# NATIONAL RESEARCH PROGRAM „CLIMATE CHANGE IMPACT ON THE WATERS OF LATVIA”

# SECOND PHASE (2007) REPORT

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**Institutes and Universities involved:**

**University of Latvia**

**LU Agency Institute of Biology**

**Latvia University of Agriculture**

**Latvian Institute of Aquatic Ecology**

**Latvian Fish Resources Agency**

**Daugavpils University, Institute of Ecology**

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**2007**

## Contents

## Aim and overall structure of the Program

**<u>Generic goal of the Program:</u>**
**Assess short-, medium-, and long-term impact of climate change on the environment and ecosystems of the inner waters of Latvia and the Baltic Sea. Create a scientific basis for adaptation of the environmental and sectorial policies of Latvia to climate change.**

**<u>Specific goals:</u>**

a) **Create several mutually non-controversial scenarios of the regime-determining parameters;**
b) **Assess possible climate change impacts on the quality of inland waters of Latvia, their availability, flood and drought risk, to facilitate adaptation of the drainage basin management and secure protection and sustainable use of water resources;**
c) **Forecast possible climate change impact on the physical regime, coastal dynamics, bio-geo-chemical regime, and ecosystems of the Baltic Sea, to facilitate protection of marine environmental quality, biological diversity, and sustainable use of its resources and services.**

Implementation of the National Research Program KALME "Impact of the Climate Change on the Waters of Latvia" commenced in October 2006. In the end of the 3-month first phase the scientific report was not required, therefore this report covers work done during the 14-month period since beginning of the Program.

Although the topic of adaptation to the climate change is complex, recognizing the overall aim to create a coherent scientific basis for the adaptation policy, as well as taking into account the practice of administrating the national research programs in Latvia as large centralized projects, the working structure of the Program, instead of consisting of independent projects, is built of nine mutually interlinked thematic work packages:

WP 1: Climate Change Impact on Runoff, Nutrient Flows, and Regime of the Baltic Sea

WP 2: Climate Change Impact on the Nutrient Run-off in the Drainage Basin

WP 3: Climate Change Impact on Freshwater Ecosystems and Biological Diversity

WP 4: Coastal Processes

WP 5: Bio-geo-chemical Processes and Primary Production in the Baltic Sea

WP 6: Climate Change Impact on Ecosystems and Biological Diversity of the Baltic Sea

WP 7: Adaptation of Environmental and Sector Policies to Climate Change

WP 8: Program Management and Public Outreach

WP 9: Runoff Extremes Caused by the Climate Change and Their Impact on Territories Under the Flood Risk

Successful work in each of the WPs depends on the outputs of other packages (Fig. 0.1). Such arrangement of the Program facilitates effectiveness and coordination of the work, although it requires additional effort of centralized management and accurate fulfilment of the time schedule. A specific work package (WP8) is charged with a responsibility of Program's central management.

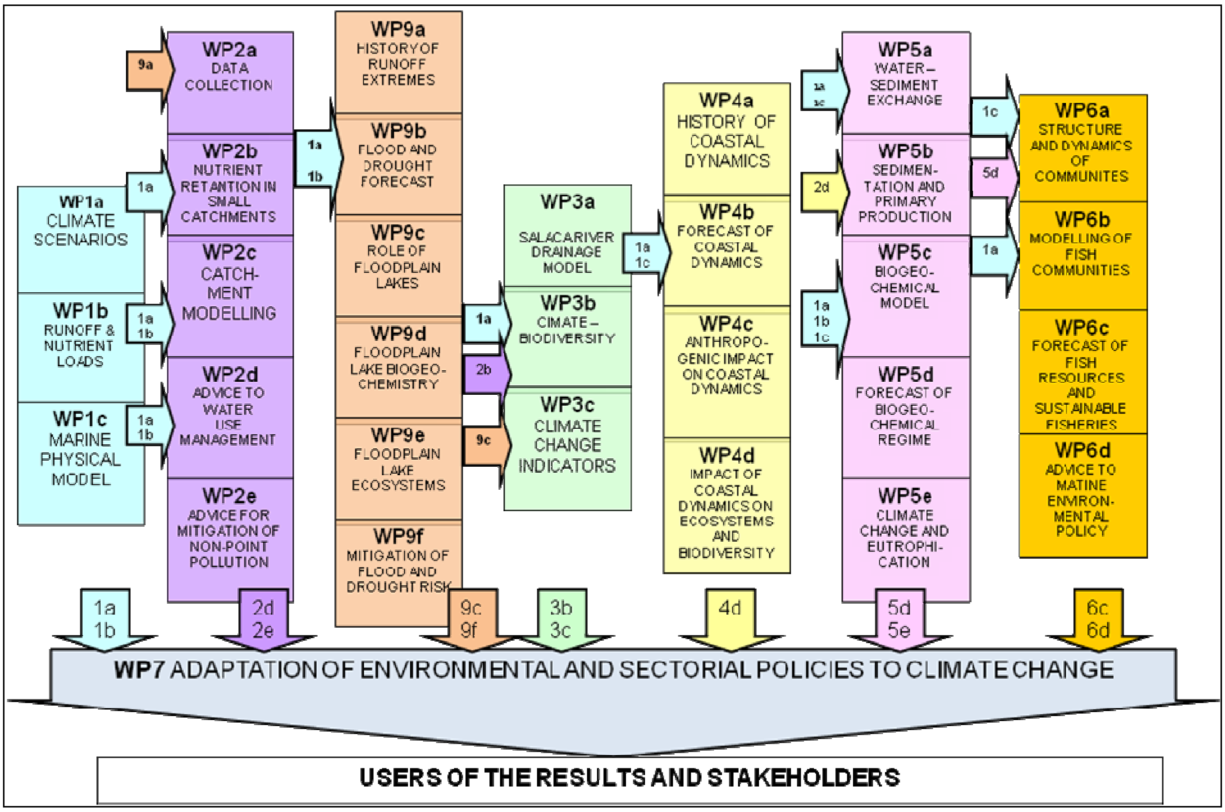


**Fig. 0.1.**: KALME work packages and their interaction. Full descriptions of the tasks are presented in the Program Application, published in www.kalme.daba.lv
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Seven natural-science WPs (1-6 and 9) produce new knowledge while the task of WP7 is to maintain a dialogue with potential end-users of Program's deliverables and its stakeholders, and to facilitate utilization of scientific knowledge while creating Latvia's national climate change adaptation policy and amending various sector policies, planning documents and regulatory acts. Program's management WP is involved also in dissemination of the results to the broad public, ensures Program's visibility and implements its educational activities.

## Work Package 1: CLIMATE CHANGE IMPACT ON RUNOFF, NUTRIENT FLOWS, AND REGIME OF THE BALTIC SEA

**Goals:**

1. Preparation of the scenarios – the series of the hydro-meteorological data, characterising the climate change.
2. Development of the mathematical model for the freshwater and nutrient run-off from the territory of Latvia, and preparation of the run-off data series, characterising the climate change.
3. Development of the three-dimensional oceanographic model for the Gulf of Riga, and calculation of the data series of the sea state in accordance to the climate change scenarios.
4. Modelling and data analysis in support for the other WPs.

**Phase 2 tasks of WP1:**

1. Determine the access conditions and retrieve the regional climate modelling (RCM) data sets from several (at least two) sources. Define several alternative climate change scenarios.
2. Modelling of the hydrological regime of the selected pilot basin (Amata) with a conceptual and physically based model. The development of the model and respective software for the hydrological modelling. Calibration and verification of the model, inclusion of the nutrient run-off functionality.
3. Investigate the impact of climate change on the river run-off and its seasonal variability: (a) evaluate the long-term run-off variability, (b) assess the long-term variability of ice cover, (c) determine the impact of large scale atmosphere circulation processes on the river runoff regime.
4. Select the sub-domain for modelling of the Baltic Sea state; prepare the calculation grid and depth distribution in this domain.

**Phase 2 results of WP1:**

**Task 1**: *Determine the access conditions and retrieve the regional climate modelling (RCM) data sets from several (at least two) sources. Define several alternative climate change scenarios.*

Preparation of climate scenarios:

1. The calculation results from 21 RCM acquired.
2. The time-series of the meteorological observation for contemporary climate (1961-1990) acquired.
3. The evaluation, ranking and selection of the model calculations of the p. 1 are performed via comparison with observations performed under the p. 2.

4. The re-evaluation of the model calculations of p.1 is performed by using them as input data for the river basin run-off model (developed within Task 2).
5. The statistically significant deviations from the observed temperature and precipitation regime are determined in the RCM computations for the territory of Latvia.
6. The non-linear amplification of small differences between observed and modelled meteorological parameters are found in comparison of modelled and observed run-off time-series.
7. A novel method of the correction of RCM calculation data series is proposed ensuring the statistical correspondence between the observed and RCM data.
8. The correction of the RCM data of p.3 is done by method of p.7; thus, four 30-year long data sets for the territory of Latvia are prepared: (a) contemporary climate – observation data, (b) contemporary climate - RCM calculations, (c-d) RCM calculations for climate change scenarios B2 and A2.

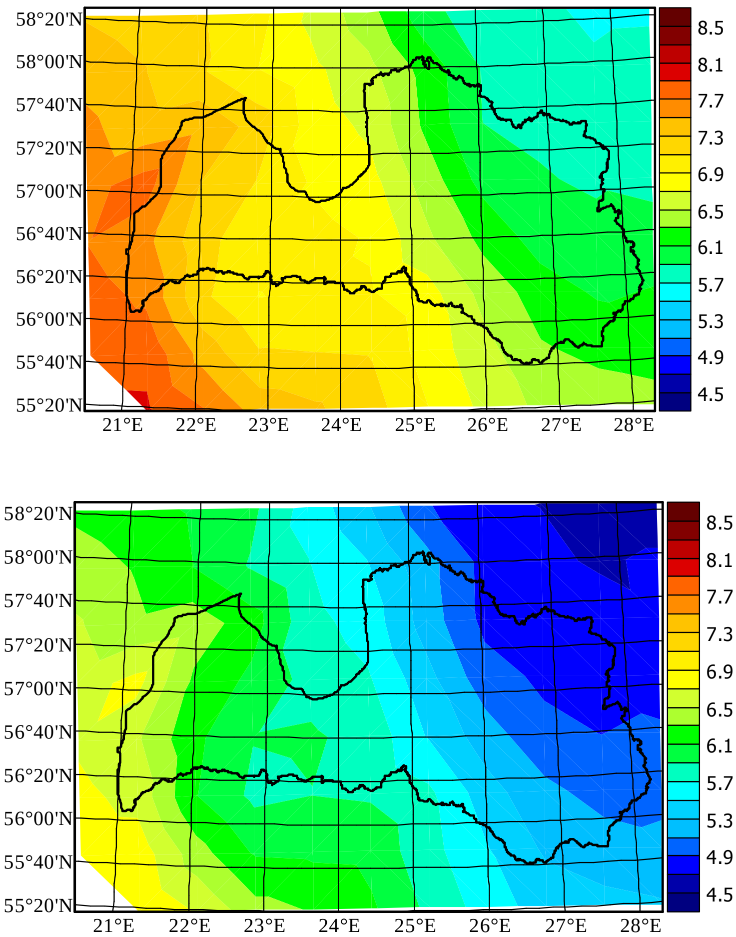



**Figure 1.1.** Annual mean air temperature over Latvia for contemporary climate. Non-corrected (upper panel) and corrected (lowe panel) calculations by the best of RCM.

**Task 2:** *Development of the mathematical model for the freshwater and nutrient run-off from the territory of Latvia, and preparation of the run-off data series, characterising the climate change.*

1. The decision of the usage of physically based run-off model is taken after comparing of its performance vs. conceptual model in the pilot basin.
2. The mathematical model of hydrological regime is developed (surface run-off and river routing).
3. The model of p.2 is calibrated for the pilot basin and used for the quality control of the RCM data.
4. The calculations by the model of p.3 are performed for the pilot basin (Aiviekste); thus, four 30-year long data sets for the territory of pilot basin are prepared: (a) contemporary climate – observation data, (b) contemporary climate – calculations from RCM data, (c-d) calculations for climate change scenarios B2 and A2.

**Task 3:** *Investigate the impact of climate change on the river run-off and its seasonal variability: (a) evaluate the long-term run-off variability, (b) assess the long-term variability of ice cover, (c) determine the impact of the large scale atmosphere circulation processes on the river runoff regime.*

The research of the long-term changes of the regime of the river run-off and its influencing factors were performed in 2007. The analysis of run-off data series for the whole observation period in Latvia (since 1860) proofed non-existence of statistically significant run-off trend. However, such an increasing trend is characteristic for winter run-off in all Latvian rivers (Fig.1.2).

The periodic variation is detected in the run-off regime (Fig. 1.3), most probably this is determined by a large scale circulation of air masses.

The atmosphere circulation processes may be characterized by the variability of the pathways of dominant air masses (inflow of air masses from North Atlantics, polar regions, Eurasia and Africa). The changes in the circulation of the air masses characterize the variability of climate change.

The ice regime in Latvian rivers is investigated, and it is proofed that the variability of the seasonal distribution of climatic indicators determines the variability of the ice regime, thus, further, influencing the change of run-off characteristics.

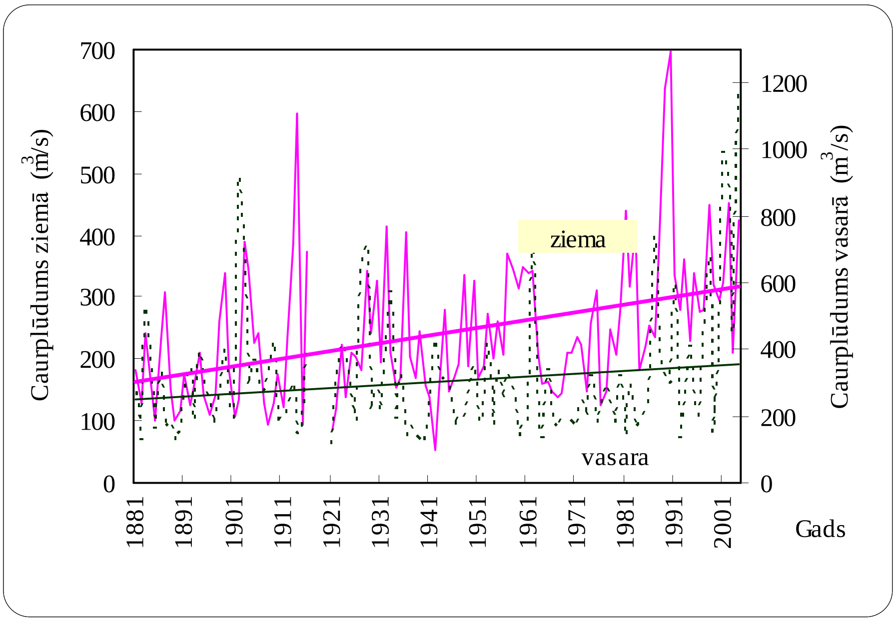



**Figure 1.2.** The mean discharge of Daugava river for winter (December-March, purple line) and summer (June-August, dashed line) months (1881-2004). Left Y axis – winter runoff, right Y axis – summer runoff.

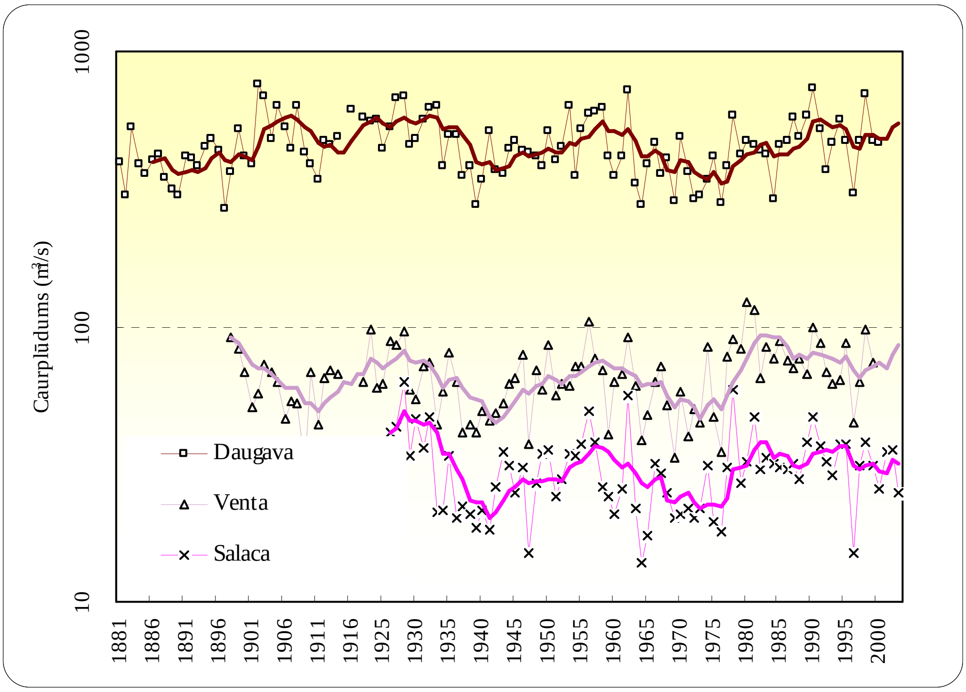



**Figure 1.3.** The character of variability of Daugava, Venta and Salaca discharges. 6-year running average of the mean annual discharge.

**Task 4:** *Select the sub-domain for modelling of Baltic sea state; prepare the calculation grid and depth distribution in this domain.*

1. The modelling domain in the Baltic Sea is selected for the climatic modelling of the sea state (Fig. 1.4).
2. The building of the modelling system is started by developing of a three-dimensional transient oceanographic model.
3. The performance of model of p.2 is tested utilizing forcing conditions from the DMI (Danish Meteorological Institute) operational atmosphere model, and the boundary conditions from the DMI operational Baltic Sea model.

The developed mathematical model may be used as the decision support tool for problems influenced by sea state parameters.

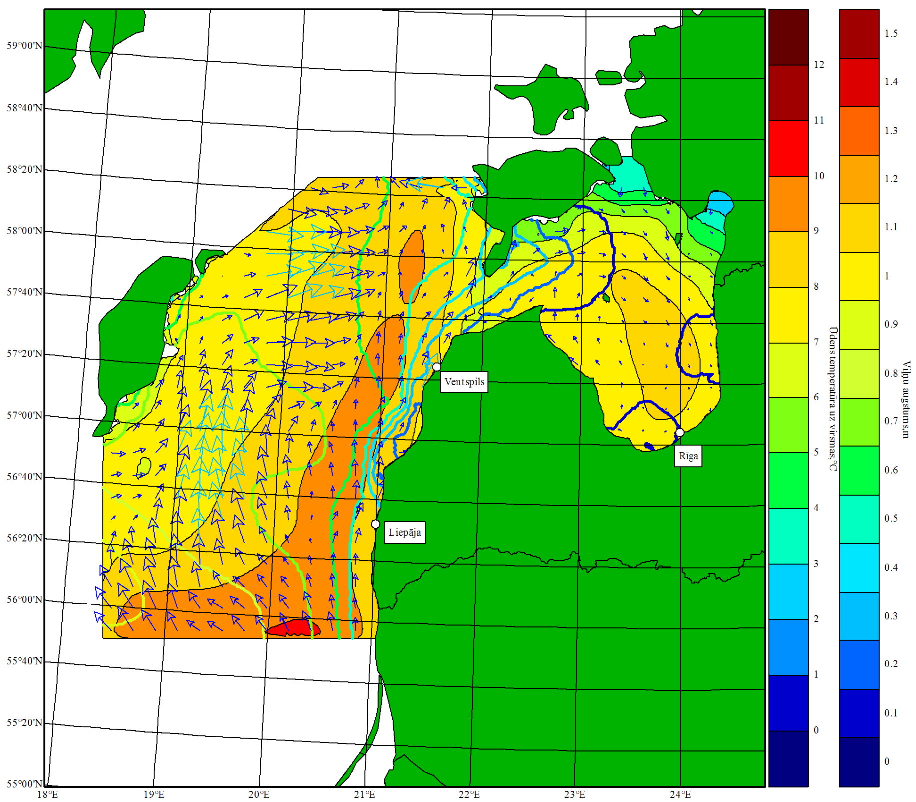



**Figure 1.4.** Selected modelling domain with calculated distribution of water temperature, surface currents and wave height.

*Scientific and economic significance of results*

The objective and systematic deviations of the RCM results for the reference period over the territory of Latvia was not scientifically proofed before.

The non-linear amplification of the negligible variations of climate signal in the hydrological system was demonstrated.

The method of the RCM data correction seems to be novel.

The prepared temperature and precipitation data sets are unique – the RCM results regionally adapted for Latvia; synthetic non-contradictory data series of contemporary and future climate.

**Summary**

The climate change scenarios for the territory of Latvia in a form of temperature and precipitation data series were prepared. The mathematical models for the modelling of river run-off and sea state were developed.

**WP1 tasks for the 3rd phase (2008):**

1. Model calculations to prepare the data series of water and nutrient run-off from the Latvian territory, compliant with the climate change scenarios.
2. Model calculations to prepare the data series of the physical state of sea, compliant with the climate change scenarios.
3. The investigation of the dependence of the variability of chemical composition of water on the character of climatic variability. The impact of the character of climate change on the precipitation and hydrological regime of inland waters.

**Work Package Coordinator: Uldis Bethers**

## Work Package Nr. 2: CLIMATE CHANGE IMPACT ON THE NUTRIENT RUN-OFF IN DRAINAGE BASIN

**Goal:**

Assessment of the climate change impact on the hydrological regime and nutrient run-off in rivers of Latvia

**Phase 2 tasks of WP2:**

1. Development of the data base and digital maps for sub-basins of the Berze river.

2. Preparation of weather data sets and data sets of hydrological parameters for 5-6 river basins.

3. Assessment of nutrient retention from diffuse pollution sources.

4. Evaluation of the available hydrological and hydro chemical models for modelling in Latvia. Validation of model application and calibration of models for the selected river basins in Latvia.

**Phase 2 results of WP2:**

**Task 1:** *Development of the data base and digital maps for sub-basins of the Berze river.*

15 homogeneous sub-basins has been selected for water quality modelling in the Berze river basin (900 $km^2$) taking into account pollution sources, land use, animal/crop husbandry, population density and other factors related to the water quality. Digital maps have been used for analyzing of the impact factors. The high precision (data from land drainage 1:2000 maps) hydro-graphic GIS map is under preparation. Professional staff of Rural Support Service is involved in the preparation of that map. Due to a very large area, data coverage and high resolution (up to field drainage level), hydrographical map has not been finished jet. GIS maps of the animal farms and animal density (data from animal register 2006) cover the whole territory of Latvia including the Bērze river sub-basins. In addition, the map of intensively used farm land (data from EU payments database) in the Bērze river basin was prepared.

Modelling of water quality needs experience and skills not developed to the necessary scientific level in Latvia today. Therefore, it may be concluded that GIS solutions for selection of sub-basins have certain scientific value considering preparation of the river basin management plans for implementation of the WFD. Basin management with the task to ensure good quality of water is not possible without model applications.

**Task 2**: *Preparation of weather data sets and data sets of hydrological parameters for 5-6 river basins.*

Hydrological and meteorological data from databases of the Latvian Environment, Geology, and Meteorology Agency**,** SIA "Melioprojekts" and Latvia University of Agriculture (LLU) were collected and the time series of flow and nitrogen and phosphorus concentrations from the monitoring sub-catchments have been prepared for modelling.

Unfortunately, the digital environmental register of the climatic, hydrological and hydro-chemical data is not available in Latvia. In this context, the data sets available in University of Latvia and LLU may be evaluated as a valuable input for solution of problems in different fields of environmental engineering and water management.

Water samples were analyzed in the Laboratory of Marine Monitoring of Latvian Institute of Aquatic Ecology. Supplementary data collection shall be organized in the year 2008.

**Task3:** *Assessment of nutrient retention from diffuse pollution sources.*

The assessment and monitoring of the nutrient fluxes from diffuse sources and retention of nutrients was continued. Variation of the nutrient fluxes depend on weather conditions, crops and fertilization. The data presented in Figure 2.1. indicate significant decrease in nitrate concentrations in the system: plot - drainage field - small catchment, in the Mellupite monitoring site. Similar results have been obtained on a drainage field – small catchment scale in the Berze site. Changes in the nitrogen concentrations could be attributed to nitrification, de-nitrification, and assimilation by algae and by macrophytes. In the monitoring site with low input from agriculture - Vienziemite - both in the drainage field and small catchment scale the nitrogen concentrations are low, close to the reference values and there is no indication of the reasonable retention.

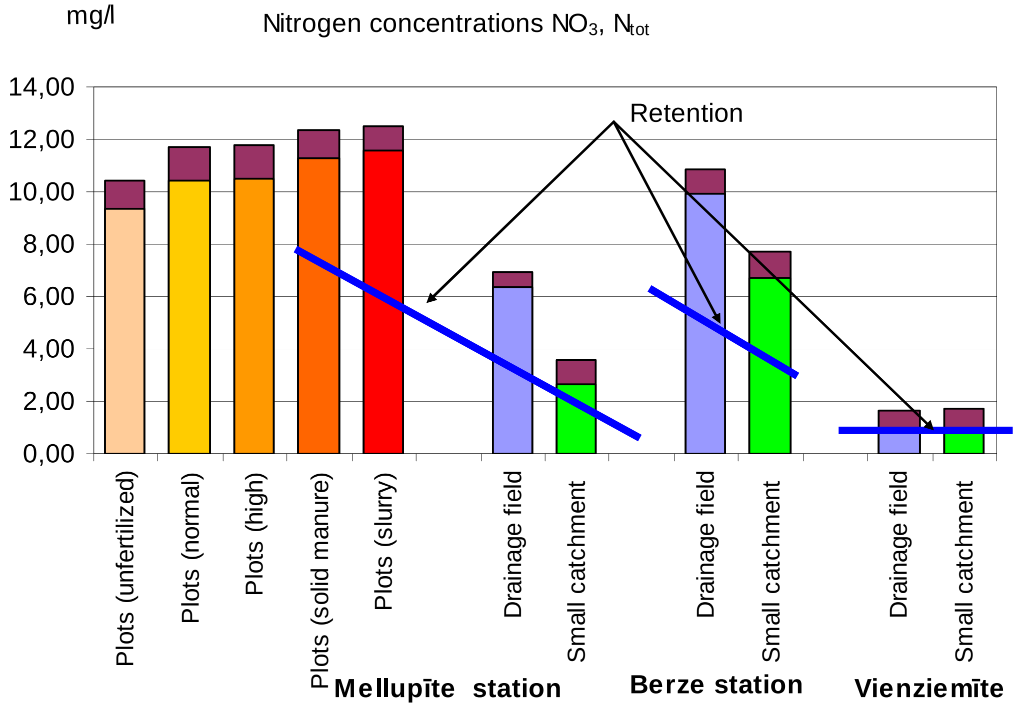



**Figure 2.1.** Average concentrations total nitrogen and nitrate nitrogen in plot, field and small catchment scale (1995 – 2006).

Nutrient export factors necessary for the water quality modelling in rivers could be calculated with sophisticated soil models like SoilNDB. These models are not calibrated in

Latvia. Therefore, the Fyris model, used for apportionment of nutrient load from rivers e.g. case study for the Berze river, rely on nutrient export factors measured in monitoring sites in the plot, field and small catchment scales. These data potentially are of great importance for calibration of the water quality models and calculation of the agricultural run-off for determination of pollution loads to the Baltic Sea, i.e. HELCOM PLC.

**Task 4:** *Evaluation of the available hydrological and hydro-chemical models for modelling in Latvia. Validation of model application and calibration of models for the selected river basins in Latvia.*

For the modelling of hydrological processes and water quality of rivers, different quantification tools have been developed in different countries. However, only tested and internationally accepted models should be used. The conceptual rainfall-runoff METQ model (recent version METQ2007BDOPT) for the modelling of the Burtnieku lake watershed (as a part of the Salaca river basin) was used. The preliminary calibration results demonstrated acceptable applicability of the model. The model calibration and validation is done on the base of the daily data from 5 meteorological and 5 hydrological stations from 1990 to 1999. The results of model calibration, showed a good coincidence ($r$ = 0.83-0.95; $R^2$– 0.63-0.90) between simulated and observed discharges. Therefore, the model can be used for further simulation of hydrological processes. The best coincidence (Figure 2.2.) was obtained for the River Salaca basin at Mazsalaca (the efficiency criterion $R^2$ is 0.90 and correlation coefficient $r$ = 0.95).

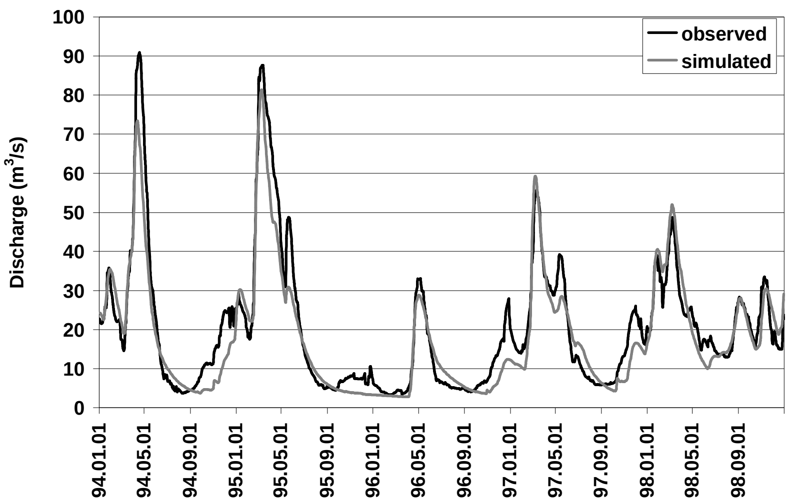



**Figure 2.2.** Observed and simulated hydrographs at runoff gauge Salaca-Mazsalaca

In addition, the preliminary calibration of the METQ2007BDOPT model was performed for the following river basins or sub-basins: Salaca, Bērze and Iecava.

Water quality simulation and modelling for this purpose so far was not developed in Latvia. Therefore, for simulation of the water quality in the Bērze river, the Fyris model, developed in Swedish University of Agricultural Sciences (SLU), was selected. One of the main preconditions was a willingness of SLU researchers to test Fyris application in the rivers of Baltic countries. Water quality sampling, which started in 2005 provided data for the first attempts of simulation for the Bērze river and its 15 sub-catchments (Figure 2.3.). Taking into account variation of weather conditions, successful modelling approach will depend on the availability of the time series of water quality data for river and sub-catchments. Therefore, water sampling should be continued.

In summary the most important result of WP2 is the development of competence and skills to use hydrological and water quality models, which will contribute to the implementation of the Water Framework Directive e.g. preparation of River Basin Management Plans in order to achieve a good ecological status in all water bodies. It is obvious that the HELCOM PLC calculations of N and P loads also requires modelling tools.

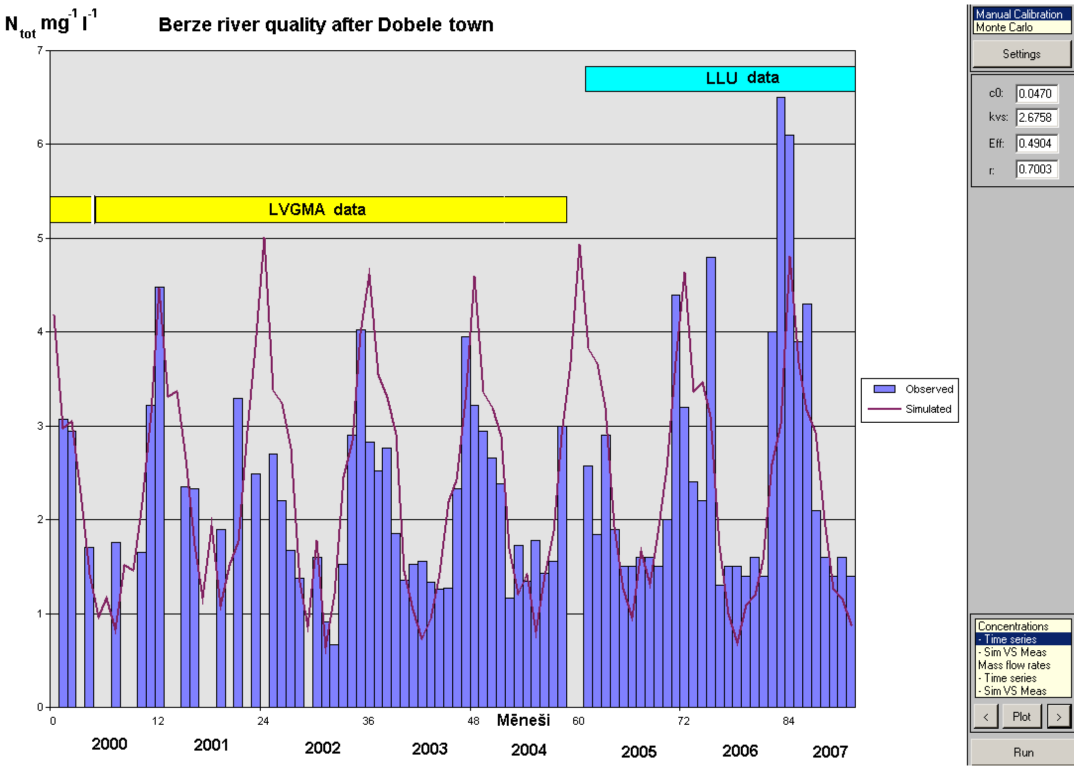



**Figure 2.3.** Simulation of total nitrogen (Ntot) concentration for sub-catchment: "Berze downstream Dobele town".

*Scientific results and economic significance of results*

Implementation of the research results of WP2 will develop capacities for water quality modelling, where progress in Latvia has been too slow. The assessment of the performance and the applicability of the models will support implementation of the required activities of WFD and the evaluation of Latvias' share and nutrient load quotas to reduce pollution of the Baltic Sea. Use of the regional climate change data with the calibrated modelling tools in the next phase of this Program will provide scientific evaluation of climate change impact to the surface water quality.

**Summary**

During the Program phase II, the time series of flow and nitrogen and phosphorus concentrations from the monitoring sub-catchments have been prepared for the assessment of performance and the applicability of the modelling tools. First successful calibration and validation of the hydrological model for rivers Salaca, Bērze and Iecava was performed in University of Latvia. In the Latvia University of Agriculture, the Fyris model, developed in the Sweden, was validated for water quality assessment in the Bērze river.

In the second phase of the NRP KALME, the assessment of nitrogen and phosphorus loss in several geographical scales (drainage plots, drainage field, small catchment) was continued. Such approach could provide the results comparable with that in the Nordic countries with similar soil and weather conditions. The research results will be an important contribution for the implementation of the Water Framework Directive e.g. to achieve a good ecological status in all water bodies in year 2015.

**WP2 tasks for the 3rd phase (2008):**

1. Improvement of the GIS data base and digital maps for sub-basins of the Berze river, providing:

Precise characteristics of the network of hydrographical systems (implementation schedule: I-XII, 2008.);

- Precise agricultural land use data from inventory of EU payment Agency data base – data of year 2007. (implementation schedule: I-V, 2008.);
- Precise inventory data from register (VII. 2007) of the large animal farms. (implementation schedule: I-V 2008.).

2. Assessment of diffuse source pollution, nutrient concentrations, export coefficients and retention (implementation schedule: I-XII, 2008.) in the following sites:

Monitoring station Mellupītes in the scale: soil – drainage field – river (small catchment),

Monitoring stations Bērze un Vienziemīte in the scale: drainage field – river (small catchment),

River Bērze basin in 15 subcatchments;

Assessment of the impact of extreme weather conditions on nutrient loss in the monitoring stations Mellupīte and Bērze;

3. Improvement of the calibration results and validation of the hydrological (METQ) and water quality (FYRIS) models (implementation schedule: I-XII 2008.). Model application tests using WP1 data from regional climate change models (implementation schedule: VII-XII 2008.).

**Work Package Coordinator: Viesturs Jansons**

## Work Package Nr. 3: CLIMATE CHANGE IMPACT ON FRESHWATER ECOSYSTEMS AND BIOLOGICAL DIVERSITY

**Goal:**

To assess possible impact of the climate change on the ecosystems and biological variability of the inner surface wares of Latvia.

**Phase 2 tasks of WP 3:**

1. Prepare the long-term climate, hydro-chemical and biological (including fishes) data sets for the model water bodies representing several water body types.

2. Continue investigations in the selected water bodies to amend the existing data-sets, with a focus on variability of species composition as a representative indicator of environmental status.

3. Carry out experimental studies of organic carbon flow and drift of benthic organisms.

**Phase 2 results of WP3**

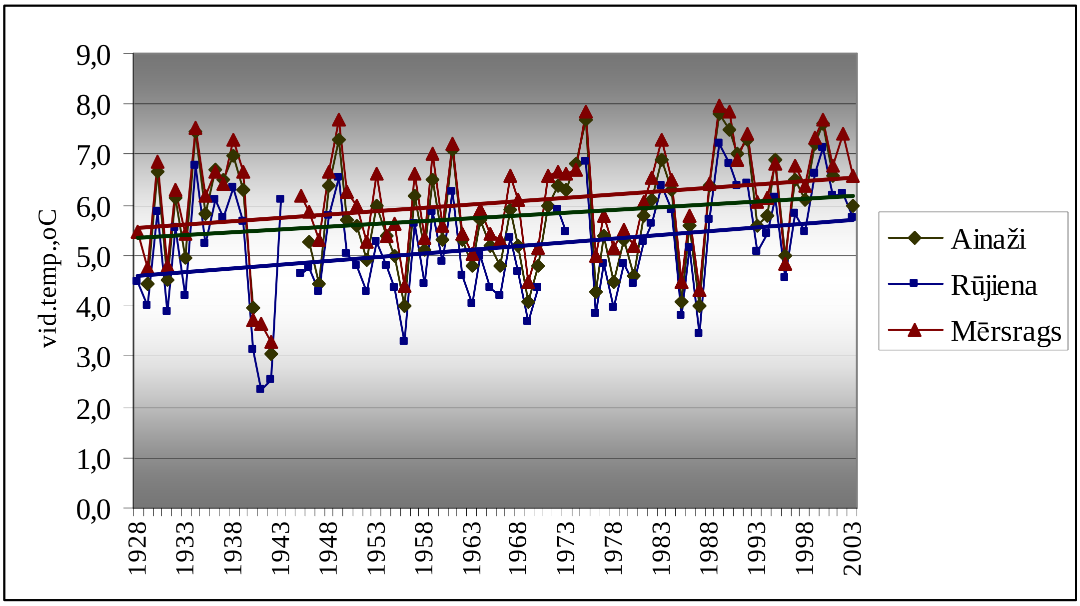
**Task 1:** *Prepare the long-term climate, hydro-chemical and biological (including fishes) data sets for the model water-bodies representing several water body types.*

In 2007, long-term climate, water chemical composition and biological data were summarized.

Air temperature is one of the most substantial climate characteristics. Its long-term variability was analyzed using data-bases from three meteorological stations situated in the basins where the selected model water bodies are situated (Rūjiena and Ainaži in the Salaca basin and Mērsrags in the Lake Engure basin).

The increase of the air temperature in these stations in 75-year time period is in the interval from 0.85$^{o}$C to 1.13$^{o}$C. The most significant changes are observed in the spring (March-April).

Data from 1950 to 2003 show that the increase in annual precipitation is typical only for Mērsrags station. The statistically significant increase in the precipitation in warm period of the year was detected in none of examined stations. At the same time significant decrease was observed in September.



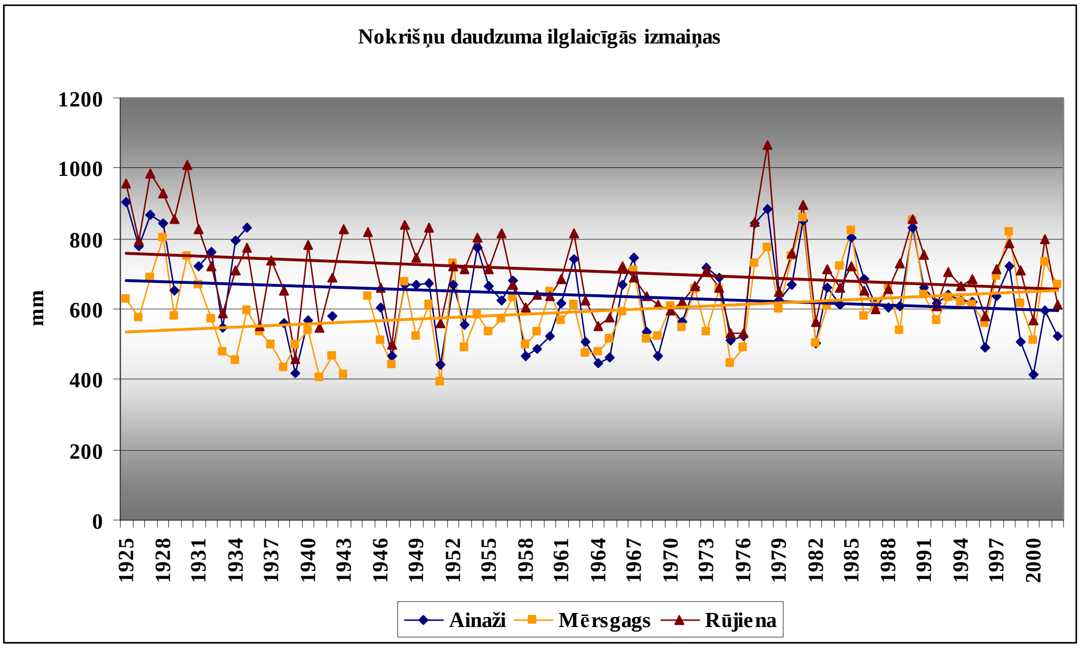




**Figure3.1.** The variability of mean annual air temperature (1928 – 2003, upper panel) and long-term changes in precipitation (1925 – 2003, lower panel) in Rūjienas, Ainažu (Salaca basin) and Mērsrags (the Lake Engures basin) meteorological stations.

The hydrological regime of rivers is characterized by an increase in the discharge. In the territory of Latvia this trend is statistically significant in January and February in the Venta, the Salaca, the Lielupe and the Gauja, in March – in the Gauja and the Salaca, and in December – in the Venta and the Lielupe. The increase in the winter discharge is typical especially for the recent decades, thus probably affecting the cycles of high-low water level.

The long-term changes in water chemical composition are related to the changes in water quality and their influencing factors, including climate change impact and effectiveness of water management. Our analysis witnesses that only in few of 23 water monitoring stations concentrations of $N\text{-}NO_3$ and $P\text{-}PO_4^{3-}$ had increasing trend, and all these positive trends occurred from 1980 to 1990. Accordingly, all statistically significant negative trends are present from 1991 to 2001. Water colour and COD have cyclic changes confirming the role of natural processes in the changes in concentration of organic matter in surface freshwaters. Since 1991, some tendency of increase in these parameters was observed. As the socio-economical changes have been taking place in the territory of Latvia since 1991, the changes were also in the composition of the main inorganic ions.

Long-term data of primary-producers – phytoplankton biomass (mg $l^{-1}$) in the River Salaca in the 90-ies of 20th century decreased in comparison with the 80-ies, continued by some increase since 2001. The increase since 1986 was observed also in the macro-phyte cover: in some river stretches it has reached up to 80 – 90 %.

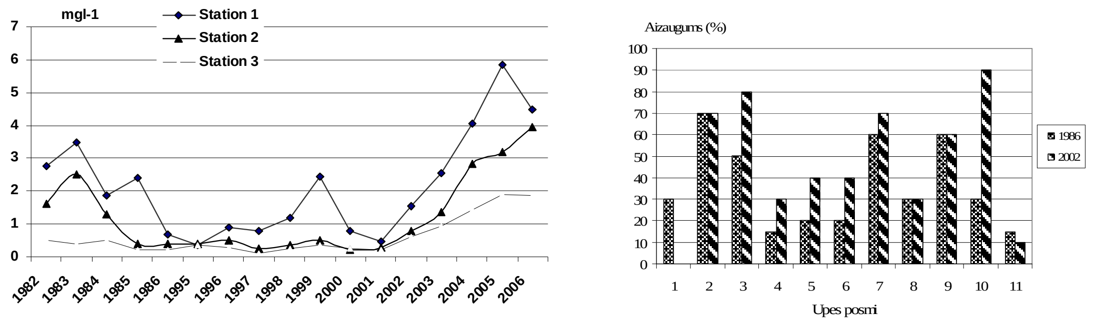



**Figure 3.2.** The increase in phytoplankton biomass (mg $l^{-1}$, left panel), and macrophyte cover (%, right panel) in the River Salaca.

At the same time, communities of benthic invertebrates are stable and characterize the river as β-mezosaprobic.

Different situation is observed in the Lake Engures where biomass and the structure of phytoplankton did not change significantly since 1995. At the same time visible changes in the benthic species composition and biomass occurred.

With regard to the fish fauna, an extensive data series was summarized in 2007. The data bases were developed fon salmon and salmon trout smolts migration since 1964; their biological data; data base for lampreys since 1960. Also data on coastal and off-shore fishing from 1984 to 2007 were summarized. Data base on electro-fishing since 1992 including data of about ~ 100 000 fish specimens was complemented as well as the data bases on fishing in 735 lakes of Latvia from 1949 to 2006. Data about distribution of potential indicator species – vendace *Coregonus albula*, whitefish *Coregonus lavaretus*, lake smelt *Osmerus eperlanus*, bitterling *Rhodeus sericeus* and sander *Stizostedion lucioperca* – in the lakes of Latvia were summarized.

The information on aquaculture in Latvia under climate change was gathered. 39 of total 43 farms has water supply from surface waters. Thus, the temperature of water used for aquaculture totally depends from natural seasonal dynamics of the environment.

The role of fish diseases is an ordinary regulator of fish populations. Diseases belong to the main limiting factors for aquacultures. Water temperature influences fish physiology, virulence, spread and diversity of pathogens and parasites. Data give evidence that most of fish diseases are closely linked to the seasonal water temperature, and there is a need for a complex analysis of water temperature and oxygen contents to forecast the possible outbreaks of fish diseases.

**Task 2:** *Continue investigations in the selected water bodies to amend the existing data-sets, with a focus on variability of species composition as a representative indicator of environmental status.*

The River Salaca was selected as model object representing the lotic systems as it is the main salmon river of Latvia, its outflow from the lake is typical for Latvian rivers, and it possesses both rhitral and potamal river stretches. The Salaca is situated in the North Vidzeme Biosphere Reserve, and it is one of the preconditions for assessing the climate change impacts in the territory with low anthropogenic load. The Lake Engure was selected as a representative lentic system as it belongs to lagoon type lakes. In the ERJRC report on the climate change and European water dimension, lagoon type lakes are recognized as the most sensitive freshwater ecosystems. Sampling was carried out also in three bog lakes in Teici Nature Reserve that have atmospheric feeding. In all selected objects hydro-chemical, bacteriological, algological and benthic invertebrate samples were collected. In these lakes also macrophyte cover and community structure was analysed as well as ichthyologic studies were carried out. For the assessment of changes in biodiversity, the sorting of samples goes down the species level, if possible.

Ichthyological investigations were also carried out in the lakes with vendace *Coregonus albula* and with lake smelt *Osmerus eperlanus*. In general, biological analyses were done for 24 fish species, and more than 6000 examples were analysed. Biological diversity monitoring data from113 locations in 44 streams and rivers were also used. In total, 34 fish, 2 lamprey and 4 crayfish species were found, and 9 of them are the protected species according EU and Latvian legislation. Four of the species - Amur sleeper *Percottus glehni*, golden carp *Carassiuss auratus*, signal crayfish *Pacifastacus leniusculus* and American freshwater crayfish *Orconectes limosus* are introduced ones. Some of species have arrived in the natural waters from the nurseries: in the Lielupe basin *Salmo salar* and grayling *Thymallus thymallus*, in the Gaujas basin – rainbow trout *Salmonific mykis*.

The obtained data significantly complement existing data bases for the assessment of fish distribution, migration behaviour and growth changes in connection with climate change.

**Task 3:** *Carry out experimental studies of organic carbon flow and drift of benthic organisms.*

It is still little known about the impact of climate change to organic carbon flow in natural aquatic ecosystems although organic carbon affects mineral weathering, nutrient turnover, leaching of metals and toxicity and influence of pollutants. In 2007, fifteen water samples were collected monthly in the Salaca basin. It is shown that concentrations of total organic carbon (TOC) are related with the seasonal changes in water discharge.

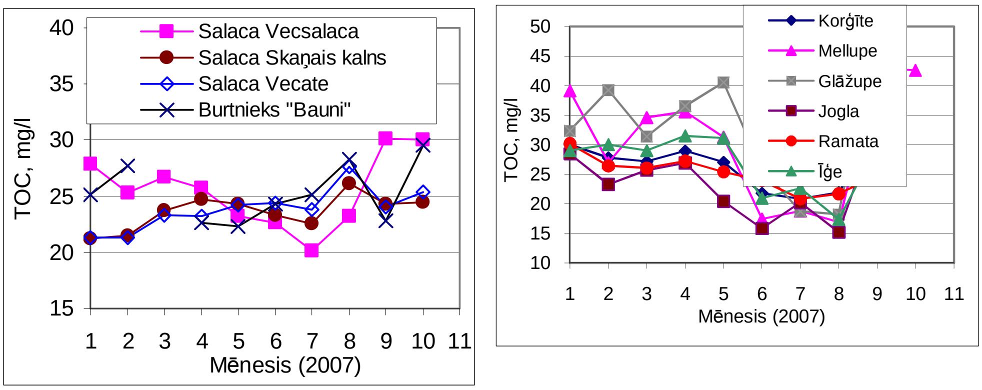



**Figure 3.3.** Concentrations of TOC in the Salaca river (left panel) and its tributaries (right panel), 2007.

The increase in TOC is caused by increased input of organic substances by spring floods. In summer low-water period the input of organic carbon and TOC is decreased. In autumn sharp TOC increase is especially pronounced in small streams, and this difference proves that TOC content is mainly related with the organic matter transported in streams by rains.

In 2007 also investigations of algae and benthic invertebrate drift were carried out. It is known that biomass and production of the salmonid fishes correlates with the density of drifting invertebrates, but the density of drift in turn correlates with the benthic productivity. In climate change situation changes in the whole food chain could be expected, but there are too little investigations for future scenarios. Therefore, drift investigations were carried out in rhitral stretches of four medium-sized lowland streams in the Venta, Gauja, Daugava and Salaca basins in spring, summer and autumn in different micro-habitats. Sampling was performed eight times per day. Altogether, more than thousand drift samples were collected.

*Scientific and economic significance of results*

Long-term climate, hydro-chemical and biological data-sets are prepared for several types of surface waters. It allows extracting of the impact of climate change parameters such as temperature, precipitation, hydrological regime and ice-cover on the background of environmental factors.

The legislation in EU, e.g. WFD, emphasizes necessity to reach good water quality in the whole EU till 2015. CC, however, is not considered in these documents. Our research for the first time in Latvia includes climate change impact to planktonic and benthic freshwater communities. Investigations in the selected model objects provided opportunity to assess the changes in species composition and structure in relation to the climate change. Economically important data on aquaculture, linked with the climate change are gathered. Data on changes in ichthiocenoses of Latvian freshwaters are the starting point for the prognosis of the climate change impact on fish resources. For the first time in Latvia, organic carbon flow, that has important role in processes going on in water environment, was investigated. For the assessment of climate change (discharge) on the benthic (algae, invertebrates) organisms, investigations of their drift were carried out.

**Summary**

Hydro-chemical and biological data sets were prepared, and research in surface freshwaters was carried out with the emphasis on changes in species composition as representative characteristic of ecological state in selected model objects. Studies of organic carbon flow and drift of planktonic and benthic organisms were carried out.

**WP3 tasks for the 3rd phase (2008):**

1. Treatment of the biological samples collected in 2007; amending of the data bases; statistical analysis and interpretation in relation to the climate change.
2. Analysis of the climatic and the hydrological extremes in the areas of model water bodies.
3. Continuation of collection and analysing of hydro-chemical (incl. TOC), hydro-biological (including fishes) samples.
4. Preparation of the maps of land-use and spatial distribution of fish species in the Salaca drainage basin.
5. Analysis of the ecological requirements of aquaculture installations and infection risk of different taxonomic-ecological fish groups.
6. Collection of the drift samples to continue analysis daily and seasonal dynamics.

**Work Package Coordinator: Gunta Spriņģe**

## Work Package Nr. 4: COASTAL PROCESSES

**Goal:**

The objective of this study is analysis of coastal changes and forecast climate fluctuation impacts on the coastal dynamic and ecosystems in Latvian terrestrial waters of the Baltic Sea, to describe the quality and biological diversity of the sea environment, marine resources and service for its sustainable use.

**Phase 2 tasks of WP4:**

1. Systematization of published and archived materials (like maps and plans) of the $20^{th}$ century and preparation of the coastal processes (erosion) digital maps. Systematization of historical cartographical and bathymetry plans, maps and estimation the coastal zone changes (erosion, accretion) in Latvian harbours.
2. Estimation and characterizing of coastal geological processes in the 20th century. Determination of changes in coastal erosion and accumulation zones; recording of hydro-technical activities (harbours, coastal protective structures), and estimation of their influence on the coastal dynamic (history of coastal processes).
3. Creation of the maps of coastal erosion and accumulation processes in the $20^{th}$ century. Preparing the maps of maximal coastal retreat and accretion zones in Latvia; the map of coastal geology (coastal typology), and the map of maximum sea-water levels (storm surge levels).
4. Field works: Mapping of the coastal erosion zones after winter- spring storms (year 2006/2007); Mapping of the coastal protective structures at the Gulf of Riga; Mapping of erosion risk at selected sites (endangered objects and population in Roja and Saulkrasti coastal zones of the Gulf of Riga).

**Phase 2 results of WP4:**

**Task 1:** *Systematization of published and archived materials (like maps and plans) of the $20^{th}$ century and preparation of the coastal processes (erosion) digital maps. Systematization of historical cartographical and bathymetry plans, maps and estimation the coastal zone changes (erosion, accretion) in Latvian harbours.*

Investigations of coastal geo-morphology in Latvia and the first substantial scientific articles and monographs on this topic appeared only in the 50s and 60s of the 20 century. The Approach in these publications was descriptive and they did not include measured data and calculations. Maps seem to be rather generalized and cartographically distorted (majority of the area belonged to the soviet time secret zone).

More detailed historical topographic maps and plans appeared only about some harbours and their surroundings. The review of historical maps, plans (1935-38, 1980-1990) and the scientific articles and monographs performed by the WP4 team allowed to produce several digital maps:

* Latvian coastline dynamics during the last 2500 years;

* Coastal processes of the Gulf of Riga in the 50ies of the $20^{th}$ century;

* Coastal erosion in the hurricane of 1969 (fig. 4.1).
* Periodicity of the Baltic coastal erosion and accumulation processes (1956-1987);
* Coastal processes of Latvia at the 80ies of the 20 century.

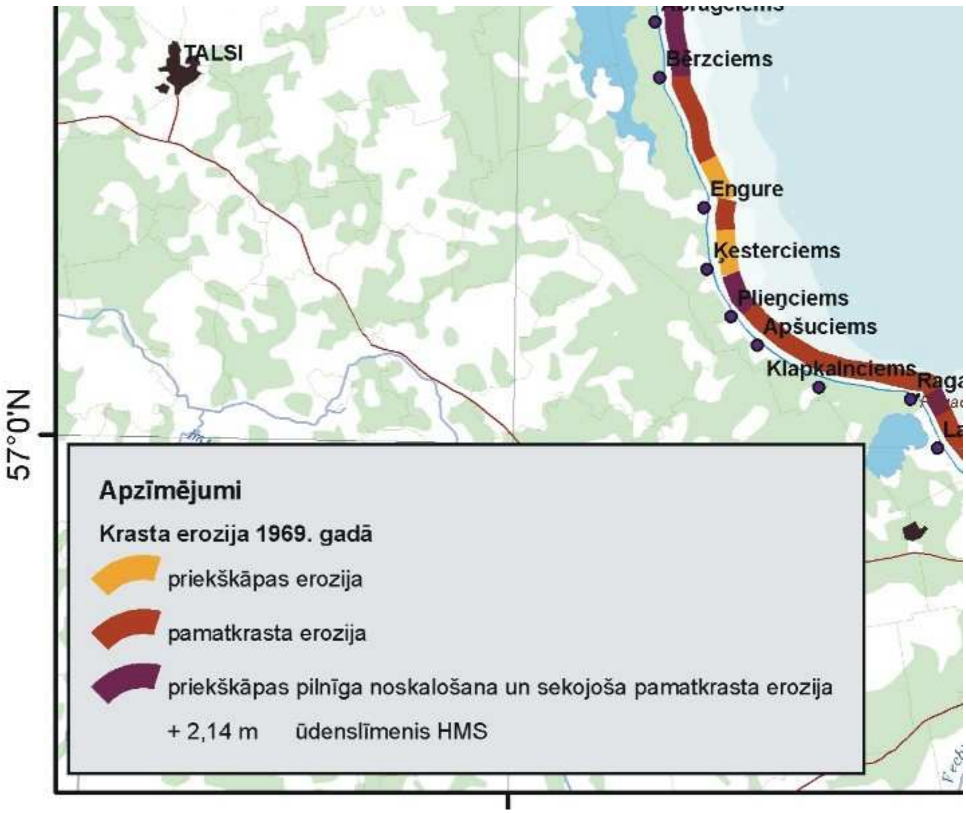



**Figure 4.1.** Fragment of the map „Coastal erosion in hurricane 1969 at the Gulf of Riga.

**Task 2:** *Estimation and characterizing of coastal geological processes in the 20th century. Determination of changes in coastal erosion and accumulation zones; recording of hydro-technical activities (harbours, coastal protective structures), and estimation of their influence on the coastal dynamic (history of coastal processes).*

In order to estimate and characterize the changes in coastal geological processes in the 20$^{th}$ century, the group analysed cartographical materials of the earliest land topographical measuring plans (1935-1938) at the scale 1:5000 and 1:2500. In addition, the soviet topographical maps produced in the 80-ies (scale 1:10000) have been analyzed. This review of topographical plans and maps gave an opportunity to determine coastal changes (retreat and accretion) during the last 50-60 years (1935-1990).

Topographical measuring plans produced in the 30ies – 40ies did not include coastal areas covered by state-owned forests. Also, such plans do not exist for the Eastern coast of the Gulf of Riga (Vidzeme).

Based on comparison of these maps, the graphs of the change of Latvian coast have been produced, and subsequently the long-term mean and maximal rates of coastal erosion calculated. These rates differ for the coast of the open Baltic and the Gulf of Riga.

Assessment of the coastal processes that took place during the last 15 years was based on the long-term coastal geological processes monitoring data and mapping of coastal erosion cells after the storms.

The analysis of topographical maps and plans of Latvian harbours and their surroundings revealed the coastline changes that characterize the influence of harbour activity and hydro-technical construction on the coastal processes.

Results these studies are presented in the maps:

* Coastal change and modern processes of the Gulf of Riga (1992-2007), fig. 4.2.

* Coastal change and modern processes of the open Baltic coast (1992-2007).

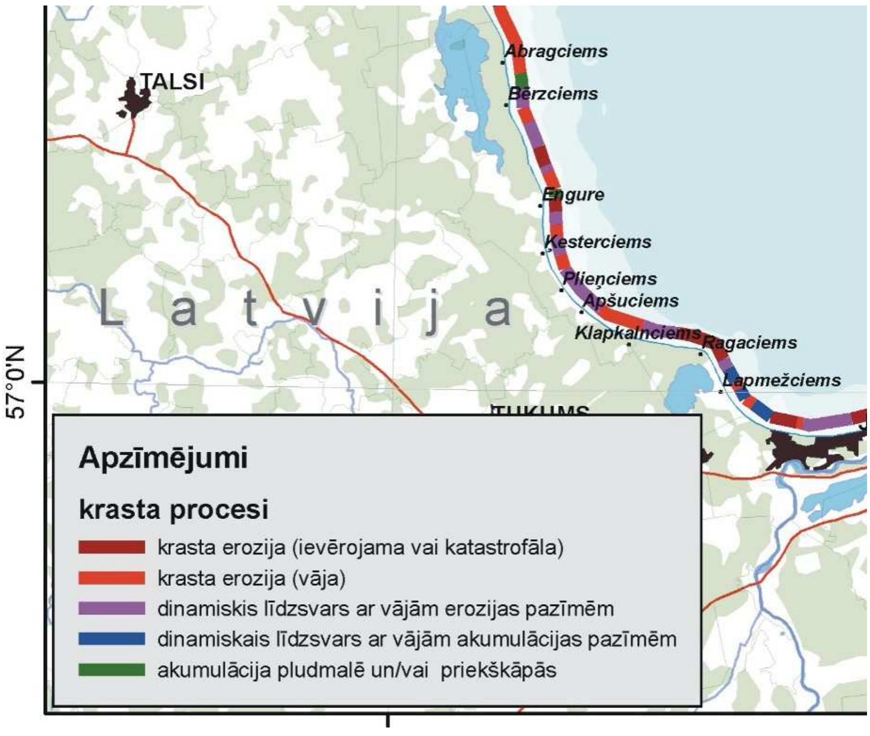



**Fig. 4.2.** Fragment of the map „Coastal change and modern processes at Gulf of Riga (1992-2007).

**Task 3:** *Creation of the maps of coastal erosion and accumulation processes in the 20th century. Preparing the maps of maximal coastal retreat and accretion zones in Latvia; the map of coastal geology (coastal typology), and the map of maximum sea-water levels (storm surge levels).*

**Compilation of the tasks 1 and 2 resulted in creation of the following digital maps:**

- Open Baltic coastal change and processes in the 20th century (1935/38-2007)
- Gulf of Riga coastal change and processes in 20th century (1935/38-2007)
- Coastal geology (types of coast), fig.4.3.
- High erosion risk coastal segments
- Local factors that determine coastal erosion
- Coastal erosion after the storms of November 2001
- Coastal erosion after the hurricane January 8/9, 2005
- Coastal erosion in storm January 15, 2007

Planned preparation of coastal administrative and maritime boundary maps has been scheduled for the 3rd phase of the Program (to be delivered in 2008). These maps (scale 1:2000) shall outline local coastal villages and towns' under coastal erosion and flood risks and serve for the subsequent risk assessment.

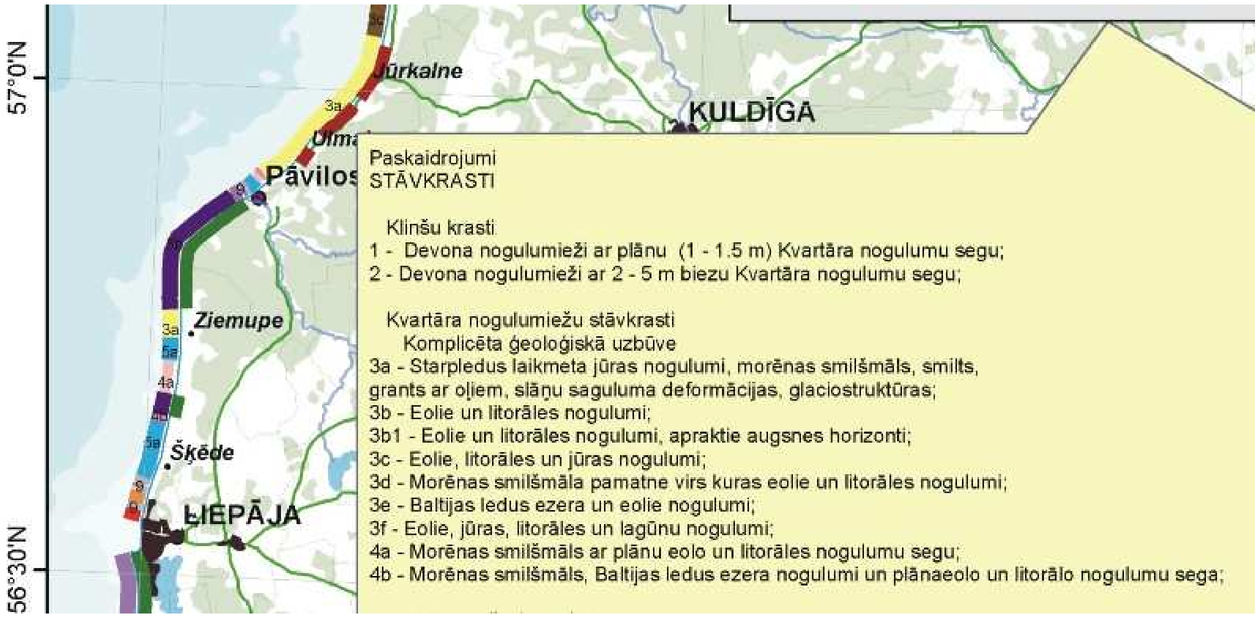



**Fig. 4.3**. Fragment of the map „Coastal geological structure".

The produced maps are presented in the NRP KALME web site, and will be published as an atlas of coastal processes in 2008.

**Task 4:** *Field works: Mapping of the coastal erosion zones after winter- spring storms (year 2006/2007); Mapping of the coastal protective structures at the Gulf of Riga; Mapping of erosion risk at selected sites (endangered objects and population in Roja and Saulkrasti coastal zones of the Gulf of Riga).*

The results of the Baltic Sea coastline survey (spring- summer- autumn 2007) have been transferred to a digital map characterizing coastal retreat during the storms.

Coastal protective structures have been mapped during the survey of the Gulf of Riga coast. A digital map of these data will be prepared in 2008.

Pilot mapping of the buildings in several local erosion risk areas (Saulkrasti, Roja) has been performed.

During the phase 3 (2008) of the Program the mapping and risk assessment will be used for production of new (2007) ortho-photo maps (scale 1:2000).

*Scientific and economic significance of results*

Quantitative data on distribution of the coastal retreat and erosion rates were obtained for the first time in Latvia. The new data will be used to prepare a series of maps depicting Latvian coastline changes and coastal processes during the 20$^{th}$ century and, in particular, the recent 15 years (1992-2007). In addition the maps will illustrate the coastal erosion that took place during separate strong storms (2001, 2005, 2007) at different wind, climate and storm surge levels in sites with varied coastal geology. These maps will describe the local factors determining the coastal erosion risk.

In 2008 these maps will be prepared and published as an atlas „Coastline change and coastal processes in Latvia".

The results obtained in this phase of the work will serve as a basis for the phase 3 (2008) focusing on the coastal erosion forecasts, flooding risks of low-lying coastal areas risks, mapping of the social and economical risk impacts and preparation of recommendations (2009) for coastal zone planning and management.

**Summary**

Complex studies of the character and intensity of coastal processes and their future development that were carried out during the second phase were based on published and un-published materials, analysis of the cartographic maps and plans as well as the systematic investigation of geology and geo-morphology and real-time monitoring that took place during the recent 15 years. The outputs of these studies served to produce initial material and digital maps for elaboration of forecasts and the risk assessment for the future 30 – 50 years, under an impact of the climate change.

**WP4 tasks for the 3$^{rd}$ phase (2008):**

1. Continuation of mapping of the coastal changes and measuring of coastal erosion in monitoring stations after winter-spring storms of 2007/2008.

2. Finalization of mapping and estimation of efficiency of coastal protective structures (open Baltic coast). Preparation of digital map.

3. Continuation of mapping and estimation of dwelling-houses, plants, cultural-historical and protected nature objects, located in high erosion risk zones.

4. Preparation of coastal erosion forecasts for different climate change scenarios. Preparation of maps for the costal administrative units that could be used for planning and management purposes.

5. Adoption of EU erosion criteria for conditions of Latvia, design of tailor-made methodology for risk assessment. Mapping of beach typology, as indicator of the coastal processes. Preparation of the digital maps.

6. Mapping of foredune typology as indicator of coastal processes.

**Work Package Coordinator: Guntis Eberhards**

## Work Package Nr. 5: BIOGEOCHEMICAL PROCESSES AND PRIMARY PRODUCTION IN THE BALTIC SEA

**Goals:**

To forecast the impact of climate change on biogeochemical cycles and ecosystem of the Baltic Sea.

**Phase 2 tasks of WP 5:**

1. Sediment-water interface processes: Literature studies, defining the terms of experiment, development of experimental system and start of experimental work, data treatment.

2. Productivity and sedimentation: Procurement of necessary equipment, system testing and beginning of observation.

3. Marine model: preparation of phytoplankton input data, parameterisation of model, model calibration, analyze of nutrient turnover.

4. Prognoses of marine productivity and quality changes: literature study, treatment of experimental and model results.

**Phase 2 tasks of WP5:**

**Task 1**: *Sediment-water interface processes: Literature studies, defining the terms of experiment, development of experimental system and start of experimental work, data treatment.*

Generally, the set task was fulfilled according to the set time table. However, elaboration of the experimental system was slightly delayed due to shortage of funding during beginning of 2007. Building of the experimental system was possible in the beginning of summer what coincided with beginning of the vacation season. This created an additional delay with starting of the experimental work. As a result, only one of planned two experiment runs was completed by the reporting deadline. The second run is planned to commence after fresh material will be sampled and it was planned to complete it by the end of December 2007. The aim of the experiment is to establish critical values of environmental conditions under which changes in biogeochemical processes in surface sediments and its overlaying waters can be observed.

During experiment the sediment cores (n=8) with overlying water were initially maintained under ambient temperature and saturating oxygen concentrations in sediments overlying water. The gentle stirring of the overlying water was provided by a rotating mixer. At $4^{th}$ day of the experiment oxygen concentration in half of experimental columns was lowered to approximately 1 ml $l^{-1}$. The observed results demonstrate large dispersion among experimental columns, most likely due to presence of macrozoobenthic organisms. Therefore, it is necessary to repeat the experiment under more homogene conditions to give larger certainty to the observed results.

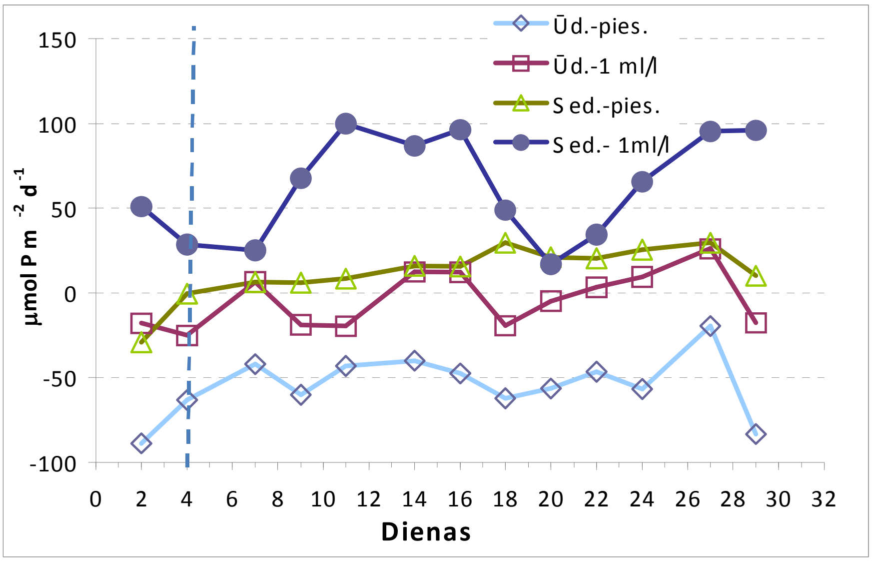



**Figure 5.1.** Phosphorus fluxes on sediment-water interface (positive values denote P release from sediments). "Ūd." denote exposition columns without sediments. Vertical line mark oxygen concentration decrease time.

The obtained results are preliminary, and it is not possible to draw final conclusions. However, the preliminary analyses of the results indicate that 2-3 days after oxygen concentration decreased to approximately 1 ml $l^{-1}$ in experimental columns with sediments, the P fluxes out of sediments increased significantly (Fig. 5.1). The observed decrease in fluxes during 18-24 day of experiment most likely is a result of technical shortcomings of the experimental system: the mixing system was not working properly during the above mentioned period. However, changes in the biogeocheical processes cannot be excluded either. Therefore, it is necessary to repeat the experiment under the same conditions. In addition, the preliminary results show that in well aerated water P adsorbs to mineral particles suspended in water, as was observed by several other researchers, while in water experiencing oxygen deficit the adsorption does not take place.

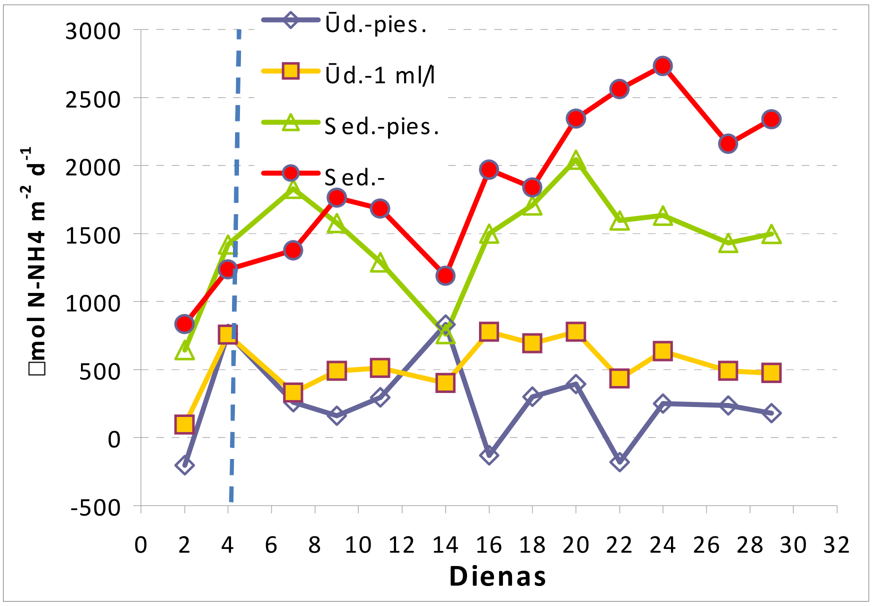



**Figure 5.2.** Ammonium nitrogen fluxes on sediment-water interface (positive value denote release of ammonium nitrogen). "Ūd." denote exposition columns without sediments. Vertical line mark oxygen concentration decrease time.

In contrary to expected, the ammonium fluxes (Fig. 5.2), although positive, did not exhibit significant difference between sediment columns with good oxygen conditions and sediment columns under oxygen deficit, except at the very late stage of the experiment. The comparative increase of ammonium fluxes in columns with low oxygen concentration coincided with a significant decrease in nitrate (Fig. 5.3) fluxes. That might indicate decrease in the nitrate pool approximately 20 days after initiation of the experiment.

At the same time nitrate fluxes (Fig. 5.3) remained low until the 14$^{th}$ day of experiment with sharp and extensive increase. Surprisingly, the fluxes in columns with good oxygen conditions exceeded fluxes in columns with low oxygen content. One possible explanation is that nitrate flux increase was a result of mass mortality of macrozoobenthic organisms. However, no direct evidence supports this assumption and therefore an additional investigation is required.

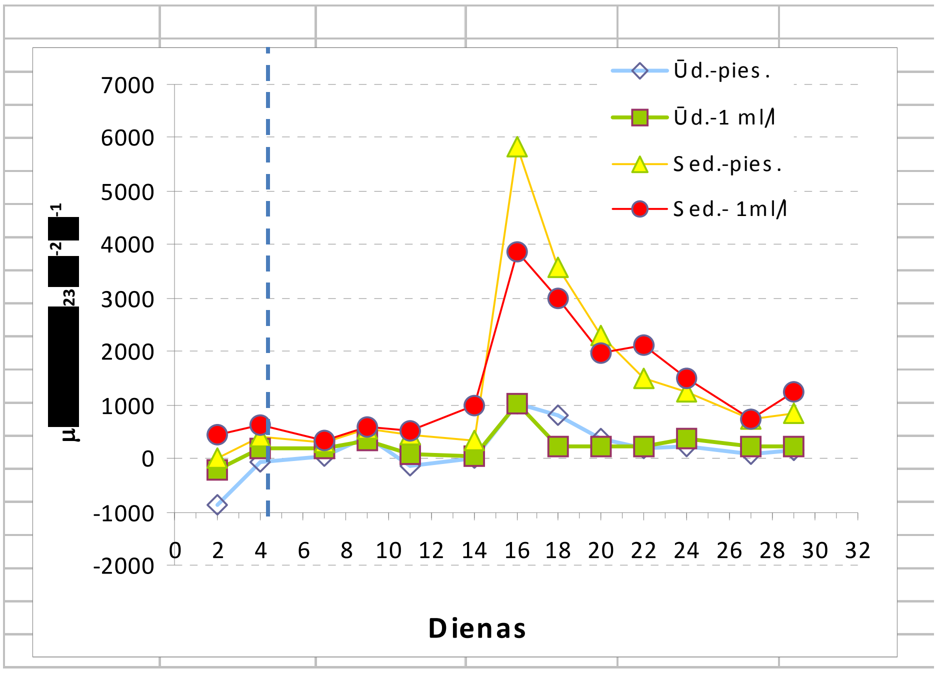



**Figure 5.3.** Nitrate nitrogen fluxes on sediment-water interface (positive value denote release of nitrate nitrogen). "Ūd." denote exposition columns without sediments. Vertical line mark oxygen concentration decrease time.

**Task 2:** *Productivity and sedimentation: Procurement of necessary equipment, system testing and beginning of observation.*

Planned tasks were performed with a delay from the work schedule due to the already mentioned shift in project funding schedule. This resulted in later than planned procurement procedure, and the purchased sediment multitrap was received only in autumn, when due to logistical reasons it was not possible to commence the planned field testing of the equipment. Other planned tasks were performed as planned, that is agreement with State Hydrography service was reached on place and conditions of sediment trap deployment. One of agreement points requires that in 2008 navigation buoy is purchased. It is planned to use Latvian Navy ships to deploy and service the sediment multitrap, and corresponding agreement with the Navy is underway.

**Task 3:** *Marine model: preparation of phytoplankton input data, parametrization of model, model calibration, analyze of nutrient turnover.*

**Model input data accumulation**

The data of nutrient loading in to the Gulf of Riga, as well as the nutrient concentrations in water were collected for use in biogeochemical model. Additionally, the data on phytoplankton and zooplankton concentrations were gathered. Special attention was given to preparation of phytoplankton input data. Changes in the methodology of analyses and change in the sampling frequency since 1995 systematically influenced phytoplankton data set and resulted in underestimation of the blue-green algae biomass as well as that of the other algae species which have small cell size.

It is likely that climate change will mostly influence the blue-green algae, enhancing their relative significance. Therefore, only those data which reflect blue-green algae dynamic with good enough confidence were used in model calibration (Fig. 5.4).

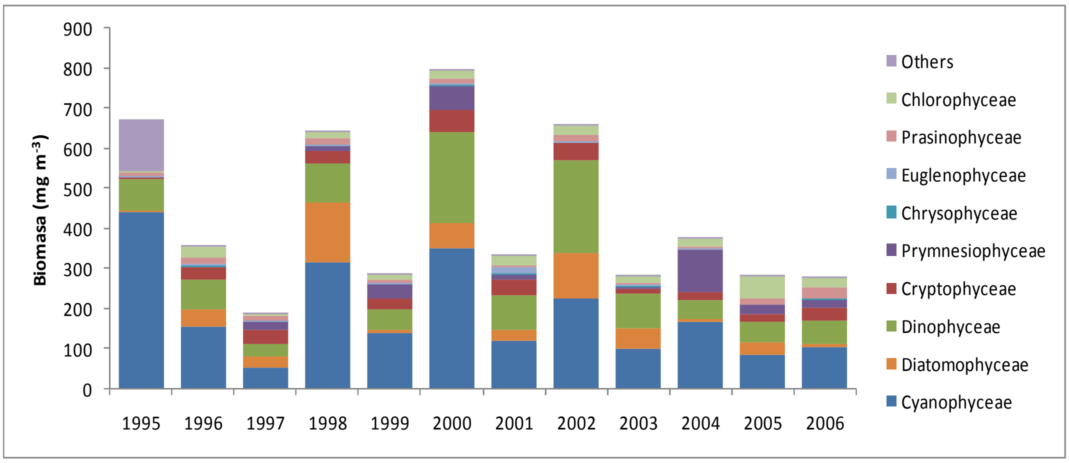
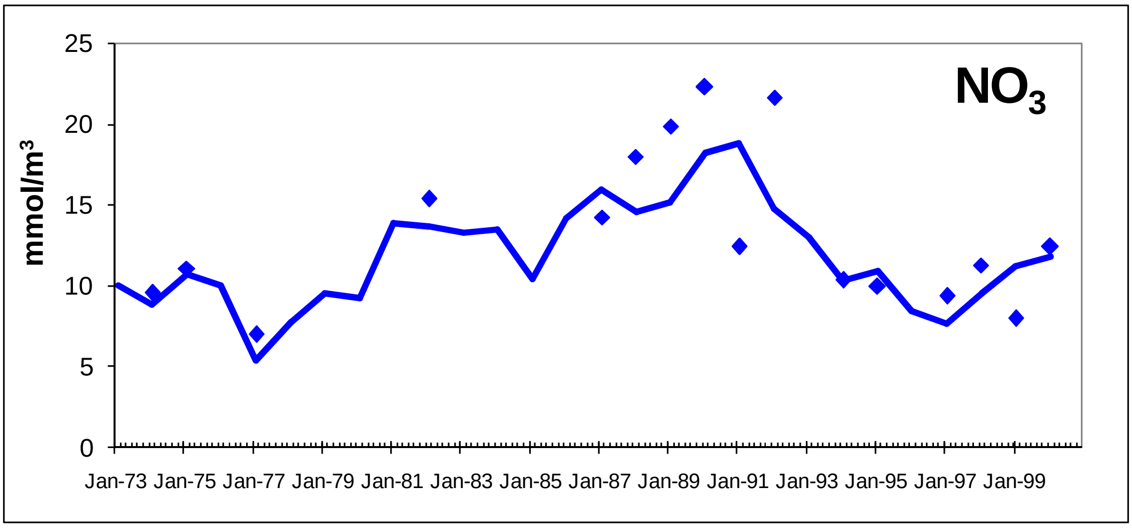



**Figure 5.4.** Summer biomass of phytoplankton in the central part of the Gulf of Riga. The data included in the data series are treated with uniform methodology, which correctly represents biomass of the blue-green algae and other small-cell species.

**Calibration of model**

In the initial structure, where three special compartments are presented, model is calibrated for time period 1973-200. Model calculations correctly represent long-term nutrient dynamics in the Gulf of Riga (Fig. 5.5) and exhibit typical seasonal dynamics of nutrients and phytoplankton.



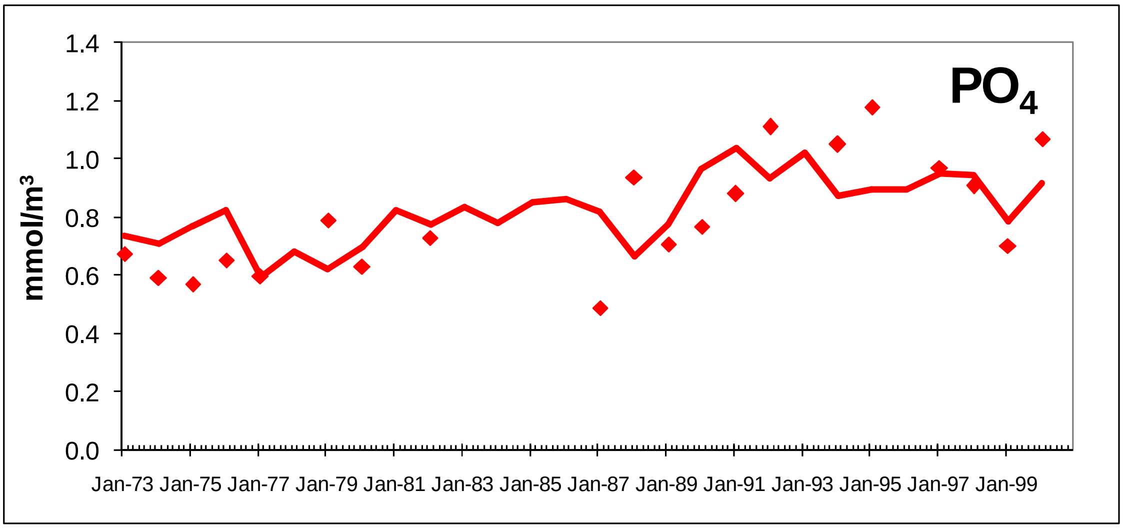




**Figure 5.5.** Winter nutrient concentrations in the Gulf of Riga: lines – calculated from the model, points – obesrved values.

Simultaneously with the work on calibration algorithm, the model restructuring was initiated. As mentioned before, model consists from two spatial units, which simulate biogeochemical processes in the coastal area, deep area – deep water/sediments and open area – photic zone. Coastal part poorly reflects processes occuring in the shallow part of the Gulf of Riga. More data for calibration are available almost exclusively from the regions close to the river runoff. Therefore, the model is beeng restructurized in order to merge the coastal and open parts.

The greatest problem in model restructurization is calibration algorithm, which performs way too slow and not always exhibit optimal model parameters. Therefore, a special program for calibration algorithm was created (Fig. 5.6).

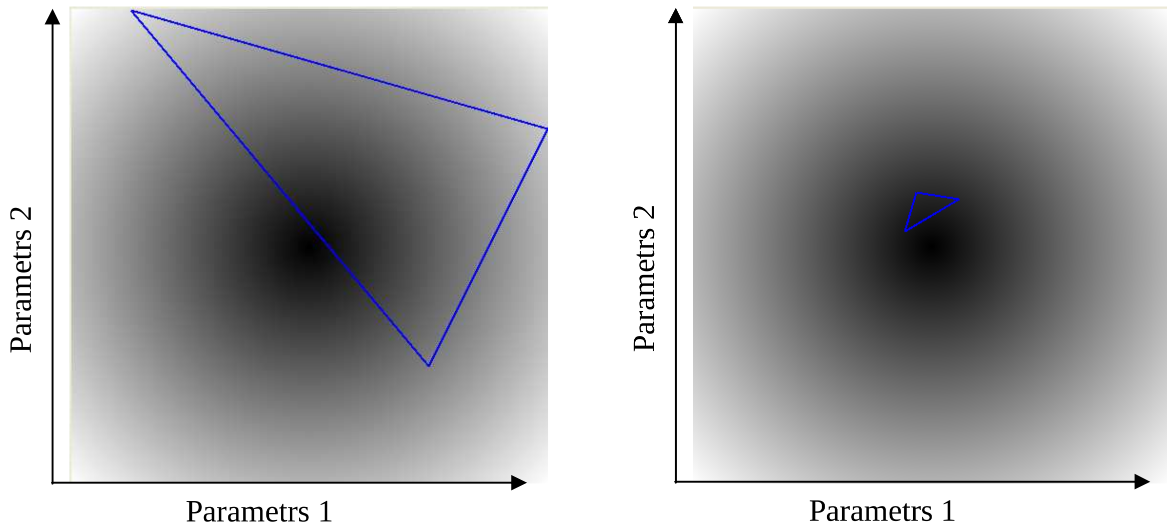



**Figure 5.6.** Optimization of two parameters in testing of two algorithms. The color represent values of minimization functions (white: maximum, black: minimum). The corners of blue triangles denote combinations of parameters, which are tested by algorithm during process of optimization (left figure: initially, right figure: approaching global minimum).

**Task 4:** *Prognoses of marine productivity and quality changes: literature study, treatment of experimental and model results.*

According to the time frame, in fourth quarter od 2007 the literature studies were initiated. Since the work is in its early stage and the experimental work was delayed, results which could be presented in the report are not acquired yet.

*<u>Scientific and economic significance of results</u>*

First new information on sediment-water interface processes under oxygen deficit conditions was obtained. This is important since most of the previous experiments were dealing either with well aerated systems or systems compleately without oxygen. Both of these extreme cases have only limited applicability in case of the Gulf of Riga.

**Summary**

Data on nutrient loads to the Gulf of Riga nad nutrient concentrations in water were collected and pre-treated. The long term data-sets of phytoplankton and zooplankton biomass, climatic, hydrochemical, ihtiological parameters for modeling of biogeochemical processes were prepared. Furthermore, an pilot experiment of sediment-water interface processes was performed, simulating the system response to oxygen concentration decrease in sediments overlying water to value of 1 ml $l^{-1}$.

**WP5 tasks for the 3rd phase (2008):**

1. Analyse the results of experimental work performed in 2007.
2. Continue the work on biogeochemical model elaboration, integration of experimentally obtained data into the model, calibration of model to simulate the alternations in biogeochemical processes caused by the climate changes.
3. Continue the experiments initiated in 2007 in order to establish changes in biogeochemical processes due to changes in oxygen conditions.
4. Establish sediment multitrap mooring in the central part of the Gulf of Riga and initiate regular observations by this instrument.

**Work Package Coordinator: Juris Aigars**

## Work Package Nr. 6: CLIMATE CHANGE IMPACT ON ECOSYSTEMS AND BIOLOGICAL DIVERSITY OF THE BALTIC SEA.

**Goal:**

To assess the impact of the consequences of climate change in the Baltic Sea on ecosystems in the Latvian waters in order to facilitate the protection of environmental quality and biodiversity and secure sustainable use of the marine resources.

**Phase 2 tasks of WP6:**

1. Series of laboratory experiments for assessment of changes in the phytoplankton community under the impact of climatic variation and anthropogenic loads in the Gulf of Riga and Baltic Sea.

2. Sampling and analysis of the field data on microzooplankton, phytoplankton, macrozoobenthos and phytobenthos in the Latvian Baltic Sea part for estimation of alterations in biodiversity, species relationships and trophic links.

3. Digitalization of historical data of fisheries surveys for data analysis and inclusion in the models.

4. The creation of a fish community model – the long-term projection of fish stock and production under the fluctuations of climatic regime and loads, using the long-term time series and results of modelling.

**Phase 2 results of WP6:**

**Task 1:** *Series of laboratory experiments for assessment of changes in the phytoplankton community under the impact of climatic variation and anthropogenic loads in the Gulf of Riga and Baltic Sea.*

Due to the delay of funding, the necessary equipment (climate chambers) were purchased later than planned and accordingly the experiments were started approx. 5 months later (not in April but September). Thus instead the experiments with spring and summer phytoplankton, investigations on autumn phytoplankton community and zooplankton production were performed.

**Experiment No.1.** The impact of increased temperature on autumn phytoplankton community structure in the Gulf of Riga. Aim: to clarify the structural changes of autumn phytoplankton in the Gulf of Riga under the influence of increased water temperature.

Material un methods. Natural phytoplankton communities were sampled in two sites of the coastal zone of the Gulf of Riga – in traverse of Dubulti and Saulkrasti. The experiment continued for 16 days – from 23 October till 7 November. Zooplankton was removed from the samples to avoid the grazing. Phytoplankton communities were exposed to the temperature which differed from the natural by -2$^{o}$C, 0$^{o}$C, +2$^{o}$C and +4 $^{o}$C, respectively. Duration of the light/dark cycle was maintained close to the field conditions. Part of the experimental series ("+piev" in the figures) received inorganic nutrient additions at the N:P ratio and concentrations characteristic for the Gulf of Riga during the first 7 days of the experiment. *In vivo* fluorescence was measured daily, samples of phyto- (species composition) and bacterioplankton (total abundance) were collected every second day. Concentrations of nitrates, nitrites, ammonium, total nitrogen and total phosphorus were measured at the first, third and eighth day of the experiment.

Our preliminary results indicate that in the series with nutrient addition, phytoplankton had the most intensive growth at +15°C, reaching the maximal values at the 10$^{th}$ day. At +9°C the development was slower and the maximal fluorescence was reached 5 days later (Figs. 6.1., 6.2.).

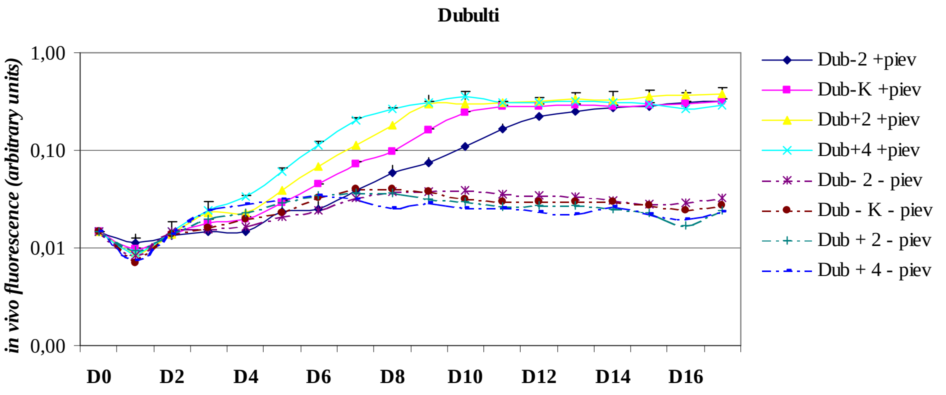



**Figure 6.1.** *In vivo* fluorescence in the series from Dubulti, incubated at 9 °C (-2); 11 °C (K); 13 °C(+2); 15 °C(+4), 23 October-7 November, 2007.

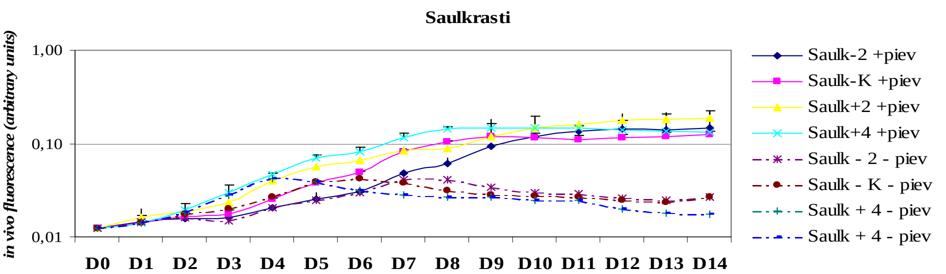



**Figure 6.2.** 4. *In vivo* fluorescence in the series from Saulkrasti incubated at 9 °C (-2); 11 °C (K); 13 °C(+2); 15 °C(+4), 23 October-7 November, 2007.

Currently the phytoplankton species composition is identified to show the response of particular species to the temperature and nutrient alterations.

Conclusions. As expected, the additions of inorganic nutrients trigger a mass development of phytoplankton which is more intense in the conditions of increased temperature, compared to natural or decreased one. Thus, if the water cooling in the autumn is delayed, phytoplankton autumn bloom can reach higher maximal values.

**Experiment No.2.** An impact of increased temperature on **zooplankton egg production** in the Gulf of Riga.

Samples were collected at the eastern part of the Gulf. The experiment was started with the next generation of copepods, hatched already in the laboratory. Egg production rate of *Acartia bifilosa* was measured at the selected temperature values: 9, 11, 13 and 15$^{o}$C. Production (number of eggs) was estimated after 24 h long exposure. The results are currently being analyzed.

**Experiment No.3.** An impact of increased temperature on **particular phytoplankton species** in the Gulf of Riga.

Aim: to investigate the response of separate dominant phytoplankton species on potential temperature increase due to delayed water cooling in autumn in the Gulf of Riga. It is expected that results of this experiment will serve as additional data for the modelling purposes.

Material and methods. Characteristic autumn-winter-spring species of the Gulf of Riga will be used as a test objects:

green alga - *Scenedesmus quadricauda,*

one of the dominant diatom species - *Navicula spp.* or *Nitschia spp*.

The development of algae will be observed at the respective temperature deviations: -2 $^{o}$C; 0 $^{o}$C (control); +2 $^{o}$C; +4 $^{o}$C from the natural. The abundance of algae will be estimated by values of *in vivo* fluorescence.

At the beginning of December 2007 **experiment No.4** will be started: An impact of increased temperature on **winter phytoplankton community** structure in the Gulf of Riga.

Aim: to identify the response of winter phytoplankton to the rise of water temperature and potential shrinking of the ice cover period in the Gulf of Riga.

Material and methods. The substrate in the experiment will be sediments from the accumulation zone of the Gulf containing over-wintering phytoplankton cells. To sustain the longevity of the experiment and circulation of substances, plankton communities will be incubated together with the benthic ones. The duration of the experiment will depend upon the physiological condition of phytoplankton; illumination cycle will be simulated close to the field situation. Incubation will occur in aerated plastic vessels of 70 l volume.

*The scientific and economic significance of the results* – short-term experiments give an opportunity to obtain additional data and deepen the understanding about the response of communities on the potential climatic variations in a real time, while in the field observations several years would be necessary. The data of the experiments are usable for future projections and calibration of models.

**Task 2:** *Sampling and analysis of field data on microzooplankton, phytoplankton, macrozoobenthos and phytobenthos in the Latvian Baltic Sea part for estimation of alterations in biodiversity, species relationship and trophic links.*

The collection of the field data at the coastal part of Latvian Baltic Proper was performed to obtain more information on response of planktonic and benthic communities and species on the environmental variation, as the existing data for last 15 years are incomplete in time and space. Current marine monitoring scheme does not include measurements of the environmental variables in the Baltic Proper – Eastern Gotland basin, and has a quite fragmented and formal approach also to the coastal zone. To fulfil the objectives of the program, the range of biological parameters sampled was planned to have the best possible coverage of all trophic links. The obtained data will be further used to prepare forecasts based both on long-term observations and the modelling results. Vessels of Latvian Naval Forces „Astra" and „Varonis" and the boat of Latvian Institute of Aquatic Ecology were used for the sampling cruises. Nine coastal stations from Ovīši to Nida and three stations in the Eastern Gotland were sampled.

The time schedule and the parameters of collected material are compiled in Table 6.1.

**Table 6.1.** Sampled field data and sampling time at the Baltic Sea, Latvian waters, in 2007

| Parameters | 15.-16.04. | 7.-9.05. | 9.-11. 06. | 13.-14.07. | 10.-12. 08 | 26.-27. 09. | 20.-22.11. |
|---|---|---|---|---|---|---|---|
| Microzooplankton – species composition, abundance, biomass | x | x | x | x | x | x | x |
| Phytoplankton – species composition, abundance, biomass, chlorophyll a concentration | x | x | x | x | x | x | x |
| Zooplankton – species composition, abundance, biomass | x | x | x | x | x | x | x |
| Macrozoobenthos – species composition, abundance, biomass | | | | | x | | |
| Hydrological parameters – temperature, salinity, oxygen concentration, pH, turbidity | x | x | x | x | x | x | x |
| Hydrochemical parameters – inorganic nitrogen compounds, phosphates, total nitrogen, total phosphorous, silicates. | x | x | x | x | x | x | x |

The analysis of the collected material will be continued in the 1$^{st}$ and 2$^{nd}$ quarter of 2008.

*The scientific and economic significance of the results* – when completed, work will give an opportunity to produce more precise forecasts of climate impact on the marine ecosystems. In turn, the alteration in condition of marine living resources will affect the economic and social stability in spheres of fisheries, regional development and tourism.

**Task 3:** *Digitalization of historical data of fish species scientific surveys for data analysis and inclusion in the models.*

The ability to forecast the recruitment or the production rate of the young fish is crucial for projections of the fish stocks and their catch. The fish recruitment is affected by various environmental factors, spawning stock size and its structure. The indices of recruitment could be obtained from the analytical assessment of the fish stock units or the scientific surveys of juvenile fish. In order to reveal the relationship between recruitment and the environmental conditions, the necessary time-series of the most important Baltic Sea fish species were supplemented with data of 2006 and the results of 2007 stock analytical assessment for spawning stock biomass and recruitment. Completely new time-series were prepared, e.g., fish maturing according to the age groups and coastal catch data. In total, data for following parameters were provided:

1. Gulf of Riga herring:

a) the abundance of a year old herring at the beginning of the year from the stock assessment for 1977-2006;

b) total spawning stock biomass and that for separate age groups 1977-2006;

c) mean body weight of the age groups in the spawning stock, 2 yrs old and older;

d) zooplankton species abundance and biomass in the Gulf, spring and summer 1977-2006;

e) mean water temperature in the Gulf, spring, at 0-20 m and 0-50 m layers, 1977-2006;

f) a sum of winter mean negative daily temperatures in Riga, 1977-2006.

2. Baltic Proper herring:

a) the abundance of a year old herring at the beginning of the year from the stock assessment for 1974-2006;

b) total spawning stock biomass and that for separate age groups 1974-2006;

c) mean body weight of the age groups in the spawning stock, 3 yrs old and older;

d) zooplankton species abundance and biomass in the eastern part of the Baltic Sea, spring and summer 1974-2006;

e) mean water temperature in the Baltic Sea, spring and summer, at 0-20 m layer, 1974-2006;

f) mean salinity at the eastern part of the Baltic Sea, 0-20 m layer, 1974 -2006.

3. Baltic Sea sprat:

a) the abundance of a year old sprat at the beginning of the year from the stock assessment for 1974-2006;

b) total spawning stock biomass and that for separate age groups 1974-2006;

c) mean body weight of the age groups in the spawning stock, 2 yrs old and older;

d) ratio of males and females in the age groups 1974-2006;

e) maturing of the fish in the age groups;

f) data on seasonal distribution of the sprat.

4. Eastern Baltic Sea cod:

a) the abundance of two year old cod at the beginning of the year from the stock assessment for 1964-2006;

b) total spawning stock biomass and that for separate age groups 1964-2006;

c) mean body weight of the age groups in the spawning stock, 3 yrs old and older;

d) reproduction volume (adequate salinity, oxygen content) in the deeps of Eastern Baltic Sea, 1964-2006.

5. Eastern Baltic Sea flounder:

a) survey results of flounder juveniles and other coastal fish in the shallow zone (0-2 m)of Irbe Strait, 1986-2007;

b) data of flounder larvae in the Gotland basin, 1970–2005;

c) salinity and oxygen content for calculation of appropriate spawning area and volume.

6. Coastal fish communities:

a) commercial catch at the coastal part of the Baltic Sea and the Gulf of Riga, 1993-2006;

b) mean catch in kg for one CPUE for main fish species according to fishing gear and coastal sub-areas, 1993-2006;

c) water temperature at the coastal zone of the Gulf, 5 m depth, spring-summer 2004-2006;

d) data of the benthic surveys in the Gulf, 1975-2006.

*The scientific and economic significance of the results* – the compiled time-series are the main basis for further development of various term forecasts on fish resources dynamics which determine the catch amount.

**Task 4:** *The creation of fish community model – the long-term projection of fish stock and production under the fluctuations of climatic regime and loads, using the long-term time series and results of modelling.*

According to the Program work plan, the fish community model will be finalized in the 1$^{st}$ quarter of 2008. Currently the analysis of relationship between the most important fish species recruitment, spawning stock biomass and environmental factors has been performed. The best sets of variables have been chosen for recruitment forecast, using the multi-factorial regression analysis.

**1. The Gulf of Riga herring**

The stock of the Gulf herring increased rapidly in early 1990s after a succession of several strong year classes. Since that time the herring stock is above the long-term mean value and strong year classes occur much more often than in the 1970s and the 80s (Fig. 6.3.).

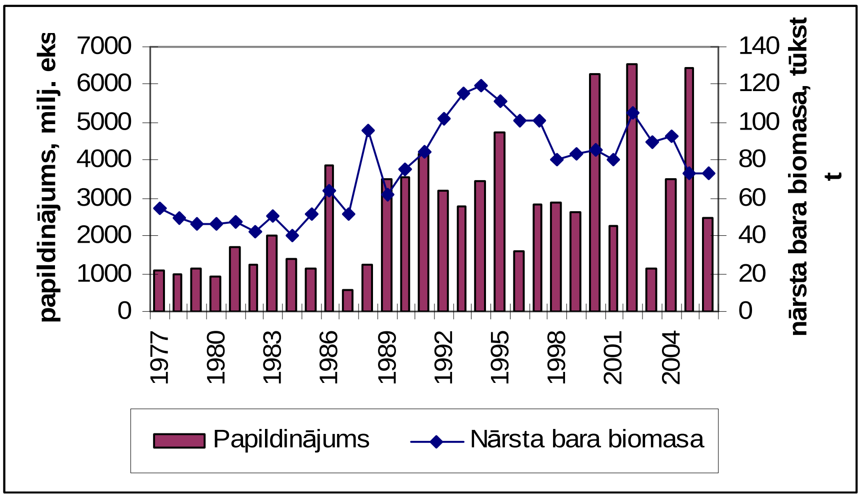



**Figure 6.3.** The recruitment ("papildinājums", bars), mill.ind., of a year old herring in the Gulf of Riga and spawning stock biomass (nārsta bara biomasa, line), thous. tons.

It has been found that the spawning stock biomass of the Gulf herring does not affect the recruitment considerably. The recruitment is more influenced by the spring water temperature in May, when the spawning occurs. Water temperature has both direct effect on the spawning and survival of eggs and larvae and indirect effect by determining the feeding conditions. The significant relationship between the abundance of zooplankton species *Eurytemora affinis* and herring recruitment is an indicator of this indirect effect (Fig.6.4.). In general, the climatic variation since the late 1980s characterized by a rise of water temperature during winter and lack of ice coverage, have been favourable for the Gulf herring. Due to the warm winters, water temperature in spring has been higher than before, causing an earlier development of zooplankton and providing better feeding conditions for the herring larvae.

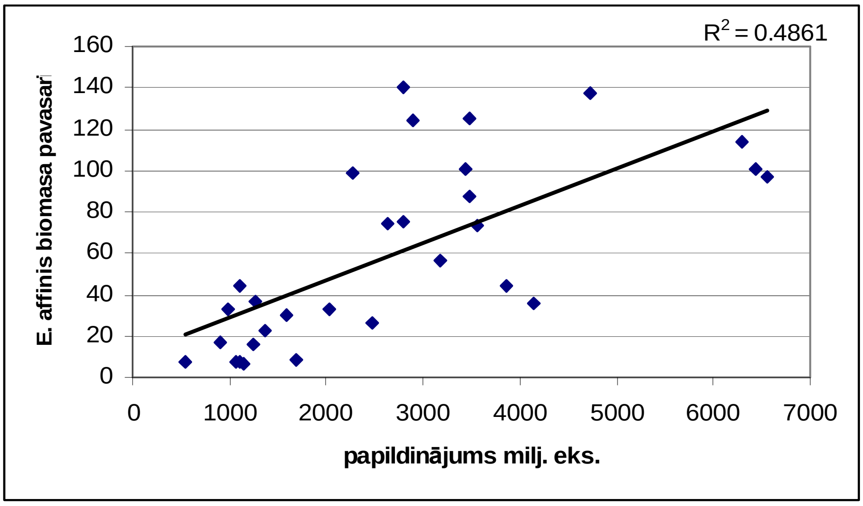



**Figure 6.4.** Herring recruitment (X axis), mill. ind., and mean biomass of *Eurytemora affinis* in spring (Y axis), 1977-2006.

**2. The Baltic Proper herring**

The Baltic Proper herring is the largest stock unit of the Baltic Sea. It occurs everywhere east of Bornholm, except the Gulfs of Riga and Bothnia. The assessment of this stock unit is complicated due to the population structure having differing growth rates and, perhaps, also stock dynamics. Since the 1970s the stock decreased reaching the lowest values in 1999, but a considerable increase has started around 2003, when the very strong year class of 2002 contributed to the stock (Fig. 6.5.).

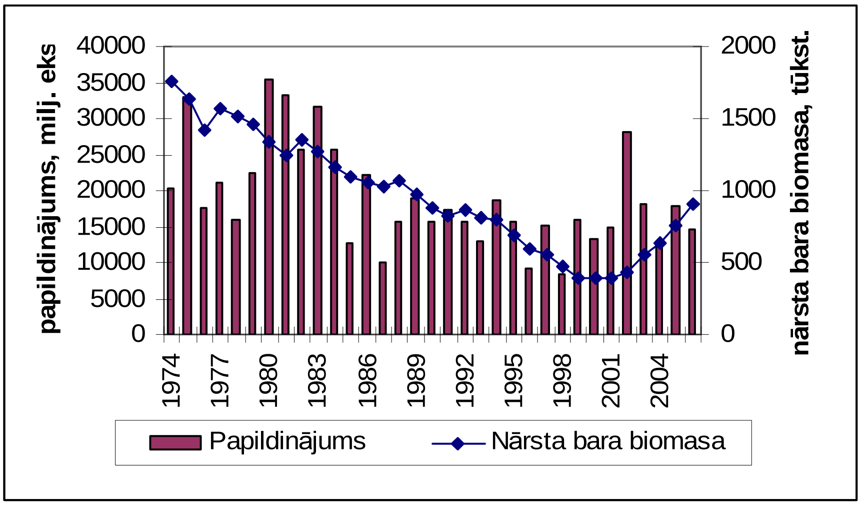



**Figure 6.5.** Baltic Proper herring recruitment ("papildinājums", bars), mill.ind. , and the spawning stock biomass ("nārsta bara biomasa", line), thous.tons.

In contrary to the Gulf herring, the spawning stock biomass of the Baltic Proper herring affects the recruitment considerably. The recruitment is influenced significantly also by hydro-meteorological regime which was indicated by relationship with Baltic Sea index (analogous to NAOI), determining the water temperature during spawn, egg survival, zooplankton abundance and feeding conditions for larvae. The observed relationship with zooplankton species *Temora longicornis* and *Pseudocalanus acuspes* indicate the significance of larval feeding quality and impact of zooplankton on feeding of adult fish, as the recruitment depends on mean body weight and egg quality of the fish. The analysis of found relationship and the biological mechanisms should be continued due to the obvious differences between Gulf and Baltic Proper herring.

**3. The Baltic Sea sprat**

Dynamics of the Baltic Sea sprat stock is similar to that of the Gulf herring. After the reduction of stock in the mid 1970s, the level of fish abundance was low throughout the 1980s. In the 1990s the stock increased due to occurrence of several strong year classes. In general during the last 18 years the production conditions have improved and strong year classes are observed more often (Fig.6.6.).

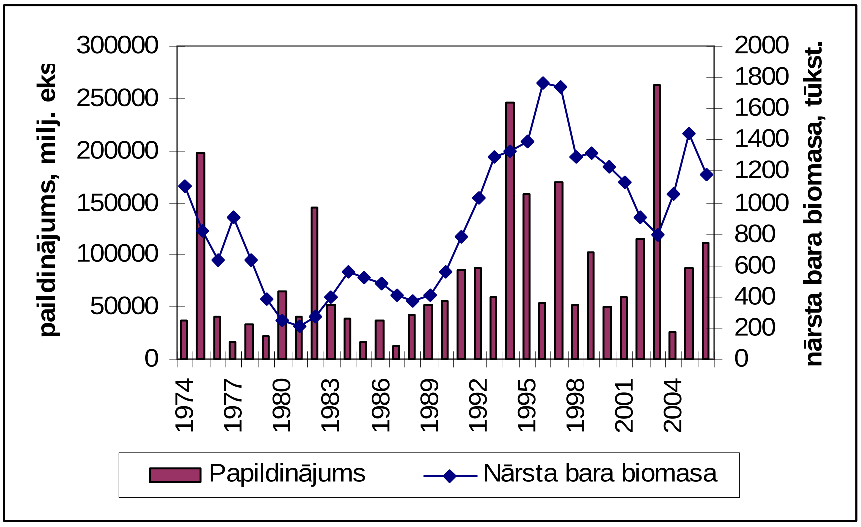



**Figure 6.6.** The Baltic Sea sprat recruitment ("papildinājums", bars), mill.ind. and the spawning stock biomass ("nārsta bara biomasa", line), thous.tons.

Like for the Gulf herring, also the sprat spawning stock biomass does not affect the recruitment considerably. It is mostly determined by the hydro-meteorological regime as indicated by relationship with the Baltic Sea index (analogous to NAOI), determining the water temperature during spawning time, egg survival, zooplankton abundance and feeding conditions for sprat larvae.

**4. The Eastern Baltic Sea cod**

The cod stock in the Eastern Baltic Sea increased considerably during the late 1970s when several strong year classes appeared. However, since the mid-80s the cod reproduction conditions deteriorated considerably due to the low frequency of North Sea salt water inflows. The stock is at low level since the early 1990s and none strong year class has been observed (Fig.6.7.).

The spawning of the cod takes place at the deeps below halocline. The productivity of the classes is determined mainly by two critical periods:

1) egg survival, depending on salinity, oxygen content and temperature;

2) sufficient amount of food (zooplankton) when larvae start the external feeding.

Water masses with salinity higher than 11 PSU and oxygen concentration above 2ml/l are defined as suitable for cod egg survival and called also the "reproduction volume" (RV). Thus the RV dynamics affect the productivity of year classes to a large extent.

Strong year classes occurred during the years when RV was available at all central spawning places of the Baltic Sea. Due to the decrease of water exchange, a successful spawn has been occurring only in the Bornholm Deep already since 1982.

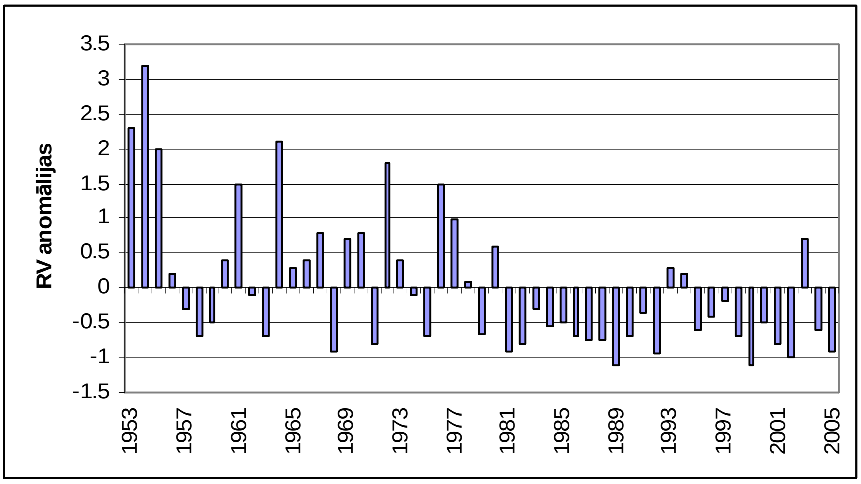



**Figure 6.7.** The anomalies of cod reproduction volume ("RV anomālijas") in the Baltic sea from the mean RV in 1952-2006.

**5. The Eastern Baltic Sea flounder**

For successful spawning of flounder an oxygen content not lower than 1 ml/l and salinity of 10,6 PSU is required. The potential space and volume of the reproduction has been calculated. Delta GLM model has been constructed having two sub-models – 1) only occurrence of larvae is analyzed; 2) only stations where larvae where present are analyzed. Then results of both sub-models are joined. The first results show that reproduction space has a significant relationship with the abundance and distribution of larvae. The presence of larvae was also substantially influenced by the time of the year.

**6. The assessment of coastal fish community structure.**

The species composition of the catch in the upwelling zones of the Gulf of Riga was analyzed. It was observed that the abundance of cold water fish increases in the upwelling areas, if the water temperature rises in the Gulf (Fig.4.8.).

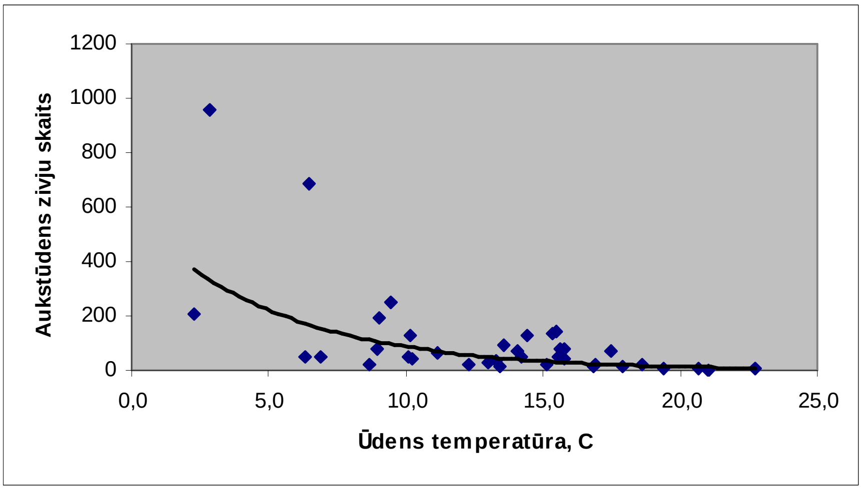



**Figure** 4.8. The abundance of cold water fish in the catch (aukstūdens zivju skaits, Y axis) and water temperature (ūdens temperatūra, X axis) at the coastal areas of the Gulf of Riga.

*The scientific and economic significance of the results*

The current analysis indicate that fish community dynamics is affected by several interlinked natural factors and human activities. The final outcome – prognostic model of fish communities – will provide the opportunity to understand the significance of each factor in various developmental stages of the fish and consequently, the impact of possible climate changes.

**Summary**

During 2007 WP6 has produced experimental data and sampled field material for further forecasts of the climate change impact on the marine ecosystems; the main work for the construction of fish community model has been fulfilled.

**WP6 tasks for the 3rd phase (2008):**

1. The finalizing of prognostic model of fish communities and use for long-term forecasts of fish stocks and year class strength under the impact of climatic regime and anthropogenic loads.

2. The continuation of experimental work – estimation of spring and summer phytoplankton community alterations. Analysis of the results and preparation of data for use in models and forecasts.

3. Processing of field material and analysis of data for assessment of changes in trophic links and biodiversity.

**Work Package Coordinator: Anda Ikauniece**

## Work Package Nr. 9: RUNOFF EXTREMES CAUSED BY THE CLIMATE CHANGE AND THEIR IMPACT ON TERRITORIES UNDER THE FLOOD RISK

**Goal:**

The aim of this work package is to forecast climate change impact on recurrence and regime of runoff extremes: floods and droughts. Identify the impact of these phenomena on flood-plane ecosystem in the Middle-Daugava region.

**Phase 2 tasks of WP9:**

1. Assessment of historical and current frequency of flood recurrence and climate change impact on it;

2. Forecast changes in regime of floods and drought based on the scenarios of hydrological regime;

3. Identify the role of natural flood-plains in stabilizing of hydrological regime;

4. Determine flood and drought impact on bio-geochemical fluxes in flood-plain systems and the catchment;

5. Assess the impact of floods and droughts on floodplain-lake ecosystems of river Daugava;

6. Mitigation of flood and drought risk.

**Phase 2 results of WP9:**

**Task 1:** *Assessment of historical and current frequency of flood recurrence and climate change impact on it.*

The existing meteorological and hydrological data series, which have been obtained at the hydrometric post *Daugava-Daugavpils* before 1987, were summarized and statistically analysed. The post at Daugavpils operates continuously since 1881 except for 1915 and 1917-1921 when observations were interrupted. In order to get an uninterrupted series of the observed diurnal runoff values, only those data obtained between 1922 and 1987 were statistically analysed. These data series are long enough to characterise the runoff regime of the Daugava River at Daugavpils adequately. During this project, they were split into individual data series, which characterise the mean diurnal runoff, the highest runoff during the spring floods, the highest runoff during the flash floods in the summer-autumn season, the lowest summer runoff as well as the lowest winter runoff.

In the Daugava River, the largest floods occur in spring caused by an intense snowmelt. During the analysed period, the spring floods were exceeded by the flash floods caused by rain in autumn only twice (in 1927 and 1952). In both of these cases, there were relatively small maximum runoffs (1580 and 1360 $m^3/s$ respectively) at the height of the spring floods. However, they were exceeded only slightly by the maximum runoff values of the flash floods (by 650 and 170 $m^3/s$, respectively). Therefore, the evaluation of the maximum runoffs of the Daugava River should be related to the period of the intense snowmelt. On the other hand, it is necessary to analyse also the summer-autumn flash flood data as well as the minimal runoff data series in order to get an objective picture of the whole river-floodplain ecosystem.

Two types of data distribution (the Gumbel's extreme values (EV1) distribution and the Pearson's III distribution) were applied during the statistical analysis of the maximum runoff data series. The distribution parameters were determined by the moments' method. The calculated maximum runoffs for spring and summer-autumn seasons and periodicity of their reoccurrence are summarized in the tables 9.1 and 9.2 according to the two types of statistic distribution.

**Table 9.1.** Maximum runoffs of the spring floods with different periods of their reoccurrence

| Probability, % | Reoccurrence period, years | Runoff, $m^3/s$ | |
|---|---|---|---|
| | | According to the Gumbel's distribution | According to the Pearsons's distribution |
| 1 | 100 | **6468** | 6445 |
| 5 | 20 | **4962** | 5002 |
| 10 | 10 | **4297** | 4339 |
| 20 | 5 | **3604** | 3623 |
| 50 | 2 | **2557** | 2533 |

**Table 9.2.** Maximum runoffs of the summer-autumn flash floods with different periods of their reoccurrence

| Probability, % | Reoccurrence period, years | Runoff, $m^3/s$ | |
|---|---|---|---|
| | | According to the Gumbel's distribution | According to the Pearsons's distribution |
| 1 | 100 | **2244** | 2176 |
| 5 | 20 | **1677** | 1678 |
| 10 | 10 | **1426** | 1442 |
| 20 | 5 | **1165** | 1186 |
| 50 | 2 | **771** | 776 |

According to the analysis of the obtained meteorological data series, the monthly mean air temperatures in Daugavpils have increased, especially in autumn and spring seasons. In contrast, the thickness of the snow cover has decreased. In addition, the seasonal distribution of precipitation has changed: there are two annual maximums – in May and August, and not in July as previously observed. There are significant shifts in the annual mean values too. The mean annual air temperature has increased by 0,7$^{o}$C, the amount of precipitation has increased by 60 mm and the thickness of the snow cover has decreased by

3,6 cm when compared to the previous climate characteristics of the 60-ties and 70-ties of the 20th century.

Usually, the minimal runoff of the Daugava River is observed at summer (June-August) as well as during the stable winter. Mean minimal summer and winter runoff values are quite similar (Fig. 9.1.). There is also a distinct similarity in their reoccurrence during the analysed period. However, there were 34 years when the minimal runoffs at winter were higher than the minimal runoffs at summer.

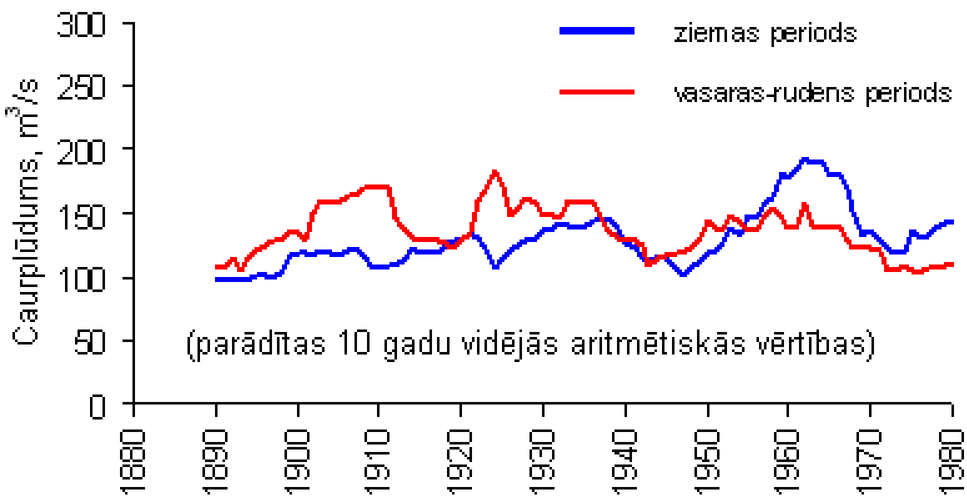



**Figure. 9.1**. Minimal diurnal runoffs ($m^3/s$) of the Daugava River at Daugavpils, winter – blue line, summer/autumn – red line.

Therefore, it should be noted that the evaluation of the minimal runoffs of the Daugava River should be calculated for both, the summer and the winter periods. Both of them are equally significant in order to evaluate the response of the whole river-floodplain ecosystem correctly.

Summarising of meteorological and hydrological data series and their statistical analysis is important for the fulfilment of the second task of this program: to predict the expected transformation of the flood-drought regime based on the hydrological regime scenarios, which are developed by the first group of experts (WP1). Such prognoses will become the basis for the development of recommendations for adaptation measures, which could help to minimize the possible damages in different fields of economy.

**Task 2:** *Forecast changes in regime of floods and drought based on the scenarios of hydrological regime.*

Method of hydrodynamic modelling was used for the calculation of the water level in the river Daugava. In order to meet the present day requirements and ensure implementation of a high technological level, the water hydrodynamic model MIKE FLOOD developed by the Danish Hydraulics Institute (DHI) was purchased and applied.

Usually the hydraulic calculations of the river water flow are carried out by one-dimensional (1D) measurements in individual districts, i.e. taking into account that the water flow is directed only forward along the river watercourse. The calculations were done in accordance with Saint-Venant's differential equations. DHI developed a mathematical model MIKE11 for this purpose.

For evaluating the water flow in the watercourse cross direction (for example, under the influence of wind or other obstacle), it is necessary to carry out measurements of both directions equally, i.e. two-dimensionally (2D). For calculations of this type, a mathematical model MIKE21 was developed in DHI. This model is usually applied for measuring of water flows in seas, lakes, and large water reservoirs.

The DHI-designed mathematical model MIKE FLOOD or, more precisely, modelling environment, is developed for hydraulic measurements in the flood-threatened territories. This modelling environment gives an opportunity to carry out dynamically related one-dimensional and two-dimensional calculations in regions. i.e. by joining results obtained in the regions were calculations were done by use the models MIKE11 or MIKE21.

This opportunity might be quite useful in two cases: first, in the river estuaries, and second, in the territories where rivers tend to flood alluvial lands when reaching a high level. In the first case, hydraulic measurements in the river (by use of MIKE11) for 1D regions are more likely, whereas in the second case, with the help of MIKE21 for 2D regions, in the sea, where the river flows. In the river, flow rates, stream velocity, and water levels, all depend on the water level of influent and the sea, while in the sea, water levels, water flow directions and rates depend on the wind, high or low tide and the flow rate of filling rivers. If necessary, the MIKE21 calculations can be performed in the river, although this measurement will take much more time.

In the second case, when for 1D regions (with the help of MIKE11) hydraulic calculations are performed in the main, and for 2D regions (with the help of MIKE21) in the alluvial lands that get flooded just like the riverbed in the cross direction, i.e. having reached certain level, the water flows over the sides of the main riverbed and floods the alluvial lands.

For minimizing the risks of flooding caused by the climate change, it is necessary to identify the flood threatened territories. Estimates of this type could allow for developing flood risk management plans which would ensure a more efficient organisation of anti-flood actions and lessen the damage to nature and economy.

**Task 3:** *Identify the role of natural flood-plains in stabilizing of hydrological regime.*

In order to determine the territories exposed to risk of flooding within the Daugava River valley from Naujene down to Jersika, according to research programme, first of all the mean and the maximal flood levels (i.e. probability of occurrence 1% or with recurrence interval 100 years of extreme floods) were ascertained. To this intent data about recorded flood levels in hydrological stations "Daugavpils", „Vaikuļāni (Līksna)", „Dviete" un „Buivīši (Nīcgale)" were aggregated and analyzed. Calculation of the mean annual and maximal flood level values within the Daugava River valley from Naujene down to Jersika was done based on data listed above (Table 9.3).

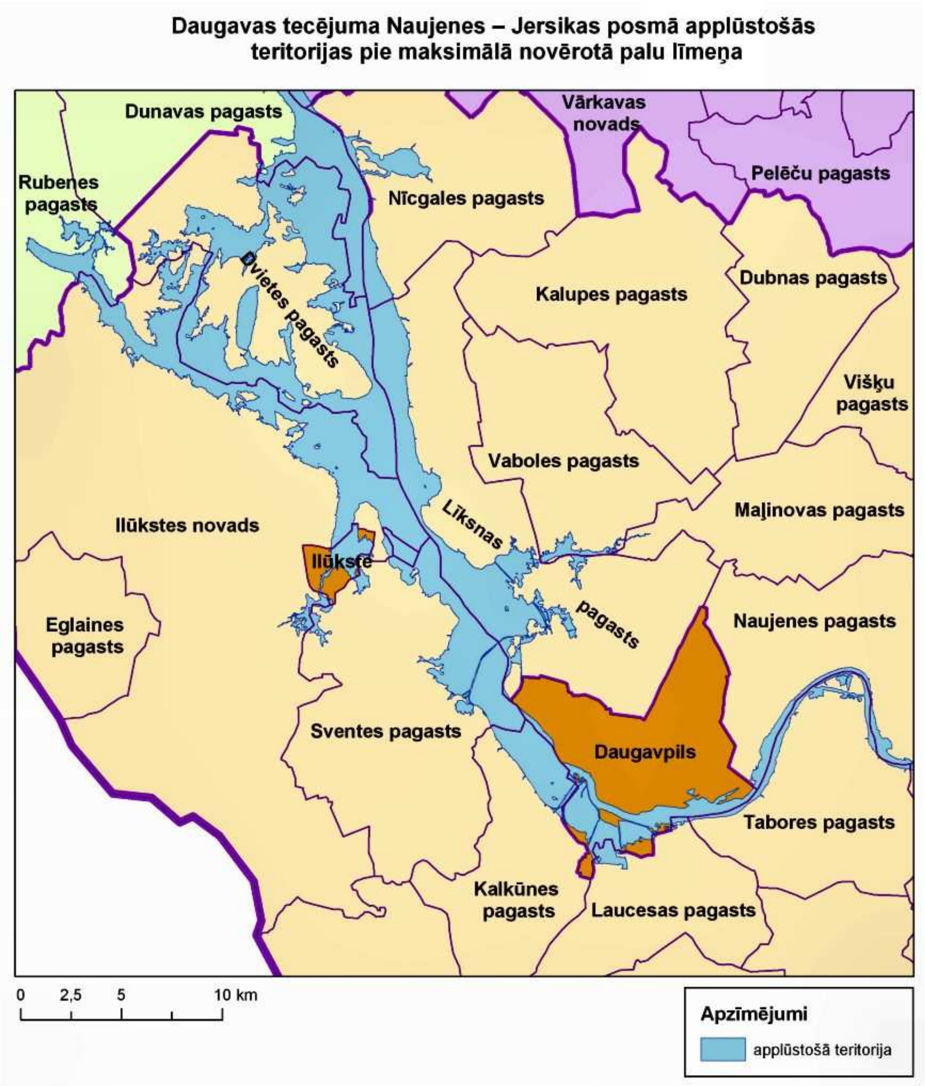



**Figure 9.2**. Territories affected by risk of flooding within the Daugava River valley from Naujene down to Jersika at max. flood level.

Hereinafter, taking into account the results of interpolation and contours of topographic map, geospatial analysis and digitizing of layers "Mean annual flood level" and "Max. flood level" as *.shp files were carried out by ArcGIS software.

During the initial period of the Program, two GIS maps "Territories affected by risk of flooding within the Daugava River Valley from Naujene down to Jersika at mean annual flood level" and "Territories affected by risk of flooding within the Daugava River Valley from Naujene down to Jersika at max. flood level" were prepared, putting together the GIS data layers listed above.

The developed maps already allow to evaluate the flood risk and to determine territories with high risk of flooding in municipalities of Daugavpils district. At the same time these maps are integrated in documents of spatial planning in these municipalities.

**Table 9.3.** Mean annual and maximal flood level values within the Daugava River valley from Naujene down to Jersika

| Hydrological station | Daugava at Daugavpils | Daugava Daugavpils railway bridge | Daugava at Vaikuļāni (Līksna) | Dviete Dviete village (Dviete floodplain) | Daugava at Buivīši (Nīcgale) |
|---|---|---|---|---|---|
| Period of hydrological records | since 1931 | 1881-1916, 1921-1940 | 1932-1980 | 1967-1978 | 1932-1962 |
| The highest recorded flood level, m a.s.l. (year) | **95,28** (1937) | **96,31** (1922) | **93,79** (1951) | **93,47** (1931) | **92,90** (1956) |
| Mean annual flood level, m a.s.l. | 92,23 | - | 90,72 | 90,1-90,4 | 89,81 |

During further implementation of the research programme it is necessary to evaluate recurrence interval of floods with other probability of occurrence (5%, 20% etc.) as well as the flood risk taking into account different hydrological scenarios in response to climate change.

**Task 4:** *Determine flood and drought impact on bio-geochemical fluxes in flood-plain systems and the catchment*

During the initial period of the research programme, the existing empirical erosion models (e.g. USLE (Wischmeier and Smith, 1978) and RUSLE (Renard et al., 1991)), as well as process-based erosion models (e.g. WEPP (Nearing et al., 1989), ANSWERS (Beasley et al., 1980) and EUROSEM (Morgan et al., 1998b)) were evaluated. The most appropriate models for assessment of sediment and nutrient load from small catchments are USLE and EUROSEM. First of all, the input data necessary for these models were defined: rainfall erosivity index *R*; soil erodibility factor *K*; topography factor *LS*; crop/vegetation factor *C*; conservation practice factor *P*.

At present the statistical processing of meteorological data is going on in order to obtain values of *R* factor and to assess its variability in response to climate change. Values of soil erodibility factor *K* will be determined from soil and geological maps and after that it will be calibrated in the field. Values of topography factor *LS* will be determined from the digital elevation model derived from topographic maps by ArcGIS. Values of crop/vegetation factor *C* and conservation practice factor *P* will be determined from aerial ortho-photo maps.

Data calculated by model will be tested in 3 study sites: 3 small gully catchments with similar lithology, but different land use – arable land (> 60% of catchment), meadows and grasslands (> 60% of catchment), and forest (> 60% of catchment).

To evaluate the role of temporary streams in transferring of sediment and nutrient from small catchments to receiving water objects, it is necessary to determine the values of sediment load during the runoff.

Sediment load was estimated applying an empirical relationship Qs = f (Q) (Knighton, 1998; Methods in Stream Ecology, 1996) which shows that the amount of suspended sediment in a stream can be quantified as sediment discharge (Qs) that is the product of sediment concentration and gully stream discharge (Q). Taking into account that bed-material load is stored in sediment sinks within boulder-floored gully channels or on the grassed floodplain of the River Daugava valley and actually does not reach recipient stream, only determination of dissolved solids discharge and suspended sediment discharge was carried out. Sediment load was determined according to the standard methods in fluvial geomorphology (Tools in fluvial geomorphology, 2003).

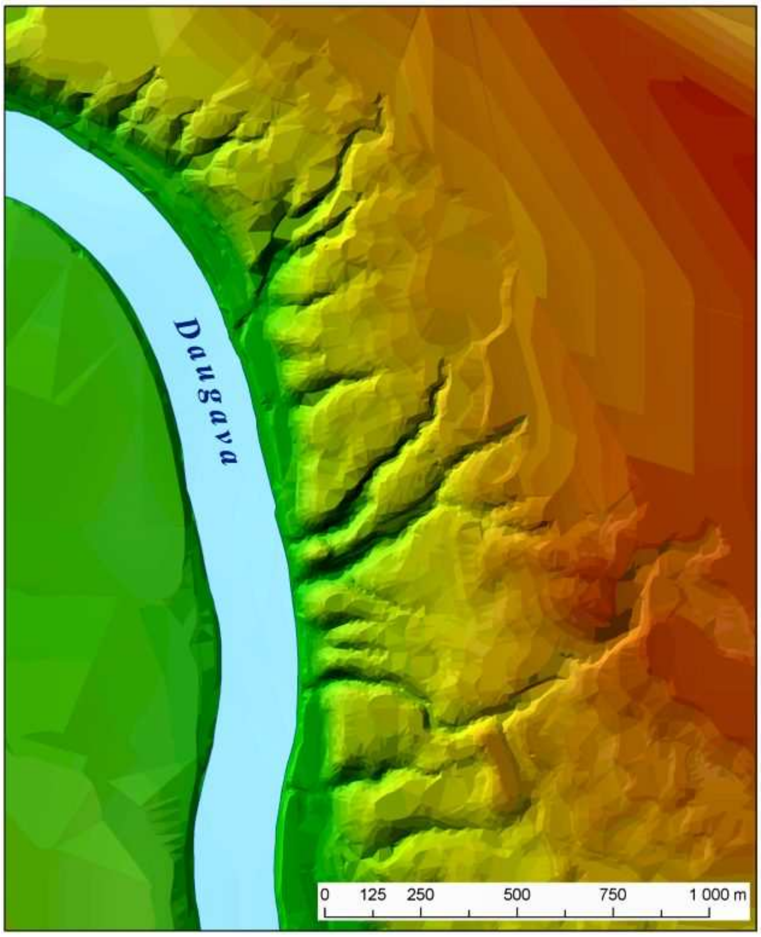



**Figure 9.3.** Fragment of digital elevation model of the River Daugava valley.

The study of the load transported by temporary gully included, first of all, an estimation of discharge in gully channels during snowmelt runoff in spring. Discharge was also estimated during the seasonal weather conditions that are not typical for Latvia, i.e. the period of continuous and excessive precipitation which triggers floods in May – June 2005, and the warm and rainy period in December – January 2007. Secondly, simultaneously with estimation of the sediment load, data was collected about total dissolved solids (TDS) and nutrient concentration, i.e. P-total an N-total, and their delivery from gully catchments to streams of higher order. TDS was measured in situ by HATCHTM Surveyor 4a probe and data logger, P-total an N-total concentrations were determined in laboratory (methods N-total - LVS 340:2001; P-total - LVS EN ISO 6878:2005/7.n).

Preliminary results indicate that summarized dissolved solids and suspended sediment discharge values during average snowmelt runoff varies from 73 g $s^{-1}$ to 108 g $s^{-1}$, respectively, and the suspended sediment yield is up to 4300 kg $day^{-1}$ (in comparison the suspended sediment yield of small tributaries and permanent water streams in this region varies from 13 600 to 15 600 kg $day^{-1}$ or 5100 to 5700 t $y^{-1}$). Recalculation of the obtained data for gully catchments indicates that the total mass of eroded material exported from a drainage basin can reach values up to 102 kg $day^{-1}$ $ha^{-1}$. Values of determined nutrient concentrations during snowmelt runoff vary within 1.26 to 4.86 mg $l^{-1}$ (N-total) and within 0.14 to 0.27 mg $l^{-1}$ (P-total). It yields the delivery up to 48 kg $day^{-1}$ of N-total and up to 2.7 kg $day^{-1}$ of P-total to the River Daugava.

Taking into account the increase of runoff predicted by climate change models, it is likely that delivery of sediment load and nutrient from streams of low order also will increase. Depending of morphology and hydrological factors of recipient streams (e.g. bed gradient, stream velocity, min. and max. discharge etc.), part of eroded material transferred from gully catchments will be deposited in river channels. Consequences of that will be silting-up of river bed, decreasing of gradient, depth and cross-section values. In its turn it will induce the decreasing of ability to fill up and to store water during floods in recipient stream (the river Daugava respectively), hence increasing the risk of flooding.

**Task 5:** *Assess the impact of floods and droughts on floodplain-lake ecosystems of river Daugava.*

To characterize the floodplain ecosystems of the River Daugava, zooplankton and phytoplankton samples were collected during 11 expeditions from January to October, 2007. Plankton samples were taken in the floodplain lakes Ļubasts, Skuķu, Dvietes and two sites in the River Daugava. Hydro-physical and hydro-chemical parameters were measured simultaneously with the sampling.

The provisional data obtained in 2005 – 2006 were analysed as well. For example, in 2005 and 2006 during the filling and drainage phase of the spring and autumn flush flood *Synchaeta* sp. and also *Synchaeta oblonga* was the dominant in zooplankton communities both by their abundance and by biomass. This may be explained by water flow from River Daugava and change in the feeding conditions. *Kellicotia longispina* was dominating in the Lake Ļubasts during the filling phase of spring flush flood but during the drainage phase - *Synchaeta* sp., in distinction of other floodplain lakes in 2005. During the phase of autumn flush flood drainage in the Lake Ļubasts the changes of zooplankton communities were not so evident as in Lake Skuķu and Lake Dvietes - possibly because there was no river water inflow into these lakes.

The number of zooplankton taxa was low during the filling phase of spring flush flood (2006) in the lakes Skuķu and Dvietes. When the number of taxa of phyto- and zooplankton was plotted against the intensity of external disturbance (the rate of water level change per day), characteristic hump-shaped curves were obtained. In both lakes, the highest species diversity of the plankton communities coincided with the intermediate intensity of disturbance as predicted by IDH (Intermediate Disturbance Hypothesis) and was not significant, except for the linear relationship (Spearman rank correlation, $r=0.63$, $P>0.1$) between the rate of water level change and the number of phytoplankton taxa in the Lake Dvietes.

**Task 6:** *Mitigation of flood and drought risk***.**

In order to produce recommendations for local municipalities on mitigation of the flood risk and associated damages and economical losses, the proportions of territories exposed to risk of flooding at mean annual flood level and max. flood level were estimated. Geospatial analysis of the obtained data show that Dviete and Pilskalne rural municipalities are the most endangered by the risk of flooding within the whole Daugava River valley from Naujene down to Jersika. Accordingly, 15% (1734,3 ha) and 13% (1651,6 ha) of the total territories of these municipalities could be inundated at mean annual flood level. At the max. flood level (1% probability floods with re-occurrence interval of 100 years) 46% (5381 ha) and 21% (2618,5 ha) of total territory of municipalities could be inundated.

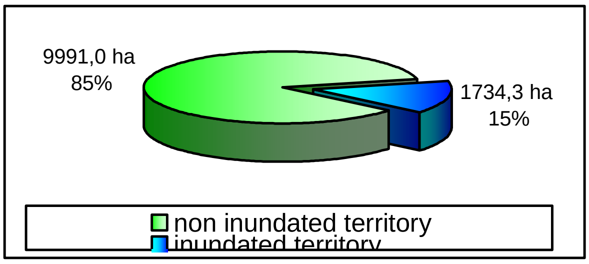



Fig. 9.4. Proportion of inundated territories in Dviete municipality at mean annual flood level.

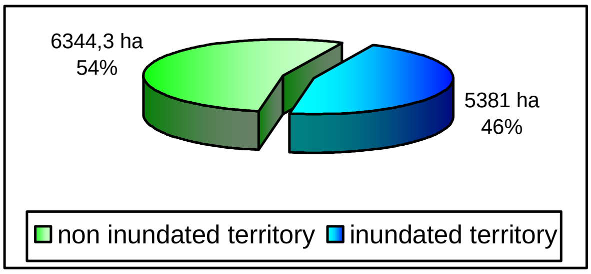
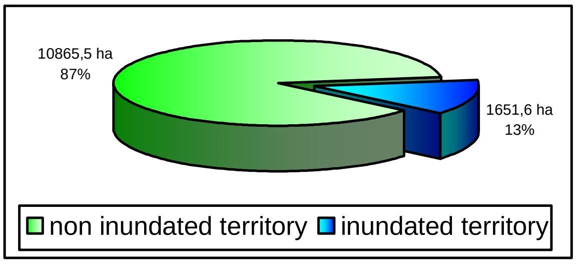



Fig. 9.5. Proportion of inundated territories in Dviete municipality at maximal (100 y re-occurence) flood level.



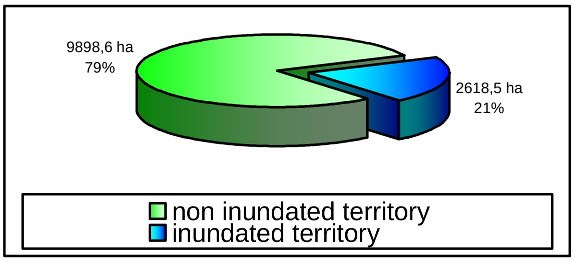




Fig. 9.6 Proportion of inundated territories in Pilsklane municipality at mean annual flood level.

Fig. 9.7 Proportion of inundated territories in Pilsklane municipality at maximal (100 y re-occurrence) flood level.

The data produced by this study are already integrated into the spatial planning documents of Daugavpils district and local municipalities in order to limit economic activities (e.g. building, farming etc.) within territories at risk of flooding, thereby to minimize economical losses caused by floods (e.g. damages of property, insurance etc.)

**Summary:**

While completing the second phase of the National Research Program, a study of the ecosystem complexes in the alluvial lands of the Daugava mid-stream was undertaken. Historical and current frequency of the repetition of extreme discharge in Daugava was assessed, and recommendations regarding the flood risks were worked out for the involved municipalities in the Daugavpils region.

**WP9 tasks for the 3rd phase (2008):**

1. to forecast flood and extreme drought events for the period of 50-100 years building on the connection between the assessed regime of extreme discharges and the character of long-term climate changes;
2. to determine the borders of the flood-endangered territories at a range of flood water levels, and to estimate the role of the Daugava river alluvial lands in minimizing the risk of flooding on the basis of the developed digital terrain model;
3. to continue systematic observations of the hydro-meteorological regime and hydrobiological parameters in the Daugava mid-stream with the aim of estimating the possible impact of the climate change on Daugava as well as on the ecosystem dynamics, trophic structure, and biological diversity of lakes in its alluvial lands;
4. to evaluate the content of nutrients and biogeochemical processes of organic carbon in the ecosystems of alluvial lands and their possible changes during the periods of extreme regime;
5. to develop the models of aquatic ecosystems using data on plankton dynamics and change of the environmental factors that were obtained in course of this study;

6. to produce recommendations for the authorities responsible for agriculture, forestry and territorial planning aiming at minimizing of the negative effects of floods and extreme droughts (in co-operation with DP7).

**Work Package Coordinator: Arturs Škute**

## Work Package Nr. 7: ADAPTATION OF ENVIRONMENTAL AND SECTOR POLICIES TO CLIMATE CHANGE

**Goals:**

In the context of the water environment, develop scientifically sound proposals to adapt environmental and sector policies in Latvia to the impacts of climate change.

**Phase 2 tasks of WP7:**

1. Identify possible impacts of climate change on the water environment in Latvia (in relation to environmental and development policy) in the context of resource management.
2. Analyse normative acts and planning documents in the context of climate change policies.
3. Undertake and compile results of a survey of municipal and other government institutions.
4. Foster dialogue between climate change and water resource researchers and development planners, policy-makers in national institutions, municipal institutions and the business sector.

**Phase 2 results of WP7:**

**Task 1:** *Identification of possible impacts of climate change on the water environment in Latvia.*

On the basis of a review of literature and research studies a list of climate change impacts was compiled, including adaptation measures and problem issues. The adaptation measures identified in Table 7.1. are based on suggestions of various sectors of government, the undertaken literature review, research findings and interviews with specialists. For the problem issues, the most appropriate adaptation measures need to be identified.

Identification of climate change impacts and impacted sectors is partly the basis for defining partners for further cooperation and dialogue, as well as for creating a list of themes for which recommendations for adaptation measures will need to be developed.

**Table 7.1.** Expressions of Climate Change in Latvia and Impacts on Activities

| ***Expressions of Climate Change*** | ***Impacted Human Activity*** | ***Adaptation Measures and Issues (I)*** |
|---|---|---|
| Dry periods in Summer | Agriculture – Plants experience moisture stress or die | - Selection of plant/crop variety<br>- Feasibility of irrigation<br>- Watering of plants<br>- Watering regime and technology<br>- (I) Availability of water for watering<br>- (I) Invasion by non-indigenous species (including pastures)<br>- Specialized agriculture (diversification of agricultural practices) |
| | Agriculture – leaching/loss of nutrients | - Adaptation of fertilization regime<br>- Protection measures against leaching/loss of nutrients to the water table and surface water |
| | Urban Environmental Management | - Selection of suitable greenery and lawn grass species<br>- Lawn management regime |
| | Water Supply and Wastewater | - (I) Availability of drinking water (including from shallow water table wells of farmsteads)<br>- (I) Quality of drinking water<br>- Adaptation of wastewater treatment |
| | Tourism and recreation – low water flows in rivers | - (I) Availability of designated swimming areas<br>- (I) Water quality in designated swimming areas<br>- (I) Quality of water in watersports areas<br>- (I) Changes in opportunities for angling |
| | Energy Supply – reduced HES generation capacity, negatively impacted bio-fuel crop production | - Optimize generation capacity of HES<br>- Bio-fuel production specialization (diversification of practices)<br>- (I) Sufficient cooling water for TEC; suitability of water for cooling purposes<br>- Diversification of energy (electricity generation) sources (wind, solar, biofuel, others) |
| | Transportation Sector – Water-based transportation | - (I) Disruption of water-based transportation |
| Increased precipitation in Winter | Territorial Planning and Regional Governance – Flood Risk and Vulnerability | - Spatial planning of development |

| | | |
|---|---|---|
| | Energy Supply – increased generation from HES | - Optimize generation capacity of HES<br>- (I) Safety of HES structures |
| Higher temperatures in the Winter – unfrozen ground/soil, no ice-cover on lakes/rivers | Agriculture – leaching/loss of nutrients from soil | - Selection of appropriate crops<br>- Soil cultivation regime<br>- Protection of rivers, lakes and sea from excess nutrient loading<br>- Protection of shallow water table from surface contamination<br>- (I) Formation of toxins in water bodies in Summer |
| | Agriculture – loss of topsoil | - Selection of appropriate crops<br>- (I) Protection of rivers, lakes and the sea from influx of eroded topsoil |
| | Agriculture and urban environmental management – frost damage to crops during extreme cold weather events | - Selection of appropriate crops<br>- Reassessment of insurance system |
| | Dangerous/emergency situations – flooding and storm events | - Preparedness for more frequent storm surge events<br>- Risk assessment in compensation plans<br>- Redesign of insurance system |
| | Territorial planning and Regional Governance – Baltic Sea erosion and storm surge | - Spatial planning of coastal zone particularly built-up areas<br>- Infrastructure development in coastal zone<br>- Apropriate locations for disposal of dredged material from harbours |
| | Fisheries – changing development phases of organisms | - Restrictions during spawning periods |
| | Fisheries – changing species composition | - Quotas and species selection |
| | Fisheries – no major Spring flooding to clean river beds/banks of aquatic vegetation | - Changes in the composition and amount of species |
| | Energy Supply – increased generation from HES | - Optimization of HES generation regime |
| | Forestry – forest harvesting made more problematic | - Selection of cutting regime<br>- (I)More wind-throw |
| | Agriculture – flooding of | - Appropriate location of cultivated fields |

| | | |
|---|---|---|
| Heavier precipitation events and higher risk of flooding in Summer | cultivated fields on floodplains | - Redesign of insurance system |
| | Water Supply and Wastewater – wastewater overflow retention for storm events | - Creation of wastewater overflow retention for storm events<br>- (I) Wastewater treatment plant capacity exceedance risks |
| | Energy supply | - (I) HES dam safety |
| Higher average annual temperature | Agriculture – change in species composition, increased ecosystem productivity | - Selection of appropriate crop<br>- (I) Greater incursion by weeds<br>- (I) Higher crop yields<br>- Increased risk to cattle from harmful insects<br>- Protection against new pests and diseases |
| | Forestry – change in species composition | - (I) Valuable coniferous species replaced by deciduous species |
| | Fisheries – change in species composition | - Fishing quota - catch size and composition<br>- Protection against invasive species<br>- Protection against new diseases |
| | Water Resource Management – floodplain eutrophication | - Anthropogenic loads |
| | Water Supply and Wastewater – changes in the chemical composition of water | - Suitability of water for human consumption and cattle |
| | Tourism and recreation | - (I) Toxin propogation in swimming water<br>- (I) Longer swimming season<br>- (I) Risks to snow and ice based tourism and recreation<br>- (I) Diversification of tourism activities |
| | Health Protection | - (I) Increased risk of contracting infectious diseases |
| Rise in Sea Level | Territorial Planning and Regional Governance – wider zone of influence | - Spatial planning along coastal and risk areas<br>- (I) Water level rise in lakes connected with the sea |
| Other types of changes | Science and governance – knowledge about processes and trends | - Adapt monitoring programmes<br>- Adapt research programmes<br>- (I) Research results implemented in practice |

**Task 2:** *Analyse normative acts and planning documents in the context of climate change policies.*

An analysis of EU and Latvian normative acts and planning documents in the context of climate change impacts and adaptation was undertaken. The analysis was necessary to understand at which levels (global, European, Latvian, sector) adaptation measures are already proposed and for which climate change issues (based on Table 7.1.) further measures need to be elaborated.

**Results of the analysis of normative acts and planning documents in the context of climate change policies.**

The first conclusions arising from the analysis of Latvian normative documents are related to content aspects of adaptation:

1. The main policy and planning documents of Latvia already require that the risks associated with climate change be assessed. However, implementation through the Environmental Impact Assessment and Strategic Environmental Impact Assessment procedures is limited - relationships between anthropogenic and natural (for example, storms, dry periods, floods) factors are excluded, as is an assessment of the magnitude of environmental impacts (the impact of climate change). Therefore it is necessary to include climate change factors in Strategic Environmental Impact Assessment procedures.

2. In relation to the degree of vulnerability, it is necessary to assess factors such as the availability of water for human use/consumption, the geomorphologic and geologic conditions associated with the water source (closely related with the risk of contamination and disease migration) etc.

3.With respect to risks identified at the national policy level, equal consideration (and following all relevant risk management principles) must also be given to environmental risks and their possible impacts on ecosystems, as well as man-made environments and humans themselves (health and well-being).

4. The cost of water does not include expected risks (external costs), but at the same time consideration is given to the full water cycle (water taking, production, distribution, collection etc.). It is necessary to take into account the full costs associated with water use based on all of these criteria.

The second group of conclusions regarding the analysis of normative acts concerns the governance process:

1. When selecting policy instruments, it is necessary to assess impacts, the level of vulnerability, all possible risks must be identified, analysed and managed, an assessment must be undertaken of responsible and otherwise involved stakeholder (organizations, institutions, groups of stakeholders etc.) capacity and readiness to react to and manage risks, it is necessary to identify and take all required preventative measures to avoid risks by minimizing the likelihood and magnitude of these risks, and for the worst case scenario through the creation of strategic reserves and an effective early warning system.

2. The most relevant preventative measures for adaptation policies and for the appropriate selection and development of instruments is the implementation of necessary policy changes

and the creation of a system, as well as overall coordination (presently in many cases this is totally missing):

- Territory planning and development, including construction;
- Water sector (including necessary changes in the EU Water Framework Directive, which are already planned);
- Environmental Impact Assessment and Strategic Environmental Impact Assessment normative acts and procedures;
- National Environmental Monitoring Programme, radically changing existing monitoring from the principle of cause and effect to impact indicators, using not only environmental indicators, but also socio-economic indicators; improving monitoring would allow for the successful development of future scenarios and modelling of possible solutions; presently such analyses and future scenarios are lacking;
- Implementing coordinated management in protected nature territories and enforcing requirements for protection zones;
- Widely use aerial photography for the preparation of risk maps for the management of environmental risk and territorial planning and development.

3. The inclusion of climate change risks in national civil protection systems through the development of a monitoring system and preparation of risk maps (renewed on a regular basis) would simply and eliminate the risk identification and evaluation (including financial) process, elaborate the creation of various predictive and development models including those systems that are related to assessment of climate change impacts on various ecosystems and biodiversity, human health and well-being. Presently, this system is splintered and incomplete as well as non-systematic in application.

4. Presently, in Latvia, the most comprehensively developed is the institutional system and this systems response capacity and responsibilities in the event of natural catastrophes (alongside other types of emergency situations) – this is part of the civil protection system plan.

The following are conclusions from the analysis of global and <u>European Union climate change adaptation policy instruments</u>:

1. The most appropriate adaptation policies and measures more or less have been identified. However, researchers emphasize that the policies and measures should be implemented taking into account the results of cost-benefit analyses (best technical means, use of environmental management and energy management systems, environmental considerations taken into account in decisions regarding consumption).

2. Flood risk management plans and flood risk maps should be integrated together with the implementation of river basin management plans in accordance with the EU Water Framework Directive (for example, all four river basins in Latvia are transboundary).

3. It is necessary to assess the effectiveness of protection policies of all transboundary river basins with the help of hydrologic models, which are sensitive to an increase in the intensity of extreme weather events.

4. As one type of adaptation measure, agriculture could be regulated with a new type of land use policy, whereby in support of environmental protection water taking, disposal of contaminated water and the use of land in areas susceptible to flooding or in water quality protection zones could be subject to a tax surcharge.

5. Insurance measures are one of the most important adaptation instruments.

6. It is important to ensure adequate and comprehensive long-term climate change monitoring.

7. The main areas in which governments should become involved in climate change adaptation are: provision of information, education and training, emergency assistance, dissemination of approaches and guidelines and provision of neccesary capacity, infrastructure planning and development.

8. No matter how comprehensive may be the body of instruments used by the EU, only political will to implement can ensure solidarity of reaction to grave and desperate situations caused by natural catastrophes.

**Scientific and economic significance of the results of the analysis of normative acts and planning documents**

The results of the analysis of normative acts and planning documents are of scientific value for international comparisons, as it highlights the progress Latvia has made with respect to the formulation of adaptation policy at the global level. The results of the anlysis will be the basis for the research programme to make recommendations regarding adaptation policy formulation and the improvement of existing policy weaknesses. Subsequently, the research will focus on the relationship between practice and normative acts in order to formulate recommendations for improvements.

**Task 3:** *Undertake and compile results of a survey of municipal and other government institutions.*

The survey was needed to determine the views of stakeholders – municipality, river basin, environmental and other sector institution specialists regarding the relevance of climate change in Latvia with regards to the water environment and the need for adaptation measures in the eyes of ”practitioners”. The survey was adapted from the International and European Ecological Policy Institute Survey which in November 2006 was implemented in 25 European countries (Latvia did not participate in this survey).

**Results of the Survey of Municipal and Relevant Institutions**

Firstly, analysis of the results (78 respondents) showed that the level of awareness is high (Figure 7.1.) and in Latvia, just as in other European countries, significant impacts from climate change are expected.

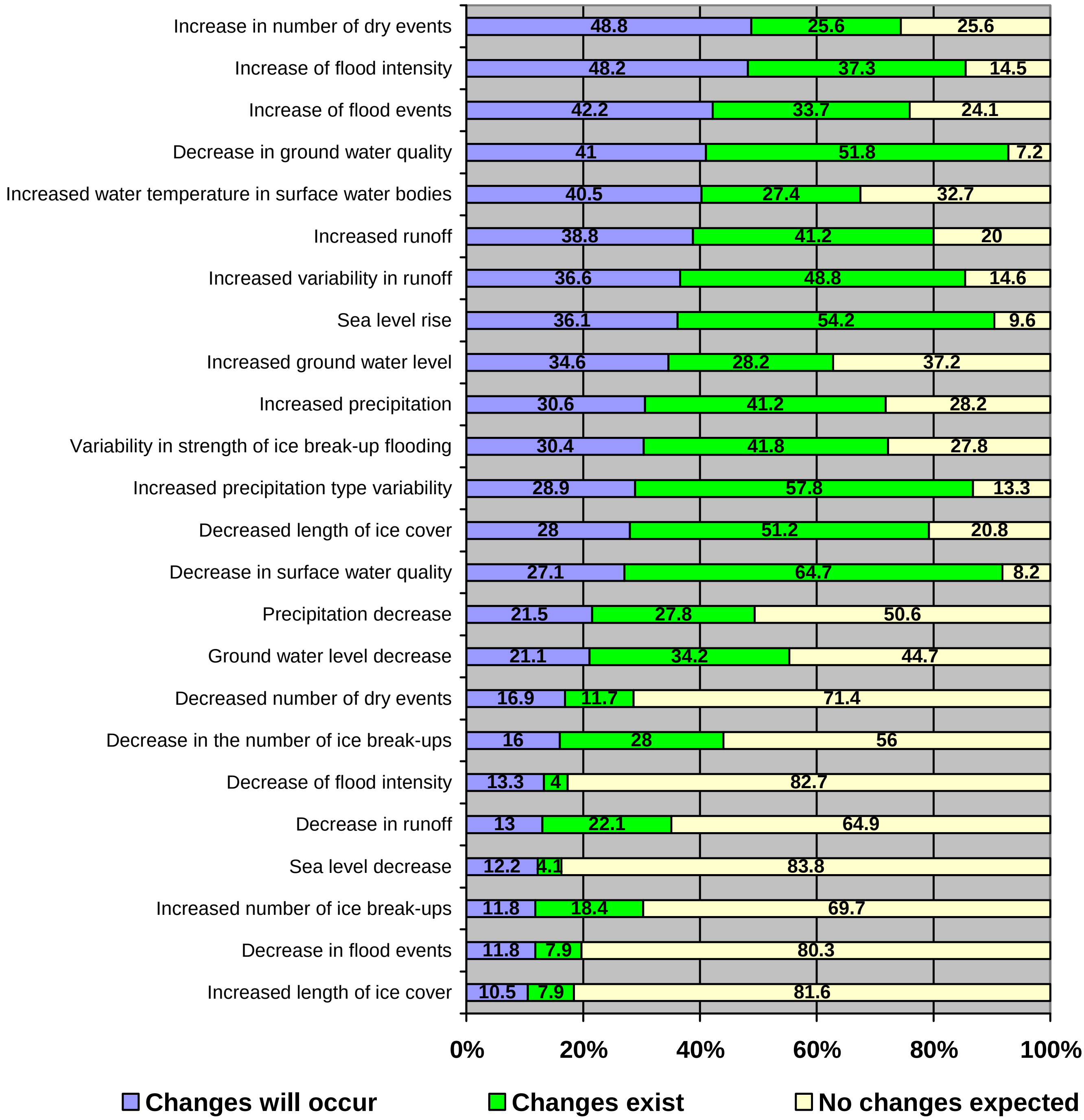



**Figure 7.1.** Stakeholder views on expected changes in water environment in Latvia due to climate change, August – November 2007, n=87 respondents, percentage

The assessment of the impact of climate change on the water environment revealed that, those surveyed view almost all climate changes negatively. This is the typical attitude of people when faced with any change, however in this case the assessment of the situation is fairly accurate. The most concern is about the deterioration of water quality, as well as flood events and dry periods. Only 1/3 of respondents indicated that within the last 5 years, to their knowledge, a climate change adaptation measure had been implemented. The adaptation measures noted are mostly technical reconstruction projects in the water and wastewater sector.

If the survey undertaken in other European countries indicates that the EU Water Framework Directive in some countries is viewed as a mechanism which is the basis and support for all EU water policy instruments, then the survey in Latvia indicated that respondents predominantly do not have an opinion regarding the role of the Water Framework Directive in promoting adaptation measures.

**Task 4:** *Foster dialogue between climate change and water resource researchers and development planners, policy-makers in national institutions, municipal institutions and the business sector.*

**Promotion of dialogue** between research teams of the Programme and with stakeholders, including national and municipal public authorities and entrepreneurs.

1. Promotion of the participation of stakeholders in research conferences and other events.

2. Dissemination of information regarding the research project to stakeholders in various planning and other events.

**Types of interventions with stakeholders**: Interventions with stakeholders regarding research results and the most effective adaptation measures can be undertaken in various ways (Figure 7.2.):

a) ”from top to bottom” – cooperation between decision-makers and policy-makers (Figure 7.2., A) to ensure that needed adaptation measures are included in normative acts, and as a result are implemented at the local/municipal level;

b) ”from bottom to top” – cooperation with sector specialists and municipal employees at the ”local” level (Figure 7.2.; B), so that the most effective adaptation measures are implemented and with time integrated into state normative acts;

c) Cooperation with all levels of stakeholders (Figure 7.2.; C), to ensure that all necessary adaptation measures are introduced into national normative acts and that at the local level there would be awareness of the need for adaptation measures.

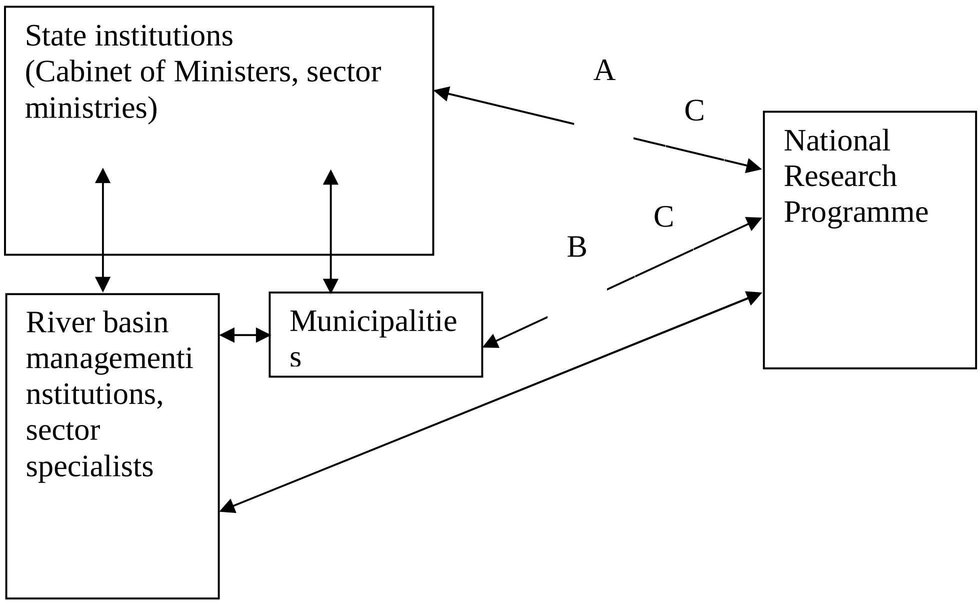



**Figure 7.2**. Possible forms of cooperation between researchers and stakeholder institutions

**Results of Interventions with Stakeholders**

The scientific relevance of the identification of impacts of climate change lies in the fact that it is possible to propose specific research questions for natural science researchers and modellers involved in the other work packages, and in practical terms aids in the identification of relevant stakeholders with whom an on-going dialogue should be maintained during the research project and in the process of developing recommendations for adaptation policies. From a research perspective it is meaningful to compare climate change impacts at the European scale. In the context of state governance the identification of climate change impacts in Latvia is the basis for a better understanding concerning which impacts it is important for Latvia to formulate its position at the EU and global level when policies and normative acts are being formulated.

The results of the survey of municipalities and other relevant institutions are important as they form the basis of an on-going dialogue between project researchers and stakeholders in the subsequent phases of the project considering the existing knowledge and awareness level of stakeholders regarding the need to adapt to climate change. The results of the survey are also significant from a social, environmental sciences and environmental education perspective, whereby stakeholder (practitioner) and researcher views regarding impacts of climate change on the water environment in Latvia are compared.

**Summary**

In Phase 2 of Work Package 7 the foundations were laid for an on-going dialogue between climate change and water resource researchers and state and municipal level specialists and the business sector. The results of the analysis of normative acts and planning documents will be the basis for the improvement of existing and the formulation of recommendations for new climate change adaptation policies in Latvia. The practical nature of Phase 2 work explains why to date publications have not been published. Publications will be forthcoming in subsequent phases of research as results of other Work Packages become available.

**WP7 tasks for the 3rd phase (2008):**

1. Based on the results of the survey of municipal and state specialists an action plan for an on-going dialogue between research programme researchers and practitioners will be developed (Objective 2).

2. Continuation of dialogue between climate change and water resource researchers and state and municipal level development planning specialists and the business sector.

3. Preparation of a publication on the results of the survey of state and municipal institution specialists.

4. Ensure that the results of the research programme are integrated into the Latvian climate change adaptation programme through participation in the work group.

**Work Package Coordinator: Kristīne Āboliņa**

## Work Package 8: PROGRAM MANAGEMENT AND PUBLIC OUTREACH

**Goals:**

Ensure that the Program tasks are fulfilled successfully and in high quality. Facilitate the development of the aquatic and climate change research in Latvia and its visibility on national and international level.

**Phase 2 tasks of WP8:**

1. Scientific guidance of the Program, coordination of the WP work and everyday management.
2. Organising of the Program's annual conference (6 February 2007), and international conference "Climate Change and Waters (Riga, 10-12 May 2007).
3. Preparation and publishing of the collection of papers "Climate Change in Latvia".
4. Cooperation with the LV Ministry of the Environment in preparing of the climate change adaptation policy.
5. Arranging of the International Advisory Board, and organizing of its 1st meeting.
6. Elaboration of the Programs' public information strategy; publishing of the information material; preparation of a popular brochure on the climate change in the Baltic Region.

**Phase 2 results of WP8:**

**Task 1:** *Scientific guidance of the Program, coordination of the WP work and everyday management.*

To better supervise Program's work and secure the link between the central coordination and the Work packages scattered in different research institutions and universities, the Program bureau regularly arranges meetings of WP coordinators. In 2007, three such meetings have already been held; one will be arranged till the end of Phase 2. The meeting minutes are published in the Programs' website.

Program bureau supervises distribution of the funds among the Work Packages and research institutions involved in the program according to the agreement with the Latvian Council of Science. It also secures preparation and submission of timely and correct finance reports to the Latvian Council of Science.

Due to mismanagement of the research funding system at LCS, in the beginning of 2007, the funds were delivered to the WPs in equal monthly increments, not according to the specific funding schedule fixed in the Agreement. After intervention of the Program bureau the cash flow normalized. Still, in some WPs (WP5 and WP6), beginning of the field observations and the experimental work delayed due to the lack of necessary materials and equipment in due time.

**Task 2:** *Organising of Program's annual conference (6 February 2007), and international conference "Climate Change and Waters (Riga, 10-12 May 2007).*

Program's annual conference was held in the frames of the annual scientific conference of University of Latvia. Session "Climate change and the waters of Latvia" took place on 6th February, 2007. Altogether, the session attracted more than 80 participants representing 3 universities of Latvia, several research institutions, as well as governmental and municipal authorities. Participants were presented with 19 oral papers and 15 posters dealing with the topics of the character of the climate change and its impact on the environmental quality and ecosystems of the inland waters of Latvia and the Baltic Sea.

On 10 – 12 May, Program hosted an international conference "Climate Change and Waters" attended by scientists and representatives of the local and national governments. Altogether, there were 125 participants representing 18 countries of the Baltic Sea region and EU. During this conference, the research and practical activities towards adaptation to the climate change in the Baltic Sea Region were presented to its participants. Apart of the practical arrangements, the NRP KALME team actively participated in this conference by giving the presentations and chairing several of its thematic sessions. In a way, this conference marked the beginning of elaboration of the climate change adaptation policy in Latvia with a focus on the aquatic issues.

**Task 3:** *Preparation and publishing of the collection of papers "Climate Change in Latvia".*

During the 2nd phase of the Program (2007) the former knowledge on the climate variability in Latvia was compiled in a form of collection of papers. The 268-page book contains 18 articles prepared by 32 authors. Topics of the articles include character of the climate change, its possible consequences, potential solutions and approach to the modelling. This work includes also proposals and the nearest-time tasks for the environmental policy.

**Task 4:** *Cooperation with the LV Ministry of the Environment in preparing of the climate change adaptation policy.*

To facilitate development of the Latvian climate change adaptation policy, Program coordinators took part in the elaboration of Latvian position during the German presidency in EU. The existing climate policy has been analysed, and the results achieved were reviewed. A seminar to the representatives of the local governments (hosted by the North-Vidzeme Biosphere Reserve) was held to facilitate including of the CC aspects in the process of spatial planning.

**Task 5:** *Arranging of the International Advisory Board, and organizing of its 1st meeting.*

To facilitate the scientific quality of the program and support its international visibility and contacts with similar programs in other countries, the International Advisory Board of the program has been formed. Prominent CC and water environment scientists from Estonia, Finland, Germany and the Netherlands, as well as the representatives of the LV Ministry of the Environment responsible for the National CC adaptation activities were invited to the IAB. The first meeting of IAB was held in Riga, 11-12 May 2007. After reviewing of the program tasks, the members of IAB put forward the following proposals to the Program:

- WP2 and WP3 was suggested to take into account that even at insignificant summary level of precipitation and runoff variations, its seasonality may alternate significantly: re-occurrence of the low water periods and the associated risks may increase;

- It is necessary to strengthen the links between the modelling WP (1) and other WPs. The current work division between WP1 and WP2 is not clear enough;
- To take into account the possible shift in the output of RCM in relation to the input data;
- WP2 has been advised to increase the sampling frequency in the Berze drainage basin to improve the quality of the modelling input data series;
- While forecasting the flows of nutrients and organic carbon in the drainage basin it is necessary to consider that CC and utilization of the renewable energy sources (e.g. bio-fuel and peat) may alternate not only the hydrological regime but also the land use;
- WP3 has been advised to reconsider the spatial scale of their investigations to cover one and the same areas by the studies of the nutrient transport and the studies of aquatic communities. Findings of the KALME Program shall address the whole territory of Latvia, therefore, the studied water bodies shall be representative enough;
- Within the context of CC, WP3 has been suggested to consider the issue of non-indigenous species in the inland waters. It has been advised to study together with the WP6 how changes in the inland water ecosystems could potentially affect biological invasions into the Baltic sea;
- It is necessary that WP3 formulates the character of scenarios needed in order to solve the prognostic tasks: averaged v. extreme values.
- Shift in the spring-flood timing has been mentioned as potentially the most significant factor that might influence the ecosystems of inland waters. WP3 and WP9 shall pay attention to this fact.
- WP4 and WP6 has been advised to study together how the intensified coastal erosion could impact the coastal biological diversity and ecosystems;
- WP5 was suggested to consider the possibility of 3D modelling of the biogeochemical processes. The currently used box-model does not allow to investigate the coastal and estuarine processes, which might have a specific importance in the context of CC;
- Program has been advised to strengthen the public information segment: information campaigns shall be held at least twice a year. Each of the WP leaders shall commit himself to prepare one popular presentation on his topic to the central national media. Also, the Program has been advised to use services of the PR professionals in its public information activities. Regrettably, the latter proposal does not seem feasible within the current budget of the Program.
- Program has been advised to strengthen the contacts with other CC research programs and projects in Latvia and the Baltic region, as well as with the developers of the CC adaptation action programmes.

The minutes of the IAB meeting have been published in the Program webpage. Next meeting will convene in May 2008 to discuss the results of the 1st and 2nd Phases.

**Task 6:** *Elaboration of Programs' public information strategy; publishing of the information material; preparation of a popular brochure on the climate change in the Baltic Region.*

Program's webpage www.kalme.daba.lv has been created and is being updated regularly. The website informs about the structure of program, its goals, and work tasks, and the work progress. File archive of the website contains the most important documents and publications of the Program, while the news section informs on actualities of CC in Latvia and elsewhere. The webpage serves both as an external dissemination tool and as a means of the internal communication among the members of the Program team.

A brochure informing about the initiation of the KALME Program has been published in Latvian and English (500 ex. in each language).

During the reporting period program coordinators gave 9 interviews to the media on the CC topics.

A text book "Climate Change and the Global Warming" (in Latvian) has been prepared and published. The book discusses the character of the climate system formation, factors affecting the climate, solutions for modelling of the climate variability. Book presents original data on the climate of Latvia and its variability; it also gives some insight into the climate technologies. Book has been published in the beginning of 2008.

The educational activities of the Program members included lecture course on applications of GIS in the environmental science, as well as the lectures to students on the relationships of the global climate and the Ocean, and climate change in the Baltic Region.

**Summary.**

***WP8 tasks for the 3rd phase (2008).***

- Support to elaboration of the national CC adaptation program;
- Preparation of the popular publications on different aspects of the climate change and global warming;
- Initiation of preparing for the international conference on CC in 2009 (ending of this Program).
- Work on development of the content of the environmental studies.

**Work Package Coordinators: Andris Andrušaitis and Maris Kļaviņš**

# Annexes

Annex1

## Aggregated performance indicators and auditable values of the Program.

| Resultativity indicators and auditable values | Number |
|---|---|
| Monographs | 1 |
| Defended PhD theses | 3 |
| Young researchers, PhD and MSc students involved in the program | 40 |
| Scientific publications in international and local sources | 38 articles<br>35 abstracts |
| Reports to media | 19 |
| Presentations at conferences | 48 |
| Created new methods | 6 |
| Organized conferences and seminars | 3 |
| Recommendations for elaboration of the environmental legislation; participation in the decision-making process and implementation of these decisions | 12 |
| Created original maps | 7 |
| Acquired and built laboratory devices | 13 |

# Published and submitted papers by the Program team.

## Collection of Papers.

Climate Change in Latvia (2007) (Ed. M.Kļaviņš), Rīga: LU apgāds

## Text book

**Āboliņa K.**, **Andrušaitis A**.,.Blumberga D, **Briede A**., **Bruņiniece I.**, Grišule G., **Kļaviņš M.** (2007) Klimata pārmaiņas un globālā sasilšana (**red. M.Kļaviņš, A.Andrušaitis**) Rīga: LU apgāds (published in February 2008) [Climate Change and Global Warming], in Latvian.

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7. **Briede A., Lizuma L.** (2007) Long-term variability of precipitation in the territory of Latvia. In: Kļaviņš M. (ed.) Climate Change in Latvia. pp.35-44
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## Participation in the international PhD courses

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2. **Bērziņa L**. NATO Science for Peace program. Institute on Uncertainties in environmental modelling and consequences for decision making. Vrsar, Croatia. 30.10. - 11.11. 2007

Annex 3

## Program Performance Indicators

| WP **No.** | Workpackage results | **Performance indicator** | **Planned number** | **Accomplished till 30.11.2007** |
|---|---|---|---|---|
| **DP1** | Quantitative scenarios of the climate change impacts | Data series | **1** | 4 |
| | Forecast of the influence of climate change on rive runoff and its seasonal and long-term change | Data series | | |
| | Model analysis | Publications | **2** | 6 |
| | Regionally adapted drainage basin model (discharge, nutrient runoff) | Understanding of the hydrological and nutrient cycles in surface waters. | | |
| | Projection of the nutrient loading | Mathematical model (method) | | |
| | | Publications | **2** | 1 |
| | | Data series | | |
| | Regionally adapted 3D marine state model | Understanding of the interrelationships of marine state parameters | | |
| | | Mathematical model (method) | **1** | |
| | | Publications | **3-5** | |
| | | Conferences | **1** | 1 |
| | 3D calculations of the Gulf of Riga for 50-100 year periods | New knowledge about influence of the CC on the status, variability of seasonal cycles and long-term alternations in the marine and inland waters. | | |
| | | Publications | **3-5** | |
| | | Conferences | **1** | |

| WP **No.** | Workpackage results | **Performance indicator** | **Planned number** | **Accomplished till 30.11.2007** |
|---|---|---|---|---|
| **WP2** | Hydrological and hydrochemical models of the river basins are calibrated | Creation of the long-term data series for hydrochemical modelling is commenced. | | ✓ |
| | | Models calibrated for the conditions of Latvia are usable for management of the water bodies and forecast of the CC influences. | | ✓ |
| | | Scientific publications | **2** | 2 |
| | | Recommendations to LV Geology Meteorology and Environment Agency | **2** | |
| | CC impact on the discharge of diffuse pollution into the Rivers of Latvia is estimated | Understanding of the character of changes and amount of the diffuse pollution. | | |
| | | Scientific publications | **1** | 2 |
| | | Recommendations to Ministry of Agriculture | **1** | 1 |
| **WP3** | Projections of the impact of CC on the ecosystems of the inland waters. Advice for adaptation to CC in the protected areas. | Understanding of the character of CC impact on the aquatic ecosystems and solutions on mitigation of the adverse effects | | |
| | | Scientific publications | **3** | 2 |
| | | Recommendations to Ministry of Environment | **1** | 1 |
| | Assessment of change in species diversity in relation to the CC. Selection of the indicator species for characterization of the environmental quality. | Elaboration of the biological indicators of CC | | |
| | | Scientific publications | **1** | 1 |
| | | Recommendations for water protection legislation, assessment of water quality and protection. | **2** | 3 |

| | | | | |
|---|---|---|---|---|
| | Assessment of CC influence on the fish communities of river Salaca (populations of wild salmon and other migratory fishes), CC induced changes in fisheries. | Preparation of the LV national report to ICES WGBAST | **1** | 1 |
| WP **No.** | Workpackage results | **Performance indicator** | **Planned number** | **Accomplished till 30.11.2007** |
| | | Research publications. | **2** | 2 |
| **WP4** | Scenarios of the potential changes in Latvian coastal strip, and assessment of the risk of the economic activity, culture/history and other objects located there in the near future (till 2050) | Assessment of the coastal processes and identification of the most endangered significant objects and areas.<br><br>Recommendations to the government and municipal authorities.<br><br>Research publications. | <br><br><br>**1**<br><br><br>**3-5** | ✓ |
| | Digital maps of the contemporary processes of the coasts of Latvia:<br>a)projection maps for the cases of extreme storms;<br>b)map of main erosion risk zones;<br>c)map of the contemporary coastal geological processes;<br>d)map of the protected nature area in the coastal strip;<br>e)map of the significant objects in the coastal erosion risk zone. | Visualization of the coastal processes and risks.<br>Cartographic material<br>Recommendations | <br>**4**<br>**1** | ✓<br>7 |
| | Recommendations for the purposes of coastal planning, territorial planning of municipalities, management activities and protection. | Development of dialogue with governmental and municipal authorities.<br>Proposals for the national planning.<br>Proposals for development of the environmental monitoring program. | <br>**1**<br>**1** | |
| | | | | |

| WP **No.** | Workpackage results | **Performance indicator** | **Planned number** | **Accomplished till 30.11.2007** |
|---|---|---|---|---|
| **DP5** | New information on influence of the regime-forming parameters on the biogeochemical processes in the Gulf of Riga. | In-depth understanding of the impact of the physical parameters on sedimentation and processes in the water – sediment interphase, usable for parametrizing and calibration of the biogeochemical model. | | |
| | | Scientific publications. | **2** | 3 |
| | | Data sets to be assimilated into the model | **1** | |
| | Projections of the environmental quality and productivity of the Gulf of Riga till 2100 for each of the selected CC scenarios. | A model of the Gulf of Riga allowing to forecast evolution of the nutrient system at various CC scenarios with appropriate level of confidence. | **2** | |
| | | Scientific publications about the model and forecasting results. | **1** | |
| | | Set of the prognostic data about oxygen and nutrient regime (input data for WP 6). | | |
| | Environmental values causing critical changes in the quality of marine environment identified. | Proposals for determination of the critical values of environmental indicators in the Latvian territorial water s and EEZ, necessary for implementation of the WFD and European Marine Strategy Directive (report). | **1** | |
| | Science –based proposals to stabilize and mitigate eutrophication of the coastal waters in the context of CC, based on the outputs of WP6,. | Report on the relationships between coastal eutrophication and CC in the Baltic Sea. | **1** | |
| | | Scientific publication. | **1** | |

| WP **No.** | Workpackage results | **Performance indicator** | **Planned number** | **Accomplished till 30.11.2007** |
|---|---|---|---|---|
| **DP6** | Projection of the influence of CC on the ecosystems and biological diversity off the coasts of Latvia. | In-depth understanding on the possible character, scale and pace of ecosystem changes. | | ✓ |
| | | Array of facts and knowledge necessary for participation of Latvia in the implementation of the HELCOM BSAP and formulation of the national plan as required by the BSAP,<br>and | **2** | 3 |
| | | Elaboration and implementation of the European Marine Strategy Directive. | **1** | 1 |
| | | Scientific publications | **2** | |
| | Prognostic model of fish growth, dynamics of fish stock, and structure of the fish community depending on development scenarios of the climatic and anthropogenic impacts.<br>Projection of the fish stocks and year-class fecundity in 5, 10 and 30-year periods. | Calibrated prognostic model. | **1** | 1 |
| | | Prognostic data series on dynamics of fish stocks and yields within the nearest 30 years. | **1** | 6 |
| | | Information and knowledge basis necessary to create and implement a sustainable management policy of the living marine resources. | **1** | 1 |
| | | Scientific publications | **2** | 3 |
| | Integrated assessment of the impact of CC in territorial waters and EEZ of Latvia. | Proposals for implementation of the WFD (Latvian coastal and transitional waters), European Marine Strategy Directive and HELCOM BSAP (Reports).<br>Proposals for protection of the marine biological diversity off the coasts of Latvia. | | ✓ |
| | | | | |

| WP **No.** | Workpackage results | **Performance indicator** | **Planned number** | **Accomplished till 30.11.2007** |
|---|---|---|---|---|
| **WP7** | Analysis of the reflection of adaptation to CC in the documents of the environmental and other policies. | Analysis of the existing adaptation policy to CC | | ✓ |
| | | Assessment of the priority research direction of the program. | | ✓ |
| | | Scientific publications. | **1** | |
| | | Proposals for adjustment of the program contents | **1** | 2 |
| | Elaboration of proposals for the national development planning, environmental policy, and sector policy documents to mitigate the possible adverse effect of CC on the water environment based on the scientific findings. | Proposals during elaboration of the policy documents. | **3** | |
| | Facilitating of the communication and establishing of dialogue between the research community and the authorities involved in the development planning and decision making, as well as the key representatives of the private sector. Information of the society about implementation of the Program and its findings. | Initiation of the dialogue. | | |
| | | A practical handbook an adaptation to the CC in the environmental and other policies. | **Handbook 2000 ex.** | |
| | | Conferences and seminars. | **3** | |
| **DP9** | Data on the re-occurrence and intensity of the past runoff extremes. | Data series. | **1** | 1 |
| | | Scientific publications | **1** | |
| | Prognostic hydrological data series, modelling of the flood and drought character. | Data series | **1** | |
| | | Mathematical model | **1** | |
| | | Scientific publications | **2** | |
| | Digital terrain model of the Naujeine – Jekabpils stretch of the Daugava valley. | Data series | **1** | 1 |
| | | ĢIS database | **1** | 1 |
| | | Scientific publications | **1** | |

| WP **No.** | Workpackage results | **Performance indicator** | **Planned number** | **Accomplished till 30.11.2007** |
|---|---|---|---|---|
| | Ecosystem changes in the floodplain lakes of the Daugava mid-flow assessed. | Data series<br>Mathematical model<br>Scientific publications<br>Conferences | **1**<br>**1**<br>**3**<br>**2** | 1<br><br>2<br>5 |
| | Transport of the nutrients and the suspended material from the upper parts of the hydrographical network to recipient water-flows and basins assessed. | Scientific publications<br>Recommendations to the Ministry of Regional Development and Local Governments, Ministry of the Environment and Ministry of Agriculture. | **2**<br>**3** | 2 |
| | Understanding of the broad society about CC and the associated risks investigated within a sociologic survey. | Recommendations to the Ministry of Regional Development and Local Governments<br>Scientific publications | **1**<br>**1** | 1 |
| | Recommendations to the agricultural, forestry and territorial planning sectors on mitigating of the flood and draught risks. | Recommendations to the municipal governments of Daugavpils and Jēkabpils regions. | **2** | |
| **8DP** | Effective governance of the program and coordination of the collaboration of WPs. | Meetings of the WP Coordinators | **13** | 5 |
| | | Technical reports on progress in implementation of the Program | According with the financers' requirements | |
| | CC research in Latvia is conducted in a high scientific quality. This is supported by an effective work of the international External Advisory Board and international relations of the Program. | Meeting reports of the International Advisory Board | **At least 4** | |

| WP **No.** | Workpackage results | **Performance indicator** | **Planned number** | **Accomplished till 30.11.2007** |
|---|---|---|---|---|
| | Fair and transparent distribution of finances amongst the WPs of the Program facilitates effective use of the allocated funds.<br>Timely prepared and good quality reports prepared in accordance with the requirements of the financier. | Carefully prepared budget requests for each of the years (phases) of the Program.<br>Directions to the financier concerning the distribution of funds among the research institutes and universities participating in the Program.<br>Precise and timely submitted financial reports. | **4**<br>**4**<br>**In accordance with the financier's schedule** | 2<br>2<br>✓ |
| | Effective strategy of information of the broad public about the impact of CC on the environment of the Baltic Region.<br>Program has good visibility. | Created and systematically updated Program website.<br>Information leaflet on the Program in two languages<br>Popular summary of the Program results.<br>Series of popular publications about various findings of the Program.<br>Reports in media about the potential CC impact on waters of the Baltic Region and Latvia and the necessary adaptation activities. | **1**<br>**1 (500-1000 ex.)**<br>**1 (500-1000 eks.)** | 1<br>1<br>✓ |
| | As a result of the aquatic environmental research school initiated by the Program, development of the new researchers and quality of their work has increased considerably. Number of SCI papers and defended PhD dissertations significantly increased. PhD courses on the topics of aquatic research take place regularly. | Papers in the internationally quoted scientific journals, % of the total number of publications.<br>PhD defences on the topics of the Program<br>Annual Program conferences as a part of the Scientific conference of UL.<br>International PhD courses | **At least 50%**<br>**At least 15**<br>**3**<br>**3** | 11 of 27=30%<br>3<br>1+1 intl. conference |

Annex 4

# Time schedule of the Program tasks

| WP No. | Task | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| WP1 | 1a Elaboration of scenarios | | | | | | | 1A | | | | | | | | | |
| | 1b Drainage basin modelling | | | | | | | | | | 1B | | | | | | |
| | 1c Marine 3D model | | | | | | | | | | | | 1C | | | | |
| | 1d Data series | | | | | | | | | | | | | | | | 1D |
| WP2 | 2a Modelling data bases | | | | | | | | 2A | | | | | | | | 2A |
| | 2b Retention processes | | | | | | | | | 2B | | | | | 2B | | |
| | 2c Model analysis | | | | | | | 2C | | | | | | | | | |
| | 2dInfluences on water resources | | | | | | | | | | | | 2D | | | | 2D |
| | 2e Changes in pollution | | | | | | | | | | | | | | | | 2E |
| WP3 | 3a Climate - biodiversity | | | | | | | | | | | 3A | | | | 3A | |
| | 3b Fluxes-climate – biota | | | | | | | | | | | | | | | 3B | |
| | 3c Indicators of the climate change | | | | | | | | | | | | | | | | 3C |
| WP4 | 4a History of coastal processes | | | | | | | | 4A | | | | | | | | |
| | 4b Projection of coastal processes | | | | | | | | | | | | 4A | | | | |
| | 4c Risk mapping | | | | | | | | | | | | | | | | 4B |
| | 4d Actions for adaptation | | | | | | | | | | 4B | | | | | | 4B |
| WP5 | 5a Boundary layer processes | | | | | | | | | | | | | | 5A | | |
| | 5b Production and sedimentation | | | | | | | | 5B | | | | | | 5B | | |
| | 5c Marine model | | | | | | | | | | | | | | 5C | | |
| | 5d Marine quality and productivity | | | | | | | | | | 5D | | | 5D | | | |
| | 5e Advice on adaptation | | | | | | | | | | | | | | 5F | | 5G |
| WP6 | 6a Structure and dynamics of communities | | | | | | | | | | | | 6A | | | | |
| | 6b Fish community model | | | | | | | | | 6B | | | | | | | |
| | 6c Projection of fisheries resources | | | | | | | | | | | | | | 6C | | |
| | 6d Advice to fisheries | | | | | | | | | | | | | | | | 6F |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6e Advice to marine environmental protection | | | | | | | | | | | | | 6D | | | 6G 6H |
| WP7 | 7a. Adaptation policy | | | | | | | 7A | | | | | | | | | |
| | 7b. Implementation | | | | | | | | 7B | | | | | | | | 7B |
| | 7c. Dialogue | | | | | | | | | | | | | | | | |
| WP8 | 8a.Management and coordination | | | | 8A 8B | 8B 8C | 8B | 8B | 8B | 8B 8C | 8B | 8B | 8B | 8B 8C | 8B | 8B | 8B 8C |
| | 8b. Distribution of funds | | | | 8C | 8C | | | | 8C | | | | 8C | | | |
| | 8c. Public information | | | | 8F | 8E | | | 8G | | | | 8G | | | | 8G |
| | 8d. External Advisory Board | | | | 8I | | | | 8I | | | | 8I | | | | 8I |
| | 8.e. Research school | | | | | 8J | | | | 8J | | | | 8J | | | |
| DP9 | 9a Runoff and climate | | | | | | | | | | | 9A | | | | | |
| | 9b Flood modelling | | | | | | | | | | | | 9B | | | | |
| | 9c Role of flood-plains | | | | | | | | 9C | | | 9C | | | | | |
| | 9d Lake ecosystems | | | | | | | | | | | | | | | | 9D |
| | 9e Material fluxes | | | | | | | | | | | | | | | | 9E |
| | 9f Recommendations | | | | | | | | 9F | | | | 9F | | | | 9G |

- Delayed activities and outputs

A1 – 9G denotes the expected deliverables of the WPs.