THE STRUCTURE AND FUNCTION OF THE PLANKTON COMMUNITY IN THE PELAGIC ZONE OF LAKE NAIVASHA, KENYA

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2002

THE
PLANK

Declaration

This thesis is my original work and has not been presented in any other university

Signed _____ Date 10/12/02

This thesis has been submitted for the examination for the degree of Masters of Science of the University of Nairobi with our approval as the University Supervisors.

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Dedication

To my parents

The Late Mbogo Njoroge and Wanjiru Mbogo

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Abstract

In Lake Naivasha minimal fish predation upon the zooplankton due to low fish biomass and the absence of true planktivorous fish is suspected, from previous studies. The relative importance of the two forces, top-down and bottom-up control, on the structuring and interaction of the plankton community in Lake Naivasha was evaluated to test this assumption. Analyses of plankton (phytoplankton and zooplankton) were conducted on data obtained from three stations in Lake Naivasha at Crescent Island Lagoon, Main Lake and Oloidien basin (St 1, St 2 and St 3 respectively) between May 1995 and April 1996. Physico-chemical parameters were measured alongside plankton sample collection.

The lake water surface temperature measured between 9.00am and 10.00am ranged between 19.5 °C and 23.5 °C declining gradually towards the bottom. The mean dissolved oxygen concentrations ranged from 6.0 mg. l^{-1} and 7.4 mg.l^{-1}. The electrical conductivity of the lake water at St 1 and St 2 fluctuated between 320µS/cm and 420µS/cm. At St 3 the conductivity was higher and ranged from 2470µS/cm to 2850µS/cm.

The Secchi disc water transparency depth decreased with increase in phytoplankton biomass. The mean Secchi disc transparency depth was 72cm at St 1, 61cm at St 2 and 27cm at St 3. The phytoplankton biomass (measured as chlorophyll-'a' mg. m^{-3}) was highest at St 3 (112.3 $\pm$ 27.1 mg. ml^{-3}) than at St 1 and St 2 (36.1mg.m^{-3} and 30.8mg.m^{-3} respectively).

The phytoplankton community was dominated by filamentous net phytoplankton (cell size >20µm). At St 1 and St 2, Chlorophyta species mainly *Cosmarium sp., Oocystis sp., Scenedesmus sp.* and *Tetraedron sp.* dominated the phytoplankton density and contributed an average of 40% (285 cells ml^{-1}) and 45% (264 cells ml^{-1}) respectively. At St 3, the Bacillariophyta species (*Synedra sp., Aulacosiera sp.* and *Nitzchia sp.*) were the dominant and represented 43% (2913 cell ml^{-1}) of the mean total phytoplankton cell density. Limited nannoplankton (<20µm) represented by the taxa *Chroococcus sp., Cosmarium sp, Oocystis sp., Tetraedron sp., Chromulina sp., Trachelomonus sp.* and *Cryptomonus sp.* were encountered.

Crustacea dominated the zooplankton community, contributing 71%, 60.5% and 90.4% of the total density at St 1, St 2 and St 3 respectively. The species *Thermocyclops oblongatus* was the most dominant species in all stations throughout the study period. At St. 3 the zooplankton density ($9.7x10^5$ m^{-3}) was higher compared to that of St 1 ($3.2x10^5$ m^{-3}) and St 2 ($7.6x10^5$ m^{-3}). Similarly the zooplankton biomass, expressed as dry weight was highest at St 3 (473.8 dry wt. mg. m^{-3}) compared with St 1 (278.6 dry wt. mg. m^{-3}) and St 2 (204.4 dry wt. mg. m^{-3})

The zooplankton body sizes ranged from 66µm to 2040µm. The occurrence of large bodied zooplankton species (*Thermocyclops oblongatus Daphnia pulex, Diaphanosoma excisum, Simocephalus vetulus)* suggested low utilisation by fish. There was thus no direct influence of predation in the structuring of the zooplankton and in turn that of the phytoplankton.

CHAPTER 1: INTRODUCTION

1.1 The plankton

A major aim of both theoretical and applied aquatic research has long been to understand the patterns of flow of carbon and other elements through the pelagic biota in lakes and seas (Stone *et. al.,* 1993). The nature and magnitude of the patterns of flow of these entities determines the production cycles of aquatic ecosystems. The plankton community both autotrophic and heterotrophic plays a very significant role in the trophic dynamics of aquatic systems, due to their prominent position in the aquatic food chain (Mavuti 1983), compounded by their intrinsic rapid turnover rates and metabolism. The phytoplankton community (primary producers), form the basis of aquatic systems' production. This is through the fixation of carbon dioxide, utilisation of sunlight and the uptake of the dissolved nutrients in water, to provide energy readily available to the higher ranks of the food chain. The major link at the trophic interface between these primary producers and the higher consumers (e.g. fish) are the heterotrophic protozoa (ciliates and flagellates), Rotifera and Crustacea zooplankton, particularly the Cladocera e.g. *Daphnia* and Copepoda (Sherr *et. al.,* 1986).

The zooplankton then form food for the early life stages of fish after hatching (Ahyaudin 1990) and adult stages of some fish species. The trophic status of a lake ecosystem thus depends on the balances within the plankton community (phytoplankton and zooplankton), their utilisation by higher vertebrates and invertebrates, and the efficiency of energy transfers between the trophic levels (Burgis 1974; Hecky & Fee 1981). Over all, the structure (species composition, biomass

and size) of the plankton community (phytoplankton and zooplankton) in aquatic systems is influenced by both predation and nutrient availability (Pérez-Fuentetaja *et. al.,* 1996).

Traditionally, aquatic systems were classified by their trophic status (oligotrophic, mesotrophic and eutrophic) with little regard to the control processes influencing the structure of the plankton (Sommer *et. al.,* 1986). Currently two control processes/forces functioning simultaneously are recognised as determining plankton structure in aquatic systems: - 1 Top-down control; - the biomass and structure of the plankton is determined by fish predation. 2. Bottom-up control; - the biomass at each trophic level is controlled by nutrient availability (Mills & Forney, 1983).

The main contribution to phytoplankton biomass and production is by nannoplankton cells (<20µm) (Agawin *et. al., 2000;* Sherr *et. al.,* 1986; Porter *et. al.,* 1985; Kalff 1983). The micro-zooplankton in the size range of 20µm-500µm then graze on the nanno-phytoplankton (Stoecker & Capuzzo 1990) consisting of protozoan ciliates and flagellates, Rotifera and Copepoda nauplii. Table 1 show the phytoplankton and zooplankton size classification referred to in this work.

Table 1. Plankton size classification used in this thesis

Plankton	Size (µm)	Classification
Bacterioplankton	<2	Bacterioplankton
Phytoplankton	<20	Nannoplankton
	>20	Phytoplankton
Zooplankton	<500	Microzooplankton
	>500	Macrozooplankton

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1936; Beadle 1932; Beauchamp 1932) to the East African lakes in 1929 and 1930-31 respectively. Reports from the expeditions gave details of the taxonomic composition, the general ecology, distribution and production of the commoner freshwater net plankton (Mavuti 1983). Other notable studies on the zooplankton were realized in the 1970s after a time lapse of over 40 years. These studies include those by Pejler (1974) on taxonomy of the lake's Rotifera species, and Mavuti (1983) on the taxonomic composition, population dynamics and production of the limnetic zooplankton.

The taxonomy of the Lake Naivasha phytoplankton was first recorded by Rich (1932a & b) and later by Lind (1965); Melack (1976); Njuguna (1983) and Kalff & Watson (1986). In addition to the taxonomy, the studies mentioned above put more emphasis on the primary productivity of the lake plankton community and with the phytoplankton-nutrient inter-relationships (Hubble & Harper 2002; Kitaka 1991; Njuguna 1983; Kalff 1983).

1.2 Justification

The plankton community plays a very significant role in nutrient cycling and retention within the water column of aquatic systems. Consequently, the efficiency of energy transfer (which influences production) through the lakes food chain depends on the structure (composition, size and abundance) of the plankton (autotrophic and heterotrophic) and the interaction (functional role) among themselves and with higher invertebrates and vertebrate (fish) consumers. The data obtained from previous studies in Lake Naivasha does not provide enough information on the control effects (top-down or bottom-up) influencing the plankton (phytoplankton and

zooplankton) community structure. This study analysed composition, size distribution and abundance in order to assess the impact of grazing capacity on the lower ranks of the plankton, hence enabling an evaluation of the importance of the microplankton and any indication of top-down effects in Lake Naivasha ecosystem.

In an effort to gain a better understanding of the Lake Naivasha ecosystem and its ecological processes, an accurate appraisal of the lake's recent plankton community dynamics is necessary. This will help establish the relative fertility of the lake's ecosystem, to justify any expansion of the commercial fishery, in terms of new fish species introductions.

Lake Naivasha is known to have poor fish diversity (5 species) and except *Lebistes sp*, no adult zooplanktivorous fish. Utilisation of the zooplankton by possibly only fish juveniles implies zooplankton size-selective predation may occur. The small sized zooplankton individuals are therefore preferentially taken resulting to a community dominated by large bodied individuals. The pressure exerted on the zooplankton (displayed in their size structure, composition and differences in their seasonal pulses), in turn influences the population dynamics and community structure of zooplankton and therefore the functioning of the whole plankton community. Large bodied zooplankton presence in any water body (where physical chemical parameters are constant) usually results to lowering of phytoplankton biomass due to increased grazing rates. The level of phytoplankton biomass in Lake Naivasha indicates the zooplankton community grazing capacity.

In the recent past, the ecology of Lake Naivasha has changed due to the lake level fluctuation and the resultant influence on the limnological characteristic of the lake and hence its productivity. Anthropogenic effects have caused increased nutrient loading into the lake that has resulted to a

change in the phytoplankton community structure and consequently that of the zooplankton. A change in one state variable results in a cascading effect on the whole ecosystem. The species composition of the plankton community evolve or change in response to the interaction of the biotic mechanisms (competition, predation and food selectivity) and the physical chemical factors (temperature, light, depth oxygen, oxygen (DO), pH, conductivity and nutrient levels) regulating the size and composition of the plankton population (Somer et. al., 1986). In such situations, the best-adapted species survive giving rise to the plankton community structure observed.

The quality of food and the amount available to a species of zooplankton (and its developmental stages) control and influence their growth and production (Rothhaupt 1995; Gliwicz & Lampert 1993,1985; Mavuti 1983). Knowledge of the plankton population structure is therefore a prerequisite in understanding the functioning of the system.

1.3 Aims and objectives

The study aimed to

1. Establish the factors influencing the biological structure (species composition, size biomass, and density) of the plankton community (phytoplankton and zooplankton).

2. Establish the effect of grazing/predation on the structure of the plankton (phytoplankton and zooplankton) community structure and species size distribution.

To attain this, the main objectives were: -

1. To measure the environmental variables (rainfall and temperature) and the physical-chemical parameters (lake level, water temperature, dissolved oxygen, pH, and conductivity) in Lake Naivasha.

2. To determine the species composition and size structure, density and biomass of the plankton (phytoplankton and zooplankton) community.

The working hypotheses were: -

1. The zooplankton community is dominated by large body sized individuals of mainly Cladocera Crustacea due to lack of fish predation.

2. The phytoplankton biomass in Lake Naivasha is low due to high rate of grazing by the high density of the large sized zooplankton.

3. The zooplankton community structure is influenced by other factors than fish predation.

CHAPTER 2: STUDY AREA AND METHODS

2.1 Lake Naivasha

Lake Naivasha is a shallow, fresh water endorrheic lake located in the Eastern arm of the Rift Valley of Kenya at 0° 45' S & 36° 20' E, 1890m above sea level. The surface area of the lake fluctuates from 120 to 180Km^2 (Harper 1991; Becht & Harper 2002). The lake level oscillations are dependant on the rainfall patterns and evaporation rates around the lake region.

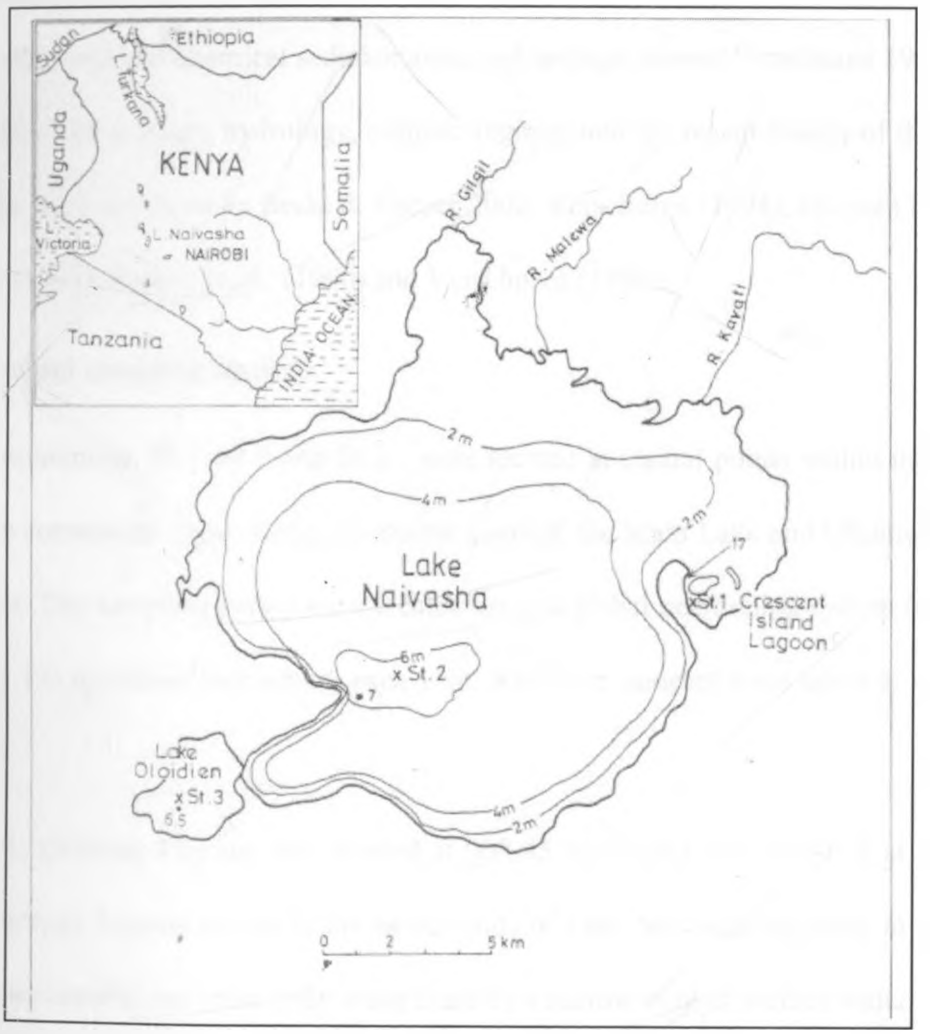

Fig. 1: The geographical location of Lake Naivasha along the eastern arm of the rift Valley and the sampling station. Source: Hickley P. 1993, Unpublished.

The catchment of the lake covers an area of about 3267 km^2 (Kallqvist 1987) extending to the Aberdare range and the Kinangop plateau to the north, the Mau Escarpment to the west and the Eburu hills to the north-east. The lake receives water from its catchment via two perennial streams: the River Malewa, the larger of the two with drainage area of 1730 km^2 and the Gilgil (drainage area, 420 km^2). Several ephemeral streams also dry immediately after the rains.

The mechanisms by which Lake Naivasha maintains its freshness include dilute inflows, biochemical and geo-chemical sedimentation and seepage losses (Verschuren 1996; Harper 1991; Ase 1987). The ecology, hydrology, climatic regimes and the recent history of the Lake Naivasha basin has been reviewed by Becht & Harper 2002; Verschuren (1994); Harper (1992); Muchiri & Hickley (1991), Harper *et al.*, (1990) and Verschuren (1996).

2.2 Principal sampling stations

The three stations, St 1, St 2 and St 3 - were located at central points within the open waters of the three constituent water bodies, Crescent Lagoon, the Main Lake and Oloidien basins of Lake Naivasha. The sampling points were located using a global positioning system (GPS) instrument (Garmin 12) to ensure location on each visit. Replicate samples were taken at each of the three stations.

Station 1, Crescent Lagoon, was located at 00° 45 80' S and 36° 24 80' E at a mean depth of 11m. Crescent Lagoon occurs to the eastern side of Lake Naivasha enclosed in an ancient crater and is connected to the Main Lake water mass by a narrow strip of surface water.

Station 2 was located at 00° 46' 30' S and 36° 20' 44' E in the Main Lake basin. At the time of this study, the mean depth was 7.5m.

Station 3 was located at 00° 48' 95' S and 36° 16' 16 E [illegible] of Lake Naivasha. At the start of the study, (May 1995), [illegible] 4.5m towards the end of 1995. Oloidien basin was once [illegible] but following the drop of the lake's water level in [illegible] Oloidien lacks surface water interaction, its distr[illegible] Main Lake (Melack 1976), from which water seepage [illegible] the two basin helps to replenish water lost [illegible] hydrological connections (surface or sub-surface) [illegible] levels in response to short-term climatic changes.

2.3 Environmental and physico-chemical para[illegible]

Data of rainfall. lake levels and air temperatures [illegible] obtained from the Sulmac Flower Farm Company. [illegible] temperatures were the highest and the lowest [illegible] respectively of each month.

Lake water temperature (°C) and dissolved [illegible] *situ* using an automated Yellow Spring [illegible] probes. The meter was calibrated by [illegible] the prevailing temperature. The [illegible] dropped to the required depth and [illegible] dissolved oxygen measurements [illegible] sampling.

Station 3 was located at 00° 48' 95' S and 36° 16' 16' E in the Oloidien basin to the south west of Lake Naivasha. At the start of the study, (May 1995), the depth at St 3 was 6m but declined to 4.5m towards the end of 1995. Oloidien basin was once connected by surface to the Main Lake, but following the drop of the lake's water level in the early 1980s, it has been cut off. Although Oloidien lacks surface water interaction, its distinctiveness depends on the water level of the Main Lake (Melack 1976), from which water seepage occurs through the swampy sill separating the two basin helps to replenish water lost through evaporation (Verschuren 1996). The hydrological connections (surface or sub-surface) between the three basins synchronise their levels in response to short-term climatic changes.

2.3 Environmental and physico-chemical parameters

Data of rainfall, lake levels and air temperatures between May 1995 and April 1996 were obtained from the Sulmac Flower Farm Company, Naivasha. The maximum and minimum air temperatures were the highest and the lowest temperatures recorded during the day and night respectively of each month.

Lake water temperature (^{o}C) and dissolved oxygen (mg l^{-1}) vertical profiles were measured *in situ* using an automated Yellow Spring Instruments model 57 oxygen / temperature meter and probes. The meter was calibrated by in air above the water surface correction for the altitude and the prevailing temperature. The oxygen-temperature probe connected to a marked cable was dropped to the required depth and shaken gently to provide stable readings.. The temperature and dissolved oxygen measurements were taken between 9.00 am and 10.00 am during time of sampling.

Conductivity (in $\mu S\ cm^{-1}$) and water pH were determined by collecting unfiltered water samples from the lake and transferring the water into a bucket from which the two parameters were measured by dipping a probe from a conductivity meter or a pH meter (Hach, USA). The pH meter calibration was made with reference solutions of known pH (pH 4 and pH 7).

Transparency of the lake water was measured using a 20cm diameter black and white Secchi disc lowered from the boat down the water column. Readings of the depth of light extinction from the water surface were recorded in centimetres.

2.4 Bacterioplankton

In May 1995, vertical samples for bacteria analyses were taken at St 1, at intervals of 1.5m to a depth of 7.5m. At St 2 and St 3, samples were collected at 1m intervals up to 6m. At each depth, three samples were collected using a 1.5 litre MacVuti sampler (Litterick and Mavuti 1985) and pooled together in a bucket. The samples for analyses were prepared by taking 20 ml of lake water from the pooled samples and preserved in small vials (20ml) using 4% formaldehyde. From the vials, 2ml aliquots were extracted and filtered through 2 µm pore black nucleopore filter and stained by adding 2 ml of $0.1 \mu g.l^{-1}$ DAPI (4,6-diamidino-2-phenylindole dihydrochroride) following Porter & Fieg (1980). The filters were mounted on a microscope slide with a drop of low fluorescence immersion oil and covered with a cover slip, then inspected at 1250-2000 magnification using a Zeiss epifluorescence microscope equipped with a DAPI set of light filter and beam splitter.

Counting of bacterial cells was done over ten fields delimited by square grids of a known area on an ocular eyepiece. The total bacterial cell density was calculated from the mean density counted per field of view.

2.5 Phytoplankton

In all the stations, three (replicates) integrated vertical phytoplankton water samples were collected using a 1.5 litre MacVuti water sampler (Litterick and Mavuti 1985) and pooled together in a bucket. At St 1, samples were taken at intervals of 1.5m to a depth of 7.5m. At St 2 and St 3, samples were collected at 1m interval up to 6m. From the pooled sample, 1-litre was removed and preserved in Lugol's iodine solution for phytoplankton enumeration in the laboratory. Another 1-litre sample for each depth was stored in a cool/ice box for chlorophyll-'a' determination.

In the laboratory, sedimentation of the phytoplankton samples was let to take place in the sample bottles for at least four days (assuming a rate of approximately 1 hr. cm^{-1} depth of sample). A vacuum pump was used to siphon off the top 950ml of water after the samples had settled, leaving the concentrated sample in the last 50ml (Bellinger 1992). The sample concentrates were put into 50ml vials from which sub-samples were extracted. Phytoplankton cell identification and counting was done under a stereo inverted microscope. A sub-sample of 1ml was extracted from the sample concentrate and transferred to a 10ml chamber fitted onto the microscope stage and let to settle for about 10-15 minutes. Observations were made at a magnification of x400. The phytoplankton was identified up to genus and species level where possible. Identification of the phytoplankton was based on the general cells morphology (size, shape e.g. elongate, round/spherical, laminate or attenuate), cell arrangement with relation to one other (e.g.

filamentous, colonial or solitary) and the presence or absence of mucilage/gelatine envelope. Method of estimating phytoplankton cell numbers was as per Lind (1958).

2.6 Chlorophyll-'a' analysis

Chlorophyll-'a' was determined as a measure of phytoplankton biomass. Chlorophyll extraction was done using ethernol as by Porra *et. al.,* 1989 and Seely & Jensen 1965. From the 1 litre samples of lake water, aliquots of a known volume (100-300ml) of water were filtered (depending on the concentration of algae) through a GF/C glass-fibre filter. The filters holding the phytoplankton cells were then transferred into a dark vessel (to prevent chlorophyll degradation due to light) and 30ml of boiling ethanol (90%) poured in to the vessel. The vessel was stored in the dark for about 12 hours to allow chlorophyll extraction to take place.

The content in the vessel was then filtered through a normal paper filter and the filtrate transferred into a spectrophotometer cuvette. The absorbance was measured at 665nm and 750nm in a Hach DR 2000 field spectrophotometer against a reference blank filled with 90 % ethanol. The extract was acidified (0.3ml 2N HCL per 100ml of extract) for phaeo-pigment correction and the absorbance read again at 665nm and 750nm.

Chlorophyll- 'a' was calculated as:-

$$\text{Chl-'a'} = (E^{b}665 - E^{a}665) \cdot (R/R) \cdot v/V \cdot l \cdot 10^{3}/a$$

Where:- Chl-'a' = Concentration of chlorophyll-'a' in mg m^{-3}

$E^{b}665$ = Extinction of extract at 665nm before acidification

$E^{a}665$ = Extinction at 665nm after acidification (values corrected for turbidity by subtraction of the 750nm reading)

a = Specific (operational) absorption coefficient for chlorophyll

V = Volume of water filtered, expressed in litres.

v = Volume of solvent used to extract the sample, in ml.

I = Path length of spectrophotometer cuvette. in cm.

R = Acid Ratio E^b665 / E^a665 for pure chlorophyll.

When the specific absorption coefficient for chlorophyll-'a' in 90 % ethanol is taken as 82 and the maximum acid ratio is 1.7 the equation simplifies to:-

$$Chl\text{-}'a' = 29.6 (E^b665\text{-}E^a665) \cdot v/V \cdot I$$

Chlorophyll results are given as mg chl- 'a' m^{-3} water.

2.7 Zooplankton

The larger zooplankton (Copepoda and Cladocera) were sampled on a monthly interval between May 1995 and April 1996 using a 10l Schindler-Patalas plankton sampler (Schindler 1969) fitted with a 55µm mesh size screen. At St 1, vertical samples were taken at intervals of 1.5m to a depth of 7.5m. At St 2 and St 3, samples were collected at 1m intervals up to 6m. The samples were washed into 50ml plankton sample bottles and preserved in 4% formaldehyde.

In the laboratory, the identification of zooplankton and counting was done under a dissecting stereomicroscope at a magnification of between x160 and x250. To prepare the samples for counting, the concentrated samples were topped up to the 50ml mark and thoroughly mixed by pouring the samples ten times between two containers in quick succession. Sub-samples of 5ml were then extracted from the mixed sample before the plankton settled out of suspension, with an automatic pipette fitted with a 14mm diameter tip and transferred to a counting trough. The chamber was then scanned under the microscope and all the animals encountered were counted.

The microzooplankton could not successfully be sampled with the Schindler-Patalas sampler, so were collected using a MacVuti water sampler (Litterick & Mavuti 1985). Samples were preserved in 4 % formaldehyde and stored in 1 litre bottles and concentrated to 50ml in the laboratory latter. Observations/identification and counting were done under an inverted stereo microscope. During enumeration, 1ml sub-samples were drawn each time, transferred into a 10ml settling chamber and let to stand for 15 to 30 minutes. The whole field of view was scanned and all the organisms encountered identified counted and recorded. The keys used for identification were by Kosté (1978) and Ruttiner-Kolisko (1974). The identification of the zooplankton was based on the general body morphology. Distinction of the various families of the Rotifera was made using the corona (ciliation on the head). The structure of the trophi in the digestive tract, the lorica (cuticular carapace) and the foot characteristics were used to identify the Rotifera to generic and species level.

The Cladocera were identified by examination of the sculpture of the carapace, shape of the head, thorax limbs. The antenna position (ventral or frontal), with relation to the head, presence or absence of rostrum, the number of segments and setae on the ramus and the anal spines and the post abdomen claws, shape and size were also used in the identification.

Examining the characteristics of the cephalothorax and the abdomen helped identify the Copepoda. The main structures used included shape of the cephalothorax (rounded or elongate), extent of separation of the cephalothorax and the abdomen. Size of the antennules relative to body size and the segmentation of the thoracopods, the symmetry of the furcal ramii and the number, length, and size of the setae on the furcal ramii were the other characteristics used for identification.

2.8 Zooplankton biomass estimation

The dry weights of zooplankton biomass were determined using the exponential regression equation developed by Edmondson & Weinberg (1971) and Dumont *et. al.*, (1975) relating dry weight to body length. For each individual species, about 100 individuals were randomly selected from the sample and their body length measured. The mean body sizes of the various species encountered in the samples were then calculated and used to determine the dry weight biomass of the zooplankton.

2.9 Zooplankton size measurements

The zooplankton body size (length) measurements were made under an inverted microscope fitted with an ocular micrometer. A plankton sub-sample was placed in a 10ml chamber and let to settle for about 10 minutes. Some of the overlying water was removed to reduce refracted images of the animals. The length size of the cladocera was measured from the top of the head to the point of insertion of the tail. Measurements of the Copepoda were done from the tip of the head to the base of the furcal ramii. The lorica length from the base of the foot opening to the corona was measured for Rotifera. Measurements were done for a maximum of 100 individuals for each species.

3.0 Statistical analysis

Most of the data arising from this work consisted of measures of parameters and plankton densities. The data can fit into normal distribution and therefore parametric tests were used.

The analysis of variance (ANOVA) was widely used to compare data obtained from within and between stations over the time of this study.

A probability of ≤ 0.05 was used to indicate the level of statistical significance. Linear regression was used for comparison on relation of one variable with another where appropriate. The standard deviation (expressed as $\pm$ SD in the text) was calculated as a measure of dispersion. Statistical methods are as described in Sokal and Rohlf (1995)

CHAPTER 3: RESULTS

3.1 Environmental parameters

3.1.1 Rainfall and lake levels

The Lake Naivasha region received 598.5mm of rainfall between May 1995 and April 1996 (Fig. 2). The mean rainfall per month over this period was 50.3mm (SD ± 30.2). Relatively high amounts of rainfall (40-90mm) were received in May-July 1995, October-November 1995 and February-April 1996. The lowest amount of rainfall (5.8mm) was received in January 1996 and the highest (89.9) in March 1996.

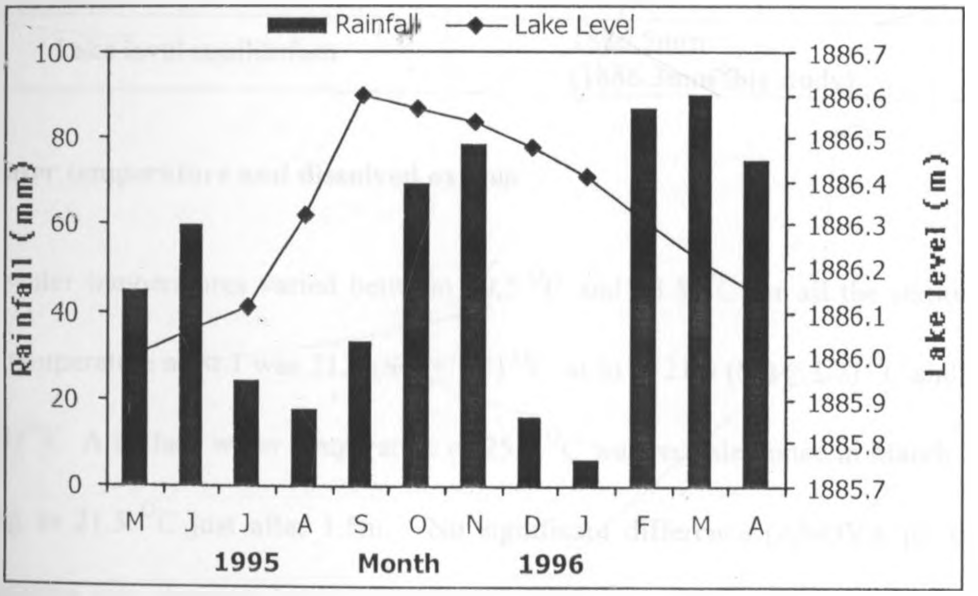

Fig. 2: Rainfall (mm) around the Lake Naivasha region and Lake levels (m) pattern between May 1995 and April 1996. Source: Sulmac Flower Farm Company Naivasha, Kenya.

The Lake levels fluctuated between 1886.0m and 1886.6m above sea level. The levels showed no correlation with the amount of rainfall received between May 1995 and 1996. The balance between rainfall, surface water inflow, evaporation and ground water loss determines the lake level. The evaporation rate is higher than the amount of rainfall received within the lake (Table

2) and thus the Lake level is highly influence by surface water inflow. The influence of river discharge was not established but, together with evaporation, affects the lake level. The influence of river discharge may explain the continued rise in lake level after June 1995 while the rainfall was dropping.

Table 2 Mean water balance estimate for Lake Naivasha (Source: Becht & Harper 2002)

Rainfall	648mm (598.5mm this study)
Evaporation	256.3 x10^6 m^3
Surface water inflow	217.4x10^6 m^3
Ground water loss	56x10^6 m^3
Lake level equilibrium	1886.5mm (1886.3mm this study)

3.1.2 Lake water temperature and dissolved oxygen

Surface lake water temperatures varied between 19.5 ^{O}C and 23.5 ^{O}C for all the stations. The mean surface temperature at St 1 was 21.4 (SD $\pm$ 1.5) ^{O}C, at St 2, 21.5 (SD $\pm$ 1.7) ^{O}C and at St 3, 21.4 (SD $\pm$1.3) ^{O}C. A surface water temperature of 25.5 ^{O}C was recorded once in March 1996 at St 2, dropping to 21.5 ^{O}C just after 1.5m. . No significant difference (ANOVA p= 0.86) in surface temperature was observed between the stations. The Lake Naivasha region experienced relatively high air temperatures during the months of January, February and March (Fig. 3) contributing to the high surface water heating.

The dissolved oxygen concentration observed at each of the three stations showed a wide range, which did not give significant differences. The surface water dissolved oxygen concentration at

St 1 ranged between 4.7 mg O_2 l^{-1} and 9.2 mg O_2 l^{-1} with a mean of 6.9 (SD $\pm$ 1.4) mg O_2 l^{-1}. At St 2, it ranged between 5.2 mg O_2 l^{-1} and 9.2 mg O_2 l^{-1} (mean 7.4 SD $\pm$ 1 mg O_2 l^{-1}) and at St 3 between 2 mg O_2 l^{-1} and 9.0mg O_2 l^{-1} (mean 6.0 SD $\pm$ 1.7 mg O_2 l^{-1}).

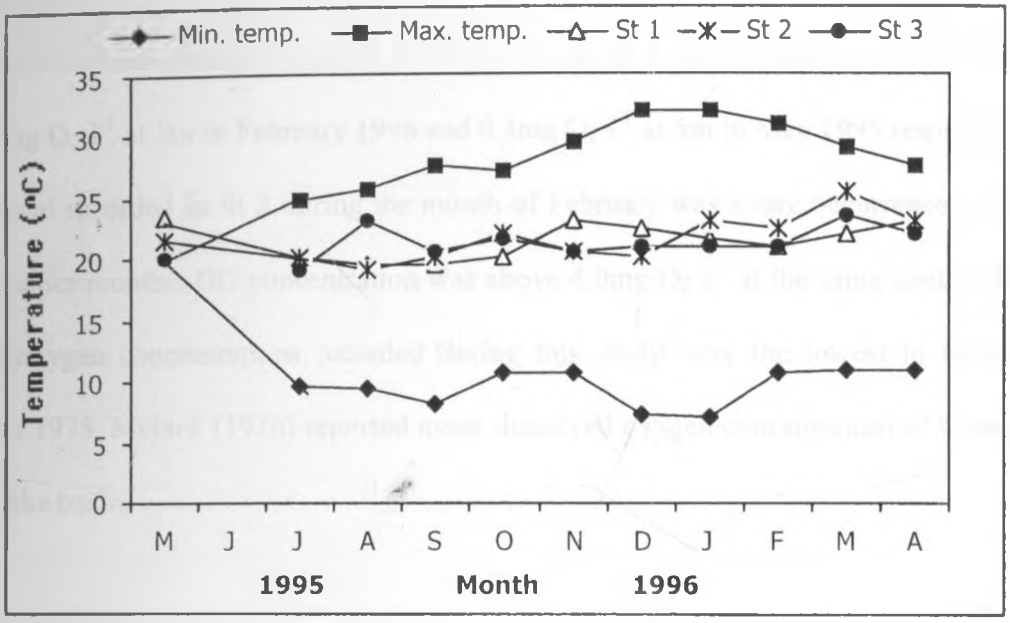

Fig. 3 Maximum and minimum air temperature (°0) around Lake Naivasha and the Lake surface water temperatures between May and April 1996.

3.1.2.1 Vertical patterns of lake water temperature and dissolved oxygen

The water temperature decreased gradually from the surface towards the bottom with no distinct vertical stratification (Fig. 4). Temperature fluctuation between surface water and the deepest point of measurement for all the stations was less than 2.0 °C. Rapid change in temperature in relation to depth was only experienced in St 1, between 0m and 2-3 m depth but no permanent stratification was realised. Generally, the three stations showed no significant difference (ANOVA p= 0.65) in water temperatures patterns. The low temperature gradient between the surface and the maximum depth of measurement and the lack of a permanent thermocline was indication of total water mixing of the whole water column.

The depth dissolved oxygen (DO) profiles between the three stations differed significantly (ANOVA p=0.069). Steep gradients in DO concentration from the surface towards bottom were observed in St 1 and St 3.

The lowest DO concentrations recorded for St 1, St 2 and St 3 were 0.3mg O_2 l^{-1} at 7.5m in April 1996, 0.5mg O_2 l^{-1} at 5m in February 1996 and 0.3mg O_2 l^{-1} at 5m in May 1995 respectively. The low DO level recorded in St 2 during the month of February was a rare occurrence considering that in all other months, DO concentration was above 4.0mg O_2 l^{-1} at the same depth. The mean dissolved oxygen concentrations recorded during this study were the lowest in the past two decades. In 1975, Melack (1976) reported mean dissolved oxygen concentration of 9.0mg. l^{-1} for the main lake basin.

3.1.4 Electrical conductivity

The electric conductivity of the lake water at St 1 and St 2 was similar and varied between 320μS m^{-1} and 402 μS cm^{-1}. The highest water conductivity of between 2470μS cm^{-1} and 2850 μS cm^{-1} was recorded at St 3. No correlation was observed between the amount of rainfall received and the conductivity. The influence of the lake water level rise (0.6m) in September was only noted at St 3 where the conductivity dropped by 90μS cm^{-1}.

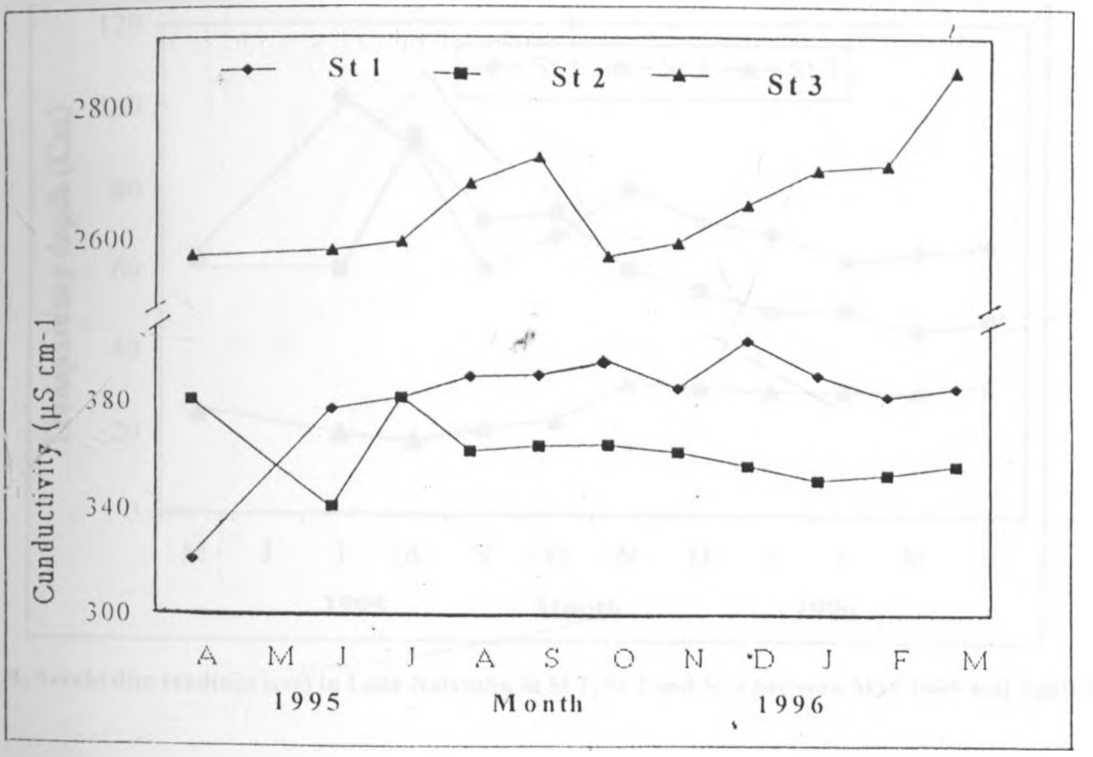

Fig. 6: Trend in lake water electrical conductivity () in Lake Naivasha at St 1, St 2 and St 3 between May 1995 and April 1996.

3.1.5 pH

The pH of the water was very similar in St 1 and St 2 fluctuating in a narrow range between pH 8.3 and pH 8.8. At St 3, the pH was higher ranging between pH 9.4 and pH 9.8. The slightly higher pH in St 3 was attributed to higher photosynthetic activity in this station as compared to

3.1.3 Water transparency

The lake water transparency (Fig. 5) was highest in St 1 ranging from 62cm to 102cm with a mean of 72 (SD ± 13) cm. In St 2 Secchi disc readings ranged between 32cm and 93cm with a mean of 61 (SD ± 14) cm.

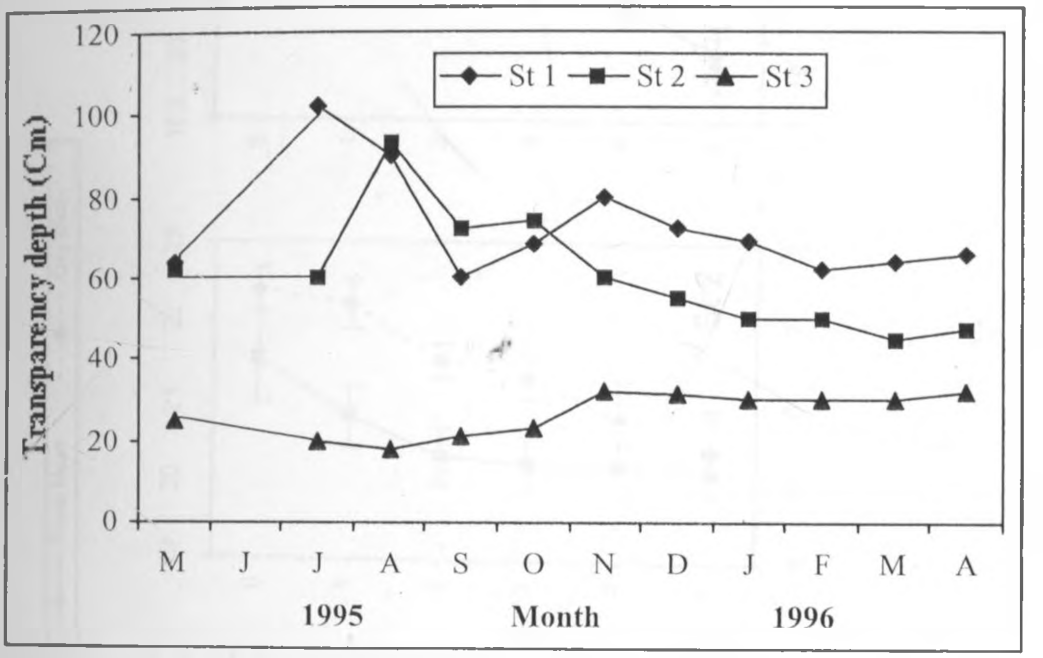

Fig. 5: Secchi disc readings (cm) in Lake Naivasha at St 1, St 2 and St 3 between May 1995 and April 1996

The lowest transparency depth was observed at St 3 ranging from 18cm to 32cm and a mean of 27 (SD ±5) cm. The readings reflected a significant difference (ANOVA $p=6.5x10^{-10}$) in water transparency among the three stations. A transparency depth greater than 1 metre was recorded only once in July 1995 at St 1.

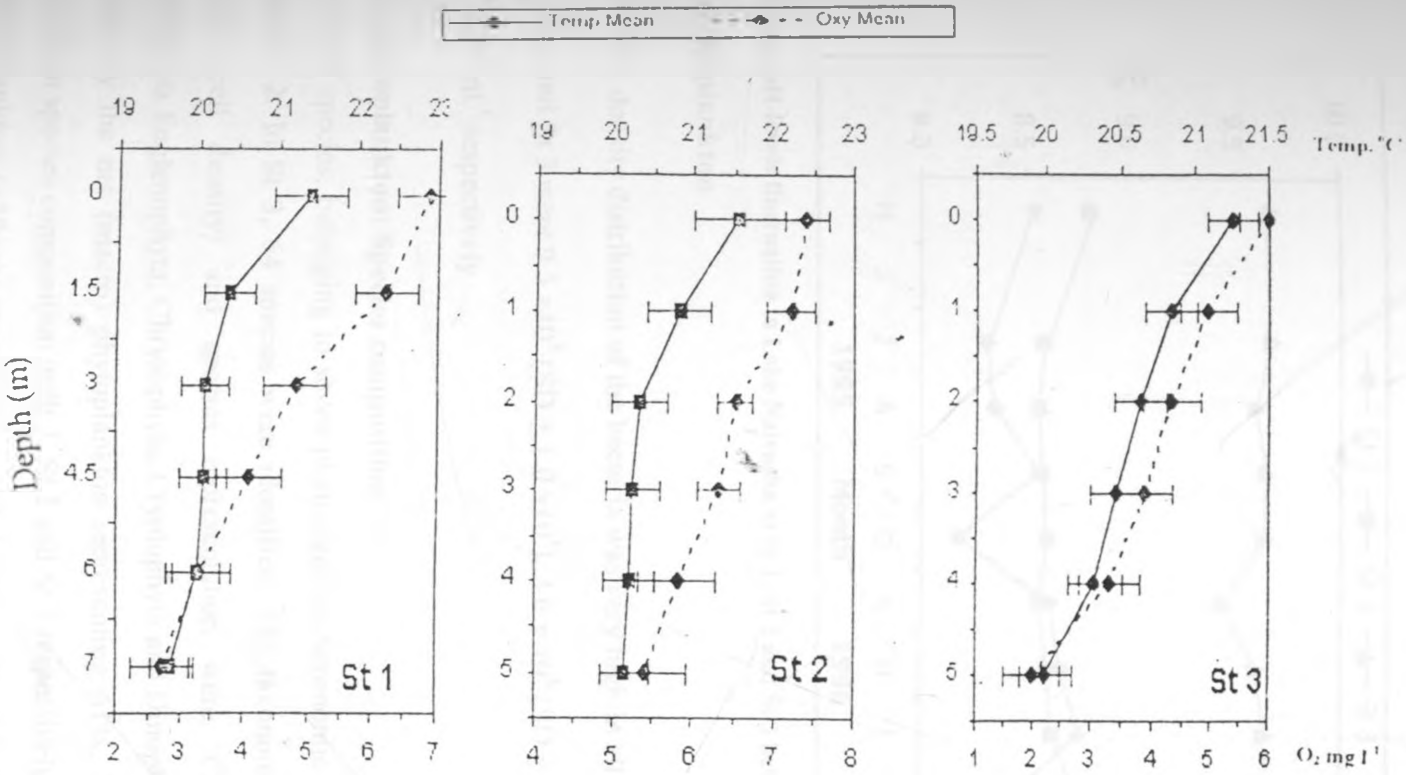

Fig: 4. Mean vertical temperature and oxygen profile at St 1, St 2 and St 3 during the study period.

the other two stations. The phytoplankton biomass at St 3 (measured as chlorophyll-'a') was about 4 times higher than in St 1 and St 2.

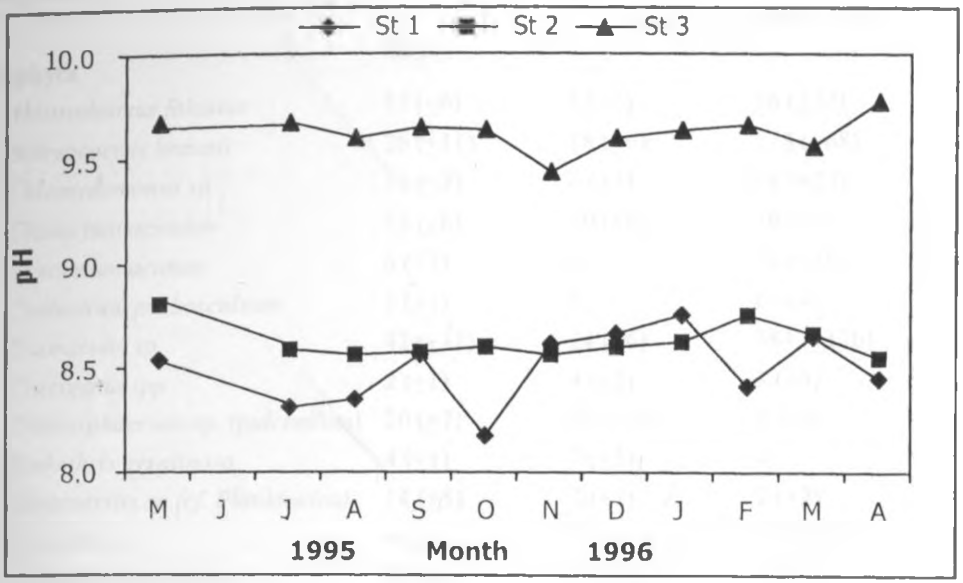

Fig. 7: Water pH-levels fluctuation in Lake Naivasha at St 1, St 2 and St 3 between May 1995 and April 1996.

3.2 Bacterioplankton

In May 1995, density distribution of the bacteria was very high in all stations. The mean densities in St 1, St 2 and St 3 were 9.3 x10^5 (SD $\pm$ 1.0 x10^5), 3.6 x 10^6 (SD $\pm$ 6.6 x 10^5) and 5.5 x 10^6 (SD $\pm$ 3.7 x 10^5) ml^{-1} respectively .

3.3 The phytoplankton: Species composition

A total of 69 species, belonging to seven phytoplankton taxonomic groups were encountered in St 1 and St 2. In St 3, 64 species were identified. The taxonomic groups in order of their numerical (cell density) and species representation were, Chlorophyta, Cyanobacteria, Bacillariophyta Euglenophyta, Chrysophyta, Cryptophyta and Dinophyta. The phytoplankton was dominated by the net (macro) phytoplankton representing 61%, 79% and 78% of the total phytoplankton species composition in St 1, St 2 and St 3 respectively. The macro -phytoplankton / net phytoplankton (>20µm) species belonged mainly to the Chlorophyta, Cyanobacteria and Bacillariophyta taxonomic groups (Table 3).

Table 3: Mean phytoplankton species cell densities (ml^{-1}) at St 1, St 2 and St 3 during the study period.

Species Name	Mean phytoplankton cell density (cells ml^{-1})		
	St 1	St 2	St 3
Chlorophyta			
Akistrodesmus falcatus	15 (±6)	6 (±2)	86 (±32)
Botryococcus braunii	26 (±11)	18 (±6)	123 (±68)
Chlamydomonus sp.	16 (±2)	5 (±3)	58 (±23)
Closterium aciculea	12 (±6)	10 (±6)	19 (±7)
Closterium acutum	6 (±3)	0	74 (±35)
Coelastrum proboscideum	1 (±1)	0	6 (±4)
Cosmarium sp	42 (±11)	24 (±6)	584 (±170)
Crucigenia spp	2 (±1)	4 (±2)	3 (±3)
Dictyosphaerium sp. (pulchellum)	20 (±7)	32 (±14)	6 (±6)
Elakothrix geratinosa	4 (±1)	7 (±3)	0
Gloecosystis sp.(cf. Planktonica)	14 (±3)	2 (±1)	2 (±2)
Oocystis sp	4 (±1)	22 (±4)	223 (±73)
Pediastrum boryanum	3 (±2)	1 (±1)	6 (±6)
Pediastrum duplex	10 (±3)	15 (±4)	5 (±3)
Pediastrum obtusum	1 (±1)	3 (± 2)	14 (±11)
Scenedesmus aciminatus	6 (±3)	6 (± 2)	84 (±35)
Scenedesmus armatus	0	0	12 (±6)
Scenedesmus bicaudatus	4 (±2)	5 (±2)	34 ±13)
Scenedesmus brevispina	0	0	48 (±16)
Scenedesmus denticulatus	5 (±1)	7 (±2)	29 (±16)
Scenedesmus intermedius	0	0	4 (±2)
Scenedesmus protuberans	16 (±)	23 (±4)	15 (±8)
Scenedesmus quadricauda	22 (±5)	31 (±7)	16 v±8)
Scenedesmus falcatus	0	0	1 (±1)
Scenedesmus sp.	0	1 (±1)	9 (±8)
Spirogyra	0	0	41 (±19)
Staurastrum sp.	9 (±4)	2 (±1)	7 (±4)
Tetraedron caudatum	1 (±1)	1 (±1)	9 (±9)
Tetraedron minimum	4 (±2)	4 (±1)	49 (±23)
Tetraderon trigonum	14 (±2)	24 (±5)	232 (±100)
Tetraedron regulare	1 (±1)	5 (±2)	58 (±25)
Tetradesmus wisconsinense	0	0	0
Westella botryoides	1 (±1)	2 (±1)	5 (±3)
Westella botryoides	1 (±1)	2 (±1)	5 (±3)
Cyanobacteria			
Aphanocapsa delicatissima	2 (±1)	13 (±4)	47 (±31)
Aphanocapsa elachista	0	2 (±1)	9 (±7)
Aphanotheca spp.	2 (±1)	4 (±2)	38 (± 15)

Chrolococcus spp	10 (±5)	3 (±1)	141(±49)
Coelosphaerium kuetzingianum	2 (±1)	6 (±3)	17 (±8)
Cylindrospermopsis raciborskii	42 (±12)	23 (±10)	297 (±94)
Dactylococcopsis spp.	1 (±1)	2 (±1)	232 (±49)
Holopidium irregulae	1 (±1)	5 (±3)	7 (±5)
Lyngbya spp	12 (±3)	19 (±5)	274 (±85)
Merismopidia tenuisima	8 (±2)	15 (±5)	32 (±13)
Microcystis aeruginosa	49 (±12)	51 (±11)	244 (±55)
Oscillatoria sp	10 (±2)	1 (±1)	39 (±16)
Spirulina sp.	1 (±1)	2 (±)	59 (±19)
Synechocystis aquatilis	1 (±1)	0	37 (±25)
Euglenophyta			
Euglena sp	0	0	18 (±12)
Trachelomonas sp.	17 (±5)	6 (±2)	36 (±16)
Phacus sp.	22 (±5)	2 (±2)	5 (±5)
Bacillariophyta			
Aulacosiera ambigua	49 (±9)	52 (±11)	760 (±123)
Aulacosiera granulata	11 (±3)	20 (±3)	151 (±78)
Navicula spp.	5 (±2)	4 (±2)	226 (±136)
Nitzchia spp.	2 (±1)	1 (±1)	611 (±203)
Synedra ulna	7 (±5)	10 (±6)	1110 (±241)
Synedra acus.	46 (±9)	38 (±6)	55 (±33)
Chrysophyta			
Chromulina sp	14 (±2)	18 (±6)	94 (±42)
Chrysococcus sp	0	2 (±1)	6 (±6)
Mallomonas sp.	0	1 (±1)	80 (±44
Cryptophyta			
Cryptomonas sp	46 (±11)	15 (±5)	153 (±62)
Rhodomonas sp	11 (±3)	5 (±1)	5 (±5)
Dinophyta			
Ceratium sp	3 (±2)	1 (±1)	11 (±7)
Glenodinium sp	2 (±1)	5 (±2)	75 (±32)
Gymnodinium sp	1 (±1)	3 (±1)	0
Peridinium spp (cf palustre)	5 (±2)	0	7 (±4)
Mean Total	**641 (±131)**	**589(± 12.0)**	**6738(± 193)**

Nannoplankton species were encountered in Euglenophyta, Chrysophyta, Cryptophyta and Dinophyta and Cyanobacteria, but they did not make a major contribution to the total. The nannoplankton were a higher proportion (31%) of the total phytoplankton at St 1 than at St 2 (21%) and St 3 (22%). In the Cyanobacteria, three species; *Chlamydomonus*, *Synechocystis* and

Chroococcus were identified representing less than 1% of the total phytoplankton cell density. In the Chlorophyta, *Cosmarium Oocystis* and *Gloeocystis* contributed between 1% and 10% of the total cell density (Table 4). The proportion of nannoplankton decreased with increase in cell density and biomass of the phytoplankton.

Table 4: Percentage contribution of the nannoplankton at St 1, St 2 and St 3 between May 1995 and April 1996

Species name	Percentage (%) contribution		
	St 1	St 2	St 3
Aphanotheca spp.	0	1	1
Chrolococcus dispersus	2	1	2
Chlamydomonus sp.	2	1	1
Cosmarium sp	7	4	9
Cricigenia tetrepedia	0	1	0
Gloecosystis sp.(cf. Planktonica)	2	0	0
Oocystis sp	1	4	3
Staurastrum sp	2	0	0
Tetraedron caudatum	0	0	0
Tetraedron minimum	1	1	1
Euglena sp	0	0	0
Trachelomonas sp	3	1	1
Chromulina sp	2	3	1
Chrysococcus sp	0	0	0
Cryptomonas sp	7	3	2
Rhodomonas sp	2	1	0
Glenodinium sp	0	1	0
Total contribution	**31**	**21**	**22**

3.4 The phytoplankton cell density

The phytoplankton cell density distributions between St 1 and St 2 showed no significant difference (ANOVA p=0.66) but there was very high difference (ANOVA p= 2.9×10^{-11}) between these two stations and St 3. The number of species in each taxonomic group varied both in time and space (Fig. 9). The highest phytoplankton cell densities were observed in St 3 samples. The mean phytoplankton cell counts in St 1, St 2 and St 3 were 642 (SD $\pm$ 288) cells ml^{-1}, 592 (SD $\pm$ 247) cells ml^{-1} and 6665 (SD $\pm$ 2549) cells ml^{-1} respectively.

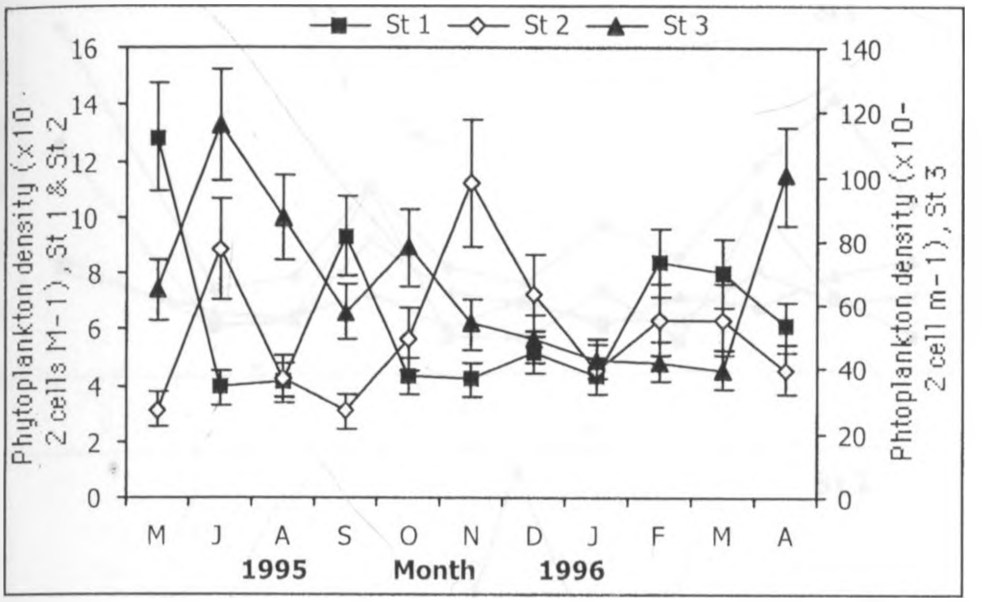

Fig. 8: Mean phytoplankton cell density (cells ml^{-1}) distribution at St 1, St 2 and St 3 between May 1995 and April 1996

3.4.1 Chlorophyta

The green algae, Chlorophyta, contributed the highest number of species in all stations. It was also the dominant taxa in St 1 and 2 contributing a mean percentage cell count of 40.2 % (SD ± 5.9) and 42.5 % (SD ± 11.3) respectively. In St 3, the Chlorophyta constituted 25.2% (SD ± 9.7) of the mean phytoplankton cell density. The mean cell density, 1863 (SD ± 1397) cells ml^{-1}, of the Chlorophyta in St 3, was higher than in the other two stations though the mean percentage (25.2 %) contribution was lower. In St 1 and 2, the mean densities of the Chlorophyta were 262 (SD ± 132) cells ml^{-1} and 263 (SD ± 158) cells ml^{-1} respectively.

In St 1 the dominant Chlorophyta species were *Scenedesmus spp* contributing 8% (53 SD ±16 cells ml^{-1}), *Cosmarium contractum* 7%(42 SD ±11 cells ml^{-1}), *Botryococcus braunii* 4% (26 SD ±11 cells ml^{-1}), *Dictyosphaerium* 3% (20 SD ± 7 cells ml^{-1}), and *Tetraedron* 3% (20 SD ± 5 cells ml^{-1}).

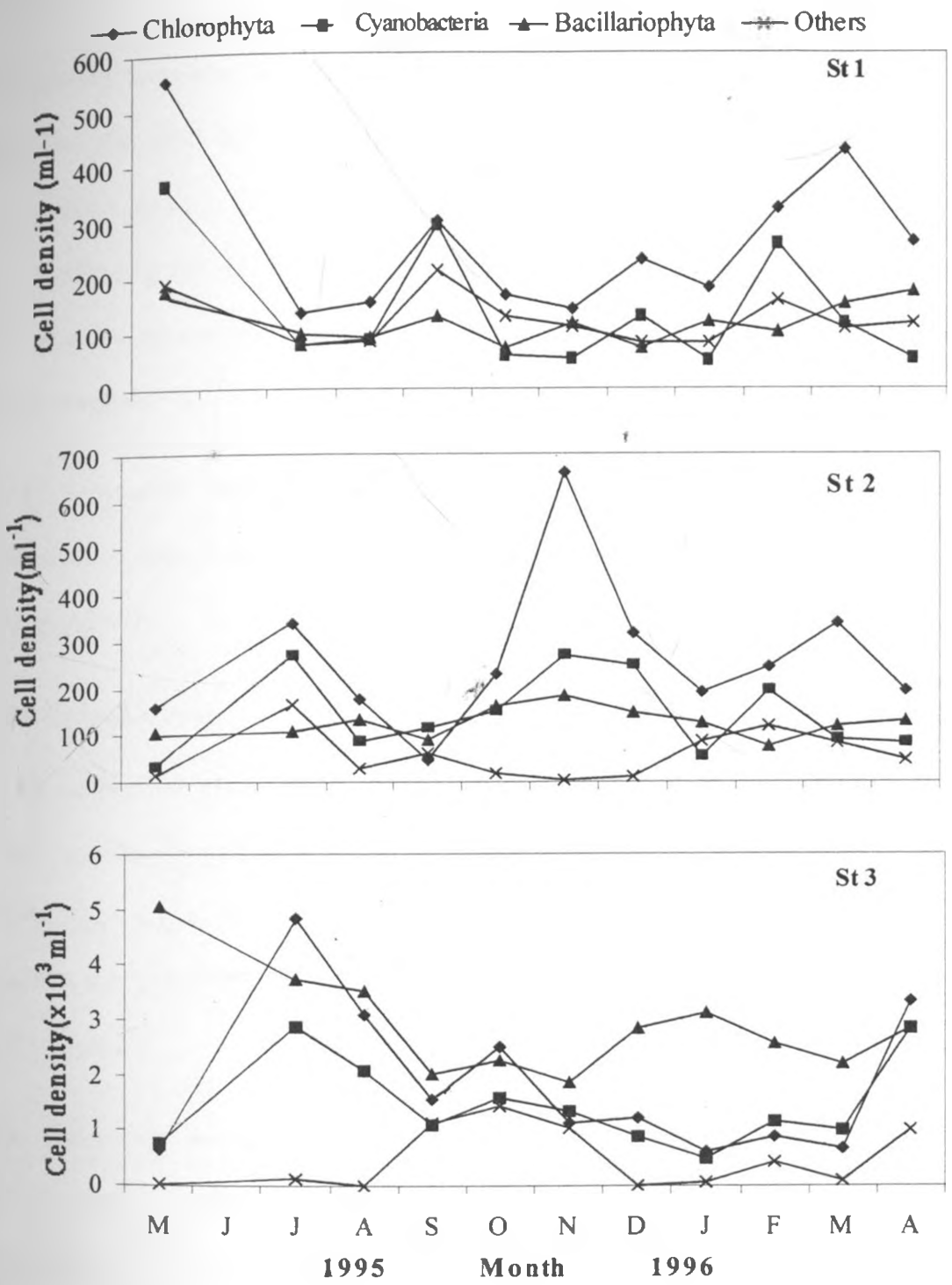

Fig 9: Phytoplankton species groups cell density (x10 cells ml^{-1}) distribution in Lake Naivasha between May 1995 and April 1996

The species *Botryococcus braunii* dominated the phytoplankton at St 2 during the months of April and May 1995. Its high density and floatation on the water surface gave a brown coloration to the water. At St 2, the other Chlorophyta species numerically significant were *Scenedesmus spp* contributing 12% (73 SD ±19 cells ml^{-1}), *Cosmarium contractum* 4% (24 SD ±6 cells ml^{-1}), *Botryococcus braunii* 4% *Dictyosphaerium* 5 % (32 SD ±14cells ml^{-1}), and *Tetraedron* 6% (6SD± 5 cells ml^{-1}).

At St 3, the class Chlorophyta was represented by fewer species, dominated by *Cosmarium contractum, Tetraedron Scenedesmus* and *Oocystis* (Table 2) *which* represented 9%, 5%, 4% and 3% respectively.

3.4.2 Cyanobacteria

In all stations, the class Cyanobacteria was the second most numerically important taxa. The mean percentage contribution of the Cyanobacteria to the total phytoplankton cell counts was 19.9% (SD ± 8.1), in St 1, 23.5% (SD ± 9.2) in St 2 and 21.5% (SD ± 5.8) in St 3. The mean cell densities were, 141 (SD ±111) cells ml^{-1} in St 1, 145 (SD ± 88) cells ml^{-1} in St 2 and 1472 (SD ± 807) cells ml^{-1}.

The commonest species of Cyanobacteria at the three stations were *Aphanocapsa SP., ChroococcuS turgidus sp., Cylindrospermopsis raciborskii, Microcystis aeuroginosa, Oscillatoria limnetica*, and *Lyngbya Merismopedia* (Table 2). At St 3, *Cylindrospermopis sp., Microcystis sp.* and *Lyngbya sp.* were the most important in cell density each contributing about 4% of the total mean cell density.

3.4.3 Bacillariophyta

The filamentous algae, Bacillariophyta, were dominated by the species *Aulacosiera sp, Navicula sp, Nitzchia sp and Synedra sp.* at all three stations. The species *Synedra sp.* and *Aulacosiera sp.* were the most important in density, contributing 10% and 8.5 % at St 1, 12% and 6% at St 2, and 17% and 14% at St 3 respectively. In St 3, Bacillariophyta species were numerically the most important

group contributing 43.5±17% (2913 SD ± 814 cells ml^{-1}) of the mean total cell density. In St 1, Bacillariophyta contributed a mean of 18% (SD ± 6.3) (118± 18 cells ml^{-1} while in St 2 it contributed 21 % (SD ± 7.9) and a density of 126 (SD ± 27) cells ml^{-1}.

3.4.4 Other phytoplankton taxa

The other phytoplankton groups, consisting of mainly ciliates and flagellated species in the taxa Euglenophyta, Chrysophyta, Cryptophyta and Dinophyta had very low species and density representation. At St 1, the four groups had a higher representation (19%) of total cell density than at St 2 (9%) and St 3 (7%) Most of the micro-phytoplankton (cell size <20μm) occurred in these four groups and accounted for less than 20% of the total phytoplankton.

The taxa Euglenophyta was represented by three species of nannoplankton *Euglena sp, Trachelomonas sp* and *Phacus sp.* At St 1, they contributed 6% (39±10 cells ml^{-1}), at St 2 1% (8±3 cell ml^{-1}), and at St 3, 1% (59±34 cells ml^{-1}) of the total mean phytoplankton cell density. The group Chrysophyta, was represented by *Chromulin sp., Crysococcus sp* and *Mallomonas sp* accounting for 2%, 3% and 1% of the total mean phytoplankton cell density at St 1, St 2 and St 3 respectively. The only two species identified in the taxa Cryptophyta were *Cryptomonus relexa*

and *Rhodomonas sp* contributing 9%, 3% and 4% in St 1, St 2 and St 3 respectively. Other species of ciliates identified were *Ceratium sp., Glenodinium sp., Gymnodinium sp.* and *Peridinium sp.* in the phytoplankton taxa, Dinophyta which in total contributed 2% (15 SD ±3 cells ml^{-1}) at St 1, 2% (10 SD ±4 cells ml^{-1}) at St 2 and 1% (92 SD ±43cells ml^{-1}).

3.5 Phytoplankton biomass

The highest concentrations of chlorophyll-'a' were recorded at St 3 (Fig 10) ranging between 112.5mg m^{-3} (March 1996) and 190.8mg m^{-3} (July 1995). The mean chlorophyll-'a' concentration at St 3 was 141.1 mg m^{-3} (SD ±27.1) over a period of eleven months. At St 1 the mean chlorophyll-'a' concentration between May 1995 and April 1996 was 36.1 mg m^{-3} (SD ± 11.8).

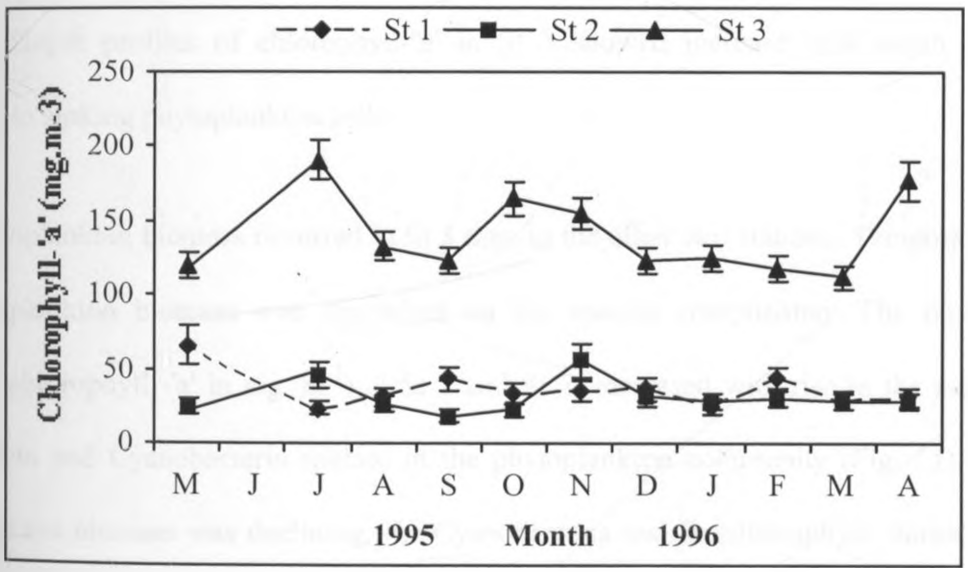

Fig. 10: Mean chlorophyll-'a' (mg m^{-3}) concentrations in Lake Naivasha at St 1, St 2 and St 3 between May 1995 and April 1996

Highest concentration (65.94mg m^{-3}) was recorded in May and the lowest (23.7mg m^{-3}) in July 1995. At St 2, the highest chlorophyll-'a' concentration (55.5mg m^{-3}) was recorded in November 1995 and the lowest (18.38mg m^{-3}) in September 1995. The mean chlorophyll-'a' was 30.8mg m^{-3} (SD ± 10.7) over the study period.

Highest concentration (65.94mg m^{-3}) was recorded in May and the lowest (23.7mg m^{-3}) in July 1995. At St 2, the highest chlorophyll-'a' concentration (55.5mg m^{-3}) was recorded in November 1995 and the lowest (18.38mg m^{-3}) in September 1995. The mean chlorophyll-'a' was 30.8mg m^{-3} (SD $\pm$ 10.7) over the study period.

Phytoplankton biomass, showed no influence ($R^2 < 0.03$ in three stations) on water transparency change. The phytoplankton biomass fluctuated within a narrow range. An occasional rise in transparency with fall in chlorophyll -'a' occurred at St 1 and St 2 in August 1995 and in July 1995 at St 3. In St 3 where the phytoplankton biomass was high throughout the study period, the transparency (mean 27cm SD $\pm$ 5) of the water showed very low fluctuation. In this station, the dissolved oxygen was lower compared to the other two stations that had lower phytoplankton biomass. Depth profiles of chlorophyll-"a' in St 3 showed increase with depth which was attributed to sinking phytoplankton cells.

High phytoplankton biomass occurred in St 3 than in the other two stations. Temporal pattern of the phytoplankton biomass was dependent on the species composition. The phytoplankton biomass (chlorophyll -'a' in mg. m^{-3}) at St 1 and St 2, increased with rise in the proportion of Chlorophyta and Cyanobacteria species in the phytoplankton community (Fig. 11). When the phytoplankton biomass was declining, the Cyanobacteria and Bacillariophyta started becoming more important.

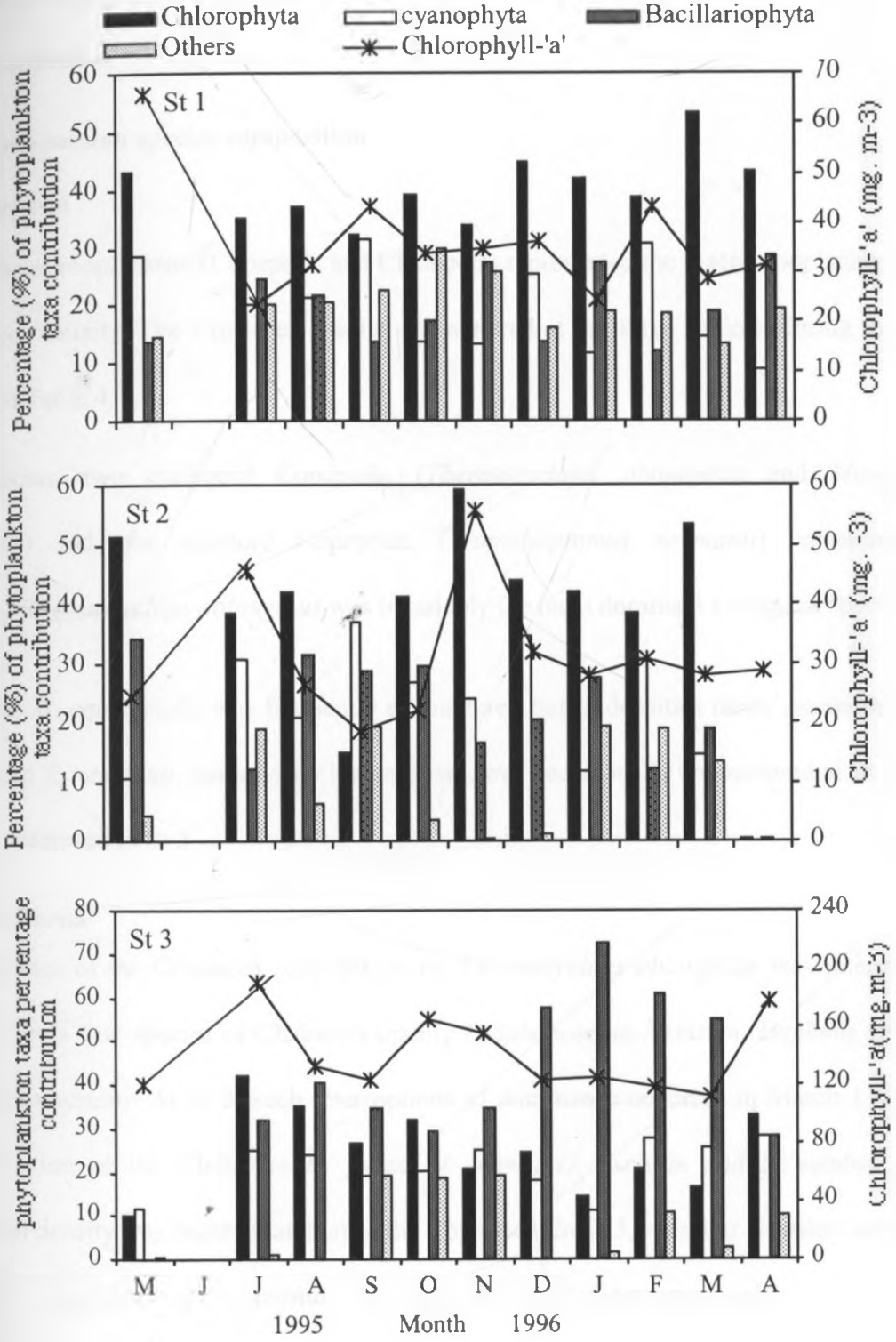

Fig: 11. Phytoplankton species groups' percentage contribution and biomass (as chlorophyll -'a' mg. m^{-3}) distribution at St 1, St 2 and St 3 between May 1995 and April 1996.

The biomass of the phytoplankton showed no correlation with the zooplankton density or biomass distribution.

3.6 The zooplankton species composition

3.6.1 Copepoda

The Crustacea zooplankton (Copepoda and Cladocera) represented the macro-zooplankton of the plankton community. The Crustacea species encountered at the three stations during this study are listed in Table 4.

Three species, two cyclopoid Copepoda, (*Thermocyclops. oblongatus* and *Mesocyclops equatorialis*) and one calanoid Copepoda, (*Tropodiaptomus neumanii*) represented the Copepoda.. *Thermocyclops oblongatus* was invariably the most dominant Crustacea species.

The species *M. equatorialis* was frequently encountered but in densities rarely exceeding 1 m^{-3}. The calanoid *T. neumanii*, numerically insignificant, was occasionally encountered at St 1 and St 2 but none occurred in St 3.

3.6.2 Cladoceraa

The dominance of the Crustacea zooplankton by *Thermocyclops oblongatus* was intermittently interrupted by a few species of Cladocera mainly *Diaphanosoma. excisum, Daphnia pulex* and *Simocephalus vetulus*. At St 2, such interruptions of dominance occurred in March 1996 when the contribution of the Cladocera *D. pulex, D. laevis, D. excisum and S. vetulus* to total zooplankton density was higher than that of the Copepoda. In St 3, a similar situation occurred in April 1996, when *Ceriodaphnia cornuta* dominated the zooplankton community.

Table 5. The Crustacea zooplankton species identified in Lake Naivasha (*The species was encountered only once in samples collected during the preliminary survey)

Species Name
Copepoda
Mesocyclops equatorialis (Kiefer)
Thermocyclops oblongatus (Sars)
Tropodiaptomus neumanii(Kiefer)
Copepodaites
Copepoda nauplii
Cladocera
Alona sp
Alonella sp
Chydorus sphericus (O.F. Muller)
Ceriodaphnia cornuta
Daphnia laevis Birge
Daphnia pulex Leydig
Simocephalus vetulus (O.F. Muller)
Macrothrix triserialis Brady*
Moina micrura Kurz
Diaphanosoma excisum Sars

Six Cladocera species, *D. excisum, D. pulex, S. vetulus, D. laevis, C. cornuta*, and *M. micrura* were most common within the Lake Naivasha basin. Three other Cladocera *Chydorus sphericus, Alona davidi* and *Alonella sp* were occasionally encountered in very low numbers in samples taken from depths close to the bottom. At St 3, *C. cornuta* and *D. excisum* were the major Cladocera with small populations of *M. micrura*.

3.6.3 Rotifera

The Rotifera constituted the largest proportion of the microzooplankton together with the Copepoda nauplii. The temporal species composition of the Rotifera in Lake Naivasha was very variable. The mean number of Rotifera species encountered at St 1, St 2 and St 3 was 10.3, 8.4 and 3.6 species respectively. Species of the genus *Brachionus* dominated the Rotifera population in all stations. The species *Brachionus calyciflorus* was the commonest, with little variability in its density distribution Other numerically important Rotifera species included *Keratella cochlearis*, *Hexarthra jenkinnae*, *Brachionus caudatus* and *Trichocerca spp.* Protozoa which are of the same size range as the Rotifera were absent from the zooplankton samples enumerated.

Table 6: The Rotifera zooplankton species identified in Lake Naivasha during the study period (*species were encounter in samples taken near lake bottom)

Asplanchna brightwelli (Gosse)
*Aneuropsis fissa (*Gosse)
*Brachionus angularis (*Gosse)
Brachionus caudatus Barrois & Daday
Brachionus calyciflorus Pallus
Brachionus dimidiatus
Brachionus falcatus Zacharias
Brachionus patulus
Keratella tropica (Epstein)
Keratella cochlearis (Gosse)
Epiphane macrourus Barrois & Daday*
Filinia spp
Hexarthra jenkinnae
Lecane spp
Mytilina ventralis (Ehrenberg)*
Polyarthra vulgaris Carlin
Trichocerca spp

3.7 Zooplankton numerical abundance and distribution

Two major peaks in population abundance were observed, one occurring just immediately after the rains in May-June 1995 and the other in September-November 1995. No significant correlation ($R<0.3$) occurred between the rainfall received between May 1995 and April 1996

and the zooplankton density distribution

in St 3 where the mean density was

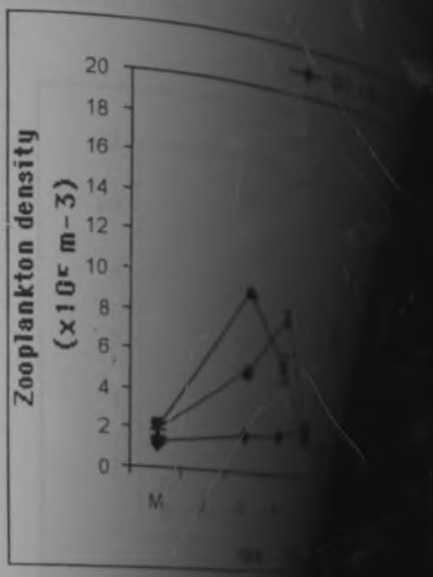

Fig. 12: Mean total zooplankton
between May 1995

In St 1 the mean zooplankton

density was 7.6×10^5 (SD

after May 1995 reaching the

in St 1. A second

trends in zooplankton

(ANOVA p=0.1) in

in rainfall received

March 1996.

The patterns in

the adult Crustacea

and the zooplankton density distribution. The highest densities of zooplankton were recorded in St 3 where the mean density was $9.72x10^5$ (SD $\pm 5.6x10^5$) m^{-3}.

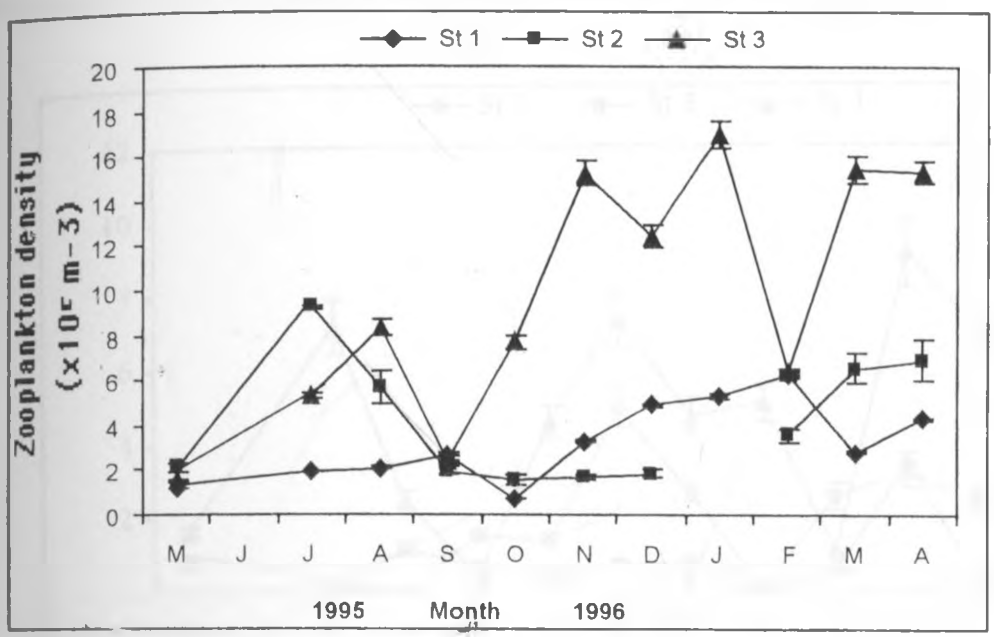

Fig. 12: Mean total zooplankton density ($x10^5 m^{-3}$) distribution in Lake Naivasha at St 1, St 2 and St 3 between May 1995 and April 1996

In St 1 the mean zooplankton density was $3.23x10^5$ (SD $\pm$ 1.8 $x10^5$) m^{-3} while in St 2 the mean density was $7.6x10^5$ (SD $\pm$11.9 $x10^5$) m^{-3}. The first ascent in zooplankton density was observed after May 1995 reaching the peak in July 1995 at St 2, August 1995 in St 3 and September 1995 in St 1. A second ascent in population density occurred after October 1995 in all stations. The trends in zooplankton distribution were very similar in the three stations but differed significantly (ANOVA p=0 1) in total densities. Higher densities of zooplankton were observed after the peaks in rainfall received around the lake region which occurred around June 1995, November 1995 and March 1996.

The patterns in temporal density distribution of the total zooplankton density (Fig. 12) and that of the adult Crustacea (Fig. 13) were similar. The density distribution of the Crustacea differed

significantly (ANOVA $p=7.48 \times 10^{-6}$) between the three stations. There was more variation in the distribution of the Crustacea Copepoda than in that of the Cladocera. The density distribution of the Cladocera at St 1 and St 2 showed no significant difference (ANOVA p=0.6,).

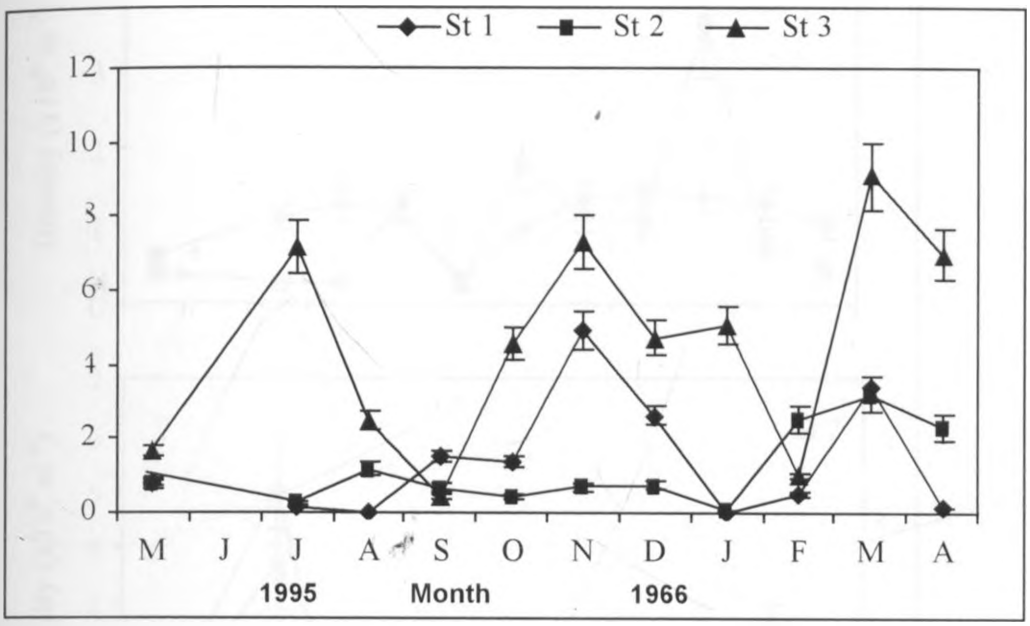

Fig. 13: Mean adult Crustacea density ($x10^{-5} m^{-3}$) distribution between May 1995 and April 1996

The mean percentage density contribution of the adult Crustacea was 44.6% (SD ±17.1) at St 1, 23.5% (SD ±16.9) at St 2 and 35.5% (SD ±17.7) at St 3. The Copepoda dominated the Crustacea population. The Copepoda densities at St 1 ranged from $6.0x10^{4}$ m^{-3} to $5.0x10^{5}$ m^{-3}. At St 2, the densities varied from <10 m^{-3} (in January 1995) to $2.6x10^{5}$ m^{-3} and at St 3, from $1.4x10^{4}$ m^{-3} to $1.3 x10^{6}$ m^{-3}.

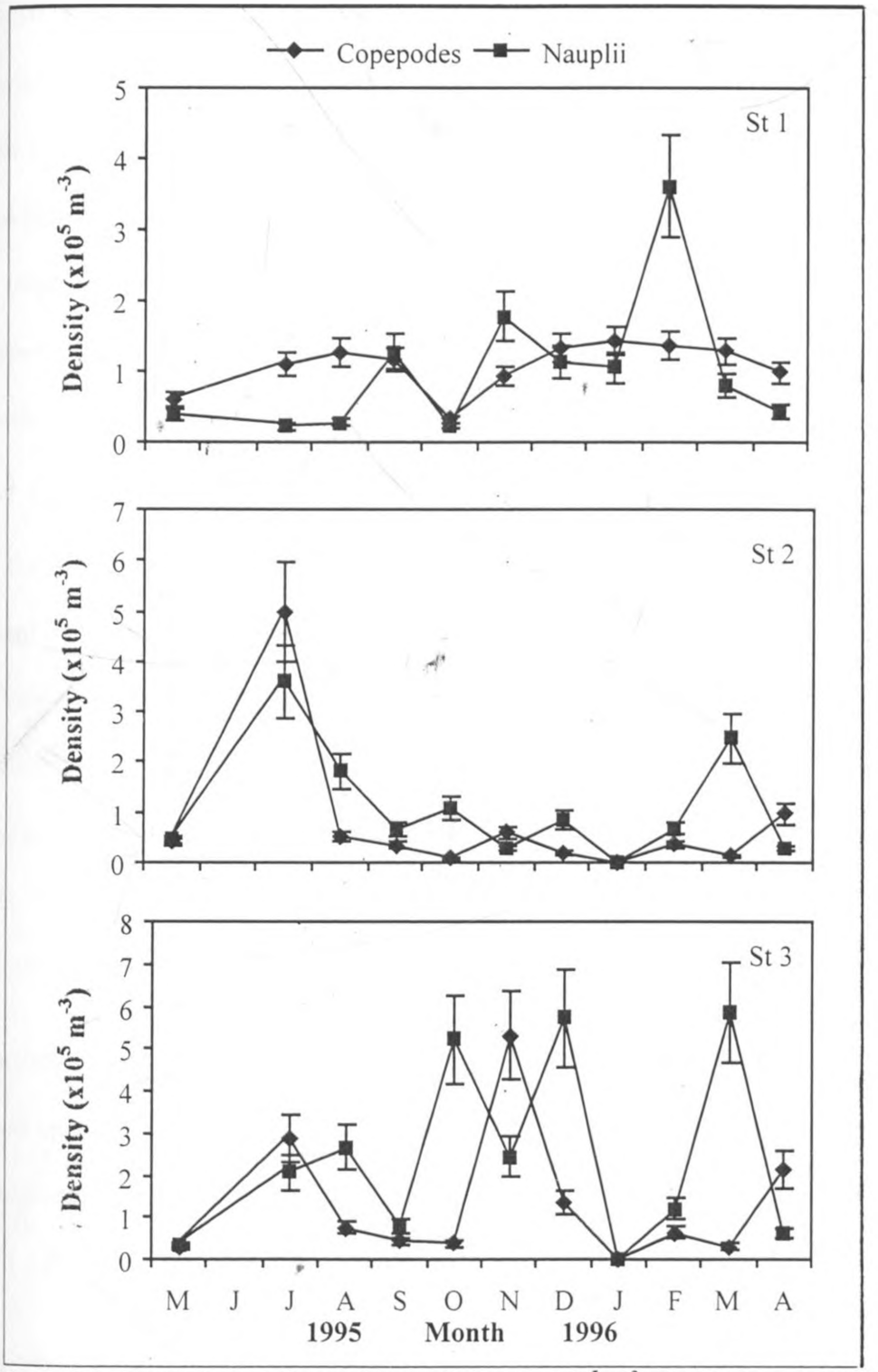

Fig. 14: Mean adult Copepoda and Copepoda nauplii density (x10^5 m^{-3}) distribution at St 1, St 2 and St 3 between May 1995 and April 1996

Thermocyclops oblongatus dominated the Copepoda species in all stations and was the only Copepoda encountered in St 3. The density of the Copepoda in St 3 was relatively higher than in the other two stations (Fig.14). The Copepoda nauplii also contributed significantly to the total zooplankton population density. The percentage contribution of the nauplii to total zooplankton in St 1 ranged from 10- 58%, in St 2, between < 1- 68% while at St 3, between 25- 81%. In St 1,the density ranged between $2.30x10^4$ m^{-3} and 3.61×10^5 m^{-3} (mean of 1.02×10^5 m^{-3}). At St 2 the density ranged between $<1.0x10^3$ m^{-1} and $3.60x10^5$ m^{-3} (mean 1.11×10^5 (SD $\pm 1.1x10^5$) m^{-3}). Station 1 and 2 showed no significant difference (ANOVA p=0.9) in total density of the nauplii.

In St 3 the densities of the nauplii were higher than in the other two stations. This resulted to a significant difference (ANOVA p=0.1) in total density between the stations. In St 3, the densities ranged between less than $1.0 \times 10^3 m^{-3}$ and 5.87×10^5 m^{-3} (mean of 2.46×10^5 (SD $\pm$ 2.20×10^5) m^{-3}). The high densities of nauplii in St 3 were not reflected in the same magnitude in the densities of the adult Copepoda. This indicated high mortality of the nauplii before they matured to adults. High nauplii densities were usually followed by a rise in adult Copepoda density in a time lag of about one month.

The contribution of the Cladocera Crustacea to the total zooplankton population was very low compared to that of the Copepoda Crustacea. At St 1 the Cladocera percentage composition varied between 2.6-19% (mean 6.0 % SD $\pm$ 5.0), at St 2, between <0-23% (mean 7.4 % SD $\pm$ 8) and at St 3 between 3-38 % (mean 11.3% SD $\pm$ 10.8).

Numerically important Cladocera species, (mean >5% of total zooplankton density) included; *D. excisum*, *S. vetulus*, *D. pulex*, *C. cornuta*, *D. laevis* and *M. micrura*. Total Cladocera densities ranged between, 4.2×10^3-3.55×10^4 m^{-3} at St 1, 3.0×10^3-9.7×10^4 m^{-3} at St 2 and 1.2×10^4-6.4

$x10^5$ m^{-3} at St 3 (Fig 15). The Cladocera population density peaks were observed in July 1995, November 1995 and March 1996 in St 1, St 2 and St 3 respectively. The lowest total zooplankton densities, in all the stations, occurred in January 1996.

At St 1, *Diaphanosoma excisum* contributed 42-96.4 % of the total Cladocera population with its density ranging from 4.0 $x10^3$ m^{-3} to 3.4$x10^3$ m^{-3}. In St 2, *D. excisum*, *D. pulex* and *S. vetulus* formed the largest proportion of Cladocera density.

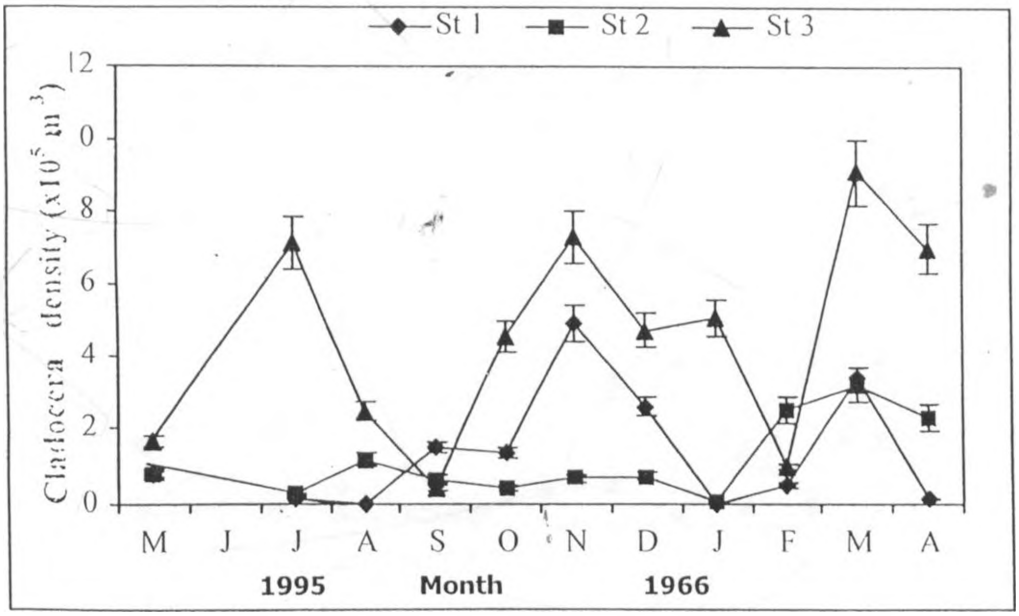

Fig. 15: Mean population density ($x10^5$ m^{-3} ± SE) distribution of the Cladocera at St 1, St 2 and St 3 between May 1995 and April 1996

At St 3, *C. cornuta* was the most important Cladocera in terms of density contributing between 2.3% and 99.9 % (with a mean of about 61.9 %) of the total Cladocera population. Its densities ranged from 1.2 $x14^4$ m^{-3} to 2.6 $x10^4$ m^{-3}. *Diaphanosoma excisum* had reasonable representation in St 3 and its density ranged between 1% to 59.8% of the total Cladocera with densities of between <1-2.3 $x10^3$ m^{-3}. *Moina micrura* occasionally showed high densities but the mean was less than 5% of total Cladocera density.

The species composition, temporal distribution and numerical abundance of the Rotifera were considerably variable at the three stations. The importance of the Rotifera in terms of numerical abundance was greatest at St 2 where their percentage contribution to total zooplankton ranged between 4.2% and 100% with a mean of 39.92% (SE $\pm$ 8.0). At St 1, the Rotifera contributed between 7.56% and 62.43% of the total zooplankton and had a mean of 25.43% (SE $\pm$ 5.65). The lowest Rotifera densities were encountered at St 3 with a percentage representation of between <1% and 29.3% (mean 7.6% SE $\pm$ 2.8) of the total zooplankton community

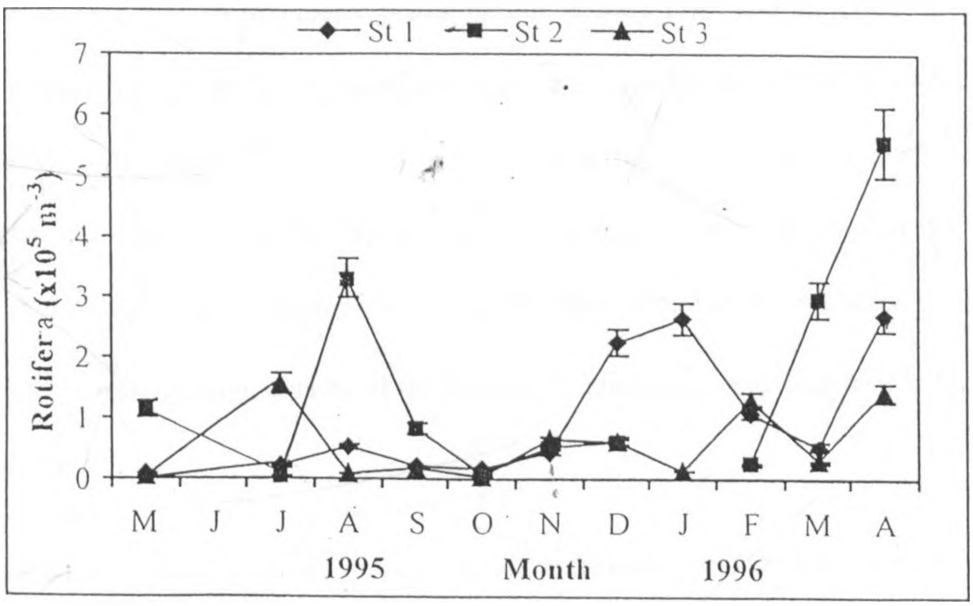

Fig. 16: Mean Rotifera density (x10^5 m^{-3} $\pm$ SE) distribution at St 1 St 2 and St 3 between May 1995 and April 1996

The Rotifera densities at St 1 ranged from 9.7 x10^3 to 2.7 x 10^5 m^{-3} and the mean was 1.2 x 10^{5}m^{-3} (Fig.16). Densities of Rotifera at St 2 ranged between 5.6 x 10^3 and 4.3 x 10^6 m^{-3}(mean 3.6x10^{4}m^{-3}). The lowest Rotifera densities were observed at St 3 where they ranged between 3.9 x 10^3 m^{-3} and 1.5 x 10^5 m^{-3}.

Three peaks in Rotifera population density were observed in August 1995, December-1995-January 1996 and April 1996 at St 1. The main Rotifera species contributing to the population peak in August 1995 was *K. cochlearis* forming 60.5% of the total Rotifera at a density of 3.8 x 10^4 m^{-3}. The peak occurring in December 1995-January 1996 coincided with an increase in the density of *B. caudatus*. This species formed 83.28% of the total Rotifera in December 1995 and 77.50% in January 1996 with densities of 23.6 x 10^5 m^{-3} and 25.6 x 10^5 m^{-3} in the two months respectively.

The Rotifera at St 1 showed two major peaks, one in January 1996 and the other in April 1996. The peak in April 1996 was the higher of the two peaks. The smaller peaks in Rotifera density occurred in May and August 1995. Rotifera densities during the peaks were 3.35 x 10^6 m^{-3} in January 1996 and 4.62 x 10^4 m^{-3} in April 1996. The January 1996 peak coincided with a high density of *B. dimidiatus*, which formed 99.9% of the total zooplankton population at a density of 3.35 x 10^6 m^{-3}. Similarly, high density of the Species *K. cochlearis* was responsible for the peaks in and April 1996.

At St 3, four small population peaks in the population distribution of the Rotifera were observed. The peaks occurred in July 1995, November 1995, February 1996 and April 1996. The species, *B. calyciflorus* was the species with the highest density (13.2 x 10^4 m^{-3}) in July 1996, constituting about 99.8% of the total Rotifera population. The two species *Hexarthra jenkinnae* and *B. calyciflorus* were responsible for the population rise during the month of November 1995 and contributed 50.87% and 46.93% of total Rotifera respectively. In February 1996 and April 1996 again *K. cochlearis* and *H. jenkinnae* were the most prominent. The species *B. calyciflorus* had a mean density of 1.78 x 10^4 m^{-3}, contributing about 34.90 % (SE $\pm$ 12.18) of the Rotifera and

between 2.19 % of total zooplankton population. Apart from *H. jenkinnae* whose mean density constituted about 2.22 % (33.23 % of the Rotifera density) of the total zooplankton density, no other species had a mean density of more than 1 %.

The Rotifera populations at St 1 and St 2 were very similar in taxonomic species composition and only varied in temporal density distribution and percentage contribution to the total zooplankton population. The two species *B. caudatus* and *B. calyciflorus* were still the dominant species, recording mean densities of 5.9 x $10^4 m^{-3}$ and 2.59 x 10^4 m^{-3} in the two stations respectively. The results for the Rotifera from the three stations show that the lowest species diversity, density and percentage contribution to the total zooplankton were found in St 3. Electrical conductivity was much higher in St 3 and probably explains the paucity of Rotifera.

3.8 Zooplankton body sizes

There were significant temporal differences (P = 0.044) in the mean body sizes of total zooplankton between the stations. Station 1, had the lowest mean body size (248.5 $\pm$ 108.8 µm). At St 2 and 3, the mean body size was 283.9$\pm$ 97.2µm and 356.2$\pm$ 85.2µm respectively between May 1995 and April 1996

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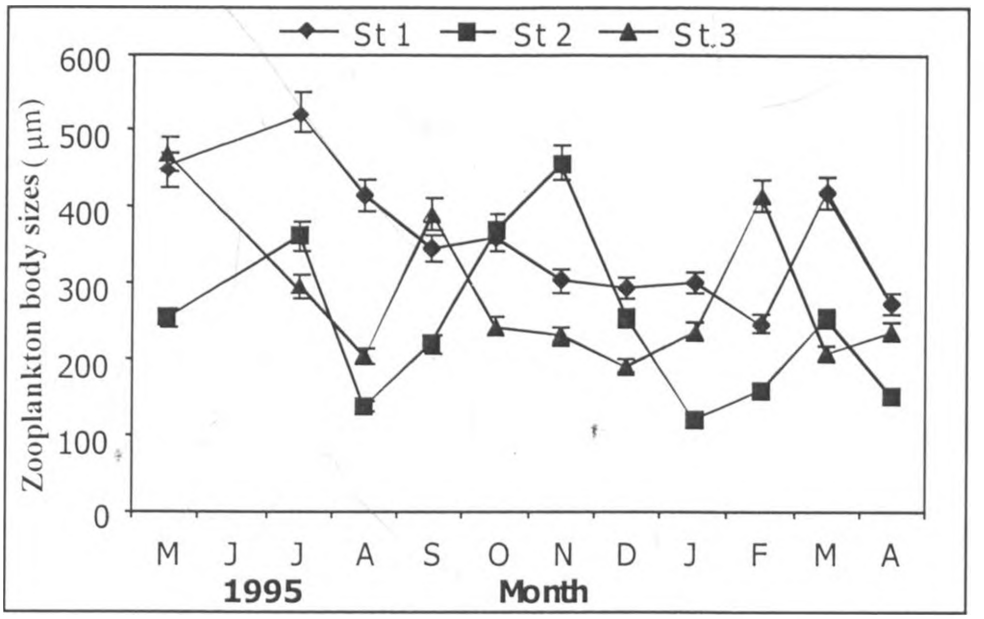

Fig. 17: Mean zooplankton community body sizes (µm) distribution at St 1, St 2 and St 3 between May 1995 and April 1996.

High proportions of large bodied species (especially Cladocera) resulted in high zooplankton community mean body sizes. In St 1, High zooplankton mean body sizes occurred in July and November 1995. The peaks coincided with high densities of adult Copepoda (*M. equatorialis* and *T. oblongatus*) and Cladocera (*D. excisum and S. vetulus)* whose body sizes ranged between 440 µm and 2040µm (Table 5).

At St 2, high mean sizes occurred in May 1995, September 1995 and February 1996. The species were *M. equatorialis*, *T. oblongatus*, *D. excisum* and *S. vetulus*. At St 3, the highest mean body size occurred in February 1996 when there was a rise in density of *C. cornuta*, *D. excisum* and *M. micrura* populations.

The mean body sizes of the adult Crustacea population were above 500µm in all stations (Fig. 19) except at St 2 in January 1996 when there was a crash in the Crustacea population. The high

mean body sizes observed was due to low density of of small sized Crustacea e.g. *Chydorus sp* and *Ceriodaphnia* whose mean body sizes is <500µm.

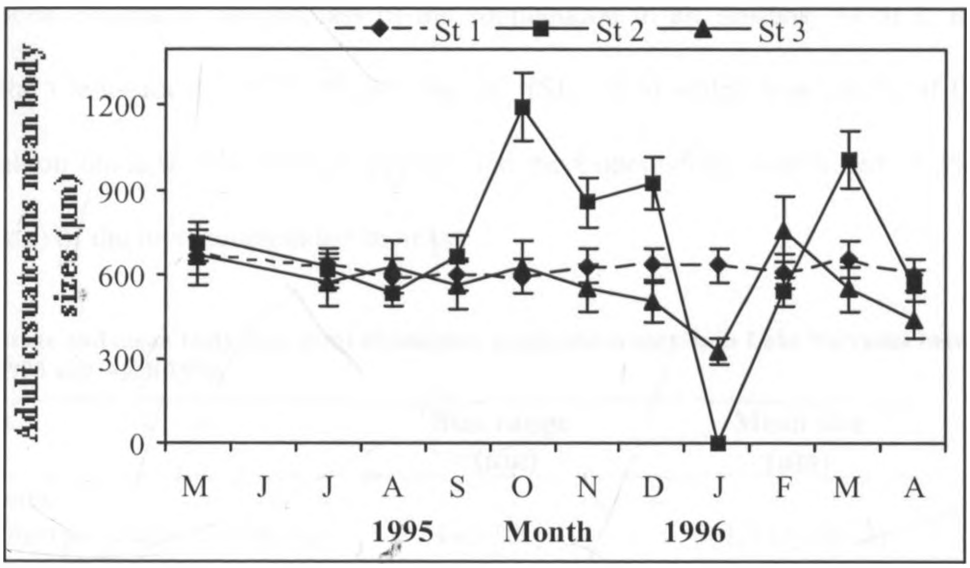

Fig. 18: Mean adult Crustacea body size (µm) distribution at St 1, St 2 and St 3 between May 1995 and April 1996.

At St 1, mean body size of the Crustacea population was 620µm (± 7.7) over the study period. The monthly mean body sizes at St 1 fluctuated narrowly between 590.4µm and 665.8µm. The highest mean sizes were observed at St 2 fluctuating between 585µm (Jan. 96) and 1196.2µm (Fig. 19). The high fluctuations were due to low stability in the species composition and densities of the Crustacea at St 2 as compared to St 1 and St 3.

3.9 Zooplankton biomass

The mean zooplankton biomass differed significantly (ANOVA $p= 3.6 \times 10^{-3}$) between St 1, St 2 and St 3. At St 1, the mean biomass was 278.57 dry wt. mg. m^{-3} (SE ± 27.35), while that of St 2 was 204.40 dry wt. mg. m^{-3} (SE ± 41.87). Greater variation was observed between St 3 and the

other two. The mean biomass at St 3 was 473.84 dry wt. mg. m^{-3} (SE $\pm$ 66.21), about two fold in magnitude that of St 1 and St 2.

Adult Crustacea dominated the biomass of the zooplankton in all stations, At St 1, the mean biomass of the Cladocera was 39.2 dry wt. mg. m^{-3} (SE. $\pm$6.6) which was 14.1% of the mean total zooplankton biomass. The adult Copepoda and the Copepodites contributed 78.2% (217.5 dry wt. mg. m^{-3}) of the total zooplankton biomass.

Table 7. The range and mean body sizes (µm) of common zooplankton species in Lake Naivasha between May 1995 and April 1996.

Species	Size range (µm)	Mean size (µm)
Copepoda		
Thermocyclops oblongatus	440-1000	661.4 ($\pm$ 103.8)
Mesocyclops equatorialis	800-1640	1178.4 ($\pm$ 126.9
Copepodites	280-680	498.4 ($\pm$ 84.5)
Copepoda nauplii	66-244	125.5 ($\pm$ 35.2)
Cladocera		
Ceriodaphnia cornuta	204.6-396	318.5 ($\pm$ 54.5)
Diaphanosoma excisum	320-1600	791.3 ($\pm$196.7)
Daphnia laevis	540-1400	1042.4 ($\pm$ 245.3)
Daphnia pulex	500-1820	1168.1 ($\pm$ 361.6)
Moina micrura	400-1180	653 ($\pm$ 203.6)
Simocephalus vetulus	480-2040	913.7 ($\pm$ 414.2)
Rotifera		
Brachionus calyciflorus	165-303.6	254.1 ($\pm$ 22.8)
Brachionus caudatus	105.6-191.4	151 ($\pm$ 16.2)
Filinia spp	66-158.4	116 ($\pm$ 26.2)
Hexarthra jenkinnae	66-112	90.1 ($\pm$ 7.7)

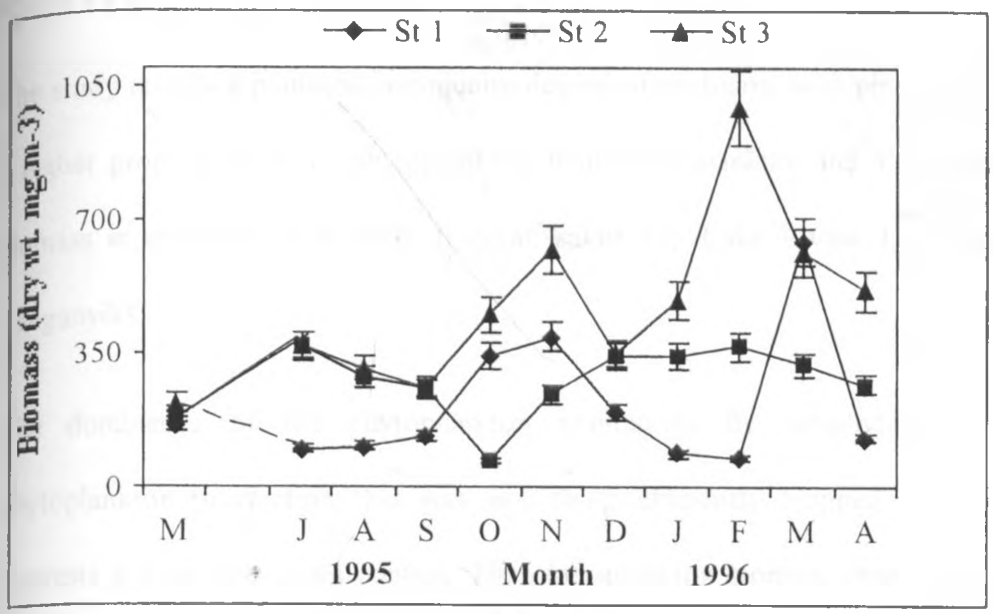

Fig. 19: Mean zooplankton biomass (dry wt. mg. m^{-3}) at St 1, St 2 and St 3 between May 1995 and April 1996.

At St 2, the Cladocera mean biomass was 110.6 dry wt. mg. m^{-3} (SE. ±41.4), which was 47.3 % of the mean total zooplankton biomass while the adult Copepoda and Copepodites contributed 84.3 dry wt. mg. m^{-3} (SE ± 12.4), about 38.5% of the total zooplankton.

Station 3 supported a higher mean Crustacea biomass than St 1 and St 2. The Cladocera had a biomass of 160.4 dry wt. $mg.m^{-3}$, 12.1 % of total zooplankton biomass, while the adult Copepoda contributed 294.4 dry wt. $mg.m^{-3}$ which was 87.4 % of the mean total biomass.

Thermocyclops oblongatus was the main single species contributing the largest proportion of the zooplankton biomass in all stations. Others in order of preference were the Cladocera *Diaphanosoma excisum*, *Daphnia pulex* and *Simocephalus vetulus*. At St 3 the Cladocera *Moina micrura* and *Ceriodaphnia cornuta* were the most important species.

CHAPTER 4: DISCUSSION

The study reveals a plankton community devoid of protozoa, with phytoplankton biomass having a higher proportion of net-phytoplankton than nannoplankton and a relatively low zooplankton biomass in comparison to other tropical Lakes e.g. Lake Awasi, L. George, L Chad and L. Tanganyika

The dominance of the phytoplankton community by net-phytoplankton suggested high phytoplankton production that was not being efficiently cropped by the zooplankton. This suggests a weak top-down control. The phytoplankton biomass observed during this study was higher than that reported by Harper (1992), Njuguna (1982) and Melack (1976) at relatively similar lake levels. Secchi disc transparencies and dissolved oxygen concentrations lower than observed by the above authors were consistent with the phytoplankton biomass. The structure of the phytoplankton species composition and biomass in Lake Naivasha showed stronger bottom-up control (the influence of nutrients through phytoplankton) than top-down control (fish predation)

The structure of the phytoplankton observed in Lake Naivasha compares to that of other lakes such as Lake George in Uganda. Burgis (1971) reported Lake George to have high phytoplankton biomass (250mg. chl-'a'. m^{-3}) dominated by blue-green bacteria (*Microcystis, Anabaenopsis* and *Aphanocapsa*). While Lake George is hypertrophic, Lake Naivasha is eutrophic with chlorophyll 'a' >10 mg m^{-3} Secchi disc transparencies < 1m (this study) and total phosphate >40ug^{-1}(Kitaka 2002). In Lake Naivasha filamentous species (*Lygnbya, Microcystis, Closterium,* and *Aulacosiera*) were also dominant. In both cases the structure of the phytoplankton indicated characteristics of bottom up control where the biomass increases and the species composition shifts toward higher density of net-phytoplankton. With the density of nannoplankton low in Lake

Naivasha, the food particle size for filtering zooplankton becomes limiting resulting in the reduction of Cladocera density

Gliwicz (1980) reported that zooplankton community responded to increased phytoplankton production by a shift towards increased densities and reduced species composition. In Lake Naivasha the shift was most clearly observed in St 3. The densities of the Cladocera species (*Daphnia spp. S. vetulus* and *D. excisum*) were lower in St 3 compared to St 1 and St 2 where phytoplankton biomass was lower. Mavuti (1983) reported higher densities of Cladocera (dominated by *D. excisum, D. pulex* and *S. vetulus*) than reported here. Lower densities and shift in composition towards exclusive domination by *T. oblongatus* were observed during this study. High phytoplankton biomass supported a higher zooplankton density and biomass while reducing the species diversity. At St 3 where the highest phytoplankton biomass (dominated by filamentous net phytoplankton especially *Lyngbya, Microcystis Synedra, Cylindrospermopsis* and *Aulacosiera*) was observed, the zooplankton density and biomass was also highest. In this station there was total dominance of the Copepoda *Thermocyclops oblongatus* attributed to the high phytoplankton biomass and species composition. In the other two stations, where the phytoplankton biomass was lower, the proportion of Cladocera Crustacea was higher.

The low density of nannoplankton was also another indication of stronger bottom-up control. Where zooplankton grazing on the phytoplankton is efficient, the larger (net) phytoplankton cells are removed from the community giving room for the nannoplankton to flourish (Christoffersen *et. al.*, 1993) in turn resulting in increase of density of flagellates and Rotifera.

The zooplankton in Lake Naivaha showed little evidence of predation by fish. With intense fish predation, the large bodied Crustacea are selectively eaten, shifting the size structure of the

zooplankton to small individuals such as Rotifera and small Cladocera e.g. *Chydorus sp. Ceriodaphnia sp.* and *Moina,* therefore also reducing the zooplankton biomass. In Lake Naivasha six fish species, *Micropterus salmoides, Tilapia zillii*, *Oreochromis leocostictus*, *Barbus amphigramma*, *Poecilia sp.* and *Lebistes reticulata* have been identified. The first three form the basis of a poor commercial fishery in terms of fish landed. The only adult zooplanktivore, *Lebistes reticulata* is not common. Large Crustacea whose mean sizes were above 500µm dominated the zooplankton community's biomass in Lake Naivasha.

The size structure density and biomass of the zooplankton species identified showed no shift from large species to small sized species. The size range of the zooplankton individuals encountered in samples all the stations was from about 100µm (Rotifera) to over 2000µm (Crustacea). The mean size of adult Crustacea was 802.8µm (SD ±199 µm). The occurrence of the large Crustacea and high densities in the samples implied they were not being cropped effectively. Predation tends to push the zooplankton mean sizes downward and results to alteration of the species composition towards small-bodied species. In Lake Chad where vertebrate predation is high, the zooplankton that occur there are very small (200-300µm) in size (Bénech *et. al.,* 1983*)*. According to the size efficiency hypothesis of Brooks and Dodson (1965), the removal of large-bodied zooplankton by fish predation results in higher densities of smaller individuals. When fish predation on large Crustacea is intense, the Rotifera population density increases. The Rotifera density in the lake showed considerable temporal variation and low contribution to the zooplankton community. The low species number and relative density of the Rotifera showed that there was no major pressure on the Crustacea to allow the Rotifera population expansion.

The Adult Crustacea also dominated the biomass of the zooplankton in all three stations. In St 1 the adult Crustacea accounted for 92.2% (255.7dry wt.mg. m^{-3}) of the total zooplankton biomass. In St 2 and St biomass contribution by the crustacea was 95.4% (194.9dry wt. mg. m^{3}) and 95.3 %(451.6 dry wt. mg. m^{3}) of the total biomass respectively.

The lack of correlation between the total zooplankton and the phytoplankton biomass indicates that other factors and not just the phytoplankton biomass influences the zooplankton structure and vice versa. Although there was presence of large zooplankton individuals in Lake Naivasha they had no effective control on the phytoplankton. This was evident from the high density of filamentous species that dominated the net phytoplankton in all the stations. The structure of the whole plankton community (phytoplankton and zooplankton) shows that the bottom-up control is stronger than the top-down control.

Returning to the hypotheses, it can be seen that the first is supported; the second is not clearly supported and evidence for the third is that the zooplankton community support the bottom-up theory of plankton structure driven by nutrients rather than by predation.

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Appendix 1: Rainfall around Lake Naivasha and lake levels between May 1995 and April 1996. (Source: Sulmac flower farm company)

Month	Rainfall	Lake Level
May 1995	44.3	1886.00
Jun 1995	59.9	1886.06
Jul 1995	23.9	1886.11
Aug 1995	17.5	1886.32
Sept 1995	33.1	1886.60
Oct 1995	69	1886.57
Nov 1995	78.6	1886.54
Dec 1995	15.5	1886.48
Jan 1996	5.8	1886.41
Feb 1996	86.9	1886.31
Mar 1996	89.6	1886.21
Apr 1996	74.4	1886.14

Appendix 2: Maximum and minimum air temperature around Lake Naivasha region between May 1995 and April 1996. (Source: Sulmac flower farm company weather station)

Month	Max temp (^{0}O)	Min temp (^{o}C)
May 1995	-	-
Jun 1995	-	-
Jul 1995	24.7	9.7
Aug 1995	25.6	9.4
Sept 1995	27.6	8.2
Oct 1995	27	10.7
Nov 1995	29.5	10.6
Dec 1995	32	7.3
Jan 1996	32	7
Feb 1996	31	10.6
Mar 1996	29	10.8
Apr 1996	27.6	10.9

Appendix 3: Lake Water temperature (°C) at St 1, St 2 and St 3 between May 1995 and April 1996.

St 1

Depth (m)	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
0.0	23.5	20	19.5	19.5	20	23	22.5	21.5	21	22	23
1.5	21.5	19	19.5	19	19.5	21	21.5	20	20.5	20.9	22
3.0	21	18.5	19	19	19.5	20.7	21.5	20	20.5	20.6	21
4.5	21	18.5	19	19	19.5	20.4	21.5	20	20.5	20.5	21
6.0	21	18.5	19	19	19	20.2	21.5	19.8	20.5	20.5	21
7.5	21	18.2	19	19	19	20	20	19.8	20	20.5	20

St 2

Depth (m)	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
0	21.5	20	19	20	22	20.5	20	23	22.5	25.5	23
1	21.5	19	19	20	20.5	20.5	19.8	22.5	22	21.5	22.5
2	21	18.5	18.5	20	20	20.5	19.5	22	21.5	21	21
3	21	18.3	18.5	19.8	20	20.5	19.5	21.5	21.5	21	21
4	21	18.3	18.5	19.8	20	20.5	19.5	21.5	21	21	21
5	21	18.3	18.5	19.8	20	20.5	19.5	21	21	21	21

St 3

Depth (m)	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
0	20	19	23	20.5	21.5	20.5	21	21	21	23.5	22
1	20	18.5	23	20.5	20.5	20.5	20.5	20.5	21	22.5	21
2	20	18	21.5	20	20.5	20.5	20.5	20.5	21.5	22	21
3	20	18	21.5	20	20	20.2	20	20.5	21.5	22	20.5
4	19.5	18	21.5	20	20	20	20	20	20.5	22.5	20.5
5	19.5	18	21.5	20	20	20	20	20	20	21	20

Appendix 4: Dissolved oxygen concentration (O_2 mg. l^{-1}) at St 1, St 2 and St 3 between May 1995 and April 1996.

St 1

Depth (m)	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
0.0	9.2	4.7	5.6	7.4	6.9	6.2	7.7	6.5	5.2	7.6	8.5
1.5	8.7	3.9	5.8	6.9	5.9	5.6	7.9	5	3.7	7.9	6.9
3.0	6.6	3.5	5.5	6.6	4.7	4.9	6.2	3.8	2.6	6	2.3
4.5	6.4	2.9	4.8	4.2	4.7	4.5	5.3	3.3	1.7	5.2	1.7
6.0	1.4	2.2	4.6	3.5	5	3.8	4.5	5.2	1	3.9	1
7.5	1	2	4.6	3	4.9	3.6	3.9	4.8	0.75	1.1	0.3

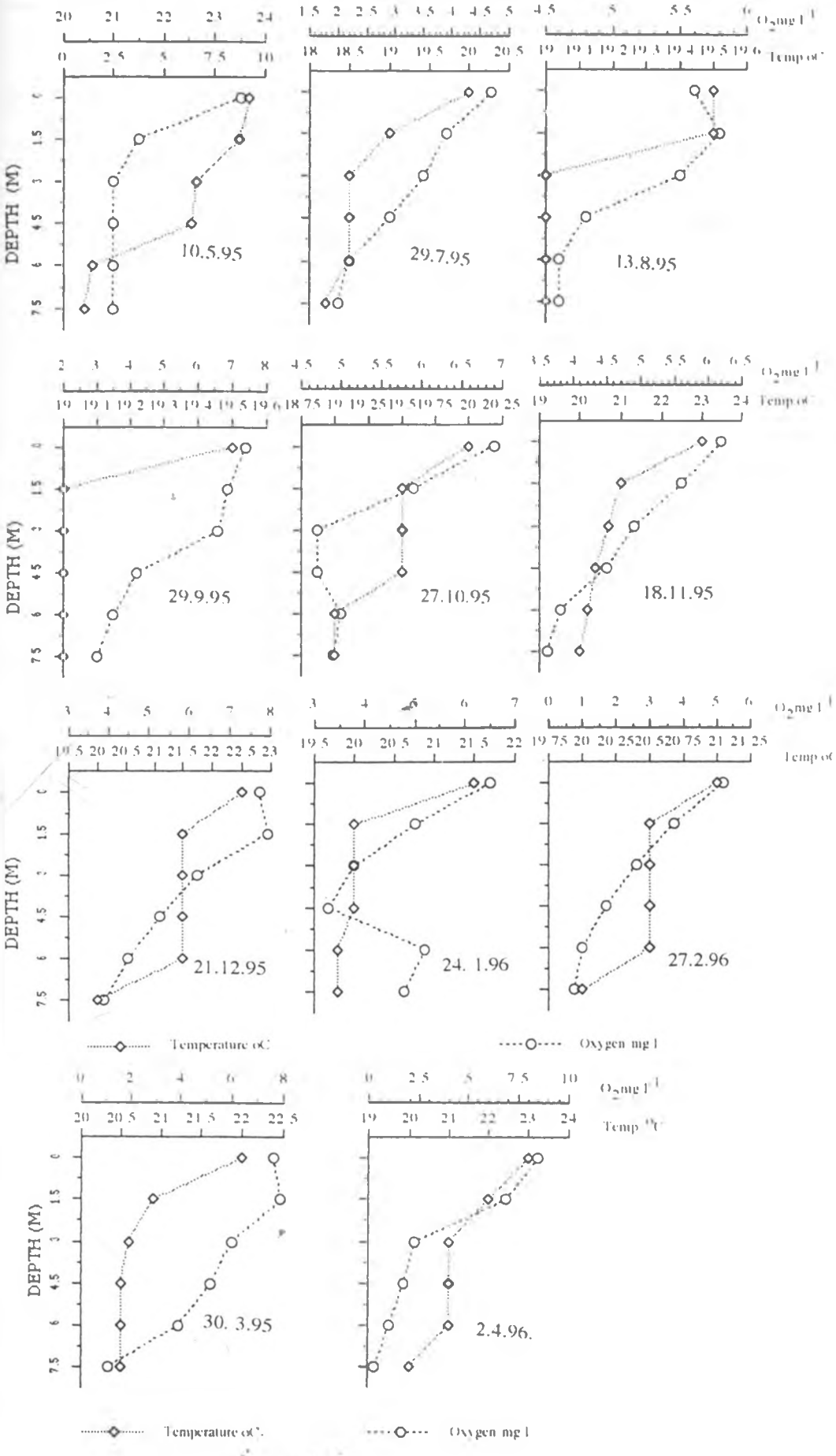
St 2

Depth (m)	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1	7	6.8	7.2	5	7.9	7.2	7.2	7.5	7.3	9.2	6.9
2	6.7	6	7.2	4.9	6.6	6.6	6.8	6.6	6.3	7.9	6
3	6.6	6.1	7.1	4.7	6.4	6.5	6.8	6.3	5	7.8	5.9
4	6.6	6	7.05	4.6	6	6.6	6.8	6	1.5	7.3	5.8
5	6.6	6.1	6.9	4.4	5.5	6.6	6.5	5.8	0.5	5.3	5.7

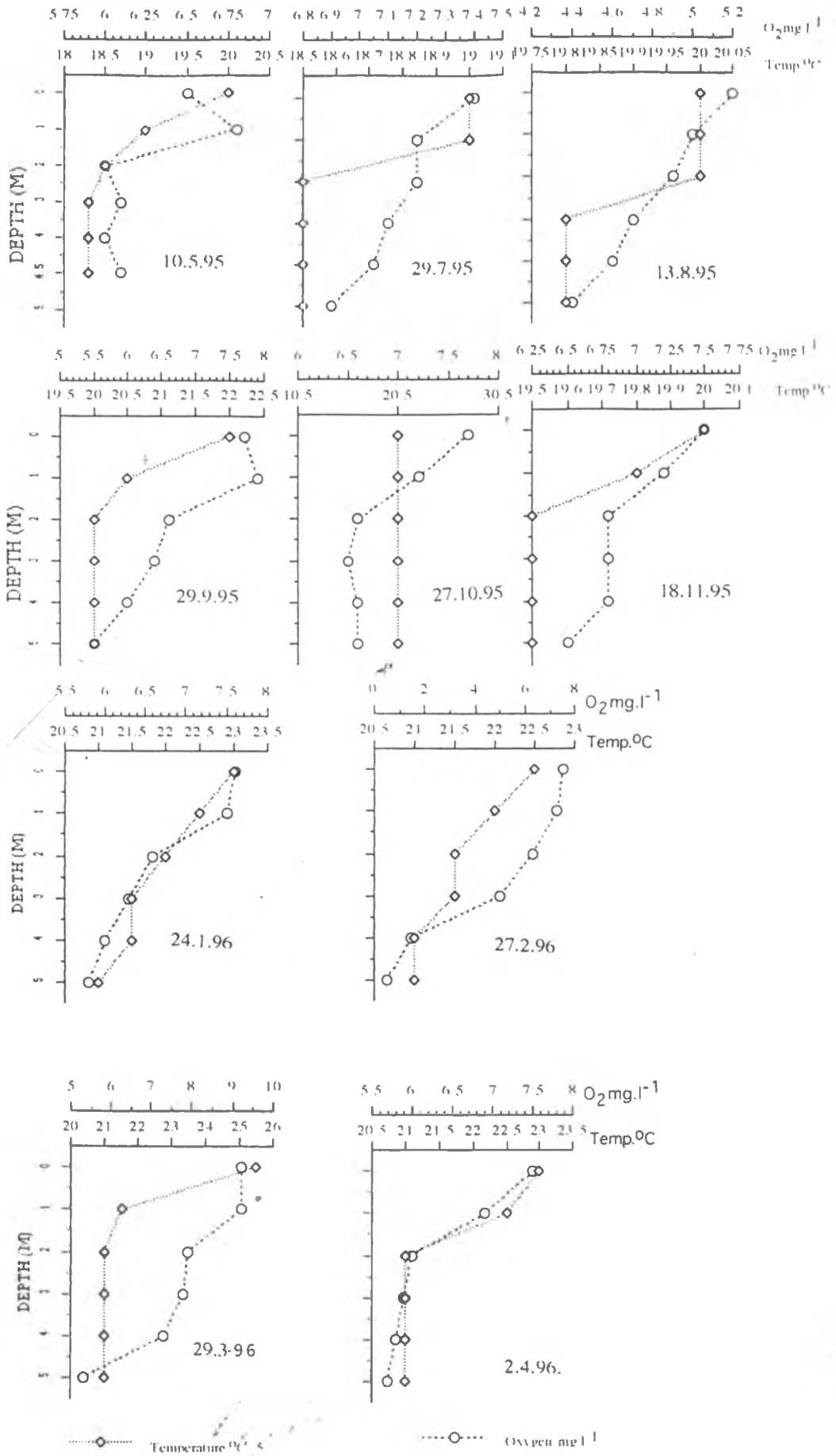
St 3

Depth (m)	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
0	7	6.8	5.5	5.2	5.7	2	5.6	5.4	5.9	7.5	9
1	6.2	6.4	4.5	4.3	4.5	1.6	5.2	4.7	5.5	5.9	6.3
2	6.2	5.9	4.3	2.9	4.5	1.5	4.7	4.3	4.6	4.5	4.9
3	4.1	5.5	4	2.9	4.5	0.25	4.4	4	4	4.3	4.8
4	4.3	4.4	4	2.8	4.3	0.1	4.3	3.8	3.4	3.2	3.8
5	0.3	0.5	3.4	1.8	3.5	0.1	3.7	3.5	2.6	2.4	2.3

April 1996


DEPTH (M)
10.5.95
29.7.95
13.8.95
29.9.95
27.10.95
18.11.95
21.12.95
24. 1.96
27.2.96
30. 3.95
2.4.96.
Temperature oC
Oxygen mg l

Appendix 5b: Temperature (°C) and dissolved oxygen (mg l^{-1}) depth profiles at St 2 between May 1995 and April 1996



Appendix 6: Secchi disc readings at St 1, St 2 and St 3 between May 1995 and April 1996.

Month	St 1	St 2	St 3
May 1995	64	62	25
Jun 1995	-	-	-
Jul 1995	102	60	20
Aug 1995	90	93	18
Sept 1995	60	72	21
Oct 1995	68	74	23
Nov 1995	80	60	32
Dec 1995	72	55	31
Jan 1996	69	50	30
Feb 1996	62	50	30
Mar 1996	64	45	30
Apr 1996	66	47	32

Appendix 7: Electrical Conductivity of lake water at St 1, St 2 and St 3 Between May 1995 and April 1996.

Month	St 1	St 2	St 3
May 1995	320	380	2570
Jun 1995	-	-	-
Jul 1995	376	340	2580
Aug 1995	380	380	2590
Sept 1995	388	360	2680
Oct 1995	389	362	2720
Nov 1995	395	363	2570
Dec 1995	384	360	2590
Jan 1996	402	355	2650
Feb 1996	389	350	2700
Mar 1996	381	352	2710
Apr 1996	384	355	2850

Appendix 8: The pH of water in Lake Naivasha between May 1995 and April 1996.

Month	St 1	St 2	St 3
May 1995	8.54	8.81	9.67
Jun 1995	-	-	-
Jul 1995	8.31	8.59	9.67
Aug 1995	8.35	8.56	9.60
Sept 1995	8.57	8.58	9.65
Oct 1995	8.17	8.60	9.64
Nov 1995	8.62	8.57	9.44
Dec 1995	8.67	8.60	9.60
Jan 1996	8.76	8.63	9.64
Feb 1996	8.42	8.76	9.66
Mar 1996	8.65	8.67	9.56
Apr 1996	8.45	8.55	9.77

Appendix 9a: Phytoplankton cell density (ml^{-1}) at St 1 between May 1995 and April 1996.

STATION 1	M	J	A	S	O	N	D	J	F	M	A	Mean	SE	Mean %
Aphanocapsa delicatissima	3	3	2	0	0	0	6	2	0	0	2	2	1	0
Aphanocapsa elachista	0	0	0	0	2	1	0	0	0	0	0	0	0	0
Aphanotheca spp.	10	2	0	0	0	4	4	0	0	0	1	2	1	0
Chrolococcus dispersus	40	12	3	13	0	0	0	0	20	3	0	8	4	1
Chroococcus turgidus	7	1	0	9	4	0	0	3	0	0	0	2	1	0
Coelosphaerium kuetzingianum	0	0	0	0	2	2	0	0	14	0	0	2	1	0
Cylindrospermopsis raciborskii	134	40	29	92	13	7	13	8	38	58	24	42	12	6
Dactylococcopsis sp.	4	0	0	0	0	0	0	0	0	4	1	1	1	0
Holopidium irregulae	3	0	0	0	0	3	0	0	9	0	0	1	1	0
Lyngbya spp	18	5	8	26	5	6	11	6	33	10	4	12	3	2
Merismopidia tenuisima	11	4	5	19	0	0	8	4	24	6	3	8	2	1
Microcystis aeruginosa	122	7	34	106	22	23	76	20	85	25	17	49	12	8
Oscillatoria sp	13	4	7	22	6	5	10	7	28	9	3	10	2	2
Spirulina spp.	0	0	0	6	4	4	2	0	0	0	0	1	1	0
Synechocystis aquatilis	0	0	0	0	1	0	0	0	6	0	0	1	1	0
Ankistrodesmus	15	0	0	0	0	1	6	7	30	54	45	15	6	2
Botryococcus braunii	97	20	1	0	0	0	0	0	13	87	63	26	11	4
Chlamydomonus sp.	27	4	15	25	14	9	10	12	24	23	9	16	2	2
Closterium aciculea	26	0	2	0	6	25	61	10	0	0	0	12	6	2
Closterium acutum	10	0	0	0	5	4	35	9	0	0	0	6	3	1
Coelastrum proboscideum	0	0	0	0	0	1	2	0	6	0	0	1	1	0
Cosmarium sp	103	13	12	22	0	4	38	31	90	93	61	42	11	7
Crucigenia quadrata	7	0	0	0	3	0	0	5	0	0	0	1	1	0
Crucigenia tetrepedia	5	2	0	3	0	0	0	5	0	0	0	1	1	0
Dictyosphaerium sp 1. (pulchellum)	62	5	11	70	8	10	16	0	0	31	9	20	7	3
Elakothrix geratinosa	9	3	5	0	0	0	4	8	11	0	0	4	1	1
Gloecosystis sp.(cf. Planktonica)	21	5	0	5	12	6	13	29	26	21	13	14	3	2
Oocystis sp	0	2	0	0	0	0	0	6	9	14	8	4	1	1
Pediastrum boryanum	0	3	17	0	7	2	0	0	0	0	0	3	2	0
Pediastrum duplex	19	12	0	0	31	27	3	0	0	10	5	10	3	2
Pediastrum obtusum	0	0	3	7	4	1	0	0	0	0	0	1	1	0
Scenedesmus aciminatus	0	4	13	27	9	5	0	3	0	3	0	6	3	1
Scenedesmus bicaudatus	0	0	8	20	4	3	1	0	0	4	0	4	2	1
Scenedesmus brevispina	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenedesmus denticulatus	0	4	9	11	10	7	0	0	0	8	4	5	1	1
Scenedesmus intermedius	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenedesmus protuberans	58	5	14	30	15	10	7	0	17	12	3	16	5	2

Appendix 9a: Cont.

Scenedesmus quadricauda	24	4	32	65	15	11	12	13	28	25	14	22	5	3
Scenedesmus spinosus	0	0	0	0	2	0	0	1	0	0	0	0	0	0
Scenedesmus falcatus	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Scenedesmus sp (Capricornutum)	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Spirogyra sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Staurastrum sp	17	0	0	0	1	0	0	22	39	17	7	9	4	1
Tetraedron caudatum	0	0	1	0	0	0	0	2	4	0	0	1	0	0
Tetraedron minimum	14	1	0	0	11	7	9	4	0	0	1	4	2	1
Tetraderon trigonum	22	4	10	15	13	8	14	14	22	19	12	14	2	2
Tetraedron regulare	12	2	0	0	0	0	0	0	0	0	2	1	1	0
Tetradesmus wisconsinense	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Westella botryoides	0	0	0	0	0	0	0	0	0	6	6	1	1	0
Trachelomonas sp.	12	4	9	24	17	20	10	8	55	24	0	17	5	3
Phacus sp.	47	16	36	49	17	0	20	17	0	12	28	22	5	3
Aulacosiera ambigua	62	9	7	17	47	66	47	33	68	86	93	49	9	8
Aulacosiera granulata	0	0	22	12	22	25	12	12	11	0	0	11	3	2
Navicula sp.	0	0	0	6	0	0	0	8	0	22	15	5	2	1
Nitzchia sp.	10	0	0	0	0	8	0	0	0	0	0	2	1	0
Synedra sp.	21	5	4	0	0	0	0	4	0	0	0	3	2	0
Synedra ulna	0	28	0	0	0	0	4	0	0	11	0	4	3	1
Synedra acus	83	55	58	93	5	17	8	61	23	32	66	46	9	7
Chromulina sp.	24	13	4	18	8	25	5	10	18	15	14	14	2	2
Chrysococcus sp.	0	0	0	0	0	0	1	0	0	3	0	0	0	0
Mallomonas sp.	0	0	2	0	2	0	0	0	0	0	0	0	0	0
Cryptomonas sp.	106	0	0	101	70	45	33	29	64	22	41	46	11	7
Rhodomonas sp.	0	21	28	0	9	9	14	8	0	22	14	11	3	2
Ceratium sp.	0	18	0	0	2	0	0	0	0	0	16	3	2	1
Glenodinium sp.	0	5	2	7	3	6	0	0	0	0	0	2	1	0
Gymnodinium sp.	0	0	0	0	0	4	0	0	0	4	0	1	0	0
Peridinium sp (cf palustre)	0	3	3	11	0	0	0	10	18	5	5	5	2	1

Appendix 9b: Phytoplankton cell density (ml^{-1}) at St 2 between May 1995 and April 1996

STATION 2	M	J	A	S	O	N	D	J	F	M	A	Mean	SE	Mean %
Aphanocapsa delicatissima	5	50	16	14	17	20	0	0	0	5	13	13	4	2
Aphanocapsa elachista	0	6	3	9	0	0	0	0	0	0	0	2	1	0
Aphanotheca sp.	0	6	0	0	12	13	0	0	0	3	7	4	2	1
Chrolococcus sp.	3	17	5	4	0	0	0	0	0	0	2	3	1	0
Coelosphaerium kuetzingianum	2	0	0	0	0	0	21	6	24	11	0	6	3	1
Cylindrospermopsis raciborskii	6	111	30	30	0	29	30	4	0	2	8	23	10	4
Dactylococcopsis sp.	0	0	0	0	7	0	9	0	10	0	0	2	1	0
Holopidium irregulae	0	0	0	0	10	0	0	0	34	10	0	5	3	1
Lyngbya sp.	2	12	6	9	19	42	49	10	34	13	12	19	5	3
Merismopidia tenuisima	1	14	7	12	19	49	42	10	16	0	0	15	5	3
Microcystis aeruginosa	10	58	18	32	65	117	97	24	78	29	30	51	11	9
Oscillatoria	1	0	0	3	0	0	0	0	0	10	3	1	1	0
Spirulina sp.	1	0	2	3	0	0	0	0	0	8	5	2	1	0
Synechocystis aquatilis	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ankistrodesmus falcatus	3	2	0	0	0	0	8	10	16	19	10	6	2	1
Botryococcus braunii	29	58	15	5	14	0	0	0	0	46	33	18	6	3
Chlamydomonus sp.	0	6	0	0	7	27	11	9	0	0	0	5	3	1
Closterium aciculare	3	0	0	0	9	32	63	7	0	0	0	10	6	2
Closterium acutum	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Coelastrum proboscideum	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Cosmarium sp.	10	23	0	4	17	44	16	37	64	35	12	24	6	4
Crucigenia quadrata	0	9	5	0	0	0	0	0	0	0	0	1	1	0
Crucigenia tetrepedia	0	0	0	0	0	0	0	6	8	16	9	4	2	1
Crucigenia truncata	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Dictyosphaerium sp 1. (pulchellum)	0	0	13	4	49	165	29	40	19	21	15	32	14	5
Elakothrix geratinosa	4	0	2	0	10	38	13	0	5	0	8	7	3	1
Gloecosystis sp.(cf. Planktonica)	0	0	0	0	2	8	0	0	3	0	3	2	1	0
Oocystis sp.	13	24	17	6	19	57	21	13	27	30	16	22	4	4
Pediastrum boryanum	0	3	0	0	2	0	5	0	0	0	0	1	1	0
Pediastrum duplex	5	10	0	0	11	51	18	12	13	33	13	15	4	3
pediastrum obtusum	9	13	12	3	0	0	0	0	0	0	0	3	2	1
Scenedesmus aciminatus	8	18	14	2	0	13	0	4	0	0	7	6	2	1
Scenedesmus armatus	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Scenedesmus bicaudatus	7	16	11	2	0	0	3	0	0	14	6	5	2	1
Scenedesmus denticulatus	6	17	7	0	6	19	0	0	0	12	5	7	2	1
Scenedesmus protuberans	12	26	18	5	20	63	24	16	24	28	17	23	4	4
Scenedesmus quadricauda	14	27	20	6	23	76	79	14	29	37	18	31	7	5
Scenedesmus spinosus	0	2	0	0	0	0	0	0	3	0	0	0	0	0
Scenedesmus falcatus	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Appendix 9b: Cont.

Scenedesmus sp.(Capricornutum)	0	0	0	0	3	0	0	3	0	0	0	1	0	0
Spyrogyra sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Staurastrum sp.	1	0	0	0	0	0	0	0	11	10	2	2	1	0
Tetraedron caudatum	4	11	0	0	0	0	0	0	0	0	0	1	1	0
Tetraedron minimum	7	14	9	1	0	0	0	0	0	7	4	4	1	1
Tetraderon trigonum	12	28	19	7	21	70	26	17	21	26	14	24	5	4
Tetraedron regulare	9	21	8	3	13	0	0	2	0	0	3	5	2	1
Tetradesmus wisconsinense	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Westella botryoides	0	7	4	0	4	0	0	0	0	5	0	2	1	0
Trachelomonas sp.	3	10	0	11	6	0	0	11	14	7	0	6	2	1
Phacus sp.	0	10	0	0	0	0	0	0	0	0	16	2	2	0
Aulacosiera ambigua	19	33	22	28	104	108	96	44	43	57	14	52	11	9
Aulacosiera granulata	26	23	16	13	39	22	16	24	11	25	9	20	3	3
Navicula sp.	4	0	0	8	0	14	0	0	7	0	9	4	2	1
Nitzchia sp.	6	0	0	0	8	0	0	0	0	0	0	1	1	0
Synedra sp.	19	7	10	0	0	0	10	0	0	0	0	4	2	1
Synedra ulna	0	0	7	0	0	9	0	7	0	0	42	6	4	1
Synedra acus.	32	44	78	39	13	31	24	50	16	38	56	38	6	6
Chromulina sp.	2	44	11	28	0	0	0	39	38	35	0	18	6	3
Chrysococcus sp.	0	10	0	0	0	0	0	0	11	0	0	2	1	0
Mallomonas sp.	0	15	0	0	0	0	0	0	0	0	0	1	1	0
Cryptomonas sp.	5	48	12	19	0	0	0	16	32	28	10	15	5	2
Rhodomonas sp.	0	10	4	6	0	0	0	10	10	0	10	5	1	1
Ceratium sp.	0	8	0	0	0	0	0	0	0	0	0	1	1	0
Glenodinium sp.	0	0	0	7	13	4	5	0	5	14	10	5	2	1
Gymnodinium sp.	3	5	0	0	0	0	5	11	8	0	0	3	1	0
Peridinium sp. (cf palustre)	0	5	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 9c: Phytoplankton cell density (ml^{-1}) at St 3 between May 1995 and April 1996.

STATION 3	M	J	A	S	O	N	D	J	F	M	A	Mean	SE	Mean %
Aphanocapsa delicatissima	10	0	0	31	0	0	0	13	129	0	330	**47**	**31**	**1**
Aphanocapsa elachista	0	0	0	0	0	77	22	0	0	0	0	**9**	**7**	**0**
Aphanotheca sp.	0	55	33	0	0	0	51	27	147	0	101	**38**	**15**	**1**
Chroococcus sp.	93	437	462	104	35	0	137	133	28	0	118	**141**	**49**	**2**
Coelosphaerium kuetzingianum	7	0	0	0	0	51	0	0	74	28	31	**17**	**8**	**0**
Cylindrospermopsis raciborskii	228	1094	205	193	565	0	85	76	184	169	471	**297**	**94**	**4**
Dactylococcopsis sp.	104	492	513	169	162	180	359	152	304	70	47	**232**	**49**	**3**
Holopidium irregulae	0	0	0	0	54	0	0	0	18	0	0	**7**	**5**	**0**
Lyngbya contorta	73	164	359	145	135	154	0	0	166	337	777	**210**	**66**	**3**
Lyngbya subtilis	62	137	128	121	116	129	0	0	12	0	0	**64**	**19**	**1**
Merismopidia tenuisima	21	118	110	48	0	0	34	19	0	0	0	**32**	**13**	**0**
Microcystis aeruginosa	26	191	154	217	431	617	205	64	55	295	424	**244**	**55**	**4**
Oscillatoria sp.	16	164	77	72	0	0	0	8	0	18	71	**39**	**16**	**1**
Spirulina sp.	124	36	0	0	81	111	0	0	46	60	188	**59**	**19**	**1**
Synechocystis aquatilis	0	0	51	0	0	33	0	0	0	42	283	**37**	**25**	**1**
Ankistrodesmus sp.	29	115	0	0	315	93	0	17	101	35	239	**86**	**32**	**1**
Botryococcus braunii	96	573	0	0	0	0	0	0	13	108	566	**123**	**68**	**2**
Chlamydomonus sp.	53	0	0	0	0	0	207	100	109	0	174	**58**	**23**	**1**
Closterium aciculea	0	0	0	56	0	60	39	27	25	0	0	**19**	**7**	**0**
Closterium acutum	0	0	0	0	145	67	91	39	38	43	392	**74**	**35**	**1**
Coelastrum proboscideum	9	0	0	0	36	20	0	0	0	0	0	**6**	**4**	**0**
Cosmarium sp.	164	1835	1217	0	726	226	518	216	352	174	1001	**584**	**170**	**9**
Crucigenia tetrepedia	0	0	0	36	0	0	0	0	0	0	0	**3**	**3**	**0**
Dictyosphaerium sp. (pulchellum)	0	0	66	0	0	0	0	0	0	0	0	**6**	**6**	**0**
Gloecosystis sp.(cf. Planktonica)	0	0	0	0	0	9	0	0	0	17	0	**2**	**2**	**0**
Oocystis sp.	152	803	304	223	508	106	0	0	92	50	218	**223**	**73**	**3**
Pediastrum boryanum	0	0	66	0	0	0	0	0	0	0	0	**6**	**6**	**0**
Pediastrum duplex	0	0	0	0	16	29	0	0	0	12	0	**5**	**3**	**0**
pediastrum obtusum	0	0	0	120	24	0	0	5	0	0	0	**14**	**11**	**0**
Scenedesmus aciminatus	0	247	253	279	61	53	0	12	0	23	0	**84**	**35**	**1**
Scenedesmus armatus	0	0	0	0	0	0	26	23	18	0	65	**12**	**6**	**0**
Scenedesmus bicaudatus	0	0	0	0	133	73	65	31	34	39	0	**34**	**13**	**1**
Scenedesmus brevispina	23	0	0	0	121	86	78	35	29	0	152	**48**	**16**	**1**
Scenedesmus denticulatus	15	0	152	0	109	33	0	0	5	0	0	**29**	**16**	**0**
Scenedesmus intermedius	0	0	0	0	0	0	0	19	21	0	0	**4**	**2**	**0**

Appendix 9c: Cont.

Scenedesmus protuberans	0	0	0	0	73	47	0	0	0	0	44	**15**	**8**	**0**
Scenedesmus quadricauda	0	75	0	0	52	40	0	0	0	8	0	**16**	**8**	**0**
Scenedesmus falcatus	6	0	0	0	0	0	0	0	0	0	0	**1**	**1**	**0**
Scenedesmus sp.(cf. Capricornutum)	0	0	0	84	0	0	17	0	0	0	0	**9**	**8**	**0**
Spyrogyra sp.	20	0	0	195	85	0	0	8	0	31	109	**41**	**19**	**1**
Staurastrum sp.	13	0	0	0	0	13	0	0	0	46	0	**7**	**4**	**0**
Tetraedron caudatum	0	0	101	0	0	0	0	0	0	0	0	**9**	**9**	**0**
Tetraedron minimum	9	0	0	251	97	80	56	42	8	0	0	**49**	**23**	**1**
Tetraderon trigonum	35	1032	710	167	0	100	117	46	42	46	261	**232**	**100**	**3**
Tetraedron regulare	18	172	218	139	0	0	0	0	0	0	94	**58**	**25**	**1**
Tetradesmus wisconsinense	0	0	0	0	0	0	0	0	0	5	0	**0**	**0**	**0**
Westella botryoides	0	0	0	0	0	0	0	0	0	27	28	**5**	**3**	**0**
Euglena sp.	0	75	0	0	0	115	0	6	0	0	0	**18**	**12**	**0**
Trachelomonas sp.	38	37	13	0	0	173	8	24	0	102	0	**36**	**16**	**1**
Phacus sp.	0	0	0	0	0	58	0	0	0	0	0	**5**	**5**	**0**
Aulacosiera ambigua	618	881	897	1420	1409	1051	620	510	370	295	291	**760**	**123**	**11**
Aulacosiera granulata	467	0	0	0	0	292	0	0	0	128	775	**151**	**78**	**2**
Navicula sp.	719	0	0	0	141	76	1430	0	0	0	126	**226**	**136**	**3**
Nitzchia sp.	1078	1762	1846	473	634	251	0	0	484	197	0	**611**	**203**	**9**
Synedra ulna	2156	1087	791	123	92	117	810	2295	1708	1573	1454	**1110**	**241**	**16**
Synedra acus.	0	0	0	0	0	76	0	331	0	0	194	**55**	**33**	**1**
Chromulina sp.	0	0	0	0	342	216	0	0	138	0	334	**94**	**42**	**1**
Chrysococcus sp.	0	0	0	0	68	0	0	0	0	0	0	**6**	**6**	**0**
Mallomonas sp.	0	0	0	466	205	130	0	0	83	0	0	**80**	**44**	**1**
Cryptomonas sp.	0	0	0	280	512	277	0	0	116	0	501	**153**	**62**	**2**
Rhodomonas sp.	0	0	0	0	0	0	0	0	50	0	0	**5**	**5**	**0**
Glenodinium sp	0	0	0	67	51	0	0	0	0	0	0	**11**	**7**	**0**
Gymnodinium sp	0	0	0	307	231	69	0	26	55	0	137	**75**	**32**	**1**
Peridinium sp. (cf palustre)	0	0	0	0	26	0	0	17	0	0	30	**7**	**4**	**0**

Appendix 10: Chlorophyll-'a' concentration depth profiles at St 1, St 2 and St 3 between May 1995and April 1996.

St 1

Depth (m)	May	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
0	31.7	47.4	33.5	30.6	31.6	23.1	42.4	29.6	29.6	62.2	19.2
1.5	34.7	43.7	39.0	24.2	25.7	33.7	37.5	31.6	29.6	68.1	35.5
3	32.1	44.4	34.8	39.5	41.2	24.9	69.1	30.6	35.5	82.4	29.6
4.5	30.4	38.5	28.6	38.0	39.5	23.1	61.2	29.6	34.5	46.4	26.6
6	29.2	41.9	33.1	33.1	35.5	21.3	28.6	24.7	30.6	68.6	20.7
7.5	25.4	42.4	40.9	39.5	41.9	19.5	20.7	26.6	27.6	68.1	10.4

St 1

Depth (m)	May	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
0	29.6	28.9	20.0	24.2	49.8	31.1	23.7	23.7	26.6	22.7	23.7
1	21.0	24.4	22.2	20.2	57.2	38.0	29.6	26.0	20.7	25.7	32.6
2	19.7	25.2	23.7	25.2	53.3	29.6	29.6	26.0	22.7	33.5	28.6
3	39.5	29.6	15.5	19.7	62.2	29.9	26.6	16.6	39.5	30.6	23.7
4	17.3	29.6	11.8	20.2	55.3	33.2	27.6	18.9	44.4	26.6	34.5
5	18.5	20.7	17.0	23.2	55.3	29.6	30.6	26.0			

St 1

Depth (m)	May	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
0	118.4	131.0	101.8	137.6	173.2	150.0	137.3	133.2	124.3	112.5	159.8
1	112.5	109.5	177.6	137.6	159.8	147.5	113.7	124.3	139.1	124.3	180.6
	118.4	171.7	142.1	118.4	174.6	170.2	127.9	130.2	106.6	112.5	162.8
	133.2	245.7	112.5	115.4	155.4	171.7	118.4	124.3	103.6	103.6	180.6
	09.5	227.9	148.2	111.0	162.8	155.4	118.4	109.5	115.4	109.5	201.3
	?.8	259.0	115.4	115.4	162.8	137.6					

Appendix 11a: Zooplankton density (m^{-3}) at St 1 between May 1995 and April 1996.

SPECIES NAME	May	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
A. brightwelli	0	133	200	0	0	67	267	333	1200	467	2800
B. angularis	0	600	467	533	800	933	867	667	1133	1733	2933
B. caudatus	2076	267	5200	1533	9000	2400	188600	204800	38400	11133	55600
B. calyciflorus	*1400*	15467	6867	12200	5100	20000	22533	38267	15333	35133	56000
B. dimidiatus	0	0	0	0	0	0	1133	2866	5400	0	66
B. falcatus	267	133	733	267	133	467	1333	3866	5867	1133	3600
B. patulus	67	267	0	0	0	133	1066	2600	4667	1533	800
K. tropica	267	800	3933	800	67	1867	133	1333	3200	133	17066
K. cochlearis	2067	2133	30733	3667	933	13133	7933	8400	19933	133	24400
E. macrourus	1200	0	0	0	0	0	0	0	1733	1067	4867
F. longiseta	2400	1200	133	400	0	933	733	800	2600	200	0
H. jenkinnae	0	0		133	0	0	1133	0	6000	0	0
P. vulgaris	0	0	0	0	0	1667	733	333	1133	467	101267
T. patina	0	0	0	67	0	0	0	0	0	0	0
T. cylindrica	0	0	2533	867	0	0	0	0	2667	533	67
T. neumanni	0	133	0	0	0	0	0	0	0	0	0
M. equatorialis	2467	3733	2200	1067	333	600	533	467	133	200	0
T. oblongatus	35800	40267	54400	63600	13200	57800	90933	105666	84400	109667	47,933
Copepodaites	22000	65467	69733	51800	18533	35067	40333	39600	49667	18133	50667
Nauplii	38533	23533	26467	127133	23555	177200	114333	104333	365533	81133	42667
Alona sp.	0	267	0	267	0	0	0	0	0	0	0
C. sphericus	0	67	0	0	67	67	466	533	133	533	0
C. cornuta	0	0	133	0	0	0	0	200	0	0	2267
D. laevis	0	0	133	0	0	67	333	466	2067	733	0
D. pulex	0	933	267	0	0	200	266	333	2333	1200	0
S. vetulus	7933	0	0	0	0	0	0	1800	0	733	0
M. micrura	0	0	0	0	0	0	0	0	1733	0	333
D. excisum	5800	34000	6533	6400	4133	17267	15733	12867	7333	13067	18267

Appendix 11b: Zooplankton density (m^{-3}) at St 2 between May 1995 and April 1996.

SPECIES NAME	May	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
A. brightwelli	200	0	0	0	0	0	0	0	100	1125	0
B. angularis	0	100	0	12700	0	7375	4250	0	3400	4250	0
B. caudatus	59400	600	4000	1500	300	3500	3125	0	6600	6875	15875
B. calyciflorus	1300	300	3625	2200	300	1875	1125	0	300	2250	10625
B. dimidiatus	0	0	3625	0	0	0	2375	4260000	27500	0	0
B. falcatus	500	0	1625	900	200	250	625	0	1500	1125	300
K. tropica	700	0	2500	800	1000	1625	1250	0	2300	125	2625
K. cochlearis	36300	200	266750	50800	300	29250	35625	0	48900	83250	441375
E. macrourus	3100	200	4000	0	0	0	0	0	0	0	0
F. longiseta	7200	500	4000	900	600	1625	8125	0	22200	3250	14875
H. jenkinnae	2100	2200	0	0	0	0	0	0	0	125	0
L. leonita	0	100	0	0	0	0	0	0	0	0	0
P. vulgaris	2300	0	24250	11100	3700	2750	3375	0	11400	9500	9125
T. patina	0	0	0			0	0	0	0	0	0
T. cylindrica	0	1400	17750	500	300	5750	1125	0	124100	184250	62250
T. neumanni	0	200	0	0	0	0	0	0	0	375	0
M. equatorialis	7600	1600	1125	4100	700	3625	1375	0	200	2875	2375
T. oblongatus	11100	25000	11125	6200	5700	44250	11250	200	3800	8875	27375
Copepodites	21600	22600	37500	24600	1500	13000	7750	0	31500	2125	68250
Nauplii	45000	36300	182375	65900	107600	27000	85500	0	69500	245375	29500
Piona sp.(mites)	0	0	0	100	0	0	0	0	0	0	0
Alona sp.	0	200	0	0	0	0	0	0	0	0	0
C cornuta	2000	0	625	900	0	0	0	0	0	625	0
D. laevis	0	0		500	600	1625	625	100	1400	24625	0
Daphnia pulex	0	600	500	300	35600	25875	15625	200	700	29625	0
S. vetulus	5200	200	875	8500	300	375	250	0	0	21875	0
M. micrura	0	0	0	0	0	0	0	0	0	0	0
D. excisum	7900	0	625	600	600	1375	875	0	3000	20625	7125

Appendix 11c: Zooplankton density (m^{-3}) at St 3 between May 1995 and April 1996.

SPECIES NAME	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
A. brightwelli	0	0	100	0	0	0	0	0	1900	0	0
B. angularis	100	0	0	0	0	0	0	0	0	0	0
B. caudatus	500	0	0	100	0	0	0	0	15600	0	0
B. calyciflorus	300	156000	1000	17400	5125	29800	21900	0	3100	0	0
B. dimidiatus	0	0	0	0	0	0	0	0	0	13000	0
B. falcatus	0	200	0	0	0	0	0	0	11800	0	0
K. tropica	0	0	0	0	0	0	0	0	2500	0	0
K. cochlearis	0	0	6900	800	0	0	0	0	76000	0	250
F. longiseta	900	0	0	0	1000	1400	1800	7300	6400	1375	0
H. jenkinnae	2100	0	100	0		32300	37400	6500	3100	14375	141875
T. cylindrica	0	0	0	0	0	0	200	0	10700	0	250
Nauplii	48200	201900	683700	69500	574000	1072600	962100	1015700	161500	1190625	970625
M. equatorialis	200	1600	0	0	0	0	0	0	3800	125	0
T. oblongatus	81200	76800	88100	58000	156375	174100	73200	19100	29600	121500	118000
Copepodites	9100	80000	16300	77000	11250	124900	76200	4800	161500	63625	40000
C. cornuta	1200	10800	14600	9000	16125	53400	67500	635800	3400	78375	261750
D. laevis	0	0	0	0	0	0	0	0	105000	0	0
D. pulex	0	0	0	0	125	0	0	0	22900	0	0
S. vetulus	3500	1200	100	300	625	0	0	0	0	0	0
M. micrura	0	0	1100	1300	750	26500	1500	400	500	61375	0
D. excisum	7000	4000	21800	3100	2125	4200	1400	6200	15400	0	0

Appendix 11a: Zooplankton biomass (dry wt. mg. m^{-3}) at St 1 between May 1995 and April 1996.

SPECIES	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
A. brightwelli	0.00	0.28	0.42	0.00	0.00	0.14	0.56	0.70	2.52	0.98	5.88
B. angularis	0.00	0.04	0.03	0.04	0.05	0.06	0.06	0.04	0.08	0.12	0.20
B. caudatus	0.72	0.09	1.80	0.53	3.12	0.83	65.37	70.99	13.31	3.86	9.27
B. calyciflorus	2.07	22.83	10.14	18.01	7.53	29.53	33.26	56.49	22.64	51.87	2.67
B. dimidiatus	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.43	0.82	0.00	0.01
B. falcatus	0.07	0.03	0.19	0.07	0.03	0.12	0.35	1.01	1.54	0.30	0.94
K. tropica	0.32	0.97	4.78	0.97	0.08	2.27	0.16	1.62	3.89	0.16	0.74
K. cochlearis	1.67	1.73	24.86	2.97	0.75	10.62	6.42	6.80	16.13	0.11	0.74
E. macrourus	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.50	4.00	0.25
F. longiseta	0.37	0.18	0.02	0.06	0.00	0.14	0.11	0.12	0.40	0.03	0.00
H. jenkinnae	0.00	0.00	0.00	0.95	0.00	0.00	8.06	0.00	42.70	0.00	0.00
P. vulgaris	0.00	0.00	0.00	0.00	0.00	0.70	0.31	0.14	0.48	0.20	0.00
T. patina	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.77
T. cylindrica	0.00	0.00	19.00	6.50	0.00	0.00	0.00	0.00	20.00	4.00	0.00
Alona sp.	0.00	0.73	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.50
C. sphericus	0.00	0.31	0.00	0.00	0.31	0.31	2.17	2.48	0.62	2.48	0.00
C. cornuta	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
D. laevis	0.00	0.00	0.07	0.00	0.00	0.03	0.17	0.24	1.06	0.38	0.43
D. pulex	0.00	62.90	18.00	0.00	0.00	13.48	17.93	22.45	157.29	80.90	0.00
S. vetulus	152.64	0.00	0.00	0.00	0.00	0.00	0.00	34.63	0.00	14.10	0.00
M. micrura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.73	0.00	0.00
D. excisum	107.11	627.90	120.65	118.19	76.33	318.88	290.55	237.62	135.42	241.32	0.52
T. neumanni	0.00	14.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
M. equatorialis	211.91	320.66	188.98	91.65	28.60	51.54	45.78	40.11	11.42	17.18	0.00
T. oblongatus	663.00	1025.63	1021.83	1024.60	170.98	868.83	1591.61	1600.48	1464.42	1714.61	0.00
Copepodites	233.14	693.77	738.97	548.93	196.40	371.61	427.42	419.65	526.33	192.16	0.75
Nauplii	32.95	20.12	22.63	108.72	20.14	151.54	97.78	89.22	312.60	69.38	0.93

Appendix 11a: Zooplankton biomass (dry wt. mg. m^{-3}) at St 1 between May 1995 and April 1996.

SPECIES	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
A. brightwelli	0.00	0.28	0.42	0.00	0.00	0.14	0.56	0.70	2.52	0.98	5.88
B. angularis	0.00	0.04	0.03	0.04	0.05	0.06	0.06	0.04	0.08	0.12	0.20
B. caudatus	0.72	0.09	1.80	0.53	3.12	0.83	65.37	70.99	13.31	3.86	19.27
B. calyciflorus	2.07	22.83	10.14	18.01	7.53	29.53	33.26	56.49	22.64	51.87	82.67
B. dimidiatus	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.43	0.82	0.00	0.01
B. falcatus	0.07	0.03	0.19	0.07	0.03	0.12	0.35	1.01	1.54	0.30	0.94
K. tropica	0.32	0.97	4.78	0.97	0.08	2.27	0.16	1.62	3.89	0.16	20.74
K. cochlearis	1.67	1.73	24.86	2.97	0.75	10.62	6.42	6.80	16.13	0.11	19.74
E. macrourus	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.50	4.00	18.25
F. longiseta	0.37	0.18	0.02	0.06	0.00	0.14	0.11	0.12	0.40	0.03	0.00
H. jenkinnae	0.00	0.00	0.00	0.95	0.00	0.00	8.06	0.00	42.70	0.00	0.00
P. vulgaris	0.00	0.00	0.00	0.00	0.00	0.70	0.31	0.14	0.48	0.20	42.77
T. patina	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T. cylindrica	0.00	0.00	19.00	6.50	0.00	0.00	0.00	0.00	20.00	4.00	0.50
Alona sp.	0.00	0.73	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. sphericus	0.00	0.31	0.00	0.00	0.31	0.31	2.17	2.48	0.62	2.48	0.00
C. cornuta	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.43
D. laevis	0.00	0.00	0.07	0.00	0.00	0.03	0.17	0.24	1.06	0.38	0.00
D. pulex	0.00	62.90	18.00	0.00	0.00	13.48	17.93	22.45	157.29	80.90	0.00
S. vetulus	152.64	0.00	0.00	0.00	0.00	0.00	0.00	34.63	0.00	14.10	0.00
M. micrura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.73	0.00	5.52
D. excisum	107.11	627.90	120.65	118.19	76.33	318.88	290.55	237.62	135.42	241.32	337.35
T. neumanni	0.00	14.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M. equatorialis	211.91	320.66	188.98	91.65	28.60	51.54	45.78	40.11	11.42	17.18	0.00
T. oblongatus	663.00	1025.63	1021.83	1024.60	170.98	868.83	1591.61	1600.48	1464.42	1714.61	890.75
Copepodites	233.14	693.77	738.97	548.93	196.40	371.61	427.42	419.65	526.33	192.16	536.93
Nauplii	32.95	20.12	22.63	108.72	20.14	151.54	97.78	89.22	312.60	69.38	36.49

Appendix 11b: Zooplankton biomass (dry wt. mg. m^{-3}) at St 2 between May 1995 and April 1996

SPECIES NAME	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
A. brightwelli	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.26	0.00
B. angularis	0.00	0.00	0.00	0.07	0.00	0.04	0.02	0.00	0.02	0.02	0.00
B. caudatus	2.02	0.02	0.14	0.05	0.01	0.12	0.11	0.00	0.22	0.23	0.54
B. calyciflorus	0.17	0.04	0.47	0.29	0.04	0.24	0.15	0.00	0.04	0.29	1.38
B. dimidiatus	0.00	0.00	0.06	0.00	0.00	0.00	0.04	71.49	0.46	0.00	0.00
B. falcatus	0.01	0.00	0.05	0.03	0.01	0.01	0.02	0.00	0.04	0.03	0.01
K. tropica	0.01	0.00	0.04	0.01	0.02	0.03	0.02	0.00	0.04	0.00	0.04
K. cochlearis	0.03	0.00	0.23	0.04	0.00	0.03	0.03	0.00	0.04	0.07	0.38
E. macrourus	0.78	0.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. longiseta	0.09	0.01	0.05	0.01	0.01	0.02	0.10	0.00	0.27	0.04	0.18
H. jenkinnae	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L. leonita	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P. vulgaris	0.08	0.00	0.86	0.39	0.13	0.10	0.12	0.00	0.40	0.34	0.32
T. patina	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T. cylindrica	0.00	0.08	1.04	0.03	0.02	0.34	0.07	0.00	7.24	10.75	3.63
Alona sp.	0.00	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. cornuta	1.20	0.37	0.54	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00
D. laevis	0.00	0.00	0.00	2.07	2.49	6.73	2.59	0.41	5.80	102.02	0.00
D. pulex	0.00	4.26	3.55	2.13	252.94	183.85	111.02	1.42	4.97	210.49	0.00
S. vetulus	23.58	0.91	3.97	38.54	1.36	1.70	1.13	0.00	0.00	99.19	0.00
M. micrura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. excisum	15.82	0.00	1.25	1.20	1.20	2.75	1.75	0.00	6.01	41.30	14.27
M. equatorialis	55.88	11.76	8.27	30.14	5.15	26.65	10.11	0.00	1.47	21.14	17.46
T. neumanii	0.00	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00
Copepodites	13.71	14.35	23.81	15.62	0.95	8.25	4.92	0.00	20.00	1.35	43.33
T. oblongatus	18.60	45.36	26.62	13.19	12.43	94.16	23.94	0.43	8.09	18.30	22.53
Nauplii	4.57	3.69	18.52	6.69	10.93	2.74	8.68	0.00	7.06	24.92	3.00

Appendix 11c: Zooplankton biomass (dry wt. mg. m^{-3}) at St 3 between May 1995 and April 1996

SPECIES NAME	May	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
A. brightwelli	000	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00
B. angularis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B. caudatus	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
B. calyciflorus	0.05	24.77	0.16	2.76	0.81	4.73	3.48	0.00	0.49	0.00	0.00
B. dimidiatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
B. falcatus	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
K. tropica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
K. cochlearis	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
F. longiseta	0.01	0.00	0.00	0.00	0.01	0.02	0.02	0.09	0.08	0.02	0.00
H. jenkinnae	0.06	0.00	0.00	0.00	0.00	0.89	1.03	0. .18	0.09	0.40	3.90
T. cylindrica	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.62	0.00	0.01
C. cornuta	0.63	5.65	7.64	4.71	8.44	27.94	35.32	332.66	1.78	41.01	136.95
S. vetulus	8.11	2.78	0.23	0.70	1.45	0.00	0.00	0.00	0.00	0.00	0.00
M. micrura	0.00	0.00	2.54	3.00	1.73	61.15	3.46	0.92	1.15	141.62	0.00
D. excisum	13.36	7.64	41.62	5.92	4.06	8.02	2.67	11.84	29.40	0.00	0.00
D. laevis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	374.45	0.00	0.00
D. pulex	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00	138.79	0.00	0.00
M. equatorialis	1.15	9.19	0.00	0.00	0.00	0.00	0.00	0.00	21.82	0.72	0.00
T. oblongatus	148.74	165.18	176.47	113.52	336.42	259.32	141.45	41.58	77.21	238.94	227.71
Copepodites	10.13	89.03	18.14	85.69	12.52	138.99	84.80	5.34	179.72	70.80	44.51
Nauplii	0.89	3.72	12.59	1.28	10.57	19.75	17.72	18.70	2.97	21.93	17.87

Appendix 12: Monthly mean sizes of the major zooplankton groups in Lake Naivasha between May 1995 and April 1996.

St 1

	M	J	A	S	O	N	D	J	F	M	A
Crustacea	716 ±89	650 ±85	650 ±85	645 ±146	645 ±146	645 ±146	645 ±146	645 ±146	645 ±146	645 ±146	536 ±138
Rotifera	149 ± 26.1	155 ± 29.3	155 ± 29.3	156 ± 53.5	156 ± 53.5	156 ± 53.5	156 ± 53.5	156 ± 53.5	156 ± 53.5	156 ± 53.5	146.7 ± 39

St. 2

	M	J	A	S	O	N	D	J	F	M	A
Crustacea	636.7 ±105.3	912.6 ±152.3	749.1 ±141.5	791.0 ±126.7	869.7 ±117.5	869.7 ±117.5	869.7 ±117.5	1176.8 ±134.4	860.9 ±143.5	839.4 ±120	650.4 ±84.7
Rotifera	150 ±20.1	130 ±21.5	140.7 ±17.0	150.9 ±19.5	150.9 ±19.5	144.2 ±18.5	141.6 ±16.7	118.8 ±1.3	151.8 ±18.2	151.6 ±18.3	150.9 ±19.5

St. 3

	M	J	A	S	O	N	D	J	F	M	A
Crustacea	6376.7 ± 85.9	567.4 ± 102.3	567.4 ± 102.3	584.5 ± 81.1	492.8± 99.0	532.8 ± 80.7	492.8 ± 99.0	490 ± 171.5	828.8 ± 138.0	532.8 ± 80.7	492.8 ± 99.
Rotifera	135 ±19	254± 2	210.7 ±47.4	165.3 ± 22.6	90 ±1	103 ±13	116 ±1.1	171.7 ±31.4	141.1 ±22.9	147.2 ±19.5	151.9 ±19.9