Bulletin of the Maritime Institute

Gdańsk, 1999, 26, 1

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HIROMB FORECASTS VERSUS SPATIAL MEASUREMENTS OF THE CURRENTS BY MEANS OF RDI'S BBADCP DURING THE POLRODEX'97 EXPERIMENT

Abstract

The paper presents the observations of the flow field within central part of the Gulf of Gdańsk, which have been carried out during POLRODEX'97 experiment in September 1997 by means of BBADCP (Broad Band Acoustic Doppler Current Profiler). In the paper some results of comparison between predicted values and measured are presented as well. The goal of the experiment it was to collect the data in order to verify numerical model calculations and to study the method of the flow field reconstruction.

The cruise took place on the RV BALTICA, which carried a shipboard RDI's BBADCP measuring device. The measurements were carried out along parallel transects with 30 s frequency of the collected averaged bins, while velocities of the current were computed relative to the bottom. The flow fields were examined at all 1-meter layers from 8 meters depth down to the bottom layer on 22 -24 of September 1997. For the analysis, the data for one layer (mid value 12 m.) were selected and prepared for the comparison.

On the basis of the results of the measurements, quasi-synoptic flow fields were reconstructed. It made possible to compare them with the results of the HIROMB forecasts. In pre-analysis phase the two forecasts, i.e.: 24 hours for 22nd and 6 hours for 23rd forecast were compared with the measurements. It showed us that the best result would be obtained for shortest time span between measurements and forecast. So, for further analysis the 6 hours forecast for 23rd was used. Then, the statistical analysis of differences was carried out. In order to find any regularity of the differences distribution it is discussed their spatial layout as well. In general, the most significant differences occurred in the northern part of the investigated area. Differences increased from the centre of the gulf toward east and north. It was clearly seen that model reproduce current velocities and directions well mainly along the Hel Peninsula and in central part of the Gulf. In other areas, velocities of the predicted currents are of another order of magnitude than measured values.

Despite the results of the comparison between measured and modelled values, the collected data showed well-expressed pattern of the flow in the gulf what could be studied further.

1. Introduction

Velocity observations using shipboard Acoustic Doppler Current Profilers (ADCP) still are difficult in interpretation, however as a result of such measurements we acquire obser-

vations at wide range of depths frequently covering almost entire water column. When the cruise route is properly planned, then dense and widely distributed in space measurements allow for calculation of the current vectors in the nodes of the selected grid using the method of linear interpolation.

During POLRODEX'97 experiment in September 1997, the observations of the flow field within central part of the Gulf of Gdańsk have been carried out by means of RDI's BBADCP (Broad Band Acoustic Doppler Current Profiler). The goal of the experiment it was to collect of the sea current data in order to verify numerical model calculations and to study the method of the flow field reconstruction. Applying of the new method for sea current investigation as the result of new measuring technique implementation into routine oceanographic work seems to be very promising way for the sea dynamic studies as well as for numerical models verification. In the paper some results of comparison between predicted values and measured are presented.

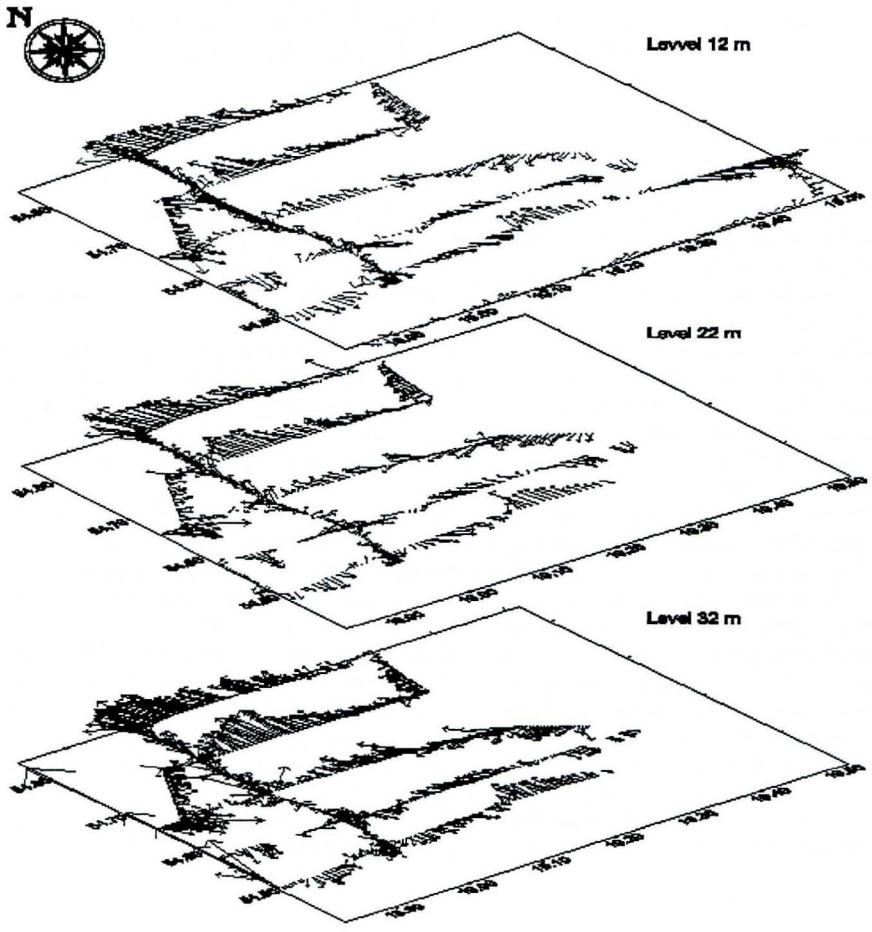

Fig. 1. Horizontal distribution of current vectors on three levels in the Gulf of Gdansk in September 1997

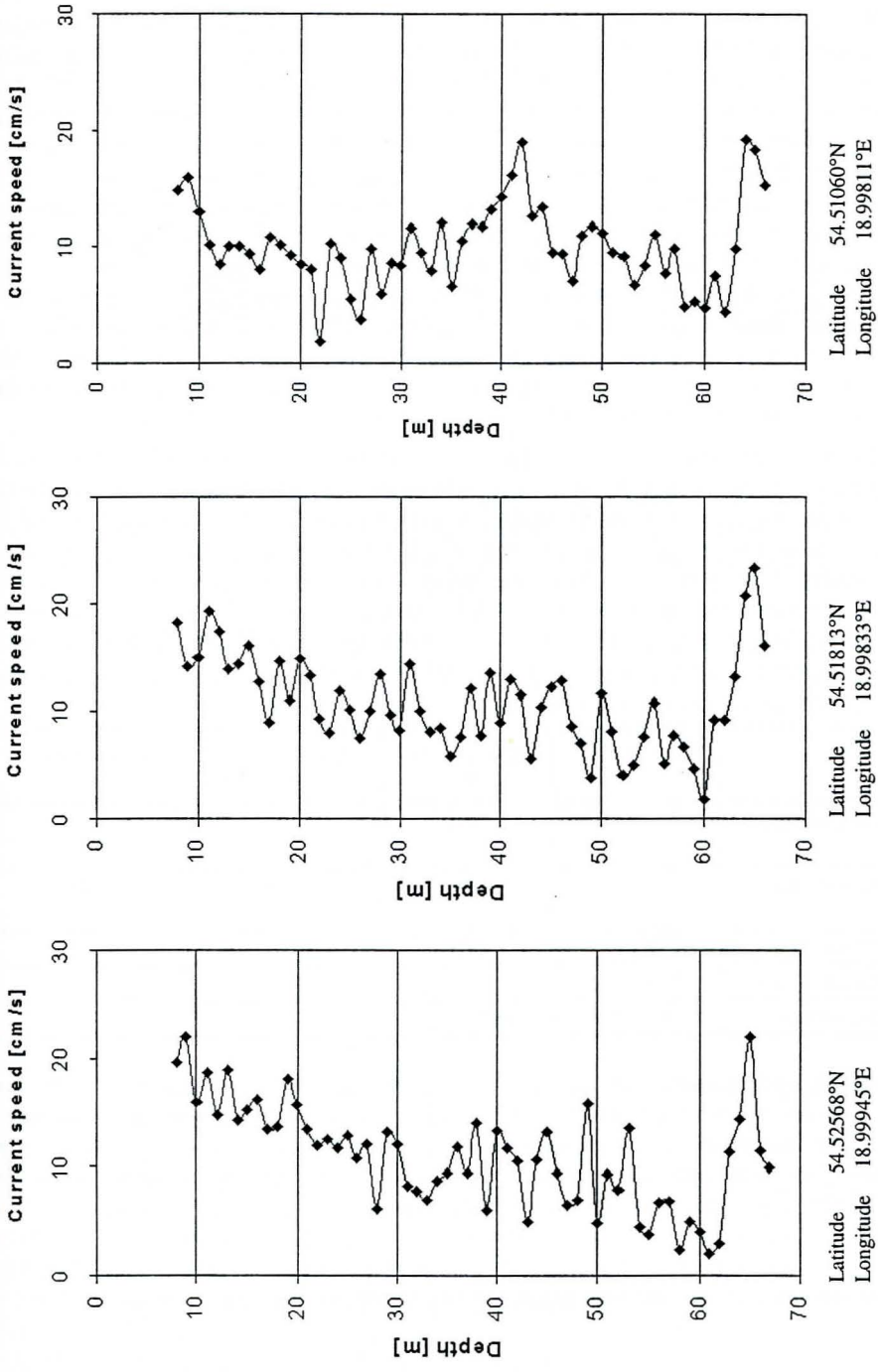

Fig. 2. Vertical distribution of current speed at selected locations in the Gulf of Gdańsk in September 1997

2. Material and methods

The cruise took place on board the RV "BALTICA", which carried the ship-mounted BBADCP, in 22 -24 of September 1997. The profiler was connected directly to the vessel navigation system, so that accurate positions and ship's course were acquired. The positions were received from a DGPS (Differential Global Positioning System) receiver, which provides more accurate positions than from a common GPS receiver. In whole were computed relative to the bottom. The measurements were carried out under way along parallel transects with 30 s frequency of the collected averaged bins. Due to the ship speed (app. 8 knots) each averaged value covers distance app. 125 meters. The flow fields were examined at all 1-meter layers from 8 meters depth down to the bottom layer. Recorded data has been worked out in order to obtain separate data sets for all layers pointed out by the reference levels: 12 m, 13 m, 14 m, 15 m, 16 m, 17 m, 22 m, 32 m., etc. Horizontal distribution of the current vectors in three selected layers: 12 m, 22 m and 32 m depth is presented on Fig. 1. Although in upper layer vertical distribution of current velocities is quite uniform, in the near bottom layer we observe significant change of the velocities (Fig. 2). High vertical gradient of the velocities is visible well.

The data from one-meter layer (mid-value 12 m) were selected and prepared for the analysis and comparison with the model. As the first step, quasi-synoptic flow field was reconstructed on the basis of measurements. Applying the method of linear interpolation, the components Vx and Vy of the current vectors have been calculated separately. In order to evaluate reliability of the reconstruction, statistical analysis of the differences between measured and interpolated values was performed. The results may be regarded as confident in light of obtained values of statistical parameters as they are presented in the table below. An average vector of the differences as calculated on the basis of average values of components differences ΔVx and ΔVy may be regarded as so small despite the value of direction difference.

	Component Vx	Component Vy	Average vect. Current speed	Average vect. Current dir.
Number of compared values	1416	1416		
Average difference (ΔVx, ΔVy)	0.50 cm/s	0.39 cm/s	0.63 cm/s	52.07^{0}
Standard Deviation	4.19	4.77		
Minimum difference	-20.01 cm/s	-22.76 cm/s		
Maximum difference	30.25 cm/s	23.56 cm/s		

In general, approximation of the flow field is sufficiently good, resulting with very small average error of the current speed and direction. As it can be seen from the probability distribution, most differences occur within the range ±5 cm/s. Some significant errors can be found in some exceptional cases only, mainly in the end of transects, where the changes of the ship's course took place. Hence, assuming uniformity of the flow field in time, velocity and direction of the currents were calculated for the nodes of HIROMB model (Fig. 4). It made possible to compare interpolated values with the results of the HIROMB predictions. In pre-analysis phase the two forecasts, i.e.: 24 hours for 22^{nd} and 6 hours for 23^{rd} were compared with the measurements. It showed us that the better result would be obtained for the shortest time span between measurements and forecast. Hence, for further analysis the 6 hours forecast for 23^{rd} was selected. Two different sets of data we-

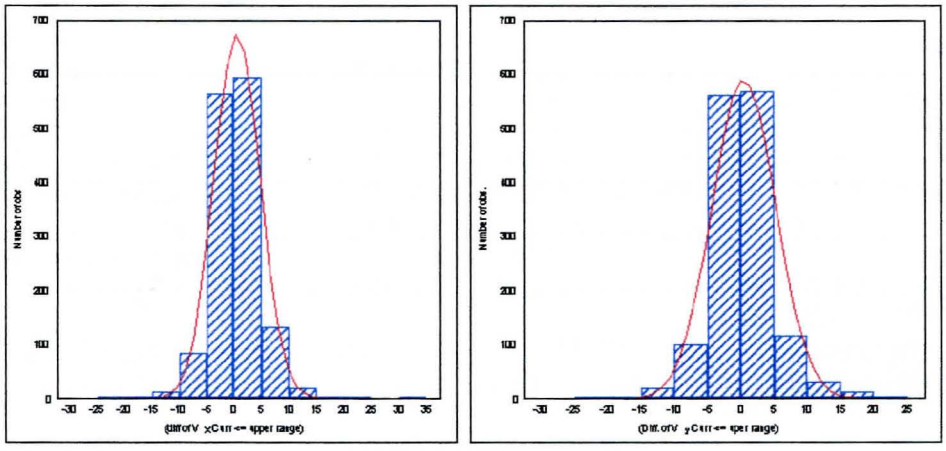

Fig. 3. Histograms of differences between measured and interpolated values of the current vector components *Vx* and *Vy*

re selected for the analysis. The first one it was set of components of the current vectors, and the second one it was set of speed and direction. The interpolated values were compared with predicted values, thus the differences were statistically analysed.

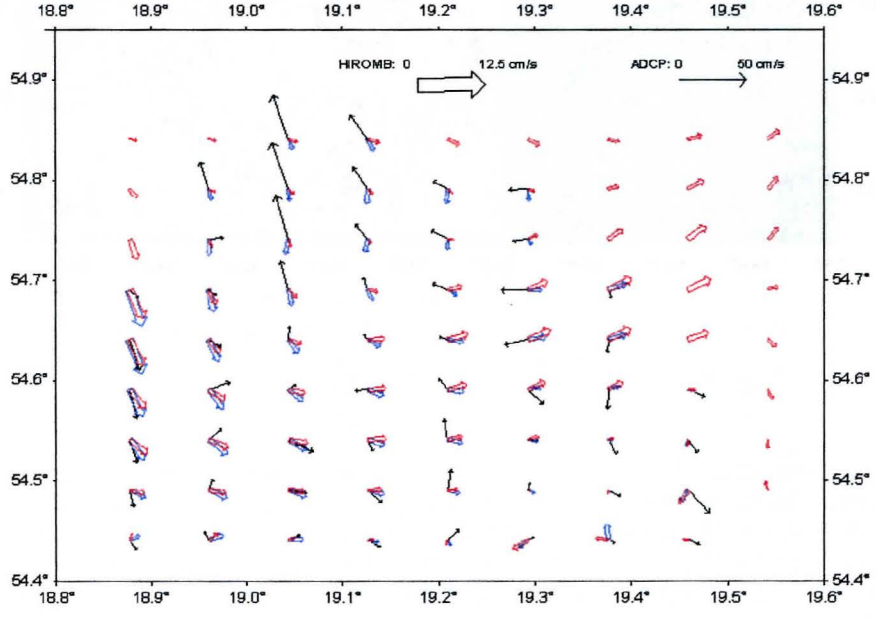

Fig. 4. Comparison between predicted by HIROMB and interpolated ADCP data for level 12 m:

- ADCP - thin arrows - measurements on 23.09.97
- HIROMB - thick blue arrows - forecast 6 h from 23.09.97
- HIROMB - thick red arrows - forecast 24 h from 22.09.97

Note: different scales are used for ADCP and HIROMB vectors

3. Discussion of the results

Accordingly to the results of the investigations carried out by Maritime Branch of IMGW in Gdynia in 1994-1997, it has been proved that ADCP-type measuring device is very useful mean for detection of subsurface currents in the Gulf of Gdańsk (Krzymiński 1993, 1996, 1997; Krzymiński, Lauer 1995, 1996). The only one limit for selection of the first upper layer it is the mounting depth of the device, which is usually located beneath the keel of the ship. From the experience it is known that the first layer that may be used for analysis this could be 10 m. Consequently, ADCP data from layer 12 meters depth (due to model layers), were selected for comparison with values of current speed and direction as predicted by HIROMB.

The differences between measured and predicted current velocities are depicted on figure 5. The most significant differences occur in the northern part of the area of investigations.

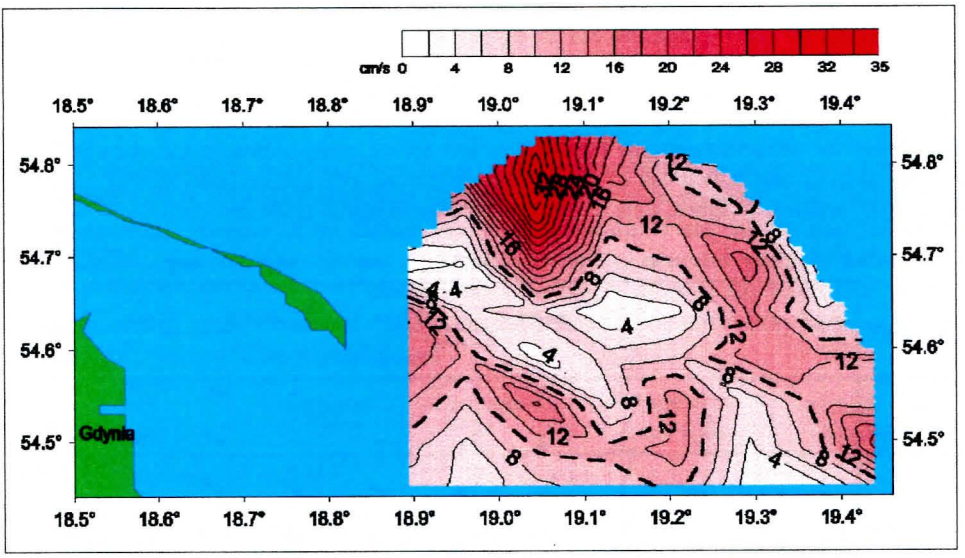

Fig. 5. Horizontal distribution of the difference between measured (ADCP) and predicted (HIROMB) current speed at 12-m depth
ADCP – interpolated, HIROMB data – 6 hours forecast for 23.09.97

Better results are observed in the central part along NW-SE line, starting from Hel Peninsula. The histograms of the differences (Fig. 6) represent a very wide range of differences from -15 to 15 cm/s, related mainly to the eastern and northern parts of the investigation area (Fig. 7). Whereas the differences being found close to the edges of the investigated area could be neglected due to interpolation errors, the others found in the northern part indicate significantly improper representation of the circulation pattern by the model.

Results of statistical analysis, which are presented in the following table, indicate that the best fit of predicted data occur in the case of velocity vector component *Vx*. Average difference is less then 1 cm/s, while in the second case the result is worse and is equal 3.1 cm/s, however there is practically no correlation between these components (Fig. 8). Better results have been obtained for direction and current speed, where weak correlation is observed.

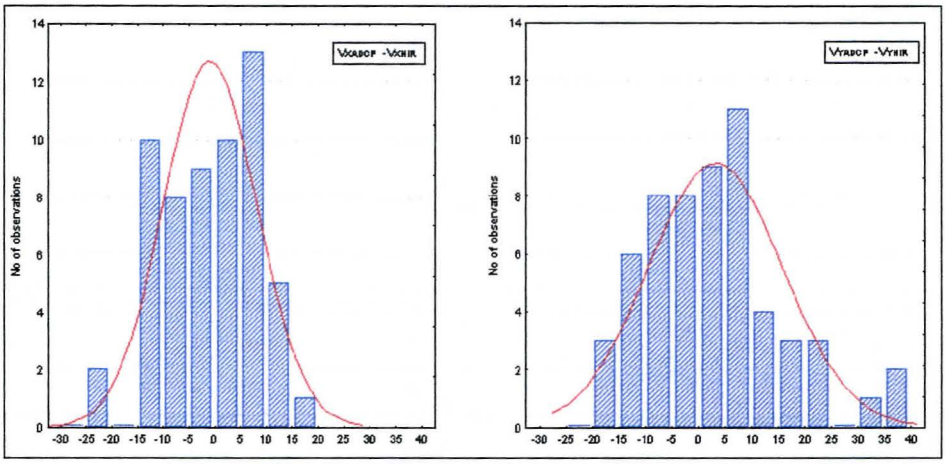

Fig. 6. Histograms of the differences between measured (ADCP) and predicted (HIROMB) components of current vectors at 12-m depth

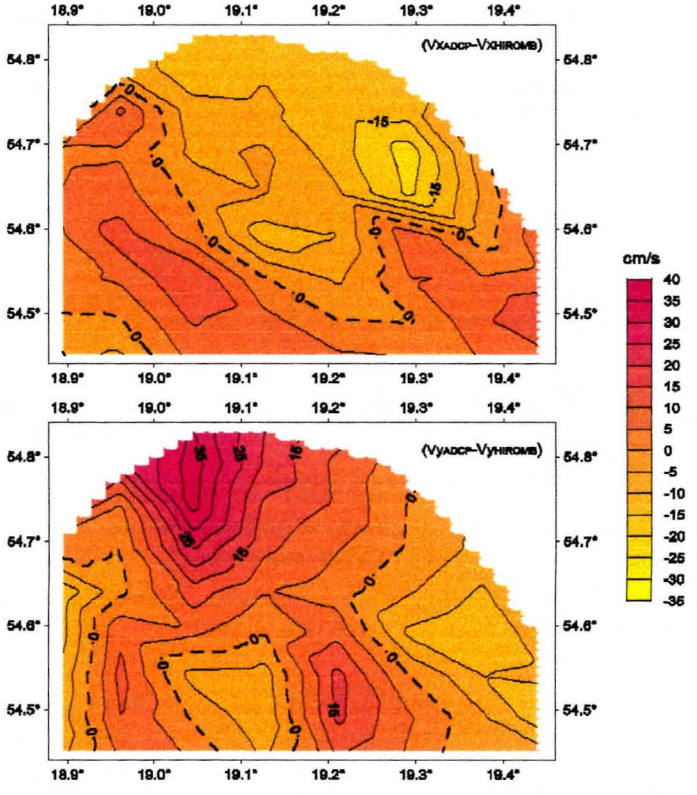

Fig. 7. Horizontal distribution of the differences between measured (ADCP) and calculated (HIROMB) components (*Vx, Vy*) of the current vectors at the depth 12 m ADCP data - interpolated, HIROMB data - 6 h forecast for 23.09.9

Variable	N. obs.	Mean	Conf. –95%	Conf. +95%	Min.	Max.	Standard deviation
ΔV_x [cm/s]	58	-0.94	-3.34	1.45	-22.32	16.86	9.11
ΔVy [cm/s]	58	3.13	-0.2	6.46	-16.42	37.40	12.65

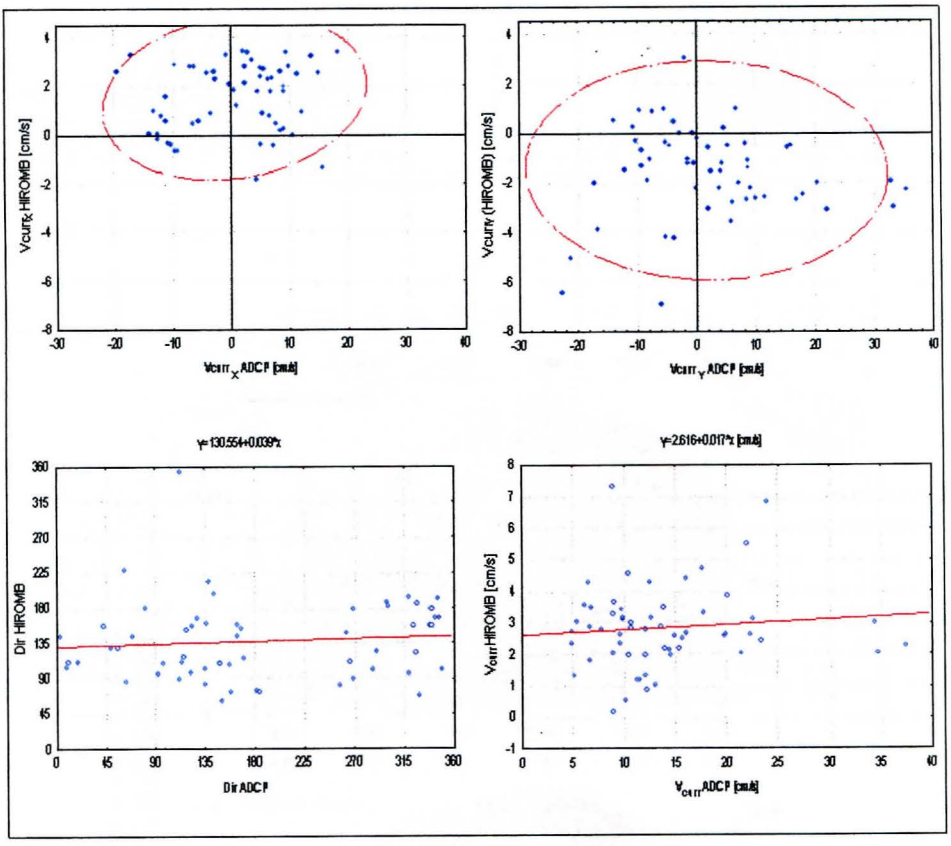

Fig. 8. Regression analysis of the components of current vectors obtained from measurements and numerical calculation

The upper pictures are related to the components *Vx* and *Vy* of the current vectors. Lower pictures are related to direction and current speed.

Regression analysis of spatial layout of the differences between predicted and measured values yields with the result showing some regularity in their location related to the shape of the coast and depth of the area, however there in no linear regression (Fig. 9). In general, differences increase from the centre of the gulf toward east and north. The model reproduces current velocities and directions well mainly along Hel Peninsula and in central part of the Gulf, while the circulation is improperly calculated for open sea and deep area. Be-

sides it, the velocities of the predicted currents are of another order of magnitude than measured values almost in whole area.

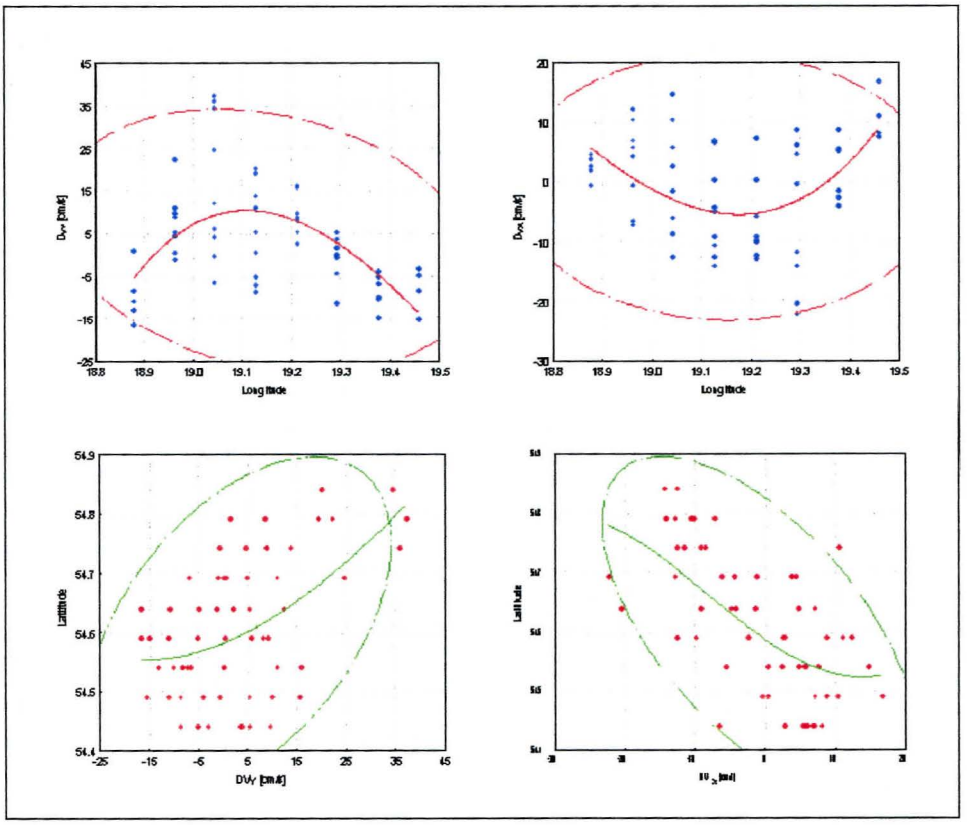

Fig. 9. Regression analysis of spatial distribution of the differences between measured and predicted values
Regression curves are approximated by negative exponential function.

Regardless of the results of the comparison between measured and modelled values, collected data show well-expressed pattern of the flow in the Gulf of Gdańsk, what will be studied further. In addition, studies on differences between measured and predicted currents for other layers will be continued.

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