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CASSARINA

Change, Stress and Sustainability: Aquatic Ecosyustem Resilience in North Africa

Contents:

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المعهد العلمي

A European Union Programme on Environmental Change in North African Wetland Lakes

Cassarina Manual for Methods and Protocols. Report number 1

CASSARINA

Change, Stress and Sustainability: Aquatic Ecosystem Resilience in North Africa

PROJECT MANUAL:

Suggested Fieldwork Procedures and Laboratory Techniques

OCTOBER 1997

R.J. Flower and S. Patrick

A combined document incorporating contributions made by CASSARINA members during the first workshop in London 16-18th January 1997. Cassarina members: A.H. Abdelzaher, F. Ayachi, H.H. Birks, L. Carvalho, N. Elkiati, A.A. Fathy, R.J. Flower, M.Kraiem, D.T. Monteith, S. Peglar, A. Peters, M. Ramdani, S. Patrick, J. Thompson.

European Commission 4th Framework Programme for Scientific and Technological Co-operation with the Developing Countries (INCO)

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CONTENTS

1 INTRODUCTION

CASSARINA is a project designed to achieve three main objectives: i) to initiate a co-ordinated monitoring programme for nine North African lakes; ii) to assess recent environmental change at each site since ca. 1900 using palaeolimnological techniques; iii) to use results to influence conservation policy for wetland lakes in North Africa.

CASSARINA is supported by the European Commission 4th Framework Programme for Scientific and Technological Co-operation with the Developing Countries (INCO) and involves the following participants from Europe and North Africa:

Environmental Change Research Centre (ECRC), University College London, UK;
Botanical Institute, University of Bergen, Norway, UK;
Institut Scientifique Zoologie et Ecologie Animale, University of Rabat, Morocco;
Faculte des Science, Department de Biologie, University of Tunis;
Faculty of Science, Department of Botany, University of El Minia, Egypt;
Institute of Environmental and Biological Sciences, Lancaster University, UK.

This manual provides a guide to field and laboratory techniques utilized during the project. Analytical control will be exercised to ensure consistency of results. The ECRC in London and the Botanical Institute in Bergen have considerable experience in sediment analysis and will undertake a principal role in the palaeolimnological aspects of the project. At the same time, however, it is intended to transfer sediment analysis skills to the North African partners where appropriate. Modern lake monitoring will be mainly undertaken by the North African scientists with analytical quality control (AQC) checks built in to help harmonize the sampling programmes. Specialist techniques such as radiometric dating of sediment cores and pesticide analysis will be subcontracted to appropriate internationally recognised laboratories.

Because of the large variety of wetland lake types in this research programme, the field techniques are difficult to prescribe precisely. For monitoring transects for example, the transect distance and water depth range will depend greatly on particular site features. Changing water levels during the winter summer periods and different extent of fringing vegetation all contribute to making generalizations difficult. Similarly for sediment coring, water depth and nature of the sub-aquatic sediment will dictate choice of coring equipment and will necessitate the use of more than one coring technique.

In addition to on-going progress reports to the European Commission, results and the relevant limnological characteristics for each monitored lake will be assembled into individual research reports during the second year of the project (see Section 4 - data exchange, storage and dissemination). At the same time, each partner group should construct and maintain a computer database of their relevant results.

The suggested guides to CASSARINA procedures contained in this document are based partly on those already established for the EU-funded European Mountain Lake programme

(MOLAR 1996) and on previous ECRC UK sampling methods (Stevenson *et al.* 1987, Patrick *et al.* 1991).

A provisional plan of the analytical responsibilities and sample transfer pathways between CASSARINA members is suggested in Figure 1.

With regard to published information on North African lakes that is directly pertinent to the sampling programme implemented by CASSARINA the following references may be useful: Palaeoecology and diatoms (Flower *et al.* 1989), diatoms (Gayral 1954, Khelifa 1989), palynology (Reille 1979), trace metals (Gomaa *et al.* 1995), pesticides (Abou-Arab *et al.* 1996), zooplankton (Ramdani 1988), fish (Kraiem 1983), fungal spores (Elnaghy *et al.* 1991), hydrology (Hollis 1986). Although considerable water chemistry data exist they are generally for particular sites (e.g. Garaet Ichkeul) and, according to Biswas (1995), for North African countries there is 'no national strategy on proper collection, analysis and dissemination of water quality data'. One objective of CASSARINA is to contribute to this challenge.

2 FIELD TECHNIQUES

2.1 Lake ecosystem attributes

2.1.1 *Site characterization and selection*

Some of the wetland lakes selected for study are well known limnologically (e.g. Sidi bou Rhaba in Morocco - Ramdani 1988) others are not. A set of comparable statistics need to be assembled for all nine study lakes. At the time of writing the final list of lakes is not decided because sediment quality assessment has not been carried out (i.e the Egyptian sites). Sediment cores will be collected from at least four lakes initially in each country and those three lakes most amenable to palaeolimnological analysis will then be used for detailed study. Those lakes in which the sediments best preserve biological remains will be selected.

The following list indicates how data should be collated for each site selected for detailed study:

Physical description: lake and catchment size, morphometry, volume relief, geology, altitude, and seasonal water level fluctuations.

Land-use: a brief description and map of catchment size, land-use and major vegetation types with an emphasis on vegetation surrounding the lake is required. Also, information on the history of land-use change in the past 100 years or more is particularly valuable.

Climate data: Rainfall and temperature data from the nearest meterological station. Some summary statistics on wind direction and speed would also be most useful.

Documented past ecological conditions: Any information concerning the lake (flora and fauna), known changes in hydrology, known fish stocking/harvesting, bird populations, pollution events etc. is important. For example the introduction of water hyacinth into Egyptian waterways in the 1890s may be useful in interpreting any sediment records of this plant. Where good past survey data exist (e.g. Sidi Bou Rhaba, see Elkhiati 1995) longer term trends in monitored abundances should be described and added to data obtained by CASSARINA.

2.1.2 *Establishing monitoring transects*

A permanent transect line will be established at each lake and positioned across a littoral region selected as being the most suitable for sampling (following the initial site survey). Since lake types will be very different a precise guide cannot be given. However, the following points should be taken into account when choosing the particular survey line.

The survey line should be established at a convenient site that has a shore-line type most representative of the particular lake as a whole.

The termini of all transect lines should be marked with a stake if water depth is < ca. 1.5 m or by a buoy and weighted rope if deeper. These marks should be fixed with compass bearings or co-ordinates taken from a hand held global positioning system (GPS). Each transect line should start on the lake shore at a point marked by a **permanent stake**. Then, depending on lake depth, the transect line should extend across the entire site, where depth is < 1 m and lake diameter is < 100 m; if the lake is larger, the line should extend from the shore to the limit of the submerged aquatic plant zone or to a maximum of 100 m with sampling at 10 m intervals (in some larger North African lakes aquatic plants are ubiquitous). If a boat is not available, then the transect should be terminated at < 1 m water depth. Note that water level will fluctuate markedly at some sites and even 0.5 m may not be achievable.

Sampling along the transect should be carried out by running a rope perpendicular to the shore from the permanent stake at the lake edge. Sampling can be carried out at regular transect intervals, spaced according to the length of transect, so that eight to ten sample points are included.

Routine water and plankton monitoring samples should be collected from beyond the end of the transect line in each lake. Similarly, fish sampling should be undertaken in a defined region near the transect line.

Benthic diatom sampling should take place at a known point along or near to the transect line.

Timing

Transects should be established and sampled as thoroughly as possible during the first site visit when the sediment cores are collected. Subsequently, the transects should be routinely

sampled three times during the project, at approximately four monthly intervals, coinciding with the main seasonal changes in the region.

Relative water depth

This should be measured on each sampling occasion. A stake driven into the lake sediment at an appropriate point along the transect line will serve as a fixed reference point for depth measurement. In sites affected by tidal movements, such measurements will be less useful but should be made at the same point in the tidal cycle. At some stage it is desirable that the gauging post should be surveyed in using a local sea-level datum point.

2.1.3 *Water quality sampling*

Individual aspects of water analysis are often simple, but considerable care must be taken with sample handling. Most importantly perhaps, when different laboratories in different countries are involved, samples should be treated in exactly the same way throughout the collection and analytical procedures. Although 'standard methods' are generally well known there are frequently major differences in protocols as recommended by different laboratories, especially between different national analytical laboratories. The recommendations given here are taken from various sources, namely Mackereth *et al.* 1978, and personal communications from experienced freshwater chemists (R. Harriman, SOAFD Pitlochry, Scotland; B. Rippey, University of Ulster; and J.F. Talling, Institute of Freshwater Ecology, UK).

Every water sample collected should have a unique alpha numeric code beginning with WA, WB, WC (depending on sample usage) followed by 5 numbers (e.g. WA00001).

Water samples should be collected from each lake on each visit. Two 1 litre samples (**samples WA & WB**) for basic water chemistry analysis should always be collected together with one smaller sample (**sample WC**) of 120 ml for total phosphorus analysis. At one in every three lakes, an extra sample of B & C should be collected for AQC checks.

The lakes will vary greatly in depth and vertical profiling of water chemistry changes is not necessary for CASSARINA purposes. Water samples should be collected from the centre of the lake or from around the end of the transect line (see Section 2.1.2). Sampling stations should be the same on each visit.

Clean polyethylene samples bottles should be used on all occasions (to clean: bottles should be acid washed (10% HCl for 48 hours) then thoroughly rinsed with distilled water). Each water bottle should be rinsed thoroughly several times in the lake water before filling **Completely** and capping from about 15 cm **below** the water surface. Care should be taken to avoid sampling disturbed mud and where samples are taken from near the end of the macrophyte survey line or the lake centre, a small boat may be necessary.

After sampling all bottles should be kept in a cold box in the **dark at around 4^0C**.

Sample WA should be collected in a washed 1 litre bottle. The sample is **not** filtered and is used for pH, conductivity and alkalinity measurements only, as soon as possible after collection (within 24 hours). Measurement of pH should be taken in the field in addition to laboratory measurement. The bulk of this sample should then be conserved (frozen) by the laboratory in the country of collection for future reference. These samples should be coded WA and dated.

Sample WB should be passed through a Whatman GF/C filter and collected in a similarly washed bottle. Filtration should be done on site using a GF/C filter apparatus and suction pump. Note that GF/C filters should be pre-washed with distilled water. Sample B is for analysis of the major ions (Ca, Mg, Na, K, SO_4 and Cl) for which preservation is **not** essential. After tightly capping, samples should be returned to the laboratory and kept in the **dark at 4^0C** until despatch to El Minia. Samples should be coded WB and dated.

(Note: in the unusual event that calcium salts precipitate in the bottled water sample B, the procedure will need modification. An additional sample should be collected and acidified with 2 ml of 1N HCl (ANALAR Grade) before despatching to El Minia).

Sample WC is collected in 120 ml bottles and should **not** be filtered. This sample is for total-P analysis and requires acidifying with 2 ml 1N HCl (ANALAR/ARISTAR grade). Coded as WC and dated.

Samples WB and WC should be despatched to the University of El Minia as soon as possible (keeping at ca. **4°C and in darkness**).

Replicate samples (B & C series) for AQC checks should be taken/posted to the ECRC and analyses will be carried out at SOAFD Laboratory, Pitlochry, Scotland. **These samples should be labelled WB(R)** and dated. Several samples from any one of the three sample lakes in each country for each sampling occasion should be used for AQC analysis in the UK **(label WQ)**.

Nitrate and total nitrogen analyses are **optional**, if selected they should be carried out in **each** North African laboratory within 24 hours of sample collection. If total nitrogen is to be analysed the water sample should **not** be acidified but an iodized bottle should be used. To iodize bottles add a small crystal of iodine to polyethylene bottle, loosely cap, and warm in drying oven at 60°C for 2-3 hours, wash-well with distilled water. **This does not fix the sample**, it solely prevents growth of wall algae/bacteria.

Overall, we envisage the following measurements:

Sample WA	pH, total alkalinity, conductivity (at 25°C)
Sample WB	cations: Na, K, Ca, Mg (Sr and Ba, optional)
Sample WB	anions: Cl^-, SO_4^{2-}
Sample WC	total phosphorus
Optional Sample WD	nitrate/total nitrogen.
Sample WQ	AQC sample

Other water quality measurements

The secchi disc depth should be measured on each occasion and notes made about the turbidity and water colour. The estimated disc depth is a mean of the values noted when the submerged disc disappears and then reappears. At very shallow sites this measurement may not be possible and this should be clearly stated in the report.

Water and air temperature should also be measured on each sampling occasion.

At one lake in each of the three North African countries a submerged continuous temperature monitoring probe will be installed. This will measure and record water temperature diurnally over a period of one year.

2.1.4 *Macrophyte sampling*

Ideally the extent and diversity of aquatic macrophyte communities should be monitored for the whole lake. This can require extensive survey work and although some attempt should be made to assess total cover the approach should be optimized by monitoring communities along a single carefully selected transect (see Section 2.1.2).

Abundance and number of species of aquatic plants at intervals along a transect line selected for each lake should be estimated (see Elkhiati 1995). (Optionally, several transect lines can be monitored and this is recommended for large or particularly diverse sites).

Estimation of plant abundances at each sampling point can be achieved semi-quantitatively by visually ranking abundances present in a 50 cm quadrat (in clear shallow water) or by using a double headed rake pulled across a pre-selected area in deeper less clear water. The rake head can be used on a pole or on a rope as conditions indicate. Abundance of common species can be ranked as:

+ uncommon (<10% of the collection),
++ common (10-50% of the collection),
+++ very common (>50% of the collection).

Note that if the lake level is low, macrophytes can be sampled within the quadrat area by hand. Note also that emergent macrophytes should be sampled by hand.

Small submerged plants may only be sampled adequately by using an Ekman grab. The necessity of using this instrument will be assessed during initial field work.

The value of 'old' data needs to be emphasized. There is already 20 years of plant abundance data for Sidi bou Rhaba in Morocco.

All macrophyte samples will be archived in Rabat.

2.1.5 *Plankton and benthic diatom sampling*

Zooplankton

Samples are to be collected on each occasion with a net mesh size of 80-100 mm. In addition to the site and date, each sample is to be given a specific code, i.e. ZP (as defined for water samples). Several net hauls should be made where water depth permits from a boat or a promontory. Sufficient material needs to be collected for identification and for pesticide analysis.

After preservation in iso propyl alchohol (IPA) (or formalin if IPA is unavailable) the samples (bottles almost full) should be dispatched to the Institut Scientifique, Rabat, for identification.

About 5 ml of concentrated zooplankton is required for pesticide analysis and all samples should be kept frozen (in large glass bottles to prevent fracture) soon after collection (see Section 2.1.9 and 3.1.6), and not preserved with chemicals

Some lakes may be too shallow to support a good zooplankton community and in this case a similar volume of a common benthic invertebrate should be collected.

Phytoplankton

One or 1.5 litre water samples should be collected, as for water sampling (Section 2.1.3), treated with 3 ml of Lugols iodine solution and allowed to settle for at least 36 hours. After decanting the samples concentrated to a known volume (e.g. 100 ml, Fathy 1993) they should be kept at 4°C until dispatch to El Minia for analysis. Because of instability of the Lugols preservative, it is recommended that samples are also treated with a few drops of formaldehyde. Each sample should be identified by site and date and given a code i.e. PP.

Benthic diatoms

In shallow water, diatom communities grow on submerged plants, stones and surface sediment. Epiphyton (growing on aquatic macrophytes), visibly uncontaminated with sediment, should be collected from ca. 40-50 cm water depth along a ca. 10-20 m stretch of shoreline near to the permanent transect line. Sources of water quality variation, eg. inflow streams, should be avoided. Diatoms on aquatic macrophytes are sampled by removing several portions (a few centimetres of stem or frond) and placing these in a 30 ml Sterilin tube together with a few drops of formaldehyde.

Plants in very shallow water (< 30 cm) should also be avoided since these are more likely to dry out as a result of fluctuations in lake level. where aquatic macrophytes do not occur diatoms growing on stones (epilithon) should be collected. 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 be 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.

If no stones or plants are present, then diatoms should be collected from any submerged surfaces (e.g. the littoral sediment surface). Diatoms growing on the littoral sediment surface can be collected into a glass/plastic pipette (taking care only to sample the upper 1-2 mm depth of surface sediment) and then transferred to a Sterilin tube and similarly preserved.

Once selected the sampling substratum type should be kept the same through out the project.

It is important to note that all diatom sampling devices need to be thoroughly cleaned or re-newed for each sampling occasion.

All benthic diatom samples need to be identified by date, site and substrate type and given a code, i.e DI.

2.1.6 *Benthic invertebrate sampling*

This is an optional activity (unless the site does not support a significant zooplankton community then ca. 5 ml volume of one species of benthic invertebrate should be collected for pesticide analysis).

2.1.7 *Fish sampling*

Where fish are present they should be collected in gill nets, but sampling protocols specific to each site will be advised by Dr Kraiem (University of Tunis) following site visits. Electrofishing is preferable in many cases but is probably not feasible for the initial CASSARINA programme.

It is possible that some of the lakes may have few fish and population estimates of species will not be attempted. However, an adequate number of specimens is needed, not least for removing tissue samples for pesticide and trace metal analyses.

Each fish to be used for future analysis needs to be given a specific code beginning with FI.

For individual fish the following are required: site name, date, species, length in mm, wet weight in grammes., sex and gonadal maturation from stage I-VII. Stomach contents should be removed and preserved in 70% alcohol for identification. Scales need to be collected from the region between the dorsal fin and the lateral line for ageing purposes.

Liver tissue should be removed from five fish using 'clean' techniques for pesticide and trace metal analysis (Section 2.1.9) and sent **frozen** to Tunis. If the fish are large then 1-2 g of liver from each of five fish is sufficient. A total of at least 5 g wet weight is needed each for pesticide and trace metal analysis (see Sections 3.1.5, 3.1.6).

Small fish (<10 cm) should be frozen whole as soon as possible after capture and sent (frozen) to the Tunis laboratory.

For **trace metals**, analysis of a bulked sample from each sampling occasion is recommended (cf. Molar Project Manual, 1996). Treatment is as for pesticide samples (see Section 2.1.9), a minimum of five fish (of the same species and of approximately the same size) are to be used but a smallerr wet weight (1 g) of liver can be removed from each fish and placed in a Whirlpak bag, labelled and frozen.

A record must be made of which fish the liver samples came from and each aluminium packet must be labelled FP for pesticide analysis and FM for trace metal analysis. Each sample should be frozen.

It is suggested that all small fish dissections are carried out at Tunis using frozen material from Morocco and Egypt.

Fish gills are often rich in cadmium and as an option these can also be removed and preserved as for liver tissue.

2.1.8 *Division and allocation of samples*

A plan of modern sample transfers between groups is suggested in Figure 1.

Water chemistry

It is suggested that each North African laboratory group arranges for measurement of pH, alkalinity and conductivity soon after each site is visited (using water sample A). Sample B, together with Sample C for nutrient analysis, should be sent to the group at El Minia for full analysis as soon as possible after sampling. Replicate samples for AQC checks should be selected at El Minia and forwarded to the ECRC in the UK.

Phytoplankton

Preserved samples (three samples resulting from each monitoring site visit) should be sent to El Minia.

Zooplankton

Preserved samples (three samples resulting from each monitoring site visit) should be sent to Rabat for species identification and relative abundance estimations.

One zooplankton sample from each site on each sampling visit should be used for pesticide determination according to criteria recommended in Section 2.1.9. Samples should be sent along with fish material to Tunis and kept frozen in dry ice.

Fish

These will be analysed and sub-sampled for subsequent pesticide analysis at Tunis. Larger fish may be dissected at the local laboratory. Scales, muscle tissue and liver should be removed. Collection of fish samples from the Moroccan and Egyptian lakes should be the responsibility of each local laboratory following guidance from Dr Kraiem in Tunis. However, since fish sampling is more complex than for plankton it may be necessary for Dr. Kraiem to visit Morocco and Egypt for the first sampling occasion to co-ordinate techniques.

Despatch of fish tissue samples (liver), for pesticide and trace metal analysis, from Tunis to the ECRC and Bergen should be undertaken by Dr Kraiem in consultation with the project co-ordinators.

Samples of fish and zooplankton should all be transported packed in dry ice (see below).

Aquatic macrophytes

Identifying and estimating abundances will be the responsibility of staff at each North African laboratory but the data will be collated by the Rabat group. Where species cannot be identified by local botanists they should be preserved (either in alcohol or pressed between absorbent paper) for identification in Rabat. Here, in conjunction with botanists at Bergen, final diagnoses can hopefully be made.

Benthic diatoms

Preserved samples (three samples resulting from each monitoring site visit) from Tunisian and Egyptian lakes should be sent to Dr Ramdani (Rabat). The task of identifying taxa and estimating diatom abundances can be undertaken in conjunction with diatomists at ECRC.

Summary of sample sizes

Water	2 x 1 l for routine analyses, 125 ml for PO_4, 500 ml for AQC.
Phytoplankton	c. 125 ml of concentrated suspension.
Zooplankton	
(i) species identification	optional
(ii) pesticides	c. 5 ml of biomass
Fish	
(i) species identification and biometrics	optional
(ii) pesticides	> 5g liver tissue
(iii) trace metals	> 5 g liver tissue

Transportation

It is important to keep biological material intended for trace metal and pesticide analysis frozen during transportation. Samples should be sent in vacuum pack containers by air with prior arrangements made for their rapid collection on arrival.

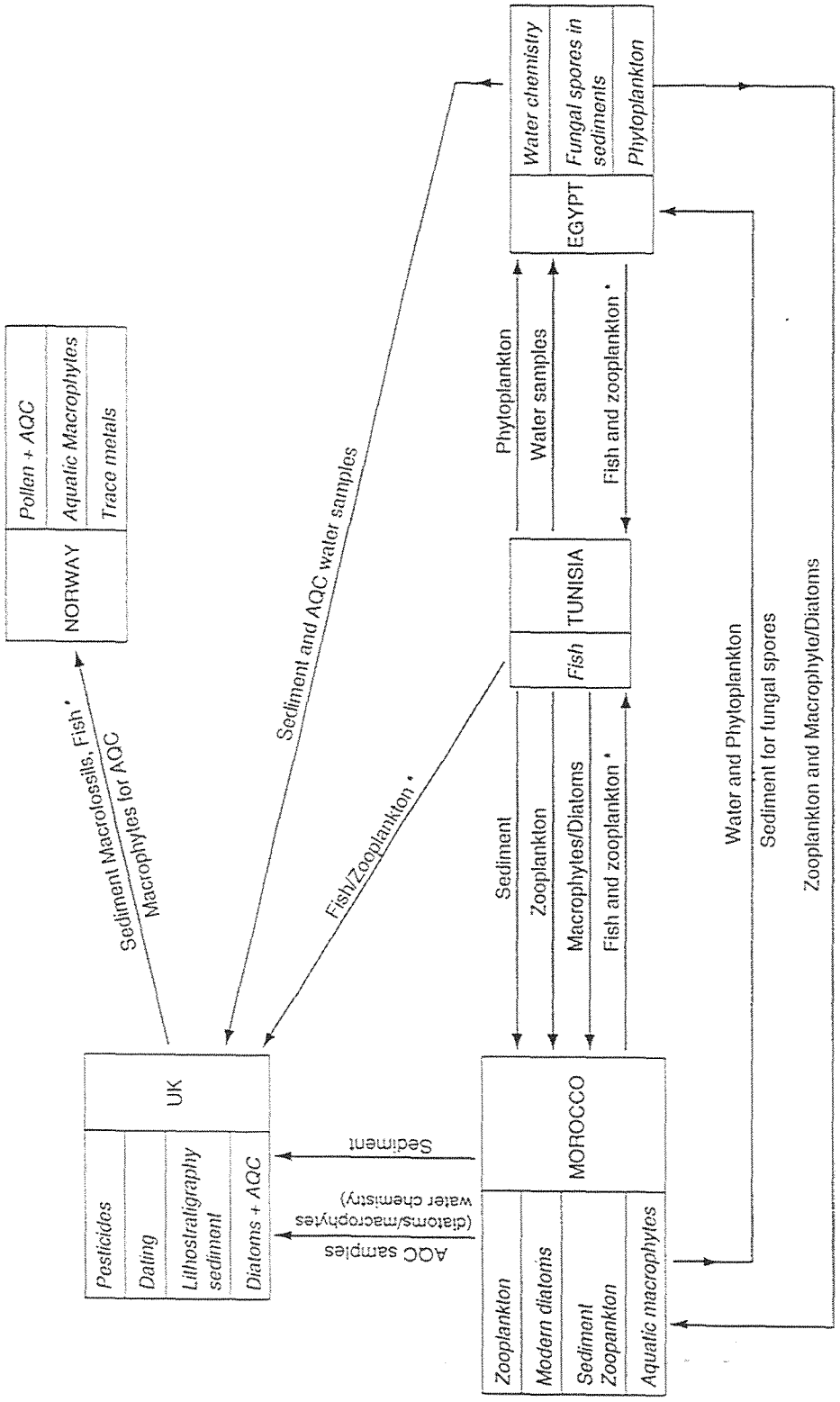

Figure 1 Main sample transfer pathway and analytical responsibilities within CASSARINA
(names in italics indicate an analytical procedure. AQC indicates analytical quality Control. * Samples for pesticide / trace metal analysis only)

2.1.9 *Lake hydrology*

Within the resources of CASSARINA we can only undertake a very simple approach to this important issue. By noting surface inflows (if present), monitoring lake levels and salinity on four occasions and combining these data with meteorological information gathered from national stations, it is hoped that some estimate can be made of the water budget for each site. In particular, rainfall, evaporation, air and water temperature, recharge/discharge data and perhaps most importantly relative water depth measurements (from a gauging post) should be measured where possible.

Where good maps of lake area and bathymetry are available lake volume to surface area should be estimated.

Some sites will already have gauging posts for measuring water level installed. Where this is not the case such posts need to be installed. A post can be constructed of metal or wood but must be marked off with paint or plastic tape at intervals of 5 cm or less. The water level can then be read directly as often as possible. If the site is visited between monitoring visits the level should always be noted. **Where possible the gauging post should be positioned at the end of the aquatic macrophyte sampling transect line.**

2.2 Procedures for past ecosystem attributes (sediments)

This major sub component of CASSARINA utilizes sediment cores to reveal past ecosystem attributes of particular lakes. Sediment coring protocols follow:

2.2.1 *Sediment coring site selection*

Sediment cores

Selection of a coring site is an important factor that can affect markedly the type of environmental sediment record produced. There is a considerable literature on the subject (e.g. Larsen & MacDonald 1993, Whitmore *et al.* 1996) Many of the issues of sediment distribution and redistribution are less critical for North African lakes since many are shallow (< 2 m deep) and now subject to high sediment accumulation rate. This combination of high accumulation rate and shallow depth will usually mean that either most are approaching a late hydrosere phase or that the basins are periodically purged of sediment either by flood events or by deflation following very wet or dry periods, respectively.

If sediment deposition within a lake basin is disturbed or interrupted the sediment record will inevitably be compromised. For this reason it is important to select permanent lakes that are not subjected to flood inundations or drying out completely. Even if these problems are avoided, wind induced sediment redistribution or sediment inwash effects may affect sediment accumulation and degrade the sediment record. This means that in some cases a pre-coring sediment survey with a grab sampler or gravity corer is needed to locate conformable sediment

sequences. Where water depth is very shallow, prospecting for suitable sediment type may require repeated sampling with a rod operated corer (see below). Despite possible problems, core site selection within a North African lake is probably a less important issue than for many North European sites with slow sedimentation and where frequent high winds induce turbulence and often focuses sediment away from the deepest point. Generally, in the simple basin morphometries of typical North African lowland lakes sampling at the deepest point is probably most satisfactory for representative sediment records. However, when historical evidence of past macrophyte communities is the focus of concern it may be necessary to take cores elsewhere. Aquatic plant macrofossils tend to be most abundant near the lake shore, within the growing macrophyte zone. Cores from this area and near any inflow would probably contain most information.

As a general guide, cores should be taken from the part of the lake (usually near the centre) where sediment depth is greatest and disturbance is minimal. Because of uncertainties in sediment core quality and integrity, **four lakes in each North African country** will be sampled, one of which will serve as a back-up site.

Surface Sediments

Samples of surface sediment should be collected during the modern macrophyte surveys to estimate the fossil representation of modern communities. This will aid interpretation of the fossil data. About 100 ml of sediment should be collected by hand in shallow water, or by a short gravity corer in deeper water.

2.2.2 *Sediment core collection*

Sediment cores will be collected from the Tunisian and Moroccan sites in the late spring of 1997. Cores from the Egyptian sites will be collected in the autumn of 1997 (see Appendix 1).

There are several coring techniques available and their use depends largely on the nature of the sediment, the sediment accumulation rate and water depth.

North African lake sediments typically contain considerable qualities of inwashed clay minerals and little organic matter. These features tend to make the sediment compact, cohesive and difficult to core. In such circumstances a modified Livingstone piston sampler (Livingstone 1955, Wright, 1967) or a similar rod corer but fitted with a 1-2 m 75 mm O/D PVC tube will be used. The former is used for longer cores and where sediment is more difficult to penetrate. The corer is operated manually by rods and is probably most appropriate for most North African lake sites. Nevertheless, the cohesive nature of most North African sediments means that sediment penetration by this low power technique may be limited to one or two metres at best. Some mechanical lifting device to aid retrieving the corer from the sediment will be required. It is prudent therefore to have materials available on site so that an 'A' frame can be constructed to help core removal. This may be set up on the sediment surface (in lakes only a few centimetres deep) or a floating platform constructed using two small inflatable boats may

have to be used where water depth is greater. In any case it is important that a local source of wooden planks is available.

At least two cores will be collected from each site, where it is necessary to use the narrow diameter Livingstone corer, two overlapping sets of cores should be taken within close proximity, e.g. 20-120 cm, 120-220 cm, and 70-170 cm, 170-270 cm etc. below the sediment surface. The water/sediment interface should be sampled using a modified Glew or similar corer with a plexiglass tube to overlap the Livingstone cores.

After retrieval, the narrow Livingstone cores should be well wrapped in clingfilm, foil, and thick polythene to prevent drying out, and stored at +4°C. In the laboratory they can be sliced into 1 cm samples and placed in Whirlpak bags. Great care must be taken to prevent contamination by first cleaning the cores by scraping the surface away using a flat-bladed knife horizontally across the core at right angles to the length of the core, to remove any material which may have been smeared during the coring. Cores collected using the larger PVC tube corer can be extruded with a piston and samples at 1 or 2 cm intervals and placed directly into Whirlpak bags (**but see special precautions necessary for samples intended for pesticide analysis, section 2.2.3**). Routinely, samples should then be stored **wet** at a temperature of 4°C.

Details of coring techniques are given in Berglund *et al.* (1986), Kummel and Raup (1967) and elsewhere. It is unlikely that many of the selected lakes will have a slow rate of sediment accumulation so that hand held gravity corers will be generally unsuitable, since they collect only 30-40 cm of sediment. Hence, selection of the Livingstone rod operated piston corer as the preferred coring instrument.

Past experience has indicated that in shallow lakes at least two metres of sediment will be required to give a potentially complete environmental record of even the past ca. 100 years. In larger lakes, with greater depth but relatively low sediment accumulation, a gravity corer (with extra weights) may be sufficient to retrieve sediment spanning the past 100 years of deposition.

2.2.3 Sediment core sampling and storage

Two sediment cores of up to 2 m long (where conditions allow) will be collected from each lake for sectioning, either in the field or at the local laboratory, at 1 cm (master core) or at 2 cm intervals (back-up core). Each core will have an alpha numeric code compatible with the system used by the ECRC. For example one Moroccan site to be cored is Sidi bou Rhaba (near Rabat), here the core codes should be RABA2 and RABA3 (RABA1 was collected from this site in 1986). Each 1 cm section samples is placed in a Whirlpak bag (to be supplied by ECRC) for temporary storage in a cold room at 4°C. (Special conditions are required for back-up samples for fungal spore analysis, see below). Each bag must be labelled with the core code, the sample depth and preferably the date.

Sub-sampling for fungal spore analysis will take place during initial core sectioning. Small size Whirlpak bags will be labelled with core code, date, depth and marked "FS" for fungal spore analysis.

Special considerations for geochemical analyses

Sub-sampling must be carried out with extreme care to avoid contamination. Since some samples will be used for trace geochemical analysis (pesticides and heavy metals) care must be taken during sediment extruding: disposable gloves should be worn and distilled water used for washing sediment sub-sampling equipment.

For pesticide analysis the follow procedures must be followed:

Equipment: For the analysis of pesticides, all equipment used for the handling, storage and preparation of samples must not be capable of imparting any contamination to the samples. Therefore, glass and metal are ideal materials. PTFE (Teflon) is acceptable where its use is unavoidable, but all other polymer and plastic utensils normally present a high a risk of contamination from leached compounds, and their use should be minimised. However, they are acceptable in certain cases, as specifically stated in the following Section. All solvents used need to be "Pesticide Residue" grade and water needs to be deionised, organic free grade (e.g. "Milli-Q" system fitted with cartridges to remove DOC). Before use, equipment must be thoroughly cleaned to remove any possibility of contamination, according to the following procedures:

Metal and plastic components of sediment coring equipment:
1) Clean with tap water
2) Clean with laboratory glassware detergent, e.g. "Decon"
3) Rinse thoroughly with hot tap water
4) 3 x rinse with deionised, organic free water
5) 3 x rinse with acetone
6) 3 x rinse with hexane
7) drain, then air dry in oven 60-100°C (NB: Combustion hazard! Use fireproof oven)

Aluminium foil is hexane washed and heated over night at 400°C.

Sampling equipment **must** be clean. If possible the sampling equipment that directly contacts the sediment should be rinsed with organic free water, acetone and hexane. This can be done using high density polyethylene (HDPE) wash bottles which are specifically made for such use and are readily available from laboratory equipment suppliers. Avoid sampling downwind of contamination sources such as exhaust fumes from generator or boat engine. Also, take special care to avoid contamination from oil, fuel, dust and other sediment.

Sample handling and storage: care must be taken when sub-sampling or cutting core material. There is a great need to avoid contamination and losses, hence exposure time of the sample to air and direct handling must be minimised. Disposable "Nitrile" rubber or HDPE gloves should

be worn, and these **must** be of the dust-free variety (some gloves are dusted to ease donning and reduce sweating). However, material should not be handled manually despite the wearing of gloves.

The core should be cut using implements cleaned as described above. In between samples, core cutting implements should be rinsed with organic free water, acetone and hexane from HDPE rinse bottles. Ideally, it is preferable to use one core specifically for pesticide analysis, or failing this, to sub-sample for pesticides first before sub-samples for other analyses are taken. Samples should be stored frozen: if this is not possible, they should be stored cool (< 4°C).

Sediment should be stored wet. Drying sediment samples has been shown to cause contamination and losses under some conditions. Air-tight glass jars with screw top lids lined with PTFE or cleaned aluminium foil are ideal, but not always practical for field situations and shipping. However, they are by far the best means of storage and especially so for poorly consolidated, wet sediments. If it is decided that the use of glass jars is not possible, then Whirlpak bags can be used. These should be used from new and only used once. A number of unused bags should be sent with the samples to assess any contribution to the blank levels. The best type of bags to use are those with a perforated seal which must be broken immediately prior to filling.

Special conditions for biological analyses

Microfossils preserved in lake sediment samples should keep without deterioration for many months without treatment but must be kept at 2-4°C but **not** frozen.

However, sediment samples are prone to fungal growth from contamination or from development of *in situ* spores even at cold room temperatures. For alternate samples from the back-up cores selected for fungal spore analysis some form of sediment preservation is required soon after sediment core sectioning. We propose that ca. 5 ml of every third sample in each master core is placed in a small Whirlpak bag and treated with a few drops of IPA orformaldehyde before storage. On the other hand, samples for culture experiments (to be undertaken only at egyptian lake sites) should not of course be preserved chemically, these should be taken from the back-up core.

2.2.4 Division and allocation of master core samples

The core sectioned at 1 cm intervals will be the 'master' core and this will used for ^{210}Pb and ^{137}Cs dating (by the University of Liverpool, UK). Details of the radio-isotope measurement are given in Stevenson *et al.* 1987 and elsewhere. The back-up will be kept in reserve should samples from the master core be lost or destroyed.

In the first instance, only alternate 1 cm sub-samples from the master core will be returned to the UK, plus 50% of each remaining sub-sample. That is to say, half of each alternate slice remains in the country of origin. Each North African group should therefore be responsible for

conserving alternate samples from each master core as well as alternate samples of back-up core material.

Of the complete 1 cm samples returned to the ECRC, each will be divided further for lithostratigraphic analysis (ECRC); radiometric dating (Liverpool); diatom analysis (ECRC); pollen analysis (Bergen); trace metal analysis (Bergen). However, only the lithostratigraphic analysis will be carried out on each alternative sample. Because the sediment accumulation rate is likely to be high at all the sites, other analyses can be carried out at 5 cm or more for macrophyte remains (see below). The alternate half samples will be used for pesticide analysis although only selected samples (perhaps 3-5 per core) will be used.

Macrophyte remains (Bergen) will be analysed from the back-up core and alternate 2 cm thick samples will be sent to Bergen via the ECRC. At the ECRC or in Bergen a small sub-sample from **within** the sediment matrix will be removed from every third sample and placed into sterile bags. These bags will be keep in a cold room until transport to El Minia for fungal culture work.

Sediment sample size requirements

Aquatic macrophyte remains	50 g wet weight
pollen	1-5 g wet weight
diatoms	1 g wet weight
pesticides	10 g wet weight
lithostratigraphic measurements	2 g wet weight
metals	2 g wet weight
radionuclides	2-3 g wet weight
zooplankton remains	5 g wet weight
fungal spores	5 g wet weight (c. 100 g for fungal culture experiments)

Each 1 cm core sample will contain about 30 g wet weight of sediment (considerably more in the more compact zone towards the base of the core) if the modified Livingstone corer (Plexiglas core tube) is used. A little more than half this weight of sediment will be available if the standard corer (steel core tube) is used.

There will be insufficient material for full analysis of every section but even by using different sample intervals for different analyses sediment quantity problems could still arise. However, for macrophyte analysis (and material for fungal culture experiments), the best compromise is to use the parallel back-up core for these analyses. Elsewhere, insufficient sample size can be overcome by bulking consecutive samples not reserved for dating/pesticide analyses. The alternate **master core** samples remaining in Morocco and Egypt should be used by the Rabat group for the analysis of zooplankton remains.

Back-up cores will be sectioned at 2 cm intervals and alternate samples will be initially stored in the country of origin. Because of shortage of sediment in the master cores, it is

recommended that samples for aquatic macrophyte remains and fungal culture should be taken from the back-up cores.

Sample analysis intervals

For microfossil analysis, high resolution analysis of sediment cores is to be preferred. However, since the North African lakes offer rapidly accumulating sediment sequences, close interval sampling is less important. The priority of the project is to produce reliable sedimentary records of environmental change for all nine sites. With this in mind, it is suggested that analyses should be undertaken at 5 cm intervals (or even 10 cm intervals for longer cores). Individual analysts may wish to modify these suggested intervals, depending on sediment quality, following discussion with the project planners.

Trace metal analysis (Bergen) and **radio-isotopes** (Liverpool) can be measured at the same intervals selected for microfossil analysis (where appropriate) but sampling for lithostratigraphic analysis (ECRC) will be carried out at 2 or 5 cm intervals depending on core length. **Pesticide analysis** will be undertaken on 10 g samples to be taken at 5 or 10 cm depth intervals, depending on the length of core collected.

3 LABORATORY TECHNIQUES

3.1 Procedures for modern lake ecosystem attributes

3.1.1 *Water chemistry*

Given the importance of achieving analytical quality control between laboratories it is intended to use common methods to determine water pH, conductivity, alkalinity and (optionally) nitrate/total nitrogen. Anion, cation and total phosphorus analyses will all be made at El Minia using Samples WB & WC, and applying standard methods (Standard Methods for the Examination of Water and Waste Water, 1989).

AnalaR grade chemicals must be used throughout.

Sample WA

pH: Made following calibration with pH 6 and pH 8 buffers. A clean well maintained combination pH electrode with a suitable meter is required and radiometer equipment is recommended. The most likely source of pH error in North African water quality types will arise from high temperature and high photosynthesis rates resulting in carbon dioxide depletion causing brief periods of very high pH in lake water (usually in mid-afternoons). Because of this, measurement should be carried out in the laboratory in addition to the field pH measurement. To standardize the procedure, it is recommended that the pH reading is always taken after one minute equilibration time with gentle stirring of the sample.

Conductivity: Calibrated Conductivity Meter with measurements corrected to 25°C. The German WTW digital model of meter is recommended. Calibration is recommended using the following to check instruments: dissolving 0.7455 g of oven dried (dried for 2 hours at 110°C) potassium chloride in 1 litre of double distilled water gives a conductivity of 1412 µS cm^{-1} at 25°C (see Mackereth *et al.* 1978).

Alkalinity: Alkalinity comprises the total content of weak acid salts (organic acids, silicate, phosphate, hydroxide, bicarbonate and carbonate), but is usually dominated by the latter two carbonates. As alkalinity is the sum of many components the units of measurement are milli-equivalents per litre (meq l^{-1}). Two titration end points should be identified using a calibrated pH meter. If the water pH is above 8.3, titrate until pH 8.3 is reached. This end point represents the phenolphthalein alkalinity and is the titration of all hydroxide and half the carbonate present. The titration is then continued until the pH 4.5 end point is reached which represents the total alkalinity of the sample. It is important that all CASSARINA participating laboratories use the pH 4.5 end point. Titration is carried out using 0.01 M HCl acid:

(i) Pipette *Z* ml (10 ml for very alkaline waters, up to 50 ml for less alkaline waters) of unfiltered water (**Sample WA**) into a conical flask.

(ii) If >pH 8.3, titrate to pH 8.3 and record volume of acid used in ml (V_1). Usually only a few drops of acid are required.

(iii) Continue titration to pH 4.5 and record volume of acid used in total, V_2, in ml (includes V_1).

Since each ml of acid contains 0.01 meq l^{-1} of acid., then each ml of titrant volume used, V, corresponds to 0.01V meq l^{-1} of alkalinity. In a sample of volume Z, alkalinity (A) can, therefore, be calculated (in meq l^{-1}) by the following equation:

$$A = \frac{10v}{z}$$

For phenolphthalein alkalinity use V_1, for total alkalinity use V_2.

Sample WB

Major ions: to be determined according to standard methods as used by the El Minia laboratory. Cations should be measured in an absorption spectrophotometer and anions by titration.

Sample WC

Total phosphorus: 25 ml of unfiltered water is placed in a 50 ml flask (grade A flask as needed to measure 40 ml accurately) along with 0.7 g potassium persulphate and 1.5 ml sulphuric acid (139 ml concentrated acid made up to 500 ml with distilled water). Digest for 1 hour in an autoclave or pressure cooker at 15 psi (121°C). After cooling make up the volume

in all flasks to 40 ml. The sample is then treated for soluble reactive P (follow Mackereth *et al.* 1978) - the phosphate is reacted with molybdate and then reduced to a Md blue complex; the lower sensitivity method should give a detection limit of about 3 mg l^{-1}.

Nitrate and chlorophyll *a* analyses are considered **optional**, but Chlorophyll is particularly suggested. The following methods are recommended:

Nitrate-nitrogen: using **Sample WD** - Cadmium-reduction method, measured spectrophotometrically at 543 nm. Requirements are:

(a) Cadmium coarse powder
(b) Ammonium chloride. Make up 2.6 g in 100 ml distilled water
(c) Borax. Dissolve 2.1 g in 100 ml distilled water
(d) Sulphanilamide. Dissolve 1 g per 100 ml of 10% (v/v) HCl acid
(e) N-1-naphthylethylene diamine dihydrochloride. 0.1 g in 100 ml distilled water
(f) HCl 2% v/v
(g) Standard nitrate solution (1 g l^{-1}). Dissolve 0.722 g potassium nitrate in 1 litre of distilled water

A set of standards must be treated simultaneously. Set up using the following dilutions of the standard nitrate solution. Take 1 ml of standard nitrate solution (0.1 g l^{-1}) and make up to 100 ml to produce a N stock solution of 1 mg l^{-1}. Use double distilled water (DDW).

(a) 10 ml of DDW in reaction vessel	(0 mg l^{-1} NO_3-N) (Blank)
(b) 7.5 ml DDW, 2.5 ml N stock	(0.25 mg l^{-1} NO_3-N)
(c) 5 ml DDW, 5 ml N stock	(0.50 mg l^{-1} NO_3-N)
(d) 2.5 ml DDW, 7.5 ml N stock	(0.75 mg l^{-1} NO_3-N)
(e) 10 ml N stock	(1.00 mg l^{-1} NO_3-N)

(1) Place 10 ml of **sample N** in a 30 ml Sterilin tube.
(2) Add 3 ml ammonium chloride, 1 ml borax and 0.5-0.6 g of spongy cadmium
(3) Shake in a mechanical shaker for 20 minutes. Timing is critical
(4) Transfer 7 ml to a 50 ml volumetric flask
(5) Add 1 ml of sulphanilamide and mix
(6) After 4-6 minutes, add 1 ml of N-1-naphthylethylene diamine dihydrochloride and mix
(7) Make up to 50 ml with DDW
(8) After 10-120 minutes measure the absorbance at 543 nm against the reagent blank (0 mg l^{-1} NO_3-N)

Total Nitrogen: If total nitrogen is to be analysed sample WD should **not** be acidified, instead an iodized bottle should be used (see Section 2.1.3).

Chlorophyll *a*: Filter a known volume of lake water (250-500 ml) using Whatman GF/C filter papers. Store filter papers in a labelled, sealed polythene bag in the dark and cold (cold box at 4°C) with 1 ml of saturated $MgCO_3$ (5%) added to the bag. Analyse within 2 days.

Warning: Acetone should not be stored in a standard fridge. If a spark-free fridge is unavailable, to obtain cold acetone store in an ice bucket.

(1) Place the filter paper in a mortar, add a pinch of sand (GPR lab Grade) and about 1 ml of cold acetone.
(2) Grind to a smooth paste, then wash the paste carefully into a 10 ml glass measuring cylinder or graduated, glass centrifuge tube.
(3) Make up to 10 ml with cold acetone. Leave to stand in the dark and cold (cold box at 4°C).
(4) Centrifuge for 10 minutes at full speed.
(5) Using a pipette, transfer the supernatant to a 1 cm glass spectrophotometer cell.
(6) Against an acetone blank determine the absorbance at 750 nm and 663 nm.

The value at 750 nm corrects for any fine colloidal matter and should be subtracted from the absorbance at 663 nm.

The chlorophyll *a* concentration in µg/l can be calculated as follows:

$$\frac{110 \times A663}{V}$$

where, A663 is the absorbance at 663 nm (-A750) and V is the volume of water filtered in litres.

3.1.2 *Aquatic macrophyte analysis*

If plants cannot be identified in the field using standard floras then samples should be collected and preserved for returning to the laboratory in Rabat. For robust plants pressing in absorbent paper will be sufficient to preserve specimens. Alternatively, delicate plants such as *Nitella* and *Ruppia* will need to be preserved in 4% formaldehyde solution. Each sample should be identified with an alpha numeric code beginning with MP.

Common plant species will be identified by scientists from the local laboratory. Where problems arise preserved samples should be sent to Rabat where diagnoses will be made. Botanists at Bergen will also help with identifications where necessary and scientists involved should liaise with Dr Elkhiati during visits to London.

3.1.3 *Plankton and benthic diatom analysis*

Phytoplankton

A quantitative assessment (count of ca. 100 cells/colonies) should be undertaken at El Minia of all algae present using an inverted microscope at x 400 magnification (cf. Lund *et al.* 1958). Species identifications should be made as thoroughly as possible using standard floras. Results

should be expressed as species abundances per litre. Diatom frustules with and without chloroplasts should be noted.

More detailed analysis of diatom species present can be undertaken by treating a sub-sample of the algal suspension with hydrogen peroxide and acid. After washing the treated suspension with distilled water (centrifuging at least three times) the diatoms can be dried on to coverslips, mounted in Naphrax and counted at x1000 magnification under oil immersion. Species identifications and abundance estimations can be made using standard diatom floras and as recommended by the project co-ordinators.

Zooplankton

Species will be identified according to standard keys for the region and taxa will be ranked for abundance scores (see Section 3.2.4).

Benthic diatoms

This method follows Battarbee (1986) and involves treatment of each fresh preserved sample with hydrogen peroxide to remove organic matter (usually very low in North African lake sediment) and 50% warm HCl to remove carbonates (usually high in North African lake sediments). One variation, is that with epipelon/epilithon/epiphyton diatom samples are usually heavily contaminated by clay particles, repeated gentle centrifuging (each at 1400 rev/min for 3 minutes) of the suspension in distilled water with a drop of ammonia solution will allow at least some of the clay particles to be decanted off.

3.1.4 *Fish analysis*

Fish species will be identified, measured and weighed. tissue for chemical analysis will be removed surgically from one species and frozen. fish age determination will be by fish scale analysis.

3.1.5 *Trace metal analysis*

Several methods are needed to estimate all the desired elements (those elements which are considered non-essential for the project are indicated in parentheses). Sediment samples will be treated in a similar way.

1. Pb, Zn, Cu (**optional** = Ca, Mg, Mn, Cr, Cd, Fe, K, Al, Mn, Na, Ni): Total dissolution of 0.25g *ignited* material (residue from loss-on-ignition; 550°C for 5 hours) is dissolved in a mixture of HF, HNO_3, and $HClO_4$ in a PTFE crucible by heating on a sand bath to near-dryness. The precipitated salts are dissolved in HCl, and measured in an Atomic Absorbtion Spectrophotometer (AAS), except for K and Na, that are measured in a flame photometer.

2. Hg: 0.2g **dried** sediment is digested by heating at ca. 70°C for 3 hours with H_2SO_4 and HNO_3. $KMnO_4$ is added until the colour stays. $K_2S_2O_8$ is added overnight. Before measurement, $NaCl(HONH_3)_2H_2SO_4$ and $SnCl_2HCl$ are added to reduce the Hg, that is then measured by AAS.

3. (Fe, S, Ti, V - **optional**). Dried sediment is formed into pellets for measurement in an X-ray fluorescence spectrometer. Known amounts of international rock standards (MRGM-1 and UM-1) are added to homogenised sediments as standards.

3.1.6 Pesticide analysis

Pesticide measurement in fish and zooplankton are similar to those described for sediments, with respect to cleanliness and contamination (Section 2.2.3).

Laboratory glassware and PTFE should be prepared according to the following procedures:

1) Clean with tap water
2) Soak in laboratory glassware detergent bath for 16 hours (overnight)
3) Rinse thoroughly with hot tap water
4) 3 x rinse with de-ionised, organic free water
5) 3 x rinse with acetone
6) 3 x rinse with hexane
7) drain, then air dry in oven 60-100°C (NB: Combustion hazard! Use fireproof oven)

NB: If equipment is badly soiled or stained, it can be cleaned in chromic acid and rinsed with de-ionised, organic free water between steps 1) and 2).

Small glass objects, e.g. Pasteur pipettes and vials should be baked in a furnace at 400°C for 16 hours (overnight).

Fish: Ideally, whole fish should be shipped frozen to the analytical laboratory. Failing this, they should be dissected in a laboratory using clean utensils as soon as possible after sampling and the livers removed, frozen and stored in cleaned glass jars or in hexane cleaned aluminium foil placed in Whirlpack bags. Samples must **not** be preserved in chemical preservative.

Zooplankton: Persistent organic pollutants concentrate efficiently in zooplankton owing to their high lipid content which readily accumulates lipophilic compounds. Thus, a sample size of between 1-5 g is sufficient to achieve similar detection limits as given for sediment samples. Careful sample handling is critical to achieve valid samples. Extra care must be taken to avoid rupturing body and cell structures. After sampling, a small amount of zooplankton should be placed on aluminium foil and carefully blotted dry with a clean, lint-free laboratory tissue (e.g. medical wipes) to remove excess water, using a new tissue for each sample. Other biological material and debris should be removed. The foil should be folded into a small package, placed

inside a clean glass jar or Whirlpak bag and then frozen and shipped in this state to Lancaster University. Samples must not be preserved in chemical preservative.

Water: Sampling of water for analysis of pesticides poses severe problems when the analytical laboratory is remote from the field area. It is therefore not recommend that water samples are taken for pesticide determination.

3.1.7 *Hydrological data analysis*

Analysis of field data will be discussed at the workshop in Tunis in February 1998.

3.2 Procedures for past lake ecosystem attributes (sediments)

3.2.1 *Lithostratigraphy*

Sediment core samples will be removed from sealed bags at the ECRC and subjected to gravimetric analysis. Sediment density is measured at every 4 or 8 cm depth by weighing two ml of sediment wet volume. Further, sediment core sub-samples are taken at 2 or 4 cm intervals (each of about 500 mg wet weight) and subjected to various heat treatments: heating to 45°C overnight for percentage dry weight determination, to 550°C for two hours to determination organic matter loss, and at 950°C for determination of carbonate loss. Resulting data are plotted against depth in each core.

3.2.2 *Radiometric measurements and dating*

Dried sub-samples of sediment (200 mg) are assayed for ^{137}Cs, ^{134}Cs, ^{210}Pb, ^{226}Ra and ^{241}Am using gamma spectrometry. Fallout radionuclides of Cs can often date the 1963 deposition layer in lake sediments and ^{210}Pb can be used the calculate the rate of sediment accumulation over the past *ca.* 150 years. However, past experience has indicated that ^{210}Pb profiles rarely decline monotonically and that occasionally major pulses of eroded soils obliterate (through dilution) the profile below detection limits. This again emphasises care during the initial site and core selection.

To help interpretation of the sedimentary radio-isotopes the catchment characteristic data suggested in Section 2.1.1 of this manual is required, especially rainfall, catchment type, size and relief, and lake morphometry.

3.2.3 *Diatom analysis*

As for benthic diatom sample treatment, 100 mg samples of dry sediment are treated with hydrogen peroxide and acid. Clay particles will undoubtedly be present in high concentration but these can be reduced as described above. The most likely problems to be encountered with the sedimentary diatoms is poor preservation caused by silica under-saturated pore waters and

low abundance due to major episodes of soil inwash to the lake. Recognising diatom fragments on concentrated mounts can also help reconstruct sediment history.

Diatoms are identified using standard keys, (mainly the *Susswasser flora von Mittel Europa* series) and counted under oil immersion at a magnification of ca. x1000 or x1200 magnification, usually under phase contrast, bright field or DIC illumination. In sediment cores, diatom cell concentrations can be determined using the microsphere method of Battarbee & Kneen (1982), for the core samples a minimum of 200 valves will be counted for each sample analysed.

The diatom count data are entered into a TILIA spreadsheet and plotted as percentage abundances using TILIA GRAPH.

3.2.4 *Zooplankton remains*

The carapace and appendages of many zooplankton and other microinvertebrates can be readily recognised in many lake sediments. The wet weight of sediment used for the analysis will determine microfossil concentrations but 2-3 g is often sufficient. The whole sample is examined under a good binocular microscope and about 200 individuals should be recognised. Cladocerans are often most abundant (e.g. *Daphnia*) and pre-sieving with a 40 mm net is helpful for removing larger forms and *Daphnia* ephippia. See Frey (1986) for calculating microfossil abundances. Permanent slides can be made by drying a drop of suspension (pre-washed with distilled water), adding a drop of 95% alcohol and mounting in EUPARAL.

Considering the abundance and treatment histories of mosquitoes in the region, the sediment record of larval exuviae may be worth examining for each lake.

3.2.5 *Aquatic macrophyte remains*

These are seeds, fruits, and certain vegetative remains in sediments. Animal remains, e.g. *Daphnia* ephippia, molluscs, ostracods, can also be recovered.

Analysis of aquatic macrophyte remains is intended to provide evidence about recent (in the past 100-200 years) changes in abundance of aquatic plant communities within each lake. Some sediment core sections could well be devoid of plant remains and sampling intervals will depend on individual core characteristics.

The analytical procedure normally requires a large sample size, ca. 50 ml. wet sediment. The amount may vary depending on sediment composition and accumulation rate. 50 ml represents approximately 2 x 1 cm sections of cores collected by the modified Livingstone corer (PVC tube 75 mm O/D) or approximately 3 x 1 cm sections of the standard Livingstone corer (steel tube 50 mm O/D). Sample volume is accurately measured in the laboratory by displacement of water. Sediment is desegregated by soaking in water, or in pyrophosphate solution if necessary before sieving through a 125 mm mesh. Fossils are then picked out during systematic examination under a stereo-microscope at x10-12 magnification. The fossils are identified and

counted, and concentration calculated per unit volume. The data are entered into a TILIA spreadsheet and plotted using TILIA GRAPH

3.2.6 *Pollen*

Pollen analysis is intended to provide evidence about recent (in the past 100-200 years) vegetation change in the vicinity of each lake. Summary pollen diagrams will be based on approximately ten samples per core in the first instance. It may well be that some levels are almost devoid of pollen whilst other sections contain major changes in pollen type. Frequency of pollen sampling will therefore finally depend on individual core characteristics.

The volume of sediment taken will depend on the rate of sedimentation, varying from 1-5 cm^3 of wet material. Tablets containing known numbers of *Lycopodium* spores will be added to each sample so that concentration and influx values of pollen and spore taxa may be calculated. Samples will be prepared by a standard chemical procedure using HCl, KOH, HF, and Erdtman's acetolysis (Method B of Berglund & Ralska-Jasiewicsowa, 1986), and mounted in silicone oil.

Slides will be traversed at regular intervals at a magnification of x400 (x1000 for critical determinations) using bright field illumination, and identifying and counting all pollen and spores encountered. Half or whole slides will be counted until a total of 500 or more land pollen and spores is reached. It may be more feasible to use a total of only 300 if concentration is very low. Algal and fungal remains, charcoal, and any other identifiable microfossils on the slides, will also be recorded.

Percentage, concentration, and influx diagrams will be produced for each site using the programs TILIA and TILIA GRAPH (Grimm, 1990).

3.2.7 *Fungal spores (Egyptian sites only)*

For spore identification, disaggregated samples will be sieved to remove debris and concentrated to an appropriate suspension concentration. Microscope slides will be prepared and scanned at 200-400x magnification for enumeration of fungal spores present. Analysis will be undertaken in El Minia using the methods described in Elnaghy *et al.* (1991).

3.2.8 *Pesticide analysis*

When analysing for pesticide residues, the primary concerns are: i) avoidance of contamination of the sample, either with analyte chemical or interferent chemical; and ii) loss of analytes from the sample.

Prior to analysis, the pesticides must be isolated from the rest of the sample (the matrix). The pesticides are extracted into an organic solvent, concentrated and subjected to a chromatographic clean-up technique to remove interferents and to separate the analytes into different fractions to enhance their identification and quantification. The pesticides are

analysed using the technique of dual-column Gas Chromatography with Electron Capture Detection (GC-ECD). Gas Chromatography with Mass Selective Detection (GC-MSD) is used for confirmatory analysis.

Selection of analytes

A survey of current and historical pesticide use on a local and regional scale would be very useful in identifying likely candidates for inclusion. The respective national regulatory bodies in each country should have details of, for example, pesticide importations and/or annual production figures for pesticide chemicals. The analysis for evidence of long-range transport of contaminants should also be considered in a small number of samples.

Sample size and detection limits

Based on a wet sediment sample size of 10 g, for the following pesticides, these detection limits can currently be attained in typical Northern English lake sediments:

Hexachlorobenzene (HCB)	0.05 ppb (ng g^{-1})*
Hexachlorocyclohexanes (eg. Lindane)	0.05 ppb (ng g^{-1})
Aldrin, dieldrin, endrin	0.05 ppb (ng g^{-1})
DDT/DDD/DDE	0.05 ppb (ng g^{-1})
Chlordanes	0.05 ppb (ng g^{-1})

* NB: Even though wet sediment is used, results are expressed on a dry weight basis. Lithostratigraphic measurements (ECRC) will be for sediment water content so that pesticide concentrations can be related to dry sediment weight.

In addition, the following pollutants can also be detected at the following concentrations:

Polychlorinated biphenyls (PCBs)	0.05 ppb (ng g^{-1})
Polycyclic aromatic hydrocarbons (PAHs)	0.05 - 1 ppb (ng g^{-1})

Other pesticides and contaminants, eg. Pentachlorophenol (PCP), Mirex, dioxins and furans (PCDDs/Fs) will be considered for analysis based on expected occurrence and on-going methods development.

4 DATA STORAGE, EXCHANGE AND DISSEMINATION

4.1 Data Storage

CASSARINA will generate a large amount of numerical information. The palaeoecological information will be kept on local databases at ECRC and Bergen but will be available in the form of TILIA GRAPH data files. Microsoft 'EXCEL' software is recommended as a common medium for storing and exchanging data concerning the modern monitoring programme.

EXCEL files should contain a first row giving the title of the dataset, a second row of the parameters as titles of data columns. The first column should contain the lake/site code, the second a unique sample code number, then the date followed by the data.

4.2 Data presentation

In the first instance it is recommended that CASSARINA scientists produce a multi-authored research report on each site sampled by the end of year 2. These reports should be based on results of the **sediment core analyses (ECRC) and lake descriptions (North African laboratories),** as based on some first monitoring results (water chemistry, vegetation etc.). *These reports will not contain the monitoring results.* Each report should comprise the following sections: introduction, site description, lake/catchment vegetation, land-use/management and fishing history, geology and soils, methods (these can be copied from report to report with reference to the Protocol Manual), sediment core collection and lithostratigraphy, ^{210}Pb dating, diatoms, aquatic macrophyte remains, pollen, trace metals, pesticide residues, conclusions, acknowledgements, references, appendices.

The results of **environmental monitoring** should be assembled into one report for each of the three lakes in each North African country. Each Report should comprise the following: introduction referring to the environmental context provided by the palaeoecological information with the following information given for each of the three lakes: methods, results (as tables) of water chemistry (showing each determinand as measured on each occasion), similarly for phytoplankton, zooplankton, fish data (number of fish, size and species), macrophyte data (as ranked abundances of each common species at each depth point sample), trace metal concentrations in fish, pesticide concentrations in fish and zooplankton; conclusions, acknowledgements, references, data appendices.

4.3 Data Exchange and Dissemination

Data files can be exchanged between work groups but it is recommended that dissemination of information outside CASSARINA is in the first instance by distributing the reports and then by writing papers following mutual agreement about the content of particular manuscripts. Scientists involved in CASSARINA will be free to access all available samples and results but individuals primarily responsible for particular analyses should take the lead in writing papers that focus on their own work. It is in the interest of all CASSARINA scientists to promote their work nationally and internationally, not only for the benefit of the scientific community but also to seek wider interest groups with a view to future expansion of the programme. Adding more sites and including remote sensing data are future objectives.

5 FUTURE MONITORING AND THE ROLE OF REMOTE SENSING

CASSARINA will generate much data concerning not only lake characteristics but also about the rate and extent of past environmental change. Clearly, once established the monitoring work should be continued into the foreseeable future as this is the only way to measure

precisely the chemical and biological aspects of aquatic ecosystem change. However, there is an important role for monitoring by remote sensing in future studies. This technique will not substitute for on-site information but high resolution satellite data will undoubtedly provide a relatively simple way of monitoring aquatic macrophyte cover, lake area and temperature, and land-use and land-cover change in areas adjacent to the study lakes. By combining site monitoring with satellite data it is envisaged that, especially for the larger sites, future surveillance will be markedly enhanced.

The 1997 London workshop was attended by Dr I. Rasool (IGBP Data Information System representative) and the potential application of various remote sensing options to CASSARINA was discussed. It was agreed that 1-5 m resolution would be necessary to usefully monitor changes in aquatic macrophyte communities and the relevance of CASSARINA data to current studies of land-use and land-cover change in the Mediterranean region, in particular by Medias-France, was noted.

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APPENDIX I Field work programme timetable

April 1997: Sediment coring in Morocco and Tunisia. Trial transects and initial monitoring of modern lake ecosystem attributes. Install gauging posts where necessary. Review field procedures and any difficulties arising from the sampling programme with scientists involved.

November 1997: sediment coring in Egypt. Trial transects and initial monitoring of modern lake ecosystem attributes. Install gauging posts where necessary. Review field procedures and any difficulties arising from the sampling programme with scientists involved.

February 1998: Two/three day workshop in Tunis followed immediately by monitoring field work:

Late February 1998: monitoring 1, for Tunisia, Morocco and Egypt.

Note that monitoring for all nine lakes must be within the same 3 week period and ideally on the same days for each country.

April 1998: monitoring 2, for Tunisia, Morocco and Egypt.

July 1998: monitoring 3, for Tunisia, Morocco and Egypt.

October 1998: monitoring 4, for Tunisia, Morocco and Egypt.

The forth monitoring session depends on finance, personnel and the amount of data gathered during the first trial monitoring occasions in 1997. A minimum of water samples, diatoms and depth records should be taken on this fourth occasion.

January 1999 - Workshop in Rabat

November 1999 - Final workshop in Egypt/London

February 2000 - Final reports: one from each country plus a summary report by the co-ordinators.

APPENDIX 2 Check list of routine sampling equipment and analytical techniques available in the participating North African laboratories (status as validated in October 1997)

Equipment/ technique	Morocco	Tunisia	Egypt
Alkalinity	✓	✓	
pH	✓	✓	
Conductivity	✓	✓	
Water filter kit	✓	✓	
Sample bottles	✓	✓	
Standard plankton nets	✓	✓	
Gauging posts	✓	✓	
Preservatives	✓	✓	
Fish nets	NA	✓	
Macrophyte rakes	✓	✓	
Sterilin tubes	✓	✓	
Fish dissection tools	✓	✓	
Transport and small boats	✓	✓	
Cold room facilities	✓	✓	
Computer databases	✓	✓	

Change, Stress and Sustainability: Aquatic Ecosystem Resilience in North Africa

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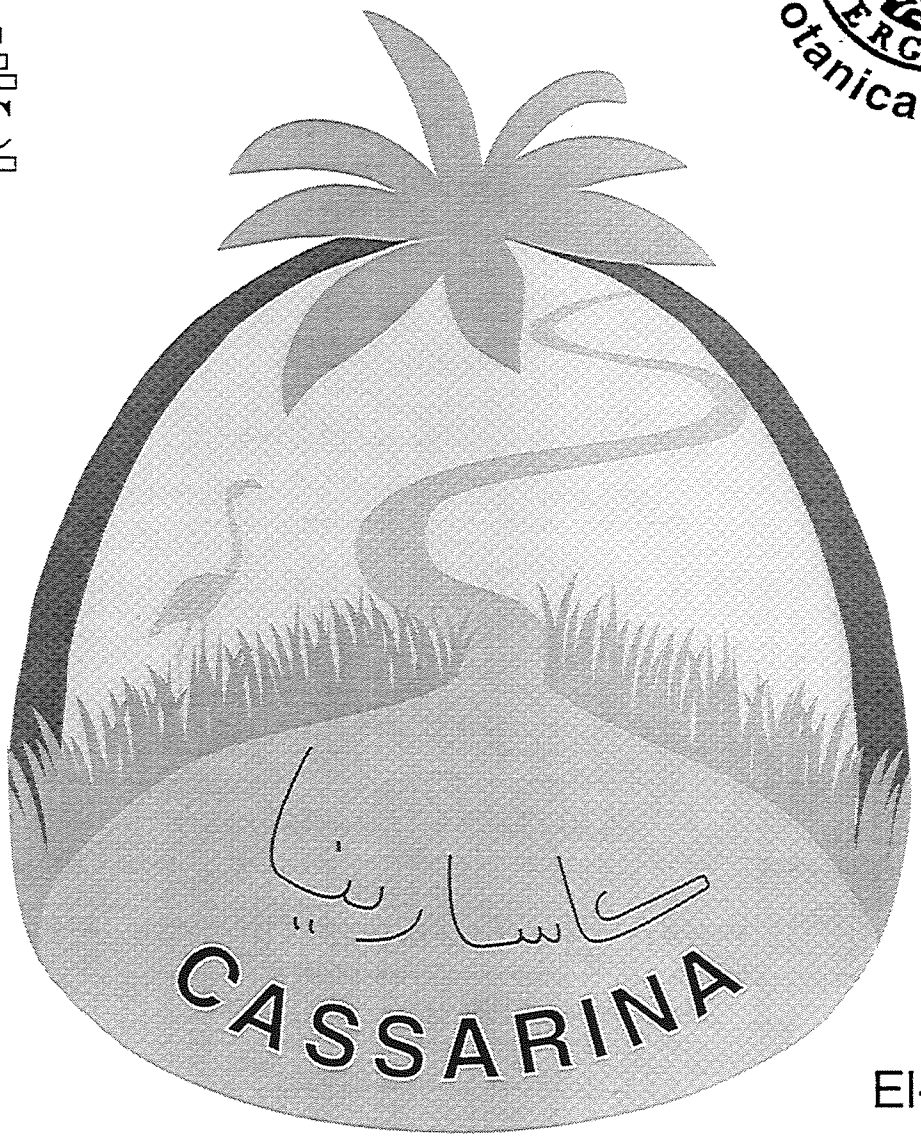


El-Minia

Egypt

FACULTE DES SCIENCES DE TUNIS

IS-Rabat

المعهد العلمي

Second Cassarina Workshop

Tunis, February 1998

Report Number 2

THE SECOND CASSARINA WORKSHOP

7th-14th February 1998

TUNIS

A workshop held to discuss the results of the first year of the CASSARINA PROJECT

Participants: H. Abdelzaher, F. Ayache, L. Baccar, H. H. Birks, N. Elkhiati, A. Fathy, C. Ben Hamza, M. Kraiem (chairperson), Y. Najib, S.T. Patrick, M. Ramdani, A.C. Stevenson, J. Thompson,

THE SECOND CASSARINA WORKSHOP

7th-14th February 1998

TUNIS

Editor: R. J. Flower

A workshop held to discuss the results of the first year of the CASSARINA PROJECT

The Workshop was convened in Tunis and held jointly at INSTM (The National Institute of Marine Sciences) and CITET (Centre for Technology and).

Environmental Change Research Centre, University College London.
RESEARCH REPORT NUMBER

April 1998

INTRODUCTION

This workshop was designed for CASSARINA partners, advisors and subcontractors to meet, to present results and to discuss procedures and progress during the fist year of the project. The workshop was divided into sections according to enable the following:

- to assess progress and results obtained so far,
- to identify any difficulties or problems so far encountered,
- to plan for the 1998 monitoring part of the project,
- t review procedures and facilitate sample exchanges,
- to discuss any problems associated with the project finances.

Advantage of the workshop location was taken to include three days of fieldwork so that sampling for the first monitoring visit of the second year of the programme could be undertaken for the three primary Tunisian CASSARINA sites. This undertaking also allowed all the partner groups to visit the three sites and gain first hand experience of the field characteristics of each.

The workshop was attended by all the CASSARINA partners, Drs Fathy and Abdelzaher from El-Minia (Egypt), Dr M. Ramdani from Rabat and Casablanca (Morocco), Dr. H. Birks from Bergen (Norway), Drs R. Flower and S. Patrick from London (UK). Dr M. Kraiem (INSTM, Tunis) hosted the workshop and acted as chairperson. Also attending the meeting were several scientists associated either directly or indirectly with the project, Dr N. Elkhiati (Morocco) is contributing to the botanical and chemical work in Morocco and elsewhere, Drs C. Ben Hamza and L. Baccar contribute to CASSARINA activities in Tunisia, Drs F. Ayache (Ministre de L'Environment) and D. Y. Nejib (CETET) are interested parties. Drs A.C. Stevenson and J. Thompson are UK scientists with previous research experience on Garaet Ichkeul, one of the Tunisian CASSARINA sites.

The workshop discussion sessions were opened by Dr K. Attia, the Director of CITET (Centre International des Technologies de L'Environment de Tunis) and a seminar room and facilities for the first two days were kindly provided by the Institute. The last day of workshop discussions was held at the INSTM (National Institute of Marine Sciences and Technologies, Salammbo, Tunis) where similar facilities were made available by the Director, Prof. A. El Abed.

Discussion sessions began on Workshop day two and the week's timetable was arranged as follows:

DAY 1. 8.2.1998. Field excursion to Garaet Ichkeul.

DAY 2. 9.2.1998. Opening of the meeting followed by a systematic account of progress made so far in the investigations of the nine primary CASSARINA sites. Firstly, results about water chemistry, phytoplankton, fungal spore analysis, zooplankton, fish and aquatic macrophyte surveys were presented and these were followed by sedimentological data for each site. The Moroccan and Egyptian sites were the main focus of the days discussions.

DAY 3. 10.2.1998. The session started with an account of the work carried out at the Tunisian sites, with special emphasis on Ichkeul, reflecting the considerable work already undertaken here. The afternoon was spent discussing financial arrangements, timetabling future monitoring and workshops, and sampling protocols.

DAY 4. 11. 2.1998. Field excursion to Megene Chetane on the Tunisian North coast.

DAY 5. 12.2.1998. Field excursion to Lac de Korba on the east coast of Cap Bon.

DAY 6. 13.2.1998. Final morning discussion session was held INSTM. The session concerned further discussions about water chemistry methods and a summary of the workshop resolutions and agreements and a check-list review of monitoring field work tasks.

WORKSHOP SESSION 1 (MORNING):

Monday 9th February. The session opened with a welcome and introductory comments from Dr Attia, the Director of CETET, who emphasized the value of environmental research in North Africa as well as the contribution Tunisian authorities were making in tackling environmental problems. Dr Attia kindly made facilities at CITET available to CASSARINA for the 8th and 9th of February. The workshop discussions were then opened by Dr Kraiem and Dr Flower. The sites and first year results were treated systematically and the Moroccan sites were dealt with first.

Morocco

Background data and zooplankton: The session was begun by Dr Ramdani and he first presented background data on the Moroccan CASSARINA sites, Merja Zerga, Merja Khala, Merja Bokka, and Lac de Sidi Bou Rhaba; this included maps and an excellent composite aerial photograph of the Merja Zerga/Merja Khala complex. Because of sediment coring problems Merja Khala was not selected as a primary CASSARINA site.

Aspects of the planktonic biota at each site in April 1997 were briefly mentioned with special reference to the zooplankton. A written report on the Moroccan and Tunisian sites was presented and included results of the vegetation transects and water analyses for each site; a part completed species lists for one Moroccan site (Merja Zerga) was also presented. Fish are present at Sidi Bou Rhaba and Merja Zerga but Merja Bokka dries out in the summer. Species include Black Bass (introduced) and *Gambusia* at the former and mullet (*Mugil cephalus* and *Liza ramada*) are common in Merja Zerga. A problem with water level estimation has occurred because the January water level was so high in Rhaba and Bokka that the staging boards (depth gauging post) were submerged. Much work is on-going.

Discussion: A short discussion followed with Dr Baccar concerning drainage into the Merja Zerga basin and sources of agrochemicals from the Qued Drader and the Nador canal. Also, fish for pesticide analysis were specified. Dr Flower suggested that liver samples should be taken from *L. ramada* in Merja Zerga. In Sidi Bou Rhaba, if larger

fish could not be found, whole *Gambusia* could be used. In the absence of fish at Merja Bokka, liver samples from six amphibians should be collected. It was decided to continue with vegetation transects at all four sites but regular water sampling would only be conducted at the three designated CASSARINA sites, Zerga, Bokka and Rhaba. Comparing aerial photographs for 1972 and 1995 and making cover estimates was suggested as a useful way to assess recent changes in water area and vegetation around the lakes over a ca. 20 year period.

Water chemistry and phytoplankton data: Data for April 1997 were presented by Dr Fathy (see APPENDIX 1 and 2). Water chemistry data for April 1997 showed that the Merja Zerga was near salt water in total soluble solids concentration, reflecting the direct sea connection. Sidi Bou Rhaba and Merja Bokka were brackish at between 2 and 5 g l^{-1} salt. Phosphate and nitrate was high at Bokka but a delay in supplying the samples for total P analysis precluded any analytical results for this workshop. Also, the nitrate values are probably over represented because of sample storage time (ca. 6 months). Lead was high in Lac de Korba.

In the discussion it was pointed out (Dr Flower) that conductivity, pH and alkalinity had not been measured and it was agreed to do these basic determinations in future sample batches. Dr Fathy noted that pH might be unreliable because of extended storage time.

The different algal groups present in April water samples from each Moroccan lake were compared and the predominance of *Microcystis aeruginosa* was noted at Sidi Bou Rhaba. The Merja Bokka sample was strongly influenced by suspended solids (clay and silt particles) which hampered determinations. Diatoms and blue-greens occurred in both the Merja Zerga and Khala.

In the discussion the toxic nature of *M. aeruginosa* was noted and reasons for the eutrophic nature of Sidi Bou Rhaba were considered (Dr Elkhiati and Dr Fathy). Ground water supply of salt and nutrients to this lake must occur but it is as yet not known if eutrophication is a recent phenomenon.

Sediment core results: Sediment cores were collected from four sites in April 1997 and Dr Flower gave a brief resume of the basic sedimentological characteristics of each sediment master core. Dating is still being undertaken and results look promising for Rhaba and Bokka but the core from Merja Zerga may be composed entirely of very recent sediment dating from the opening of the Nador Canal in 1956. Dr H. Birks presented very preliminary data on macrofossil analyses of the Moroccan lake cores: most information is available for Merja Bokka where a relatively rich lake flora and fauna was indicated for some period in the recent past. Many aquatic plant species have definitely disappeared at this site and have been replaced by ruderal taxa. One characteristic macrofossil was frequently found but unidentified and Dr Kraiem suggested that they could be annelid eggs.

The first part of the morning meeting closed at 11.45 and resumed at 12.15 with a presentation about the Egyptian sites.

Egypt

Dr Fathy presented a brief introduction to the physical characteristics of three CASSARINA sites, Lake Edku, L. Burullus and L. Manzala. The back-up site, Lake Qarun was also mentioned as a possible site but this awaits assessment following a second sediment sampling visit to Egypt in March 1998. A report entitled 'The Northern Lakes' was presented that included descriptions of the sites along with phytoplankton and chemistry data for all nine CASSARINA sites. Because of logistic difficulties the Egyptian lakes were not sampled until later in the year, November 1997.

Water chemistry and phytoplankton data for three Egyptian sites: All three lakes had moderately high pH and were weakly brackish with between 2 and 4 g l^{-1} total soluble salts (see APPENDIX 1 and 2). Phosphate was very high for Edku and Burullus had high Chlorophyll *a* and lead concentrations. Total phosphate was not recorded but this key measurement will be done in future monitoring.

The phytoplankton was abundant and diverse, with Edku and particularly Burullus possessing the most species and highest crops. The Edku sample was taken from close to the reed beds and contained a high number of euglenoids. Burullus contained most diatoms. A very preliminary attempt was made to compare the phytoplankton samples from each of the North African lakes, although results are not adequate for careful analysis it is clear that Burullus possessed the highest abundance of phytoplankton and probably indicates major eutrophication at this site. No dinoflagellates were found in the Egyptian lakes.

WORKSHOP SESSION 1 (AFTERNOON)

This session continued with presentations about the Egyptian lakes.

Video film: The first session was devoted to a video film made by Dr Abdelzaher to demonstrate sediment coring techniques and the nature of the field sites in Egypt.

Fungal spores: The seminar session continued with a presentation by Dr Abdelzaher on fungal spore analyses of sediment samples. It was hoped that fungal spore analysis of sediment cores would reveal evidence of pollution impacts however in preserved samples, resting spores proved too few for counting and Dr Abdelzaher has decided to abandon this aspect of fungal spore work. He suggested however that work on culturing fungi from fresh sediment samples of Egyptian lake sediments would be investigated under sterile conditions. Also, experiments on the suppression of seed germination using Egyptian lake sediment from different levels in sediment cores would be undertaken.

Afterwards, Dr Fathy made several more chemical and phycological comparisons between the sample lakes.

Sediment core results for the three Egyptian lakes: The session was concluded by Dr Flower describing the basic lithostratigraphy of the sediment cores from the three Egyptian lakes. Special mention was made of the Edku cores. Preliminary analysis had

shown that the master core was not suitable for radiometric dating and the need to collect another sediment core from this lake was emphasized. Because sediment sampling equipment was left in Egypt after the November field work it was decided to undertake a second visit to this lake, during March 1998, to try and retrieve better sediment cores.

The final afternoon session was used to review the monitoring fieldwork methods and accomplishments in 1997:

SAMPLING PROCEDURES AND PROTOCOLS

Dr Flower presented a check-list of procedures undertaken at each site for monitoring work (see APPENDIX 3). It was emphasized that each field task should be checked off when completed as it is most important that sampling should be as complete as possible. Each sheet should have site and date noted for future reference. Items on the check-list were reviewed sequentially beginning with water sampling and chemical analysis.

Water chemistry

Water samples A, B, C, and D : Dr Fathy reviewed the sampling strategy. The need to collect the samples from under the water so that bottles were completely full and avoiding re-suspended sediment was noted. Dr Fathy wished to amend the sample volumes collected:

It was agreed that:

- Sample A, determinands should be measured in the field and that alkalinity should be measured within 2 days.
- Filtered sample B can be reduced from 1000 ml to 500 ml to make filtration easier and aid transportation.

However Dr Flower noted that CASSARINA partners had already been issued with new 1000 ml bottles, alternative clean 500 ml bottles should be found or continue to use the larger bottles.

It was also agreed that:

- El Minia would measure conductivity, pH and alkalinity on ALL Sample B samples

However Dr Fathy noted that in the absence of visiting scientists, samples should be sent by post to El Minia as soon as possible after collection and certainly within one month.

It was also agreed that:

- It is only necessary to collect one ACC sample from ONE of the three lakes during each monitoring visit.

Two more suggestions were made by Dr Fathy and it was agreed that these would be desirable but should be regarded as **optional** since they represent changes from the agreed 1997 protocol document. These were:

- an additional sample of unfiltered water should be collected for chemical oxygen demand determination,
- during optional Chlorophyll *a* measurements, absorption at additional wave lengths should be made i.e. at 663, 630, 645, and 455.5 nm.

It was noted that in 1997 only results for Chlorophyll *a* analyses at the Moroccan lakes had been reported.

Although previously designated as 'optional' (see The First Workshop Report), Dr Fathy urged CASSARINA members to make nitrate determinations at their CASSARINA sites since they are important and it is not possible to leave this measurement for later analysis in El Minia. He undertook to circulate a recommended description of methods.

Dr Flower noted that to aid interpretation of chemistry data it is often very instructive to examine the ion ratios and compare these with those in seawater. Relative 'excesses' or 'deficits' of ion concentrations compared with seawater (all relative to chloride which is assumed to be derived directly or indirectly from seawater) can give information about *water sources*. The ratios of common ions in seawater relative to chloride are 0.14 (SO4:Cl), 0.556 (Na:Cl), 0.02 (K:Cl), 0.067 (Mg:Cl), 0.021 (Ca:Cl) by weight .

Discussion of water chemistry methods was deferred to the AQC section.

Phytoplankton

Phytoplankton data were available for all sites and in addition to concentration by Lugols iodine it was suggested that samples should be centrifuged if buoyant taxa such as *Microcystis* would not settle out.

Zooplankton

No zooplankton was collected from the Egyptian sites in 1997 and was collected at the Tunisian sites only in December 1997.

It was agreed that:

- The primary sample of zooplankton should be collected from the OPEN WATER of each site. Additional samples from shallow pools, marginal vegetation and drainage channels are useful for species lists but should be regarded as secondary.
- It is very important to harmonize sampling dates for the 1998 sampling occasions in each country. Although exactly similar dates for sampling would be difficult to achieve sample dates should be within three weeks and individual North African groups should communicate between each other about precise sampling dates

Discussion of monitoring dates was deferred until the following afternoon.

Fish

In 1997 fish had only been sampled at the three Egyptian sites and one Tunisian site. Dr Kraiem discussed the identification of fish sampled at the former sites and it was agreed that the common species used for pesticide sampling was *Tilapia zillii*. Drs Fathy and Abdelzaher agreed to confirm this identification.

It was emphasized that sampling of ALL biological attributes MUST be undertaken at or near to the time of water sampling. It was recognised that Merja Bokka and M. Chetane did not contain fish and here amphibian liver tissue would be used for pesticide analysis.

It was agreed:

- To measure the length (total and 'fork' length - to the centre edge of the caudal fin) of six fish (labelled 1 to 6) from each site for each monitoring occasion.
- Measurement of weights should also be performed as an optional task. Size of amphibians should also be recorded.
- That a few scales from the 'shoulder' region of each fish should be placed in small plastic bags - scales from each fish MUST BE KEPT SEPARATE and labelled. Fish scale bags should be labelled 1 to 6 to indicate from which fish they were taken. Dr Kraiem noted that preservatives were not needed.
- For pesticide and trace metal analysis, six fish specimens should be collected from each site on each visit. Where possible fish length should be around 20 cm. Dr Kraiem recommended that *Liza ramada* should be selected for pesticide analysis in Merja Zerga, Ichkeul and Lac de Korba. No recommendation could be made for Sidi Bou Rhaba and Dr Ramdani would try to collect the most appropriate species as soon as possible. If *Gambusia* (small) were selected then six whole fish should be sampled.
- Six amphibians (*Rana* or *Triturus*) should be collected at Chetane and Bokka.
- Liver samples (or whole small specimens) should be conserved at -18^{0}C until the next workshop in Morocco. Where individual fish are too small, livers from three **equal sized** specimens can be bulked together. Alternatively, for very small fish (e.g. *Gambusia*) whole specimens should be collected for whole body measurements.

Vegetation transects

These had been established at all nine sites during 1997. It was emphasized that sampling should be carried out at the same place and AT THE SAME SAMPLING INTERVAL at each site during each monitoring occasion.

Epiphytic diatoms

These were collected from all the sites in 1997. For the 1998 monitoring it was emphasized that the SAME species of aquatic plant in the same location should be

collected on EACH sampling occasion. Several pieces of plant leaf or stem, several centimetres long need to be placed in a whirlpac bag and preserved in IPA.

Water temperature

It was emphasized that *in situ* lake water temperature must be recorded at the time of sampling.

Water depth

Seven sites had depth gauging posts emplaced in 1997. The two exceptions were Lake Edku and Lake Ichkeul, where a concrete irrigation structure and a previously installed steel gauging board were used, respectively. The problem of submerged depth gauging posts in the winter period was noted. Dr Thompson emphasized the desirability of determining the relationship between depth and volume for each water body. In future, relationships between lake area and depth should computed.

Secchi disc depth (SDD)

This was measured at each site in 1997. The water transparency should be measured on each monitoring visit. If no boat is available then the depth of visibility of a submerged white object should be measured by wading out but taking care not to disturb sediment. Dr Baccar suggested that the ratio of SDD to maximum depth should also be noted.

Temperature recorders

These were placed in Sidi Bou Rhaba, Ichkeul and Lake Burullus and will be removed in November 1998.

Sediment cores

Cores were taken from 11 lakes and 9 were selected as CASSARINA sites. Dr Flower noted that most should produce good results but the M. Zerga core is problematic. The core from Edku Lake was of little chronological value and a second attempt will be made to sample this lake in March 1998.

WORKSHOP SESSION 2 (MORNING)

This Tuesday morning session was opened by Dr Kraiem.

Tunisia

Initial discussion of the Tunisian site data started by noting that four CASSARINA sites were initially investigated in 1997, Lac de Korba, Garaet Ichkeul, Megene Chetane and Sebkha Kelbia. On the basis of sediment characteristics and water availability, the first three were selected as CASSARINA primary sites.

Dr F. Ayache introduced the lake study areas in Northern Tunisia. Megene Chetane is located on the north coast in the 'Mogods' region characterised by relatively high rainfall (500-800 mm y^{-1}). This small lake is near the foot of sandstone Jebel Chetane and there is a partly drained peat bog/valley mire fed by several springs that in turn supply the lake. The lake is a biological reserve and partly protected and is near to the limit of degraded land for agriculture. There are plans to extend the reserve.

Lac de Korba is located on Cap Bon, an intensively agricultural area in the north-east of Tunisia. It is a notable bird refuge but at its southern end, pollution from Korba town is a major problem. The lake occupies a long but narrow depression on the east coast and is separated from the sea by a low sand ridge. The lake is connected to the sea by an temporary channel through the sand dunes and is, to a limited extent, affected by tidal movements. There are plans to clean up the site by controlling sewage effluents. Several international groups including Bird Life International are interested in this site.

Dr Baccar gave an account of the Garaet Ichkeul National Parc region. After outlining the catchment and establishment points of the recent barrages on inflowing rivers, the limits of the park were described as including the marshlands (approximating to the 0.9 m contour) and the Jebel Ichkeul (512 m). The lake is well known for its over-wintering and former reed nesting bird populations and is registered as a Ramsar Site and a Biosphere Reserve.

However, bird numbers have declined since the 1980s probably as a result of a combination of several factors. These include, changes brought about by controlling freshwater inflows, agricultural disturbances, climate change and changes elsewhere in bird populations. Although lake access is now controlled, there are more barrages planned for several inflows, the Douimis and the Mellah Rivers.

Whilst acknowledging that regulating the supply of freshwater to the lake has had some ecological effects, Dr Baccar emphasized that dry years in the early 1990s exacerbated seawater intrusion and contributed to a decline in environmental quality of the lake. One effect has been a reduction in the natural *Phragmites* and *Scirpus* marsh areas, although these communities still survived in some locations in 1994. Despite this decline in the aquatic system, Dr Baccar pointed out that strong conservation measures had been implemented for the Jebel and its vegetation. The mountain vegetation communities have been fairly stable in recent years and further protection measures include closure of mining activities and relocation of people from the mountain to Menzel Bourguiba.

Water chemistry: Dr Ben Hamza gave a brief account each of the three sites and noted that both Ichkeul and Korba were influenced by direct seawater inputs that varied according to season. M. Chetane was mainly fed by groundwater springs and was the only lake to have ca. zero alkalinity, to be acid in reaction and to have total dissolved salts less than 1 g l^{-1}. The turbidity of water in this lake changes markedly according to season. Both Korba and Ichkeul have fairly high pH and alkalinity and experience marked seasonal changes according to the relative amounts of freshwater and seawater inflows. In summer months, hypersaline conditions occur in both lakes, up to 50 and 80 g l^{-1}, respectively. However, Korba usually remains above 30 g l^{-1}.

A discussion followed about the sources of acidity in M. Chetane, one view was that acidity was mainly generated by oxidation of reduced sulphur compounds within the lake and the other that it was contributed by groundwater and exacerbated by recent changes in hydrology (removal of potential inflowing water to supply local irrigation needs).

It was agreed:

- to carried out extra water sampling at this site to try and discover more about acidity sources. Hence, on the next site visit water samples should be taken from both ground water springs and the water draining the small peat bog (the main inflow to the lake) as well as from the lake.

Zooplankton: Dr Ramdani gave an account of zooplankton at the three Tunisian sites and it was noted that sampling did not occur until December 1997. At Lac de Korba species of Cladocera, Copepoda and Rotifera were found. Ostracoda also occurred with *Cyprinius* common. At M. Chetane copepods *Diaptomus* and *Eucyclops* were present and Cladocera were represented by *Ceriodaphinia*, a large form indicating lack of fish predation. Fungal parasitism was noted on some copepods in Korba.

Fish: Dr Kraiem gave a brief review of Tunisian fish noting the migratory nature of many fish species (e.g. mullet) in brackish waters connected to the sea, such as Ichkeul. Alternatively, other species penetrate brackish waters from freshwater rivers e.g. *Barbus callensis* and *Pseudophoxinus*. Both common species of 'mullet' occur in Ichkeul, *Mugil cephalus* and *Liza ramada,* but fish in Lac de Korba have not yet been fully surveyed.

A provisional list of fish species is given for the three sites (APPENDIX 4) but no results for scale/weight comparisons were presented. Amphibians occur at M. Chetane and species determinations are required.

It was agreed:

- to sample *L. ramada* where possible for scales and livers.

Phytoplankton and water chemistry: Dr Fathy gave a brief account of the phytoplankton for which only Korba possessed a diverse assemblage in March 1997 (see APPENDIX 1 and 2). Common algae here were diatoms and dinoflagellates, the latter indicating marine conditions. Ichkeul had very few algae, probably as a consequence of turbid water, and diatoms predominated. M. Chetane also had little phytoplankton.

The ion water chemistry supported the basic measurements reported by Dr Ben Hamza and details of differences between measurements are dealt with in the AQC section. Dr Fathy did however note that high levels of lead occurred in Korba and Ichkeul. Dr Baccar and others suggested an urban pollution source in Korba but all agreed that more measurements were needed. Dr Flower added that any pollution links could be verified by analysis of trends of trace metal concentrations to be determined later in the sediment cores, these could support suggestions about contamination.

Sediment core results: No sediment chronologies are yet available and only preliminary analyses have been carried out so far. Dr. Birks described macrofossil remains in cores from Ichkeul and Korba. Charophyte remains were noted in the Korba core and mollusc shells were common in some core sections; shells from the Ichkeul core were given to Dr Kraiem who kindly offered to help with identifications.

Dr Flower described the lithostratigraphies of the three cores and showing that profiles were fairly uniform in Ichkeul and Korba but that large changes in the amount of organic matter in the Chetane core indicated considerable catchment disturbance in the past. Diatoms were unfortunately poorly preserved in the Korba core but an excellent fossil record occurred in the Chetane material.

Dr Stevenson gave a brief account of marsh vegetation change in the Ichkeul National Park. During the 1980s transect studies recorded major losses of *Scirpus* and *Phragmites* marsh as the lake became more saline and *Salicornia* spread across the exposed shore zone. In the lake *Ruppia* largely replaced *Potamogeton pectinatus* around 1990.

A discussion followed about management objectives with Dr Baccar suggesting that ecological constraints did not only apply only to over-wintering wildfowl and that the whole hydrological system should be considered since other ecological features of the park are important. Dr Stevenson said that until a food resource within the lake was restored geese numbers would remain low. With the event of wetter winters since 1995 and with planned improvements in freshwater supply it is to be hoped that recovery of those plants intolerant of full salt water will occur. Whether the few *Scirpus* plants found during the 1998 survey represents the beginning of a recovery or the last remnants of once extensive communities can only be evaluated by regular monitoring.

WORKSHOP SESSION 2 (AFTERNOON)

Management of CASSARINA

Dr Patrick opened the session with some comments about financial constraints. He noted that some 70% of the project funding will be used during 1998. Any financial problems specific to individual partners grants should be discussed separately but it was emphasized that any short-falls in funding, for example in travel and subsistence allocations, cannot be supported within the EU current grant framework. However, following consultation with the project co-ordinators, moneys can be moved between headings.

Timing of 1998 monitoring work:

Dr Patrick noted that several monitoring visits were poorly co-ordinated and sampling was incomplete in 1997 and that three monitoring visits in 1998 would probably be inadequate. He again emphasized the need to co-ordinate sampling dates for monitoring in each country to within several weeks of each other.

It was therefore agreed that:

- four monitoring visits will be made to each CASSARINA primary site in 1998 and it is extremely important to undertake all the check-list tasks during each visit.

Timing of site sampling visits for CASSARINA monitoring in 1998 were agreed as:

Monitoring visit 1: February - early March

2: May - early June

3: August- early September

4: November - early December

It was agreed that:

- the timing of the monitoring field work visits in each country should be similar so that all sampling is carried out within a 2-3 week time frame.

- Advantage be taken of the final monitoring session to hold the third workshop in Rabat within the week 3-9th December 1998.

Reports

To enable the co-ordinators to assemble annual reports for the EU administrators, quarterly data reports containing the data from each sampling visit to each of the three lakes in each North African country are required. These reports MUST ALL contain:

- basic water quality measurements (temperature, Secchi disc depth, water depth, pH, alkalinity, conductivity/total salts),
- fish/amphibian data (fish species lengths weights),
- vegetation transect results.

In addition, individual North African scientists should contribute data from their specialist activity, e.g. zooplankton (Rabat), phytoplankton adundances (El Minia), fish scale data (Tunis), and ion chemistry (El Minia).

Analytical quality control (AQC)

Dr Flower began this section by emphasizing the importance of cross-validation of results as the only way to inspire confidence in CASSARINA data sets for publication and future work.

Vegetation analysis

Species identifications are undertaken by each North African group in consultation with local botanists. Specimens of some species have been shared and samples returned to the UK for species confirmation, for example Dr Stevenson (a botanist with considerable experience of the Mediterranean flora) has undertaken confirmatory plant identifications for Chetane, Ichkeul and elsewhere. Dr Elkhiati, in conjunction with Dr Birks, has contributed to botanical identifications for specimens from the Tunisian lakes and will co-operate further on the Moroccan sites. Dr Flower has returned aquatic macrophyte species from the Egyptian lakes for secondary species identification at the ECRC by D. Monteith.

Phytoplankton analysis

This is the responsibility of Dr Fathy and samples for AQC of the diatom algae have been exchanged with Dr Flower. The following observations have been made concerning the planktonic diatoms:

Egypt

BURULLUS: Nov. 1997. *Cyclotella meneghiniana* +++, *Cyclotella ocellata* ++, *Stephanodiscus invisitatus* ++ (a flat and very finely striated diatom ca 15 µm diameter,) also *Cyclostephanus tholioformis* (like *S. invisitatus* but smaller and convex central area). To be sure about this last taxon some SEM work would be useful. *Stephanodiscus rotula* and *S. (Cyclostephanus) dubius* were formerly recorded but do not occur in this material.

Other taxa, *Aulacoseira granulata*, *Cyclotella pseudostelligera*, *C. atomus*. *Amphiprora alata* and *Nitzschia* spp. are also found.

EDKU: *Cyclotella ocellata*++, *C. meneghiniana* ++, *C. atomus* (small), *Stephanodiscus invisitatus, Aulacoseira granulata.* Also *Nitzschia* spp. *Synedra ulna.* Again formerly recorded *Stephanodiscus rotula* and *S. dubius* do not occur in this material.

MANZALA: *Cyclotella. ocellata* +++, C. *meneghiniana* +, *Stephanodiscus invisitatus* +, *Aulacoseira granulata* + are present.

Morocco

M. BOKKA: Benthic taxa are *Gyrosigma* and *Navicula pygmea*, *Amphora veneta*, *Nitzschia hungarica.* (some *Stephanodiscus invisitatus* & *Cyclotella ocellata* were present but are unlikely taxa for this site).

M. ZERGA: *Gyrosigma*, *Nitzschia* spp. *Navicula cryptocephala*, *Cyclotella atomus* . *C. ocellata*, *Stephanodiscus invisitatus* and *Aulacoseira granulata* are also present but they are very unlikely to grow at this high salinity site and must be contaminants.

SIDI BOU RHABA: Very little diatom phytoplankton- *Nitzschia* spp. (Some *C. ocellata* and *St. invisitatus* present in the sample but these do not occur at this site).

Tunisia

ICHKEUL: *Nitzschia* and a few *Cocconeis placentula* (also *C. ocellata* contaminant).

CHETANE: *Eunotia* spp. *Synedra ulna* (also *C. ocellata* and *St invisitatus* again- these must be contaminants- they cannot grow in acid conditions).

KORBA - A very interesting abundance of *Thalassiosira weisflogii* - typical of a saline lagoon. (some *Cyclotella ocellata* again and this must be contaminant and *T. weisflogii* is probably formerly identified as *C. comta*).

These interesting results show the need to collaborate between specialists so that taxonomy can be harmonised and species identifications validated. In the above comparisons it is clear that some cross contamination has occurred and more stringent precautions are needed. Use of new sub-sampling apparatus for handling phytoplankton
samples from EACH lake should solve the problem.

Zooplankton

Dr Ramdani noted that some ostracod species were difficult to identify and Dr Stevenson offered the services of a UK colleague, with taxonomic experience in this group, to check identifications. To achieve comparability between sites it was agreed that zooplankton data should be presented as both concentration and percentage abundance's of common species.

Fish

The fish fauna of Morocco and Tunisia is well known and species identifications for the Egyptian lakes will be confirmed by both the El Minia partners and Dr Kraiem. Amphibians will be identified at the University of Tunis.

Water chemistry

Water samples collected in April 1997 and pH, conductivity and alkalinity were measured by the different CASSARINA groups. During presentations of the data it was apparent that minor methodological differences in analytical on site or near site measurements had occurred. Table 1 shows results of comparable measurements conducted on these samples. Data on full water chemistries performed by the El Minia groups are given in APPENDIX 1.

Table 1 **Comparison of pH, conductivity and alkalinity results from the analytical groups**

pH	**El MINIA**	**RABAT**	**TUNIS**	**LONDON**
ZERG		7.72		7.66
BOKK		7.68		7.90
RHAB		8.21		8.29
ICHK			7.5	8.01
SHET			5.8	4.91
KORB			7.61	
IDKU	7.6			8.24
BULR	8.5			8.66
MANZ	8.0			9.02
Conductivity				
ZERG		35000		19000
BOKK		3100		2960
RHAB		8000		8360
ICHK			38000	47000
SHET			1200	1190
KORB			44000	
IDKU	2200			2825
BULR	3800			4950
MANZ	2200			2727
Alkalinity mg l^{-1}				
ZERG	201	113		
BOKK	309	179		
RHAB	449	244		
ICHK	194		180	
SHET	-0.7		0	
KORB			300	
IDKU	334			262
BULR	290			228
MANZ	312			253

NB Sum of cations and anions differed by <6% for the Tunisian water chemistry data.

It was agreed that:

- all conductivity/salinity measurements should be carried out and corrected to 25°C and meter drift should be checked by using standard salt solution (see CASSARINA Manual for Methods and Protocols) before each monitoring period.

pH is the least stable of the measurements and differences are attributed to different storage times as well as experimental differences.

It was agreed to:

- calibrate pH electrodes using pH 7 and 9 buffers prior to measurement. At the ONLY acid site in the CASSARINA programme, M. Chetane, calibration should be made using pH 4 and 7 buffers.

Alkalinity determination must be made on samples in sealed bottles within 48 hours and concentrations should be expressed as mg CaCO3 at pH 4.5 and 4.2. From these measurements, equivalence alkalinity can be calculated (see the determination of alkalinity and acidity in water 1981. Methods for the examination of waters and associated materials. 37pp: HMSO London). **This method is strongly recommended and is given in APPENDIX 5**). The data from Moroccan lakes were expressed in °F and these data will be harmonised in future.

Error analysis: for ion concentration measurements it is good analytical practise to quote the detection limit of each analytical technique. At the beginning of each set of analyses ONE sample should be run in triplicate so that Standard Deviation and the measurement mean can be calculated. These data should be quoted on data sheets. Sum of cation and anion concentrations should agree to <10%.

WORKSHOP SESSION 3 (MORNING)

The workshop was re-convened at the National Institute of Marine Sciences and Technology at Salammbo, Sidi Bou Said using facilities kindly made available by Professor A. El Abed, the Institute's Director. Professor Abed opened the session with a welcoming talk describing the Institute's work noting a recent emphasis on environmental quality of coastal lagoons and continental waters.

Dr Flower gave a summary of the workshop proceedings and re-emphasized the recommendations and protocol refinements that are needed to achieve a successful monitoring programme for 1998.

Recommendations and instructions for future work

The following summary points were made:

Water Quality: ALL groups responsible for monitoring survey must carry out **temperature, pH, alkalinity** and **conductivity/salinity**(25^0C), **water depth and transparency** measurements at EACH lake on EACH of the four 1998 monitoring occasions. Sample B can be reduced to 500 ml and alkalinity is measured at pH 4.5 and 4.2 and expressed as mg Ca CO_3 (see APPENDIX 5). Sample B is to be sent to El Minia within one month. Chlorophyll *a*, COD and nitrate analyses are optional. Instruments must be calibrated as recommended (see AQC section).

Biology: It is very important to do the following at each site on EACH of the four 1998 monitoring occasions:

i Phytoplankton and epiphytic diatoms
ii Zooplankton net sample from an OPEN water location
iii Vegetation transect, see field notes so that EXACT distances are repeated and note water depths at each sampling point
iv fish, six specimens of the SAME species to be sampled and measured at EACH lake on each visit (liver and scales to be removed and kept separately). Samples to be kept frozen until December 1998.

The PERCENTAGE abundances of the common species (for phytoplankton, zooplankton and vegetation transects) MUST be calculated.

Reports: The co-ordinators need the basic data (pH, Alkalinity, salinity/conductivity etc. and results of the vegetation transect surveys) for each monitoring occasion within SIX WEEKS of each visit. This is to enable data checks and compilation.

Sediment work: Results of all core analyses - lithostratigraphy, diatoms, macrofossils, pollen, trace-metals, pesticides (Rabat, Bergen and London) are to be presented in report form by March 1999 at the latest.

Sample exchanges: To be undertaken at the next workshop in Rabat (December 1998), (sample B water samples to be exchanged earlier).

Finances: Partners are urged to budget carefully since each group is responsible for funding its own fieldwork and workshop attendance costs.

Conclusions: 1997 has been a successful year for CASSARINA and all participants are thanked for their efforts. However, there is a clear need for better co-ordination of the timing of sampling visits in 1998. Also, we need to establish a routine so that ALL CASSARINA sampling requirements are completed on EACH visit. Basic water chemistry data (on-site pH/conductivity etc.) for Tunisia are urgently required for 1997 as are percentage data on zooplankton and phytoplankton abundance for all nine primary CASSARINA sites.

APPENDIX 1

PHYTOPLANKTON DATA FOR THE NINE CASSARINA LAKES

Morocco and Tunisia - April 1997, Egypt - November 1997

MOROCCO

Algal Taxa	Rhaba	Kelbia	Zerga
Bacillariohyta			
Anomoneis	14	0	0
Cyclotella menegbiniana	27	154	34
Fragilaria sp.	0	60	20
Melosira granulata	0	14	40
Pleurosigma sp.	0	127	0
Total Bacillariophyta	**31**	**145**	**94**
Cyanophyta			
Anabaena elenkinii	0	54	0
Microcystis sp.	2094	14	0
Merismopedia glauca	167	20	0
Total Cyanophyta	**2261**	**88**	**0**
Dinophyta			
Peridimium bipes Stein	100	0	0
Total Dinophyta	**100**	**0**	**0**
Chlorophyta			
Dunaliella salina	207	0	0
Total Chlorophyta	**207**	**0**	**0**
Euglenophyta			
Euglena proxima Dangeard	0	0	34
Total Euglenophyta	**0**	**0**	**34**

EGYPT

Algal Taxa	Idku	Manzalla	Burullus
Chlorophyta			
Coleastrum cambricum	0	0	67
Crucigenia quadrata Morren	40	14	134
Chlorella sp.	647	0	4834
Chlorococcum turgidus Nagel.	0	0	1434
Dictyosphaerium	0	0	34
Gleocystis major Gerneck	27	14	0
Kirchinerella contorta Bohlin	100	7	0
Monoraphidium capricornutum Nygaard	0	0	246
Monoraphidium contortum Komarava	0	207	234
Scenedesmus acuminatus Chodat.	0	0	34
Scenedesmus bijuga (Turp.) Lag.	34	20	67
Scenedsmus incrassatulus Bohlin	34	0	0
Scenedsmus quadriquda	7	0	101
Schroederia setigera (Schroed) Lemmermann.	20	0	67
Tetraedron muticum (A.Braun) Hansgirg.	27	0	0
Tetraedron trigonum Hansgirg *var. gracile* Reinsch.	20	0	0
Total Chlorophyta	**956**	**262**	**7252**
Euglenophyta			
Euglena acus Ehrenberg	40	0	0
Euglena gracilis Klebs	73	0	0
Euglena proxima Dangeard.	80	0	100
Phacus macrostigma Pachmann	60	0	34
Total Euglenophyta	**253**	**0**	**134**
Bacillariophyta			
Cyclotella menegbiniana	34	7	34
Cymbella sp.	14	7	67
Melosira granulata	20	0	0
Navicula sp.	100	0	100
Fragilaria capucina	0	0	34
Stephanodiscus rotula Hendey	54	0	1734
Stephanodiscus dubins Hustedr	27	0	67
(X)	20	0	0
(Y)	14	7	34
Total Bacillariophyta	**283**	**21**	**2070**
Chrysophyta			
Chrysococcus nyguardii Thomasson	0	0	67
Rhadomonas ovalis Nygaard	100	660	200
Total Chrysophyta	**100**	**660**	**267**

Algal Taxa	Idku	Manzalla	Burullus
Cyanophyta			
Chroococcus turgidus Nagel	0	0	234
Cylindrospermum	0	0	67
Lyngbya contorta Lemmermann	0	0	34
Merismopedia elegans Braum	0	0	34
Merismopedia glauca (Ehrenb.) Nagelei	0	27	400
Microcystis aeruginosa Kutzing	0	0	100
Oscillatoria lacustris (Kleb.) Geitler	0	20	0
Oscillatoria tenuis var. natans Gomonl.	7	7	0
Phormidium sp.	7	7	67
Total Cyanophyta	**14**	**61**	**936**

TUNISIA

Algal Taxa	Sheetan	Ichkeul	Korba
Bacillariophyta			
Cyclotella comta Kutzing	0	0	346
Cyclotella menegbiniana	100	54	74
Fragilaria capucina	0	27	0
Fragilaria ulna	0	0	14
Melosira granulata	14	0	14
Navicula numerosa	7	0	4
Pleurosigma sp.	0	0	7
Total Bacillariophyta	**121**	**81**	**459**
Dinophyta			
Peridinium bipes Stein	0	0	647
Gyrodinium pusillum	0	0	7
Total Dinophyta	**0**	**0**	**654**
Chlorophyta			
Chilomonas paramaecium	0	0	706
Total Chlorophyta	**0**	**0**	**706**

APPENDIX 2

CHEMISTRY DATA FOR THE NINE CASSARINA LAKES

Morocco and Tunisia - April 1997, Egypt - November 1997

Physical and chemical analyses of North African lakes studied

Factor	Egypt			Tunis			Morocco			Maximum allowable in fresh water
	Edku	Burullus	Manzalla	Lac de Korba	Merja Sheetan	Garaet Ichkeul	Merga Bokka	Merga Zerga	Sidi bou Rhaba	
Temperature (°C)	24	22.5	19	-	-	-	-	-	-	
pH	7.6	8.5	8	-	-	-	-	-	-	
Conductivity (mhos-1)	2.2x10-3	3.8x10-3	2.2x10-3	-	-	-	-	-	-	
Total soluble salts (gml-1)	1.602	2.822	1.482	52.216	0.85	43.186	2.082	26.592	4.764	1.5 gml-1
Alkalinity (mgl -1)	261.5	228	253	-	-	-	-	-	-	
Inorg.Carbon (mgl-1)	67.99	54.72	63.25	-	-	-	-	-	-	
Chlorophylla (µg-1)	2.80	5.20	1.20	-	-	-	-	-	-	
Chloride-Cl (gl-1)	0.453	0.860	0.420	21.33	0.280	14.00	0.453	10.00	4.00	0.2-0.6 gl-1
Phosphate-P (µgl-1)	163.07	10.90	8.31	90.36	8.57	7.53	103.1	7.01	10.12	
Nitrate-N (µgl-1)	473.72	61.26	44.33	73.99	144.36	23.20	183.07	42.22	71.87	45 mgl-1
Total nitrogen	622.22	394.59	399.11	-	-	-	-	-	-	
Sulphate-SO4 (mgl-1)	1023	383	257	3579	160	2748	256	2493	78	400 mgl-1
Silicate-Si (mgl-1)	5.83	3.29	3.28	0.65	0.31	0.44	0.83	4.11	1.62	
Calcium-Ca (mgl-1)	83.4	70.5	28.5	500	41.2	485	221	587	75.8	200 mgl-1

Factor	Egypt			Tunis			Morocco			Maximum allowable
	Edku	Burullus	Manzalla	Lac de Korba	Merja Sheetan	Garaet Ichkeul	Merga Bokka	Merga Zerga	Sidi bou Rhaba	in fresh water
Magnesium Mg (mgl-1)	28.2	54.0	51.0	678	27	750	72	562	60.6	150 mgl-1
Sodium-Na (mgl-1)	363	711	381	10995	204	8004	345	6734	1335	
Potassium-K (mgl-1)	22	20	31	437	9	310	11	223	28	
Boron-B (mgl-1)	0.29	0.38	0.22	6.93	0.22	3.94	0.38	2.87	1.03	
Copper-Cu (mgl-1)	0.00	0.04	0.06	0.18	0.04	0.16	0.06	0.23	0.05	0.20-30 µgl-1
Zinc-Zn (mgl-1)	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.03	0.00	0.2-48 µgl-1
Iron-Fe (mgl-1)	0.21	0.12	0.00	0.59	0.00	0.96	0.00	0.37	0.56	10-1500 µgl-1
Manganese-Mn (mgl-1)	0.00	0.00	0.00	0.00	2.37	0.00	0.00	0.00	0.00	0.03-21 µgl-1
Lead-Pb (mgl-1)	0.10	0.24	0.19	0.62	0.00	0.38	0.00	0.38	0.00	0.03-13.0 µgl-1
Chem.Oxyg. Demand (COD mgOl-1)	110	280	130	-	-	-	-	-	-	

APPENDIX 3

CHECK LIST OF TASKS TO BE PERFORMED ON EACH FIELDWORK SAMPLING VISIT TO EACH PRIMARY CASSARINA SITE

Summary checklist for data collection at the main CASSARINA sites * indicates optional task

TASK \ SITE	BOKK	RHAB	ZERG	ICHK	KORB	SHET	IDKU	BULR	MANZ
Water sample A (pH, mS,°C, Alk)									
Water sample B (ion analysis) filtered, 1 litre									
Water sample C (phosphate) not filtered , 120 ml									
Water sample D (AQC), 125 ml unfiltered									
*Chlorophyll a									
Zooplankton (taxonomy)									
*Invertebrates									
Fish/amphibians (taxonomy)									
Fish wts/lengths									
Fish scales									
Fish /amphibians (for pesticides)									
Phytoplankton from 1.5 litre									
Vegetation transect (s)									
Epiphytic diatoms									
Water temperature									
Water depth									
Secchi disc depth									
Temperature recorder									
Sediment cores									

Note: Fish should be about 20 cm long and fish scales and liver removed. Liver must be frozen and returned to the UK. If ONLY small fish (<10 cm long) then send at least five FROZEN whole fish to UK/Tunis.
Note 2. Only one sample for AQC need be collected on each trip.

APPENDIX 4

FISH CHECKLIST FOR THE TUNISIAN CASSARINA SITES

Fish checklist in main CASSARINA Tunisian sites

Lake / Fish/Amphibans	Ichkeul	Korba	chitane	
Syngnathidae				Sedentary Fish.
Syngnathus abaster	+			
Gobiidae				
Gobius niger	+			
Zosterisessor ophiocephalus	+			
Pomatochistus microps	+	+		
Blenniidae				
Lipophrys pavo	+			
Clupeidae				
Alosa fallax algeriensis	+			
Engraulidae				
Engraulis encrasicolus	+			
Atherinidae				
Atherina boyeri	+			
Cyprinodontidae				
Aphanius fasciatus	+	+		
Anguillidae				Marine Fish
Anguilla anguilla	+			
Mugilidae				
Mugil cephalus	+	+		
Liza ramada	+			
Liza saliens	+			
Liza aurata	+	+		
Soleidae				
Solea aegyptiaca	+			
Solea senegalensis	+			
Solea vulgaris	+			
Moronidae				
Dicentrarchus labrax	+			
Sparidae				
Sparus auratus	+			
Lithognathus mormyrus	+			
Belonidae				
Belone belone gracilis	+			
Hemiramphidae				
Hyporamphus picarti	+			
Cyprinidae				Freshwater Fish
Barbus callensis	+			
pseudophoxinus callensis	+			
Poecilidae				
Gambusia affinis holbrooki	+			
Amphibiens	++	+	++	

APPENDIX 5

GUIDE TO ALKALINITY MEASUREMENT

(Taken from: The determination of alkalinity and acidity in water 1981. Methods for the examination of waters and associated materials. 37pp: HMSO London.)

A supplement to the CASSARINA MANUAL FOR METHODS AND PROTOCOLS

B Determination of Total Alkalinity in Natural, Treated and Waste Waters (Range 0–20 mg/l as $CaCO_3$)

B1 Performance Characteristics of the Method

B1.1	Determinand	Alkalinity to pH 4.5.	
B1.2	Type of sample	All types of water of pH > 4.5.	
B1.3	Basis of the method	Titration of the sample with a standard solution of acid to successive pH values of 4.5 and 4.2[7] with instrumental pH measurement.	
B1.4	Range of application	0–20 mg/l as $CaCO_3$.	
B1.5	Standard deviation*	Synthetic Solution Nominal Total Alkalinity (mg/l as $CaCO_3$)	Total standard deviation mg/l as $CaCO_3$
		0†	0.09
		2.0	0.19
		5.0	0.22
		8.0	0.18
		13.0	0.29
		18.0	0.29
		†boiled and cooled distilled water. Each value of standard deviation has 9 degrees of freedom.	
B1.6	Limit of Detection	0.47 mg/l as $CaCO_3$ 5 degrees of freedom. *data obtained from a trial undertaken by the Sussex River & Water Division Laboratory, Southern Water Authority.	
B1.7	Sensitivity	1.0 ml of acid (0.02N) ≡ 5.01 mg/l $CaCO_3$.	
B1.8	Bias	No important bias detected.	
B1.9	Interferences	Certain inorganic anions and organic matter may affect the determination of the titration and point (see section B3).	
B1.10	Time required for analysis	6 determinations per hour including standardization of the pH meter.	

B2 Principle

The sample is titrated instrumentally with a standard solution of acid to successive pH values of 4.5 and 4.2 in order to determine the true equivalence point of the titration.

When the alkalinity present is due to carbonate and bicarbonate titration of the sample with acid liberates carbon dioxide. The loss of carbon dioxide from the sample during

titration is extremely variable depending upon the original concentrations of carbonate species present, and upon the titration conditions employed.

At high levels of alkalinity the effect of carbon dioxide at a titration end point of pH 4.5 is not significant. However below about 20 mg/l as $CaCO_3$ the effect of carbon dioxide may be significant and must be minimized. Once the equivalence point of the titration in the vicinity of pH 4.5 has been exceeded a plot of hydrogen ion concentration against volume of standard acid used becomes linear. Extrapolation of this linear section of the graph to zero hydrogen ion concentration determines the equivalence point due to the total alkalinity of the sample. This is shown diagramatically in figure 1.

In practice the two pH values, 4.5, and 4.2, are sufficient to define the linear section of the calibration graph.

B3 Interferences

Difficulties in end-point detection may be experienced in the presence of organic substances. Finely divided suspensions of calcium carbonate and magnesium hydroxide eg in waters softened by a soda-lime process, can contribute alkalinity and may be the cause of fading end-points (see section B8).

B4 Hazards

No particular hazards are known to be associated with this method.

B5 Reagents

Analytical grade reagents and chemicals shall be used. Water as prepared in section B5.1 shall be used throughout.

B5.1 Demineralized Water, Carbon Dioxide Free

Use demineralized, or distilled water, of pH not less than 6.0.

If the pH of the demineralized water is less than 6.0, immediately before use boil the water for at least 15 minutes in a suitable flask and allow to cool to room temperature whilst keeping the flask closed with a guard tube containing soda-lime.

B5.2 Sodium Carbonate

Immediately before use dry 2 ± 1 g of sodium carbonate, anhydrous, for 60 ± 5 minutes in an electric oven set at 265 ± 5°C and allow to cool in a desiccator.

B5.3 Hydrochloric Acid Solution (0.1N)

Using a graduated pipette fitted with a safety bulb add 9.0 ± 0.1 ml of hydrochloric acid (d_{20} 1.18) to a 1000 ml calibrated flask. Dilute to volume with water (B5.1) and mix well.

Standardize this solution as follows:–

Weigh out accurately 0.1600 ± 0.0050 g of sodium carbonate into a 250 ml beaker and note the weight of sodium carbonate taken.

Add 100 ± 5 ml of water (B5.1) to the beaker and insert a magnetic rotor. Place the beaker on a magnetic stirrer and stir to dissolve the carbonate. Insert electrodes (B6.1) connected to a pH meter. Titrate with hydrochloric acid solution (B5.3) with continuous stirring until the meter reads pH 4.5 ± 0.05. Note the titre.

Carry out a blank determination by titrating 100 ± 5 ml of water (B5.2) only and note the titre.

Let the mass of sodium carbonate taken $= M$ g
Let the titration of sodium carbonate $= T_1$ ml
Let the blank titration $= T_2$ ml

Then the normality (N_1) of the hydrochloric acid solution

$$= \frac{M \times 18.870}{(T_1 - T_2)}$$

B5.4 Hydrochloric Acid Solution (0.02N

Pipette 50±0.1 ml of hydrochloric acid solution (B5.3) into a 250 ml calibrated flask. Dilute to volume with water (B5.1) and mix well.

Prepare freshly for use and calculate the normality as follows:–

The normality (N_2) of hydrochloric acid solution (B5.4) = $N_1 \times 0.2$.

Alternatively use suitable commercially available standard solutions of hydrochloric acid.

Sulphuric acid solutions of corresponding normality may be used instead of the hydrochloric acid solutions.

B5.5 Buffer Solution pH 4.0[4]

Dissolve 10.20±0.01 g of potassium hydrogen phthalate, previously dried at 105°C for 1 hour, in about 500 ml of water (B5.1). Transfer the solution to a 1000 ml calibrated flask and dilute to volume with water.

The pH of this solution is dependent upon temperature as shown below:

°C	pH
15	4.00
20	4.00
25	4.01

B5.6 Buffer Solution pH 6.9[4, 5]

Dissolve 3.39±0.01 g of potassium dihydrogen orthophosphate, and 3.55±0.01g of disodium, hydrogen orthophosphate, anhydrous, in about 500 ml of water (B5.1). Transfer the solution to a 1000 ml calibrated flask and dilute to volume with water. The pH of this solution is dependent upon temperature as shown below:

°C	pH
15	6.90
20	6.88
25	6.87

Note: The two buffer solutions B5.5 and B5.6 can be replaced by equivalent commercially available buffer solutions.

B6 Apparatus

B6.1 pH Meter and Compatible Electrode System

Suitable for the measurement of pH to within ±0.05 units over the range pH 3 to pH 10.

The electrode system may consist of separate indicating and reference units, or these may be combined within a single assembly.

Each equipment must be used strictly in accordance with the supplier's recommendations.

Immediately before use standardize with buffer solutions (B5.5) and (B5.6).

B6.2 Magnetic Stirrer and Rotor

Suitable to mix 200 ml of solution without splashing. A 25 mm rotor is usually effective.

B7 Sample Collection and Preservation

Preferably using a polyethylene bottle of suitable capacity fill the bottle completely with sample and insert a stopper so that no air remains inside the bottle. If glass containers are used these should be checked to ensure that the glass does not contribute to the alkalinity of the sample.

Ideally, samples should be analysed as soon as possible after collection since certain samples may undergo significant changes on storage. However, if storage is unavoidable the samples should be maintained at 4±1°C.

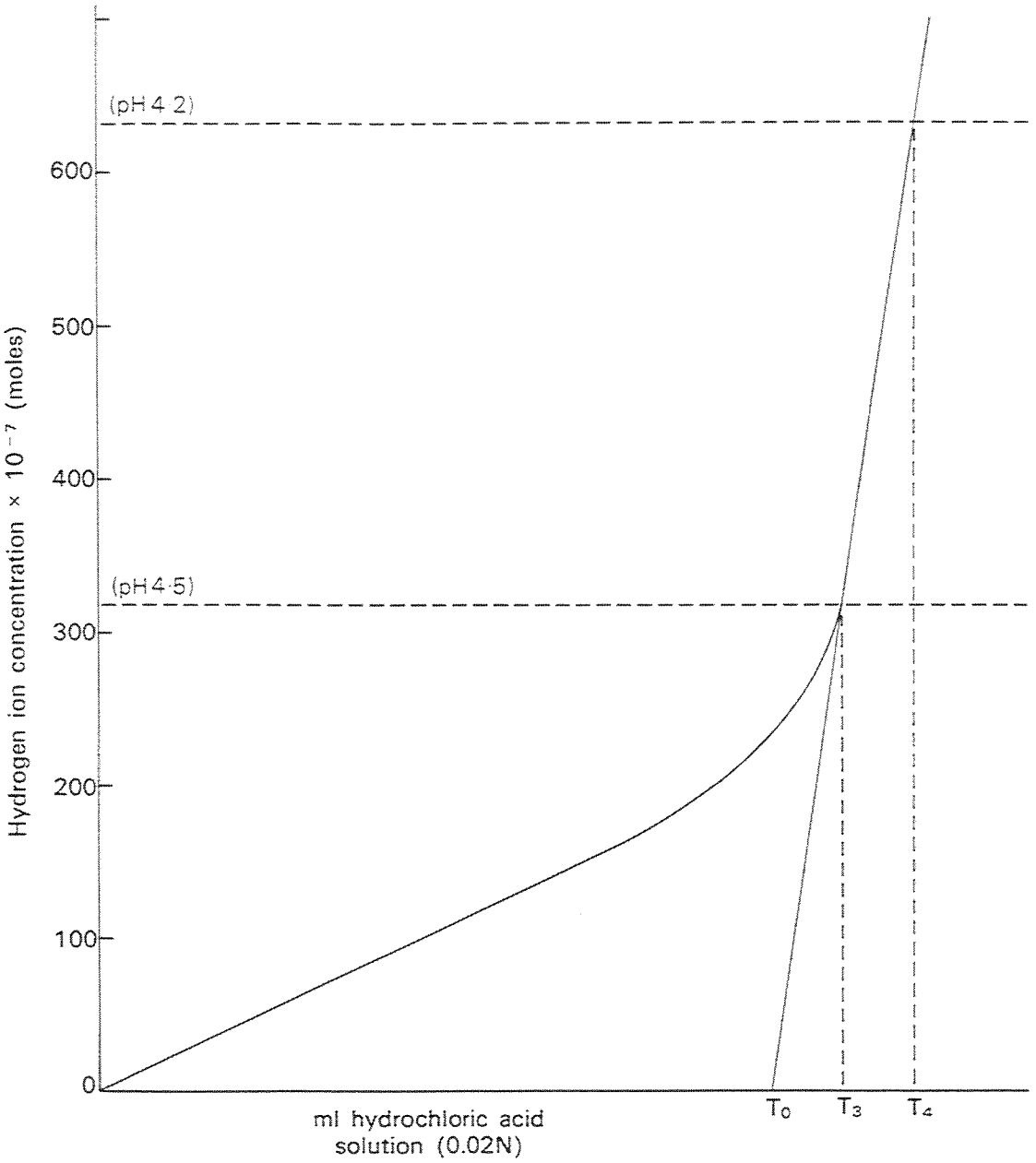
B8 Sample Pretreatment

If necessary remove any turbidity present by filtering sufficient sample through a suitable filter paper, e.g. grade GF/C. Immediately determine the alkalinity of the filtrate as described in section B9.

However, if the suspended matter is alkaline, it may be desirable to include this alkalinity in the total alkalinity of the water sample. See sections A9.16 onwards of the high range method.

B9 Procedure

Step	Procedure	Notes
B9.1	Preatreatment Stage If necessary filter the sample as described in section B8.	
B9.2	Transfer by cylinder 200±1 ml of sample to a 250 ml beaker.	
B9.3	Place the beaker on a magnetic stirrer and insert a stirring rotor and electrodes (B6.1) connected to a pH meter.	
B9.4	Start the stirrer and using a micro-burette titrate cautiously (see note a) with hydrochloric acid solution (B5.4) until the meter reads pH 4.5±0.05. Note the titre and let this be T_3 ml.	(a) Have the micro-burette tip below the surface of the sample.
B9.5	Continue the titration dropwise until the meter reads pH 4.2±0.05. Note the total titre and let this be T_4 ml.	
B9.6	Calculation (see figure 1) Total alkalinity $= (2T_3 - T_4) \times N_2 \times 250$ mg/l as $CaCO_3$.	



At pH 4.5, hydrogen ion concentration $= 316 \times 10^{-7}$ moles
At pH 4.2, hydrogen ion concentration $= 632 \times 10^{-7}$ moles
T_3 ml = volume of hydrochloric acid solution (0.02N) required to titrate the sample to pH 4.5.

T_4 ml = total volume of hydrochloric acid solution (0.02N) required to titrate the sample to pH 4.2.

T_0 ml = volume of hydrochloric acid solution (0.02N) corresponding to zero hydrogen ion concentration ie the true equivalence point of the titration

Then $T_0 = T_3 - (T_4 - T_3)$

$= 2T_3 - T_4$

Change, Stress and Sustainability: Aquatic Ecosystem Resilience in North Africa

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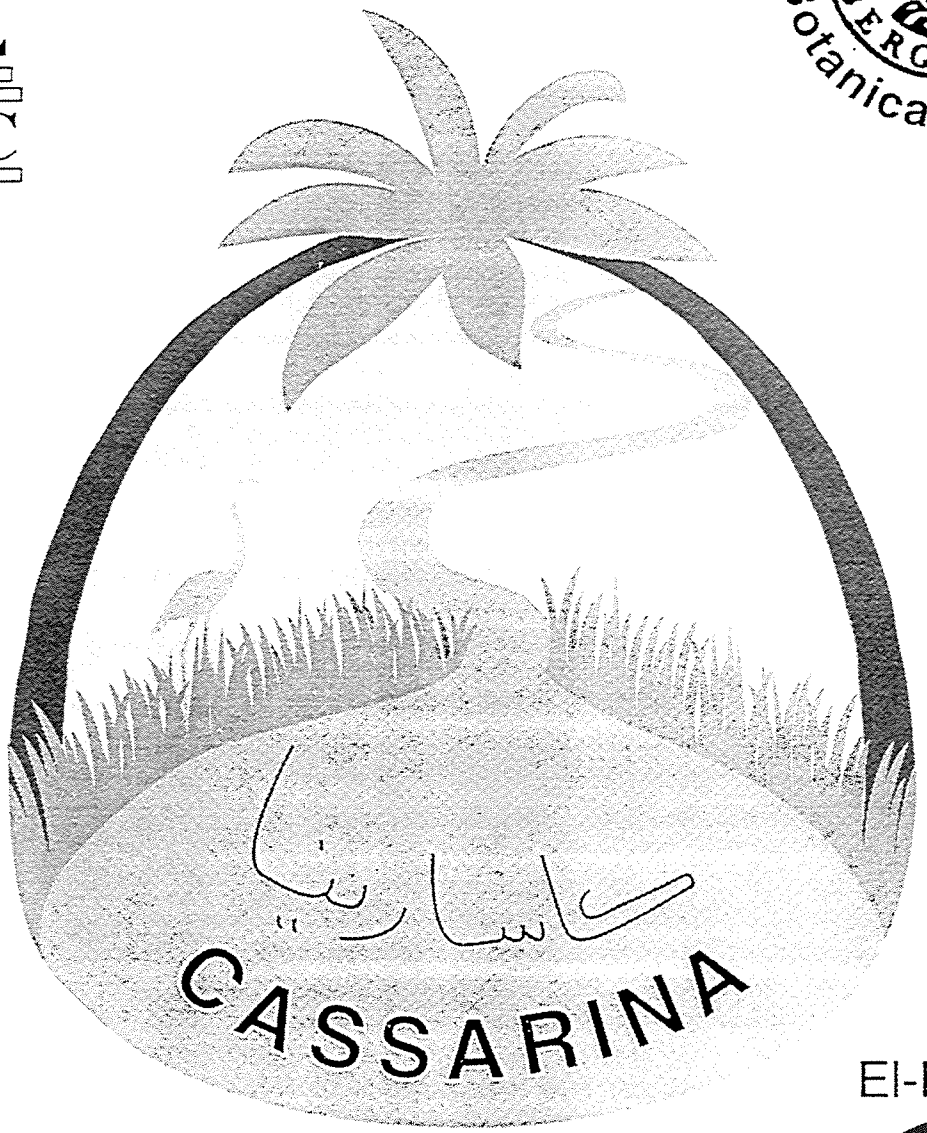

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المعهد العلمي

First Year Fieldwork Report
1997 - 1998
Report Number 3

THE *CASSARINA* PROJECT FOR NORTH AFRICAN WETLAND LAKES

THE FIRST YEAR FIELDWORK REPORT 1997-98

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MARCH 1998

Contract ERBIC18CT960029

CONTENTS

Executive Summary

1. CASSARINA is an INCO-DC project designed to achieve three main objectives: to carry out a coordinated monitoring programme for nine North African lakes, to assess the extent of environmental change at each site since ca. 1900, to promote conservation policies for North African wetland lakes.
2. This report gives an account of the current status and progress of the CASSARINA PROJECT during its first year of fieldwork, March 1997 - March 1998. The achievements of CASSARINA so far are broadly in line with the plan of work described in the original project proposal.
3. The project was initiated by a three day workshop held in London during 16-18 January 1997 with the aim of agreeing sampling strategies and protocols and setting field work schedules. A second workshop was convened in Tunis (February 1998) to discuss the first years results.
4. As a result of the first workshop a report 'CASSARINA Manual For Methods and Protocols' was written and distributed to CASSARINA participants. As a result of the second workshop in Tunis small amendments were made to this document.
5. Field work began in March 1997 with the project coordinators and Dr Ramdani (Rabat) visiting four Moroccan lakes, Sidi Bou Rhaba, Merja Bokka, Merga Zerga, and Merja Khala. Sediment coring and preliminary monitoring surveys were conducted and the first three sites are designated as primary CASSARINA sites.
6. In April 1997 the coordinators and Dr Kraiem (Tunis) visited four Tunisian lakes, Garaet Ichkeul, Lac de Korba, Merja Chetane and Merja Kelbia. Sediment coring and preliminary monitoring surveys were conducted and the first three sites are designated primary CASSARINA sites.
7. In November 1997 the coordinators and Drs Fathy and Abdelzaher (El Minia) visited three Egyptian lakes on the Nile Delta. Sediment coring and preliminary monitoring surveys were conducted but designation of the three CASSARINA lakes awaited a return visit in February 1998. The final decision is that Lakes Edku, Burullus and Manzala are designated primary CASSARINA sites and that Lake Qarun is a secondary site.
8. Analytical control samples for water chemistry and sediment sub-samples for microfossil and chemical analyses have been dispatched to the specialist partners and sub-contractors.

INTRODUCTION

Lakes and wetlands in North Africa are under severe threat from pollution, siltation, drainage and climate change. Many conservationally valuable sites have already disappeared and there is an urgent need to assess those that remain. CASSARINA is an INCO-DC project designed to achieve three main objectives: to initiate a coordinated monitoring programme for North African wetland lakes, to assess the extent of environmental change at each site since ca. 1900 and, where appropriate, to promote conservation policies for these lakes.

CASSARINA started in late 1996 and in January 1997 the project coordinators convened a general workshop in London so that all the partners and subcontractors could meet and finalize strategies for achieving CASSARINA objectives (see the CASSARINA proposal document). The practical aspects of CASSARINA are split into two parts: (i) the collection and analysis of sediment cores so that environmental change since ca. 1900 can be reconstructed and (ii.) the implementation of a modern biological and water sampling programme, initially for nine North African lakes. It was agreed that four lakes from each North African country (Morocco, Tunisia and Egypt) would be investigated so that the three most suitable for monitoring could be selected as CASSARINA sites. Sediment coring of twelve lakes was planned for 1997. During each sediment coring visit the ground work and initial decisions concerning the monitoring work, to be undertaken in 1998, were taken in the light of field experience of the individual sites.

METHODS AND TECHNIQUES

The first general workshop in London was used to discuss fully the sampling and analytical strategies, particularly for water chemistry (what, where and how to measure chemical determinands) and biological samples (how to preserve, identify and dispatch samples). Also, it was important to assess the feasibility of carrying out particular measurements and tasks taking into account occasionally difficult or unusual local conditions. These conditions centred not only on field circumstances but also on bureaucratic regulations in place for scientific work in North African countries. Not least were the difficulties in obtaining official documents permitting site access and arranging import/export of field equipment and samples between the UK and Norway and each of the North African countries.

The main conclusions and jointly agreed procedures for CASSARINA work are incorporated into a first workshop report entitled 'CASSARINA Manual for Methods and Protocols' (1997). Several amendments were subsequently made to these methods and these are included in the report of the Second CASSARINA Workshop held in Tunis February 1998 (Flower & Patrick 1998).

FIELD WORK

The first fieldwork visits were focused primarily on collecting sediment cores and establishing monitoring sites at each of four sites in the North African countries.

Sediment coring: In March 1997 the ECRC sediment coring equipment was taken to Morocco and four wetland lakes, Sidi Bou Rhaba, Merja Bokka, Merja Zerga and Merja Khala were cored. At least two sediment cores with undisturbed sediment surfaces were collected from each of these lakes. Based on field observations (water depth, sediment consistency, diversity of aquatic biota and land-use around each lake) three of the lakes were designated CASSARINA sites. One master and one back-up core from Sidi Bou Rhaba, Merja Bokka and Merja Zerga were sectioned at 1 or 2 cm intervals for analysis later in laboratories in either Rabat, London , Bergen or El Minia. Similarly, four lakes were visited in Tunisia. In April 1997 sediment cores were collected from Garaet Ichkeul, Lac de Korba, Megene Chetane and Sebkha Kelbia. The first three of these were selected as CASSARINA sites and sediment cores were sectioned and samples distributed to the different working groups. Later, in November 1997, field work took place in Egypt where four lakes were selected for initial investigation, Lake Edku, Lake Bullurus, Lake Manzala and Lake Qarun. The first three of these sites were visited and sediment cores successfully collected. However, because of minor logistic problems, the fourth lake was not sampled. Furthermore, on return to the UK radiometric measurements on the Edku master core indicated that it did not contain recent sediment. It was therefore decided to re-sample this lake in March 1998, and at the same time carry out, coring of Lake Qarun.

Monitoring: During the sediment coring visits to each sites ground work for the 1998 monitoring studies was carried out. Transect lines for aquatic macrophyte surveys were established, phytoplankton, water samples and some fish and zooplankton sampling was carried out. Current water level at each site was measured by reference to gauging points selected or emplaced in each lake and submersible temperature loggers were located at 50 cm depth at fixed locations in one lake in each North African country. Temperature loggers were fixed in Sidi Bou Rhaba (Morocco), Garaet Ichkeul (Tunisia) and Lake Burullus (Egypt). Fish were sampled at several sites, sizes determined and liver and scale samples removed for later analysis. In the 1998 monitoring programme modern site attributes will be more systematically sampled. However, for several sites (Megene Chetane and Merja Bokka) no fish were present and other species will need to be considered for monitoring and this was discussed at the second workshop in Tunis, 1998. Water samples for analytical quality control purposes were also collected so that results from the laboratory at El Minia will be checked by reference to measurements made on replicate samples at a UK laboratory. These results were also discussed at the second workshop.

1997-98 FIELD WORK ACHIEVEMENTS

The first year of CASSARINA field work (March 1997 - March 1998) has been successfully completed in general accordance with the plan outlined in the original CASSARINA Proposal Document. There have been the obvious logistic problems associated with establishing effective working links in North Africa, communication (lack of email for some North African partners and different work regimes) and bureaucracy (concerning equipment import/export and official permission to work on particular sites). These were of little lasting significance with the exception that the equipment hold-up by Egyptian customs and doubtful sediment cores from Lake Edku

necessitated another sediment sampling visit. This was successfully carried out in February 1998.

With regard to workshops, the general meeting in London and the three local meetings in each country prior to sediment sampling were carried out on time. In the original proposal document we planned a second general workshop meeting in London for May/June 1998. However, in order to optimize travel, to convenience our North African partners and to facilitate sample exchanges, we brought the meeting forward to February and moved the location to Tunis to coincide with the first systematic monitoring surveys in February/March 1998.

RESULTS

The results of field surveys and sampling carried out during 1997 are given in the following section. However, few analytical results are so far available for the sediment core studies other than of sediment lithostratigraphic measurements and these were presented at the Tunis meeting (see Second CASSARINA Workshop Report, 1998). Sediment samples from the Moroccan and Tunisian lakes are currently undergoing analysis by the various specialist groups and we are confident of positive results for most sites. However, we know already that for microfossils we have generally excellent preservation but at least one site has an interrupted record.

Results of the 1997 vegetation transect surveys for each of the nine primary CASSARINA sites are also given here together with fish data for the Egyptian sites. Vegetation surveys and other monitoring data for the February 1998 monitoring work in Tunisia are also reported here

MOROCCO

Morocco was visited in April 1997 to collect sediment cores and initiate monitoring sites. Four sites were investigated in some detail and of these three were chosen as CASSARINA sites.

SIDI BOU RHABA (SITE CODE = RHAB)

This site was visited on the 3rd and 4th of April, 1997. The open water lake is ca. 200 x 1500 m and was almost 2 m deep in the spring period. There are no surface inflows or outflows and water level can drop by ca. 1 m by the late summer so that a larger portion of the southern section of the lake dries out and is colonized in places by chenopods. The lake is surrounded by woodland (*Eucalyptus, Juniperus* and *Olea*) and relatively undisturbed scrub. The lake water was turbid and distinctly green in colour. Below about 1 m depth the lake bottom consists of soft dark brown sediment.

Sediment coring

Two cores were collected from a raft operated the central region of open water. Cores were collected within several metres of each other and located at **34.24065° N,**

06.67257° W. Core RHAB1 was collected during a previous visit (1990) and the 1997 cores were designated RHAB2 and RHAB3. RHAB2 is the master core (sectioned at 1 cm intervals with half of every second slice being left in Morocco for zooplankton analysis and with the other half being wrapped in aluminum foil for pesticide analysis). The sediment was sufficiently soft for two drives using 7.5 cm diameter PVC tubing, so that RHAB2 consists of two sections: 0-142 cm and 142-214 cm. RHAB3 was sampled at 2 cm intervals and consisted of two core sections 0-126 and 126-283 cm. RHAB2 was continued down for a further 4 m and analysis of this longer record will be performed later outside the main CASSARINA project.

Water depths at the coring site were 198 and 203 cm respectively for cores RHAB2 and RHAB3.

Monitoring

Secchi disc depth: 55 cm

Temperature recorder: this was placed on the west side of the lake at the edge of the *Phragmites* zone near a single palm tree in 1 m of water. The recorder is located at 75 cm depth on a steel post and was initiated at 14.00 GMT (16.00 Morocco time) on April 4th 1997.

Transects: a single transect for aquatic macrophytes was made from the eastern shore along a bearing of 345^0 N .

Gauging post: The end of the transect (70 m from the shore) was marked by a post. On the day of sampling (April 4th 1997) approximately 40 cm of the post remained above the water surface with 180 cm below .

Water samples: A, B (filtered) and C (phosphate) were collected with B and C being taken back to the UK for forwarding to Egypt.

Phytoplankton: This was sampled by collecting 1.5 l of open lake water and sedimenting for three days with Lugols iodine before decanting to ca. 100 ml.

Pesticides and trace metals: A sample of very small fish (all less than 5 cm, the species awaits determination) and zooplankton were frozen in a glass bottle.

Attached diatoms: One sample of aquatic vegetation was collected for epiphytic diatom analysis.

Vegetation transect survey:

Sidi Bou Rhaba. 4th April 1997. Vegetation transect. Start point 34.24274 N, 06.67193 W. Compass heading 345^0					
Quadrat number	Distance (m)	Depth (cm)	Plant species		Remarks
1	0	50	*Chara aspera* *Ruppia maritima* *Chaetomorphasp.*	50% 45% 5%	Close to bank vegetation of *Juncus maritimus, Scirpus lacustris*, Gramineae
2	5	70	*Chara aspersa* *Ruppia maritima*	50% 50%	
3	10	90	Chara aspersa Ruppia maritima Uncovered mud	50% 40% 10%	
4	15	110	*Chara aspersa* *Ruppia maritima* Uncovered mud	10% 30%	
5	20	130	*Chara aspersa* *Ruppia maritima*	35% 65%	
6	25	150	*Chara aspersa* *Ruppia maritima* Uncovered mud	10% 35% 55%	
7	30	150	*Ruppia maritima* Uncovered mud	10% 90%	
8	35	160	Uncovered mud		
9	40	160	Uncovered mud		
10	45	160	Uncovered mud		
11	50	160	Uncovered mud		
12	55	170	Uncovered mud		
13	60	180	Uncovered mud		
14	65	180	Uncovered mud		

MERJA BOKKA (SITE CODE = BOKK)

This site was sampled on 6th April 1997. The lake is now ephemeral, almost drying out by late summer. It is approximately 250 m in diameter and is very shallow (ca. 20 cm depth) yet before the 1950s it was a permanent water body with extensive emergent macrophyte communities. Intensive agriculture (for cereals on the northern side and for *Eucalyptus* on the southern side) in the past thirty years has diminished this lake. Ploughing and cereal production is undertaken on the lake foreshore and a wheat/sunflower crop is currently planted within the *Juncus/Scirpus/Typha* marginal zone. Several small low islands are present within the lake and are covered with a *Glyceria* community. Several former higher lake level shorelines can be seen around the lake indicating that in the recent past the water level was 1-2 m higher than now. The

inflow stream is also now redundant with any seasonally flowing water abstracted for agriculture. *Phragmites* was common but apparently removed by burning and draining in the 1950s. The lake possesses a few introduced small carp and many amphibians, especially newts.

The open water is brown-red and turbid. This colouration was caused by eroded top soil inwashed from the cultivated areas surrounding the lake. This material has accumulated in the lake and has partly settled out to overlay, to a depth of 2-3 cm, the more natural and much darker lake sediment.

Sediment coring

Two sediment cores were collected from near the centre of the lake at **34.37255° N, 06.29019° W** in a depth of water of 13 cm. BOKK1 is the master core and measured 86 cm long on the first drive and a further 30 cm resulted from the second drive, making a total length of 116 cm. BOKK2 is a total of 110 cm long, consisting of a first drive of 74 cm and a second of 36 cm. The sediments were very compact and friable below about 30 cm sediment depth.

Monitoring

Secchi disc depth: 2.5 cm.

Water samples: A, B (filtered) and C (phosphate) were collected with B and C being taken back to the UK for forwarding to Egypt.

Phytoplankton: None was collected at this site due to extremely high turbidity.

Zooplankton: samples were collected with a net.

Pesticides and trace metals: No fish were caught and instead about ten amphibians were placed in a glass bottle and frozen.

Gauging post: A post was pushed into the sediment at the coring site so that 40 cm remained exposed above the water. Interestingly, water depth at this site was 12 cm at noon but only 7 cm by mid afternoon: a strong afternoon breeze pushed the water to the north-eastern side of the lake.

Attached diatoms: A sample of submerged *Glyceria* was taken for diatom analysis

Vegetation Transect:

Merja Bokka. 5th April 1997. Vegetation transect. Start point 34.37241 N, 06.28715 W. Compass heading 325^0				
Quadrat number	Distance (m)	Depth (cm)	Plant species	Remarks
1	0	0	*Typha angustifolium* 10% *Lithrum hysopifolium* 10% *Glyceria flutians.* 20% Uncovered 70%	Q1 is 20 m from cereal culture and start of ploughed fields. Near *Juncus maritimus, Scirpus lacustris*, Gramineae.
2	5	0	*Chara vulgaris* 50% Gramineae? 1% Uncovered mud 49%	
3	10	0	*Chara vulgaris* 40% Uncovered mud 60%	
4	15	0	Uncovered mud 100%	
5	20	0	Chara vulgaris 10% Uncovered mud 90%	
6	25	0	*Chara vulgaris* 25% Uncovered mud 75%	
7	30	2	*Chara vulgaris* 10% Uncovered mud 90%	
8	35	5	Uncovered mud 100%	
9	40	5	Uncovered mud 100%	
10	45	5	Uncovered mud 100%	
11	50	8	Uncovered mud 100%	
12	55	8	Uncovered mud 100%	
13	60	10	Uncovered mud 100%	
14	65	10	Uncovered mud 100%	

At the time of sampling the water level was low and had recently receded; also in this very shallow lake the wind was effective in pushing water up-wind so exposing more lake sediment.

MERJA ZERGA (SITE CODE = ZERG)

This site was sampled on the 7th April 1997. This large lagoon is approximately 6 km in diameter and open to the sea at the north-west corner, it is therefore tidal to some extent. The water depth varies between a few cm and 40 cm depending on the tidal cycle and location, except in the drainage channels where 2 m of water can occur at high tide. Fringing *Phragmites* beds have been much reduced in recent years, fish traps are very common and increasingly intensive agriculture is causing agro-chemical contamination. Nevertheless, the site still attracts many visiting water birds. Agriculture is encroaching on the lake, the upper foreshore is used for crop production and the lower foreshore is

used for sheep and cattle grazing. Subsistence accommodation is increasing all around the lagoon.

Sediment Coring

Two cores were collected from about 250 m off the southern margin of the lagoon, near the inflowing Nador Canal. Here, there is about 20 cm of water overlying 30 cm of soft sediment and resting on hard packed marine clays with *Cardium* shells. Core location was **34.83574° N, 06.28536° W**. ZERG1 (master core) is 39 cm long and ZERG2 is 30 cm long. The hard packed clays make coring impossible without power equipment.

Monitoring

Secchi disc depth: 12 cm.

Phytoplankton: 1.5 l of water were collected and sedimented with Lugol's iodine.

Water samples: A, B (filtered) and C (phosphate) were collected with B and C being taken back to the UK for forwarding to Egypt.

Zooplankton and fish: none were sampled on this visit

Pesticides and trace metals: none were sampled

Vegetation transect: initiated on the southern foreshore near to the outflow of the Nador canal.

Attached diatoms: a portion of submerged macrophyte was removed for diatom analysis.

Vegetation transect:

Merja Zerga. 7th April 1997. Vegetation transect. Start point 34.82747 N, 06.29045 W. Compass heading 10^0				
Quadrat number	Distance (m)	Depth (cm)	Plant species	Remarks
1	0	0	*Salicornia* 25% *Chenopodium* 25% Uncovered 50%	Q1 is near grazed pasture, with *Juncus maritimus*, *Hordeum maritimum*, *Spergularia campestris*, *Sueda fruticosa*, Gramineae.
2	10	0	*Salicornia* 30% *Hordeum* 10% *Chenopodium* 10%	
3	20	0	*Salicornia* 20% Uncovered 80%	
4	30	0	*Salicornia* 70% Uncovered 30%	
5	40	0	*Salicornia* 70% Uncovered 30%	
6	50	0	Salicornia 70% Uncovered 30%	
7	60	0	*Salicornia* 80% Uncovered 20%	
8	70	0	*Salicornia* 70% Uncovered 30%	
9	80	0	*Salicornia* 70% Uncovered 30%	
10	90	0	*Salicornia* 85% Uncovered 15%	
11	100	0	*Salicornia* 90% Uncovered 10%	
12	110	0	*Salicornia* 95% Uncovered 5%	
13	120	1	Uncovered 100%	Several m past the water's edge
14	130	5	*Chaetomorpha* 20% *Enteromorpha* 10% Uncovered 70%	
15	140	7	*Chaetomorpha* 10% *Enteromorpha* 20% Uncovered 70%	

MERJA KHALA (SITE CODE = KHAL)

This site forms the north basin of the Merja Zerga and was sampled on the 6th April 1997. One core was collected to provide back-p material. Merja Khala is an oval body of water some 800 m in diameter and about 40 cm deep at normal high tide. It is fringed mainly by *Juncus*. The main body of water is dominated by large patches of *Ulva* and *Enteromorpha.*

Sediment coring

A single 30 cm long core was collected in 30 cm of water at **34.87227° N, 06.25489° W.** This core is regarded as a back-up sample, the main CASSARINA site in this region being the Merja Zerga.

Monitoring

Secchi disc depth: greater than water depth and therefore considerably clearer than in the main Merja.

Pesticides and trace metals: Only a few samples of the sediment core KHAL1 were prepared for possible analysis, no living material was collected for pesticide analysis.

Vegetation transect data: A transect was selected on the northern foreshore of the Merja Khala. Since this is a secondary CASSARINA site data are presented in a local report (Ramdani, in prep.).

Water samples: A, B (filtered) and C (phosphate) were collected with B and C being taken back to the UK for forwarding to Egypt.

TUNISIA

LAC ICHKEUL (SITE CODE = ICHK)

This is a large (ca. 15 x 5 km) lake in northern Tunisia and has been subjected to major disturbance in recent decades. Although it is surrounded by productive agriculture (mainly cereal crops) the main changes stem from hydrological interference with the five inflowing rivers. All but one of these inflows has been barraged so that, whereas in the past water flowed from the lake via the Tinja River to the sea, seawater now flows into the lake during most seasons of the year. Consequently, the salinity of Ichkeul has become more variable in recent years and even hypersaline water has been recorded during recent summers.

This site was visited on the 19th and 26th of April 1997 for the initial monitoring survey and sediment core collection and again on February 8th 1998 for further monitoring.

Sediment coring

Two sediment cores, ICHK2 and ICHK3, were collected from the sector of the lake near to the Sedjenane and Douimis rivers in the north-west (ICHK1 was collected during an earlier visit in 1984). They were both collected in 63 cm of water and located at

37.16754° N, 09.62393° W. The length of ICHK3 was 98 cm as measured in the field and 92 cm extruded. ICHK3 was collected 4 m away from ICHK2 and, in the field, measured 96 cm. In the coring area *Ruppia* was common but coring was carried out between the patches of the submerged macrophytic vegetation.

The sediment was brown in the top 1-2 cm and black below. Other than living *Hydrobia* on the surface sediment, no shells were encountered in the sediment during core extrusion.

Monitoring

Secchi disc depth: This was measured at the gauging post site which is located on an exposed shore on the north side of the Jbel. On April 20th 1997 the Secchi depth was 5 cm, the water being brown and turbid with mixing by a strong breeze from the north-west. On February 8th 1998, very similar conditions prevailed and the Secchi depth was 6 cm. However, on the west shore of the lake (see Vegetation Transect 14), water was less mixed and Secchi depth was 45 cm.

Gauging post: Water depth was monitored at a hydrograph station on the north shore of the Jbel. This was not functioning at the time due to blockage of the hydrograph cylinder. The reading on the gauging post was 4.5 on the lower scale, this is 55 cm BELOW the 0.0 mark on the gauge. On February 8th 1998 water level was high and measured 1.5 m on the gauging post, i.e. 105 cm higher level than in the previous April.

Temperature recorder: placed at the base of the hydrograph, location **37.12064° N, 09.69530° W** and initiated at 11.30 (GMT) on April 26th 1997.

Pesticides and trace metals: Samples of liver from several specimens of mullet caught in the lake outflow in the Tinja were removed and frozen. Approximately 10 g of liver tissue were removed from each of two species of mullet, placed into aluminum foil and then into whirlpac bags and frozen. In February 1998, samples from three fish were removed, three for pesticides and three for trace metals.

Water samples: A, B (filtered) and C (phosphate) were collected with B and C being taken back to the UK for forwarding to Egypt.

Vegetation transects: Two transects were selected on the lake foreshore. One crossed the Djoumine former wetland area (T3) on the eastern side of the lake and the other crossed the Sedjnane wetland on the west side of the lake (T14). NB these transect numbers refer to survey lines established in the mid 1980s by A.C. Stevenson *et al.* (unpublished). These transects were re-sampled in February 1998.

T3 *First vegetation monitoring survey* (20.4.1997): The start of this transect was within 12.5 m of the Parc Nationale concrete sign on the road from Menzel Bourgiba to Jbel Ichkeul. The land immediately to the north of the first part of the transect line has been reclaimed for cereal crop production.

Lac Ichkeul - 20.4.97- Vegetation transect - Transect 3 (east side if the lake) Start 37.11268^0 N, 09.71629^0 E, End: 37.12064° N, 09.71606° E. Compass heading 0^0					
Quadrat	Distance (m)		Plant species		Remarks
1	0	0	*Anacyclus clavatus* *Cotula cornopifolia* *Hordeum marinum* *Trifolium* *Frankenia laevis* *Euphorbia exigua* Uncovered	40% 5% 5% 5% 5% 5% 35%	12.5 m away from the National Park sign at road side. All vegetation below 30 cm high
2	60	0	*Anacyclus clavatus* Thistle A *Sonchus* sp. *Lolium multiflorum* *Phalaris canariensis* Uncovered	10% 30% 15% 15% 10% 20%	Vegetation below 40 cm high (thistles ca. 35 cm)
3	120	0	*Frankenia laevis* *Hordeum marinum* *Cotulacoronopifolia* *Sonchus* sp. Uncovered	70% 5% 5% 5% 15%	Average height < 15 cm. Exposed sediment with desiccation cracks
4	180	0	*Hordeum marinum* *Cotula coronopifolia* *Atriplex* sp Uncovered	5% 5% 5% 85%	see above
5	240	0	*Hordeum marinum* *Cotula coronopifolia* Uncovered	50% 25% 25%	
6	300	0	*Phalaris canariensis* *Cotula coronopifolia* *Ammi visnaga* *Salicornia* Uncovered	5% 5% 5% 5% 80%	New assemblage, earth cracked but wet- inundation community.
7	360	0	*Salicornia*	100%	Big 40 cm high bushy clumps of *Salicornia*
8	420	0	*Salicornia* Uncovered	80% 20%	Bushes more frequent.
9	480	0	*Salicornia* Uncovered	50% 50%	A few regenerating *Phragmites* in this area
10	540	0	*Salicornia* Uncovered	60% 40%	Dried filamentous algae in the locality
11	600	0	Dry fil. algae Uncovered	20% 80%	Scattered *Tamarix* in locality,.
12	660	0	Dry fil. algae Uncovered	10% 90%	*Cardium* on surface sediment, end of *Salicornia* zone.
13	700	0	*Ruppia* Uncovered	10% 90%	Sediment moist, many small dead *Cardium*, some *Balanus* on solid substrata.
14	760	0	*Ruppia* Uncovered	10% 90%	*Ruppia* dead.
15	820	1 cm	*Phragmites* stems Uncovered	20% 80%	*Phragmites* dead with *Balanus*. Red algal balls - *Ceramium*

NB *Salicornia* noted here more properly refers to the perennial plant *Arthrocnemum fruticosum.*

T3 *Second vegetation monitoring survey* (8.2.1998). Note that because of the water depth (ca. 1 m higher than in April 1997) the transect was terminated at 820 m.

Lac Ichkeul - 08.2.98- Vegetation transect - Transect 3 (east side if the lake) Start 37.11268^0 N, 09.71629^0 E. Compass heading 0^0					
Quadrat	Distance (m)	Water depth (cm)	Plant species		Remarks
1	0	0	*Sonchus sp.*	10%	12.5 m away from the National Park sign at road side. All vegetation below 20 cm high
			Anacyclis linearilobus	5%	
			Rumex sp.	5%	
			Trifolium stellatum	2%	
			Chenopodium	5%	
			Euphorbia exigua	2%	
			Erodium sp.	2%	
			Cirsium sp.	2%	
			Anathemis maritimus	2%	
			Uncovered	64%	
2	30	0	*Allium sp.*	10%	Vegetation below 20 cm high
			Arum sp.	5%	
			Ranunculus sardous	15%	
			Cotula coronopifolia	10%	
			Gramineae	15%	
			Uncovered	45%	
3	60	0	*Frankenia laevis*	40%	Average height < 20 cm.
			Ranunculus sardous	5%	
			Cotula coronopifolia	5%	
			Gramineae	5%	
			Anthamis camomile	5%	
			Trifolium stellata	2%	
			Uncovered	38%	
4	90	0	*Anthamis camomile*	10%	Height of vegetation up to 25 cm
			Cotula coronopifolia	60%	
			Allium sp.	5%	
			Frankenia laevis	5%	
			Gramineae	5%	
			Uncovered	15%	
5	120	6	*Frankenia laevis*	30%	5 m beyond waters edge
			Cotula coronopifolia	60%	
			Anacyclus linearilobus	10%	
6	150	5	*Frankenia laevis*	10%	Plants submerged and in poor condition.
			Limonium sp	10%	
			Anthamis camomile	60%	
			Anacyclus linearilobus	10%	
			Uncovered	10%	
7	180	10	*Frankenia laevis*	60%	
			Cotula coronopifolia	5%	
			Cynodon dactylon	5%	
			Crypsis sp	5%	
			Anthamis camomile	10%	
			Uncovered	15%	
8	210	21	*Salicornia*	10%	Gramineae mostly dead plants from the previous year
			Gramineae	60%	
			Uncovered	30%	
9	240	33	*Salicornia*	50%	
			Gramineae	20%	
			Uncovered	30%	
10	270	35	*Salicornia*	50%	Green filamentous algae (mainly *Cladophora*) around some macrophytes
			Salsola (remains)	5%	
			Cladophora	5%	
			Gramineae	20%	
			Uncovered	30%	

11	300	31	*Salicornia* Gramineae Uncovered	40% 10% 50%	
12	330	34	*Salicornia* Gramineae Uncovered	50% 5% 45%	
13	360	40	*Salicornia*	100%	Near line of *Tamarix*, one bush 12 m SE of Q13

NB Transect 4 was terminated at 360 m because water depth made sampling by foot difficult.

T14 -*First vegetation monitoring survey* (27.4.1997). This transect started 20 m from a right-angled bend on a track 500 m off the Mateur-Bizerte road (C57) on the east shore of Ichkeul between the Sedjenane and Melah rivers. The transect start was marked by GPS co-ordinates. The transect is near that established by A.C. Stevenson in 1984. It is almost 2 km long and crosses the eastern shore where low water level and imperceptible shore-slope gives a large expanse of seasonally wet littoral zone. (unknown plant species to be determined by Dr Kraiem and colleagues). Re-sampling was carried out on February 8th 1998.

Lac Ichkeul - 27.4.97- Vegetation transect - Transect 14 (west side of the lake), Start 37.15232^0 N, 09.56349^0 W. Compass heading 60^0

Quadrat Number	Distance (m)	Depth (cm)	Plant species		Remarks
1	0	0	*Hordeum marinum* *Salicornia* *Frankenia laevis* *Spergula marina* Uncovered	20% 10% 15% 5% 50%	Start 30 m from road, flat, grazed plain, *Salicornia* reduced vegetation <10 cm high.
2	150	0	*Salicornia* *Aeluropus littorlis* Uncovered	60% 5% 35%	Sediment fissured.
3	300		*Salicornia* Uncovered	90% 10%	Many cattle footprints
4	450		*Salicornia* Uncovered	50% 50%	
5	600	0	Uncovered	100%	
6	750	0	*Salicornia* Uncovered	80% 20%	Very occasional *Phragmites* shoots.
7	900	0	*Salicornia* *Phragmites* Uncovered	70% 5% 25%	Phragmites up to 20cm high
8	1050	0	*Phragmites* Uncovered	10% 90%	*Salicornia* absent. Quadrat next to dry/wet sediment boundary
9	1200	1	*Phragmites* Uncovered	5% 95%	Regenerating *Phragmites* all about 10 cm high
10	1350	1	*Phragmites* Uncovered	15% 85%	Regenerating *Phragmites* all about 10 cm high
11	1500	1	*Phragmites* Open wate Uncovered	50% 15% 85%	Phragmites all about 10cm high

12	1650	2	Uncovered	100%	
13	1800	2	Uncovered	100%	Many flamingos
14	1950	3	Uncovered	100%	Many flamingos

From these vegetation transects it is apparent that there is still considerable potential for *Phragmites* regeneration . Root stocks are still viable especially in the western region of the lake shore and if salinity is reduced the reed-bed community should return.

T14 *Second vegetation monitoring survey* (8.2.1998): Note the higher water level on this occasion limited transect length to 410 m.

Lac Ichkeul - 08.2.98 - Vegetation transect - Transect 14 (west side of the lake), Start 37.15232^0 N, 09.56349^0 W. Compass heading 60^0					
Quadrat number	Distance (cm)	Depth (cm)	Plant species		Remarks
1	0	0	*Frankenia laevis* Gramineae Uncovered	80% 2% 18%	Start is 10m from the road embankment. Small *Tamarix* bush near.
2	60	0	*Salicornia* *Aeluropus littoralis* Uncovered	60% 2% 38%	*Scirpus littoralis* clump growing 3 m S of Q2. Near water's edge.
3	120	24	Uncovered	100%	vegetation cover patchy, mud more compact than at T4
4	180	39	*Salicornia*	100%	
5	230	45	*Salicornia* Uncovered	75% 25%	
6	290	45	*Salicornia* *Scirpus littorals* Uncovered	80% 1% 19%	*Scirpus* present as small isolated clumps
7	350	47	*Salicornia* Uncovered	80% 20%	
8	410	48	*Salicornia*	100%	

NB This transect was terminated at 410 m because water depth made further sampling by foot difficult.

LAC KORBA (SITE CODE = KORB)

A long narrow shallow lake (approximately 6 x 0.3 km) on the east coast of the Cap Bon peninsular. It is separated from the sea by a vegetated low sand dune approximately 100 m wide. The main influences on water quality are: the south end of the lake receives pollution from the town of Korba; two breach points in the sand dune allows connection with the sea; seasonal inflow of freshwater occurs at the north end of the lake. Also at

the north end of the lake a low causeway provides access to the seaward side of the sand dunes. Land-use around the lake is predominantly agriculture with cereal crop production and some cattle grazing. On most of the western margin of the lake there is a salt marsh wetland plant community dominated by *Salicornia (= Arthrocnemum fructicosum).*

The lake margin on the east side is sandy silt and this tends to be more argillaceous on the western side. A salt marsh vegetation community occupies most of the length of the western shore of the lake. *Salicornia* overwhelmingly dominates and is present as bushy plants separated by occasional inter-connected pools. At the water/salt marsh community margin the sediment is black and sulphurous, submerged macrophytes are not present but large colonies of *Cladophora* and *Chaetomorpha* are common in the littoral zone. The eastern sandy shore of the lake is rather different, there is no extensive salt marsh community and submerged aquatic macrophytes occur, notably several species of Charophytes.

In the central region of the lake depth varies from 30 to 50 cm. In the north part the central surface sediment consists of hard packed grey clays, probably ancient and marine in origin. In the middle central region, water depth is 50 cm with some 30 cm of black sediment overlying grey clay. In the central region the lake bed was covered by a dense mat of green algae, mainly *Enteromorpha*, and many chironomid larvae were present.

This site was visited on the 21st April 1997 for sediment core collection and field survey and again on 12th April 1998 for the first monitoring survey.

Sediment coring

Two sediment cores were collected from the middle central region of the lake (**36.61764^0 N, 10.89130^0 E**). The coring area was about 40 m off from a land fill site on the western shore, an area that was formerly the site of a Roman port. Cores KORB1 (42 cm long) and KORB2 (98 cm long) were collected in 50 cm of water.

Monitoring

Secchi disc depth: April 1997 - 15 cm; February 1998 - 25 cm.

Phytoplankton: 1.5 l of water were collected and sedimented on each occasion.

Gauging post: This was emplaced at the coring site so that 35 cm was exposed above the lake surface in April 1997. In February 1998 the water level was about 5 cm higher.

Pesticides and trace metals: No biological samples were collected.

Water samples: A, B (filtered) and C (phosphate) were collected with B and C being taken back to the UK for forwarding to Egypt.

Vegetation transects: The transect line was established across the west shore of the north part of the lake on land very slightly sloping towards the lake. The transect start was marked by a wooden post on the path between agricultural crops and the start of the

wetland salt marsh community, the point was also marked by GPS. Only the lower part of the transect is affected by small daily tidal changes of a few centimetres. The communities on the upper part of the transect are maintained by seasonal inundations.
First vegetation monitoring survey (21.4.1997):

Lac de Korba - 21.4.97- Vegetation transect - Transect 1, Start 36.63476^0 N, 10.90157^0 E, Compass heading 137^0 (located 350 m south of the causeway - high tide)				
Quadrat number	Distance (m)	Depth (cm)	Plant species	Remarks
1	0	0	*Atriplex* sp. 30% *Salicornia* 70%	Start: 2 m from edge of cereal crop
2	20	0	*Salicornia* 100%	*Salicornia* very bushy, 40 cm high
3	40	0	*Salicornia* 100%	
4	60	30	*Salicornia* 50% Open water pool 50%	*Salicornia* ca 30 cm above water surface
5	80	30	*Salicornia* 50% Open water 50%	
6	100	30	*Salicornia* 75% Open water 25%	
7	120	0	*Salicornia* 100%	
8	140	30	*Salicornia* 10% Green fil. algae 10% Open water 80%	Open lake water ca 20 m further.

NB *Salicornia* noted in the vegetation transect table probably refers to the perennial plant *Arthrocnemum fruticosum.*

Second vegetation monitoring survey:

On February 12th 1998 the lake was calm and weather fine and a blue-green algal scum was present in the south part of the lake, indicating a pollution source from the town of Korba. Two large flocks of flamingos were roosting at the lake.

Lac de Korba - 12.2.1998 - Vegetation transect - Transect 1, Start 36.63476^0 N, 10.90157^0 E, Compass bearing 137^0 (located 350 m south of the causeway).				
Quadrat number	Distance (m)	Depth (cm)	Plant species	Remarks
1	0	0	*Atriplex* 60% *Salicorni a* 30% Gramineae 10%	Field cultivation is within 2 m W of Q 1
2	20	5	*Salicornia* 100%	Bushy plants
3	40	10	*Salicornia* 100%	
4	60	35	*Salicornia* 30% *Enteromorpha* 60% Open water 10%	Edge of open pool
5	80	20	*Salicornia* 30% *Enteromorpha* 60% open water 10%	Edge of open pool
6	100	38	Open water 95% *Enteromorpha* 5%	Dead *Salicornia* in pool

7	120	35	*Salicornia* *Enteromorpha* Open water	70% 10% 20%	
8	140	35	*Enteromorpha* Open water	40% 60%	Green fil. algae associated with *Enteromorpha*
9	160	22	Green fil. algae *Enteromorpha* *Microcystis*	60% 30% 10%	Slight ridge in substratum near margin of salt marsh
10	180	41	Uncovered	100%	Black mud under open water

MEGENE CHETANE (CODE = SHET)

A small clear softwater lake (ca. 90 m in diameter), north facing, overlooking the sea on the north Tunisian coast. The outflow is in the north-west corner and when surveyed was about 60 cm above the current lake level. Catchment vegetation includes cork oak with a diverse scrub understorey. The catchment within the vicinity of the lake is protected by a perimeter fence, 2 m high and some 50 - 100 m from the lake shore. Above the lake, subsistence farming is practiced and the small aquifer supplying water to the lake is being exploited for irrigation. *Nuphar* and fish were introduced by forestry authorities but the fish were lost due to drying out of the lake in 1995. This lack of water probably resulted from diversion of the lake's natural spring water supply for local irrigation. Aquatic vegetation is diverse with *Scirpus, Typha, Nuphar, Isoetes, Juncus* spp. including *J. acutus* being common at the lake margin. Amphibians were also abundant.

The underwater sediment was everywhere covered with desiccation fissures marking the loss of surface water in 1995. Water depth was low when surveyed, despite being early in the year. Depth in the centre of the lake was 97 cm within the fissures and 92 cm deep between the fissures. The former shoreline indicates a water depth of about 1.6 m when the basin is full after winter rain. The lake is fed mainly by a spring fed stream that drains a small valley mire some 18 m above the level of the lake. The bog area is given over to subsistence agriculture with a motor driven pumping system to provide irrigation during the summer. This exploitation of the lake's water supply was almost certainly responsible for the loss of surface water in 1995. The two springs that supply the lake and bog are located at 37.15071 N, 9.09617 E, and 37.15048 N, 9.09748 E, respectively.

This site was sampled on the 23rd April 1997 and re-visited for monitoring on 11th February 1998.

Sediment coring

Location of the two sediment cores was near the lake centre at **37.15276^0 N, 09.09781^0 E**. Cores are coded SHET1 (master core) and SHET2. Coring was made difficult by the hard 1-2 cm thick brown crust overlying softer black sediment. Interestingly there was no marked rehydration of this crust despite two years of overlying water. Because of the desiccation features on the sediment surface, sediment areas between the fissures were

selected for coring. Both cores were collected within 30 cm of one another. The top of core SHET1 was inclined at 45^0 due to uneven depression of the surface crust during corer penetration. The top of SHET2 was rather disturbed due to breaking up of this surface crust. It was therefore difficult to choose the master core for dating but we shall submit samples from both for initial radiometric analysis.

Monitoring

Secchi disc depth: On 23.4.97 the water was very clear so that the Secchi depth exceeded the maximum water depth, 97 cm. However, when revisited on 11.2.98 the water was brown in colour and moderately turbid with a Secchi depth of 38 cm.

Water samples: A, B (filtered) and C (phosphate) were collected with B and C being taken back to the UK for forwarding to Egypt.

Phytoplankton: 1.5 l of open water was collected and sedimented on both occasions.

Gauging post: this was placed in the centre of lake and on 23.4.97 the post top was 40 cm above the lake water level. When re-visited in February 1998 the water level was higher by about 50 cm and the gauging post could not be seen. Another gauging post was therefore established at the water's edge, less than 50 cm away from the vegetation transect start point. This new stake was positioned so that 45 cm was above the current water level and 41 cm below. The height of this post compared with the original one must be determined by level survey at a later date.

Pesticides and trace metals: no samples of living material were collected.

Vegetation transect: April 1997: This short transect was begun at the dry (in April 1997) margin of the small lake on the north-west side, about 10 m west of the then redundant outflow. The start of the transect was marked on the shore by a small pile of stones. The wave cut sandy ledge around the present lake was some 6 m away from the water's edge at that time. The exposed sandy littoral zone was extensively covered with yellow flowers (*Cotulus coronopifolia*) and some grasses.

First vegetation monitoring survey (23.4.1997):

Megene Chetane. 23rd April 1997. Transect 1. Location of T1 start: 37.15350° N, 09.09760° E. Transect bearing 95°					
Quadrat	Distance (m)	Depth (cm)	Plant species		Remarks
1	0	0	*Cistus monspeliensis* uncovered	25% 75%	Edge of scrub at lake shore
2	2	0	*Cotula coronopifoli a* *Hordeum marinum* *Anagallis arvensis* Uncovered	40% 5% 5% 50%	Exposed lake shore - low lake level- dry and sandy
3	4	0	*Cotula coronopifolia* *Hordeum marinum* Uncovered	30% 20% 50%	As for 2
4	6	0	*Cotula coronopifolia* *Lolium multiflora* Uncovered *Juncus* A	60% 5% 30% 5%	

5	8	0	*Cotula coronopifolia* *Juncus* A *Hordeum marinum*	80% 5% 10%	
6	10	0	*Cotula coronopifolia* *Juncus* A	80% 20%	
7	12	10	*Juncus* A Open water	50% 50%	*Juncus* in filamentous aquatic form
8	14	20 cm	*Juncus* A Open water	50% 50%	*Juncus* in emergent form
9	16	35 cm	*Juncus* A *Isoetes velata* Open water	5% 5% 90%	
10	18	40 cm	*Juncus* A Open water	50% 50%	End of macrophyte zone 10 m further in *Nuphar* and *Scirpus lacustris*

Note that the species of open water *Juncus* is not yet to identified to species.

In February 1998 the lake level was about at its maximum and water was flowing out of the outflow channel (this channel is straight and is probably an artificial cutting made in the past to reduce the lake level). The sandy littoral zone was inundated and the water extended to the wave cut margin. Water turbidity was also high and probably resulted from winter rains washing soil into the lake via the main inflow stream (at the south-west corner of the lake). Because of the high water level and water colour, vegetation re-survey was difficult without a boat. However, using chest waders and a rake the submerged vegetation to a depth of 1.13 m was assessed.

Second vegetation monitoring survey (11.2.1998):

Megene Chetane - 11.2.98. Transect 1, start, 37.15350^0 N, 09.09760^0 E. Transect bearing 95°					
Quadrat number	Distance (m)	Depth (cm)	Plant species/cover		Remarks
1	0	0	*Cystis mospeliensis* *Phylleria* Uncovered	70% 25% 5%	Edge of catchment scrub vegetation
2	2	48	Green fil. algae *Isoetes* Uncovered	40% 40% 20%	Submerged fore-shore
3	4	70	*Cotula coronopifolia* *Isotetes*	80% 20%	*Cotula* - old stems from last year.
4	6	84	*Cotula coronopifola* *Juncus* sp. A Uncovered	60% 10% 30%	Vegetation is a mix of new growth and plant remains from last year
5	8	98	*Cotula coronopifola* *Isoetes*	80% 20%	
6	10	101	Gramineae Uncovered	80% 20%	Gramineae dead, mainly *Hordeum*
7	12	100	Gramineae	100%	All detrital

8	14	113	*Cotula coronopifola* 50% Uncovered 50%	

NB. Depth of water prevented sampling beyond Quadrat 8.

SEBKHET KELBIA

Sediment in Sebkhet Kelbia proved too hard to core adequately and despite its former ecological importance is was therefore not selected as a primary CASSARINA site. A short (ca 20 cm long) core and water samples were collected from the eastern part of the wetland, located at 35.39854 N, 10.33262 E.

EGYPT

Because sampling Egyptian lakes presented considerably greater logistic difficulties than Moroccan and Tunisian lakes, not least because of the need to air-freight all the sediment sampling equipment from London, initial sampling was not possible until November 1997. As before the field work strategy plan was to collect sediment cores from four sites and initiate monitoring studies at the three sites most suitable for CASSARINA purposes.

The lakes planned for investigation were Edku, Burullus, Manzala, and Qarun but delays associated with site access problems prevented us from sampling Lake Qarun on the first trip. The first three are all coastal lakes on the northern margin of the Nile Delta and all have connections with the Mediterranean Sea. They are selected as the three primary CASSARINA sites and core pairs were obtained from all three lakes. Lake Qarun is however also an important site for birds and for palaeoecology and it will be cored at a later date. Lake Maryut was the largest of the western Nile Delta lakes but this lake is severely polluted and has been investigated in some detail elsewhere (e.g. Saad 1985, Stanley & Warne 1993).

The three coastal lakes selected for CASSARINA are all extensive in area but are shallow being less that 2 m deep. There has been major land-use changes in the past 100 years around each site but until recently the greatest changes have been brought about by hydrological constructions associated with irrigation and water supply. Nevertheless the most recent changes impinging these lakes are: (i) land reclamation activities planned to provide more living space and agricultural potential and (ii) pollution. In a region that is as densely populated as Bangladesh (Haq 1994) these Nile Delta lakes are under severe pressure from direct human intervention and this must pose a greater threat to their survival as conversationally important water bodies than any likely future changes in global climate.

The fieldwork carried out in November 1997 was designed primarily to collect sediment cores rather than to conduct lake-wide surveys. Consequently, the notes below refer only

to those parts of each lake visited to arrange sediment core sampling. These were the northern shores of Edku and Burullus and the south-western shore of Manzala.

Because of logistical difficulties in November a second field trip to Egypt was made in March 1998 to re-core Edku and to make trial sampling at Qarun.

LAKE EDKU (SITE CODE = IDKU)

This site was visited on the 14th and 15th of November, 1997. This large (ca. 20 x 8 km) shallow lake in northern Egypt has been subjected to major disturbance in recent decades. It is surrounded by productive agriculture on its southern side, by ongoing land reclamation activities on the eastern side and by housing and industry on the west side (where much reclamation has already taken place). The northern boarder of the lake is a sand ridge that separates the lake from the sea. This narrow corridor of land carries a road, railway and supports several villages, including the town of Edku itself. Date palm groves and subsistence agriculture are predominant on this northern side of the lake. The region immediately to the north-west of the lake is characterized by urban sprawl that extends to Alexandria, combined with industrial installations at Abu Qir. The main industrial installations are an oil and a gas refinery (WEPCO and GASCO), an oil powered electricity generating plant, a paper processing plant and the well known Abu Qir fertilizer manufacturing utility.

The hydrological regime of this lake is dominated by freshwater runoff from the agricultural regions in the south and seawater inputs from the north. The lake is joined to the sea by a short channel just east of Abu Qir where the flow was from the lake to the sea at the time of sampling. The connection is not sluiced.

Where undisturbed from land reclamation and development, the margin of the lake consists of extensive beds of *Phragmites* and *Typha*. Several island are also covered by these plants and everywhere water hyacinth (*Eichhornia crassipes*) is growing well. Along the relatively undisturbed margins of the lake the emergent macrophyte stands were some 200-300 m wide. Lake access for sampling was therefore difficult except where narrow channels had been cut through the reeds for fishing purposes.

Sediment coring

November 1997: Two sediment cores IDKU1 and IDKU2 were collected from the sector of the lake near to the north shore approximately equidistant from Abu Qir and Edku town. They were both collected in 85 cm of water and located at **31.26611° N** and **31.21092° E** at about 5 m out from the fringing emergent macrophytes. The length of IDKU1 was 40 cm as measured in the field (39 cm extruded) and IDKU2 was also 40 cm. In the coring area, *Pomatogeton* was occasionally present together with some charophytes, but sediment sampling was carried out between the patches of submerged vegetation.

The sediment was brown throughout. *Hydrobia*, *Abra*, *Cardium* and *Planorbis* shells were encountered in the sediment during core extrusion.

Trial radiometric dating immediately after fieldwork on return to the UK showed that the Edku cores consisted mainly of sediment deposited before the 18th century, probably indicating a sediment re-deposition problem. This site was therefore re-visited in February 1998 to collect cores from the central region of the lake rather than the marginal zone.

February 1998: The site was revisited on the 7th of February 1998 and using a fast inflatable boat the central area of the lake was visited. A location some 5 km from the Abu Qir base (31.1504 N, 30.1242 E) was first selected with a water depth of 1.20m (31.25064 N, 30.20681 E). Trial coring showed the sediment to be rather compacted here and so the location was moved ca. 1 km east. At this point, some 500 m from the fringing vegetation on the east side of the lake water depth was 1.30 m and sediment was slightly less compacted. Three cores were collected from this location, IDKU3, IDKU4 and IDKU5, and were 59, 68 and ca. 65 cm in length respectively. IDKU3 was selected as the master core, IDKU4 was prepared for macrophyte, pollen and fungal spore analysis and IDKU5 was left unextruded and transported intact to the UK for magnetic analysis.

Monitoring - November 1997

Secchi depth: 38 cm and the water was brown and rather turbid.

Water samples: Two 1 l samples (one filtered through a GF/C filter) and one unfiltered 100 ml sample were collected from near the end of the vegetation transect.

Phytoplankton: 1.5 l of lake water was collected from near the end the vegetation transect and treated with several ml. of Lugols Iodine.

Zooplankton: None was collected during this visit.

Fish pesticides and trace metals: Samples of liver from specimens of Bolti (*Tilapia niloticus*) caught in the lake were removed and frozen. A total of approximately 10 g of liver tissue were removed from the fish and placed into aluminum foil and then into whirlpac bags and frozen. Three fish were sampled for pesticide content and three fish for trace metal contamination.

The size of each fish was measured:

Fish 1 (trace metals)	Total length = 19 cm	Length to caudal fin base = 17 cm
Fish 2 (trace metals)	Total length = 20.5 cm	Length to caudal fin base = 18 cm
Fish 3 (trace metals)	Total length = 19 cm	Length to caudal fin base = 16.5 cm
Fish 4 (pesticides)	Total length = 19 cm	Length to caudal fin base = 16.5 cm
Fish 5 (pesticides)	Total length = 19 cm	Length to caudal fin base = 16.5 cm
Fish 6 (pesticides)	Total length = 22 cm	Length to caudal fin base = 19 cm

February 1998:

Fish	1 (Pesticides)	Total length = 16.5 cm	Fork length = 14 cm	Weight = 86 g
	2 (Pesticides)	= 15 cm	= 12 cm	= 74 g
	3 (Pesticides)	= 14 cm	= 11.5 cm	= 57 g
	4 (Trace metals)	= 13 cm	= 10.5 cm	= 37 g
	5 (Trace metals)	= 14.5 cm	= 11.5 cm	= 56 g
	6 (Trace metals)	= 13 cm	= 10.5 cm	= 39 g

Note: Because of small fish size, each 'fish' sample consists of three equal sized individuals bulked to provide enough liver tissue for analysis so that the scales, length and weight measurements refer to one specimen in each group.

Fish scales: Several scales were removed from the shoulder region of each fish (see 'note' above) and placed into individual whirlpac bags for analysis later in Tunis.

Gauging post: A simple pumping station (a water wheel set into a concrete base frame) has been constructed at the north end of the access channel. This device is occasionally used to pump water from the lake into the date palm groves immediately to the north of the lake. Water depth was measured from the south corner of the concrete base frame. The *straight* edge of the concrete plinth extended **48** cm above the surface of the water.

Vegetation transect: The dominant vegetation along one transect, 270 m long, was recorded at 30 m intervals. The transect began at a point 3 m due south of the Edku railway line and continued along the east side of the access cutting out into the partially open water of the main lake. The start of the transect was marked with a pile of stones and the end was marked with a wooden stake. Because of the semi permanent nature of the access channel some modifications of the fringing vegetation had occurred. In addition to the clearance of emergent vegetation, the edges of the channel were colonized by water hyacinth and *Typha* was frequently present as a fringing growth along these lateral margins of the main *Phragmites* stand. Consequently, the vegetation types used in the transect descriptions were taken from 1 m within the vegetation stand rather than from along the immediate edge of the channel. Patches of *Potamogeton pectinatus* were common beyond the reed beds but none occurred on the transect survey.

First vegetation monitoring survey (15.11.1997).

LAKE EDKU - 15.11.97 - Vegetation transect - Start 31.26574^0 N, 30.21107^0 E Finish 31.26409^0 N, 30.21127^0 E. Sampling at 30 m intervals.			
Quadrat Number	Distance (m)	Plant species	Remarks
1	0	*Typha* 10% *Gramineae* 90% (mainly *Cynamidon dactylum*)	Start: stones at edge of railway embankment.
2	30	*Phragmites* 95% *Typha* 5%	Undisturbed reed beds
3	60	*Phragmites* 98% *Typha* 1% *Halochnemon* sp. 1%	

4	90	*Phragmites* 75% *Portulaca olireca* 15% *Convolvulus arvensis* 10%	
5	120	*Phragmites* 100%	
6	150	*Phragmites* 100%	
7	180	*Phragmites* 100%	
8	210	*Phragmites* 100%	
9	240	Water hyacinth 100%	Open water with floating vegetation. No submerged macrophytes present.
10	270	Water hyacinth 100%	Open water with floating vegetation. No submerged plants

February 1998 vegetation data to be given in a later report.

LAKE BURULLUS (SITE CODE = BULR)

This site was visited on the 15th and 16th of November, 1997. This large (ca. 60 x 10 km) shallow northern Delta lake probably has been subjected to less disturbance than Edku but is subjected to land reclamation, particularly along it southern and western edges. Productive agriculture consisting largely of date palm and sugar cane plantations on these sides has been encouraged by increased supply of Nile water for irrigation in recent decades. The northern border of the lake is a sand ridge that separates the lake from the sea, the latter is some 2-3 km distant. This narrow strip of land is currently under development with a major road linking Rashida with Dumyat under construction and there are plans to establish a new town on the north shore of the lake.

The hydrological regime of this lake is a balance resulting from freshwater runoff from the agricultural regions in the south and west and from seawater inputs from the north east via the small channel at El Borg.

The lake is classified as a 'Ramsar' site and plays host to large populations of migratory water birds. Extensive beds of *Phragmites* and *Typha* surround much of the lake and with the numerous small islands these also support large numbers of resident birds. *Typha* is more abundant that at Edku but water hyacinth is less so. Immediately beyond the reed beds on the northern side of the lake there are extensive patches of submerged *Pomatogeton pectinatus* (known locally as "waar") which are regarded as important refuges for bolti (*Tilapia*) fry. Charophytes are also present. The emergent macrophyte belt is some 200-330 m wide along the northern shore and so makes assess to the open lake difficult. The margins of narrow channels cut through the reeds for fishing purposes were used for sample transects.

According to local people, the lake is becoming more fresh and this is causing increased problems from bilharzia. Water quality is apparently being lowered by sewage and

agrochemicals supplied mainly from the southern and western regions surrounding the lake. However, fishing is good with *Tilapia* up to 5 kg being caught.

Sediment coring

Two sediment cores BULR1 and BULR3 were collected from the western sector of the lake in open water about 1.5 km south of the north shore fringing reed beds. Both cores were collected in 1.35 m of water and located at **31.42063° N** and **30.63400° E**. The length of BULR1 was 35 cm (as measured in field) and BULR3 was 34 cm. No submerged macrophytes were present in the open water coring area. The sediment was brown throughout and from about 2 cm to 8 cm sediment depth the sediment was composed largely of *Cardium* shells and bivalve fragments.

The exposed shallow open water site was unsuitable for accumulation of the remains of aquatic macrophytes and consequently a third core was taken from a small bay within the marginal vegetation on the north shore (**31.43164° N, 30.63755° E**). Coring was carried out between the patches of submerged vegetation *(P. pectinatus)*. Core BULR3 was 68 cm long and collected from a water depth of 1 m. The greater length of the marginal core reflects the greater organic content of the sediment and less compaction compared with sediment at the open water location.

Monitoring

Secchi disc depth: 38 cm at the open water sediment coring site and the water was brown and rather turbid.

Gauging post: There were no permanent structures on the shore at the point of sampling but in the access channel within the reed beds a substantial boat mooring post had been driven into the shallow water sediment. The straight part of the mooring post was marked at 20 cm intervals and measured to be 86 cm above the present water level. Water depth at the post was 60 cm. Location of the mooring post is **31.436123° N, 30.64183° E.**

Temperature: Lake Burullus was selected as the Egyptian site for temperature measurement at twice daily intervals. A solid state temperature logger (Whatman Instruments) was attached to a stake and fixed into position about 50 cm west of the mooring post so that the logger was located at 50 cm water depth.

Water samples: Two 1 l samples (one filtered through a GF/C filter) and one unfiltered 100 ml sample were collected from near the end of the vegetation transect.

Phytoplankton: 1.5 l of lake water was also collected from near the end the vegetation transect and treated with several ml. of Lugols Iodine.

Zooplankton: None was collected on this visit.

Fish pesticides and trace metals: Samples of liver from specimens of *Tilapia* caught in the lake were removed and frozen. A total of approximately 3 g of liver tissue were removed from the fish and placed into aluminum foil and then into whirlpac bags and frozen. Three fish were sampled for pesticide content and three fish for trace metal contamination.

The size of the fish was measured:

November 1997

Fish 1 (trace metals)	Total length = 11.5 cm	Length to caudal fin base = 9 cm
Fish 5 (trace metals)	Total length = 14.0 cm	Length to caudal fin base = 12 cm
Fish 6 (trace metals)	Total length = 11.5 cm	Length to caudal fin base = 9 cm
Fish 2 (pesticides)	Total length = 13.0 cm	Length to caudal fin base = 11 cm
Fish 3 (pesticides)	Total length = 12.0 cm	Length to caudal fin base = 10 cm
Fish 4 (pesticides)	Total length = 12.0 cm	Length to caudal fin base = 10 cm

Note: Compared with the other two sites these fish are too small, they represent a different age class and make for difficult dissection of the livers. It is recommended that all bolti sampled should be about 20 cm long.

February 1998:

Fish 1 (Pesticides)	Total length = 14.5 cm	Body length = 12.0 cm	Weight = 53 g
2 (Pesticides)	= 12.0 cm	= 10.0 cm	= 36 g
3 (Pesticides)	= 13.5 cm	= 10.5 cm	= 45 g
4 (Trace metals)	= 11.5 cm	= 9.5 cm	= 23 g
5 (Trace metals)	= 11.0 cm	= 9.0 cm	= 22.7 g
6 (Trace metals)	= 12.0 cm	= 9.5 cm	= 22.5 g

Note: Because of small fish size, each 'fish' sample consists of three equal sized individuals bulked to provide enough liver tissue for analysis so that the scales, length and weight measurements refer to one specimen in each group.

Fish scales: Several scales were removed from the shoulder region of each fish and placed into individual whirlpac bags for analysis later in Tunis.

Vegetation transect: The dominant vegetation along one transect, 450 m long, was recorded at 30 m intervals. The transect began at the northern edge of the lake within about 7 m of a shore dwelling and continued out along the western side of an access channel cleared for boats. Because of the semi permanent nature of the access channel some modifications of the fringing vegetation had occurred. In addition to the clearance of emergent vegetation, the edges of the channel were colonized in places by water hyacinth. *Typha* was more abundant than was apparent at Lake Edku.

First vegetation monitoring survey (15.11.1997):

Lake Burullus - 15.11.97 - Vegetation transect - Transect 1, Start 31.26182^0 N, 30.38496^0 E; Finish 31.25893^0 N, 30.38503^0 E. 30 m intervals.			
Quadrat Number	Distance (m)	Plant species	Remarks
1	0	*Typha* 100%	Start at lake edge: Post 6 m from house used as starting point.
2	30	*Typha* 100%	Boat mooring and temperature logger emplacement.
3	60	*Typha* 100%	
4	90	*Typha* 80% Water Hyacinth 20%	
5	120	Shelly sediment 100%	Open water, no submerged plants

6	150	*P. pectinatus* *Najas armata*	80% 20%	Open water channel
7	180	*P.pectinatus* *N.armata*	90% 10%	Open water channel
8	210	*N. armata*	100%	Open water channel
9	240	*P. pectinatus*	100%	Open water channel
10	270	*Typha* *Phragmites*	90% 10%	2nd island of *Typha*
11	300	*Typha*	100%	Macrophyte stand c. 15m wide
12	330	*Typha*	100%	Macrophyte stand c. 5m wide
13	360	*P. pectinatus* *N. armata*	90% 10%	Open water channel
14	390	*P. pectinatus* *N. armata*	95% 5%	Open water channel
15	420	*P. pectinatus* *Phragmites*	99% 1%	Open water channel
16	450	*P. pectinatus*	100%	Open water

The second vegetation monitoring survey will be reported later.

LAKE MANZALA (site code = MANZ)

This site was visited on the 18th and 19th of November 1997. The lake is large extending to some 1200 km^2 in area. Considerable reclamation has taken place and Meininger & Gamil (1994) note that the lake area was originally 1710 km^2. The main opening of the lake to the sea is at El Gamil in the north-eastern part of the lake. The lake is fed by several canals the largest of which is the Bahr el Baqr. The canals carry water enriched with agrochemicals and/or untreated sewage and thus pollute the lake, grossly in the eastern sector. The lake is traversed, in an east - west direction, by the Dumyat - Port Said road. This road is constructed across several islands and landfill/drainage activity is and has been very extensive in this region and much of the area north-west of the road is now wholly or partly reclaimed.

The south-western region of the lakes is probably least disturbed with no obvious signs of water pollution and still retains large areas of aquatic plants and major stands of *Phragmites* and *Typha*. These stands are cut and harvested and sometimes treated with herbicides; water hyacinth has colonized larger areas of the lake. Furthermore, the 'Peace Canal' was constructed in the 1980s along the western and southern margins of the lake. This canal allows Nile water to flow around the edge of the lake from Dumyat to the Sinai. Immediately along side the canal a new road is currently being constructed and the sampling points for CASSARINA were selected following access by this road. This margin of the lake has therefore been severely disturbed during the 1980s but the effects seems fairly limited with regard to disturbances of the lake vegetation. Despite reclamation and disturbances, the reed beds are still extensive and some parts of the lake remain rich in bird life and fish.

Sediment coring

Three cores MANZ1, MANZ2 and MANZ3 were collected from the open water central region of the south-western sector of the lake, about 15 km east of Fariskur. Water depth was 1.35 m and the bed of the lake in this region was covered with *Potamogeton*

pectinatus. The water was very clear and free of any significant suspended matter. The location of the sediment cores was **31.29561° N, 31.88191°** E. The length of MANZ1 was 53 cm (as measured in field) and MANZ2 and 3 were 82 and 40 cm respectively. The sediment was brown throughout and some shell fragments were present in the deeper section.

Monitoring

Gauging post: There were no permanent structures on the shore at the point of sampling but a substantial boat mooring post had been driven into the shallow water sediment about 6 m east from the start of the vegetation transect. The mooring post was marked at 20 cm intervals and the top was **58 cm** above the present water level. Location is the same as that for the start of the vegetation transect.

Temperature: Water temperature was 19^0C

Secchi depth: At the open water sediment coring site this exceeded the depth of water (>1.35 m). At the area of the vegetation transect the water was more brown and rather turbid with a Secchi depth of 50 cm.

Water samples: Two 1 l samples (one filtered through a GF/C filter) and one unfiltered 100 ml sample were collected from the open water site from where the sediment cores were collected.

Phytoplankton: 1.5 l of lake water was also collected from the coring location and treated with several ml. of Lugols Iodine.

Zooplankton: None was collected on this visit

Fish pesticides and trace metals: Samples of liver from specimens of *Tilapia* caught in the lake near the vegetation transect were removed and frozen. A total of approximately 10 g of liver tissue were removed from the fish and placed into aluminum foil and then into whirlpac bags and frozen. Three fish were sampled for pesticide content and three fish for trace metal contamination.

The size of the fish was measured:

November 1997:

Fish 1 (trace metals)	Total length = 20 cm	Length to caudal fin base = 17 cm
Fish 2 (trace metals)	Total length = 20 cm	Length to caudal fin base = 17 cm
Fish 3 (trace metals)	Total length = 21 cm	Length to caudal fin base = 17 cm
Fish 4 (pesticides)	Total length = 21 cm	Length to caudal fin base = 18 cm
Fish 5 (pesticides)	Total length = 21 cm	Length to caudal fin base = 17 cm
Fish 6 (pesticides)	Total length = 20 cm	Length to caudal fin base = 17 cm

March 1998:

Fish 1 (Pesticides)	Total length = 22 cm	Fork length = 17 cm	Weight = 245 g
2 (Pesticides)	= 19.5 cm	= 16 cm	= 151 g
3 (Pesticides)	= 18 cm	= 15 cm	= 128 g
4 (Trace metals)	= 18 cm	= 15 cm	= 128 g

Note: Only four fish were obtained on this sampling occasion.

Fish scales: Several scales were removed from the shoulder region of each fish and place into individual whirlpac bags for analysis later in Tunis.
Vegetation transect: The transect was started on the shore of the lake at a point 60 m north-east of a small bridge crossing the Peace Canal. The start point was about 1 m from the water's edge where a large raft of water hyacinth had developed. The transect is some 100 m north of a small fishing base consisting of several huts and simple moorings for some 15 boats. The area immediately in front of the huts was reportedly treated with herbicides about 8 years ago. In front of the huts a wide channel is kept largely free of vegetation for boat access. This area was chosen for the transect and the transect line runs along the poorly defined northern limit of this channel.

The natural depth of water was nowhere more than 1.75 m and the south-west region is made up of a mosaic of roadbeds (mainly *Phragmites* but some *Typha*) and patches of open water partly colonized by water hyacinth. At the beginning of the transect, a water depth of around 2.5 m was recorded and this marks an over-deepened channel resulting from the removal of sediment for construction of the Peace Canal embankments in the early 1980s. *Ceratophyllum demersum* was locally abundant.

First vegetation monitoring survey (17.11.1997):

Manzala - 17.11.97 - Vegetation transect - Transect 1, Start 31.32003^0 N, 31.81229^0 E. Sample intervals 60m. Compass bearing 84^0 E.					
Quadrat Number	Distance (m)	Depth (m)	Plant species		Remarks
1	0	0	*Juniperus*	100%	Small bush (*Juniperus*) at lake margin.
2	60	2.5	Algal mat	100%	Blue green mat on bottom sediment
3	120	2.5	Mud *Pot. pectinatus*	95% 5%	
4	180	1.5	Shelly mud *Ceratophyllum demersum*	95% 5%	
5	240	1.5	Shelly mud *C. demersum*	90% 10%	
6	300	1.75	Shelly mud *C. demersum*	80% 20%	
7	360	1.5	Shelly mud *C. demersum*	60% 40%	Large patch of water hyacinth 2 m North
8	420	1.75	Shelly mud *C. demersum*	50% 50%	
9	480	1.75	Water Hyacinth *C. demersum*	100% 100%	*C. demersum* is underneath the water hyacinth.
10	540	1.5	Shelly mud *C. demersum*	85% 15%	
11	600	1.5	Shelly mud *C. demersum*	50% 50%	
12	660	1.25	Shelly mud *C. demersum*	75% 25%	
13	720	1.25	Shelly mud *C. demersum*	60% 40%	
14	780	1.5	Shelly mud *C. demersum*	20% 80%	
15	840	1.5	Shelly mud *C. demersum*	80% 20%	

16	900	1.25	Shelly mud *C .demersum*	75% 15%	
17	960		*Phragmites*	100%	*Phragmites* beds here were ca. 50m wide with open water on other side.

The second vegetation monitoring survey will be reported later.

LAKE QARUN (Code = QARU)

This lake is fed by a branch of the River Nile and is located south of Cairo and the Nile Delta region. It is saline and possesses very few aquatic macrophytes. It is of considerable interest as a human impacted site undergoing salinization due to diversion and abstraction of its fresh water supply. However, being different in nature to the coastal lakes it has been selected as a secondary CASSARINA site.

Sediment coring was undertaken on March 10th 1998 and two ca. 1 m long sediment cores were collected from the deepest point in the lake (8.46 m).

INITIAL CONCLUSIONS

The first year of field work for the nine primary CASSARINA sites has been in almost all aspects successfully completed. For the palaeo-environmental aspects of the project, sediment cores have been collected from all the sites and are currently under-going analyses for chronologies, lithostratigraphy, geochemistry, pesticides, pollen, diatoms, macro-fossils, zooplankton remains and magnetic minerals. This latter analytical technique was not included in the original proposal but scientists at the University of Liverpool have undertaken this work without funding.

For the monitoring aspect of the project, vegetation transects and monitoring for phytoplankton, zooplankton, fish and water quality (temperature, water chemistry, water depth and turbidity) have been started for all nine primary sites. Samples are currently at various stages, under-going exchange between laboratories and analytical procedures.

Problems so far have been minor and include loss of several water depth gauging posts and limiting of several vegetation transects because of high water. Direct analysis of sediment cores for fungal spores has not provided useful results but this work will proceed using culture methods to encourage fungal growth in lake sediment samples.

During the initial vegetation surveys it soon became apparent that for the larger lakes (especially the Egyptian sites) some form of remote sensing capability is required to enable adequate monitoring on a wider scale. Advantage has therefore been taken to establish contacts with remote sensing and satellite surveillance groups in each North African country with a view to incorporating this technique in any future CASSARINA programme.

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