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## ASSESSMENT OF THE TEMPORAL VARIABILITY OF HYDRO-PHYSICAL PARAMETERS IN THE HIROMB MODEL

### Abstract

*Comparison between long-term measurements carried out during POLRODEX'97 experiment and results from HIROMB is presented. Analysis based on graphical presentation and statistical measure (reliability index) shows that model reproduces current direction fairly well, while current magnitude is underestimated. Time variability of salinity, temperature and water level variation reproduced by the model indicates discrepancies from observations.*

### 1. Introduction

POLRODEX'97 experiment was carried out in the region of the Bay of Gdańsk in the period 11<sup>th</sup>-30<sup>th</sup> September 1997.

This paper gives an overview of temporal variability of hydro-physical conditions during the experiment, based on long-term measurements of currents, salinity, temperature and their representation by HIROMB model.

### 2. Meteorological conditions during POLRODEX'97 experiment

Hydrodynamic conditions in the Gdańsk Bay region are dominated by meteorology over the area. Wind at the coastal station Hel (Fig. 1) at the beginning of September 1997 increased its speed from 2 till 10 m/s in the first decade of September. Next days velocity of wind varied in the range 2-6 m/s. Wind in the first decade of the month changed its direction from NE-E through S till NW. Next days direction was changeable in the range S-W-NW. Wind with its maximum speed was directed NW. Changes in wind conditions are reflected by variation of water levels at the coastal stations (Fig. 2) Gdańsk, Gdynia, Hel. In the first decade of September very pronounced increase in water level was registered at three stations mentioned above (from approx. 490 cm till 560 cm). Later, water levels at those stations varied between 510 cm and 550 cm. It is very characteristic that they have the same features, with small differences one from the other.

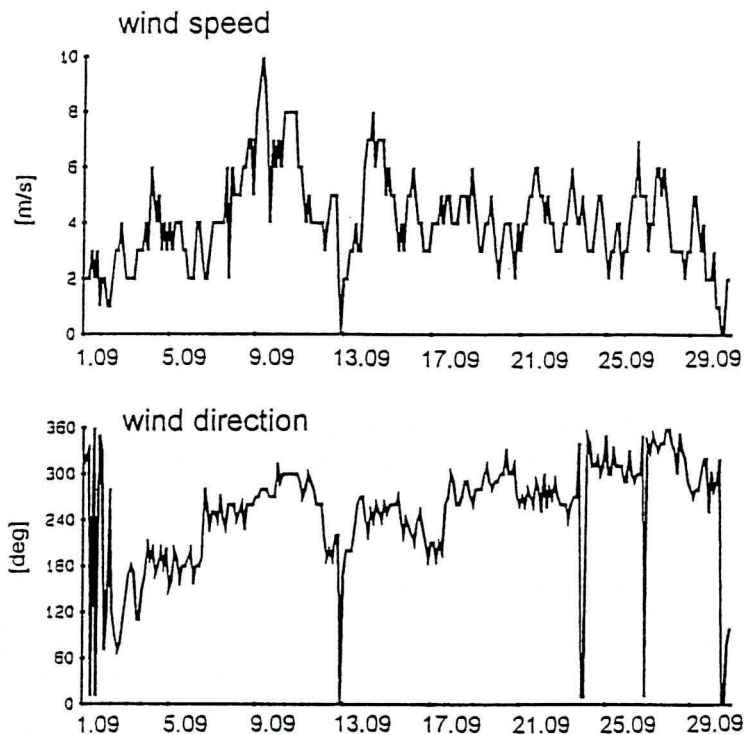


Fig. 1. Wind conditions at the coastal station Hel

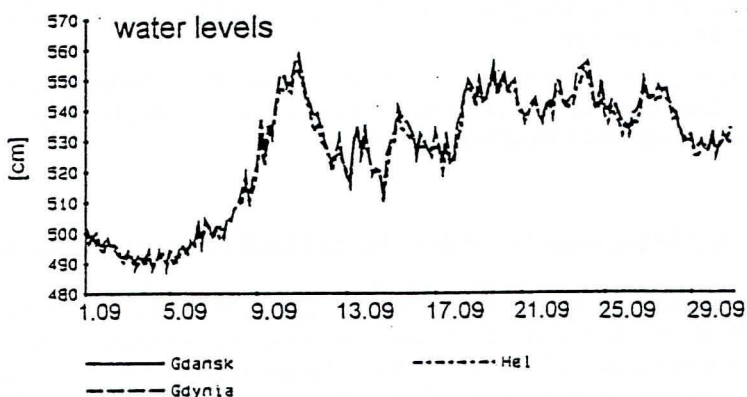


Fig. 2. Water level variation at the coastal stations Hel, Gdynia and Gdańsk

### 3. Measured versus modelled long-term changes: salinity, temperature, currents

Analysis of the temporal variability of hydro-physical parameters is based on long-term registrations from the following locations:

- BETA platform (55°29'N, 18°11'E):  
measurements on levels: 11 m, 35 m, 67 m:  
salinity, temperature, currents and variation of free surface, in the period 11-30.09.1997,
- ZN4 (54°40'N 18°50'E):
  - \* measurements on levels: 10 m, 40 m, 68 m – currents, in the period 22-25.09.1997;
  - \* measurements on level 52 m – currents, salinity, temperature, in the period 22-25.09.1997;
  - \* CTD measurements from 'ORP ARCTOWSKI' in the period 22-25.09.97 every hour.

### Results from the HIROMB model were delivered by SMHI every 6 hours.

Comparison between measured and calculated currents, salinity, temperature at three levels at BETA platform are shown in Figures 3, 4, 5, respectively. Variation of free surface elevation in the same location is given in Figure 6.

From these figures it is well seen that current magnitude is under-estimated by the model, while direction of current from the model resembles measurements. Salinity distributions in the same time are over-estimated, while water temperature is reproduced relatively well for depths 11 m and 67 m. Registration at the depth of 35 m shows change of termocline position during the experiment; this phenomenon is not reproduced by the HIROMB model.

Comparison between measurements and HIROMB model can be done by the use of statistics. Average velocity magnitude for the period of comparison is under-estimated on three levels very distinctively (~ 60%), while average direction is in relatively good agreement (Table 1). Analysis of the standard deviations for the above mentioned characteristics leads to a conclusion that as well current speed and its direction were very changeable within this period. Statistical values for salinity and temperature (Table 2) support conclusions drawn from overview of Figures 2, 3 and 4.

Table 1. Comparison between measured and calculated currents – statistical comparison – BETA platform,  $ERROR = [HIROMB - Measured]/Measured$

Level 11 m	Velocity magnitude [m/s]		Velocity direction [deg]	
	Measured	HIROMB	Measured	HIROMB
Mean	0.115	0.357901E-01	180.48	165.52
Standard dev.	0.081	0.0189	80.50	82.38
Error [%]	-68.8		-8.3	
Level 35 m				
Mean	0.927049E-01	0.341513E-01	173.344	224.252
St. dev.	0.060	0.024	92.74	85.7
Error [%]	-63.2		29.4	
Level 67 m				
Mean	0.944531E-01	0.380797E-01	169.531	216.133
St. dev.	0.055	0.028	94.81	85.48
Error [%]	-59.7		27.5	

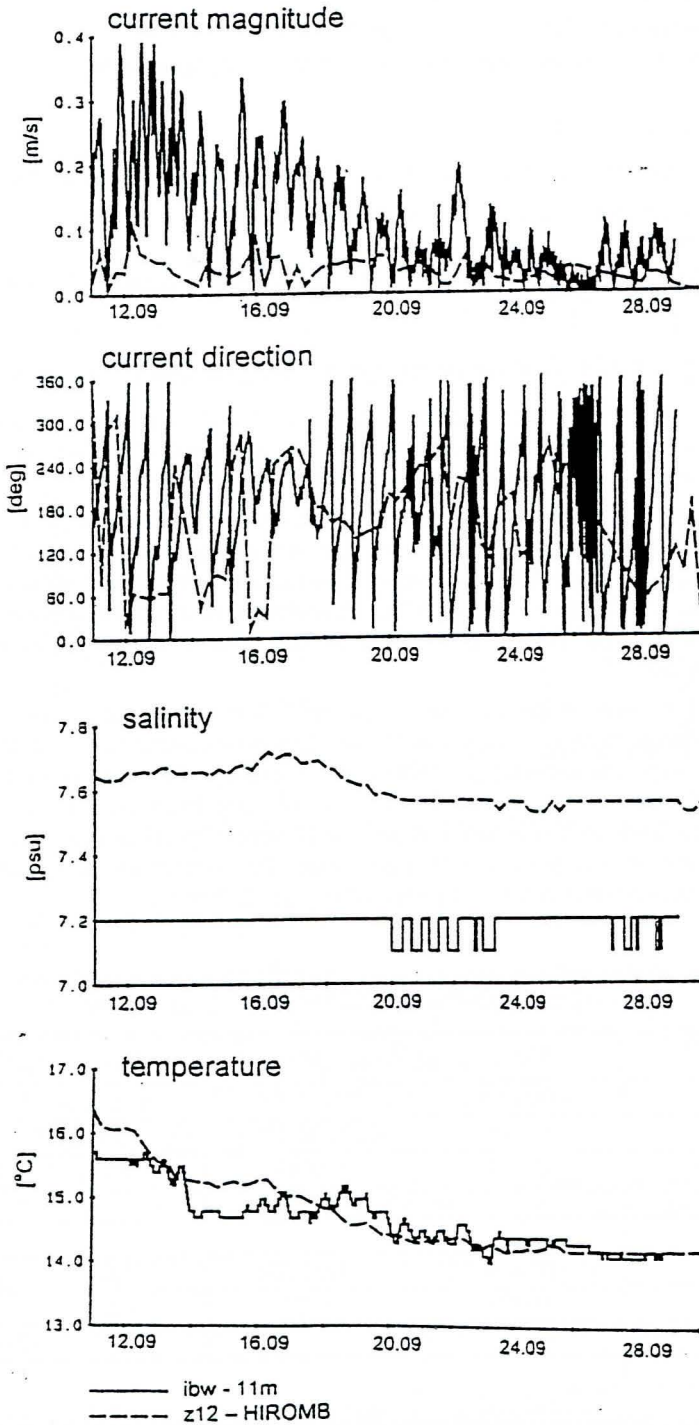


Fig. 3. Currents, salinity, water temperature measured and calculated by HIROMB model at the depth of 11 m at the BETA platform

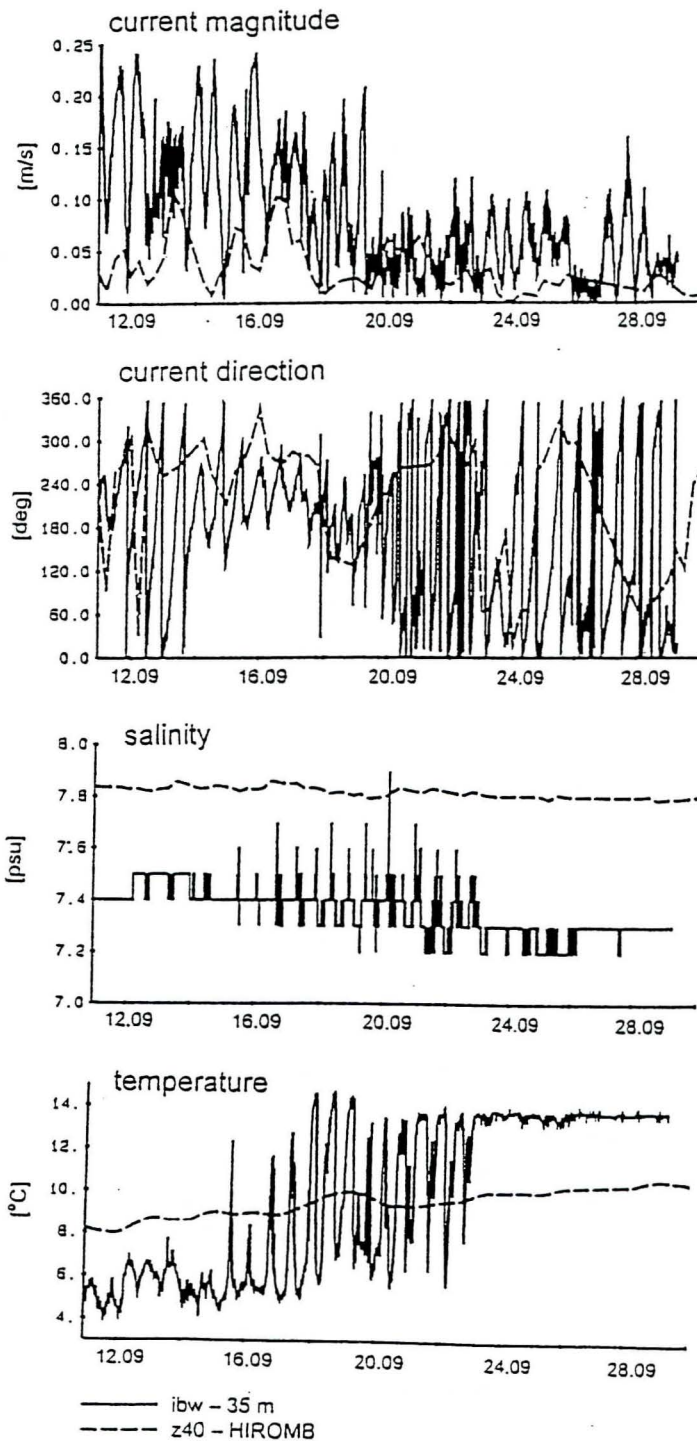


Fig. 4. Currents, salinity, water temperature measured and calculated by HIROMB model at the depth of 35 m at the BETA platform

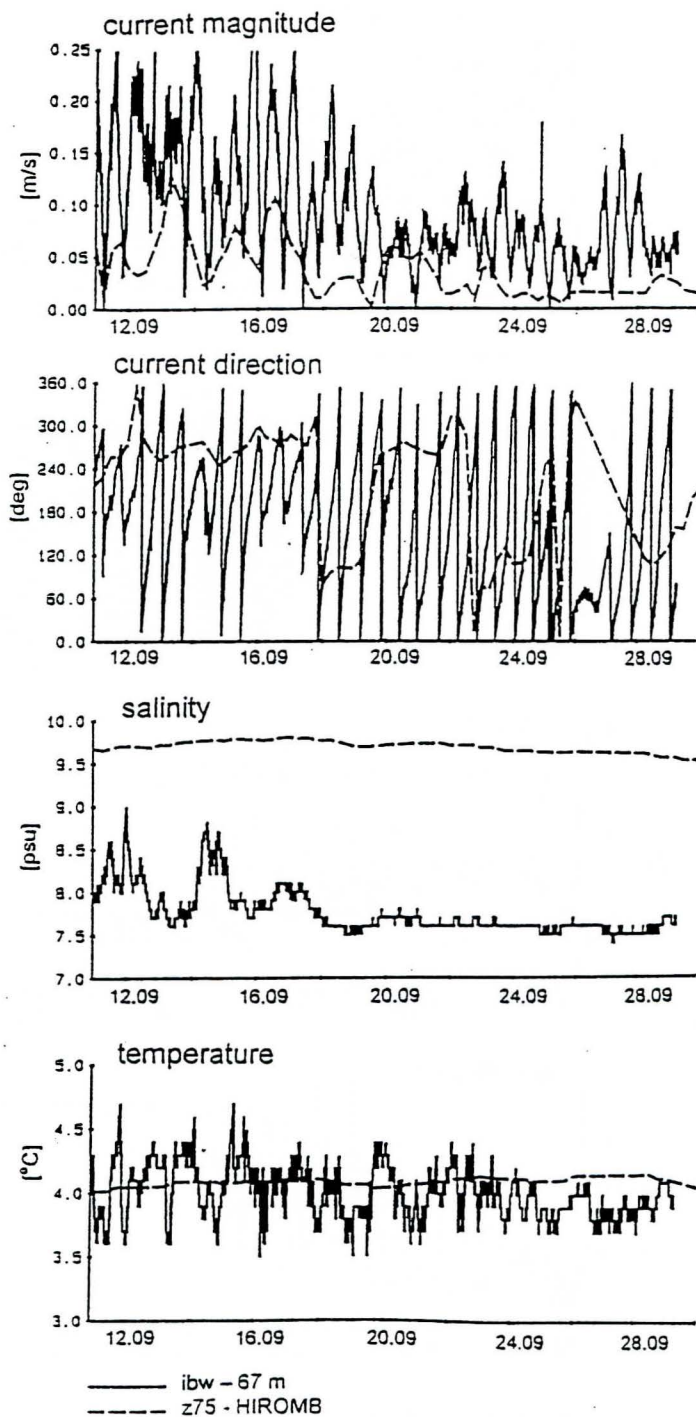


Fig. 5. Currents, salinity, water temperature measured and calculated by HIROMB model at the depth of 67 m at the BETA platform

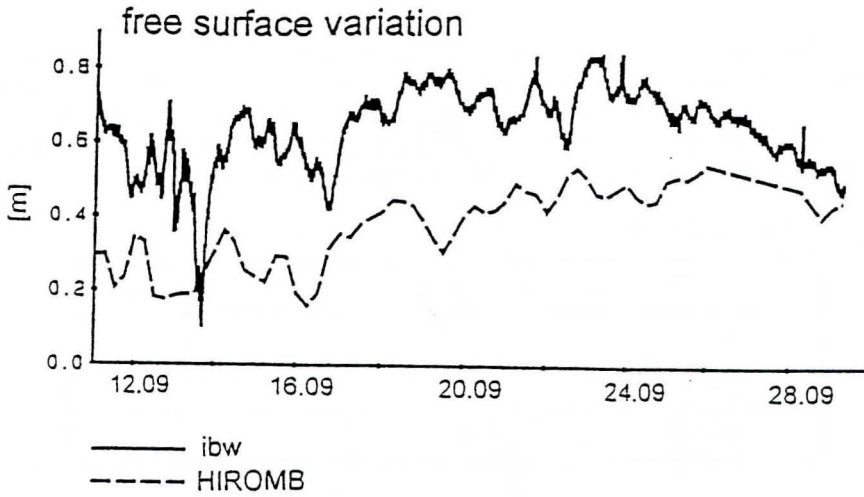


Fig. 6. Variation of free surface elevation measured and calculated by HIROMB at the BETA platform

Table 2. Comparison between measured and calculated salinity and temperature- statistical comparison - BETA platform

Level 11 m	Salinity [psu]		Temperature [°C]	
	Measured	HIROMB	Measured	HIROMB
Mean	7.19	7.61	14.74	14.80
Error [%]	5.8		0.41	
<b>Level 35 m</b>				
Mean	7.36	7.82	9.36	9.37
Error [%]	6.3		0.11	
<b>Level 67m</b>				
Mean	7.79	9.69	4.01	4.09
Error [%]	24.4		1.99	

Comparison between measured and calculated conservative parameters (e.g. salinity, temperature) including their temporal variability, can be done by the reliability index RI [1] defined as:

$$RI = \frac{1 + \sqrt{\frac{1}{T} \sum_{t=1}^T \left[ \frac{1 - \frac{Y_t}{X_t}}{1 + \frac{Y_t}{X_t}} \right]^2}}{1 - \sqrt{\frac{1}{T} \sum_{t=1}^T \left[ \frac{1 - \frac{Y_t}{X_t}}{1 + \frac{Y_t}{X_t}} \right]^2}}$$

$Y_t$  - observation for time  $t$ ;  
 $X_t$  - model result for time  $t$ ;  
 $T$  - number of data points in time.

Calculated indexes (Table 3) show clearly that salinity in the lower-most layer, and temperature in the intermediate layer are not well reproduced by the model. Water level variations represented by the model reproduce unsatisfactorily measurements (RI = 1.86). Comparison between mean values for salinity and temperature (Table 2) and RI indexes for the same layers enable to conclude that statistical measures can lead to wrong conclusions.

Table 3. Reliability index for salinity and temperature – BETA platform

Level [m]	RI – salinity	RI - temperature
8-12	1.059	1.019
30-40	1.060	1.470
60-75	1.540	1.059

Some examples of comparison between measured and calculated currents in location ZN4 are given in Figures 7-9, while those for salinity and water temperature in Figures 10-12. Statistical comparison between measured and calculated salinity and temperature distributions are shown in Table 4, while reliability indexes in Table 5. Results in location ZN4 indicate that salinity distribution in the HIROMB model is over-estimated in comparison with measurements; on the average about 10%. The reliability index for salinity displays poor agreement between model and measurements for the layer 40-50 m. Water temperature is well represented till the depth of 40 m; in the deeper part it is underestimated. Similar conclusions can be drawn based on reliability index (Table 5).

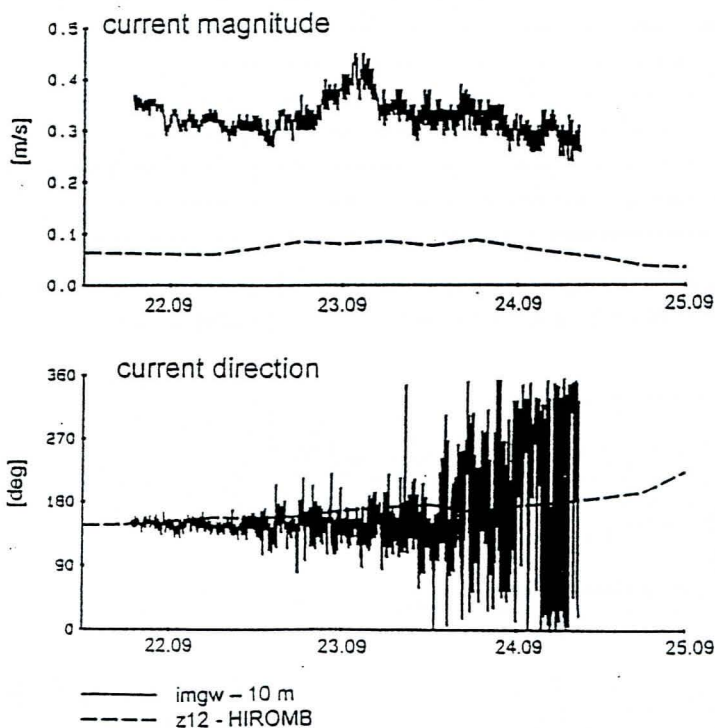


Fig. 7. Currents measured and calculated by HIROMB at location ZN4 at the depth of 10 m



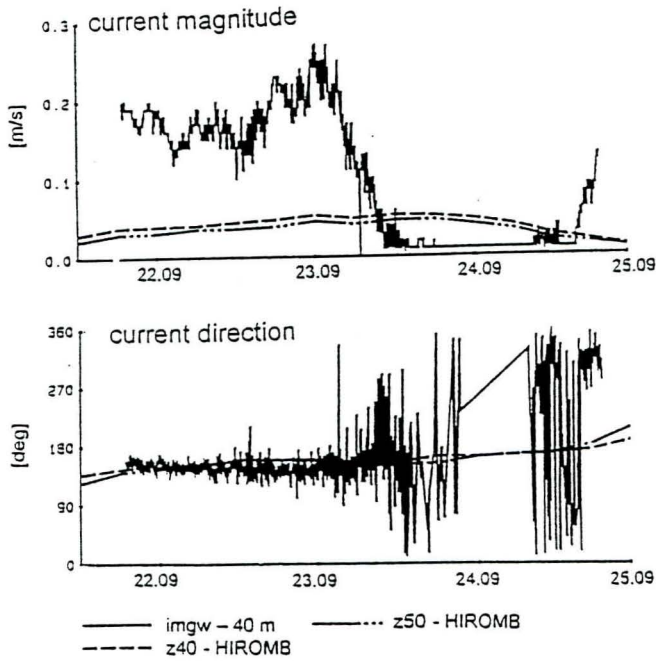


Fig. 8. Currents measured and calculated by HIROMB at location ZN4 at the depth of 40 m

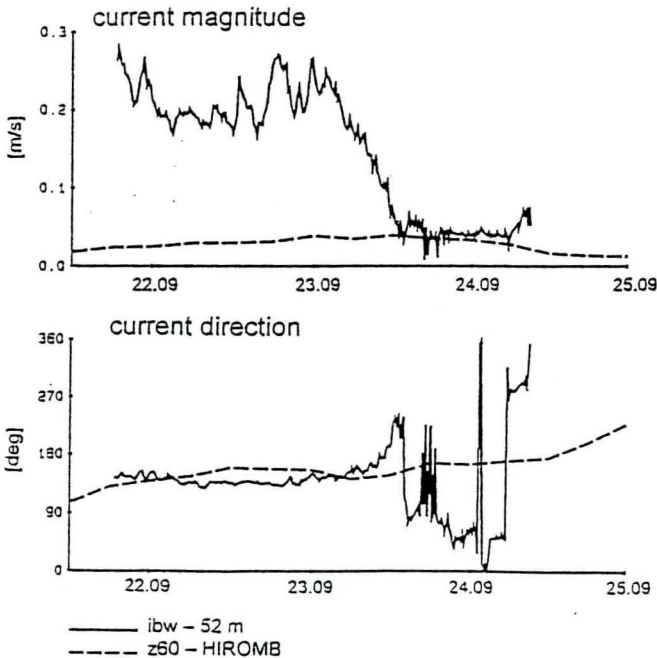


Fig. 9. Currents measured and calculated by HIROMB at location ZN4 at the depth of 52 m

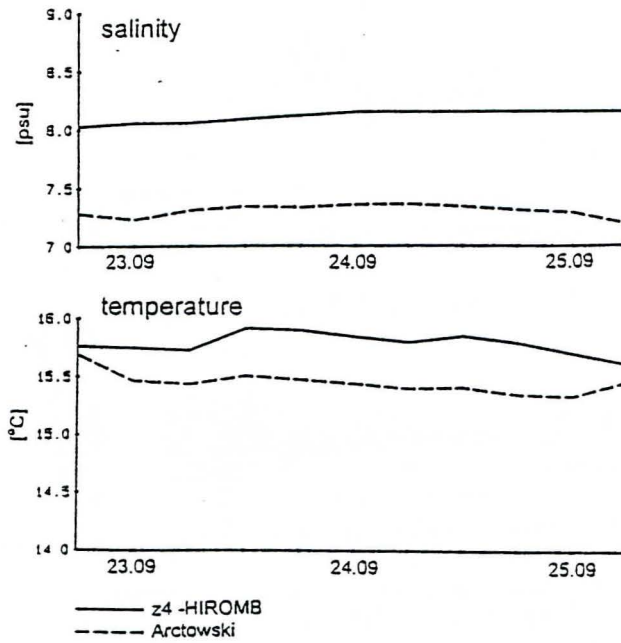


Fig. 10. Averaged salinity and temperature measured by CTD and calculated by HIROMB at location ZN4 at the depth of 0 - 4 m

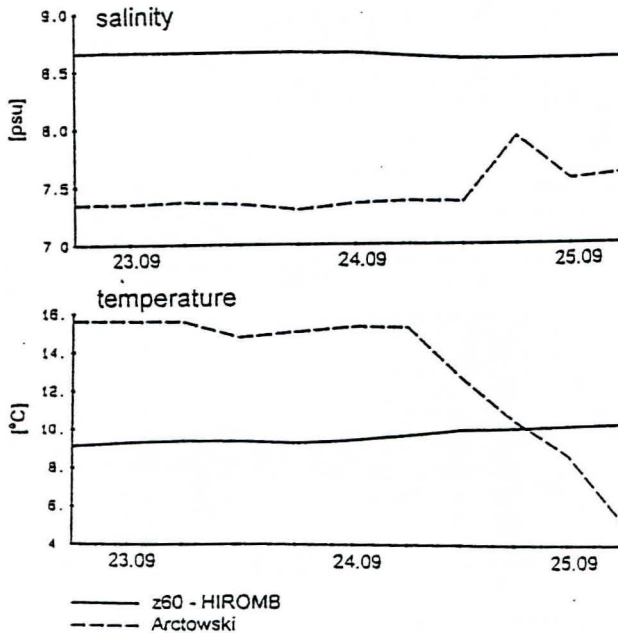


Fig. 11. Averaged salinity and temperature measured by CTD and calculated by HIROMB at location ZN4 at the depth of 50 - 60 m

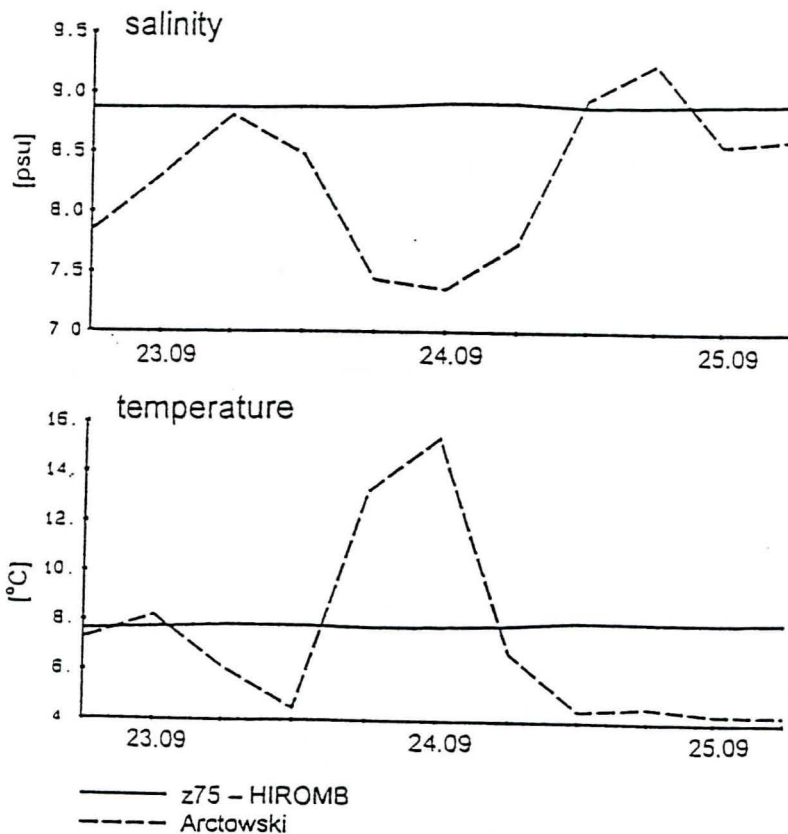


Fig. 12. Averaged salinity and temperature measured by CTD and calculated by HIROMB at location ZN4 at the depth of 60 - 75 m

Table 4. Statistical comparison for ZN4 based on measurements from 'ORP ARCTOWSKI'

Layer [m]	Salinity [psu]			Temperature [°C]		
	Measured	HIROMB	Error [%]	Measured	HIROMB	Error [%]
0-4	7.30	8.11	11.09	15.45	15.79	2.20
4-8	7.31	8.12	11.08	15.55	15.81	1.60
8-12	7.31	8.11	11.90	15.46	15.83	2.39
12-18	7.32	8.10	10.66	15.4	15.83	2.46
18-24	7.33	8.09	10.37	15.47	15.81	2.19
24-30	7.33	8.07	10.09	15.47	15.72	1.62
30-40	7.34	8.06	9.80	15.47	15.02	-2.90
40-50	7.35	8.24	12.10	15.46	12.52	-19.01
50-60	7.44	8.63	15.99	13.20	9.69	-26.59
60-75	8.31	8.89	6.98	7.21	7.89	9.43

Table 5. Reliability index for salinity and temperature - location ZN4

Layer	RI – salinity	RI – temperature
0-4	1.112	1.023
4-8	1.111	1.024
8-12	1.109	1.025
12-18	1.107	1.026
18-24	1.104	1.025
24-30	1.100	1.023
30-40	1.099	1.050
40-50	1.693	1.142
50-60	1.162	1.567
60-75	1.107	1.615

#### 4. Conclusions

Based on long-term measurements and results of HIROMB model the following conclusions can be drawn that:

- the analysed period was characterised by dynamic changes of currents in the water column, this phenomenon was not adequately represented by the model;
- in the second half of September change in thermocline position was observed; this phenomenon was not reproduced by the model accurately;
- salinity distribution was over-estimated by the model in comparison with measurements.

#### References

- [1] Leggett R.W., Willams L.R., 1981, *Reliability index for models*. Ecol. Model. 13.