NRP „CLIMATE CHANGE IMPACT ON THE WATERS OF LATVIA” FOURTH PHASE (2009) DRAFT SUMMARY REPORT

KALME CLIMATE, ADAPTATION, BALANCE, CHANGE, ECOSYSTEMS

KALME
VALSTS PĒTĪJUMU PROGRAMMA
KLIMATA MAIŅAS IETEKME UZ LATVIJAS ŪDEŅU VIDI

NATIONAL REASEARCH PROGRAMME „CLIMATE CHANGEIMPACT ON THE WATERS OF LATVIA”

FOURTH PHASE (2009)

DRAFT SUMMARY REPORT

Institutes and Universities involved:

University of Latvia
UL Agency Institute of Biology
Latvia University of Agriculture
Latvian Institute of Aquatic Ecology
Latvian Fish Resources Agency
Daugavpils University, Institute of Ecology

Program directors:

Andris Andrušaitis, Dr.biol. , Assoc. prof., Head of Department of Hydrobiology, Faculty of Biology, University of Latvia

Māris Kļaviņš, Dr. hab. chem., Professor, Academician of Latvian Academy of Sciences, Head of Department of Environmental Science, Faculty of Geography and Earth Sciences, University of Latvia

2009

Contents

Aim and overall structure of the Program

Generic goal of the Program:

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 environmental and sectorial policies of Latvia to climate change.

Specific goals:

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, water availability, flood and drought risk, to facilitate adaptation of the drainage basin management and secure protection and sustainable use of the water resources;**
c) **Predict the 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, marine biological diversity, and sustainable use marine resources and services.**

Implementation of the National Research Program KALME "Impact of the Climate Change on the Waters of Latvia" commenced in October 2006.

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 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 the climate change;

WP 8: Program management and public outreach;

WP 9: Runoff extremes caused by the climate change and their impact on territories under flood risk.

Successful work in each of the WPs depends on the outputs of other packages (Fig. 01). 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 the responsibility of Program’s central management.

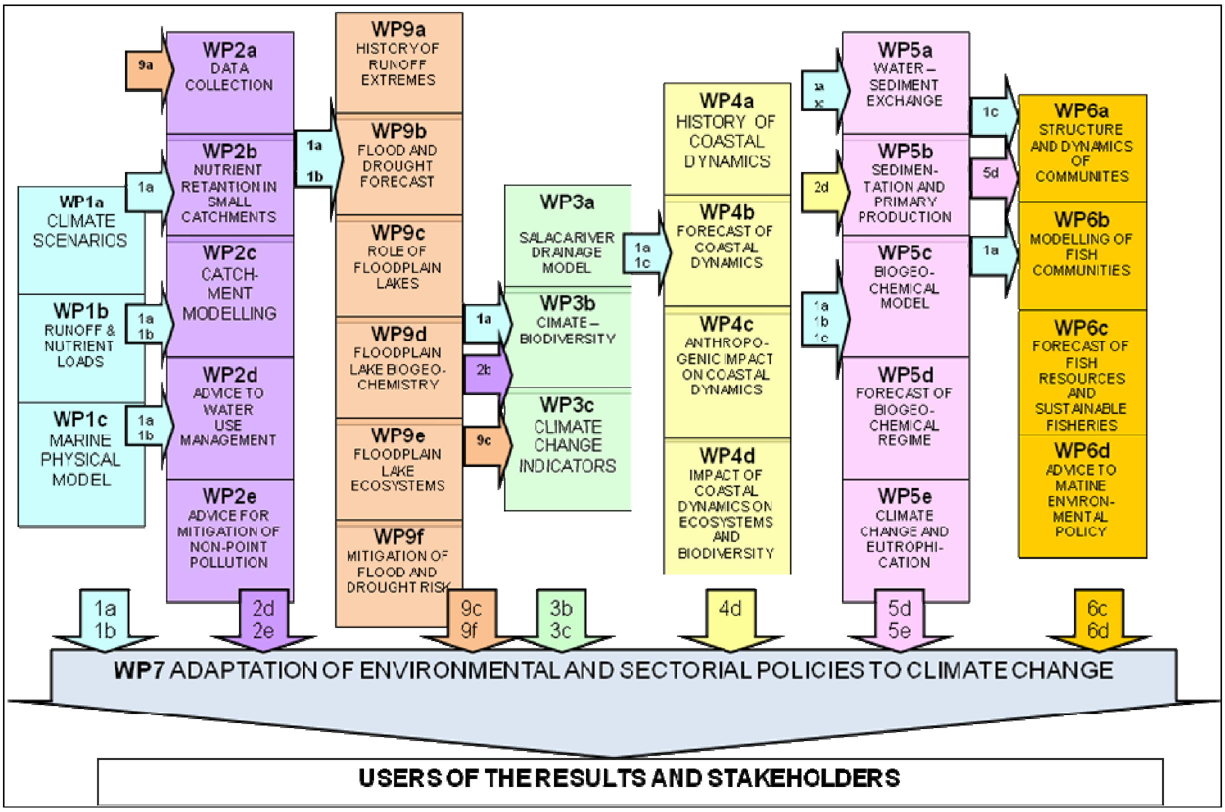


Fig. 0.1.**: KALME work packages and the flows of information among them. Full descriptions of the tasks are presented in Program application, published in* ***www.kalme.daba.lv *.*

Seven natural-science WPs (1-6 and 9) produce new knowledge, while the task of WP7 is to maintain a dialogue with the potential end-users of Program’s outputs and its stakeholders. This WP facilitates 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. The management WP is responsible also for Program’s visibility and implements its educational activities.

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

1.1. Goals:

1. Preparation of hydro-meteorological data series characterising the climate change (scenarios)
2. Development of the mathematical model for the water and nutrient runoff from the Latvian inland catchments. Calculations for preparation of the runoff data series, characterising the climate change.
3. Development of 3D model for the Gulf of Riga, and performing calculations to prepare data series of sea state parameters, compliant with the climate change scenarios.
4. Modelling and data analysis support for other WPs.

1.2. Tasks of WP1 for the 4th stage[1]:

1. Analysis of the results of hydrological modelling.
2. Modelling of nutrient (nitrogen and phosphorus) runoff to the Gulf of Riga.
3. Non-steady climatic calculations of Gulf of Riga for the contemporary climate and two climate change scenarios.
4. Research on long-term variation of climatic indicators.

1.3. The results of WP1 for Stage 4:

Task 1: work contents, results:

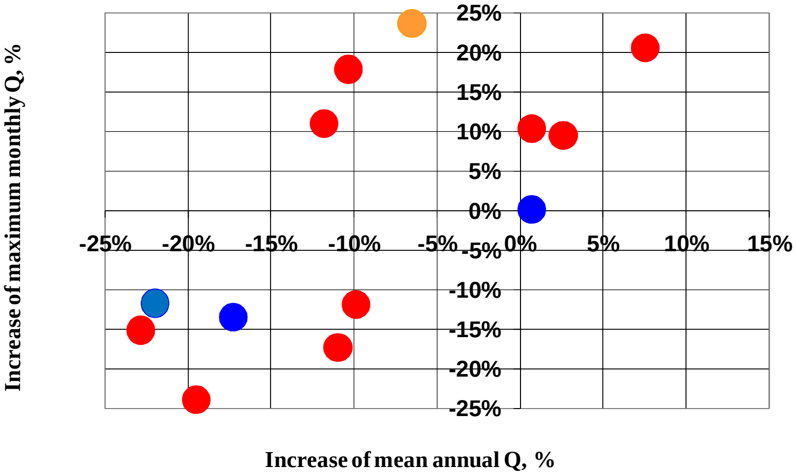


Fig. 1.1. Change of hydrological characteristics of Bērze river according to ensemble of RCMs (red dots) and ensemble of hydrological models (blue dots).

Modelling of water runoff

---

[1] Hereafter Tasks as defined in a Contract for Stage 4 of the Programme

1. The double-model-ensemble approach (i.e. ensemble of the regional climate models vs. ensemble of the hydrological models) was developed for the analysis of runoff changes due to the climate change (Fig.1.1.).
2. The analysis of the hydrological modelling results for the Latvian river basin districts determined the trends of regional variation. This analysis shows that the regional hydrological differences will decrease with the climate change (Figs. 1.2 and 1.3).

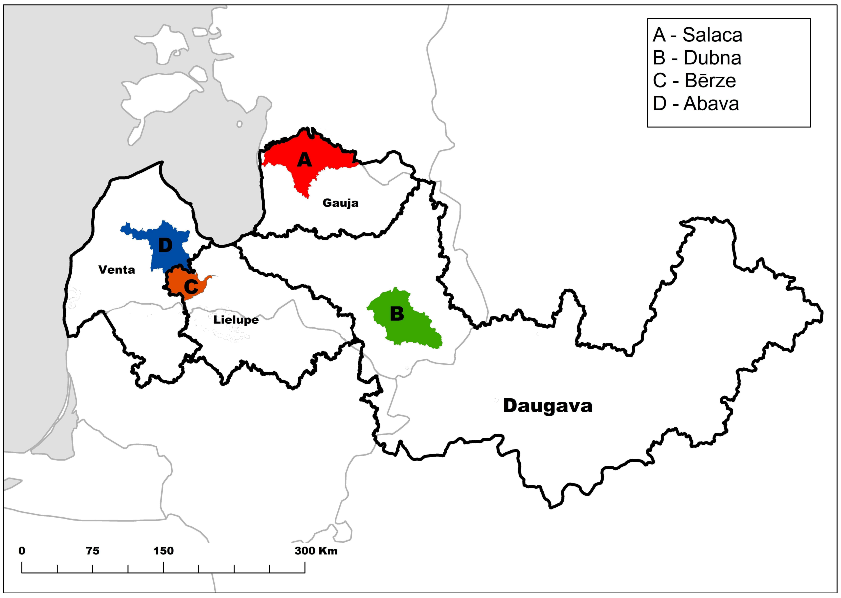


Fig. 1.2. Considered river basin districts (RBD).

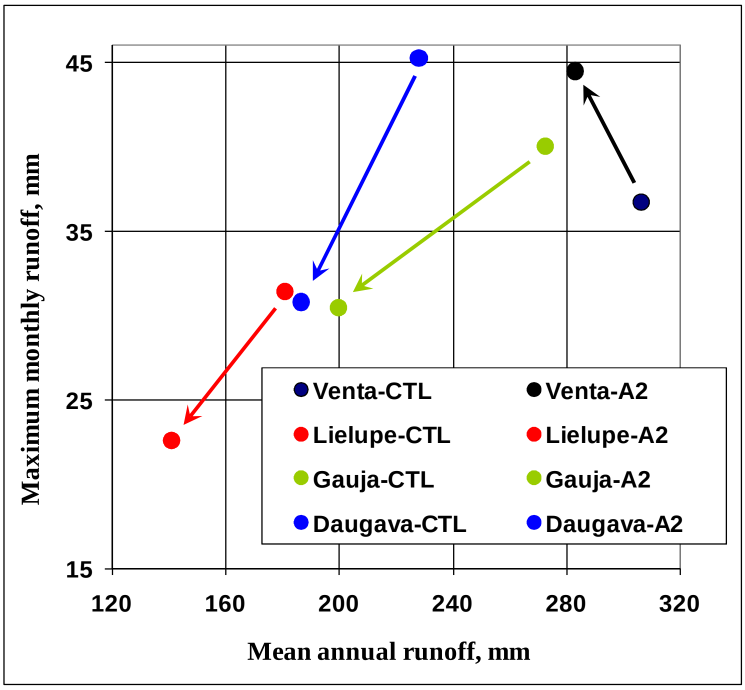


Fig. 1.3. Impact of the climate change on the hydrological characteristics of RBD.

3. The statistical analysis of minimum and maximum discharges was performed. The higher (in comparison with the mean flow) decrease of 90% low-flow value was found (see illustration for Bērze river in Fig.1.4).

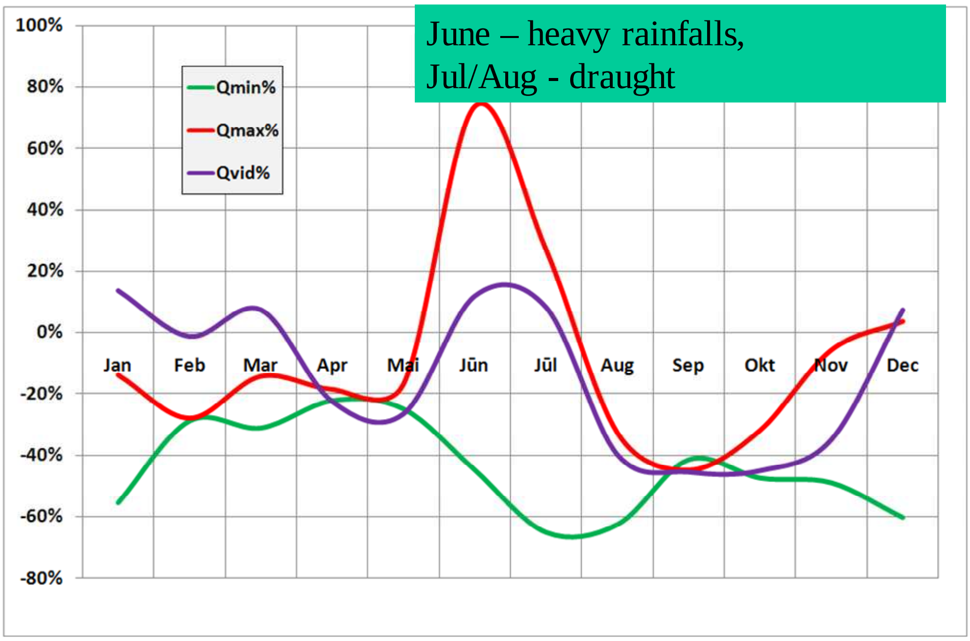

June – heavy rainfalls,
Jul/Aug - draught

Fig. 1.4. Impact of climate change on Bērze discharge – seasonal change at 10% high-flow, 90% low-flow, and mean discharge.

<u>**Task 2:** work contents, results:</u>

Modelling of nutrient runoff. The data series of daily nutrient load of the Gulf of Riga were prepared in co-operation with the WP6 for contemporary climate and climate change scenario A2. See example in Fig.1.5.

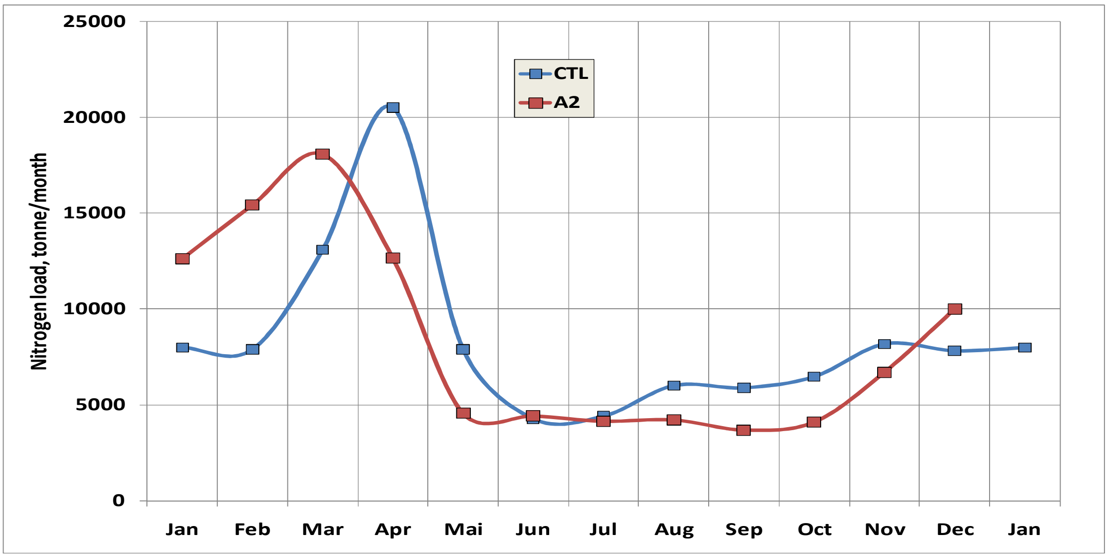


Fig. 1.5. Monthly mean total nitrogen load to the Gulf of Riga for the contemporary climate and climate change scenario A2.

Task 3: work contents, results:

Sea state modelling

1. The attempts of climatic modelling with the 3D hydrodynamic model developed during Stage 3 failed.

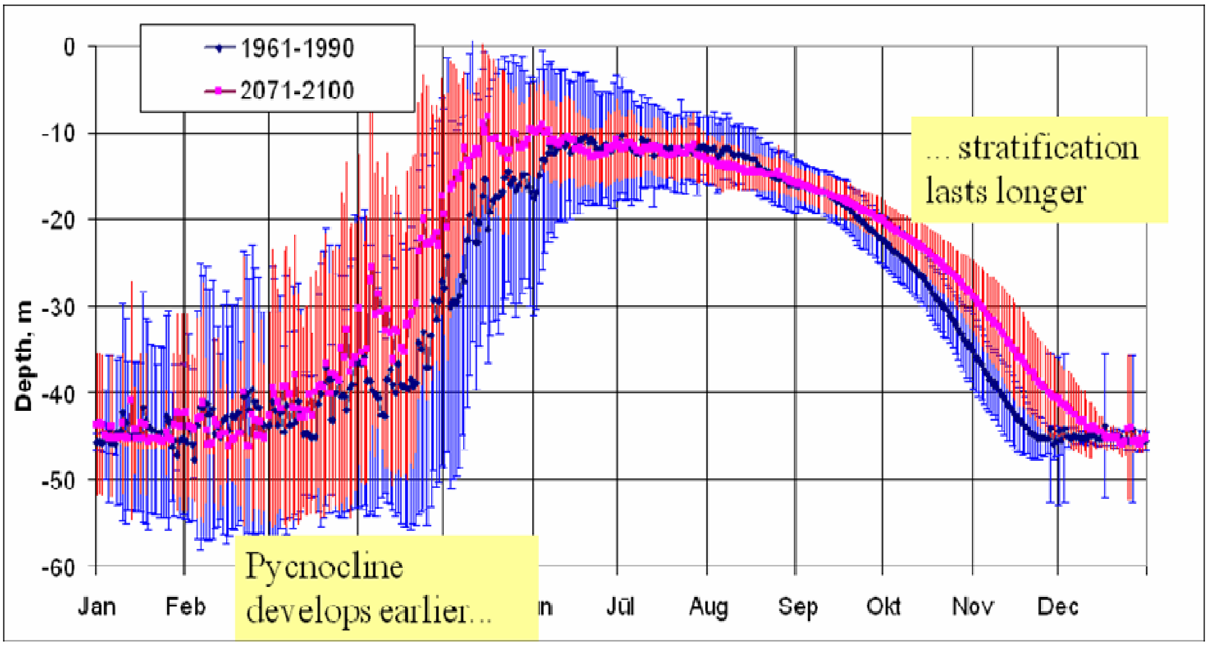


Fig. 1.6. Variation of the daily picnocline depth for the Gulf of Riga under contemporary climate and climate scenario A2.

2. One-dimensional model of vertical stratification was developed and calibrated for the Gulf of Riga.
3. The climatic calculations are performed by the model of p.2 for the contemporary (1961-1990) climate and the climate change scenario A2 (2071-2100), generating the corresponding data series of sea state characteristics.

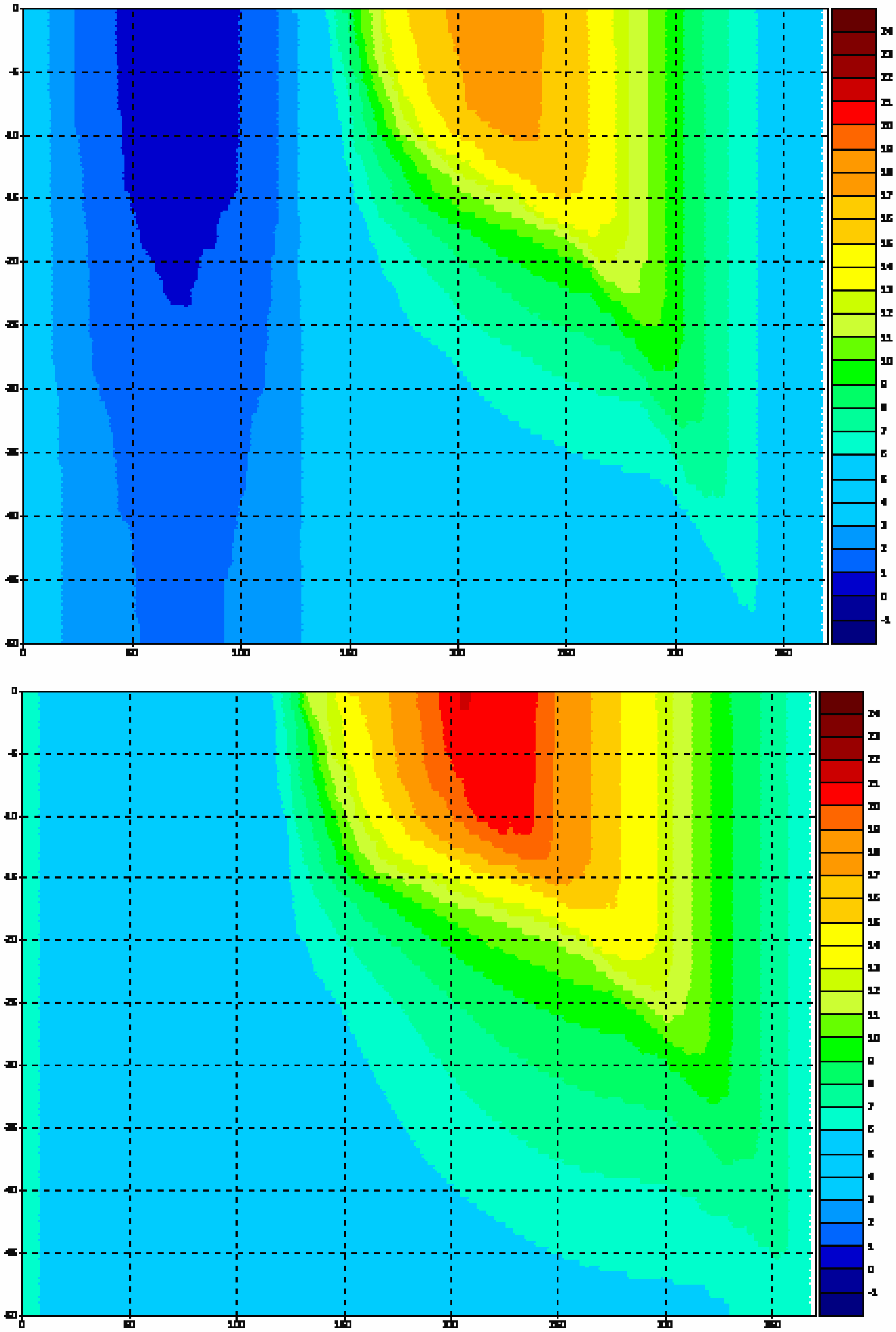


Fig. 1.7. Time development of the vertical temperature distribution for the Gulf of Riga. Contemporary climate (upper), climate change scenario A2 (lower).

4. The initial analysis of the impact of climate change on the stratification and temperature regime of Gulf of Riga is performed (Figs. 1.6-1.7).
5. The modelling support for the modelling of ecosystem of the Gulf of Riga based on calculations of nutrient loads (Task 2) and physical fields (p.3) is provided to the WP 6.

Task 4: work contents, results:

Research of long-term variation of the climatic indicators.

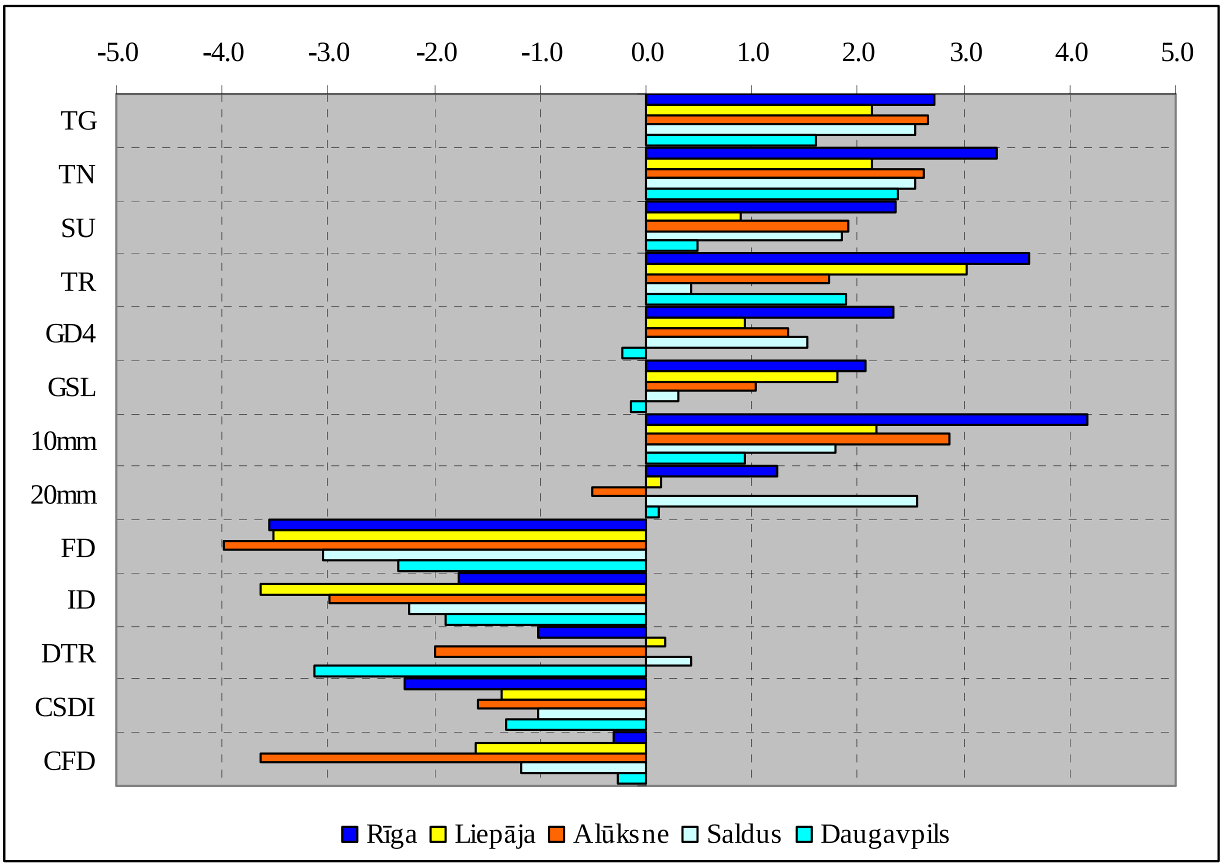


Figure 1.8. Mann-Kendal test trend statistics for extreme climate events.

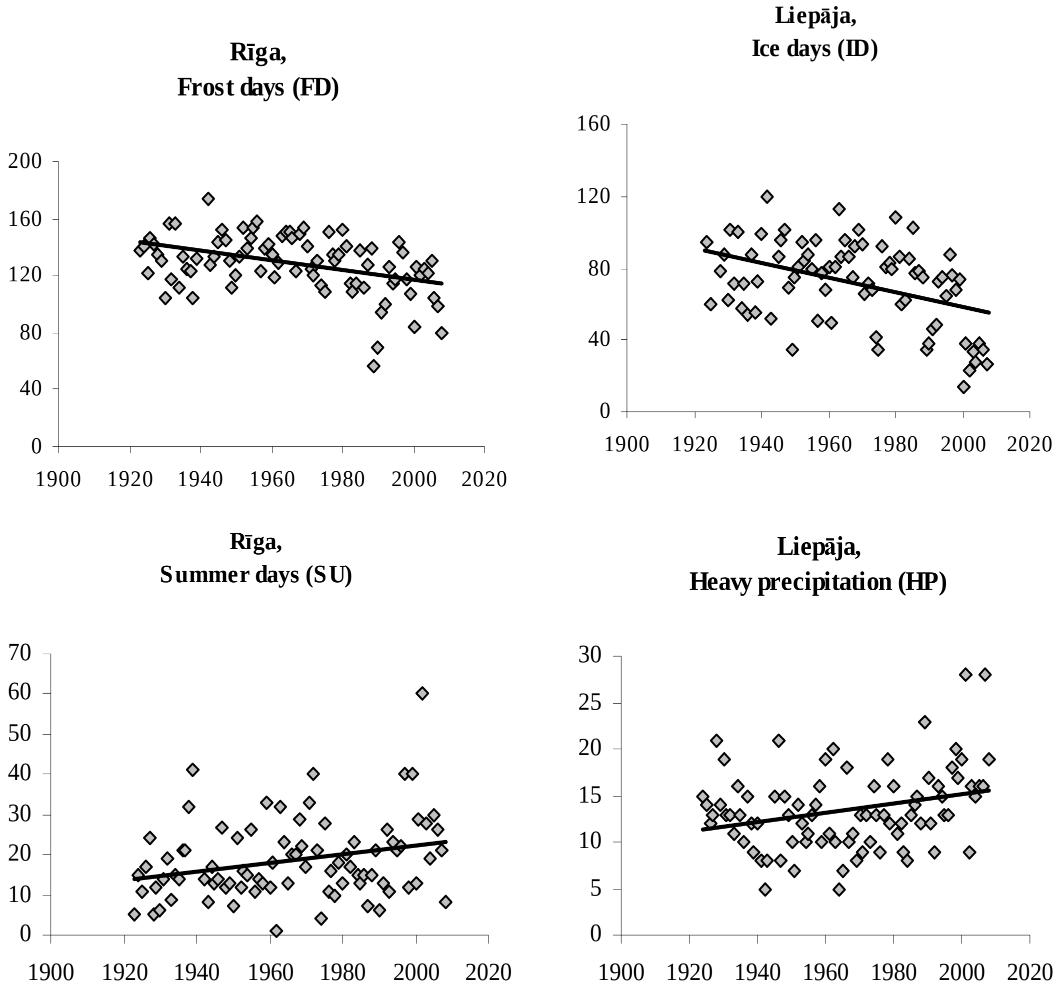


Figure 1.9. Trends of changes of extreme climate events in Latvia

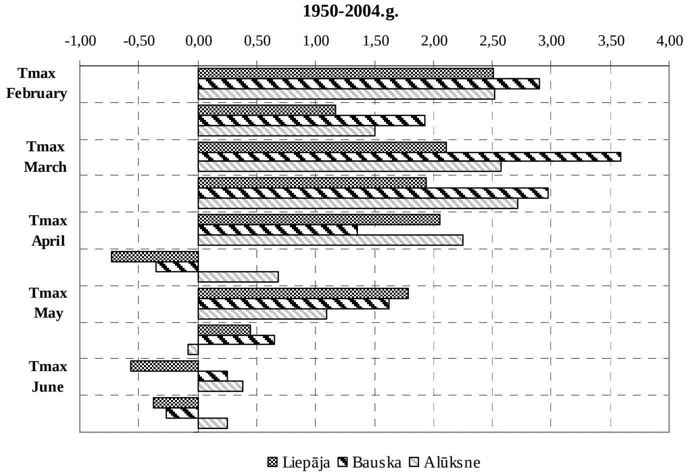


Figure 1.10. Seasonal changes of maximal temperatures

1. In 2009, trends of large scale atmospheric circulation processes in Latvia were analysed and the character of their long term variation evaluated. It has been shown that is possible to identify 27 major atmospheric circulation types, and their interchange can be considered as a major factor influencing weather conditions in Latvia.
2. Wavelet analysis has been applied to study the river discharge periodicity.

Scientific and economic impact of the research results.

Scientific results (methodological results):

- A novel method for the comparison and skill assessment of regional climate models is developed and applied.
- The method of bias correction of the climate modelling results is developed. The novelty of the method is in (a) double downscaling (statistical downscaling of dynamically downscaled climatic fields via histogram equalisation), (b) use of the moving time window instead of seasonal bias correction for the construction of cumulative distribution functions which are required for the histogram equalisation.
- The application of RCM data for forcing the hydrological models was investigated.
- The double model ensemble approach (ensemble of regional climate models vs. ensemble of hydrological models) was used for the analysis of the future run-off analysis.
- The one-dimensional model of the vertical stratification of the Gulf f Riga was developed and applied for the climatic calculations.

Scientific results (conclusions, data series)

- The data series of climatic parameters (temperature, precipitation, humidity, wind speed) which in a statistical sense are equal to observations during the contemporary climate conditions were produced. The data series of meteorological parameters with daily resolution were prepared for the whole territory of Latvia. These data series correspond to the contemporary climate and the climate change scenarios B2 and A2.
- The approach for the calculation of water and nutrient runoff was developed, including development of hydrological models for the basins of Latvian rivers.
- The daily data series of water and nutrient runoff were calculated; these data series in statistical sense are close to the corresponding discharge observations. The data series of hydrological parameters with daily time resolution are prepared for Latvian rivers (spatial resolution – water bodies identified in the River Basin District Management Plans) corresponding to the contemporary climate and climate change scenarios B2 and A2. The data series of nutrient loads to the Gulf of Riga are prepared.
- The climatic calculations of the vertical stratification of the Gulf of Riga are performed for the contemporary climate and climate change scenario A2.

- The conclusions about the expected climate change in territory of Latvia are drawn on the basis of analysing meteorological RCM data series.
- The conclusions about expected climate change impact on the river runoff regime in territory of Latvia are drawn on the basis of analysing hydrological modelling results.

Economic impact

The economic impact of the WP1 results is related to their potential (almost direct) use in the sectors which depend on the character on interaction of climatic parameters (either meteorological on hydrological). The list of these branches include, but is not limited with, energetic (hydro-energetics, renewable energetic – wind / solar, energy consumption), agriculture (adaptation of agricultural practice etc), forestry, building, tourism, fisheries, transport.

1.4. Summary

The scenarios of nutrient runoff and sea state of the Gulf of Riga were prepared during the Stage 4. The investigations of the impact of climate change on the river runoff regime were continued. The significant part of work during the last programme year was devoted to the presentation of the research results in conferences, dissemination and documenting, as well as providing data analysis and modelling support to other WPs.

Work Package Coordinator: Uldis Bethers

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

2.1. Task of the WP2:

Assessment of the Climate Change Impact on the Hydrological regime and Nutrient Run-off in rivers of Latvia

2.2. Sub-tasks of the Work package WP2, Phase IV:

1. Finalizing the digital GIS maps for sub-basins of the Bērze River. Data evaluation for use of alternative water quality models (SWAT model).
2. Final assessment of nutrient emission from the non-point sources and evaluation of nutrient retention for parameterization of the FYRIS model.
3. Finalizing of calibration of the hydrological (METQ) and water quality models (FYRIS); assessment of climate change impact, simulation with different scenario data delivered by WP1.
4. Adaptation of the update version of the FYRIS model for simulation of climate change impacts in cooperation with developers of FYRIS model (SLU, Sweden).

2.3. Results of sub-tasks of the Work package WP2, Phase IV.

Task 1, results of the implementation and work content:

Modelling procedures for decrease of uncertainty of the results needs the high accuracy data on land use and size of river basin and sub-catchments. Previous GIS data base of the river basins was based on watershed area acquired from the topographic maps. During implementation of the phase 4, accurate catchment boundaries of Berze River were set and high precision GIS map for modelling was prepared. The map was digitized using agricultural drainage maps (scale 1:2000). The detailed GIS data base containing all necessary data on catchment' area, agricultural crops and layers describing the layout of tile drainage systems is finished for all catchments, see fig. 2.1.

In future this information will be important for the calibration of alternative water quality models, e.g. the SWAT model in the BONUS RECOCA project.

Task 2, results of the implementation and work content:

Research on leaching and runoff losses of the nitrogen and phosphorus in Latvia started in several geographical scales in October 1993. The temporal and spatial variations of nutrient run-off are considerable. Therefore, for the evaluation of the nutrient fluxes from agricultural sources, time series including long-term data are necessary and assessment of agricultural non-point pollution and retention of nutrients in several scales was continued in 2009. The available long-term data series allow evaluating the nitrogen and phosphorus run-off on monthly and seasonal scale. Our study showed (Fig. 2.2.) that the main part of agricultural run-off has been generated during winter and non growing period of crops. Only 27% off the nitrogen leaching accrued during the summer period. 73% of run-off has been observed during the period of late autumn – winter - early spring. The main part of non-point pollution (nutrient loads) could be attributed to the winter months (December, January, February), when nutrient run-off constitutes about 43% of the total year run-off. Therefore this period is generally regarded as being of high significance.

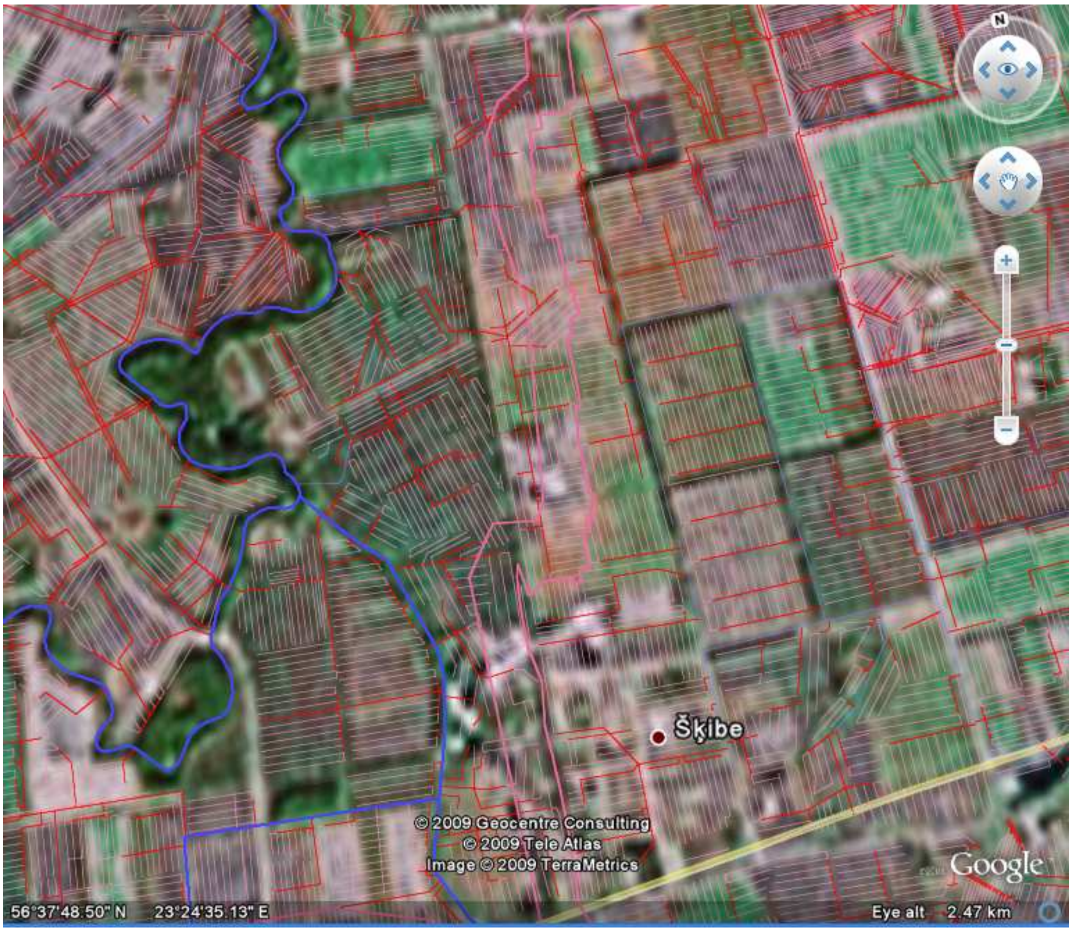


Fig. 2.1. Part of hydrographical network of the Bērzes river basin

Simulation of climate change (models) today does not include all eventual impacts of factors influencing the agricultural run-off and impacts of their combinations. Especially high risk of nutrient leaching is characteristic for combination of extremely dry periods during the growing season followed by mild winter with high precipitation. For example, extremely high nutrient run-off during winter 2006 - 2007 was a consequence of high soil mineral nitrogen content that was not used by crops during dry summer of 2006. As a result of these environmental conditions, 56% of yearly nitrogen run-off occurred during December-January-February. These results suggest that small increase of river run-off or even certain decrease of it of may be accompanied by a significant increase of the non point source pollution.

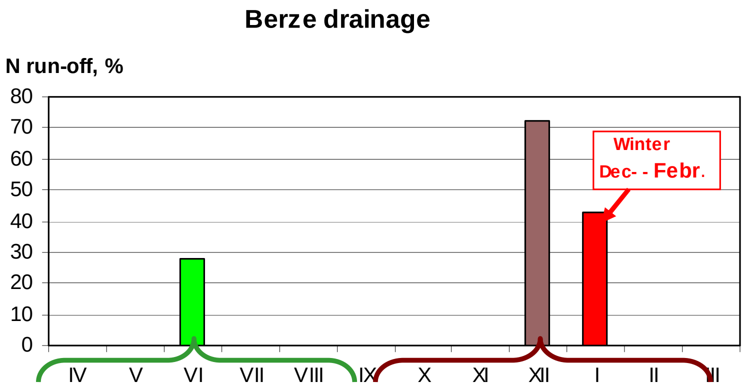


Fig. 2.2. Seasonal distribution of the nutrient run-off (average X.1993. –XII.2008.)

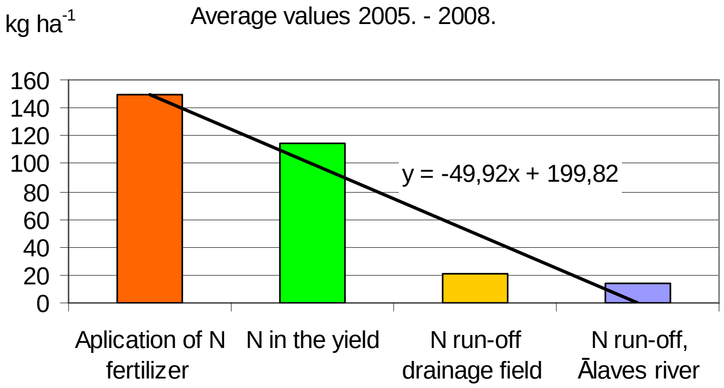


Fig. 2.3. Retention of nitrogen in area of intensive agriculture of Bērze river catchment.

DP2 research results (Fig. 2.3.) indicate that intensive crop production use about 75% of the applied nitrogen fertilizers. N-leaching with the drainage run-off reached 15 % of the N loss, but the river run-off – constitutes 10% if this loss.

Task 3., results of the implementation and work content:

For the simulation of hydrological processes in the past and future, the conceptual water balance model - the latest version of METQ2007BDOPT was applied. The model was developed by Professor A.Zīverts with semi-automatic calibration performance. The METQ2007BDOPT model was calibrated (1961-1990) and validated (1991-2000) for the studied ten river basins and sub-basins (Table 2.1.). The modelling results showed a good coincidence between the observed and simulated daily discharges: the Nach-Sutcliffe efficiency R^2 varies from 0.86 to 0.52 and correlation coefficient r – from 0.93 to 0.75 for the calibration period, and R^2 = 0.87-0.43 and r = 0.95-0.70 for validation period. The best match was obtained for the River Salaca at Lagaste and the River Vienziemīte.

Table 2.1.

Results of the METQ2007BDOPT model calibration and validation.

River basin and hydrological station	Period of the calibration (1961-1990)		Period of the validation (1991-2000)	
	R^2	r	R^2	r
Imula – Pilskalni[4)]	0.66	0.77	0.43	0.70
Bērze - Baloži	0.72	0.85	0.62	0.80
Bērze – Biksti[3)]	0.67	0.83	0.43	0.76
Iecava – Dupši [4)]	0.66	0.82	0.44	0.79
Vienziemīte – Vienziemīte	0.86	0.91	0.63	0.84
Salaca – Lagaste	0.80	0.93	0.87	0.95
Salaca - Mazsalaca	0.76	0.88	0.77	0.87
Briede - Dravnieki	0.69	0.85	0.72	0.87
Seda – Oleri [2)]	0.60	0.81	0.62	0.87
Rūja – Vilnīši [1)]	0.52	0.75	0.57	0.77

[1)] operating since 1978; [2)] operating since 1979; [3)] operating since 1980; [4)] – closed in 1995

The model calibration-validation provided daily river discharge data series for 10 hydrological stations and 15 sub-basins of the River Bērze. The simulation of hydrological behaviour of the river runoff in past and future climate conditions, statistical analysis of long-term annual, seasonal data and extreme events of the climate and hydrological data series was finalised for the following periods:

- Control period HCCTL (1961-1990)
- Climate scenario HCA2 (2071-2100)
- Climate scenario HCB2 (2071-2100)

Climate change was projected by the selected regional climate model RCAO-HCCTL and further statistical downscaling for the investigated (WP1 output). Using the river basins of Bērze and Salaca as an example, figure 2.4 presents the projected changes in seasonality of the river runoff, represented here as differences in climate between years 1961-1990 and 2071-2100.

The results of model simulations for the studied river basins allow following conclusions:

- comparing with the control period, the long-term annual air temperature will grow by 3.8-4.1 ^{o}C according the HCA2 scenarion, and by 2.5-2.7 ^{o}C according the HCB2 scenario; the mean air temperature will increase in all seasons, but the most considerable increase is forecasted for the winter and autumn seasons;

- the growing season when daily mean temperature exceeds +5 ^{o}C, will increase from 35 to 40 days according to the HCA2 scenario and from 31 to 35 days according the HCB2 scenario;

- climate change may facilitate an increase of precipitation by 10-12% (HCA2) and by 6-9% (HCB2); the main increase could be observed during winter while the decrease – over the second half of the year;

- the number of days with heavy rainfall when precipitation exceeds 10 mm per day will increase;
- comparing to the control period, the annual river flow will decrease by 2-25% (HCA2) and by 3-11% (HCB2), except for the River Bērze where discharge may increase by 6 % (HCB2), see Fig. 2.4.;
- the river discharge is forecasted to increase in winter season by 6-18% HCA2 and 4-12% HCB2 scenario and to decrease in autumn and spring. No considerable changes are expected for summer. The major part of the total annual river runoff will occur in winter followed by spring, autumn and summer season.

The distribution of total mean annual river runoff in the studied river basins is presented in Fig. 2.4. Results of scenarios are presented as relative change in monthly runoff in comparison to the control.

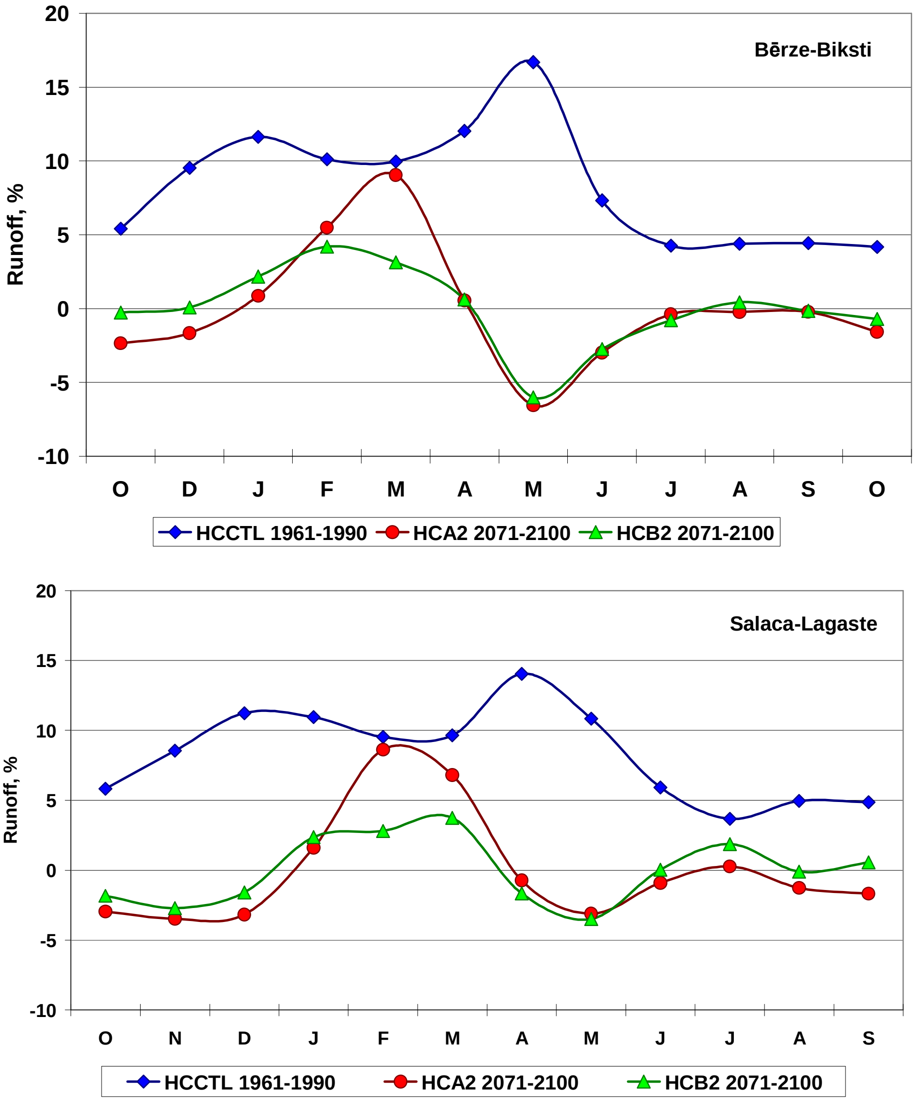
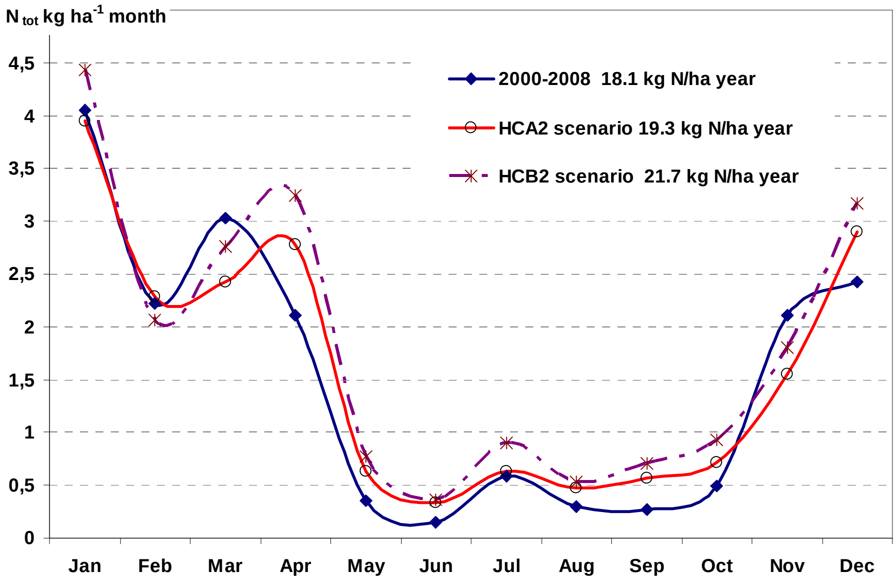


Fig. 2.4. Annual cycle of run-off for hydrological year from October to September.

Monthly nitrogen and phosphorus loads for Bērze river are presented in Fig. 2.5. plant Yearly loss of these plant nutrients are projected to increase by 6-7% (HCA2) or by 19-20% (HCB2).



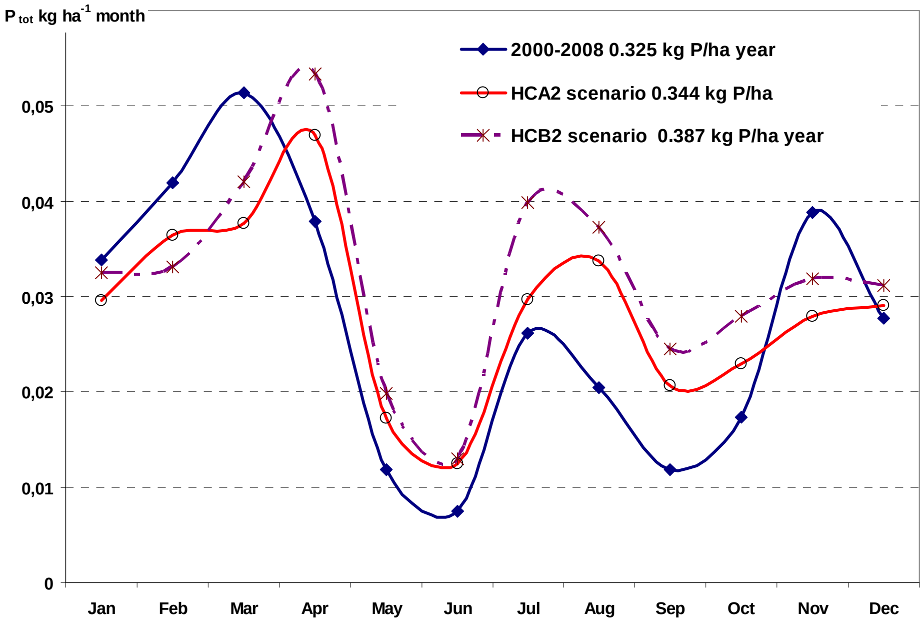


Fig. 2.5. Monthly N un P run-off in Bērze River

During the implementation of the KALME programme, FYRIS model has been improved by model developers in the Swedish University of Agricultural Science (SLU). Therefore finalizing the model validation, the updated model version has been tested for climate change simulation. Cooperation with SLU and mutual assistance to improve simulation results was very useful for the improvement of the last FYRIS version e.g., phosphorus run-off simulation. An important feature of the FYRIS model is source apportionment for riverine loads of pollutants, see Fig. 2.6. and 2.7.

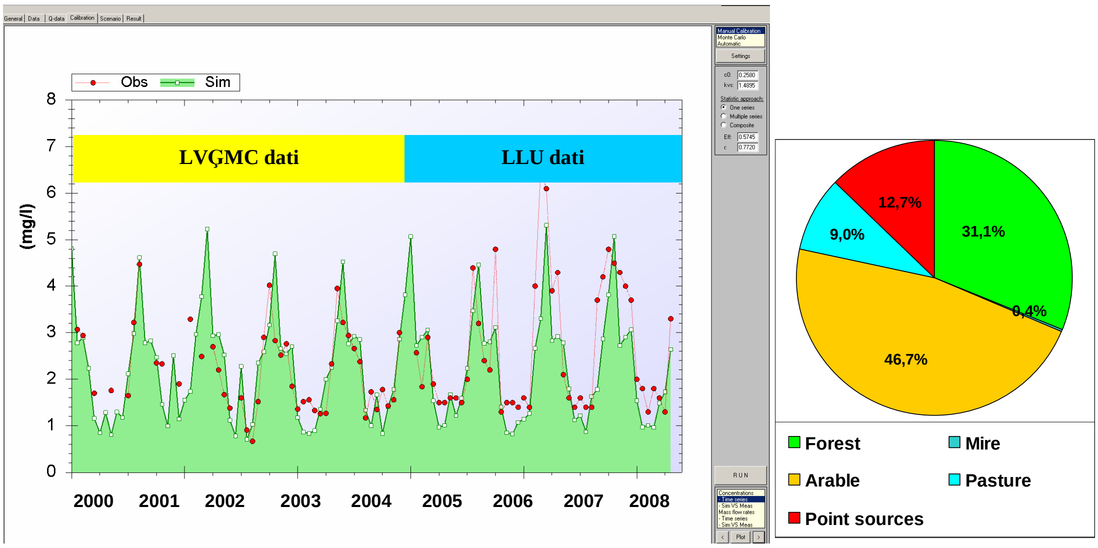


Fig. 2.6. Simulated and observed nitrogen concentrations and pollution sources. Bērze River sub catchment 12. (Downstream Dobele town).

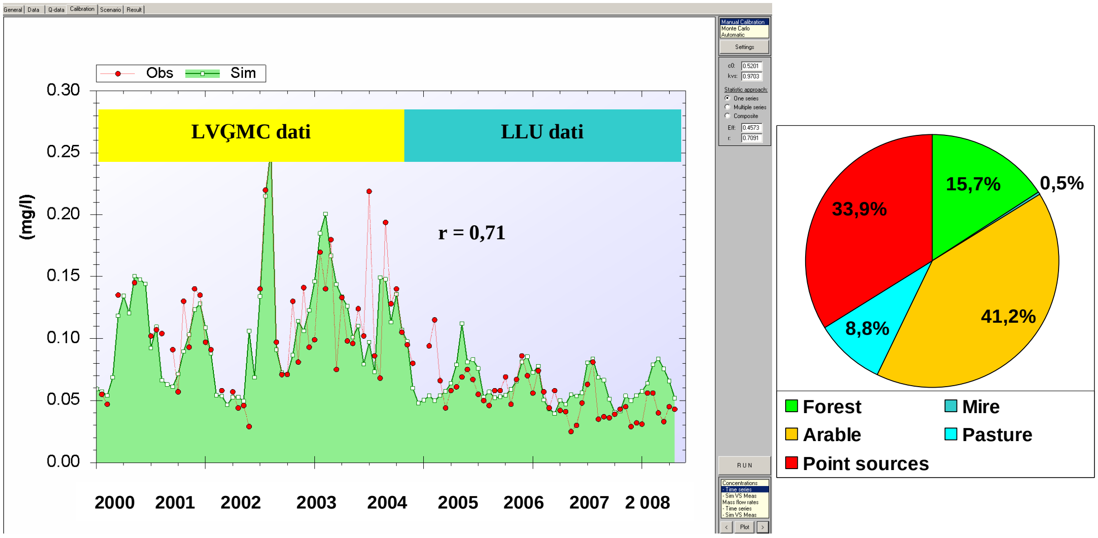


Fig. 2.7. Simulated and observed phosphorus concentrations and pollution sources. Bērze River sub catchment 12. (Downstream Dobele town).

Scientific and economic significance of results

One of the main results of implementation of WP2 tasks is calibration of water quality model according to the procedures recommended by FP5 EUROHARP project e.g., river basin divided in the homogenous sub catchments and at least 5 year monthly water quality data for model validation. Thus, although some progress seems to have been achieved before implementation of the KALME programme, it was no possible to state with confidence that the water quality modelling at that time have yet been resolved in Latvia. Besides modelling of climate change impact, research results will have high importance for water management. In that context, we must recognize that modelling is a key component of catchment management systems necessary for implementation of WFD to reach good water quality status by 2015.

Modelling and assessment of monitoring data should be based on long term data sets and comprehensive information about characteristics of the catchment. Therefore, the results of detailed study of Bērze River basin (900 km^2) will be useful in the future development of model applications in Latvia.

Experience, collected data sets, international training and cooperation has significantly increased research capacities of Department of Environmental Engineering and Water Management of Latvia University of Agriculture to perform modelling of water quality at international standard of quality.

2.4. Summary

Implementing the main tasks of WP2, calibration and validation of hydrological and hydro chemical models was finalized. The modelling results by WP2 have demonstrated that climate change:

- may increase the normal year air temperature by 2-4 ^{o}C; increase may occur during all seasons, highest increase of temperature is predicted during autumn and winter;
- could create an increase of the precipitation, especially during winter;
- may decrease and change seasonal distribution of the river run-off e.g., less run-off during spring and autumn floods, increase of run-off in winter;
- due to the climate change yearly plant nutrient run-off (loads) are projected to increase by 6-20%, especially during winter;

Seasonal peaking factors as extremely dry weather conditions in the summer in combination with autumn floods and mild winters may be highly variable from one year to another. It is important to note that the intensity, as well as the total strength of rainfall extremes, is of importance in determining the extent of nutrient leaching in field level, but it is impossible to evaluate that with the today’s modelling tools. Therefore, model applications may still have a lot of uncertainty to evaluate extreme nutrient run-off and to determine the proper scale of appraisal (field, small catchment and river basin level).

The combinations of crop and management practices, including crop rotations and tillage, and natural factors, such as soil type and slope, affect water runoff into streams and percolation into groundwater, which could affect soil erosion, and the movement and leaching of nutrients into the aquatic systems. Climate changes could change agricultural practice e.g. as regards the new crop rotation and soil tillage that also may add a lot of uncertainty to nutrient run-off predictions.

Work Package Coordinator: Viesturs Jansons

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

3.1. Task of the WP3

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

3.2. Phase 4 tasks of WP NR3

1. To complete sampling and to process laboratory analyses, to improve data sets, to perform statistical analysis and data interpretation in connection with the climate change;

2. To assess changes in freshwater biodiversity under the climate change impact;

3.To characterize changes of water chemical composition and biological communities under the impact of climate change;

4. To describe the structure of ichthyocenoses of river Salaca and lake Burtnieku and their future development;

5. To set up the climate change indicators for Latvian inland surface waters.

3.3. WP 4 Fourth stage results

Task 1: The analysis of extreme climate in model objects.

In 2009, the sampling programme was finished. Complex hydro-chemical and hydro-biological studies were carried out in the Salaca River and Lake Engure. Laboratory processing of samples was done and data sets were improved.

Analyses of number of the wet days indicated that since the last 20 years of 19th century to the beginning of 20th century the daily maximums significantly decreased, but since the fifties of the 20th century till the nineties – significantly increased. In general, only in winter season a significant increase is observed for the 1-day and 5-days maximal atmospheric precipitation sum.

Positive trend as well as decadal variability is observed for numbers of days with intensive precipitation where daily sum is larger and or equal to 10mm.

Gathering of information on land cover in Salaca basin was completed and flows of substances were analysed.

Strong relationship between the specific runoff of N_{tot} and proportion of agricultural lands was determined, but such relationship was not present in case of reactive phosphorus. On contrary, total organic carbon (TOC) decreases with the increase of agricultural lands (Fig.3.1.).

The role of discharge for the concentration of TOC is important. The largest concentrations of particulate organic carbon (POC) are observed in the periods of algal blooms (Lake Burtnieku, Salaca) and the increased river discharge (tributaries of Lake Burtnieku).

Analyses of the relationships between environmental factors and biota confirm that correlations exist between phytoplankton total biomass, diatom biomass and cyanobacterial biomass, e.g., in summer period positive tie exists between total algal biomass and especially – cyanobacterial biomass and temperature TOC, POC, N_{tot}.

Long-term data analyses of Latvian State Geological, Meteorological and Environmental agency confirm that data on organic matter parameters (e.g.COD, water colour), biogenic elements and main inorganic ions could be used for trend analyses of waters in Latvia excluding TOC as the data rows are not homogenous. In general, since 1991 COD and water colour have increasing trends like as other European regions and North America.

*Table 3.1. Values of Mann-Kendal test for sums of precipitation for 1-day (RX1) and 5 – days (RX5) (1925.-2006.)**

Stacija	Ziema		Pavasaris		Vasara		Rudens		Gada	
	RX1	RX5	RX1	RX5	RX1	RX5	RX1	RX5	RX1	RX5
Ainaži	**2.67**	**3.94**	-1.02	-1.30	-0.58	1.35	-1.02	0.72	-1.32	0.98
Rīga	**4.85**	**4.70**	0.49	0.82	1.27	1.15	1.74	**2.45**	1.83	1.28
Daugavpils	**1.90**	**3.67**	0.55	1.39	**-2.17**	-0.86	-0.54	1.01	-1.66	-0.33
Gulbene	**5.12**	**6.57**	0.65	0.71	-0.30	0.01	-0.33	1.73	-0.45	0.14
Jelgava	**2.36**	**3.82**	0.65	1.28	0.76	0.43	1.30	1.36	0.86	0.89
Kolka	1.21	**2.85**	0.07	-0.10	-1.12	0.18	1.87	1.15	-0.70	0.61
Liepāja	1.54	1.99	-0.71	0.72	0.66	0.39	0.99	-0.53	0.89	-0.48
Mērsrags	**4.38**	**5.16**	1.64	1.97	0.42	0.28	1.25	1.65	1.37	0.75
Priekuļi	**4.13**	**3.93**	1.20	0.85	0.03	0.43	1.36	-0.35	1.53	0.28
Stende	**4.11**	**4.74**	-0.46	1.24	-1.14	-1.24	0.77	0.57	-1.49	-1.84
Ventspils	**2.71**	**2.77**	-0.57	0.55	0.07	1.29	0.54	0.55	0.89	0.30

*Statistically significant values ($p \leq 0.01$) in bold, RX1- maximal 1-day precipitation amount, RX1- maximal 5-days precipitation amount,

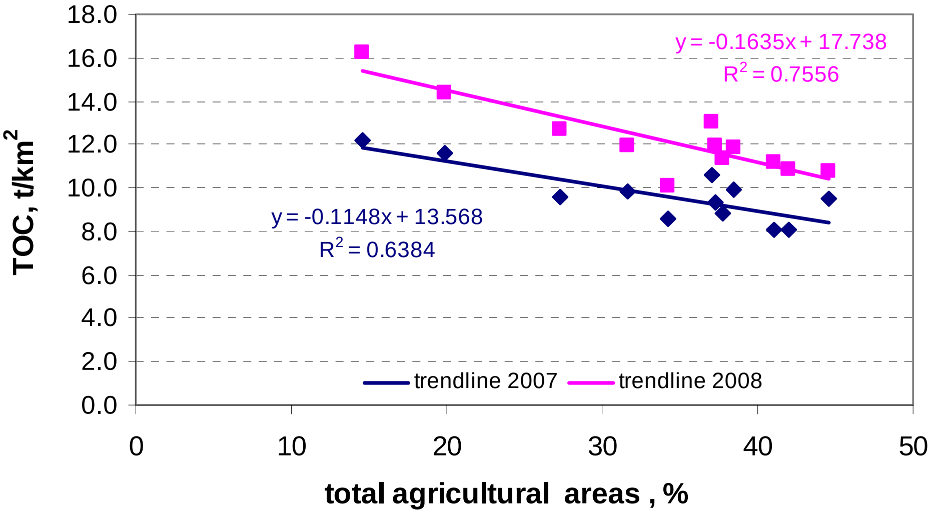
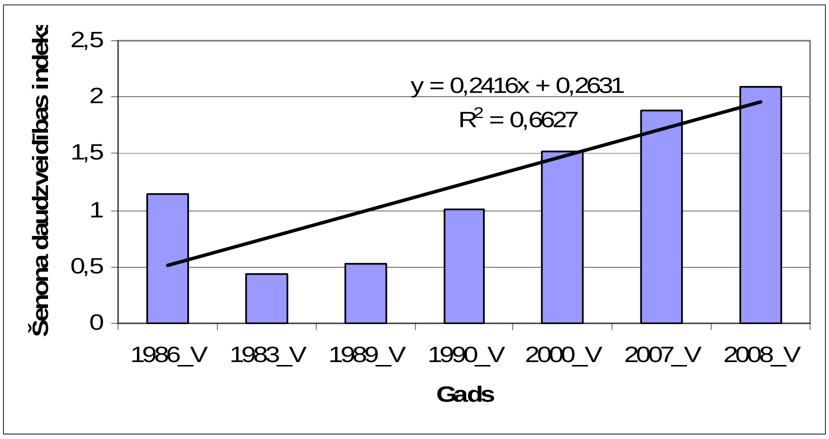


Fig. 3.1. Relationshop between specific runoff of TOC (t/km2) and proportion of agricultural lands.

Task 2: Assesing changes in freshwater biodiversity under the climate change impact

Contemporary changes of freshwater biodiversity are largely caused by the arrival of species typical for southern part of Europe, *e.g.* Ponto-Caspian species *Sabanejewia aurata* and changes in species distribution area, e.g. *Rhodeus sericeus* that in 20ies of 20th century was found in South-West part of Latvia but today is present also in the Northern part of the country.

Currently the changes in structure and distribution of freshwater communities are continuing and it may be expected that these processes will affect freshwater biodiversity also in future; however it is impossible to quantify this impact. Example of Shannon' index changes at the Salaca mouth present quite a diverse picture (Fig. 3.2.)



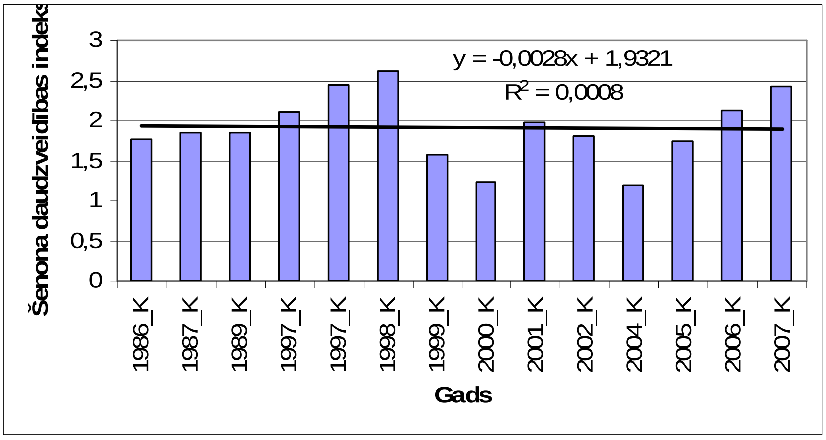


Fig. 3.2. Shannon's index at the outflow of Salaca (upper chart – middle part, lower chart – left coast littoral).

Task 3: Characteristic changes of water chemical composition and biological communities under climate change

Comparison of aquatic vegetation in Salaca in 1986 and 2009 confirms the increasing proportion of emergent macrophytes. At the same time, the invasive species *Elodea canadensis* spread widely.

Dominance shift from benthic diatoms to green algae is observed in Salaca.

In Lake Burtnieku even in the time period since 1996 to 2006, visible changes in the structure of fish communities took place.

Investigations of drift of the benthic invertebrates reveal that drifting species composition and density are affected by the seasonal expressions of the climate change. The most abundant species diversity and density is observed in the beginning of June when the last development stage larvae dominate and water insects are flying out (Fig.3.3.)

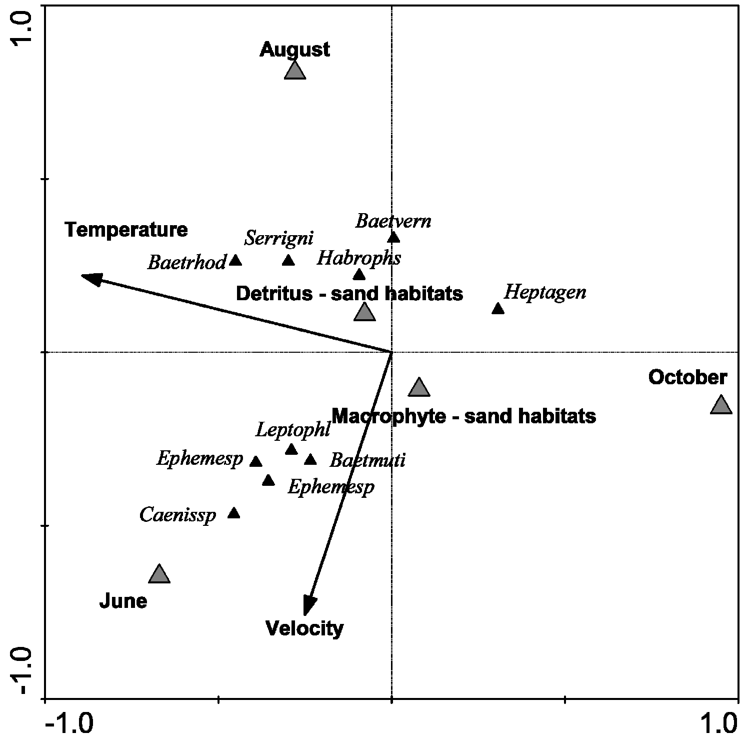


Figure 3.3. Ordination analysis of Ephemeroptera species composition in drift samples in Strīķupē belowsand-macrophyte and sand-detritus microbiotops in June, August and October of 2007. . Axis 1 explains 11,5%, Axis 2 9,4% of total data dispersion.

Task 4: Structure of ichthyocenoses of the River Salaca and the Lake Burtnieku and projection of their future development

Fish fauna of Lake Burtnieku was affected by climate change during the whole time of lake's development.

Since 1994 to 2006, 17 fish species have been found: *Esox lucius, Abramis brama, Blicca bjoerkna, Rutilus rutilus, Scardinius erythrophthalmus, Tinca tinca, Carassius carassius, Carassius auratus, Leuciscus idus, Leuciscus cephalus, Alburnus alburnus, Leucaspius delineatus, Stizostedion lucioperca, Perca fluviatilis, Gymnocephalus cernua, Lota lota* and *Cobitis taenia*. Also carp and eel have been recorded. Artificial restocking has not left permanent effect.

Since 1996 the increase in number of silver bream, tench and pike perch is typical. Especially flourishing is the population of pike perch population (Fig.3.4). This phenomenon is evidently related to successful spawning and survival of the young fish due to climate change.

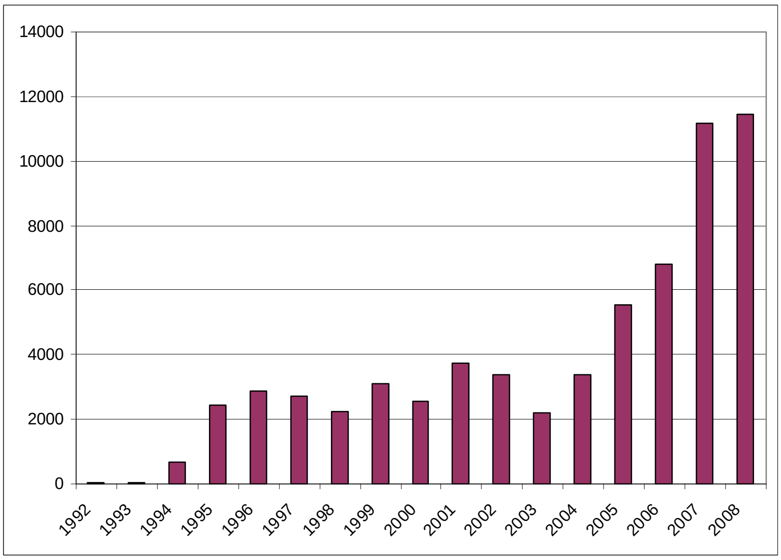


Figure 3.4. Catch of pikeperch Stizostedion lucioperca (kg) in Lake Burtnieku since 1992 till 2008.

In general, it is assumed that the fish fauna could change significantly during the coming 50-70 years due to the decrease of cold-water and increase of warm-water species. In concerns lakes as well as rivers.

Task 5: Setting up climate change indicators for Latvian inland surface waters.

Results of investigations show that such climate parameters as increase in mean annual temperature, increase in precipitation, decrease in ice-covered days, increase in winter discharge, increase in number of extremely wet days and days with intensive precipitation are primarily indicators of climatic conditions. These changes cause changes in water chemical composition, e.g., COD and water colour have increasing trends.

Climate change impacts also the structure freshwater communities and their functions. In the case of the Salaca river, ratio of *Cyanobacteria* in total phytoplankton biomass clearly increases, as increases the amount of green algae in benthic communities. Macrophyte overgrowth due to prolonged vegetation season is observed as well.

Ratio of development stages of benthic invertebrates, e.g., *Ephemeroptera* and *Trichoptera* in seasonal drift samples also could be could to be connected with the climate change.

The development of ecologically sensitive fish species such as rheophilic salmonids or comparatively termophilic *Alburnoides bipunctatus* and *Rhodeus sericeus* are found to be potential environmental indictors reflecting the climate change.

Changes in fish physiology and behaviour, e.g., change of migration time and spawning time, belong to the group of functional climate change indicators.

Biogeographic distribution area of some species may also be used as the climate change indicators, e.g. expansion fish species *Rhodeus sericeus* and arrival of southern fish species *Sabanejewia aurata.*

Scientific and economic significance of results

The assessment of changes in the number of days with intensive precipitation has been performed to forecast the extreme precipitation events that may be important for economics. Data on organic carbon flows show relationships with river discharge and development of phytoplankton. Scientific novelty is present in the drift investigations linked with feeding of young salmonids. Structural and functional climate change indicators for Latvian freshwater are defined. Projection of freshwater fish fauna development is preformed.

Summary

In 2009 sampling and processing of samples has been finished. Data sets are updated and statistical analyses of data are finished. For the first time in Latvia analyses of day numbers with high precipitation were carried out. Structural and functional changes of freshwater aquatic ecosystems are assessed. The changes of freshwater biodiversity are analysed. Analysis of fish communities of River Salaca and Lake Burtnieku are provided. Climate change indicators for Latvian inland waters are stated.

Work Package Coordinator: G. Spriņģe

Work Package Nr. 4: COASTAL PROCESSES

4.1. WP General aim

The subject of this research is analyzing coastal changes and forecasting climate fluctuation impacts’ on the coastal dynamic and ecosystems in Latvian territorial waters of the Baltic Sea.

4.2. WP Fourth stage tasks:

1. Detailed mapping of coastal erosion and flooding risk (scale appropriate for local planners and developers).

2. Risk evaluation and recommendations for planning, coastal protection and coastal management purposes for the period of next 15 and 50 years.

3. Preparation of recommendations for government level and expert working group for “*Adaptation to climate change*”.

4. Preparation of texts and digital maps for the edition of Latvian coast atlas “Coastal processes. Forecast and risk”.

4.3. WP Fourth stage results.

Task 1. Content and results:

Based on the coastal erosion forecast, the digital data layer for use in GIS environment was prepared. Data accuracy and scale corresponds to territory planning needs (Fig. 4.1.). The data layer provides significant contribution to assessment of assets in high erosion risk coastal territories, planning and development, preparations for necessary actions, alternatives for adaptations under increased erosion and flooding risk conditions. It also serves as a baseline for the coastal protection projects.

Fig. 4.1. Coastal erosion risk zone for 15 and 50 year period. Visualization of digital data layer, base – ortophoto from „Metrum" Ltd.

Task 2. Content and results:

Risk level has been evaluated for coastal erosion and wind surge flooding in low laying coastal areas. Most important structures, buildings, facilities and protected nature areas with high erosion and flooding risk have been identified.

Forecast of coastal dynamics associated with coastal erosion risk (2009-2023):

1. Long term mean and maximum values of coastal erosion rate will be close to ones observed during the last decade (0.5-3.0 m/year),

2. Coastal erosion will continue in previously erosional coastal stretches, with several zones potentially at risk.

Forecast of coastal dynamics associated with coastal erosion risk (2023-2058):

1. Long term mean and maximum values of coastal erosion rate will be 30-100 % higher than measured during last decade (1.0-6.0 m/year),

2. Total length of coastal sections with erosion risk will be 10-20 % higher than measured during last decade,

3. Total land area lost due to coastal erosion will reach approximately 1070 ha by the year 2058.

Task 3. Content and results:

Maps of coastal areas with highest erosion risk have been prepared (figs. 4.2. and 4.3.). Recommendations prepared for coastal zone planning, management and protection (government level and expert working group “Adaptation to climate change”) (table).

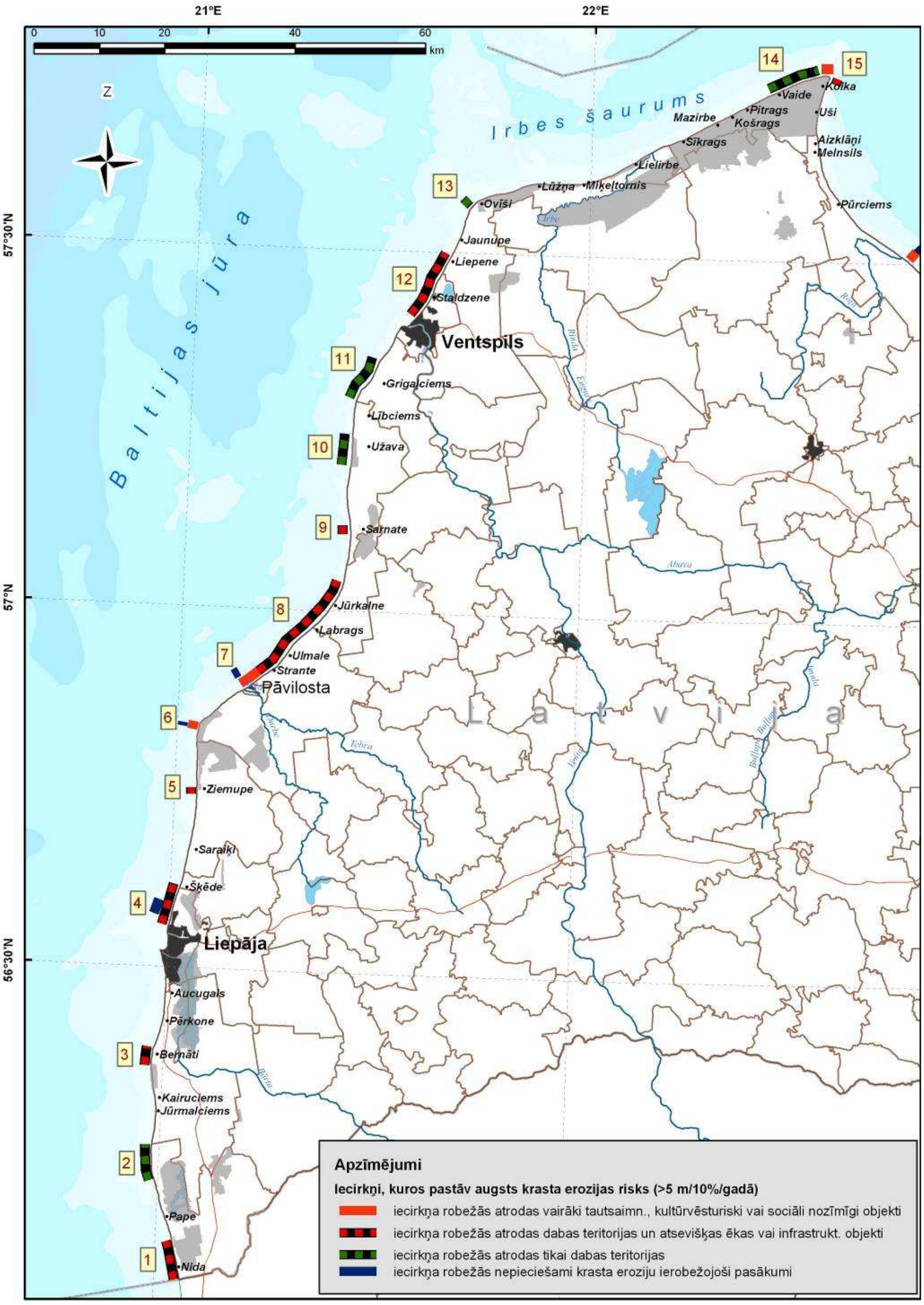


Figure 4.2. Coastal sections at the Kurzeme coast of Baltic Proper with high erosion risk and recommendations for coastal protection measures in each section (references in table 4.1.).

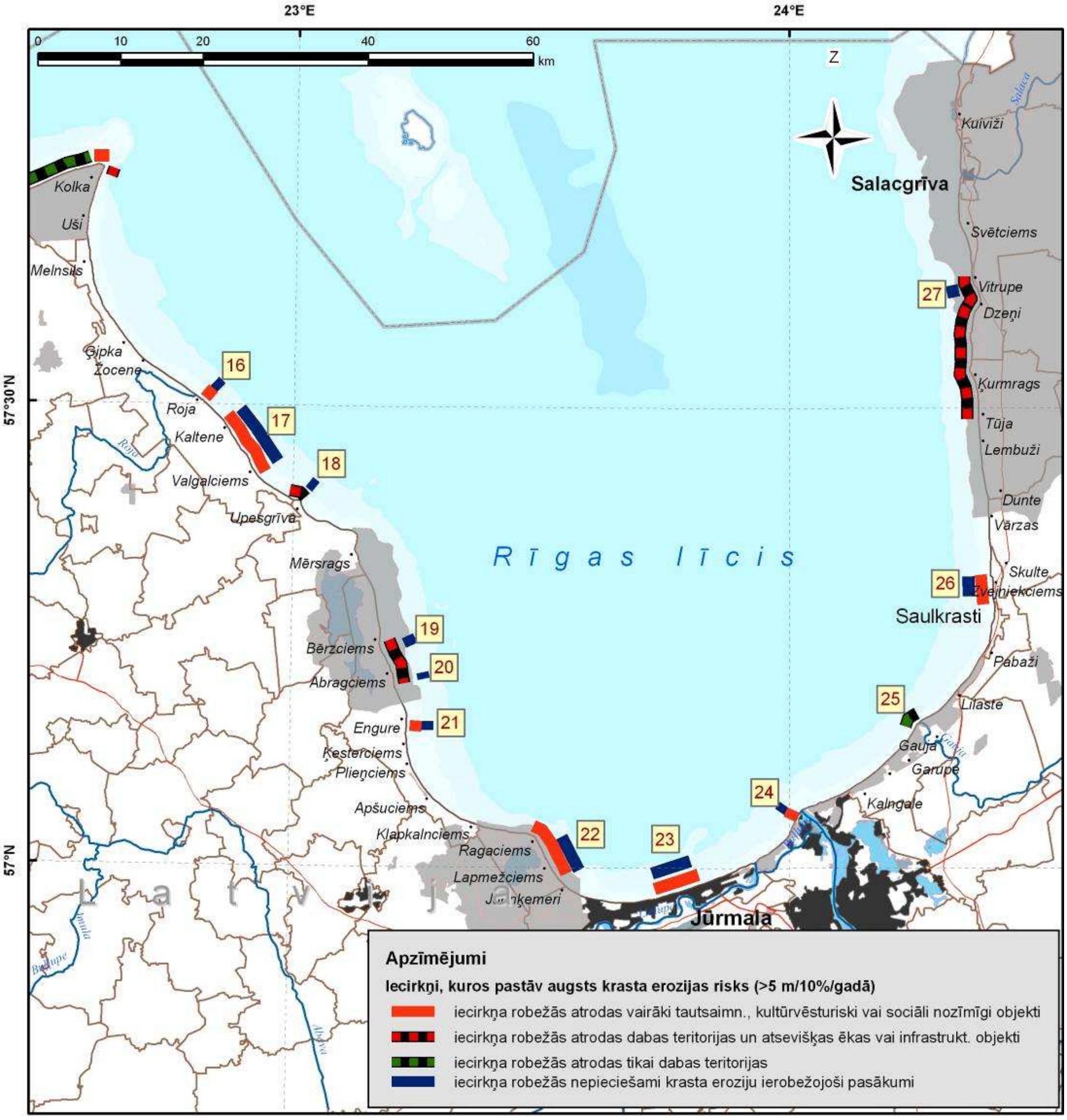


Figure 4.3. Gulf of Riga coastal sections with high erosion risk and recommendations for coastal protection measures in each section (References in table 4.1.).

Table 4.1.

Coastal sections with high erosion risk

No.	Section	Section length (m)	Erosion risk level (during a year)	Main objects within the section	Recommended action (code)
1.	Nida	5500	5m/20%	6 buildings, nature areas	A
2.	Mietrags	5500	5m/25%	Nature areas	A
3.	Bernāti	3000	15m/25%	Nature areas, 3 buildings	A
4.	Liepāja-Šķēde	7000	10m/25% > 5m/15% (decrease in risk level northward)	Liepāja sewage water treatment plant, WW2 memorial, Wind energy farm, infrastructure objects, cultural heritage.	C (>2000 m)
5.	Ziemupe	800	5m/15%	Ziemupe old cemetery	AB
6.	Akmeņrags	800	5m/15%	Akmeņrags lighthouse buildings, mobile communications infrastructure	C1B (300 m)
7.	Pāvilosta (north)	500	5m/20%	7 buildings	CB (500 m); D
8.	Labrags embayment	19000	10m/30% > 5m/15% (lowest risk level in southern part)	Local roads, culture objects, 7 buildings, infrastructure objects	A
9.	Sārnate	1000	5m/15%	Nature areas, 5 buildings	A
10.	Užava	4000	5m/15%	Nature areas	A
11.	Melnrags (Lībciems-Grigaļciems)	7000	10m/30% > 5m/15% (lowest risk level in centre)	Nature areas	A
12.	Ventspils-Liepene	11000	10m/25% > 5m/15% (differences in risk level within the section)	Infrastructure objects, 3 buildings, nature areas (large amount of different buildings and objects are in 50-60 year risk area)	D; and/or C (3000 m)
13.	Ovīšu cape	1000	5m/20%	Nature areas	A
14.	Vaide-Kolka	5000	5m/15%	Nature areas	AB
15.	Cape of Kolka	1000	5m/25%	Infrastructure and culture objects, Nature areas (2-5 farmsteads are in 50-60 year risk area)	A
16.	Roja (south)	1000	5m/15%	7 buildings, local roads and other infrastructure (large amount of different buildings and objects are in 50-70 year risk area)	D; and/or C1 (600 m)
17.	Kaltene-Valgalciems	7000 (3000)	5m/10% (differences in risk level within the section)	>26 buildings, local roads and other infrastructure, nature areas	C1 (short sections with total length of ~3000 m)
18.	Upesgrīva	1000	5m/10%	8 buildings	C1
19.	Bērzciems	1000	5m/10%	10 buildings, local roads and other infrastructure, nature areas	C1 (800 m)
20.	Abragciems	1000	5m/15%	8 buildings, local roads and	C1 (~300 m)

				other infrastructure, nature areas	and AB
21.	Engure (south)	1000	5m/10%	Engure old cemetery, 10-12 buildings (>20 buildings and infrastructure are in 50-70 year risk area)	D; and/or C1 (700 m)
22.	Bigauņciems-Lapmežciems	7000 (1200)	5m/20% > 5m/10% (lowest risk level in northern part)	15-20 buildings, local roads and other infrastructure	C1 and AB (7000 m)
23.	Jūrmala (center)	10000 (3000)	5m/15% > 5m/10% (differences in risk level within the section)	5-10 buildings	B (10000 m); C (~1000 m)
24.	Daugavgrīva	1000	5m/15%	Industrial area, nature area	CB (~1000 m)
25.	Gauja embouchure	2000	10m/15%	Nature area	A
26.	Zvejniekciems-Saulkrasti	3000	5m/15% > 5m/10% (lowest risk level in southern part)	15-20 buildings, local roads and other infrastructure, nature areas	C1B
27.	Vidzeme coast (Vitrupe)	30000 (1200)	5m/10% (differences in risk level within the section, difficult to predict)	10-20 buildings, local roads and other infrastructure, nature areas, ViaBaltica road	A and C1 (short sections with total length of ~2000 m)

Recommendations for coastal protection measures (explanations for table):

A – No coastal protection actions are needed, in the most of cases such actions can be considered as undesirable;

AB – No coastal protection structures are needed, “green actions” and/or “soft methods” is feasible;

B – Coastal protection actions combining several “green” and “soft methods” can be considered as suitable;

C – Necessity for “hard” coastal protection structures;

C1 – Necessity for “hard” coastal protection structures with advantage for simplified and/or “light” structure types;

CB – Combining of “hard” coastal protection structures and “green actions” can be considered as suitable;

D – Necessity for actions providing sediment bypassing to pass obstacles (port jetties) to eliminate erosion in artificial sediment deficit areas.

Task 4. Content and results

Due to the finance shortage during stage four, preparation of map atlas “Coastal processes – forecast and risk” has been cancelled.

Work Package Coordinator: L. Kalniņa

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

5.1. The objective of work package:

Predict the impact of climate change on biogeochemical cycles and the Baltic Sea ecosystem

5.2. Tasks for phase 4 of the research programme[2]:

1. Finalize the experiments to clarify how biogeochemical processes change at different oxygen concentrations.
2. Continue sedimentation field measurements using the deployed sediment multitrap. Multitrap shall be equipped with a CTD logger to monitor changes in hydrological conditions.
3. Continue development of the biogeochemical model, extending the time-period covered by predictions and integrating the runoff and nutrient load scenarios developed by WP 1 and WP 1 simulations of physical conditions under climate change.
4. Develop recommendations for adaption to climate change in cooperation with all other work packages.

5.3. Results according to the tasks for phase 4 of the research programme:

Factors influencing environmental quality and productivity of the Gulf of Riga

Salinity, one of the most important physical parameters in the Baltic Sea ecosystem, is the result of a balance between freshwater runoff and salt water inflows from the North Sea. Small saltwater inflows into the Baltic Sea take place relatively frequently (HELCOM 2003), but large inflows are restricted to exceptional weather conditions and occur as salt water pulses. Parallel to a change in dominant wind direction, a reduction in frequency and intensity of salt water inflows has been observed since the 1970ies (Schinke and Mathäus 1998). Consequently salinity in the Baltic Sea has decreased during the last 30 years. This decreasing trend is also obvious in the Gulf of Riga (Fig. 5.1). Since 1986 only two major salt water inflows were registered, that occurred in January 1993 and January 2003, in addition to several weaker inflows in 2002, 2003, 2006 and 2007 (Feistel et al. 2008). The observed changes in the hydrological regime of the Baltic Sea are the main cause for the oxygen deficiency in the Central Baltic Sea. In the Gulf of Riga, however, where the oxygen pool in the bottom water is periodically renewed, changes in the Baltic Sea inflow regime had no noticeable effect on oxygen conditions.

---

[2] According to the task defined in the work contract for programme phase 4

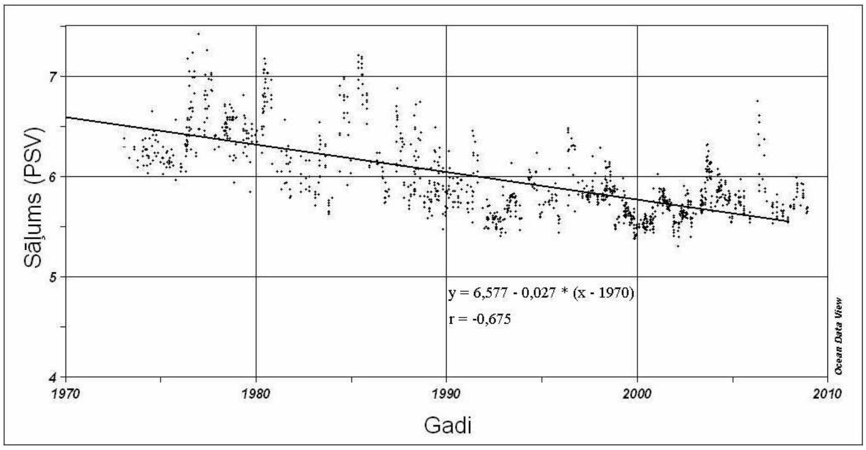


Figure 5.1: Salinity in the bottom layer of the Gulf of Riga during 1973 – 2008. Data from four monitoring stations (119., 120., 135., 121., 121A un 137A) at about 40 m depth (Skudra 2009.).

The seasonal dynamic of oxygen in the Gulf of Riga is mainly determined by meteorological conditions, together with biological processes. During spring, when the water layer warms up, a thermal stratification develops (Fig.5.2) that separates a warm upper layer (average temperature at 15 m depth 14 °C) from a cold bottom layer (average temperature at 30 m depth 4 – 6 °C).

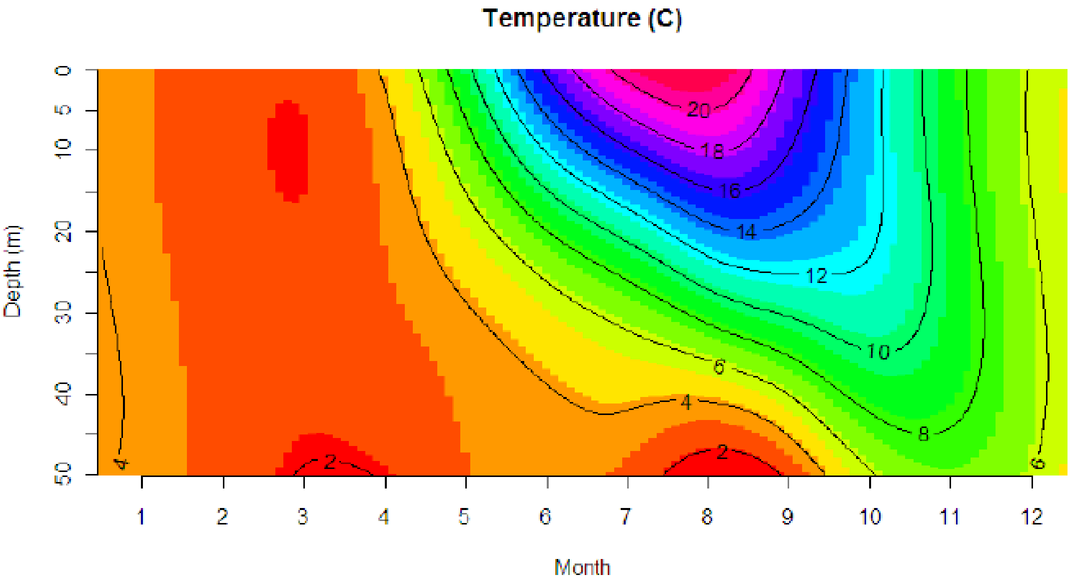


Figure 5.2: Average seasonal dynamics of water temperature in the Gulf of Riga, 1973 – 2008

The thermocline largely restricts the water exchange between the upper and the bottom layer and therefore also limits the oxygen transport into the deeper waters. At the same time, mineralization of organic material sedimenting during spring and summer phytoplankton development causes intense oxygen consumption, causing a drop in dissolved oxygen concentrations in the bottom water (Fig. 5.3). The magnitude of oxygen consumption is determined by the amount of sedimenting organic matter, which in turn is controlled by the nutrient pools in the water layer.

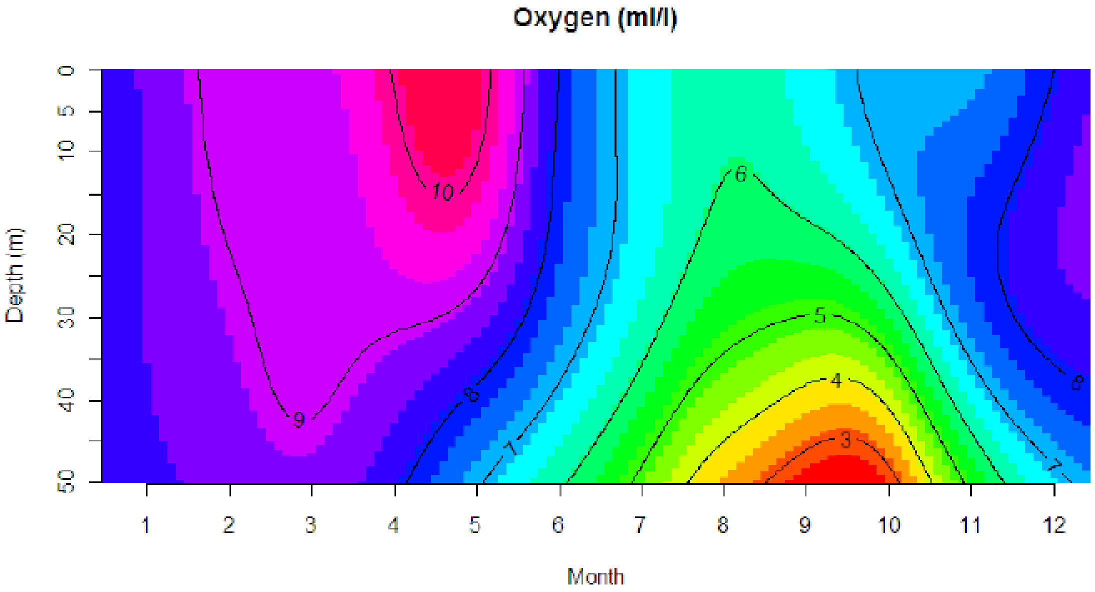


Figure 5.3: Average seasonal dynamics of oxygen concentrations in the Gulf of Riga, 1973 – 2008

Oxygen and temperature dynamics in the bottom layer directly control the type and intensity of biogeochemical processes in the sediment surface layer. It is well known that, nitrogen demineralised from organic matter is first released as ammonium and then, in oxygen rich water or sediment environments, further oxidized to nitrate. Nitrate in turn is partially released to the water column and partially denitrified, removing nitrogen from the ecosystem. Therefore, we expected that at high bottom water oxygen concentrations nitrogen would be primarily released as nitrate, which was partially confirmed by our experimental results (Fig. 5.4), but during the oxygen deficiency periods - as ammonium.

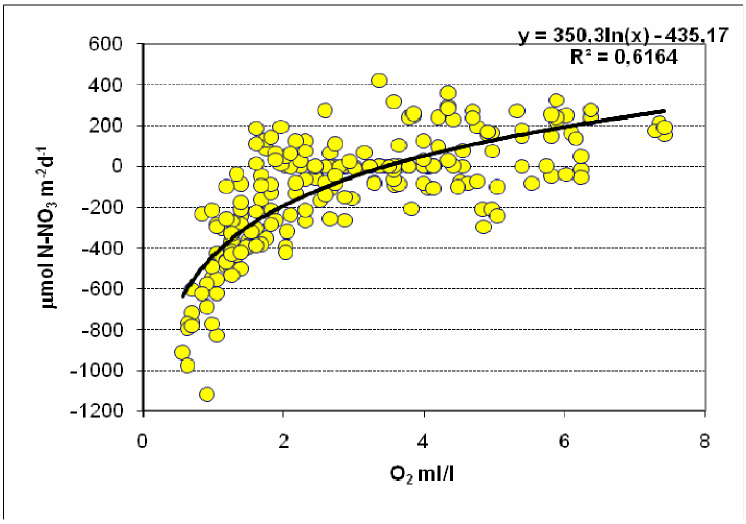


Figure 5.4.: Relationship between bottom water oxygen concentrations and nitrate flux at the sediment-water interface.

Predictions of environmental quality and productivity in the Baltic Sea and the Gulf of Riga ecosystem

With the resources available in the research programme, it was not feasible to start modelling environmental quality in the entire Baltic Sea. Therefore model development focused on the Gulf of Riga ecosystem. Changes in the Gulf of Riga ecosystem were predicted with the biogeochemical model refined and calibrated during programme phase 2. Forcing data, which characterizes the physical structure of the water column in the Gulf of Riga at current climate conditions (control run) and future climate conditions according to the ICCP A2 emission scenario, were delivered by WP 1. They are based on a 1D-model of physical processes in the Gulf of Riga for the time period 1961 – 1990 (control run) and 2071 – 2100 (A2 climate change scenario). The modelled vertical temperature distributions were then used to drive the water exchange between upper and demersal box in the biogeochemical model and to force the rates of temperature dependent biogeochemical processes. Additionally we used the seasonal distribution of runoff and thus nutrient loads predicted by WP 1 for the A2 climate scenario, keeping the total loads at current level.

Predicted changes in the physical structure of the Gulf of Riga are earlier warming of the water column and its intensified and prolonged stratification. Therefore the water exchange between upper and bottom layer decreases (Fig. 5.5).

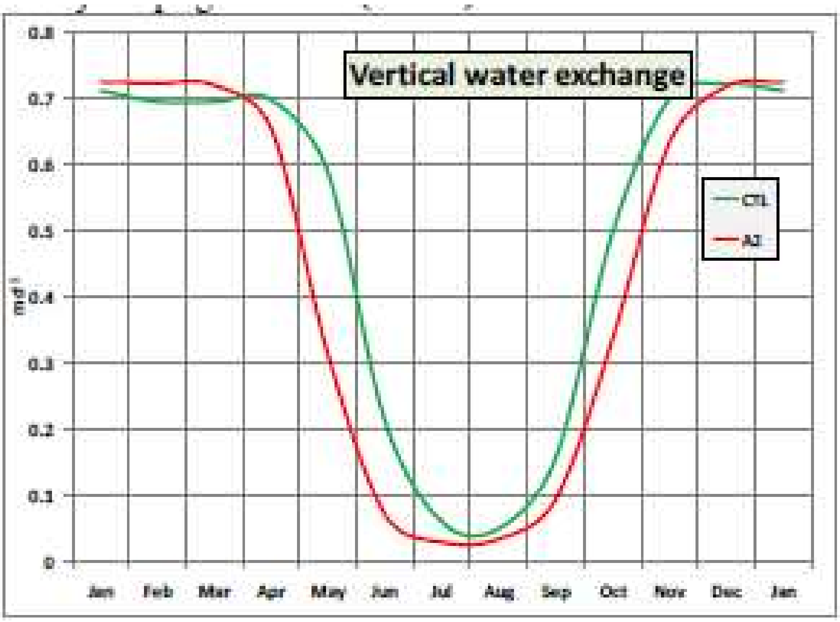


Figure 5.5. Water exchange between upper and demersal box in the biogeochemical model. Monthly mean values for 30 year simulation periods (CTL: control run 1961 – 1990, A2: A2 scenario 2071 – 2100)

On average, the water temperature in the upper layer increase by 3 °C, in the bottom layer by 1.5 °C. The temperature increase mainly accelerates the heterotrophic fluxes in the biogeochemical model. Therefore the nutrient regeneration rates significantly increase. Compared to the control run, i.e. contemporary climate conditions, nutrient accumulation below the thermocline increases (Fig. 5.6).

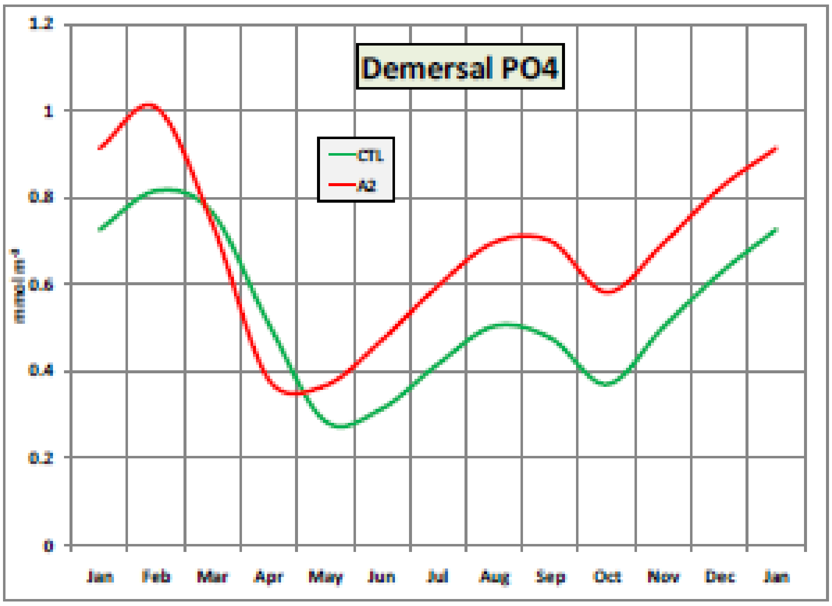


Figure 5.6. Phosphate concentrations in the demersal box of the biogeochemical model. Monthly mean values for 30 year simulation periods (CTL: control run 1961 – 1990, A2: A2 scenario 2071 – 2100)

Hence, the intensified stratification in the A2 climate scenario decreases the nutrient flux into the upper layer only slightly. The increased nutrient regeneration also causes higher winter nutrient concentrations. Together with earlier warming and stratification of the water column, the increased winter nutrient pool causes intensified and earlier phytoplankton development during spring (Fig. 5.7). Also during summer the A2 scenario predicts higher phytoplankton biomass, which is mainly caused by increased nutrient regeneration in the euphotic zone. The model also predicts that blue-green algae blooms will increase significantly (Fig. 5.8). Altogether the A2 climate scenario indicates that the productivity of the Gulf of Riga ecosystem will increase, both for primary as well as for secondary producers. The simulated primary production increased from 212 g C m^{-2} $year^{-1}$ to 298 g C m^{-2} $year^{-1}$, while the annual average zooplankton biomass increased from 17.1 g C m^{-2} to 24.3 g C m^{-2}.

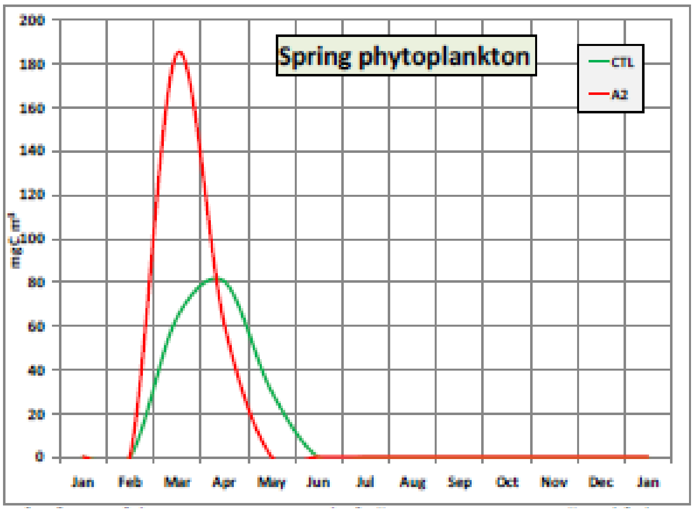


Figure 5.7. Biomass of spring phytoplankton species. Monthly mean values for 30 year simulation periods (CTL: control run 1961 – 1990, A2: A2 scenario 2071 – 2100)

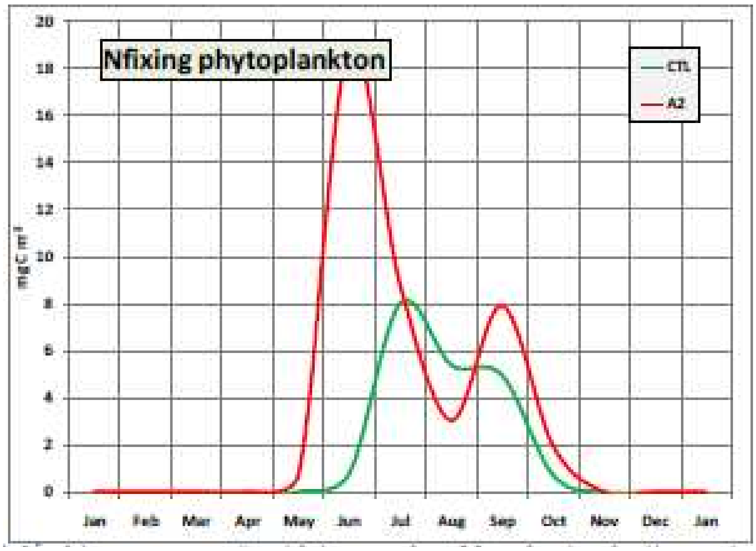


Figure 5.8. Biomass of cyanobacteria. Monthly mean values for 30 year simulation periods (CTL: control run 1961 – 1990, A2: A2 scenario 2071 – 2100)

Negative impacts on the ecosystem are caused mainly by the predicted decline in bottom water oxygen concentrations (Fig. 5.9). The oxygen concentration decline is the result of three co-acting processes: Reduced oxygen solubility in the warmer surface layer, reduced oxygen transport due to the intensified and prolonged stratification, and increased oxygen consumption in heterotrophic processes. The modelled oxygen concentrations, however, do not drop low enough to stop denitrification. On the contrary, in the A2 scenario denitrification is larger than in the control run (Fig. 5.10).

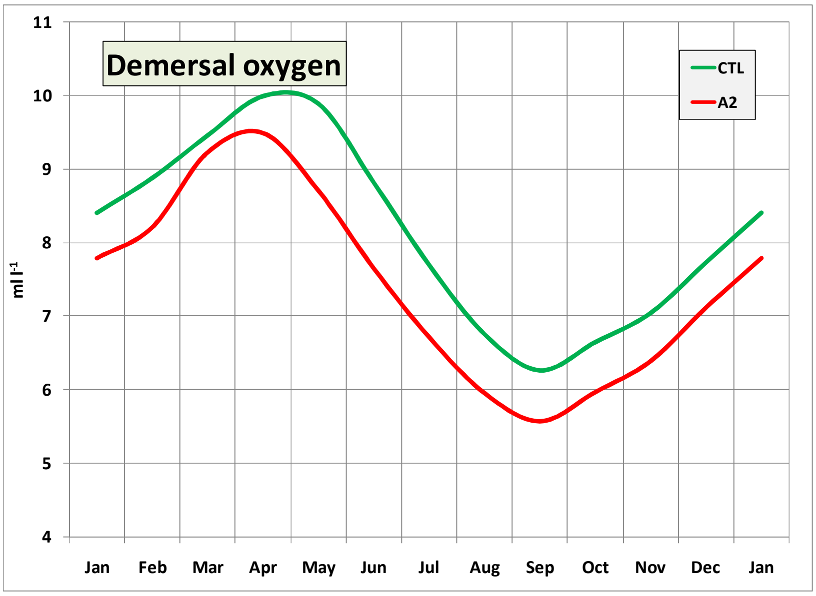


Figure 5.9. Average oxygen concentrations in the demersal box of the biogeochemical model (10 – 50 m water layer). Monthly mean values for 30 year simulation periods (CTL: control run 1961 – 1990, A2: A2 scenario 2071 – 2100)

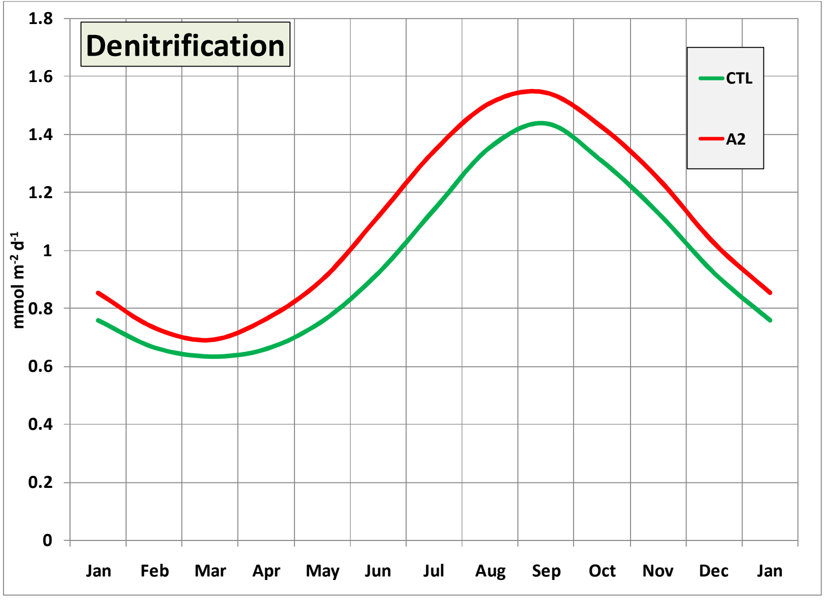


Figure 5.10. Simulated denitrification flux. Monthly mean values for 30 year simulation periods (CTL: control run 1961 – 1990, A2: A2 scenario 2071 – 2100)

The predicted changes in denitrification do not completely agree with empirical results, which indirectly show the intensity of denitrification under limited oxygen supply, even though the critical oxygen concentration at which denitrification stops is not reached. Nitrate accumulation in the bottom layer of the Gulf of Riga (Fig. 5.11) suggests that the denitrification rate drops significantly in August – September, when oxygen concentrations reach their minimum.

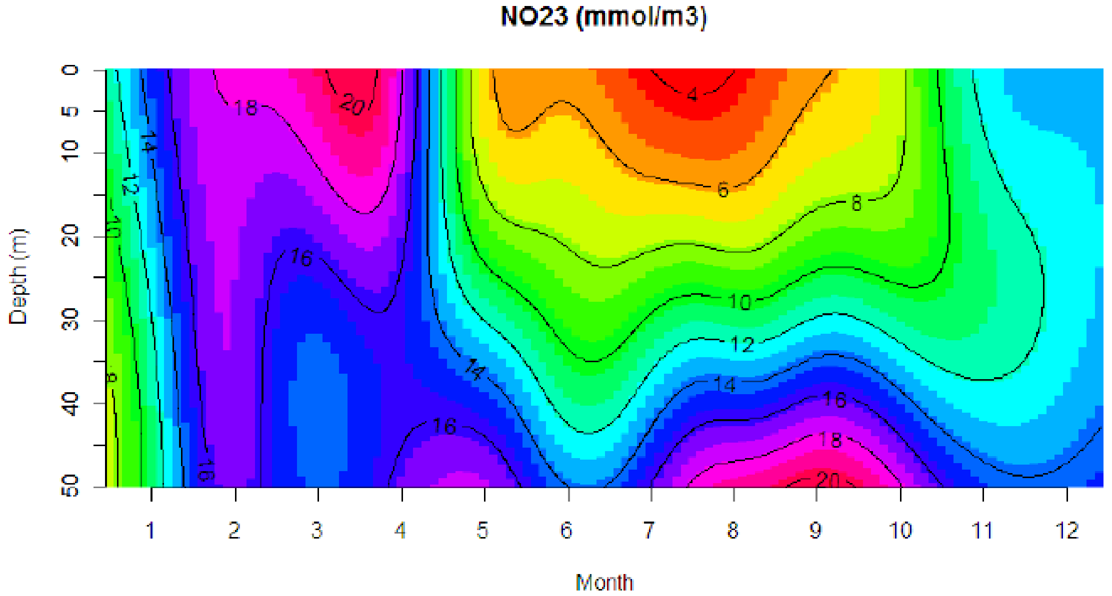


Figure 5.11. Average seasonal dynamics of nitrate + nitrite concentrations in the Gulf of Riga, 1973 – 2008

This contradiction shows that additional empirical data on the intensity of denitrification in various depths ranges of the Gulf of Riga should be collected, because oxygen concentrations are dependent on water depth. Also sediment types distinctly vary with water depth. Additional information on the relationship between denitrification rates and oxygen concentrations then can be used to refine the biogeochemical model calibration and improve predictions of denitrification intensity. Denitrification, as the most important nitrogen sink in the ecosystem, plays a crucial role in the management of eutrophication of the Gulf of Riga.

Scientific and economic importance of the work package results

Experimental results and the scenarios modelled have significantly contributed to our knowledge base on the environment of the Gulf of Riga and its driving factors. The results have been presented at national and international scientific conferences and have contributed to scientific publications. Moreover, the results have shown gaps in our understanding of the processes controlling denitrification in the Gulf of Riga that should be filled by future research.

The work package results are especially important with respect to activities connected to the Baltic Sea Action Plan and Latvian national obligations to comply with the objectives of the Water Framework Directive and Marine Strategy framework directive. The work package results allow evaluating the efficiency of planned environmental management measures, which is crucial, especially under limited financial resources.

1.4 Summary

The predicted climate change will enhance the seasonal stratification of the water column in the Gulf of Riga, which will in turn negatively affect the oxygen budget of its bottom water. Accelerated nutrient regeneration will cause higher nutrient concentrations in winter. Together with earlier warming and stratification of the water column this accumulation causes intensified, earlier phytoplankton development in spring. The predicted change in phytoplankton composition with increased cyanobacteria blooms, however, will negatively affect the Gulf of Riga ecosystem and make it more vulnerable to increases in phosphorus load.

Recommendations to stabilize and reduce eutrophication

- The predicted climate changes reduce bottom water oxygen concentrations in the Gulf of Riga. Therefore climate change will increase the vulnerability of the Gulf of Riga ecosystem towards nutrient inputs, and, to achieve the same effect as under contemporary climate conditions, nutrient loads have to be reduced to a larger extend.
- Climate change will most likely increase cyanobacteria blooms in the Gulf of Riga and make the ecosystem especially vulnerable towards increases in phosphorus loads. Therefore phosphorus load reductions are especially important for the management of eutrophication in the Gulf of Riga.

References:

HELCOM (2003) The Baltic Marine Environment 1992-2002. Baltic Sea Environment Proceedings No. 87. Helsinki Commission.

Feistel, R., Nausch, G., Hagen, E. 2008. Water exchange between the Baltic Sea and the North Sea, and conditions in the deep basins. HELCOM Indicator Fact Sheets 2008. Online. Viewed Oct 10, 2008.
http://www.helcom.fi/environment2/ifs/ifs2008/en_GB/waterexchange/

Schinke, H.and Matthäus, W. (1998) On the causes of major Baltic inflows – an analysis of long time series. Cont. Shelf Res. 18: 67-98.

Work Package Coordinator: Juris Aigars

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

6.1. Aim of WP:

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.

6.2 Work package tasks in 2009:

1. Update and completion of the fish community model for the long-term projection of stock and production for Gulf of Riga herring, Baltic Sea sprat and cod.

2. Projection of possible changes of biodiversity and ecosystems in the Gulf of Riga and the Baltic Sea.

3. Recommendations for the management of marine environment according to the climate change forecasts.

4. Recommendations for the fisheries management according to the fish stock development tendencies.

5. Reporting of the results – presentations and publications.

6.3Results of the WP6.

Task 1: content of the work and results.

A mid-term forecasting model developed in 2008 was used to produce several calculations of herring stock and catch dynamics at various regimes of water temperature. The herring stock assessment in 2009 confirmed the relation of stock size and water temperature included in the model.

Similar mid-term forecasting model was developed for the Eastern Baltic cod. To describe the stock-recruitment ratio, modified Ricker model was used with an added function *f(Env)* which reflects a linear combination of environmental factors. Several scenarios were provided for cod stock and recruitment mid- and long-term forecasts taking into account the potential climate change and local environmental situation.

1. Ricker model using reproductive volume (RV) as the environmental factor. Model was simulated at various levels of RV and fishing mortality – F=1.08 and F=0.3.

2. Ricker model using forecast of Baltic Sea salinity ($Sal_{80\text{-}100}$) fluctuations as the environmental factor. Salinity scenarios are according to IPCC A2 including variation around median till 2100 and decrease by 1 psu till 2100. Fishing mortality in the model had following values: F=1.08, F=0.7, F=0.3 and F=0 (no fishing).

The results of mid-term forecast indicate the substantial increase of stock occurs only if the fishing mortality is being reduced (Figs.6.1,6.2) at the situation when RV grows at the second year of period and then fluctuates around the median. At high fishing mortality stock increase occurs only for some years.

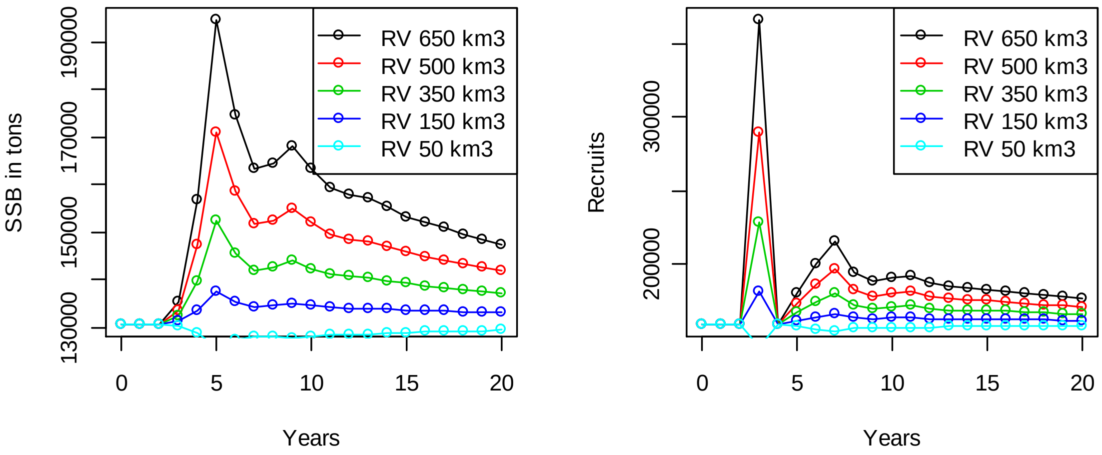


Fig.6.1 Mid-term forecast of cod spawning stock and recruitment dynamics. RV is the environmental factor. Scenario with F=1.08 and RV increase at year 2.

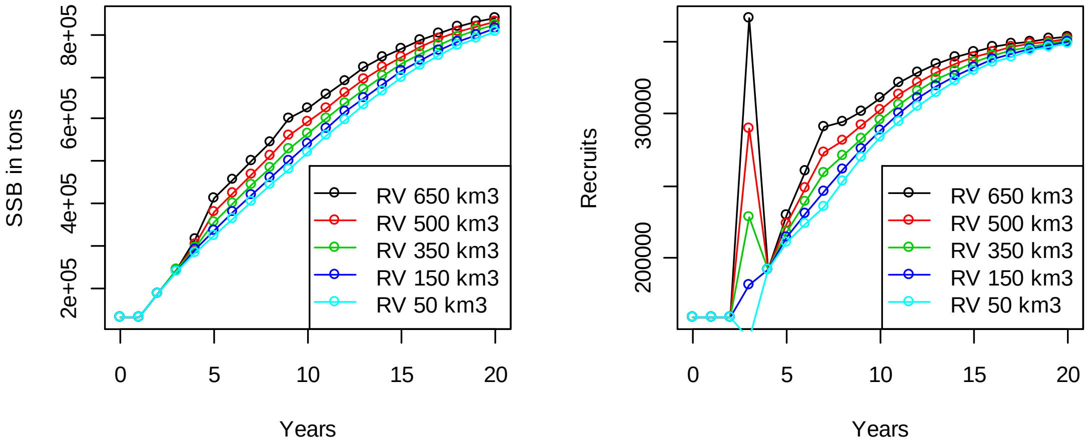


Fig.6.2 Mid-term forecast of cod spawning stock and recruitment dynamics. RV is the environmental factor. Scenario with F=0.3 and RV increase at year 2.

Using the model with salinity fluctuations and high fishing mortality F = 1.08, the spawning stock extincts independently from any climate scenario (Fig.6.3). If F is reduced to 0.7, spawning stock shows certain stabilization. Stabilization of the stock has higher level when F is limited furthermore. In general the climate impact on the forecasted spawning stock is small. It becomes more significant when the F= 0.7.

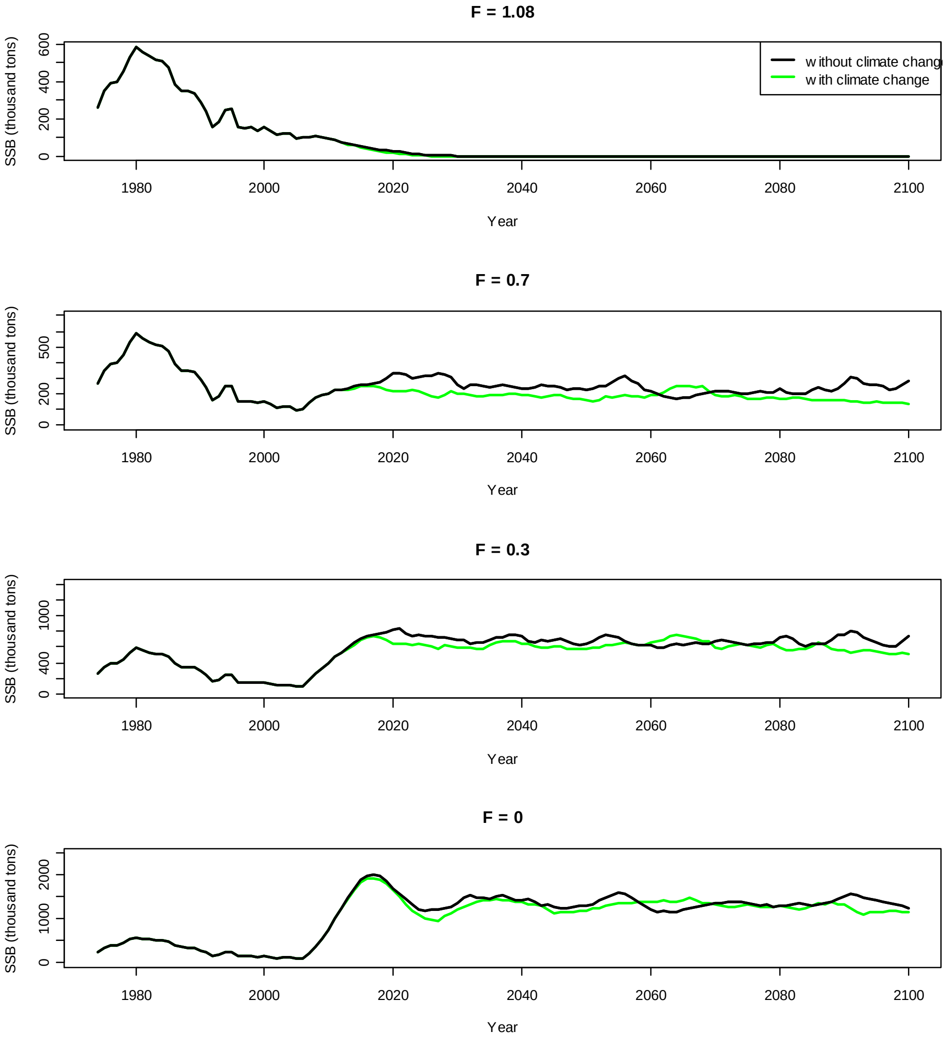


Fig. 6.3. Dynamics of cod spawning stock at various salinity forecasts and fishing mortality levels.

The analysis of sprat stock dynamics showed that the long-term changes of stock can be described with a periodic function. Abundance variation of the year old sprat or stock recruitment was reflected by the second order parabolic equation $y_1=a+b\times x+c\times x^2$, showing a vague increasing tendency for a 38 yrs period (Fig.6.4). The equation $y_2=y_1+b_1\times sinx+c\times cosx$ was used to find a smoothed curve describing the annual recruitment variation with a period of 25 yrs. One more periodic function was employed for a 12 year period to have the best model fit - $y_3=y_2+b_2\times sinx+c\times cosx$ (Fig. 6.5).

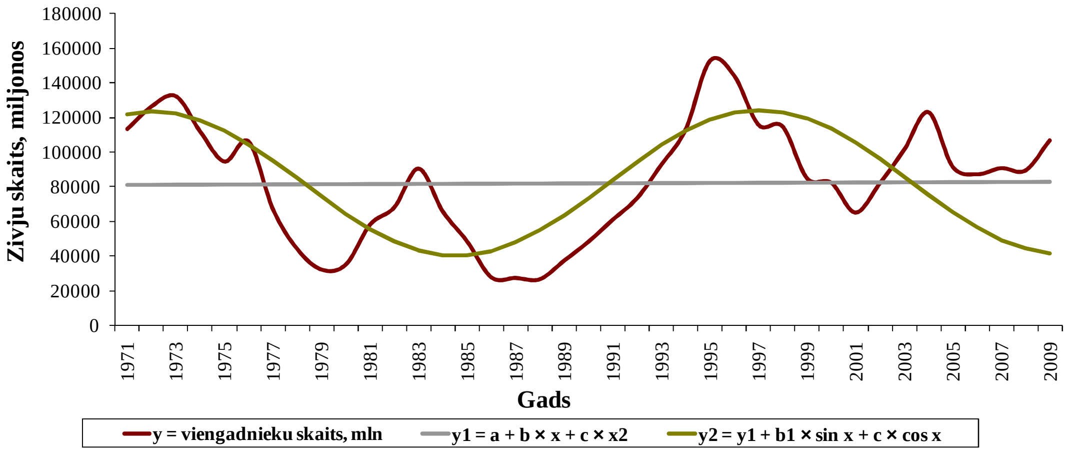


Fig. 6.4. Tendency of productivity of sprat year classes (y axis – abundance of fish in mill., red curve – abundance of 1 year old fish).

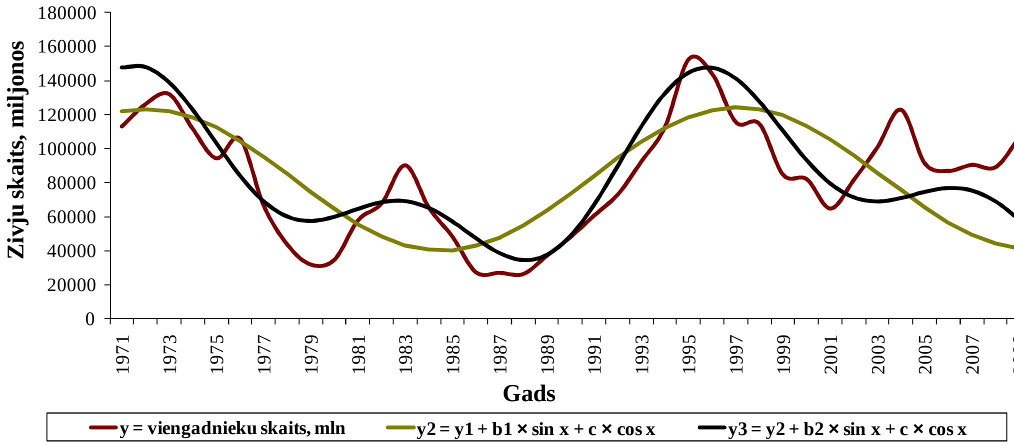


Fig. 6.5. Function curves of productivity of sprat year classes (y axis – abundance of fish in mill., red curve – abundance of 1 year old fish).

The generated catch forecast of sprat produce differs significantly from the forecast curves used by ICES (Fig. 6.6). WP6 forecast includes the period till 2030 while ICES has till 2017. The major difference lies within constant productivity of year classes used in ICES forecasts whereas our approach is to project the productivity alterations and only afterwards the catch is forecasted.

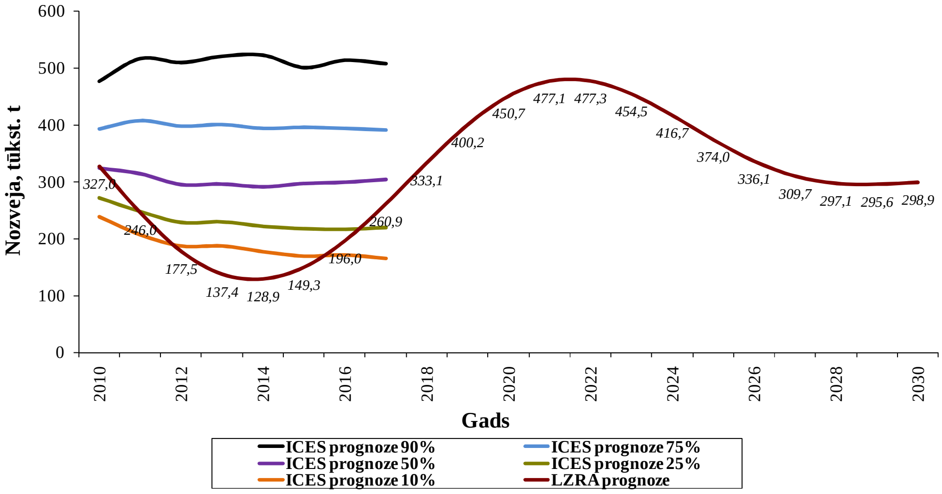


Fig 6.6 . Comparison of sprat catch forecasts by WP6 (LZRA) and ICES (y axis – catch, thous.t).

According to the model results, in 2010-2015 the decrease of both stock and catch is expected. After 2015 the stock and catch will have a cycle of growth for 7-11 yrs. Thus the catch limits should be modified and fishing mortality reduced accordingly to keep the sufficient level of stock.

Task 2: content of the work and results.

Gulf of Riga

The water temperature increase in the sea is indicated both by globally and regionally provided climate change scenarios. In the areas of the Gulf where the depth exceeds 20m seasonal thermocline will be present a month longer. The disappearance of ice cover means earlier development of phyto- and zooplankton communities and shift of macrozoobenthos breeding time. In **winter** the phytoplankton community will hardly have any significant species change, however the experiment results suggest decrease of share of arctic species like *Achnantes taeniata* and growth of boreal taxa *Thalassiosira baltica*, *Chaetoceros spp.* and *Melosira nummuloides.*

During **spring** the composition of dominant species will be determined by nutrient concentrations and water stability. If according to WP5 results, the nutrient concentrations will increase and water stratification sets earlyer then at present, the current dominance of diatoms will be replaced by dinoflagellates (*Peridiniella catenata*). If the wind activity will be strong causing higher water turbulence then diatoms could maintain their dominant position as the turbulence helps the cells to remain in the water column. The results of experimental series indicate the increased species diversity (Shannon index) in the conditions of higher temperature. Also spring zooplankton development will start earlier without any changes in species composition as the total abundance is built by 3- 4 taxons until the temperature reaches +15°. In case of dinoflagellate dominance as a food source higher proportion of rotifers is possible.

Also in **summer** the wind strength will have certain significance besides the temperature increase and water stratification. If the wind activity will be stronger the increased abundance of cyanobacteria will not be observed, contrary to the forecast by WP5 model. At the coastal areas of the gulf upwellings will occur more frequently, enlarging the nutrient concentrations and favouring the development of diatoms *Actinocyclus octonarius*, *Skeletonema costatum*, green algae *Monoraphidium contortum*, *Oocystis spp.*, flagellates, including *Dinophysis acuminata*, *Chrysochromulina spp*. Growth of cyanobacteria – most probably *Aphanizomenon flos-aquae* – will be more characteristic for the open areas of the Gulf at the end of summer, beginning of autumn. Observations of the last 10 yrs when summers have been more windy than in 1990s indicate a stepwise decline of cyanobacterial share in the total phytoplankton abundance (Fig.6.7).

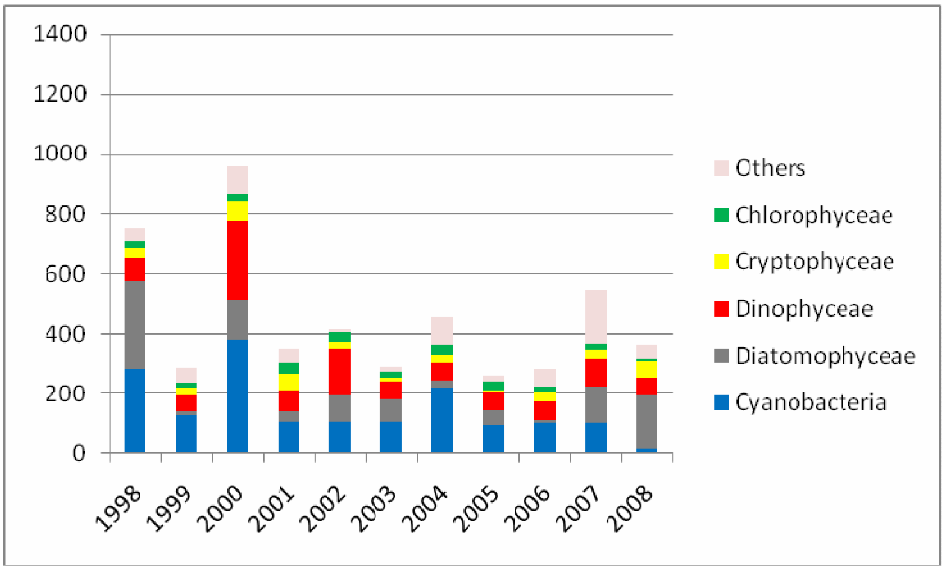
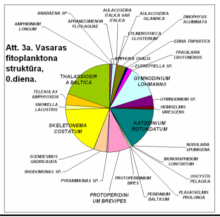
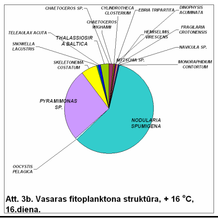
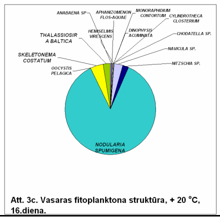
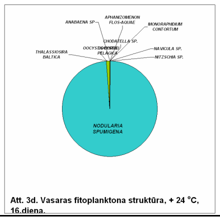
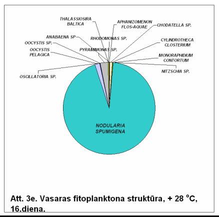


Fig.6.7. Biomass (mg/m^3) dynamics of phytoplankton groups at the open part of the Gulf of Riga, summer 1998 - 2008.

However, with the growth of phosphate concentrations and water temperature an increase of total phytoplankton biomass is possible exactly as a result of successful cyanobacterial development (Table 6.1).

Table 6.1

Shift of summer phytoplankton species with the water temperature increase (%)				
Start of experiment	**End of experiment**			
Gulf of Riga	**+16°C**	**+20°C**	**+24°C**	**+28°C**
				
Increase of potentially toxic species, % of total biomass				
7	59	87	99	94
Shannon index				
1,6	1,2	0,7	0,1	0,5
Increase of total **biomass,** times				

	1	1,3	17,8	3,4

Zooplankton community can have a higher share of freshwater species (*Cyclops* spp., *Daphnia* spp.) as the salinity will decrease both in the sea and the Gulf. Abundance of copepod *Acartia bifilosa* and cladocerans *Evadne nordmanni*, *Pleopsis polyphemoides* could decrease because these species have higher optimal salinity. Still, the changes in the food web would affect mostly the lower levels since the total zooplankton abundance is more likely to increase and food source for fish will not be modified substantially. The low oxygen concentrations below thermocline (according to WP5 suggestions) will be unfavourable for the relict copepod species *Limnocalanus macrurus*. *L.macrurus* is a valuable fish food item although has low numbers already for 30 years.

Increase of primary production in combination with prolonged low oxygen concentration will classically lead to decline of macrozoobenthic communities in the areas deeper than 30 m. Similar situation has been already observed in 1990s (6.8.).

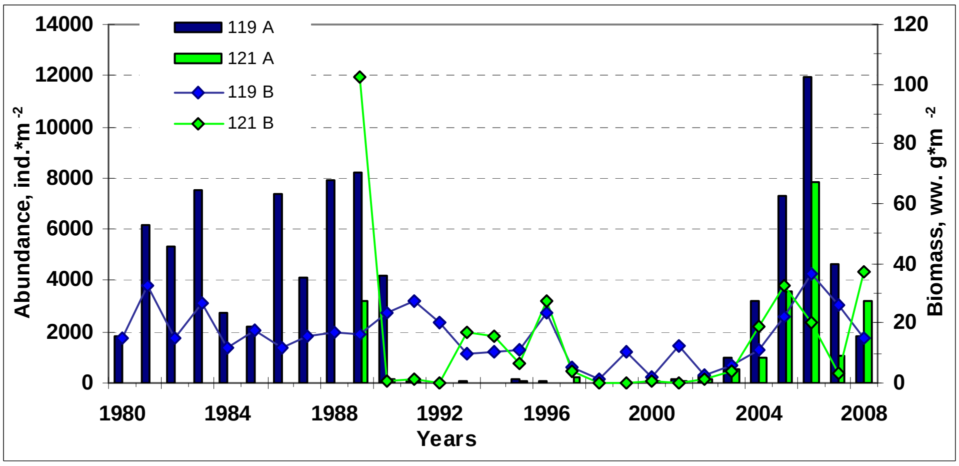


Fig.6.8. Dynamics of macrozoobenthos abundance (A) and biomass (B) at the central part of the Gulf of Riga 1980-2008.

Consequently the self-purification possibility of the Gulf varies and the food base for benthic fish is reduced. At the same time the importance of coastal areas will raise for thriving functioning of the Gulf since long unfavourable conditions are not expected there. In the areas with soft bottom sediments *Gammarus sp.*, *Bathyporeia pilosa*, *Marenzelleria viridis* and *Macoma baltica* will increase their proportion in the total zoobenthos abundance and biomass. All these taxons belong to the group having moderately eutrophied environment as the optimal one.

Course of future for phytobenthic communities will depend on the level of nutrient concentrations at the coastal areas. Short-living algae will be more present if nutrient concentrations grow. Increased wind activity will diminish water transparency and thus also limit prosperous development of perennial algal species. The impact of more frequent upwellings due to windiness upon macroalgal communities requires further investigations.

Autumn will be less distinguishable, summer species will stay in the plankton for a longer period. It is possible that phytoplankton autumn bloom will be without peaks but distributed over longer time period, since combination of nutrients, temperature and light intensity, necessary for diatom development, will be shifted in time. The occurrence of diatom *Coscinodiscus granii* will be less frequent and *Actinocyclus octonarius* will become the dominant species. Projected environmental conditions and food source will be longer favourable for zooplankton growth, including also invasive species.

The Baltic Sea

Seasonal course in the Baltic Sea will resemble the processes in the Gulf with an earlier start of **spring** since already the last 10 years haven't had ice cover. Faster stratification will limit the range of spring bloom with the decrease of diatoms due to reduced availability of nutrients. Therefore a share of flagellates will increase, supporting also the development of smaller size zooplankton groups, mostly rotifers.

Changes in the ecosystems of the Baltic Sea will be related to trans-boundary processes to much higher extent than in the Gulf. As the example, at the southern part of Latvian Baltic coast level of primary production and water trophy is determined by the transformed freshwater inflow originating from the Curonian lagoon. So the future of at least this area depends greatly on the Nemunas runoff dynamics.

The development of cyanobacteria during **summer** in the Baltic Proper will be determined by wind intensity and number of sunny days which is more important for cyanobacterial growth than the water temperature itself (BACC, 2008). During the last eight years no mass occurrence of cyanobacteria has been recorded (HELCOM, 2007). Due to decreasing salinity the species composition of zooplankton community will gradually become similar to the taxonomic structure of the Gulf.

The strengthening of stratification at the open part of the sea will decline the quality of benthic habitats. Areas without macrofauna will extent in the direction of shallower parts of the sea. Species structure at the sites with seasonal oxygen deficiency will shift from attached filter feeders to mobile, opportunistic species which will not assure the uptake of organic particles by filtration.

Task 3: content of the work and results.

Taking into account the abovementioned potential changes of marine ecosystems, following management suggestions are provided for the next five years:

- revise the reduction of nitrogen loads for Latvia in the frame of the Baltic Sea Action Plan (HELCOM BSAP) in order to introduce the load reduction also for the Gulf of Riga not present in the current version;

- elaborate and implement the load reduction activities as soon as possible in all related areas (agriculture, water resources management etc.);

- create zonation of the coastal underwater areas with various level of protection according to the functional importance of the site;

- perform regular observations of marine environment and provide model calculations of processes, based on the observations for flexible management decisions.

Task 4: content of the work and results.

The current environmental conditions are favourable for the Gulf of Riga herring thus the increase of stock could be expected. Still the calculations of fishing mortality indicate that illegal fishing constitutes a significant part of the total catch. If the illegal fishing can be stopped now, the stock biomass after 2020 would be on a much higher level and so also the allowed catch.

The same problem is related to the cod – the level of stock is significantly influenced by the illegal fishing, thus causing high fishing mortality and reducing the total allowed catch.

Therefore a successful fisheries management requires the reduction of fishing mortality via exclusion of illegal fishing almost independently of the climate. The climate change can improve or worsen the productivity of year classes but in the situation of intensive fishing will not solve the level of stocks.

6.4.Summary

The productivity of the Gulf of Riga herring will increase at higher mean water temperature in May. Dynamics of the Baltic cod stock will relay on fishing mortality by positive or negative modifications of salinity fluctuation. The abundance of sprat will vary in the cycle of 7-11 years not so directly related to climate change.

Rise of temperature will prolong the productive period for pelagic communities and increase the total biomass. Phytoplankton spring blooms will occur earlier. A proportion of freshwater representatives will be higher in zooplankton community. At the deep parts of Latvian marine areas the long stratification will deteriorate quality of benthic habitats. The importance of coastal areas will increase as the central productive regions of Latvian marine waters.

The results of WP indicate that for successful management of marine resources in the conditions of climate change the restriction of consequences from human activities upon the marine ecosystems is of utmost importance. Reduced nutrient loads, also in trans-boundary aspect, cautious fisheries policy and fulfilment of requirements for protected areas are the main criteria for continuous thriving functioning of marine ecosystems.

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

9.1. Work package goal:

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

9.2. Tasks of the 4th stage:

1. Determine the flood and drought impact on bio-geochemical fluxes in flood-plain systems and the catchment;
2. Assess the impact of floods and droughts on floodplain-lake ecosystems of river Daugava;
3. Suggest the measures to mitigate the flood and drought risk.

9.3. Results of 4d stage tasks:

Task 1 Summary and results

Finishing the work on this task during the 4th phase was done, firstly, by continuing the assessment of potential soil losses using the empirical model USLE applying GIS, and secondly, by comparison of theoretically estimated values and the measured values of sediment and nutrient load transferred from headwater catchments into the river. It allowed forecasting of the impact of climate change scenarios on bio-geochemical fluxes in flood-plain systems and the catchments.

Unlike the 3rd phase when the modelling approach was tested for comparatively small areas, in this stage modelling was performed for the territory of more than 200 km^2 located in Augšdaugava depression. Considering that, it was necessary:

1. to prepare additional geospatial data (R rainfall runoff factor or erosivity factor; K soil erodibility factor; LS topographic factor; C land cover and management factor; P support practice factor) for the entire territory of modelling
2. solve the issues of limited max. output number of pixels for development of grids (*Extent* could not exceed 24 million pixels in ArcGIS) to find the correct algorithm for modelling and calculating the raster data in smaller parts with subsequent merging separate grids into the bigger one.

Results of modelling (Fig 9.1) show that the main part of territory under study is not affected by soil erosion risk or the potential soil losses have low values. However, as can easily be seen from USLE equation ($A = R \cdot K \cdot LS \cdot C \cdot P$), R or rainfall erosivity factor has a substantial and direct impact on amount of eroded material. Hence, it is an obvious conclusion that seasonal changes in amount of precipitation and shortening the reoccurrence periods of extreme rainfall in Latvia, particularly in its south-eastern part (Seņņikovs et al. 2008), will trigger increasing of R-factor values. In its turn, it is highly probable that it will trigger the intensification of erosion and thereby will intensify sediment and nutrient transferring from headwater catchments to the recipient water bodies.

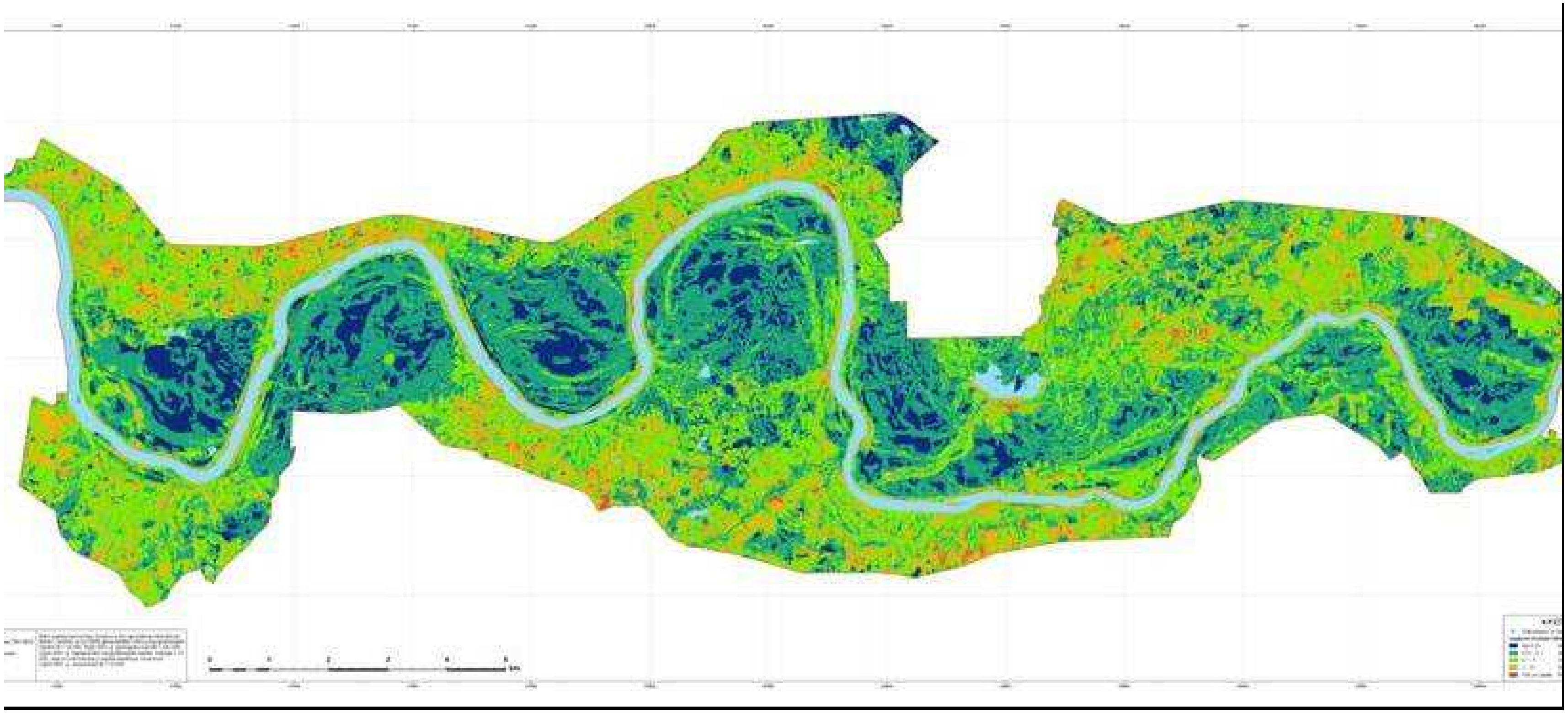


Figure 9.1. Values of erosion obtained by applying empirical USLE model integrated in GIS, which shows potential loss of soil from surface unit (t • ha-1• yr-1) in Augšdaugava depression (ESRI grid raster data, pixel 2 m)

Comparison of estimated values obtained by modelling and the measured values of sediment and nutrient load transferred from headwater catchments clearly shows that in some cases the observed amount of erosion products delivered from gully catchments are higher than theoretically calculated, e.g. suspended sediment load shortly can reach up to 8,000 kg day^{-1} during extreme runoff events. In general, one of the main sources of sediment load transported to water bodies is the material eroded within gully channels rather than erosion products transferred from catchments themselves. Suspended sediments and nutrient output are very responsive to extreme runoff events, which occur over short time spans due to a small size of gully catchments and rapid flow of water, leading to a strong underestimation of loads when using statistical methods based on the mean monthly concentration.

Variations of nutrient loads are mainly related to the variety of runoff formative weather conditions. The obtained results on average concentrations of nutrients vary within catchments from 0.01 to 1.23 mg l^{-1} of N-NO^{3-}, from 0.21 to 1.73 mg l^{-1} of N-tot, from 0.03 to 0.82 mg l^{-1} of P-PO$_4^{3-}$ and from 0.04 to more than 1.01 mg l^{-1} of P-tot. However, the maximal values of the measured concentrations coincide with a peak discharge runoff.

Table 9.1

Min. and max. Concentrations of nutrients measured in gully streams during different runoff formation conditions

Nutrients Runoff formation	N-NO$_3^-$		N-tot		P-PO$_4^{3-}$		P-tot	
	min. conc. (mg·l^{-1})	max. conc. (mg·l^{-1})	min. conc. (mg·l^{-1})	max. conc. (mg·l^{-1})	min. conc. (mg·l^{-1})	max. conc. (mg·l^{-1})	min. conc. (mg·l^{-1})	max. conc. (mg·l^{-1})
rain in winter on bare soil	0,14	0,20	0,33	0,48	0,13	0,22	0,16	0,23
norm. snow melting in spring	0,35	1,23	0,56	1,73	0,03	0,15	0,06	0,22
extreme snow melting in spring	0,05	0,77	0,21	1,06	0,03	0,82	0,05	1,01
groundwater drainage in summer	0,03	0,32	0,37	0,47	0,04	0,31	0,04	0,33
norm. rain in autumn	0,01	0,24	0,49	0,95	0,06	0,06	0,28	0,43

Results of analyzing of suspended sediment and nutrient area-specific load (kg·ha^{-1}·d^{-1}) during different runoff formation conditions demonstrate the positive effect of vegetation cover in mitigation of erosion products output, e.g. in catchments with high proportion of canopy vegetation runoff formation in gully channels was not observed in some cases (Fig 9.2 and Fig 9.3). However, the presence of vegetation in headwater catchments does not prevent totally the formation of suspended sediment and nutrient load. It is associated with the decomposition of fallen leaf remains and other organic particles which are washed into the streams from forest litter. This fact is very important, because considering the data of climate changes modelling adopted for Latvia, the forecasted increase of mean monthly temperature in December and January and shortening of cold season will have an impact on duration of the period with higher rates of organic matter decomposition and additional production of nutrients transferred from the headwater catchments.

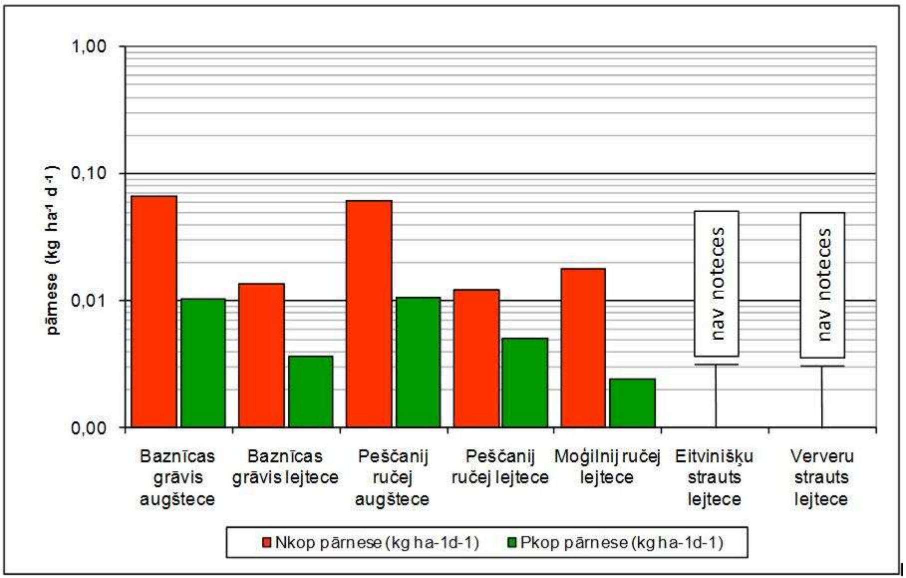


Figure 9.2 Area specific load (kg·ha^{-1}·d^{-1}) of nutrient transferred from selected headwater gully catchments during norm. snow melt in spring (description of gully catchments are given in previous report)

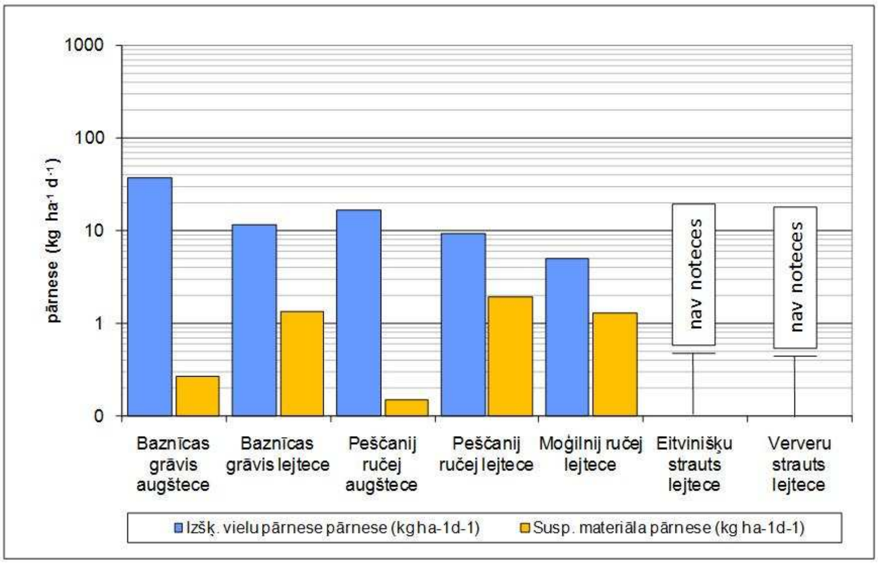


Figure 9.3 Area specific load (kg·ha^{-1}·d^{-1}) of suspended sediments and total dissolved solids transferred from selected headwater gully catchments during norm. snow melt in spring (description of gully catchments are given in previous report)

The mean daily suspended sediment load from gully catchments are 20 to 30 times lower in comparison to the suspended sediment yield of small rivers in SE Latvia, but considering the high number of gully streams in this region, they are important sources of eroded material transferred to the receiving stream.

Task 2 Summary and results

During 2009, the long-term changes in statistical probability of the low water periods (hydrological droughts) of the Middle Daugava River, which could affect the floodplain lake ecosystems, were evaluated. The daily mean discharge data series of the Daugava River at Daugavpils since 1936 were analysed. Probability distribution of the maximum drought event (the relative runoff deficit and the low flow duration) was estimated for the all-year droughts, summer droughts and winter droughts of two 40-years long observation periods (1936-1977 and 1966-2007, respectively). The discharge data series were obtained from the Global Runoff Data Centre, 56068 Koblenz, Germany. The task was performed by applying the "*Nizovka 2003 - Distributions of Low Flow Extremes*" program elaborated by the Department of Mathematics and the Institute of Hydrology, Agricultural University of Wroclaw (Poland).

According to this study, probability distribution of the Daugava's low-flow periods changed significantly over time (Gruberts 2009). Today, it is more probable, that the runoff deficit and duration of the low-flow periods will not exceed the same values when compared to the first 40 years of hydrological observations (Fig.9.4). On the one hand, such changes for the winter droughts could be explained by the shortening of the winter duration and increasing of the air temperatures in Latvia during the last decades. On the other hand, the observed changes in distribution of summer droughts are, probably, related to substantial changes in the land use within the Daugava's drainage basin, condition of the land amelioration systems *etc.*.

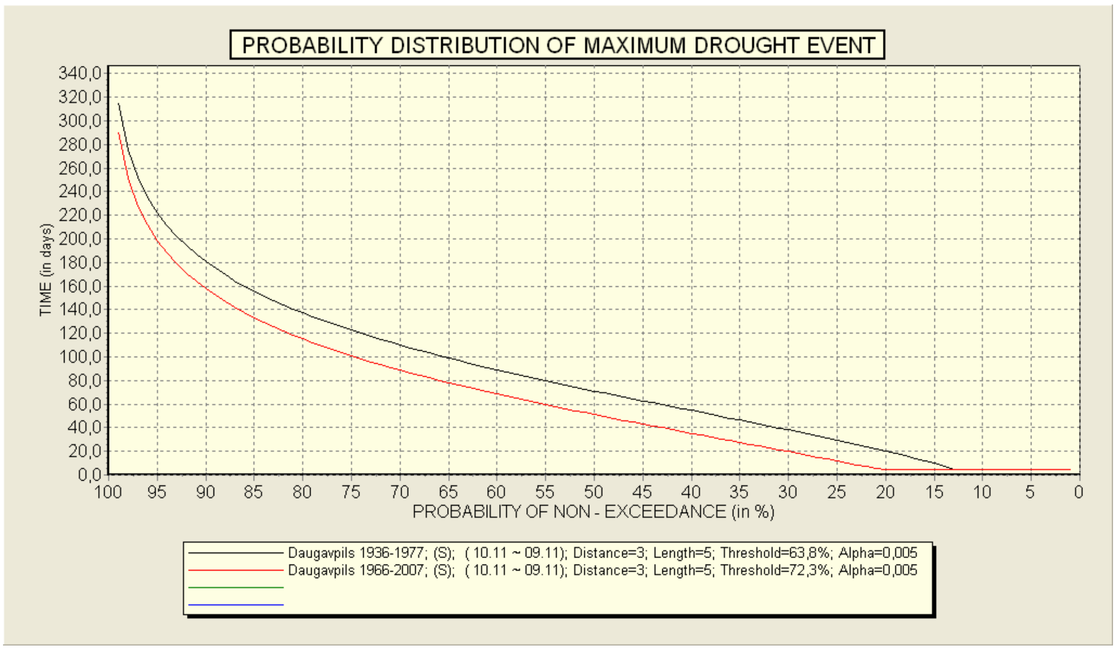


Figure 9.4 Long-term changes in the probability of real time duration of the all year droughts for the Daugava River at Daugavpils

Along with the existing trends of climate change, further shortening of the winter droughts and less severe discharge deficit of the Daugava River at Daugavpils is expected. This, in turn, could have significant impact on the ecosystems of the Daugava's floodplain lakes: their water chemistry and quality, plant and animal communities, overgrowing by the macrophytes *etc.*.

Based on the seasonal observations performed during the last 5 years, a possible impact of the future winter hydrologic and weather conditions on the phytoplankton communities of the Daugava River and its largest floodplain lakes was evaluated. Unusually warm January 2007 could be used as an example of such conditions, when there was untypically high water level and temperature observed in the Daugava River at Berezovka (Fig. 9.5). In addition, there was no ice cover in the river and its floodplain lakes at all.

Under such ice-free winter conditions, phytoplankton communities of the Daugava River upstream and downstream from Daugavpils as well as of its largest floodplain lakes were dominated by different species of the blue-green algae (mainly *Oscillatoria* sp.) (Fig. 9.6). In some cases (like the lake Koša and Dvietes), they formed relatively high total biomass without any reference to their trophic state in summer (Fig. 9.7).

Along with the existing trends of climate change, such hydrologic and weather conditions are expected to be observed more frequently in the floodplain of the Middle Daugava. Therefore, more frequent blooming of the blue-green algae during the winter low water period as well as a significant reduction of water quality in the Daugava River at Daugavpils is expected.

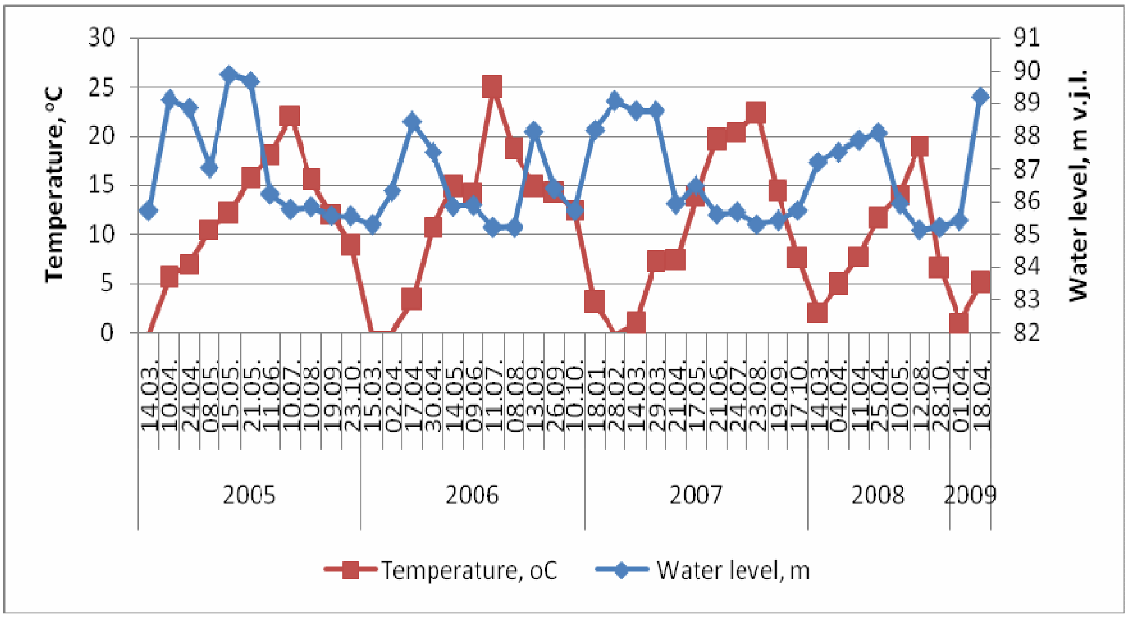


Figure 9.5 The water level and temperature dynamics of the Daugava River at Berezovka in 2005-2009 (Suveizda S., unpubl.)

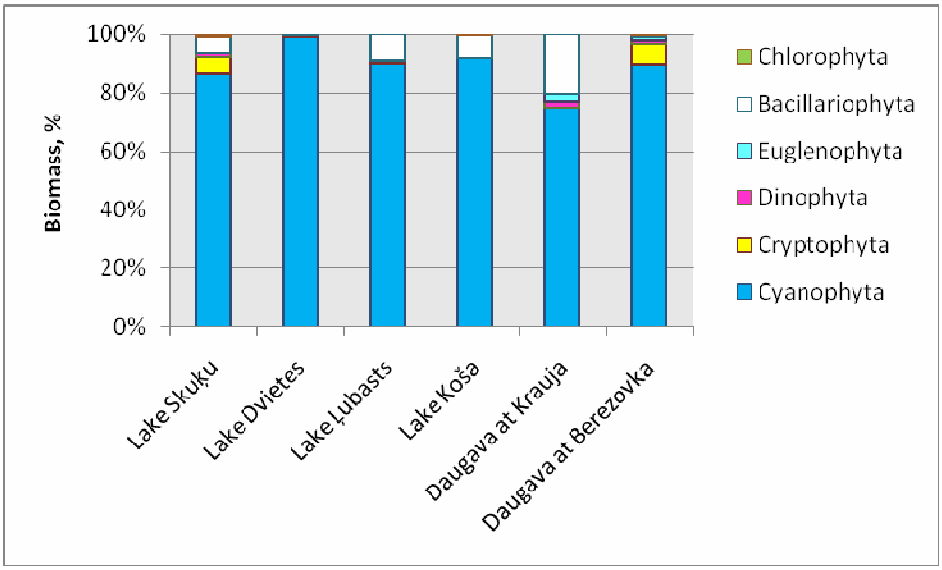


Figure 9.6 Relative proportion of different algae groups in total phytoplankton biomass of the Daugava River and its largest floodplain lakes, January 18, 2007

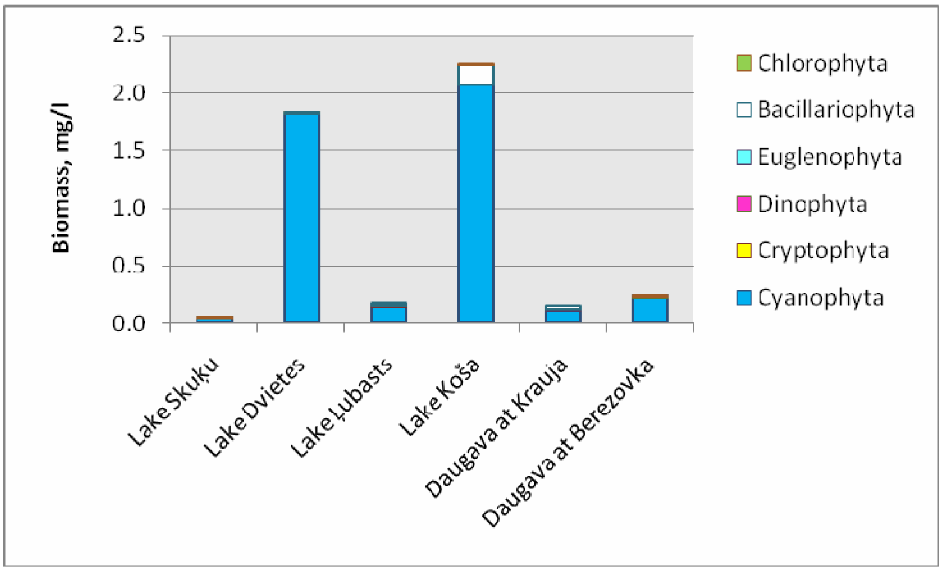


Figure 9.7 Total biomass of different phytoplankton groups of the Daugava River and its largest floodplain lakes, January 18, 2007

The analysis of zooplankton organisms was performed, summarizing data for 2005 – 2008 year in the Skuku and Dvietes lakes, and also in the Daugava River upstream and downstream of the floodplain lakes. The results of study of the floodplain lakes results were summarized for a low water period (2004, 22 floodplain lakes and reservoirs of the Daugava River).

By means of the RDA analysis (Canoco for Windows 4.5.), it was found, that changes of zooplankton abundance, biomass, species diversity and taxa are significantly affected by temperature and water level fluctuations, especially in spring, coinciding with the flood or the flash flood season. During water level raising the total abundance of zooplankton was increased in the Dvietes Lake (Fig. 9.8). A possible water rise is as a favourable environmental factor in floodplain lakes. On the other hand, during falling of the water level and low water period the abundance and biomass of Copepoda increase.

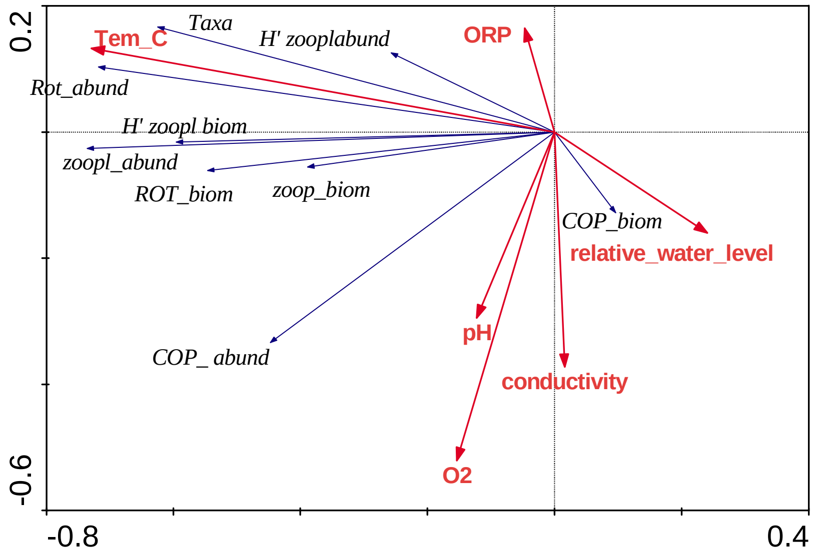


Figure 9.8 Result of the RDA, Dvietes Lake.

It was found also, that in the Daugava River below inflow of waters of floodplain lakes in the river (Berezovkas inflow in Daugava), a considerable role in the water level fluctuations (Fig. 9.9), can indicate the influence of the floodplain floods and flood water on the river.

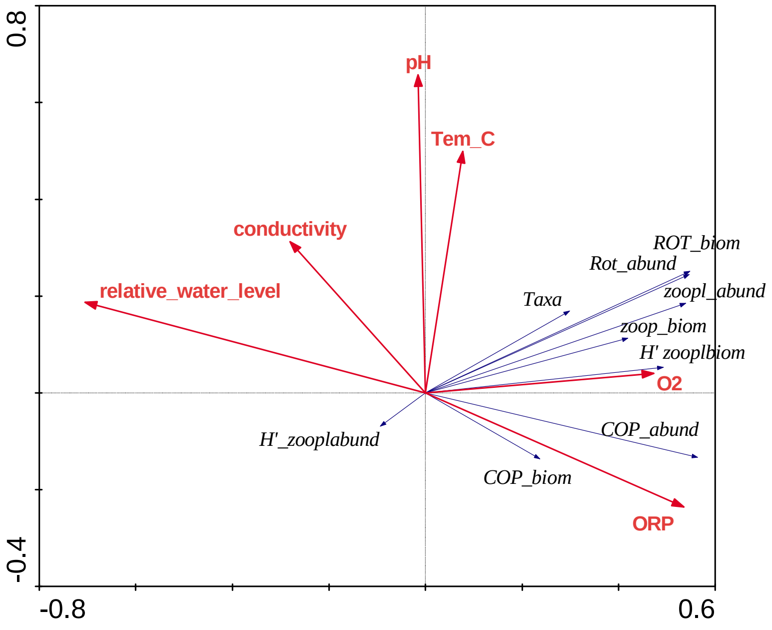


Figure 9.9 Result of the RDA, Daugava River below Berezovkas inflow

It was established, that in low water period frequency of flooding has a lasting impact on floodplain lakes that are flooded frequently (several times a year), and a considerable pointer is also morphometry of lakes and nutrient amount (Fig. 9.10). In low water period in the shallow and in the overgrown floodplain lakes a considerable fraction of zooplankton is represented by Cladocera: small Bosminidae and Chydoridae. A negative relationship between abundance of Cladocera and the oxidation-reduction potential (r= -0.664, P < 0.01) probably alludes to the presence and activities of bacterioplankton and their role as a food source for zooplankton. On the other hand, in the deepest floodplain lakes a considerable fraction of zooplankton is represented by the Rotifera.

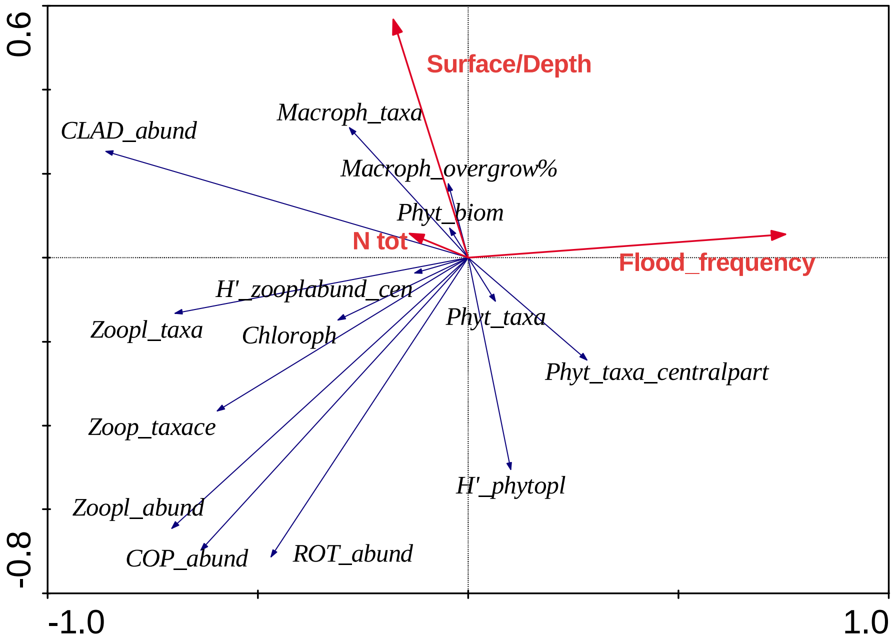


Figure 9.10 Result of the RDA, generalization of 22 floodplain lakes

Task 3 Summary and results

The obtained results demonstrate that from areas with higher proportion of arable land and less canopy vegetation cover, the transfer of eutrophying substances is considerably higher, i.e. load of supplied suspended sediment and nutrients is 3 – 20 times higher. Considering the forecasted increase of number of extreme hydro-meteorological events and more frequent formation of Hortonian runoff induced by climate changes, local municipalities have to include in their spatial development and planning programs the measures targeted to afforest the areas susceptible to erosion. Such preventive measures will diminish the risk of erosion and flash-floods on the one hand and will mitigate the supply of eutrophying substances to the recipient water bodies on the other hand, hence minimizing the risk of floods in general due to decreasing amount of material, which is accumulating and silting up the river channels.

9.4. Summary

In course of achieving objectives of the fourth stage of WP9, series of hydrological and meteorological data that are necessary for modelling were analysed. A study of the role of hydrological conditions for the ecology of phytoplankton an zooplankton communities in the floodplain lakes in the Middle Daugava continued in 2009 and a typical composition of the algae communities was determined as well as their dominant taxa in the situations of various flooding frequency.

Apart from the above mentioned, analysis of major results of the expedition aimed at the study of the Daugava inundation, that was undertaken on 26 March, 2006, was carried out, and a report was written regarding the possible use of a floating instrument platform for hydrological study of the river- floodplain system.

Historical and current frequency of the repetition of extreme discharge in Daugava was assessed, and recommendations in regards of the flood risks were worked out for the involved municipalities in the Daugavpils region.

Major hydrological functions of the Middle Daugava floodplain are reduction of annual amplitude of water level fluctuation by 3-4 meters and detention of the timing of the highest flood water levels in the year by 1-2 days downstream from the Dvietes floodplain. In addition, the floodplain accumulates a large amount of suspended and dissolved matter, which, in turn, stimulates productivity of floodplain meadows, wetlands and lakes. Floods are regarded as an essential factor of maintaining the high biological diversity in the river floodplain ecosystems.

Work Package Coordinator: Arturs Škute

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

7.1. Work package goals:

Develop reseasrch-based recommendations for the adaptation of environmental and sectoral water related policies in Latvia to climate change.

7.2. Work package Phase 4 Objectives:

1. Transform the results of Work packages 1-6 and 9 into specific recommendations that can be included in normative acts and planning documents, including an assessment of the potential impact of recommendations on sustainable development in Latvia.
2. Based on the results of undertaken research develop an adaptation brochure and a web-based publication on adaptation to climate change impacts for municipal personnel, including water sector specialists and land use planners.
3. Organize a seminar for municipal personnel, including water sector specialists and land use planners regarding the results of research on climate change in the water sector in Latvia.

7.3. Work package Phase 4 results:

Task 1. Work undertaken and results:

In cooperation with Work Packages 1-6 and 9 and based on the results of research undertaken during NRP Phases 1-3 adaptation measures to climate change were recommended. A greater number and more specific adaptation measures were proposed for inland waters than for the marine environment. Adaptation measures pertaining to the Baltic Sea ecosystem were more problematic because of a greater number of factors and complex interrelationships to be taken into account. Recommendations for adaptation to climate change in the water sector in Latvia ar compiled in the adaptation measure brochure (DP7 Task 2).

Recommendations regarding measures for adaptation to climate were submitted to:

1. Responsible institutions during the development of laws/regulations and strategies/plans:
    a. Revisions to the Protection Zone Law in the Latvian Parliament – adaptation measures in the context of Baltic Sea coastal erosion.
    b. Coastal Zone Development Strategy being drafted by the Ministry of Regional Development and Municipal Affairs.
    c. Revisions to the Spatial Planning Law - Ministry of Regional Development and Municipal Affairs.
    d. National Climate Change Adaptation Strategy developed by the Ministry of Environment.
    e. River Basin Management Plans developed by the State Environment, Geology and Meteorology Agency.

2. Recommendations regarding adaptation to climate change were submitted to responsible organizations, even if law/regulations or strategies/plans were not being developed or revised. The following recommendations were submitted:
    a. Climate change adaptation measures for wastewater collection/treatment systems (Ministry of Environment).
    b. Climate change adaptation measures in relation to the use of plant protection products - State Plant Protection Service.
    c. Climate change adaptation measures for large cities in Latvia.
3. An information brief was submitted to the Strategic Analysis Committee of the President's Office and to the Cabinet of Ministers highlighting the significance of climate change to the economy of Latvia.

Task 2. Work undertaken and results

An adaptation to climate change brochure for the professional audience was produced which contains the results of four years of of research by the NRP. The following topics were addressed by the publication:

1. Observed and predicted climate change in Latvia and the potential impact on the economy (pages 1-30).
2. The international and national legal framework for adaptation to climate change (pages 30-40).
3. Necessary adaptation measures in specific sectors of the economy – agriculture, forestry, fisheries, energy, education and research, communal services and other areas of activity such as land use planning and river basin management (pages 40-60).

To ensure that the content and design of the adaptation brochure meets the needs of the target audience consultations were held with representatives of relevant Ministries and with an environmental planning consultant.

2000 copies of the brochure were printed and distributed to users free of charge. The publication is also available to others upon request. Information concerning the availibility of the brochure was publicized electronically (e-mail, internet) and the brochure is available for download from the KALME web-page.

A summary of recommendations regarding climate change adaptation measures were made available in the 2nd edition of the KALME newsletter (the first edition of the KALME newsletter was published at the end of Phase 3 of the project).

To minimize the impact of the KALME project on climate change the adaptation brochure was printed on 100% recycled paper using natural plant-based ink.

Task 3 Work undertaken and results

A final project seminar will take place at the beginning of December in conjunction with the publication of project brochure. Seminar participants will include KALME researchers and relevant government personnel from Ministries, municipalities, agencies, as well as land use planners and environmental consultants.

On 22.05.2009. a workshop was organized between KALME researchers and the national body responsible for the preparing river basin management plans (State Environment, Geology and Meteorology Agency). The workshop was not only a venue for proposing adaptation measures for the plans, but also gave the opportunity to discuss the merits and shortcomings of various adaptation measures.

The scientific and economic significance of the results

The goal of Work package 7 was not to undertake research a such, however, a scientific result of the work is the compilation of themes/topics for future research related to the development of more appropriate measures for adaptation to climate change in the water sector.

The proposed measures for adaptation to climate change in Latvia are of strategic importance to economic development in Latvia because:

a) For the first time adaptation measures for climate change have been identified that are specific to the climate change impacts to be experienced by Latvia, more so than the measures presented in the EU White Paper on adaptation to climate change (01.04.2009).

b) Proposed adaptation measures can be used in sector planning activities to reduce negative impacts of climate change on the economy and to gain from the positive aspects of climate change.

c) The proposed adaptation measures will form the basis for the Latvian National Adaptation Strategy in the water sector and the methodology used in KALME can serve as a ”good practice” example to be used by other sectors.

d) Implementation of proposed adaptation measures could help lessen negative impacts on the complex and fragile Baltic Sea environment through the reduction of the discharge of biogenic compounds from adjacent land areas.

The adaptation to climate change brochure has economic added value as it provides many government sector personnel (national and municipal specialists and planners, river basin managers, land use planners, forestry, fisheries, communal services, energy, and agricultural specialists) and educators and researchers in Latvia with practical recommendations regarding adaptation to climate change.

7.4. Summary

Phase 4 activities of the KALME project resulted in the compilation and synthesis of research results and the formulation of sector-based recommendations and measures for adaptation to climate change. Additionally, the undertaken work has contributed to the Latvian National Adaptation Strategy and other legal and planning initiatives, as well as fostered discussions in the research community and state and municipal institutions regarding climate change and adaptation . The adaptation brochure will be a useful guide for many sectors of the economy when dealing with issues of adaptation to climate change.

Work Package Coordinator: Kristine 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 4 tasks of WP8:

1. Scientific supervision of the Programme, coordination of the WP work, daily management of the Programme implementation;
2. Organizing the annual Programme conference on 20th February, 2009;
3. Publishing of the Proceedings of the Conference;
4. Cooperation with the Ministry of the Environment in development of the climate adaptation policy;
5. Arranging of the 3rd meeting of the Advisory Board to ensure high level of Programme's scientific quality;
6. Dissemination of the outputs of the Programme to broad public.

Phase 4 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 management and the Work Packages scattered in different research institutions and universities, the Program Secretariat regularly arranges meetings of WP coordinators. In 2009, three such meetings have already been held.

Program Secretariat 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.

Task 2: *Organising of Program's annual conference (20 February 2009)*

Program's annual conference was held within the framework of the 67th annual Scientific Conference of University of Latvia. Session "Climate change and the waters of Latvia" took place on 20th February, 2009. Altogether, the session attracted more than 80 participants representing 3 universities of Latvia, several research institutions, as well as governmental and municipal authorities and other stakeholders. Participants were presented with 19 oral papers and 19 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.

Task 3: *Preparation and publishing collection of papers for University of Latvia 67th Conference session"Climate Change and Waters"*

During the 4nd phase a collection of papers presented at 67th UL Conference session “Climate Change and Waters” has been prepared and published. The 101-page book contains 34 papers and abstracts prepared by 62 authors.

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

In addition to the work described in the report of WP 7, in 2009 Programme participants took place in the elaboration of Latvian position regarding the climate change adapting solutions in the agricultural sector. Representatives of the Programme participated in presenting of information and formulating of the Latvian position concerning the EU ‘White Paper’ on adaptation to the climate change where information of the adaptation measures elaborated by the Programme participants was summarized.

Several participants of the Programme are members of the specialized work group established by the Minister of the Environment; programme director Prof. M. Kļaviņš is the chair of this work group. The objective of this group is to elaborate the adaptation strategy to the climate change. Thus, the application and implementation of the Programmes’ scientific results into development the state policy is streamlined.

Studies on significant principles and criteria to be taken into account while developing the national climate change adaptation policy and relevant regulations have been performed within the frames of the Programme. These issues are important also for harmonizing the national and international legislative frameworks. Opportunities to further develop the education on the climate change in the higher education system of Latvia have been undertaken as well.

Task 5: *Arranging of the International Advisory Board, and organizing of its 4st meeting.*

To facilitate the scientific quality of the Programme and secure its international visibility and links with the similar research activities in other countries, the International Advisory Board (IAB) was established. Several internationally reputable experts on the climate change research related with the water environment, as well as high level officers of the Latvian Ministry of the Environment responsible for elaboration of the climate change adaptation policy have been invited to join the IAB. The third session of the IAB will take place on 16th-17th November 2009 as a back-to-back event with the meeting of the BALTX Science Steering Group. Prior this meeting the results of Program will be reported to the BALTEX/KALME seminar „Impact of the Climate Change on the water Environment of Latvia, and its impact in the southern basin of the Baltic Sea”.

Task 6: *Public information about Programme results.*

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.

During the reporting period program coordinators gave many interviews to the media on the CC issues.

Work Package Coordinators A. Andrušaitis, M.Kļaviņš

Annexes

Annex1

Aggregated performance indicators and auditable values of the Program.

Resultativity indicators and auditable values	**Number**
Monographs	1
Defended PhD theses	1
Young researchers, PhD and MSc students involved in the program	4
Scientific publications in international and local sources	48
Reports to media	84
Presentations at conferences	18
Created new methods	130
Organized conferences and seminars	
Recommendations for elaboration of the environmental legislation; participation in the decision-making process and implementation of these decisions	14
Created original maps	31
Acquired and built laboratory devices	15

Annex 2

Published and submitted papers by the Program team.

Collection of Papers.

1. Climate change in Latvia (2008) (Ed. M.Kļaviņš), Rīga :LU
2. **M.Kļaviņš**, D.Blumberga, **I.Bruņiniece, A.Briede, G.Grišule, A.Andrušaitis, K.Āboliņa** (2008) Klimata mainība un globālā sasilšana. (M.Kļaviņa un A.Andrušaiša redakcija). LU Akadēmiskais apgāds: Rīga, 174 lpp.

Text book

Kļaviņš M., Blumberga D., Bruņiniece I., Briede, A., Grišule, G., Andrušaitis A., Āboliņa K. (2008) Klimata mainība un globālā sasilšana. LU Akadēmiskais apgāds, 174 lpp.

Climate change in Latvia (2008) (Ed. M.Kļaviņš), Rīga :LU

Scientific papers

1. **Andrušaitis A., Kļaviņš M**. (2007) Vides zinātne: klimata maiņas reģionālā ietekme uz ūdeņu ekosistēmām un adaptācija tai. Zinātne, pētniecība un inovācija Latvijas izaugsmei. LR Stratēģiskās analīzes komisija 3(14), Rīga: Zinātne, 142-163
2. **Bakute A., Apsīte E**. (2009). Konceptuālā modeļa METQ pielietošanas iespējas Latvijas upju hidroloģiskajā monitoringā (Aplication of the METQ for Hydrological Monitoring of Rivers in Latvia). Latvijas Universitātes raksti. Zemes un vides zinātnes (Acta Universitatis Latviansis, Earth and Enviroment Sciences) Nr. 724., Rīga, pp 77-88.
3. **Balode M., Purvina S., Purina I., Yurkovska V., Barda I., Strode E., Putna I., Balodis J., Pfeifere M.** (iesniegts) Experimental studies on the possible impact of climate change on development of Baltic HAB species. Proceedings of the 13th ISSHA, November 2008.
4. **Bethers U., Seņņikovs J.** (2009). Ensemble modeling of impact of climate change on runoff regime of Latvian rivers. Proc. 18th World IMACS / MODSIM Congress, Cairns, Australia.
5. **Bethers U., Seņņikovs J., Timuhins A., Valainis A., Bethers P.** (2009). Ensemble modeling of impact of climate change on runoff regime of Latvian rivers. J. of Stochastic Environmental Research and Risk Assessment (submitted)
6. Blumberga D., **Kļaviņš M**. (2009) Climate change education in Latvia. In: “Climate change education”, Emerald Press, (accepted for publication)
7. **Briede A,**, L.Lizuma, **M.Klavins** (2009) Long term changes of precipitation in Latvia. Hydrol. Res. (accepted for publication)
8. **Briede A**., Lizuma L.,**Klavins M**. (2009) Long term changes of precipitation in Latvia. Hydrol. Res. (accepted for publication)

9. **Bruniniece I., Klavins M.** (2009) Normative principles for adaptation to climate change policy design and governance Int. J. Clim. Change Strat. Manag., (accepted for publication)
10. Casini, M., Hjelm, J., Molinero, J.-C., Lövgren, J., Cardinale, M., Bartolino, V., Belgramo, A. and **Kornilovs,** G. (2009). Trophic cascades promote threshold-like shifts in pelagic marine ecosystems. Proc. of the Nat. Ac. of Sci. of the USA, Vol. 106, No 1, 197-202.
11. Casini, M., Lövgren, J., Hjelm, J., Cardinale, M., Molinero, J.-C. and **Kornilovs, G.** (2008). Multi-level trophic cascades in a heavily exploited open marine ecosystem. Proc. of the Royal Society B, 275: 1793-1801.
12. Conley, D., Björck, S., Bonsdorff, E., Carstensen, J., Destouni, G., Gustafsson, B.G., Hietanen, S., Kortekaas, M., Kuosa, H., Markus Meier, H.E., **Müller-Karulis, B**., Nordberg, K., Norkko, A., Nürnberg, G., Pitkänen, H., Rabalais, N.N., Rosenberg, R., Savchuk, O.P., Slomp, C.P., Voss, M., Wulff, F., and Zillen, L. (2009) Hypoxia – related processes in the Baltic Sea. Environmental Science & Technology. Vol. 43: 3412-3420.
13. Deelstra, J., Eggestad, H.O., Iital, A., **Jansons, V.** (2009). Extreme Runoff Conditions in Small Agricultural Catchments. XII Biennal International Conference Hydrological Extremes in Small Basins 18–20 September 2008, Cracow, Poland, Book of Abstracts. Jagiellonian University Cracow, Poland. ISBN 978-83-88424-38-0. pp 93-96.
14. Deelstra, J., Eggestad, H.O., Iital, A., **Jansons, V**. (2009). Hydrology in small agricultural catchments; pathways and their impact on nutrient and soil loss. In Hermann, A. & Schumann, S. (Eds). International Workshop on Status and perspectives of Hydrology in Small basins, Goslar – Hahnenklee, Federal Republic of Germany, 30 March – 2 April 2009: ISBN 978-3-89720-996-1, pp 75 – 79.
15. **Druvietis, I., Springe, G., Briede, A., Kokorīte, I. & Parele E**. 2009. A comparative assessment of bog aquatic environment of Ramsar site Teici Bog Reserve and North Vidzeme Biosphere Reserve, Latvia. LU raksti. Pieņemts publicēšanai.
16. **Eberhards G., Grīne I., Lapinskis J., Purgalis I., Saltupe B.,** Torklere A. (2009) Changes in Latvia's Baltic seacoast (1935-2008). Baltica, Vol. 22 (1);
17. **Grinberga, L**. and Priede, A. Elodea canadensis in Latvia. Acta Biologica Universitatis Daugavpiliensis. Pieņemta publicēšanai.
18. **Gruberts D.,** 20081. Use of a Drifting Instrumental Platform In A River-Floodplain Study. In: Sorial G. A., Hong J. (eds.) Proceedings of the 4th International Conference "Environmental Science and Technology 2008". Houston, Texas, USA, July 28-31 2008. v. 1, 39-46. ISBN 978-0976885306
19. **Ikauniece A., J. Aigars, B**. **Kalveka, V. Jermakovs and I. Jurgensone** (2009) Ecosystem changes and possible management solutions in the Eastern Baltic Sea – effort of Latvian KALME. ICES CM/G:13
20. **Ikauniece A., J. Aigars, B. Kalveka, V. Jermakovs and I. Jurgensone**. Marine environmental processes and biodiversity variation in the light of climate change – case of Latvia (iesniegts Boreal Environ.Res.).
21. Jaagus J**, Briede, A**., Rimkus, E., Kalle, R. (2009) Precipitation pattern in the Baltic countries under the influence of large-scale atmospheric circulation and local landscape factors. International Journal of Climatology (on line published)

22. **Jansons, V., Abramenko, K.,** Timbare, R**., Bērziņa, L.** (2009). Risk assessment of the agricultural pollution with nitrates in Latvia. LLU Raksti 22 (316), 2009; pp.1-11
23. Kalvāne, G, Romanovskaja, D, **Briede, A**, Baksiene, E (2009) Influence of climate change on phenological phases in Latvia and Lithuania. Clim Res 39:209-219.
24. **Kļaviņš M., Āboliņa K.** (2008) Globālā sasilšana un Latvija. Klimata pārmaiņas: izaicinājumi Latvijai starptautiskajā vidē (red. G.Reire) Latvijas Valsts prezidenta kanceleja: Rīga, 22-54
25. **Klavins M.,** Bruniniece I., V.Bisters (2009) Development of national climate change adaptation policy in Latvia. Int. J. Clim. Change Strat. Manag., 1(1), 75-91
26. **Klavins M., Rodinov V.** (2008) Long-term changes of river discharge regime in Latvia. Hydrol. Res., 39(2), 133-141
27. **Klavins M., Rodinov V.** (2009) Influence of large scale atmospheric circulation on climate change in Latvia. Boreal Environmental Research (submitted)
28. **Klavins, M., Briede, A., Rodinov, V.** (2009) Changes in ice regime of rivers in the Baltic region in relation to climate variability. Climate Change, Vol.95, Nr 3-4: 485-498.
29. **Klavinš, M., Rodinov, V., Timukhin, A., Kokorite, I.** (2008) Patterns of river discharge: long-term changes in Latvia and Baltic region. Baltica, 22 (1-2), 25-39
30. **Kokorite I., Klavins M., Rodinov** V. Impact of catchment properties on aquatic chemistry in rivers of Latvia. Water Research. Pieņemts publicēšanai 11.08.2009.
31. **Lapinskis J.** (2009) Jūras krasta rajonēšana Latvijā pēc litomorfodinamiskām pazīmēm. RTU Zinātniskie raksti, 19 (1), 168-174
32. Möllmann, C., Diekmann, R., **Müller-Karulis, B., Kornilovs, G., Plikshs, M.** and Axe, P. (2009) Reorganization of a large marinē ecosystem due to atmospheric and anthropogenic pressure: a discontinuous regime shift in the Central Baltic Sea. Global Change Biology. 15: 1377-1393, doi: 10.1111/j.1365-2486.2008.01814.x
33. **Paidere, J.** 2009. Influence of hydrology (flooding frequency) on zooplankton in the floodplains of the Daugava River (Latvia). Acta Zoologica Lituanica, Versita, Warsaw (In press).
34. **Sennikovs, J. and Bethers, U**. (2009), Statistical downscaling method of regional climate model results for hydrological modelling. Proc. 18th World IMACS / MODSIM Congress, Cairns, Australia.
35. **Skuja, A., Ozoliņš, D. and Poppels, A.** (2009) Seasonal and diel pattern of mayfly (Ephemeroptera) drift in Korge stream in Latvia. – In: International Perspectives in Mayfly and Stonefly Research. Proceedings of the 12th International Conference on Ephemeroptera and the 16th International Symposium on Plecoptera, Aquatic Insects 31, Supplement 1, Stuttgart. In press.
36. **Škute A., Gruberts D., Soms J, Paidere J.** 2008[3]. Ecological and hydrological functions of the biggest natural floodplain in Latvia. Ecohydrology & Hydrobiology, vol 8, No 2-4:77-92

---

[3] Tika publicēts 2009.gadā.

37. **Springe G., Grinberga L. and Briede A.** The role of the hydrological and hydromorphological factors in the forming of ecological quality of the medium-sized lowland streams. Hydrology Research. In press.
38. **Springe, G., Briede, A., Druvietis, I., Parele, E., Rodinovs, V., Skuja**, A. Impacts of climate change on shallow lagoon lake ecosystem. Hydrobiologia. Iesniegts publicēšanai.
39. Tomczak, M.T., **Müller-Karulis, B.,** Järv, L., Kotta, J., Martin, G., **Minde, A**., Põllumäe, A., Razinkovas, A., **Strake, S.,** Bucas, M., Blenckner, T. (2009) Progress in Oceanography. Article in press. Doi:10.1016/j.pocean.2009.04.017.

Prepared publications

1. **Apsīte E., Bakute A.** and Kurpniece K., Pallo I. Climate Change Impacts on River Runoff at the End of the 21st Century in Latvia. FENNIA, NGM Special Issue (pieņemta publicēšanai)
2. **Apsīte E., Bakute** A. and Kurpniece K., Pallo I. River Runoff Projection of Future Climate in Southeast of the Baltic Sea Basin. Climate Research, Special 23 /Enviromental change and socio-economic response in the Baltic region/, (iesniegta publicēšanai)
3. **Jansons, V., Sudars.R,** (2009) Dimensions of Agri-Environmental Research in the Department of Environmental Engineering and Water Management. Pieņemts publicēšanai LLU rakstos)

Abstracts

1. Aksjuta K., Bāra J., **Lazdāns D.,** Nitcis M., 2009. Nature management plans and awareness raising for local people applying GIS tools. Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 44.lpp.
2. **Aleksejevs, Ē. un Birzaks, J.** (2008) Spidiļķa Rhodeus amarus Bloch izplatība Latvijā. LU 66. zinātniskā konference. Klimata mainība un ūdeņi. Rakstu krājums, Rīga, LU: 5-6.
3. **Balode M., Purviņa S., Puriņa I., Bārda I., Strode E., Putna I., Balodis J., Pfeifere M., Jurkovska V**. Globālās sasilšanas varbūtējā ietekme uz bīstamo aļģu attīstību Baltijas jūrā. LU 67. konferences Rakstu krājums Klimata mainība un ūdeņi, Februāris 2009, LU, Rīga.
4. **Balode M..** Climate impact on HAB. Report of the ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD), 31th March- 2nd April.
5. **Bārda I., Puriņa I., Purviņa S., Balode M**.. Toksisko aļģu attīstība un mikrocistīnu producēšana Pierīgas ezeros. LU 67. konferences Rakstu krājums Klimata mainība un ūdeņi, Februāris 2009, LU, Rīga.
6. **BārdaI, Purina I., Balode M**. Structural analyses of summer phytoplankton as indicator of water quality in eutrophic – hypertrophic lakes. ASLO Aquatic Sciences Meeting 2009, 25-30 January, Nice, France.
7. **Birzaks, J**. Jauna zivju suga Sabanejewia aurata (De Filippi, 1865) Latvijā. LU 67.Zinātniskā konference, 20.02.2009.„Klimata mainība un ūdeņi”. Rakstu krājums LU, 2009.
8. Brakovska A., Stepanova M., Škute R., **Škute A.,** 2009. Diversity survey of samples of Rotatoria group in lakes Svente and Brigene. Book of abstracts of 5th International Conference "Research and conservation of biological diversity in Baltic Region”. Daugavpils, Latvia. p.25.
9. Deksne R., **Škute A.**, Škute R. 2009. Dynamics of zooplankton in Daugava through seasons in the section of the river between Kraslava and Dunava. Book of abstracts of 5th International Conference "Research and conservation of biological diversity in Baltic Region”. Daugavpils, Latvia. p.32 - 33.
10. Deksne R., **Škute A**., Škute R. 2009. Klimata mainības ietekme uz Daugavas zooplanktonu Latvijas un Baltkrievijas teritorijā. Latvijas Universitātes 67.zinātniskās konferences tēzes. Sējums „Klimata mainība un ūdeņi” – Rīga, LU akad.apgāds, 2009. 55.-62.lpp.
11. **Druvietis, I**. (2009) Lagūnas tipa piejūras ezeru fitoplanktona īpatnības. LU 67.Zinātniskā konference, 20.02.2009.„Klimata mainība un ūdeņi”. Rakstu krājums LU, 2009:63
12. **Druvietis, I. Konošonoka, I., and Parele, E.** (2009) Structure of periphyton communities associated with substrate type in lower reaches of Salaca River, North Vidzeme biosphere Reserve In: 5th International Conference “Research and conservation

of Biological diversity in Baltic region, Book of Abstracts, Daugavpils 22-24 April 2009: .39.

13. **Druvietis, I., Kokorīte, I., Poppels, A. and Skuja, A.** (2009) Influences of water and substrate quality for periphyton and invertebrate communities in small rivers of western Latvia and Slītere National park”. In: 5th International Conference “Research and conservation of Biological diversity in Baltic region”. Book of Abstracts, Daugavpils 22-24 April 2009: 40.
14. Gårdmark, A. Wikström, A., Bastardi. F., Eero, A., **Müller-Karulis, B**., Heikinheimo, O., Neuenfeldt, S., van Leeuwen, A., Lindegren, M., Tomczak, M., Niiranen, S., Blenckner. T. "Biological Ensemble Modelling of the Eastern Baltic cod future" at the ICES/PICES/UNCOVER Symposium on Rebuilding Depleted Fish Stocks – Biology, Ecology, Social Science and Management Strategies, Warnemünde, November 4th, 2009.
15. Gårdmark, A. Wikström, A., Bastardi. F., Eero, A., **Müller-Karulis, B**., Heikinheimo, O., Neuenfeldt, S., van Leeuwen, A., Lindegren, M., Tomczak, M., Niiranen, S., Blenckner. T. "Biological Ensemble Modelling to improve fisheries science & management" at the workshop on The marine ecosystem in changing climate - on the added value of coupled climate-environmental modelling of the Baltic Sea, Swedish Meterological and Hydrological Institute, Norrköping, October 16th, 2009.
16. Gårdmark, A. Wikström, A., Bastardi. F., Eero, A., **Müller-Karulis, B**., Heikinheimo, O., Neuenfeldt, S., van Leeuwen, A., Lindegren, M., Tomczak, M., Niiranen, S., Blenckner. T. "Ensemble modelling of the Baltic Cod Future" at the IBED Conference: Linking Science and Management in the Baltic Sea Ecoregion, Copenhagen, September 10th 2009.
17. **Grīnberga, L** (2009) Makrofīti kā ūdens kvalitātes indikatori Salacā. LU 67.Zinātniskā konference, 20.02.2009.,,Klimata mainība un ūdeņi. Rakstu krājums LU, 2009: 65-67.
18. **Grīnberga, L** Including aquatic vegetation as bioindicators in educational process on environmental studies. In: 3rd International conference, Environmental science and education in Latvia and Europe: Education and science for climate change mitigation, Conference proceedings, October 23 2009, Riga: 33-34
19. **Grinberga, L.** (2009) Environmental factors influencing the distribution of macrophytes in middle-sized streams in Latvia. In: Reports of Finnish Environmetal Institute 15/2009: 154.
20. **Grīnberga, L.** and Priede, A. (2009) Invasion of Elodea canadensis in Latvia In: 5th International Conference „Research and Conservation of Biological Diversity in Baltic Region”, Daugavpils, 22-24.04.2009: Book of Abstracts, „Saule”, Daugavpils, 2009: 50.
21. Grinvalds K. Differences of benthic vegetation community at two coastal sites of the Gulf of Riga. 7th BSSC, 17-21 August, Tallinn, Estonia.
22. Grišanovs A., **Soms J.,** 2009. ĢIS risinājumi augsnes erozijas iespējamības novērtēšanai dabas parkā „Daugavas loki”. Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 42.lpp.

23. **Gruberts D.,** 2009. Klimata un Daugavas noteces ilgtermiņa mainība Daugavpilī. Krāj.: Plikša I. (sast.) Klimata mainība un ūdeņi. Latvijas Universitātes 67. zinātniskā konference „Klimata mainība un ūdeņi”. Rīga, Latvia, 2009.gada. 20. februāris. Rīga, LU Akadēmiskais apgāds, 68.-75. lpp.
24. Gruberts D., **Soms J.,** 2009. Runoff Extremes of the Daugava River at Daugavpils (Latvia). In: Kovar P., Maca P., Redinova J. (eds), Water Policy 2009, Water as a Vulnerable and Exhaustible Resource. Proceedings of the Joint Conference of APLU (Association of Public and Land-Grant Universities) and ICA (Association for European Life Sciences Universities). Prague, CULS Prague, Czech Republic, 23 – 26 June 2009. p.180. ISBN 978-80-213-1944-8
25. **Gruberts D.**, Uļjans J., 2009. Ūdens fizikāli ķīmisko parametru mainība Dvietes palienes ūdens objektos 2007. - 2008. gadā. Krāj.: Ģeogrāfija. Ģeoloģija. Vides zinātne. Latvijas Universitātes 67.zinātniskā konference. Rīga, 2009. g. 30. janvāris. Rīga, LU Akad. apgāds, 49.-51. lpp.
26. **Gruberts D**., Zutis J., 2009. Upes micīte (Ancylus fluviatilis) kā ūdens vides stāvokļa bioindikators: Akmeņupes piemērs. Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 40. lpp.
27. Harlinska A., **Strake S., Labucis A**. Population structure and reproduction of the copepod Acartia bifilosa in the Gulf of Riga, Baltic Sea: field data. 7th BSSC, 17-21 August, Tallinn, Estonia.
28. **Ikauniece A., J. Aigars, B. Kalveka, V. Jermakovs and I. Jurgensone**. Marine environmental processes and biodiversity variation in the light of climate change – results of the Latvian National research programme. 7th Baltic Sea Science Congress, Tallinn, 17-21 August, 2009.
29. **Ikauniece A., J. Aigars, B. Kalveka, V. Jermakovs and I. Jurgensone**. Ecosystem changes and possible management solutions in the Eastern Baltic Sea – effort of Latvian KALME. ICES Annual Science Conference, Berlin, 21-25 September, 2009.
30. Iliško E., **Soms J.,** 2009. Dabas vērtības Lazdukalna upītes ielejā un Daugavas ielejas Ververu lokā. Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 8.lpp.
31. Jurkjāne I., **Parele E., Škute A.,** 2009. Study of ecological conditions of the river Daugava from Piedruja to Plavinas. Book of abstracts of 5th International Conference "Research and conservation of biological diversity in Baltic Region”. Daugavpils, Latvia. p.61.
32. Jurkjāne, I**., Parele, E., Škute., A.** (2009) A study of an ecological conditions of the River Daugava from Piedruja to Plavinas. 5th International Conference “Research and Conservation of Biological Diversity in Baltic Region”, Book of Abstracts, Daugavpils, 22 – 24 April 2009: 61.
33. **Kokorite I., Konosonoka I., Druvietis I. (**2009) Assessment of water quality and ecological status of the Lake Burtnieks, North-Vidzeme Biosphere Reserve, Latvia. 2nd European Large Lake Symposium 2009. Norrtälje, Sweden. 10.–14.08.2009.

34. **Kokorīte I., Rodinovs V.** (2009) Ūdens kvalitātes mainība Daugavā. LU 67.zinātniskā konference. 02.02.2009.
35. **Kornilovs, G.,** Raid, T., and Stepputis, D. Do the regular reading exercises improve the quality of assessment? The case of Baltic herring. ICES Annual Science Conference, Berlin, 21-25 September, 2009.
36. Korsaka J., **Osipovs S**., 2009. Ortofosfātjonu satura noteikšana Daugavpils upēs (Laucesa, Meļņička, Gļinovka, Šuņupe, Daugava), izmantojot spektrometrisko noteikšanu ar plūsmas analīzes metodi (FIA). Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 15.lpp.
37. Kursīts D**., Soms J.,** 2009. Dabas pieminekļi dabas parkā „Daugavas loki” ekotūrisma attīstības un dabas aizsardzības pasākumu kontekstā. Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 43.lpp.
38. **Laizāns K., Soms J.,** 2009. Noteces veidošanās apstākļu ietekme uz biogēnu un suspendētā materiāla pārneses apjomiem no gravu sateces baseiniem Daugavas ielejā. Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 19. lpp.
39. **Lapinskis J.** (2009) Coastal erosion risk in Latvia and climate change mitigation. Environmental science and education in Latvia and Europe: Education and science for climate shange mitigation. Riga, October 23, 2009. Proceedings pp. 55-57.
40. **Lazdāns D.,** 2009. Conservation biology of specially protected nature territories using GIS tools. In: Book of abstracts. 5th International Conference “Research and Conservation of Biological Diversity in Baltic Region”. Daugavpils, Latvia, 22 – 24 April, 2009. Daugavpils University Acad. Press. “Saule”, p.81.
41. **Lazdāns D.,** Mozulis J., 2009. Daugavpils pilsētas un Daugavpils rajona tūrisma iespēju interaktīvā datu bāze. Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 41.lpp.
42. Lizuma L., **A.Briede, M.Kļaviņš** : Ekstremālo nokrišņu ilgtermiņa mainības raksturs. Klimata mainība un ūdeņi. Rakstu krājums LU, 2009.
43. Lūkins M., Melluma A., **Soms J.,** 2009. Ainavu struktūras laiktelpisko izmaiņu analīze dabas parkā Daugavas loki: ģeogrāfiskie un kultūrvēsturiskie aspekti. Krāj.: Ģeogrāfija. Ģeoloģija. Vides zinātne. Referātu tēžu krājums. Latvijas Universitātes 67.zinātniskā konference. Rīga, 2009.g. 03.februāris. Rīga, LU Akad. apgāds, 93.-95.lpp.
44. Lūkins M., **Soms J.,** Melluma A., 2009. Temporal and Spatial Changes of Forest Habitats Structure in the Nature Park “Daugavas Loki”. In: Book of abstracts. 5th International Conference “Research and Conservation of Biological Diversity in Baltic Region”. Daugavpils, Latvia, 22 – 24 April, 2009. Daugavpils University Acad. Press. “Saule”, p.83.

45. **Ozoliņš D**. (2009) Dynamics of aquatic macroinvertebrate communities in the stream Slampe re-established riverbed. In: The Book of Abstract of International Conference for Students of Nature Sciences Coins 2009. Vilnius University. Faculty of Nature Sciences, April 21 – 25, Vilnius, Lithuania: 48.
46. **Ozoliņš, D. and Skuja, A.** (2009) Potential climate change impact on macroinvertebrate drift in Korģe stream. – In: 3rd International conference, Environmental science and education in Latvia and Europe: Education and science for climate change mitigation, Conference proceedings, October 23 2009, Riga: 70-71.
47. **Paidere, J.** Daugavas palieņu ezeru applūšanas biežuma ietekme uz zooplanktona cenozēm. 2009. Rakstu krājums. Klimata mainība un ūdeņi. Latvijas Universitātes 67. zinātniskā konference „Klimata mainība un ūdeņi". Rīga, Latvia, 2009.gada. 20. februāris, Rīga, LU Akadēmiskais apgāds, 76.-77.lpp.
48. **Paidere, J.,** Čevere I., Stalidzāne D. 2009. Dvietes un Skuķu ezera zooplanktona raksturojums. Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009. gada 15.-18. aprīlis. Daugavpils, DU Akadēmiskais apgāds „Saule", 39.lpp.
49. **Paidere, J.,** Stalidzāne D., Čevere I. 2009. Taxonomical distribution and diversity of zooplankton in the Daugava River and their floodplains (Latvia). Book of Abstracts 5th Internaciona Conference „Research and Conservation of Biological Diversity in Baltic Region". Daugavpils, 22 – 24 April 2009, Latvia., 99.
50. Pupiņa A., Pupiņš M., **Škute A**. 2009. Bombina bombina L. areāla paplašināšanās Latvijā kā klimata pasiltināšanās iespējamās sekas. Latvijas Universitātes 67.zinātniskās konferences tēzes. Sējums „Klimata mainība un ūdeņi" – Rīga, LU akad.apgāds, 2009. 80.-81.lpp.
51. Pupiņš M., Pupiņa A., **Škute A.** 2009. Klimata pasiltināšanās un iespējamās Emys orbicularis L. pirmās ziemošanas sekmīgu stratēģiju skaita paplašināšanās Latvijā. Latvijas Universitātes 67.zinātniskās konferences tēzes. Sējums „Klimata mainība un ūdeņi" – Rīga, LU akad.apgāds, 2009. 82.-83.lpp.
52. **Purviņa S., Puriņa I., Bārda I., Strode E., Putna I., Jurkovska V., Balode M.** Paaugstinātas temperatūras ietekme uz Rīgas līča ziemas sezonas fitoplanktonu un bakterioplanktonu. LU 67. konferences Rakstu krājums Klimata mainība un ūdeņi, Februāris 2009, LU Rīga.
53. **Purviņa S., Purina I., Barda I., Strode E., Putna I., Yurkovska V., Balode M.** The effect of elevated temperature on autumn phytoplankton and bacterioplankton from the Gulf of Riga. ASLO Aquatic Scientific Meeting. 25-30 January 2009 Nice, France.
54. Raid, T**., Kornilovs,** G., Lankov, A., Nisumaa, A.-M., Shpilev, H. and Järvik, A. Dynamics of the Gulf of Riga herring stock: combined effects of stock and environment. ICES/PICES/UNCOVER Symposium on Rebuilding Depleted Fish Stocks – Biology, Ecology, Social Science and Management Strategies, Warnemünde, November 4th, 2009.
55. Razdobudko J., **Soms J**., 2009. Meža biotopu laiktelpiskās izmaiņas dabas parka „Daugavas loki" Daugavpils rajonā ietilpstošajā daļā. Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule", 8.lpp.

56. Rutkovska S., Zeiļa I., Pučka I., Litvinceva J., 2009. Spatial distribution of separate widely spread invasive plant species. A case of the Ruģeļi and Grīva housing estates of Daugavpils. In: Book of abstracts. 5th International Conference "Research and Conservation of Biological Diversity in Baltic Region". Daugavpils, Latvia, 22 – 24 April, 2009. Daugavpils University Acad. Press. "Saule", p. 119.
57. **Skuja, A**. (2009) Drift and microhabitat preference of caddisflies Trichoptera in Tumšupe stream. – In: 13th International Symposium on Trichoptera, Program & Abstracts. 22-27 June, 2009, Bialowieza, Poland: 34.
58. **Škute A., Soms J., Paidere J., Gruberts D**., 2009. Impact of climate change on the biggest natural river-floodplain system in Latvia. ASLO Aquatic Sciences Meeting 25-30 January, Nice, France, - p.248.
59. **Soms J**., 2009. Lineārās erozijas un nogāžu procesu veidotie reljefa kompleksi Daugavas ielejā Krāslavas – Naujenes posmā kā vides izmaiņu indikatori holocēnā. Krāj.: Ģeogrāfija. Ģeoloģija. Vides zinātne. Referātu tēžu krājums. Latvijas Universitātes 67.zinātniskā konference. Rīga, 2009.g. 30.janvāris. Rīga, LU Akad. apgāds, 246.-248.lpp.
60. **Soms J.,** Iliško E., 2009. Aizsargājamo biotopu un augu sugu atradņu telpiskais izvietojums Lazdukalna upītes ielejā un Ververu lokā (Daugavas senleja). Krāj.: Ģeogrāfija. Ģeoloģija. Vides zinātne. Referātu tēžu krājums. Latvijas Universitātes 67.zinātniskā konference. Rīga, 2009.g. 04.februāris. Rīga, LU Akad. apgāds, 56.-58.lpp.
61. **Soms J.,** Iliško E., 2009. Analysis of Spatial Distribution of the Sedge Carex pilosa Scop. With Respect to Erosion Landforms in South-Eastern Latvia: Ecogeomorphological Aspects. In: Book of abstracts. 5th International Conference "Research and Conservation of Biological Diversity in Baltic Region". Daugavpils, Latvia, 22 – 24 April, 2009. Daugavpils University Acad. Press. "Saule", p.130.
62. **Soms J., Laizāns K**., 2009. Biogēnu un suspendētā materiāla pārnese no gravu sateces baseiniem Augšdaugavas pazeminājumā dažādos noteces veidošanās apstākļos. Krāj.: Ģeogrāfija. Ģeoloģija. Vides zinātne. Referātu tēžu krājums. Latvijas Universitātes 67.zinātniskā konference. Rīga, 2009.g. 30.janvāris. Rīga, LU Akad. apgāds, 81.-83.lpp.
63. **Soms, J.** 2009. Re-activation of erosion processes in permanent gullies as geomorphic response to extreme rainfall event. Folia Geographica: Series Geographica – Physica. ISSN 0071-6715 accepted and corr., in press.
64. **Spriņģe, G., Aleksejevs, Ē., Birzaks, J., Druvietis, I., Grīnberga, L., Parele, E.** (2009) Klimata maiņas strukturālie un funkcionālie indikatori iekšzemes ūdeņos. Klimata mainība un ūdeņi. LU Rakstu krājums, 2009: 99.
65. **Spriņģe, G., Briede, A., Kokorīte, I., Druvietis, I., Grīnberga, L., Parele, E**. 2009. Ilgtermiņa pētījumi Latvijas saldūdeņos. Geogrāfija. Geoloģija. Vides zinātne: Referātu tēzes. LU, 2009.
66. **Spriņģe,** G..Climate change indicators in freshwaters of Latvia. In: 3rd International conference, Environmental science and education in Latvia and Europe: Education and science for climate change mitigation, Conference proceedings, October 23 2009, Riga:86-87.

67. **Strāķe S**. Baltijas jūras planktonā dominējošā kopepoda Acartia bifilosa izplatība un olu produkcija saistībā ar vides faktoriem: lauku dati. LU 67 konference Zinātniskā Klimata mainība un ūdeņi, Februāris 2009, LU Rīga.
68. Strazdiņa, S., **Spriņģe, G.** The role of actual scientific researches in raise of awareness about climate change. In: 3rd International conference, Environmental science and education in Latvia and Europe: Education and science for climate change mitigation, Conference proceedings, October 23 2009, Riga:89-90.
69. Tukāns A., **Osipovs S**., 2009. Amonija jonu satura noteikšana Ilūkstes upes ūdeņos, izmantojot spektrometrisko noteikšanu ar plūsmas analīzes metodi (FIA). Krāj.: Oļehnovičs D. (sast.), Daugavpils Universitātes 51. starptautiskās zinātniskās konferences tēzes. DU 51. starptautiskā zinātniskā konference, Daugavpils, Latvija, 2009.g. 15.-18. aprīlis. Daugavpils, DU akad.apgāds „Saule”, 17.lpp.

Annex 3

Program Performance Indicators

WP **No.**	Workpackage results	**Performance indicator**	**Planned number**	**Accomplished till 16.11.2009**
DP1	Quantitative scenarios of the climate change impacts	Data series	**1**	✓
	Forecast of the influence of climate change on rive runoff and its seasonal and long-term change	Data series		✓
	Model analysis	Publications	**2**	**13**
	Regionally adapted drainage basin model (discharge, nutrient runoff)	Understanding of the hydrological and nutrient cycles in surface waters.		**9**
	Projection of the nutrient loading	Mathematical model (method)		✓
		Publications	**2**	✓
		Data series		**7**
	Regionally adapted 3D marine state model	Understanding of the interrelationships of marine state parameters		**15**
		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..		**0**
		Publications	**3-5**	**2**
		Conferences	**1**	✓

WP **No.**	Workpackage results	**Performance indicator**	**Planned number**	**Accomplished till 16.11.2009**
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**	**3**
		Recommendations to LV Geology Meteorology and Environment Agency	**2**	**1**
	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**	**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**	**47**
		Recommendations to Ministry of Environment	**1**	**3**
	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**	**15**
		Recommendations for water protection legislation, assessment of water quality and protection.	**2**	**4**
	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**
		Scientific publications	**2**	**7**
		Recommendations for water protection legislation, assessment of water quality and protection		**40**

WP **No.**	Workpackage results	**Performance indicator**	**Planned number**	**Accomplished till 16.11.2009**
		Research publications.	**2**	5
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.		✓
		Recommendations to the government and municipal authorities.	**1**	**2**
		Research publications.	**2**	**5**
	Digital maps of the contemporary processes of the coasts of Latvia:	Visualization of the coastal processes and risks.		✓
	a)projection maps for the cases of extreme storms;	Cartographic material	**4**	**13**
	b)map of main erosion risk zones;	Recommendations	**1**	**1**
	c)map of the contemporary coastal geological processes;			
	d)map of the protected nature area in the coastal strip;			
	e)map of the significant objects in the coastal erosion risk zone.			
	Recommendations for the purposes of coastal planning, territorial planning of municipalities, management activities and protection.	Development of dialogue with governmental and municipal authorities.		
		Proposals for the national planning.	**1**	**1**
		Proposals for development of the environmental monitoring program.	**1**	**1**

WP **No.**	Workpackage results	**Performance indicator**	**Planned number**	**Accomplished till 16.11.2009**
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**	**10**
		Data sets to be assimilated into the model	**1**	**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**	**2**
		Scientific publications about the model and forecasting results.	**1**	**2**
		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**	**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**	**1**
		Scientific publication.	**1**	**1**

WP **No.**	Workpackage results	**Performance indicator**	**Planned number**	**Accomplished till 16.11.2009**
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, and Elaboration and implementation of the European Marine Strategy Directive.		✓
		Scientific publications	**2**	2
	Prognostic model of fish growth, dynamics of fish stock, and structure of the fish community depending on development scenarios of the climatic and antropogenic impacts. 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**	1
		Information and knowledge basis necessary to create and implement a sustainable management policy of the living marine resources.	**1**	1
		Scientific publications	**2**	2
	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).		✓
		Proposals for protection of the marine biological diversity off the coasts of Latvia.		✓

WP **No.**	Workpackage results	**Performance indicator**	**Planned number**	**Accomplished till 16.11.2009**
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**	**3**
		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**	**12**
	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.**	**10.12.2009.**
		Conferences and seminars.	**3**	**3(+1)**
				1(+1)
DP9	Data on the re-occurrence and intensity of the past runoff extremes.	Data series.	**1**	**1**
		Scientific publications	**1**	**1**
	Prognostic hydrological data series, modelling of the flood and drought character.	Data series	**1**	**1**
		Mathematical model	**1**	**1**
		Scientific publications	**2**	**1**
	Digital terrain model of the Naujeine – Jekabpils stretch of the Daugava valley.	Data series	**1**	**1**
		ĢIS database	**1**	**1**
		Scientific publications	**1**	**1**

WP **No.**	Workpackage results	**Performance indicator**	**Planned number**	**Accomplished till 16.11.2009**
	Ecosystem changes in the floodplain lakes of the Daugava mid-flow assessed.	Data series	**1**	**1**
		Mathematical model	**1**	**1**
		Scientific publications	**3**	**4**
		Conferences	**2**	**21**
	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	**2**	**3**
		Recommendations to the Ministry of Regional Development and Local Governments, Ministry of the Environment and Ministry of Agriculture.	**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	**1**	**1**
		Scientific publications	**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**	**2**
8DP	Effective governance of the program and coordination of the collaboration of WPs.	Meetings of the WP Coordinators	**13**	**11**
		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**	**3**

WP **No.**	Workpackage results	**Performance indicator**	**Planned number**	**Accomplished till 16.11.2009**
	Fair and transparent distribution of finances amongst the WPs of the Program facilitates effective use of the allocated funds. 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.	**4**	4
		Directions to the financier concerning the distribution of funds among the research institutes and universities participating in the Program.	**4**	4
		Precise and timely submitted financial reports.	**In accordance with the financier's schedule**	✓
	Effective strategy of information of the broad public about the impact of CC on the environment of the Baltic Region. Program has good visibility.	Created and systematically updated Program website.	**1**	1
		Information leaflet on the Program in two languages	**1 (500-1000 ex.)**	**2x500- ex.**
		Popular summary of the Program results.	**1 (500-1000 eks.)**	
		Series of popular publications about various findings of the Program.		
		Reports in media about the potential CC impact on waters of the Baltic Region and Latvia and the necessary adaptation activities.		✓
	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.	**At least 50%**	30%
		PhD defences on the topics of the Program	**At least 15**	6(5 more prepared)
		Annual Program conferences as a part of the Scientific conference of UL.	**3**	3+1 intl. conference
		International PhD courses	**3**	1

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							🟩	🟩	🟩	🟩	🟩	🟩 4B	🟩	🟩	🟩	🟩
	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.