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MAGDALENA KAMIŃSKA

Institute of Meteorology and Water Management, Maritime Branch, Gdynia, Poland

MEASURED AND PREDICTED VALUES OF WATER TEMPERATURE AND SALINITY WITH SPECIAL FOCUS ON THE SURFACE LAYER

Abstract

The Baltic is a stratified sea. The upper layer is under the influence of atmospheric and terrestial factors. The mechanisms of these external factors on the surficial and subsurface water layer are well recognised but the vertical exchange in the water body is still not sufficiently investigated. Field measurements at sea are time consuming and expensive. A model of the Baltic Sea distributed to and accessible by institutions investigating the Baltic Sea is advantageous because of easier exchange modelled data. The modelling, especially of the surface layer is important due to the fact that outside the coastal zone continuous measurements of physical parameters is difficult.

The comparison between measured in situ and modelled data serves as a tool for the corrections to HIROMB resulting in better approximation of real phenomena occurring in the Baltic Sea. Temperature and salinity values obtained on board r/v Baltica during the POLRODEX'97 expetriment were compared with modelled values. The analysis showed significant differences between in situ measurements and obtained from the HIROMB model.

1. Introduction

The paper presents comparison between water temperature and salinity values measured in situ from the board of r/v Baltica in the Gulf of Gdańsk and data generated in HIROMB model.

2. Material

The data for model verification were collected during two cruises in the Gulf of Gdańsk: 22-23 September 1997 (I) and 25-26 September 1997 (II). The area of in situ measurements was divided into subregions according to the period of CTD observations. The borders of the subregions were delineated in the middle of the distances between CTD stations. Depending on the time of observations, appropriate forecast of water temperature and salinity was used. Water temperature and salinity values were calculated by the HIROMB model using following forecasts in the case of I project period 12, 18 and 24 h forecast from 22 September was used and 6 h from 23 September 1997, in the case of II project period - 6, 12 and 18 h forecast from 25 September 1997. Figs. 1 and 2 present the respective networks of measurement stations during the I and II period of the study.

The in situ measurements were carried out at standard HELCOM levels, i.e. 0, 5, 10, 15, 20 m and every 10 m down to 2 m above the bottom.

Measurements were made at the irregular space net. In the first measurement period, stations were placed every 5 NM in meridional direction and every 20 - 25 NM in longitudinal direction. The arrangement of CTD stations in the second period was more complicated. The most dense net was at the Vistula river mouth, where the distances between neighbouring stations were approximately 3 NM. The distances between stations, moving from the coast to the deep water area increased from 5 to 10 NM. The distances between stations in longitudinal direction were equal to 10 - 15 NM. The analysis was carried out for 6 upper lavers of the model: 0-4, 4-8, 8-12, 12-18, 18-24 and 24-30 m.

Temperature and salinity, measured from the surface to the depth of 30 m, were compared with the forecast data. At present, the spatial resolution of the numerical model is 3 NM in the horizontal plane and 24 layers in vertical direction. The thickness of the layers varies from 4 m in the mixed layer and up to 20 m in the deepest parts of the investigated basin.

3. Methods

To compare the data generated by HIROMB model with measured values, correlation coefficients were calculated between the relevant parameters. The number of data used for calculations was 6-11 from the I experimental period and 4-6 from the II period.

Correlation coefficients between the measured and modelled by HIROMB values of sea water temperature and salinity were very low, from 0.1 to 0.4 at the confidence level of 0.05. Examples of correlation coefficients calculated for data from the I experiment period are shown in Fig. 3. Correlation coefficients were calculated by means of the „Statistica" programme.

The differences between the measured and modelled data were also calculated whereas the model data of one layer were compared to the measured data from this layer and two adjacent layers - above and beneath one, e.g. the data from model layer 4-8 m were compared with the in situ data from 5 m, 0 m and 10 m. The model layers referring to the levels of in situ measurements were analysed and discussed. The differences are presented as diagrams (Figs. 4-7) and horizontal distribution pictures (Figs. 8-19). The modelled temperature and salinity values are given in the regular grid nodes with the resolution of 3 NM. The distribution of the measured in situ values is irregular. Using „Surfer" programme the measured values were interpolated at the grid of the numerical model. After all, kriging was used, in particular quarters of a circle (due to the need of the special treatment of the area near the Vistula mouth), with the minimum number of five values for interpolation, semi-diameter (horizontal anisotropy) was equal to 1/3 of the length of the area along the parallel and the meridian.

After the interpolation of the measured values, the differences between the modelled and the interpolated values of the in situ measurements were calculated.

4. Discussion

Correlation coefficients between the measured and modelled by HIROMB values of sea water temperature and salinity were very low, from 0.1 to 0.4 at the confidence level of 0.05. Examples of correlation coefficients calculated for data from the I experiment period are shown in Fig. 3. One reason of the low correlation values was the low number of data for comparison.

The correlation between the measured and modelled data was calculated in order to check the consistency between the predicted and the actual data and to assess the extent of deviations for the modelled data. Unfortunately, this goal was not reached. It is only possible to say that the correlation is not statistically significant for the number of data used in calculations.

The differences between measured and modelled values of temperature and salinity fell in the I period within the range -0.15 to +3.87°C (Fig.4) and +0.48 to +3.82°C in the II (Fig.5). The respective differences in salinity were: -1.63 to 1.64 PSU (Fig.6) in the I period and -1.19 to +2.01 PSU in the II period (Fig.7).

The measured water temperature values were included between 14.98°C (W2 station) and 15.87°C (E station) in the first period of measurements. Generally, along the profile E-P1 in the eastern part of the Gulf of Gdańsk, the measured water temperature was slightly higher than along the profile in the western part (W-P118). This statement is true for the lower layers too.

The salinity distribution was more complicated. The lower values were measured in the shallow water area along the profile in the eastern part of the Gulf (E-E1-E2) and at the W3E station. In the first period of measurements, the surface salinity values were between 6.538 PSU (W3E station) and 7.304 PSU (P1 station).

In the second period of measurements, the surface water temperature in the investigated area was between 14.7°C (ZN2) and 15.7°C (P110). Similarly as in the case of temperature, the lowest salinity slightly exceeding 5.8 PSU, as well as temperature were measured near the Vistula river mouth. The highest value of surface salinity was measured at P101 station, where it was equal to approximately 7.6 PSU. In the second period of measurements it could be clearly seen that winds, surface and subsurface currents modify the Vistula water spreading.

Sea water temperature generated by HIROMB was generally higher than measured in situ. It means that the model insufficiently accounts for the cooling effect of the Vistula river water. Similar effect was observed in salinity values, the model produced higher salinity values than the measured values. Besides, there was certain asymmetry observed in horizontal distribution of differences; positive (+) differences of both - temperature and salinity - were found in the western part of the Gdańsk Deep while negative (-) were calculated for the values from the eastern part of this area.

5. Conclusions

Correlation coefficients between the measured and modelled by HIROMB values of sea water temperature and salinity were very low, from 0.1 to 0.4 at the confidence level of 0.05. Correlation between HIROMB data and measured in situ indicated that the values calculated by the model are not reliable.

The differences between modelled and measured data might result from the neglected influence of the Vistula river in the model.

Errors in bathymetry evaluation (shallow nearshore area of the Gulf of Gdańsk is probably not well depicted in the model) could be another important source of differences between the model and measured data.

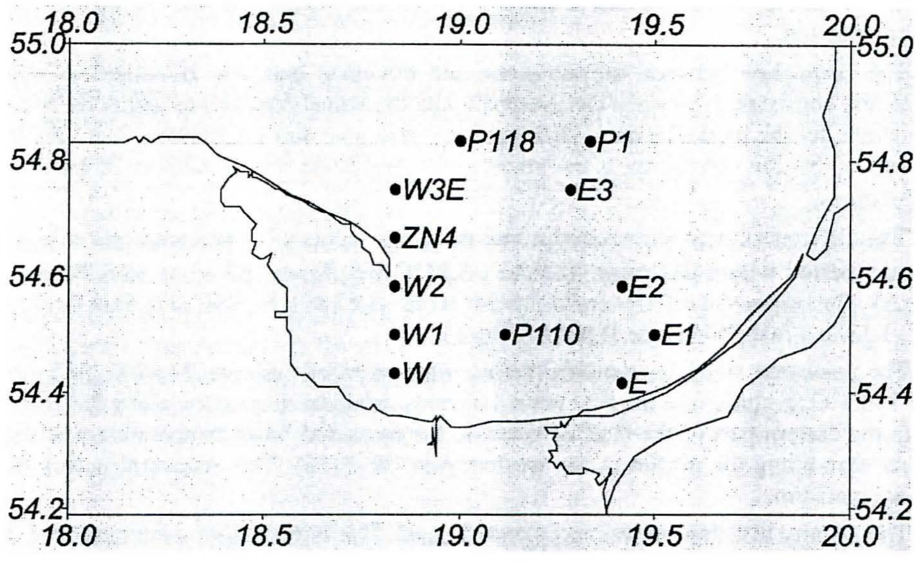

Fig.1. Network of measurements stations in Polrodex'97 experiment (22-23 September)

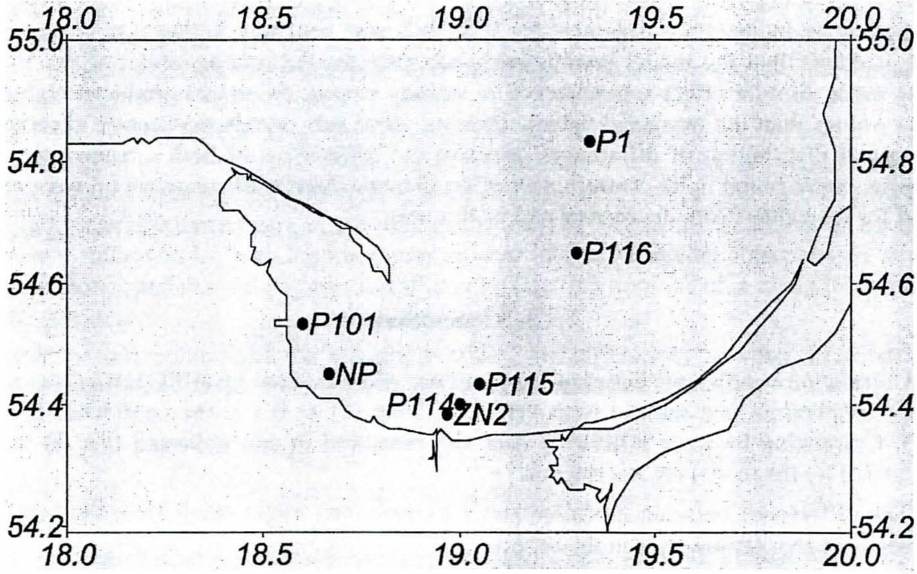

Fig.2. Network of measurements stations in Polrodex'97 experiment (25-26 September)

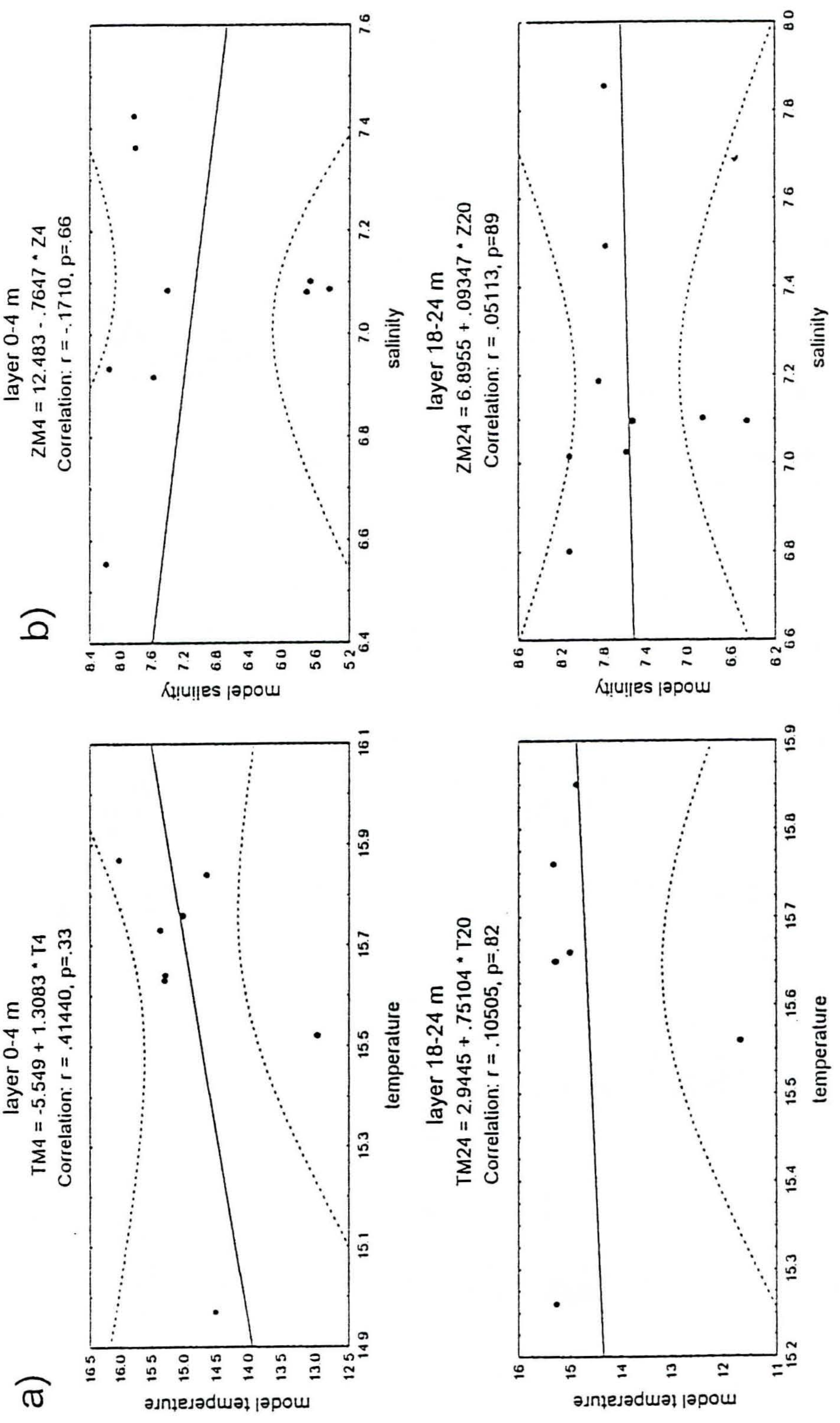

Fig. 3. Examples of regression function between measured and modelled walues of: a) temperature. b) salinity

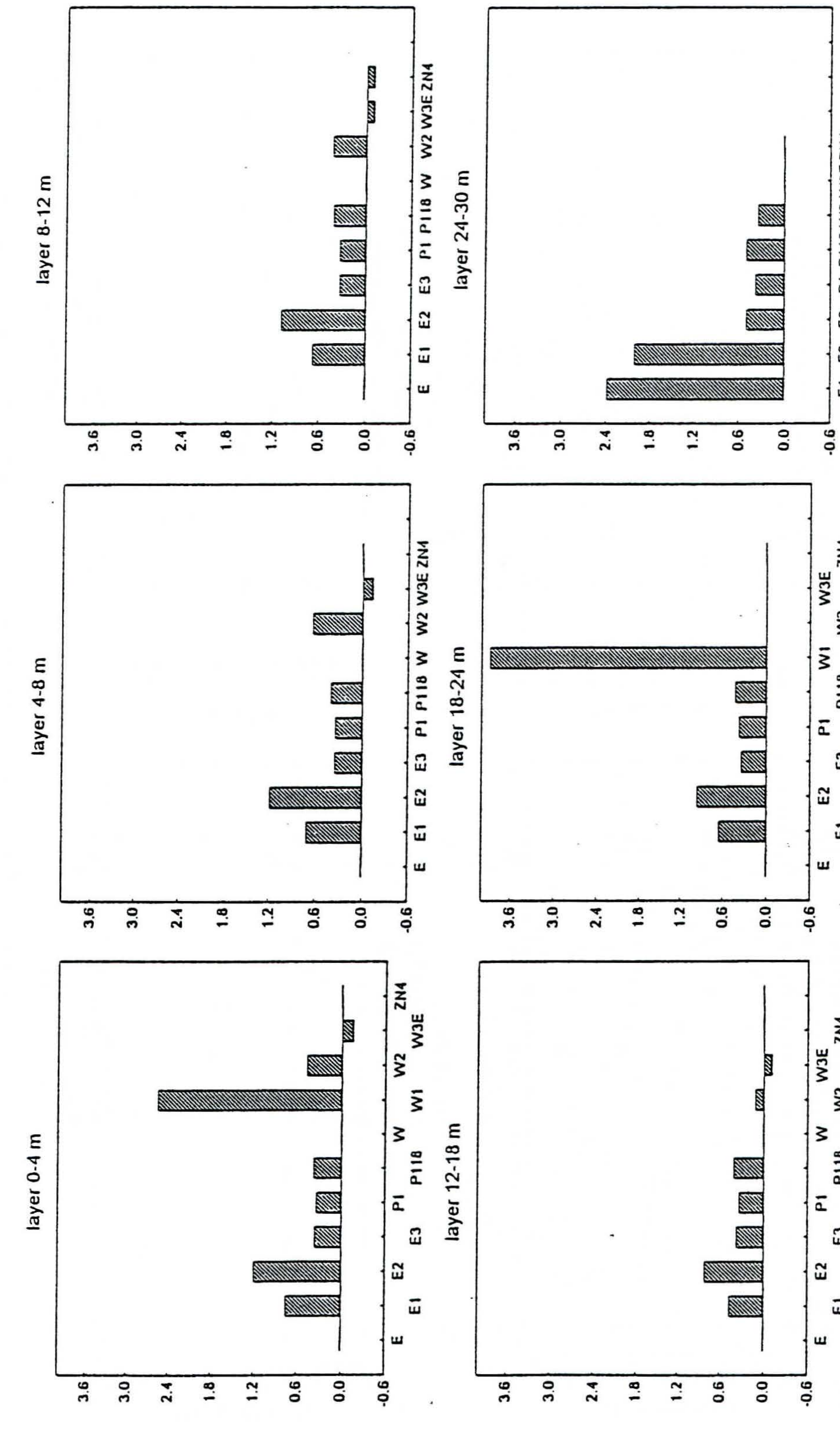

Fig. 4. Differences in temperature between measured and modelled values (22-23 September)

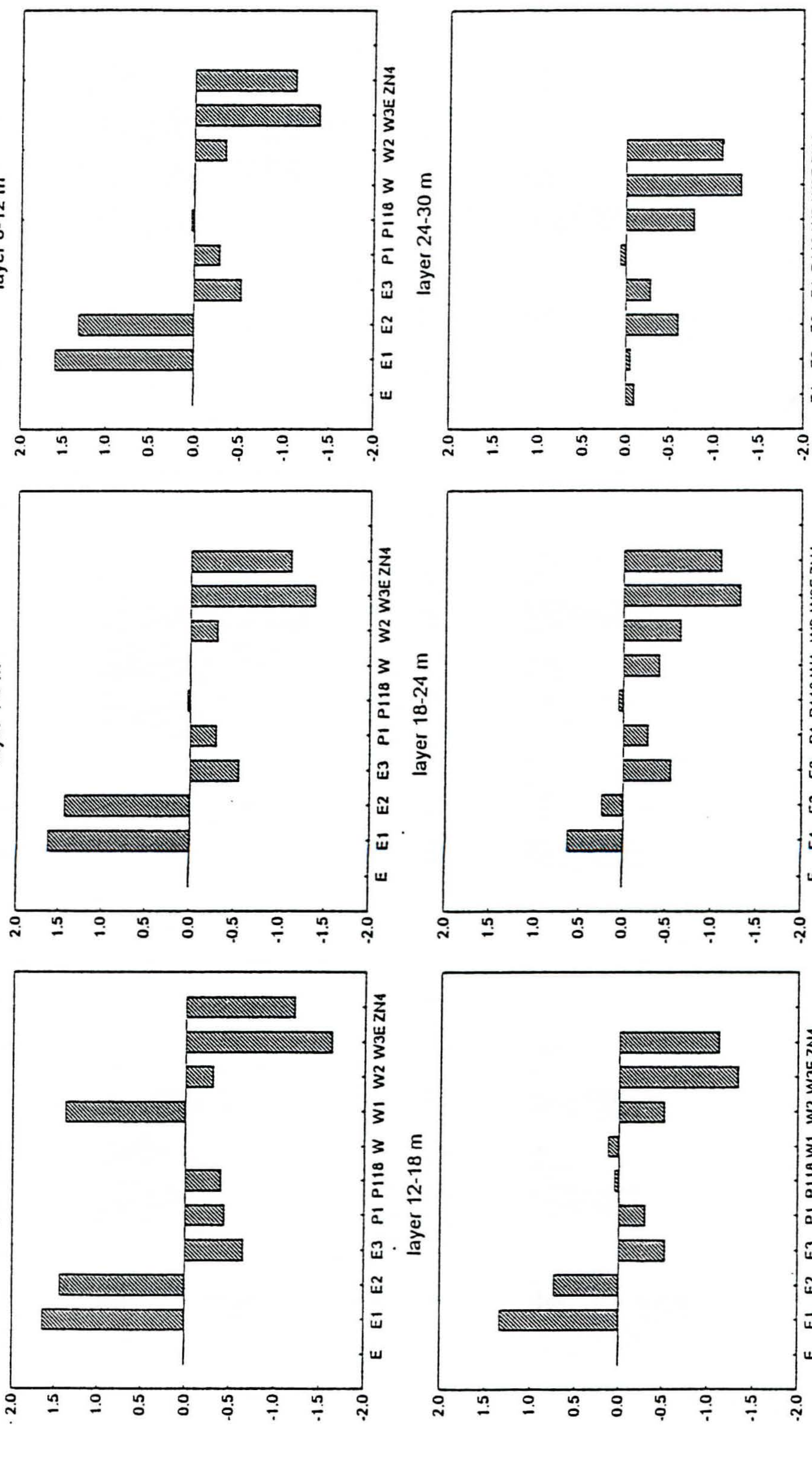

Fig. 5. Differences in salinity between measured and modelled values (22-23 September)

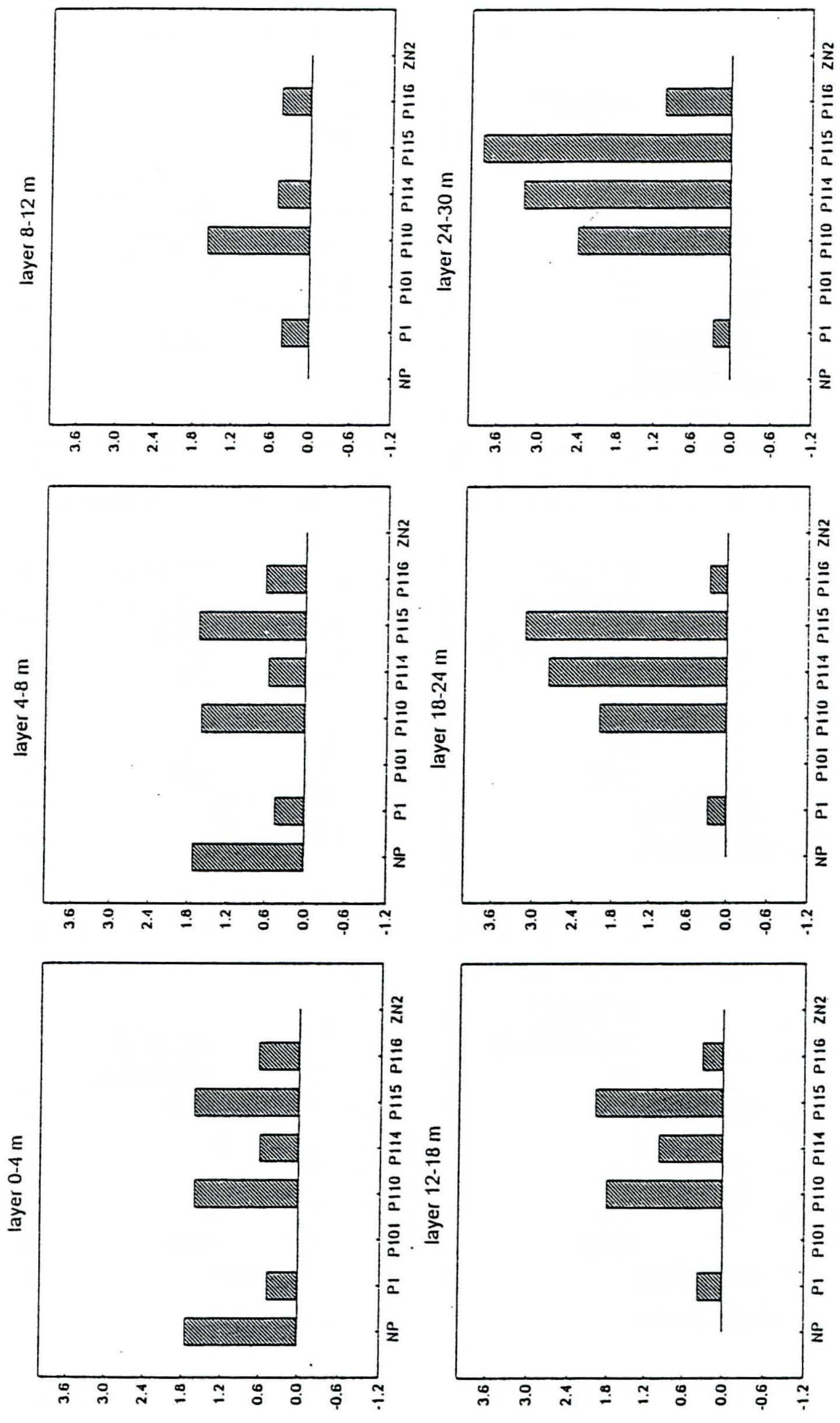

Fig. 6. Differences in temperature between measured and modelled values (25-26 September)

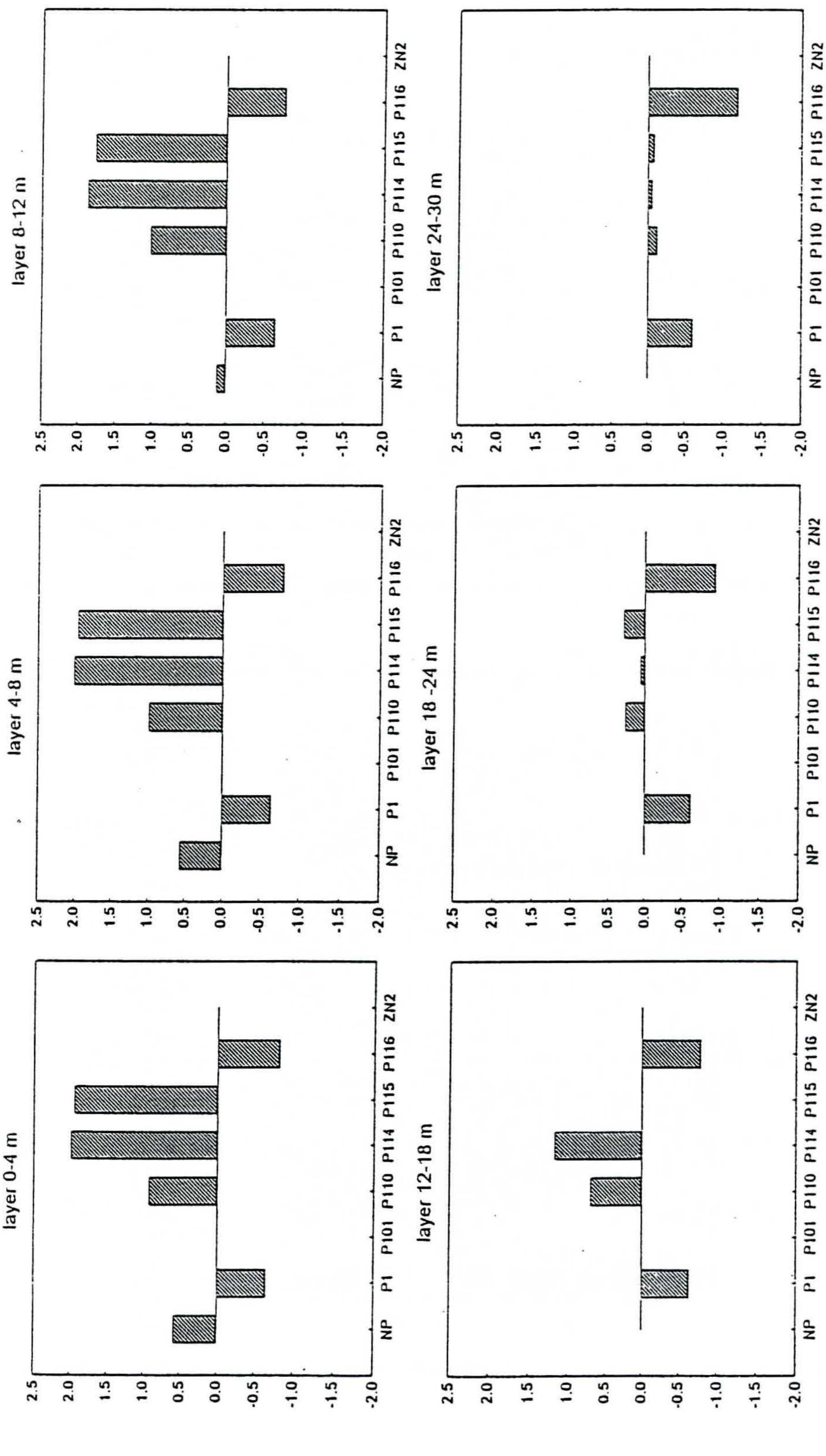

Fig. 7. Differences in salinity between measured and modelled values (25-26 September)

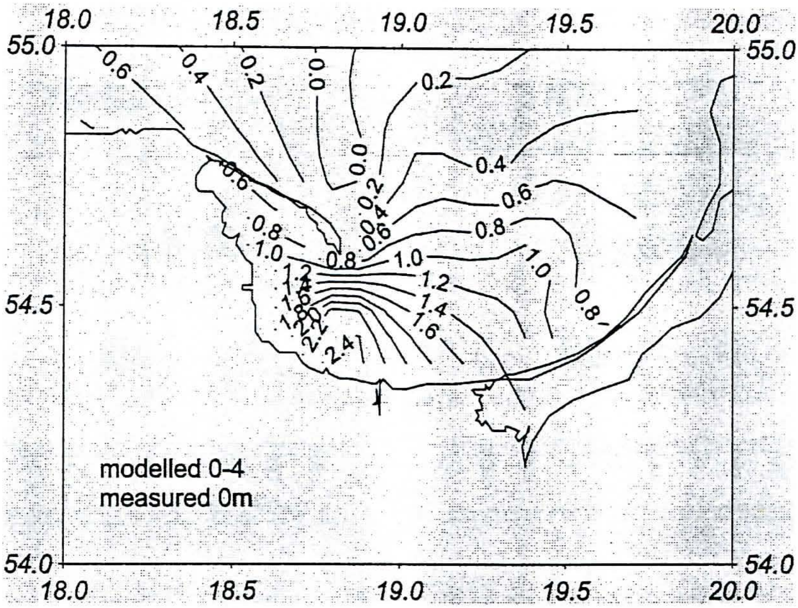

Fig. 8. Isolines of differences between measured and modelled temperature (22-23 September)

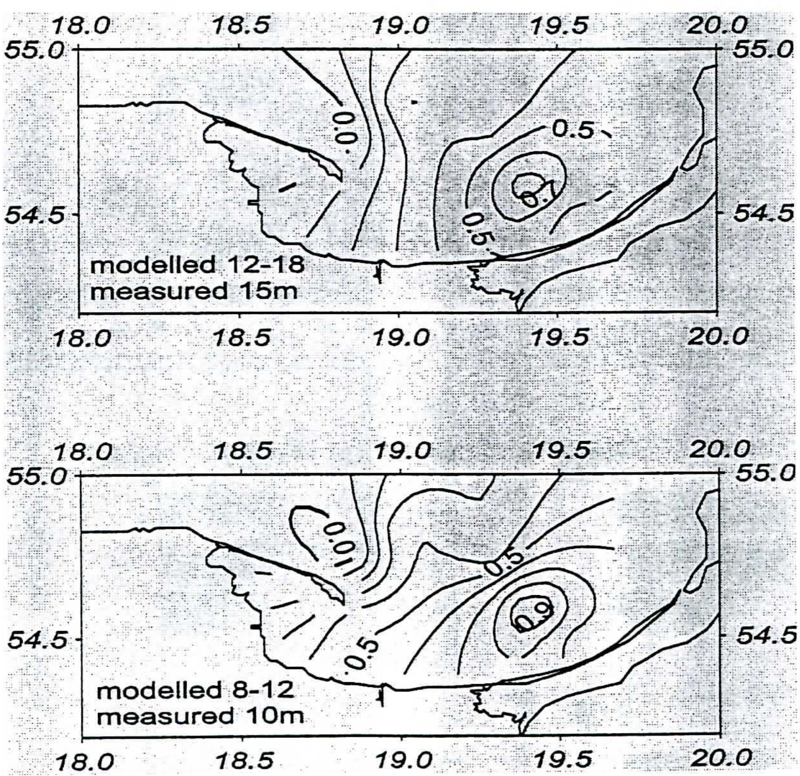

Fig. 9. Isolines of differences between measured and modelled temperature (22-23 September)

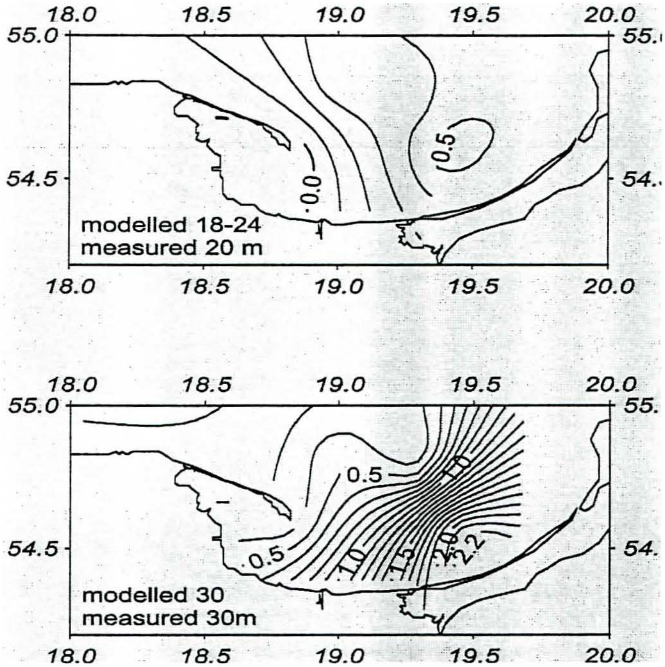

Fig. 10. Isolines of differences between measured and modelled temperature (22-23 September)

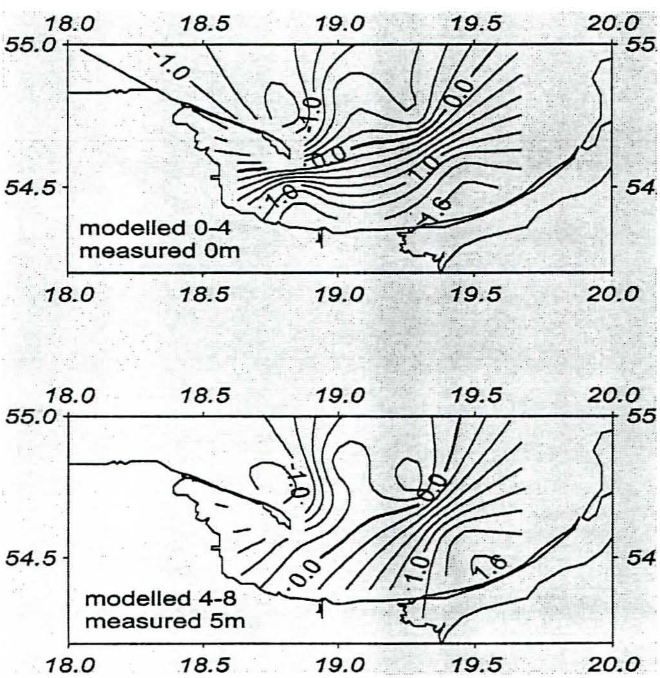

Fig. 11. Isolines of differences between measured and modelled salinity (22-23 September)

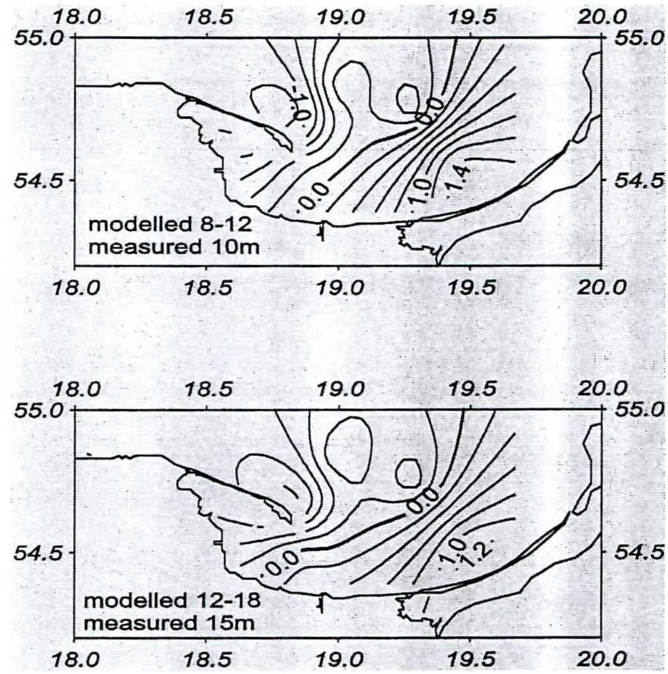

Fig. 12. Isolines of differences between measured and modelled salinity (22-23 September)

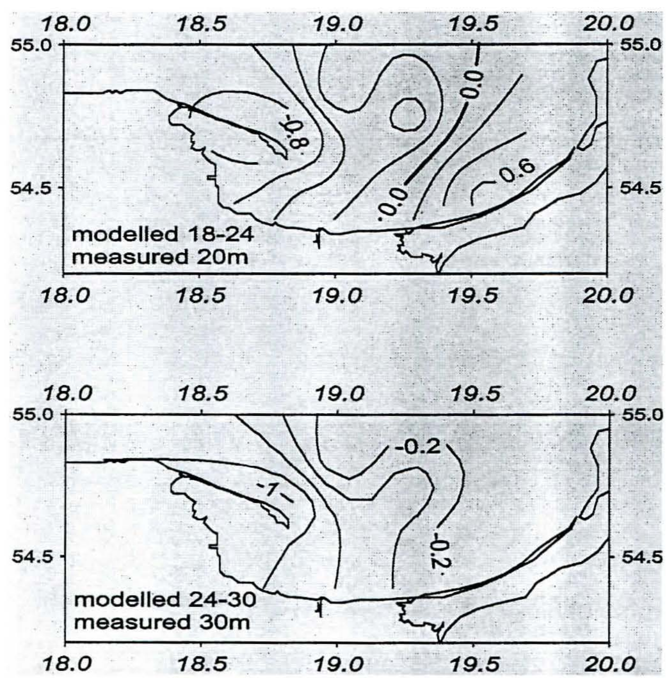

Fig. 13. Isolines of differences between measured and modelled salinity (22-23 September)

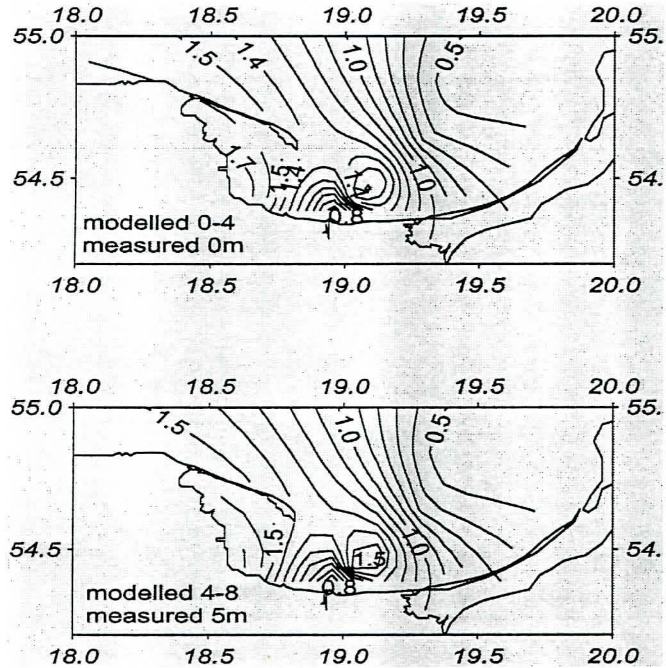

Fig. 14. Isolines of differences between measured and modelled temperature (25-26 September)

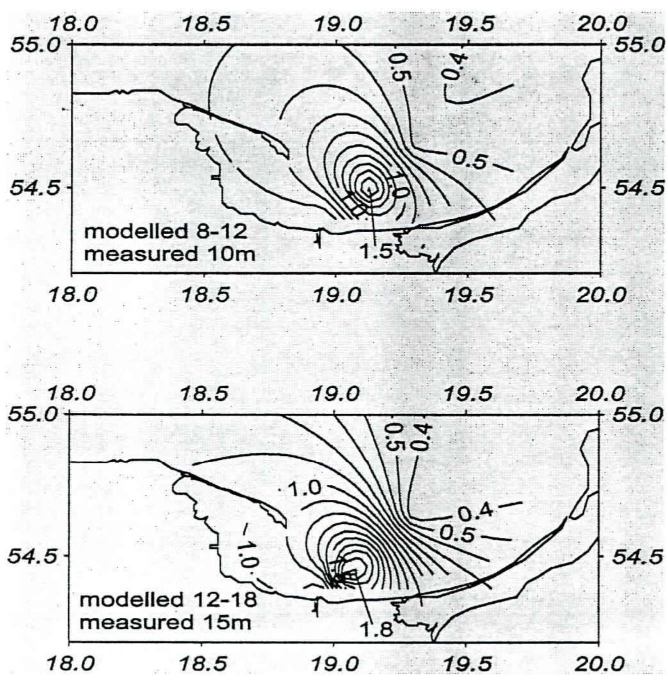

Fig. 15. Isolines of differences between measured and modelled temperature (25-26 September)

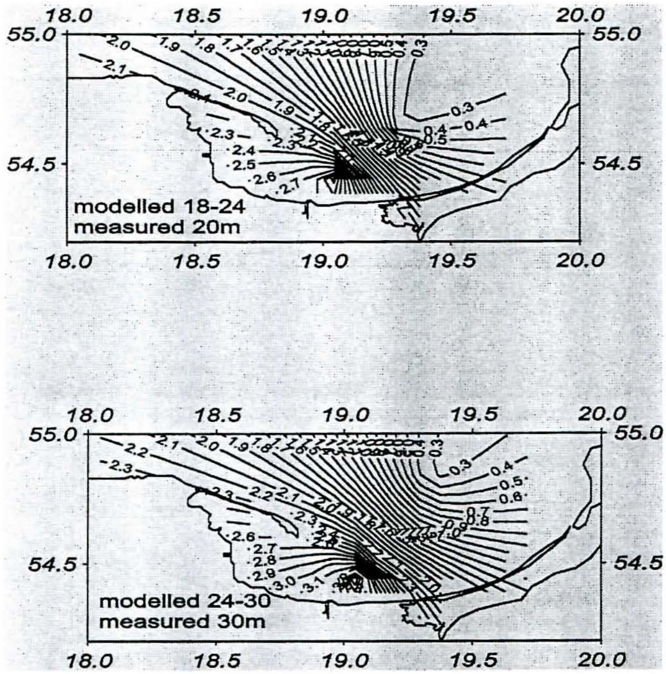

Fig. 16. Isolines of differences between measured and modelled temperature (25-26 September)

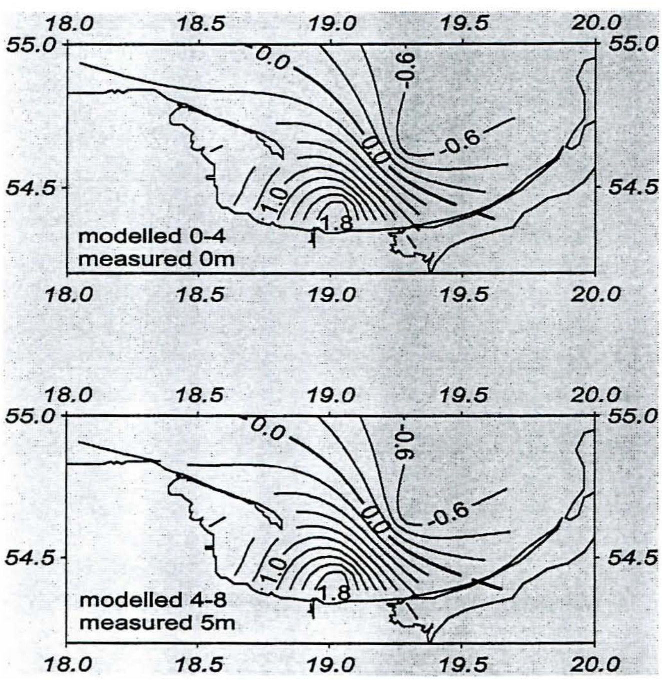

Fig. 17. Isolines of differences between measured and modelled salinity (25-26 September)

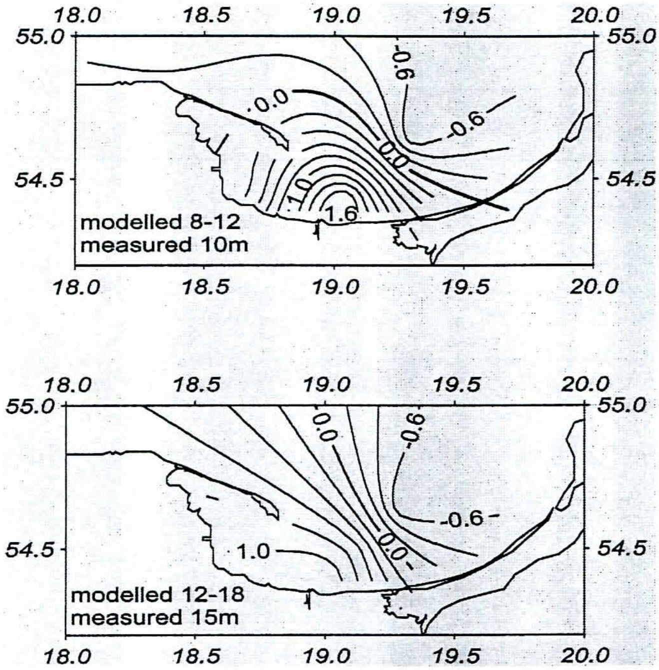

Fig. 18. Isolines of differences between measured and modelled salinity (25-26 September)

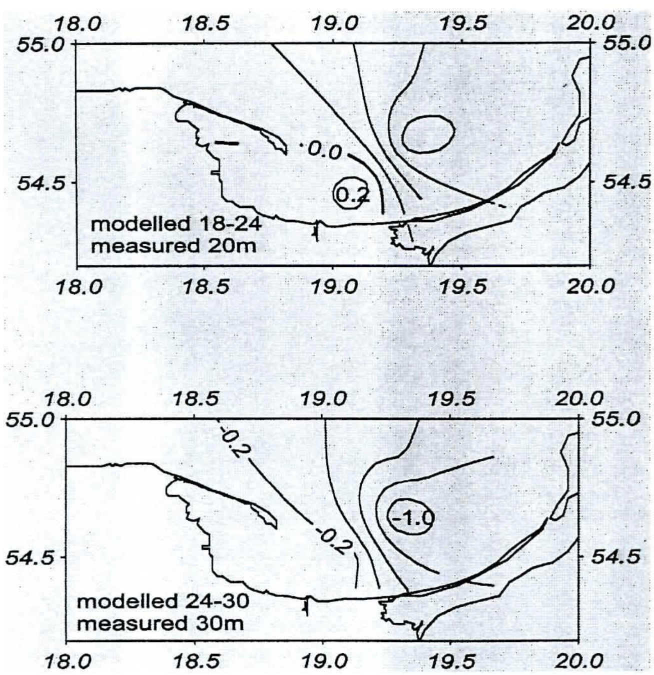

Fig. 19. Isolines of differences between measured and modelled salinity (25-26 September)