MOLAR

Mountain Lake Research

PROGRESS REPORT 2/1998

March 1997 - March 1998

Measuring and modelling
the dynamic response of
remote mountain lake ecosystems
to environmental change

A programme of **Mo**untain **L**ake **R**esearch
MOLAR

Norwegian Institute for Water Research

REPORT

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Abstract

MOLAR is an extensive European co-operative research project with 23 partners. It is funded within the European Commission Framework Programme IV: Environment and Climate with assistance from INCO. It is co-ordinated by the Environmental Change Research Centre (ECRE) at University College London and the Norwegian Institute for Water Research (NIVA). The project has four major strands also called Work Packages, and progress for the second working year of each of the Work Packages (WP) is reported here. Part A is a summary of the activities under each WP, while in part B detailed reports from each of the contract partners are given. The overall conclusion is that the project is proceeding according to plan.

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1. Høyfjellsjøer	1. High mountainlakes
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3. Biologi	3. Biology
4. Europeisk samarbeid	4. European co-operation

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MOLAR Summary Progress Report 2/1998

March 1997 - March 1998

Contract no.: ENV4-CT95-0007

Measuring and modelling the dynamic response of remote mountain lake ecosystems to environmental change:

A programme of Mountain Lake Research - MOLAR

MOLAR co-operative partners:

01	University College London, UK (*administrative coordinator*)	(UCL)
02	University of Helsinki, SF	(UHEL)
03	University of Edinburgh, UK	(UED)
04	Norwegian Institute for Water Research, N (*scientific coordinator*)	(NIVA)
05	Universität Innsbruck, Institut für Zoologie, A	(UIBK)
06	Austrian Academy of Sciences, Limnological Institute, A	(ILIMNOL)
07	Universidad de Barcelona, ES	(FBG)
08	Universidad de Granada, ES	(UGR-ES)
09	University of Bordeaux (URA CNRS), Arcachon, F	(CNRS)
10	Consejo Superior De Investigaciones Cientificas, Barcelona, ES	(CSIC)
11	University of Bergen, Botanical Institute, N	(UIB-BI)
12	University of Bergen, Institute of Zoology, N	(UIB-ZI)
13	CNR-Istituto Italiano di Idrobiologia, Pallanza, I	(CNR-III)
14	University of Liverpool, UK	(ULIV)
15	Institute for Environmental Science and Technology, Dubendorf, CH	(EAWAG)
16	University of Zurich, CH	(UZurich)
17	Charles University, Prag, Czech Republic	(FSCU)
18	Hydrobiological Institute, Ceske Budejovice, Czech Republic	(HBI-ASCR)
19	Institute of Zoology, Bratislava, Slovak Republic	(IZ-SAS)
20	Polish Academy of Sciences, Institute of Freshwater Biology. Kracow, PL	(IFB-PAS)
21	National Institue of Biology, Ljubljana, Slovenia	(NIB)
22	Kola Science Cebtre, Apatite, Russia.	(INEP)
23	Laboratorio Studi Ambientale, Sezione aria e aqua, Ticino, CH	(LSA)

Preface

MOLAR is an extensive European research project with 23 co-operative partners. It is funded within the European Commission Framework Programme IV: Environment and Climate with assistance from INCO. MOLAR builds on the success of the EU funded AL:PE projects.

MOLAR was launched March 1st 1996, and the first project meeting was held two weeks later in Prague, Czech Republic. Annual project meetings have been held in Barcelona, Spain in March 1997 and in Bled, Slovenia in March 1998.

For wide spread information MOLAR has a home page on Internet (http://prfdec.natur.cuni.cz/hydrobiology/molar/welcome/htm). In September 1997 also the MOLAR Project Manual was published in its final version.

When the Project Proposal was prepared, there were 22 co-operative partners involved in MOLAR. After the project had been accepted by the European Commission, a Swiss Group from Laboratorio Studi Ambientale, Sezione aria e aqua, Ticino (LSA) joined the project and is now working voluntary under the same programme as the rest of the project group.

This Progress Report summarises the activities during the second working year of the project. It is compiled from contributions given by all project partners. Convenors for the four different parts (Work Packages) of the project have been responsible for reporting of the progress within each part.

Oslo, 30. April 1998

Bente M. Wathne

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Summary

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This project has four major strands also called Work Packages, and progress for the second working year of each of the Work Packages (WP) is reported here. Part A is a summary of the activities under each WP, while in part B detailed reports from each of the contract partners are given. Convenors for the four different Work Packages have been responsible for reporting of the progress within each part.

The main conclusion after evaluations at the annual project meeting and reports from the project partners is that the project is on schedule and working according to plans.

SUMMARY PROGRESS REPORT OF MOLAR

PART A

1. GENERAL OBJECTIVES

MOLAR is an extensive European co-operative research project originally established with 22 partners. After voluntary participation from a third Swiss group (participant no. 23 on the first page) it was extended and is working with 23 partners.

MOLAR is funded by the European Commission Framework Programme IV: Environment and Climate with assistance from INCO. It is co-ordinated by the Environmental Change Research Centre (ECRE) at University College London and the Norwegian Institute for Water Research (NIVA). A Steering Group of senior scientists from laboratories engaged in the key areas of MOLAR has been established. The Steering Group is responsible for harmonisation of administrative and scientific co-ordination, and an important tool for optimal administration of the total MOLAR project.

The arctic and alpine regions of Europe represent the most remote and least disturbed environments in Europe, yet they are threatened by acid deposition, toxic air pollutants and by climate change. The remote lakes that occur throughout these regions are especially vulnerable for a number of related reasons:

- many mountain lakes have little ability to neutralise acidity because of their low base status, and acid deposition often increases with altitude;
- nitrate levels are often higher in mountain lakes because their catchments have little soil and vegetation to take up nitrogen deposition;
- toxic trace metals and trace organics accumulate in the food chain more easily in soft water than hard water lakes, and some pollutants (e.g. mercury, volatile organics) accumulate progressively in cold regions;
- the productivity and ecological dynamics of mountain lakes is strongly controlled by climatic influence on the length of the ice-free season and the period of thermal stratification, yet climatic warming in Europe is predicted to be greatest in arctic-alpine regions.

Because of this sensitivity, remote mountain lakes are not only vulnerable to environmental change, they are also excellent sensors of change, and their sensitivity and high quality sediment records can be used to infer the speed, direction and biological impact of changing air quality and climate. The MOLAR project builds on the success of the EU funded AL:PE (Acidification of Remote Mountain Lakes: Palaeolimnology and Ecology) project, which represented the first comprehensive study of remote mountain lakes at an European level (Wathne *et al.* 1995, 1997).

This project has **four overall objectives**, each corresponding to a major strand also called Work Package in the proposal:

- to measure and model the dynamic responses of remote mountain lake ecosystems to acid (sulphur plus nitrogen) deposition;

- to quantify and model pollutant (trace metals, trace organics) fluxes and pathways in remote mountain lakes and their uptake by fish;

- to measure and model the temporal responses of remote mountain lake ecosystems to climate variability on seasonal, inter-annual and decadal time-scales.

- To continue the development of a high quality environmental database on remote mountain lake ecosystems in Europe and to disseminate results widely to enhance public awareness, environmental education and environmental decision making.

The main deliverables of this project will be the development of predictive models for acidity, pollutant flux and climate variability that can be used in scenario assessment studies, especially those scenarios associated with present and forthcoming UN-ECE protocols and General Circulation Model (GCM) predictions for Europe. A desirable future objective would be the linking of these models to evaluate the interaction between acidity, trace pollutant and climate. However this must inevitably wait until a later phase of the research. In addition to model development, much of the field and laboratory work proposed is innovative for studies of such remote sites, especially:

- the focus on the seasonal dynamics of the lake system;
- the emphasis on nitrogen deposition and its biological impact;
- the study of microbial food webs in relation to acidity;
- the on-site collection and measurement of atmospheric pollutants;
- the use of radio-tracers to validate pollutant transport models;
- the study of trace metals (especially mercury) and trace organic uptake by fish;
- the on-site monitoring of climate conditions and their relationship to water column behaviour;
- the development of a methodology to infer climate trends from the high resolution analysis of recent sediments.

These objectives were unachievable four years ago because of the almost complete lack of information on remote arctic and alpine lakes. It is now possible to carry out such work because of the knowledge gained about individual sites from the AL:PE project with respect particularly to accessibility, morphometry, chemistry, biology, sediment accumulation rate and pollution status.

2. SPECIFIC OBJECTIVES FOR THE REPORTING PERIOD

Within work packages 1 - 3 (WP1, WP2 and WP3) the second working year of the project has been an intensive period, where the full sampling programme has been in operation. The integrating activities in work packages 4 (WP4) follow the activities within the first three WPs. For the reporting period the specific objectives have been the following:

- Finish MOLAR Project Manual for sampling and analysis, WP4
- Meteorology sampling and analysis, WP2 and WP3
- Deposition sampling and analysis, WP1 and WP2

- Snow sampling and analysis, WP2
- Major water chemistry sampling and analysis, WP1, WP2, and WP3
- Micro organic and heavy metal sampling and analysis, WP2
- Water column , WP1, WP2, and WP3
- 1. and 2. level microbiology sampling and analysis, WP1
- Invertebrate sampling and analysis, WP1
- Zooplankton sampling and analysis, WP1
- Diatom sampling and analysis, WP1 and WP3
- Chironomid, Chrysophyte and Cladocera sampling and analysis, WP3
- Sediment trap sampling and analysis, WP2 and WP3
- Sediment core analysis, WP2 and WP3
- Soil core sampling and analysis, WP1 and WP2
- Test fishing and fish analysis, WP1 and WP2
- Climate data collection and harmonisation, WP3
- Database design, WP4
- First transfer of data, WP1, WP2, WP3, and WP4
- Critical load modelling, WP1
- Work package Workshops, WP1, WP2, WP3
- Quality Assurance programme, WP4
- Steering group meetings in Barcelona and Brussels, WP4
- Project meeting in Barcelona

3. SPECIFIC OBJECTIVES FOR THE NEXT REPORTING PERIOD

During the next working year, the sampling programme will finish and the following analysis will be the closing activities together with in-depth evaluation of the results. The listed activities describe the specific objectives:

- Meteorology sampling and analysis, WP2 and WP3
- Deposition sampling and analysis, WP1 and WP2
- Snow sampling and analysis, WP2
- Major water chemistry sampling and analysis, WP1, WP2, and WP3
- Micro organic and heavy metal sampling and analysis, WP2
- Water column , WP1, WP2, and WP3
- Invertebrate analysis, WP1
- Zooplankton analysis, WP1
- Diatom analysis, WP1 and WP3
- Chironomid, Chrysophyte and Cladocera analysis, WP3
- Sediment trap sampling and analysis, WP2 and WP3
- Sediment core analysis, WP2 and WP3
- Soil core sampling and analysis, WP1 and WP2
- Fish analysis, WP1 and WP2
- Climate data collection and harmonisation, WP3
- Transfer of data, WP1, WP2, WP3, and WP4
- Critical load and food web modelling, WP1

- Pollutant flux modelling, WP2
- Climate/lake dynamics modelling, WP3
- Work package Workshops, WP1, WP2, WP3
- Quality Assurance programme, WP4
- Steering group meetings in Bled and Barcelona, WP4
- Project meeting in Bled

4. MAIN ACTIVITIES UNDERTAKEN

4.1 MOLAR Work Package 1 (WP1)

MOUNTAIN LAKE ECOSYSTEM RESPONSE TO ACID DEPOSITION

Bente M. Wathne, NIVA

Activities within Workpackage 1 (WP1) and the twelve primary lakes chosen for studies are as a total proceeding according to plan. The progress reported within MOLAR WP1 at annual project meeting in Bled followed the main headlines given in the project proposal. The listed topics are addressed:

1. On site measurements of sulphur and nitrogen deposition
2. Seasonal variability of water chemistry
3. Seasonal variability of biota
4. Test hypothesis: histological and physiological attributes of fish indicate early acid stress
5. Test hypothesis: microbial activity in pelagic food web increases with acidification intensity
6. Evaluate applicability of various critical load models to mountain lake ecosystems, and develop a linked chemical-biological model for scenario assessment

Measurements of *deposition* are running at 11 of the 12 primary lakes. Some results are still not reported, but this will be done within the next months after QA procedures at the laboratories. All 12 lakes have been sampled for *water chemistry*, and all analytical laboratories have delivered their results. Results from deposition and lake water chemistry for 1996 and 1997 are stored by CNR and NIVA. Intercalibration exercises have been carried out both by CNR and NIVA. In September a Workshop on deposition and water chemistry was held in Bern, Switzerland. Special emphasise was put on the intercalibration exercises, and analytical problems for some of the components and their possible solutions were discussed.

Ten lakes should follow the *benthic invertebrate* programme in WP 1. Three lake has not been sampled according to the WP1 sampling protocol. In two lakes only a few samples have been taken for the time being. The lakes will hopefully be sampled according to the sampling protocol in 1998. One was not sampled in 1996 and 1997. A plan for sampling here in 1998 is prepared. Data have been transferred to Bergen, UIB-ZI.

Test *fishing* and following age determination are finalised in seven lakes as planned. All heavy metal analysis in kidney and liver, as well as mercury in muscle is carried out. Liver histology analysis is in progress. Also blood plasma ions and liver enzymes activities are analysed and measured. Analysis of micro-organic pollutants in fish is in progress and will be finalised by September 1998.

Pelagic food webs 1st level is sampled in 12 lakes. Field work is completed, and from several lakes more layers were analysed. Data from the ice-covered period is also included. Intercalibrations of some methods is done, one intercalibration exercise is evaluated. Data files from 1996 and 1997 are not complete - missing data will be gathered. *Pelagic food webs 2nd level* is investigated in 6 lakes during the ice-free seasons in 3 to 5 depths. Field work is completed. Additionally, from two lakes more, fluxes except of primary production were measured. Analyses of data is done, but their final elaboration must be completed in confrontation with 1st level data - biomasses plus species composition of phyto- and zooplankton, and with chemical data - chlorophyll, organic carbon, nutrients. Special files for each lake is constructed by the respective partners. Design of result file for the central databank not yet clear

The *MAGIC model* has already been used for two lakes (Gossenköllesee and Redo). Special workshops have been arranged to carry out the calculations and discuss the necessary data from these two sites. The first results from this work were shortly described by Chris Curtis. Reporting for the two sites are agreed and planned. A Workshop for deposition, water chemistry and modelling is planned in London during autumn 1998.

4.2 MOLAR Work Package 2 (WP2)

MEASURING AND MODELLING MAJOR ELEMENT AND POLLUTANT FLUXES IN MOUNTAIN LAKES AND THEIR IMPACT ON FISH

Roland Psenner & Hansjörg Thies, UIBK

Workpackage 2 (WP2) comprises 6 primary (Gossenköllesee, Estany Redó, Lochnagar, Øvre Neådalsvatn, Jörisee III, Starolesnianske Pleso) and 3 secondary sites (Stavsvatn, Laghetto Inferiore, Lago Paione Superiore). Topics of WP 2 are: Bulk deposition and snow pack: ions, 210Pb, PCB, PAH, SCP; Lake water physics, chemistry (including hydrology); Distribution (speciation) of 210Pb, PCB, PAH, and metals in lake water; Sedimentation of 210Pb, PCB, PAH, SCP; Sediment cores: PCB, PAH, 210Pb, 137Cs, SCP; Soil inventory of 210Pb and 137Cs in the catchment; PCB, PAH, and metals in fish; Modelling the transport of elements and pollutants. Depending on the subject and the site, most work is on schedule, e.g. field work of WP 2 is (partly) accomplished, lab analyses are so far in good progress and final data evaluation already started for some aspects (e.g. for fish; lake water chemistry forecast by MAGIC model).

Deposition and lake water samples have been collected and analysed at all primary sites as scheduled. In Gossenköllesee (GKS) several additional measurements and experiments have been performed to get a better understanding of hydrology (e.g. inlet gauges, tracer injection into lake). Modelling has been done at a workshop in Bern and Innsbruck. Chris Curtis and Dick Wright applied MAGIC to GKS. Fifteen months for metal sampling in rain have now been finished. GKS and Redo do show higher values for Cd in deposition than the reference site Kårvatn in Norway. Hg in deposition was only sampled and analysed in GKS and Kårvatn, the latter showed lower Hg values. Snow pits at GKS showed strong differences in evolution, absolute amount of water equivalent, ion concentrations and ion fluxes. The right choice of representative sites and sampling periods is essential to results (one sampling in winter is critical). A comparison of different types of precipitation collectors at GKS revealed great differences for water equivalent even within a small catchment.

Results on the composition of the organochlorine compounds and polycyclic aromatic hydrocarbons from the dissolved phase are available. At this moment, the particulate phase of atmospheric deposition samples is being analysed. The dissolved phase of atmospheric deposition samples are being completed. Redo and GKS lakes have been sampled for PAH and PCB in three different periods of the year; air and lake water has been analysed in those lakes, Øvre Neådalsvatn is still left. Redo is very high in Lindane, which matches with fish data (20 times higher than any ALPE 2 fish). Phenathren dominates the PAH in GKS in deposition, air and water.

Sample work up and analyses for fish are almost completed but quantification is still in progress. All fish samples (liver and muscle) from MOLAR sites plus samples from Bedoichov reservoir are taken. Organochlorine compounds in muscle samples from AUBE and BEDOICHOV were analysed using the same analytical procedure that used in the ALPE fishes. All bile samples have been processed, some PAH metabolites, namely hydroxy-PAH have been detected and quantified. Evaluation is in progress and results may be available until the end of 1998. For HCB and HCH, GKS is the less polluted site, but for PAH it is more polluted than Redo. Redo is very high in Lindane. Yet another lake in the Tatra should be analysed because BEDOICHOV is not a part of MOLAR. It is situated only at 700 m a.s.l. and has a forested catchment.

Soil cores have been collected from Redo, Gossenköllesee, Nagar and Øvre Neådalsvatn, and are presently being analysed for radionuclides. Rainwater and snow pack samples have been taken at Redo, Gossenköllesee, Nagar and Øvre Neådalsvatn for the period 1996/97. 210Pb in these samples have been determined for almost all samples received to date. The results have also yielded good data on the deposition of 7Be. The initial rainwater samples received from Øvre Neådalsvatn were too small - 1L samples are needed - this is now being corrected. Measurements continues as long as possible, preferably up to September. In view of the data obtained on 210Pb and 137Cs in the water column, there is a wish to carry out radiometric measurements on some fish samples during 1988, if these are available. Reports on most sediment cores for dating should be available by April 98. Suspended particle concentrations show seasonality in GKS. The concentration of particulate Pb-210 > aqueous Pb-210, but Cs-137 is inverse to this, as it is more soluble. Lake water residence time has resulted to be a key parameter !

Anodic stripping voltammetry (ASV) is used for analysis of lead and cadmium, cathodic stripping voltammetry for cobalt and nickel. Trends of higher values have been observed above sediment and metalimnion of GKS and REDO.

Deposition sampling for spherical carbon particles (SCP) has now finished. Snow profile data confirm the trends outlined in Barcelona that SCP are more concentrated in lower levels of the snow core presumably due to ablation. The bulk deposition data confirms the episodic nature of the deposition. All samples for bulk deposition, snow profiles, sediment traps, and lakewater have been received and most of them are analysed. Neådalsvatn showed rather weak performance in sampling, and it is proposed to all sites to sample ca. 40 L of lake water for SCP filtration (take big buckets, fill them and let SCP settle overnight, siphon-out the water and filter the rest).

Fish tissue were sampled from Jörisee, Øvre Neådalsvatn, Redo, Stavsvatn and and Gossenköllesee. Histological sections of liver, gills and kidney were prepared and evaluated. Quantitative results will be available from macrophages in the liver, melanomacrophages in the kidney, lipid degeneration of hepatocytes, and goblet cells on gill filaments and gill lamellae. Lakes with low deposition in Hg may have low Hg in fish. Low TOC in lake water allows demethylation of Hg, which is further supported by low OC in sediments. Light penetration into lakes is correlated with the demethylation rate. Different pathologic aspects (e.g. number of lipid vacuoles enhanced) are visible at the histological level in MOLAR lakes. Fish in GKS and Redo showed the best histological pattern. Several physiological parameters were analysed. The oxidative stress is high in Neådalsvatn, very low in GKS and medium in Redo. Glycogen status is high in GKS and low in Neådalsvatn. Riboflavin and conditional factors are similar in REDO and GKS.

WP2 workshops on data gathering and comparisons are planned in autumn '98 in Innbruck (fish) and in December `98 or January `99 in Prague (other biota).

4.3 MOLAR Work Package 3 (WP3)

CLIMATE VARIABILITY AND ECOSYSTEM DYNAMICS AT REMOTE ALPINE AND ARCTIC LAKES

Nigel Cameron, UCL

Overall, the work in Work Package 3 is proceeding well and according to the schedule set out in the proposal. Excellent progress has been made in assembling climate data for temperature, pressure and precipitation from meteorological stations throughout Europe. These have enabled the production of mean monthly air temperature series back to 1781 that can be used, after corrections for altitude and exposure, at the individual MOLAR study sites. Predicted air temperature records match closely data from on site automatic weather stations.

Sediment core analyses covering approximately the same time period are also making good progress. Good ^{210}Pb-based sediment chronologies are now available at all sites and show that sample resolution varies between 2 and 10 years. The analyses of the biological record from the cores is in varying stages of completion and an important remaining task is the finalisation of the training sets needed for pH and temperature reconstruction. The ultimate aim of WP3 is the development of lake models that can be used to hindcast and forecast changes in mountain lake ecosystems associated with climate variability. Two models, DYRESM and AQUASIM, are being calibrated. This work is still in its initial phase. Whilst there are some current problems in simulating accurately lake water temperatures in spring at the point of ice-out and snow-melt, we are optimistic that the models will be ready for application as scheduled.

4.4 MOLAR Work Package 4 (WP 4)

INTEGRATING ACTIVITIES

Simon Patrick, UCL

The MOLAR protocols manual was completed and distributed to all participating scientists, and the programmes of chemical and biological harmonisation and quality control have proceeded as planned.

A relational database has been established at the Botanical institute, University of Bergen, Norway. Some data have been transferred to this database and are being used to examine ways in which the database should be amended to maximise its efficiency for MOLAR purposes. The system of transferring data from site operator and/or laboratories to scientists with overall responsibility for key scientific areas, for checking prior to onward transfer to the database is proceeding smoothly.

The MOLAR world-wide web site
(http://prfdec.natur.cuni.cz/hydrobiology/molar/welcome/htm)
has been updated, enlarged and its format restructured. Developments in progress include insertion of hypertext links to individual laboratories and other relevant projects and an on-line list of reports, publications and presentations from the AL:PE and MOLAR projects.

Key presentations of the MOLAR project were made at the European Conference on Environmental and Societal change in Mountain Regions, held at the University of Oxford, UK, and presentations have similarly been prepared for the Headwater 98 meeting in Merano, Italy, in April 1998, SETAC at Bordeaux, France, in April 1998 and SIL in Dublin, Ireland, in August 1998.

Negotiations have commenced for the organisation of an international conference on mountain lakes, currently planned to take place in the year 2000. Proposals for funding support have been prepared for the EU and national organisations.

5. JOINT PUBLICATIONS

MOLAR Home page on Internet (http://prfdec.natur.cuni.cz/hydrobiology/molar/welcome/htm)

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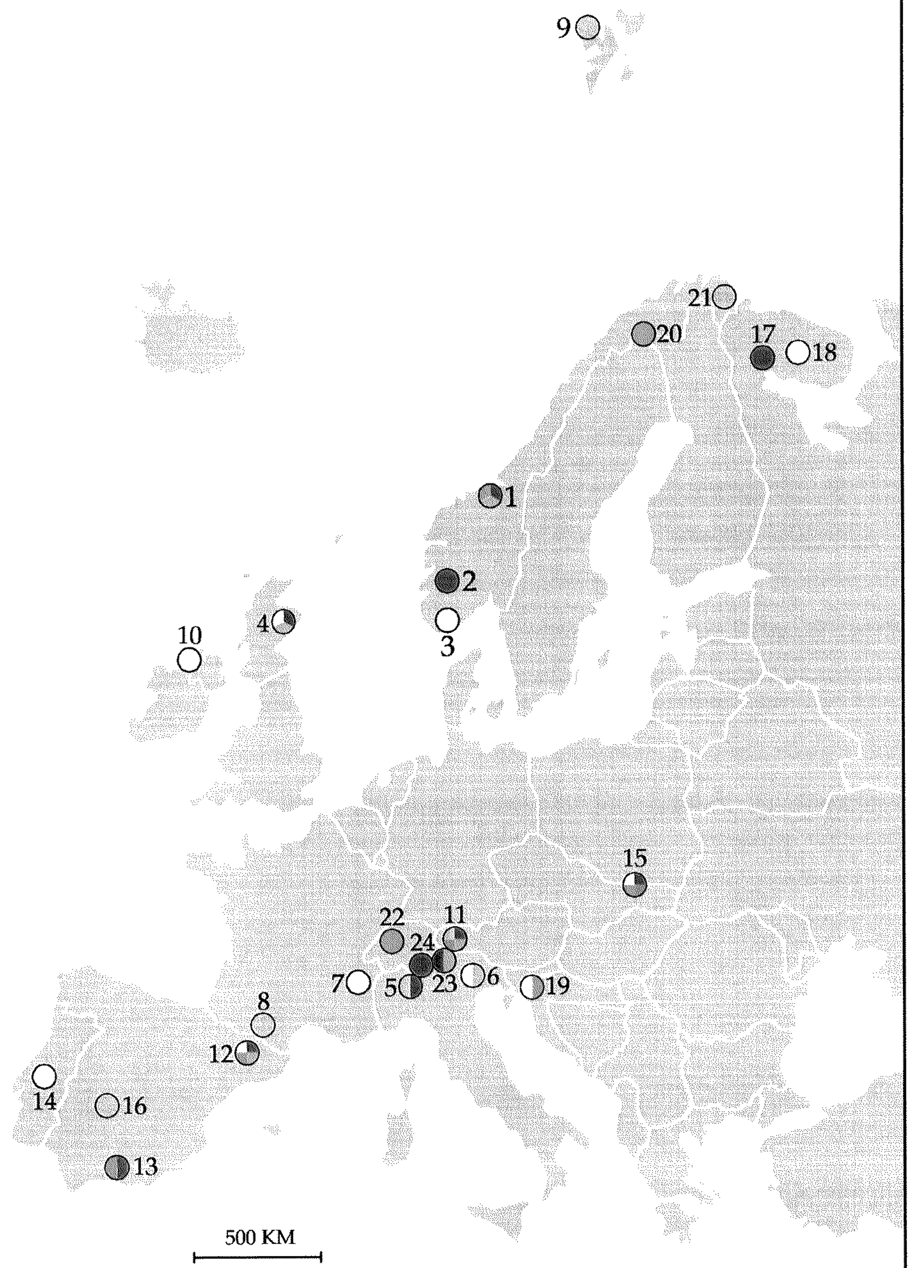
Figur 1. MOLAR sites: distribution, location and status within the MOLAR/AL:PE network.

Site nr.	Site name MOLAR/AL:PE	MOLAR WP1	MOLAR WP2	MOLAR WP3	MOLAR secondary	Other AL:PE site
1	Ø. Neådalsvatn	●	●	●		
2	Stavsvatn	●				
3	Lille Hovvatn					○
4.1	Lochnagar	●	●			
4.2	Sandy Loch					○
4.3	Loch nan Eun					○
5.1	Lago Paione Superiore	●				
5.2	Lago Paione Inferiore.				●	
6.1	Lago Lungo					○
6.2	Lago di Latte				●	
7.1	Lac Rond					○
7.2	Lac Combeynod					○
7.3	Lac Blanc					○
7.4	Lac Noir					○
8	Etang d'Aubé				●	
9	Arresjøen				●	
10	Lough Maam					○
11.1	Schwarzsee ob Sölden				●	
11.2	Gossenköllesee	●	●	●		
12.1	Lago Aguilo					○
12.2	Lago Redo	●	●	●		
13	La Caldera	●				
14	Lagua Escura					○
15.1	Starolesnianske Pleso	●	●			
15.2	Terianske Pleso			●		
15.3	Dlugi Staw	●				
15.4	Zieloni Staw					○
16	Laguna Cimera				●	
17	Chuna	●				
18	Chibini					○
19.1	Zgornje krisko jezero					○
19.2	Jezero Ledvicah			●		
20	Limgambergtjern				●	
21	Saanajärvi			●		
22	Hagelsee			●		
23	Jörisee	●	●			
24	Laghetto Inferiore	●				



SUMMARY PROGRESS REPORT OF MOLAR

PART B

DETAILED REPORTS OF THE INDIVIDUAL PARTNERS

01	University College London, UK (*administrative coordinator*)	(UCL)
02	University of Helsinki, SF	(UHEL)
03	University of Edinburgh, UK	(UED)
04	Norwegian Institute for Water Research, N (*scientific coordinator*)	(NIVA)
05	Universität Innsbruck, Institut für Zoologie, A	(UIBK)
06	Austrian Academy of Sciences, Limnological Institute, A	(ILIMNOL)
07	Universidad de Barcelona, ES	(FBG)
08	Universidad de Granada, ES	(UGR-ES)
09	University of Bordeaux (URA CNRS), Arcachon, F	(CNRS)
10	Consejo Superior De Investigaciones Cientificas, Barcelona, ES	(CSIC)
11	University of Bergen, Botanical Institute, N	(UIB-BI)
12	University of Bergen, Institute of Zoology, N	(UIB-ZI)
13	CNR-Istituto Italiano di Idrobiologia, Pallanza, I	(CNR-III)
14	University of Liverpool, UK	(ULIV)
15	Institute for Environmental Science and Technology, Dubendorf, CH	(EAWAG)
16	University of Zurich, CH	(UZurich)
17	Charles University, Prag, Czech Republic	(FSCU)
18	Hydrobiological Institute, Ceske Budejovice, Czech Republic	(HBI-ASCR)
19	Institute of Zoology, Bratislava, Slovak Republic	(IZ-SAS)
20	Polish Academy of Sciences, Institute of Freshwater Biology. Kracow, PL	(IFB-PAS)
21	National Institue of Biology, Ljubljana, Slovenia	(NIB)
22	Kola Science Cebtre, Apatite, Russia.	(INEP)
23	Laboratorio Studi Ambientale, Sezione aria e aqua, Ticino, CH	(LSA)

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period:	March 1st 1997 - February 28th 1998
Partner:	ECRC, University College London
Principal Investigator:	Dr S. Patrick
Scientific staff:	Dr N. Rose, Dr N. Cameron, Dr C. Curtis, Prof. R.W. Battarbee
Address:	26 Bedford Way, London WC1H 0AP, UK
Telephone:	+44 171 436 9248
Fax:	+44 171 380 7565 Email: spatrick@geog.ucl.ac.uk

I. OBJECTIVES FOR THE REPORTING PERIOD:

- Development & adaptation of critical loads models;
- Continued receipt and SCP analysis of samples from WP2 sites (deposition samples, sed traps, soil and sediment cores);
- Sample collection at Lochnagar, maintenance of the weather station and collection of monitored data;
- continued sampling of sediment trap (until removed by ice), epilithon & plankton;
- preparation of core samples;
- analysis of core lithostratigraphies;
- sub-sampling of cores for dating, particle size, magnetic, chironomid, cladoceran & pigment analyses;
- completion of diatom analytical comparison (AQC);
- completion of SCP analyses;

II. OBJECTIVES FOR THE NEXT PERIOD:

- Calibration of critical loads models;
- Collect and receive final samples. SCP analysis of all samples;
- Interpretation of results and development of a model to try and quantify the pathway from atmospheric deposition to the sediment record;
- Prepare draft manuscripts ready for submission to international journals;
- harmonisation of diatom samples to be added to the AL:PE training set;
- completion of diatom, chrysophyte analyses for cores, living communities and sediment trap samples;
- transfer of data to Bergen;
- application of calibration data-sets to down-core assemblages;
- integration of WP3 sub-areas;

PART B

III. Are there any particular problems? Is your part of the project on schedule ?

No serious problems, lack of samples received from some sites, lack of snow at Lochnagar!; project on schedule.

IV. MAIN RESULTS OBTAINED: METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS (use other pages as necessary but preferably no more than 2)

Model development and calibration in WP1 and analyses in WP3 are ongoing.

Sediment cores from all WP2 and new WP3 sites have been analysed for SCP. All cores show reasonable profiles. Full deposition records have so far been obtained for Lochnagar, Gossenkollersee and Ovre Neadalsvatn. Other samples are still outstanding. Deposition patterns show an episodic nature and an attempt will be made to put this into a meteorological context. Soil SCP profiles have been analysed from received cores (Lochnagar only!) and show that a significant amount of deposition is stored in the catchment. However, current data suggest that movement of particulates from the catchment to the lake is limited and is probably not an important pathway for SCP in the sediment record. Snow profiles have been received from most sites confirming early results that SCP appear to ablate down the column. A full integrated snow sample at the end of the winter is therefore recommended for future sampling. Lake water, inflow and outflow stream water, sediment trap samples have also been analysed in order to add further compartments to the model.

At Lochnagar soils and sediment cores have been taken over and above MOLAR requirements in order to try and better explain catchment variation in storage and obtain a full basin inventory for SCP. Results of this study will hopefully help more fully interpret data from less intensively monitored sites. 18 months of weather data is now available from the Lochnagar AWS.

V. List of Publications arising from the project (include copies):

Rose, N.L., Harlock, S. & Appleby, P.G. The spatial and temporal distributions of spheroidal carbonaceous fly-ash particles (SCP) in the sediment records of European mountain lakes. *submitted to Water Air and Soil Pollution.*

N. G. Cameron, H. J. B. Birks, V. J. Jones, F. Berge, J. Catalan, R. J. Flower, J. Garcia, B. Kawecka, K. A. Koinig, A. Marchetto, P. Sánchez-Castillo, R. Schmidt, M. Šiško, N. Solovieva, E. Stefkova & M. Toro Valasquez. Surface-sediment and epilithic diatom pH calibration sets for remote European mountain lakes (AL:PE Project) and their comparison with the Surface Waters Acidification Programme (SWAP) calibration set. *in prep.*

Signature of Partner: Dr S. Patrick

Date: March 1st 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: March 1 1997 - February 28 1998

Partner: UHEL

Principal Investigator: Atte Korhola

Scientific staff: Sanna Sorvari, Milla Rautio, Laura Forsström, Juhani Virkanen, Seppo Hassinen, Heikki Olander

Address: Lab of Physical Geography, University of Helsinki, PO Box 9 (Siltavuorenpenger 20 A), FIN-00014 Helsinki, Finland

Telephone: +358-9-191 8669

Fax: +358-9-191 8670 E-Mail: atte.korhola@helsinki.fi

I. OBJECTIVES FOR THE REPORTING PERIOD:

The objectives were to carry out and continue the sampling and analyses of water chemistry, water column profiling, zooplankton, chrysophytes, chironomids, epilithic diatoms, diatom transect, and sediment traps. The core material was aimed to be analysed for dating, SCP (UCL), magnetics, pigments, CNS (Pallanza), chrysophytes, chironomids, diatoms, and cladocera.

II. OBJECTIVES FOR THE NEXT PERIOD:

- all physico-chemical and biological analyses to be completed
- all meteorological data to be collected
- an additional core for pigment analyses to be collected
- statistical analysis of the data
- reporting the results

III. Are there any particular problems ? Is your part of the project on schedule ?

- there is a slight delay in some of the water chemistry determinations;
- two short-time interruptions in automatic weather station due to problems in energy supply;
- no cladoceran and few chironomid remains in the core material
- otherwise the project is on schedule.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

METHODOLOGY

Water chemistry, including water column profiling, was sampled weekly during July and August 1997, once a month during September-October, and once in two months during the ice-cover period. Samples for major ions, TOC, SO_4, Cl, Si, NH_4-N, and NO_2-N. were sent immediately to the Laboratory of Physical Geography for analyses. Samples for total phosphorus and nitrogen were frozen and analysed later using the internationally agreed standards. Oxygen, pH, temperature and conductivity were measured *in situ* using equipments from HANNA Instruments. Alkalinity was measured in the laboratory within 24 hours.

Phyto- and zooplankton samples were taken bi-weekly during July and August 1997 from the deepest point of the lake (24 m) using five depths (0, 2, 5, 10, 23 m) and the samples preserved using Lugol's Iodene and Formalin, respectively. 250 ml was stored for phytoplankton and 10 l for zooplankton analyses (sieved through a 50 1m mesh). Several vertical zooplankton hauls were taken simultaneously with water column profiling using a 200 1m plankton net. A composite sample for chlorophyll-a was taken from ten depths simultaneously with the plankton sampling. 2-3 l of water were filtered immediately in the field from each depth, and the filters were frozen for analyses. Extraction was carried out using 90% acetone. After the extraction samples were filtered and measured the absorbance at the following wave-lengths: 750, 663, 647, 630, 480, 430 and 410 nm. The chlorophyll a concentrations were calculated after Jefferey and Humphrey (1975).

Epilithon diatom samples were collected twice a month during the open water season. Epilithic diatoms were removed from stones at the water depth of 40-50 cm along a *ca* 10 m stretch from the shoreline, using a toothbrust. Three stones were washed into a 250 ml polythene bottle; three composite samples were taken on each sampling visit.

Accumulated material was collected monthly during the open-water season using sediment traps; after the autumn overturn traps were left in the lake for the ice-cover period. For the biological transect, hard bottom samples were collected by diving at 8.8.1997.

Sediment cores were analysed for Pb-210, Cs-137, SCP, LOI, dry-weight, diatoms, cladocerans, chironomids, and total chrysophyte concentration using standard methods. Continuous measurement of 7 meteorological variables (air temperature, epilimnetic water temperature, relative humidity, wind speed, wind direction, infra-red radiation, precipitation) was carried out by automatic weather station using 30 minute mean values. Due to problems associated with the energy supply, some interruptions in the operation of the station were faced during the mid-winter period.

RESULTS

Lake characteristics and selected chemical parameters are listed in Table 1. The lake was thermally stratified between the middle of July and the beginning of September (Fig. 1A). Maximum surface-water temperature, +14.6 C, was recorded at the beginning of August. The measured pH fluctuated between 5.4-7.5 (Fig. 1C). The pH was lowest during the snow melt period (June), whereas the values were relatively constant during the rest of the year. The hypolimnic oxygen concentrations were low (2.9 ppm) in the late spring (May/June); otherwise, the water was almost saturated. Alkalinity and conductivity were stable throughout the year.

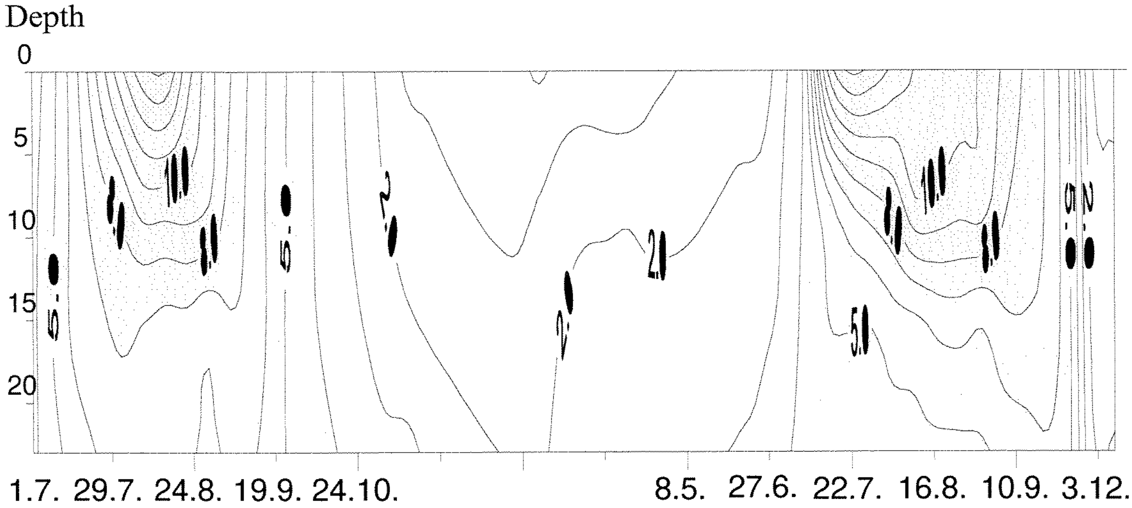
Phytoplankton was dominated by chrysophytes and diatoms; also chlorophytes were quite abundant. Quantitative analyses are in progress. Chlorophyll-a reached its maximum during the autumn overturn period (Fig. 1B). In general, the values were extremely low in comparison with more southerly sites. The crustacean zooplankton community consited of ten species, of which the copepods *Cyclops abyssorum* and *Eudiaptomus graciloides* were most abundant. *Holopedium gibberum* was the dominant cladoceran taxon. Appendix 1 lists the preliminary species data of phyto- and zooplankton. Table 2 comparaes the abundance of calanoids, cyclopoids, and cladocerans during the sampling season. The more precise counting, and identification of rotifers, is in progress.

Table 1. Physiographic and water chemistry data for Lake Saanajärvi. The limnological values refer to epilimnetic measurements carried out in the lake during the 1996-1998 (July 4 1996- February 18 1998; n ≈ 25). Catchment area excludes water area.

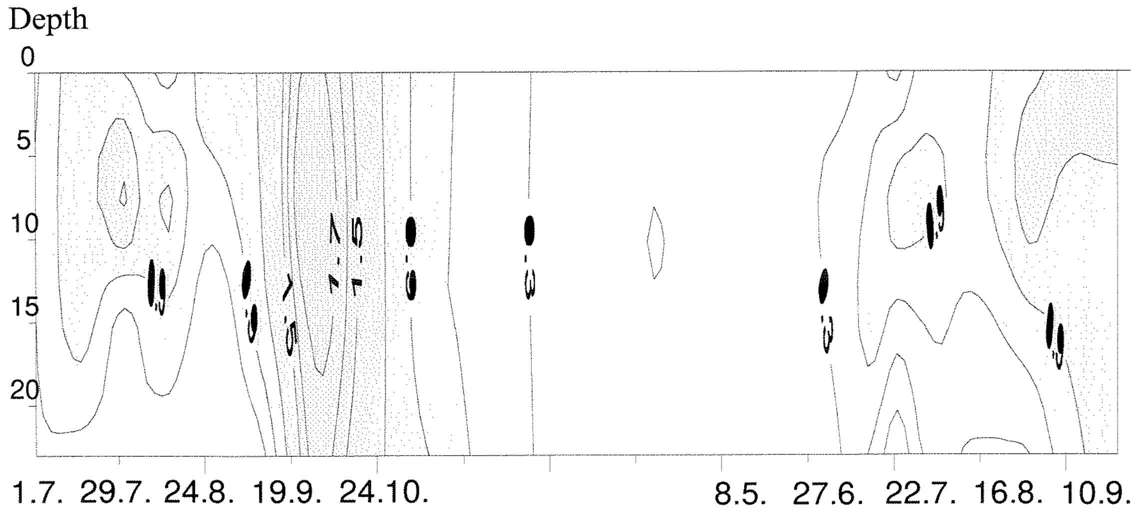
Parameter	Value	
Latitude	69°03'N	
Longitude	20°52'E	
Altitude (m a.s.l.)	679.4	
Catchment area (ha)	460.6	
Lake area (ha)	69.9	
Maximum lake depth (m)	24.0	
	Mean	Range
Secchi (m)	8.7	5.7-10.5
Water temperature (°C)	6.1	-0.2-14.6
pH	7.0	5.4-7.5
Conductivity ($\mu S\ cm^{-1}$)	28.2	24.6-37.0
Oxygen ($mg\ l^{-1}$)	9.7	8.5-12.7
Cl ($mg\ l^{-1}$)	1.59	0.68-2.84
SO_4 ($mg\ l^{-1}$)	4.2	0.8-5.9
Si ($mg\ l^{-1}$)	0.51	0.1-0.77
NH_4-N ($\mu g\ l^{-1}$)	0.6	0.2-1.0
NO_3-N ($\mu g\ l^{-1}$)	42	10-0.178
TP ($\mu g\ l^{-1}$)*	4.0	3.0-5.0
TN ($\mu g\ l^{-1}$)*	122.0	111.0-130.0
Ca ($mg\ l^{-1}$)*	2.8	2.5-3.1
K ($mg\ l^{-1}$)*	1.6	1.4-1.8
Na ($mg\ l^{-1}$)*	9.4	9.0-9.8
Mg ($mg\ l^{-1}$)*	5.9	3.8-7.6

* marked parameters are measured open-water period in summer 1996

A. Temperature (°C)



B. Chlorophyll-a (µg/l)



C. pH

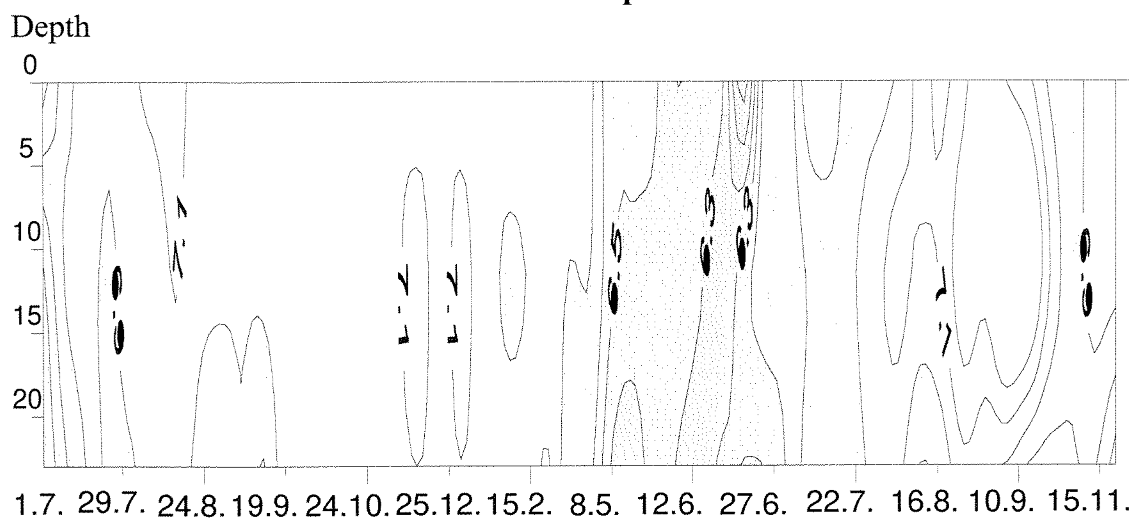


Fig.1. Seasonal fluctuation of temperature, chlorophyll-a, and pH in lake Saanajärvi.
Table 2. Abundance of Calanoida, Cyclopoida and Cladocera

Group	Mean abundance ind./m^3	Maximum abundance ind./m^3	Minimum abundance ind./m^3
Calanoida	439	626	200
Cyclopoida	131	330	5
Cladocera	81	180	5

Sediment trap assemblages consisted mainly of suspended and resuspended planktonic diatoms (*Cyclotella* and *Aulacoseira* species). For the core material, radiometric dating indicate a mean sedimentation rate of of 0.024 cm yr^{-1} for the preceding 150 years. The mean sedimentation rate during the last 30 is claculated to be 0.053 cm yr^{-1}. The chronology is confirmed by the SCP profile, with a clear increase in concentrations at *ca.* 4.2 cm. Magnitude of the record indicate a hemispherical background level of carbonaceous particles. Low sedimentation rates are typical to arctic lakes with low primary production.

Diatoms and chrysophycean cysts were well preserved in sediments of lake Saanajärvi, whereas cladoceran and chironomid remains were not. Diatoms were analysed from a 10-cm long sediment core, using a 2-mm resolution. In total, 203 diatom taxa belonging to 30 genera were identified. Diatom assemblages were relatively constant throughout the core, except in the top 4-5 cm (≈ 1850 A.D.) where relative frequencies and concentrations of *Cyclotella comensis* and *C. glomerata* increased markedly with the expense of *C. rossii*, *Aulacoseira subarctica* type II, and *Fragilaria* spp. The total diatom concentration also increased at the same point. No significant trends were observed in the weighted averaging (WA-PLS, PLS) reconstructed pH values. Several hypotheses, including (i) airborne pollution, (ii) climatic change, and (iii) catchment disturbances have been put forth to explain the recent changes in diatom assemblages. The diatom change coincides with a marked increase in mean annual temperature that has been documented in the area since the termination of the Little Ice Age. Our evidence favours climate change as the main causative mechanism for the observed diatom compositional changes, although other explanations cannot be ruled out.

Appendix 1. List of zooplankton species found in the water column during the open water period

Cyclopoida
Cyclops abyssorum

Calanoida
Eudiaptomus graciloides

Cladocera
Holopedium gibberum
Daphnia longispina
Bythotrephes longimanus
Bosmina obtusirostris
Alonella nana
Alonella excisa
Chydorus sphaericus
Polyphemus pediculus

V. List of Publications arising from the project (include copies):

Sorvari, S. & Korhola, A. 1998. Recent diatom assemblage changes in subarctic Lake Saanajärvi, NW Finnish Lapland, and their palaeoenvironmental implications. *Journal of Paleolimnology* (in press).

Korhola, A. 1997. The suitability of northern freshwater ecosystems as indicators of climatic change. *Symposium on Climate Change Effects of Northern Terrestrial and Freshwater Ecosystems. Arktikum, Rovaniemi, Finland, 18th - 20th September, 1997.*

Sorvari, S. & Korhola, A. 1997. Recent diatom assemblage changes in subarctic Lake Saanajärvi, NW Finnish Lapland - A Paleolimnological Approach. *Symposium on Climate Change Effects of Northern Terrestrial and Freshwater Ecosystems. Arktikum, Rovaniemi, Finland, 18th - 20th September, 1997.*

Sorvari, S., Korhola, A. & Blom, T. 1997. Recent diatom assemblage changes in subarctic Lake saanajärvi, NW Finnish Lapland. *7th International Symposium on Palaeolimnology, 28 Aug. - 2 Sept. 1997. Heiligkreuztal, Riedlingen, Germany. Würzburger Geographische Manuskripte* **41**: 205-206.

Korhola, A. 1996. Northern lakes as key witnesses for climatic change. *Universitas Helsingiensis* 3/1996: 16-19.

Korhola, A. 1996. Ilmasto jättää jälkensä järveen. Syrjäiset vuoristojärvet tutkijoiden arkistoina. [Climate leaves traces in lakes. Remote mountain lakes as archives of investigators] *Helsingin Sanomat*, Tiede ja Ympäristö. 17.2.1996.

Signature of Partner: **Atte Korhola**

Date: 27 February, 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: October 1996 to Febuary 1998

Partner: The University of Edinburgh

Principal Investigator: Roy Thompson

Scientific staff: Anna Agusti-Panareda

Address: Department of Geology and Geophysics, Edinburgh University

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Fax: 0131 668 3184 E-Mail: egph08@holyrood.ed.ac.uk

I. OBJECTIVES FOR THE REPORTING PERIOD:

1. To collate, harmonise and analyse appropriate long-term instrumental climate records for the regions under considerations.

2. To model the relationships between climate records for mountain weather stations (at study sites) with those for lowland stations.

II. OBJECTIVES FOR THE NEXT PERIOD:

1. To apply the multiple regression method to all work package III sites.

2. To integrate our climate work with data obtained from the automatic weather stations and hence to take into account local climatic effects in our reconstructions.

3. Finally, to reconstruct variations in radiation, growth season and ice cover duration at the Molar sites for use in modelling studies of the temporal responses of remote mountain lakes to climatic variability.

4. To compare the sediment record at study sites with instrumental records of temperature and precipitation.

PART B

III. Are there any particular problems ? None
Is your part of the project on schedule ? Yes

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

METHODOLOGY

Climate reconstructions for the last 200 years have been made using stepwise multiple regression.

RESULTS

1. Climate data gathering:

We have assembled monthly time series of temperature , pressure and precipitation. The monthly temperature records in our data base presently consist of: 21 long series of 217 years (1781-1997) in central Europe; 19 series of 101 years (1890-1990) in the Scandinavian area; 5 series of 100 years in Russia; 16 series of 28 years (1952-1979) in Spain and France; and about 50 series of 58 years (1931-1988) in the Alpine region and Britain. There are fewer long series for monthly precipitation, namely 20 series of 200 years in Europe. Most pressure series are short, except for the series of 200 years from Edinburgh, Geneva and Basel, as well as the series from Saentis (1883-1988), Zurich (1864-1988) and Paris (1874-1987).

2. Homogenisation:

Twenty-one regional air-temperature series since 1781 AD has been completed along with their extension to 1997.

3. Spatial coherence:

Using monthly mean and daily mean climate (air-temperature, air-pressure) data we have proven for the first time that lowland and upland sites correlate well. Thus in Europe, the spatial coherence of mountain climate is very similar to that of the lowlands. It is very likely that mountain climate change is very representative of lowland climate change and visa versa.

4. Other parameters:

Wind speed and relative humidity have a low spatial coherence. Hence, the reconstruction of those climate parameters at the MOLAR sites will probably not be possible.

5. Retrodiction:

Successful retrodiction of 200 years of monthly mean air-temperature at mountain sites close to the MOLAR sites (i.e. transfer sites) have been performed. The skill of those reconstructions varies with season and site. In the Alps and Norway the skill is generally high (ranging up to 82%). Whereas in northern Finland the skill is high for the September and October retrodictions (71% and 83%), but low for the January retrodiction. In general the skill is highest in spring and summer.

DISCUSSION

1. Study of climatic spatial variability

Before making a reconstruction of the climate at the Molar sites it is necessary to know how a given climatic variable varies in space (from one site to another). That is to say, we need to know how representative a particular site is of its surrounding area. We have carried out spatial variability studies for monthly and seasonal temperature in the Pyrenees and northern Scandinavian. Monthly temperature at our highest reference series site in the Pyrenees (Pic du Midi) is better correlated with French sites in winter and with Spanish sites in spring.
Generally, correlations are highest along a south-west north-east direction. In contrast, for Norway, Sweden and Finland the spatial variation of temperature is found to be more isotropic, that is, the correlation coefficient between temperature series decreases radially.

2. Skill

The ability of our method to reconstruct climate back in time for a given site or region depends on three main factors. Namely, (i) the homogeneity of the reference time series used, (ii) the representativeness of the reference sites for the given region, and (iii) the local climatic lapse rate. The mean error associated with our reconstructions has been computed for the Scandinavian region. For northern Scandinavia annual temperature prediction errors are less than 0.3 ^{O}C. In the south of Scandinavia reconstruction errors are closer to 0.1 ^{O}C. Annual prediction errors are three times less than typical monthly errors. We anticipate errors of less than 0.1 ^{O}C for annual temperature reconstructions at most of the Molar sites due to factor (ii).

CONCLUSIONS

1. We are very close to obtaining 200 year air-temperature retrodicted series at the MOLAR sites.

2. The final stage of our programme of work involves incorporating regional 'lapse rates' and local exposure into our climatic transfer functions.

3. Large data sets of daily observations have been built up which should allow the work to be completed on time.

V. List of Publications arising from the project (include copies):

None

Signature of Partner:

Date:

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period:	01/03/97 to 28/02/98
Partner:	Norwegian Institute for Water Research (NIVA)
Principal Investigator:	Bente M. Wathne
Scientific staff:	Bjørn Olav Rosseland, Leif Lien, Sigurd Rognerud, Richard Wright, Ann Kristin Buan, Einar Kleiven (NIVA) Torunn Berg (Norwegian Institute for Air research, NILU).
Address:	P.O. Box 173 Kjelsås N-0411
Telephone:	+47 22185211
Fax:	+47 22185200 E-Mail: bente.wathne@niva.no

I. OBJECTIVES FOR THE REPORTING PERIOD:

- Scientific co-ordination of MOLAR
- Co-ordinate Work Package 1 activities, including special responsibility for fish in Work Package 1 and 2, and water chemistry
- Sampling and analysis after the agreed MOLAR programme for Neådalsvatn, Stavsvatn, Limgambergtjern and Arresjøen
- Heavy metal analysis in deposition and lake water for Redo and Gossenköllesee
- Report WP 1 results and edit annual progress for the total project

II. OBJECTIVES FOR THE NEXT PERIOD:

- Scientific co-ordination of MOLAR
- Co-ordinate WP 1 activities, including special responsibility for fish in WP 1,2, and water chemistry
- Sampling and analysis after the agreed MOLAR programme for Neådalsvatn, Stavsvatn, Limgambergtjern and Arresjøen
- Report WP 1 results and edit annual progress for the total project
- Accomplish modelling activities within WP 1
- Complete database for chemistry and fish
- Prepare draft manuscripts for publication in international journals

PART B

III. Are there any particular problems ? Is your part of the project on schedule ?

The sediment trap in Øvre Neådalsvatn was lost during the winter season 96/97 and not replaced. The active sampling period is then from July to Septemer 1996 only. There has been a delay in the deposition sampling for organic pollutants but the samples will be gathered during spring 1998.

IV. MAIN RESULTS OBTAINED:

The Norwegain lakes Øvre Neådalsvatn and Stavsvatn have been sampled according to the agreed plans. The secondary sites Arresjøen and Limgambergtjern were not sampled in 1997.

Øvre Neådalsvatn was successfully testfished in August 1997 in co-operation with Austria, and all fish parametres were sampled according to WP 1 and 2 programmes. Stavsvatn was resampled in June 1997 to complete a sample- size useful for statistics. All fish from WP1&2 lakes have been age determined, and all muscle, liver and kidney samples have been analysed for heavy metals. A complete database including all primary fish data from AL:PE 1&2 and MOLAR is in progress at NIVA.

Seasonal variations in water chemistry is followed for Øvre Neådalsvatn and Stavsvatn. Deposition sampling at Kårvatn close to Øvre Neådalsvatn and Møsvatn in the same area as Stavsvatn has also followed the plans, apart from the sampling at Kårvatn of organic micropollutants, as explained above. Deposition sampling and analysis at Kårvatn and Møsvatn are the responsibility of NILU.

Water chemistry data for all lakes with planned sampling have been reported to NIVA and CNR-III in Pallanza. Evaluation of the data is in process.

V. List of Publications arising from the project (include copies):

None

Signature of Partner: Bente M. Wathne

Date: 1/3-98

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period:	1 March 1997	to 28 February 1998
Partner:	UINN-IZ	University of Innsbruck Inst. of Zoology & Limnology
Principal Investigator:	Dr. Roland Psenner	
Scientific staff:	Dr. Hansjörg Thies Dr. Ulrike Nickus Dr. Rudolf Hofer Dr. Reinhard Lackner	
Address:	Institute of Zoology and Limnology Technikerstr. 25 A-6020 Innsbruck	
Telephone:	+43 512 507-6130	
Fax:	+43 512 507-6130	E-Mail: roland.psenner@uibk.ac.at

I. OBJECTIVES FOR THE REPORTING PERIOD:

- Collection of meteorological data
- Sampling and analysis of lake water, tributaries, snow and rain
- Heavy metal analysis including heavy metal speciation
- Sampling of organic micropollutants from air and lake water
- Sampling of radioactive lead in precipitation and lake water
- Sampling and analysis of microbial food webs
- Diatom and chrysophycean sampling
- Coring and exposition of sediment traps
- Fishing and begin of fish analyses
- Preparation of samples and raw data for evaluation

II. OBJECTIVES FOR THE NEXT PERIOD:

We want to go on with the weekly analysis of lake water and precipitation until 30 September 1998 in order to cover 2 years (1 October 1996 to 30 September 1998). Therefore we have put much emphasis in collecting, storing, and analysing samples (including quality control and delivery to different partners), but less effort on evaluation and comparison. In the period until February 1999, we will focus almost entirely on further analysis and evaluation of samples already obtained as well as on additional samples that will be collected until 1 October 1998. Analysis and evaluation includes also the additional project – funded by the Austrian Ministry of Science - regarding hydrology and modelling.

PART B

III. Are there any particular problems ? Is your part of the project on schedule ?

We had problems with water analysis because of changes in the water supply system at the institute: The problems have been solved by installing a new water treatment device for suprapure water (Milli-Q) and a new ion chromatograph for simultaneous analysis of anions and cations (Dionex). The project is on schedule for sampling, sample storage and delivery to other partners. We have still much work to do for evaluating all samples because of the weekly sampling (105 weeks altogether) and because at our sampling and analysis for all Workpackages has to be done.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

As stated above, we have focussed on sampling and immediate analysis of samples which could not be stored. Since we have a very tight programme (2 days a week spent on site at the station), further analysis and evaluation has ben shifted to the second phase of the project.

RESULTS

Water chemistry sampling and analysis has been done at Gossenköllesee (GKS) lake water, tributaries, springs, snow and rain according to the MOLAR project manual. All major ions and nutrients were sampled weekly or biweekly. Analytical quality control has been performed in cooperation with Bente Wathne and Rosario Mosello. Samples for heavy metals were taken from GKS surface and precipitation and sent to Norway for analysis. Sampling for heavy metal speciation and radionuclides in lake water of GKS was done in March and July by Peter Appleby and Stan van den Berg. Organic micropollutants in air and surface water have been collected in March and July 1997 by Rosa Vilanova, Pilar Fernandez and Guillem Carrera Ruiz. Large volume samples have been filtered for SCPs in Summer 1997 and sent to Neil Rose after filtration on Whatman GF/C filters.
Microbial food web studies have been performed according to the MOLAR manual. Fish have been sampled in GKS, Jörisee, Ovre Neodalsvatn, Redo and Stavsvatn; they were processed on site, or sent to Innsbruck, France, Spain and Norway for further analysis. Histological sections of liver, gills and kidney were prepared and partly evaluated.
Three additional sediment cores have been taken for contemporary chironomids and sent to Gunnar Raddum. Sediment traps for diatoms and chrysophytes (monthly) and SCPs and Pb (3 July, 29 November) have been taken.
Soil samples have been taken in July by Peter Appleby. The MAGIC Model has been applied to GKS in January 1998 by Dick Wright, NIVA, and Chris Curtis, UCL, in cooperation with Uli Nickus and Hansjörg Thies.
Schwarzsee ob Sölden (SOS), the secondary site, was sampled on 18 September 1997 for water chemistry.

CONCLUSIONS

Our primary conclusion is that we have now a nearly complete data set of relevant parameters, from physics and chemistry to biology. In comparison with some additional measurements such as a lithium dilution experiment, gauging of springs and tributaries, soil analysis etc. we expect to gain a good understanding of fluxes and dynamics in GKS.

V. List of Publications arising from the project (include copies):

Sommaruga-Wögrath S, Koinig K, Schmidt R, Tessadri R, Sommaruga R, Psenner R (1997). Temperature effects on the acidity of remote alpine lakes. *Nature* **387**: 64-67.

Koinig KA, Schmidt R, Wögrath S, Tessadri R, Psenner R (1998) Climate Change as the primary cause for pH shifts. *Water, Air, Soil Pol* **104**:167-180

Koinig KA, Schmidt R, Psenner R (1998) Effects of Air Temperature changes and acid deposition on the pH history of three high alpine lakes, Proceedings of the 14th International Diatom Symposium (in press)

Koinig KA, Sommaruga-Woegrath S, Schmidt R, Tessadri R, Psenner R (1998) Acidification processes in high alpine lakes - Impacts of atmospheric deposition and global change. Conference Volume of the HeadWater Conference 1998, Meran (in press)

Signature of Partner:

Date: 18 March 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 31.1.1997 - 31.1.1998

Partner: OAW.IL_
Institut for Limnology, Austrian Academy of Sciences

Principal Investigator:
Prof.Dr. Roland Schmidt

Scientific staff:
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I. OBJECTIVES FOR THE REPORTING PERIOD:

a) Completing the geochemical analyses of the sediment core Gossenköllesee (GKS2)
b) Diatom evaluation of GKS2
c) Chrysophycean cyst evaluation of GKS2
d) Diatom and chrysophycean cyst evaluation of sediment trap samples of GKS
e) Sampling and counting of epilithic and epiphytic littoral and planktonic diatoms of GKS
f) Taking additional cores for chironomide analyses (G. Raddum)

II. OBJECTIVES FOR THE NEXT PERIOD:

Completing d) e)
Chrysophycean cyst evaluation of core and sediment trap samples of Tereansko Plezo and Hagelsee (if diatom/cyst ratio satisfactory), Jezero Ledvicah

III. Are there any particular problems ? Is your part of the project on schedule ?

On schedule

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

see additional pages

V. List of Publications arising from the project (include copies):

Signature of Partner:

Date: 25.2.1998

Ad OAW.IL Report Part B/IV

R. Schmidt
Ch. Kamenik
K. A. Koinig

Main results obtained

Methods

From the 514 subsamples of the 5 sedimente cores taken in july 96 in Gossenköllesee (GKS), analyses of WD, DW, LOI, grain size and CHN (Carlo Erba) were completed. By the use of standard techniques (Battarbee 1986, MOLAR project Manual 1997), diatoms of GKS95 were counted in LM (Leitz Diaplan), for chrysophycean cyst assemblages (Duff *et al.* 1995; Facher & Schmidt 1996) SEM (Jeol JSM35) was used adapted with an image analysing system for storage of the SEM pictures and measurements in a PC database. This allows a better taxonomic harmonisation. These methods were also adapted to the sediment trap samples (Bloesch type) located at 7 m depth of GKS (diatoms and chrysophytes) and for diatom samples of the littoral epilithon (sampled monthly after ice break (July) until the onset of the ice layer in late November) and of the littoral transect (sampled once by divers in 1995 from the littoral to 9m depth in 2m intervals).

Results

a) Chrysophytes

Different methods of zonation indicate, that the chrysophycean cyst assemblage in the core section 0-10 cm does not change in a statistically significant way. However, three zones can be distinguished, if boundaries in 3 and 6.5 cm are considered to be important.
Sediment trap results of siliceous stomatocysts in GKS indicate a distinct seasonality. Maxima occurred at the time of ice-break and the beginning of ice-cover. Winter/spring, summer and autumn forms were distinguished. Small cysts prevailed during summer, whereas large one predominated in autumn.

b) Diatoms

A large amount of the diatom community consists of *Cyclotella* and *Fragilaria*. Diatom assemblages show no significant changes in species composition. However, *Cyclotella* are more abundant in the upper core section while the lower section is dominated by a course *Fragilara* (called *F.* Xlarge).

Discussion

a) Chrysophytes

The fossil stomatocyst assemblage composition only showed little analogy to the calibration set in Facher & Schmidt (1996). The inferred pH is lowered by 0.2 to 0.4 units in the core section 6.5 to 3 cm. Due to a very high estimated standard error of prediction, this shift is not significant. Generally the estimated pH is 0.5 to 0.8 units too low, due to the low number of circumneutral lakes in the calibration data set.

b) Diatoms

Many diatom species observed in the sediment of Gossenköllesee are not included in the AL:PE data-set, limiting at present prediction.

Conclusions

Siliceous stomatocysts indicate no significant trends of pH change in GKS in the time interval investigated.

Diatom inferred pH trend based on the current AL:PE data set are likely to reflect changes in the amount of species not included in the data set. An extension of the data-set, e. g. by the new MOLAR-sites might lead to more reliable pH trends.

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1-3-1997 to 28-2-1998

Partner: UNIVERSITAT DE BARCELONA, DEPARTAMENT D'ECOLOGIA. (UBCN.DE)

Principal Investigator: Jordi Catalan

Scientific staff: Lluís Camarero, Marisol Felip, Maria Rieradevall, Marc Ventura, Sergi Pla, Frederic Bartomeus

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I. OBJECTIVES FOR THE REPORTING PERIOD:

- On site measurements of sulphur and nitrogen deposition on L. Redó (Pyrenees)
- Monthly measurements of surface water chemistry in L. Redó
- Invertebrate sampling during the ice-free period in L. Redo
- Monthly sampling of the pelagic food web in L. Redó
- Monthly benthic diatom sampling in L. Redó
- Measurement of phytoplankton and bacteria activities in L. Redó
- Fish sampling in Lake Redó
- Weather recording in Lake Redó
- Snow collection and chemical composition measurement in L. Redó
- Sedimenting particles sampling in Lake Redó
- Monthly measurements of physical, chemical and biological characteristics in the water column of L. Redó (Pyrenees) and L. Cimera (Gredos)
- Development of taxonomic system for chrysophytes
- Sediment record analysis for L. Redó and L. Cimera

II. OBJECTIVES FOR THE NEXT PERIOD:

- Continue the regular sampling in L. Redó and L. Cimera until June 1998.
- Continue all the analytical work to finish by July 1998.
- Intensive data processing of the data obteined in the different workpackages for L. Redó
- Intensive modelling in workpackages 1, 2 and 3 subjects in relation with L. Redó
- Model development and application related to the objective of work package 3.

III. Are there any particular problems ? Is your part of the project on schedule ?

There were not major problems in the development of the project during the reporting period. Taking into account the intrinsic risk to install automatic instrumentation at 2240 m a.s.l. in the mountains, we can conclude that we have been very lucky. The only problem has appeared with the sensor recording the lake level, which has demonstrated being very sensitive to lighting. For some of the potential problems, there were already planned more than one option, thus we could accomplish all the objective scheduled for the period. Field work has been done as scheduled, and analytical work do not deviates from planned.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS*
(use other pages as necessary but preferably no more than 2)

Given that most of the sampling programme and analytical work are still in progress, it has not been a detailed treatment of the available data; however some obvious aspects can be commented as preliminary results for L. Redó site.

WP1: *Mountain lake ecosystem response to acid deposition*

Due to the difficulties to reach the lake, deposition measurements have been made on monthly integrated samples. However, we collected weekly and daily samples at a lower altitude and we have compared them with the monthly lake deposition. It appears that there were no differences between the two sites, thus we can use the data on the lower station to follow the deposition in the lake catchment with high resolution. On the other hand, a comparison of the chemical composition of the deposition with data from previous years (1987, 1994) has shown a trend of decreasing base cations.

The seasonal pattern in the lake water chemistry have followed the patterns previously described in former studies. The specific timing, however, has accommodated to the shorter length of the ice and snow cover that occurred this year.

A clear seasonality in all the biota studied (invertebrates and diatoms) have been found during the ice free period of the lake. The pattern observed still has to be related to the physical and chemical changes occurring during the studied period. Concerning fish and microbial biota, analytical work is still in process, thus there are not yet results to comment for this period.

In co-operation with R. Wright (NIVA) and C. Curtis (UCL), FAB and MAGIC models have been applied to lake Redó. The lake is not acidified, thus the models have been mainly use to test future scenarios related to possible changes in sulphur and nitrogen emissions and to possible climate change and associate variations in dust deposition. The main conclusions is that the lake could hardly be acidified, even under the worse case considerated; but on the other hand, it is very sensitive to changes in base cation deposition; its alkalinity can vary up to 100% within reasonable future scenarios.

WP2. *Measuring and modelling major element and pollutant fluxes in mountain lakes and their impact on fish*

Pollutant deposition sampling and analysis have been carried out regularly in the lake. It appears as a major difficulty for assessing total deposition inventories the period with snow. However, given the little knowledge, which exist at present, on the pollutant pathways within the lake and the catchment in these remote sites, there is a reasonable hope to produce valuable results. A large set of data have been collected on organic contaminants, SCPs and metals, which with the Pb-210 as tracer, could allow for developing a first model illustrating the process from atmosphere to sediments.

WP3. *Climate variability and ecosystem dynamics at remote alpine and arctic lakes*

On site meteorological data shows a very high variability in weather conditions at those altitudes. This fine record will allow a better understanding of the variability found in chemical and biological characteristics. A lot of new data have been produced to better reconstruct past dynamics from the sediment record and forecast the consequences of future scenarios.

Signature of Partner:

Jordi Catalan
Date: Barcelona 13 March 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: March 1, 1997- February 28, 1998

Partner Instituto del Agua. Universidad de Granada; ES (UGR-ES)

Leading Scientist: Prof. L. Cruz-Pizarro

Scientific Staff: Dr. P. Sánchez-Castillo
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I. OBJECTIVES FOR THE REPORTING PERIOD:

Development of activities scheduled within WP 1 for the second year of the Project:

- Bulk deposition
- Snow chemistry
- Surface water (chemical analysis of major ions and nutrients; AQC: In- laboratory and
- external).
- Water column profiling (WP3) (including chlorophyll).
- Contemporary zooplankton (large :zool and small zoos (enumeration and biomass).
- Contemporary diatoms
- 1st level of microbiology : Abundance/biomass of bacteria, picocyanobacteria,
- phytoplankton, heterotrophic flagellates and ciliates
- 2nd level of microbiology chlorophyll, phytoplankton primary production, phytoplankton exudation, bacterial production. Estimation of bacterivory.

II. OBJECTIVES FOR THE NEXT PERIOD:

- Additional measurements of bulk deposition, snow chemistry and major water chemistry
- Spring/early summer determinations (numbers, biomasses) of zooplankton and diatoms

PART B

- Spring/early summer measurements of biological parameters (1st. Level microbiology) and processes (2nd level microbiology), paying particular attention to estimates of photosynthetic rates
- Additional estimates of bacterivory
- Contribution to the construction of flow-chart models of the pelagic carbon flow
- Publication of results

III Great difficulties in reaching the lake during winter

TOC and DOC values ranging below the instrument detection limits, making some results indecisive. Bacterivory assessment: we got a Paracoccus desnitrificans strain having an individual size close to that found for the lake spp. To assure realistic determinations. After and adequate growth and labelling of material , the performed bacterivory experiments failed as the presence of mucilaginous materials made quantification almost impossible.
Apart from this, our part of the project is on schedule

IV. MAIN RESULTS OBTAINED

Samples for surface water chemistry were taken in 17 occasions along the ice-free period at the pelagic area of the lake. On each sampling date, four depths were sampled on the vertical profile.
Contemporary zooplankton and diatoms samples as well as parameters (physical, chemical, biological) and processes (1st and 2nd level of microbiology) were taken/performed on five occasions: at the beginning (July 17), middle (August 5, 13 and 27) and at the end (October 10) of the ice-free period.

Sampling for bulk deposition analysis started on November 11 and since then has been recorded on a weekly basis.
For sampling and analysis , we have strictly followed the standard techniques agreed by convenors and lead laboratories (compiled in the Project Manual).

In comparison with 1996 data, chemistry values show a reduction in inorganic nutrient concentrations. NO_3^- ranged from 294 µgN/l to 79 µgN/l and SRP never reaches values greater than 1 µgP. Values for TP and , particularly, for TN are also lower than obtained for the same period in 1996. The latter one shows a clear seasonal pattern as concentration increases from snowmelt (June/July) to the next freeze (October) whereas inorganic nitrogen shows just a definitive reverse pattern in time, so that TN / NO_3^- ratio decreases from 81% to 17% along such period.
pH values (mean for the water column) steadily increases during the sampling period from 7.80 to 8.93. The highest values were measured at the greatest depths.
Chlorophyll concentration (mean for the profile) ranges from 0.2 to 1.0 µg/l. These values are close to the lowest ones ever measured in the lake. The patter of variation in the water profile (peaks at intermediate depths) and in time (consistent decrease) conforms that obtained in previous records.

By the time of submitting this report we are still processing the phytoplankton data.

Zooplankton assemblage is rather poor. Mixodiaptomus laciniatus is the dominant species both in terms of number of individuals and in biomass: mean values for the water column, between 5,8 and 34,3 ind/l and between 14.5 and 82.0 µgDW/l, respectively.
Diaptomus cyaneus was rarely found close to the bottom with densities never above 0.5 ind/l.
The population of Daphnia pulicaria, which represents the only holeoplanktonic species in the lake, was found since beginning of August, reaching densities close to 10 ind/l by the end of the ice-free period.
The presence of Acanthocyclops vernalis and Chydorus sphaericus was merely accidental in the plankton samples.
By middle of August, Hexarthra bulgarica, the only pelagic rotifer species, develops and reaches populations densities of 17 ind/l at beginning of the autumn.

Gross primary production (GPP) ranged from 0.5 to 2.09 µgC/l/h (mean values for the water column). The maximum autotrophic production was measured on late August. Extracellular production (E) fluctuated between 0.045 and 1.46 µgC/l/h which represents between 22% and 69% of GPP.

Bacterial production (BP) ranged between 0.005 and 0.03 µgC/l/ h. The percentage of BP in relation to GPP was extremely low (from 0.5 % to 3.9%). This sharply faced up to the expected values for oligotrophic systems (about 30%). This result suggests a weak coupling between phytoplankton and bacteria which hardly can be related to "lack" of extracellular carbon available to bacteria.
It is remarkable the extremely low data for bacterial abundance (always below 10^6
Cell/ml and biomass (never reaching 30 µgC/l) measured in the lake.

Signature of Partner:

Date:

MOLAR REPORT 1998

Jean-Charles Massabuau

Contractor: Centre National de la Recherche Scientifique (CNRS)
Subject area: Fish, fish physiology
Leading scientist: Jean-Charles Massabuau
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I OBJECTIVES FOR THE REPORTING PERIOD

- Organising fish physiology sampling in selected lakes
- Organising and co-ordinating with the Department of Ecology, University of Barcelona, a test fishing in lake Redo (Spanish Pyrénées)
- Analysing fish blood and selected parameters of gill histology (scanning microscopy) for the lakes sampled during the period 1997-1998.
- Realising and producing a film "Looking for artic charr in remote mountain lakes"

II OBJECTIVES FOR THE NEXT PERIOD

- Interpreting fish blood data combined to gill histology (scanning microscopy) for the lakes sampled during the programme.
- Producing a movie entitled "Test fishing in remote mountain lakes" based on the Fish-meeting held in Arcachon in 1996.
- Producing a draft for an interdisciplinary paper on "the water-chemical constraints limiting trout *Salmo trutta fario* adaptation in remote mountain lakes".
- Organising the 1999 Molar meeting in Arcachon.

III MAIN RESULTS OBTAINED

Organising fish physiology sampling in selected lakes

We co-ordinated the fish sampling effort that was oriented toward the ecophysiology of *S. t. fario* and the artic charr *Salvelinus alpinus* in the selected sites. The site responsible persons used the standardised technique developed during the fish meeting held in 1996 in Arcachon.

Field sampling packages (in the kit format) were send to all site responsible persons to prepare tissues for scanning and electronic microscopy and to sample blood plasma. The following lakes were successfully sampled:

- Lake Stavsvatn, Norway, 27 june 1997, *S. t. fario* (resp. person, L. Lien)
- Lake Gossenkoellosee, Austria, 8-9 july 1997, *S. t. fario* (resp. person, R. Lackner)
- Lake Ovre Neadalsvatn, Norway, 27 august 1997, *S. t. fario* (resp. person, L. Lien)
- Lake Redo, Spain, 7-11 september 1997, *S. t. fario* (resp. person, J.-C. Massabuau)
- Lake Joerisee, Switzerland, 1 october 1997, *S. t. fario* (resp. person, B. Hinder)

Blood and gill samples were sent (either frozen or fixed as required) to the Laboratory of Ecophysiology and Ecotoxicology of Aquatic Systems in Arcachon and to the CNRS Strasbourg.

Test fishing in Redo (spanish Pyrénées)

Lake Redo was testfished from 7-11 September 1997. Seven scientists from 3 countries (Spain, France and Austria) participated. The test-fishing was performed by the University of Sevilla. The fish sampling was performed by the CNRS Arcachon and the University of Innsbruck

Tissues and blood from trout *S. t. fario* were successfully sampled and sent to the different participants. Oxygen and temperature profiles were determined.

Physiological analysis

When studying the ecology of remote mountain lakes and the role biodetectors can play as early alarm of air born pollution and climate changes, a basic question is to understand how fish succeed to live – *i.e.* to maintain their hydro-mineral balance - in such extreme biotopes where low mineralisation is the first major stress. Taking advantage of the palette of water ionic composition observed in the Molar lakes, we consequently studied the minimal concentration of key ions (Na, Cl, Ca, alkalinity) compatible with fish life. This should give us the baseline to interpret secondarily contamination processes.

Plasma ion analysis. In fish blood, the main contributors of osmolarity are the Na and Cl ions. Consequently, natremia ([Na]b) and chloremia ([Cl]b) were measured and compared to reference data obtained in the same fish species living in more mineralised waters (Alsatian plain and Vosges mountains, north-eastern France). Results were analysed as a function of water chemistry data (mineral load, water [Na], [Cl], [Ca] and alkalinity). When possible, comparison was performed with the arctic charr *Salvelinus alpinus*.

The results show that *S. t. fario* can maintain a normal blood Na concentration ≥ 110 $mmol{\cdot}L^{-1}$ in waters where the mineral load is as low as ≈ 4 $mg{\cdot}L^{-1}$ but that the blood Cl concentration starts to decrease when the mineral load becomes lower that 8-10 $mg{\cdot}L^{-1}$. This blood Cl effect is not directly correlated to the concentrations of Na and Cl in the water but closely dependent on the concentration of calcium. When the Ca concentration in the water is higher than 40 $\mu mol{\cdot}L^{-1}$, *S. t. fario* can maintain a normal chloremia even if [Cl]w is as low as 3 µmol·L^{-1} (the case of lake Gossenkellesee, Austria). This is coherent with literature data on the role of Ca in impermeabilising biological membranes but give new insights into critical limits compatible with fish life in remote mountain lakes. Note that it is in lake Aubé (french Pyrénées), where the water calcium concentration is only 14 µmol·L^{-1}, that trouts exhibit the lowest chloremia (70-75 mmol·L^{-1} for [Cl]w = 7-9 µmol·L^{-1}). Moreover, in this lake we did not only found *S. t. fario* but also some examples of minnow, dace and artic charr. Minnow and dace were introduced as baits by fishermen. By analysing natremia and chloremia in the artic charr we found that its blood Na and Cl concentrations were much higher that in the *fario* blood. This confirms the exceptional ability of this species to inhabit extremely low mineralised waters.

Scanning microscopy All the fish gills (from *fario* trouts and artic charr) collected in the Molar lakes are now prepared for the anatomical analysis in scanning microscopy. For TEM, resin blocks are available if required. The analysis integrated with blood data clearly shows that the proliferation of chloride cells (characteristic of osmoregulatory problems) in trout gill increases when the ionic content decreases. The apical surface was large and the microvilli density high. In some cases the cells were coalescent. It is generally agreed that these cellular complexes present cellular junction with low resistance. In lake Aubé, the artic charr gill present a very small augmentation of the chloride cell number by comparison to what is observable in trout gill from the same lake. Taken together with the blood data (higher natremia and chloremia in artic charr that in fario trout), it confirms the superiority of the artic charr to adapt to extremely low mineralised waters. There are however two exceptions to this general trend which are lake Arroesjen and Joerisee. In lake Arroesjen, Spitzberg, there is no proliferation of chloride cell although the Ca concentration is about 20 µmol·L^{-1} but it is worthwhile noticing that the NaCl concentration in the water is exceptionally high (Na ≈ 240 µmol·L^{-1}; Cl ≈ 260 µmol·L^{-1}). Indeed, the lake is very close to the sea and contaminated by sea salts. In lake Joerisee, there is a large proliferation of chloride cell although the ionic concentrations are very closed to Gossenkollesee.

Film production "Looking for artic charr in remote mountain lakes"

We realised a video-movie whose aim was (i) to present a test fishing performed by MOLAR scientists within the framework of this program and (ii), with the use of an underwater camera, some aspects of the biotope where the artic charr is living. The film (13 min, color, Pal, Secam, NTSC, betacam, etc) has been produced by the CNRS Audio-Visuel and is today available in french and in english.

Age determination

Otolith reading for age determination is a fundamental point in the analysis of fish physiology when one have to correlate exposition time to various environmental conditions, accumulation rates and fish ages. In the case of fishes living in extremely diluted waters like artic charr, it is well known that otolith reading becomes extremely difficult. Considering lake Aubé, this is definitively true while the recent history of introduction of artic charr is well known: in autumn 1996, they were either 2 or 4 years old. We are using this particular fish stock strategy to intercalibrate otolith reading by comparing results from NIVA (Norway) and CEMAGREF Aix en Provence (France).

Reporting period: From 1th March 1997 to 28 February 1998

Partner: Consejo Superior de Investigaciones Científicas. Department of Environmental Chemistry. Barcelona.

Principal Investigator: Joan O. Grimalt

Scientific Staff: Dr. Pilar Fernandez, Ms. Rosa Vilanova, Mr. Guillem Carrera, Ms. Lourdes Berdié

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I. OBJECTIVES FOR THE REPORTING PERIOD

1) *Completion of the development of all analytical methods for the analysis of organic trace compounds in snow, air (gas and particulate phase), water (dissolved and particulate phase), bulk, wet and dry deposition samples.*

All methods have been completed and tested. Several paper have been published or are in submission for reporting these methods (see list of publications)

2) *Sampling and analysis of snow, air, water, bulk, wet and dry deposition samples.*

Field sampling in lakes Redo and Gossenköllesee has been completed. Field sampling in lake Øvre Neadalsvatn has started (first sampling –winter- already performed). The analysis of the samples is in progress results are available for the two first lakes. Deposition samples from Jorisee, Redo and Gossenköllesee have also been collected.

3) *Analysis of fish.*

Sample collection from lakes Redo, Stavsvatn, Gossenköllesee, Øvre Neadalsvatn, Bedoichøv, Aube and Jorisee has been completed. The composition of hydroxylated polycyclic aromatic hydrocarbons in bile of fishes from all lakes has been analyzed. The composition of organochlorinated hydrocarbons in muscle of fished from lakes Bedoichøv, Aube and Jorisee has been examined.

II OBJECTIVES FOR THE NEXT PERIOD

Completion of field sampling in Øvre Neadalsvatn. Completion of the analyses of snow, air, water, bulk, wet and dry deposition samples. Completion of the fish analyses.

Cross-correlation of the results from atmospheric, water, precipitation and sediment samples.

Cross-correlation between the results of the fish analyses and the hystological, physiological and enzymatic parameters determined by other groups.

Cross-correlation between the composition of trace organic compounds in air, water and fish.

III PARTICULAR PROBLEMS. SCHEDULE.

All our tasks in the project go without any major problem and on schedule.

The only problem is concerned with the precipitation samples from Øvre Neadalsvatn. No viable samples have been received in our laboratory. The only set that was received only concerned the particulate fraction and was not in suitable conditions for analysis. We hope that adequate samples will be received in the next period.

IV MAIN RESULTS ACHIEVED.

Methodology.

C_{18} solid-phase disks have been observed to be useful for the measurement of organochlorine compounds (OC) and polycyclic aromatic hydrocarbons at pg/l in atmospheric precipitation samples with reproducibilities of 5-15% and extraction efficiencies of 80-100%. Quantitation and detection limits of 0.14-3.5 pg/l were achieved from the analysis of 0.25-10 l of water, *e.g.* bulk precipitation or snow. The use of C_{18} disks allows the determination of these organic pollutants in remote areas affording collection and extraction of large numbers of samples with limited instrumentation.

On the other hand, a method for the analysis of trace OC in large numbers of muscle fish samples has been developed. This method provides higher precision than that observed in the most uniform fish populations. Among all sample handling steps, evaporation losses has been observed to constitute the main aspect of recovery decrease. These can be minimized to less than 10% when it is avoided that the extract go to dryness. In any case, the effect of these losses can be compensated by correction by a tetrabromobenzene surrogate.

Sample grounding with sodium sulphate provides significant higher concentrations than freeze-drying. Soxhlet extraction for 18 h is sufficient to draw most OC from the muscle samples, no significant peaks representing measurable concentrations of these compounds have been found by further extraction after this period.

Repeatibility and reproducibility is smaller than the dispersion between fishes of similar length and age from the same lake for all compounds except a-HCH.

From the point of view of instrumentation (gas chromatography coupled to mass spectrometry using chemical ionization in the negative ion mode –GC-NICI MS-), the use of ammonia as reagent gas provides lower limits of detection and quantitation than methane for most OC. This lower limits allow the detection and quantitation of species with three and four chlorine substituents in aromatic rings which are difficult to determine at trace levels when methane is used as reagent gas. The use of ammonia as reagent gas also facilitates the quantitation of the DDT derivatives.

The mass spectra obtained with ammonia and methane correspond to the molecular incorporation of thermal electrons rather than true chemical ionization reactions. Despite the differences in fragmentation patterns associated to these two reagent gases, the use of one or the other does not require changes in the compound-specific ions selected for the selected ion monitoring mode.

Field studies

The study of fish concentrations and sediment inventories (430-2800 meters above sea level, 40-67ºN) shows that lake elevation is the major variable determining the accumulation of low volatility OC such as 4,4'-DDE, 4,4'-DDT and penta- to hepta-chlorobiphenyls. These compounds are also significantly correlated with annual average air temperatures. In contrast, volatile OC (sub-cooled liquid vapor pressure > $10^{-2.5}$ Pa) do not exhibit any gradient with elevation. The results obtained in the study illustrate that in temperate regions global distillation of OC involves the selective retention of the low volatility compounds at the coldest areas. This fractionation effect is responsible for the accumulation of high concentrations of potentially harmful compounds in high altitude ecosystems.

V. LIST OF PUBLICATIONS ARISING FROM THE PROJECT

P. Fernandez, R. Vilanova and J.O. Grimalt
PAH distributions in sediments from high mountain lakes.
Pol. Arom. Comp. **9**, 121-128 (1996)

L. Berdie, M. Santiago-Silva, R. Vilanova and J.O. Grimalt*
Retention time repeatability as a function of the injection automatism in the analysis of trace organochlorinated compounds with high-resolution gas chromatography.
J. Chromatogr. A **778**, 23-29 (1997)

R. Vilanova, P. Fernandez and J.O. Grimalt
Atmospheric persistent organic pollutants in high altitude mountain laks. A preliminary study
In:SEA-AIR EXCHANGE: PROCESSES AND MODELLING. Edited by J. Pacyna. NILU. 1997. Accepted for publication

G. Carrera, P. Fernandez, R. Vilanova and J.O. Grimalt
Analysis of trace polycyclic aromatic hydrocarbons and organochlorine compounds in atmospheric deposition by solid-phase disk extraction
J. Chromatogr. A, accepted for publication

R. Chaler, R. Vilanova, M. Santiago-Silva, P. Fernandez and J.O. Grimalt
Enhanced sensitivity in the analysis of trace organochlorine compounds by negative ion mass spectrometry using ammonia as reagent gas
J. Chromatogr. A, accepted for publication

L. Berdié and J.O. Grimalt
Assessment of the sample handling procedures of a man power minimized method for the analysis of organochlorine compounds in large numbers of fish samples
J. Chromatogr. A, accepted for publication

L. Berdié, J.O. Grimalt, P. Fernandez, R. Vilanova, D. Pastor, R. Psenner, R. Hofer, B.O. Rosseland, P.G. Appleby, J. Catalan and R.W. Battarbee
Selective cold trapping of organochlorine compounds in high altitude lakes
Nature, Submitted for publication

Signature of partner

date: 28th February 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1-3-1997 to 28.2.1998

Partner: Botanical Institute, University of Bergen

Principal Investigator: H.J.B. Birks

Scientific staff: Einar Heegaard
John-Arvid Grytnes

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Fax: + 47 55 58 96 67

E-Mail: John.Birks@bot.uib.no
Jon.Grytnes@ bot.uib.no

I. OBJECTIVES FOR THE REPORTING PERIOD:

- Development of the MOLAR primary data-base using ACCESS software.
- Development of an unambiguous site/variable/sampling time coding system and series of data-base tables between Bergen, Oslo, and London.
- Statistical analysis of data collected during the AL:PE projects that form the basis of part of MOLAR Work Package 3.
- Storage of MOLAR data after analytical quality control.

II. OBJECTIVES FOR THE NEXT PERIOD:

- Continue the development of the MOLAR primary data-base.
- Provide statistical advice and help within the MOLAR project, particularly Work Packages 1 and 3.
- Satisfactory ways of coping with real missing data.

PART B

III. Are there any particular problems ? Is your part of the project on schedule ?

- No problem in connection with the data-base design or structure.
- The absence of any data from MOLAR colleagues has created the problem that the data-base design and structure cannot, as yet, be fully tested.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

The main statistical work by H.J.B. Birks has been on the development of the AL:PE modern diatom-pH calibration data-set, the development of predictive models for lake-water pH using diatoms preserved in lake sediments, and the comparison of diatom pH preferences in high-altitude/high-latitude lakes (AL:PE and MOLAR) and low-altitude (SWAP) lakes. The resulting pH inference model has a root mean square error of prediction (RMSEP) of 0.33 pH units, based on weighted averaging partial least squares. Optima for the major diatom taxa have been estimated by Gaussian logit regression using maximum-likelihood estimation. The results obtained highlight (a) the high quality of the AL:PE diatom data-set as a predictive tool and (b) the uniqueness of high-altitude/ high-latitude lakes in terms of the light climate, pH optima, and diatom assemblages.

V. List of Publications arising from the project (include copies):

Cameron, N.G., Birks, H.J.B., Jones, V.J. and 13 others. (1998) Surface-sediment and epilithic diatom pH calibration sets for remote European mountain lake (AL:PE project) and their comparison with the Surface Waters Acidification Programme (SWAP) calibration set. *J.Paleolimnology* (submitted).

Birks, H.J.B. (1998) Numerical tools in fine-resolution paleolimnology-progress, potentialities, and problems. *J.Paleolimnology* (submitted).

Lotter, A.F., Birks, H.J.B., Hofmann, W. & Marchetto, A. (1997) Modern cladocera, chironomid, diatom, and chrysophyte cyst assemblages as quantitative indicators for the reconstruction of environmental conditions in the Alps. I. Climate. *J.Paleolimnology* **18**, 395-420.

Signature of Partner: H.J.B. Birks

Date: 12.ii.98

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 01.03.96 – 28.02.97

Partner: LFI, Institute of Zoology, University of Bergen

Principal Investigator: Gunnar G. Raddum

Scientific staff: Arne Fjellheim, Oyvind A. Schnell

Address: Institute of Zoology, University of Bergen, N-5007 Bergen, Norway

Telephone: +47 55582236

Fax: +47 55589674 E-Mail: gunnar.raddum@zoo.uib.no

I. OBJECTIVES FOR THE REPORTING PERIOD:

Field work

Sorting and handling of samples

Data processing

II. OBJECTIVES FOR THE NEXT PERIOD:

Field work

Sorting and handling of samples

Data processing

III. Are there any particular problems ? Is your part of the project on schedule ?

Lake Limgambergtjern (a Norwegian secondary lake) was excluded from the sampling programme due to reductions of the financial support. Otherwise the project is on schedule.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

Sorting and processing of qualitative and quantitative invertebrate samples finished.

Species lists and data of seasonsal variation obtained.

Invertebrate data delivered for statistical treatment.

V. List of Publications arising from the project (include copies):

Signature of Partner: Gunnar G. Raddum

Date: 12/3-98

PART B

Reporting period: from 1-3-1997 to 28-2-1998

Partner: Consiglio Nazionale delle Ricerche – Istituto Italiano di Idrobiologia (CNR-III)

Principal Investigator: A. Lami
Scientific staff: R. Mosello, P. Guilizzoni, M. Manca, A.M. Nocentini, A. Pugnetti, A. Boggero, C. Callieri, R. Bertoni, A. Marchetto, R. Bettinetti, P. Comoli, G.A. Tartari, V. Libera and M. Contesini

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Italy
Telephone: +39-323-518 300
Fax:: +39-323-556 513 e-mail: lami@iii.to.cnr.it

I. OBJECTIVES FOR THE REPORTING PERIOD:

- Data collection in the drainage basin of Lake Paione Superiore (LPS) on: meteorological base parameters, amount of precipitation, chemistry of atmospheric deposition, lake chemistry, microbial pelagic food web including bacteria, autotrophic picoplankton, heterotrophic nanoflagellates, ciliates, phytoplankton, zooplankton;
- Sample collection for lake water chemistry analysis on the secondary site, L. Paione Inferiore (LPI);
- Sediment core analysis for pigments and elemental carbon and nitrogen.
- Investigation of macroinvertebrates and co-operation with experts to assess the taxonomical benthic refinement;
- Organisation of workshop on Analytical Quality Control for chemical analyses;
- Participation in specific workshop for method and data harmonisation.

II. OBJECTIVES FOR THE NEXT PERIOD:

In the last year of the contract we expect to complete the analysis of all the samples collected in the previous two years. We also expect to validate the data collected and transfer them to the data collection centre.

III. Are there any particular problems ? Is your part of the project on schedule ?

As regards the scheduled work on L. Paione Superiore we are on time with almost all the analytical work done.

IV. MAIN RESULTS OBTAINED: METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS (use other pages as necessary but preferably no more than 2)

Workpackage 1

Collection of volume of precipitation and meteorological data

Since July 1996 an automatic weather station (AWS) has been installed on LPS. This equipment has provided data on temperature, solar radiation, wind direction and speed, amount of precipitation.

With the aim of collecting all the meteorological data relevant to our geographical area, we are also collecting data from other high altitude AWS in co-operation with the Meteorological Service of the Piedmont Region. This will help to construct a fuller set of meteorological information relevant to the work involved in the MOLAR Workpackage 1 and 3, and is being done in collaboration with Dr R. Thompson, Univ. of Edinburgh.

Chemistry of atmospheric deposition

Atmospheric deposition was sampled at the station of Graniga, located at 1080 m a.s.l., in the same valley where lakes Paione Superiore and Inferiore (2269 and 2002 m a.s.l.) are located. Samplings and chemical analyses were performed weekly. The volume of precipitation during 1997 was 1610 mm. Results show pH values ranging from 3.87 to 6.56, with a median value of 4.83. The main cations are ammonium and hydrogen ion (median values of 33 and 15 $\mu eq\ l^{-1}$), while sulphate and nitrate (31 and 37 $\mu eq\ l^{-1}$) are the main anions.

Lake chemistry

The LPS sampling for 1997 are summarised in Tab. 1. In LPI we took only outflow samples. The situation is similar to that of the previous years, with the mean concentrations of solute in LPS and the surface values in LPI showing total ionic concentrations ranging between 122-185 and 192-236 $\mu eq\ l^{-1}$ in the two lakes respectively, with conductivity values of 8-12 and 11-13 $\mu S\ cm^{-1}$ at 20°C. Figure 1 shows the trends, observed over the last 7 years, of pH, alkalinity, sulphate and total inorganic nitrogen (TIN), expressed in $\mu eq\ l^{-1}$, for the two lakes. The main difference lies in their alkalinity values, which range between 0-10 $\mu eq\ l^{-1}$ in LPS (broken line) and between 20-40 $\mu eq\ l^{-1}$ in LPI (full line). As a consequence pH is between 5.2-6.3 in LPS, while in LPI the range is 6.1-6.8. Alkalinity and pH values moreover show well-defined seasonal trends, with minimum values at the snow-melt (June-July) when large amounts of pollutants (especially nitrate and sulphate) reach the lakes, and maximum values at the end of the summer and during the snow cover. Minimum summer values of nitrate correspond to maximum phytoplankton uptake. Figure 1 clearly shows a significant increase in pH (particularly in LPS) and a decrease in sulphate and TIN corresponding to the same long-term trends observed in atmospheric depositions.

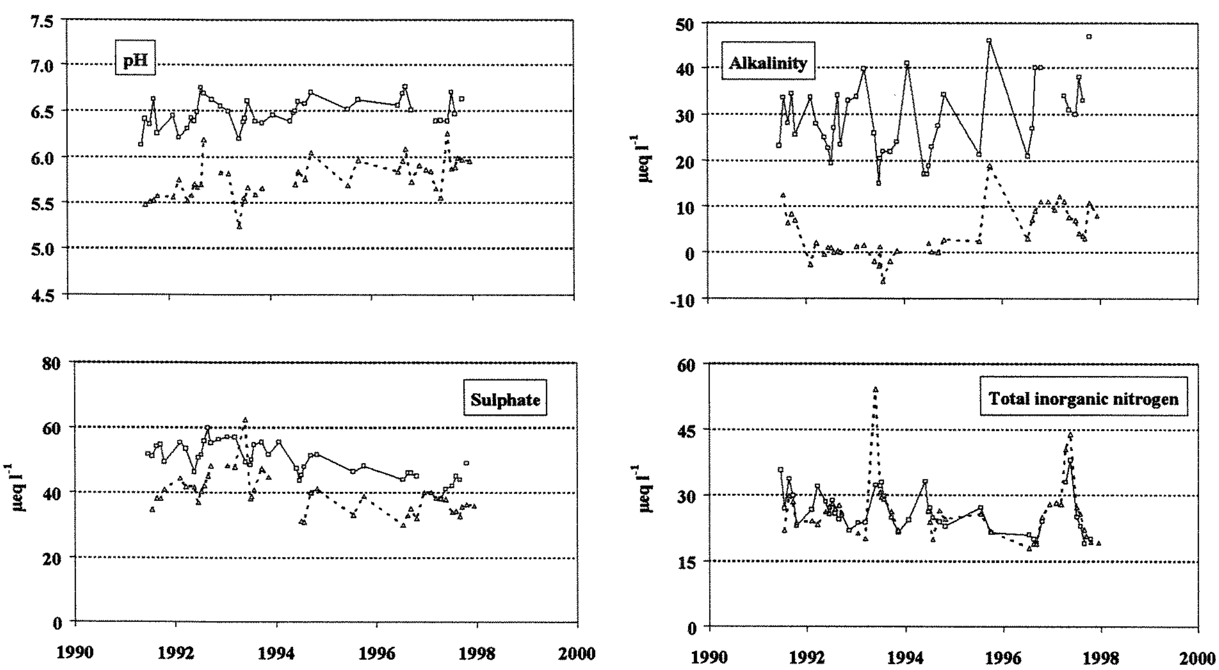

Fig. 1 - Trends of pH, alkalinity, sulphate and total inorganic nitrogen in lakes Paione Superiore (broken line) and Inferiore (full line).

Microbial (pelagic) Food Webs - 1st Level

<u>*APP, Bacteria, HNF, ciliates and phytoplankton*</u>

Nine samplings were performed during 1997 (cf. Tab. 1) to count and measure the micro-organisms present in the Lake Paione food web. As in the previous year the autotrophic picoplankton (APP), bacteria (HPP), heterotrophic nanoflagellates (HNF), ciliates and phytoplankton were identified, counted and their biomass expressed in terms of carbon content (from biovolume measurements). The intercalibration of HNF and bacteria counted using different procedures in C. Budejovice and in our laboratory was performed. The depths were the same as those chosen in 1996: one meter below the surface and one meter from the bottom.

APP. *Synechococcus* sp. was rarely found, and APP is mainly composed by coccoid cells of 2 µm and eukaryotic algae. The abundance was higher on the surface than at the bottom with the sole exception of 1 September sample. The numbers range from 0 to 619 and from 0 to 180 cell ml^{-1} in surface and bottom samples respectively. The carbon content is not higher than 0.03 µg C l^{-1}.

HPP. All the different bacterial forms were found in this lake: cocci, rods, vibrions, and in some months the filamentous forms were characteristic. In August very large rods were found, so that the carbon and biomass values were high. The pattern of bacteria numbers in this lake is related to the presence of ice cover: under the ice the higher values are found in surface samples, while conversely in the ice free period the bottom numbers are higher. Carbon and biomass were, with the sole exception of August, higher at the bottom. The ranges of the number values were 0.166-0.907 and 0.114-0.972 million cell ml^{-1} for surface and bottom respectively. Carbon varied from 5 to 63 µg C l^{-1}.

HNF. The heterotrophic nanoflagellates found at the two depths were of two sizes: smaller than 3 µm and larger, but no more than 10 µm. Their number and biomass were higher at the bottom than at the surface. The value of 2.530 million HNF per liter was reached in October. The carbon value ranged from 0.1 to 37 µg/l.

Ciliates. The ciliate community is represented by prostomatida, oligotrichida and scuticociliatida. The two genera of prostomatida recognized to date are *Urotricha* and *Holophrya*. Protargol preparations are in process and at the moment at least 3 species of *Urotricha* seem to be present in this lake: *U. furcata, ovata* and *agilis*. Among the oligotrichida, *Halteria* sp. and *Strombidium* sp. are the only organisms found. *Strombidium* sp. organisms were observed in fission. In summer 1997 the *Strombidium* presence was not very important, as was also the case in summer 1996. Prostomatida were dominant in summer and winter. Under the ice cover the carbon values were very low, with the highest carbon values being measured at the bottom, in summer. The range of the number values was 49-2002 and 33-11042 individuals l^{-1} on the surface and the bottom respectively. Carbon varied from 0.03 to 13 µg C l^{-1}.

Phytoplankton. In 1997 phytoplankton comprised mainly Chrysophyceae and Dinophyceae. The group of Chlorophyceae was also present with *Chlamydomonas* spp., but with few individuals. The highest number was reached in March (1561 ind ml^{-1}) with a peak under the ice cover, in the surface sample, due to cf. *Chromulina* sp. Many colonies of *Dinobryon sertularia,* which were not so massive in 1996, were found. Near the bottom the highest phytoplanktonic abundance was observed in August (1440 ind ml^{-1}) due to the presence of *Gymnodinium* sp.

The results can be summarized in two figures. In figure 2 the carbon confined in the microbial loop is presented as a mean value for the two depths, showing the partitioning among the communities. In 1997 the total carbon concentration was nearly the same at surface and bottom: 21 and 27 µg C l^{-1} respectively. In figure 3 the seasonal pattern of the carbon in the microbial food web of LPS is shown separately for the phytoplanktonic and the microbial loop communities. Heterotrophic organisms dominate the water column most of the year and most of the carbon is present near the bottom. Under the ice cover carbon is generally less than in the ice free period for all organisms. However, the peak of Bacteria in December and of Chrysophyceae in March, both under the ice, should be noted.

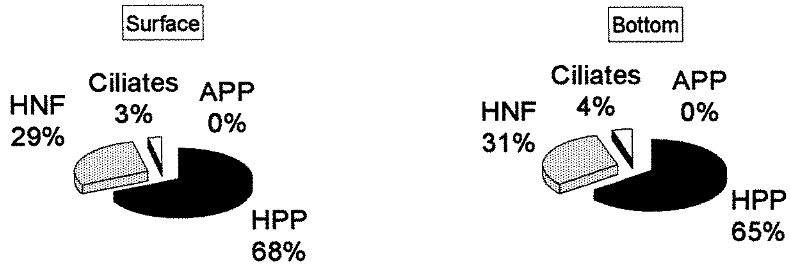

Fig. 2 - Carbon percentage in the microbial-loop of LPS.

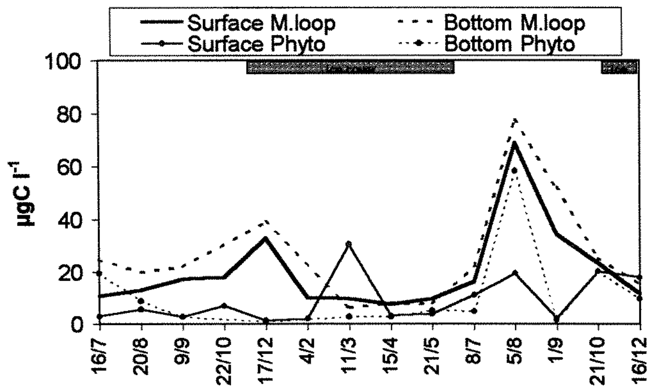

Fig. 3 - Carbon distribution in the microbial food web of LPS.

Zooplankton
In accordance with the sampling protocol, we collected both quantitative and qualitative (ZOOQ) samples on each date of the ice-free period (cf. Tab.1). Abundance and biomass estimates were obtained for both small (ZOOS) and large zooplankton (ZOOL) fractions. We obtained the biomass of ZOOS samples by converting body length into biomass through length/biomass regression equations. Direct biomass of ZOOL was estimated by weighing replicate live samples, previously dried on filters, which were collected at the same time as the fixed ones. The same dried samples will also be used to measure carbon content by means of a CHN elemental analyser.

Tab. 1 - Summary of the samples collected.

	Chem.	ZOOS	ZOOL	ZOOQ	phyto	APP	HPP	HNF	ciliates	benthos
4-2-97	*(3)				*(1)	*(1)	*(1)	*(1)	*(1)	
11-3-97	*(3)				*(2)	*(2)	*(2)	*(2)	*(2)	
15-4-97	*(3)				*(2)	*(2)	*(2)	*(2)	*(2)	
21-5-97	*(3)				*(2)	*(2)	*(2)	*(2)	*(2)	
8-7-97	*(3)	*(2)	*integr.	*	*(2)	*(2)	*(2)	*(2)	*(2)	*
5-8-97	*(3)	*(2)	*integr.	*	*(2)	*(2)	*(2)	*(2)	*(2)	*
1-9-97	*(3)	*(2)	*integr.	*	*(2)	*(2)	*(2)	*(2)	*(2)	
16-9-97	*(1)									*
21-10-97	*(2)	*(2)	*integr.	*	*(2)	*(2)	*(2)	*(2)	*(2)	*(2)
17-12-97	*(2)				*(2)	*(2)	*(2)	*(2)	*(2)	

In brackets : number of depths sampled

Macroinvertebrates
Qualitative kick samples were taken during the ice-free period in LPS at 3 littoral, 2 inlets and 2 outlets (100 and 200 m downstream) stations, using a net with a 225 µm mesh aperture. A further

6 core samples were taken in the deepest, central part of the lake with a gravity corer (diameter = 6 cm). These samples were taken at the same time as those for water chemistry (cf. Tab.1).
In July the ice-melt was beginning, while in October the lake was 2 m lower than the normal level. The depth level considered was about 50-100 cm and littoral sampling stations were selected taking account of differences in substratum. It was possible to sample 4 to 6 stations per date for a total number of 20 littoral and 6 deep samples.
The macrobenthos of the littoral community is prevalently composed of Insecta, particularly Diptera Chironomidae, which represent more than 90%. Second in importance are Oligochaeta, while Plecoptera (Nemouridae and Leuctridae), Trichoptera (Limnephilidae and Rhyacophilidae) and Coleoptera (Dytiscidae) are quite well represented. Hydracarina and Turbellaria are less frequent. Other groups, such as Culicidae, Empididae, Limoniidae, Simulidae and Tipulidae, are negligible. The profundal community is qualitatively and quantitatively poorer, composed as it is almost exclusively by Chironomids, while Oligochaets are present only in two cores out of six.

Workpackage 3

Pigment analysis

Six sediment cores (SAA96, HAG96/2; LEDV4, TERI6, GSK3 and RCM1) arrived at our Institute during the first year of the contract. Pigment measures have been completed on 5 cores (HAG96/2, LEDV4, TERI6 RCM1, and OVN5). The identification and quantification of the specific carotenoids of algae was performed by High Pressure Liquid Chromatography (HPLC) and about 600 samples have been measured so far. The same number of samples have been analysed for carbon, nitrogen and sulphur content. The sediment remaining after the pigment extraction was transferred to the laboratory responsible for zooplankton remains analysis. The analytical programme will be completed by June 1998.

V. List of Publications arising from the project (include copies):

Signature of Partner:

Scientific responsible	Administrative responsible
Dr. A. Lami	Dr. R.de Bernardi
Date: 04/03/1998	Consiglio Nazionale delle Ricerche Istituto Italiano di Idrobiologia IL DIRETTORE (Dr. R. de Bernardi)

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: **01-03-97 / 01-03-98**

Partner: **Laboratorio Biologico - Provincia Autonoma di Bolzano (I)**

Principal Investigator: **Dr. Bertha Thaler**

Scientific staff: **Danilo Tait, Andrea Scapin**

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South Tyrol - Italy

Telephone: 39 471 950431

Fax: 39 471 951263 E-Mail: Danilo.Tait@provinz.bz.it

I. OBJECTIVES FOR THE REPORTING PERIOD:

- Water chemistry sampling and analyses for Lago di Latte (Milchsee) and Lago Lungo (Langsee)
- Zooplankton and phytoplankton sampling, species identification, enumeration, biovolume calculation and chlorophyll-a analyses for Lago di Latte and Lago Lungo.
- Chemical analyses of precipitation
- Elaboration of the obtained data

II. OBJECTIVES FOR THE NEXT PERIOD:
Same as above

III. The sampling and analyses have been performed according to the schedule. Data have been delivered.

IV. MAIN RESULTS OBTAINED

Precipitation

Atmospheric precipitation chemistry has been analysed during the period 04/11/96-09/12/97 directly at the lake by means of nine bulk samples. Analyses have been performed also in weekly bulk samples collected at a nearby located station (Riffian) for the whole year 1997. Bulk and wet weekly data are available also for another station (Renon) in the area located at 1700 m altitude, which functions routinely since many years. The deposition data of this last station do not differ significantly from the data measured at the lake itself, while the data recorded in the station Riffian are affected from agricultural influence and bird droppings (high ammonia values). The most representing values for the watershed seem therefore those measured at the lake (tab. 1).

Tab.1 Depositions values (g m^{-2} y^{-1}) at Milchsee (Texelgruppe).

Year	*H+*	*Ca^{2+}*	*Mg^{2+}*	*Na^{+}*	*K^{+}*	*N-NH4*	*S-SO4*	*N-NO3*	*Cl-*
1996	0.005	0.17	0.04	0.10	0.10	0.44	0.36	0.26	0.13
1997	0.004	0.18	0.07	0.06	0.13	0.67	0.48	0.33	0.26

The performed analyses confirm that deposition in the area is lower than in other sites of Central Europe also because of the low amount of precipitation typical for the area (around 1500 mm above 2000 m altitude). The distribution of the deposition values during the year showed minimum values in winter and higher values during late spring and summer, which corresponds to a similar distribution pattern of the precipitation amounts.

Lake chemistry

Lago di Latte (Milchsee) has been sampled seven times during 1996 and seven times during 1997. Samples have been taken at several depths at the deepest part of the lake. The adjoining lake Lago Lungo (Langsee) has been sampled two times during 1996 and three times during 1997. Temperature has been measured for the whole water column, while oxygen, pH, conductivity, chlorophyll have been measured at five to nine different depths, where also samples for chemical analyses have been taken. The measured chemical variables are: major ions, nitrate ammonia, reactive soluble P, total P, total dissolved P, total dissolved and total nitrogen, TOC, dissolved reactive silica, and iron. Chlorophyll has been calculated according to Goltermann. Dissolved major ions concentrations were higher in the winter period and lower during summer probably because of dilution due to higher precipitation amounts, while their percentage composition remained more or less constant throughout the year. During winter stagnation a marked increase of the concentrations toward bottom was registered.

Lake biology

Zooplankton and phytoplankton samples have been taken at the same depths chosen for chemical analyses. Phytoplankton biomass was estimated by counting (Utermöhl, 1958) and by the mean cell volume. Zooplankton samples were taken at every meter depth, but 3 samples were filtered together in situ through 100 μ mesh and analysed as single specimen.

Rotifers were counted in aliquots under a dissecting microscope and crustaceans under a stereomicroscope. Weighted means both for chemical and biological variables have been calculated.

The phytoplankton of Milchsee is essentially composed of Dinophyceae and Chrysophyceae. During 1995 and 1996 small Zygnemaphyceae became important and produced a strong increase of the biomass. In Langsee *Staurodesmus crassus*, a small species of Zygnemaphyceae, dominated the whole period of investigation. Also present are here Dinophyceae, Chrysophyceae, Cryptophyceae and Chlorophyceae.

Phytoplankton biomass values in Milchsee were until 1994 at the level typical for high mountain lakes (up to 560 mg m^{-3}), but increased later because of the strong development of a small Zygnemaphyceae species up to a maximum of 1400 mg m^{-3}. Langsee displays a much higher primary production with biomass up to 3200 mg m^{-3}, a very high value for high altitude lakes. Over the period of observation a clear increase of the biomass was recorded for both lakes.

The zooplankton of Milchsee and Langsee is mainly composed of rotifers, with *Keratella hiemalis* and *Polyarthra dolichoptera* as dominant species. The rotifers abundances were in both lakes quite high and reached the maximum values of 230 Ind.l^{-1} for Milchsee and 500 Ind. l^{-1} for Langsee. The only copepod species present in both lakes was, until 1995, *Cyclops abyssorum tatricus*, a species typical for high altitude lakes. Afterwards also some diaptomids were found in Milchsee. While cyclopoids reached densities up to 22 Ind. l^{-1} in Langsee, these remained always well below 1 Ind. l^{-1} in Milchsee. The percentage of Cladocera (*Chydorus sp., Bosmina sp*) among the total zooplankton is in both lakes small, but showed a light increasing tendency during the last years.

V. List of Publications arising from the project (include copies):

Signature of Partner: Beatrix Thaler

Date: 13 February 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 01/03/97 to 28/02/98

Partner: University of Liverpool, GB (ULIV)

Principal Investigator: Dr P G Appleby

Scientific staff:
Dr C M G van den Berg
Professor J A Dearing
Dr C Colombo
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PART B

I. OBJECTIVES FOR THE REPORTING PERIOD:

1. To develope procedures for measuring fallout ^{210}Pb in rainwater samples and to use the methods to measure atmospheric fluxes of ^{210}Pb at the principal WP2 sites.
2. To collect soil cores from the principal WP2 sites and to prepare them for radiometric analyses to determine long-term atmspheric fluxes of ^{210}Pb and ^{137}Cs.
3. To develope procedures for measuring ^{210}Pb and ^{137}Cs in the water column samples and their distribution between the particulate and soluble phases, and to use the methods to determine concentrations in the water columns of the principal WP2 lakes.
4. To optimise voltammetric procedures to determine trace metals (lead, cadmium, cobalt and nickel) in water column samples
5. To collect water column samples at filter cut-offs of 0.1, and 0.4 μm.
6. To initiate the metal determination in the lake water samples
7. To date sediment records from WP2 and WP3 sites by ^{210}Pb, ^{137}Cs and ^{241}Am.
8. To investigate the possibility of using fallout ^{210}Pb and ^{137}Cs as tracers in studying the take-up of trace metals in lake biota.
9. To carry out magnetic analyses on sediment cores from the WP3 sites.

II. OBJECTIVES FOR THE NEXT PERIOD:

1. To complete our measurements of fallout radionuclides at each of the main WP2 sites via both rain water measurements and soil cores.
2. To complete the water column sampling by collecting samples from the Norwegian lake
3. To complete measurements of fallout radionuclides in the water column samples from each of the main WP2 lakes, including sediment trap material.
3. To complete the metal determinations, and to interpret the data including modelling of transport
5. To complete the dating of the sediment cores.
6. To complete the magnetic analyses of the sediment cores.
7. To analyse sediment cores from the WP2 sites for trace metals.
8. To carry out radiometric analyses on biota samples from the WP2 sites.
9. To develope and test models for the transfer of fallout radionuclides and trace metals through the WP2 catchment/lake systems.

III. Are there any particular problems ? Is your part of the project on schedule ?

The main problem we have experienced has been in the development of a suitable range of filters for analysing the particulate fraction. In order to obtain information about the size range, we used 0.1 μm and 0.45 μm in series. In the initial two tests the 0.45 μm filters proved unsatisfactory, but we have now found a suitable type. The voltammetric method appeared to be insufficiently sensitive to detect lead and cadmium in some of the water column samples. The procedure was re-optimised and this led to a great improvement of the method. Otherwise, most of the methods used have proved satisfactory, the results appear to be good, and the project is more or less on schedule.

PART B

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS*

1. Atmospheric Deposition of Radionuclides

Methods

Direct Measurements

Radioactive fallout is being measured in rainwater samples collected from Gossenkollesee, Redo, Ovre Neadalsvatn, Lochnagar and Jorisee. ^{210}Pb in the samples is removed from solution by coprecipitation with manganese dioxide. The precipitate is separated from the supernatent liquid by filtration, dried and the ^{210}Pb activity determined by gamma spectrometry. Yields were determined using standard solutions prepared from a certified Amersham ^{210}Pb standard.

Soil Cores

Soil cores have been collected from sites adjacent to Gossenkollesee, Redo, Ovre Neadalsvatn and Lochnagar, sectioned, and dried overnight at 40°C. The dried samples are being analysed for fallout ^{210}Pb, ^{137}Cs and ^{241}Am by gamma spectrometry to determine the fallout inventories.

Results

Mean ^{210}Pb concentrations in rainwater samples to date are 78±7 Bq kl^{-1} at Lochnagar, 72±7 Bq kl^{-1} at Redo and 136±13 Bq kl^{-1}. The analyses are also determining concentrations of the cosmogenic radionuclide ^{7}Be.

Analyses of the soil cores are not yet complete.

Discussion

Measurements of the ^{210}Pb flux in Europe compiled from the literature show that at a local level there is a strong correlation between fallout and rainfall. Higher fallout levels in Central Europe compared to those in Great Britain reflect the usual west to east increase within continents, presumably due to a build of ^{222}Rn concentrations in the atmosphere as the prevailing winds transport air masses over the land surface. Mean concentrations in rainfall calculated from these earlier data range from 76±13 Bq kl^{-1} for the UK to 129±16 Bq kl^{-1} in Central Europe. The new data are consistent with these values and should allow us to estimate radionuclide fluxes at MOLAR sites with greater confidence.

2. Radionuclides in the Water Column

Methods

Particulate and dissolved ^{210}Pb and ^{137}Cs have been measured in the water columns of Gossenkollesee and Redo using an INFILTREX II water sampler. The particulate fraction was determined using 1 µm and 0.45 µm filters in series. These were dried and weighed to determine the suspended sediment concentrations and analysed for ^{210}Pb and ^{137}Cs by gamma spectrometry. The soluble fraction was determined using exchange columns with appropriate extraction materials. These were removed in four separate sections, dried and analysed for ^{210}Pb and ^{137}Cs, again by gamma spectrometry.

Results

Mean suspended sediment concentrations were 0.5 mg L^{-1} in Gossenkollesee and 0.3 mg L^{-1} in Redo. There were significant differences between summer and winter, though these are still being investigated.

Mean ^{210}Pb concentrations were 4.6 Bq kL^{-1} in Gossenkollesee and 3.0 Bq kL^{-1} in Redo. ^{137}Cs was also detected, with mean concentrations of 2.1Bq kL^{-1} in Gossenkollesee and 0.9 Bq kL^{-1} in Redo. In Gossenkollee, the fractions of the total concentration on the particulates were 0.81 for ^{210}Pb and 0.28 for ^{137}Cs. The corresponding figures for Redo were 0.75 and 0.45 respectively. These values probably underestimate the ^{210}Pb partition fraction due to fine particulates passing through the filters and overestimate the ^{137}Cs partition fraction due to losses from the exchange column.

Discussion

Measurements of the ^{210}Pb in lake waters compiled from the literature range from 1.9 kL^{-1} in Crystal Lake (Wisc) to 17 kL^{-1} in Perch Lake (Ontario). Mean partition fractions are calculated to be 0.75 for ^{210}Pb and <0.20 for ^{137}Cs. Concentrations and partition fractions from Gossenkollesee and Redo all lie within this range. Using simple models, ^{210}Pb concentrations in lake water are determined by the atmospheric flux, water residence time, particle residence time, partition fraction, and a catchment/lake transport parameter. The measured data will be used to evaluate these models.

Since there has been no significant deposition of ^{137}Cs for at least 10 years, concentrations of this radionuclide in the water column presumably reflect either transport from the catchment or remobilisation from the bottom sediments. The importance of these sources will be tested by comparing measurements made in the summer with those made under the ice during the late winter.

3. Metals in the water column of the lake

Methods

Water samples were collected from the water column of Redo and GKS, in summer and winter conditions. Unfiltered and filtered (0.4 µm and 0.1 µm) samples were collected. Analyses were carried out by anodic and cathodic stripping voltammetry in the Liverpool Oceanography Laboratories

Results and discussion

Concentrations of lead, cadmium, nickel and cobalt were determined in all fractions.the water column profiles looked reasonable for all metals: for instance high surface concentrations of lead in Redo in Summer can be explained by atmospheric inputs, decreasing with depth due to particle scavenging. Overal the total lead concentrations varied from 0.3-1 nM in Redo, and from 0.6 to 1 nM in lake GKS. Nickel concentrations were 3 (surface) to 2 nM in Redo and 1.5 (GKS) to 2.5 nM in GKS. These metal data are still being interpreted as the analyses are not yet completed.

4. Sediment Dating

Methods

Cores from Lochnagar (NAG8), Ovre Neadalsvatn (OVNE4&7), Saanajarvi (SJ96/1), Gossenkollesee (GKS2), Jorisee (JORI3), Hagelsee (HAG96-1), Nizne Terianske (TERI7), Jezero Ledvicah (LEDV5), Redo (RCM2), Cimera (CIM97-1) are being analysed for the radionuclides ^{210}Pb and ^{137}Cs by gamma spectrometry. Dates will be calculated by ^{210}Pb using an appropriate model and validated by ^{137}Cs and/or ^{241}Am.

Results

Work has been completed on Saanajarvi, Lochnagar, Ovre Neadalsvatn, Gossenkollesee and Terianske, and substantially completed on Ledvicah, Hagelsee and Redo. The cores from Jorisee and Cimera are at an early stage. The small sample size has been a problem in some cases, but not insuperable. Chronologies for the completed sites are presently being determined.

V. List of Publications arising from the project (include copies): None to date

Signature of Partner: P.G. Appleby

Date: 12/3/98

Bundesamt für Bildung und Wissenschaft
Office fédéral de l'éducation et de la science
Ufficio federale dell'educazione e della scienza

EU - FORSCHUNGSPROGRAMME
Wissenschaftlicher Bericht

Programm Environment	**BBW-Nr.** 95.0518-1
	EU-Nr. ENV4 - CT95 - 008

Projekttitel MOLAR: Measuring and modelling the dynamic response of remote mountain lake ecosystems to environmental change.

[X] **Zwischenbericht**

[ ] **Schlussbericht**

Berichtsperiode : Vom 1.3.97 bis 1.2.98

Beitragsempfänger

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Dieser Bericht ist ausgefüllt und unterschrieben in **zwei** Exemplaren dem BBW einzureichen. Es sind die **jährlichen Rapporte und der Schlussrapport für die EU-Kommission** beizulegen, falls diese dem BBW nicht bereits vorliegen.

Ort und Datum	Unterschrift des Beitragsempfängers
Bern, 11. Februar 1998	

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PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1 February 1997 to 31 January 1998

Partner: EAWAG Dübendorf

Principal Investigator: Dr AF Lotter

Scientific staff: Dipl. biol. C. Bigler, Drs G. Goudsmit, B. Müller, G. Lemcke, DM Livingstone, M. Sturm

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I. OBJECTIVES FOR THE REPORTING PERIOD:

During the reporting period the major objectives of the Swiss contribution to the MOLAR WP3 were:

- i) to continue the sampling and the measurements of water-column biology, physics and chemistry, and water-column sediment fluxes at Hagelseewli
- ii) to finish most of the sediment analyses
- iii) to continue the measurements of on-site meteorology at Hagelseewli
- iv) to establish empirical relationships between surface air temperatures and epilimnetic water temperatures in lakes at different altitudes.

II. OBJECTIVES FOR THE NEXT PERIOD:

For the last phase we plan to continue the monthly biological and chemical measurements at Hagelseewli until September/October 1998. Applications of the AQUASIM lake model are planed.
Furthermore, we plan to finish all sediment analyses (diatoms, dating). In collaboration with the University of Edinburgh the compilation and modelling of the available meteorological data will be carried out.

PART B

III. ARE THERE ANY PARTICULAR PROBLEMS? IS YOUR PART OF THE PROJECT ON SCHEDULE?

The project is on schedule. However, the following minor problems occurred during the reporting period:

- due to data-overflow we lost ten days of meteorological data during summer 1997
- due to unfavourable meteorological conditions (snow, avalanches, bad weather) a water-column sampling of the frozen Hagelseewli was not possible since mid-September 1997

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS*

The results obtained at the Swiss MOLAR site Hagelseewli (2339 m asl) can be grouped into the following categories:

Relationship air temperature – water temperature
Investigations (Livingstone & Lotter, 1998) show that there is a close correlation between air and surface water temperatures in lowland Switzerland. It was, therefore, of interest to test the hypothesis that this relationship is also valid for lakes at higher elevations. Between May and October 1997 ten mini-thermistors were installed in lakes of different altitudinal belts in Switzerland to measure the water surface temperature. The results suggest a good correlation between air and water temperatures for the summer season (Fig. 1).

Meteorology
The on-site meteorological measurements carried out in 10 minute-intervals were used to calculate daily means (Fig. 2). They reveal the climatically extreme situation of the site: daily mean temperature may be below 0°C even during summer. During the months of November 1996 and April 1997 the monthly mean temperatures were between 2 and 4°C below the freezing point, whereas the solar radiation was at minimum values between October 1996 and March 1997 (see Fig. 2). The highest wind-speeds were measured during the winter season when the lake was ice-covered. The lake was completely ice-covered during seven months (October 1996 to May 1997). Marginal parts of the lake, especially at its northern shore, were open already in May 1997 and the lake was completely ice-free towards the end of July 1997. Because of this long ice-cover the water column is decoupled from the atmosphere for nine to ten months of the year.

Lake physics
Figure 3 illustrates the thermal regime of the water column measured by means of two thermistor chains at the deepest part of the lake. During the ice-free period of 1996 and 1997 the lake mixed completely. Surface temperatures never exceeded 8°C.

Water column chemistry and biology
The mixing of the water column is also evidenced by the oxygen measurements (Fig. 4). Oxygen depletion in the deeper parts of the water column increasingly occurred under the ice-cover. The high phosphate concentrations (Fig. 5) suggest solution processes of phosphorus out of the sediment.
Chlorophyll *a* measurements (Fig. 6) showed the highest values during the ice-free periods of 1996 and 1997 in water depths greater than 10 m.

Sediment traps

Since the installation of the sediment traps five measurements have been carried out (Fig. 7). During the ice-free periods planktonic taxa (*Cyclotella comensis*) dominated the assemblages, whereas periphytic taxa (*Fragilaria pinnata, Achnanthes minutissima*) dominated the trap material of the ice-covered period. The accumulation rates calculated based on the exposure time show the same picture, suggesting a diatom bloom during open-water conditions, whereas under the ice there are mainly blooms of periphytic taxa (Bigler, 1998).

Sediments

Diatom analyses of surface sediments along a longitudinal West-East transect showed a characteristical zonation of diatom assemblages: surface sediments in shallower parts are mainly dominated by periphytic *Fragilaria pinnata* assemblages, whereas the deeper parts or the basin are dominated by planktonic *Cyclotella comensis*. As a consequence of the high light penetration during the ice-free period periphytic diatoms occur on surface sediments in all water depths throughout the whole basin (Bigler, 1998).

Diatom analyses in contiguous 0.5-cm samples of a 37-cm long sediment core (work still in progress) show several changes between the dominant planktonic *Cyclotella comensis* and periphytic *Fragilaria* taxa. Based on the sediment trap results it may be hypothesised that these changes in the ratio of planktonic/periphytic diatoms may indicate periods of changing length of ice-cover on Hagelseewli.

V. LIST OF PUBLICATIONS ARISING FROM THE PROJECT

Bigler, C. 1998. Verbreitung von Diatomeen im Oberflächensediment eines alpinen Sees im Berner Oberland (Hagelseewli 2339 m ü.M.). Diplomarbeit, phil.-nat. Fakultät, Universität Bern. 79 pp.

Livingstone, D.M. & Lotter, A.F., 1998. The relationship between air and water temperatures in lakes of the Swiss Plateau: a case study with palaeolimnological implications. *Journal of Paleolimnology*, in press.

Signature of Partner:

Date: 12 February 1998

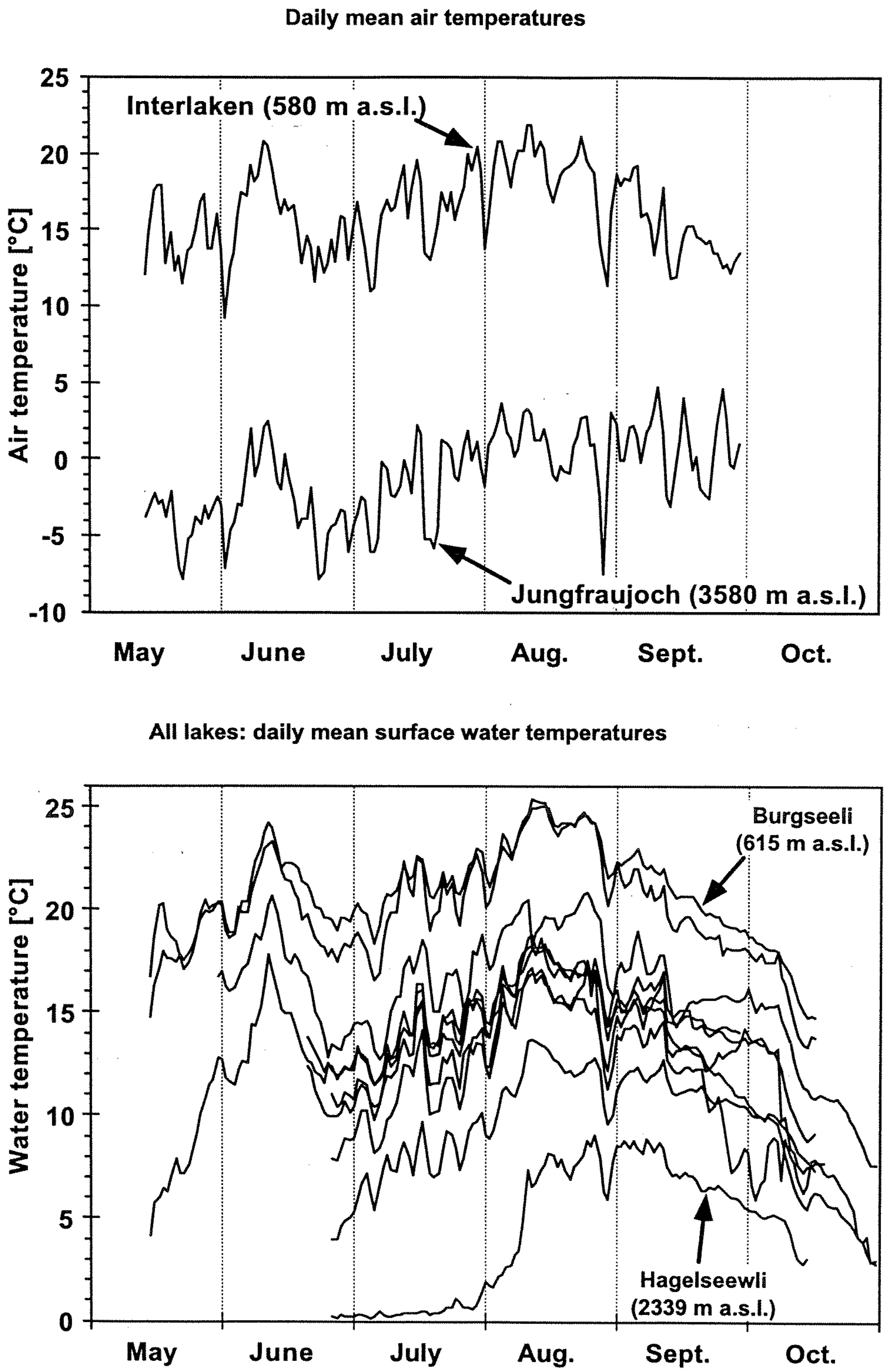

Figure 1. Daily mean air temperatures from automatic weather stations at Interlaken and Jungfraujoch compared to surface water temperatures (mini-thermistor data) from ten lakes at different altitudes.

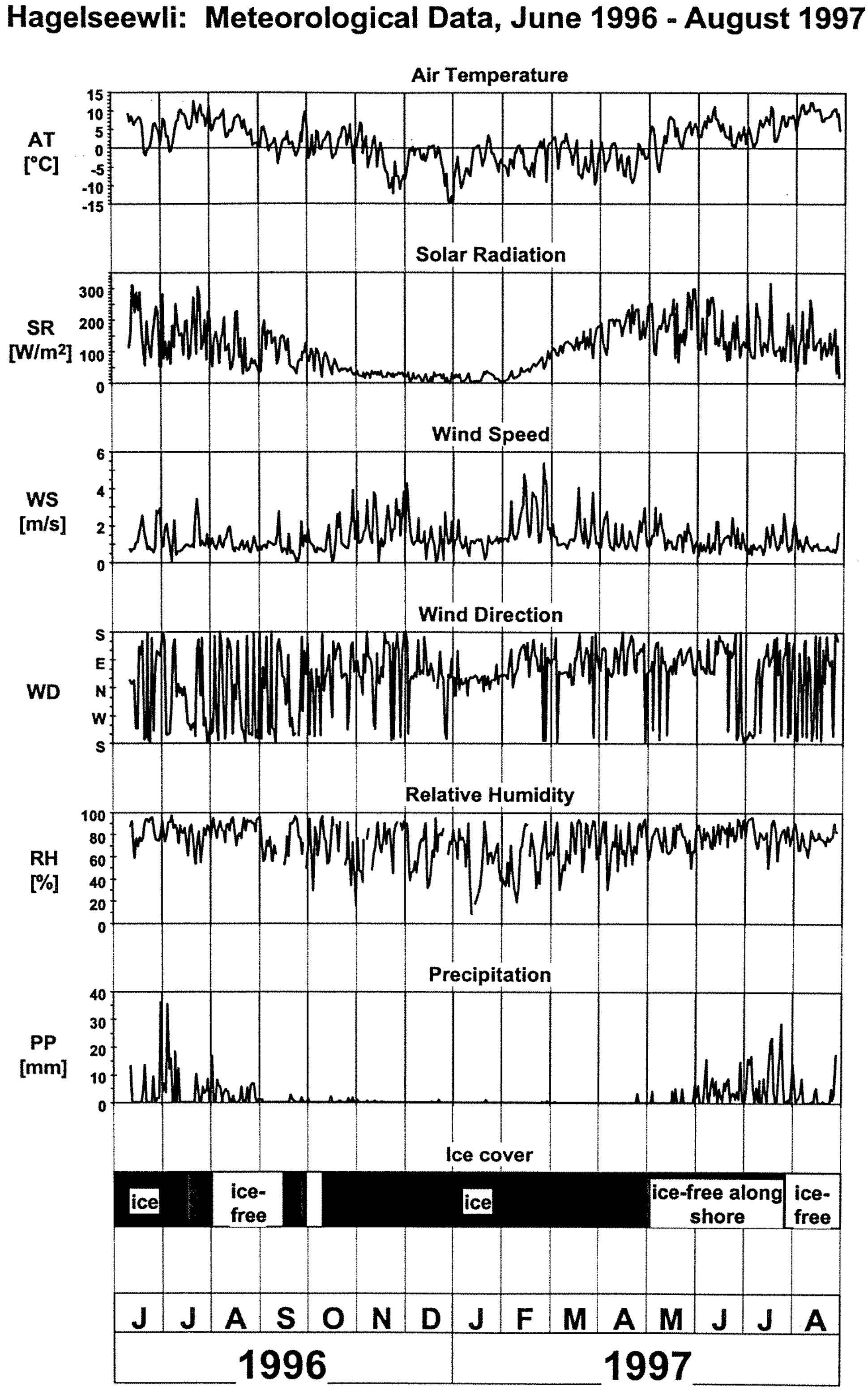

Figure 2. Meteorological data and ice-cover measured for 1996 and 1997 at Hagelseewli.

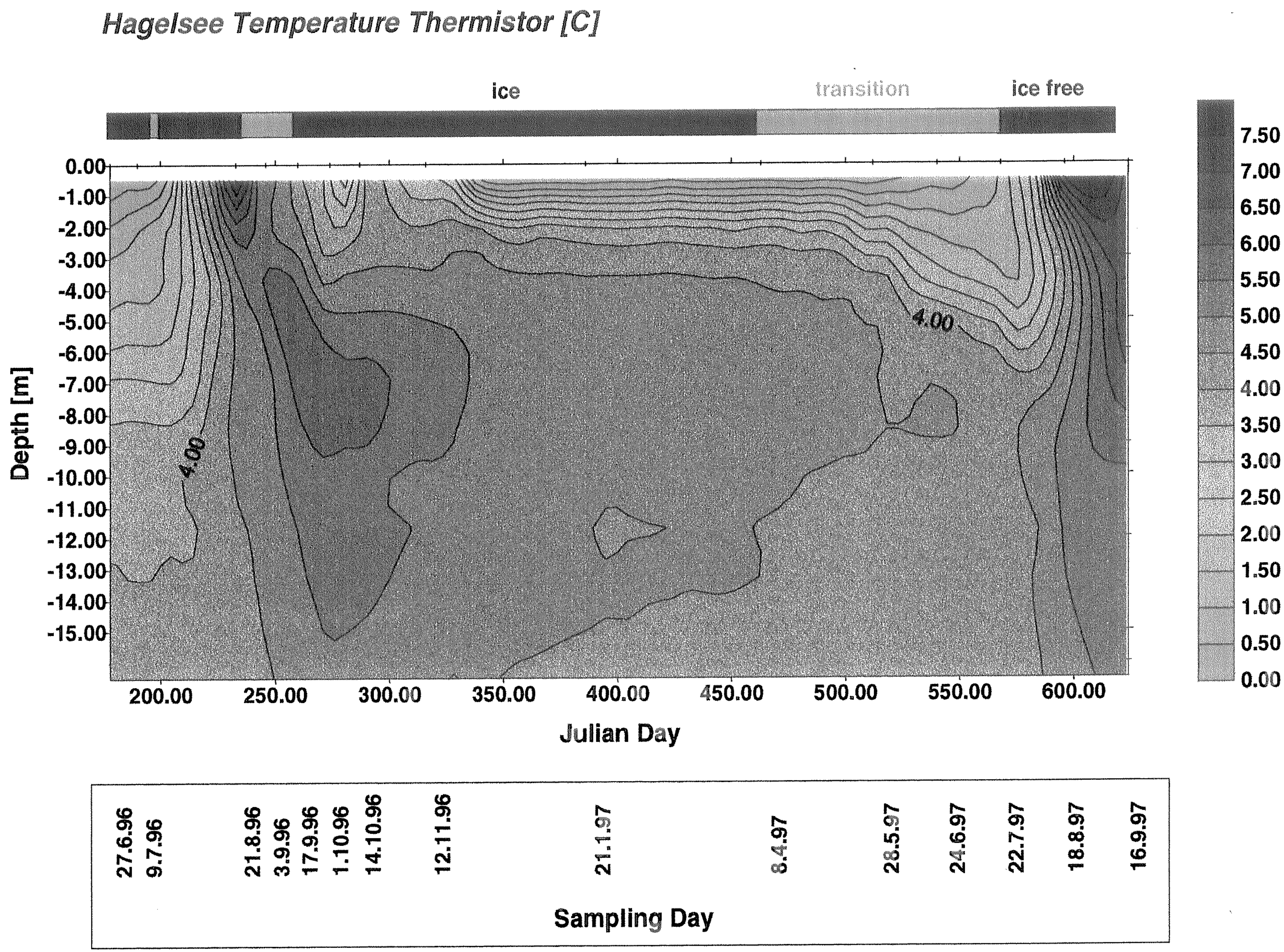

Figure 3. Water temperatures (°C) in Hagelseewli in 1996 and 1997.

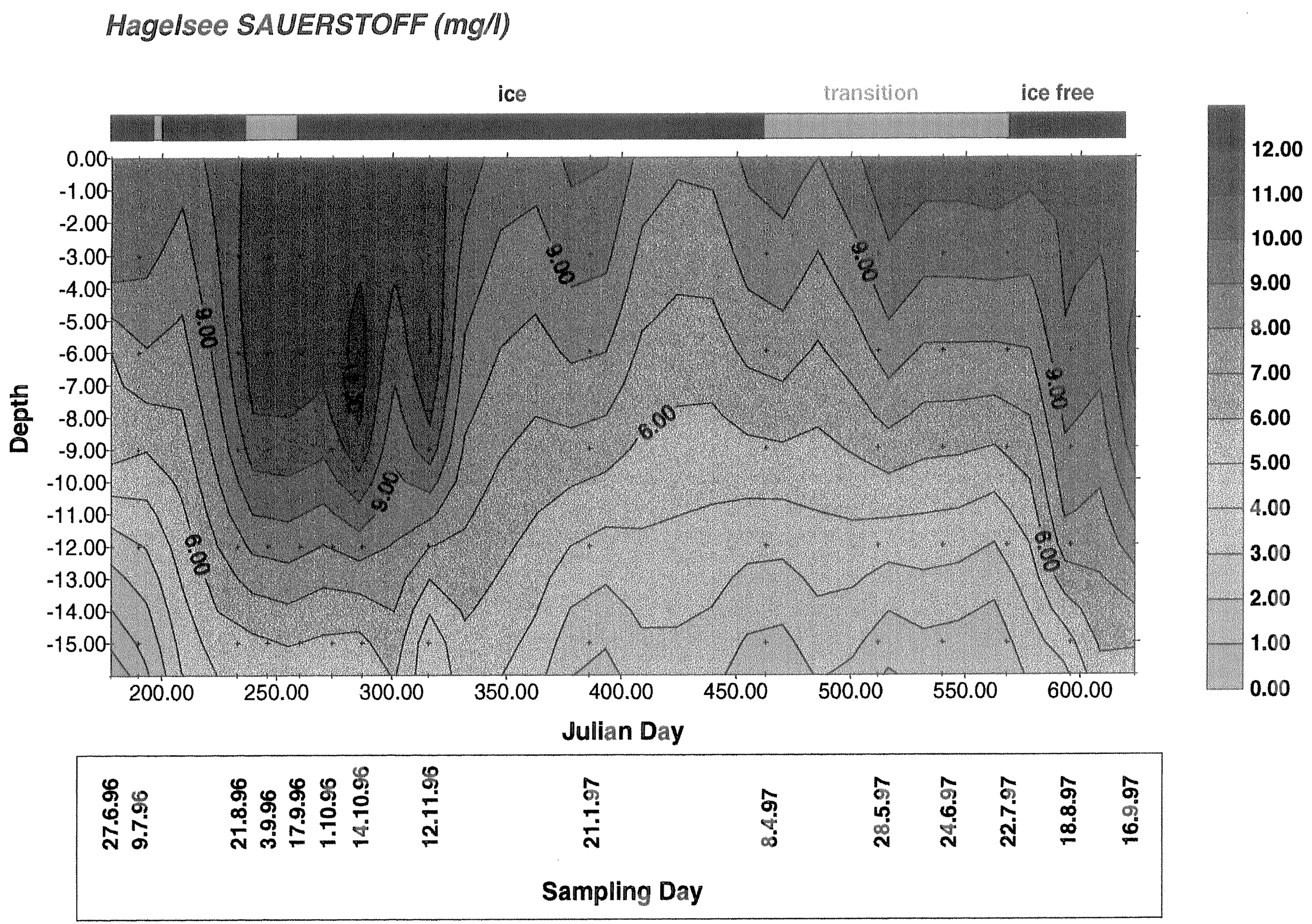

Figure 4. Oxygen concentrations (mg O_2/l) in Hagelseewli in 1996 and 1997.

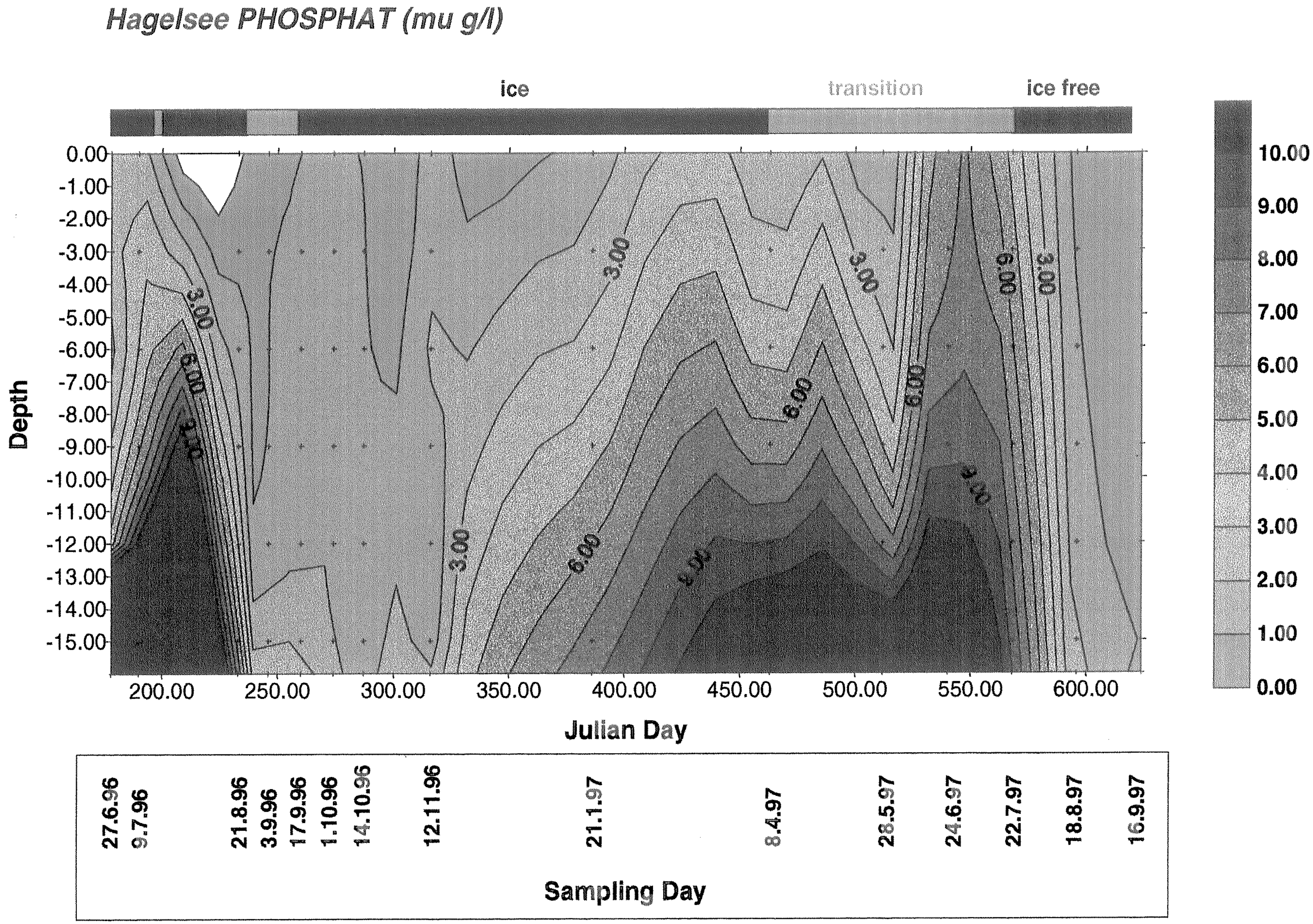

Figure 5. Phosphate concentrations ($\mu g\ PO_4/l$) in Hagelseewli in 1996 and 1997.

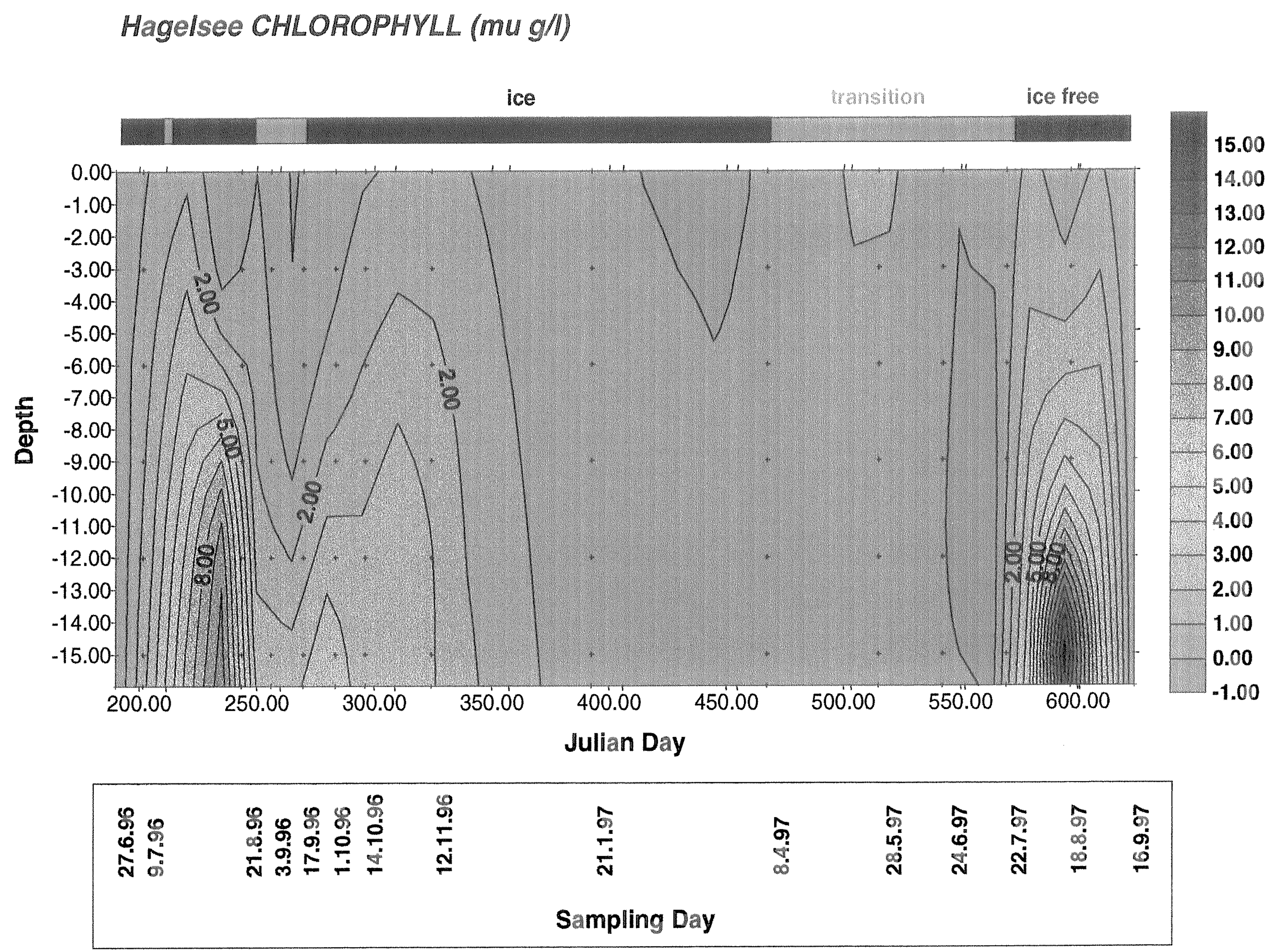

Figure 6. Chlorophyll a concentrations (μg/l) in Hagelseewli in 1996 and 1997.

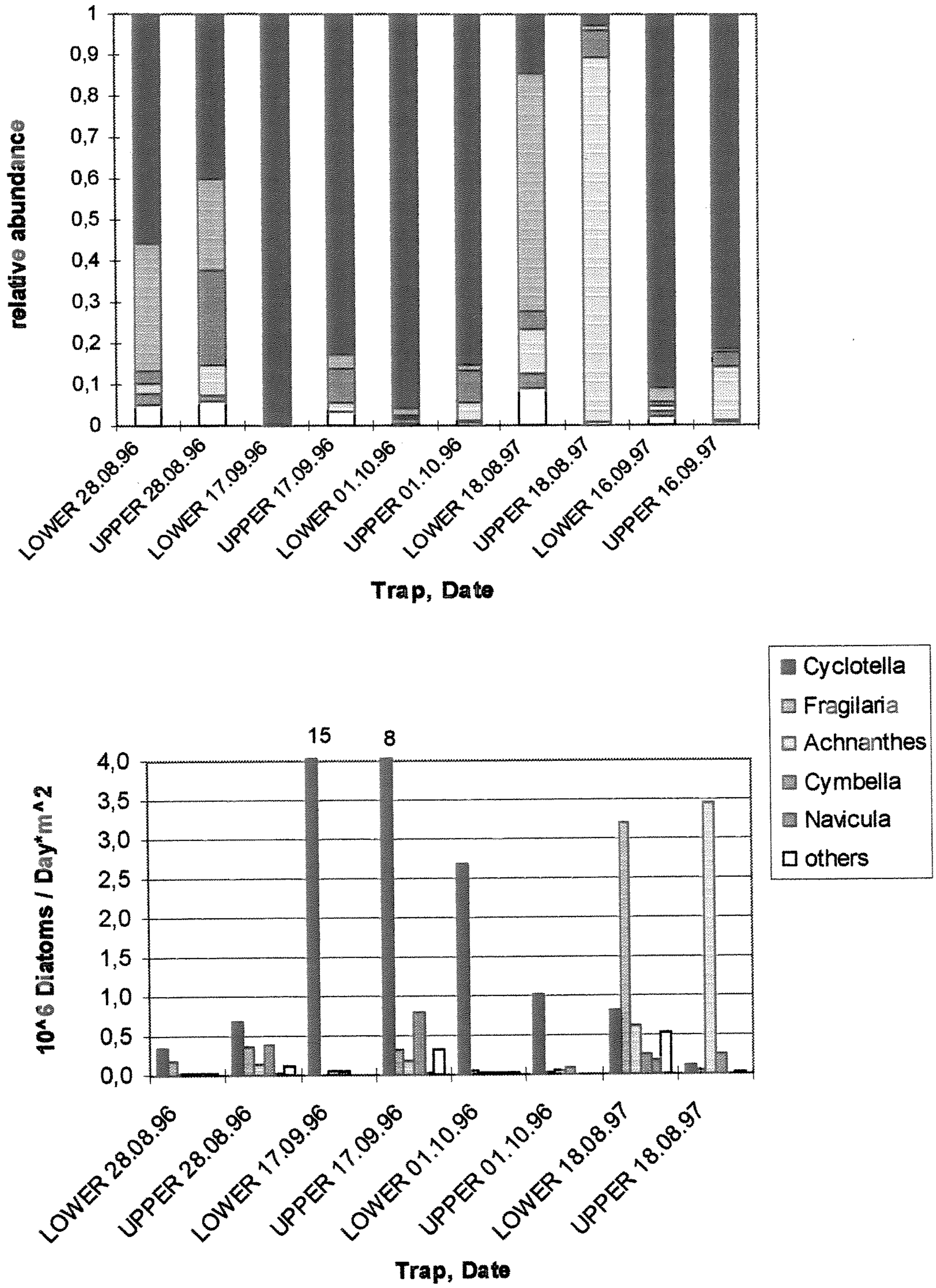

Figure 7. Diatom analyses of sediment traps expressed as relative abundances and accumulation rates. The lower trap was exposed 1 m above sediment surface (17 m water depth), whereas the upper trap was exposed in 2 m of water depth.

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period:	1997
Partner:	K. Hanselmann
Principal Investigator:	H.R. Preisig
Scientific staff:	M. Gabathuler, B. Hinder, B. Steiner Trad Saadi

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I. OBJECTIVES FOR THE REPORTING PERIOD:

The "chemistry" goals for the sampling period 1997 were to collect lake water samples from different depths to study the influence of the stratification and sample the bulk and wet only deposition in order to see general trends or differences in input conditions over two years. For the "Biology" the goals were the following:

Field experiments

1. Manipulations using limnocorrals to study the interaction between N, particles and microbiota.
2. Dense measurements of chemical, physical and biological parameters at surface and in the water column in Joeri lake III and VII to improve the knowledge of the seasonal dynamics in clear and turbid high mountain lakes.

Lab experiments

1. Characterization of the erosion particles found at the Joeri lakes (CEC, BET-area, adsorption capacity, mineralogy, size distribution). Lab experiments with batch cultures of algae to understand the

interaction between algae, particles and nutrients. Comparison of the growth rate under different conditions: particle-free cultures, particle-rich cultures, growth with mined particles.

The goal for the physical measurements was to get a high quality data set without any data gaps. With additional weather stations the meteorological characteristics of the catchment were investigated.

II. OBJECTIVES FOR THE NEXT PERIOD:

The next sampling period should give more information about the lake water stratification under possibly different meteorological conditions. It seems that these conditions are highly important for the behavior of the lake. A snow profile will be taken in Spring 1998 to get a complete record of deposition samples. The deposition processes did not show unexpected behavior and is quite regular. The snow melting will be analyzed with the installed lysimeter. To understand the sedimentation processes in lake III it is important to continue to investigate on the sediment core which has been collected. A goal for the next sampling period is still to analyze one single rainfall event but the restricted accessibility of the field station may not allow this sampling. The planning of sampling was fulfilled until now.

It would be interesting to correlate the results obtained so far by our investigations with the information acquired by other groups on the pollution conditions at the Jöriseen, e.g. organic micropollutants and SCP. With this information the status quo and history of the input of pollutants could be improved.

For the understanding of the *status quo* and of the input of nutrients and pollutants it seems reasonable to continue these investigations for another season. It would be very important to continue the sampling at Jöriseen to study changes that may occur (e.g. acidification of the lake water). The problems with the accessibility of the Jöriseen field station should be taken into consideration and possibly some improvements could be done concerning sample transport and storage.

Field experiments:

1. To investigate the influence of sudden changes in environmental conditions on the planktonic microbiota living in particle-rich and particle-free water, respectively, daily sampling of the limnocorrals in Joeri lake VII during a longer period of time is planned. Determination of bacterial numbers and biovolume, algal biovolume and chlorophyll concentration will be done.
2. Comparison of water column profiles of nutrients, phytoplankton and bacteria in the particle-rich lake III with the particle-free lake VII to investigate the interaction between microbiota, particles and nutrients.

Lab experiments:

1. Lab experiments with batch cultures of algae are planned to understand the interaction between algae, particles and nutrients. Comparison of the growth rate under different conditions: particle-free cultures, particle-rich cultures, growth with mined particles (further studies after the preliminary experiments of 1996).
2. Biodiversity of bacteria in Joeri lakes III and VII and in the limnocorrals will be compared with TGGE techniques (temperature gradient gel electrophoreses).

The main goal for physical measurements will be again to gather a very good data set without any gaps. In addition a snow model and a lake model will be applied to the catchment. There will be an attempt to model lake surface temperatures from input parameters like radiation, temperature and wind as well as lake data like turbidity and depth. For this purpose intensive surface temperature measurements will be done. Exact catchment outlines will be found through colouring of water in the catchment.

III.Are there any particular problems ? Is your part of the project on schedule ?

- bacterial counting in samples containing high quantities of particles (Joeri lake III, 1 m above ground)
- technical problems with the Hydropolytester
- accessibility is limited, also at important times like snowmelt and ice-cover build-up
- no measurements can be made during a long time when the ice melts, too soft for walking, too hard for boating
- seasons measured may not be representative for a longer period

IV.MAIN RESULTS OBTAINED: METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS (use other pages as necessary but preferably no more than 2)

The goal of the chemistry part of MOLAR is to measure the main ionic components K, Ca, Mg, Na (ICP-AES, data checked by IC) SO_4, NO_3, Cl, NH_4 (IC), alkalinity (Gran Titration), pH and conductivity in deposition samples (bulk, wet only and snow) at the high alpine site "Jöriseen" in order to quantify the input of nutrients (N and P) and anthropogenic influenced substances [e.g. acids, heavy metals Cd, Pb and Zn (Zeeman-Furnace-AAS)]. Furthermore the input is correlated with the recovery of those agents in lake water.

Atmospheric deposition has been sampled in different ways. Weekly samples of bulk and wet only deposition has been collected in summer and the snowcover has been profiled in winter. The atmospheric deposition sampled during the accessibility of the Jöriseen field station showed no differences between 1996 and 1997 if the different air conditions are taken into consideration. The input during "clean air conditions" (when there is only limited exchange of air masses between the polluted valleys, the Swiss Midlands and the highalpine site) was much smaller than during "summer" conditions (when mixing of air masses occurred). The deposition samples were acidic (pH about 5) and showed mostly a negative alkalinity. The main ionic input has been determined as Ca and sulfate.

The input of anthropogenic influenced species (like acids, nitrate,...) did not influence heavily the lake water situation. The lake water had a pH around 7 and an alkalinity around 100 ?eq/l. Nitrate was used as a nutrient for the biological active species in the lake and did not represent a pollution for this ecosystem. The sampling of lake water showed differences between the two sampling years 1996 and 1997. In 1996 clear indications for stratification were found, whereas in 1997 only few dates showed a stratification. This is due to very different meteorological conditions. In 1996 the lake was icefree about 2 month earlier than in 1997. The patterns of Ca and sulfate correlate well, but they are too high to come only from deposition, which means that we may have an input of anhydrite ($CaSO_4$) which cannot originate from the granite massive in which the lake is embedded. There may exist some still unknown anhydrite source.

Microorganisms in mountain lakes are challenged by extreme conditions of living: nutrients are only available in very low concentrations, sudden weather events may cause rapid hydrological changes and the ice free period, where they can grow and propagate, is very short. Glacial lakes contain high amounts of erosion particles which are supposed to influence the availability of nutrients and to change the living conditions for the microbiota. The test site, the Joeri lakes, offers more than twenty lakes, some are fed by turbid glacial inlets, others contain clear water. Adsorption experiments with particles from the site have shown that they are carriers for ions like ammonium. We would like to know if algae and bacteria can profit from these nutrient reservoirs and if the benefit is the same for both. The water column profile of turbidity parallels the distribution of phosphorus and ammonium. The chlorophyll *a* maximum in the particle-rich Joeri lake III was found far below the thermocline which could be caused by higher nutrient concentrations at this depth. The effects of clay minerals on metabolism and growth of microbes in soil is well known, but the knowledge of aquatic systems is scarce. Lab experiments have shown that addition of particles from the Joeri lakes' sediments to batch cultures of *Synechocystis* 6309 sp. shortens the lag phase. This could influence the recovering time of the microbiota in alpine ecosystems after extreme weather changes. Although there exist some studies about the influence of clay minerals on algal communities [2][3][4], nothing is known about seasonal fluctuations of microbial and algal communities which live in association with clay minerals. Field manipulation with limnocorrals support the hypothesis that an algal community specially adapted to particle-associated life exists. This observation supports the findings of Bidle and Fletcher [1] who suggested a peculiar bacterial community adapted to particle-associated life.

Meteorological and hydrological data were gathered at the Jöri site with frequencies of up to 10 minutes. These data sets were corrected for erroneous values and analyzed. The goal for the analysis was to physically characterize the catchment and to determine the physical environment for vegetation and organisms in the lakes. Rough calculations of the energy balance of one lake were made. They included the calculation of the absorption of direct and diffuse global (short wave) radiation from sun and atmosphere respectively; the absorption of infra-red (long wave) radiation from the atmosphere; the emission of infra-red (long wave) radiation from the lake surface; the exchange of latent heat between lake surface and atmosphere due to evaporation and condensation; and the convective exchange of sensible heat between lake surface and atmosphere. It was shown that neglecting precipitation and throughflow leads to substantial errors. Lake surface temperature measurements at different lakes show that energy input to the surface is dependent on several parameters which are not all measured and therefore cannot yet be adequately quantified. With intensive surface water measurements in more than ten lakes in 1998, the importance of the different parameters will be evaluated. Meteorological measurements within the catchment were compared to measurements around the catchment of other research institutes. Temperatures at the Jöri site are generally much lower in the winter than at surrounding weather stations, whereas in summer they correspond well to the local lapse rate. Global radiation measurements within the catchment can be extrapolated without major errors, if shading effects are considered. A new method for estimating incoming long wave radiation was developed, using maximum, minimum and measured global radiation as well as air temperature and relative humidity. Correlations with measured values show a good agreement, better than previous methods using cloud cover. However the method would have to be applied to other sites in order to verify its superiority. Lake ice processes are important because ice on a lake largely changes the habitat of organisms with low temperatures and little light. Estimating the building of an ice cover can best be done with an energy budget model or by using threshold conditions. The disappearance of the cover is best approximated with a degree day model, adjusted with snow height for mountain environments. All the newly developed methods will be further improved and validated. A physical lake model will be applied to the main lake. From the results of the model one should be able to make correlations to chemical and biological measurements. Also there will be an attempt to model the hydrology of the catchment including snowmelt hydrology.

V. List of Publications arising from the project (include copies):

Signature of Partner:

Date: 27 February 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: March 1, 1997 - February 29. 1998

Partner: Faculty of Science, Charles University, Prague, Czech Republic

Principal Investigator: Dr. Jan Fott

Scientific staff: Dr. Evzen Stuchlik. Dr. Martin Cerny, Dr. Miroslava Prazakova, Martin Blazo

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Fax: +420 2 29 97 13 E-Mail: fott@cesnet.cz

I. OBJECTIVES FOR THE REPORTING PERIOD:

a/ Field work:
Field work at the site 15.1 Starolesnianske Pleso (WP1 and 2, site operator Evzen Stuchlik) and 15.2 Terianske Pleso (WP3). Sampling surface sediment of a set of Tatra lakes (WP3, establishing a calibration set for Cladocera). Operating precipitation collectors in the catchment of Starolesnianske Pleso (bulk collectors) and at Skalnate Pleso (WADOS collector).

b/ Laboratory work:
(i) analysing phytoplankton and zooplankton from the sites O. Neadalsvatn, Stavsvatn, Lochnagar, Gossenköllesee and Starolesnianske Pleso, analysing phytoplankton only from the site Dlugi Staw, analysing zooplankton only from the sites Hagelsee, Jörisee and Terianske Pleso.
(ii) chemical analyses of lakewater, rainwater and snow from the sites Starolesnianske Pleso, Terianske Pleso and from the weather station Skalnate Pleso.
(iii) analysing remains of Cladocera from the WP3 cores Terianske Pleso and Gossenkollesee and from the surface sediments of Tatra lakes.

II. OBJECTIVES FOR THE NEXT PERIOD:

a/ Field work:
Continuation of the field work as before until June 1998
b/ Laboratory work:
Continuation of the laboratory work as before from samples to be taken until June 1998 at the sites Starolesnianske Pleso and Terianske pleso, and from samples received from other sites.
c/ Processing raw data to the form required by the central database and sending them to the database Bergen.
d/ Preparing the Final report and manuscripts.

III. Are there any particular problems ? Is your part of the project on schedule ?
Some samples have not yet reached the Prague laboratory (WP3 core Gossenkollesee for Cladocera, zooplankton Hagelsee).

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

Sampling at the Tatra sites (Starolesnianske pleso, Terianske pleso)
Field measurements and sampling for chemical and biological analyses were carried out according to the schedule (Tab. 1) approved at the 2nd MOLAR conference in Barcelona. Sampling at the Terianske lake included measurement basic physical and chemical parameters on the vertical profile (temperature, pH, oxygen, conductivity) with use of the Hydrolab probe and taking samples from 10 depths on the vertical. Sampling at the Starolesnianske lake included also taking samples of rainwater in weekly intervals; this was carried out by a local observer. Other activities are listed at the bottom of the Table 1.

During the winter 1996-97 a snow sampling programme at the site Starolesnianske was carried out, giving the first data on stratification, water equivalent, ionic composition and concentration on spheroid carbonaceous particles (SCP) in the snow cover. The February sampling had to be skipped as the site was not accessible. The integrated sampling of the snow pack, planned for April (including also sampling for organic contaminants), could not have been realised due to a sudden thaw. This sampling will be done in March 1998.

Sediment coring in Tatra lakes above the tree line (in collaboration with the team from the Academy of Sciences, Ceske Budejovice), was carried out in March 1997 (6 lakes) and September (24 lakes). The surface sediments have been analysed for remains of Cladocera. The objective is to find relationship of cladoceran abundance to environmental variables and comparison or merging the Tatra data set with a similar set from the Alps.

Running precipitation collectors at Starolesnianske pleso: There are 4 bulk collectors. Norwegian type (made at NILU, Oslo) installed in the catchment of the Starolesnianske lake. Samples of precipitations were taken according to the schedule (Tab. 2) by a local observer.

Tab. 1: Field activities in the year 1997

Sampling term	Lake	sampling &measurements
12.3.97	Terianske pleso	profiling & sampling from the vertical (biology and chemistry)
29. 5.97	Terianske pleso	profiling & sampling from the vertical (biology and chemistry)
29. 6.97	Terianske pleso	profiling & sampling from the vertical (biology and chemistry)
6. 8.97	Terianske pleso	profiling & sampling from the vertical (biology and chemistry)
29.8.1997	Terianske pleso	profiling & sampling from the vertical (biology and chemistry)
22.9.1997	Terianske pleso	profiling & sampling from the vertical (biology and chemistry)
23.10.1997	Terianske pleso	profiling & sampling from the vertical (biology and chemistry)
14.3.1997	Starolesnianske pleso	profiling & sampling from 1m depth (biology and chemistry)
27.5.1997	Starolesnianske pleso	profiling & sampling from 1m depth (biology and chemistry)
27.6.1997	Starolesnianske pleso	profiling & sampling from 1m depth (biology and chemistry)
4.8.1997	Starolesnianske pleso	profiling & sampling from 1m depth (biology and chemistry)
29.9.1997	Starolesnianske pleso	reduced sampling due to bad weather
22.8.1997	Starolesnianske pleso	profiling & sampling from 1m depth (biology and chemistry)
22.10.1997	Starolesnianske pleso	profiling & sampling from 1m depth (biology and chemistry)
30.1.1997	Snow - Starolesnianske p.	snow sampling and coring
14.3.1997	Snow - Starolesnianske p.	snow sampling and coring
10.3.-16.3.1997	sediment	coring at 6 lakes
1.9.-5.9.1997	zooplankton grazing	field experiment at Starolesnianske pleso
22.9.-30.9.1997	ICP, sediment	synoptic sampling, coring 24 lakes

Tab. 2: Sampling schedule for lakewater and for precipitation collectors (Bulk 1 - 4) at the site Starolesnianske pleso, 1997.

Sampling	Frequency	Sample type	Analyses	Note
Lakewater	weekly	spot sample	major ions, nutrients	biweekly since August 1997
BULK 1 precipitation	weekly	integrated over 1 week	major ions, nutrients	biweekly since November 1997
BULK 2 precipitation	weekly	integrated over 1month	radionuklids, metals	since July 1997
BULK 3 precipitation	weekly	integrated over 1month	SCPs	since July 1997
BULK 4 precipitation	weekly	integrated over 1 week	precipitation quantity only	in January 1998 replaced to the station Skalnate pleso

Running a MOLAR precipitation collector at the weather station Skalnate pleso: Since November 1996 a collector „wet only and dry only" (type WADOS, product of Kronais, Austria) has been installed at the meteorological station at Skalnate pleso. The station, with a permanent professional staff, belongs to the Geophysical Institute of the Slovak Academy of Sciences. Since November 1997 a collector of horizontal precipitation has been installed there.

Chemical analyses of lakewater and rainwater from the two Tatra sites were carried out continuously. Samples were taken from Starolesnianske pleso (1 depth), Terianske pleso (10 depths), samples from the bulk collectors and from the wet/dry collector at Skalnate pleso. Other obtained data are vertical profiles of temperature, pH, conductivity and oxygen measured in terms according to the Tab. 1 together with data on chlorophyll concentration. Other chemical analyses were performed on snow samples from snow cores. SCPs were analysed in London from samples of rainwater (bulk), snow and lakewater.

Chemical analyses - QA/QC: In 1997 we analysed 3 test samples (from ISPRA and from NIVA), two of them simulating lakewater and one simulating rainwater. The analyses were reasonably successful.

Biological analyses of plankton were based on the determination of species, their abundance, size structure and biomass of phytoplankton and zooplankton. Table 3 shows the list of MOLAR lakes with indication which samples were analysed in the Prague laboratory.

Tab. 3: List of the MOLAR lakes indicating those, phytoplankton (P) and zooplankton (Z) of which were analysed in the Prague laboratory.

Lake	Country		
O. Neadalsvatn	Norway	P	Z
Stavsvatn	Norway	P	Z
Lochnagar	UK	P	Z
Lago Paione Superiore	Italy		
Gossenköllesee	Austria	P	Z
Lago Redo	Spain		
La Caldera	Spain		
Starolesnianské Pleso	Slovakia	P	Z
Terianské Pleso	Slovakia	P	Z
Dlugi Staw	Poland	P	
Chuna	Russia		
Jezero v Ledvicah	Slovenia		
Saanajärvi	Finland		
Hagelsee	Switzerland		Z
Jörisee	Switzerland		Z
Laghetto Inferiore	Switzerland		

Zooplankton were sampled as vertical hauls by a quantitative net (large zooplankton, ZOOL), point samples on the vertical (small zooplankton, ZOOS), samples from the shore zone (ZOOLit) and samples for dry weight (ZOOB). The phytoplankton were taken on the vertical. In the year 1997 four to eight samplings were carried out at each lake.

Sediment Cladocera (samples from sediment cores). In 80 samples (slices 2 mm) of the sediment core Terianske pleso we have counted remains of Cladocera. The other core to be analysed in the Prague laboratory (as soon as it comes) is that from Gossenköllesee.

J. Fott has organised inter-calibration of analysis sediment Cladocera by sending subsampled sediment to four participating analysts; three of them responded up to now. While there were no differences in taxonomy (i.e. determination of cladoceran remains to species level), some systematic shift in determinations of abundancy among the three analysts was apparent.

V. List of Publications arising from the project (include copies):

The project is now in the stage of gathering data. Therefore, no synthesising papers have appeared as yet. One paper related to the project is in the print:

Kopacek J., Stuchlik E., Fott J., Vesely J., Hejzlar J., in press: Reversibility of acidification of mountain lakes after reduction of nitrogen and sulfur emissions in Central Europe. Accepted in Limnology & Oceanography.

Another paper, now under preparation, will be presented at the Congress of the International Limnological Society (SIL) in Dublin, August 1998:

Straskrabova V., Simek K., Macek M., Fott, J., et Blazo M., in prep.: Pelagic food webs and microbial loop in clear-water mountain lakes sensitive to acidification.

Signature of Partner:

Jan Fott Jan Fott

Date: March 8, 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: March 1, 1997 - February 28, 1998

Partner: HBI ASCR - Hydrobiological Institute, Academy of Sciences of the Czech Republic

Principal Investigator: Věra Straškrabová

Scientific staff: Josef Hejzlar, Petr Hartman, Jiří Kopáček, Miroslav Macek, Karel Murtinger, Jiří
Jiří Nedoma, Karel Šimek, Jaroslav Vrba

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I. OBJECTIVES FOR THE REPORTING PERIOD:
- Summarization of microbial food webs results from 1996 at the project meeting in Barcelona.
- Organization of intercalibration among 5 partners on methods for bacterial biomass estimations.
- Main season of monitoring phosphorus, nitrogenous compounds and organic carbon in lake profile of Nižne Terianské Pleso and in precipitation and lake water at Starolesnianské Pleso (Tatra Mts).
- Sampling of sediments in the lakes of Tatra Mts for nutrient, organic matter and metal ananlyses.
- Second season of analyzing bacteria, picocyanobacteria, heterotrophic flagellates and ciliates (1st level microbiology) in 9 lakes (from Norway, United Kingdom, Switzerland, Italy, Poland Slovakia, Russia).
- Second season of measuring microbial processes (2nd level) in 3 lakes (in Norway, Slovakia and Poland).
- Coordination of sampling, analyses and measurements for microbiology 1st level and 2nd level in 12 lakes and 8 lakes, respectively.

II. OBJECTIVES FOR THE NEXT PERIOD:
- Summarization of microbial food webs results from 1997 at the project meeting in Bled.
- Elaboration of results from 1997 - sediment analyses and microbial biomass.
- Evaluation of the results for microbiology 1st and 2nd level from 1996 and 1997 - intercomparison among lakes and labs, comparison with phytoplankton and zooplankton biomass.
- Additional measurements of several chemical and biological parameters and microbial processes in the lakes from Tatra Mts and in Lago Paione Superiore (Italy).
- Second sampling of sediments from the lakes in Tatra Mts, evaluation of adsorption isoterms of phosphorus.
- Construction of flow-chart models of carbon flow in the pelagic region of mountain lakes.
- Organization of MOLAR and mountain lake ecology session at SIL (International Society for Limnology) Congress in Dublin.
- Publication of results.

PART B

III. Are there any particular problems ? Is your part of the project on schedule ?

No particular problems.
Our part of project is on schedule.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS*
(use other pages as necessary but preferably no more than 2)

details in separate annex

METHODOLOGY : sediments
chemical analyses
intercalibration of microbial biomass
microbial biomass and processes

RESULTS AND DISCUSSION
nutrients and organic matter in precipitation and lakes in Tatra Mts
microbial biomass in 9 lakes
microbial processes, primary production, bacterial production, bacterial elimination in lakes

CONCLUSIONS

Bacterial abundances and biomasses in MOLAR lakes are comparable with the lower range of values found in mesotrophic lowland lakes in winter. In some lakes (Starolesnianské and Paione), bacterial biomass is higher and close to the values from eutrophic lowland lakes - the probable reason is high concentration of organic matter of allochthonous origin. Numbers of HNF are far lower than in lowland lakes, bacterivory apparently is performed by mixotrophic flagellates.

The percentage of phytoplankton exudation (both dissolved and incorporated by bacteria) from the total primary production increases (TPP) from 20% to 90% with the decrease of TPP from 17 $\mu g.l^{-1}$ C per hour to 0.005 $\mu g.l^{-1}$ C per hour in different lakes.

Bacterial production rate and elimination rate in particular lake seems to be related to TPP.

V. List of Publications arising from the project (include copies):

Straškrabová, V., Hartman, P., Macek, M., Nedoma, J., Šimek, K., Vrba, J., 1997: S helikopterou za mikroby horských jezer (Using helicopter to investigate microbes in mountain lakes - in Czech). In: Lukavský, J. and Švehlová, D. (eds), Limnologický výzkum pro rozumné hospodaření s vodou, Doubí u Třeboně, 29.9.-3.10.1997, ČLS, SLS, p.188.

Kopáček, J., Stuchlík, E., Straškrabová, V., submitted: Catchment vegetation and stage of acidification: Factors governing trophic status of mountain lakes in the Tatra Mountains. Freshwater Biology, submitted.

Signature of Partner:

Date: March 15, 1998

Annex to DETAILED REPORT OF THE INDIVIDUAL PARTNERS PART B

HBI ASCR March 97-Febr. 98

METHODOLOGY

Sediments - sediment cores were sampled from 23 lakes in Tatra Mts and layers 0-1 cm, 1-5 cm and 5-10 cm analyzed (pH, C, N, P, Na, K, Ca, Mg, AL, Fe, Mn) - analyses not yet completed.

Chemical analyses - Starolesnianské Pleso (Work Package 1, 2, 3): (i) lake water 34 samples per year, surface layer, total P, soluble reactive P, organic N, ammonia N, organic C and Si analyzed from samples delivered by site operators, (ii) bulk and wet-only precipitation in similar frequency, the same analyses except of Si.

- Nižné Terianské Pleso (Work Package 3): 7 samplings per year in 10 layers, the same analyses as in Starolesnianské Pleso, samples delivered by site operators.

Intercalibration of microbial biomass - in March 1997, one samples from Redo Lake was analyzed for bacterial biomass by 6 partners. Sample was difficult because it contained a lot of depris and long filaments. However, the differencies between partners were in similar range as the variability of results in subsamples by the same partner. Intercalibration of bacterial and heterotrophic flagellate biomass from all samples from Lago Paione Superiore has been done regularly in parallel with one partner for the whole season - results are in elaboration.

Microbial biomass - "1st level microbiology" (Work Package 1) in preserved samples delivered by site operators, from 9 lakes (∅vre Neådalsvatn, Stavsvatn, Chuna, Starolesnianské, Nižné Terianské, Dlugi Staw, Lochnagar, Lago Paione Superiore, Jörisee), 4 - 6 times per season, in 1 to 3 depths, abundances and volumes of bacteria (BAC), heterotrophic and autotrophic flagellates (HNF and ANF), picocyanobacteria (PICY) and ciliates (CIL) analyzed (CIL analyses still in process). CIL in Dlugi Staw and Lago Paione Superiore, BAC in Jörisee analyzed by other partners.

Microbial processes - "2nd level microbiology" (Work Package 1) measured in expeditions to the lakes Starolesnianské Pleso (3 depths, 4 measurements in June and September), ∅vre Neådalsvatn (5 depths, 2 measurements in July), Dlugi Staw (4 depths, 1 measurement in September), primary production by phytoplankton, exudation and bacterial uptake of exudates, bacterial production by thymidine and leucine method, bacterial elimination using fluorescently labelled bacteria.

RESULTS AND DISCUSSION

Nutrients and organic matter in precipitation and lakes in Tatra Mts.

Average weekly precipitations at Starolesnianské Pleso were 29 mm, range 0 - 113 mm. Total P in the range of 2.4 - 513 $\mu g.l^{-1}$, average 59$\mu g.l^{-1}$, reactive P from 0 to 446 $\mu g.l^{-1}$, average 35 $\mu g.l^{-1}$, ammonia N from 55 to 2400 $\mu g.l^{-1}$, average 6.00 $\mu g.l^{-1}$, organic N from 5 to 5290 $\mu g.l^{-1}$, average 660 $\mu g.l^{-1}$, organic C from 0.1 to 170 $mg.l^{-1}$, average 8.7 $mg.l^{-1}$.

In Starolesnianské Pleso (surface layer) concentrations of ammonia N were from 7 to 53 $\mu g.l^{-1}$, most values in the range of 10 - 30, organic N from 140 to 330 $\mu g.l^{-1}$, most values in the range of 180 - 250, total P from 3 to 12.3 $\mu g.l^{-1}$, most values in the range of 5 - 10, reactive P was not detectable, organic C from 0.57 to 1.24 $mg.l^{-1}$, most values in the range of 0.7 - 1.1. Reactive Si was in the range of 0.15 - 0.24 $mg.l^{-1}$.

In Nižné Terianské Pleso, ammonia N concentrations at the surface were high after ice-melt, then remained in the range of 9 - 14 $\mu g.l^{-1}$, towards deeper layers usually decreased, in the depths below 20 m, more then 50% of samples were close to detection limit (below 7 $\mu g.l^{-1}$). Organic N concentration in water column fluctuated from 40 to 85 $\mu g.l^{-1}$ in May, and increased towards autumn to 100 - 160 $\mu g.l^{-1}$. Total P was quite low (2.3 - 4.9 $\mu g.l^{-1}$) whereas reactive P was below the detection limit (<1). Organic C remained mostly within the range of 0.6 - 1.25 $mg.l^{-1}$. Silica was from 0.61 - 1.00 $mg.l^{-1}$, except of several bottom samples with higher concentration up to 1.53.

Microbial biomass in 9 lakes. Bacterial numbers fluctuated between 0.1 to 4.0 x 10^6 cells per ml, average value in all lakes and layers was 0.58. The maximum value was found in Dlugi Staw in August both at the surface and near the bottom and it was extraordinary. Average cell volume was 0.28 μm^3 (range 0.06 to 0.6) with average cell length 1.19 μm (0.6 to 3.9). Long filaments often were found after ice-melt and again towards the autumn in lakes with scarce crustaceoplankton. Total bacterial biomass in pelagic region was below 22 $\mu g.l^{-1}$ C in 4 lakes, whereas it reached values up to 50 - 92 in Lago Paione Superiore, Lochnagar

and Starolesnianské Pleso, and 144 $\mu g.l^{-1}$ C in August in Dlugi Staw. Average value of all samples was then 21.7 $\mu g.l^{-1}$ C. Picocyanobacteria were very scarce, the only lake with values above 1000 per ml was Lochnagar (in two samplings even up to 23000 per ml). Heterotrophic nanoflagellates were very low in Dlugi Staw, ∅vre Neådalsvatn, Chuna and Lochnagar: they did not surpass 60 ind. per ml, and also the abundances of autotrophic flagellates, espec. bacterivorous Dinobryon, were low in the first two of these lakes (not surpassing 65). In three lakes, Nižné Terianské, Stavsvatn and Jörisee, HNF abundances were higher (up to 135 per ml), with more abundant autotrophic flagellates (up to 850 per ml) and Dinobryon (up to 170). Highest HNF abundances were regularly found in Starolesnianské Pleso and Lago Paione Superiore (up to 460 per ml) and autotrophic flagellates (and Dinobryon) reached more than 1000 per ml. Cell volumes of HNF mostly fluctuated in the range of 20 to 50 μm^3 (average volume 35μm^3), but, occasionally, both the small cells (6-7 μm^3) and the large ones (above 150) were found in small quantities.
Microbial processes in 3 lakes. Total primary production of phytoplankton (TPP) was the highest in Starolesnianské Pleso in June and in September, always higher at the bottom than at the surface, values in the ranges of 1.65 - 16.98 $\mu g.l^{-1}$ C per hour. In both the other lakes, TPP was more than one order lower, in the range 0.023 - 0.351 $\mu g.l^{-1}$ C per hour. There were considerable differences in the partition of assimilated carbon among phytoplankton, bacteria and exudates. 40 - 70% of TPP was incorporated in phytoplankton in Starolesnianské Pleso and ∅vre Neådalsvatn, compared to 1 to 27% only in Dlugi Staw. Bacteria incorporated 8 to 26% of TPP in ∅vre Neådalsvatn and Dlugi Staw, but 1 to 12% only in Starolesnianské Pleso. Dissolved exudates contained 8 to 39% of TPP in Starolesnianské Pleso and ∅vre Neådalsvatn, but 50 to 75 % in Dlugi Staw. Though the big differences in TPP among lakes, bacterial production measured by thymidine uptake was very similar. Leucine method yielded slightly lower values in Dlugi Staw than in other two lakes. Bacterial elimination rates and production rates calculated from elimination experiments were the highest in Starolesnaianské Pleso (reached up to -0.32 per hour and 0.86 per hour, respectively). In ∅vre Neådalsvatn, the respective maximum values were -0.36 per hour and 0.66 per hour. The minmum values were measured in Dlugi Staw: -0.22 per hour and 0.005 per hour.

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: March 1, 1997 - February 29, 1998

Partner: Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia

Principal Investigator: Dr. Ferdinand Šporka

Scientific staff: Dr. Elena Stefkova, Dr. Ilja Krno, Dr. Peter Bitusik

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I. OBJECTIVES FOR THE REPORTING PERIOD:

a/ Field work:
Field work at the site 15.1 Starolesnianske pleso (WP1 and 2, site operator Evzen Stuchlik) and 15.2 Terianske pleso (WP3). Operating Automatic Weather Station (AWS) in the Terianske pleso.

b/ Laboratory work:
(i) analysing diatoms from sediment core from the site Terianske pleso, analysing diatoms from epilithon macrozoobenthos from littoral and medial from the sites Terianske pleso and Staroslesnianske pleso.
(ii) separating of chironomid head capsules from the upper part (13 cm long) of the core taken from the Terianske pleso
(iii) analysing invertebrates from the site Starolesnianske pleso

II. OBJECTIVES FOR THE NEXT PERIOD:
a/ Field work: Continuation of the field work as before until June 1998
b/ Continuation of the laboratory work as before from samples to be taken until June 1998 at the sites Starolesnianske Pleso and Terianske Pleso.
c/ Processing raw data to the form required by the central database and sending them to the database Bergen.
d/ Preparing the Final report and manuscripts.

PART B

III. Are there any particular problems ? Is your part of the project on schedule ?
Our part of project is on schedule.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

Sampling at the Tatra sites (Starolesnianske pleso, Terianske pleso)

Field measurements and sampling for chemical and biological analyses were carried out according to the schedule (approved at the 2nd MOLAR conference in Barcelona). Sampling at the Starolesnianske pleso included taking samples invertebrates from medial and littoral zone and diatoms from littoral zone. Sampling at the Terianske pleso included taking samples chironomids from medial and littoral zone and diatoms from littoral zone.

Sediment coring from Terianske pleso was done in 1996. Samples for diatom and chironomid analysing were sent us from UCL. The diatom samples are cleaned and prepared for counting Chironomid head capsules were picked up and counted from the upper - 13 cm - long - sediment core.

Sediment traping was installed in Terianske pleso in october 1996. Sampling was at the intervals indicated in the site protocols for WP3, ie. once in the ice-covered period and monthly in the ice-free period (4 times together). Samples were divided into two subsamples. One part was sent to Mondsee to analyse Chrysophycean cysts and the other is analysed for diatoms in our institute.

Tab. 1: Field activities in the year 1997

Sampling term	Lake	sampling & measurements
1.7.97	Starolesnianske pleso	sampling (invertebrates & diatoms)|
29.8.97	Starolesnianske pleso	sampling (invertebrates & diatoms)|
23.10.97	Starolesnianske pleso	sampling (invertebrates & diatoms)|
12.3.97	Terianske lake	profiling & sampling from vertical (biology and chemistry)
29.5.97	Terianske lake	profiling & sampling from vertical (biology and chemistry)
27.6-29.6.97	Terianske lake	installation AWS
3.7.97	Terianske lake	sampling (chironomids & diatoms)
30.7.97	Terianske lake	sediment trap sampling
28.8.97	Terianske lake	sampling (chironomids & diatoms), sediment trap sampling
23.9.97	Terianske lake	sediment trap sampling
21.10.97	Terianske lake	sampling (chironomids & diatoms), sediment trap sampling
12.12.97	Terianske lake	uninstallation AWS
14.1.98	Terianske lake	profiling & sampling from vertical (biology and chemistry)
18.3.98	Terianske lake	profiling & sampling from vertical (biology and chemistry)

Biological analyses of invertebrates were based on the determination of species, their abundance of invertebrates and chironomids.

V. List of Publications arising from the project (include copies):

Signature of Partner:

Ferdinand Šporka

Date: March 26, 1998

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: **January 1997- December 1997**

Partner: **Institute of Freshwater Biology,**

Scientific staff: Prof. Barbara Kawecka
Dr Andrzej Kownacki
Dr Elzbieta Dumnicka
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I. OBJECTIVES FOR THE REPORTING PERIOD:

- Completion of the tasks included in WP1 for the Lake **Dlugi Staw**:

- Deposition sampling and analysis
- Water chemistry sampling and analysis
- epilithic diatom determination
- microbial food webs - ciliates taxonomic determination
- zooplankton sampling and analysis
- macroinverterbrates sampling and analysis
- prepared the digitalized maps of the Dlugi Staw catchment

II. OBJECTIVES FOR THE NEXT PERIOD:

Development of the activities scheduled within WP1 for the third year of the Project

III. The Polish part of the project is on schedule.

IV.MAIN RESULTS OBTAINED

METHODOLOGY

Surface **water chemistry** samples for major ions were taken almost once a month, while bulk **deposition** were sampled weekly in the Meteorology Station near to the lake area. Epilithic **diatom** were sampled in July and September.

Microbial food webs (1st level)- **ciliates** determination. Sampled on the same dates as above. Samples for bacteria, HNF, PICY and PHY were sent immediately to the Hydrobiological Institute, CAS, C. Budejovice.
Microbial food web (2nd level) were sampled in July 1997 by Prof. Straskrabova team from Ceskie Budejovice.
Zooplankton samples (qualitative and quantitative) were taken monthly during the ice-free period from the deepest part of the lake (8 m). Sampled in: July, August, September and October 1997.
Quantitative samples of **macroinvertebrates** from 8 m depth and qualitative samples from lake littoral sampled in: July, August, September and October 1997.

RESULTS and DISCUSSION

Deposition

Deposition
DLUGI STAW

	volume mm	pH	Conductivity $\mu S.cm^{-1}$	Cl $mg.dm^{-3}$	$N\text{-}NO_3$ $mg.dm^{-3}$	$S\text{-}SO_4$ $mg.dm^{-3}$	SO_4 $mg.dm^{-3}$	$N\text{-}NH_4$ $mg.dm^{-3}$	Na $mg.dm^{-3}$	K $mg.dm^{-3}$	Ca $mg.dm^{-3}$	Mg $mg.dm^{-3}$
mean	**51,10**	**4,38**	**34,47**	**1,09**	**0,62**	**0,96**	**2,878**	**0,32**	**0,39**	**0,89**	**0,42**	**0,09**
min	1,54	3,6	9,092	0,04	0,04	0,26	2,216	0,004	0,004	0,004	0,03	0,02
max	682	5,02	181,1	16,1	8,37	7,48	3,776	1,41	8,38	15,52	4,45	0,52
SD	105,3	0,26	27,30	2,50	1,22	1,06	0,531	0,29	1,37	2,38	0,65	0,09

Results show pH values ranging from 3.6 to 5.02, with mean value of 4.38. In July and August, in Poland there were very heavy rains (8.07 volume of 223 mm was noted). In relation to the chemical parameters measured in the precipitation the most characteristic are smaller mean pH, Cl, sulphate and nitrate values than measured in previous year.

Water chemistry

Water chemistry
DLUGI STAW

	alkalinity $meq.dm^{-3}$	pH	Conductivity $\mu S.cm^{-1}$	Cl $mg.dm^{-3}$	$N\text{-}NO_3$ $mg.dm^{-3}$	$S\text{-}SO_4$ $mg.dm^{-3}$	SO_4 $mg.dm^{-3}$	$N\text{-}NH_4$ $mg.dm^{-3}$	Na $mg.dm^{-3}$	K $mg.dm^{-3}$	Ca $mg.dm^{-3}$	Mg $mg.dm^{-3}$
mean	**0,05**	**4.98**	**24,20**	**0,26**	**0,66**	**0,92**	**2,878**	**0,06**	**0,31**	**0,11**	**1,81**	**0,15**
min	0,001	5,13	18,05	0,16	0,49	0,71	2,216	0,02	0,17	0,06	1,31	0,08
max	0,1	5,91	31,33	0,55	0,9	1,21	3,776	0,11	0,44	0,16	2,24	0,26
SD	0,03	0,27	4,61	0,12	0,12	0,17	0,531	0,032	0,090	0,038	0,322	0,060

Lake water pH varied from 5.13 to 5.91. The values of Ca and Mg were 1.81 and 0.15 mg/l respectively. Cl value was 0.26 mg/l while SO_4 value was 2.88 mg/l.

Epilithic diatom

The samples of epilithic diatoms were taken two times: in July and September. Diatom communities was very scarce, 115 taxons were found (See Appendix 1). The epilithic flora was dominated by *Achnanthes marginulata* Grun., north-alpine species. The other diatom species found in higher number was *Achnanthes minutissima* Kütz and *Cymbella minuta* Hilse, which live in big variety of environment conditions (e.g. pH 4.3-9.2).
Epilithic diatom communities of Dlugi Staw are characteristic for high mountains lake with oligotrophic and slowly acidic conditions.
In compare with 1996 diatom communities were more scarce, which was connected with rainy weather in summer 1997

1st level of microbiology - Ciliates

8 species of Ciliates were found during the ice-free period of sampling (see Appendix 2). Their density increased to the maximum in October, in bottom (8 m depth) and surface layers (1 m below water surface).

Zooplankton

Dlugi Staw	**3.07**		**1.08**		**1.09**		**8.10**	
	ind	ind/m^3	ind	ind/m^3	ind	ind/m^3	ind	ind/m^3
Chydorus sphaericus	0	0	3	7	6.7	13	37	106
Alonella excisa	0	0	1.7	3	2	4	28.6	79
Acanthocyclops vernalis	0	4	6	15	17	1	0.3	3

Only three species of zooplankton were found,: *Chydorus sphaericus* and *Alonella excisa* (Cladocera) and *Acanthocyclops vernalis* (Copepoda). The number (quantity and quality samples) of two first species increased during the sampling season to the maximum in October. *Acanthocyclops vernalis* was found in higher number only in September. Comparing with 1996 number of zooplankton species is much lower, with no Rotatoria species.

Macroinvertebrates

In the lake Dlugi Staw 23 taxonomic groups were found (see Appendix 3).
In profundal Nematoda dominated during all season, also Chironomidae (represented by 6 taxons), Ostracoda and two Oligochaeta taxons were noted. In this zone maximum density of macroinvertebrates was found on October (19 500 n/m^2). In littoral zone Oligochaeta dominated. There were also Nematoda, Trichoptera, Chironomidae, Coleoptera and Colembolla taxons. The number of invertebrates was higher in July and August.
In compare with previous year in profundal zone there were no *Cernosvitoviella tatrensis,* species characteristic for this high mountain region, while in this zone two species of Chironomidae (*Micropsectra coracina* and *Heterotrissocladius marcidus)* were found.
The changes along depths gradient might be the result of rapid water exchange in the lake during heavy rains in summer 1997.

Signature of Partner: Joanna Galas

Date: 27.02.1998

Appendix 1. Epilithic diatom communities in D^{3}ugi lake (High Tatra Mts. Poland).

Station	D^{3}ugi lake									
Data	3.07.1997					17.09.1997				
Taxons / Sample	1	2	3	4	5	1	2	3	4	5
AC060A Achnanthes curtissima Carter	8	6	3	6	16	2	2	2	2	1
AC025A Achnanthes flexella (Kütz.) Brun								1		
Achnanthes helvetica (Hust.) L.-Bertalot	11	7	12	15	8	9	4	13	5	11
Achnanthes brasolettiana Grun.						1	2			
AC001A Achnanthes lanceolata (Bréb.) Grun.	2	+	1			6	38	3		
AC043A Achnanthes lapidosa Krasske		+								
AC038A Achnanthes laponica (Hust.) Hust							1			
AC022A Achnanthes marginulata Grun.	157	149	86	144	62	106	43	65	55	98
AC013A Achnanthes minutissima Kûtz. var. minutissima	3	14	16	9	10	5	24	29	15	11
AC048A Achnanthes scotica Jones & Fower	1	2	1		2	1	2	1		1
AC136A Achnanthes subatomoides (Hust.) L.-Bertalot & Hust	16	8	11	7	17	7	1	6	8	4
Achnanthes sp.			1		+	1				
AM012A Amphora pediculus (Kütz.) Grun.					+	1	1			
AU009A Aulacoseira islandica (O. Müll). Simonsen								+		+
AU004C Aulacoseira lirata (Ehr.) Ross var. biseriata (Grun.) Haworth	+	1		+	+	+				
AU9999 Aulacoseira spp.	1		+	+	+	5	+	+		1
BR006A Brachysira brebissonii (Bréb. in Rabenh.) Grun		+		2	+	1		1	+	1
BR001A Brachysira vitrea (Grun.) Ross						+	1	+	+	
Caloneis aerophila Bock				+	1		1			
CA002A Caloneis bacillum (Grun.) Cleve	1									
CO001A Cocconeis placentula Ehr. var. placentula		+		+		+	+			
CO001B Cocconeis placentula var. euglypta (Ehr.) Grun.		+					1		+	+
CY003A Cyclotella meneghiniana Kütz.						1		1	1	
CY019A Cyclotella radiosa (Grun.) Lemm.							+			
CM022A Cymbella affinis Kütz.		+							+	
CM007A Cymbella cymbiformis Agardh var. cymbiformis		+								
CM020A Cymbella gaeumannii Meister	+	+	1		13	+		+		
CM017A Cymbella hebridica (Grun.) Cleve	+									
CM031A Cymbella minuta Hilse ex Rabenh var. minuta.	3	11	17	14	7	13	22	16	69	15
CM009A Cymbella naviculiformis Auersw..					+					
CM103A Cymbella silesiaca Bleisch ex Rabenh.		+				1	+	1	1	1
CM003A Cymbella sinuata Gregory	+		1			2	2			
DE001A Denticula tenuis var. crassula (Naegeli. ex Kütz.) W.& G.								2		
DT001A Diatoma elongatum (Lyngb.) Ag.							+			
DT002A Diatoma hyemale (Roth) Heib var. hyemale.					+					

Station	D^{3}ugi lake									
Data	3.07.1997					17.09.1997				
Taxons Sample	1	2	3	4	5	1	2	3	4	5
DT002B Diatoma hyemale var.mesodon (Ehr.) Kirchner	6	6	9	6	1	17	6	7	7	20
DP9999 Diploneis sp.	+									
EU013A Eunotia arcus Ehr. var arcus	+	1	4	1	+	1	2	2	2	3
EU016A Eunotia diodon Ehr..		+				1		+	+	2
EU009A Eunotia exigua (Bréb. ex Kütz.) Rabh.var. exigua	9	10	16	6	1	10	5	15	6	18
EU025A Eunotia fallax A. Cleve	1	1	1	3	+	2	2	3	2	7
EU025A Eunotia fallax A. Cl. var. groenlandica (Grun.) L-Bertalot & Nörpel	1	+	3							
EU047A Eunotia incisa W. Sm. ex Gregory			1				1			
Eunotia incisa boreo-alpine group	2	4	3	2	1	4	1	1	2	1
EU003E Eunotia praerupta Ehr. var. muscicola J.B. Petersen	+	+			+			+		
EU003A Eunotia praerupta Ehr. var. praerupta	1	1				+				1
Eunotia praerupta bigibba group	1	1	6	2	1	6	8	2	5	12
EU003A Eunotia praerupta Ehr. sensu lato	1	+	+	2	+	+	1	1	3	1
Eunotia side view	1	+	6	1	2	+	11	3	6	9
EU9999 Eunotia sp.		+				+				1
FR009A Fragilaria capucina Desm. var. capucina	+	1	4			1	+	+	13	4
Fragilaria capucina var. gracilis (Oestrup) Hust.							+	9	+	
Fragilaria capucina var. perminuta (Grun) L.-Bertalot						1		2	+	
FR008A Fragilaria crotonensis Kitton							+	18	2	
FR001A Fragilaria pinnata Ehr.var. pinnata	1	2	1	2	3	2		6	11	
FR005D Fragilaria virescens var. exigua Grun. in Van Heurck		1			1					
Fragilaria bands					+	2	3	4		
GO003A Gomphonema angustatum (Kütz.) Rabenh. var. angustatum	1					+	3	1		
GO003A Gomphonema angustum Agardh			1		1	1	9		+	
GO029A Gomphonema clavatum Ehr.		+	1		+	1		+	1	1
GO004A Gomphonema gracile Ehr.						+	1			
GO001A Gomphonema olivaceum (Hornemann) Bréb.						1				1
GO013A Gomphonema parvulum (Kütz.) Kütz. var. parvulum	1	+	+	2	1	1	+	1	4	1
GO023A Gomphonena truncatum Ehr. var. truncatum	+		1	1	+					
Gomphonena side view						2	23	2	1	
HN001A Hannaea arcus (Ehr.) Patr. in Patr. & Reime var. arcus		1		1	+		+		6	1
HA001A Hantzschia amphioxys (Ehr.) Grun. var. amphioxys	3	1	1	+	+	1	+	1		2
ME005H Melosira distans var.alpigena (Grun.in Van Heurck) Sim.	8	6	16	8	119	6	1	7	14	9
MR001A Meridion circulare (Grev.) Ag. var. circulare			3			3	1			2
Navicula capitatoradiata Germain	+	1	1	1		1	3	1		1
NA046A Navicula contenta Grun. in Van Heurck	1	1	1	2		1	2	1	2	+
NA007A Navicula cryptocephala Kütz.	+	1				1	4	6	1	3

Station	D³ugi lake									
Data	3.07.1997					17.09.1997				
Taxons / Sample	1	2	3	4	5	1	2	3	4	5
Navicula cryptotenella L.-Bertalot					+			+		2
Navicula gallica var. perpusilla (Grun.) L.-Bertalot	+	5		3		2	1	2	1	1
Navicula goeppertiana (Bleisch) H. L. Smith var. goeppertiana		+				+		+		+
NA044A Navicula krasskei Hust.	2	2	1	2		1	2	1	1	2
NA009B Navicula lanceolata (Agardh) Ehr.		1	4	+	+	6	11	13	4	1
NA481A Navicula levanderi Hust.			1				1			
NA025A Navicula mutica Kütz.	+		1	1	+	+	1	+		
NA013A Navicula pseudoscutiformis Hust.					+					
NA014A Navicula pupula Kütz.			1							
NA133ANavicula schmassmannii Hust.			1	1	+	1			1	
NA160A Navicula submolesta Hust.	2	+	2		+	+		1	+	
NA054A Navicula veneta Kütz.		1	1				2	1	1	
Navicula spp.		+	+				+			
NE003A Neidium affine (Ehr.) Pfitzer.	+						1	1		
NE003B Neidium affine var. longiceps (Greg.) Cleve					+					
Neidium affine (group)	1				+					1
NE004A Neidium bisulcatum (Lagerst.) Cleve bisulcatum	+	1	5	1	+	+		2	+	
NE007A Neidium dubium (Ehr.) Cl. var. dubium			1							
Neidium cf. dubium						+				
NI034A Nitzschia hantzschiana Rabenh.	+					1	+		3	3
Nitzschia sp small form	+		+	+		+		1		1
Nitzschia spp.							+		+	1
PI014A Pinnularia appendiculata (Agardh) Cleve		+	+		1	1		1	1	2
PI055A Pinnularia balfouriana Grun. ex Cleve						+				
PI012A Pinnularia borealis Ehr.	+	1		1	+	+		1		1
ZZZ997 Pinnularia caudata (Boyer) Patrick					+	1		1		2
PI001A Pinnularia gibba Ehr.						+				
PI004A Pinnularia interrupta W. Sm.					+					
PI011A Pinnularia microstauron (Ehr.) Cl. var. microstauron	3	+	+		+	+				2
Pinnularia [microstaron species 1] Alpe Roland Schmidt	+									
PI022A Pinnularia subcapitata Greg. var. subcapitata	3	3	1	1		2	4		2	+
PI007E Pinnularia viridis var. sudetica (Hilse) Hust.	+	+	+			1	1	+	2	1
PI007A Pinnularia viridis (Nitzsch) Ehr.		1	2		+	+	1			
PI9999 Pinnularia sp.			1	1	+					
SA001A Stauroneis anceps Ehr. var. anceps		+								
SA001B Stauroneis anceps f. gracilis Rabenh.			+	+	1					
SA9999 Stauroneis sp.		+								

Station	D³ugi lake									
Data	3.07.1997					17.09.1997				
Taxons Sample	1	2	3	4	5	1	2	3	4	5
ST009A Stephanodiscus alpinus Hust.	+	1	+	+		1	1			+
ST001A Stephanodiscus hantzschii Grun.			+							
SU002A Surirella ovata Kütz.							1			
SU9999 Surirella sp.								+		
SY001A Synedra ulna (Nitzsch) L.-Bertalot			+			2		+	+	+
TA001B Tabellaria flocculosa (Roth.) Kütz. var. flocculosa	4	7	5	8	2	7	4	24	7	13

Appendix 2. Planktonic ciliates in Dlugi Staw 1997

	3.07		1.08		1.09		08.10	
	surface	bottom	surface	bottom	surface	bottom	surface	bottom
Cyclidium	0.0	0.0	0.0	0.0	13.5	0.0	0.0	0.0
Hymenostome	0.0	0.0	0.0	0.0	26.9	0.0	0.0	0.0
Scutico 1	0.0	43.5	0.0	0.0	0.0	0.0	0.0	0.0
Scutico 2	0.0	0.0	0.0	0.0	0.0	31.4	0.0	0.0
Urotricha d	0.0	0.0	0.0	0.0	53.9	0.0	94.2	188.5
Urotricha m	0.0	29.0	15.7	0.0	0.0	31.4	11.8	0.0
Urotricha s	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0
Lacrymaria	0.0	0.0	0.0	0.0	13.5	0.0	0.0	0.0
TOTAL	**0.0**	**72.5**	**15.7**	**0.0**	**107.7**	**62.8**	**117.8**	**188.5**

Appendix 3. Macroinvertebrates in Dlugi Staw

DLUGI STAW	3.07. profundal n/m^2	3.07. kick	1.08. profundal n/m^2	1.08. kick	01.09 profundal n/m^2	01.09 kick	08.10 profundal n/m^2	08.10 kick
NEMATODA	1791	3	1592	2	15721	2	2388	1
OLIGOCHAETA								
Cernosvitoviella tatrensis		28		40				
- sp		50		119				1
Cognettia sp.	398	116		100	199	49		5
- sphagnetorum		29		12		6		3
- glandulosa		5		7		1		
- lapponica								1
Enchytraeidae juv.					398	1	199	1
Enchytreus buchholzi			531					
Achaeta sp.								1
CRUSTACEA								
Ostracoda	796						398	
PLECOPTERA								
Nemuridae juv.						1		
TRICHOPTRA								
Limnephilus coenosus		1		2		2		
Acrophylax zerberus		1						
DIPTERA								
Limonidae (Pedicia sp.)		1						
Tanytarsini (Micropsectra sp.) (juv.)		1	265		796	1		
Limnophyes sp.		1				1		1
Heterotrissocladius marcidus	1791		265				796	
Procladius sp.					199			
Micropsectra coracina					2189	1	2189	
Orthocladiinae (juv.)			531	1				1
COLEOPTERA ad.		2		1		1		1
COLEOPTERA pupae				3			199	1
Collembola						1		2
TOTAL	**4776**	**238**	**3184**	**287**	**19502**	**67**	**6169**	**19**

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: March 1997 - March 1998

Partner: 21 National Institute for Biology
Laboratory for freshwater and terestrial ecosystems research

Principal Investigator: Anton Brancelj

Scientific staff: dr. Alenka Gaberscik
M.Sc. Olga Bercic-Urbanc
Milijan Sisko - assisstant
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I. OBJECTIVES FOR THE REPORTING PERIOD:

1.) water column sampling
2.) major water chemistry
3) sampling of contemporary diatoms, Cladocera and Chironomidae in littoral zone
4.) contemporary zooplankton and phytoplankton (diatoms)
5.) sediment traps (SCP, diatoms and cladocerans remains
6.) sediment core diatoms and cladocera from lake Ledvica
7.) sediment core cladocera from lake Redo
8.) meteorological data collection

II. OBJECTIVES FOR THE NEXT PERIOD:
In 1998 we will continue with water column profil sampling for chemistry, zooplankton and chlorophyll concentration with start after ice-break down. With approx. a monthly intervals we will collect and analysed contain of the sediment traps. In spring, summer and autumn samples for zoobenthos and periphyton analyses will be taken and analysed too.
Meteorological data will be collected all the year round with sampling frequency of 0.5 hour.
In the first four month of 1998 we will finish analyses of sediment for cladocerans remains from lake Redo as well as samples of contemporary diatoms from lake Ledvica collected during 1997.

PART B

III. Are there any particular problems ? Is your part of the project on schedule ?

Problems: the only serious problem we have during field work was high water level and rainy weather. Water level oscillated for up to two meters due heavy rain-falls during summer. As a result we have to omitted some samplings of water-column profile and littoral biota.
Schedule: approx. 90 % of planed analyses and activities were done till end of February 1998. We are late with analyses of contemporary diatoms from lake Ledvica and sediment traps (Cladocera, Diatoms) collected during 1997. We already started with sediment analyses of cladoceran remains from lake Redo.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

1+2.) In total, we sampled from March 1997 till February 1998 ten times water column profile and additionaly seven times for major water chemistry Water column analyses and major water analyses show no significant differences from 1996. The first sampling in 1997 was done in March, when c. 60 cm thick ice covered the lake. The second one was on May 21 when aprox. 50% of ice was melted. The last sampling was in January 1998 when 80 cm thick ice covered the lake We sampled with 2.5 m interval from surface to the bottom of the lake. Only during ice-cover period we found NO_2 to be present in the lake. Oxygen saturation was well about 100 % for most of the year. Exception was at the end of ice-cover period when droped bellow 50% at the deepest point. Water pH was between 7.2 and 8.1, with high alcalinity (900-2300 μequv $^{l-1}$) and high conductivity (110-280 μS cm^{-1}). Comparing with 1996 we found in 1997 up to 3 times lower conc. of N-NH_4 (average c. 35 μg l^{-1}) and SO_4 (average c. 1 mg l^{-}). At the same time values for tot. P were up to 4 times higher (average c. 40 μgl^{-1}) comparing that in 1996.

3.) Contemporary diatoms and cladocera were collected on four occasions during ice-free period. There was no differences from the previous year in the cladoceran species composition. There were some differences in quantity but this differences we presume to arose mainly due to "dillution effect" of high water level.

4.) Sampling of conmtemporary zooplankton was in approx. Monthly intervals from March till Nov. 1997. Zooplankton species composition was the same as in previous year and the maximum value of the biomass (as g of DW m^{-3}) was in 1997 the same as in 1996. Some minor differences we observed in total biomass (as sum over the year) which was in 1997 slightly lower than in 1996.

5.) Sediment traps were emptied in approx. Monthly intervals during ice-free period. A total number of SCP particles collected in the sedimnet traps between Oct. 1 1996 and Oct 26 1997, was c. 2500 particles cm^2. Comparing with two nearby lakes (lake Planina: 5 km and lake Krn: 10 km away and at c. 300 m lower altitude) lake Ledvica had the highest values of cumulative SCP flux (lake Planina: c. 1200 particles cm^2 and lake Krn: 1600 particles cm^2) for the same period.

6.) Sediment core diatoms and cladocera from lake Ledvica. In all remains of only four Cladocera species were found in the sediment of lake Ledvica. Remains of one of them (*Alona guttata*) were in very low number; whilst remains of *Daphnia longispina,* one of the most common contemporary species were underestimated. Frequency of remains of *Chydorus sphaericus*, the most important species in the sediment, increased evenly from the depth of 30 cm to the depth of 16 cm. At that depth the frequency dropped for as factor of 4 and remained the same till the top of the sediemnt core. According to preliminary datation depth of 16 cm correrspond to 1910, when a near-by alpine pasture was abandoned. A detail analyses of diatom remains

7.) Sediment core cladocera from lake Redo: analyses already started and till now remains of 6 cladoceran species were identified.

8.) Meteorological data collection: meteorological station, positioned in the vicinity of the lake collecetd eight parameters (wind direction and speed, solar energy and radiation, pressure, temperature, hummidity and precipitation) without any major problems. The main problem was ice formation which stopped readings of wind speed and direction for 3 days. Minimum temperatures, recorded in 1997 were c. -15°C and maximum were c. 22 °C. The maximum wind speed (as an half-hour average) was c.10.m s^{-1}.

V. List of Publications arising from the project (include copies):

Brancelj, A., G. Kosi, M. Šiško, 1997: Distribution of algae and crustacea (Copepoda & Cladocera) in mountain lakes in Slovenia with different trophic levels. Periodicum Biologorum: 99(1):87-96.

Gaberšcik, A., O. U. Bercic, A. Brancelj, M. Šiško: Mountain lakes - remote but endangered. Proceedings, 1st international conference on environmental restoration, Ljubljana, July 6-9. 1997

Signature of Partner:

dr. Anton BRANCELJ

Date: March 1 1998

PART B

DETAILED REPORT OF THE PARTNER 22

Reporting period: 28.02.97 - 28.02.98

Partner: Institute of North Industrial Ecology Problems of Kola Science Center

Principal Investigator: Prof. Moiseenko T.

Scientific staff: Dr. Vladimir Dauvalter (Sedimentology), Dr. Anatoly Lukin (Ichthyology), Dr. Boris Ilyashuk (invertebrates), Andrey Sharov, Oksana Vandish, (Footveb), Sergey Sandimirov (meteorology, hydrology), Dr. L. Kudryavtseva (analytical work).

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I. OBJECTIVES FOR THE REPORTING PERIOD:

Intense monitoring of the lake Chuna site within the WP - 1 Program. Investigation of chemical composition of atmospheric precipitations, water chemistry, state of biological communities - phyto-, zooplankton, fishes in North-East of Europe.

II.OBJECTIVES FOR THE NEXT PERIOD:

Continuation of monitoring, generalization of results and accounts. Impact assessment of atmospheric transfers on water quality of the North European lakes and their biodiversity. Criteria of early choppiness of water ecosystems. Geochemical and paleoecological reconstruction of climate changes and environment in the European North.

III. Are there any particular problems ? Is your part of the project on schedule ?

It is necessary to note that the weather conditions of two years of researches have considerably differed: cold and rainy 1996 and hot summer with small amount of deposits in 1997. Therefore there were some problems with samples selection in June 1996 because of the avalanches' danger, and in July 1997 because of forest conflagration at the mountains' foot.

MAIN RESULTS OBTAINED

Combination of conditions of high Arctic latitudes with altitude causes significance of the Chuna site for European Project - understanding the pollutants' transfer from Europe and early worry in water ecosystem.

The investigation's methodology was kept within the framework of WP-1 instruction.

Deposition. The deposits in the Chuna site are characterized as acidic, the pH varies from 4,83 to 4,9 in winter period and 4,30-6,00 in summer period. Àcidity of deposits is connected to the sulfate contents in them.

Water chemistry. Water of the Chuna-lake has low salt level, conductivity is 8-12 µS/cm and Ca is dominant cation as well as of all lakes MOLAR-site. Dominant anion in the majority of the water samples is SO_4 - 1,9-2,0 mg/l. The relation HCO_3/SO_4 is on the average 0,5-0,6 on two years of study. It indicates to instability of ions composition and acidification of the Chuna-lake waters. The vertical stratification of the basic ions in lake is not actually observed. Seasonal dynamics is expressed a little. During the flood period and high water (1997) the lowest pH = 5,53 - 5,57 was observed in May 31 - June 1. At the same time alkalinity of a surface layer of water has reduced up to 7 - 8 µeqv/l.

The contents of organic substance in water of lake is low (TOC - 1,6-2,6 mg/l). Phosphorus and nitrogen are present in insignificant quantities (Ptot up to 5 µgP/l, Ntot from 40 up to 374 µgN/l

Definition in separate samples of such elements as Co, Cr, Cd, Pb, Hg, As (ICP MS) has shown that their contents in water of the Chuna-lake is lower than a limit of detection by this method (less than 1 ng/l).The definition Ni, Cu, Mn, Sr, Al, Fe was carried out by Graphite Atomic Absorption Spectroscopy. The contents of Ni = 0,5-1 µg/l, Cu = 0,4-0,6 µg/l, Mn = 0,5-1 µg/l, Sr = 3-4 µg/l.

Sediment chemistry. Sediments of the Chuna lake are characterized by exceeded concentrations of heavy metals (Ni, Cu and Pb) in the upper of 4-5 cm of the core. Factors of contamination (C_f, according to Håkanson, 1980), i.e. a quotient of concentrations from the uppermost (0-1 cm) to the lowermost (17-18 cm for the Chuna lake) layers, for Ni, Pb and Cu are 7.5, 4.6 and 2.5, respectively. The exceeding Ni, Cu and Pb concentrations in the upper 4-5 cm layers of the Chuna lake sediment core is accounted by atmospheric emissions of Severonickel Company smelters situated close to the lake (as regards Ni and Cu), a net of automobile roads and the general increase in Pb contamination in the atmosphere of the northern hemisphere (Norton et al., 1990). The onset of increasing Ni and Cu concentration is caused by beginning of metallurgical Company activity. Increasing Pb concentrations in the Chuna lake sediments is explained, mainly, by beginning of intensive development of the Kola Peninsula. Reduced concentrations of Zn, Cd and Al in the upper sediment layers say about changing in the lake water chemistry directed to pH decrease.

Phytoplankton. The number of phytoplankton species varied between 9 and 20 during different periods. The dominated algae were *Peridinium pygmaeum* (from May to July), *Cryptomonas marsonnii* (in spring and autumn), *Stephanodiscus alpinus* (11 of July), *Aulacoseira spp.* (15 of August) and *Elacatotrix gelatinosa* (29 of August). Small flagelats were predominated near surface on 1 of June and 29 of August. Few diatoms species from plankton were registered*: Stephanodiscus alpinus* 40% (from total number of valves), *S. hantziae* 40%, *S. parvus* 2.4%, *Fragilaria virescens v. exigua* 18%, *Synedra tenera* 14.4%, *Cyclotella pseudostelligera* 1%, which was not found in sediments.

Zooplankton. In the investigated lake there were recorded total 1 species of Rotatoria, 3 species of Cladocera and 6 species of Copepoda. The most frequently occurring species in 1996-1997 both were *Bosmina obtusirostris*, *Holopedium gibberum*, *Cyclops scutifer*, *Eudiaptomus gracilis*. Dominant species in 1997 were: in June - *Kellicottia longispina*, *Bosmina obtusirostris*, *Cyclops scutifer*, in July - *Holopedium gibberum*, *Acanthocyclops vernalis*, *Cyclops scutifer*, in August - *Holopedium gibberum*, *Cyclops scutifer*, *Eudiaptomus gracilis* and in October - *Bosmina obtusirostris*, *Eudiaptomus gracilis.*
During study period in 1996-1997 of the Chuna Lake under the influence of water acidification we did not reveal significant differences between years in zooplankton species composition, biomass and number of individuals in m^{-3}. Species of broad ecological requirements, which are capable to survive under low pH and low temperature (*Holopedium gibberum*, *Bosmina obtusirostris*, *Eudiaptomus gracilis*) were found.

Invertebrates. Total 46 taxa were recorded in the Chuna lake from kick and grab samples (Appendix). The number of taxa has varied depending on the sampling point. The highest species richness (19 species) was found in the outlet stream. The species of Nematoda, Oligochaeta, Ephemeroptera, Plecoptera, Trichoptera, Limoniidae and Chironomidae were recorded among the stream invertebrates. The lake at depth 5 m was inhabited by lowest number invertebrate species (9). Only small mussels (*Pisidium sp.)*, chironomids, nematode and oligochaete worms were represented in the invertebrate communities of the lake at depths 5 and 15 m. In contrast, shore zone of the lake and lentic localities (inlet and outlet) were inhabited by higher number of taxa.

Fish. For investigated period it is determined that the lake in Chuna-tundra is inhabited by brown trout (*Salmo trutta L.*) only. The number of the population is low due to small sizes of the lake and limited food base. Young specimens of brown trout in spring period by river following from lake migrate to lake system located down stream. Other part of fish population generates dwarf form that explains high rate of growth in the first years of life and its decrease in 4-6 years. Spawning of brown trout take place in II-III decade of September on sites with pebble ground and at the depth from 1,5 up to 2,5 m. The first spawning specimens were observed in the age of 3 +.The visual diagnosing of fishes has not revealed serious deviations from norm.

DISCUSSION and CONCLUSIONS

The weather conditions of two years of researches have considerably differed: cold and rainy 1996 and hot summer with small amount of deposits in 1997. However, the temperature of water has not varied. Ion composition and low pH indicate on lake acidification, which is clear during a high water. The basic hydrochemical parameters of the lake Chuna in 1997 a little differed from those in 1996. The seasonal variations also are insignificant.

The composition and biomass of phytoplankton on warmer 1997 year have not increased, nevertheless, and have even decreased on average. The more careful analysis of the data is necessary for understanding of this phenomenon. One of explanations can be small inflow of nutrient elements from catchment due to dry 1997 summer. Few diatoms species from plankton were registered: *Stephanodiscus alpinus* 40% (from total number of valves), *S. hantziae* 40%, *S. parvus* 2.4%, *Fragilaria virescens v. exigua* 18%, *Synedra tenera* 14.4%, *Cyclotella pseudostelligera* 1%, which did not found in sediments.

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Acidification of waters was proved by a state of invertebrate. The acidification value of the Chuna lake was characterized as mesoacidic using the acidification index by Raddum et al. (1988) and Fjellheim and Raddum (1990). The meaning of acidification index was higher in September (0.40) than in August (0.33).

In the period of 1996-1997 the population of Brown trout had no young fishes (0+,1+). It might be explained by two different causes: 1) anthropogenic impact (acidification ?); 2) migration of young fishes down stream. The further analysis and generalization of all data are necessary for the final conclusion, that it is supposed to be executed in 1998.

V. List of Publications arising from the project:

Moiseenko T.I., Dauvalter V.A., Kagan L.Ya. 1997. Mountain lakes as a marker of air pollution // Russian Journal of Water Resources, V. 23, No. 5.- P. 600-608 (in Russian, translated in English).

Dauvalter V., Moiseenko T., Kagan L. Tendency to acidification of Russian subarctic mountain lakes // Acid Snow and Rain. Niigata University, Niigata, Japan, 1997.- P. 457-462.

Dauvalter V., Moiseenko T., Kagan L. 1996. Mountain lakes of Russian subarctics as markers of air pollution: acidification, metals and paleolimnology // 5th International Conference on Atmospheric Sciences and Applications to Air Quality, 18-20 June, 1996, University of Washington, Seattle, Washington, USA.- P. 48.

Kagan L., Moiseenko T., Dauvalter V. 1996. Influence of heavy metals on diversity of diatoms of aquatic ecosystems of the Kola North // Proc. Internat. Sympos. on Heavy Metals in the Environment, 15-18 October 1996, Pushchino, Russia - P. 237.

Moiseenko T., Dauvalter V., Kagan L., Vandysh O., Sharov A. 1997. Mountain lakes in European Arctic as indicator of local and global pollution // European Conference on Environmental and Societal Change in Mountain Region, 18-20 December, 1997, University of Oxford, UK - P. 73.

Dauvalter V., Moiseenko T., Kagan L. Prerequisite for acidification of Russian subarctic mountain lakes // Cambridge Publication, Biogeomon, J. Conference Abstracts, V. 2, No. 2. .- P. 159.

Signature of Partner:

Date:

Deposition.

The deposits in Chuna site are characterized as acidic, the pH vary from 4,83 to 4,9 in a winter period and 4,30-6,00 in a summer period. Sulphate is dominant anions. Their contents in snow samples is 0,96-1,12 ìã/ë, in rain - up to 4,5-4,8 ìã/ë. The concentration of nitrate in deposits much below and changes from 0,020 up to 0,210 ìãN/ë. Thus, acidity of deposits is connected to the contents in them sulphate.

Base anions.

The water of Chuna-lake has low solt level, conductivity is 8-12 µS/cm. Ca is dominant cation. Its concentration is 0.9-1,2 mg/l in winter period (under ice) and 0,8 - 0,9 mg/l in a summer season. The prevalence among cations of Ca is characteristic as well as of all lakes MOLAR-site. Dominant anion in the majority of the water samples are SO_4 - 1,9-2,0 mg/l. The relation HCO_3/SO_4 on the average 0,5-0,6 on two years of study and it changes from 0,2 up to 1,2 in 1997. It indicates to instability of ions composition and acidification of waters Chuna-lake. The vertical stratification of the basic ions in lake is not actually observed. Seasonal dynamics is expressed a little.

PH

Waters of lake is slightly acidify, pH changes in an interval 6,1 - 6,3. During a high water 1997 the lowest pH = 5,53 - 5,57 were observed May 31 - June 1. In the same time alkalinity of a surface layer of water is reduced up to 7 - 8 µeqv/l.

Nutriens.

The contents of organic substance in water of lake is low (ÒÎÑ 1,6-2,6 mgÑ/l). Phosphorus and nitrogen are present at insignificant quantities (Ptot up to 5 µgP/l, Ntot from 40 up to 374 µgN/l), and the greatest concentrations are marked in May - June, that is connected to seasonal dynamics of these elements. Concentration of silica in water is 0,37-1,39 mg/l, the least ones were observed during a snowmelt time.

Heavy metals

Definition in separate samples of such elements, as Co, Cr, Cd, Pb, Hg, As (ICP MS) has shown, that their contents in water of Chuna-lake is lower than a limit of detection by this method (less than 1 ng/l).

The definition Ni, Cu, Mn, Sr, Al, Fe was carried out by Graphite Atomic Abcorption Spectroscopi. The contents of Ni = 0,5-1 µg/l, Cu = 0,4-0,6 µg/l, Mn = 0,5-1 µg/l, Sr = 3-4 µg/l. During a snowmelt time the contents Ni and Cu in a surface layer is higher. It can be as a result of watershed inputs, where these elements get due to activity of the enterprise. The contents Al in water of Chuna-lake changed from 3 up to 93 µg/l, Fe - from 2 up to 20 µg/l, the maximum was at the beginning of snowmelt time.

It is necessary to note, that the weather conditions of two years of researches considerably differed: cold and rainy 1996 and hot summer with small amount of deposits in 1997. Nevertheless, the basic hydrochemical parameters of lake ×óíà in 1997 differed from those in 1996 a little. The seasonal variations also are insignificant, that indicate about high resistance of Chuna-lake.

Laboratorio Studi Ambientali: reporting period from 1-3-1996 to 10-2-1998

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I. MAIN OBJECTIVES

- Data collection in the drainage basin of Lake Inferiore (LI) on: meteorological base parameters, amount of precipitation, chemistry of atmospheric deposition, lake chemistry, microbial pelagic food web including phytoplankton and zooplankton; preliminary investigation of macroinvertebrates only in 1996.
- Sample collection for lake water chemistry analysis on the secondary site, Laghetto Superiore (LS);
- Participation in specific workshop for method and data harmonisation.

II. ACTIVITIES PERFORMED AND RESULTS OBTAINED

Workpackage 1

Meteorogical and volume of precipitation data collection

Since 1991 an automatic weather station provides data every ten minutes on temperature, vapour pressure, relative humidity, solar radiation, wind direction and speed, amount of precipitation (heated device). The station is located in Robiei at 1890 m asl and it is seven km far away.

Chemistry of atmospheric deposition

Atmospheric deposition was sampled in the watershed of the lake, in a site located at 2100 m a.s.l. During the summer samplings and chemical analyses were performed weekly. The mean volume of wet precipitation during 1996-1997 was 910 mm and the water equivalent value for snow fell in winter 1996-1997 was 1196 mm.

Results show pH values ranging from 4.21 to 5.93, with a median value of 4.99, while conductivity ranges between 3 and 35 µS cm^{-1} with a median value of 10 µS cm^{-1}. Yearly alkalinity deposition was concentrated in six events, occurring in June and September,

with a total volume of 54 mm (6% of the global yearly volume). The main cations are ammonium, calcium and hydrogen ions (median values of 26, 17 and 11 μeq l^{-1}), while sulphate and nitrate (34 and 21 μeq l^{-1}) are the main anions. On a yearly basis, the volume weighted acidity value is 11 μeq l^{-1} for a pH of 4.85.
The snow points out mean value pH of 5.27 and conductivity of 3.6 μS cm^{-1}. The main cations are hydrogen ion, calcium and ammonium (median values of 5, 4 and 3 μeq l^{-1}), while nitrate and sulphate(6 and 4 μeq l^{-1}) are the main anions.

Lake chemistry

The lake was sampled ten times (four in 1996 and six in 1997), nine of them during the ice-free period and in March 1997 under the ice cover. In LI we considered twelve depth levels with 2.5 m step, while in LS we took three times at six different depth during the summer 1997.
LI inflow (outflow for LS) and outflow were sampled weekly in 1996 and monthly in 1997.
The mean concentrations of solute in LI show that total ionic concentrations range between 180-260 and 260-410 μeq l^{-1} in two layers laid one upon other with 20 m and 10 m thickness respectively , the conductivity values of 8-12 and 12-20 μS cm^{-1} at 20°C.
Figure 1 presents the trends of pH, alkalinity, sulphate and nitrate expressed in μeq l^{-1}, for the lake, observed over the last 12 years. During last decade pH and alkalinity values increase while sulphate and nitrate decrease

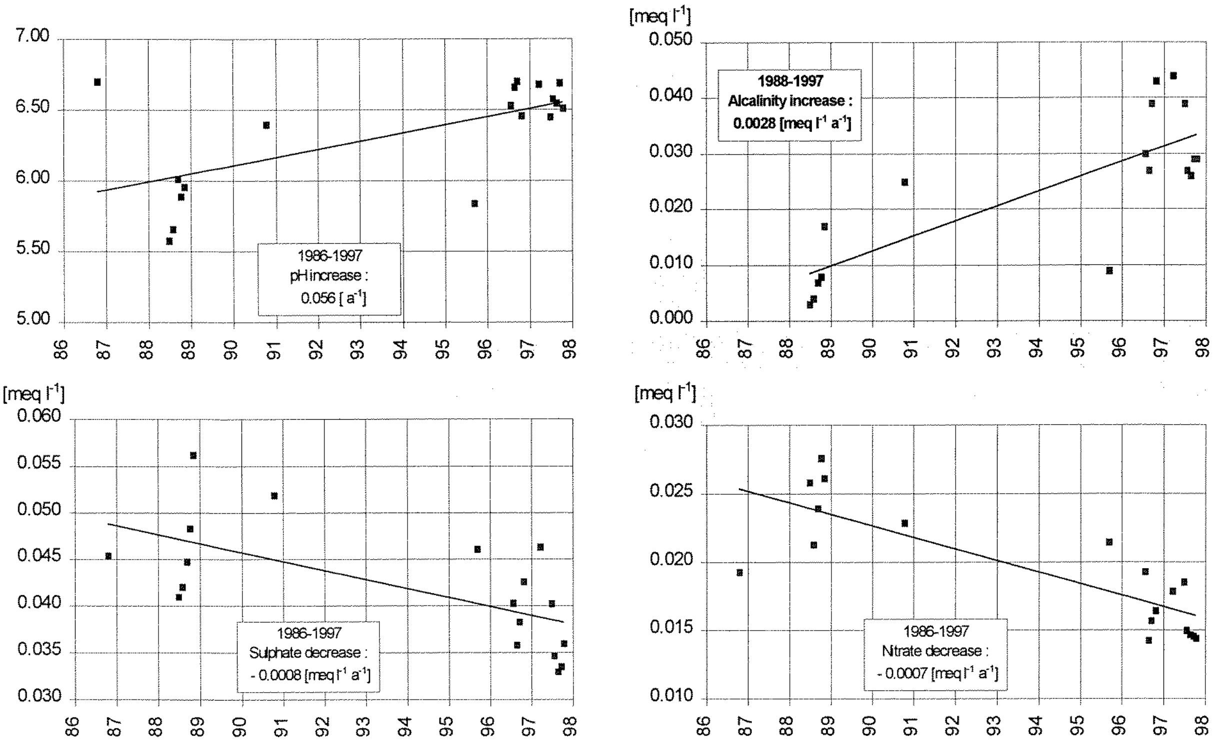

Fig. 1 - Trends of pH, alkalinity, sulphate and nitrate in lake Laghetto Inferiore

Microbial (pelagic) Food Webs- 1st Level

Phytoplankton

Four samplings were performed during summer/autumn 1996 and five during summer/autumn 1997 to count and measure the *algae* present in the LI. Following Laboratorio Studi Ambientali protocol phytoplankton (PHY) was sampled with a Schröder bottle from 0 to 25 meters, and it was identified, counted and had a biomass evaluation, from reckoned biovolume measurements, traced back to geometrical figures.

Preliminary evaluation shows three phytoplankton groups: Dinophyceae, Chrysophyceae, and Cryptophyceae. Flagellated forms are the most common, mainly *Peridinium elpatiewskij*, *Dinobryon divergens (?) Rhodomonas minuta* and *Cryptomonas spp.*

Zooplankton

From July to October 1996 and from June to October 1997, the small fraction of zooplankton (ZOOS) as rotifers and immature stages of crustaceans was collected concentrated on a 41 μm net with opening diameter of 10 cm, along the whole water column. The samples, preserved in Lugol solution were counted and sized entirely, with a distinction of species and developmental stage. Zooplankton (ZOOL) samples (200 μm net with opening diameter of 10 cm), were collected only in 1996 but due to 1996 very low presence it was not collected in 1997. For taxonomic determinations, we used the same 41 μm net samples.

Measurements of the biovolume of large and small zooplankton were carried out as phytoplankton one. In 1997 we sent to Jan Fott four dry samples of ZOOL, to be analysed for biomass.

Rotifers are depicted first by *Keratella hyemalis* and than by *Polyarthra vulgaris-dolicoptera*, while Copepods are represented by *Cyclops abyssorum tatricus*, which adults have very low abundance. A non-negligible amount of Rotifers eggs was found at the end of the season (October).

Macroinvertebrates

Qualitative kick samples were taken weekly during the ice-free period in LI during 1996 at littoral and outlet (50 m downstream) stations. A net with a 475 μm mesh aperture was used, attached to a 20×25 cm metal frame, with a 1.5 m long handle. The depth level considered was less than 1 m and littoral sampling stations were selected taking account of differences in substratum.

The invertebrate material from all the sampling points was sorted from the sediment in the field and fixed in 80% alcohol; a stereoscope (magnification up to 40×) was helpful for dividing macroinvertebrates into the main orders to give a relative density. The main group was Plecoptera represented by *Nemoura* and *Protonemoura*.

Workshop and intercalibration activities

In 1996 we participated in the 1st MOLAR Workshop, held in Prague, Ceck Republic.

We participate a Workshop in Pallanza, 5-7 June 1996, for AQC and the harmonisation of methods of chemical analysis of surface lake water samples and atmospheric deposition.

In April 1997, we attend the 2nd MOLAR Workshop, held in Barcelona, Spain as well the workshop on Sampling, Chemical Analysis and Quality Assurance of Atmospheric Deposition and Surface Waters held in Bern, Switzerland on the 25-26 September 1997.

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