COPEDEC VI, 2003, Colombo, Sri Lanka

Integrated approach to environmental impact assessment of transboundary waters of the Vistula Lagoon

by

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ABSTRACT

The Vistula Lagoon is one of the largest transboundary lagoons in the Southern Baltic Sea. Poland and Russia share the Lagoon therefore only integrated approach to solve environmental problems may provide successful solutions. In order to follow this idea a mathematical modelling system (2D Mike 21) describing both physical and chemical processes in the Vistula Lagoon, will be applied as a tool for describing hydrodynamics, as well as for the assessment of water quality status of the Lagoon.

Within a transboundary basin it is a very frequent problem that the data, necessary for running the models, are not always freely available. In case of the Vistula Lagoon, Poland and Russia (Kaliningrad Region) do not have a common data base and they do not exchange the data on a day to day basis. Therefore it is a recommended solution to build an operational modelling system that will predict hydrodynamics in the Lagoon on the basis of the existing observations from permanent stations at each country. For that purpose two operational models may be used: HIRLAM and HIROMB. HIROMB is a baroclinic multi-layer Baltic Sea model predicting water levels, current velocity and direction at the open boundary in the Gulf of Gdańsk. HIRLAM model is a limited area atmosphere model giving the wind forecast data. It is possible to use the operational models independently both in Poland and Russia for short-term forecast for the entire area of the Vistula Lagoon with use of Mike 21 system. Time and space distributions of the water level, mean current speed and direction in the entire area would be the results of the calculations.

In the paper it is presented how in practice the operational models may be used for integrated water management, as well as the comparison of results acquired with use of the data from operational models and monitoring.

1. INTRODUCTION

The Vistula Lagoon is one of the largest transboundary lagoons in the Southern Baltic Sea (Fig. 1). It is a shallow (av. depth 2.7 m) coastal ecosystem located on the Polish-Russian border.

Two countries share the Lagoon therefore only integrated environmental impact assessment may provide successful solutions. In order to achieve this goal a mathematical modelling system (2D Mike 21) describing both physical and chemical processes in the Vistula Lagoon, will be applied as a tool for describing hydrodynamics, as well as for the assessment of water quality status of the Lagoon.

Within a transboundary basin it is a very frequent problem that the data, necessary for running the models, are not always freely available. In case of the Vistula Lagoon, Poland and Russia (Kaliningrad Region) do not have a common data base and they do not exchange the data on a day to day basis. Therefore it is a recommended solution to build an operational modelling system that will predict hydrodynamics in the Lagoon on the basis of the existing observations from permanent stations at each country. For that purpose two operational models may be used: HIRLAM and HIROMB. HIROMB is a baroclinic multi-layer oceanographic model, operationally run in the Swedish Meteorological and Hydrological Institute, for the use in the entire Baltic Sea. The model predicts water levels, current velocity and direction at the open boundary in the Gulf of Gdańsk. HIRLAM model is a limited area atmosphere model giving the wind forecast data.

The access to these data for prognostic purposes is free for the countries that are members of the HIROMB Agreement. Poland and Russia are invited to the Agreement. It means that authorities responsible for water management (end-users) in Kaliningrad Region and in Poland have the access to the HIROMB and HIRLAM digital forecast.

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Figure 1: Location of the Vistula Lagoon.

It is planned that the described above approach will be used independently both in Poland and Russia. Polish and Russian end-users will be able to collect the wind forecast data from the meteorological model HIRLAM and water level and current data - from the oceanographic model HIROMB. Next, the observed water level data from national gauges will be used in order to tune the open boundary condition. From the Polish side, water level data from Krynica Morska, Gdańsk, and Hel (Fig. 1) may be taken. Russian end-user may take the data from Pionerskiy and Baltiysk stations (Fig. 1). After completing these tasks, the end-user can initiate a short-term forecast for the entire area of the Vistula Lagoon with use of Mike 21 system. Time and space distributions of the water level, mean current speed and direction in the entire area would be the results of the calculations.

In the paper it is presented how in practice the operational models may be used for integrated water management as well as the comparison of results acquired with use of the data from operational models and monitoring.

2. CHARACTERISTICS OF THE VISTULA LAGOON

Vistula Lagoon is located in the south-eastern part of the Baltic Sea, east of the Gulf of Gdańsk (Fig. 1). The Lagoon has an elongated shape, going from south-west to north-east, with a length of 91 km. The average width of the Lagoon is about 9 km, at the widest point - 13 km. The surface area is 838 km^2, of which 473 km^2 belongs to Russia, and the remaining part to Poland (Łomniewski, 1958). The length of the coastline is of about 270 km, and the volume of water in the Lagoon is about 2.3 km^3. The average depth of the Lagoon is 2.7 m, and the maximum natural depth is 5.2 m close to the Baltiysk Strait.

The Vistula Lagoon is separated from the Baltic Sea by the Vistula Spit - a sand peninsula 55 km long. The Lagoon exchanges water with the sea through the Baltiysk Strait, which has a width of approximately 400 m, length of two kilometers and the average depth of 8.8 m. Currents in the Baltiysk Strait vary during a year. Mostly these are unidirectional currents over the depth (65%) from which 44% falls to an outflow and 21% - inflow. 7% falls to two-layer currents and 28% to two-stream currents. Two-layer and two-stream regimes are to be considered as intermediate reorganization processes (Lazarenko, Majewski, 1975).

Baltiysk Strait continues up to the harbor of Kaliningrad as a fairway (navigation channel) crossing the Lagoon. The channel is twice deeper than the largest natural depth in the Lagoon. Despite its relative narrowness, it plays an important role as a way of salt transport from the Gulf to the Lagoon.

The currents and water level fluctuations in the Lagoon are determined by three factors: river discharges, wind action and water level changes in the Baltic Sea. There are no tidal fluctuations inside the Vistula Lagoon.

The main controlling factor for the Vistula Lagoon water levels and currents is the wind, even during the period of high spring river discharges. The water level changes caused by the variations of the Baltic Sea are significant only close to the Baltic Strait and the Kaliningrad navigation channel.

The Kaliningrad navigation channel plays an important role in the Lagoon water dynamics. As a rule, the channel compensates for wind-driven currents in the mouth of the Pregola River, i.e. at the channel currents directed against wind (over all depth, or only near sea bed) may occur.

Practically every year ice forms in the shallow regions of the Vistula Lagoon. However, depending on the winter temperature, ice-coverage is rather variable in different years. Most often the entire Lagoon is covered practically simultaneously, with the exception of Kaliningrad navigation channel and the Baltiysk Strait, because of intensive shipping activity. The average duration of ice-coverage is about 58 - 63 days during the winter season (Lazarenko, Majewski, 1975).

With respect to salinity the Vistula Lagoon is found to be a transitional area. The average salinity (1950 - 1965) for the eastern part of the Lagoon (spring-autumn) is 2.5-4.3 PSU, for the central part 3.9-5.0 PSU, and for the southern part 1.0-3.4 PSU (Lazarenko, Majewski, 1975). This is a result of salt water inflows from the Baltic Sea that influence all aquatic areas of the Lagoon, including the mouth of the Pregola River. At the Baltiysk Strait salinity may reach 7 PSU (Bocheński, Talaga, Olech, 1999).

The prevailing winds above the Lagoon are from south-west direction. The average wind speed is between 4 and 6 m/sec, and the probability of calm weather is from 3 up to 4% (Lazarenko, Majewski, 1975).

The catchment area of the Vistula Lagoon is 23,871 km^2. Major rivers discharging into the Lagoon are: Pregola, Elbląg, Pasłęka, Nogat, etc. (Fig. 2).

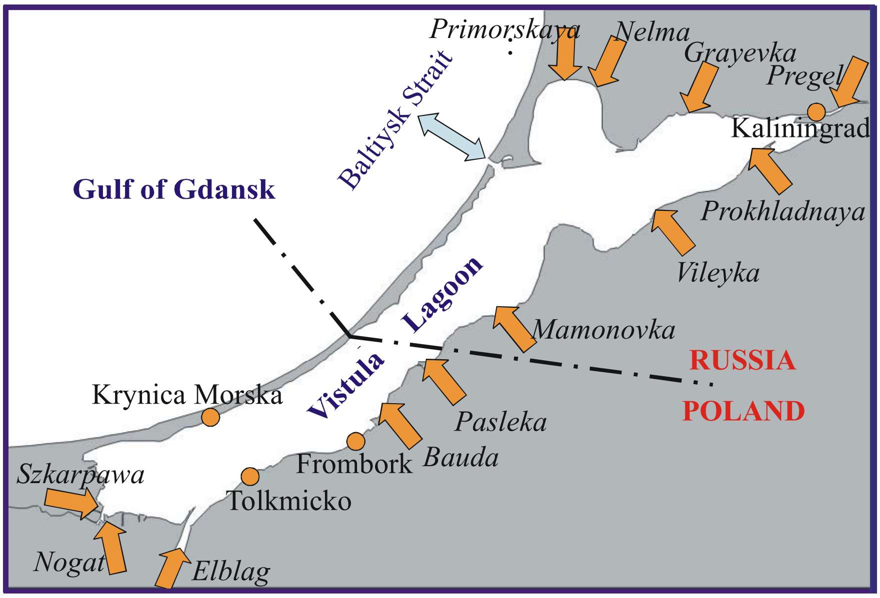


Figure 2: Schematic map of the Vistula Lagoon and discharges to the Lagoon.

The main part of the annual fresh water inflow (40%) is coming from the Pregola River (Tab. 1). In 1998 it was 42% and dropped to 39% in the next 1999 and 2000 years.

RIVER	Year 1998	Year 1999	Year 2000	Average from years 1998 - 2000
Polish Rivers				
Pasłęka	20,7	23,7	18,9	21,1
Elbląg	28,8	26,0	24,3	30,9
Nogat	16,5	18,6	10,9	15,6
Bauda	3,1	2,9	2,2	2,7
Sum Rivers	**69,1**	**71,2**	**56,3**	**70,3**
Russian Rivers				
Pregola	65,5	59,3	48,0	57,6
Mamonovka	5,7	5,4	5,4	5,5
Prokhladnaya*	11,2	12,8	10,2	11,4
Nelma	2,3	2,2	1,7	2,1
Sum Rivers	**84,7**	**79,7**	**65,3**	**76,6**

** - estimated discharge due to missing data for 1998 – 2000*

Table 1: Discharges from main Polish and Russian rivers (m^3/s) in years 1998 – 2000 based on information from Institute of Meteorology and Water Management, Regional Water Management Board - Poland and Roshydromet - Russia

The water balance for Vistula Lagoon is presented in Table 2.

	Ingoing (km^3)	%
Water from the rivers	3.62	17.1
Marine inflow	17.00	80.2
Precipitation	0.50	2.4
Ground water	0.07	0.3
Total	21.19	100.0
	Outgoing (km^3)	%
Flowing to the sea	20.48	96.9
Evaporation	0.65	3.1
Total	21.13	100.0

Table 2: Water balance of Vistula Lagoon (1951-1965, [(Silicz, 1975)

The main inflow (80%) is coming through the Baltiysk Strait as marine waters. The total volume of marine water inflowing to the Lagoon during 24 hours is estimated as 23 million cubic meters, which makes about 1% of the total water body of the Lagoon (Chubarenko B. & Chubarenko I., 1998). 17% of the inflow is coming from the catchment. Atmospheric precipitation and underground discharge make up about 3% and are almost equal to the part of the balance originating from evaporation. Thus, the major contributor to the water balance of Vistula Lagoon is the water exchange through the Baltiysk Strait.

3. MODELLING APPROACH

Transport of substances in the water body depends on forces, determining water motion. Real atmospheric conditions, water exchange with the Gulf of Gdańsk and river discharges have to be known for long-term integration of the equations of hydrodynamics. On the basis of the calculated currents and nutrient inputs, water quality parameters may be determined.

In order to model water quality, i.e. transport of substances dissolved in water and their processes, first water hydrodynamics have to be determined and calibrated. In case of missing data for calibration of water currents, it is possible to use water levels and salinity data (as an indirect method) for hydrodynamics calibration. This approach allows also for preliminary calibration of transport processes. Such procedure was applied the presented case study of the Vistula Lagoon.

In the past various numerical models were applied to investigate flow fields and mass transport in the Vistula Lagoon. First 2D models were used in order to simulate storm surges in the Lagoon (Catewicz, Jankowski, 1983, Szymkiewicz, 1992). Later, starting from 1994, two-dimensional deterministic model Mike 21 developed in the Danish Hydraulic Institute (DHI) was used. The system comprised few different modules: hydrodynamics, water quality and eutrophication that were used for modeling of hydrobiological and hydrochemical processes (Ołdakowski, Kwiatkowski, 1995, Chubarenko B. & Chubarenko I., 1997, Kwiatkowski, Rasmussen, Ezhova, Chubarenko B., 1997, Chubarenko I., Tchepikova, 2001).

At present the Mike 21 modelling system (DHI - Water & Environment, 2001) has been applied again to assess hydrodynamics and consequences of river basin inputs on the Vistula Lagoon water quality, after the economic changes in Poland and Russia in the 1990's. This time possibility of operational models usage (HIROMB, HIRLAM, UMPL) has been tested. Small Lagoon depths (mean value 2.7 m) allow for 2D simplification.

One-year period (1998) served for the model calibration and then the model will be validated using data from the period of 1999-2000. Calibrated and validated model will be used to assess influence of the climatic conditions and different scenarios of anthropogenic impact on the selected water quality indicators.

3.1 Mike 21 model description

Mike 21 is a software package containing a comprehensive modelling system for 2D free surface flows. It may be applied to the simulation of hydraulic and related phenomena in lakes, estuaries, bays, coastal areas and seas where stratification can be neglected.

Mike 21 is a result of more than 20 years of continuous development and is tuned through the experience gained from thousands of applications worldwide. DHI continues to use the model in its own studies, thus giving a valuable symbiosis between development and application.

Mike 21 is constructed in a modular manner around the four main application areas:

- coastal hydraulics and oceanography,
- environmental hydraulics,
- sediment processes,
- waves.

Mike 21 can be used to study a wide range of phenomena related to hydraulics, like tidal exchange and currents, storm surges, heat and salt recirculation, water quality, etc.

The present generation of Mike 21 is based on a fully Windows integrated Graphical User Interface and is compiled as a true 32-bit application.

The Hydrodynamic Module (Mike 21 HD) is the basic module in the Mike 21 package. It provides the hydrodynamic basis for the computations performed in the modules for Environmental Hydraulics and Sediment Processes.

The HD Module simulates water level variations and flows in response to a variety of forcing functions in lakes, estuaries and coastal areas. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with the bathymetry, bed resistance coefficients, wind field, hydrographic boundary conditions, etc.

The system solves the full time-dependent non-linear equations of continuity and conservation of momentum. The solution is obtained using an implicit ADI finite difference scheme of second-order accuracy.

The effects and facilities include convective and cross momentum, bottom shear stress, wind shear stress at the surface, barometric pressure gradients, Coriolis forces, momentum dispersion (through e.g. the Smagorinsky formulation), wave-induced currents, sources and sinks (mass and momentum), evaporation, flooding and drying.

The outcome of a simulation is the water level and fluxes (velocities) in the computational domain and may be used as an input to environmental modules.

The group of environmental modules includes the fundamental module, the Advection-Dispersion Module (AD), and process modules: the Water Quality Module (WQ), the Eutrophication Module (EU), the Heavy Metal Module (ME), the Spill Analysis Module (SA).

All modules use output from the HD Module, and the AD Module is used automatically by the process modules.

The AD Module simulates the spreading of dissolved substances subject to advection and dispersion processes, e.g. salt, heat, coliform bacteria, xenobiotic compounds. Linear decay and heat dissipation to the atmosphere are included.

The AD equation is solved using one of the explicit, third-order accuracy finite difference schemes QUICKEST-SHARP or ULTIMATE-QUICKEST. These schemes avoid the well-known problems with the mass balance, overshooting and undershooting in AD models. A third possibility is to use the simple UPWIND scheme. Typical applications include cooling water recirculation and water quality studies.

The WQ Module solves the system of differential equations describing the physical, chemical, and biological interactions involved in the survival of bacteria, oxygen conditions and excess levels of nutrients in coastal areas.

As a basis for the description of the water quality conditions the AD Module calculates the salinity and water temperature.

The following variables can be modelled:

Dissolved BOD (mg/l) BODd,

Suspended BOD (mg/l) BODs,

Settled BOD (mg/l) BODb,

Ammonia (mg/l) NH4,

Nitrites (mg/l) NO2,

Nitrates (mg/l) NO3,

Dissolved oxygen (mg/l) DO,

Phosphorus (mg/l) PO4,

Faecal coliforms (Mpn/100 ml) CF,

Total coliforms (Mpn/100 ml) CT,

One or more user defined pollutants.

The WQ Module is integrated with the AD Module, which describes physical transport processes at each grid point of the model. The process equations are solved with the AD Module using a rational extrapolation method in an integrated two-step procedure.

The WQ Module is used for a range of environmental investigations:

- studies of hygienic problems related to bacteria from wastewater outfalls and other sources. This includes survival of bacteria related to different environmental conditions.
- oxygen conditions affected by BOD and other oxygen consuming substances (e.g. ammonia),
- evaluation of the potential for eutrophication problems, i.e. algae blooms related to nutrient levels (nitrogen and phosphorus),

- decay of chemical substances and effect evaluation based on resulting concentration levels.

The description here is based on the DHI Water and Environment materials. The detailed information on the model can be found at the developer's, DHI Water and Environment websites, e.g. www.dhisoftware.com.

3.2 Hydrodynamic short-term forecast for operational purposes

Hydrodynamic short-term forecast should be very important in different emergency cases as SAR (search-and-rescue) actions and chemical spills. Both Polish and Russian administrations are interested in hydrodynamic forecast enabling prediction of drift of floating objects or castaways and spill propagation. Such forecast should become one of the main part of a future computer-aided rescue and oil combating system in the Vistula Lagoon and Baltiysk Strait, which is already functioning for the open Polish sea waters.

The 2D Mike 21 modelling system will be used for operational purposes by the staff of institutions responsible for Vistula Lagoon water management in Poland and Russia. Both Polish and Russian sides will be able to run their own forecast, based on the same atmospheric and hydrodynamic forecast input, tuned by the observations from their own permanent stations.

In forecast tests, the area of the Vistula Lagoon together with the Baltiysk Strait will be simulated. The open boundary will be assigned using 1NM grid of the HIROMB - operational model of the Baltic Sea. HIROMB is a baroclinic multi-layer oceanographic model based on the BSH Hamburg model. It was modified and implemented in the SMHI, Norrköping, for the operational use in the entire Baltic Sea, primarily aimed on combating oil spills. Till December 2001, the model results were disseminated to the members of HIROMB Agreement at 3 NM resolution. From that time, forecast data of 1 NM resolution are available, for 48 hours ahead.

Because of problems of a proper description of the Baltic Sea water parameters (water amount, heat and salinity balance in the model), the absolute values of model data (especially water level) shall be tuned using appropriate measurements in Poland or Kaliningrad region.

The simulated area in the Gulf of Gdańsk should have a shape of a belt along the coast, with the ratio of its length to width about 5:1.

It is assumed that when using HIROMB data at the open boundary in the Gulf of Gdańsk, HIRLAM data would be used as the driving force in the hydrodynamic model. Limited area atmosphere model HIRLAM (in its Swedish version, run operationally in SMHI) data are used as driving forces in HIROMB. The access to these data for scientific and prognostic purposes is free for non-commercial use for the countries that are members of the HIROMB Agreement. Poland is joining this agreement soon, Russia is also invited to the Agreement. It means that end-users in Kaliningrad region and in Poland should soon have the access to the HIROMB and HIRLAM digital forecast.

3.3 General assumptions of hydrodynamic numerical modelling of the Vistula Lagoon

At the present stage of the project it was not possible to initiate short-term operational forecast. First, the hydrodynamic model had to be set up and calibrated on the basis of existing data from measurements. It was decided to calibrate the model of the Vistula Lagoon only, without Baltiysk Strait and a part of the Gulf of Gdańsk, driven by wind from measurements and from operational model of atmosphere UMPL (Interdisciplinary Centre for Mathematical and Computational Modelling, Warsaw University).

The modelled domain covered the complete Vistula Lagoon with the seaward open boundary at the entrance to the Baltiysk Strait, together with the lowest Pregola River stretch till the water gauge in the port of Kaliningrad (Fig. 2), thus enabling comparison of the model results with the recorded data. Pregola River upstream the Kaliningrad harbour, as the all other rivers, was treated as water source in the model (not as open boundary).

There was a problem where to set the seaward open boundary. The only permanent measuring station is the water level gauge in the port of Baltiysk, close to the Lagoon. Thus it was reasonable to use these observed level data as the model boundary condition at the entrance to the Lagoon. The most interesting for the water quality aspects is the joint system of the Vistula Lagoon, Baltiysk Strait and Gulf of Gdańsk investigated together. However, measurement data for comparison are very scarce in the south-eastern Gulf area and that is why the Gulf was not included in the model domain.

The most important driving factors, like wind friction, water level variations at the open boundary generating water exchange in the Baltiysk Strait and river discharges to the Lagoon, were taken into account.

It is estimated that amount of water exchange between the Lagoon and Gulf is approximately 5 times greater than total river input to the Lagoon.

River discharge has a little influence on currents in the Lagoon. Among all rivers only Pregola River mean annual discharge exceeds 80 m^3/s. Mean discharges of other rivers do not exceed 40 m^3/s. Thus all the rivers, except Pregola, were considered as sources of water without momentum.

Ice formation and melting, because of complexity of their description, was not included in the model. However, presence of ice cover was taken into account when calculating wind stresses.

3.4 Data used for the hydrodynamic simulations

Model calibrations was performed using 1998 atmospheric, hydrological and salinity data. Validation will be done using appropriate data of 1999 - 2000.

Data on water level measurements were obtained from the following stations: Baltiysk – for the open boundary condition (Fig. 3) and from: Kaliningrad, Krasnoflotskoye, Krynica Morska, Nowa Pasłęka, Tolkmicko, Nowe Batorowo, Oslonka – for calibration.

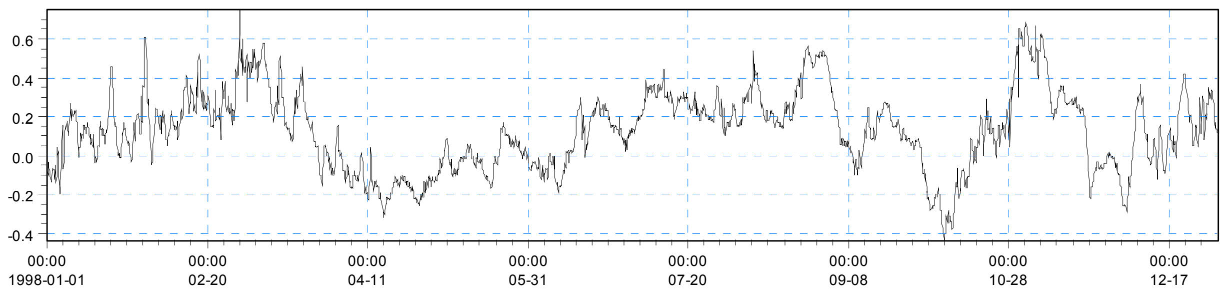
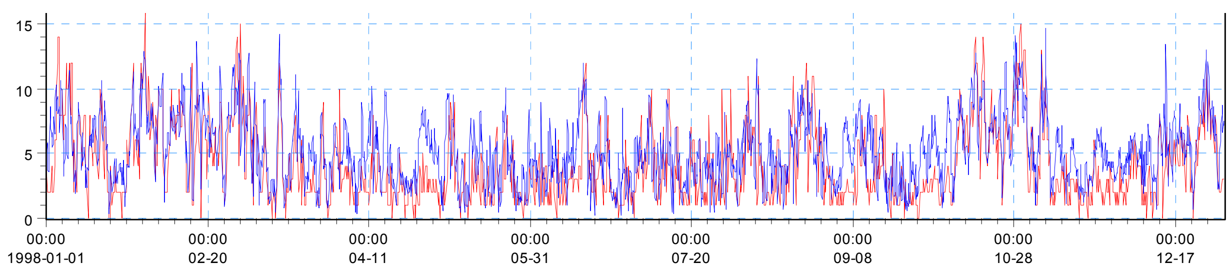
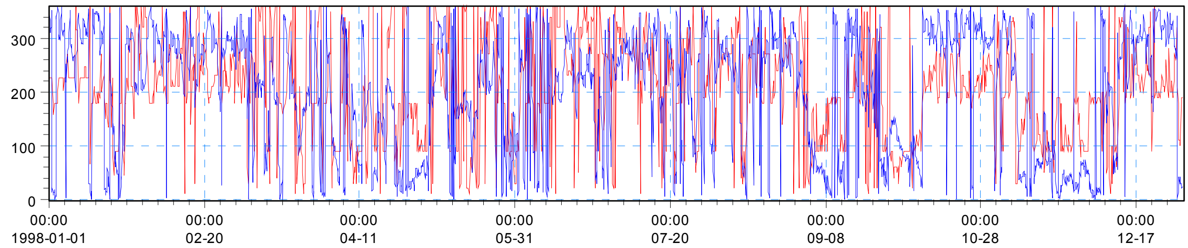


Figure 3: Open boundary condition - water level (m) records in Baltiysk) every 3 hours

Wind velocity and direction data came from two sources: Baltiysk where actual wind was measured, and from the atmosphere model UMPL (UK Unified Model for Poland area, covering all Central Europe and the Baltic Sea) run operationally in the University of Warsaw; the wind analysis data from UMPL were available every 3 hr with the horizontal resolution of 17 km (Fig. 4).



a) red line – observations in Baltiysk, every 8 hours; blue line – synoptic wind (UMPL analysis), every 3 hours



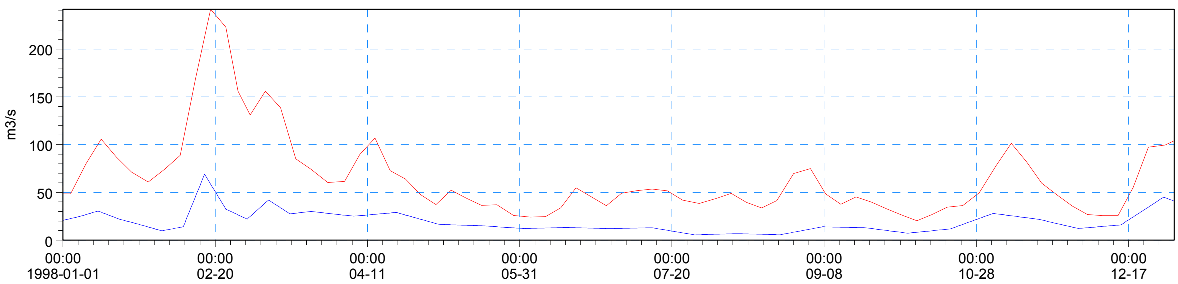
b) red line – observations in Baltiysk, every 8 hours; blue line – synoptic wind (UMPL analysis), every 3 hours

Figure 4: Wind forcing in the model: a) wind velocity, b) wind direction

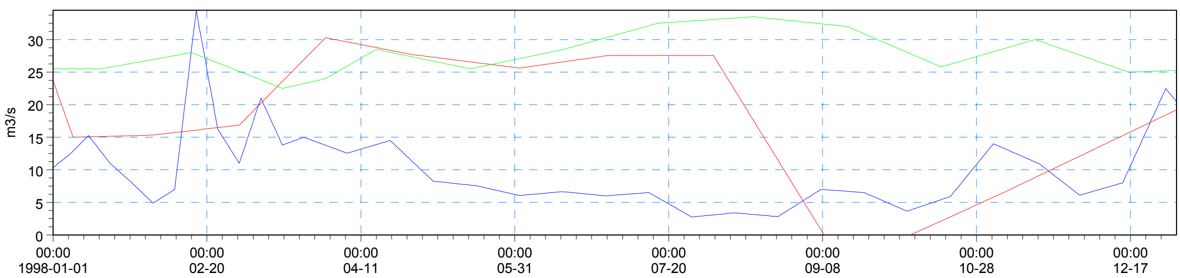
Information on ice coverage was obtained from: Baltiysk, Krasnoflotskoe, Krynica Morska, Tolkmicko.

Following 13 rivers covering the drainage basin of the Vistula Lagoon were included in the model: Nelma together with Primorskij Canal and, Primorskaja as one source, Pregola, Prokhladnaja, Vilejka together with Mamonovka as one source, Pasłęka, Bauda, Elbląg, Nogat together with Szkarpawa as one source (Fig. 2). The data on discharges were as 5-days and monthly averages.

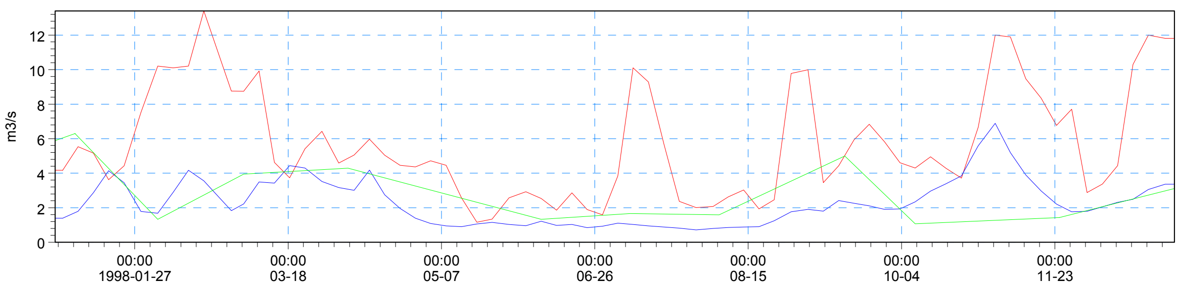
Pictures below present distribution of river discharges through the year 1998 in all rivers included in the model (Fig. 5).



red – Pregola, blue - Pasłęka



red – Nogat, blue – Prokhladnaya, green – Elbląg



red – Mamonovka, blue – Nelma, green - Bauda

Figure 5: River discharges in m^3/s

Data on salinity was obtained from: Baltiysk - for a boundary condition, and Krasnoflotskoye, Tolkmicko – for calibration.

4. MODELLING PARAMETERS AND RESULTS

The model operates on regular orthogonal computational grid with cell dimensions of 200 m.

Following numerical parameters were set up in the model:

- time step – 18 s,
- bottom friction Manning coefficient – 0.0016 in the Lagoon,
- horizontal eddy viscosity constant in the Lagoon - Vh = 0.1 m^2/s,
- horizontal eddy diffusivity constant in the Lagoon Dh = 5.0 m^2/s.

Results of calibration of water levels in year 1998 are presented below (Fig.6).

Figure 6: Water level observed and simulated: red – measurements, blue – wind Baltiysk, green – synoptic wind (from UMPL model).

Calculated water levels show very good agreement with the measured ones both for the case of model run with wind data from measurements, as the driving force, as well as for the case of the data form the UMPL model (synoptic wind).

The model was also calibrated against salinity measurements that were taken in 19 points in the Lagoon (Fig. 7).

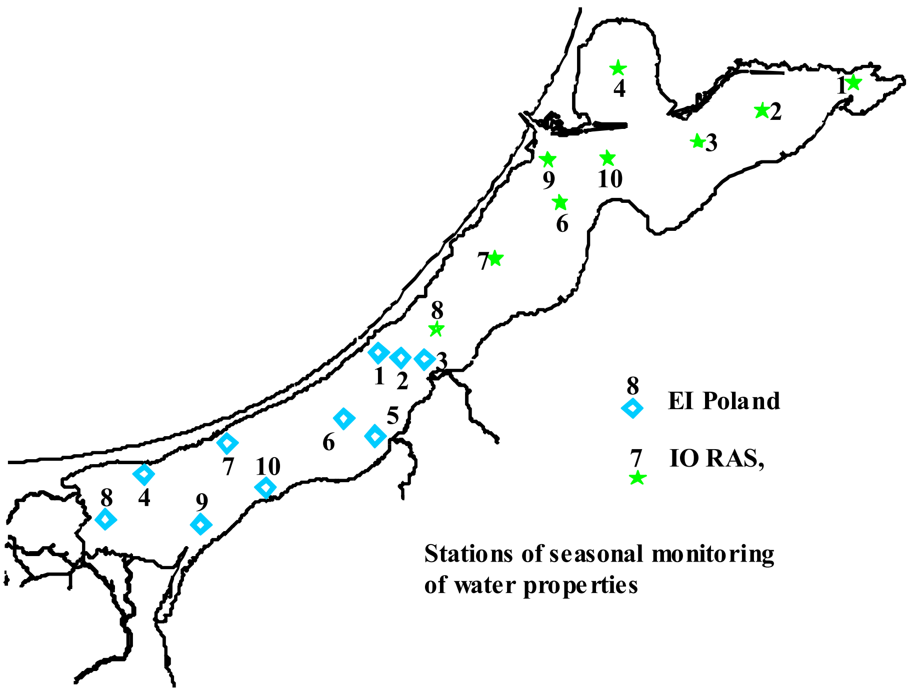
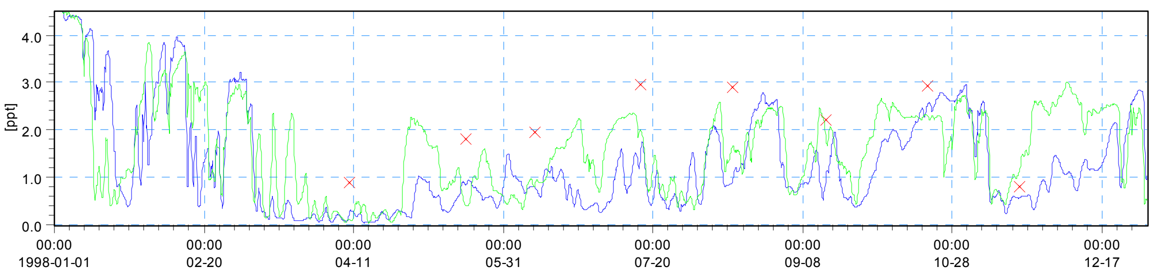
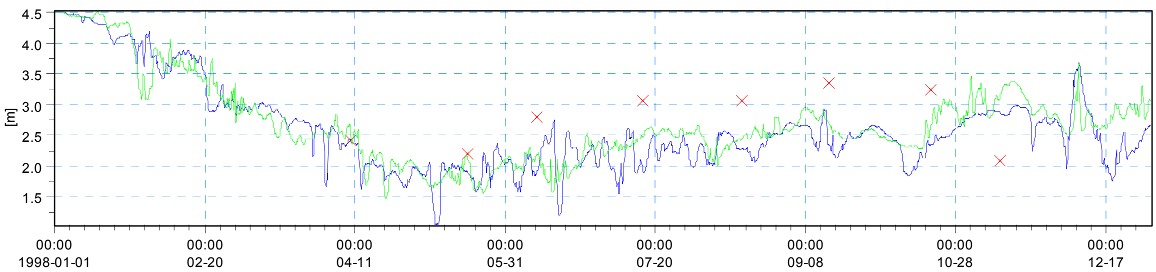


Figure 7: Stations of seasonal monitoring of water salinity (EI – data from Environmental Inspection in Olsztyn, Poland; IO RAS – data from the Shirshov Institute of Oceanology of the Russian Academy of Sciences).

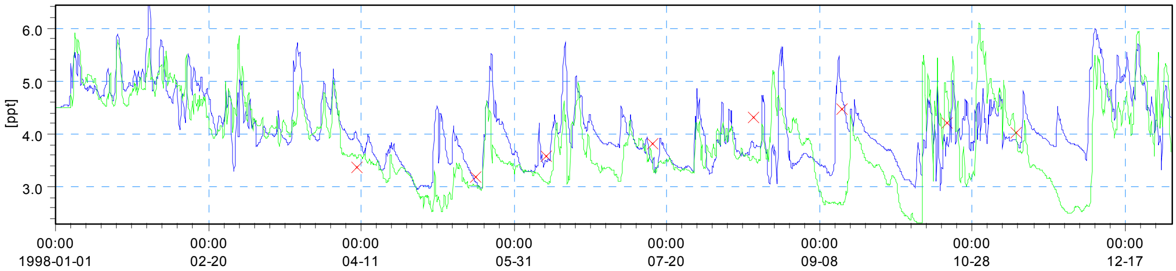
Some results of salinity calibration are presented in Figure 8.



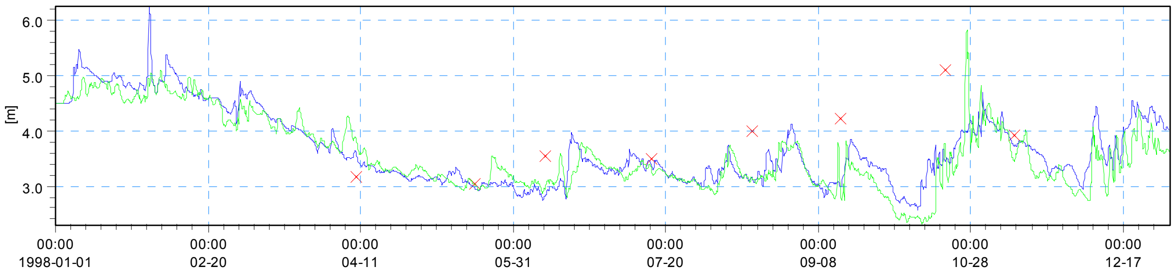
Russian monitoring station R1



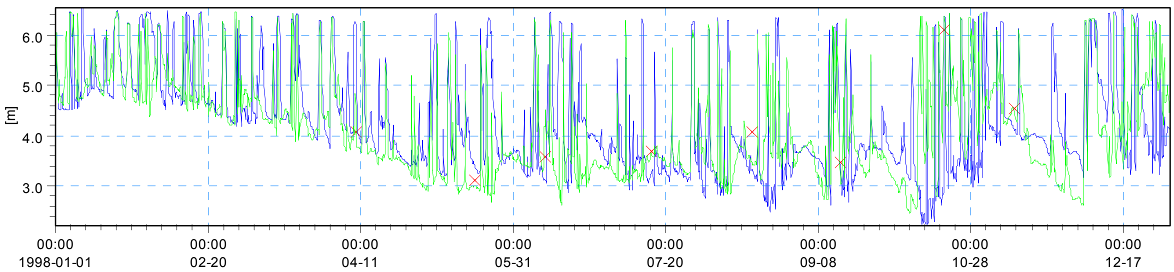
Russian monitoring station R3



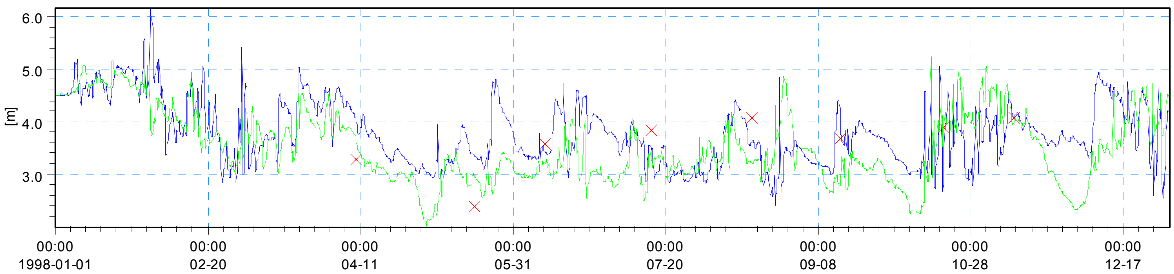
Russian monitoring station R6



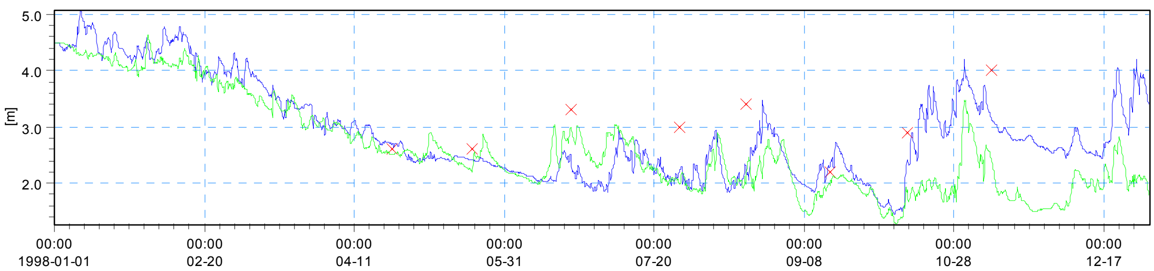
Russian monitoring station R7



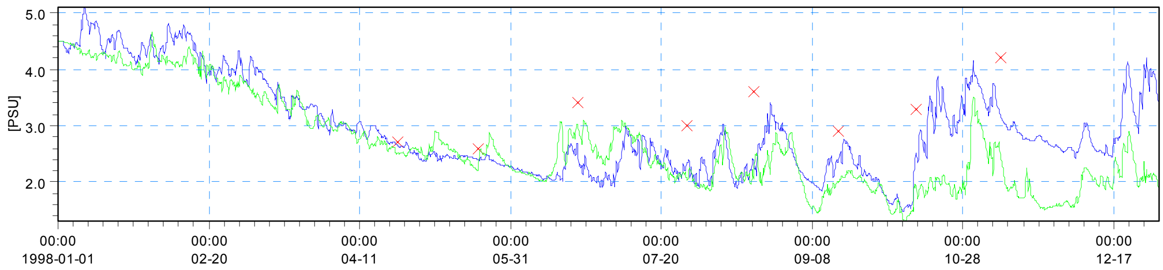
Russian monitoring station R9



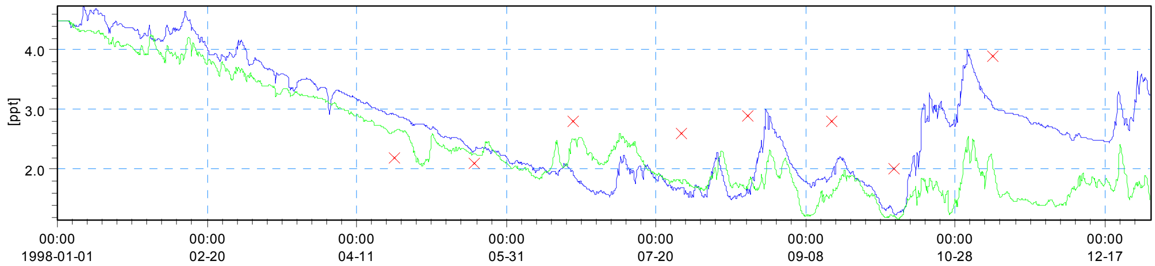
Russian monitoring station R10



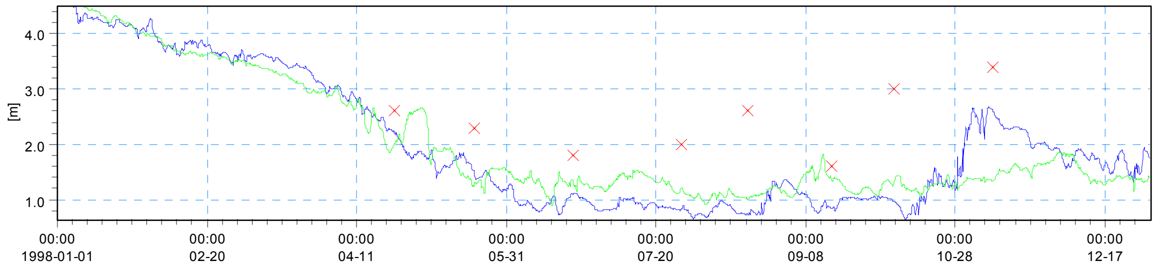
Polish monitoring station P1



Polish monitoring station P2



Polish monitoring station P5



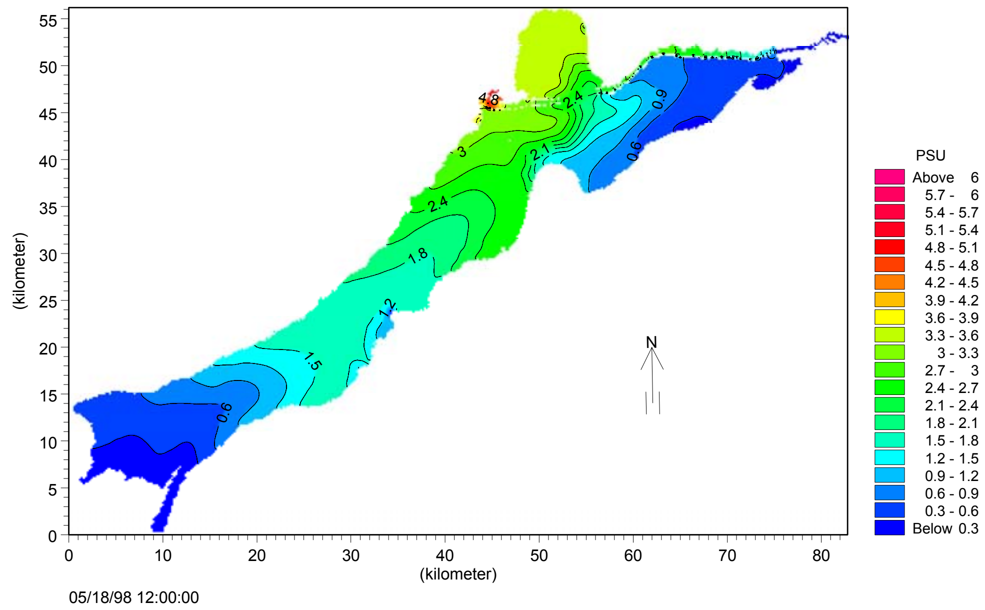
Polish monitoring station P7

Figure 8: Salinity in PSU observed and simulated: red – measurements, blue – wind Baltiysk, green – synoptic wind.

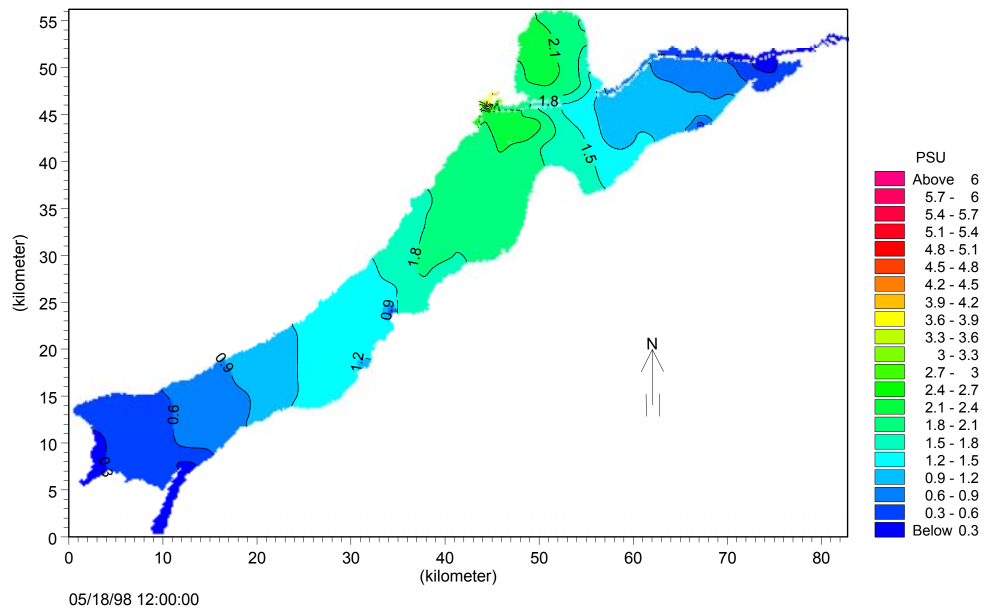
Calculated salinity variations show similar trends when calculated with measured wind data in Baltiysk and analysed wind data from UMPL model. Also good agreement with measured salinity can be observed, especially in the Russian part of the Lagoon. Salinity calculated with use of the wind data from Baltiysk tends to have slightly higher values.

Below distribution of salinity calculated with the wind data from measurements (Baltiysk station) and from the UMPL model analysis is presented.

Salinity distribution,18-05-1998

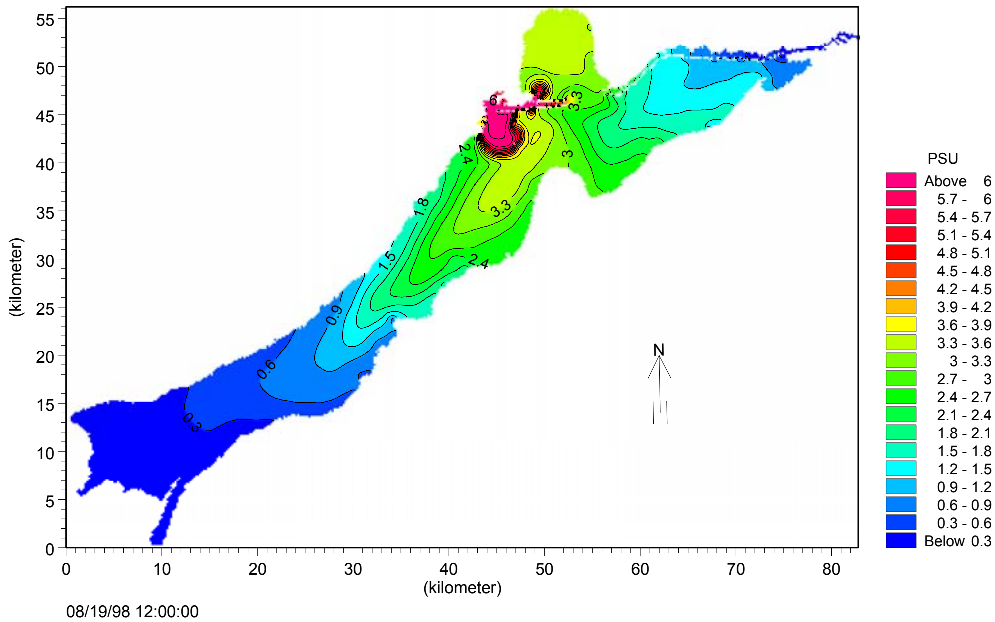


with measured wind data

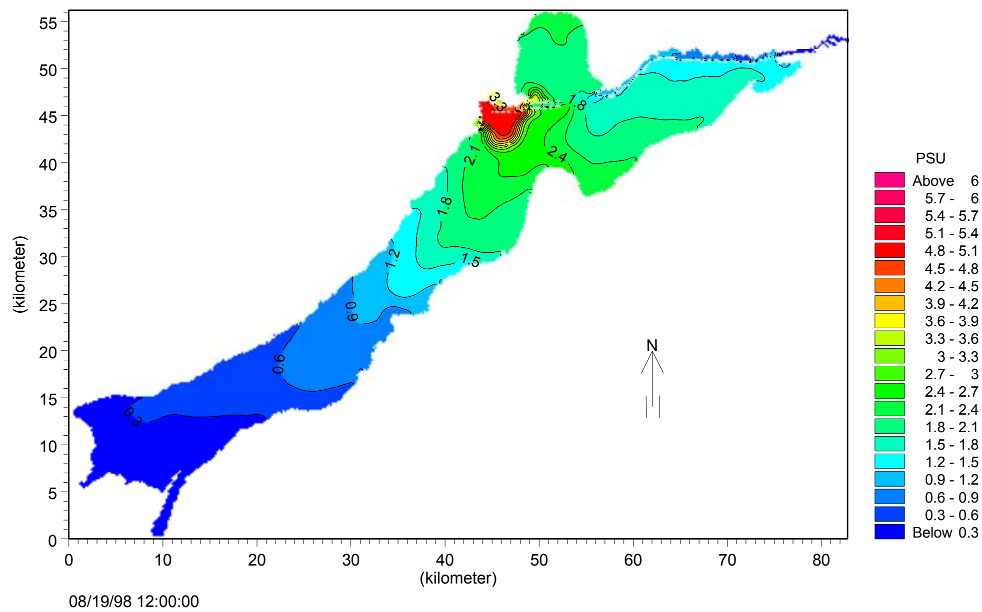


with synoptic wind data

Salinity distribution,19-08-1998



with measured wind data



with synoptic wind data

Figure 9: Salinity distributions calculated with wind data measured in Baltiysk and UMPL model analysis data

Spatial distributions of salinity calculated with the measured and UMPL wind data show some differences. Waters seem to be better mixed over the Lagoon when the UMPL wind data is used. Smaller salinity gradients are observed in this case. However, the general pattern is sustained.

The comparison of water levels and salinity distributions calculated with the measured and UMPL wind data prove that it is possible to use data from operational models as driving forces, without significant lose of modelling quality.

5. CONCLUSIONS

The Mike 21 model (hydrodynamic and water quality) is intended to be used to evaluate a potential to improve the environmental situation of the Vistula Lagoon by reducing nutrient discharges from the major Polish and Russian rivers. Furthermore, the impact of planned abatement actions in both countries, in respect to the environmental situation, will be evaluated.

In order to perform water quality calculations it is necessary to determine flow fields in the Lagoon with the use of hydrodynamic model. Next the water quality calculations may be conducted. It is necessary, however, to calibrate hydrodynamic and water quality models, before they are used for forecast purposes. First the hydrodynamic model has to be calibrated.

The Vistula Lagoon is a transboundary basin and it is a very frequent problem that the data necessary for running the models are not always freely available, especially from the other country. To avoid this problem it is recommended to build an operational modelling system, that will predict driving forces and boundary conditions for the models.

In this paper possibility of operational models usage for running hydrodynamic model of the Vistula Lagoon has been discussed.

To predict water levels, current velocities and directions at the open boundary, the HIROMB model forecast data have been proposed. For wind direction and velocity prediction, the HIRLAM model data have been proposed. Both Poland and Russia have free access to these data.

Comparison of modelling results with use of actually measured data (wind velocities and direction) and predicted data, has been presented in the paper. To simplify the task, only prediction of wind data was considered. Therefore it was possible to use an operational atmosphere model UMPL which is run in the University of Warsaw.

Results of calibration of the hydrodynamic model ran with the measured and UMPL data, proved that in both cases water levels and salinity are predicted with very similar accuracy. Therefore usage of operational model, instead of actually measured data may be recommended in this situation.

ACKNOWLEDGEMENTS

Funding for this research was provided by the European Union project MANTRA-East (contract EVK1-CT-2000-00076).

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