MEASURING AND MODELLING THE DYNAMIC RESPONSE
OF REMOTE MOUNTAIN LAKE ECOSYSTEMS TO
ENVIRONMENTAL CHANGE

A programme of **MO**untain **LA**ke **R**esearch

MOLAR

MOLAR DIATOMS SAMPLING PROTOCOLS: LIVING COMMUNITIES, TRAPS

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Diatom Sampling Protocols: Living Communities, Traps

Sampling of living diatom communities (epilithon and, where appropriate, the plankton) and sediment diatom assemblages will be carried out at sites in work packages 1 and 3. Within these work packages the aims of this research have been set out.

Work Package 1

- To assess the seasonal variability in diatom communities in relation to seasonal changes in the physical and chemical environment

Work Package 3

- To assess seasonal variability in diatom communities by intensive sampling at small number of key sites (cf. above)

- To establish the relationship with other groups of 'fossilisable' organisms (chrysophytes, cladocerans, chironomids) and measured environmental variables

- To assess underlying trends and natural variability in climate from the fine detail analysis of the uppermost sediment at key sites

As set out in the MOLAR proposal and discussed at the Prague meeting the sites involved in these work packages and diatomists responsible for the analyses are tabulated below. Local site operators are responsible for carrying out the more frequent sampling.

1. Methods

1.1 Diatom communities

Sampling living diatom communities to assess their seasonal variability

i) In WP 1 this will involve sampling of each lake 2-3 times during the ice free period. Methods for epilithon sampling will follow those used in the ALPE programme (see below).

ii) In WP 3 sampling of diatom communities will be carried out at monthly intervals with one detailed transect to assess within lake variability and all benthic habitat types (epilithon, epiphyton, epipelon, epipsammon).

iii) In addition to sampling the epilithon, diatom plankton, when present, will also be sampled.

The chrysophyte sampling protocol is outlined elsewhere by Roland Schmidt.

1.2 Diatom community sampling: field methods for epilithon & plankton

Diatom epilithon is removed from stones, visibly uncontaminated by sediment, taken from c. 40 - 50 cm water depth along a c. 10 - 20 m stretch of shoreline. Sampling sites close to possible point sources of water quality variation, eg. inflow streams, should be avoided. Stones in shallower water (< 30 cm) should also be avoided since these are more likely to dry out as a result of fluctuations in lake level.

Algal growth on the stone is detached from the whole of the upper surface using a toothbrush and by repeated washings with distilled water from a wash bottle. The sample is collected in a 1 litre capacity polythene water sample bottle or similar via a polythene funnel. Three stones should washed into the bottle in this way to give a single mixed sample. At least three such composite samples should be taken on each sampling visit so that between sample variability can be inspected. Samples should be preserved by addition of a few drops of Lugols Iodine immediately after collection.

Living diatom material, both periphyton and plankton should be preserved with Lugol's Iodine. However, where SEM is planned the group from ILIMNOL argued that formaldehyde is a preferable preservative as they believe that Lugol's Iodine can damage silica surfaces.

Sampling of diatom plankton will follow standard techniques (Lund *et.al.* 1958). Initially it was suggested that where a planktonic diatom community is present, 250 ml or more of lake water would be collected from the surface water above the deepest point of the lake. Given that phytoplankton develop at different levels in the water column it was suggested that an amalgamation of water from the whole water column would be better approach. This could either be collected using a tube sampler, a tube with a pump or Rutner bottle. Where possible samples can be taken along with the depth profiles for water chemistry (see also Jan Fott's suggestions for efficient phytoplankton sampling and analysis).

Samples are to be preserved using Lugol's Iodene. Diatom cells are concentrated by settling, as detailed in the reference. A qualatative assessment (count of c. 100 valves) for diatom frustules with and without chloroplasts should be made (using either a wet mount on a microscope slide, or using an inverted microscope) before cleaning the material for detailed taxonomic and quantitative work.

1.3 Variation in diatom communities with depth: transect work

In the highly transparent waters of mountain lakes the photic zone extends to greater depths than in many other lake types and in some MOLAR sites may extend to the deepest point of the lake. Therefore at the WP 3 sites a single transect, during the summer period of 1996, will be made to sample all diatom communities and their variability in relation to depth.

The protocol is outlined jointly from the previous experience of the Barcelona & UCL laboratories.

The transect will be carried out preferably on the side of the lake with the lightest aspect. However, in addition to the need to sample on a side of the lake which is comparable with other lakes (lightest aspect), it may also be desirable to include the greatest diversity of benthic diatom habitats (substrates), for example epilithon, epiphyton, epipsammon, epipelon. Where possible divers will be employed to carry out the sampling. Alternatively a rope transect can be laid out with a shore station, anchor and buoys (Raven 1988). Sampling would then be made from a boat using an Ekman grab. The sampling interval will depend on the gradient of the lake bed, so rather than sampling at prescribed horizontal intervals, (eg. horizontal intervals of c. 2-5 m), it may be more appropriate to sample at approximately even vertical intervals. The spacing

of the transect samples will vary with the depth of the photic zone and maximum depth of the study lake. However, a *minimum* of 5 sampling stations with samples from all the benthic habitats is required. As indicated above, the means of sampling will vary between groups and may include: a boat and transect line using an Ekman grab; divers picking samples and using some type of closed-chamber epilithon sampler (see protocol for reference); or at Lake Redo the use of a robot sampler. Replicate samples of each substrate should be taken at each sampling station, in order that within station variability can compared against between station variation. Where divers take the samples it will be necessary to have some form of closed chamber sampler to remove epilithon from bedrock (brush & syringe Barcelona design, cf. Flower 1985). Epipsammon should be sampled according to Round (1965).

2. Diatom preparation, identification and counting: living communities, trap & fossil assemblages

All samples will be prepared by the laboratory who will carry out the diatom analysis. Preparation will follow the methods used in the ALPE project (Battarbee 1986, Wathne *et.al.* 1995)

Preparation and counting of diatoms from sediment cores will follow standard procedures (Battarbee 1986). Cleaned diatoms are identified and counted under oil immersion at a magnification of c. x 1000 or x 1200 usually under phase contrast, bright field or DIC illumination In cores diatom cell concentrations are determined using the microsphere method of Battarbee & Kneen (1982), for the core samples a minimum of 100 valves will be counted in contiguous samples (Renberg 1990).

Sediment coring protocols are discussed elsewhere, diatom and chrysophte sub-samples will be taken from the dated mastercore, which will be sliced at 2 mm intervals throughout the core.

3. Taxonomic harmonisation

Taxonomic harmonisation will be achieved through workshops (the first meeting took place in London 13-14 June 1996, jointly with cladoceran and chironomid analysts) and the exchange of diatom material in the form of published references, descriptions, microscope slides, photographs and material for SEM examination.

It would be desirable and useful to document the expertise we have built up in ALPE and MOLAR with the production of a diatom iconograph which could be circulated, at least initially, amongst the MOLAR diatom group.

An analytical quality control exercise (Kreiser & Battarbee 1987, Munro *et.al.* 1990) will be carried out. To some extent the lakes fall into 2 types, those with planktonic diatom floras and those with mainly benthic diatom floras. The idea was put forward that a group of 3 analysts (Sanna, Andre, Karin) dealing with the former would exchange and count slides and a group of 3 analysts dealing with the latter (Sergi, Elena, Nigel) would exchange and count slides. A comparison would then be made between the 3 counts for each of the 6 sites. In this way differences in taxonomic concepts can be identified quickly.

4. Sediment Trapping

4.1 Rationale for sediment trapping & diatom/chrysophyte work

Sediment traps provide a useful means of investigating the relationship between living diatom and chrysophyte communities and the records of these communities in recent sediment (eg. Cameron 1995). The rationale for their use is set out below.

i) Traps provide a link in space between diatom communities and lake sediment diatom assemblages.

ii) Traps enable short term events to be resolved. Where these events give a weak signal being either of too short a duration or of too low an intensity, for example where too few valves accumulate to register in the stratigraphic record, traps may provide the only clear record.

iii) Traps provide a continuous relative measure of the composition of the diatom mixture arriving at the sediment during any exposure period. They are a simple means of estimating relative diatom productivity as opposed to the measures of standing crop given by sampling living communities.

iv) Resuspension of sediment can be monitored by sediment traps. Comparison in time & space (not concerned so much with this in these well mixed lakes) between traps of species composition, live to dead cell ratios, and dry weight of sedimenting material collected may allow estimation of the intensity of resuspension.

4.2 Sediment trap design

Sampling will be at the intervals indicated in the site protocols for WP3, ie. monthly in the ice-free period and once at the end of the ice-covered period.

i) There are various pre-existing designs for sediment trap arrays, and to some degree for the traps themselves, amongst the groups. However, it is not felt that this limited diversity of design is critical and therefore can be retained.

ii) The traps themselves must be simple, cylindrical traps (having no modifications that would influence sediment collection, such as funnel shaped mouths etc.). The exception to this will be the marine sediment traps used in Lake Redo, but here Sergi Pla will employ a comparable, cylindrical trap array in addition to the marine traps. The design of the traps will follow the recommendations of a review article on sediment trap technique (Bloesch & Burns 1980, also Blomqvist & Hakanson 1981). Andy Lotter will circulate a copy of the former article to those of the diatom/chrysophyte group who do not have a copy. A key element of the recommendations for cylindrical traps is that the ratio height:width of the trap mouth (aspect ratio) must be greater than 5.

iii) A single array of traps will be employed in each lake. This will be suspended c. 1.5 m to 3 m above the lake bed and close to the coring point or deepest point of the lake. The trap array could have replicate cylinders (3 or 4) so that between trap variability can be examined. However, it may be preferable to amalgamate SM, given that the monthly amounts of sedimenting material are likely to be low and that in many published studies between trap variability has been shown to be small. Our primary aim is to have enough SM for analyses. An alternative would be to use larger traps, so long as the aspect ratio is the same (see ii above). It should be noted that at three lakes: Ovre Neadalsvatn, Lake Redo and Gossenkollersee; sediment trapping at bi-annual intervals is also required by WP2. Site operators should be

aware of this when sampling and distributing sedimenting material collected at the intervals required by WP2.

iv) It will be useful to continue trapping during the period of ice cover. Consideration should be given to avoiding dragging of the traps by ice. Traps may be placed underneath the ice in the winter once ice has formed or the marker buoy may be a subsurface float located by a pole.

v) It should be possible to make comparisons of sediment flux between and within lakes at different times. Hence the use of similar trap designs.

vi) Wet sediment will be examined for live/dead/broken cells prior to cleaning and counting. Wet mounts can be made as for plankton counting using either a microscope slide & coverslip or inverted microscope and counting chamber. This will provide a measure of sediment resupension prior to taxonomic work on cleaned slides. The purpose of this is to gain an approximate idea of sources of sedimenting material eg. from resuspension vs. recently living cells. A percentage count of the classes live/dead/broken cells or valves will be adequate.

vii) Relatively large cylindrical traps are preferable as sampling intervals are quite short and productivity may be low. In addition to diatoms and chrysophytes, sediment dry weight, loss-on-ignition and in Gossenkollersee, Redo, and Ovre Neadalsvatn ^{210}Pb analysis will be made for WP2

viii) For diatom counting of sedimenting material aswell as core assemblages we should routinely count chrysophyte cyst numbers so that both cyst and diatom concentrations can be counted and if required cyst to valve ratios can be calculated. The microsphere technique (Battarbee & Kneen 1982) was reiterated as the method for calculating fossil concentrations. Copies of this publication and the ECRC protocol for preparing diatom samples and slides have been distributed to those who required this information.

^{210}Pb analysis will be made for WP2.

MOLAR sites & diatomists involved in WP1 & WP3

Site	Diatomist	MOLAR WP 1	MOLAR WP 3
Chuna	Nadia Solovieva	X	
Øvre Neådalsvatn	Nigel Cameron	X	X
Stavsvatn	Nigel Cameron	X	
Lochnagar	Nigel Cameron	X	
La Caldera	P.Sanchez-Castillo	X	
Redo	Sergi Pla	X	X
Paione Superiore	?Aldo Marchetto	X	
Dlugi Staw	Barbara Kaweka	X	
Starolesnianske Pleso	Elena Stefkova	X	
Terianske Pleso	Elena Stefkova		X
Gossenköllesee	Karin Koinig	X	X
Jezero Ledvicah	Milijan Sisko		X
Saanajärvi	Sanna Sorvari		X
Hagelsee	Andy Lotter		X
Laguna Cimera (secondary site)	Manolo Toro	X	x

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