Report

Bass, J. A. B.; **May, L.**. 1996 *Zooplankton interactions in the River Thames. Zooplankton sampling procedures. Interim report.* NERC/Institute of Freshwater Ecology, 7pp. (IFE Report Ref: ERL/T04073o7/1)

Institute of Freshwater Ecology

ZOOPLANKTON INTERACTIONS IN THE RIVER THAMES

Zooplankton sampling procedures

Interim Report

J.A.B.Bass
L.May

Natural Environment Research Council

Institute of Freshwater Ecology
Eastern Rivers Laboratory
Monks Wood, Abbots Ripton,
Huntingdon, Cambs PE17 2LS

Telephone: 0148-777-3381 Fax: 0148-777-3467

ZOOPLANKTON INTERACTIONS IN THE RIVER THAMES
Zooplankton sampling procedures

Project Manager: Mr J.A.B.Bass

Interim Report to National Rivers Authority (Thames Region) - 31 January 1996

Principal Investigators:

Mr J.A.B.Bass
Dr L.May

Contract Completion Date: 31 March 1996
CEH Project No: T0407307
IFE Report No: T0407307/1

The Institute of Freshwater Ecology is part of the Centre for Ecology and Hydrology of the Natural Environmental Research Council.

EXECUTIVE SUMMARY

River management schemes proposed for the River Thames, such as the construction of new reservoirs or the transfer of water from other catchments, are likely to result in changes in water quality and quantity downstream with potential impacts on the river zooplankton. This report aims to provide guidance to the NRA on sampling procedures suitable for monitoring zooplankton populations in the River Thames in order to establish current (baseline) conditions and detect and monitor future change.

Recommendations:
1) Relatively large sample volumes of river water should be collected from discreet depths with a small battery-powered submersible pump.
2) Monitor separately the abundance of small abundant taxa (eg rotifers) and large comparatively infrequent taxa (eg Cladocera and copepodites).
3) Examine contemporary and seasonal differences in zooplankton at 5 river sites.
4) Examine spatial differences in zooplankton populations at 2 river sites, of relevance to grazing pressure on phytoplankton and food resource availability to other dependant fauna.

IFE Study - Outline Cost Estimates:

Sampling in 1996 -	£18,000
Sample processing, faunal identification, data analysis, report preparation -	£16,700

CONTENTS

1. Background

River management schemes proposed for the River Thames, such as the construction of new reservoirs or the transfer of water from other catchments, are likely to result in changes in water quality and quantity downstream. This is likely to impact on the river zooplankton by changing their abundance and seasonal occurrence. These effects may have important implications for other trophic levels within the river community. For example, phytoplankton populations may be modified by altered grazing pressures, leading to an increase in troublesome algal blooms. The growth and survival of the juvenile fish, which feed on zooplankton, may be changed, altering the balance of fish species within this popular coarse fishery. In addition, the macroinvertebrate community, which includes species used as water quality indicators, is likely to respond to the changed food supply.

In spite of their apparent importance as grazers of phytoplankton and food for fish within the river community, the zooplankton of the River Thames has received little attention from biologists in the past. However, now that management changes to the river are planned, it is important to collect baseline data for the River Thames zooplankton community which can be used to predict the likely effects of a variety of proposed river management strategies and monitor the effects of the water management policies ultimately adopted. The problems of designing a suitable zooplankton sampling strategy which will (1) provide baseline zooplankton data for the River Thames and (2) effectively detect and monitor changes resulting from the water management policies ultimately adopted, are addressed below.

This Interim Report precedes both the literature review of river zooplankton and detailed discussion with Thames NRA biologists. In consequence, specific details of the sampling protocol may be revised in the Final Report (March 1996).

2. Objectives

This report aims to provide guidance to the NRA on sampling procedures suitable for monitoring zooplankton populations in the River Thames in order to establish current (baseline) conditions and detect and monitor future change. The main objectives of the monitoring programme are:

- to identify the main zooplankton species present
- to establish broad, seasonal patterns of zooplankton abundance
- to detect change

Current NRA sampling locations for phytoplankton (as supplied by NRA - see Appendix) have been taken into account.

3. Outline sampling strategy

Many factors must be taken into consideration when designing sampling strategies for the estimation of zooplankton densities in river environments. The most important of these are:

- rapidly changing population densities
- patchy spatial distribution
- wide ranging sizes and shapes of zooplankton organisms
- suitability of sample preservation techniques
- feasibility

These factors are discussed below, under the relevant headings.

3.1 Site selection

Zooplankton are generally unevenly distributed within a river due to patterns of water flow and turbulence, their own ability (or inability) to control their swimming speed and direction, and downstream changes in water quality. This must be taken into account when determining the number and location of sampling sites along and across a section of river.

Stratified sampling procedures are necessary to overcome these problems. As a result, we propose that zooplankton are collected at 5 sites along the river between Buscot and Reading, utilising situations where the NRA already record phytoplankton and other variables on a regular basis. It is proposed that, at 2 of these 5 sites, samples should be collected from 2 water depths (0.3m and 1.0m) at each of 5 locations across the width of the river. *It should be noted that such stratified sampling requires the use of a boat.*

3.2 Sampling interval

Zooplankton population densities can change very rapidly in rivers, partly due to changes in food availability and predation rates, but also because they are, by their very nature[1], particularly susceptible to washout events during periods of high flow. To obtain an overview of the zooplankton in the River Thames, therefore, requires fairly short interval sampling (i.e. at similar time intervals similar to those required for effective monitoring of the phytoplankton).
As river zooplankton is dependant on the presence of suitable phytoplankton densities, it is proposed to confine sampling to spring, summer and early autumn.

3.3 Sampling Methods

Within the zooplankton, different groups vary widely in the size of individual animals and the population densities that they can attain. These factors are important considerations when determining sampling methods and sample size. In general, small taxa (such as

---

[1] plankton : drifting organisms in oceans, lakes or rivers (Chambers 20th Century Dictionary, New Edition 1983)

rotifers and copepod nauplii) are found in greater abundance than larger taxa (such as Cladocera and copepodites).

Zooplankton samples can be collected by a variety of methods including plankton nets, closing bottles or water pumps. In general, plankton nets are inappropriate for quantitative sampling in river environments due to the problems of estimating the amount of water flowing through them while the sample is being collected. This would require accurate measurements of flow rates at each sampling location, for each sample taken. For this reason, samplers which collect a known volume of water, such as closing bottles, water pumps, or even buckets, are likely to provide better samples for quantitative analysis. Where samples need to be collected from discreet depths, as is the case for the River Thames, closing bottles and pumps have obvious advantages over a bucket on the end of a piece of string! A detailed assessment of the relevant literature will be provided in the Final Report.

The choice between closing bottles (e.g. Ruttner bottles, Friedinger samplers) and pumps depends on the amount of water that needs to be collected. Bottles collect only small volumes (usually 1-10 litres) which may be insufficient for low densities of zooplankton. For the River Thames, it is probably better to collect relatively large sample volumes from discreet depths with a battery-powered pump and ancillary equipment such as that described below.

Once collected, the animals present in a large water sample must be concentrated into a smaller volume of water for transportation back to the laboratory. Although sedimentation and centrifugation are the most effective methods of concentrating samples whilst retaining as many as possible of the organisms they contain, these methods are rarely practical in the field or for large sample volumes. For the River Thames study, the most practical method of concentrating the samples collected is probably by passing known volumes of water through a sieve of suitable diameter to avoid spillage (20cm). The choice of mesh size determines the size ranges of the animals retained. A mesh size of 63µm will collect most of the larger zooplankton, but very much smaller mesh sizes of about 30µm (i.e. similar to a phytoplankton net) must be used for rotifers (see Bottrell *et al.*, 1976). At typical pumping rates of around 15 litres per minute water can be pumped directly through a 63µm sieve of 20cm diameter into a container of known volume. However, with a mesh size of about 30µm considerably slower throughflow rates will be possible and careful decanting into the sieve of a know pumped volume may be more practical. It is anticipated that comparatively high population densities of very small rotifers will occur in the Thames during spring-early summer. At this time, 1 litre samples of unfiltered water will yield sufficient animals to calculate population densities of the most common taxa.

Zooplankton sampling equipment

The equipment described below has been used to sample zooplankton successfully from a boat and the river bank on the R. Great Ouse over a number of years. The design is suitable for collecting comparatively large volumes of water at discrete locations within large rivers.

1) A small submersible bilge pump (eg Aquaflow, Aquamarine, Southampton), capable of delivering over 400 litres (using one battery) at c.15 litres per minute (with height of "lift"

<2m).
2) Two rechargeable 12 volt batteries (fully sealed lead/acid gel type).
3) Four metres of clear, semi-rigid and smooth plastic tubing, of c. 2cm internal diameter.
4) A light but rigid aluminium pole (length 2 m) with graduated depth markings.
5) A robust 20 litre water container with intermediate volumes marked.
6) 20cm diameter sieves with appropriate mesh apertures.
7) A selection of 1 litre and 0.5 litre polyethylene labelled sample containers, washbottles for filtered river water and 70% ethanol (IMS) and a spillproof dispenser for Lugol's Iodine.

The bilge pump is strapped at the end of the aluminium pole with about 2.5m of the tubing attached to the pump outlet. The lowermost 1.5m of tubing is also strapped to the pole, in line with the pump, with 1.0m of tubing remaining free to direct water into a container or sieve. A short length (c. 20cm) of clear tubing is placed on the pump inlet in order to minimise pump-avoidance by mobile taxa. A water-resistant on/off switch is fitted on-line between the battery and the pump, this may be strapped at the opposite end of the graduated pole to the bilge pump. Push-fit spade battery terminals permit a change of battery during fieldwork, should this be necessary.

3.4 Sample preservation

Large zooplankton

Following retention of the larger zooplankton on a 63µm sieve, a washbottle containing water is used to rinse material to the edge of the sieve. A second washbottle containing 70% ethanol (Industrial Methylated Spirit) is used to jet material from the sieve into a labelled container, in which it is stored prior to identification in the laboratory.

Small zooplankton

It is recommended that samples collected for the enumeration of rotifers and other small zooplankton species should be preserved in Lugol's iodine in preparation for counting. However, some live material should also be retained and examined soon after the samples are collected as an aid to identification because preserved rotifers are notoriously difficult to identify to species level. It has also been found that anaesthetizing the animals with procaine hydrochloride prior to fixation with formaldehyde also allows the soft bodied rotifer species to be more readily recognised and counted in preserved samples (May, 1985?). It should be noted, however, that there are Health and Safety considerations linked to the safe use of procaine hydrochloride.

3.5 Sampling Locations

The selection of proposed sampling sites is made with a view to investigate seasonal and downstream changes in contemporary zooplankton populations within the middle reaches of the R.Thames. At three sites (*) samples of well mixed river water will be obtained - one site at the confluence with a major tributary and two sites just downstream from weirs. At a further two sites("), distant from upstream weirs, the potentially patchy distribution of zooplankton will be investigated.

suggested sites-

*Newbridge	SU40300140
*Days Lock	SU56809350
*Caversham Lock	SU72107420
"Radley College Boathouse	SU53809880
"Wallingford Bridge	SU61008950

at * sites -

(Precise sampling locations to be determined)
20 litres of water pumped through a 63µm sieve, for the larger and less frequent zooplanktonic taxa (preserved with 70% ethanol). 1 litre of unfiltered water (preserved with Lugol's iodine) for small and numerous taxa, also an additional 500ml for scanning living rotifers, to aid specific identification (chilled storage).

at " sites -

(Precise sampling locations to be determined)
20 litres of water pumped through a 63µm sieve, for the larger and less frequent zooplanktonic taxa (preserved with 70% ethanol). Additionally, ten unfiltered one litre samples (preserved with Lugol's iodine) to be taken across the river channel, from five points (at 0.3m and 1.0m from the water surface). One 500ml sample for scanning living rotifers, to aid specific identification (chilled storage).

3.6 Examination of samples in the laboratory

Qualitative analyses

The identification of some components of the zooplankton (eg certain rotifer species) requires examination of live material. This procedure requires the use of high power microscopes, measuring graticules and specialised techniques for restraining the live animals and for examining the mouthparts (trophi) of difficult rotifer species. There are a range of keys available for the identification of rotifer species. It is recommended that all such identifications are in accordance with Koste (1978). The requirement to examine live material limits the number of samples that can be processed within a realistic timescale.

Quantitative analyses

As the sampling strategy outlined above generates a large number of samples: (3 sites with single samples x2 zooplankton size categories: two sites x5 locations with x2 depths x2 zooplankton size categories (= 46 samples on each sampling date). It may be desirable to "pool" samples to reduce counting effort, ignoring the potential localised zooplankton patchiness. However, it should be noted that the 'average' zooplankton concentrations from pooled data may not reflect zooplankton grazing pressure (on algae) and also underestimate their availability to mobile fish fry (which depend on them as a food resource during their

first weeks of life). The method of pooling samples, e.g. by depth or within site, will be determined by consultation with NRA, taking account of the objectives of the study and the level of resources available.

The prepared zooplankton samples (randomly sub-sampled, as necessary) should be examined and counted in the laboratory as follows:

For the larger zooplankton organisms, preserved in ethanol, the sample is placed in a sieve and the alcohol replaced by water (to avoid bubbles forming in the counting chamber). The sieve contents are rinsed into a volumetric flask, made up to a known volume, then transferred to a beaker where the contents are well mixed prior to transfer of 1ml to a Sedgewick Rafter counting chamber. The contents of the whole chamber are scanned under a microscope (at x40 magnification) to overcome the potentially uneven distribution of animals. The population density of animals in the sample is calculated from the sub-sample size selected.

For the smaller organisms such as the rotifers, it is recommended that counts are made using a sedimentation chamber and inverted microscope at x100 magnification.

3.7 Estimated costs of sample collection and analysis by IFE staff

The following estimates are only provisional; firm costings can be provided if and when IFE are invited to undertake all or part of the proposed research.

Fieldwork -

15 site visits between March and September at two week intervals.
Two staff sampling plus one person for safety cover.
5 sites between Reading and Newbridge.
Provision of all equipment and materials required.

Approximate cost: £18,000 (excl. vat)

Sample processing, faunal identification, data analysis, report preparation -

counts from 46 samples on each of 15 sampling occasions.
live samples (15) scanned following each sampling occasion.

Approximate cost: £16,700 (excl. vat)

4. References

Bottrell, H.H., Duncan, A., Gliwicz, Z.M., Grygierek, E., Herzig, A., Hillbricht-Ilkowska, A., Kurasawa, H., Larsson, P. & Weglenska, T. (1976) A review of some problems in zooplankton production studies. *Norw. J. Zool.* 24: 419-456.

Koste, W. (1978) *Rotatoria: Die Rädertiere Mitteleuropas.* Publ. Gebrüder Borntraeger, Berlin, 2 vols, 673pp.

May, L. (1985) The use of procaine hydrochloride in the preparation of rotifer samples for counting. *Verh. Internat. Verein. Limnol.* 22: 2987-2990.

Appendix: Thames NRA Fish and Phytoplankton Survey details for the River Thames

(Thames NRA)

River Thames Phytoplankton Survey 1992-1995

August 1992 - August 1994 the following sampling sites:

Site Name	Grid Reference
Somerford Keynes	SU01809480
Inglesham	SU20409840
Newbridge	SU40300140
Folly Bridge	SP51400550
Radley College Boathouse	SU53809880
Abingdon Lock	SU50609700
Days Lock	SU56809350
Wallingford Bridge	SU61008950
Goring Lock	SU59608080
Caversham Lock	SU72107420
Romney Lock	SU97307810
Below Ravens Ait	TQ17406770

Samples taken over a 2-day period: sites sampled in an upstream direction.

From September 1994 onwards samples have been taken at Inglesham, Abingdon, Caversham Weir and Romney Weir. Samples are taken in 1 day, but again in an upstream direction.

The methodology used is shown on Figures 2 & 3.

Algal counts have been made for the periods 8/92-8/93 and 6/94-8/94. We are now considering the value of looking at Picoplankton, but I have no details of this.

River Thames Adult Fish Survey 1992, 1993 and 1994

Hydroacoustic and Electric Fishing

between Sandford and Benson Lock - divided into 5 reaches with approximate mean length of 6km:

Reach 1	Sandford Lock to Abingdon Lock
Reach 2	Abingdon Lock to Culham Lock
Reach 3	Culham Lock to Clifton Lock
Reach 4	Clifton Lock to Day's Lock
Reach 5	Day's Lock to Benson Lock

Specification for the River Thames Juvenile Fish Survey 1992, 1993, 1994 and 1995

Survey also carried out in 1991, but key objective was to establish methodology was suitable for River Thames sampling.

METHODOLOGY

The aim is to survey and describe the juvenile fish populations at selected sites in the River Thames between Oxford and Day's weir by seine netting.

Survey Sites - The following 14 sites will be sampled (see Appendix 1)

Site 1	-	SP498 075 Left Bank
Site 2	-	SP527 024 Right Bank
Site 3	-	SU539 986 Left Bank
Site 4	-	SU515 967 Left Bank
Site 5	-	SU498 957 Abingdon Marina
Site 6	-	SU497 948 Right Bank
Site 7	-	SU523 944 Right Bank
Site 8	-	SU531 939 Right Bank
Site 9	-	SU548 955 Right Bank
Site 10	-	SU555 957 Right Bank
Site 11	-	SU570 946 Right Bank
Site 12	-	SU568 933 Right Bank
Site 13	-	SU578 932 Left Bank
Site 14	-	SU586 933 Right Bank

Sampling will be undertaken at each site during late July between the hours of 11.00 am and 5.00 pm, preferably on a warm, sunny day. At every site, the following three habitat types will be identified and sampled once;

Shallow without macrophytes (<15% macrophyte cover, <1m mean depth)
Deep without macrophytes (<15% macrophyte cover, >1m mean depth)
Shallow with macrophytes (>35% macrophyte cover, <1m mean depth)

The Consultant will undertake a reconnaissance survey of the 14 sites to ensure all of the microhabitats are available at all sites. If these microhabitat types are not represented at the specified site, they may be fished within a zone extending 100m upstream and 100m downstream of the site and a revised grid reference recorded and notified to the Project Manager prior to commencing the sampling. A trial run of the sampling technique will be undertaken at the pre-start meeting, prior to formal sampling .

Sampling will be carried out by seine-net of dimensions 25m long x 3m deep constructed of 3mm knotless mesh netting throughout fitted with wing-end spreaders. The net shall be set from the bank by pulling in a semi-circle from the shore by a team member either wearing a dry suit and a buoyancy aid, or from a small boat. The depth of water sampled shall not be greater than 2m. Where macrophyte rich sites are sampled, the net shall be drawn in to the bank until fish are no longer able to escape and macrophytes trimmed using a scythe. The cut leaves and stems shall be sorted to remove all fish and placed on the bank; the net can then be hauled in the normal way.

The method for measuring area and volume swept by the net for use in calculation of biomass and density results is as follows:

As the seine net is set, five markers (net floats on approx 2m twine to a weight) will be dropped at equal intervals around the circumference (outside the net - see diagram below). Once the net has been hauled, the distance from a central point on the bank to each marker will be measured and the angle of each segment determined. The area for each segment and the whole netted area should then

be calculated.

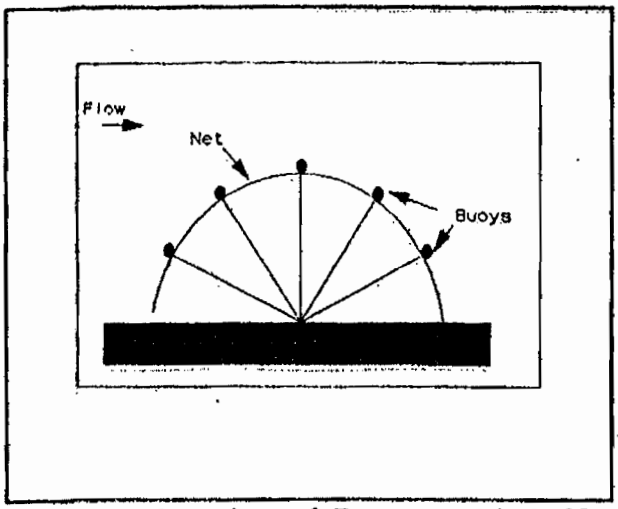

Figure 1: Location of Buoys to Mark Net Circumference

The successful contractor must supply all sampling equipment to be used and must present seine nets for inspection, and approval by NRA fisheries staff prior to the commencement of field work.

All fish smaller than 10cm FL will be anaesthetised in 2-phenoxy ethanol and then preserved in the field in 6% Formalin. The total number of fish sampled at each sub-site will be counted and if greater than 200 a random, statistically derived representative sample will be identified to species level, fork length (FL) measured to the nearest mm and a selection of scales removed. If 200 or less fish are sampled at a site, all fish will be measured as above.

Validation of the identification of juveniles will be undertaken on 10% (by number) of the specimens by a double-blind process and a record kept of the degree of disagreement, and reported. All samples must be preserved in fresh solutions of 6% Formalin at a ratio of approximately 25 parts liquid to 1 part fish within 3 months of field sampling. The samples must be retained in suitable containers, clearly labelled both inside and outside with site reference and date sampled, and must be returned to the NRA on completion of this contract.

A site report of all the environmental data shall be completed for each site with additional comments on; weather (sunny,cloudy, raining), cloud cover in eighths, approximate wind strength (Beaufort scale), and direction (compass), water clarity (Secchi disk) and including all habitat variables collected. An example of the site report format required is included in Appendix 2. It is also recommended that the Contractor complete a checklist at each site to ensure that all necessary data has been collected. An example (which may not be exhaustive) is provided in Appendix 2.

The habitat variables (i - v) defined below, will be assessed at each site. Parallel and horizontal transects will be positioned so that they cross at the approximate centre of the sampled area. Assessment of the habitat variables will be made, at all sites, by the same surveyor.

i) Depth - vertical depth to the nearest cm at metre intervals along each transect (see transects marked in Figure 2).

ii) Substrate type - inspection and classification of particle size as below for the sample area as a whole;
   a) % Plant
   b) % Clay

c) % Silt ((0.062mm grain size)
d) % Sand (0.062 - 2mm)
e) % Gravel (2 - 64mm)
f) % Rubble (64 - 250mm)
g) % Boulder (250 - 4000mm)
h) % Bedrock (solid rock)

iii) Cover - inspection and classification as below and before any macrophytes are trimmed). Aquatic macrophytes to be identified to species level and assessed using the DAFOR scale. Submerged plants to be sampled using a weed grab.

a) % submerged macrophyte
b) % floating macrophyte
c) % emergent macrophyte
d) % overhanging vegetation (within 1m of water surface)
e) % undercut bank
f) % other - please specify (eg. fallen branch)

iv) Velocity - to be measured at 0.2, 0.4, 0.6 and 0.8 water column depth, in metres per second to three significant figures, at points a, b, c, d and e as shown in Figure 2. Velocity will be low and will have to be measured using an electromagnetic current meter (which is sensitive to lower flows). Measurements must be made before any macrophytes are cut.

v) Temperature - to be measured at mid water column depth at metre intervals on both transects, to the nearest 0.1°C.

vi) Conductivity - to be measured mid-water using a conductivity meter, measured in micro-siemens per centimetre (μscm^{-1}).

vii) Mapping - a sketch map and a colour photograph of each sample location (3 per site, 42 in total) will be taken. The sketch will include mapping of cover.

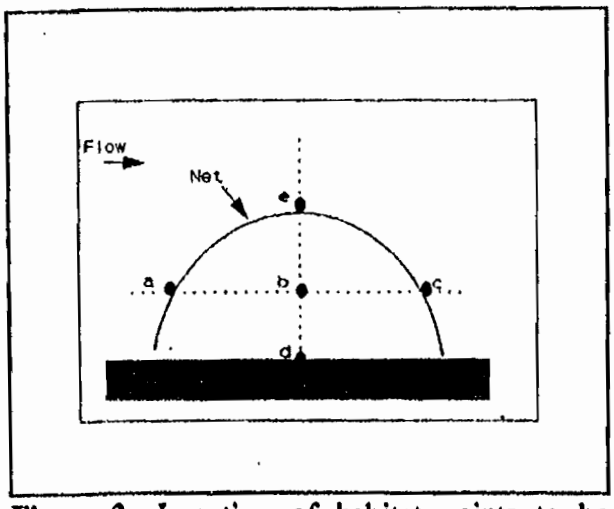

Figure 2: Location of habitat points to be sampled

Existing information on fish and environmental conditions will be provided for review.

Fig. 2

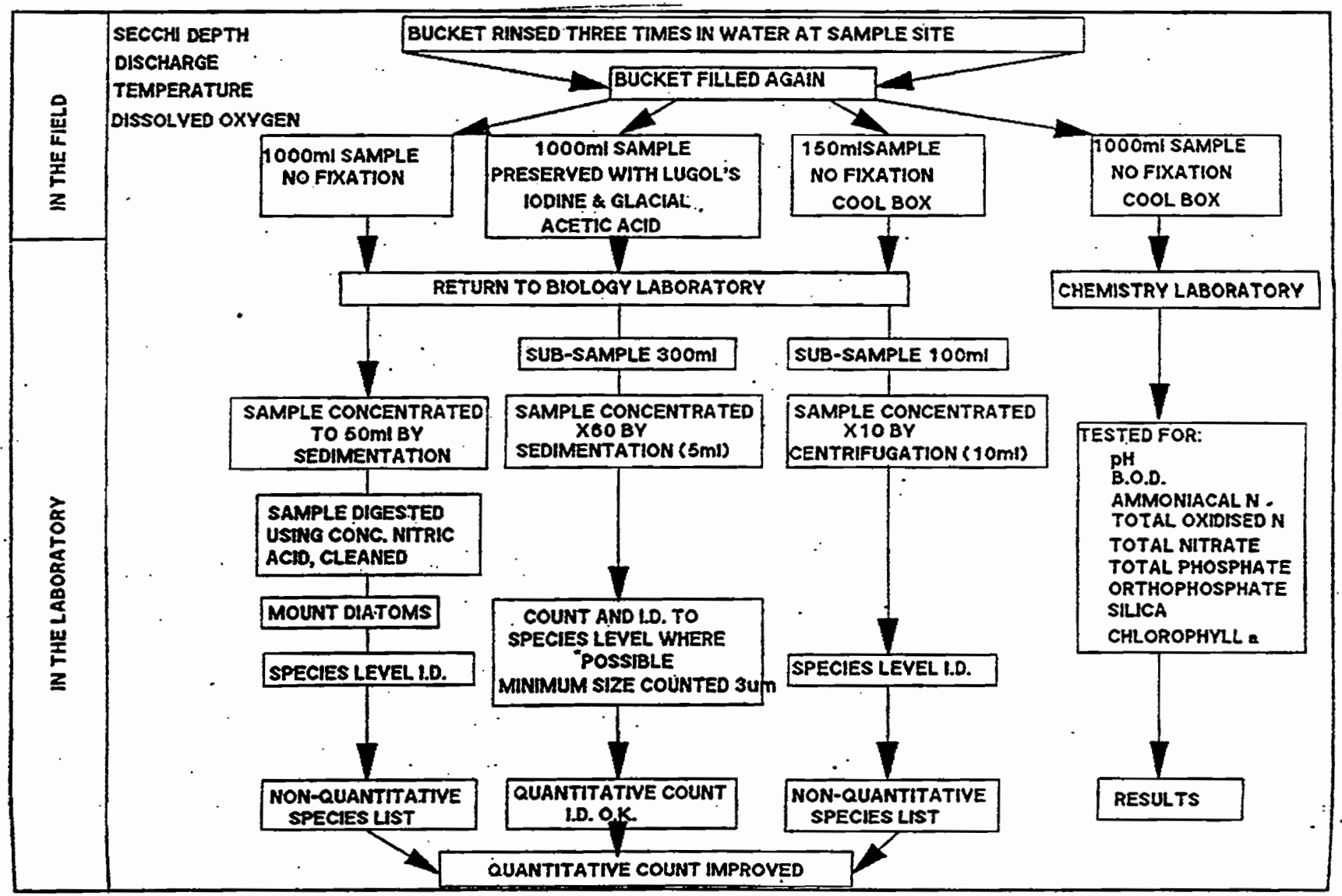
IN THE FIELD
IN THE LABORATORY
SECCHI DEPTH
DISCHARGE
TEMPERATURE
DISSOLVED OXYGEN
BUCKET RINSED THREE TIMES IN WATER AT SAMPLE SITE
BUCKET FILLED AGAIN
1000ml SAMPLE NO FIXATION
1000ml SAMPLE PRESERVED WITH LUGOL'S IODINE & GLACIAL ACETIC ACID
150mlSAMPLE NO FIXATION COOL BOX
1000ml SAMPLE NO FIXATION COOL BOX
RETURN TO BIOLOGY LABORATORY
CHEMISTRY LABORATORY
SUB-SAMPLE 300ml
SUB-SAMPLE 100ml
SAMPLE CONCENTRATED TO 50ml BY SEDIMENTATION
SAMPLE CONCENTRATED X60 BY SEDIMENTATION (5ml)
SAMPLE CONCENTRATED X10 BY CENTRIFUGATION (10ml)
TESTED FOR:
pH
B.O.D.
AMMONIACAL N
TOTAL OXIDISED N
TOTAL NITRATE
TOTAL PHOSPHATE
ORTHOPHOSPHATE
SILICA
CHLOROPHYLL a
SAMPLE DIGESTED USING CONC. NITRIC ACID, CLEANED
MOUNT DIATOMS
SPECIES LEVEL I.D.
COUNT AND I.D. TO SPECIES LEVEL WHERE POSSIBLE MINIMUM SIZE COUNTED 3um
SPECIES LEVEL I.D.
NON-QUANTITATIVE SPECIES LIST
QUANTITATIVE COUNT I.D. O.K.
NON-QUANTITATIVE SPECIES LIST
RESULTS
QUANTITATIVE COUNT IMPROVED

Fig.3 METHOD USED TO IMPROVE THE ACCURACY OF ALGAL IDENTIFICATION