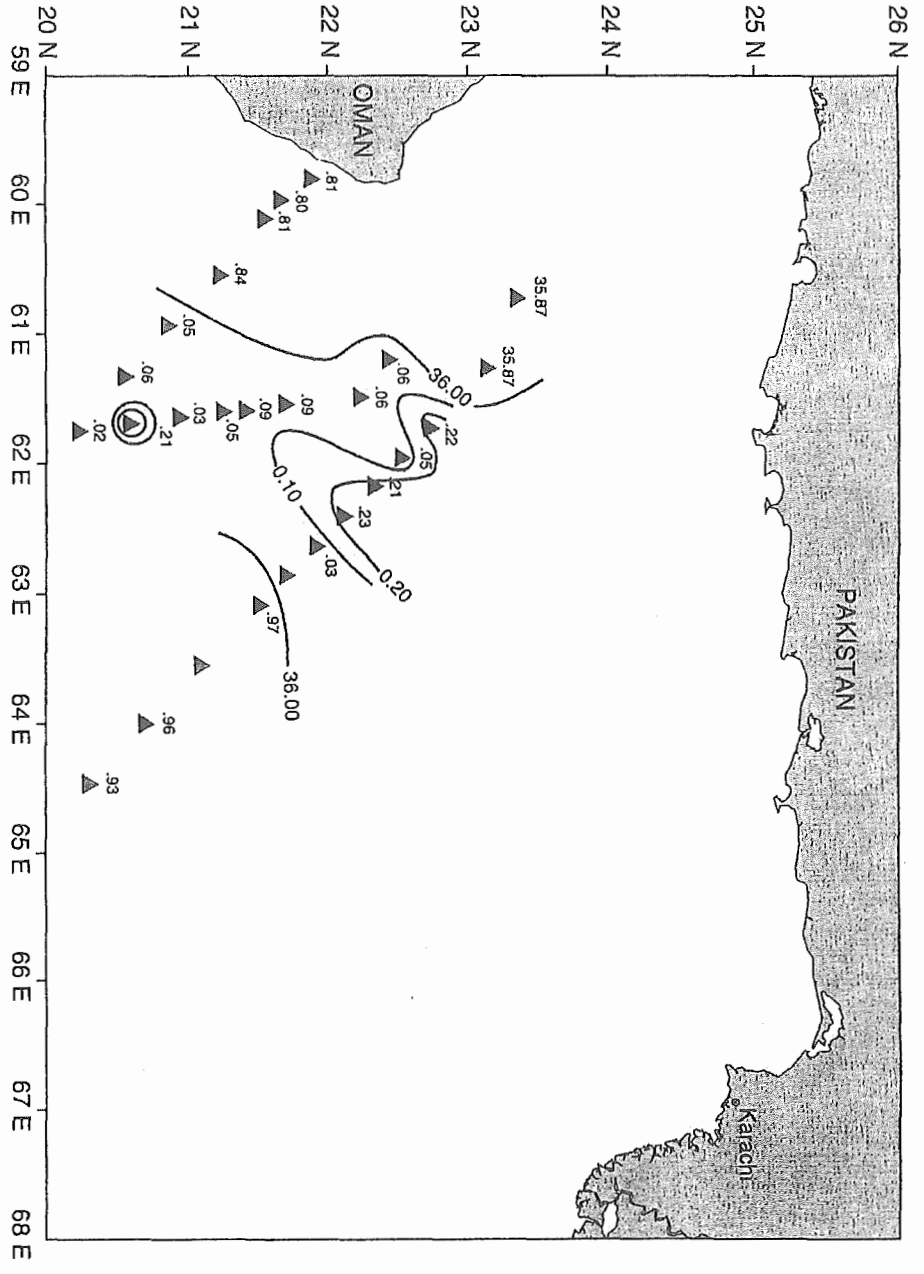

Fig. 5. Co-salinity (PSU) lines during August.

In December (Fig. 6), the ASSM shows that the water from the southwest occupies most of the Murray Ridge with a concentration of 36.90. The only water with salinities above 36.0 occurs over the top of the western Murray Ridge.

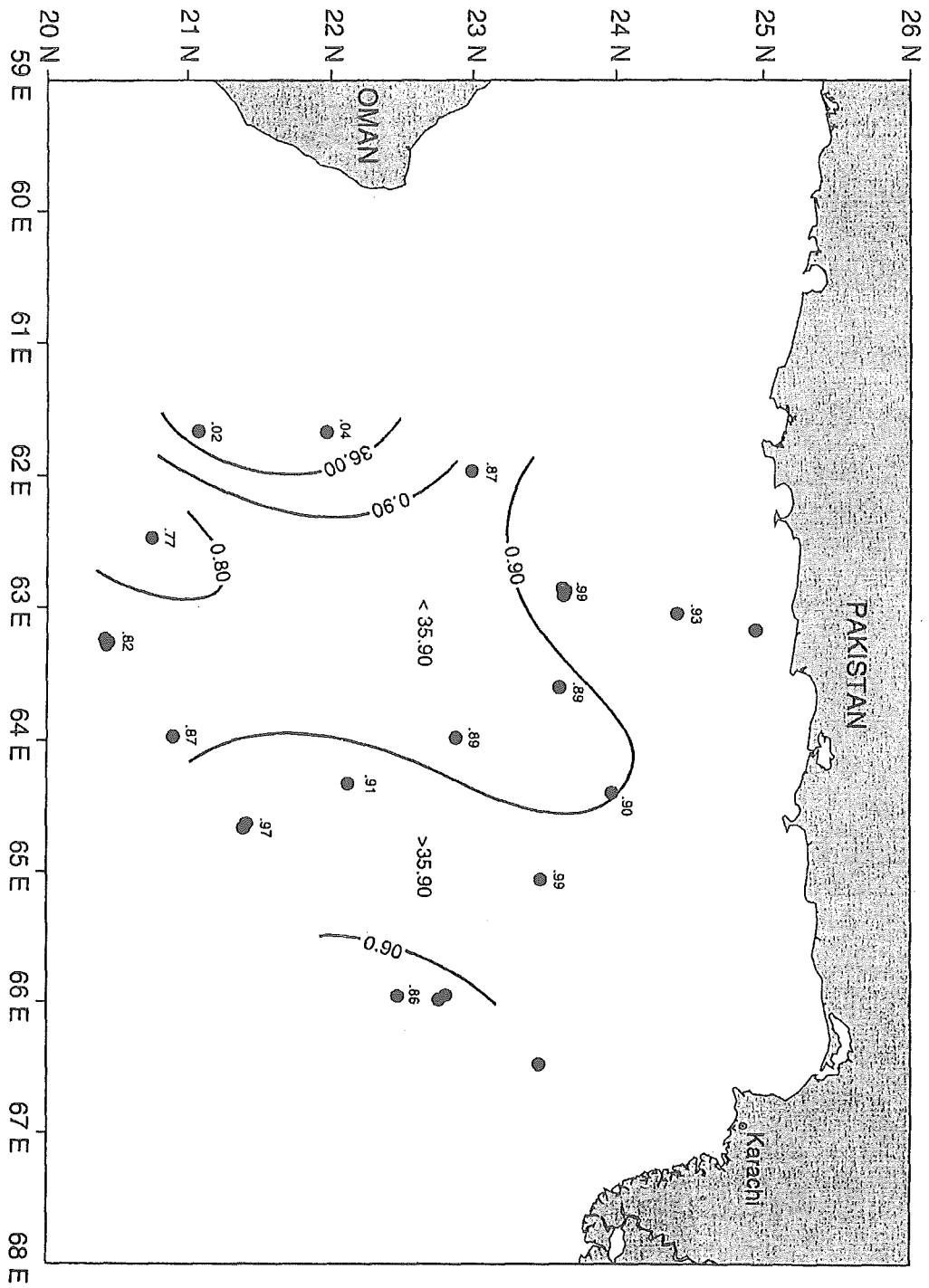

Fig. 6. Co-salinity (PSU) lines during December.

CONCLUSION

Arabian Sea subsurface salinity minima (ASSM), on average, can be found in between 25.80-26.00 Sigma Theta surface. Year round salt content over Murray Ridge is varied from 35.90 to 36.20 PSU. High and Low of ASSM water has been observed during the months of December and August respectively. In this study the freshest ASSM water has been found in December 1994 and the most saline in May 1994 and August 1995. The depths of the layer are shallowest in August 1995 (100-185 m) and the deepest in May 1994 (149-280 m).

ASSM appears in the north Arabian Sea from Southeast and South. The flow from Southeast has fresher water than South. Strong mixing over 21.5°N/61.5°E suggest influence of Murray Ridge topography.

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