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# Deliverable No.50

## Report on existing hydrological, climatological and limnological data in a Danube sub-basin including identification of gaps in the data and new analyses to be undertaken (Task 4.4).

**Organization name of lead contractor for this deliverable: UNIBUC-ECO**

**Revision Final**

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|---|---|---|
| **Dissemination Level (tick appropriate box)** | | |
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**Introduction**

This deliverable contains a description of the existing data, a short gaps analysis and the new task to be undertaken in order to reach the objectives of the Task 4.4. It contains also short information about the existing modeling effort on the phytoplankton and zooplankton communities and possible development for benthos communities as well as integration of models. A summary of existing data is been provided with minimal description of existing data including number of data, minimum, maximum, average and standard deviation. During the last couple of months the data set regarding the hydrology and climate has been enlarged with daily data on: water level of the Danube River in Braila station, discharge, air temperature and water temperature at the same station from 1957 up to 2005. This data set will allow a more accurate analysis of the changes (if any) occurred during the last almost 50 years in these parameters. In the same time it will allow us to link the existing time series in LDWS (Lower Danube Wetland System) on phytoplankton, zooplankton, benthos and macrophytes with data concerning these climatic and hydrological parameters in an attempt to distinguish between different drivers of changes and especially to tackle the influence of climate changes on river margin systems.

**Aim of the task 4.4:**
As defined in the project application the aims of the task 4.4 are:

1. Identification of effects of climate change on the buffer capacity of river marginal wetlands (along the lower stretches of large rivers) – Study case: Lower Danube Wetland System/ Small Island of Braila;
2. Analysis of knowledge on the relationships between riparian wetlands and adjacent surface waters including identification of gaps and requirements for new information.

**Objectives:**
The objectives established for the first 18 months of the project are:

a. Data sources identification
b. Identification of studies sites
c. Designing and development of the database
d. Data quality assurance
e. Collection of data
f. Evaluation of data quality
g. Specification of requirements on climatic scenarios
k. Completion of database

## Approach for WP1- Task 4.4.

Based on an extensive analysis of existing data, information and knowledge about the Lower Danube River System we are proposing to use as an effective approach the model presented in figure 1. We are expecting that based on our long-term database (daily values from 1957 up to 2005 on several climatic and hydrological parameters) to be able to distinguish trends or patterns in the data that could provide indication about the changes occurred in the last 50 years. The LDWS has suffered multiple changes in the last 40 year and for example the actual surface of the wetlands has been reduced with 80 % from the initial floodplain surface due to damming. Important changes occurred also in the floodplain water retention capacity with a reduction of almost 4,5 cubic kilometers (Gastescu, 1993).

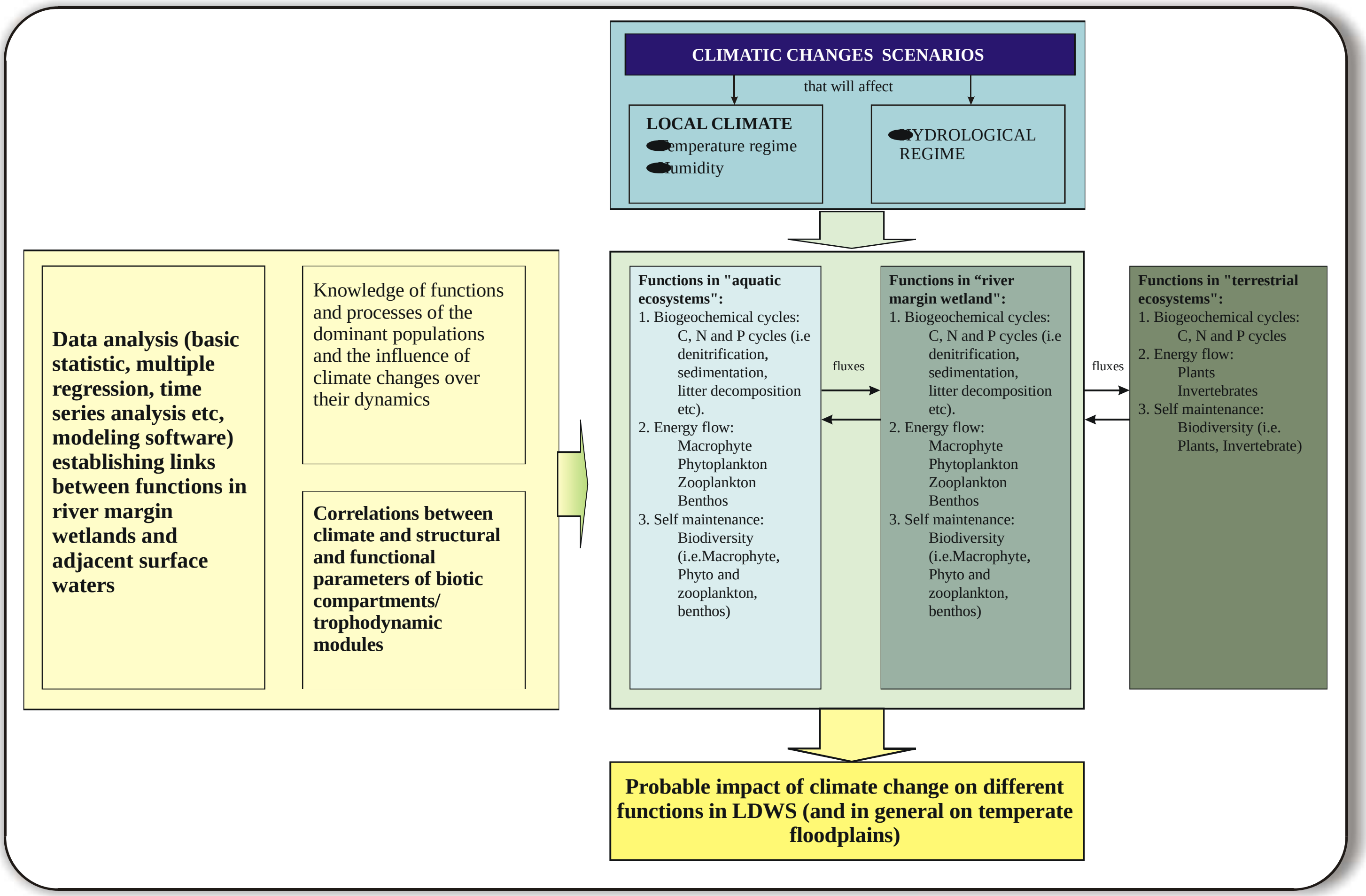



**Figure 1. Approach for data analysis in WP1 task 4.4**

The trend and pattern analysis must be realized in the context mentioned above but also complicated further by the development of two large reservoirs in the over Danube sector (Iron gate I and II) and of more than 45 other reservoirs in the middle and upper sectors of the Danube river. In the same time a huge number of reservoirs have been build along main tributaries for power generation or water supply. This complex situation will have a great importance in separating changes due to direct anthropogenic driving forces and to climate changes. Nevertheless we are hoping that we will be able to develop linkages between the main parameters of the climatic and hydrological setting on one hand and some of the ecological structures and processes on the other hand (as presented in the conceptual approach from figure1, see also the next part). Despite the fact that the database is comprising data about many other compartments (see list in legend of figure 4) we are focusing our effort on four main groups (biotic compartments/ tropho-dynamic modules): phytoplankton, zooplankton, benthic invertebrates and wetland vegetation.

**Identification of studies sites and main compartments/tropho-dynamic modules**

The Lower Danube River System (LDRS) is comprising the river stretch of 840 km, between the Black Sea and the Iron Gate II man made reservoir together with the associated floodplains, inner and coastal deltas, functions as a key component of the second largest (2857 km long) river in Europe (Figure 2). It serves as a buffer system between the larger river basin and the sea bearing the footprint of the economies of the direct riverine countries: Romania, Yugoslavia, Bulgaria, Republic of Moldavia and Ukraine.

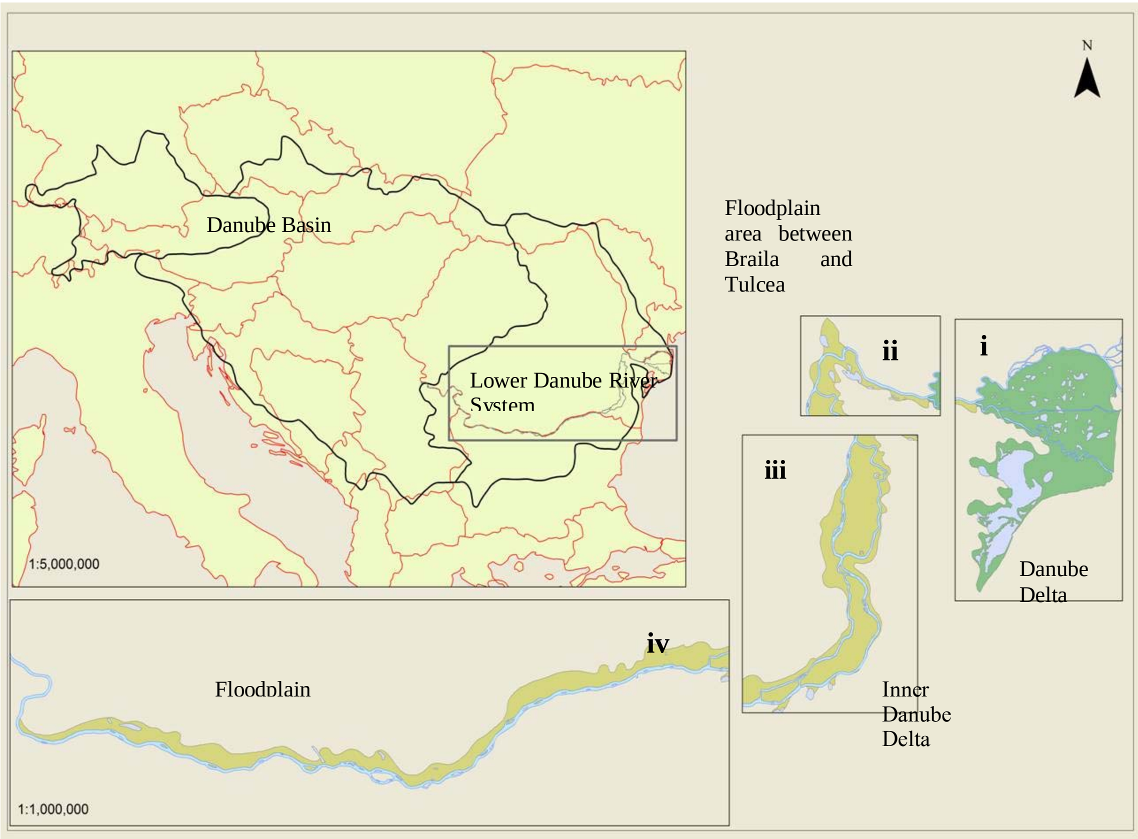
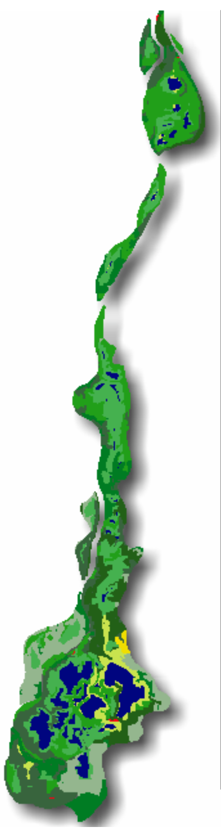



**Figure 2. Location and structure of Lower Danube River System (LDRS)**

This complex system is composed by 4 main components: i. Danube Delta with a surface of 5193 $km^2$ ii. the Danube floodplain with a surface of 700 $km^2$ between Danube Delta and Inner Delta
iii.Inner Delta with a surface of 2413 $km^2$ and iv. the Romanian side of the floodplain with a surface of 1500 $km^2$ (Vadineanu et al. 2001, 2002).
Our attention is focused on the downstream wetlands of LDRS namely the Lower Danube Wetlands System (LDWS), which form almost 80% of the whole system. The first 3 components (i, ii, iii) are part of the Lower Danube Wetlands system. The data collected so far is focusing on the LDWS mainly on the **Small Island of Braila** (part of the component iii) and Danube Delta (component i). Having a total surface of 8307 square kilometers and a high structural complexity the LDWS was and still remained one of the largest wetland systems in Europe.
Small Island of Braila (SIB) as mentioned before is a component of the Inner Danube Delta (iii) and it is one of the few areas from a total of 2413 square kilometers of natural wetlands that has been maintained under natural and seminatural condition. The total estimated surface of SIB is about 210 square kilometers, developed along Danube River stretch, between Danube kilometers 175 downstream and 237 upstream. The structure of the SIB comprises 13 habitat types, many of them included on the list of habitat directive (Table 1).

**Table 1. Major ecosystem categories and their spatial distribution in the Small Island of Braila wetland system**



| | Habitat type | Cod DH | Area (ha) |
|---|---|---|---|
| 1 | Natural eutrophic lakes | 3150 | 2318 |
| 2 | Forested marshes | 91E1* | 544 |
| 3 | Riparian Galleries and tickets | 92D0 | 1710 |
| 4 | *Salix* and *Populus* galleries | 92A0 | 3181 |
| 5 | Lowland hay meadow | 6510 | 1589 |
| 6 | *Typha* and reed beds and belts | 7410* | 2609 |
| 7 | Riparian mixed forest | 91F0 | 2238 |
| 8 | Meadows on calcareous | 6410 | 1604 |
| 9 | Alluvial forest | 91E0 | 46 |
| 10 | Alluvial meadow of river valley | 6440 | 60 |
| 11 | River with muddy banks | 3270 | 60 |
| 12 | Channels and Danube arms | 3280/3281* | 5100 |
| 13 | Anthropic systems | - | 15 |
| **Total area** | | | **21074** |

DH- EU Habitat Directive; * Not on the DH but important for the functioning of the SIB

**Danube Delta** is another key component of the LDWS with a total surface of more than 5000 square kilometers. It has a great diversity of geomorphologic features (river branches, network of subsidiary channels, lakes, levees, floodplains), providing a wide range of renewable resources and habitats for 1688 plant and 3735 animal species (Baboianu1998, Vadineanu et al. 1998).

It is obvious that many changes occurred in the SIB area as well as changes in the Danube Delta are interconnected and located mainly upstream in the Danube basin. A schematic representation of the LDRS is presented in figure 3, indicating also the links with upstream systems but also the interconnection (expressed through exchanges of energy and matter) between different system components. In fact the complexity of the investigated system is an argument for the long-term data analysis in order to meet the aim of task 4.4. In the same time together with the figure 4 (a representation of the different trophodynamic modules and their relationships at landscape and ecosystems level) shows the great diversity and complexity of modules for which the data must be obtain in order to characterize in full extent the state and the dynamics of this systems as a first step towards an integrated analysis of data and as a precursor for establishing the impact of climate changes on river margin wetlands.

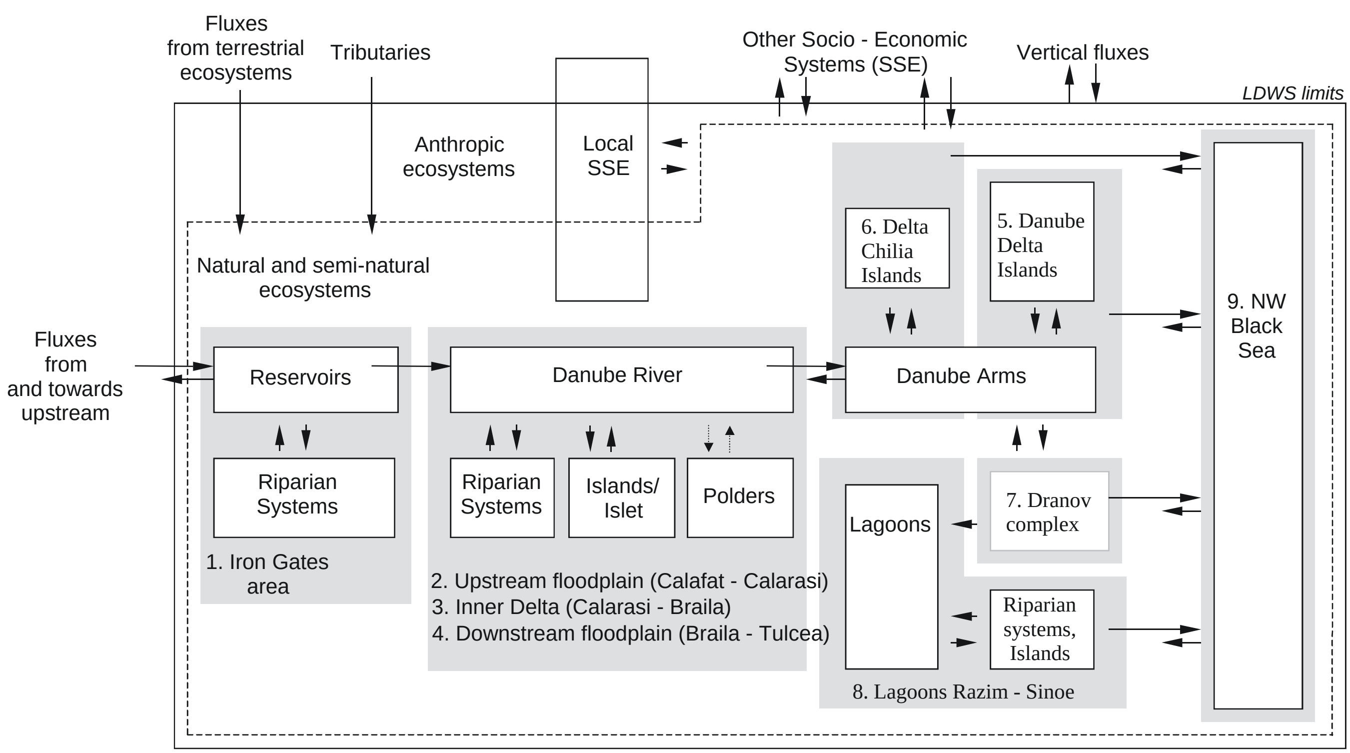



**Figure 3. Homomorphous model of the Lower Danube River System (ecosystem types and relationships)**

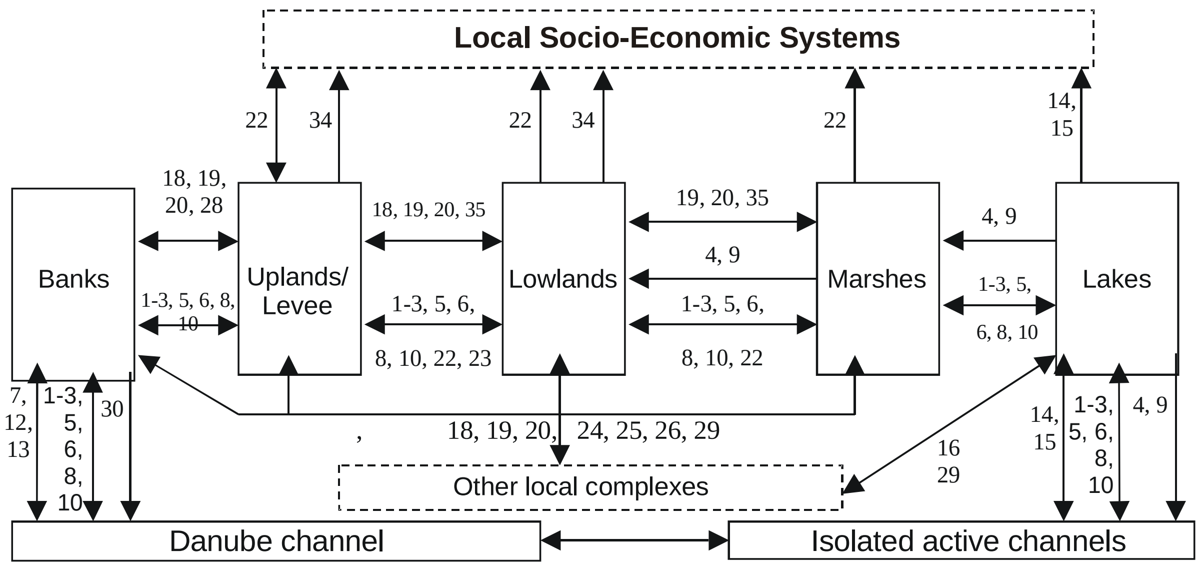



**Figure 4. Homomorphous model and components of the ecosystems types in LDWS (landscape and ecosystem level)**

Legend:

**1 Surface water**
**2, 3 Organic matter (dissolved/ particulate)**
**4 Aquatic plants**
**5 Phytoplankton**
6 Bacterioplankton
**7, 12, 13 Zoobenthos**
**8, 10 Zooplankton**
**9 Phytophylous fauna**
11, 14, 15 Fishes
**27 Soil/sediment**
28 Underground water
**29 Atmosphere**
**30 Detritus**
31 Terrestrial microorganisms
35 Amphibians
21, 22, 23 Mammals
16, 24, 25, 26 Birds
**32, 33, 34 Terrestrial plants**
**17, 18, 19, 20 Terrestrial invertebrates**

Having in mind that we are dealing with a very complex structure in terms of interconnected ecosystem types and diversity of compartments/trophodynamic modules as well as very complex relationships at different scales (within compartments up to relationships between ecosystems) we will focus our attention towards the following compartments: 1,2,3,4,5,7,9,12,1317,18,19,20,27,29, 30,32,33,34 (the compartment marked in the legend of figure 4).

## Data sources identified

A comprehensive analysis of different information sources has been carried out in the first months of the project. This is summarized in the table 2. An extensive bibliographical list is also available. Many of the existing data have been already included in the database and will be presented in the next section. It has to be mentioned that in many cases we do not have information about the quality of the former data.

In what concern the data provided as a result of different research project a metadata (including methods used) is available.

**Table 2. Research activity in the Lower Danube River System**

| PERIOD | INVESTIGATED AREA | AUTHORS | INVESTIGATED ASPECTS |
|---|---|---|---|
| 1879-1947 | Danube river and Danube Delta | Schaarschmidt 1879-1881 | Algae types in Romania (species list) |
| | | V.Grimalsky 1933-1938 | (Nutrients and general data about the influence of Danube river on Danube Delta lakes |
| | | V.Leonte 1942-1947 | Biological data on several lakes and small lakes in Danube Delta |
| 1956-1967 | Danube River | Leonte-Teodorescu, 1959 Oltean; Popescu-Gorj; E.Cristea; 1960, Busnita;Enaceanu; Brezeanu; 1961 | Influence of the hydrology on primary production |
| | Danube river and MW | Botnariuc-Beldescu, 1964, 1968, Gruia, 1969 | Primary production and productivity |
| 1970-1990 | Research Danube River and in Danube Delta | Boldor,O; Oltean,M; 1981<br>Botnariuc, Boldor, 1975.<br>Botnariuc et all 1981.<br>Oltean et all, 1985, Hiel'Ekueta<br>1985<br>Oltean,M; Nicolescu,N 1981 | More than 30 research contracts |
| 1990-2002 | Danube River and Danube Delta | Vadineanu et all.1990, 1992,1994<br>Cristofor,1994<br>Nicolescu N, 1996, 1995, | Relationship between the phytoplankton and light regime<br>Research project developed in the Danube Delta and floodplain area |
| 1990-2003 | Scaling up from processes and phenomena taking place in Danube delta to processes and phenomena that are taking place in the Danube floodplain area | Vadineanu et all.<br>Gomoiu et all. | |
| 1998-2004 | Scaling up from processes and phenomena taking place in Danube delta to processes and those from the Danube basin | Vadineanu et all. | International research programs at which the UNIBUC-ECO was partner |

**Existing data:**

A short summary of existing data for the above mentioned sites and tropho-dynamic modules include:

- Dynamics of the structural and functional parameters of the main tropho-dynamic modules (TDMs), hydrogeomorphic units (HGMUs) and locale climate (temperature, precipitation, light) as well as river hydrology (level, discharge) in the last 3 decades in the coastal Danube Delta and selected parts of former and existing floodplain and inner delta;
- Functional models of the relationships between different TDMs and HGMUs and mechanisms of response of the dominant populations to temperature, nutrient and light regimes, modulated by hydrological fluctuations (local river margin wetlands (RMW) and their aquatic and terrestrial adjacent ecosystems);
- Structural models and qualitative/ semi-quantitative functional relationships between main ecosystem types, including energy, mass and information transfer (population dispersion/ migration, nutrient retention/ releasing etc.).

**Database design**

The database was developed in Microsoft Access being a flat database, but having a hierarchical approach and in which biological compartments are described in terms of structural parameters and functional parameters. Climatic and physico-chemical as well as hydrological parameters are also included in the database. Metadata are also presented showing the methods used (this is especial useful in chemical analyses were methods have changed during years and the accuracy of the methods have also changes in time).

**Table 3. Existing data sets in the LDWS (Small Island of Braila and Danube Delta lakes)**

| BIOLOGICAL COMPARTMENT/ TROPHO-DYNAMIC MODULE ABIOTIC COMPARTMENT/ HYDROGEOMORPHIC UNIT | STRUCTURAL OR FUNCTIONAL PARAMETER | SITE | PERIOD | FREQUENCY |
|---|---|---|---|---|
| Phytoplankton | % dominant groups density | Danube Delta Lakes | 1975-1994 | monthly/seasonally |
| | chlorophill "a", primary production | Danube Delta Lakes | 1985-1994 | monthly/seasonally |
| | chlorophill "a" | SIB | 1993-1995, 1999-2003 | monthly/seasonally |
| | % dominant groups density | SIB | 1999-2003 | monthly/seasonally |
| | primary production | SIB | 1998 - 2003 | monthly/seasonally |

| **Biological compartment/ tropho-dynamic module abiotic compartment/ hydrogeomorphic unit** | **Structural or functional parameter** | **Site** | **Period** | **Frequency** |
|---|---|---|---|---|
| Zooplankton | species richness, groups density and biomass | Danube Delta Lakes | 1980-1994 | monthly/seasonally |
| | species richness, groups density and biomass | SIB | 1993-1995, 1999-2003 | monthly/seasonally |
| | secondary production, assimilation, respiration, nutrient excretion, turn-over rates | Danube Delta Lakes, SIB | 1980-1994, 1993-1995, 2000-2003 | monthly/seasonally |
| Bacterioplankton | density, redox potential, respiration | DD Lakes | 1978 | seasonally |
| | density/ biomass, respiration | DD Lakes | 1991-1997 | seasonally |
| | biomass (ATP plankton fragmentation) | | 1983-1990 | monthly, seasonally |
| Macrozoobenthos Mollusca, Oligochaeta, Chironomidae | density/biomass, production and other functional parameters for dominant species | DD Lakes, SIB | 1948-1986 1975-1994, 1976-1993, 1993-2005 | annualy monthly/seasonally |
| Fish | Morphological heterogeneity, production, prolificity<br>Nutrition<br>Migration | DD Lakes<br><br>SIB | 1961-1995<br>1969<br>1965-1994 | Seasonally<br>monthly |
| | morf. heterogeneity, production, prolificity, respiration, nutrition | SIB | 1956-1994 | monthly/seasonally |
| Amphibians | density dynamics | SIB | 1968-1970 | seasonally |
| | Biomass | SIB | 1994-1997 | seasonally |
| Aquatic plants | Biomass | DD Lakes | 1979-1994 | monthly |
| | | SIB | 1992-present | monthly/ seasonally |
| | chlorophill "a" content | DD Lakes | 1984-1986, 1993-1994 | seasonally |
| | photosynthesis and respirat | DD Lakes | 1985-1986 | daily/ seasonally |
| | Biomass production | DD Lakes | 1980-1995 | annually |
| | primary production | SIB & DD | 1960-1975 | daily/ seasonally |
| Terrestrial/ periodically flooded vegetation | Species richness, density/ biomass<br><br>density/biomass, distribution/ coverage, production | DD Lakes & levees<br><br>LDWS | 1982-1983,1988,1990<br><br>1993-2002 | seasonally<br><br>seasonally |

| Biological compartment/ tropho-dynamic module abiotic compartment/ hydrogeomorphic unit | Structural or functional parameter | Site | Period | Frequency |
|---|---|---|---|---|
| Aquatic insects (Trichoptera) | Species richness, sex ratio | Danube Delta<br><br>SIB | 1988 -1990, 2001 – 2003<br>1988 -1990 | monthly/summer - autumn |
| Terrestrial invertebrates | Species richness, sex ratio (Carabids) | SIB | 1994 - 1999 | monthly |
| Litter | mass loss<br>decomposition rate | SIB | 1993, 1996-1999 | bimonthly |
| River hydrology | Danube level<br>Danube discharge | Braila (km 170), Harsova (km 254) | 1957 - 2004 | daily |
| Local climate | Air temperature; Water temperature<br>Wind speed Wind direction<br>Cloud coverage Visibility Precipitation | Braila (km 170), Harsova (km 254) | 1957 - 2004 | daily |
| Water column | Depth<br>Secchi depth<br>Temperature, pH, Conductivity, Dissolved O2<br>Nutrients (TRP, DIN) | Danube Delta, SIB | 1975 - 1993, 1994 - 2003 | monthly/seasonally |
| Soil/Sediment | pH, humidity<br>Nutrient content (total N, total P, $PO_4$, $NO_2$, $NO_3$, $NH_4$)<br>Organic content<br>Denitrification<br>Mineralization, Nitrification | SIB<br>SIB<br>SIB<br>SIB<br>SIB | 1995 1997<br>1994 2003<br>1994 2003<br>1996 1997<br>1996 1997 | Monthly<br>seasonally<br>seasonally<br>Monthly<br>Monthly |

Two categories of information have been collected and will need further attention in the next period for different analyzes:

- Large data sets (table 3) on the dynamics of the structural and functional parameters of the main TDMs, HGMUs, local climate and river hydrology appropriate for further statistical processing;
- Knowledge explaining dynamics of the dominant populations in relation with local and large distance (catchments) driving forces: mechanisms of response to hydrological regime, trophic state, light, moisture and seasonality conditions, as well as on structural and functional relationships between different ecosystems.

Based on the this data (table 3) a short gap analysis pointed out some of the important problems identified both in the data set and in the tools needed for the analysis:

- Un-complementarities between some data sets both spatially (different systems) and temporally (for different time periods);
- Lack of efficient tools for scaling up from local ecosystem to landscape level;
- Inadequate modeling of specific and complex regional landscape of LDWS;

Beside these gaps there are same important drawbacks linked with the huge Danube basin (over 817000 square kilometers) that will impose certain characteristics to the data analysis on one hand and to the climatic modeling on the other hand. Both for Danube Delta and Small Island of Braila, the hydrological regime is having a more important influence then the direct, on site climate effect, suggesting that it is of a greater importance to establish links between the parameters of the hydrological regime (discharge and/or water level) and different biological structures than to establish for example links between precipitation on site and different biological TDM's.

Based on this we have concentrated our effort in order to gather daily data concerning principal hydrological parameters (Danube water level and discharge) as well as climatic data (air temperature and water temperature) at Braila station. More than 60000 data on the above parameters have been collated and introduced in the database for future use. Nevertheless we are still missing data about water temperature (from 1964 up to 1977, more than 5100 daily values) as well as the data about the air temperature (from 1967 up to 1977, more than 4000 daily values). We have to stress once more the difficulty encounter in the data collection due mainly to bureaucracy in different institutions as well as to the data storage. In fact this was the main reason for the delay in reporting for this phase of the project.

In the next time frame our intention is to enlarge the data set by obtaining also the above missing data and by adding new data up to the starting of the monitoring of hydrological condition in the Danube River by the International Danube Commission.

The data sets were checked for any inconsistency with regard to quality. Different data were cross check using other sources when this was possible in order to ensure the data quality. As these are recovered data from different sources (as already mentioned from former projects) different methods have been used during time for the parameter estimation. Usually this data is provided in the metadata but in many cases the information is missing due to different reasons.

**Results**

For the first reporting period there were no results foreseen to be presented, nevertheless we concluded that a short review of the data is a need for understanding the complexity of the existing data.
In the same time there is a need to see if from the start there are some indications about trends in the data sets that could be linked with the change in the climate.
We are also foreseen the use of Stella modeling software and models developed using statistical equations to estimate the impact of climate change on the mentioned TDM's as well as on the main functions like primary productivity of phytoplankton or secondary production of benthic invertebrates.
Basic statistical information is been provided in table 4 and figure 5 (histograms).

**Table 4. Number of data and basic statistics for the hydrological data and climate data (daily values 1957-2004)**

| Parameter | Valid N | Mean | Mean confidence -95% | Mean confidence +95% | Median | Minimum | Maximum | Std.Dev. |
|---|---|---|---|---|---|---|---|---|
| N_CM | 17501 | 298 | 296 | 300.2 | 290 | -5 | 648 | 142 |
| Q_M3_S_1 | 17531 | 6169 | 6133.9 | 6205.2 | 5810 | 1027 | 15000 | 2408 |
| T_WATER_C | 13078 | 13 | 12.9 | 13.1 | 13 | -1 | 29 | 8.4 |
| T_AIR_C | 11996 | 9.7 | 9.5 | 9.8 | 10 | -21 | 33 | 9.3 |

Legend: N_CM- Danube level (cm); Q_M3_S_1 – Danube discharge ($m^3$*s-1); T_WATER_C – Water temperature (C); T_AIR_C – Air temperature (C );

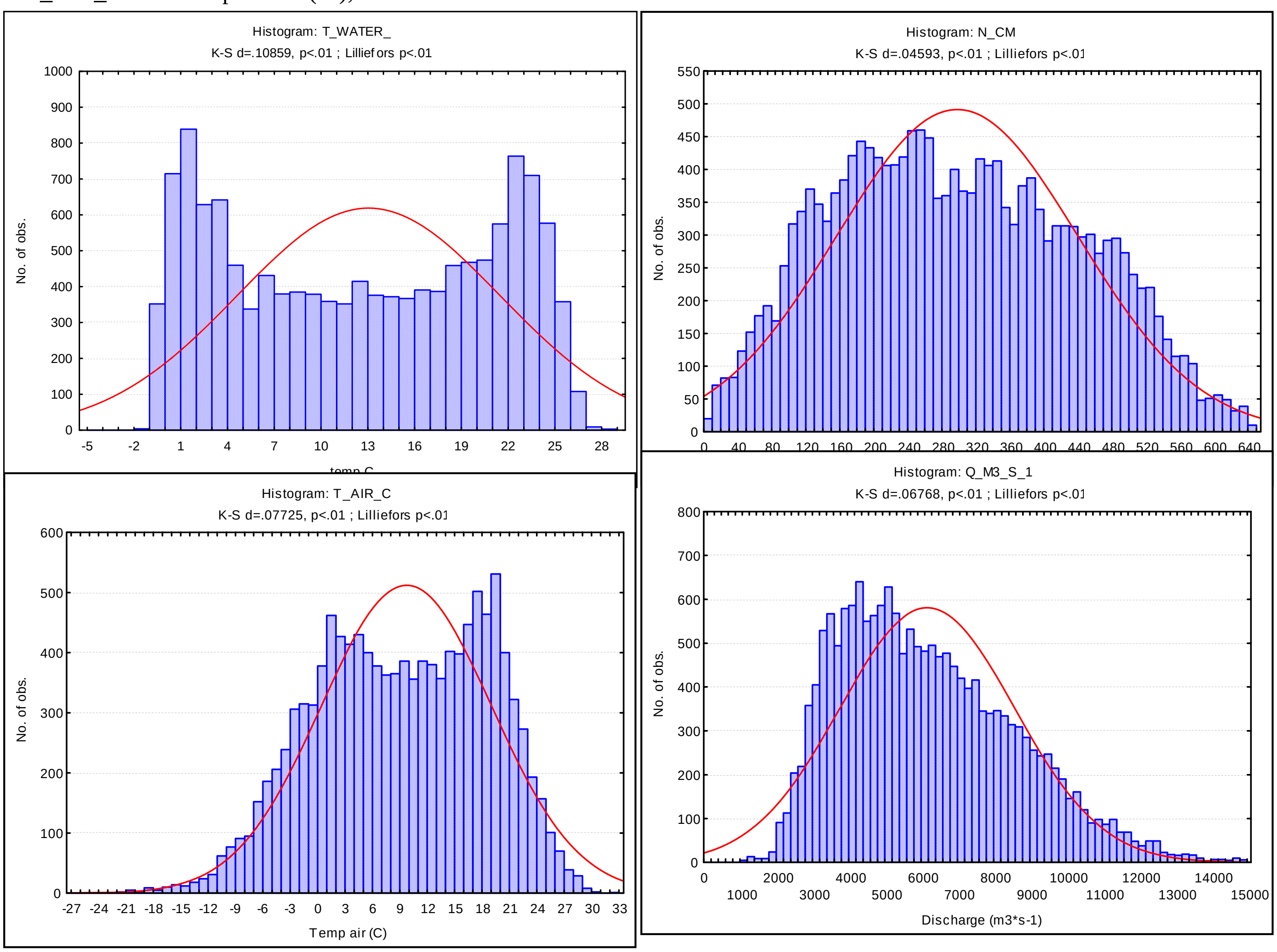



**Figure 5. Histograms for the water temperature (a), water level (b), air temp (c) and discharge (d)**

**Danube river hydrological regime**

Figure 6 is presenting the mean Danube discharge for the following periods: 1975 up to 1979 a second period starting in 1981 up to 1984 and the last period from 1985-1989. These periods have been selected because starting with period 1981 up to 1985 some of the worse eutrophication conditions have been encountered especially in the Danube Delta lakes. This could be in fact a direct link between eutrophication process in Danube Delta and the hydrological regimen as an exponent of the climatic change. With the use of the extended data set on hydrology we will test also this kind of hypotheses.

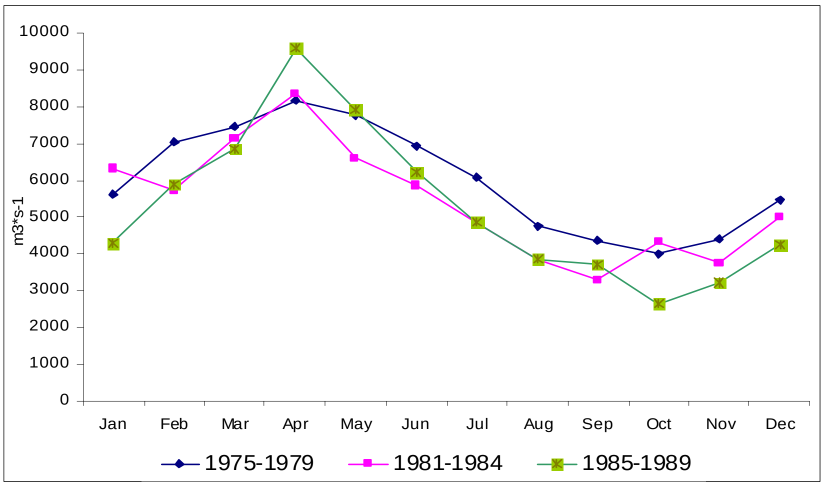



**Figure 6. Mean monthly discharge data, 1975-1989**

The mean annual Danube discharge (1957-2004) is presented in figure 7 but further statistical analysis should be realized to better explain the tendency.

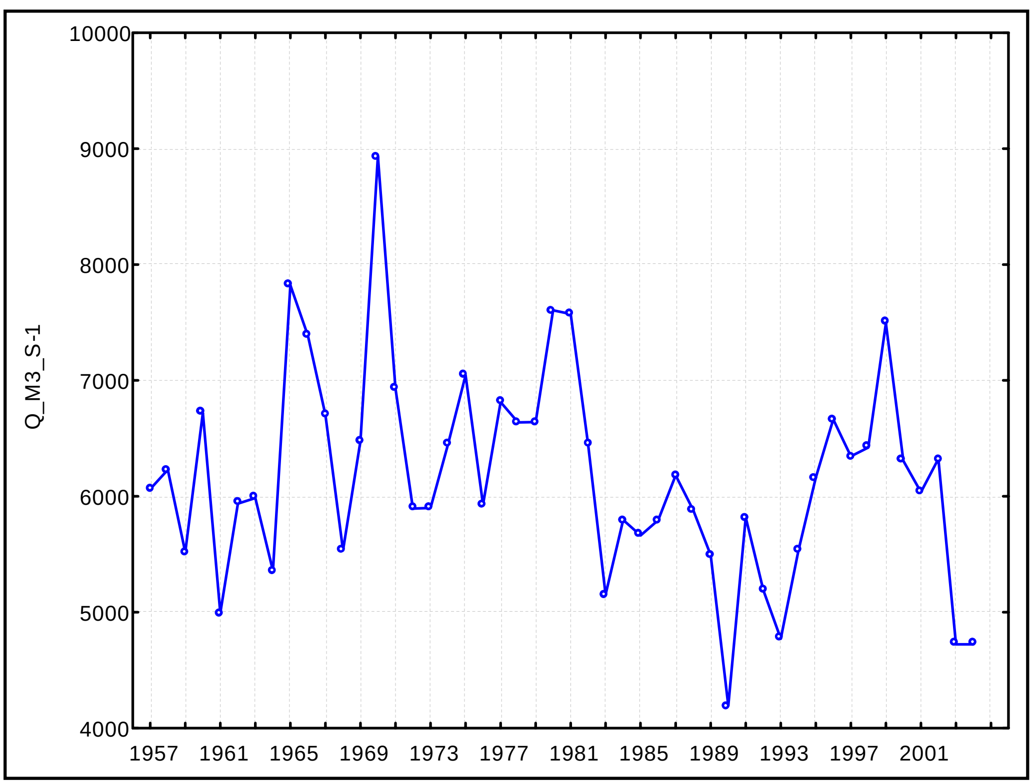



**Figure 7. Mean annual discharge data, Braila hydrological station 1957-2004**

Mean annual values of chlorophyll “a” (obtained from 10 up to 12 monthly values) as well as mean PO4, NO3 and N/P ratio are presented in figure 8.

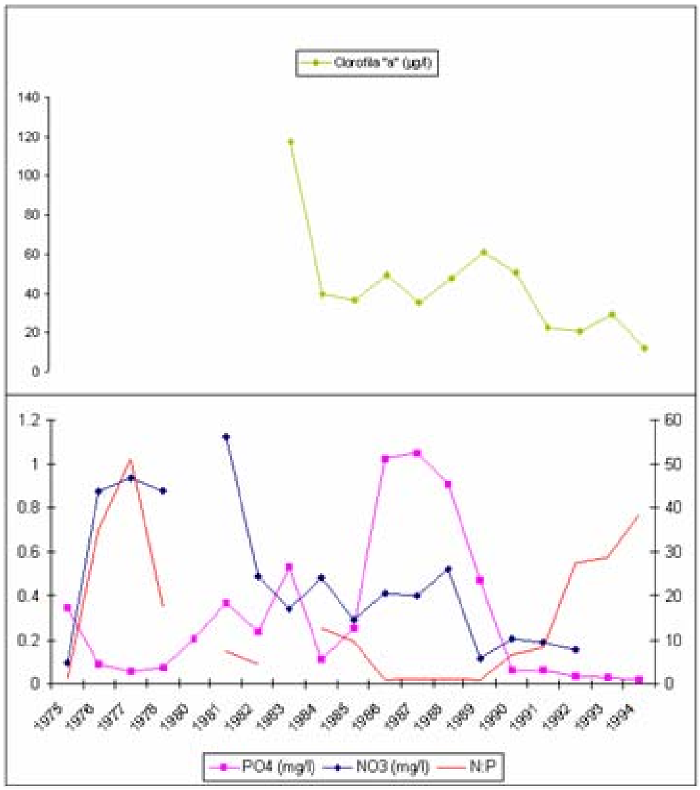



**Figure 8. Dynamics of the chlorophyll a concentration (a) and the dynamics of the main nutrients (b)**

If table 4 is presenting statistical information about the hydrological and climate regime, table 5 is focusing upon the nutrients and physico-chemical parameters of the Danube Delta lakes for the period 1985-1995. Data about TDM’s are extended in time well before 1985 as well as after 1995. After 1980 the research program was designed at time and space scale in order to: i) cover and assess the difference between or within the shallow lake complexes, ii) identify the specific and general trends in their dynamics, iii) identify the main mechanisms and driving variables (both internal and external) involved into the process.

The research was carried out along three main phases: a) a three years extensive research subprogram (1979 / 1981) addressed to almost all open water bodies; b) an eight years intensive research focused (1982 / 89) on eight representative lakes and c) five years (1990-2004) integrated monitoring.

Monthly data are available for the first and second phase of the research program and whereas for the monitoring phase samples were collected at two months interval.

**Table 5. Statistics of data for Danube Delta system for the period 1985-1995**

| PARAMETER | NUMBER OF CASES | MEAN | CONFID.- 95.000% | CONFID. +95.000% | MEDIAN | MIN. | MAX. | AMPL. | DEV. STAND. |
|---|---|---|---|---|---|---|---|---|---|
| TR_CM | 678 | 70.37 | 66.50 | 74.25 | 50.00 | 7.00 | 250.00 | 243.00 | 51.38 |
| AD_CM | 648 | 191.32 | 186.12 | 196.52 | 190.00 | 18.00 | 400.00 | 382.00 | 67.45 |
| T_A | 648 | 0.40 | 0.37 | 0.42 | 0.29 | 0.07 | 2.78 | 2.71 | 0.30 |
| PH | 183 | 8.42 | 8.33 | 8.51 | 8.50 | 7.00 | 9.70 | 2.70 | 0.63 |
| ALCAL | 183 | 271.86 | 264.05 | 279.68 | 267.00 | 160.00 | 450.00 | 290.00 | 53.60 |
| COND. | 157 | 477.50 | 422.48 | 532.51 | 400.00 | 300.00 | 3580.00 | 3280.00 | 349.00 |
| O2_MG_L | 181 | 7.71 | 7.43 | 7.98 | 7.30 | 2.70 | 15.10 | 12.40 | 1.87 |
| COD_MG_L | 1655 | 24.40 | 23.92 | 24.88 | 22.80 | 2.80 | 117.20 | 114.40 | 9.90 |
| CHLA_UG_ | 1790 | 37.51 | 35.66 | 39.36 | 21.85 | 0.47 | 213.30 | 212.83 | 39.85 |
| PO4MG_L | 1804 | 0.08 | 0.08 | 0.08 | 0.06 | 0.00 | 0.40 | 0.40 | 0.07 |
| SI_MG_L | 1819 | 0.93 | 0.90 | 0.96 | 0.80 | 0.01 | 4.41 | 4.41 | 0.72 |
| NO3_MG_L | 1601 | 0.37 | 0.35 | 0.40 | 0.11 | 0.00 | 2.31 | 2.30 | 0.49 |
| NH4_MG_L | 1638 | 0.29 | 0.26 | 0.32 | 0.18 | 0.00 | 21.34 | 21.33 | 0.60 |
| N_TOTAL | 1615 | 0.64 | 0.60 | 0.68 | 0.36 | 0.01 | 21.51 | 21.51 | 0.80 |
| DIN_TRP | 1576 | 20.76 | 18.45 | 23.07 | 8.43 | 0.06 | 776.50 | 776.44 | 46.76 |

**Long term data on nutrient in Danube Delta system**
Based on these data sets a dynamic of the main nutrients in the Danube Delta lakes could be realized starting back in 1975 (figure 8).

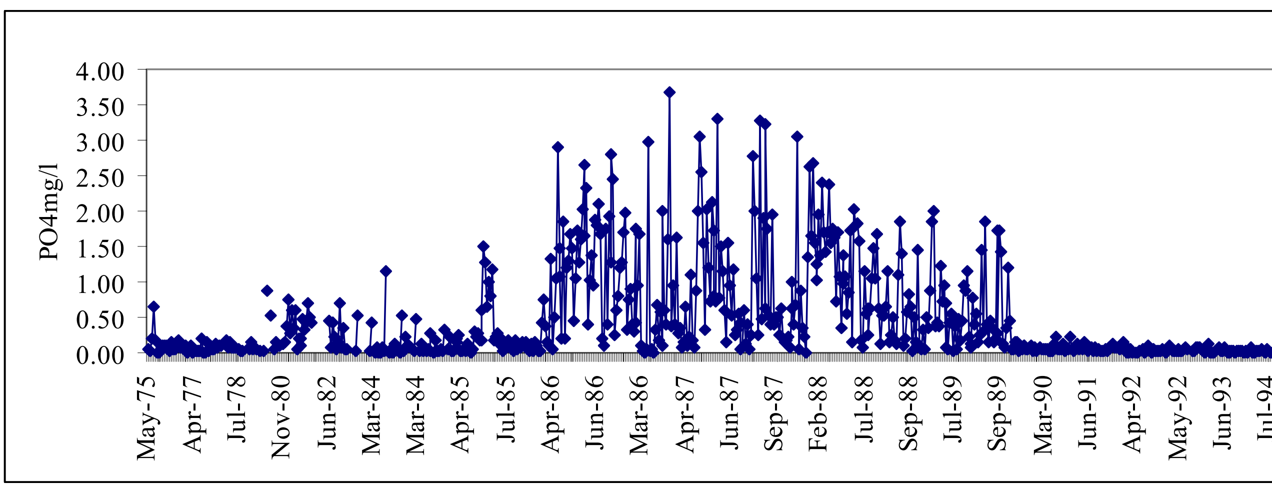



**Figure 8. Dynamics of PO4 in Danube delta lakes from 1975 up to 1994**

**Models to be tested and further developed**

Based on a previous work during a national project entitled “Functional Role of Biodiversity” we are proposing also a model that we will further develop to model the direct and indirect effects of climate on primary phytoplankton production (Adamescu, 2005) and zooplankton production (Cazacu, 2005). The models (two models on phytoplankton dynamics including principal groups and total biomass figure 9 and 10) as well as a model describing the dynamics of primary productivity and one on zooplankton) have been developed in Stella on the bases of empirical equation developed using Statistica software on real data. The models were tested using the data from the same selected systems (wetlands from LDWS).

**Modeling with Stella 4.0 based on multiple correlation equations (Ec. 1-6)**

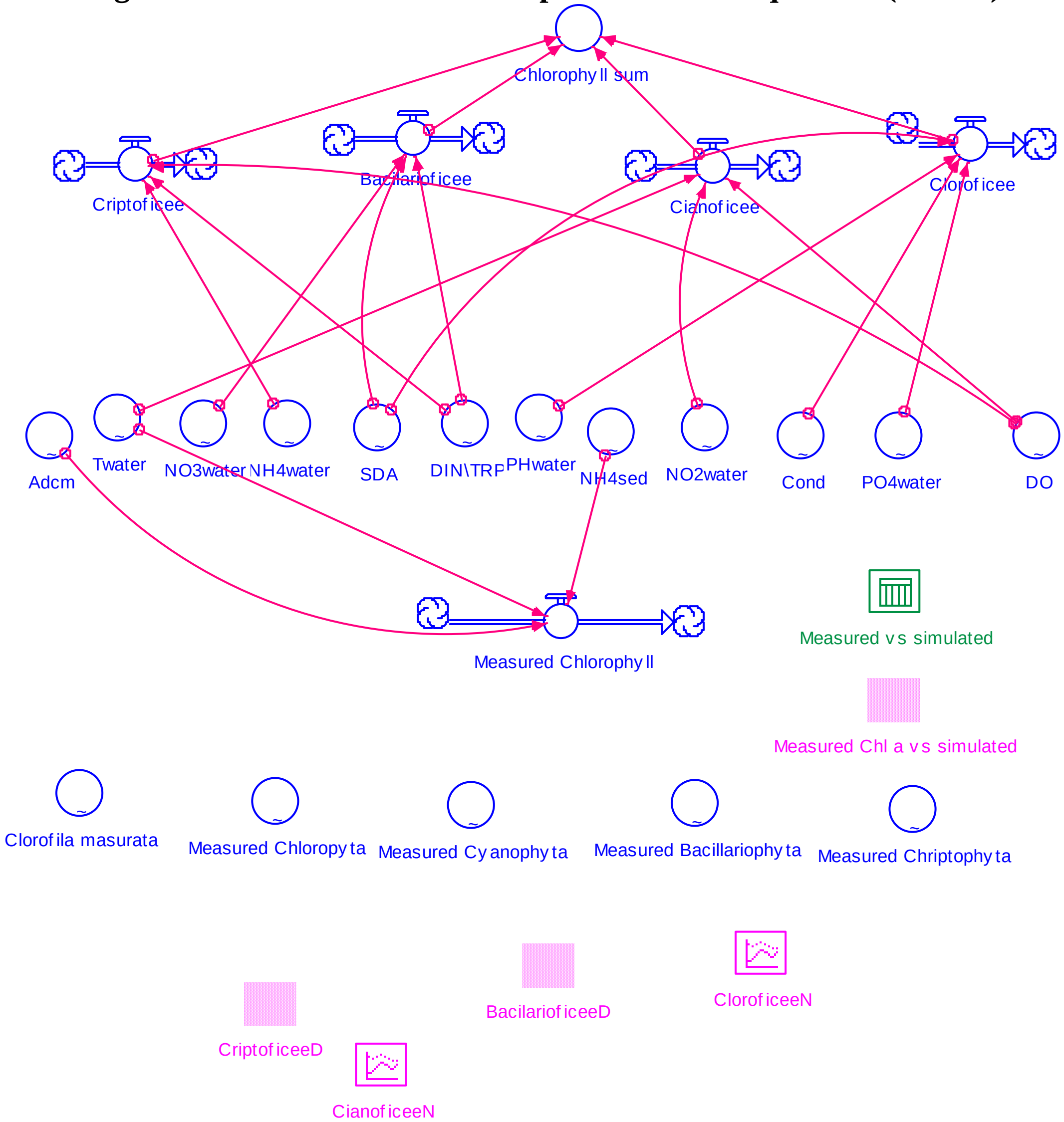



**Figure 9. Stella model on phytoplankton dynamics**

Euro-limpacs

**Ec 1.** Bacillariophyta = 6.35486536-.06007456*SDA-3.3225621*NO3water+.024751509*DIN\TRP
**Ec. 2.** Cyanophyta = .052984329+.085915196*Twater-36.725989*NO2water+.053384014*DO
**Ec. 3.**Chlorophyta = -4.5375751-.06921083*SDA+1.04231281*PHwater-37.557591*PO4water+14.3870413*Cond
**Ec. 4.**Simulated chl = 6.27883478+.084016176*Adcm-.90608866*Twater+.107511866*NH4sed
**Ec. 5.**Chriptophyta = 2.15854606-21.157077*NH4water-.18557855*DO+.006299826*DIN\TRP
**Ec. 6.**Chl sum = (Bacillariophyta+Cyanophyta+Chlorophyta+Chriptophyta)

Adcm = GRAPH(TIME)
(0.00, 112), (1.08, 127), (2.17, 137), (3.25, 150), (4.33, 113), (5.42, 127), (6.50, 110), (7.58, 127), (8.67, 60.0), (9.75, 25.0), (10.8, 50.0), (11.9, 37.0), (13.0, 52.0)
Measured_Bacillariophyta = GRAPH(TIME)
(0.00, 1.27), (1.08, 7.52), (2.17, 15.7), (3.25, 4.84), (4.33, 1.10), (5.42, 1.02), (6.50, 2.35), (7.58, 2.00), (8.67, 1.19), (9.75, 1.21), (10.8, 2.14), (11.9, 1.58), (13.0, 1.50)
Measured_Cyanophyta = GRAPH(TIME)
(0.00, 0.43), (1.08, 0.63), (2.17, 0.02), (3.25, 0.00), (4.33, 0.09), (5.42, 0.00), (6.50, 0.78), (7.58, 0.00), (8.67, 0.46), (9.75, 0.62), (10.8, 0.64), (11.9, 0.76), (13.0, 0.75)
Measured_Clorophyta = GRAPH(TIME)
(0.00, 0.77), (1.08, 3.69), (2.17, 6.95), (3.25, 3.53), (4.33, 2.10), (5.42, 1.76), (6.50, 8.12), (7.58, 2.26), (8.67, 1.14), (9.75, 2.09), (10.8, 0.98), (11.9, 0.59), (13.0, 1.63)
Measured_Chl = GRAPH(TIME)
(0.00, 3.09), (1.08, 16.1), (2.17, 26.8), (3.25, 11.6), (4.33, 4.56), (5.42, 4.30), (6.50, 13.7), (7.58, 5.70), (8.67, 3.21), (9.75, 4.73), (10.8, 4.45), (11.9, 3.66), (13.0, 4.39)
Cond = GRAPH(TIME)
(0.00, 0.24), (1.08, 0.26), (2.17, 0.27), (3.25, 0.31), (4.33, 0.37), (5.42, 0.36), (6.50, 0.35), (7.58, 0.37), (8.67, 0.28), (9.75, 0.24), (10.8, 0.28), (11.9, 0.27), (13.0, 0.32)
Measured_Chriptophyta = GRAPH(TIME)
(0.00, 0.62), (1.00, 4.22), (2.00, 4.17), (3.00, 3.21), (4.00, 1.27), (5.00, 1.52), (6.00, 2.43), (7.00, 1.43), (8.00, 0.43), (9.00, 0.81), (10.0, 0.7), (11.0, 0.73), (12.0, 0.52)
DIN\TRP = GRAPH(TIME)
(0.00, 257), (1.08, 478), (2.17, 377), (3.25, 213), (4.33, 32.0), (5.42, 17.0), (6.50, 22.0), (7.58, 33.0), (8.67, 304), (9.75, 238), (10.8, 413), (11.9, 417), (13.0, 388)
DO = GRAPH(TIME)
(0.00, 6.51), (1.08, 6.96), (2.17, 6.98), (3.25, 2.55), (4.33, 2.49), (5.42, 2.20), (6.50, 2.42), (7.58, 2.59), (8.67, 8.04), (9.75, 8.24), (10.8, 15.0), (11.9, 13.7), (13.0, 11.3)
NH4water= GRAPH(TIME)
(0.00, 0.031), (1.08, 0.013), (2.17, 0.015), (3.25, 0.015), (4.33, 0.018), (5.42, 0.021), (6.50, 0.019), (7.58, 0.021), (8.67, 0.131), (9.75, 0.027), (10.8, 0.067), (11.9, 0.05), (13.0, 0.042)

NH4sed = GRAPH(TIME)
(0.00, 12.9), (1.08, 24.5), (2.17, 42.9), (3.25, 12.5), (4.33, 27.1), (5.42, 7.56), (6.50, 7.76), (7.58, 23.5), (8.67, 7.73), (9.75, 58.2), (10.8, 34.6), (11.9, 20.9), (13.0, 41.8)
NO2water = GRAPH(TIME)
(0.00, 0.025), (1.08, 0.027), (2.17, 0.033), (3.25, 0.019), (4.33, 0.007), (5.42, 0.008), (6.50, 0.005), (7.58, 0.004), (8.67, 0.027), (9.75, 0.025), (10.8, 0.031), (11.9, 0.027), (13.0, 0.044)
NO3water = GRAPH(TIME)
(0.00, 2.13), (1.08, 2.14), (2.17, 1.19), (3.25, 0.548), (4.33, 0.043), (5.42, 0.026), (6.50, 0.042), (7.58, 0.061), (8.67, 2.14), (9.75, 2.11), (10.8, 2.17), (11.9, 2.22), (13.0, 0.982)
PHwater= GRAPH(TIME)
(0.00, 8.30), (1.08, 8.60), (2.17, 8.70), (3.25, 8.50), (4.33, 8.40), (5.42, 8.30), (6.50, 8.00), (7.58, 8.10), (8.67, 8.90), (9.75, 8.80), (10.8, 8.30), (11.9, 8.30), (13.0, 8.10)
PO4water = GRAPH(TIME)
(0.00, 0.008), (1.08, 0.005), (2.17, 0.003), (3.25, 0.003), (4.33, 0.002), (5.42, 0.003), (6.50, 0.003), (7.58, 0.002), (8.67, 0.007), (9.75, 0.009), (10.8, 0.005), (11.9, 0.005), (13.0, 0.003)
SDA = GRAPH(TIME)
(0.00, 62.5), (1.08, 47.2), (2.17, 58.4), (3.25, 100), (4.33, 100), (5.42, 100), (6.50, 100), (7.58, 100), (8.67, 100), (9.75, 100), (10.8, 100), (11.9, 100), (13.0, 100)
Twater = GRAPH(TIME)
(0.00, 8.47), (1.08, 8.06), (2.17, 8.81), (3.25, 9.11), (4.33, 9.64), (5.42, 9.52), (6.50, 8.85), (7.58, 8.45), (8.67, 11.7), (9.75, 12.4), (10.8, 9.59), (11.9, 9.06), (13.0, 11.5)

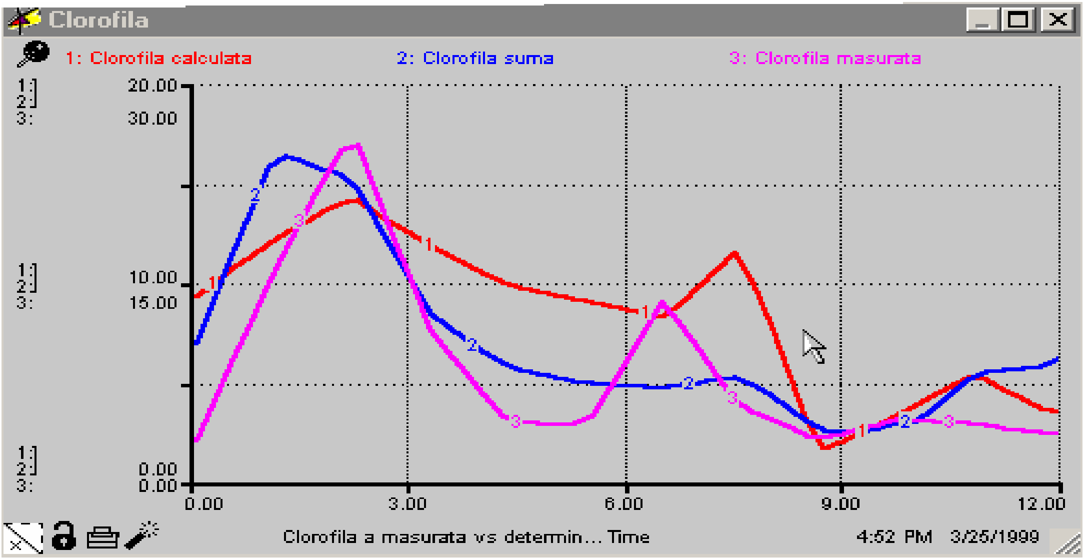



**Figure 10. Results from running the model with real field data compared with simulated data**

## FUTURE ACTIVITIES

a. Supplementing data sets by collating new data and field and laboratory experimentation (i.e. reconstitution of missing flooding/ saturation regime for some ecosystems and periods);
b. Improving/ developing new tools for up scaling local functional models to landscape levels;
c. Adapting and checking structural large river models for specific sites of LDWS;
d. Statistical analysis of the data sets focusing on establishing relationships between climate and hydrological time series and TDM's;

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