Lake Erie 1998: Assessment of Abundance, Biomass and Production of the Lower Trophic Levels, Diets of Juvenile Yellow Perch and Trends in the Fishery.

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LAKE ERIE 1998: ASSESSMENT OF ABUNDANCE, BIOMASS AND PRODUCTION OF THE LOWER TROPHIC LEVELS, DIETS OF JUVENILLE YELLOW PERCH AND TRENDS IN THE FISHERY.

by

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ABSTRACT

A multi-trophic level biomonitoring program was conducted in all three basins of Lake Erie in 1998. The primary goal of this study was to determine whether there had been significant changes in nutrient and lower trophic level conditions since 1993-94, when similar studies were conducted, that may have impacted the fishery. There have been few significant changes since the two earlier studies in any of the basins. Although some changes have occurred in the zooplankton and benthos, there are no clear links to changes in the fishery. Gradients in total phosphorus (TP) , chlorophyll (Chl) and Chl:TP ratios from west to east are similar to those observed in 1993-94. The impact of zebra mussels grazing on phytoplankton is still much higher in the east than the west and central basins.

TP levels in the west basin are similar to those observed in 1993. An increase in Chl:TP ratios and comparison of observed to predicted levels of Chl suggest grazing impact on phytoplankton has decreased. Despite this lower grazing pressure, zooplankton biomass has declined in the west basin since 1993. However, juvenile fish do not appear to be food-limited and conditions in the west basin appear to be generally favourable to fish production.

A more extensive array of sampling sites in 1998 showed that concerns in the 1993 study regarding extrapolation of west-central results to the whole central basin are valid for some parameters. Broad spatial extrapolation of TP levels appears justified but not for Chl which exhibits a distinct west to east gradient. Grazing impacts at west central stations are more similar to west basin stations and lower than the rest of the central basin. Zooplankton biomass at the nearshore west-central station has increased since 1993. Dreissenid and other benthic biomass has also increased since 1993 throughout most of the central basin but not at the west-central sites.

TP, Chl and Chl:TP ratios in the east basin have changed little since 1993-94 and still reflect the highest grazing impact by dreissenids at inshore sites compared to any of the other basins. Seasonal areal primary production (SAPP), already atypically low compared to TP levels in the earlier studies, declined even further in the nearshore in 1998. Zooplankton production in the east basin is the lowest of the three basins but shows no distinct trend since 1993. Offshore zooplankton communities show noticeable grazing impact based on size. Zebra mussels exhibit the highest densities in the east basin and filtering potential has increased since 1993-94 because of higher biomass. Yellow perch do not appear to be food-limited in the east basin although there are signs that decreased zooplankton abundance has negatively impacted rainbow smelt.

RÉSUMÉ

Un programme de biosurveillance de plusieurs niveaux trophiques a été réalisé en 1998 dans les trois bassins du lac Érié. L'étude avait pour objectif premier de déterminer si des changements importants étaient survenus depuis 1993-1994, période où des travaux similaires avaient été réalisés, dans les matières nutritives et les conditions des niveaux trophiques inférieurs, ce qui pourrait avoir un effet sur les pêches. Depuis ces deux études, il y a eu peu de changements importants dans les matières nutritives, l'éclairement ou les conditions des niveaux trophiques inférieurs dans les trois bassins. Même si certaines modifications se sont produites dans le zooplancton et le benthos, aucun lien ne semble pouvoir être fait avec des changements dans la pêche. Les gradients observés dans le phosphore total (PT), la chlorophylle (Chl) et le rapport Chl:PT d'ouest en est sont semblables à ceux qui ont été notés en 1993-1994. L'impact du broutage par les moules zébrées sur le phytoplancton est encore beaucoup plus élevé dans le bassin de l'est que dans les bassins de l'ouest et du centre.

Les niveaux de PT dans le bassin de l'ouest sont semblables à ceux de 1993. Une augmentation des rapports Chl:PT et la comparaison des niveaux prédits et observés de Chl permettent de penser que l'impact du broutage sur le phytoplancton a baissé. Les moules zébrées sont dominantes par rapport aux moules quaggas dans le bassin de l'ouest malgré une baisse de leur effectif. En dépit de la réduction de la pression de broutage exercée par les moules zébrées sur le phytoplancton, la biomasse de zooplancton a baissé dans le bassin de l'ouest depuis 1993. Toutefois, les poissons juvéniles ne semblent pas être limités sur le plan alimentaire, et les conditions générales dans le bassin de l'ouest semblent favorables à la production de poisson.

L'élargissement du nombre de stations d'échantillonnage en 1998 a montré que les préoccupations soulevées dans l'étude de 1993 sur l'extrapolation des résultats du centre ouest à l'ensemble du bassin central sont valides pour certains paramètres. Une vaste extrapolation spatiale des niveaux de PT à l'ensemble du bassin semble justifiée, ce qui n'est pas le cas pour Chl, qui présente un net gradient d'ouest en est. L'impact du broutage aux stations du centre ouest ressemble à celui des stations du bassin de l'ouest, et il est plus faible que dans le reste du bassin central. La biomasse de zooplancton à la station littorale du centre ouest a augmenté depuis 1993. La biomasse de dreissénidés et d'autres organismes benthiques a également augmenté depuis 1993 dans la plus grande partie du bassin central, mais pas aux stations du centre ouest.

Les valeurs de PT, de Chl et du rapport Chl:PT ont peu évolué dans le bassin de l'est depuis 1993-1994, et reflètent encore le plus fort impact du broutage par les dreissénidés aux stations littorales par rapport à tous les autres bassins. La production primaire saisonnière par unité de surface, qui est déjà anormalement basse par rapport aux niveaux de PT des études antérieures, a encore baissé en 1998 dans les eaux littorales. Les niveaux sont maintenant typiques des lacs improductifs du Bouclier canadien, et il n'y a aucun signe de limitation par l'éclairement de la croissance du phytoplancton, sauf dans la zone pélagique profonde pendant les périodes d'isothermie. C'est dans le bassin de l'est que la production de zooplancton est la plus basse sur les trois bassins, et aucune tendance n'apparaît depuis 1993. Les communautés pélagiques de zooplancton manifestent un net impact du broutage en fonction de la taille. Les moules

zébrées connaissent leur densité la plus haute dans le bassin de l'est, et leur potentiel de filtration s'est accru depuis 1993-1994 à causse de la hausse de la biomasse. Les perches ne semblent pas connaître de limitations sur le plan alimentaire dans le bassin de l'est, mais certains signes indiqueraient que la baisse de l'abondance de la biomasse a eu un impact négatif sur l'éperlan.

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1. Introduction

Lake Erie has undergone dramatic changes over the last two decades. Implementation of phosphorus management, accidental introductions of exotic species and overexploitation of fisheries have reduced productivity and altered food web structures in all three basins.

Since phosphorus control programs were initiated in the late 1970s following the signing of the Canada-U.S. Great Lakes Water Quality Agreement (GLWQA) of 1972, the west and central basins have changed in trophic status. Between 1972 and 1985 phosphorus loading declined by 55% and by 1988-92 spring phosphorus concentrations had dropped to below target levels of 10 $\mu g\ L^{-1}$ in the central basin (Neilson et al. 1995). This decline in phosphorus was reflected in changes to the phytoplankton and zooplankton communities. Phytoplankton populations responded to decreasing phosphorus concentrations with a decrease in total biomass and a shift from a community dominated by diatoms to one with a greater proportion of Chlorophyta (Munawar and Munawar 1999). Between 1972 and 1992, lakewide phytoplankton species diversity increased, "eutrophic species" became rare and a gradual increase in "mesotrophic-" and "oligotrophic species" occurred (Munawar and Munawar 1999). Likewise the zooplankton community changed from one dominated by cladocerans and cyclopoid copepods to one with higher proportions of calanoid copepods (Johannsson et al. 1999a). Impacts by two exotic mussels (*Dreissena* spp.) introduced in the mid 1980s on phytoplankton biomass have been recognized (Nicholls and Hopkins 1993; MacIssac et al. 1992).

Fish communities are affected by both bottom up and top down pressures such as the changing nutrient status of the lake and associated impacts on lower trophic level production as well as by changes in commercial and sport-fishery harvest. The top predator walleye (*Stizostedion vitreum*) recovered from low abundance in the 1960's following a harvest restriction related to mercury contamination in the early 1970s (Hatch et al. 1987) to increased abundance throughout the lake by the 1980s. Following record harvests in the lake in the 1980s, walleye harvests are again in a gradual state of decline.

In the early 1990s, the Council for Great Lakes Research Managers, under the auspices of the International Joint Commission, recommended that a research and monitoring program be established for Lake Erie. To that end, the Lake Erie Biomonitoring program (LEB) was initiated in 1993 to determine the status of water quality and trophic production in the three basins of the lake and to monitor changes over time. Sampling conducted by the Department of Fisheries and Oceans (DFO) in 1993 (Dahl et al. 1995) suggested that changes were occurring at all trophic levels following the invasion of dreissenid mussels, however, the magnitude and direction of the impacts were basin specific. Further sampling in the east basin in 1994 (Graham et al. 1996), emphasized that dreissenids were having an impact on pelagic production with nearshore areas showing greater impacts than offshore areas.

A position statement presented at the international Lake Erie Committee meeting in March 1998 identified the urgent need for further monitoring to assess the current status of the lake and to understand the trophic links between phytoplankton, zooplankton, benthic and fish communities. To address this concern a sampling program was implemented through a partnership between the DFO and the Ontario Ministry of Natural Resources (OMNR). In comparison to the 1993-1994

LEB programs, monitoring in 1998 was expanded to include additional parameters and additional sampling sites in all three basins.

This report is intended to provide a description of conditions in Lake Erie in 1998 and to make comparisons with those documented in the 1993 and 1994 LEB reports. Included are estimates of lower trophic level abundance, biomass and species composition for phytoplankton, zooplankton, and benthos. Daily and seasonal primary production rates estimates for the east basin are presented as well as size-fractionated rates for the west and east basins. Chlorophyll *a* (Chl), Secchi disk transparencies, phosphorus concentrations and other water quality parameters are included. Data pertaining to the diet of young yellow perch in both the east and west basins is reported as an index of the link between zooplankton production and young-of-the-year fish production. Measures of abundance and growth of a selection of fish species are presented using data gathered by various OMNR assessment programs. Consideration of such a wide range of trophic levels will help to establish current energetic pathways and may therefore provide valuable information for development of an ecosystem model that should provide insights into changes occurring in the fishery.

2. Methods

2.1. Sampling

The Lake Erie Biomonitoring (LEB) project sampled 15 stations in 1998: four in the east basin (E1, E2, E3, E5), two in each of the east-central (EC1, EC2), central (C1, C2) and west-central (WC1, WC2) basins and five in the west basin (W1, W2, W3, W6, W7,) (Table 1a, Fig. 1). In the east and west basins five of the nine stations correspond to sites sampled during the 1993, 1994 LEB projects (Dahl et al. 1995; Graham et al. 1996). Three additional OMNR stations (E5, W6, and W7) were included in 1998. The central and east-central basin stations corresponded with established DFO sampling sites from the Lake Erie Trophic Transfer project (LETT). Additional sites were sampled for benthos: 10 in the east, 1 in the east-central, 2 in the central, and 2 in the west basins (Table 1b).

Initial samples were collected in April although regular sampling on alternate weeks did not start until May and then continued through late October. Limited sampling was continued until December. Sampling was restricted on some occasions because of weather and equipment availability. In the west basin Chl and Secchi disk depth were measured weekly at W1, W2 and W3 from April 15^{th} until Dec. 4^{th}. Stations W6 and W7 were not sampled for water quality or Chl. Samples for phytoplankton were collected at select stations.

All sampling in the east and east-central basins was conducted onboard the OMNR research vessels, *Erie Explorer* and *James-A*, based in Port Dover. Sampling in the central, west-central and west basins was carried out using the *K.H. Loftus*, *Centennial*, and *Keenosay*, based in Wheatley, Ontario. All sampling took place between 0800 and 1700 h.

2.2. Calculating Seasonal Weighted Means

Seasonal means, weighted for variable intervals between sampling dates (SWM), were calculated for the May 1 - Oct 31 sampling period at each station for all physical, chemical and biological parameters. At a number of stations, data was collected before May 1 or after Oct 31. In these instances, all of the data collected are presented in the appropriate table but only those data collected during the May to October period are used in the calculation of seasonal means. Some stations had a number of days where nutrient parameters had levels that were below the detectable limit (DL). These cases were dealt with in the following manner: if > 25% of the values were below the DL, no SWM was calculated. If <25% of the values were below the detection limit, the values were set as one half of the detection limit and the seasonal mean was calculated as above.

2.3. Water Samples

Composite water samples were collected to determine phytoplankton biomass, primary production, and water quality parameters: total phosphorus (TP), total filtered phosphorus (TFP), soluble reactive phosphorus (SRP), total nitrogen (TN), nitrate-nitrite (NO_3-NO_2), ammonium (NH_3), dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), particulate organic nitrogen (PON) particulate organic carbon (POC), chlorides (Cl), silica (SiO_2), sulphate (SO_4), and chlorophyll *a* (Chl).

Water samples were collected by one of two methods. At west basin, east-central basin and shallower, nearshore stations (as well as during early central basin sampling), a VanDorn sampler was used to collect a standard volume from 3-4 evenly spaced depths within the water column. These subsamples were pooled to provide a single composite sample for that station. At deeper sites a water column integrator was used. During isothermal or weakly stratified conditions, samples were collected from 1 m below the surface to 2 m above the bottom. Under thermally-stratified conditions, water was collected from the surface to 1 m above the thermocline (Z_m) (see Tables 2a-o for method used for each sampling).

Samples were collected in clean, neoprene-wrapped 10 L polycarbonate jugs. In the west basin, phytoplankton samples were collected and water was filtered for Chl, onboard, usually within 2 h of collection. Water for water quality and phytoplankton analysis was held in the carboys and, along with east basin water samples, was transported to CCIW for processing, usually within 7 h of collection. The temperature of the sample water was maintained at ± 2°C of ambient during transportation.

2.4. Physical Parameters

Secchi disk depth and weather conditions, including wind direction, wind speed and cloud cover, were measured at each station on all sampling dates. Secchi disk depth was determined with a 20-cm diameter, black and white disk lowered over the shady side of the boat. Attenuation of photosynthetically available radiation (PAR= 400-700 nm), was measured at all stations on most sampling dates with the exception of E5 because equipment was not available.

Light attenuation was determined by measuring light levels at several intervals through the water column using a Li-192S underwater quantum sensor (Li-Cor, Nebraska). Vertical spacing of the readings depended on the clarity of the water and station depth. Generally, readings were taken at 0, 0.25, 0.5, 0.75, 1, 1.5, 2, 2.5, and 3m depths. Below 3m, readings were taken at 1m intervals until light levels were 10% of the surface reading. The attenuation coefficient for PAR (ε_{par}) was calculated as the slope of a simple linear regression of the natural logarithm of light intensity vs. depth. Euphotic depth (Z_{eu}=1% surface light penetration) can be calculated as the natural logarithm of 100 divided by ε_{par}.

Incident solar irradiance was measured with a Li-190 quantum sensor (Li-Cor, Lincoln, Nebraska) mounted on the roof of the Canada Centre for Inland Waters (CCIW) in Burlington. Thirty minute integrals (moles m^{-2}) were logged to a Campbell CR5 microprocessor datalogger. Sensors were calibrated annually by the manufacturer.

Profiles of temperature and dissolved O_2 were obtained at east and east-central stations using an Excel TD400 sub-datalogger (Richard Brancker Ltd, Ottawa). Profile data were down-loaded to a portable computer. At the central, west-central and west stations, as well as at station E5, temperature and dissolved oxygen were collected at 0.5 m depth intervals with a YSI-58 meter (Yellow Springs Institute, Ohio) and recorded manually.

Thermal stratification was determined by plotting temperature vs. depth and visually identifying rate of temperature change. The water column was considered thermally-stratified when a rapid change in temperature, separated by a thermocline plateau in the plotted slope, was observed. At stratified stations where temperature was collected using the YSI meter (central and west-central) the stratified layers were determined as follows: where there was evidence of a temperature difference between the top and bottom of the water column, the YSI probe was slowly raised from the bottom until an increase in temperature was observed indicating the bottom of the thermocline. The probe was then raised further until changes in the water temperature slowed and approximated the surface temperature indicating the top of the thermocline.

2.5. Water Quality and Chlorophyll a

Four replicate aliquots of lake-water (0.5-2 L) were filtered on GF/C glass fibre filters (Whatman Co.) and frozen for later analysis. Filters were ground in 90% acetone, and the extracts analyzed spectrophotometrically (Strickland and Parsons 1972). Two filters were initially analyzed. If replicate values differed by >10%, the second set of filters was processed and the 4 values were averaged to obtain the final concentration. Chl concentrations used in the primary production calculations are uncorrected for phaeopigments.

Unfiltered water samples were collected for TP analysis. Sample water was also filtered through a cellulose-acetate 0.45-μm Sartorius membrane filter for TFP, other nutrients and major ions. Particulate organic carbon and particulate organic nitrogen samples were collected on ashed GF/C filters. All nutrient analysis were performed by the National Laboratory for Environmental Testing (NLET) (Environment Canada 1995).

2.6. Phytoplankton

Phytoplankton biomass and species composition were measured at three stations: W3, WC2 and E2. Samples were preserved in Lugol's solution and identified and enumerated using the inverted microscope technique (Vollenweider *et al.* 1974; Munawar and Munawar 1999).

2.7. Primary Production

Primary production (PP) experiments were conducted on both whole water and samples that were fractionated into three size categories (<2 µm, 2-20 µm and >20 µm). Fractionated (PP) was conducted according to methods in Munawar et al. (1999). Approximately 6 µCi of $^{14}CO_3$ was added to a 200 mL whole water sample. Four replicates of 50 ml each of this spiked water were added to clear, 200 mL, polycarbonate Erlenmeyer flasks. The flasks were tightly capped and incubated for 4 h at 240 μ E s^{-1} m^{-2}. At the end of incubations total activity (TA) was determined by adding 1 mL of spiked water to a scintillation vial containing 250 µL of ethanolamine. The remaining 49 mL were poured through a 20-µm Nitex mesh screen onto a 2-µm Nuclepore filter. This filter, containing the 2-20-µm fraction, was saved for counting. The residue on the 20-µm Nitex mesh was backwashed onto a 0.45-µm filter and saved for scintillation counting. The filtrate from the 2-20 µm fraction was filtered onto a 0.45-µm Nuclepore filter and this >2 µm fraction was saved for counting. Ten mL of scintillation fluor (Ultima gold, Packard Co.) was added to all samples (TAs and filters) in plastic scintillation vials before scintillation counting (see end of this section for counting protocol).

Depth integrals of PP were determined using whole lakewater samples and ^{14}C incubator methodology. This methodology is consistent with that used in many other projects including LEB 1993-94 (Dahl et al. 1995; Graham et al. 1996), Fee et al. (1989, 1992), and Millard et al. (1996a). Tracer solution was prepared by diluting stock $Na_2{}^{14}CO_3$ (Amersham Co.) with a carrier solution of Na_2CO_3 to an alkalinity typical of the lower Great Lakes. Five-mL aliquots were flame-sealed in glass ampoules. The contents of one ampoule were dispensed from a clean plastic syringe through an in-line, cellulose-acetate, filter into 1 L of whole lakewater. The inoculated sample was well mixed and aliquots were dispensed into 11 to 13 light and 2 dark Pyrex bottles (Corning). Bottles were incubated for four hours at close to *in situ* temperatures (±2°C). The incubator was identical to that described by Fee et al. (1989). The light source used was a 150-W, high–pressure, sodium-vapour lamp. Bottles were exposed to a light gradient to obtain a PP vs. light curve by positioning them at varying distances from the light source in a clear 3-mm acrylic template. The light level at all bottle positions was checked at least once during an incubation using a Biospherical QSP-200 scalar quantum sensor (Biospherical, San Diego, California, recalibrated yearly by the manufacturer). Light measurements at each bottle position were invariant over the incubation and replicate light measurements in the incubator were unnecessary. When bottles were removed at the end of an incubation they were replaced with a dummy set of filled bottles to ensure a consistent light environment for incubations not yet complete. Uptake at the end of the experiment was determined by taking a 5-mL aliquot from each bottle and placing it in a glass scintillation vial with 1 mL of 0.5 N HCl. These vials were bubbled in a special vacuum apparatus (Shearer et al. 1985) for 30 min to remove unincorporated inorganic ^{14}C. Samples were removed from the bubbler, capped, shaken and left overnight with caps loosened, to further ensure the removal of unincorporated tracer, prior to the addition of 10 mL of scintillation fluor (Universol ICN). In addition, 5-mL was removed from each of three randomly chosen bottles and placed in scintillation vials with 200 μL ethanolamine to determine the total ^{14}C available for uptake. Samples were counted in a Beckman LS5000 TD liquid scintillation counter for 20 min or to a 2 sigma level of accuracy of 2%, whichever was achieved first. Quench corrections were made using the external standard and the H-number technique (Beckman Co.).

2.7.1. Calculations

Daily and seasonal estimates of PP, and mean epilimnetic irradiance on a 24-h basis, were calculated using the computer programs of Fee (1990). Data on Chl, light attenuation, photosynthetic parameters, solar irradiance and mixing depth are required as input to the programs. The photosynthetic parameters $P^B{}_m$ (mg C mg Chl^{-1} h^{-1}), the carbon uptake rate at light-saturating irradiance, and α^B (mg C mg Chl^{-1} E^{-1} m^{-2}), the slope of the light-limiting part of the PP vs. light intensity curve, were derived using the curve-fitting program PSPARMS (Fee 1990) and the PP vs. light intensity data measured in the incubator. $P^B{}_m$ and α^B were normalized per unit of Chl as denoted by the superscript B.

Seasonal areal PP (SAPP) was estimated using the YPHOTO and YTOTAL programs (Fee 1990). Theoretical cloudless irradiance data can be generated with these programs and used to determine the potential maximum rates of PP. Rates can then be compared among systems without the confounding effects of variable solar input.

2.8. Zooplankton

2.8.1 Sampling

Macrozooplankton were collected with 64-μm mesh Wisconsin plankton nets, 3-m long with a 0.5-m diameter opening. In late July these were exchanged for nets with a 0.4-m diameter opening. Filtering efficiencies of the net hauls were measured with a Rigotia flowmeter mounted in the mouth of the net a third of the diameter from the rim. Meter readings were taken before and after each haul. The efficiency was calculated as the observed number of rotations m^{-1} divided by the number of rotations m^{-1} at 100% efficiency.

Zooplankton profile depth was defined by the thermal structure of the water column. During isothermal conditions, the net was pulled vertically from 2 m above the lake bottom to the surface at a rate of 0.8 to 1.0 m s^{-1}. During stratification, each stratum was sampled independently and the contents preserved separately. Epilimnetic samples were collected from the top of the thermocline to the surface. A closing net was used to collect metalimnetic and hypolimnetic samples. The net was cinched at the desired depth using a secondary line and brought to the surface. Metalimnetic samples were taken from the bottom of the thermocline to the top of the thermocline, and hypolimnetic samples from 2 m above the lake bottom to the bottom of the metalimnion. In windy conditions, when the net did not go straight down, the wire angle was used to adjust the required line length, ensuring that the desired depth was achieved. Two replicate samples were collected. In cases where the meter readings differed, a third haul was done for a meter reading only. At station E5, zooplankton sampling was conducted with a Schindler-Patalas trap. Two 30-L samples were collected from mid water column. All zooplankton samples were washed into 250-mL jars and preserved with 4% sugared, neutralized formalin. The two replicate zooplankton samples were later combined, mixed thoroughly and split. One sample was analyzed, and the other archived. This procedure reduced sampling error.

Additional zooplankton samples were collected on days when fish sampling did not correspond with regular zooplankton sampling. In the west basin, two zooplankton samples were collected with a diaphragm pump. Thirty to forty L of water were collected from mid-column, passed through a 63-μm mesh net, and preserved with 10% sugared, neutralized formalin. In the east basin (E5), two zooplankton samples were collected from mid-water with a 30-L Schindler-Patalas trap and preserved with 10% sugared, neutralized formalin.

2.8.2. Enumeration and Biomass Determination

Each zooplankton sample was rinsed to remove excess formalin then resuspended in 50 or 100 mL of distilled water, depending upon the density of material in the samples. The sample was gently but thoroughly mixed and a known volume subsampled with a Stempler pipette. A minimum of 400 animals were counted, with at least 100 individuals of the major groups[1] included, or if animals were scarce, 20% of the sample was counted. Rotifers were not included in these counts. Cladocera were measured from the top of the helmet to the base of the tail spine (*Bythotrephes* were measured to the first tail spine), whereas copepods were measured from the anterior tip of the cephalothorax to the end of the caudal rami. *Dreissena* veliger length was measured across the widest section of the shell. As in 1993 and 1994, we could not routinely distinguish between *Bosmina liederi* and *Bosmina freyi*, and thus bosminids were identified to genus. Although the majority of *Eubosmina* encountered were *E. coregoni* some could not be identified to species. Therefore, eubosminids were also classified to genus. For similar reasons, *Diaphanosoma birgi*, and *Chydorus sphearicus* were also classified as *Diaphanosoma* spp. and *Chydorus* spp., respectively.

Zooplanktors were enumerated and measured using a digitizing system (Summa Sketch III, Oakville, Ontario). Counts were tabulated and densities obtained using a computer program, ZoopBiom, developed by R. Hopcroft (University of Guelph, Ontario). This program incorporates length-weight regression equations for zooplankton and for *Dreissena* (Hillbricht-Ilkowska and Stanczykowska 1969) allowing for calculations of mean size, and volumetric measures of density and biomass. The zooplankton length-weight regressions came from several sources and were confirmed using Lake Erie plankton (Appendix 1).

Whole-water column estimates for zooplankton mean community size, density and biomass were calculated from data estimates of individual thermal strata, weighted for strata depth. Seasonal means were calculated from these whole water column estimates weighted for variable time intervals between sampling dates.

2.9. Benthos

2.9.1. Sampling

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[1] Zooplankton groups included: cladocera, adult copepods, juvenile calanoid copepods + nauplii, and juvenile cyclopoid copepods + nauplii

Sampling was conducted between April and June 1998. A total of 30 sites, representing a variety of substrate types (silts, sand and gravel sediments) were sampled once for the occurrence of *Dreissena* mussels and benthic invertebrates. Benthic data from some of these sites were used to compare with matched data collected from the same sites during the LEB and LETT surveys in 1993.

Usually four benthic samples were collected using a mini-PONAR (area 0.0223 m^2) at each site. At site E1, a large-PONAR (area 0.0529 m^2) was used to sample the coarse gravel. Each sample was sieved through a 250-μm net and preserved in 8% neutral formalin.

2.9.2. Enumeration and Biomass Determination

In the laboratory, all samples were screened through a 1-mm screen. The *Dreissena* large enough to be retained by the 1-mm screen were examined in all 4 replicates from each site. These mussels were separated into zebra and quagga mussels, enumerated and weighed.

Only two of the replicates from each site were examined for the invertebrates retained on a 250-μm screen, including the newly settled Dreissena of between 0.25 and 1.70 mm length. Invertebrates were sorted under a stereo-microscope and separated into taxonomic groups. Biomass was calculated as 'wet weight with shells'. Mussels and other molluscs were blotted on filter paper to remove excess water and weighed to the nearest 0.01 mg. These data were reported by Jarvis et al (2000). For the present report, the weight of the molluscs shells were removed , based on percentage shell weight for each genera, and the biomass reported as wet g m^{-2} shell-free. Shell-free weight of *Dreissena* was 56% of the total blotted weight, that of the Sphaeriidae and Gastropoda averaged 30%.

2.10. Fish

2.10.1. Juvenile fish

Fish were collected from three sites in the west end of the lake: Wheatley Provincial Park, Pigeon-Bay (near Leamington-Point Pelee) and Cedar Creek. As these sites correspond roughly with stations WC1, W1 and W7, respectively, they will be referred to by the station designation. In the east end of the lake, fish were collected from Inner Long Point Bay (station E5) and from the east-central basin (station EC1).

Sampling was conducted with different equipment in different regions of the lake. At stations WC1, W1 and W7, an 18.3-m beach seine was employed in waters up to 1.5 m deep. At E5 and EC1, a 6.1-m long outboard trawl (3.8-mm mesh body, 1.3-mm mesh cod end) was employed in waters less than 10 m deep. Sampling occurred on an approximate biweekly basis from mid-July until Aug 26 in the west and until Sept 24 in the east. Accompanying meteorological (cloud cover, air temp, wave height) and limnological data were collected on each sampling date.

Fish were sorted by age (young-of-the-year (YOY) or year-and-older (YAO)), placed on ice and returned to the lab within two hours of collection. Total length (TL) and weight measures were recorded for 20 randomly chosen individuals per species-age category. Up to 30 YOY individuals from each species-age category were preserved for diet analysis. These fish were placed in 10% formalin for two to seven days and then transferred to 10% isopropyl alcohol after a rinse in distilled water.

2.10.2. YOY Yellow Perch Diet Determination

For a particular sampling site and day, up to 30 YOY yellow perch were examined for gut contents. The gut contents were dissected out under a stereomicroscope. Each fish was thoroughly rinsed with distilled water and measured for total length and weight. The gut, defined as all of the digestive tract forward of the pyloric ceaca including the oesophagus, was excised, placed in a petri-dish, and covered with water. The wall of the gut was teased apart using forceps and probes and the gut contents were pushed out. The tissue was washed several times with a pasteur pipette and then all of the holding water was transferred to a separate vessel for counting. Gut contents were identified, counted and measured using the same digitizing equipment and computer program as employed for the zooplankton analysis (see section 2.8.2). Prey items were identified to lowest taxonomic level possible. Up to 100 individual prey items of a given taxonomic category, were measured after which only counts were taken. Where many incomplete organisms of the same taxonomic group were present, heads were used as the unit of counting. Curled or encased invertebrates, such as amphipods or trichopterans, were uncurled or removed from their case before total length was measured. Zooplankton lengths were converted to biomass utilizing length-weight regressions (Appendix 1.) Similar length-weight regressions for benthic invertebrates were used to calculate the biomass of benthic prey (Johnson and Brinkhust 1971; Nalepa and Quigley 1980).

2.10.3. Bottom trawl index surveys

In the west basin, index trawling has been conducted annually since 1988 during the last two weeks of August at 27-45 depth stratified random locations. Trawls of 10-minute duration (at 1.6 kts.) utilized a two-seam, 10-m Biloxi bottom trawl (12-m ground line) with a 13-mm mesh cod end. Length measurements were taken from 30 randomly chosen individuals per species-age group per trawl. Weight measures (for length weight regressions), were recorded less frequently.

In the east basin, fall index trawling has been conducted at eight fixed stations since 1980: four stations in Inner Long Point Bay and four in the nearshore of Outer Long Point Bay. Trawl gear consisted of a 6.1-m modified Biloxi bottom trawl. Two trawls of ten minutes duration, were run at each station on a weekly basis for the months of September and October. Beginning in 1984, concurrent trawls directed at rainbow smelt, were conducted at four locations in the offshore waters of outer-Long Point Bay. Starting in 1996, these weekly offshore trawls were restricted to the month of October. Offshore, a 10-m Biloxi bottom trawl was utilized instead of the 6.1-m trawl, otherwise sampling was identical inshore and offshore. Trawl catches were divided into two age categories: YOY and YAO. Length and weight were measured on randomly chosen individuals from each age group. YAO individuals were also sampled for sex, maturity and age determination.

2.10.4. Index Trawl Fish Size-At-Age Determination

Predicted weight for yellow perch collected in OMNR index trawls was calculated for the east and west basins using the Wisconsin bioenergetics model (Hanson et al. 1997). The approach is more thoroughly described in Johnson et al. (1999). Input parameters included observed weight and daily water temperature from Union and Port Dover pumping stations. We assumed a constant zooplankton diet (energy density of 1000 cal g^{-1}), constant consumption rate, and a constant perch energy density of 1000 cal g^{-1}. Predicted weight on Aug 15 was compared between years.

Rainbow smelt size-at-age was compiled from the October trawl data only, in order to make recent estimates comparable to post-1984 data.

2.10.5. Community Index Gillnet Surveys

Basin-specific community index gill netting has been conducted annually since 1989 through a successful partnership between OMNR and the Ontario Commercial Fisheries' Association (OCFA). Both canned and bottom set graded mesh gillnets (32-152 mm stretched monofilament mesh, 14 mesh sizes in total, 30.5 m per mesh) have been fished at 78 to 121 sites lakewide, randomly distributed by depth strata within each basin. Due to logistic constraints, no samples were collected in the west or west-central basin in 1989; the east-central, Pennsylvania Ridge region, or east basin in 1996; or the east basin in 1997. All sampling was conducted between August and October each year, moving from the east to west basin.

Total catch from each gillnet was counted and weighed by species and mesh size. A random subsample of the catch (40 to 100 individuals per species-age group) was measured for length, weight, sex and age (scales).

2.10.6. Commercial Fish Harvest

Catch and effort in the commercial fishery are monitored by way of regulations requiring the disclosure of information associated with all landed catches. Regulations also set limits on gear use. Gillnets used to catch yellow perch and walleye are restricted to mesh sizes of 2 1/4 in (5.7 cm) and 3 1/2 in (8.9 cm), respectively. Smelt fishing gear is restricted to 33-37 m mid-water trawls with 19-mm cod ends. Reporting regulations (daily catch records) provide accurate statistics of landed harvest and the effort expended to catch a particular species.

2.10.7. Catch per Unit Effort (CPUE)

All OMNR-OCFA partnership gill net CPUEs were calculated as mean kg caught per 24-hr set. OMNR smelt index CPUE is calculated as mean numbers caught per minute of trawl time. Commercial harvest CPUE is reported as either kg landed per km of gill net set (for yellow perch), as number landed per km of gill net set (for walleye) or as kg landed per hour of trawl time (for rainbow smelt).

3. Results

Comparisons to 1993 and 1994 results refer to the previous LEB projects (Dahl et al. 1995; Graham et al. 1996).

3.1. Light Attenuation and Temperature

Transparency as indicated by the light attenuation coefficient (ε_{par}), Secchi depth, and euphotic depth (Tables 2a–o) has generally increased since 1993 and 1994. Compared with 1993-1994, SWMs for ε_{par} in 1998 were 10% lower in the east (E1, E2, E3), and 13–30% lower in the west (W1, W2, W3) and offshore west-central (WC2) regions. However, they were 25% higher in the nearshore of the west-central basin WC1.

A gradient in ε_{par}, noted in 1993, still existed from the west (basin average = 0.58 m^{-1}) to the east basins (basin average = 0.25 m^{-1}). There was a slight difference in Secchi disk depths between the two basins in 1998 when the east basin seasonal mean was only about 1.2 times that of the west basin. This gradient was less pronounced than that noted in 1993 when the seasonal mean Secchi disk depth in the east basin was 2.7 times that in the west basin. This gradient was particularly apparent when only the offshore stations, which had less seasonal variability, were compared. Offshore, ε_{par} values were 60% lower in the east than in the west; a 40% decrease occurred between the west and west-central basins, 18% between the west-central and central basins, and 25% between the east-central and east basins. Maximum values in the west basin were three times those in the east. Offshore central and east-central basin sites, sampled for the first time in 1998, had mean ε_{par} values of 0.26 and 0.28 m^{-1}, respectively, similar to the more variable east nearshore mean of 0.27 m^{-1}. While the mean west, nearshore ε_{par} was 60% higher than at the east nearshore stations, mean values actually increased at nearshore sites from west-central, to central, to east-central (0.36, 0.46, 0.79 m^{-1}; respectively).

Nearshore ε_{par} values showed a high degree of seasonal variation. The highest value (2.46 m^{-1}) was recorded at EC1. Overall, the highest variation also occurred at station EC1 followed closely by the west stations (Figs 2a,b). The west-central and central basin nearshore stations fluctuated to a lesser degree. The east basin showed the most consistent nearshore ε_{par} values throughout the season; the largest fluctuations occurring from mid-August onward. The one ε_{par} measurement recorded at E5 from September 9 (0.68 m^{-1}) was comparable to west basin nearshore values. Notably, while one or two of these frequent nearshore peaks in ε_{par} corresponded to Chl peaks, most did not and were most likely due to light absorbance by resuspended abiotic material. In the east, the transparency at the nearshore stations was high enough that the euphotic depth (Z_{eu}) consistently extended to the bottom. This occurred only occasionally at nearshore sites in the other basins.

The shallower nearshore stations (E1, E3, EC1, and C1) as well as all west stations remained thermally unstratified throughout the sampling season. Nearshore site WC1 (16.9 m deep) showed some thermal stratification at various times throughout the season. As seen in 1993, the offshore east basin remained stratified for a longer period than the more west stations (Figs. 3a,b). Station E2 was thermally stratified by May 19 and remained this way until at least October 22. At offshore stations C2 and WC2 stratification was observed by early July and remained until at least mid September. Station EC2 was stratified by early June but became isothermic as early as late August.

3.2. Nutrients

Seasonal mean TP concentrations showed no consistent trend across years (1993, 1994, 1998) in any of the basins (Table 3a,b). Among stations in the east basin, the maximum coefficient of variation (COV) of TP was 14% among the three years with no one year showing consistently low or high values. In the west and west-central basins no consistent trend between 1993 and 1998 was observed among stations. The average TP in the west basin was only 1.7 ug L^{-1} lower in 1998 than in 1993 (n =3), a 10% decrease and well within the range of expected natural variation.

A west to east gradient of decreasing mean TP concentration, similar to that reported in 1993, was observed in 1998 (Tables 4a-m). The gradient was greatest between the west and west-central basins (35% decrease) and less between the central, east-central and east basins (4% and 9% decreases, respectively). Much of this west-east gradient was due to differences in the nearshore station values, which tended to be higher, and more seasonally variable than those at respective offshore sites. As with nearshore transparency, this variability was greatest in the west and lessened eastward (Figs. 4a,b). In the east, the large TP peaks noted in the spring (E3) and fall (E1) of 1994 were not observed in 1998. In fact, station E3 displayed unusually low fall values from late September to mid-October (<5 $\mu g\ L^{-1}$). At station E5, a shallow embayment in the east basin, mean TP concentrations remained fairly constant with a July 15 to Oct 22 average of 11.3 ug L^{-1}. TP concentrations in the nearshore of the central basin increased through September and October from 6.9 ug L^{-1} to 25.2 ug L^{-1}. Stations W1, W2 and W3 in the west basin displayed large TP peaks in July (Fig. 4b); this only occurred at W3 in 1993. However, unlike the fall peaks seen at all three stations in 1993, W3 values dropped off after August and stayed low (<10 $\mu g\ L^{-1}$) for the fall. This fall drop off is responsible for the lower comparable SWM TP value noted previously.

TP concentrations at thermally-stratified, offshore stations tended to be higher during spring and fall when the waters were isothermal. When the water column was thermally stratified, the TP concentrations were much lower and stayed fairly constant. When offshore values are averaged over the stratified period alone, the entire central basin was shown to have essentially the same TP concentration: 9.3, and 9.0 $\mu g\ L^{-1}$; respectively, for the east-central and west-central basins. The one measure taken at C2 on July 27 (9.2 $\mu g\ L^{-1}$) was similar. Mean TP was 8.6 $\mu g\ L^{-1}$ at the east basin offshore station during thermal stratification.

Soluble reactive phosphorus concentrations were high in the spring but quickly dropped to low summer levels at all stations. In the east-central, central, west-central and west basins, summer concentrations were often below the detection limit (0.2 $\mu g\ L^{-1}$) while east basin values remained marginally higher.

Seasonal mean silica concentrations increased by 70-78% at the east basin stations between 1993-1994 and 1998 (Fig. 5a). In the west and west-central basins, the changes between 1993 and 1998 were small but consistent across stations (Fig. 5b). SiO_2 decreased by 9-13% in the west-central basin and increased by 6-13% in the west basin. The decreasing west to east gradient in basin mean SiO_2 concentrations noted in 1993 was less apparent when the east-central and central basin means were included in 1998. Seasonal mean silica concentrations were 1.05, 0.71, 0.81, 0.54, and 0.57 mg L^{-1} respectively, for the west through east basins. Silica concentrations reached limiting levels of <0.30 mg L^{-1} for short periods during the summer at the offshore, stratified, sites E2, EC2 and WC2. Limiting values were also observed in the early spring in the nearshore of the west- and east-central basins. Silica was rarely limiting in the west basin. A value <0.30 mg L^{-1} was observed once and most values were >0.95 mg L^{-1}.

In the east basin, the seasonal pattern of SiO_2 concentrations was similar to that in previous years with higher concentrations in the spring and fall. Station E5, which was only sampled from July to Oct, had both the highest concentration measured (2.16 mg L^{-1}) and the highest SWM (1.50 mg L^{-1}) of any station. The east-central basin fluctuated between 0.25 and 0.75 mg L^{-1} until September when values reached as high as 1.10 mg L^{-1} (EC1) and 0.92 mg L^{-1} (EC2). At station C1, values remained consistent at approximately 0.70 mg L^{-1}, only climbing above 1.50 mg L^{-1} in September through October. A similar fall increase was seen in the west-central basin in 1993, but did not occur in 1998 when values remained relatively constant, fluctuating around 0.70 mg L^{-1} through to the end of October. The three peaks noted for the west stations in 1993 were not apparent in 1998. The offshore station W3 remained fairly constant at 1.00 mg L^{-1} while concentrations fluctuated at stations W1 and W2.

Seasonal mean NO_3-NO_2 concentrations were similar to those reported in 1993 and 1994. The east basin seasonal mean of 238 $\mu g\ L^{-1}$ was essentially the same as in 1993 (232 $\mu g\ L^{-1}$) and only 25% higher than in 1994 average (191 $\mu g\ L^{-1}$) (Table 3a,b). Nearshore and offshore seasonal means were similar at 236, 237, and 241 $\mu g\ L^{-1}$ for stations E1, E2, and E3, respectively. At the west-central basin stations, the nearshore seasonal mean concentration (248 $\mu g\ L^{-1}$) was similar to that in 1993 (250 $\mu g\ L^{-1}$) while the offshore concentration (272 $\mu g\ L^{-1}$) was noticeably higher (222 $\mu g\ L^{-1}$) than in 1993. Concentrations at west sites W1 and W3 had decreased since 1993 by 29 and 20%, respectively. The mean concentration at west station W2 (357 $\mu g\ L^{-1}$) had increased slightly over the 1993 concentration (324 $\mu g\ L^{-1}$). An overall gradient of decreasing average concentration from west to east, was noted in 1993 and 1998, although the lowest average exists in the east-central basin. Basin averages were 309, 260, 258, 207, and 238 $\mu g\ L^{-1}$ for the west, west-central, central, east-central, and east basins, respectively. The only station to display very low nitrate values, and thus suggest a high growth demand and possible limiting supply, was E5 (Table 4d). Concentrations at this station in the shallow embayment of Inner Long Point Bay were below detection limits (<10 $\mu g\ L^{-1}$) until October when values on two sample days were low relative to the rest of the east basin at 198 and 144 $\mu g\ L^{-1}$. Seasonal patterns differed between basins as well. Concentrations dropped steadily in the west basin from May (approx. 600 $\mu g\ L^{-1}$) until mid-Aug (approx. 250 $\mu g\ L^{-1}$ nearshore, 150 $\mu g\ L^{-1}$ offshore) after which they remained fairly constant. In the west-central basin, low values in May climb quickly to peak values (>400 $\mu g\ L^{-1}$) in June before steadily declining to autumn lows. No decline was apparent at stations C1, EC1 or EC2. In the east basin, concentrations dropped gradually from approximately 300 $\mu g\ L^{-1}$ in May to 150 $\mu g\ L^{-1}$ in early July after which they climbed steadily to about 280 $\mu g\ L^{-1}$ in late November. Nearshore station E1 peaked at 392 $\mu g\ L^{-1}$ in October.

As in 1993, Cl concentrations showed little variation throughout the season and were very similar at all stations within a basin. While a gradient of increasing Cl concentration from west to east still existed in 1998, the average concentration in both the west and east basins have decreased slightly from those reported previously. Mean concentrations for the west-central basin are virtually unchanged since 1993 and were very similar to concentrations in the east-central and central basins. The seasonal mean concentration at station E5 (15.8 mg L^{-1}) is higher than any other station.

Concentrations, averaged per basin, were 9.4, 13.7, and 14.7 mg L^{-1} for the west, central, and east basins, respectively.

3.3. Phytoplankton

3.3.1. Indices of Biomass

Seasonal mean Chl concentrations were higher in1998 than in 1993 at all comparable stations except W3 where the mean was slightly lower. Increases in the east basin were less pronounced than in the west and, in fact are slightly lower than 1994 means at stations E1 and E2. A west to east gradient of decreasing basin-averaged Chl, noted in 1993, was also evident in 1998. The basin averages for the east, east-central, central, west-central and west are 1.53, 2.13, 2.83, 4.55, and 4.89 $\mu g\ L^{-1}$, respectively (Tables 5a-m).

Seasonal patterns of Chl concentration were similar to those seen in 1993. In the east basin, values remained fairly constant and low (<3 $\mu g\ L^{-1}$) for most of the season. Concentrations at the offshore station E2 were consistently higher than at E1 or E3 except for a period in late August where offshore Chl failed to peak as it did in 1993 and 1994 (Fig. 6a). Station E5 showed high Chl concentrations until late September when values dropped well below those at E2. Similarly, Chl concentrations in the offshore east-central and central basins were consistently higher than those at nearshore stations for most of the sampling season. Chl concentrations in the west-central and west basins fluctuated considerably when compared to the other basins and to themselves in 1993 (Fig. 6b). Offshore west-central values were higher than nearshore values only during spring and fall peaks whereas in 1993 they were consistently higher. In the west, the offshore (W3) was consistently lower than the nearshore (W1) except for its peak in mid August. A second, higher peak, which occurred at W3 in October 1993 was absent in 1998; levels continued to drop off until the end of October. As noted previously, TP values also dropped off during this period as well.

A west to east decline in the ratio of Chl to TP was particularly apparent when only nearshore stations were considered (Table 6). Within each basin ratios at offshore stations were higher than at nearshore stations although the west central basin was an exception in 1998, however Chl:TP was lower in the nearshore than offshore at west central stations in 1993. Chl:TP at the nearshore location WC1 increased from 0.25 in 1993 to 0.44 in 1998 while the offshore remained almost identical between 1993 (0.31) and 1998 (0.35). The Chl:TP ratios in the east basin and at station W2 remained similar to those reported in 1993 and 1994 (east only). In the west, Chl:TP had increased since 1993 from 0.26 to 0.35 and from 0.23 to 0.36 at stations W1 and W3 respectively.

Seasonal mean particulate organic carbon (POC) and nitrogen (PON) concentrations had increased, compared to 1993, at all comparable stations. 1994 values, available only for the east basin, fall in between the 1993 and 1998 values (Table 3a,b). The gradient from east to west is less apparent than the one that exists for Chl. East basin station E5 had relatively high seasonal (July-Oct) mean POC and PON concentrations of 0.704 mg L^{-1} and 0.107 mg L^{-1}, respectively.

3.3.2. Biomass and Species Composition

West Basin (W3)

The phytoplankton biomass ranged between 1.7 and 4.4 gm^{-3} (Fig. 7). Peaks of biomass were observed during the spring (late May, early June) and in the summer (late August). The spring peak was dominated by Chlorophyta, Diatomeae and Dinophyceae. The summer peak was mainly composed of Diatomeae (62%) and Chlorophyta-Cyanophyta (22%). The fall biomass was once again dominated by Chlorophyta and Diatomeae.

Station W3 showed a high species diversity in all three seasons investigated (Table 7). The number of species ranged from 111 to 137 over the sampling season with a total of 210 species identified. The species belonging to Chlorophyta, Chrysophyceae and Diatomeae were prevalent throughout the period of investigation. Sixteen dominant species (contributing more than 5% to biomass at least once during the season) are given in Table 8. A majority of species in this category belong to the groups Diatomeae and Cryptophyceae. Sixty three species belonging to the less common category (contributing 1-5% of the biomass at least once during the season) are given in Table 9. This category is mainly composed of Chlorophyta and Diatomeae. The one hundred thirty nine species identified as rare species (contributing less than 1% to the total biomass at least once during the season) are shown in Table 10. The overall species composition confirms the continued oligotrophication of Lake Erie discussed in Munawar and Munawar (1999).

The phytoplankton biomass was fractionated into three categories (<2 μm, 2-20 μm and >20 μm) by means of a computer program based on cell dimensions. The seasonal distribution of biomass composition by size is shown in Fig. 8a. The nanoplankton (2-20 μm) was the most prevalent size throughout the period of investigation with few exceptions. The microplankton/net plankton (>20 μm) contributed 67 and 60% to the total biomass in July and late August, respectively.

Phytoplankton biomass in 1998 showed an increase of four times the value recorded in 1993, although chlorophyll *a* did not show any significant change (Table 11). The taxonomic composition has also changed significantly between the years. For example, the Chlorophyta contributed more than 30% to the biomass in 1998 compared to 5% in 1993. Conversely, the Diatomeae contribution decreased drastically from 67% in 1993 to 35% in 1998. Similarly the Cryptophyceae flagellates showed reduction in their contribution, from 19% in 1993 to 10% in 1998.

Central Basin (WC2)

The phytoplankton biomass ranged between 1.4 and 4.3 gm^{-3} (Fig. 9). Two peaks of biomass were observed, once during the summer and the other during the fall. The summer peak was dominated by Diatomeae (54%) and Chrysophyceae (16%). The fall peak was mainly composed of Cyanophyta (43%) and Diatomeae (20%).

The central station showed a high species diversity in all three seasons. The number of species ranged from 66 to 140 over the sampling season with a total of 196 species seen. The species of Chlorophyta, Diatomeae and Chrysophyceae were the main contributors. Nineteen dominant species were identified and were mainly comprised of Diatomeae and Chlorophyta. Fifty two species belonging to the less common category are given in Table 12. Once again Diatomeae and

Chlorophyta dominated. One hundred twenty five species were identified as rare species (Table 13). The species composition reflects species found in oligotrophic environments.

The seasonal distribution of size fractionated biomass composition is shown in Fig. 8b. Once again, the nanoplankton was dominant throughout the period of investigation (mean, 58% biomass).

In 1998, Chlorophyll *a* increased slightly but the phytoplankton biomass showed an increase of more than three times the concentration recorded for 1993. Similar to the observations at station W3, the taxonomic composition also changed between the years at the central station. For example, Chlorophyta increased from 5% in 1993 to 22% in 1998 whereas Diatomeae decreased from 44% in 1993 to 32% in 1998.

East Basin (E2)

The phytoplankton biomass range between 1.1 and 3.7 gm^{-3} (Fig. 10). Two peaks of biomass were observed in the summer (July and September). The July peak was dominated by Diatomeae (66%). In this cruise, various other groups contributed modest amounts ranging from 1-12% of the total biomass. The late summer peak was dominated by a mixture of various groups such as Diatomeae (23%), Chlorophyta (22%), Cryptophyceae (17%) and others.

Similar to the west stations, high species diversity occurred in all three seasons in the east basin. The number of species ranged from 92 to 127 over the sampling season with a total of 199 species identified at this station. The prevalent taxonomic groups at E2 were Chlorophyta, Chrysophyceae and Diatomeae. The Diatomeae showed a systematic reduction in their number of species from spring (26%) to summer (19%) and fall (13%). Eighteen dominant species were found with the majority of species in this category belonging to the groups Diatomeae and Chrysophyceae. More than 58 species belonging to the less common category are given in Table 14. The less common species category mainly consisted of Diatomeae, Chrysophyceae and Chlorophyta species. One hundred twenty three species were identified as rare species (Table 15). The east basin also exhibited a predominantly oligotrophic species structure.

As at stations W3 and WC2, nanoplankton dominated the biomass size composition at station E2 throughout the sampling period (Fig. 8c) with a mean contribution of 62%. Their contribution was highest during the spring and moderate during the fall season

At the east station the seasonal weighted mean chlorophyll *a* values did not change much between 1993, 1994 and 1998. On the other hand the phytoplankton biomass doubled between 1993 and 1994 and again between 1994 and 1998. The comparison of taxonomic composition indicated a wide range of variation between the years for various groups. For example, the Chlorophyta (21% in 1993) decreased to 8% in 1994 but increased to 18% in 1998. The Chrysophyceae maintained similar contribution in all three years of comparison. The Diatomeae showed considerable variation ranging from 29% in 1993 to 16 % in 1994 and 35% in 1998. The Cryptophyceae flagellates maintained similar percent composition during 1993 and 1994 but decreased in 1998. The Dinophyceae flagellates were also quite variable between years: the highest contribution was 37% in 1994, and contributions were similar or lower during 1993 and 1998.

3.4. Primary Production

3.4.1. Size-fractionation

The seasonal fluctuations of primary production in various size fractions of phytoplankton (<2 um, 2-20 um, >20 um) for stations E2 and W3 indicated that the productivity was low during spring and fall seasons, and higher between July and September (Fig. 11, 13 & 14). The August peak was comprised of a mixture of all size fractions.

The size-fractionated PP at E2 was considerably lower than W3. Extremely low PP was recorded during the spring and fall seasons, with relatively higher rates during the summer (July to September). The nanoplankton and picoplankton fractions dominated while the rate of the microplankton and netplankton was extremely low.

The west basin showed lower mean rates of size-fractionated PP during the spring and higher rates in the summer. The fall rates were moderate. The central basin showed low rates in the spring, moderate rates in the summer and highest rates during the fall. The east basin exhibited moderate rates during the summer and extremely low rates during both the spring and fall seasons. As far as the size composition is concerned the west basin appeared to harbour a good mixture of the three size fractions. The central basin exhibited a reduction of the contribution of the larger size fraction in the spring and summer but high values for the larger plankton in the fall. The east basin showed some unique characteristics with extremely low rates in general and almost complete elimination of microplankton and net plankton contribution during the spring and fall.

The long-term fluctuations of the size-fractionated primary production are shown in Figure 12 for W3 and E2 stations from 1988 to 1998. W3 demonstrated very high production rates for nanoplankton and microplankton and netplankton during the pre- mussel period. In the years following the dreissenid invasion, the production rate for all three fractions remained very low. At E2 similar trends were observed although the production rate was relatively lower during 1988 at this station.

The nanoplankton and picoplankton dominated mean size-fractionated PP during 1992 at station W3. On the other hand, during 1998 the net plankton showed a dramatic increase in production, replacing picoplankton while nanoplankton remained the same. During 1992, the picoplankton at E2 showed the highest rate of production while the other two fractions indicated low rates. Conversely, in 1998, extremely low rates were exhibited by all three fractions.

3.4.2 Volume-based rates

Seasonal mean rates for P_{opt} in the east basin were lower than reported in 1993 and 1994. Means were lower by 36, 32, and 40% at stations E1, E2, and E3, respectively compared to 1994 (Table 3a). As in previous years, rates were highest at station E2 (5.03 mg C m^{-3} h^{-1}) followed by E1 (4.15 mg C m^{-3} h^{-1}) and E3 (3.52 mg C m^{-3} h^{-1}) (Tables 16a-c, 17). Mean P_{opt} at station E5 (7.8

mg C m-3 h-1) was noticeably higher than at the other stations but was comparable to station E3 when normalized for Chl ($P^B{}_m$ 2.94 mg C mg Chl^{-1} h^{-1}) (Table 16d). The seasonal means of P_{opt} rates, normalized for Chl ($P^B{}_m$), were also lower than in previous years. Mean $P^B{}_m$ at stations E1, E2, and E3 were 23, 18, and 37% lower, respectively, than in 1994. Mean $P^B{}_m$ was highest at E1 (3.23 mg C mg Chl^{-1} h^{-1}) followed by E3 (2.75 mg C mg Chl^{-1} h^{-1}) and E2 (2.49 mg C mg Chl^{-1} h^{-1}).

3.4.3. Seasonal areal rates

As in 1993 and 1994 seasonal (May 1-Oct 31), areal, PP (SAPP) was greater offshore than nearshore. Values were 32.5, 105.9 and 42.3 g C m^{-2} for stations E1, E2 and E3 respectively. This is a decrease from the 1993 and 1994 values at stations E1 and E3. At the offshore station the 1998 value (105.9 g C m^{-2}), while higher than the 1994 value (85.8 g C m^{-2}), was essentially the same as that in 1993 (105.3 g C m^{-2}) (Table 18).

3.4.4. Observed vs. predicted seasonal areal rates

Potential SAPP predicted from mean TP concentrations was calculated using the SAPP vs. TP relationship developed by Millard et al. (1999). Variations of the equation were used in the 1993 and 1994 LEB reports (Dahl et al. 1995, Graham et al. 1996, see also Millard et al. 1996a, Millard et al. 1999).

$$PP = 390.5\ [TP] / (18.45 + [TP])$$

Observed values of SAPP were compared to those calculated with and without depth limitation of photosynthesis profiles (Table 19). Depth limitation means that photosynthetic profiles were realistically truncated by the bottom while non depth-limited rates of PP were obtained by allowing photosynthesis depth profiles to extend to their fullest expression based on transparency only. These rates are theoretical only because profiles extended beyond the actual station depth but reflected potential productivity based on phosphorus levels and are useful for comparison to the deeper offshore site E2. This difference was only an issue at the shallow nearshore east basin stations E1 and E3. The impact of physical depth limitation on areal rates in a shallow clear water column can be determined by comparing truncated to non-truncated rates. This provided a clearer picture of the degree to which areal rates were impaired by depth alone when compared to rates predicted from phosphorus levels. Removing depth limitation increased PP by 62 and 24% at stations E1 and E3 respectively. Impact was much more noticeable at E1 because the water column is shallower than at E3.

In all comparisons the potential values of SAPP were less than predicted although this was most noticeable at the nearshore stations. Even when depth limitation of primary production profiles was removed , areal rates in the nearshore east basin were well below predicted values. At station E2, the difference between TP-predicted and observed (20%) was not as high as in 1994 (27%) but similar to the difference in 1993 (14%). The difference at nearshore station E1 was similar to that in 1994 (62%) while observed PP at E3 has been below the predicted PP by 35, 40, and 54% in 1993, 1994 and 1998, respectively.

SAPP for the west-central and west basin stations were similar to those in 1993 except for the offshore (W3) where a lower SWM TP value equates to a potential SAPP of 152.3 C m^{-2} (198.6 C m^{-2} in 1993).

3.5. Mean Epilimnetic Irradiance (•)

Areal PP is dependant upon the levels of light within the mixed (epilimnion) layer of the water column. This underwater light regime can be characterized with a single value, the mean epilimnetic irradiance • (mE m^{-2} min^{-1}), that integrates the effects of ε_{par}, Z_m and incident solar irradiance. By calculating • under theoretical cloudless conditions, variability in this value due to cloudy conditions is removed and the resultant variability is due only to changes in ε_{par} and Zm (Tables 16 a-d). A gradient of decreasing seasonal mean • exists as one moves from nearshore to offshore because of the increase in the SWM for Z_m. This gradient was also noted in 1993 and 1994. In 1998, values at E1, E3, and E2 (19, 17 and 14 mE m^{-2} min^{-1}) were higher than those reported for 1993 and 1994. The lower offshore mean is attributable to the deeper Zm. The extended length of the stratified period compared to 1993, contributed to the higher mean • in 1998. Conversely, nearshore • tends to decrease from spring to mid-summer as ε_{par} increases. In 1998, E1 and E3 had similar mean • although E3 had a deeper Zm but a consistently lower ε_{par}.

3.6. Zooplankton

3.6.1. Density

Seasonal mean (SWM) zooplankton abundance (no. m^{-3}) was two times smaller in the east, east-central and nearshore central basins of Lake Erie than in the west-central and west basins: mean of zooplankton (no veligers) for the east stations was 15.7 10^3 m^{-3} compared with 25 10^3 m^{-3} for the west stations (Fig. 15, Tables 20a-c). Noticeable exceptions were densities at stations E5 and W1. E5 was not included in the comparison because it is located in an embayment and because it was sampled only from July until October. Station W1, which experienced declines in mean densities of calanoids, cyclopoids, and cladocerans since 1993, had a mean density (16 10^3 m^{-3}). The pattern, described in 1993, of higher densities at all nearshore stations, relative to offshore stations, was not apparent in 1998.

A basic seasonal pattern of changes in density can be discerned, particularly for the non-stratified stations in the west half of the lake; however, the pattern is plastic and not always observed at all stations (Figs. 16-22). In looking for patterns, the data from 1993 and 1994 were also examined (Dahl et al 1995, Graham et al. 1996). Generally for stations WC1 and those in the west basin, density peaked in the June-July period associated predominantly with increases in cladocerans and sometimes cyclopoids. The crash in late-July or August resulted from declines in all zooplankton groups. Often second and third peaks were observed in late-August and September which could blend together. In the east half of the lake, densities were lower and the seasonal patterns more erratic at the unstratified stations. Density increased in June/July at these sites. When decreases were observed in August they were generally associated with a decline in cladocerans alone.

At the stratified stations, the density of zooplankton increased in June and July. A dramatic decrease in mid-summer was observed only at E2 in 1993 and was associated with a decline in cladocerans. At the other stations/years, cladocerans also declined by August, but they were either a small proportion of the total abundance and/or the other groups compensated for their decrease. Density remained high into October.

3.6.2. Biomass

As with density, SWM biomass at stations in the east basin were smaller than those in the west basin (Figure 23). E5, which had a noticeably higher mean density, was similar to other east basin stations with regard to biomass; the population consisted of high numbers of small zooplankton (primarily bosminids and copeopod nauplii). The smallest mean biomass was encountered at station EC1.

In the east basin, SWM biomass ranged from 9 to 25 mg m^{-3} across the three years – 1993, 1994, 1998 – and showed no onshore-offshore trend (Table 21a). The two nearshore sites (E1, E3) followed the same pattern: high in 1993 and 1998, low in 1994. Offshore (E2), SWM biomass in 1998 was 30% lower than in the 1993-1994 period. SWM biomass could not be calculated for the May to October season for Inner Long Point Bay because sampling did not start until July. Veliger biomass was 50 – 90% lower in 1998 at E1 and E2 but increased slightly at E3.

Biomass increased between the east and central basins by 2 to 5 fold, except at EC1. Within the basin, biomass increased from east to west (Table 21b). The SWM biomass of cladocerans was similar at EC2, C1, C2 and WC1 (no data for WC2). The gradient in biomass was generated by increases in cyclopoids and calanoids. Only one comparison can be made between data from 1998 and 1993, that is at WC1. Here calanoids increased while all other groups, including veligers, decreased by at least 30%. Overall, biomass was 20% lower in 1998 at WC1 than in 1993. Where comparisons could be made between nearshore and offshore sites, no consistent pattern emerged. SWM biomass was lower in the nearshore of the east-central and central basins in 1998 than in the offshore, but lower in the offshore of the west-central basin in 1993 (offshore not available in 1998).

SWM biomass was not higher in the west basin than in the central basin in 1998 or 1993 (Table 21c). In 1998, SWM biomass at the five sites in the west basin ranged from 30 to 74 mg m^{-3}, covering the range of biomasses observed from the offshore of the east-central basin to the west-central basin. No nearshore to offshore patterns in biomass were apparent in the west basin. At stations W1 and W3 decreases in overall biomass compared to 1993 were caused by decreases in all categories (calanoids, cyclopoids, cladocerans, and veligers) at W1 and all non-veliger categories at W3.

Seasonally, in the west basin, biomass was high in June-July due primarily to high cladocera biomass (W1 and W3) or high cladocera and cyclopoid biomass (W2, W6, W7) (Figs. 28-30). This was followed by a rapid drop in biomass in early- (W2, W3, W6, W7) to mid- (W1) August. Biomass subsequently increased into the fall at all stations except W3. Similar patterns occurred at W1 and W3 in 1993. In the central basin, all stations except the east-central nearshore (EC1), had a seasonal pattern similar to that of the west basin, with the exception that much of the high May-July biomass is made up of cyclopoids and cladocera (particularly at WC1) (Figs. 26-28). In the east basin, there was very little zooplankton biomass prior to late June (E2, E3) or late July (E1) (Figs. 22, 23). Unlike the more west stations, east basin biomass was composed largely of calanoids while cladocerans made a much smaller contribution. The exception, again, is station E5 where the biomass of small cladocerans (*Bosmina* spp.) predominated for most of the sampling period (July 15- Oct 22).

3.6.3 Size

For most of the season, the mean size of individuals in the zooplankton community was smallest (176–300 μm) at station E5 (Inner Long Point Bay). The community here was composed largely of *Bosmina* spp. and immature copepods. As at other east basin stations, in 1993, as well as in 1998, mean length increased in October (E5; 490 μm). At the other stations (E1, E2, E3) mean length generally ranged between 300 and 500 μm before rising in the fall (Fig. 31). Length peaked (>500 μm) at each station in mid July (E2, E3) or mid August (E1). Nearshore E1 had the lowest mean length (<300 μm) prior to the mid-August peak; a pattern observed in 1993 and 1994.

In the central basin, the nearshore stations (EC1, C1, WC1) demonstrated patterns in mean length more typical of the west basin (Figs. 31, 32). Means at these stations were low in April (200-400 μm), then higher in the first part of the season (>400 μm) and lower (300-400μm) from August into the fall. Maximum mean lengths in the earlier part of the season were near 700μm at the east-central and nearshore central basin stations, but only approached 500μm at station C2 and the west-central basin stations.

In the west basin the above pattern was evident at all five stations (Fig. 32). Maximum mean lengths, which occurred between mid-May and the first week in July, ranged from 570 μm (W6) to 942 μm (W3). By early August the range of mean lengths had dropped to between 200 and 400 μm at all sites. Mean length at nearshore station W1 began to increase again in the late fall.

Mills et al. (1987) has proposed that mean zooplankton community length can serve as an indicator of balance between piscivores and planktivores within the fish community. Their suggested criteria of 0.8 mm mean length for zooplankton caught in a 153-μm mesh net is approximately equivalent to 0.57 mm mean length for zooplankton caught with a 64-μm mesh net (Johannsson et al. 1999b). In 1998, using the criterion of mean May to July length of $\leq$ 500 μm to indicate planktivore dominance, the fish community was skewed towards planktivorous species at 2 of the 5 stations in the west basin (stations W2 and W6), in the west-central and offshore central basin, and at all sites sampled in the east basin. Mean May-July lengths were slightly larger in the west basin than in the east. Basin averaged lengths were 373, 487, and 532μm, for all stations in the east, central and west basins, respectively.

More extreme planktivory in the east basin than the west basin is in accord with the general east to west gradients in zooplankton size observed in 1998. *Diacyclops thomasi, Mesocyclops edax, Daphnia retrocurva* and *Epischura lacustris* were larger in size in the west and central basins than in the east basin. *Bosmina* spp. showed the reverse trend and was larger in the east and central basins than in the west basin. *Bosmina* spp. were abundant throughout the summer in the east and central basins but were generally not abundant in the west basin in June-July when *Daphnia spp.* were dominant. *Bosmina* spp. were smaller in August than earlier in the year at all sites. Therefore, the overall smaller size of *Bosmina* spp. in the west basin was due to a lack of larger *Bosmina* spp. earlier in the season which would serve to increase the seasonal mean length. In the east basin, *Bosmina* spp. tend to be larger and *D. retrocurva* smaller in 1998 than in the earlier years. No other trends were evident in the east basin. At WC1, *D. retrocurva* were smaller while *Diacyclops thomasi*, *M. edax* and *E. lacustris* were larger in 1998 than in 1993. In the west basin, *D. thomasi* and *M. edax* were again larger, while *Leptodiaptomus minutus* were smaller in 1998 than in 1993. W1 and W3 in 1993 showed very different patterns in species composition and size structure. In 1998, the patterns at W1 were similar to those at W3, and consequently, 6/9 species were larger in 1998 than in 1993.

3.6.4. Species composition

The duration of high relative abundance, as measured by the proportion of days in which a particular species was "common" (i.e. comprised ≥5% of the total biomass) was used as an index of dominance (Tables 22 a-c). When comparing 1993 and 1998 few patterns were apparent. The proportion of high biomass days was down for veligers at all comparable sites except for W3 where it increased slightly. The commonness of *Daphnia* spp., which are often cited as being important contributors to planktivorous fish diets, differed between basins and among species. *Daphnia retrocurva* were common on 50% of days sampled in the west but on only 20% of days at the nearshore station in the east basin (E1). *Daphnia galeata mendotae* was the most common daphnid in the central basin, particularly in the central and west-central basins. Other species of *Daphnia* were infrequently common in the east and more so in the west. No *Daphnia* spp. were observed in any of the E5 samples. In both the east and west basins *Bosmina* spp. were common between 30 and 50% of the time. The percentage of *Bosmina* spp. at the offshore site E2 was somewhat higher at (73%). In the central basin, bosminids were very common at the nearshore east-central and central stations (100% and 83%, respectively), and less so at WC1 (40%), C2 (50%), and EC2 (70%).

Other species utilized by YOY yellow perch (see Fish: Juvenile diet) were less common than daphnids or bosminids. *Chydorus sphaericus* were never common in the east or west and were only common 8% of the time at offshore station C2. *Diaphanosoma* spp. (grouped under "Sitidae" in the fish diet section) were found at most stations but were only common on occasion at EC1 (10%), E1 (10%), W6 (8%), and W7 (17%).

Despite changes in the relative abundance of several species since the 1993-1994 period, most of the dominant species remained the same in 1998. A number of additional species, not observed in previous LEB sampling, were identified in 1998. This apparent increase in diversity may simply reflect the increase in sampling intensity. The lack of complete inclusiveness of the survey was evidenced by the observation of certain zooplankton species in the diets of fish, but not in water column samples taken from the same site at the same time (e.g. *Bythotrephes* from W7 fish and *Daphnia* from E5).

In the west basin, *C. sphaericus, Holopedium gibberum, Bythotrephes cederstroemi, Ceriodaphnia* spp. *C. reticulata, Daphnia parvula, D. galeata mendotae, Skistodiaptomus reighardi* and *Eucyclops speratus* were observed in 1998 but not 1993. Again, in the west-central basin *D. g. mendotae, C. reticulata, C. sphaericus, Alona sp.*, and *S. reighardi* were seen in 1998 but not 1993.

In addition, several species were observed in the east part of the central basin that had not been observed in the west-central basin in either 1993 or 1998: *D. pulicaria* (EC2), *Polyphemus pediculus* (EC1), *Sida crystallina* (EC1) and *Senecella calanoides* (EC1). In fact, EC1 had a zooplankton community generally characteristic of warm inshore waters. In addition to the new species mentioned above, the following species were observed more frequently at EC1 than at the other stations: *Leptodiaptomus ashlandi, S. reighardi, Eurytemora affinis, H. gibberum, P. pediculus*, and *C. sphaericus.* In the east basin, the only species observed in 1998 and not in 1993 or 1994 were *C. reticulata* and *Paracyclops fimbriatus poppei. Eucyclops agilis* and *E. speratus* were observed in the east basin in earlier years but not in 1998.

3.7. Benthos

3.7.1 Non-Dreissena abundance

Average densities of benthic invertebrates at LEB sampling stations in 1998, as well as available densities from 1993, are presented in Tables 23a-d. Average benthic biomass is presented in Tables 24a-d. Both show very high variability between replicates. The 1998 data represents the spring and early summer whereas the 1993 data represents the entire season (May-Oct).

Average non-dreissenid benthic biomass has remained relatively unchanged since 1993 at comparable stations (E2, E3, WC1, WC2, W1, W3). Slight differences in mean biomass can be attributed to changes in one or two species. Increases at E2 and WC1 were due mainly to increases in oligochaete density and biomass. Non-mussel biomass at E3 was relatively unchanged; while oligochaete biomass increased, chironomid biomass had decreased. Density and biomass at WC2 increased due to an increase in sphaerid clams. Non-mussel biomass at W1 was down slightly due to decreases in oligochaetes and chironomids whereas a similar decrease in oligochaetes and chironomids at W3 was more than offset by a large increase in the Ephemeroptera (*Hexagenia* sp.) biomass.

At each of the stations sampled in both years, chironomid numbers and biomass were lower in 1998 than in 1993 while nematodes had increased considerably at each station. Oligochaete numbers increased greatly in the east (E2,) and west-central (WC1,) basins but had decreased in the west (W1, W3) basin.

Overall, 1998 non-dreissenid benthic biomass was considerably lower in the west basin than in the east. Stations W1, W2 and W6 had a non-mussel biomass of 5.9, 2.5, and 2.6 g m^{-2} (shell-free wet weight), respectively. Higher non-dreissenid biomass (comparable to the east stations) occurred at W3 and W7; this was mainly due to the high Ephemeroptera biomass which comprised 66 and 83%, respectively, of the total invertebrate biomass at these stations. Non-mussel biomass at the nearshore west-central, and central basin stations, as well as both of the east-central basin stations, were similar to west values. Oligochaetes made up the largest portion of the biomass at these stations. Comparatively higher non-mussel biomass at offshore stations WC2 and C2, was due to very high oligochaete and oligochaete/chironomid densities, respectively. In the east basin, excluding dreissenid mussels, the biomass was dominated by oligochaetes (particularly at the deeper stations E2 and E4) as well as ostracods, and chironomids (at the shallower stations). At the shallow stations in Inner Long Point Bay (E10 and J11) gastropods and amphipods (*Gammarus* spp.) also comprised a large portion of the biomass. At station E1, which had the lowest dreissenid density, Ephemeroptera comprised a large portion of the biomass; similar to that seen at station W7.

3.7.2. Dreissena abundance

Dreissena sp. mussels made up the greatest percentage of the benthic biomass at most stations (Fig. 33). This has changed little since 1993. East basin stations E2 and E3 were dominated by *Dreissena bugensis* , which comprised 97 and 99% of the biomass at these stations. Species composition of the Dreissena has changed somewhat in the east half of the lake where the zebra mussel *D. polymorpha* has been displaced by *D. bugensis*. Typically at E3 D. bugensis comprised 68% of the mussel biomass in 1993, but comprised 100% of the biomass in 1998. While invertebrate biomass at shallow stations E1 and E10 had relatively low proportions of mussels (12 and 64%, respectively), greater than 90% of the biomass at stations E4 and J11 was *Dreissena* spp. Similarly most of the biomass (>90%) at stations EC2, C1, and C2, was *Dreissena* spp. At the east-central nearshore station (EC1) mussels (exclusively *D. bugensis*) comprised 34% of the biomass. In the west-central basin, 70 % of the biomass at WC1 was mussels, a decrease from 99.5% in 1993. At offshore station WC2, the low mussel biomass observed in 1993 (20.8% of total) had decreased to 0.2% in 1998. Biomass at the west basin stations had the lowest relative proportions of *Dreissena* spp. due to their patchy distribution. While 99.7% of the biomass at station W2 was comprised of mussels, the proportion at W1 dropped from 90.8% in 1993 to 0% in 1998. Similarly at W3 it dropped from 98.8% to 30.7%. No mussels were present in the samples from stations W6 and W7 (Fig. 33).

3.7.3. Dreissena spp. by basin

Due to the high variability of Dreissena between replicate samples, especially in the west basin, average densities and biomass of the mussels for each basin were calculated utilizing data from both the LEB and LETT surveys at 16 sites, sampled consistently in each of 1992, 1993, and 1998. The term " central basin" here includes all the area of the east- and west-central as well as the central basin.

In 1998, the average density of dreissenids was highest in the east basin (9525 m^{-2}) followed by the central basin (4221 m^{-2}) while average biomass was similar between these two basins (1210 and 1085 m^{-2}, respectively) (Fig. 34). The west basin had a comparably low average density (22.5 m^{-2}) and biomass (7 g m^{-2}). Density and biomass of dreissenids, when averaged per basin, show a pattern of increasing values from west to east. With the exception of high west values in 1993 and high biomass in the east basin in 1998, this pattern is consistent from 1992 to 1993, and 1998. The D. *bugensis* proportions of the density and biomass follow a similar pattern. Both in a particular year from west to east and at a particular site from 1992 to 1998, the percentage of quagga mussels increase. Excluding Inner Long Point Bay, on average, 100% of the mussels in both the east and central basin were D. *bugensis* in 1998. Lakewide, average zebra mussel density has declined from 3114 m^{-2} in 1992 to 2 m^{-2} in 1998 while quagga mussel density has increased from 886 m^{-2} in 1992 to 5729 m^{-2} in 1998. In the east basin during 1998, *D. polymorpha* was only present at shallow sites in the Inner Long Point Bay, which were not sampled in 1993.

3.7.4. Dreissena spp. depth distribution

In 1998 average density of *Dreissena* spp. for the whole lake (30 stations), was greatest at depths of 5-10 m (6419 m^{-2}). At both shallower and deeper depths, densities were similar and approx. 50% of that observed at the 5-10 m depth. Only the shallowest depths (0-5 m) had populations that weren't dominated by quagga mussels (79.8 % *D. polymorpha*). This is in contrast to 1993 where the highest dreissenid densities were encountered in waters deeper than 30 m and the proportion of quagga mussels increased as depth increased (Table 25).

3.7.5. Invertebrates by basin

There were few significant changes in the average densities of invertebrates between 1993 and 1998 (Tables 26a-e). In the east basin, total invertebrate density was significantly higher in 1998. This was due mainly to very high numbers of newly settled quagga mussels (<1mm in length). Densities of Lumbricidae worms in waters <15m deep, and the Chironomini in waters >15m deep, were significantly lower in 1998 than in 1993. No specimens of the deep-water amphipod *Diporeia hoyi* were found in any of the profundal samples from east Lake Erie, including sites near the tip of Long Point (E2, 930, 940, and M29) that still supported the amphipods in September 1993 (Table 27).

No significant differences occurred between 1993 and 1998 with respect to the benthic fauna of the central basin at sites < 15 m, while beyond 15 m there was a statistical reduction in amphipods. In the west basin, there were significant changes in the density of the invertebrates; decreases occurred in total density, and in the numbers of oligochaetes, ostracods, and chironomids. However, there was a significant increase in density of the mayfly *Hexagenia* in the west basin since 1993. The exotic amphipod *Echinogammarus ischnus* was found only at sites W5 and 967 in the west basin.

3.8. Fish

3.8.1 Juvenile diet

Twenty-three species of juvenile fish were captured during nearshore trawling and seining operations during 1998, and of those only yellow perch were caught in sufficient numbers on most dates at the different stations to facilitate comparison of the diets. Of the 277 young-of-the-year (YOY) yellow perch that were examined, 170 were from the east basin and 77 were from the west basin. The 30 fish from the east-central basin station EC1 were all obtained on the same day (August 4). No YOY yellow perch diets were examined from the west-central station (WC1)

For the majority of fish sampled, food did not appear to be limiting. Mean gut fullness at each site averaged between 3 (half full) and 4.5 (near-full) for the sampling period between mid-July and late August (Fig. 35). Mean gut fullness at station E5, sampled for a longer period than the other stations, declined through the month of September; 36% and 80% of the fish having near-empty stomachs on September 10th and 24th, respectively. Of the 277 yellow perch guts examined, only one, from E5 on September 24, had a completely empty stomach.

Despite having similar levels of fullness, diet composition was distinctly different between the east and west basins. In July, >80% of the fish sampled from the west basin were exclusively utilizing zooplankton, while > 70% of the fish at E5 had a benthic invertebrate component to their diet. The proportion of exclusive planktivores at E5 remained fairly constant (20-30%) throughout the summer, declining briefly to 13% in early September (Fig. 36). The proportion of exclusive planktivores in the west basin remained high (>80%) until late August, when the proportion declined to 27-33%, a level similar to the east basin. Station EC1, sampled only once on Aug 4, was similar to the west basin stations: 90% of the fish were exclusively planktivorous.

Numerically, and in terms of biomass, zooplankton dominated the YOY yellow perch diets throughout the season (Fig. 37). Through July and early August, zooplankton were more prominent in the diets of YOY yellow perch in the west basin than in the east basin, however, the fractions became more similar by the end of August.

Copepod zooplankton were the dominant prey group observed in YOY yellow perch diets (Table 28). Greater than 80% of fish at each station, on each sampling date, consumed copepods, with the exception of W7 on August 26 when no copepods were consumed. Copepod nauplii were frequently found in the guts of east basin fish, but never in fish from the east-central and west basins. Chydorids were frequently observed in east basin guts (60-100%) but rarely in east-central or west basin fish. Daphnid and bosminid species dominated the west basin guts until late August when they were less frequently observed. These cladoceran species were rarely observed in more than 50% of the east basin guts, and their frequency of observation remained similar throughout the sampling season. The large cladocerans *Leptodora* and *Bythotrephes* were only observed at W7 prior to the middle of August, with the exception of a low frequency of occurrence at E5 on July 15.

Amphipods and dipteran larvae were the most frequently observed benthic invertebrates at all stations on all dates, although they were rarely observed at non-east basin stations prior to late August (Tables 23a-d). Tricopteran larvae, ostracods, gastropods and isopods were found in significant numbers in east basin fish at various times throughout the season, but were rarely observed in fish from the west or east-central basins.

No veliger larvae were found in any fish guts although several small adult dreissenid mussels were found in W7 guts in mid July. Larval fish were observed at varying frequencies at W7 throughout the sampling season, but were never found at other stations.

A similar picture of the diet composition is seen when diet content is presented as percent of total number (Table 29). Copepods were the dominant prey item in all basins, with bosminids (E5, EC1) and daphnids (W7) representing much of the remaining diet. Sitids and chydorids were numerically dominant at various times of the year at all stations. Benthic invertebrates and larval fish rarely exceeded 5% of the numerical diet composition, although their prominence increased in late August at west basin stations.

Differences in fish diets between east and west basins were greatest when gut content is expressed as percent of total biomass (Table 30). While copepods (W1 and W7) and daphnids (W7) were major contributors to gut biomass prior to mid-August, east basin fish consumed predominantly benthic invertebrates during the same time period. Amphipods, insects, tricopterans, and isopods dominated the biomass of the fish diets at E5 until September, when most of the prey biomass became zooplankton. Alternatively, by late August, west basin diet biomass became dominated by larval fish (W7), diptera (W1 and W7) and non-dipteran insect larvae (W7). During this time the mean size of zooplankton that were consumed decreased as did the mean zooplankton size in the water column (Fig. 38).

The average diet for an individual YOY yellow perch in Lake Erie (Table 31) reinforces the above patterns. Copepods (all stations) and either bosminids (E5, EC1) or daphnids (W7) contribute the largest fractions to the biomass of the diets. Benthic invertebrates were more important at E5 prior to mid-August, while their importance increased in the west basin after mid-August. Larval fish were only observed at W7 where they were observed on all sampling dates, but only contributed a large fraction of the biomass in late August.

When zooplankton size and species composition in the diets was compared to zooplankton in the water column it was apparent that YOY yellow perch were selective in their feeding. The mean length of zooplankton in the diets was consistently larger than that of zooplankton collected from the water column. Mean length in the diet was always >500 μm and approached 1mm at some point during the sampling season at all stations. Ivlev's measure of food selection was used to compare proportions of zooplankton prey items in an average diet with proportions present in the water column at stations in the east and west (E5, W1, and W7) (Fig. 39). Values ranged from –1, indicting avoidance, to +1, indicating positive selection. Values close to zero indicate similar proportions in the diet and the environment and suggest random, non-selective feeding. On average, YOY yellow perch selected for larger taxa (*Bythotrephes* and *Polyphemus*) and avoided small taxa (copepod and veliger larvae). Chydorids were selected for at all sites, while electivities for the remaining taxa varied between stations.

3.8.2. Young-of-the-year size

Young-of-the-year (YOY) yellow perch weights were standardized to a common date (August 15), and east basin values compared to those in the west basin (Fig. 40). The trend in the east has been a gradual increase in predicted weight since the late 1980s despite fluctuations of up to one gram between years. Successive yearly increases were recorded from 1996 to 1998. West basin size has been higher than east basin size for all comparable years except for 1998 when east basin size was slightly higher. In general, the mean weight in the west basin has exhibited a downward trend since the peak of 4 g in 1991.

YOY walleye growth data is only available for the west basin. The mean total length of YOY walleye, were taken from fish caught in mid- to late- August in all sampling years and are therefore directly comparable. Mean length declined throughout most of the 1990s before recovering in 1998 and 1999 to lengths similar to the long-term average. (Fig. 41)

While total length of YOY smelt has remained relatively constant throughout the sampling period, there has been a general downward trend in mean size of yearling smelt (Fig. 42). Yearling smelt size fluctuates up and down on an alternate year basis. This oscillation has been attributed to a strong feedback between yearling growth and YOY abundance: in years of strong recruitment cannibalism is high and growth of yearlings is good; conversely, when YOY abundance is low, yearling growth declines.

3.8.3. Index fishing

The biomass of fish caught in the OMNR / OCFA Partnership Gillnet Program is presented in Figure 43. When all species are considered together, a decline in CUE was observed from 1989 to the early 1990s in all but the west basin. While the east-central and, to a lesser extent, east basins have shown some rebound in recent years, the central and west-central basin CUEs have continued to decline. In the west basin, a different pattern is apparent: the CUE increased from 1990 to 1993 and then declined from 1994 to present.

Yellow perch CUE declined in all but the west basin from 1989 until the mid- 1990s, after which CUEs increased in the central basin. The east basin yellow perch CUE's remained low through 1998. In the west basin, CUEs peaked in 1996 then declined to long-term average levels. Higher CUEs in recent years may be associated with a strong 1996 year-class.

Walleye CUE has fluctuated in all basins through the time series, however, an overall downward trend is apparent. A strong 1996 year-class, indicated by the OMNR juvenile trawl index (Ontario Ministry of Natural Resources 2000), does not show up in the gillnet index due to the relatively small size of the fish which don't contribute substantially to the overall biomass index.

The smelt index survey, with CUE reported as number of fish caught per minute of trawling, is only conducted in the east basin. There was an overall decline in CUE from the 1980's to 1998 (Fig. 44).

3.8.4. Commercial fish harvest

Yellow perch CUE peaked in 1988 as a result of the strong 1984 and 1986 year classes (Fig. 45). This high CUE fell rapidly between 1989 and 1991 and has remained relatively constant through 1998, although at levels lower than those observed in the mid- to late-1970s, . Walleye CUE has risen since the mid-1970s due to the closure of the fishery between 1970 and 1976 and aided by strong recruitment in 1982 and 1986. High CUEs were recorded in the mid- to late-1980s. By 1990 strong year- classes had passed through the fishery and CUEs declined 40% relative to the late-1980 levels. Walleye CUEs have continued to decline gradually from 1990 to 1998. Smelt CUE has declined in the east basin, and fluctuated without trend in the central basin since effort statistics were first recorded in 1985 (Fig. 46).

4. Discussion

4.1. West basin

In 1993, the west basin could be classified as mesotrophic based on the classification scheme of Wetzel (Wetzel 1983; Dahl et al. 1995) or oligotrophic based on phytoplankton indices (Johansson and Millard 1998). TP concentrations in the west have not changed from those reported for 1993. The seasonal mean basin average was 15.7 $\mu g\ L^{-1}$ in 1993 and 17.7 $\mu g\ L^{-1}$ in 1998. These concentrations fall within the range of west basin values reported elsewhere for the west basin during the mid to late 1990s. In 1997, Charlton et al. (1999) observed a range of summer (May-Aug) TP concentrations (12.5-25.4 $\mu g\ L^{-1}$) that encompass the concentrations observed at our sites over the same seasonal period.

TP concentrations, fluctuated widely at all stations during the 1998 season (5.9 – 63.3 $\mu g\ L^{-1}$). Nicholls et al. (1999) suggest that a series of spiked TP concentrations across a season in shallow locations may be attributable to TP that is first bio-sedimented as mussel faeces and subsequently resuspended. Resuspension may therefore contribute to a higher proportion of particulate P in the TP-pool of shallow stations.

West basin mean chlorophyll concentration (4.89 $\mu g\ L^{-1}$) was marginally higher than that observed in 1993 (4.18 $\mu g\ L^{-1}$), due primarily to large increases in Chl concentrations at the nearshore stations. Seasonal mean Chl at the offshore station was slightly lower than in 1993. This may be attributable in part to low autumn TP concentrations. This seasonal mean is still well below those reported by Neilson et al. (1995) of 8.73 $\mu g\ L^{-1}$ for the years 1983-87 and by Charlton et al. (1999) of 13.8 $\mu g\ L^{-1}$ for the years 1968-1972. Chl concentrations can be controlled by both "bottom-up" processes such as nutrient supply and by the "top-down" grazing of secondary producers (Carpenter et al. 1996). The increase in the ratio of Chl to TP at stations W1 and W3 may be indicative of decreased grazing pressure at these two stations.

Mazumder (1994) developed equations to describe the relationship between Chl and phosphorus under varied trophic and grazing conditions. Central to his food-chain definitions was the degree to which phytoplankton was grazed by large herbivorous cladocerans. He defined a heavily grazed system as being functionally "even-linked" and a system where grazers are controlled as being functionally "odd-linked". At a given TP level, predicted Chl is higher in odd-linked systems. In 1993, Chl:TP ratios at all west basin stations were best predicted with Mazumder's "even-linked" equation indicative of high grazing impact by zebra mussels. In 1998, Chl:TP ratios at both the nearshore (W1) and offshore (W3) stations had increased and were now best predicted with the "odd-link" equations suggesting that a decrease in grazing had occurred. The SWM density and, in particular, biomass of cladocerans had decreased at both of these stations since 1993. Additionally, the benthic surveys showed that densities of dreissenid mussel grazers were very low at 3 of the west basin stations in 1998 compared to 1993. While decreased zooplankton grazing may have contributed in part to the higher relative chlorophyll concentrations, Nicholls and Hopkins (1993) concluded that most of the reduction in Chl and phytoplankton in Lake Erie after the arrival of dreissenids was due to zebra mussel and not zooplankton grazing.

The large increase in SWM phytoplankton biomass that occurred between 1993 and 1998 at station W3 is also consistent with the assumption of decreased grazing on phytoplankton. However the large increase in phytoplankton biomass is hard to reconcile with the slight decrease in SWM Chl observed at that station. The phytoplankton community showed an increase in species diversity and shift in dominant family types. The large increase in Chlorophyta species, which are typically hard to extract for Chl, may explain this discrepancy.

Graham et al. (1996) noted that observed SAPP in the west basin was lower than the potential set by TP concentrations but similar to that predicted by Chl levels. Although west basin SAPP was not measured in 1998, values may have been closer to the potential given that grazing pressure decreased. As well, indirect measures of primary production suggest a more productive system: phytoplankton biomass had increased considerably offshore, and transparency of the water was higher (lower ε_{par}) as were nearshore Chl concentrations. As well there was a more extreme draw-down of nitrate, and higher seasonal means of POC and PON, compared to 1993. A comparison of west basin June-July fractionated PP between 1992 and 1998 showed that, while total PP didn't change much, there was a change in the most productive size fraction. In 1998, the largest (>20 μm) phytoplankton accounted for a larger percentage of the primary production, while the contribution of the smallest fraction had decreased significantly.

The addition of three new west stations in 1998 has emphasized the large variation in the mean size, abundance and biomass of zooplankton between sites. This heterogeneity within the basin would best be characterized with a more intensive sampling regime that included a grid of sites or transects. The seven species of zooplankton seen in 1998 but not 1993 may simply be a result of this increased sampling intensity.

The zooplankton biomass of all taxonomic groups decreased at W1 and W3 from 1993 to 1998; veligers decreased at W1 but not at W3. Zooplankton biomass observed at W2 and W6, in 1998, was similar to that observed at W1 and W3 in 1993. The biomass at W7 was higher still. The patterns of biomass development within stations suggests that each station represents local conditions in the basin and it would be inappropriate to average the data across stations, particularly if the stations were different in the two years. The decreases in cladocerans and copepods at W3 may have contributed to the increases in POC, PON and nanoplankton and netplankton biomass. However, the change in zooplankton alone would not have been sufficient to change the system from functioning as an 'even-' to an 'odd-linked' system. The zooplankters present in 1993 were already typical of 'odd-linked' systems, that is, dominance of small species with few large *Daphnia* present. Grazing by dreissenids had caused the system to take on the appearance of an 'even-linked' system in 1993. Declines in dreissenids are likely responsible for the change in the Chl:TP ratio.

The size structures of the zooplankton communities at W1 and W3 were similar in the two years and suggest that the level of planktivory on zooplankton had not changed between 1993 and 1998. It is interesting to note that *Bythotrephes,* a large predatory cladoceran, occurred repeatedly at stations W1 and W7 in 1998, but was never observed in 1993 during the LEB project, nor during six spatial surveys between 1992 and 1996 (a total of 48 samples) (Johannsson et el. 1999a). *Bythotrephes* was a preferred diet item of YOY yellow perch in the west basin in July, 1998

Average non-dreissenid benthic biomass has changed little from that reported in 1993 and from that of the pre-dreissenid west basin (Dermott 1994), with the exception of Ephemeroptera. As noted by Dahl et al. (1995), increased biomass from zebra and quagga mussels represents an addition to benthic production and not a replacement of the native species (other than the endangered Unionidae clams). Although quagga mussels increased in relative numbers at W2 and W3, zebra mussels remained the dominant mussel in the west basin in 1998. The large (48%) decrease in total benthic biomass from 1993 to 1998 resulted from low numbers of *Dreissena* spp. at west stations, implying that less energy was being shunted to the benthos by way of mussel production. It should be noted, however, that similar low mussel biomass occurred in 1992 and that these fluctuations may represent process error associated with the patchy dreissenid distribution on soft sediments in the west basin (Coakley et al. 1997). Similar, large decreases in densities of oligochaetes, ostracods, and chironomids have been observed since 1993. These declines may reflect long-term reductions in food resources attributable to the mussels, as was found in Lake Ontario by Haynes et al. (1999). Alternatively, they may be due to increased predation from the expanding round goby (*Neogobius melanostomus*) population in the west basin. Regardless, a decrease in oligochaete and chironomid larval density may have consequences for juvenile fish that rely on benthic resources. The burrowing mayfly, *Hexagenia,* was present at 5 of the 6 west stations in 1998 and comprised a large portion of the biomass at W3 and W7. This significant increase in mayfly density reflects the recovery of the species (Krieger et al. 1996) that will once again benefit some benthic feeding fish like yellow perch. Although the exotic amphipod *Echinogammarus ischnus* was found only at sites W5 and 967 in the west basin, this amphipod is now common on cobble reefs throughout Lake Erie (R. Dermott, Fisheries & Oceans Canada, Burlington, pers. comm.).

Using gut fullness of YOY yellow perch as an indicator of food availability, it is apparent that juvenile fish were not food-limited in the west basin in 1998. From mid-July until mid-August most of the diet was zooplankton, primarily daphnids and copepods. By late August, following the declines in zooplankton, particularly cladocerans, YOY yellow perch proportionally increased their intake of dipteran larvae (W1), insect larvae and larval fish (W7). Correlation between the ontogenetic diet shift of YOY yellow perch and abundance of zooplankton prey has been documented previously by Mills and Forney (1983), and Wu and Culver (1994). Gopalan et al. (1998) report a YOY yellow perch diet switch that is similar to the one reported here both in terms of timing (late August) and average contribution of benthic biomass post-switch (approx. 60%).

Preference for particular zooplankton prey was evident at the west basin sites. Fish from both sites showed a strong preference for chydorid cladocerans (principally *Latona* sp.), *Bythotrephes* sp. and *Polyphemus* sp. and an avoidance of veliger larvae and copepod nauplii. Size also played a role in selection. In most cases, the mean size of the preferred zooplankton was >600 μm, with strong selection of prey items >1 mm. Small zooplankters (<400 μm) were either rarely consumed (nauplii) or completely avoided (veliger larvae). This observation differs from that of Graham et al. (1999) when veliger larvae were consumed by YOY yellow perch. Ivlev's index does not permit direct comparison of indices between stations or taxa. However, differences in prey selection between sites may be the result of habitat differences between the two stations. For example, W7 is near a sand beach at the mouth of a tributary draining a wetland, while W1 is an exposed sand beach with little to no submerged structure.

Favourable environmental conditions for fish production (including food availability, ambient temperature, predator densities, etc.) can be surmised by considering indicies of YOY growth. In the west basin, growth indexes for YOY yellow perch and walleye show a general downward trend through the 1990's although data from the last two years suggest a recovery to levels more similar to the long-term averages. Of note is the fact that average seasonal lake temperatures were above average in 1998 and may have contributed to better growth.

4.2. Central basin

Sampling in the central basin presents the logistical problem of having few suitable ports to work from, particularly for boats small enough to sample shallow nearshore areas. This may explain the lack of historic sampling in this basin. Dahl et al. (1995) sampled only in the west end of the basin (WC1 and WC2) and expressed concern when extrapolating parameters such as TP and Chl over the entire basin, given the strong east- west gradient between basins. Additional sampling in 1998 in the central and east-central basins confirmed that this concern is valid for some parameters. In 1993, the west-central basin could be classified as either mesotrophic, based on nutrient levels (Dahl et al. 1995), or oligotrophic, based on phytoplankton indices (Johansson and Millard 1998).

Concentrations of TP have changed little from those reported for the west-central basin in 1993; although in 1998 there were no longer differences between the nearshore and offshore. The basin average TP was 11.6 $\mu g\ L^{-1}$ in 1998, 11.8 $\mu g\ L^{-1}$ in 1993. The mean TP concentration at offshore station WC2 during the thermally stratified period can confidently be applied to the offshore of the central and east-central basins. Nearshore, SWM TP concentrations were similar through out the central basin (WC1, C1, EC1), although the amount of seasonal variation is different.

Chl showed a larger gradient across the central basin than TP. Chl decreases from west to east, suggesting that values in the west-central basin, particularly in the nearshore, are not representative of the central basin as a whole. Chl concentrations at both WC1 and WC2 are more characteristic of the west basin than the central or east-central basins. Average Chl in the west-central basin was greater in 1998 than in 1993 due mainly to increases in the nearshore. At east-central and central basin stations Chl concentrations were best predicted from TP concentrations using the equation that Mazumder (1994) proposed for functionally "even-linked" systems. This suggests that heavy grazing of phytoplankton was occurring both nearshore and offshore regions of the east-central and central basins. In 1993, the Chl:TP ratios in the west-central basin were also best described by the "even-linked" equation; however, in 1998 the ratios increased and were best predicted using the "odd-link" equation. Grazing pressure on phytoplankton had therefore decreased in the west-central basin.

Indicators of primary production such as the increase in Chl, POC and PON and the drawdown of nitrate suggest that SAPP in the west-central basin may have been higher than in the early 1990s. SAPP is likely lower in the east end of the central basin, as both Chl and transparency are considerably lower there.

Zooplankton seasonal mean biomass decreased from the west-central to east-central basin following the pattern in Chl and, to a lesser extent, TP. Both the biomass and density of cladocerans and cyclopoids decreased from 1993 to 1998 at WC1, the only station where a comparison could be made. The resulting high proportion of calanoids compared to cyclopoids and cladocerans, is unexpected; the proportion being more characteristic of oligotrophic waters. The mean May-July size of the zooplankton community in the west-central and offshore central basins was <500 μm, and thus indicative of heavy predation by planktivores. The prominent daphnid, *D. retrocurva*, were smaller at these sites than elsewhere in the central basin. This heavy predation on herbivorous zooplankton, combined with a decreased mussel population is in agreement with the decreased grazing suggested by the Chl:TP ratios. In the east-central and nearshore east basin, the zooplankton mean size decreased from >500 μm in May-July to <300 μm later in the summer, first in the nearshore and then in the offshore. This pattern is indicative of predation by YOY fish and suggests that the fish moved offshore as the season progressed.

Inter-year comparisons of benthic biomass and production are confined to data from the west-central basin, which may not reflect conditions in the entire central basin. The west-central basin data suggested that dreissenid biomass may have declined; however, averages for the whole basin suggested otherwise. Offshore station WC2, which is subjected to low oxygen levels in the hypolimnion, may not be indicative of the rest of the offshore central basin. Charlton (1994) found that higher average oxygen conditions occurred in the hypolimnion of the central basin in 1993. However in the summer of 1998 hypolimnetic oxygen levels were again < 1 mg L^{-1} (Charlton et al. 1999). Lower oxygen levels would explain the poor survival of the *Dreissena* and amphipods at station WC2, and the increase in density of tubificid oligochaetes in 1998, compared to 1993. Station C2, had a large mussel biomass, and the highest benthic biomass of any Lake Erie station sampled. The combined LEB/LETT data, showed an increase in quagga biomass suggesting that benthic production may have increased in the central basin, providing that growth rates of the larger mussels have not decreased as suggested by Chase and Bailey (1999).

Dahl et al. (1995) noted that in 1993 the mean non-dreissenid benthic biomass in the west-central basin had not changed since pre-zebra mussel days and that the large increases in total benthic biomass were due to the additional dreissenid biomass. Non-dreissenid biomass at both west-central stations increased by 75% in 1998 due to an increase in oligochaetes. In addition, dreissenid biomass decreased in both the nearshore and offshore. Using biomass as an index of benthic production, production decreased in the nearshore of the west-central basin but increased offshore. Overall, total benthic production of the central basin has likely increased due to the large increase in dreissenid biomass since 1993.

YOY yellow perch diet data is very limited for the central basin; 30 fish from one day in mid-summer (Aug 4). From this limited sample, the diet of nearshore east-central yellow perch was more similar to that of nearshore west basin yellow perch than to that of Inner Long Point Bay (E5) fish.

4.3. East basin

The east basin has always been the least productive of the three basins and remained so in 1998. In 1993, the basin had been classified as either oligotrophic (Dahl et al. 1995) or ultra-oligotrophic based on phytoplankton indices (Johansson and Millard 1998). Seasonal mean TP and Chl concentrations and Chl:TP ratios have changed little since 1993-94. Chlorophyll concentrations are still best predicted assuming an "even-linked" systems (Mazumder 1994), suggesting that grazing is limiting phytoplankton standing crop. Nearshore seasonal mean Chl in 1998 was lower than in the offshore and even lower than values predicted using the "even-link" equation suggesting a severe grazing impact. Although predicted values suggested a decrease in grazing pressure during the period of thermal stratification in 1993-94, the even-link equation was the best predictor of Chl throughout the 1998 sampling season.

Higher SRP, nitrate and silica levels compared to other basins and to the east basin in previous years reflects a relatively low phytoplankton standing crop. Even in the offshore, SRP levels never fall below the detection limit whereas in Lake Ontario SRP was rarely above detection levels during the summer (Johannsson et al. 1998). Similarly, the shallow drawdown of nitrate is indicative of a lower growth demand by the phytoplankton community in general and similar trends in silica specifically suggest lower diatom growth as well.

There are indications of decreased phytoplankton production since 1993-94 including significant decreases in the mean PP rates of the netplankton and, in particular the microplankton since 1992 despite increased phytoplankton biomass and similar TP and Chl concentrations over the same period. Again, this may be reflect the changing species composition in the phytoplankton community or decreased availability of TP. Additional evidence of a decline in phytoplankton production is that nearshore and offshore P_{opt} (3.8 and 7.8 mg C m^{-3} h^{-1}, respectively) was lower in 1998 than in 1993-94. In comparison, P_{opt} in Lake Ontario is typically in the range of 8.0 – 13.4 mg C m^{-3} h^{-1} at TP levels of 10 μg L^{-1} (Millard et al. 1996a). Both of the Chl-corrected photosynthetic parameters (P^B_m and α^B), were also lower in 1998. In the more productive system of Bay of Quinte, Lake Ontario, P^B_m and α^B have shown an increase in inter-annual variability for seasonal means of these parameters since the invasion of dreissenid mussels (Scott Millard, Fisheries & Oceans Canada, Burlington, pers. comm.). It remains to be seen whether this is true in the less productive system of the east basin of Lake Erie. P^B_m values (2.49 mg C mg Chl^{-1} h^{-1} offshore, 3.23 mg C mg Chl^{-1} h^{-1} nearshore) were comparable to those observed in the offshore of Lake Ontario where the 6-year mean (1987-92) was 2.86 mg C mg Chl^{-1} h^{-1} (Millard et al. 1996a).

Seasonal areal PP had declined at the two nearshore stations since 1993-94. Offshore SAPP was similar to that of 1993 but higher than 1994. The decrease from 1993 to 1994 was attributed to a shift in species composition of the phytoplankton which favoured the less photosynthetically active dinoflagellates over the more active diatoms (Graham et al. 1996). Utilizing the same 1993 data, a report released by Lake Erie Lakewide Management Plan (Johannsson and Millard 1998) concluded that the nearshore phytoplankton populations in the east basin were impaired (based on standing crop, photosynthesis, loss of key species and trophic transfer to *Diporeia*) due to grazing by dreissenid mussels. This impairment appears to be even more acute in 1998. The amount of seasonal PP is far below what would be predicted from the amount of TP present. At E3, where measurements were taken during all three years, the ratio of predicted to observed SAPP has been steadily increasing. Impairment of SAPP in the offshore appears to be less consistent since SAPP was only 14% below the predicted level in 1998, similar to percentage in 1993 but down from that in 1994 (27% below predicted). SAPP at nearshore east basin stations is now far below the potential production set by TP levels and more typical of values found in shield lakes. SAPP in these lakes is lower than Lake Erie at equivalent TP levels because of the impact of lower transparency.

Phytoplankton growth is not light-limited except in the offshore during the spring and fall isothermal periods. Growth limiting values of mean epilimnetic irradiance <3.5 mE m^{-2} min^{-1} (Hecky and Guildford 1984) and <5.0 mE m^{-2} min^{-1} for Lake Ontario (Millard et al. 1996b) have been proposed. Values this low rarely occurred in the east basin because of the high transparency and shallow depth of the inshore stations. Low water column light levels were observed only in the offshore in early spring and late fall and at E3 in the late fall.

The lower production of phytoplankton in the east, relative to the other basins, resulted in lower relative zooplankton biomass. Lower relative zooplankton biomass, in combination with the relatively colder temperatures of the east waters and the lower proportion of cladocerans (which have higher relative production: unit biomass ratios than copepods (Shuter and Ing 1997) should result in lower annual production in the east. No obvious pattern within the east basin was apparent when comparing biomass at either a single site between 1993-94 and 1998, or when comparing nearshore to offshore. The zooplankton community of the east basin was controlled not only by food limitations (bottom up) but also by predation impacts (top-down) (Dahl et al. 1995, Graham et al. 1996). Cladoceran biomass was noticeably higher in the nearshore in 1998 and noticeably lower in the offshore, than in previous years. Offshore, total biomass was also substantially lower than in 1993 and 1994 (59% and 32% lower; respectively). These shifts were likely driven by predation pressures because phytoplankton biomass was higher in 1998 than in 1993-1994. Predation pressure, as indicated by mean zooplankton size, suggested that the fish community was dominated by planktivores in the east basin. Mean May-July zooplankton size was well below 500 μm at all stations. It was lowest in the inner bay, slightly higher at nearshore E1 and highest at E3 and E2. Despite the higher relative offshore mean community size at E2, it was still lower than in 1993 and 1994 when mean May-July size was more indicative of a balanced fish community. While the 1998 indices of YOY rainbow smelt in the offshore of Long Point Bay were the highest recorded since 1992 (Ontario Ministry of Natural Resources 1999), the yearling fish index indicates that numbers were well below those of 1993, but similar to those of 1994; 1994 and 1998, were the lowest and second lowest yearling-and-older catches on record. The high number of YOY smelt did not affect the abundance of calanoids as might be expected. The low number of one-year-old smelt, may partially account for the higher cladoceran biomass nearshore.

The east basin had the highest density of mussels in the lake. Although abundance had not increased significantly since 1993, their biomass had, partly reflecting the increasing age of the population. Average *Dreissena* spp. shell length increased between the early 1990s and 1998 (Jarvis et al. 2000). Thus the increased filtering ability of the larger mussels place greater demands on phytoplankton production in the basin. Dreissenid densities have increased in the shallower, 5-10 m depths of the lake and this increase in numbers might explain the lower nearshore phytoplankton production in 1998. The lower density of *Dreissena* in water shallower than 5 m may reflect the high predation by diving ducks. Petrie and Knapton (1999) found a 67% decline in mussels in Long Point Bay attributed to the increased waterfowl predation rates (estimated to be between 43 and 220% of the mussels per year).

There were few changes in the non-dreissenid invertebrate populations in the east basin since 1993. The Lumbriculidae worms were rare and the filter feeding Polychaete *Manayunkia* absent, compared to samples collected in 1979 (Dermott 1994). No specimens of the deep-water amphipod *Diporeia* were collected in 1998, thus removing a potential food source for lake whitefish (*Coregonus artedi*) and rainbow smelt populations in the east basin.

4.4. Inner Long Point Bay

LEB sampling was conducted at station E5, in Inner Long Point Bay, for the first time in 1998. Despite a truncated sampling season relative to other sites, a picture of an environment unique from that of the outer bay has emerged. The Inner Bay warms more quickly than the rest of the east basin in the spring, has mean TP concentrations more similar to central or west-central basin values, has a relatively high mean SiO_2 concentration and high nitrate demand. Unlike the rest of the east basin, NO_3+NO_2 values were below detection limits until well into the fall. Chl values were the highest of all east stations, but well below those observed in the west. Abundance of zooplankton was as high as in the west basin; however, zooplankton biomass was relatively low due to the small types of zooplankton present (mainly bosminids, copepodites and nauplii).

The small mean size of zooplankton prey along with a relatively high abundance and diversity of benthic invertebrates yielded a YOY yellow perch diet that was dominated by benthic prey rather than the pelagic prey utilized in the west. Diets comprised exclusively of zooplankton were rare, and remained so throughout the season (approx. 30%). While bosminids and copepods were consumed, a large part of the diet came from benthic invertebrates. This is in stark contrast to previous studies of west basin YOY yellow perch which showed exclusive use of zooplankton (in some cases exclusively *Daphnia* spp.) until a particular fish size was reached (Wu and Culver 1992). The index of gut fullness suggests that E5 fish had consumed as much prey as fish from more westerly stations. Previous studies (Mills and Forney 1981; Pycha and Smith 1954) have suggested that benthic prey may have a lower net energy return compared to zooplankton prey. The observation of an exceptionally large recruitment index in 1998 (Ontario Ministry of Natural Resources 1999) and had a high growth index (predicted weight, Fig. 33) challenges this hypothesis.

The degree to which the Inner Bay fish diets can be extrapolated to the nearshore of the rest of the east basin is unclear. Nearshore zooplankton density is considerably lower in the rest of the east basin suggesting lower potential production of fish that are exclusively planktivorous in their first year of life (e.g. emerald shiner, gizzard shad, and alewife). However, fish which utilize both planktonic and benthic food resources may be relatively unaffected by the late-season decreases in zooplankton biomass observed in the east basin. This group would include such species as yellow perch, white perch, trout- perch, freshwater drum, and spot tail shiner. Walleye undergo a rapid transition to piscivory, and their first year diets are therefore more dependent on availability of small fishes, than on late-summer and fall zooplankton resources.

4.5. The fishery

Percid abundance, estimated during the OMNR/OCFA partnership gillnet surveys, may be indicative of the pelagic fisheries potential of the environment; it is based on biomass and thus reflects changes in both abundance and size. In general, the trophic gradient across the lake basins is reflected in the index: CPUEs were higher in the west and lower in the east. When total fish biomass is considered, declines from the 1980s through the early 1990s (in all but the west basin) correlate with declining nutrient levels over the same period. In contrast, the total biomass caught in 1998 showed increases since 1995 in the east and east-central basins while total biomass declined through 1998 in the west and central basins. However, the long life expectancy of many fish species incorporates lags, and tends to spread annual production dynamics across several years. Further, the cumulative total biomass across all basins in 1998 remains well below that observed earlier in the time-series. Similarly, while trends in yellow perch and walleye biomass have oscillated within the basins during the past decades, total lakewide biomass remains at or below the decadal average.

It is difficult to link changes in abundance of top-level predators with changes occurring at lower trophic levels. The diet of planktivorous YOY yellow perch can give some indication of the influence of changes in zooplankton abundance on the percid community. In 1998, YOY yellow perch did not appear to be food limited in either the west or the east. Smelt, an important forage fish in the east and central basins may have a greater dependence on zooplankton than YOY percids. There is some indication that decreased zooplankton size and abundance in the east has led to a reduction in size-at-age of young smelt (Dermott et al. 1999). Abundance of smelt has been declining in the east basin since the mid-1980s as indicated by index trawls and landings from the commercial fishery. Changes in the abundance of top-level predators will naturally lag behind changes in lower trophic levels. The effects of newly introduced species, such as the predatory cladoceran *Bythotrephes cederstroemi*, may take a number of years to manifest itself. The continuing eastward expansion of the round goby provides the potential for altering energy pathways of the food web and re-introducing some of the benthic production back to the pelagia.

5. Summary

Changes at several trophic levels occurred between 1993-94 and 1998 although these were not as pronounced as those reported in earlier LEB reports (Dahl et al. 1995; Graham et al. 1996) for the mid 1980s to 1993-94 period. Trophic classification for each basin remained unchanged because total phosphorus and chlorophyll have stayed relatively constant. However, these classifications were based on pelagic conditions. The shift in biomass to the benthos due to dreissenid colonization and lack of change in TP loadings and in situ concentrations suggests that ecosystem trophic status has not declined but benthic processes and production have become relatively more important. High phytoplankton species diversity was observed in all three basins compared to 1993.

In the west and west-central basins there were indications that grazing pressure on phytoplankton had declined, possibly the result of decreases in both herbivorous zooplankton and in localized *Dressenia* spp. densities. Benthic biomass had decreased due to reductions in oligochaetes, ostracods, and chironomids. However, long term improvements in the water quality of the west basin have allowed *Hexagenia* densities to increase.

More extensive spatial sampling of the central basin in 1998 confirmed the gradient of decreasing chlorophyll and zooplankton biomass from west to east. Decreasing Chl:TP ratios from west-central to east-central and from offshore to nearshore reflect gradients in grazing pressure due to dreissenid mussels. Anomalous zooplankton species in the east-central nearshore and greatly different *Dreissena* spp. densities in the central and west-central offshore reinforce the need for basin-wide sampling to accurately describe ecological conditions.

The east basin continued to have the lowest pelagic production. Intense grazing pressure in the nearshore suppressed primary production because chlorophyll concentrations were also held to levels well below what would be predicted from TP concentrations. Young-of-the-year yellow perch from both east and west basins showed no signs of food limitation although each population utilized pelagic and benthic food sources to varying degrees. While some of the earlier changes in the fishery may be related to declining nutrient levels, recent changes are harder to characterize, suggesting complex mechanisms which may include changes in habitat utilization, foraging efficiencies and survival. Lake Erie has, and will continue to change. Improved assessment, monitoring and synthesis such as that obtained through the 1998 LEB partnership will improve our understanding of these changes and their impact on the fisheries.

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Table 1a. Lake Erie station identification and locations. Station depths (m) are seasonal averages for 1998.

LEB Station[1]	Established Station[2]	Mean Depth	Latitude (North)	Longitude (West)
E1	††	6.0	42° 46.77'	80° 08.70'
E2	LETT #938	37.6	42° 37.58'	80° 03.27'
E3	LETT #937	9.0	42° 42.82'	80° 13.77'
E5	††	2.6	42° 37.27'	80° 21.50'
EC1	LETT #943	12.3	42° 34.43'	80° 38.53'
EC2	LETT #945	21.5	42° 24.00'	80° 38.62'
C1	LETT #950	9.1	42° 35.25'	81° 26.50'
C2	LETT #952	23.1	42° 21.52'	81° 26.57'
WC1	MNR #1	16.9	42° 04.60'	82° 20.40'
WC2	MNR #3	22.4	41° 59.00'	82° 08.40'
W1	MNR #8	10.1	41° 59.20'	82° 34.50'
W2	MNR #5	11.6	41° 53.00'	82° 36.80'
W3	LETT #970	10.9	41° 49.34'	82° 58.33'
W6	MNR # 6	12.1	41° 51.25'	82° 45.80'
W7	MNR #7	10.1	41° 59.50'	82° 45.80'

[1]E east basin, waters east of Long Point.
EC east-central basin , waters west of Long Point and east of Port Burwell.
C central basin, waters west of Port Burwell and east of Pointe aux Pins.
WC - west-central basin, waters west of Pointe aux Pins and east of Point Pelee.
W west basin , waters west of Point Pelee.

[2]LETT Lake Erie Trophic Transfer project (DFO).
MNR historical provincial site.
†† unnumbered provincial site.

Table 1b. Additional Lake Erie stations utilized for benthic sampling only, 1998. Station depths (m) are seasonal averages.

Reference No.	Sample Date	Mean	Basin Location[1]	Latitude	Longitude
930	May 25	58.5	E	42° 28.95'	80° 02.80'
933 *	May 26	15.6	E	42° 49.00'	79° 34.08'
934	May 26	28.0	E	42° 42.52'	79° 30.47'
939 (E4) *	June 10	57.0	E	42° 34.00'	79° 55.00'
940 *	April 21	48.0	E	42° 26.48'	79° 50.08'
942 *	April 21	15.9	E	42° 15.55'	79° 49.90'
M29	May 25	46.0	E	42° 32.60'	80° 91.40'
N27	June 10	7.0	E	42° 38.00'	80° 16.90'
E10	June 16	2.8	IB	42° 37.50'	82° 21.00'
J11	June 17	2.0	IB	42° 38.60'	82° 23.30'
944 *	May 21	17.5	EC	42° 31.90'	80° 38.42'
954 *	April 22	24.2	C	42° 01.50'	81° 26.62'
956 *	April 22	11.0	C	41° 41.33'	81° 26.93'
967 *	May 25	12.0	W	41° 53.50'	82° 39.98
971 *	May 26	9.5	W	41° 56.87'	83° 03.02'

[1]E east basin, waters east of Long Point.
IB inner Long Point Bay (east basin).
EC east-central basin , waters west of Long Point and east of Port Burwell.
C central basin, waters west of Port Burwell and east of Pointe aux Pins.
W west basin , waters west of Point Pelee.

* benthic sampling matched sites (in addition to stations E2, E3, EC1, EC2, C1, C2, W3); see "Methods".

Table 2a. Physical parameters for station E1. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sampling Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980505	6.5	1, 3, 5	6.5	0.165	6.0
980605	5.5	1, 2.5, 4	5.5	0.212	5.5
980617	5.5	0 - 4	5.5	0.268	4.0
980715	5.4	1, 2.5, 4	5.4	0.242	5.3
980731	7.6	1, 3, 5	7.6	0.296	5.0
980812	5.8	0 - 4	5.8	0.423	3.8
980827	5.4	0 - 4	5.4	0.457	2.1
980908	5.4	0 - 4	5.4	0.126	4.5
980925	6.1	0 - 4	6.1	0.155	3.0
981009	6.4	0 - 4	6.4	0.494	2.0
981022	4.9	0 - 4	4.9	0.188	4.9
981118	5.9	0 - 4	5.9	0.323	5.9
SWM[4]	5.9		5.9	0.270	4.3

[1] mixing depth equated to bottom depth on all dates.
[2] equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3] euphotic depth truncated at bottom depth on all dates.
[4] SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2b. Physical parameters for station E2. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m	Sample Depth[1]	Z_{eu}	ε_{par}	Secchi
980505	37.4	0 - 20	15.0	0.307	4.8
980519	7.5	1, 19, 36	33.5	0.138	5.0
980605	13.5	1, 19, 36	37.8	0.028	8.5
980617	6.5	0 - 5	17.6	0.262	6.5
980629	14.0	0 - 13	33.0	0.140	6.0
980715	10.0	0 - 13	21.0	0.219	5.7
980730	16.3	0 - 15	24.8	0.186	5.0
980812	17.0	0 - 17	18.3	0.251	4.7
980827	11.0	0 - 10	17.3	0.266	3.9
980908	17.0	0 - 20	24.8	0.186	3.5
980928	14.5	0 - 14	18.2	0.254	4.8
981022	17.0	0 - 17	14.3	0.322	2.8
981118	37.4	0 - 20	4.5	1.025	1.0
SWM[2]	14.2		23.4	0.208	5.1

[1] equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.

[2] SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2c. Physical parameters for station E3. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980505	10.0	1, 5, 8	10.0	0.206	9.0
980519	*5.5	0 - 8.4	9.4	0.212	5.0
980605	9.1	1, 4.5, 7	9.1	0.159	9.1
980617	8.8	0 - 7	8.8	0.184	7.0
980629	*6.0	0 - 7	8.8	0.212	7.0
980715	8.5	0 - 7	8.5	0.280	5.5
980730	*7.0	0 - 7	8.8	0.175	4.8
980812	8.5	0 - 7	8.5	0.331	4.5
980827	*3.5	0 - 7	8.5	0.236	3.8
980908	8.5	0 - 7	8.5	0.208	4.4
980928	8.5	0 - 7	8.5	0.218	6.0
981008	9.1	0 - 7	9.1	0.243	3.0
981022	8.9	0 - 7	8.9	0.188	5.9
981118	8.7	0 - 7	8.7	0.392	2.3
SWM[4]	7.7		8.8	0.222	5.6

[1] mixing depth extended to bottom depth except where indicated (*).
[2] equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3] euphotic depth truncated at bottom depth on all dates.
[4] SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2d. Physical parameters for station E5. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}	ε_{par}	Secchi
980715	2.8	1, 1.5, 2			2.3
980730	2.9	1, 1.5, 2			2.8
980812	2.8	1, 1.5, 2			1.9
980827	2.4	1, 1.5, 2			2.3
980909	2.3	1.2	2.3	0.679	1.9
980924	2.6	1.3			2.6
981008	2.5	1.3			1.5
981022	2.4	1.2			2.3
SWM[3]	2.6				2.2

[1] mixing depth extended to bottom on all dates.
[2] equal volumes from discrete depths were pooled to create integrated sample.
[3] SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2e. Physical parameters for station EC1. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980415	13.4				1.0
980512	12.4	1, 5, 9	12.4	0.320	2.9
980527	12.1	0 - 20	*9.4	0.491	2.5
980608	13.0	1, 6, 11	*5.9	0.786	1.0
980622	12.3	1, 6, 10	*12.0	0.383	2.0
980708	11.9	1, 6, 10	11.9	0.242	5.0
980723	11.5	1, 5, 9	*1.9	2.467	0.3
980805	12.2	1, 6, 10	12.2	0.342	2.5
980818	12.5	2, 6, 11	*9.8	0.471	1.7
980903	12.0	1, 6, 10	*7.0	0.662	2.0
980916	12.7	1, 6, 10	*5.8	0.800	1.4
980930	12.0	0 - 6	*7.9	0.585	1.0
SWM[4]	12.2		8.7	0.702	2.1

[1]mixing depth extended to bottom on all dates.
[2]equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3]euphotic depth truncated at bottom depth except where indicated (*).
[4]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2f. Physical parameters for station EC2. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}	ε_{par}	Secchi
980415	22.1				1.0
980512	22.0	0 - 20	16.1	0.285	4.0
980527	21.3	0 - 20	19.3	0.239	7.5
980608	22.1	0 - 20	21.4	0.039	4.6
980622	21.8	0 - 20	21.4	0.197	7.3
980708	*11.0	1, 6, 19	21.0	0.220	5.5
980805	*16.0	1, 8, 15	14.3	0.322	2.8
980819	*14.0	1, 7, 14	16.9	0.273	2.9
980903	22.2	5, 10, 15	20.5	0.225	5.0
980917	*17.0	0 - 11	11.4	0.402	3.8
980930	21.0	0 - 14	11.2	0.411	3.2
SWM[3]	18.0		17.8	0.253	4.7

[1]mixing depth extended to bottom depth except where indicated (*).
[2]equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2g. Physical parameters for station C1. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m [1]	Sample Depth [2]	Z_{eu} [3]	ε_{par}	Secchi
908415	10.3				1.0
980512	10.0	1, 5, 9	10.0	0.371	2.0
980528	9.1	0 - 8	9.1	0.455	1.5
980609	10.3	1, 4, 8	10.3	0.279	5.0
980623	10.0	1, 5, 8	10.0	0.412	1.8
980706	8.8	1, 4, 7	*7.9	0.583	3.8
980807	8.7	1, 4, 6	8.7	0.463	3.5
980817	7.5	1, 3, 4, 5	7.5	0.277	2.0
980903	8.9	1, 4, 7	8.9	0.485	2.9
980914	9.2	1, 4.5, 8	*7.2	0.638	2.0
980928	9.0	1, 4, 7	*8.1	0.567	4.2
981015	9.0	1, 3.5, 8	9.0	0.339	3.8
981026	8.0	1, 3, 6			
SWM [4]	9.0		8.7	0.458	3.0

[1]mixing depth extended to bottom on all dates.
[2]equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3]euphotic depth truncated at bottom depth except where indicated (*).
[4]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2h. Physical parameters for station C2. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}	ε_{par}	Secchi
980415	24.0				2.5
980512	23.8	0 - 20	23.8	0.143	2.8
980527	23.2	0 - 20	17.2	0.268	5.0
980608	23.4	0 - 20	23.4	0.016	4.3
980622	23.4	0 - 20	23.4	0.112	5.5
980706	*10.0	1, 7, 14, 21	17.9	0.258	4.5
980807	*12.0	1, 6, 11	16.8	0.274	3.7
980817	*11.0	1, 4, 7, 11	22.4	0.206	6.0
980903	*13.0	1, 5, 9, 13	12.1	0.382	3.5
980914	22.8	1, 8, 16, 21	10.7	0.430	3.8
980928	23.0	1, 7, 14, 21			3.5
981015	23.0	1, 8, 14, 21	14.3	0.322	3.3
981026	22.7	1, 10, 20			2.0
SWM[3]	18.1		17.5	0.258	4.1

[1]mixing depth extended to bottom except where indicated (*).
[2]equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2i. Physical parameters for station WC1. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980415	17.8				1.4
980420	17.3				2.6
980428	16.9				1.8
980504	17.3				2.8
980511	16.9	1, 8, 14	*14.5	0.318	4.0
980513	17.0	1, 6, 11, 15			3.5
980519	17.1	1, 7, 15			3.0
980526	16.8	1, 8, 15	16.8	0.238	7.0
980604	17.0	1, 8, 15	17.0	0.036	6.5
980608	17.1	1, 6, 10, 15	17.1	0.118	4.9
980611	*13.0	1, 8, 15			4.1
980615	17.1	1, 8, 15	17.1	0.165	4.0
980618	*10.0				3.5
980622	17.1	0 - 15	17.1	0.232	4.1
980629	17.3	1, 8, 15	*13.8	0.334	4.8
980706	17.4	1, 5, 8, 15	*13.4	0.343	4.3
980713	17.1	1, 8, 15	*14.0	0.328	4.5
980723	*5.0	1, 3, 5	*12.1	0.382	4.1
980727	16.9	1, 9, 15	*13.9	0.332	4.3
980805	16.9	1, 8, 14	*16.9	0.244	4.5
980811	*9.0				4.5
980817	16.5	1, 5, 10, 14	*14.4	0.321	4.0
980826	16.8	1, 5, 10	*11.1	0.413	4.0
980831	*10.0	1, 5, 10			3.0
980910	16.3	1, 7, 14	*7.7	0.601	2.1
980914	*11.0	1, 6, 11	*10.2	0.453	2.6
980921	16.8	1, 5, 10	*9.4	0.489	3.0
981015	17.0	1, 8, 15	*8.2	0.561	2.5
981020	16.7	1, 8, 15			2.3
981026	15.9	1, 7.5, 15	*12.0	0.385	3.0
981109	16.9	1, 8, 14			2.5
SWM[4]	15.5		13.0	0.356	3.8

[1]mixing depth extended to bottom except where indicated (*).
[2]equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3]euphotic depth truncated at bottom depth except where indicated (*).
[4]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2j. Physical parameters for station WC2. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980415	23.2				1.2
980420	22.8				3.0
980428	22.8				2.5
980504	22.8				3.0
980511	22.5	1, 10, 20	*12.5	0.370	4.0
980513	22.4	1, 7, 13, 20			
980519	22.8	1, 11, 21			5.0
980528	22.3	0 - 20	*16.1	0.287	4.5
980604	22.9	1, 10, 20	*12.2	0.378	4.0
980609	22.5	0 - 20	22.5	0.103	3.0
980615	22.3	1, 10, 20	*14.9	0.309	3.5
980623	22.3	0 - 20	*14.4	0.319	4.1
980629	22.3	1, 10, 20	*15.7	0.293	4.5
980706	*5.0		*13.4	0.344	
980713	*15.0	1, 7, 14, 20	22.3	0.168	4.5
980723	*16.0	1, 8, 15	22.3	0.088	3.9
980727	*11.0	1, 10, 20	*15.1	0.304	4.5
980805	*8.0	1, 4, 7	*14.7	0.314	3.8
980811	*8.0				4.3
980817	*12.0	1, 5, 9, 13	*15.2	0.302	5.0
980826	*14.0	1, 5, 10	*17.5	0.263	6.0
980903	*17.0	1, 5, 10, 15	*16.2	0.283	3.8
980910	*18.0	1, 6, 12, 18	*10.6	0.434	5.0
980914	22.4	1, 7, 13, 19	*12.3	0.375	3.0
980921	*20.0	1, 10, 14	*11.6	0.396	3.2
980928	22.8	1, 7, 14			3.4
981015	23.0	1, 8, 14, 21	*11.5	0.401	4.0
981026	22.0	1, 10, 20	*10.7	0.432	2.8
981109	21.7	1, 11, 19			4.2
SWM[4]	18.3		14.8	0.315	4.1

[1]mixing depth extended to bottom except where indicated (*).
[2]equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3]euphotic depth truncated at bottom depth except where indicated (*).
[4]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2k. Physical parameters for station W1. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980415	10.0				1.5
980420	10.1				2.0
980428	10.1				2.0
980504	10.2				3.1
980511	10.3		10.3	0.368	2.9
980513	10.3				3.8
980520	10.1				4.0
980525	10.3				2.5
980603	10.0		*7.9	0.585	1.8
980609	10.3		*9.0	0.512	2.5
980615	10.2		10.2	0.336	2.8
980623	*5.0		10.2	0.369	2.1
980629	10.2	1, 5.5, 10	10.2	0.301	4.3
980707	10.2		10.2	0.398	3.8
980713	10.2		*8.6	0.538	3.2
980724	*7.0		*3.4	1.364	0.8
980729	10.2		*3.4	1.335	1.1
980804	10.0	1, 5, 8	10.0	0.411	2.5
980811	*7.0				2.2
980818	10.0	1, 5, 8			2.2
980826	10.1	1, 5, 8	*4.7	0.970	0.6
980831	10.0				1.1
980910	9.6	1, 4.5, 8	*4.2	1.106	1.1
980916	10.0	1, 4.5, 9	*2.6	1.774	1.1
980924	10.0	1, 4.5, 8			0.6
980930	10.3		*5.0	0.917	1.1
981016	10.0	1, 4.5, 8			1.2
981019	10.0				0.8
981029	10.0	1, 4.5, 8			2.0
981109	9.9	1, 5, 8			2.0
981204	10.1	1, 4.5, 8			0.4
SWM[4]	9.7		7.2	0.760	1.9

[1]mixing depth extended to bottom except where indicated (*).
[2]equal volumes from discrete depths were pooled to create integrated sample.
[3]euphotic depth truncated at bottom depth except where indicated (*).
[4]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 21. Physical parameters for station W2. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980415	11.9				1.9
980420	12.4				1.1
980428	11.7				2.5
980504	11.8				2.1
980511	11.7	1, 4.5, 9	*7.0	0.655	1.1
980513	11.9	1, 5, 9			2.0
980519	11.7				3.5
980525	11.7	1, 5, 9			4.5
980603	11.7	1, 5, 9	11.7	0.366	2.0
980610	11.2	1, 4.5, 9	*9.7	0.473	3.5
980615	11.8	1, 4.5, 10	11.8	0.215	4.0
980623	11.6	1, 5, 9	11.6	0.341	4.0
980629	11.8	1, 4.5, 10	*9.8	0.472	2.5
980707	11.8	1, 5, 10	11.8	0.346	3.0
980713	11.6	1, 5, 10	11.6	0.162	3.5
980724	*9.0	1, 5, 9	11.6	0.336	2.3
980729	11.8	1, 5, 10	*9.7	0.476	2.8
980804	11.6	1, 5, 10	11.6	0.361	4.0
980811	11.6				2.0
980818	11.5	1, 6, 9.5			2.0
980826	11.9	1, 5, 10	*9.7	0.474	2.0
980831	11.3	1, 4.5, 9			2.0
980910	11.3	1, 5, 9	*8.6	0.534	3.5
980916	11.6	1, 5, 9	*11.4	0.405	3.0
980924	11.6	1, 4.5, 9			1.2
980930	11.1	1, 5, 8	*10.2	0.451	3.0
981016	11.6	1, 5.5, 10			2.5
981019	11.1	1, 4.5, 9			2.0
981029	12.1	1, 5.5, 10			6.5
981109	11.3	1, 5, 9			5.1
981204	11.3	1, 5, 9			0.6
SWM[4]	11.5		10.5	0.413	2.9

[1]mixing depth extended to bottom on all dates except where indicated (*).
[2]equal volumes from discrete depths were pooled to create integrated sample.
[3]euphotic depth truncated at bottom depth except where indicated (*).
[4]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2m. Physical parameters for station W3. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980420	10.9				3.0
980512	11.1	1, 5, 9	*7.9	0.579	2.0
980526	10.7	1, 4, 8	*6.6	0.696	1.5
980610	11.2	1, 4.5, 9	*5.6	0.824	1.5
980624	11.1	1, 5, 9	11.1	0.346	3.9
980707	11.0	1, 4, 9	*10.7	0.430	3.7
980724	12.1	1, 5, 10	*7.2	0.644	2.0
980804	10.7	1, 5, 8	10.7	0.378	2.5
980820	10.8	1, 4, 8	*7.7	0.600	1.1
980831	10.9	1, 5, 9			2.0
980916	10.9	1, 5, 9	10.9	0.362	2.7
980930	10.6	1, 4, 8	*8.9	0.518	2.1
981016	11.6	1, 5.5, 10			1.1
981029	10.0	1, 5.5, 9			2.6
981109	10.6	1, 5, 8			3.2
981204	10.6	1, 5, 9			0.4
SWM[4]	11.0		8.8	0.534	2.2

[1]mixing depth extended to bottom on all dates.
[2]equal volumes from discrete depths were pooled to create integrated sample.
[3]euphotic depth truncated at bottom depth except where indicated (*).
[4]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2n. Physical parameters for station W6. Mixing depth (Z_m), sampling depth, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}	ε_{par}	Secchi
980416	12.2				0.5
980420	12.3				0.8
980429	12.8				1.0
980505	12.4				1.5
980512	12.2	1, 5, 10	4.7	0.975	1.1
980520	11.8				3.0
980525	12.5	1, 5, 10			4.0
980526	11.7				3.5
980603	12.7	1, 5, 10	8.5	0.541	1.8
980610			8.5	0.541	2.0
980616	12.2	1, 5, 10	12.0	0.362	2.0
980624	12.1	1, 5, 10	12.0	0.098	4.2
980629	12.3	1, 4.5, 10	12.0	0.314	3.0
980707	12.4	1, 5, 10	12.0	0.356	3.5
980713	12.1	1, 5, 10	12.0	0.174	4.5
980724	12.1	1, 6, 11	6.5	0.713	1.8
980729	12.2	1, 5, 10	6.8	0.681	2.2
980804	12.1	1, 6, 10	9.7	0.477	2.5
980811	11.8				2.1
980820	12.0	1, 5, 10	9.0	0.512	1.4
980826	12.1	1, 5, 10	6.3	0.729	1.1
980831	11.7	1, 5, 10			1.3
980910	11.3	1, 5, 9	5.5	0.834	1.8
980916	11.8	1, 5, 9	7.0	0.656	1.6
980924	11.8	1, 5.5, 10			2.0
980930	11.5	1, 5, 9.5	7.5	0.615	1.9
981016	11.9	1, 5.5, 10			1.9
981019	12.5	1, 5, 10			1.1
981029	12.4	1, 5.5, 10			1.7
981109	11.8	1, 5, 10			3.5
981204	11.8	1, 6.5, 10			0.4
SWM[3]	12.0		8.5	0.559	2.2

[1]mixing depth extended to bottom on all dates.
[2]equal volumes from discrete depths were pooled to create integrated sample.
[3]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 2o. Physical parameters for station W7. Mixing depth (Z_m), sampling, euphotic depth (Z_{eu} = 1% light penetration) and Secchi depth are all in metres. The light attenuation coefficient (ε_{par}) is expressed in metres^{-1}.

Date	Z_m[1]	Sample Depth[2]	Z_{eu}[3]	ε_{par}	Secchi
980416	10.0				1.0
980420	10.1				1.0
980429	10.1				1.5
980505	10.3				3.1
980512	10.3	1, 4, 8	10.3	0.412	2.5
980520	10.3				4.0
980525	10.3				2.5
980526	10.0				2.5
980603	10.2		*4.0	1.147	1.3
980610	10.2	0 - 9	*5.2	0.888	1.5
980616	10.1		*9.2	0.499	2.0
980624	10.3		10.3	0.325	4.3
980629	10.2	1, 4.5, 8	10.2	0.392	3.3
980707	10.2		10.2	0.350	2.8
980713			10.1	0.232	3.5
980724	10.0		*5.0	0.915	1.5
980729	10.1		*4.9	0.947	2.1
980804	10.0	1, 5, 8	10.0	0.436	2.7
980811	*7.0				2.0
980818	10.0	1, 5, 8			1.9
980826	10.2	1, 5, 8	*5.2	0.890	1.0
980831	10.0				1.5
980910	9.6				1.5
980916	9.8	1, 5, 8	*8.8	0.522	1.2
980924	10.0	1, 5, 8			1.2
980930	10.0	1, 5, 8	*6.4	0.715	1.5
981016	10.0	1, 5, 8	*7.1	0.653	1.8
981019					1.2
981029	10.0	1, 5, 8			1.5
981109	10.0	1, 5, 8			2.8
981204	9.9	1, 5, 8			0.4
SWM[4]	9.9		7.6	0.649	2.1

[1]mixing depth extended to bottom except where indicated (*).
[2]equal volumes from discrete depths were pooled to create integrated sample, or a continuously sampled integrated range.
[3]euphotic depth truncated at bottom depth except where indicated (*).
[4]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 3a. Comparison between 1993, 1994 and 1998 for selected water quality and photosynthesis parameters at east basin stations. All values shown are seasonal weighted means for dates between May 1 and October 31 in each year.

	E1			E2			E3		
Parameter	1993	1994	1998	1993	1994	1998	1993	1994	1998
Chl ($\mu g\ L^{-1}$)	1.06	1.54	1.18	2.11	2.24	2.14	1.12	1.27	1.28
TP ($\mu g\ L^{-1}$)	7.8	10.1	10.2	8.5	8.1	9.4	6.6	8.5	8.2
SRP ($\mu g\ L^{-1}$))	0.8	2.0	0.8	1.5	1.2	0.7	0.9	1.2	0.7
SiO_2 ($mg\ L^{-1}$)	0.34	0.41	0.66	0.28	0.26	0.46	0.25	0.40	0.58
POC ($mg\ L^{-1}$)	0.129	0.199	0.236	0.186	0.240	0.309	0.133	0.177	0.222
PON ($mg\ L^{-1}$)	0.023	0.030	0.039	0.031	0.036	0.051	0.021	0.025	0.036
• $_{par}$ (m^{-1})	0.319	0.365	0.270	0.232	0.252	0.208	0.254	0.254	0.222
P_{opt} ($mg\ C\ m^{-3}\ h^{-1}$)		6.54	4.15	6.92	7.44	5.03	4.55	5.89	3.52
Areal PP ($g\ C\ m^{-2}$)		41.20	32.50	105.30	85.80	105.90	53.80	61.20	42.30

Table 3b. Comparison between 1993 and 1998 for selected water quality and photosynthesis parameters at west-central and west basin stations. All values shown are seasonal weighted means for dates between May 1 and October 31 in each year.

	WC1		WC2		W1		W2		W3	
Parameter	1993	1998	1993	1998	1993	1998	1993	1998	1993	1998
Chl ($\mu g\ L^{-1}$)	2.67	5.00	3.99	4.10	4.55	6.04	3.52	4.43	4.47	4.20
TP ($\mu g\ L^{-1}$)	10.8	11.4	12.8	11.8	17.5	17.4	15.5	18.0	19.1	11.8
SRP ($\mu g\ L^{-1}$))	1.3	0.6	0.9		1.3	3.0	3.5		2.9	0.6
SiO_2 (mg L^{-1})	0.82	0.72	0.77	0.70	0.94	1.00	0.90	0.97	1.03	1.18
POC (mg L^{-1})	0.222	0.369	0.292	0.367	0.427	0.469	0.326	0.362	0.280	0.340
PON (mg L^{-1})	0.036	0.074	0.050	0.070	0.066	0.083	0.053	0.064	0.048	0.058
$\bullet_{par}$ (m^{-1})	0.285	0.356	0.370	0.315	0.927	0.760	0.568	0.413	0.771	0.534

Table 4a. Nutrient and major ion data for station E1: total phosphorus (TP, $\mu g\ L^{-1}$), total filtered phosphorus (TP-filt, $\mu g\ L^{-1}$), soluble reactive phosphorus (SRP, $\mu g\ L^{-1}$), total nitrogen (TN, $\mu g\ L^{-1}$), nitrate-nitrite (NO_3-NO_2, $\mu g\ L^{-1}$), ammonia (NH_3, $\mu g\ L^{-1}$), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980401	6.3	4.7	1.1					0.86	20.8	3.4	15.3	22.8
980505	11.1	7.3	0.5	592	322	15	53	0.53	21.5	3.2	14.8	20.9
980605	11.0	8.8	1.0	638	261	51	58	0.33	21.0	2.9	14.8	21.7
980617	8.6	4.9	0.2	526	281	9	61	0.34	21.0	3.1	15.2	24.0
980715	7.6	6.4	0.2		164	18		0.47	19.4	3.5	14.9	24.6
980731	7.7	3.0	0.9	596	170	19	77	0.41	21.3	3.5	14.7	21.7
980812	9.0	5.3	0.5	461	192	34	51	0.71	20.9	2.6	15.1	21.8
980827	14.7	4.5	0.4	508	183	11	35	1.08	21.5	2.9	14.9	22.8
980908	11.9	4.4	0.6	524	203	26	44	0.71	21.1	2.6	14.7	22.5
980925	9.8	6.1	2.2	491	215	35	50	1.00	22.2	2.9	13.7	22.6
981009	14.0	8.4	1.7	540	299	11	39	1.08	21.1	2.5	14.4	21.3
981022	6.8	5.9	0.7	617	392	19	91	1.44	22.4	3.0	15.1	21.2
981118	7.8	6.6	2.9	501	292	24	64	0.85	22.0	2.3	14.4	22.7
SWM[1]	10.2	6.0	0.8	552	236	23	57	0.66	21.1	3.0	14.8	22.5

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 4b. Nutrient and major ion data for station E2: total phosphorus (TP, µg L^{-1}), total filtered phosphorus (TP-filt, µg L^{-1}), soluble reactive phosphorus (SRP, µg L^{-1}), total nitrogen (TN, µg L^{-1}), nitrate-nitrite (NO_3-NO_2, µg L^{-1}), ammonia (NH_3, µg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980402	10.7	8.5	6.5					0.93	20.6	2.6	15.2	22.2
980505	12.5	8.4	0.5	556	288	16	44	0.31	20.9	3.0	14.3	21.5
980519	16.1	23.8	0.4	771	303	25	48	0.45	18.4	3.3	15.4	23.1
980605	9.0	6.5	0.7	584	300	32	65	0.70	21.6	2.8	14.8	23.0
980617	9.1	4.3	0.2	524	274	7	58	0.39	20.5	3.3	14.7	23.2
980629	7.1	4.7	1.1	517	251	10	73	0.38	20.0	4.9	14.7	20.6
980715	10.0	4.9	0.5		162	12		0.35	20.2	3.8	14.9	22.7
980730	11.5	4.6	2.8	734	187	38	64	0.27	21.1	4.9	14.7	22.9
980812	8.1	4.6	0.2	426	171	5	53	0.29	20.3	3.2	14.7	20.1
980827	7.8	3.8	0.5	472	218	16	61	0.37	20.6	2.8	14.0	22.2
980908	8.8	4.0	0.4	535	254	22	61	0.67	21.4	3.3	14.5	22.9
980928	6.4	3.8	0.4	424	219	<5 †	66	0.49	22.4	3.5	14.4	22.5
981022	8.5	3.9	1.3	477	254	21	56	0.76	21.6	3.3	14.8	21.6
981118	19.1	11.0	6.4	481	285	19	25	1.10	22.0	3.0	14.0	22.3
SWM[1]	9.4	6.4	0.7	552	237	17	50	0.46	20.8	3.5	14.7	22.3

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

† - detection limit of the analytical procedure; one half this value was used in calculating the SWM.

Table 4c. Nutrient and major ion data for station E3: total phosphorus (TP, μg L^{-1}), total filtered phosphorus (TP-filt, μg L^{-1}), soluble reactive phosphorus (SRP, μg L^{-1}), total nitrogen (TN, μg L^{-1}), nitrate-nitrite (NO_3-NO_2, μg L^{-1}), ammonia (NH_3, μg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980401	6.2	4.5	2.2					0.89	20.6	2.4	15.2	22.9
980505	13.0	12.1	0.3	636	296	15	49	0.55	21.4	3.3	14.2	21.1
980519		6.3	1.0	591	308	15		0.38	17.2	3.6	15.7	24.6
980605	8.7	5.8	0.5	624	288	47	72	0.61	21.1	3.0	14.6	21.7
980617	7.0	3.8	0.2	500	265	11	71	0.41	20.6	3.0	14.7	23.0
980629	7.0	4.7	0.9	476	226	6	68	0.39	20.1	3.7	15.0	20.0
980715	10.1	4.6	0.9		160	11		0.39	19.9	3.4	14.9	23.7
980730	7.6	4.3	0.8	560	214	23	74	0.39	21.4	3.6	14.7	21.6
980812	8.6	4.1	0.4	414	118	5	48	0.51	20.0	2.9	15.1	20.9
980827	6.6	4.5	0.4	591	303	39	90	1.31	21.3	2.8	14.6	22.5
980908	8.2	3.0	0.3	511	224	44	62	0.51	21.4	2.7	14.3	22.4
980928	4.9	3.8	1.4	442	235	9	90	0.51	22.4	2.8	14.5	23.9
981008	8.5	6.6	1.3	492	244	11	58	0.75	21.0	2.6	14.5	21.5
981022	6.8	4.3	0.8	557	327	28	82	1.11	22.1	2.7	14.5	21.7
981118	13.5	11.9	8.0	474	278	36	35	1.26	22.1	2.7	13.8	22.2
SWM[1]	8.2	4.7	0.7	527	241	20	65	0.58	20.7	3.1	14.8	22.3

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 4d. Nutrient and major ion data for station E5: total phosphorus (TP, μg L^{-1}), total filtered phosphorus (TP-filt, μg L^{-1}), soluble reactive phosphorus (SRP, μg L^{-1}), total nitrogen (TN, μg L^{-1}), nitrate-nitrite (NO_3-NO_2, μg L^{-1}), ammonia (NH_3, μg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980715	11.7	5.7	1.1		< 10†	14		1.17	14.5	4.5	15.1	23.1
980730	11.5	4.7	1.3		< 10†	9		1.08	15.0	6.2	14.9	21.4
980812	14.1	5.6	0.3	481	< 10†	15	34	2.16	13.0	4.6	15.8	21.1
980827	12.1	4.4	0.2	547	< 10†	12	45	1.97	13.8	4.5	15.4	22.2
980908	14.0	8.3	0.8	428	< 10†	16	31	1.36	17.8	4.1	15.7	23.4
980924	8.9	4.9	< 0.2†	388	< 10†	6	44	1.76	19.8	4.0	15.0	21.5
981008	8.2	5.3	1.1	471	198	5	57	1.16	23.7	3.5	18.8	32.9
981022	8.6	3.3	0.7	441	144	10	51	0.86	22.1	2.9	15.3	21.9
SWM[1]	11.3	5.4	0.7	458	‡	11	44	1.50	17.4	4.4	15.8	23.6

[1]SWM seasonal weighted mean of dates between May 1 and October 31.
† detection limit of the analytical procedure; one half this value was used in calculating the SWM.
‡ no SWM calculated due to number of values below the detection limit of the procedure.

Table 4e. Nutrient and major ion data for station EC1: total phosphorus (TP, μg L^{-1}), total filtered phosphorus (TP-filt, μg L^{-1}), soluble reactive phosphorus (SRP, μg L^{-1}), total nitrogen (TN, μg L^{-1}), nitrate-nitrite (NO_3-NO_2, μg L^{-1}), ammonia (NH_3, μg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980512	4.1	7.9	0.2	849	234	25	207	0.26	18.8	3.4	14.7	22.9
980527	5.9	2.6	0.5	568	241	35	96	0.59	20.8	3.0	14.3	22.6
980608	5.2	3.0	0.5	456	231	31	88	0.81	21.1	2.8	13.5	21.8
980708	10.7	5.4	0.2	459	218	8	43	0.43	20.4	2.8	13.8	19.9
980723	23.6	5.2	1.3	570	255	34	24	0.58	21.0	3.4	14.2	22.1
980805	8.7	5.1	0.2	482	211	16	55	0.16	20.2	3.3	13.6	20.0
980818	9.9	4.8	1.4	532	220	17	54	0.62	21.1	2.7	14.0	22.0
980903	12.5	4.6	1.9	568	268	32	45	1.10	21.9	3.2	14.1	22.5
980916	14.6	6.1	2.5	502	210	5	34	0.83	21.1	2.7	13.8	21.6
980930	16.4	4.9	0.2	458	226	20	28	1.12	21.8	2.8	13.6	20.5
SWM[1]	10.9	4.8	0.9	526	231	22	63	0.64	20.9	3.0	13.9	21.5

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 4f. Nutrient and major ion data for station EC2: total phosphorus (TP, μg L^{-1}), total filtered phosphorus (TP-filt, μg L^{-1}), soluble reactive phosphorus (SRP, μg L^{-1}), total nitrogen (TN, μg L^{-1}), nitrate-nitrite (NO_3-NO_2, μg L^{-1}), ammonia (NH_3, μg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980527	9.1	4.1	0.5	471	182	46	52	0.38	19.8	3.3	22.1	20.0
980708	8.8	4.9	<0.2†	475	227	5	54	0.49	20.6	3.0	13.1	19.2
980805	9.2	4.6	<0.2†	405	195	5	44	0.33	20.3	2.5	13.8	20.2
980819	8.6	5.7	1.4	492	213	17	57	0.21	19.6	2.8	13.5	20.7
980903	8.4	4.5	0.8	651	221	9	78	0.24	20.7	3.0	13.8	22.3
980917	11.8	5.4	<0.2†	512	171	22	43	0.77	21.6	2.6	12.5	20.5
980930	16.3	6.3	<0.2†	475	155	47	29	0.92	21.5	2.8	13.0	20.3
SWM*	9.6	4.9	‡	489	202	18	53	0.44	20.5	2.9	14.8	20.2

[1]SWM seasonal weighted mean of dates between May 1 and October 31.
† detection limit of the analytical procedure.
‡ no SWM calculated due to number of values below the detection limit of the procedure.

Table 4g. Nutrient and major ion data for station C1: total phosphorus (TP, µg L^{-1}), total filtered phosphorus (TP-filt, µg L^{-1}), soluble reactive phosphorus (SRP, µg L^{-1}), total nitrogen (TN, µg L^{-1}), nitrate-nitrite (NO_3-NO_2, µg L^{-1}), ammonia (NH_3, µg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980512	11.1	3.6	0.4	602	326	25	54	0.77	19.0	3.3	14.5	22.8
980528	6.7	3.1	0.4	463	227	45	69	0.77	21.4	2.7	13.9	23.1
980609	5.0	3.5	0.4	509	265	45	102	0.94	21.0	2.7	13.2	21.2
980623	11.9	3.8	2.0	593	271	74	50	0.69	20.2	2.6	13.4	21.1
980706	10.2	3.9	0.6		256	27		0.73	21.3	2.9	14.0	21.5
980807	6.4	4.0	1.1	552	236	30	86	0.50	21.1	3.2	14.0	23.1
980817	6.6	2.4	0.4	527	247	5	80	0.48	21.1	2.6	14.3	22.6
980903	6.9	3.4	0.9	579	349	27	84	1.42	22.8	2.6	14.3	22.3
980915	16.1	4.2	<0.2†	494	234	33	31	0.63	21.5	2.7	13.5	23.2
980928	18.2	5.8	<0.2†	556	138	100	31	1.31	22.3	2.9	13.2	21.3
981015		23.5	16.0	536	224	62		1.93	22.3	2.4	14.1	21.8
981026	25.2	16.4	7.6	465	204	17	18	1.17	21.8	2.7	14.0	21.3
SWM	11.3	5.9	2.2	543	247	42	61	0.92	21.4	2.8	13.9	22.1

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

† detection limit of the analytical procedure; one half this value was used in calculating the SWM.

Table 4h. Nutrient and major ion data for station C2: total phosphorus (TP, $\mu g\ L^{-1}$), total filtered phosphorus (TP-filt, $\mu g\ L^{-1}$), soluble reactive phosphorus (SRP, $\mu g\ L^{-1}$), total nitrogen (TN, $\mu g\ L^{-1}$), nitrate-nitrite (NO_3-NO_2, $\mu g\ L^{-1}$), ammonia (NH_3, $\mu g\ L^{-1}$), nitrogen:phosphorus ratio, silica (SiO_2, $mg\ L^{-1}$), dissolved inorganic carbon (DIC, $mg\ L^{-1}$), dissolved organic carbon (DOC, $mg\ L^{-1}$), chloride (Cl, $mg\ L^{-1}$) and sulphate (SO_4, $mg\ L^{-1}$).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980527	9.2	3.8	0.4	528	266	30	57.39	0.70	20.6	2.8	13.9	21.8

Table 4i. Nutrient and major ion data for station WC1: total phosphorus (TP, μg L^{-1}), total filtered phosphorus (TP-filt, μg L^{-1}), soluble reactive phosphorus (SRP, μg L^{-1}), total nitrogen (TN, μg L^{-1}), nitrate-nitrite (NO_3-NO_2, μg L^{-1}), ammonia (NH_3, μg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980406	11.7	6.2	4.8					0.27	19.9	2.5	13.5	19.4
980511	12.0	3.1	0.5	425	124	22	35	0.39	21.1	2.7	13.5	20.8
980526	5.4	3.5	0.5	378	158	34	70	0.64	20.5	2.7	13.5	25.3
980611	12.0	5.0	0.7	829	458	24	69	0.88	21.1	3.2	14.5	19.8
980706	10.2	2.6	<0.2†	718	358	37	70	0.75	21.4	3.3	13.4	21.3
980723	9.9	3.6	<0.2†	612	288	22	62	0.98	21.3	3.0	12.5	20.1
980805	10.3	2.9	0.3	659	314	19	64	0.84	20.9	2.8	13.1	22.4
980817	8.0	4.0	0.4	559	243	5	70	0.44	21.0	2.8	13.6	22.8
980831	11.8	4.4	<0.2†	438	165	6	37	0.98	20.6	2.5	12.0	20.3
980914	10.5	3.4	1.0	478	214	33	46	0.54	21.1	2.5	13.3	22.4
980928	17.1	5.8	2.3	413	130	52	24	1.02	21.3	2.7	12.9	19.7
981015		4.8	0.5	506	151	23		0.32	21.9	2.9	13.5	21.0
981026	16.6	5.7	0.8	417	128	11	25	0.44	22.0	2.8	13.8	21.4
SWM[1]	11.4	4.0	0.6	562	248	26	53	0.72	21.2	2.9	13.3	21.4

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

† detection limit of the analytical procedure; one half this value was used in calculating the SWM.

Table 4j. Nutrient and major ion data for station WC2: total phosphorus (TP, μg L^{-1}), total filtered phosphorus (TP-filt, μg L^{-1}), soluble reactive phosphorus (SRP, μg L^{-1}), total nitrogen (TN, μg L^{-1}), nitrate-nitrite (NO_3-NO_2, μg L^{-1}), ammonia (NH_3, μg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980406	15.2	10.6	8.1					0.43	20.3	2.4	14.0	20.5
980511	12.7	3.8	0.4	544	238	24	43	0.55	19.4	2.7	13.6	22.2
980528	10.9	4.7	0.9	568	325	34	52	0.97	21.4	3.0	13.7	19.8
980609	7.7	3.4	0.4	702	357	34	91	0.62	20.0	2.8	14.0	22.8
980623	12.7	4.2	1.0	700	387	40	55	1.06	20.6	2.8	13.8	20.8
980706	9.4	2.6	<0.2†	610	302	21	65	0.63	21.0	2.9	13.7	21.9
980723	5.9	3.9	<0.2†	763	378	19	129	0.25	21.4	3.3	14.2	21.3
980805	8.3	3.2	<0.2†	567	271	5	68	0.55	20.9	4.4	12.4	21.7
980817	7.1	3.4	0.4	537	259	7	76	0.41	20.9	2.7	14.0	22.5
980903	10.3	3.4	<0.2†	483	239	13	47	0.56	21.1	2.6	13.1	22.7
980914	14.1	4.8	<0.2†	479	191	15	34	0.72	21.3	2.6	13.7	22.9
980928	17.5	3.1	<0.2†	510	180	35	29	0.80	21.3	3.1	13.9	20.9
981015	20.3	18.4	1.3	460	189	24	23	1.25	22.1	2.5	14.6	21.9
981026	22.3	7.4	0.7	446	178	4	20	0.74	22.5	2.7	14.1	21.5
SWM[1]	11.7	5.1	‡	574	274	22	59	0.70	21.1	2.9	13.8	21.7

[1]SWM seasonal weighted mean of dates between May 1 and October 31.
† detection limit of the analytical procedure.
‡ no SWM calculated due to number of values below the detection limit of the procedure.

Table 4k. Nutrient and major ion data for station W1: total phosphorus (TP, µg L^{-1}), total filtered phosphorus (TP-filt, µg L^{-1}), soluble reactive phosphorus (SRP, µg L^{-1}), total nitrogen (TN, µg L^{-1}), nitrate-nitrite (NO_3-NO_2, µg L^{-1}), ammonia (NH_3, µg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980511	14.2	5.3	0.4	871	607	16	61	1.30	18.4	2.8	11.7	19.1
980609	11.8	3.7	0.7	708	466	19	60	1.02	20.9	2.8	11.8	18.8
980623	10.0	4.0	0.5	649	404	20	65	0.78	20.4	2.5	12.0	16.1
980707	12.0	3.5	<0.2†	571	299	27	48	1.04	20.7	2.7	11.3	17.0
980724	24.0	8.9	5.4	616	261	52	26	1.17	20.7	3.0	9.9	17.8
980804	10.0	3.1	0.6	448	166	5	45	0.24	19.6	2.6	9.3	17.3
980818	16.4	4.1	0.6	479	171	9	29	1.43	19.5	2.2	8.7	16.9
980831	17.5	3.9	<0.2†	417	124	43	24	1.55	20.2	2.6	10.7	19.3
980916	13.4	3.9	<0.2†	433	187	16	32	0.95	20.1	2.3	10.0	18.6
980930	27.2	4.7	24.7	549	<5†	68	20	1.05	0.3	5.0	3.4	7.1
981016	15.5	3.8	0.5	362	105	21	23	0.70	21.2	2.3	12.6	17.9
981029	63.3	3.6	0.6	356	127	12	6	0.40	21.1	2.2	10.8	17.5
SWM[1]	17.4	4.4	3.0	554	258	25	39	1.00	21.1	2.8	10.2	17.0

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

† detection limit of the analytical procedure; one half this value was used in calculating the SWM.

Table 41. Nutrient and major ion data for station W2: total phosphorus (TP, µg L^{-1}), total filtered phosphorus (TP-filt, µg L^{-1}), soluble reactive phosphorus (SRP, µg L^{-1}), total nitrogen (TN, µg L^{-1}), nitrate-nitrite (NO_3-NO_2, µg L^{-1}), ammonia (NH_3, µg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980513	14.7	6.7	0.5	1299	1130	26	88	1.54	19.5	3.0	14.6	23.6
980610	9.8	4.0	0.7	842	556	36	86	1.08	21.4	3.1	12.1	18.8
980623	9.5	4.3	0.3	657	385	24	69	0.68	20.3	2.7	11.1	17.4
980707	11.8	3.8	<0.2†	653	346	34	55	0.93	21.0	2.7	11.1	18.0
980724	33.2	5.4	1.7	557	288	18	17	0.93	21.2	2.7	10.2	18.5
980804	12.3	4.0	1.1	548	221	16	45	0.50	20.7	3.1	9.9	19.3
980818	14.6	4.0	1.0	474	157	11	32	1.25	19.9	2.3	8.4	18.0
980831	16.4	4.9	<0.2†	537	266	15	33	1.24	20.4	2.6	10.1	21.4
980916	13.4	4.1	<0.2†	401	146	30	30	0.49	20.3	2.5	10.1	18.9
980930	41.4	8.1						0.77			2.6	7.0
981016	24.3	6.8	1.0	370	159	8	15	0.78	20.5	2.2	9.4	17.9
981029	14.8	10.3	4.7	464	249	14	31	1.70	20.6	2.2	10.3	18.2
SWM[1]	18.0	5.3	‡	612	357	22	46	0.97	20.7	2.7	10.1	18.2

[1]SWM seasonal weighted mean of dates between May 1 and October 31.
† detection limit of the analytical procedure.
‡ no SWM calculated due to number of values below the detection limit of the procedure.

Table 4m. Nutrient and major ion data for station W3: total phosphorus (TP, µg L^{-1}), total filtered phosphorus (TP-filt, µg L^{-1}), soluble reactive phosphorus (SRP, µg L^{-1}), total nitrogen (TN, µg L^{-1}), nitrate-nitrite (NO_3-NO_2, µg L^{-1}), ammonia (NH_3, µg L^{-1}), nitrogen:phosphorus ratio, silica (SiO_2, mg L^{-1}), dissolved inorganic carbon (DIC, mg L^{-1}), dissolved organic carbon (DOC, mg L^{-1}), chloride (Cl, mg L^{-1}) and sulphate (SO_4, mg L^{-1}).

Date	TP	TP-filt	SRP	TN	NO_3-NO_2	NH_3	N:P	SiO_2	DIC	DOC	Cl	SO_4
980512	10.3	2.6	0.3	857	600	18	83	0.92	18.4	2.7	10.0	19.0
980526	11.0	3.2	0.9	715	457	44	65	1.01	21.1	3.0	10.7	16.9
980610	11.7	2.7	0.6	710	398	35	61	1.09	20.5	3.1	8.5	17.5
980624	8.5	3.3	0.4	616	336	62	72	1.27	20.3	2.9	8.4	16.5
980707	13.1	4.2	0.3	665	374	19	51	1.01	20.7	2.6	9.6	18.7
980724	31.2	3.8	1.4	565	263	27	18	1.02	20.1	2.7	9.0	16.9
980804	8.7	4.0	1.2	517	252	5	59	1.24	19.3	2.3	8.4	17.7
980820	15.3	2.8						1.31			6.5	12.4
980831	10.7	3.9	<0.2†	443	220	9	41	1.13	19.2	2.1	8.3	16.3
980916	8.3	2.9	<0.2†	415	258	5	50	1.17	19.6	2.1	7.9	16.8
980930			0.9	502	276	10		1.23	20.3	2.4	2.4	6.7
981016	5.9	3.8	1.1	443	243	6	75	1.50	20.9	2.2	8.4	17.5
981029	9.6	4.3	0.6	455	276	10	47	1.48	20.3	2.1	7.2	16.8
SWM[1]	11.8	3.4	0.6	561	313	20	56	1.18	20.1	2.5	8.0	16.0

[1]SWM seasonal weighted mean of dates between May 1 and October 31.
† detection limit of the analytical procedure; one half this value was used in calculating the SWM.

Table 5a. Indices of phytoplankton biomass for station E1: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, $mg\ L^{-1}$) and particulate organic nitrogen (PON, $mg\ L^{-1}$).

Date	Chl_{un}	Chl_{cor}	POC	PON
980505	0.48	0.17	0.246	0.038
980605	0.25	0.02	0.149	0.021
980617	0.73	0.35	0.197	0.025
980715	0.64	0.27	0.123	0.021
980731	1.01	0.67	0.318	0.058
980812	1.63	1.34	0.227	0.032
980827	3.90	3.53	0.534	0.108
980908	2.07	1.52	0.327	0.067
980925	1.15	0.93	0.223	0.030
981009	1.60	1.21	0.234	0.037
981022	0.16	0.06	0.056	0.004
981118	0.85	0.67	0.077	0.011
SWM[1]	1.18	0.85	0.236	0.039

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5b. Indices of phytoplankton biomass for station E2: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, mg L^{-1}) and particulate organic nitrogen (PON, mg L^{-1}).

Date	Chl_{un}	Chl_{cor}	POC	PON
980505	4.40	3.01	0.653	0.067
980519	1.05	0.76	0.551	0.093
980605	0.50	0.25	0.151	0.029
980617	1.59	1.10	0.293	0.038
980629	1.17	0.69	0.200	0.049
980715	3.17	2.52	0.330	0.053
980730	2.49	1.89	0.342	0.051
980812	2.89	2.65	0.310	0.055
980827	2.00	1.70	0.266	0.052
980908	2.16	1.82	0.259	0.046
980928	2.69	2.18	0.291	0.046
981022	2.46	1.79	0.213	0.033
981118	1.31	0.42	0.236	0.030
SWM[1]	2.14	1.67	0.309	0.051

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5c. Indices of phytoplankton biomass for station E3: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, $mg\ L^{-1}$) and particulate organic nitrogen (PON, $mg\ L^{-1}$).

Date	Chl_{un}	Chl_{cor}	POC	PON
980505	0.71	0.44	0.360	0.056
980519	1.17	0.96	0.272	0.042
980605	0.29	0.09	0.151	0.020
980617	0.96	0.80	0.179	0.023
980629	1.44	0.94	0.156	0.024
980715	1.63	1.15	0.236	0.037
980730	1.62	1.23	0.264	0.061
980812	2.75	2.43	0.426	0.069
980827	1.41	1.26	0.273	0.040
980908	1.09	0.86	0.193	0.035
980928	1.16	0.81	0.148	0.022
981008	0.94	0.60	0.140	0.018
981022	0.98	0.73	0.087	0.013
981118	0.87	0.62	0.080	0.011
SWM[1]	1.28	0.98	0.222	0.036

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5d. Indices of phytoplankton biomass for station E5: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, $mg\ L^{-1}$) and particulate organic nitrogen (PON, $mg\ L^{-1}$).

Date	Chl_{un}	Chl_{cor}	POC	PON
980715	2.16	1.89	0.609	0.080
980730	3.20	2.93		
980812	3.27	2.97	0.966	0.144
980827	2.80	2.63	0.971	0.202
980909	3.68	2.78	0.828	0.116
980924	2.38	1.83	0.618	0.079
981008	1.37	1.01	0.281	0.035
981022	1.95	1.56	0.359	0.048
SWM[1]	2.67	2.26	0.704	0.107

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5e. Indices of phytoplankton biomass for station EC1: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, mg L^{-1}) and particulate organic nitrogen (PON, mg L^{-1}).

Date	Chl_{un}	Chl_{cor}	POC	PON
980415	3.71	4.54		
980512	2.21	2.01	0.480	0.062
980527	2.28	1.80	0.254	0.049
980608	1.50	1.37	0.184	0.025
980622	1.11	0.94		
980708	2.58	2.11	0.230	0.036
980723	1.79	0.64	0.358	0.051
980805			0.062	0.003
980818	1.09	0.80	0.247	0.074
980903	1.61	1.17	0.333	0.058
980916	3.30	2.44	0.395	0.068
980930	1.36	1.07	0.212	0.029
SWM[1]	1.85	1.36	0.263	0.044

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5f. Indices of phytoplankton biomass for station EC2: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, $mg\ L^{-1}$) and particulate organic nitrogen (PON, $mg\ L^{-1}$).

Date	Chl_{un}	Chl_{cor}	POC	PON
980415	3.49	4.28		
980512	2.59	2.24		
980527	3.88	3.54	0.641	0.047
980608	1.93	1.70		
980622	0.91	0.74		
980708	2.81	2.50	0.295	0.039
980805	2.35	1.94	0.304	0.070
980819	1.20	0.70	0.284	0.051
980903	1.99	1.44	0.381	0.067
980917	3.90	2.91	0.541	0.108
980930	3.07	2.34	0.457	0.070
SWM[1]	2.41	1.98	0.398	0.059

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5g. Indices of phytoplankton biomass for station C1: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, $mg\ L^{-1}$) and particulate organic nitrogen (PON, $mg\ L^{-1}$).

Date	Chl_{un}	Chl_{cor}	POC	PON
980415	3.03	3.68		
980512	2.05	1.74	0.402	0.054
980528	1.76	1.40	0.147	0.025
980609	0.84	0.64	0.108	0.031
980623	1.10	0.33	0.165	0.026
980706	2.21	1.94		
980807	0.80	0.57	0.238	0.046
980817	1.36	1.17	0.200	0.040
980903	1.71	0.87	0.192	0.031
980914	7.65	6.57	0.249	0.044
980928	5.95	4.98	0.474	0.090
981015	0.61	0.57	0.071	0.013
981026	1.40	1.07	0.261	0.050
SWM[1]	2.26	1.80	0.240	0.043

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5h. Indices of phytoplankton biomass for station C2: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, $mg\ L^{-1}$) and particulate organic nitrogen (PON, $mg\ L^{-1}$).

Date	Chl_{un}	Chl_{cor}	POC	PON
980415	8.69	10.02		
980512	4.00	3.68		
980527	2.92	1.94	0.315	0.046
980608	2.50	2.17		
980622	1.79	1.40		
980706	3.53	3.17		
980807	3.04	2.04		
980817	1.51	1.07		
980903	5.86	4.98		
980914	3.86	3.11		
980928	4.58	3.44		
981015	2.04	1.67		
981026	8.04	6.25		
SWM[1]	3.39	2.70	na	na

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5i. Indices of phytoplankton biomass for station WC1: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, mg L^{-1}) and particulate organic nitrogen (PON, mg L^{-1}).

Date	Chl_{un}	Chl_{cor}	POC	PON
980415	5.80	6.75		
980420	6.93	8.55		
980428	9.46	7.75		
980504	8.94	8.09		
980511	4.84	4.41	0.413	0.083
980519	4.37	4.01		
980526	1.07	0.87	0.162	0.020
980604	1.62	1.34		
980608	2.50	1.94		
980611			0.230	0.088
980615	1.98	1.67		
980622	2.17	1.80		
980629	3.11	2.34		
980706	5.06	4.34	0.399	0.099
980713	3.63	2.54		
980723	3.49	2.07	0.399	0.067
980727	3.52	2.41		
980805	3.85	3.07	0.405	0.065
980817	2.28	1.67	0.277	0.070
980826	2.40	1.69		
980831	9.02	6.62	0.639	0.099
980910	5.45	4.88		
980914	6.49	5.41	0.377	0.066
980921	6.60	5.81		
980928	7.07	5.88	0.293	0.050
981015	12.79	11.56	0.519	0.100
981020	11.30	8.82		
981026	6.90	4.81	0.460	0.085
981109	11.74	9.02		
SWM[1]	5.00	4.10	0.369	0.074

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5j. Indices of phytoplankton biomass for station WC2: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, mg L^{-1}) and particulate organic nitrogen (PON, mg L^{-1}).

Date	Chl_{un}	Chl_{cor}	POC	PON
980415	9.38	10.96		
980420	7.87	9.16		
980428	8.00	6.35		
980504	6.41	5.55		
980511	2.06	1.60	0.399	0.088
980519	2.50	2.01		
980528	1.68	1.20	0.259	0.041
980604	2.50	1.74		
980609	2.45	1.87	0.225	0.061
980615	2.12	1.74		
980623	3.55	2.81	0.316	0.057
980629	4.46	4.01		
980706	5.12	4.61	0.327	0.062
980713	2.94	2.07		
980723	4.02	3.54	0.587	0.125
980727	5.20	4.48		
980805	4.07	3.21	0.407	0.065
980817	2.26	1.34	0.265	0.058
980826	2.40	1.69		
980903	3.74	3.01	0.350	0.058
980910	2.34	2.21		
980914	5.80	5.08	0.476	0.083
980921	4.98	4.48		
980928	7.45	6.22	0.527	0.089
981015	5.17	3.81	0.255	0.050
981026	12.51	10.16	0.390	0.070
981109	9.13	7.02		
SWM[1]	4.10	3.32	0.367	0.070

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5k. Indices of phytoplankton biomass for station W1: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, mg L^{-1}) and particulate organic nitrogen (PON, mg L^{-1}).

Date	Chl_{un}	Chl_{cor}	POC	PON
980415	9.46	12.23		
980420	3.16	3.74		
980428	4.92	4.08		
980504	3.85	3.01		
980511	2.39	1.74	0.348	0.059
980520	3.14	2.74		
980603	4.81	4.08		
980609	6.05	5.48	0.323	0.054
980615	8.03	7.28		
980623	3.33	2.87	0.362	0.052
980629	2.86	1.87		
980707	5.36	4.68	0.384	0.076
980713	5.56	5.15		
980724	4.87	3.07	0.483	0.092
980729	8.72	7.55		
980804	5.78	5.15	0.517	0.092
980818	6.93	3.81	0.718	0.125
980826	3.16	1.20		
980831	7.40	6.35	0.607	0.104
980910	5.34	5.01		
980916	9.08	6.95	0.562	0.092
980924	8.69	6.22		
980930	8.31	7.08	0.498	0.094
981016	8.00	6.35	0.477	0.089
981019	10.70	7.35		
981029	7.45	5.81	0.417	0.073
981109	6.35	4.88		
981204	4.31	1.00		
SWM[1]	6.04	4.79	0.469	0.083

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 51. Indices of phytoplankton biomass for station W2: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, mg L^{-1}) and particulate organic nitrogen (PON, mg L^{-1}).

Date	Chl_{un}	Chl_{cor}	POC	PON
980415	2.06	2.54		
980420	3.33	4.01		
980428	4.29	3.41		
980504	8.09	7.08		
980511	4.81	3.88		
980513			0.449	0.069
980525	2.89	2.54		
980603	4.04	3.54		
980610	2.92	2.67	0.296	0.055
980615	1.68	1.40		
980623	3.25	2.74	0.299	0.045
980629	8.53	7.75		
980707	5.34	4.54	0.389	0.069
980713	4.76	4.28		
980724	6.44	5.95	0.297	0.054
980729	7.65	12.90		
980804	4.90	3.68	0.452	0.083
980818	5.39	4.68	0.592	0.116
980826	3.52	3.01		
980831	6.52	3.01	0.487	0.087
980910	3.69	3.01		
980916	6.71	5.48	0.409	0.068
980924	6.79	4.88		
980930	3.08	2.47	0.241	0.043
981016	2.81	2.41	0.205	0.038
981019	4.02	2.07		
981029	1.57	1.14	0.178	0.027
SWM[1]	4.43	3.79	0.362	0.064

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 5m. Indices of phytoplankton biomass for station W3: chlorophyll ($\mu g\ L^{-1}$) uncorrected (Chl_{un}), and corrected (Chl_{cor}) for phaeopigments, particulate organic carbon (POC, $mg\ L^{-1}$) and particulate organic nitrogen (PON, $mg\ L^{-1}$).

Date	Chl_{un}	Chl_{cor}	POC	PON
980512	3.05	2.54	0.383	0.066
980526	2.83	2.34	0.282	0.056
980610	4.18	3.54	0.520	0.076
980624	1.82	0.27	0.227	0.035
980707	4.21	3.61	0.363	0.082
980724	5.14	4.61	0.449	0.082
980804	3.55	3.07	0.311	0.052
980820	9.41	8.49	1.090	0.178
980831	5.36	2.54	0.570	0.091
980916	3.58	3.01	0.277	0.042
980930	5.17	4.21	0.332	0.061
981016	2.97	2.41	0.270	0.044
981029	1.38	0.87	0.178	0.031
981109	6.44	4.75		
981204	1.46	0.74		
SWM[1]	4.20	3.32	0.340	0.058

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 6. Predictions of seasonal mean chlorophyll ($\mu g\ L^{-1}$) from total phosphorus (TP $\mu g\ L^{-1}$) using the equations of Mazumder (1994).

Station	Observed TP	Observed Chl	Predicted Chl Even-link[1]	Predicted Chl Odd-link[2]	Observed Chl:TP
1993					
E1	7.80	1.06	1.72	4.11	0.14
E2	8.50	2.11	1.82	4.36	0.25
E3	6.60	1.12	1.57	3.69	0.17
WC1	10.80	2.67	2.11	5.16	0.25
WC2	12.80	3.99	2.37	5.86	0.31
W1	17.50	4.55	3.00	7.51	0.26
W2	15.50	3.52	2.73	6.81	0.23
W3	19.10	4.47	3.19	8.07	0.23
1994					
E1	10.10	1.54	2.02	4.92	0.15
E2	8.10	2.24	1.76	4.22	0.28
E3	8.50	1.27	1.82	4.36	0.15
1998					
E1	10.20	1.18	2.04	4.95	0.12
E2	9.38	2.14	1.93	4.66	0.23
E3	7.72	1.28	1.71	4.08	0.17
E5	11.25	2.67	2.17	5.32	0.24
EC1	10.20	1.85	2.04	4.95	0.18
EC2	9.56	2.41	1.95	4.72	0.25
C1	11.31	2.26	2.18	5.34	0.20
C2*	9.20	3.39	1.91	4.60	0.37
WC1	11.43	5.00	2.20	5.38	0.44
WC2	11.77	4.10	2.24	5.51	0.35
W1	17.35	6.04	2.97	7.45	0.35
W2	17.93	4.43	3.04	7.66	0.25
W3	11.76	4.20	2.24	5.50	0.36

[1] Chl = 0.71 + 0.13 [TP]
[2] Chl = 1.38 + 0.35 [TP]
*TP concentration based on only one sample day; May 27, 1998.

Table 7. Mean numbers (L^{-1}) and percentages of algal species identified at W3 (West station), WC2 (Central station) and E2 (East station) in various seasons in 1998.

Algal group	W3						WC2						E2					
	Spring		Summer		Fall		Spring		Summer		Fall		Spring		Summer		Fall	
	number	%	number	%	number	%	number	%	number	%	number	%	number	%	number	%	number	%
Cyanophyta	5	3.5	8	6.8	5	3.9	5	5.8	10	8.9	9	8.4	11	10.4	3	3.0	6	5.7
Chlorophyta	42	33.2	42	36.1	36	31.4	25	32.4	40	34.9	35	33.0	36	34.5	27	24.7	30	28.1
Chrysophyceae	25	20.0	22	18.5	28	24.3	13	16.2	22	19.4	17	16.0	19	18.6	30	27.8	25	23.1
Diatomeae	35	27.3	25	21.5	27	23.4	18	23.3	21	18.1	25	23.5	26	25.5	21	19.0	15	13.6
Cryptophyceae	10	7.9	10	8.5	10	8.4	9	11.6	10	8.9	11	10.3	12	11.2	9	8.2	14	13.2
Dinophyceae	10	7.9	10	8.4	10	8.4	8	10.3	11	9.6	9	8.4	9	8.7	10	8.9	9	8.6
All Taxa	126		117		113		77		115		106		103		109		108	

Table 8. Dominant phytoplankton species contributing greater than 5% to the total biomass (for at least one cruise) during 1998, at stations W3, WC2 and E2.

Station / Group	W3	WC2	E2
Cyanophyta	*Microcystis aeruginosa*	*Anabaena spiroides* *Oscillatoria limnetica*	*Chroococcus dispersus var. minor*
Chlorophyta	*Tetraedron minimum* *T. minimum var. tetralobulatum*	*Ankistrodemus falcatus spirilliformis* *Ankistrodesmus falcatus mirabilis* *Chlamydomonas globosa* *Chlorella vulgaris* *Scenedesnus bijuga* *Tetraedron minimum*	*Chlorella homosphaera* *C. vulgaris* *Tetraedron minimum*
Chrysophyceae	*Chrysochromulina parva*	*Chrysochromulina parva* *Mallomonas sp.*	*Chrysochromulina parva* *Dinobryon sociale* *Mallomonas sp.* *Rhizochrysis sp.*
Diatomeae	*Cyclotella glomerata* *C. meneghiniana* *C. michiganiana* *C. ocellata* *C. stelligera* *Fragilaria crotonensis* *Melosira binderana*	*Cyclotella glomerata* *C. ocellata* *C.stelligera* *Fragilaria crotonensis* *Melosira islandica*	*Cyclotella atomus* *C. glomerata* *C. meneghiniana* *C. stelligera* *Fragilaria crotonensis* *Synedra acus* *S. acus var. radians*
Cryptophyceae	*Cryptomonas erosa* *C. ovata* *C. tetrapyrenoidosa* *Rhodomonas minuta var. nanoplanctica*	*Katablepharis ovalis* *Rhodomonas minuta*	*Rhodomonas minuta*
Dinophyceae	*Peridinium sp.*	*Gymnodinium helveticum* *G. varians*	*Peridinium sp.*

Table 9. Phytoplankton species contributing 1 - 5 % to the total biomass (for at least one cruise) during 1998 at station W3.

Group	Species	Group	Species	Group	Species
Cyanophyta		Chrysophyceae (con't)		Diatomeae (con't)	
	Chroococcus dispersus var. minor		*Erkenia subaequiciliata*		*S. acus var. radians*
	Merismopedia sp.		*Mallomonas elliptica*		*Tabellaria sp.*
Chlorophyta			*Mallomonas sp.*	Cryptophyceae	
	Carteria sp.		*Ochromonas sphagnalis*		*Cryptomonas caudata*
	Chlamydomonas foveolarum		*Pseudokephryion sp.*		*C. marssonii*
	C. globosa		*Rhizochrysis sp.*		*Cryptomonas sp.*
	Chlamydomonas sp.	Diatomeae			*Katablepharis ovalis*
	Chlorella homosphaera		*Asterionella formosa*		*Rhodomonas minuta*
	C. vulgaris		*Coscinodiscus rothii*	Dinophyceae	
	Coelastrum sphaericum		*Cyclotella atomus*		*Ceratium hirundinella*
	Cosmarium sp.		*C. bodanica*		*Glenodinium pulvisculus*
	Franceia ovalis		*C. comta*		*Gymnodinium helveticum*
	Gloeocystis gigas		*C. glomerata*		*Gymnodinium paradoxum*
	G. planctonica		*Cyclotella sp.*		*G. uberrimum*
	Gloeocystis sp.		*Cymatopleura sp.*		*G. varians*
	Oocystis elliptica		*Diatoma elongatum*		*Gymnodinium sp.*
	Oocystis sp.		*Fragilaria sp.*		*Hemidinium sp.*
	Pediastrum boryanum		*Melosira granulata*		*Peridinium aciculiferum*
	P. simplex		*M. islandica*		*P. africanum*
	Scenedesmus bijuga		*Melosira sp.*		*P. inconspicuum*
Chrysophyceae			*Stephanodiscus astraea var. minutula*		*P. pygmaeum*
	Dinobryon divergens		*S. tenuis*		
	D. sociale		*Synedra acus*		

Table 10: Phytoplankton species contributing <1% to the total biomass (for at least one cruise) during 1998 at station W3.

Group	Species	Group	Species	Group	Species	Group	Species
Cyanophyta		Chlorophyta (con't)		Chrysophyceae (con't)		Diatomeae (con't)	
	Anabaena flos-aquae		*Closteriopsis sp.*		*Kephyrion sp.*		*Nitzschia acicularis*
	A spiroides		*Selenastrum minutum*		*Mallomonas areolata*		*N. acuta*
	Aphanocapsa delicatissima		*Sphaerocystis schroterii*		*M. denticulata*		*N. dissipata*
	A. grevillei		*Stylosphaeridium stipitatum*		*M. globosa*		*N. gracilis*
	Aphanocapsa sp.		*Tetraedron caudatum*		*M. lata*		*N. holsatica*
	Aphanothece sp.		*Tetrastrum elegans*		*M. ovum*		*N. palea*
	Chroococcus limneticus		*T. heterocanthum*		*M. rhopaloides*		*Nitzschia sp.*
	Chroococcus sp.		*T. staurogeniaeforme*		*Ochromonas nana*		*N. vermicularis*
	Coelosphaerium naegelianum		*Treubaria setigera*		*O. scintillans*		*Rhizosolenia eriensis*
	Coelosphaerium sp.		*T. setigerum*		*O. vallesiaca*		*R. gracilis*
	Gloeocapsa sp.		*Treubaria sp.*		*Phalansterium sp.*		*R. longiseta*
	Gomphoshaeria lacustris	Chrysophyceae			*Pseudokephyrion poculum*		*Rhoicosphenia curvata*
	Merismopedia punctata		*Achnanthece sp.*		*Salpingoeca frequentissima*		*Rhoicosphenia sp.*
	M. tenuissima		*Chromulina sp.*		*Stipitococcus urceolatus*		*Stauroneis sp.*
	Microcystis flos-aquae		*Chromulina minuta*	Diatomeae			*Stephanodiscus hantzschia*
	M. incerta		*Chrysolykos planktonicus*		*Amphora sp.*		*S. niagarae*
	Microcystis sp.		*Chyrococcus sp.*		*Asterionella gracillima*		*Surirella sp.*
	Oscillatoria limnetica		*Dinobryon bavaricum*		*Chroomonas acuta*		*Surirella ovata*
Chlorophyta			*D. divergens*		*Cocconeis sp.*		*Tabellaria fenestrata*
	Actinastrum hantzschii		*D. elegentissimum*		*Cymatopleura solea*	Cryptophyceae	
	Ankistrodemus falcatus var. acicularis		*D. sociale*		*Cymbella sp.*		*Cryptomonas rostratiformis*
	A. falcatus var. mirabilis		*Dinobryon sp.*		*C. ventricosa*		*Chroomonas sp.*
	A. falcatus var. spirilliformis		*Epipyxis sp.*		*Fragilaria capucina*	Dinophyceae	
	Characium sp.		*Kentrosiga sp.*		*Gomphonema sp.*		*Gymnodinium ordinatium*
	Chromulina mikrocanta		*Kephyrion ovum*		*Navicula sp.*		*Peridinium dinobryon*

Table 11. Comparison of seasonal weighted mean biomass (SWM, g m^{-3}) and percent of total biomass (%) by phytoplankton taxonomic group, and chlorophyll *a* during 1993 (Graham et al. 1995), 1994 (Dahl et al. 1996) and 1998 at stations W3, WC2 and E2.

Taxonomic Group	W3				WC2				E2					
	1993		1998		1993		1998		1993		1994		1998	
	SWM	%	SWM	%	SWM	%	SWM	%	SWM	%	SWM	%	SWM	%
Cyanophyta	0.007	0.9	0.121	4.2	0.026	3.5	0.407	15.3	0.008	2.3	0.012	1.5	0.102	5.5
Chlorophyta	0.040	5.3	0.889	30.9	0.042	5.6	0.577	21.7	0.076	21.7	0.069	8.7	0.334	18.1
Euglenophytae	0.001	0.1	0.000	0.0	0.003	0.4	0.000	0.0	0.001	0.3	0.003	0.4	0.000	0.0
Chrysophyceae	0.045	5.9	0.280	9.7	0.093	12.4	0.262	9.9	0.066	18.8	0.136	18.1	0.380	20.6
Diatomeae	0.512	67.3	1.034	35.9	0.330	43.8	0.842	31.7	0.105	29.9	0.130	16.5	0.649	35.1
Cryptophyceae	0.151	19.8	0.309	10.7	0.157	20.9	0.323	12.2	0.062	17.7	0.143	18.1	0.162	8.8
Dinophyceae	0.005	0.7	0.245	8.5	0.102	13.6	0.246	9.3	0.033	9.4	0.296	37.5	0.220	11.9
Total biomass	0.761		2.878		0.753		2.657		0.351		0.789		1.847	
Chl a (mg m^{-3})	4.47		4.37		3.99		4.33		2.11		2.24		2.39	

Table 12. Phytoplankton species contributing 1 - 5 % to the total biomass (for at least one cruise) during 1998 at station WC2.

Group	Species	Group	Species
Cyanophyta		Diatomeae	
	Anabaena gonidia		*Coscinodiscus rothii*
	Aphanocapsa elachista		*Cyclotella atomus*
	Aphanocapsa grenvillei		*Cyclotella comta*
	Chroococcus dispersus var. minor		*Cyclotella meneghiniana*
	Gomphosphaeria lacustris		*Cyclotella michiganiana*
	Microcysis aeruginosa		*Fragilaria capucina*
	Microcystis sp.		*Fragilaria sp.*
	Oscillatoria tenuis		*Melosira binderana*
Chlorophyta			*Melosira italica*
	Chlamydomonas sp.		*Melosira granulata*
	Chlorella homosphaeria		*Melosira sp.*
	Coelastrum sphaericum		*Navicula sp.*
	Gloeocystis gigas		*Stephanodiscus niagarae*
	Gloeocystis sp.		*Synedra acus*
	Gloetaenium loitlesbergerianum		*Tabellaria fenestrata*
	Kirchneriella lunaris	Cryptophyceae	
	Oocystis parva		*Cryptomonas caudata*
	Selenastrum minutum		*Cryptomonas erosa*
	Tetraedron minimum lobulatum		*Cryptomonas ovata*
	Tetraedron minimum tetralobultum		*Cryptomonas sp.*
Chrysophyceae			*Cryptomonas tetrapyrenoidosa*
	Dinobryon divergens		*Rhodomonas minuta nanoplanctica*
	Dinobryon sociale	Dinophyceae	
	Erkenia subaequiciliata		*Ceratium hirundinella*
	Kephyrion sp.		*Glenodinium pulvisculus*
	Ochromonas sp.		*Gymnodinium paradoxum*
	Salpingoeca frequentissima		*Gymnodinium uberrimum*
			Peridinium incospicuum

Table 13: Phytoplankton species contributing <1% to the total biomass (for at least one cruise) during 1998 at station WC2.

Group	Species	Group	Species	Group	Species	Group	Species
Cyanophyta		Chlorophyta (con't)		Chlorophyta (con't)		Diatomeae (con't)	
	Aphanocapsa sp.		*Elakatothrix gelatinosa*		*T. trigonum*		*Achnanthece minutissima*
	A. delicatissima		*Franceia ovalis*		*Tetrastrum staurogeniaeforme*		*Cocconeis sp.*
	A. pulchara		*Gemellicystis sp.*	Chrysophyceae			*Achnanthece sp.*
	Aphanothece clathrata		*Gloeocystis planctonica*		*Chromulina sp.*		*Cyclotella bodanica*
	Aphanothece sp.		*Golenkinia radiata*		*Chrysolykos planctonica*		*Cymbella ventricosa*
	Chroococcus sp.		*Kirchneriella contorta*		*C. skujaii*		*Cymbella sp.*
	C. dispersus		*Kirchneriella sp.*		*Chyrococcus sp. mirrorante*		*Diatoma elongatum*
	C. limneticus		*Lagerheima citriformis*		*Desmerella sp.*		*Nitzschia acicularis*
	Merismopedia sp.		*Micratnium pusillum*		*Diceras chodatii*		*N. amphiria*
	M. tenuissima		*Nephrocytium sp.*		*Dinobryon bavaricum*		*N. palea*
	M. punctata		*Oedogonium sp.*		*D. elegentissima*		*N. dissipata*
	Microcystis incerta		*Oocystis sp.*		*D. pediforme*		*Nitzschia sp.*
	Oscillatoria sp.		*O. borgei*		*Kephyrion petasatum*		*Rhizosolenia gracilis*
	Oscillatoria minima		*O. crassa*		*K. ovum*		*R. eriensis*
	Radiococcus geminata		*O. gloeocystiformis*		*Mallomonas sp.*		*Sephanodiscus astrea manitula*
Chlorophyta			*O. lacustris*		*M. tonsurata*		*S. hantzschia*
	Actinastrum hantzschii		*Pedinomonas minutissima*		*M. producta*		*Surirella sp.*
	Carteria sp.		*Pediastrum duplex*		*M. globasa*		*Synedra sp.*
	C. cardiformis		*P. simplex*		*Pandorina morum*		*S. acus radians*
	Characium sp.		*P. boryanum*		*Ochromonas nana*		*Tabellaria flocculosa*
	Chlamydomonas foveolarum		*Quadrigula lacustris*		*O. sphagnalis*	Cryptophyceae	
	Closterium parvulum		*Scenedesnus incrassatulus*		*O. scintillans*		*Chroomonas acuta*
	Closteriopsis sp.		*S. bijuga alternans*		*Pseudokephryion alaskanum*		*C. nordstedii*
	Coelastrum sp.		*S. quadricauda*		*P. pocculum*		*Cryptomonas marssonii*
	Coelastrum microporum		*S.quadrata maximum*		*Pseudokephryion sp.*		*C. rostratiformis*
	Cosmarium sp.		*S. bijuga lagerheim*		*Rhizochrysis sp.*	Dinophyceae	
	C. phaseolus		*S. quadricauda*		*Salpingoeca sp.*		*Dinoflagellate sp.*
	Crucigenia quadrata		*Schroederia judayll*		*Stelexomas sp.*		*Glenodinium sp.*
	Crucigenia sp.		*Sphaerocystis schroterii*		*Synura sp.*		*Gymnodidium sp.*
	C. rectangularis		*Schroederia setigera*	Diatomeae			*Peridinium sp.*
	Dictyosphaerium sp.		*Staurastrum sp.*		*Asterionella gracillima*		*P. pygmeum*
	D. pulchellum		*Tetraedron sp.*		*A. formosa*		*P. aciculiferum*

Table 14. Phytoplankton species contributing 1 - 5 % to the total biomass (for at least one cruise) during 1998 at station E2.

Group	Species	Group	Species
Cyanophyta		Diatomeae (con't)	
	Anabaena flos-aquae		*Cyclotella comta*
	Aphanocapsa sp. pulchara		*C. michiganiana*
	Coelosphaerium kutzingianum		*C. ocellata*
	Gomphosphaeria lacustris		*Cyclotella sp.*
	Merismopedia sp. aeruginosa		*Diatoma elongatum*
	Oscillatoria limnetica		*Fragilaria capucina*
	O. minima		*Melosira binderana*
	Oscillatoria sp.		*M. islandica*
Chlorophyta			*Nitzschia acicularis*
	Carteria cordiformis		*Synedra hantzschii*
	Chlamydomonas globosa		*Synedra sp.*
	Gloeocystis gigas		*Tabellaria fenestrata*
	Gloeocystis sp.	Cryptophyceae	
	Oocystis borgei		*Cryptomonas caudata*
	O. lacustris		*C. erosa*
	Scenedesmus bijuga		*C. ovata*
	Tetraedreon minimum var. tetralobulatum		*C. tetrapyrenoidosa*
Chrysophyceae			*Cryptomonas sp.*
	Chrysomonad sp.		*Katablepharis ovalis*
	Chryococcus sp.		*Rhodomonas minuta var. nanoplanctica*
	Dinobryon bavaricum	Dinophyceae	
	Erkenia subaequiciliata		*Ceratium hirundinella*
	Kephyrion littorale		*Glenodinium pulvisculus*
	Kephyrion sp. boreale		*Glenodinium sp.*
	Ochromonas elegans		*Gymnodinium helveticum*
	O. obliqua		*G. paradoxum*
	Ochromonas sp.		*G. uberrimum*
	Pseudokephryion poculum		*G. varians*
Diatomeae			*Gymnodinium sp*
	Asterionella formosa		*Peridinium inconspicuum*
	Coscinodiscus rothii		*P. sp. conspicuum*

Table 15. Phytoplankton species contributing <1% to the total biomass (for at least one cruise) during 1998 at station E2.

Group	Species	Group	Species	Group	Species	Group	Species
Cyanophyta		Chlorophyta (con't)		Chlorophyta (con't)			
	Anabaena circinalis		*Franceia sp.*		*Sphaerocystis schroeteri*	Diatomeae	
	A. clathrata		*F. dorcherii*		*Stylosphaeridium sp.*		*Achnanthes minutissima*
	Anabaena spiroides		*Gemellicystis sp.*		*Tetrastrum staurogeniaefor*		*Achnanthes sp.*
	Aphanocapsa delicatissima		*Golenkenia radiata*		*Ulothrix sp.*		*Amphora ovalis*
	Aphanothese sp.		*Gloeocystis planktonica*	Euglenophytae			*Cocconeis sp.*
	Coelesphaerium sp.		*Gyromitus cordiformis*		*Trachelomonas sp.*		*Cyclotella bodanica*
	Gloeocapsa sp.		*Kirchneriella sp.*	Chrysophyceae			*Cymbella sp.*
	G. sp. Aeruginosa		*Kirchneriella contorta*		*Chromulina sp*		*C. ventricosa*
	Gomphosphaeria sp.		*K. lunaris*		*Chrysamoeba sp.*		*Fragilaria sp.*
	Merismopedia sp.		*Lagerheima ciliata*		*Chrysococcus punctiformis*		*Gomphonema sp.*
	Microcystis sp.		*Micractinium sp.*		*Chrysococcus sp.*		*Melosira sp.*
Chlorophyta			*Nephocytium sp.*		*Chrysolykos planktonica*		*Navicula sp.*
	Actinastrum Hantzschii		*Oocystis crassa*		*C. planctonicus*		*Nitzschia dissipata*
	Ankistrodesmus falcatus		*O. parva*		*C. skujai*		*Nitzschia sp.*
	A. falcatus var. acicularis		*O. pusilla*		*Chrysolykos sp.*		*Rhizosolenia eriensis*
	A. falcatus var. mirabilis		*O. solitaria*		*Diceras sp.*		*Rhoicosphenia curvata*
	A. falcatus var. spirilliformis		*Oocystis sp.*		*Dinobryon borgei*		*Stephanodiscus astraea var. minutula*
	Carteria sp.		*O. submarina*		*D. divergens*		*S. niagarae*
	Characium sp.		*Pediastrum boryanum*		*Dinobryon sp.*		*Stephanodiscus sp.*
	Chlamydomonas sp.		*P. simplex*		*Kephyrion ovum*		*Surirella sp.*
	Closteriopsis sp.		*Pedinomonas minutissima*		*Kephyrion sp.*		*Tabellaria flocculosa*
	Closterium parvulum		*Quadrigula lacustris*		*Monochrysis sp.*	Cryptophyceae	
	Closterium sp.		*Quadrigula sp.*		*Ochromonas nana*		*Chroomonas acuta*
	Coelastrum microporum		*Scenedesnus bijuga var. alternans*		*O. scintillans*		*C. nordstedii*
	Coelastrum sp.		*S. denticulatus*		*O. silvarum*		*Chroomonas sp.*
	C. sphaeriucum		*S. dimorphus*		*O. sphagnalis*		*Cryptaulax rhomboidia*
	Cosmarium sp.		*S. incrassatulus*		*Pseudokephyrion depressum*		*Cryptomonas marssonii*
	Crucigenia quadrata		*S. quadricauda*		*P. ellipsoideum*		*C. rostratiformis*
	C. rectangularis		*S. quadricauda var. maxima*		*P. ovum*		*Rhodomonas sp.*
	Dictyosphaerium pulchellum		*Scenedesnus sp*		*Pseudokephryion sp.*	Dinophyceae	
	Elakatothrix gelatinosa		*Schroederia setigera*		*Salpingoeca frequentissima*		*Peridinium aciculiferum*
	Franceia ovalis		*Selenastrum minutum*		*Salpingoeca sp.*		*P. africanum*

Table 16a.. Seasonal observations and seasonal weighted means (SWM) for primary production rates (P), parameters ($P^B{}_m$, α^B), and mean epilimnetic irradiance (•) at station E1. P_{opt} (mg C·m^{-3}·h^{-1}) is the primary production rate at optimal irradiance and is the product of $P^B{}_m$ and chlorophyll. The photosynthetic parameters were derived from the photosynthesis vs. irradiance curve. $P^B{}_m$ (mg C mg Chl^{-1} h^{-1}) is the maximum, and α^B (mg C mg Chl^{-1} E^{-1} m^{-2}) the slope of the light-limited part of the curve. The superscript B indicates that both parameters were normalized to chlorophyll as an index of biomass. Daily integral PP rates (ΣP=mg C m^{-2} d^{-1}) and • (m E m^{-2} min^{-1}) were both calculated with theoretical cloudless (cldlss) and empirical (emp) solar irradiance as denoted by the subscripts.

Date	ΣP_{emp}	ΣP_{cldlss}	P_{opt}	$P^B{}_m$	α^B	•$_{emp}$	•$_{cldlss}$
980505	30	35	0.66	0.93	2.49	16.83	25.09
980605	64	86	1.21	4.86	4.10	15.57	24.52
980617	134	172	2.51	3.44	3.02	14.64	21.82
980715	47	50	0.78	1.22	0.86	20.94	22.47
980731	176	183	2.60	2.57	3.56	18.40	19.01
980812	185	196	3.24	1.99	2.86	13.00	14.05
980827	424	447	8.94	2.29	2.61	11.41	12.09
980908	660	829	14.92	7.21	3.88	16.35	22.38
980925	251	307	5.25	4.56	4.62	11.27	17.80
981009	238	265	7.23	4.52	5.26	6.41	7.63
981022	6	6	0.97	0.64	0.53	10.17	12.08
981118	38	49	3.26	1.63	1.94	4.58	6.57
SWM[1]	194	227	4.15	3.23	3.13	14.71	19.10

[1]SWM- seasonal weighted mean of dates between May 1 and October 31.

Table 16b. Seasonal observations and seasonal weighted means (SWM) for primary production rates (P), parameters ($P^B{}_m$, α^B), and mean epilimnetic irradiance (•) at station E2. P_{opt} (mg C m^{-3} h^{-1}) is the primary production rate at optimal irradiance and is the product of $P^B{}_m$ and chlorophyll. The photosynthetic parameters were derived from the photosynthesis vs. irradiance curve. $P^B{}_m$ (mg C mg Chl^{-1} h^{-1}) is the maximum, and α^B (mg C mg Chl^{-1} E^{-1} m^{-2}) the slope of the light-limited part of the curve. The superscript B indicates that both parameters were normalized to chlorophyll as an index of biomass. Daily integral PP rates (ΣP=mg C m^{-2} d^{-1}) and • (mE m^{-2} min^{-1}) were both calculated with theoretical cloudless (cldlss) and empirical (emp) solar irradiance as denoted by the subscripts.

Date	ΣP_{emp}	ΣP_{cldlss}	P_{opt}	$P^B{}_m$	α^B	• $_{emp}$	• $_{cldlss}$
980505	471	588	4.59	1.04	2.92	2.28	3.40
980519	364	439	1.88	1.79	2.70	19.32	24.58
980605	474	579	1.12	2.24	3.69	22.31	35.13
980617	292	394	3.99	2.51	2.17	13.57	20.23
980629	739	764	6.34	5.42	2.36	18.37	18.63
980715	551	590	4.37	1.38	1.64	15.25	16.36
980730	473	933	6.16	2.47	2.87	4.55	12.44
980812	1142	1209	9.22	3.19	5.81	7.96	8.61
980827	571	600	4.55	2.28	5.72	10.37	10.99
980908	613	741	4.45	2.06	4.40	6.92	9.47
980928	857	905	8.52	3.17	6.40	4.81	6.74
981022	236	260	3.21	1.31	3.75	3.01	3.57
981118	36	47	2.27	1.73	4.35	0.26	0.38
SWM[1]	588	687	5.03	2.49	3.85	10.96	14.45

[1]SWM - seasonal weighted mean of dates between May 1 and October 31.

Table 16c. Seasonal observations and seasonal weighted means (SWM) for primary production rates (P), parameters ($P^B{}_m$, α^B), and mean epilimnetic irradiance (•) at station E3. P_{opt} (mg C m^{-3} h^{-1}) is the primary production rate at optimal irradiance and is the product of $P^B{}_m$ and chlorophyll. The photosynthetic parameters were derived from the photosynthesis vs. irradiance curve. $P^B{}_m$ (mg C mg Chl^{-1} h^{-1}) is the maximum, and α^B (mg C mg Chl^{-1} E^{-1} m^{-2}) the slope of the light-limited part of the curve. The superscript B indicates that both parameters were normalized to chlorophyll as an index of biomass. Daily integral PP rates (ΣP=mg C m^{-2} d^{-1}) and • (mE m^{-2} min^{-1}) were both calculated with theoretical cloudless (cldlss) and empirical (emp) solar irradiance as denoted by the subscripts.

Date	ΣP_{emp}	ΣP_{cldlss}	P_{opt}	$P^B{}_m$	α^B	• $_{emp}$	• $_{cldlss}$
980505	65	76	0.66	0.93	2.49	11.98	17.86
980519	320	384	3.62	3.10	4.01	19.04	24.23
980605	86	114	1.04	3.60	3.51	14.47	22.79
980617	217	287	3.00	3.13	2.21	14.22	21.19
980629	485	508	5.05	3.51	3.34	23.81	24.16
980715	229	246	3.34	2.05	1.42	14.33	15.38
980730	200	338	3.19	1.97	2.22	8.35	22.81
980812	576	618	9.57	3.48	2.77	11.23	12.14
980827	345	364	4.17	2.96	3.37	22.01	23.33
980908	120	131	1.24	1.14	4.09	10.49	14.36
980928	217	227	2.59	2.23	4.15	10.72	11.56
981008	172	332	5.08	5.41	5.75	3.75	9.60
981022	34	37	0.46	0.47	1.00	8.12	9.65
981118	79	105	2.67	3.08	4.47	2.82	4.04
SWM[1]	251	299	3.52	2.75	3.22	13.57	17.91

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 16d. Seasonal observations and seasonal weighted means (SWM) for primary production rates (P), parameters ($P^B{}_m$, α^B), and mean epilimnetic irradiance (•) at station E5. P_{opt} (mg C m^{-3} h^{-1}) is the primary production rate at optimal irradiance and is the product of $P^B{}_m$ and chlorophyll. The photosynthetic parameters were derived from the photosynthesis vs. irradiance curve. $P^B{}_m$ (mg C mg Chl^{-1} h^{-1}) is the maximum, and α^B (mg C mg Chl^{-1} E^{-1} m^{-2}) the slope of the light-limited part of the curve. The superscript B indicates that both parameters were normalized to chlorophyll as an index of biomass. Daily integral PP rates (ΣP=mg C m^{-2} d^{-1}) and • (mE m^{-2} min^{-1}) were both calculated with theoretical cloudless (cldlss) and empirical (emp) solar irradiance as denoted by the subscripts.

Date	ΣP_{emp}	ΣP_{cldlss}	P_{opt}	$P^B{}_m$	α^B	$•_{emp}$	$•_{cldlss}$
980730	167	231	6.75	2.11	2.43	11.74	32.07
980812	279	290	8.76	2.68	4.02	23.40	25.30
980827	304	317	10.07	3.60	4.74	24.32	25.78
980909	305	318	10.45	2.84	4.33	13.35	24.14
980924	165	209	7.51	3.16	3.77	9.11	20.86
981008	69	103	3.99	2.91	3.41	6.79	17.39
981022	129	134	5.42	2.79	4.09	13.22	15.71
SWM[1]	211	230	7.80	2.94	3.92	14.89	22.83

[1]SWM seasonal weighted mean of dates between May 1 and October 31.

Table 17. Common statistics for P_{opt} (mg C m^{-3} h^{-1}) and the determinant variables for integral primary production: chlorophyll (Chl μg L^{-1}), light attenuation (ε_{par} m^{-1}), $P^B{}_m$ (mg C mg Chl^{-1} h^{-1}) and α^B (mg C mg Chl^{-1} E^{-1} m^{-2} h^{-1}). Seasonal means are for May 1 to October 31 for all parameters and are weighted for variable time intervals between sampling dates.

	Station	Seasonal Weighted Mean	Standard Deviation	Minimum	Maximum	n
P_{opt}						
	E1	4.15	4.44	0.66	14.92	11
	E2	5.03	2.40	1.12	9.22	12
	E3	3.52	2.44	0.46	9.57	13
	E5	7.80	2.38	3.99	10.45	7
$P^B{}_m$						
	E1	3.23	2.02	0.64	7.21	11
	E2	2.49	1.17	1.04	5.42	12
	E3	2.75	1.34	0.47	5.41	13
	E5	2.94	0.45	2.11	3.60	7
α^B						
	E1	3.13	1.45	0.53	5.26	11
	E2	3.85	1.57	1.64	6.40	12
	E3	3.22	1.28	1.00	5.75	13
	E5	3.92	0.74	2.43	4.74	7
Chl						
	E1	1.18	1.07	0.16	3.90	11
	E2	2.14	1.06	0.50	4.40	12
	E3	1.28	0.58	0.29	2.75	13
	E5	2.67	0.77	1.37	3.68	8
	EC1	1.85	0.71	1.09	3.30	10
	EC2	2.41	1.01	0.91	3.90	10
	C1	2.26	2.20	0.61	7.65	12
	C2	3.39	1.86	1.51	8.04	12
	WC1	5.00	3.10	1.07	12.79	24
	WC2	4.10	2.41	1.68	12.51	23
	W1	6.04	2.33	2.39	10.70	23
	W2	4.43	1.99	1.57	8.53	23
	W3	4.20	2.02	1.38	9.41	13

Table 17. Cont'd

Station	Seasonal Weighted Mean	Standard Deviation	Minimum	Maximum	n
ε_{par}					
E1	0.27	0.13	0.13	0.49	11
E2	0.21	0.08	0.03	0.32	12
E3	0.22	0.05	0.16	0.33	13
EC1	0.70	0.62	0.24	2.47	11
EC2	0.25	0.11	0.04	0.41	10
C1	0.46	0.12	0.28	0.64	11
C2	0.26	0.13	0.02	0.43	10
WC1	0.36	0.14	0.04	0.60	19
WC2	0.32	0.10	0.09	0.43	20
W1	0.76	0.46	0.30	1.77	15
W2	0.41	0.12	0.16	0.65	15
W3	0.53	0.16	0.35	0.82	10
W6	0.56	0.24	0.10	0.97	16
W7	0.65	0.28	0.23	1.15	15

Table 18. Seasonal* areal-based (g C m^{-2}) and volume-based (g C m^{-3}) primary production (PP). PP was calculated with both empirical (emp) and theoretical cloudless (cldls) solar irradiance. Areal PP calculated with empirical irradiance was expressed as a percentage of the cloudless values (% cldls). The calculation of % cldlss was considered not applicable (na) to volumetric rates.

	E1			E2			E3			E5		
Date	Emp	Cldls	% cldls	emp	cldls	% cldls	emp	cldls	% cldls	emp	Cldls	% cldls
Areal												
1993				105.3	139.6	75.4	53.8	70.1	76.7			
1994	41.2	59.4	69.4	85.8	126.3	67.9	61.2	86.5	70.8			
1998	32.5	40.2	80.8	105.9	134.2	78.9	42.3	52.8	80.1	18.7	21.3	87.8
Volume												
1993				14.3	16.3	na	8.6	10.0	na			
1994	11.6	14.1	na	13.0	15.4	na	10.9	13.2	na			
1998	7.2	8.2	na	10.5	11.7	na	6.6	7.6	na	8.6	9.6	na

* E5 values are for the July 30-Oct 31 period. Primary production was not measured before July 30 at E5.

Table 19. Observed and predicted seasonal* areal primary production (SAPP - g $C \cdot m^{-2}$) for east basin stations in each of the LEB studies. Observed PP was calculated using the programs of Fee (1990). Primary production depth profiles were truncated by depth at shallow stations. Potential PP values were determined by allowing the model to extend the profile beyond the station depth, to the potential depth set by transparency. Seasonal PP was predicted from the seasonal mean TP concentration and the equation of Millard et al. (1999). Percent difference refers to the comparison of potential values relative to predicted.

Station	Observed PP	Potential PP	Predicted PP based on TP	% Difference
1993				
E2	105	105	122	14
E3	54	66	102	35
1994				
E1	41	50	137	64
E2	86	86	118	27
E3	61	73	122	40
1998				
E1	33	53	139	62
E2	106	106	132	20
E3	42	52	120	56

* May 1 to October 31.

Table 20a. Comparison of zooplankton seasonal (May-Oct) mean density (no. m^{-3}) from stations in the east basin of Lake Erie, for 1993, 1994 and 1998. Station E5, sampled from July-Oct, for the first time in 1998 is included.

	E1			E2			E3			E5
	1993	1994	1998	1993	1994	1998	1993	1994	1998	1998
Cladocera	3175	968	2240	5130	2778	4412	1541	1553	4123	40733
Cyclopoida	7551	5685	9986	3592	5882	2893	6920	3794	7804	26362
Calanoida	7193	3137	7682	3726	1943	3906	7891	2960	6892	2370
[a]Total	17919	9790	19908	12448	10603	11211	16352	8307	18819	69465
D. veligers	2702	3087	297	12373	3121	1503	6496	2935	5177	71
[b]Grand total	20621	12877	20205	24821	13724	12714	22848	11242	23996	69536
Date Range	14-May 20-Oct	10-May 18-Oct	05-Jun 22-Oct	14-May 05-Oct	10-May 18-Oct	05-May 22-Oct	12-May 20-Oct	10-May 18-Oct	19-May 22-Oct	15-Jul 22-Oct
n	11	20	10	10	20	11	12	20	12	8

[a] Includes Cladocera, Cyclopoida and Calanoida.
[b] Includes Cladocera, Cyclopoida, Calanoida and *Dreissena* veliger larvae.

Table 20b. Seasonal (May-Oct) mean density (no. m^{-3}) of zooplankton from stations in the central basin of Lake Erie, 1998. Comparable data from 1993 is included for stations WC1.

	EC1	EC2	C1	C2	WC1	
	1998	1998	1998	1998	1993	1998
Cladocera	7478	3260	8154	6970	31672	10729
Cyclopoida	4249	3629	4906	15553	24139	22866
Calanoida	3470	4785	4277	12808	7023	21134
[a]Total	15197	11674	17337	35331	62834	54729
D. veligers	662	220	32	3154	14841	14184
[b]Grand total	15859	11894	17369	38485	77676	69815
Date Range	12-May 30-Sep	12-May 30-Sep	12-May 26-Oct	12-May 26-Oct	06-May 26-Oct	11-May 15-Oct
n	10	10	12	12	13	10

[a] Includes Cladocera, Cyclopoida and Calanoida.
[b] Includes Cladocera, Cyclopoida, Calanoida and *Dreissena* veliger larvae.

Table 20c. Seasonal (May-Oct) mean density (no. m^{-3}) of zooplankton from stations in the west basin of Lake Erie, 1998. Comparable data from 1993 is included for stations W1 and W3.

	W1		W2	W3		W6	W7
	1993	1998	1998	1993	1998	1998	1998
Cladocera	19716	5407	10952	13564	13181	19408	26036
Cyclopoida	12526	4990	17640	6209	3879	19035	21194
Calanoida	12737	5365	9892	3621	2596	8085	8906
[a]Total	44979	15762	38484	23395	19656	46528	56136
D. veligers	17268	4154	6635	19424	33457	12132	20388
[b]Grand total	62247	19916	45118	42819	53113	58660	76524
Date Range	06-May 26-Oct	11-May 29-Oct	11-May 29-Oct	06-May 27-Oct	12-May 29-Oct	12-May 29-Oct	12-May 29-Oct
n	14	12	11	14	14	12	12

[a] Includes Cladocera, Cyclopoida and Calanoida.
[b] Includes Cladocera, Cyclopoida, Calanoida and *Dreissena* veliger larvae.

Table 21a. Comparison of zooplankton seasonal (May-Oct) mean biomass (mg m^{-3}) from stations in the east basin of Lake Erie for 1993, 1994 and 1998. Station E5, sampled from July-Oct, for the first time in 1998 is included.

	E1			E2			E3			E5
	1993	1994	1998	1993	1994	1998	1993	1994	1998	1998
Cladocera	1.89	0.96	4.58	4.94	6.76	4.54	1.03	1.37	6.09	11.88
Cyclopoida	3.35	6.23	5.24	4.59	5.94	2.19	3.64	2.73	4.97	6.68
Calanoida	14.94	5.14	15.29	10.85	5.84	7.64	14.86	4.97	14.31	2.20
[a]Total	20.18	12.33	25.11	20.38	18.54	14.37	19.53	9.07	25.37	20.76
D. veliger	4.79	4.65	0.27	15.74	3.42	1.27	6.16	2.43	4.52	0.06
[b]Grand total	24.97	16.98	25.38	36.12	21.96	15.64	25.69	11.5	29.89	20.82
Date Range	14-May 20-Oct	10-May 18-Oct	05-Jun 22-Oct	14-May 05-Oct	10-May 18-Oct	05-May 22-Oct	12-May 20-Oct	10-May 18-Oct	19-May 22-Oct	15-Jul 22-Oct
n	11	20	10	10	20	11	12	20	12	8

[a] Includes Cladocera, Cyclopoida and Calanoida.
[b] Includes Cladocera, Cyclopoida, Calanoida and *Dreissena* veliger larvae.

Table 21b. Seasonal (May-Oct) mean biomass (mg m-3) of zooplankton from stations in the central basin of Lake Erie, 1998. Comparable data from 1993 is included for stations WC1.

	EC1	EC2	C1	C2	WC1	
	1998	1998	1998	1998	1993	1998
Cladocera	7.74	26.68	21.65	28.13	49.77	22.80
Cyclopoida	3.46	7.84	17.56	18.43	31.51	22.60
Calanoida	3.59	10.31	12.16	25.05	19.22	35.52
[a]Total	14.79	44.83	51.37	71.61	100.50	80.92
D. veliger	0.34	0.08	0.03	2.09	13.19	9.27
[b]Grand total	15.13	44.91	51.40	73.71	113.69	90.19
Date Range	12-May 30-Sep	12-May 30-Sep	12-May 26-Oct	12-May 26-Oct	06-May 26-Oct	11-May 15-Oct
n	10	10	12	12	13	10

[a] Includes Cladocera, Cyclopoida and Calanoida.
[b] Includes Cladocera, Cyclopoida, Calanoida and *Dreissena* veliger larvae.

Table 21c. Seasonal (May-Oct) mean biomass (µg L-1) of zooplankton from stations in the west basin of Lake Erie, 1998. Comparable data from 1993 is included for stations W1 and W3.

	W1		W2	W3		W6	W7
	1993	1998	1998	1993	1998	1998	1998
Cladocera	32.19	18.22	19.98	41.81	39.17	22.80	48.70
Cyclopoida	9.69	3.79	14.40	6.31	4.61	20.07	16.76
Calanoida	15.60	8.11	11.62	7.69	2.37	9.80	8.89
[a]Total	57.48	30.12	46.00	55.81	46.15	52.67	74.35
D. veliger	13.63	3.03	4.72	15.20	24.58	7.33	12.88
[b]Grand total	71.12	33.15	50.72	71.01	69.73	60.01	87.23
Date Range	06-May 26-Oct	11-May 29-Oct	11-May 29-Oct	06-May 27-Oct	12-May 29-Oct	12-May 29-Oct	12-May 29-Oct
n	14	12	11	14	14	12	12

[a] Includes Cladocera, Cyclopoida and Calanoida.
[b] Includes Cladocera, Cyclopoida, Calanoida and *Dreissena* veliger larvae.

Table 22a. Summary of zooplankton species occurrence at 4 stations in the east basin of Lake Erie in 1998 and, where available, in 1993 and 1994. Numbers indicate the proportion of sampling days on which that species comprised ≥ 5% of the total biomass. + indicates the species was present but never comprised ≥ 5% of the total biomass.

	E1			E2			E3			E5
Taxon	1993	1994	1998	1993	1994	1998	1993	1994	1998	1998
CLADOCERA										
Bosmina spp.	0.455	0.286	0.400	0.700	0.750	0.727	0.417	0.381	0.417	1.000
Daphnia longiremis		+	0.100	+	+	+			0.083	
Daphnia retrocurva	0.091	0.095	0.200	+	0.500	+		0.095	+	
Daphnia galeata mendotae	+	+	+	+	0.100	0.272		+	0.083	
Ceriodaphnia reticulata						+				+
Diaphanosoma spp.	+	+	0.100			+			+	+
Eubosmina spp.	+	+	0.100		0.050	+		+	+	
Polyphemus pediculus		+							+	
Holopedium gibberum			+	+		+			+	
Sida crystallina		+								
Chydorus sphaericus	+	+	+					+	+	+
Alona sp.	+	+						+	+	
Bythothrephes cederstroemi	+	0.095	0.200	+	0.450	0.091	0.083	0.095	0.167	
Leptodora kindti	+	+	0.100	0.200	0.050	+	+	+	0.167	
COPEPODA										
Calanoida										
Leptodiaptomus ashlandi	+	+		0.100	0.200	+		+	+	

Table 22a. Cont'd

Taxon	E1 1993	E1 1994	E1 1998	E2 1993	E2 1994	E2 1998	E3 1993	E3 1994	E3 1998	E5 1998
Leptodiaptomus minutus	0.273	0.047	0.600	0.300	0.300	0.364	0.500	0.333	0.417	
Leptodiaptomus sicilis			+	+	0.150	+	+	+	+	
Leptodiaptomus siciloides	+		+	+	+	+	+		+	
Skistodiaptomus reighardi		+								+
Skistodiaptomus oregonensis	+	0.143	0.400	0.200	0.250	0.364	0.333	0.143	0.417	+
Epischura lacustris	0.273	0.429	0.300	0.700	0.650	0.455	0.750	0.476	0.417	
Epischura lacustris cop.	0.273	0.476	0.100	0.500	0.400	0.636	0.583	0.619	0.167	+
Eurytemora affinis	0.091	0.048	+	0.300	0.100	+	0.083	+		
Limnocalanus macrurus				+						
Senecella calanoides					+					
Calanoid copepodid	0.636	0.667	1.000	0.400	0.400	0.455	0.333	0.333	0.833	0.375
Calanoid nauplii	0.273	0.286	0.200	0.300	0.250	+	0.083	0.286	+	+
Cyclopoida										
Diacyclops thomasi	0.091	0.381	+	0.800	0.850	0.182	0.333	0.333	0.167	+
Cyclops vernalis	+	+	+	+	+	+		+	+	
Mesocyclops edax	+	+	0.300	0.100	0.150	0.182	+	+	0.083	
Tropocyclops extensus	0.273	+	0.200	0.100	+	0.091	0.250	0.048	+	0.250
Eucyclops agilus	+	+								

Table 22a. Cont'd

	E1			E2			E3			E5
Taxon	1993	1994	1998	1993	1994	1998	1993	1994	1998	1998
Eucyclops speratus					+				+	
Cyclopoid copepodid	0.727	0.952	0.800	0.500	0.900	0.636	0.417	0.667	0.833	1.000
Cyclopoid nauplii	0.237	0.143	0.300	+	0.100	+	0.167	0.143	+	0.500
Harpactacoida			+	+	+	+	+		+	
Dreissena veligers	0.636	0.714	+	1.000	0.900	0.636	0.833	0.762	0.417	+

Table 22b. Summary of zooplankton species occurrence at 6 stations in the central basin of Lake Erie in 1998 and, where available, in 1993. Numbers indicate the proportion of sampling days on which that species comprised ≥ 5% of the total biomass. + indicates the species was present but never comprised ≥ 5% of the total biomass.

	WC1		WC3*	C1	C2	EC1	EC2
Taxon	1993	1998	1993	1998	1998	1998	1998
CLADOCERA							
Bosmina spp.	0.923	0.400	+	0.833	0.500	1.000	0.700
Daphnia longiremis	+	+	+	0.083	+	+	0.100
Daphnia retrocurva	+	+	+	0.167		0.100	0.300
Daphnia galeata mendotae		0.400		0.333	0.417	0.100	0.200
Daphnia pulicaria							+
Diaphanosoma spp.	+	+	+	+		0.100	+
Ceriodaphnia reticulata		+		+			
Ceriodaphnia spp.							+
Eubosmina spp.	0.231	+	+	0.333	0.167	+	+
Polyphemus pediculus							
Holopedium gibberum	+	+		+	+	+	+
Sida crystallina							
Chydorus sphaericus		+			0.083		
Alona sp.		+					
Bythothrephes cederstroemi	0.154	0.400	+	0.333	0.333	+	0.200
Leptodora kindti	+	+	+	+	+	+	+
COPEPODA							
Calanoida							
Leptodiaptomus ashlandi	0.077	0.200	+	+	0.083	+	+
Leptodiaptomus minutus	0.308	+	+	0.083	+	0.100	0.500
Leptodiaptomus sicilis	0.154		+	+	+	+	+
Leptodiaptomus siciloides	0.231	+	+	0.083	+	0.100	+
Skistodiaptomus reighardi		+			+	+	
Skistodiaptomus oregonensis	0.077	0.600	+	0.083	0.750	0.200	0.700
Epischura lacustris	0.385	0.300	+	0.167	0.250	0.300	0.400
Epischura lacustris cop.	+	0.200	+	+	+	0.200	0.100

Table 22b. Cont'd

Taxon	WC1 1993	WC1 1998	WC3 1993	C1 1998	C2 1998	EC1 1998	EC2 1998
Eurytemora affinis	0.154	+	+	+	+	+	+
Limnocalanus macrurus	+	+		+			+
Senecella calanoides							
Calanoid copepodid	0.692	0.900	+	0.583	0.583	0.500	0.600
Calanoid nauplii	0.077	0.200	+	0.167	+	0.100	+
Cyclopoida							
Diacyclops thomasi	0.846	0.300	+	0.417	0.250	0.500	0.300
Cyclops vernalis	0.077	+	+		+	0.100	+
Mesocyclops edax	0.308	0.200	+	0.083	0.167	0.300	0.300
Tropocyclops extensus	0.077	+	+	+	0.167	+	+
Eucyclops agilus		+	+				
Eucyclops speratus							
Cyclopoid copepodid	0.846	0.900	+	0.583	0.833	0.600	0.500
Cyclopoid nauplii	+	+	+	0.167	+	+	+
Harpactacoida	+			+	0.083	0.100	+
Dreissena veligers	0.231	0.100	+	+	0.083	0.200	+

* Only species presence/absence is noted because no samples were collected in July or August.

Table 22c. Summary of zooplankton species occurrence at 5 stations in the west basin of Lake Erie in 1998 and, where available, in 1993. Numbers indicate the proportion of sampling days on which that species comprised ≥ 5% of the total biomass. + indicates the species was present but never comprised ≥ 5% of the total biomass.

	W1		W2	W3		W6	W7
Taxon	1993	1998	1998	1993	1998	1998	1998
CLADOCERA							
Bosmina spp.	0.357	0.364	0.333	0.214	0.429	0.417	0.500
Daphnia longiremis	+	0.091	+	0.143	+	+	+
Daphnia retrocurva	0.500	0.364	0.500	0.429	0.500	0.500	0.417
Daphnia galeata mendotae		0.273	+		+	+	+
Daphnia parvula			+				+
Ceriodaphnia reticulata			+		+	+	+
Ceriodaphnia spp.					+		
Diaphanosoma spp.	0.143	+	+		+	0.083	0.167
Eubosmina spp.	0.143	0.091	0.417	0.071	+	0.167	+
Polyphemus pediculus							
Holopedium gibberum		+	+		+	+	+
Sida crystallina							
Chydorus sphaericus		+	+		+	+	+
Alona sp.							+
Bythothrephes cederstroemi		0.273	0.083				
Leptodora kindti	+	+	+	0.071	0.214	+	0.083
COPEPODA							
Calanoida							
Leptodiaptomus ashlandi	0.143	0.091	0.083	0.071	0.071	+	+
Leptodiaptomus minutus	+	0.273	0.083	+	+	+	+
Leptodiaptomus sicilis	0.143	0.091	+	0.071	+	+	+
Leptodiaptomus siciloides	+	0.273	0.167	+	+	0.083	+
Skistodiaptomus reighardi			+			0.083	+
Skistodiaptomus oregonensis	+	0.363	+	+	+	+	
Epischura lacustris	0.071	0.091	+	+	+	+	+
Epischura lacustris cop.	0.214	+	+	+	+	+	+

Table 22c. Cont'd

	W1		W2	W3		W6	W7
Taxon	1993	1998	1998	1993	1998	1998	1998
Eurytemora affinis	0.357	+	0.167	0.214	+	0.167	+
Limnocalanus macrurus	0.071	0.182	+	0.071	0.071	+	+
Senecella calanoides	+			+			
Calanoid copepodid	0.357	0.727	0.750	0.429	0.286	0.833	0.583
Calanoid nauplii	0.071	+	+	+	+	+	+
Cyclopoida							
Diacyclops thomasi	0.429	0.455	0.333	0.286	0.143	0.333	0.167
Cyclops vernalis	+	+	0.083	+	0.071	0.083	+
Mesocyclops edax	0.071	0.273	0.167	+	0.071	0.167	0.167
Tropocyclops extensus	+	+	+	+	0.214	0.083	0.250
Eucyclops agilus				+	+	+	+
Eucyclops speratus				+			
Cyclopoid copepodid	0.214	0.364	0.917	0.357	0.429	0.917	0.750
Cyclopoid nauplii	0.071	+	+	+	+	+	+
Harpactacoida	+			+	+		+
Dreissena veligers	0.643	0.272	0.417	0.571	0.714	0.666	0.417

Table 23a. Average densities (with standard errors, S.E.) for different benthic taxonomic groups at stations in the east basin of Lake Erie, 1998. Annual densities from 1993 are provided where available. Densities are number of individuals m^{-2}.

	E1		E2				E3				E4	
Species	1998	S.E.	1993	S.E.	1998	S.E.	1993	S.E.	1998	S.E.	1998	S.E.
Nematoda	5290	2587	8189	1468	12825	7065	10004	1291	16493	1778	12623	6818
Platyhelminthes/Nemertea	161	66	411	155	1710	540	395	64	495	0	945	405
Oligochaeta	3531	1111	20632	2529	22523	6008	3331	465	1845	90	11093	3308
Hirudinae	176	176	7	7	0	0	12	8	68	68	45	45
Amphipoda	104	28	0	0	0	0	1018	314	158	23	0	0
Isopoda	10	10	0	0	0	0	103	103	0	0	0	0
Ostracoda	19868	6260	4850	631	12915	4500	2139	678	5670	1080	8888	4253
Cladocera	0	0			0	0			0	0	135	135
Harpacticoida	10414	7125	1935	675	4118	1418	21440	6314	34290	5400	5535	2025
Ephemeroptera	66	28	0	0	0	0	9	9	0	0	0	0
Trichoptera	10	10	0	0	0	0	204	64	23	23	0	0
Chironomidae	1429	522	317	68	90	90	3078	416	1125	315	0	0
Gastropoda	76	19	9	7	0	0	1983	497	878	248	0	0
Sphaeriidae	57	19	257	82	225	45	108	34	158	113	0	0
Dreissena polymorpha	0	0	31	15	0	0	1906	723	29	23	0	0
Dreissena bugensis	95	38	91679	25691	24908	7448	69697	19331	37659	5198	49185	585
Total *Dreissena*	95	38	91710	25705	24908	7448	71603	19086	37688	5828	49185	585
% Quagga	100.0		99.9		100.0		97.3		99.9		100.0	
Total Benthos	41283	17677	128317	29009	79313	12218	115428	23732	98910	450	88448	7898
% *Dreissena*	0.2		71.5		31.4		62.0		38.1		55.6	

Table 23b. Average densities (with standard errors, S.E.) for different benthic taxonomic groups at stations in the east (E10, J11), east-central (EC) and central (C) basins of Lake Erie, 1998. Annual densities from 1993 are provided where available. Densities are number of individuals m^{-2}.

	E10		J11		EC1		EC2		C1		C2	
Species	1998	S.E.	1998	S.E.	1998	S.E.	1998	S.E.	1998	S.E.	1998	S.E.
Nematoda	2408	608	10265	5324	4001	2345	4694	3794	4811	2291	6161	2417
Platyhelminthes/Nemertea	428	158	306	306	203	113	23	23	45	45	68	68
Oligochaeta	6008	518	6278	563	11556	7524	11763	10053	4559	869	68778	15768
Hirudinae	0	0	135	0	68	68	45	0	0	0	0	0
Amphipoda	3263	788	3155	1328	23	23	0	0	0	0	0	0
Isopoda	68	23	486	171	0	0	0	0	0	0	1080	1080
Ostracoda	8640	1890	26361	18531	0	0	4212	2052	3060	2205	1566	522
Cladocera	2115	1305	522	522	0	0	540	540	1989	99	2156	1634
Harpacticoida	14310	3240	39150	23490	1071	549	22671	11781	50391	33651	55094	39956
Ephemeroptera	90	0	0	0	0	0	0	0	23	23	0	0
Trichoptera	45	0	360	90	0	0	0	0	0	0	0	0
Chironomidae	2565	450	8136	2313	1080	405	225	135	2070	495	360	135
Gastropoda	833	653	8789	5900	0	0	23	23	0	0	158	158
Sphaeriidae	0	0	23	23	0	0	0	0	23	23	4878	4878
Dreissena polymorpha	218	113	9576	7560	0	0	0	0	0	0	0	0
Dreissena bugensis	1334	248	0	0	4446	3744	6075	5535	10004	9419	11799	11754
Total *Dreissena*	1553	113	9576	7821	4446	3744	6075	5535	10004	9419	11799	11754
% Quagga	85.9		0.0		100.0		100.0		100.0		100.0	
Total Benthos	52718	15188	119894	22541		14792	50270	32585	76973	48128	151344	11709
% *Dreissena*	2.9		8.0		19.7		12.1		13.0		7.8	

Table 23c. Average densities (with standard errors, S.E.) for different benthic taxonomic groups at stations in the west-central (WC) and west (W) basins of Lake Erie, 1998. Annual densities from 1993 are provided where available. Densities are number of individuals m^{-2}.

	WC1				WC2				W2	
Species	1993	S.E.	1998	S.E.	1993	S.E.	1998	S.E.	1998	S.E.
Nematoda	805	370	6273	6228	4374	548	18329	7034	1553	248
Platyhelminthes/Nemertea	551	416	1044	1044	154	107	1733	194	360	226
Oligochaeta	6842	2343	21330	20835	10894	1702	10062	423	4005	3015
Hirudinae	7	5	0	0	6	6	0	0	0	0
Amphipoda	39	35	0	0	5	5	0	0	383	293
Isopoda	199	195	0	0	0	0	0	0	0	0
Ostracoda	3546	1636	522	522	4663	899	1962	873	0	0
Cladocera			0	0			0	0	1328	608
Harpacticoida	520	194	26213	26033	5528	497	53883	4347	2318	1373
Ephemeroptera	0	0	0	0	0	0	0	0	0	0
Trichoptera	0	0	0	0	0	0	0	0	0	0
Chironomidae	947	432	45	45	1197	170	968	248	180	0
Gastropoda	330	178	0	0	0	0	0	0	225	0
Sphaeriidae	29	14	23	23	2486	354	3960	630	0	0
Dreissena polymorpha	1546	892	32	23	88	13	0	0	12373	1575
Dreissena bugensis	11442	4487	4648	2385	201	47	657	567	7269	788
Total *Dreissena*	12988	4674	4680	3690	289	47	657	567	19643	18608
% Quagga	88.1		99.3		69.5		100.0		37.0	
Total Benthos	26801	8717	61241	52016	29595	2756	97416	16074	29993	24368
% *Dreissena*	48.5		7.6		1.0		0.7		65.5	

Table 23d. Average densities (with standard errors, S.E.) for different benthic taxonomic groups at stations in the west basin of Lake Erie, 1998. Annual densities from 1993 are provided where available. Densities are number of individuals m^{-2}.

	W1				W3				W6		W7	
Species	1993	S.E.	1998	S.E.	1993	S.E.	1998	S.E.	1998	S.E.	1998	S.E.
Nematoda	1680	427	5445	2430	3491	727	13635	810	3713	653	8888	698
Platyhelminthes/Nemertea	2	2	0	0	161	76	0	0	0	0	0	0
Oligochaeta	5382	951	1800	720	8126	1168	608	158	2070	45	810	180
Hirudinae	73	53	45	45	247	47	45	45	90	90	0	0
Amphipoda	25	16	0	0	325	173	0	0	23	23	0	0
Isopoda	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda	11103	1761	1755	135	3342	547	473	68	270	270	3645	135
Cladocera			13680	4590			675	360	6458	698	11475	3645
Harpacticoida	23717	3898	15098	518	13457	2007	945	270	6705	1170	5153	3803
Ephemeroptera	4	2	23	23	3	3	270	90	23	23	180	45
Trichoptera	12	12	0	0	20	9	23	23	0	0	23	23
Chironomidae	888	271	675	90	609	119	113	23	68	23	630	180
Gastropoda	4	2	45	0	305	97	0	0	23	23	0	0
Sphaeriidae	400	123	293	68	267	43	0	0	90	45	23	23
Dreissena polymorpha	2227	2104	0	0	31615	9006	90	45	0	0	0	0
Dreissena bugensis	0	0	0	0	6	4	45	23	0	0	0	0
Total *Dreissena*	2227	2104	0	0	31621	9008	135	135	0	0	0	0
% Quagga	0.0		0.0		0.0		33.3		0.0		0.0	
Total Benthos	45514	6740	38858	1913	61974	9178	16920	450	19530	135	30825	6570
% Dreissena	4.9		0.0		51.0		0.8		0.0		0.0	

Table 24a. Average biomass (with standard errors, S.E.) for different benthic taxonomic groups at stations in the east basin of Lake Erie, 1998. Biomass estimates from 1993 are provided where available. Biomass is wet, shell-free weight (g m^{-2}).

	E1		E2				E3				E4	
Species	1998	S.E.	1993	S.E.	1998	S.E.	1993	S.E.	1998	S.E.	1998	S.E.
Nematoda	0.369	0.022	0.155	0.020	0.241	0.125	0.171	0.030	0.338	0.044	0.075	0.010
Platyhelminthes/Nemertea	0.569	0.064	0.074	0.029	0.169	0.017	0.393	0.072	0.214	0.030	0.082	0.020
Oligochaeta	1.750	0.120	12.593	1.555	15.287	3.803	3.906	0.440	7.112	0.692	7.726	0.689
Hirudinae	0.190	0.190	0.004	0.004	0.000	0.000	0.090	0.064	0.595	0.595	0.266	0.266
Amphipoda	0.460	0.229	0.000	0.000	0.000	0.000	3.573	0.926	0.702	0.022	0.000	0.000
Isopoda	0.002	0.002	0.000	0.000	0.000	0.000	0.030	0.030	0.000	0.000	0.000	0.000
Ostracoda	5.312	2.225	0.143	0.021	1.609	0.197	0.055	0.016	0.366	0.134	0.988	0.316
Cladocera	0.000	0.000			0.000	0.000			0.000	0.000	0.005	0.005
Harpacticoida	0.286	0.246	0.022	0.006	0.055	0.035	0.177	0.047	0.234	0.088	0.049	0.000
Ephemeroptera	7.342	1.002	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000
Trichoptera	0.061	0.061	0.000	0.000	0.000	0.000	1.669	0.553	0.086	0.086	0.000	0.000
Chironomidae	6.711	1.482	0.114	0.054	0.004	0.004	2.653	0.479	1.641	0.126	0.000	0.000
Gastropoda	0.696	0.303	0.000	0.000	0.000	0.000	1.623	0.139	1.362	0.352	0.000	0.000
Sphaeriidae	0.022	0.014	0.092	0.048	0.019	0.018	0.039	0.011	0.104	0.035	0.000	0.000
Dreissena polymorpha	0.000	0.000	0.552	0.366	0.000	0.000	115.382	52.370	0.186	0.186	0.000	0.000
Dreissena bugensis	3.369	3.339	264.005	81.157	503.938	181.004	246.287	63.893	1669.424	210.917	518.996	295.965
Total *Dreissena*	3.369	3.369	264.557	79.321	503.938	181.212	361.669	111.460	1669.611	211.197	518.996	296.023
% Quagga	100.0		99.8		100.0		68.1		99.9		100.0	
Total Benthos	27.137	0.031	277.753	83.414	521.321	185.769	376.050	113.823	1682.418	209.829	528.188	296.094
% *Dreissena*	12.4		95.3		96.7		96.2		99.2		98.3	

Table 24b. Average biomass (with standard errors, S.E.) for different benthic taxonomic groups at stations in the east (E10, J11), east-central (EC) and central (C) basins of Lake Erie, 1998. Biomass estimates from 1993 are provided where available. Biomass is wet, shell-free weight (g m^{-2}).

	E10		J11		EC1		EC2		C1		C2	
Species	1998	S.E.	1998	S.E.	1998	S.E.	1998	S.E.	1998	S.E.	1998	S.E.
Nematoda	0.033	0.019	0.274	0.034	0.074	0.045	0.045	0.027	0.095	0.058	0.079	0.032
Platyhelminthes/Nemertea	0.273	0.191	0.098	0.098	0.068	0.001	0.094	0.094	0.126	0.126	0.086	0.086
Oligochaeta	4.510	3.638	5.534	3.605	6.731	5.183	3.329	2.233	1.085	0.668	50.947	45.816
Hirudinae	0.000	0.000	0.444	0.303	0.718	0.718	0.185	0.085	0.000	0.000	0.000	0.000
Amphipoda	4.109	0.279	6.006	2.929	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.000
Isopoda	0.253	0.040	0.552	0.182	0.000	0.000	0.000	0.000	0.000	0.000	4.784	4.784
Ostracoda	1.431	1.175	1.582	1.013	0.000	0.000	0.666	0.269	0.149	0.108	0.081	0.003
Cladocera	0.049	0.001	0.013	0.013	0.000	0.000	0.011	0.011	0.028	0.004	0.020	0.010
Harpacticoida	0.189	0.084	0.397	0.240	0.012	0.007	0.470	0.203	0.433	0.010	0.655	0.546
Ephemeroptera	0.361	0.228	0.000	0.000	0.000	0.000	0.000	0.000	2.613	2.613	0.000	0.000
Trichoptera	0.189	0.156	1.294	0.691	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chironomidae	1.724	0.382	6.130	2.882	1.382	0.930	0.518	0.261	0.323	0.040	4.441	1.789
Gastropoda	6.659	2.176	4.293	3.076	0.000	0.000	0.002	0.002	0.000	0.000	0.197	0.197
Sphaeriidae	0.000	0.000	0.093	0.093	0.000	0.000	0.000	0.000	0.013	0.013	2.200	2.200
Dreissena polymorpha	13.705	10.755	448.571	397.340	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dreissena bugensis	22.522	1.188	0.000	0.000	4.748	3.953	174.239	168.391	45.105	44.757	2759.41	2759.367
Total *Dreissena*	36.227	9.597	448.571	397.340	4.748	3.953	174.239	168.391	45.105	44.757	2759.41	2759.367
% Quagga	62.2		0.0		100.0		100.0		100.0		100.0	
Total Benthos	56.457	9.430	475.449	406.103	13.754	10.881	179.558	171.574	49.970	48.396	2822.94	2814.87
% *Dreissena*	64.2		94.4		34.5		97.0		90.3		97.8	

Table 24c. Average biomass (with standard errors, S.E.) for different benthic taxonomic groups at stations in the west-central (WC) and west (W) basins of Lake Erie, 1998. Biomass estimates from 1993 are provided where available. Biomass is wet, shell-free weight (g m^{-2}).

	WC1				WC2				W2	
Species	1993	S.E.	1998	S.E.	1993	S.E.	1998	S.E.	1998	S.E.
Nematoda	0.023	0.010	0.196	0.196	0.129	0.028	0.391	0.096	0.025	0.012
Platyhelminthes/Nemertea	0.050	0.031	0.073	0.073	0.076	0.055	0.289	0.039	0.235	0.201
Oligochaeta	1.649	0.426	8.136	7.727	6.647	1.185	9.768	0.217	1.164	0.857
Hirudinae	0.010	0.007	0.000	0.000	0.022	0.022	0.000	0.000	0.000	0.000
Amphipoda	0.112	0.106	0.000	0.000	0.002	0.002	0.000	0.000	0.428	0.069
Isopoda	0.066	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ostracoda	0.105	0.053	0.016	0.016	0.129	0.023	0.312	0.194	0.000	0.000
Cladocera			0.013	0.013			0.074	0.002	0.015	0.001
Harpacticoida	0.005	0.002	0.719	0.707	0.070	0.013	1.420	0.124	0.087	0.044
Ephemeroptera	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Trichoptera	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chironomidae	1.445	0.827	0.628	0.628	12.311	1.583	10.430	2.089	0.162	0.056
Gastropoda	0.291	0.126	0.000	0.000	0.000	0.000	0.000	0.000	0.434	0.158
Sphaeriidae	0.008	0.005	0.024	0.024	1.206	0.127	10.844	0.171	0.000	0.000
Dreissena polymorpha	347.630	161.074	0.000	0.000	0.263	0.218	0.000	0.000	421.825	315.012
Dreissena bugensis	416.490	171.375	22.476	13.318	5.147	3.875	0.064	0.044	434.409	281.615
Total *Dreissena*	764.120	244.813	22.476	13.558	5.410	3.995	0.064	0.044	856.235	598.748
% Quagga	54.5		100.0		95.2		100.0		50.7	
Total Benthos	767.884	247.250	32.287	9.203	26.002	5.630	33.654	1.666	858.783	599.719
% Dreissena	99.5		69.6		20.8		0.2		99.7	

Table 24d. Average biomass (with standard errors, S.E.) for different benthic taxonomic groups at stations in the west basin of Lake Erie, 1998. Biomass estimates from 1993 are provided where available. Biomass is wet, shell-free weight (g m^{-2}).

	W1				W3				W6		W7	
Species	1993	S.E.	1998	S.E.	1993	S.E.	1998	S.E.	1998	S.E.	1998	S.E.
Nematoda	0.064	0.031	0.161	0.102	0.081	0.018	0.215	0.002	0.084	0.009	0.157	0.046
Platyhelminthes/Nemertea	0.001	0.001	0.000	0.000	0.187	0.104	0.000	0.000	0.000	0.000	0.000	0.000
Oligochaeta	4.002	0.989	3.561	0.067	4.068	0.831	0.547	0.084	1.413	0.259	0.294	0.184
Hirudinae	0.094	0.033	0.433	0.433	0.752	0.154	0.217	0.217	0.373	0.373	0.000	0.000
Amphipoda	0.050	0.025	0.000	0.000	0.925	0.585	0.000	0.000	0.003	0.003	0.000	0.000
Isopoda	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ostracoda	0.286	0.046	0.049	0.008	0.076	0.018	0.029	0.009	0.010	0.010	0.127	0.005
Cladocera			0.484	0.341			0.031	0.014	0.200	0.096	0.257	0.144
Harpacticoida	0.222	0.031	0.366	0.155	0.109	0.020	0.129	0.078	0.190	0.007	0.189	0.181
Ephemeroptera	0.009	0.006	0.009	0.009	>0.000	>0.000	26.523	6.515	0.067	0.067	7.692	2.102
Trichoptera	0.031	0.031	0.000	0.000	0.039	0.021	0.188	0.188	0.000	0.000	0.138	0.138
Chironomidae	1.630	0.781	0.413	0.042	0.299	0.081	0.062	0.026	0.055	0.020	0.402	0.044
Gastropoda	0.014	0.009	0.221	0.056	0.656	0.273	0.000	0.000	0.079	0.079	0.000	0.000
Sphaeriidae	0.188	0.046	0.191	0.063	0.148	0.057	0.000	0.000	0.102	0.088	0.005	0.005
Dreissena polymorpha	64.800	64.416	0.000	0.000	624.100	249.577	1.381	1.380	0.000	0.000	0.000	0.000
Dreissena bugensis	0.000	0.000	0.000	0.000	0.001	0.001	10.970	10.959	0.000	0.000	0.000	0.000
Total *Dreissena*	64.800	65.599	0.000	0.000	624.101	254.033	12.351	12.351	0.000	0.000	0.000	0.000
% Quagga	0.0		0.0		0.0		88.8		0.0		0.0	
Total Benthos	71.393	66.669	5.887	0.711	631.440	250.533	40.293	18.680	2.576	0.624	9.260	2.279
% *Dreissena*	90.8		0.0		98.8		30.7		0.0		0.0	

Table 25. Mean density (no. m^{-2}) with standard error of dreissenid spp. at various depths in Lake Erie, 1998 estimated as the number of mussels retained on a 1 mm screen. n = number of replicates from all sites sampled.

Depth (m)	1993 n	1993 Dreissenid density		1993 Zebra mussel density		1993 Quagga mussel density		1993 % Quagga	1998 n	1998 Dreissenid density		1998 Zebra mussel density		1998 Quagga mussel density		1998 % Quagga
		mean	S.E.	mean	S.E.	mean	S.E.			mean	S.E.	mean	S.E.	mean	S.E.	
0-5	0	na	na	na	na	na	na	na	13	2927	1180	2334	123	591	541	20.2
5-10	30	1336	590	742	293	594	395	44.5	12	6419	3463	0	0	6419	3463	100.0
10-20	52	3206	921	1557	404	1649	640	51.4	26	3233	1090	143	130	3089	1090	95.5
20-30	34	1858	581	408	159	1450	463	78.0	12	3431	1535	0	0	3431	1535	100.0
30+	15	5217	1362	8	8	5208	1364	99.8	12	3172	882	0	0	3172	882	100.0
Lakewide	131	2658	454	895	184	1763	349	66.3	75	3712	746	455	234	3257	734	87.7

Table 26a. Average invertebrate densities (no. m^{-2}) with standard error in the east basin of Lake Erie, at depths <15m, for 1993 (n=3) and 1998 (n=8). Included are stations E3, 933, 942. Mean depths for each year were 12.6 m and 13.2 m, respectively. Significant differences between years (t_{crit}=2.26 ; df 9) are indicated with an asterisk followed by the p-value. Prefixes include: P = phylum, Cl = class, O = order, F = family, SF = sub-family, and T=tribe.

	1993		1998		
	mean	S.E.	mean	S.E.	
P. Coelenterata *Hydra*	0	0	65	65	
P. Nematoda C. Adenophora	6150	3698	6557	2514	
P. Platyhelminthes	30	30	293	100	
P. Nemertea *Prostoma*	45	45	0	0	
Cl. Oligochaeta	3060	1838	4070	2505	
F. Enchytraeidae	0	0			
F. Naididae	735	735	28	28	
F. Tubificidae	2160	1196	4031	2592	
F. Lumbricidae *Sparganophilus*	810	385	11	7	* p<0.01
F. Lumbriculidae *Stylodrilus*	165	165	0	0	
Cl. Polychaeta *Manayunkia speciosa*	0	0	0	0	
Cl. Hirudinae	0	0	17	17	
O. Hydracharina	0	0	0	0	
O. Harpacticoida	11700	10900	10693	5416	
Cl. Ostracoda	540	540	2304	881	
O. Amphipoda	270	206	79	30	
F. Haustoridae *Diporeia*	0	0	0	0	
F. Gammaridae	270	206	79	30	
O. Isopoda F. Caecidotea	0	0	6	6	
O.Ephemeroptera *Hexagenia*	0	0	0	0	
O. Trichoptera	15	15	6	6	
F. Chironomidae	600	397	695	204	
Pupae Chironomid	30	30	17	12	
T. Chironomini	540	375	405	169	
T. Tanytarsini	0	0	71	65	
S.F. Diamesinae	0	0	0	0	
S.F. Orthocladiinae	0	0	17	12	
S.F. Tanypodinae	30	30	180	69	
Cl. Gastropoda	90	69	270	143	
F. Hydrobiidae	45	26	68	26	
F. Planorbidae	30	30	17	12	
F. Pleuroceridae *Elimia*	15	15	0	0	
F. Physidae *Physella*	0	0	0	0	
F. Valvatidae	0	0	186	124	
F. Sphaeriidae	0	0	79	47	
Pisidium	0	0	62	37	
Sphaerium	0	0	17	12	
F. Dreissenidae	13890	6572	73002	26476	
Dreissena polymorpha > 1mm	4245	2172	11	7	
Dreissena bugensis > 1mm	4950	2842	14529	4282	
Dreissena spp. <1mm	4695	2455	58462	28468	* p<0.001
Total Number m^{-2}	36390	17594	98331	23903	* p<0.001
Total Meofauna[1]	18390	11215	19950	8566	
Total Macrofauna – Dreissena	4110	2070	5379	2726	

[1] Meofauna include Hydra, Nematoda, Nematomorpha, Tardigrada, Polychaeta, Hydracarina, Harpacticoida and Ostracoda.

Table 26b. Average invertebrate densities (no. m^{-2}, with standard error) in the east basin of Lake Erie, at depths >15m, for 1993 (n=3) and 1998 (n=5). Included are stations E2, E4, 940. Mean depths for each year were 46.5m and 48.4 m, respectively. Significant differences between years (t_{crit}=2.44 ; df 6) are indicated with an asterisk followed by the p-value in brackets. Prefixes include: P = phylum, Cl = class, O = order, F = family, SF = sub-family, and T=tribe.

	1993		1998		
	mean	S.E.	mean	S.E.	
P. Coelenterata *Hydra*	0	0	0	0	
P. Nematoda C. Adenophora	~~55588~~	~~7287~~	12051	3177	
P. Platyhelminthes	0	0	1062	381	
P. Nemertea *Prostoma*	0	0	0	0	
Cl. Oligochaeta	10393	2726	16389	3378	
F. Enchytraeidae	0	0			
F. Naididae	345	345	0	0	
F. Tubificidae	8323	3391	16389	3378	
F. Lumbricidae *Sparganophilus*	0	0	0	0	
F. Lumbriculidae *Stylodrilus heringianus*	1553	1553	0	0	
Cl. Polychaeta *Manayunkia speciosa*	0	0	0	0	
Cl. Hirudinae	0	0	18	18	
O. Hydracharina	0	0	0	0	
O. Harpacticoida	4140	791	4158	1076	
Cl. Ostracoda	5822	1077	10107	2297	
O. Amphipoda	0	0	0	0	
F. Haustoridae *Diporeia*	0	0	0	0	
F. Gammaridae	0	0	0	0	
O. Isopoda :Caecidotea	0	0	0	0	
O.Ephemeroptera: *Hexagenia*	0	0	0	0	
O. Trichoptera	0	0	0	0	
F. Chironomidae	173	114	54	36	
Pupae Chironomid	0	0	0	0	
T. Chironomini	173	114	0	0	* p<0.10
T. Tanytarsini	0	0	0	0	
S.F. Diamesinae	0	0	0	0	
S.F. Orthocladiinae	0	0	9	9	
S.F. Tanypodinae	0	0	45	29	
Cl. Gastropoda	0	0	0	0	
F. Hydrobiidae	0	0	0	0	
F. Planorbidae	0	0	0	0	
F. Pleuroceridae *Elimia*	0	0	0	0	
F. Physidae *Physella*	0	0	0	0	
F. Valvatidae	0	0	0	0	
F. Sphaeriidae	259	149	90	57	
Pisidium	259	149	90	57	
Sphaerium	0	0	0	0	
F. Dreissenidae	71760	41060	30681	8693	
Dreissena polymorpha > 1mm	86	86	0	0	
Dreissena bugensis > 1mm	9660	4458	4077	1518	
Dreissena spp. < 1mm	62014	37552	26604	8013	* p<0.001
Total Number m^{-2}	150024	40872	74664	10501	* p<0.10
Total Meofauna[1]	67448	7718	27432	5133	
Total Macrofauna – Dreissena	10817	2704	16551	3446	

[1] Meofauna include Hydra, Nematoda, Nematomorpha, Tardigrada, Polychaeta, Hydracarina, Harpacticoida and Ostracoda.

Table 26c. Average invertebrate densities (no. m^{-2}, with standard error) in the central basin of Lake Erie, at depths <15m, for 1993 (n=3) and 1998 (n=6). Included are stations EC1, C1, 956. Mean depths for each year were 9.7 m and 10.7 m, respectively. Significant differences between years (t_{crit}=2.36 ; df 7) are indicated with an asterisk followed by the p-value in brackets. Prefixes include: P = phylum, Cl = class, O = order, F = family, SF = sub-family, and T=tribe.

	1993		1998		
	mean	S.E.	mean	S.E.	
P. Coelenterata: *Hydra*	45	45	0	0	
P. Nematoda Cl. Adenophora	5835	4684	3122	1182	
P. Tardigrada	0	0	0	0	
Cl. Turbellaria	0	0	263	170	
P. Nemertea *Prostoma*	0	0	0	0	
Cl. Oligochaeta	2955	1435	6594	2514	
F. Enchytraeidae	0	0			
F. Naididae	1215	1215	0	0	
F. Tubificidae	1740	1267	6414	2353	
F. Lumbriculidae	0	0	180	163	
Cl. Polychaeta	0	0	0	0	
Cl. Hirudinae	0	0	23	23	
O. Hydracharina *Hydracarina*	0	0	0	0	
O. Harpacticoida	2370	1381	17184	13631	
Cl. Ostracoda	1515	897	1050	854	
O. Amphipoda	60	40	8	8	* p<0.10
O. Isopoda *Caecidotea*	0	0	0	0	
O. Ephemeroptera *Hexagenia*	0	0	8	8	
O. Trichoptera	15	15	0	0	
F. Chironomidae	330	227	1088	394	
T. Chironomini	255	212	345	235	
T. Tanytarsini	0	0	8	8	
S.F. Diamesinae			75	50	
S.F. Orthocladiinae	0	0	0	0	
S.F. Tanypodinae	75	40	578	204	
Cl. Gastropoda	0	0	0	0	
F. Hydrobiidae	0	0	0	0	
F. Planorbidae *Gyraulus*	0	0	0	0	
F. Pleuroceridae	0	0	0	0	
F. Physidae *Physella*	0	0	0	0	
F. Valvatidae *Valvata*	0	0	0	0	
F. Sphaeriidae	0	0	8	8	
Pisidium	0	0	8	8	
Sphaerium	0	0	0	0	
F. Dreissenidae	45	26	5256	3072	
Dreissena polymorpha > 1mm	15	15	0	0	
Dreissena bugensis > 1mm	30	30	2715	1603	* p<0.10
Dreissena spp. < 1mm	0	0	2541	1824	
Total Number m^{-2}	13185	6659	35286	18749	
Total Meofauna[1]	9765	5222	22116	15647	
Total Macrofauna - Dreissena	3375	1577	7914	2618	

[1] Meofauna include Hydra, Nematoda, Nematomorpha, Tardigrada, Polychaeta, Hydracarina, Harpacticoida and Ostracoda.

Table 26d. Average invertebrate densities (no. m^{-2}, with standard error) in the central basin of Lake Erie, at depths >15m, for 1993 (n=6) and 1998 (n=11). Included are stations WC1, WC2, 944, 945, 952, 954 . Mean depths were 20.2 m and 20.9 m, respectively. Significant differences between years (t_{crit}=2.12 ; df 16) are indicated with an asterisk followed by the p-value in brackets. Prefixes include: P = phylum, Cl = class, O = order, F = family, SF = sub-family, and T=tribe.

	1993		1998		
	mean	S.E.	mean	S.E.	
P. Coelenterata *Hydra*	78	78	80	59	
P. Nematoda Cl. Adenophora	12458	4905	7015	2304	
P. Tardigrada	126	86	237	191	
Cl. Turbellaria	94	53	599	252	
P. Nemertea *Prostoma*	0	0	0	0	
Cl. Oligochaeta	8466	877	24594	8470	
F. Enchytraeidae	0	0	0	0	
F. Naididae	1906	1233	69	52	* p<0.10
F. Tubificidae	6283	1860	24608	8498	
F. Lumbriculidae	45	45			
Cl. Polychaeta *Manayunkia speciosa*	0	0	0	0	
Cl. Hirudinae	17	15	8	6	
O. Hydracharina *Hydracarina*	1	1	0	0	
O. Harpacticoida	32556	12527	31271	9130	
Cl. Ostracoda	4746	1710	1928	519	* p<0.10
O. Amphipoda	59	27	4	4	* p<0.05
O. Isopoda F. Asellidae *Caecidotea*	77	77	196	196	
O. Ephemeroptera *Hexagenia*	0	0	0	0	
O. Trichoptera	0	0	0	0	
F. Chironomidae	816	237	397	112	* p<0.10
T. Chironomini	324	197	246	101	
T.Tanytarsini	0	0	12	12	
S.F. Diamesinae	0	0	16	13	
S.F. Orthocladiinae	0	0	0	0	
S.F. Tanypodinae	15	15	70	24	
Cl. Gastropoda	58	49	45	29	
F. Hydrobiidae	0	0	0	0	
F. Planorbidae *Gyraulus*	0	0	0	0	
F. Pleuroceridae	0	0	0	0	
F. Physidae *Physella*	0	0	4	4	
F. Valvatidae *Valvata*	8	8	41	28	
F. Sphaeriidae	1544	854	1746	934	
Pisidium	979	797	1435	827	
Sphaerium	0	0	311	167	
F. Dreissenidae	5955	3831	19239	14219	
Dreissena polymorpha > 1mm	1066	703	4	4	
Dreissena bugensis > 1mm	926	740	3620	1995	
Dreissena spp. < 1mm	3962	3023	15614	12820	
Total Number m^{-2}	67537	16266	88921	17213	
Total Meofauna[1]	49965	18343	42628	11710	
Total Macrofauna – Dreissena	11617	1541	27054	9202	

[1] Meofauna include Hydra, Nematoda, Nematomorpha, Tardigrada, Polychaeta, Hydracarina, Harpacticoida and Ostracoda.

Table 26e. Average invertebrate densities (no. m^{-2}, with standard error) in the west basin of Lake Erie, for 1993 (n=18) and 1998 (n=8). Included are stations W1, W3, 967, 971. Mean depths for each year were 20.2 m and 20.9 m, respectively. Significant differences between years (t_{crit}=2.08 ; df 24) are indicated with an asterisk followed by the p-value in brackets. Prefixes include: P = phylum, Cl = class, O = order, F = family, SF = sub-family, and T=tribe.

	1993		1998		
	mean	S.E.	mean	S.E.	
P. Coelenterata *Hydra*	867	847	0	0	
P. Nematoda Cl. Adenophora	3776	962	6117	1878	
P. Tardigrada	0	0	0	0	
P. Platyhelminthes	67	48	6	6	
P. Nemertea *Prostoma*	99	86	0	0	
Cl. Oligochaeta	6918	1080	1935	564	* p<0.01
F. Enchytraeidae	0	0	0	0	
F. Naididae	1444	354	0	0	* p<0.05
F. Tubificidae	5136	875	1935	564	* p<0.05
F. Lumbricidae *Sparganophilus*	0	0	0	0	
F. Lumbriculidae	0	0	0	0	
Cl. Polychaeta *Manayunkia speciosa*	604	540	0	0	
Cl. Hirudinae	292	107	45	17	
O. Hydracharina *Hydracarina*	0	0	0	0	
O. Harpacticoida	36220	11363	6148	2086	* p<0.10
Cl. Ostracoda	10671	2470	658	252	* p<0.05
O. Amphipoda	191	87	6	6	
Gammarus	191	87	0	0	
Echinogammarus	0	0	6	6	
O. Isopoda *Caecidotea*	7	7	0	0	
O. Ephemeroptera *Hexagenia*	17	10	90	43	* p<0.05
O. Trichoptera	27	13	6	6	
F. Chironomidae	1393	253	529	130	* p<0.05
Pupae Chironomid	3	3	6	6	
T. Chironomini	787	231	118	50	* p<0.10
T. Tanytarsini	35	19	0	0	
S.F. Orthocladiinae	29	17	6	6	
S.F. Tanypodinae	539	127	383	96	
Cl. Gastropoda	58	33	28	12	
F. Hydrobiidae	47	32	11	11	
F. Planorbidae	0	0	0	0	
F. Pleuroceridae *Elimia*	0	0	0	0	
F. Physidae *Physella*	5	5	0	0	
F. Valvatidae	69	27	19	9	
F. Sphaeriidae	383	106	141	65	
Pisidium	329	96	124	66	
Sphaerium	55	25	17	12	
F. Dreissenidae	13583	8309	39	33	
Dreissena polymorpha > 1mm	10467	6492	17	12	
Dreissena bugensis > 1mm	0	0	5	5	
Dreissena spp. < 1mm	3117	1868	17		
Total Number m^{-2}	74700	15813	19640	4419	* p<0.05
Total Meofauna[1]	51634	13668	16822	4542	
Total Macrofauna - Dreissena	9483	1302	2779	653	

[1] Meofauna include Hydra, Nematoda, Nematomorpha, Tardigrada, Polychaeta, Hydracarina, Harpacticoida and Ostracoda.

Table 27. Density of *Diporeia hoyi* (no. m^{-2}) at Lake Erie sites with depths • 27 m sampled in 1979, 1992-1993, and 1998.

Site (depth) / 1979 equivalent	1979[1]	1992-1993		1998
	no. m^{-2}	no. m^{-2}	S.E.	no. m^{-2}
930 (58)/ L29	1380	810	84.8	0
934 (28)/ O33	0	0	0	0
E2 (40)/ N29	3420	30	0	0
E4 (57)/ N30	1560	0	0	0
940 (48)/ L30	30	52	22.2	0
M29 (46)/ M29	2520	1995	285	0
EC2 (27)/ M23	30	0	0	0

[1] 1979-data from (Dermott and Kerec, 1997).

Table 28. Frequency of occurrence of different prey items in the stomach contents of young-of-the-year yellow perch collected from sites in the east (E), east-central (EC) and west (W) basins of Lake Erie in 1998. Frequency of occurrence is defined as the percentage of all stomachs from a given site, on a given day in which each prey category occurred.

	E5						EC1	W1		W7			
	Jul 15	Jul 30	Aug 10	Aug 27	Sep 10	Sep 24	Aug 4	Jul16	Aug 26	Jul 17	Jul 29	Aug 12	Aug 26
Copepod	86.7	90.0	90.0	95.0	93.3	80.0	100.0	100.0	100.0	85.7	95.5	100.0	0.0
Copepod nauplii	23.3	23.3	0.0	100.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnid	0.0	30.0	16.7	0.0	53.3	43.3	3.3	50.0	6.7	71.4	90.9	100.0	33.3
Bosminid	46.7	30.0	50.0	65.0	40.0	33.3	100.0	87.5	13.3	100.0	100.0	85.7	0.0
Bythotrephes sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.8	0.0	0.0
Leptodora sp.	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.4	50.0	7.1	0.0
Chydoridae	60.0	66.7	70.0	85.0	100.0	93.3	3.3	6.3	20.0	14.3	0.0	0.0	0.0
Sitidae	50.0	83.3	83.3	0.0	96.7	56.7	0.0	37.5	33.3	85.7	63.6	85.7	33.3
Polyphemus sp.	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	0.0	0.0
Amphipoda	53.3	56.7	60.0	20.0	16.7	30.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
Diptera	40.0	40.0	56.7	65.0	46.7	30.0	6.7	18.8	73.3	0.0	4.6	0.0	66.7
Insect*	3.3	10.0	10.0	5.0	13.3	10.0	3.3	0.0	0.0	0.0	0.0	0.0	33.3
Tricoptera	10.0	30.0	20.0	0.0	16.7	26.7	0.0	0.0	6.7	0.0	0.0	0.0	0.0
Isopoda	16.7	6.7	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hirudinea	6.7	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nematoda	0.0	3.3	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nemertea	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ostracoda	10.0	0.0	0.0	45.0	40.0	53.3	3.3	0.0	20.0	0.0	0.0	0.0	0.0
Gastropoda	16.7	0.0	0.0	0.0	16.7	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerid clam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0
Dreisenna spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0
D. veligers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
larval fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	9.1	7.1	100.0

* Unidentified, non-dipteran insect larvae, in many cases Ephemeroptera

Table 29. Percent of total number of prey items represented by a given taxon in the stomach contents of young-of-the-year yellow perch collected from sites in the east (E), east-central (EC) and west (W) basins of Lake Erie in 1998. Percentage of the total (number) is defined as the percentage that each prey category contributed to the total number of prey items in all stomachs at a particular site on a particular day.

	E5						EC1	W1		W7			
	Jul 15	Jul 30	Aug 10	Aug 27	Sep 10	Sep 24	Aug 4	Jul 16	Aug 26	Jul 17	Jul 29	Aug 12	Aug 26
Copepod	47.1	51.8	14.6	8.9	69.5	39.9	64.7	95.1	93.4	44.6	65.6	73.5	0.0
Copepod nauplii	2.5	2.3	0.0	0.0	>0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnid	0.0	1.1	0.5	0.0	7.4	7.0	>0.0	1.4	>0.0	32.4	27.6	20.9	6.7
Bosminid	35.8	3.7	29.4	72.4	6.5	3.6	35.3	1.4	0.1	7.2	4.8	2.9	0.0
Bythotrephes sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Leptodora sp.	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.4	0.1	0.0
Chydoridae	3.7	4.3	3.3	1.8	7.9	25.6	>0.0	>0.0	0.1	0.2	0.0	0.0	0.0
Sitidae	3.0	27.1	44.8	15.3	7.0	9.2	0.0	1.8	0.2	11.7	0.8	2.5	6.7
Polyphemus sp.	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Amphipoda	3.7	5.7	4.2	0.1	0.1	1.2	0.0	0.0	0.0	0.0	>0.0	0.0	0.0
Diptera	0.8	1.8	1.6	0.9	0.8	4.4	>0.0	0.2	5.8	0.0	0.2	0.0	13.3
Insect*	>0.0	0.4	0.1	>0.0	0.1	0.3	>0.0	0.0	0.0	0.0	0.0	0.0	6.7
Tricoptera	0.2	1.7	0.4	0.0	0.1	1.1	0.0	0.0	>0.0	0.0	0.0	0.0	0.0
Isopoda	0.2	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hirudinea	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nematoda	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nemertea	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ostracoda	0.1	0.0	0.0	0.6	0.6	6.1	>0.0	0.0	0.2	0.0	0.0	0.0	0.0
Gastropoda	0.4	0.0	0.0	0.0	0.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerid clam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>0.0	0.0	0.0	0.0	0.0
Dreisenna spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
D. veligers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
larval fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.1	0.1	66.7
Other†	0.5	0.0	0.7	>0.0	>0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0

* unidentified, non-diptera insect larvae, in many cases Ephemeroptera.

† unidentified invertebrates.

Table 30. Percent of total biomass of all prey items represented by a given taxon in the stomach contents of young-of-the-year yellow perch collected from sites in the east (E), east-central (EC) and west (W) basins of Lake Erie in 1998. Percentage of the total (biomass) is defined as the percentage that each prey category contributed to the total volume of prey items in all stomachs at a particular site on a particular day.

	E5						EC1	W1		W7			
	Jul 15	Jul 30	Aug 10	Aug 27	Sep 10	Sep 24	Aug 4	Jul16	Aug 26	Jul 17	Jul 29	Aug 12	Aug 26
Copepod	8.8	4.8	2.0	2.4	27.6	0.0	35.0	91.5	46.4	24.8	46.9	11.2	0.0
Copepod nauplii	>0.0	>0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnid	0.0	0.6	0.2	0.0	3.5	1.7	0.1	2.1	0.0	54.5	42.0	7.8	0.7
Bosminid	13.1	0.1	8.0	73.2	2.9	0.2	63.4	0.3	0.0	4.3	5.0	0.3	0.0
Bythotrephes sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
Leptodora sp.	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	1.1	0.1	0.0
Chydoridae	0.3	0.8	1.3	3.1	40.2	33.1	0.4	1.1	0.3	1.6	0.0	0.0	0.0
Sitidae	2.2	12.4	18.4	13.0	10.7	7.7	0.0	1.8	0.2	5.9	0.5	0.4	0.2
Polyphemus sp.	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Amphipoda	28.9	41.5	51.7	0.5	0.9	10.8	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Diptera	11.6	5.2	5.7	7.6	10.1	20.6	1.1	3.2	50.9	0.0	0.9	0.0	13.9
Insect*	0.7	1.1	0.4	0.2	0.5	0.8	0.1	0.0	0.0	0.0	0.0	0.0	12.7
Tricoptera	2.0	12.5	3.2	0.0	1.8	11.1	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Isopoda	30.0	21.1	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hirudinea	>0.0	0.0	0.0	0.0	0.0	>0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nematoda	0.0	>0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nemertea	0.0	0.0	0.0	0.0	0.0	>0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ostracoda	>0.0	0.0	0.0	0.2	0.2	1.6	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Gastropoda	0.9	0.0	0.0	0.0	1.6	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerid clam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
Dreisenna spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>0.0	0.0	0.0	0.0
D. veligers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
larval fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.2	0.0	72.5
Other†	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.2	0.0

* unidentified, non-dipteran insect larvae, in many cases Ephemeroptera.
† unidentified invertebrates.

Table 31. The average percent of the total prey biomass represented by a given prey taxon in the stomach contents of young-of-the-year yellow perch collected from sites in the east (E), east-central (EC) and west (W) basins of Lake Erie in 1998. Average of the biomass percentages is defined as the average percentage that each prey category contributed to the total volume of prey items in each stomachs at a particular site on a particular day.

	E5						EC1	W1		W7			
	Jul 15	Jul 30	Aug 10	Aug 27	Sep 10	Srp 24	Aug 4	Jul 16	Aug 26	Jul 17	Jul 29	Aug 12	Aug 26
Copepod	28.3	26.5	4.2	6.5	28.8	14.5	69.8	91.4	60.6	31.1	49.4	57.5	0.0
Copepod nauplii	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnid	0.0	1.4	0.2	0.0	4.5	2.6	0.4	1.9	0.0	38.0	30.6	32.0	2.0
Bosminid	12.7	1.1	12.3	20.2	3.4	1.7	28.2	0.3	0.0	7.4	3.1	1.5	0.0
Bythotrephes sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
Leptodora sp.	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	3.2	0.1	0.0
Chydoridae	0.9	2.1	2.3	10.6	28.2	36.4	0.3	0.6	0.2	1.1	0.0	0.0	0.0
Sitidae	4.7	24.2	32.3	34.2	12.4	10.2	0.0	1.1	0.5	7.0	0.4	1.9	0.6
Polyphemus sp.	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Amphipoda	26.3	22.5	28.2	2.0	1.5	6.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Diptera	8.2	7.6	12.5	25.6	15.3	10.4	1.1	4.7	35.7	0.0	4.5	0.0	21.5
Insect*	2.8	0.5	0.5	0.4	0.7	2.0	0.1	0.0	0.0	0.0	0.0	0.0	10.8
Tricoptera	2.8	10.2	3.5	0.0	3.4	9.3	0.0	0.0	2.6	0.0	0.0	0.0	0.0
Isopoda	5.9	3.2	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hirudinea	>0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nematoda	0.0	>0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nemertea	0.0	0.0	0.0	0.0	0.0	>0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ostracoda	>0.0	0.0	0.0	0.6	0.3	1.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Gastropoda	2.2	0.0	0.0	0.0	1.5	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerid clam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Dreisenna spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
D. veligers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Larval fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	3.6	>0.0	65.2
Other†	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0

* unidentified, non-dipteran insect larvae, in many cases Ephemeroptera.

† unidentified invertebrates.

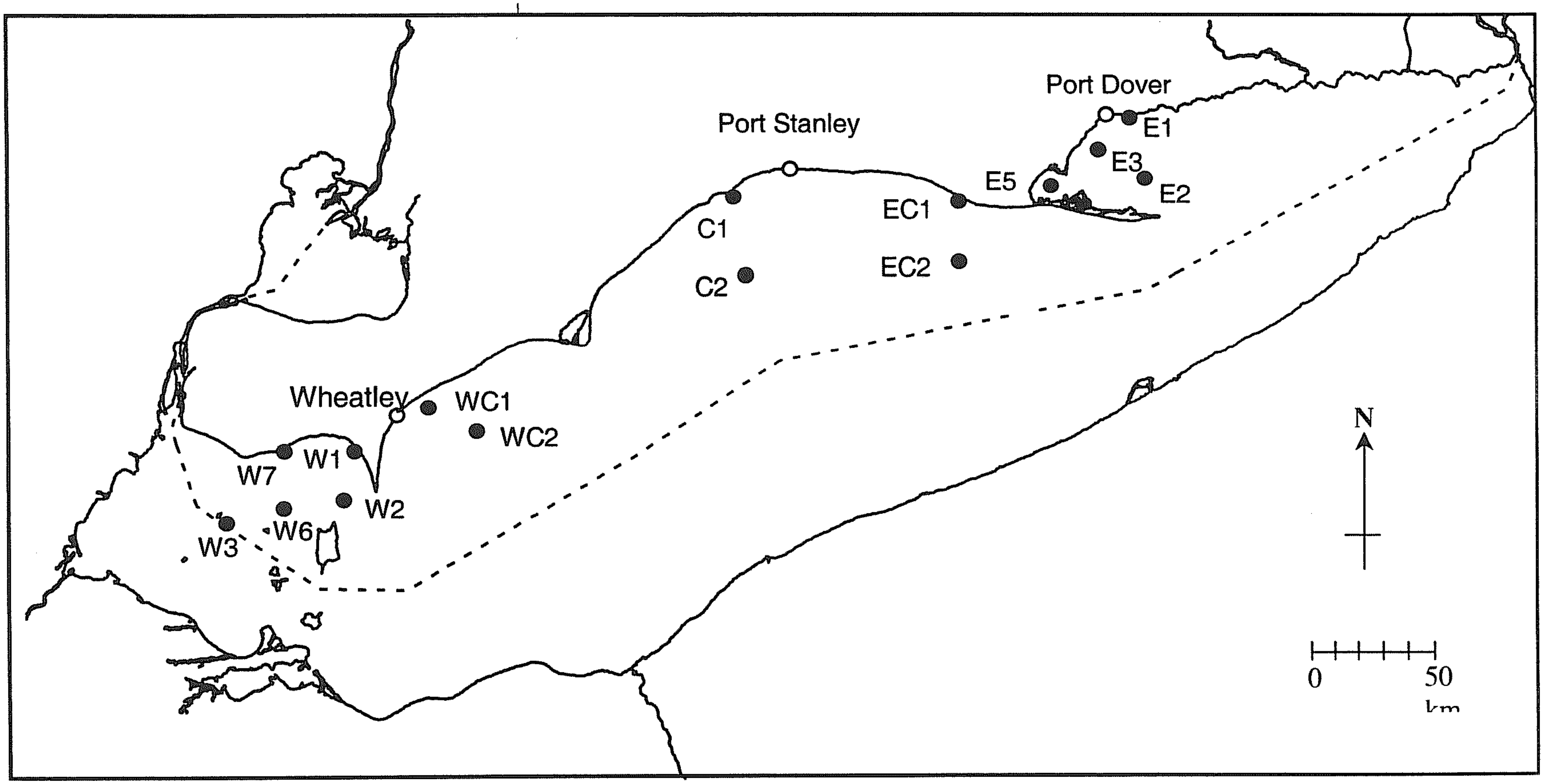


Figure 1. Lake Erie sampling stations in 1998. E = east basin, EC = east-central basin, C = central basin, WC = west-central basin, and W = west basin. Dotted line denotes the international boundary.

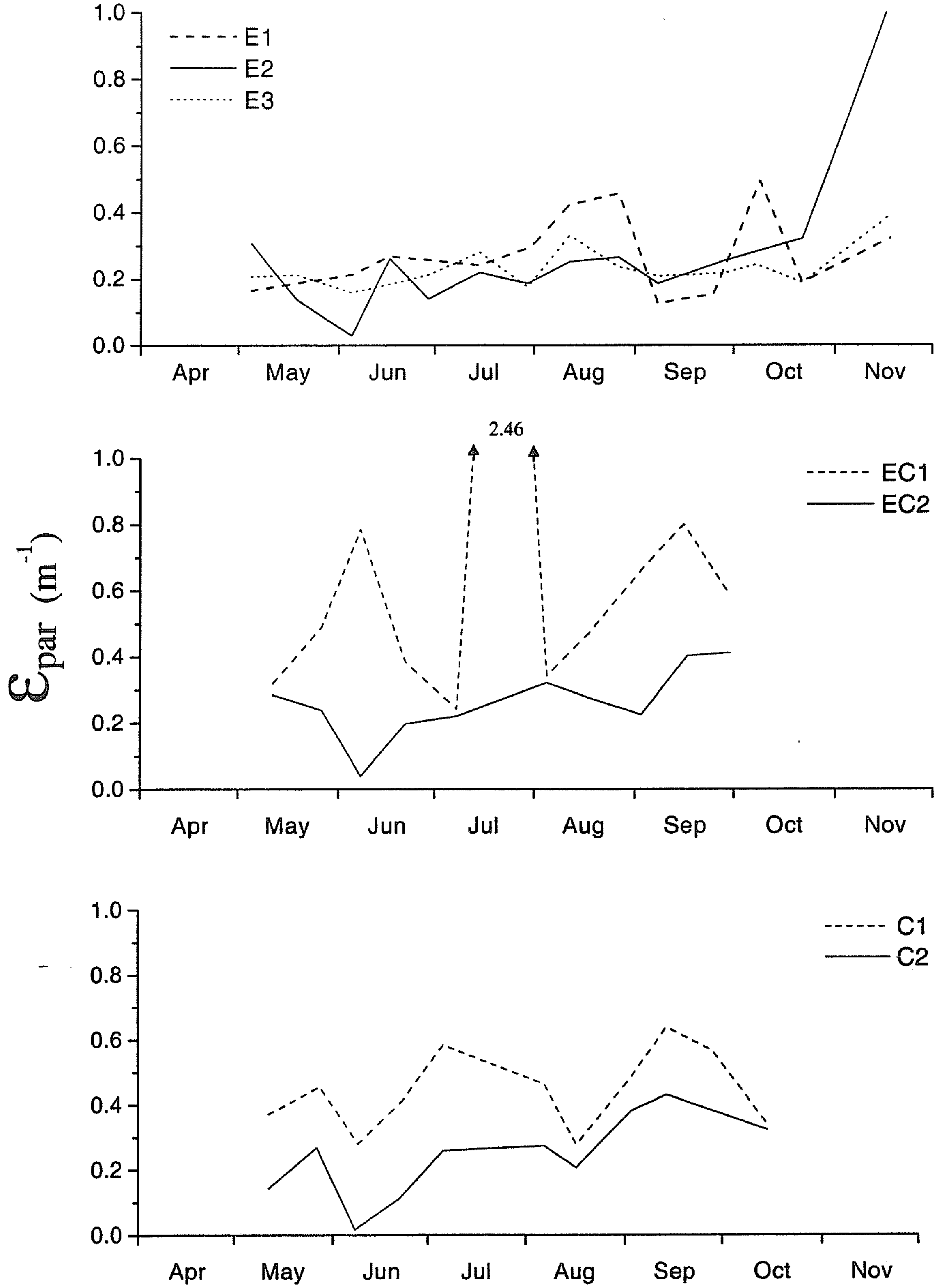


Figure 2a. Seasonal light extinction (ε_{par}) at nearshore (broken lines) and offshore (solid lines) stations in the east, east-central and central basins of Lake Erie, 1998.

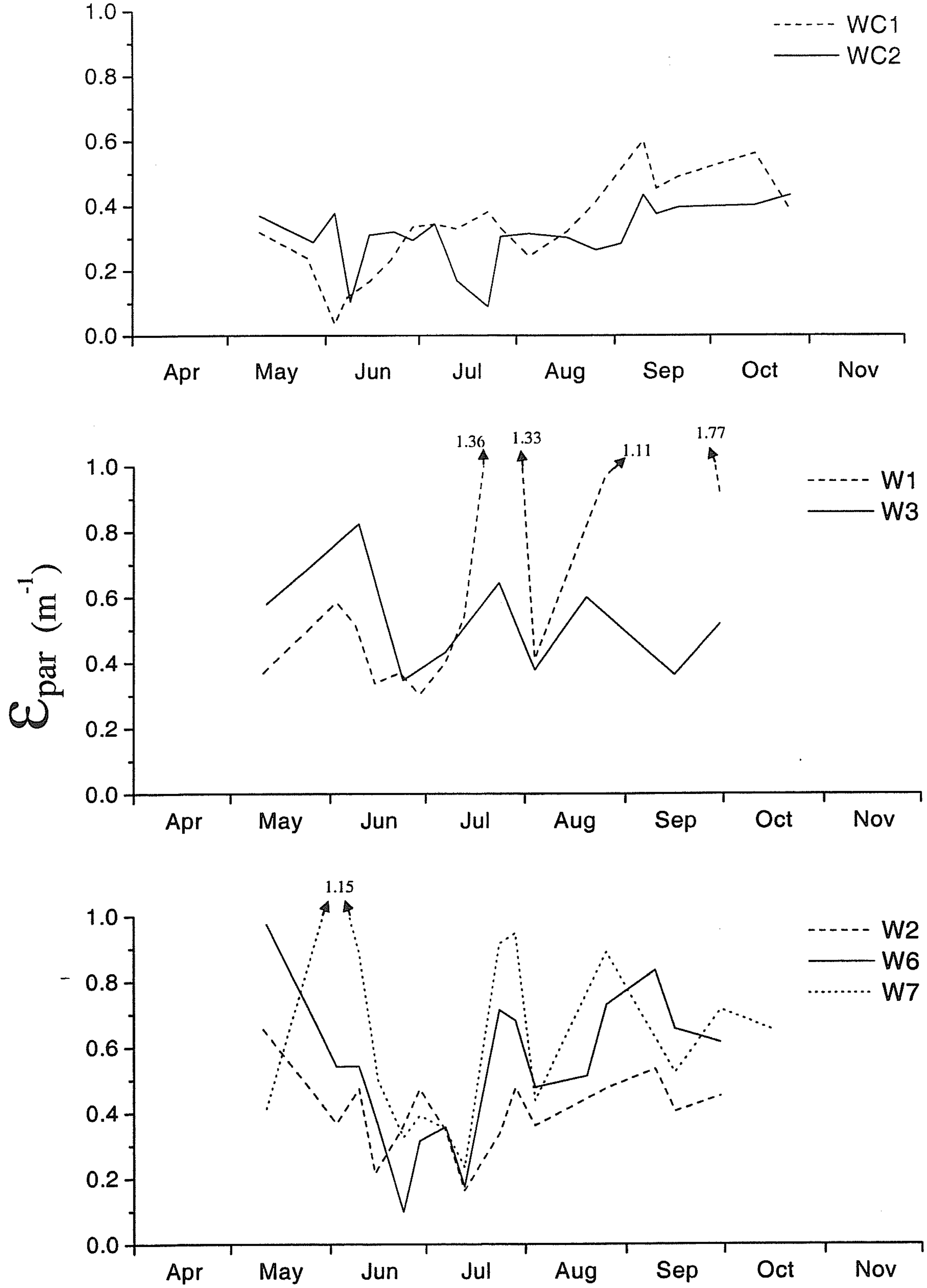


Figure 2b. Seasonal light extinction (εpar) at nearshore (broken lines) and offshore (solid lines) stations in the west-central and west basins of Lake Erie, 1998.

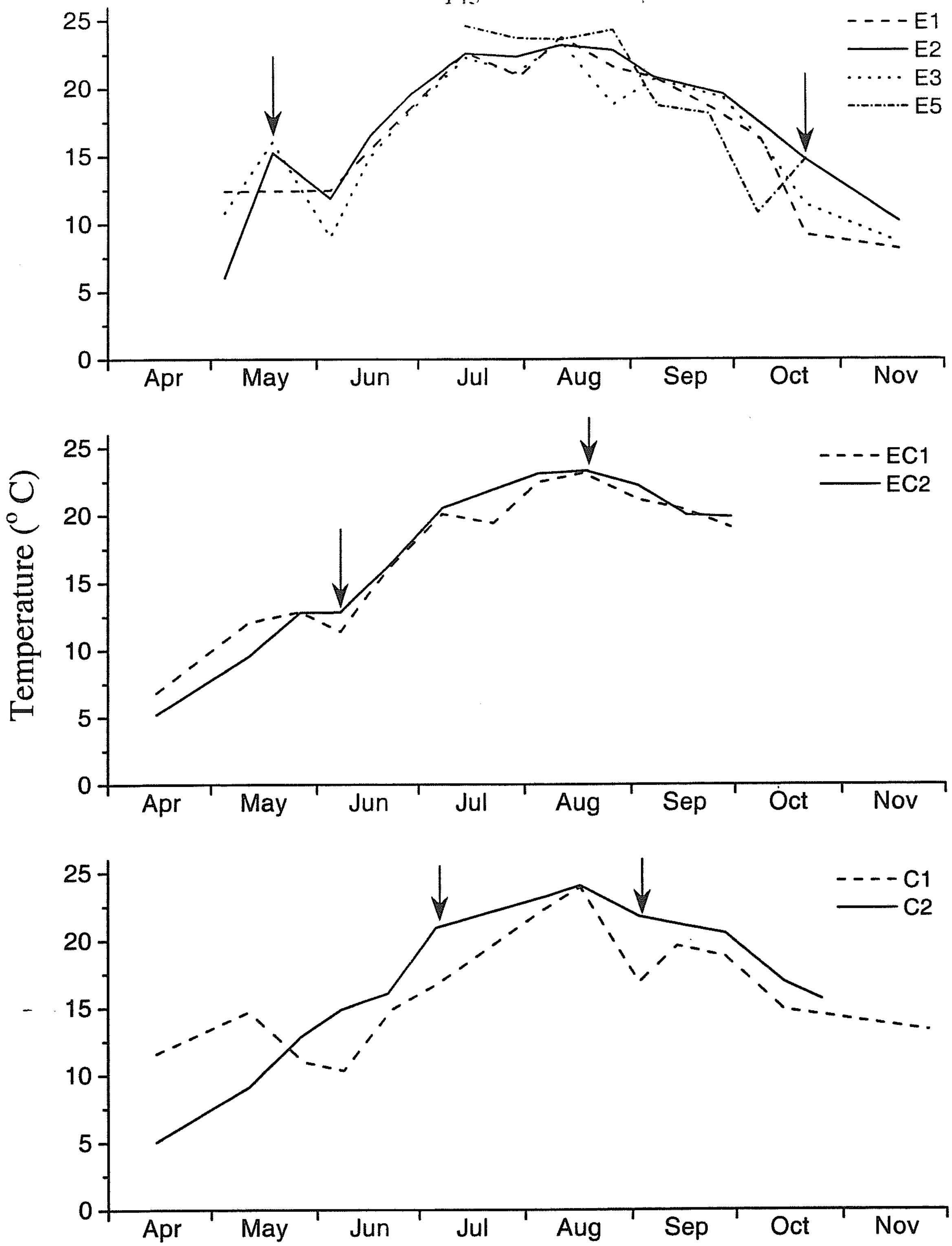


Figure 3a. Seasonal mean epilimnetic temperature at nearshore (broken lines) and offshore (solid line) stations in the east, east-central, and central basins of Lake Erie, 1998. Arrows denote the first and last sample date on which thermal stratification was observed at offshore stations.

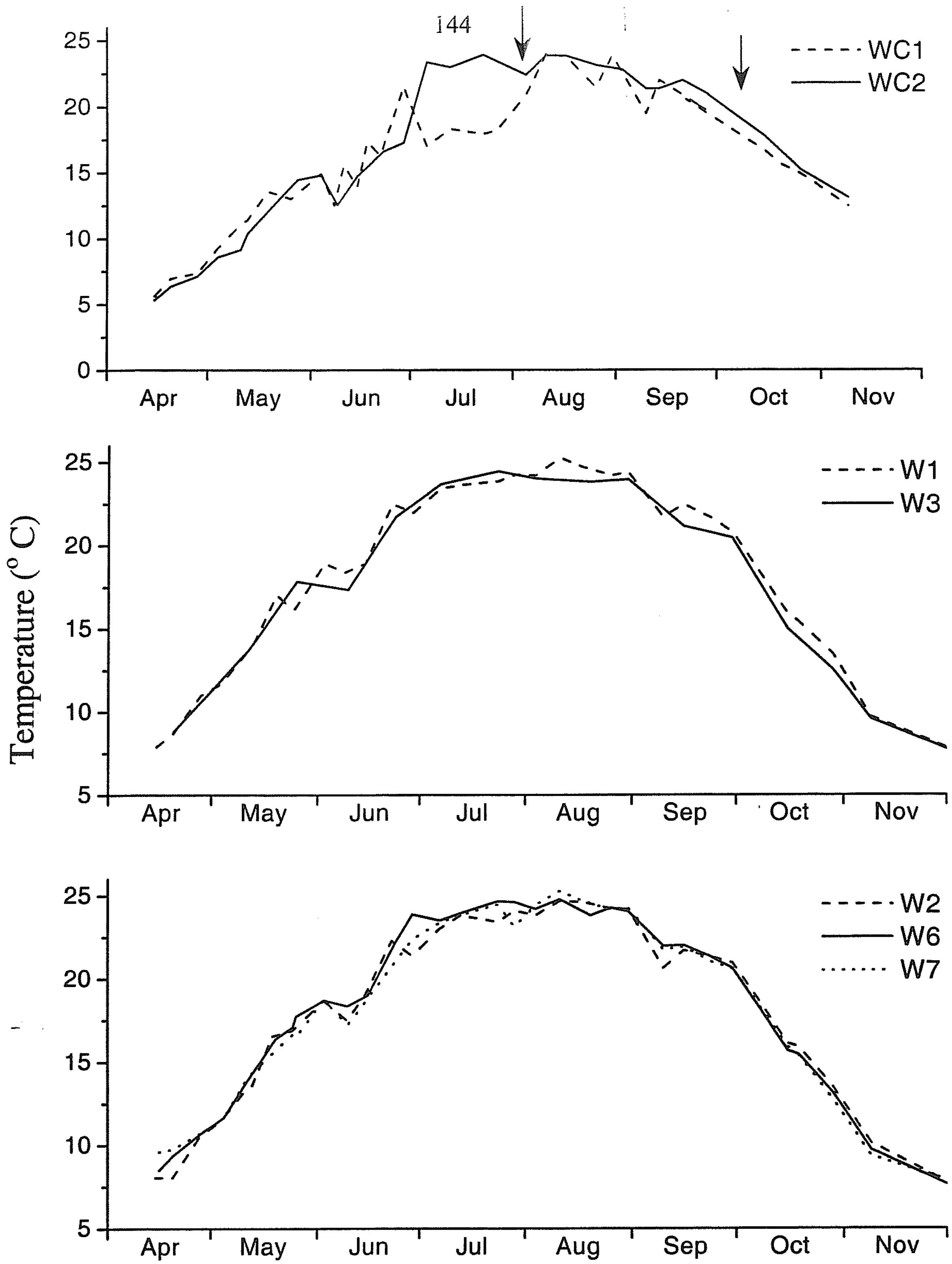


Figure 3b. Seasonal mean epilimnetic temperature at nearshore (broken lines) and offshore (solid lines) stations in the west-central, and west basins of Lake Erie, 1998. Arrows denote the first and last sample date on which thermal stratification was observed at offshore station WC2.

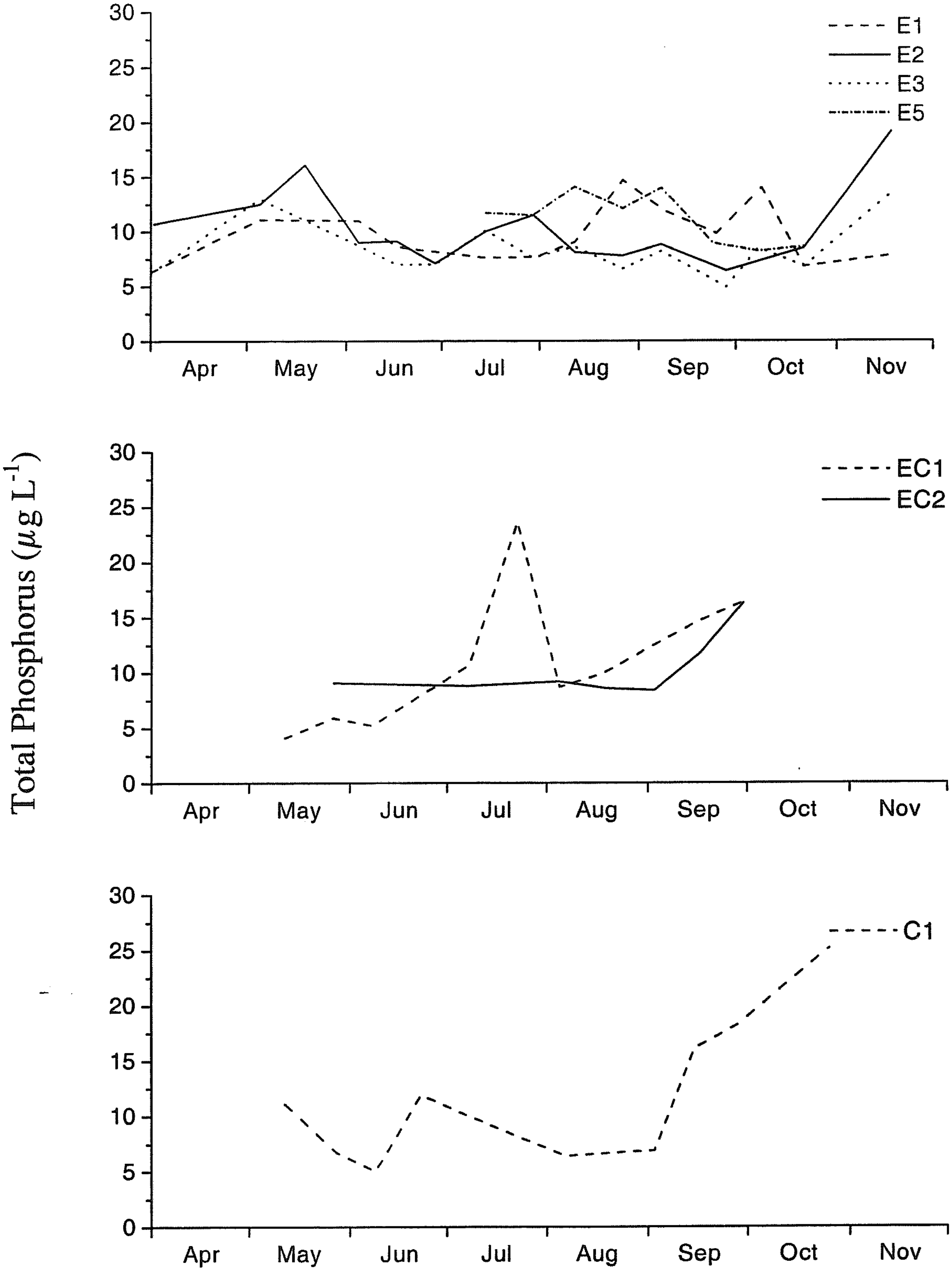


Figure 4a. Seasonal total phosphorus at nearshore (broken lines) and offshore (solid lines) stations in the east, east-central and central basins of Lake Erie, 1998.

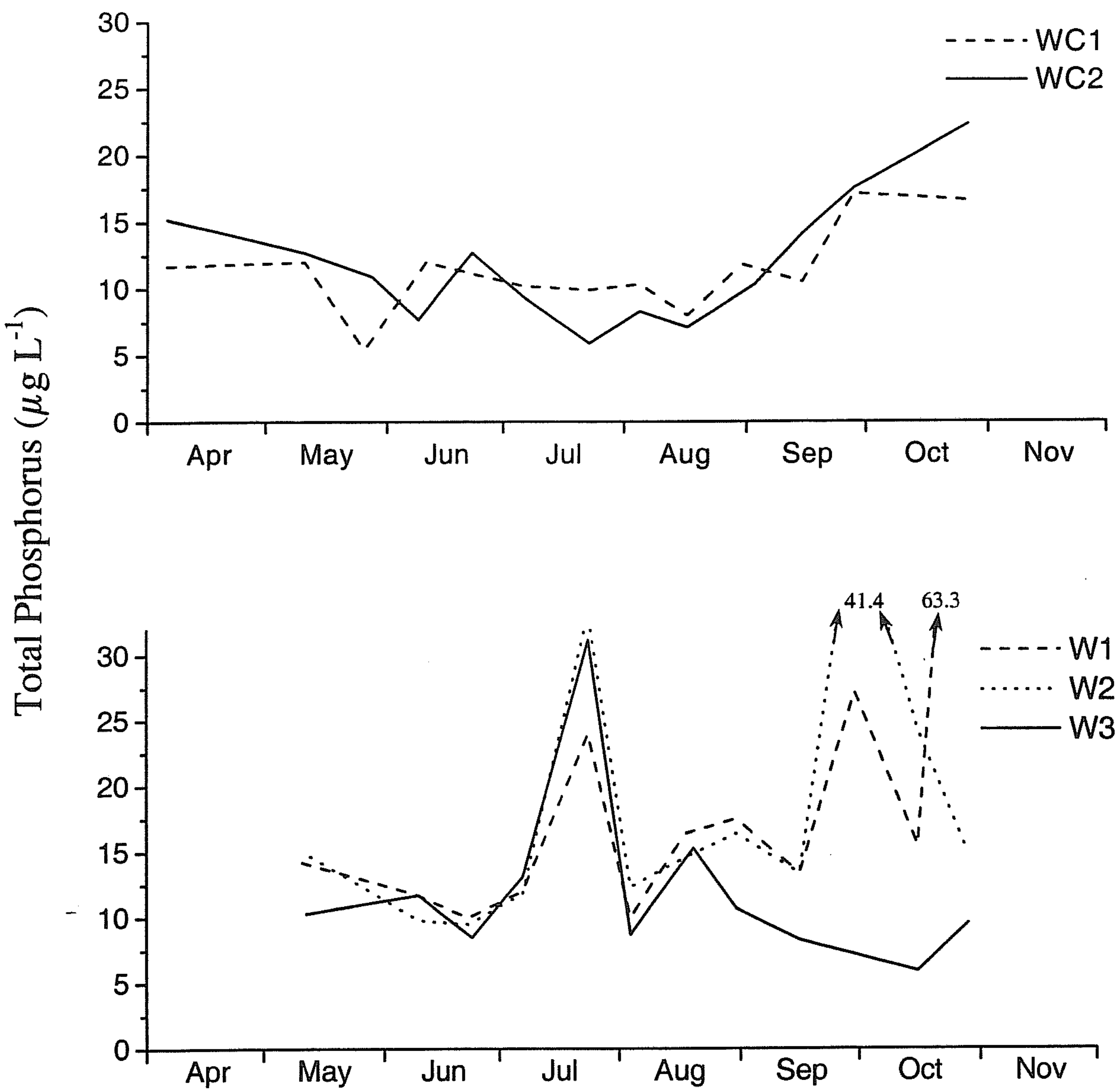


Figure 4b. Seasonal total phosphorus at nearshore (broken lines) and offshore (solid lines) stations in the west-central and west basins of Lake Erie, 1998.

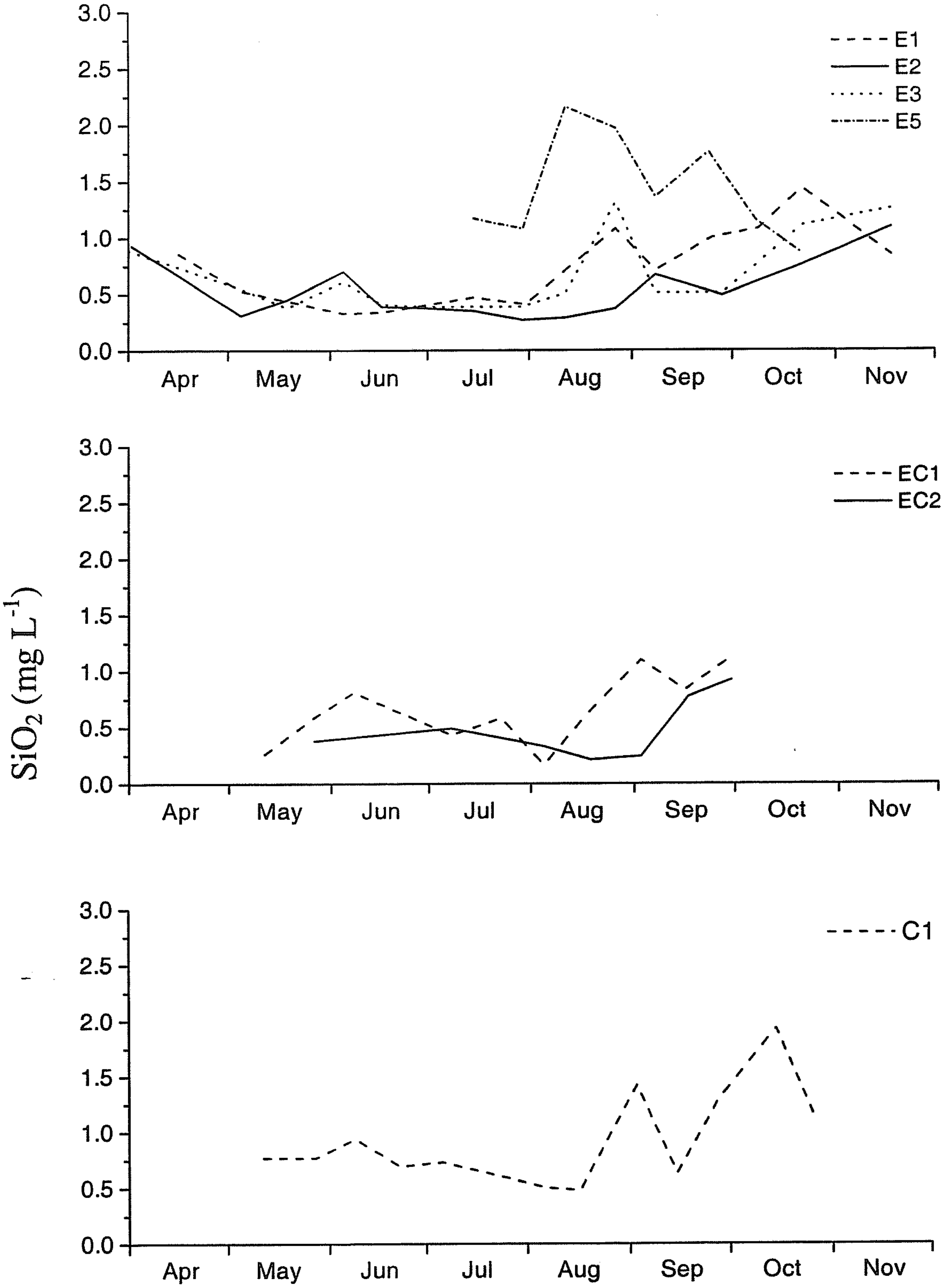


Figure 5a. Seasonal SiO_2 concentrations at nearshore (broken lines) and offshore (solid lines) stations in the east, east-central and central basins of Lake Erie, 1998.

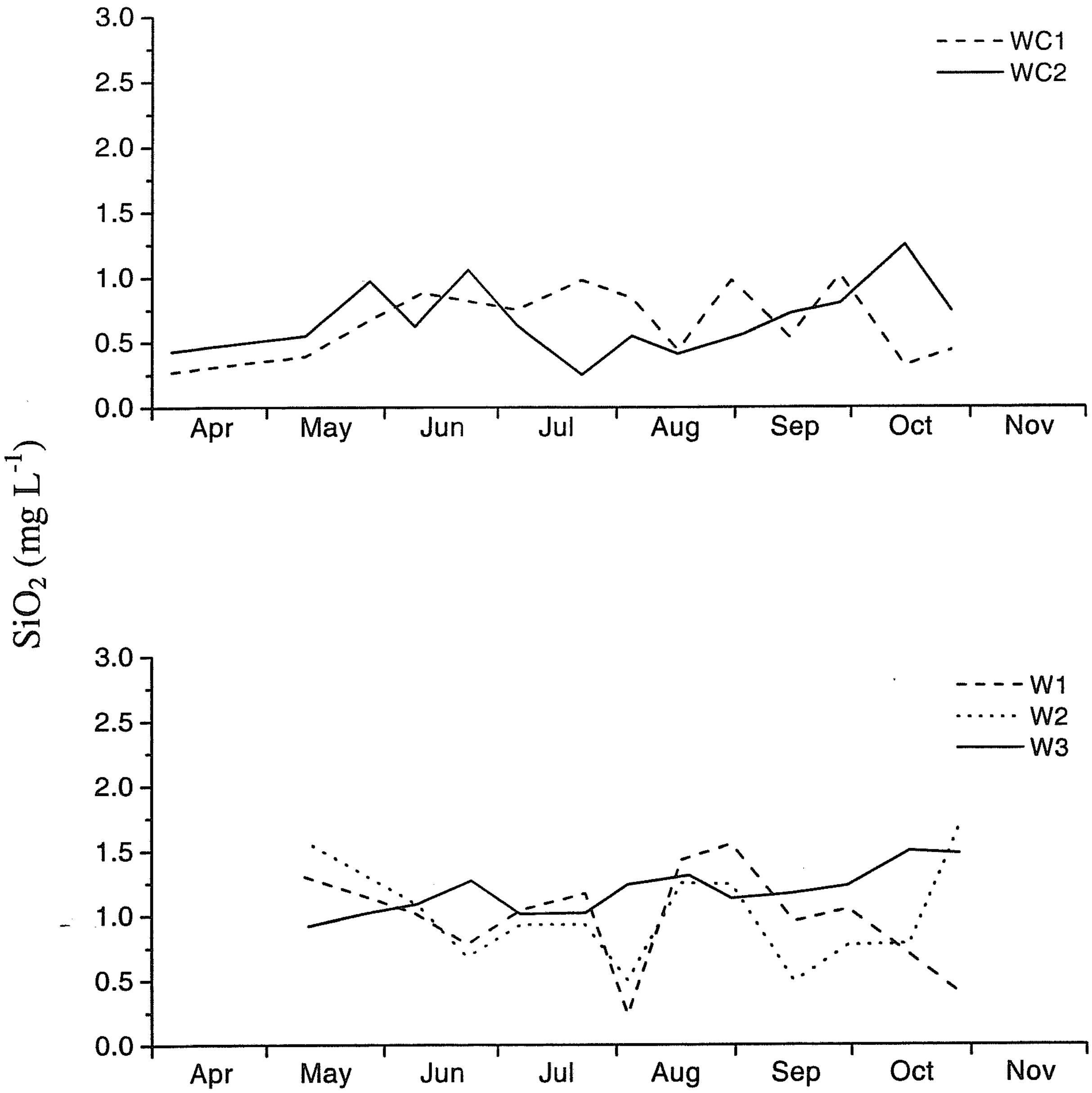


Figure 5b. Seasonal SiO_2 concentrations at nearshore (broken lines) and offshore (solid lines) stations in the west-central and west basins of Lake Erie, 1998.

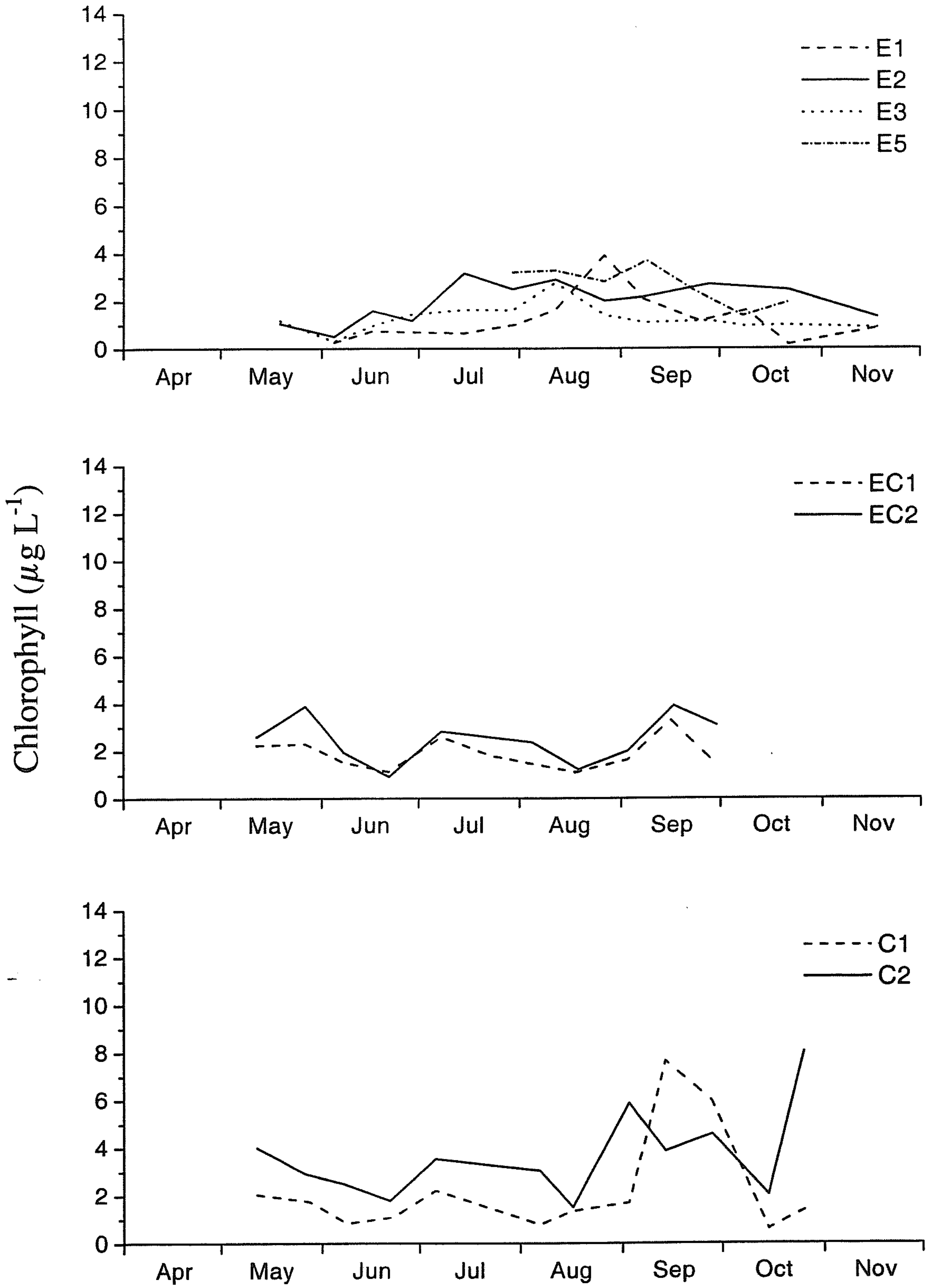


Figure 6a. Seasonal uncorrected chlorophyll at nearshore (broken lines) and offshore (solid lines) stations in the east, east-central, and central basins of Lake Erie, 1998.

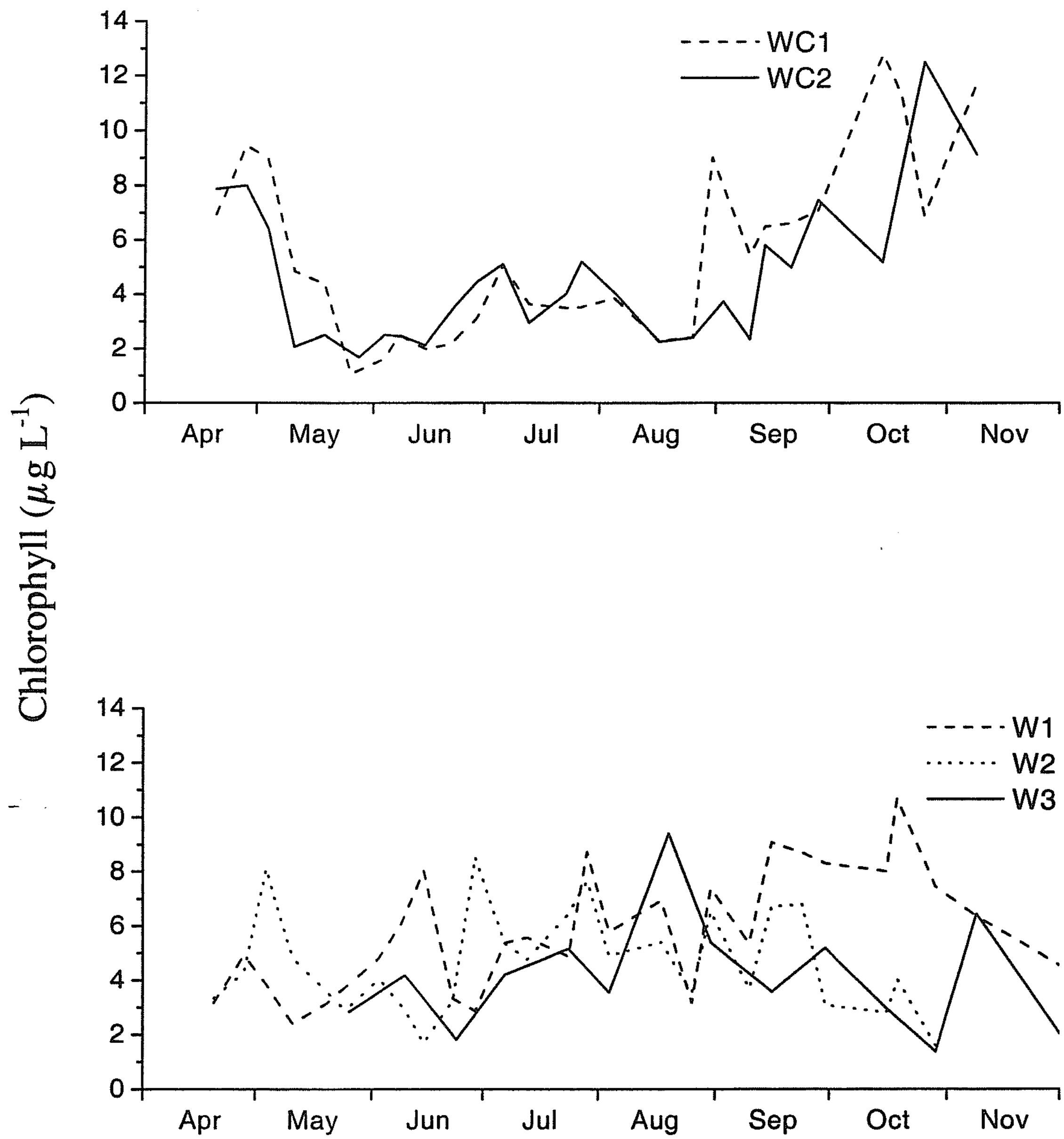


Figure 6b. Seasonal uncorrected chlorophyll at nearshore (broken lines) and offshore (solid lines) stations in the west-central, and western basins of Lake Erie, 1998.

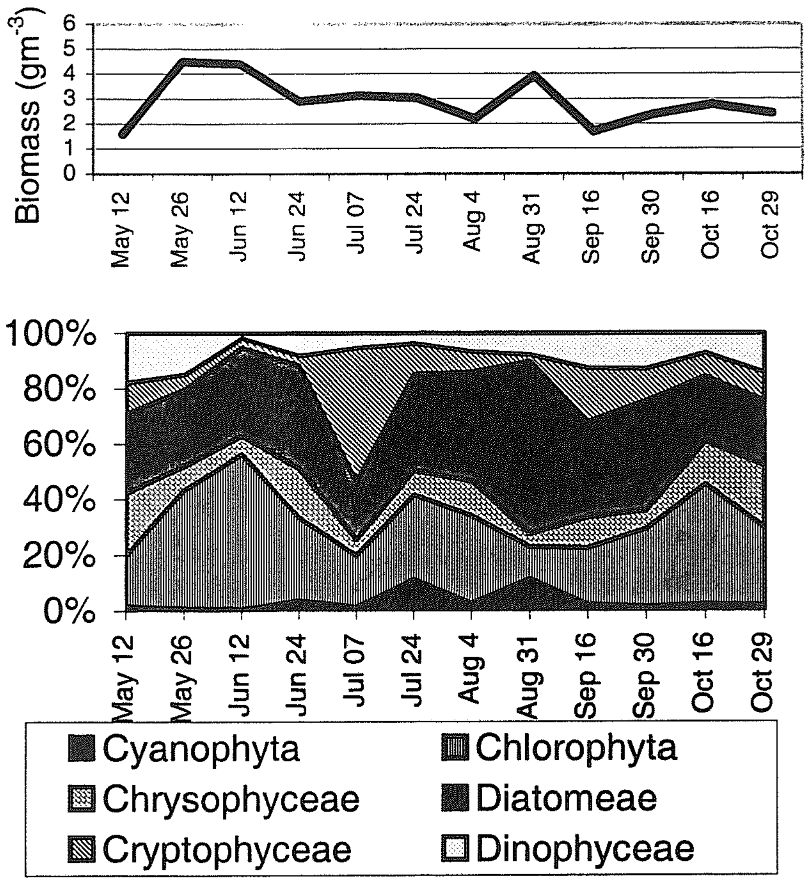
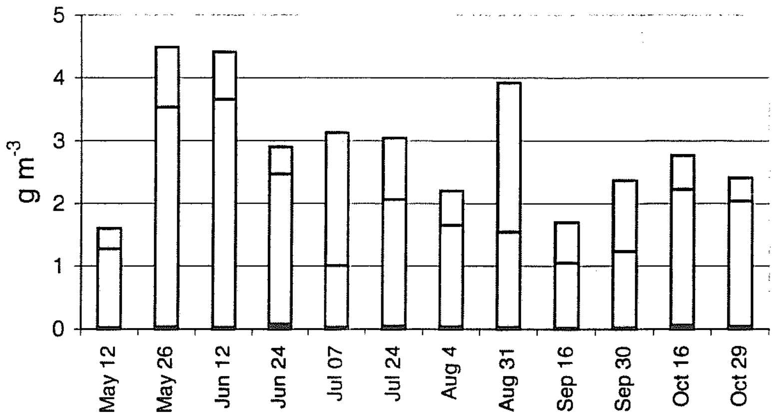
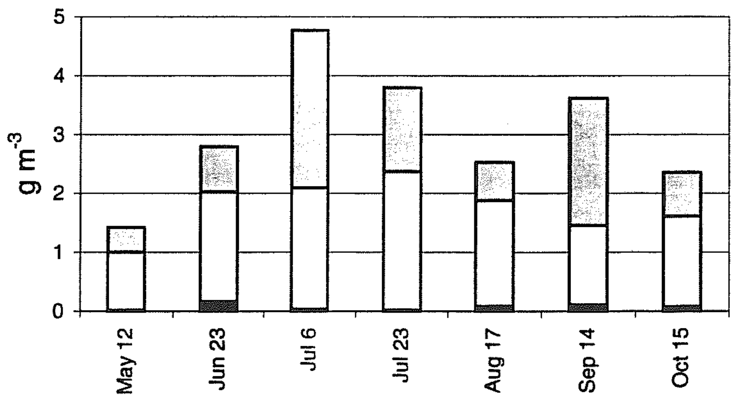


Figure 7. Seasonal distribution of phytoplankton biomass and taxonomic composition at station W3 during 1998.

a)



b)



c)

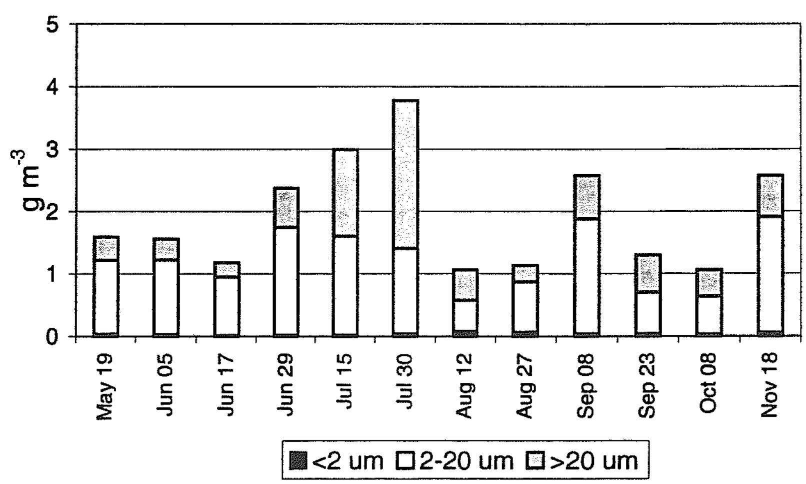


Figure 8. Seasonal variation of phytoplankton biomass by size in 1998 at a) station W3; b) station WC2; c) station E2.

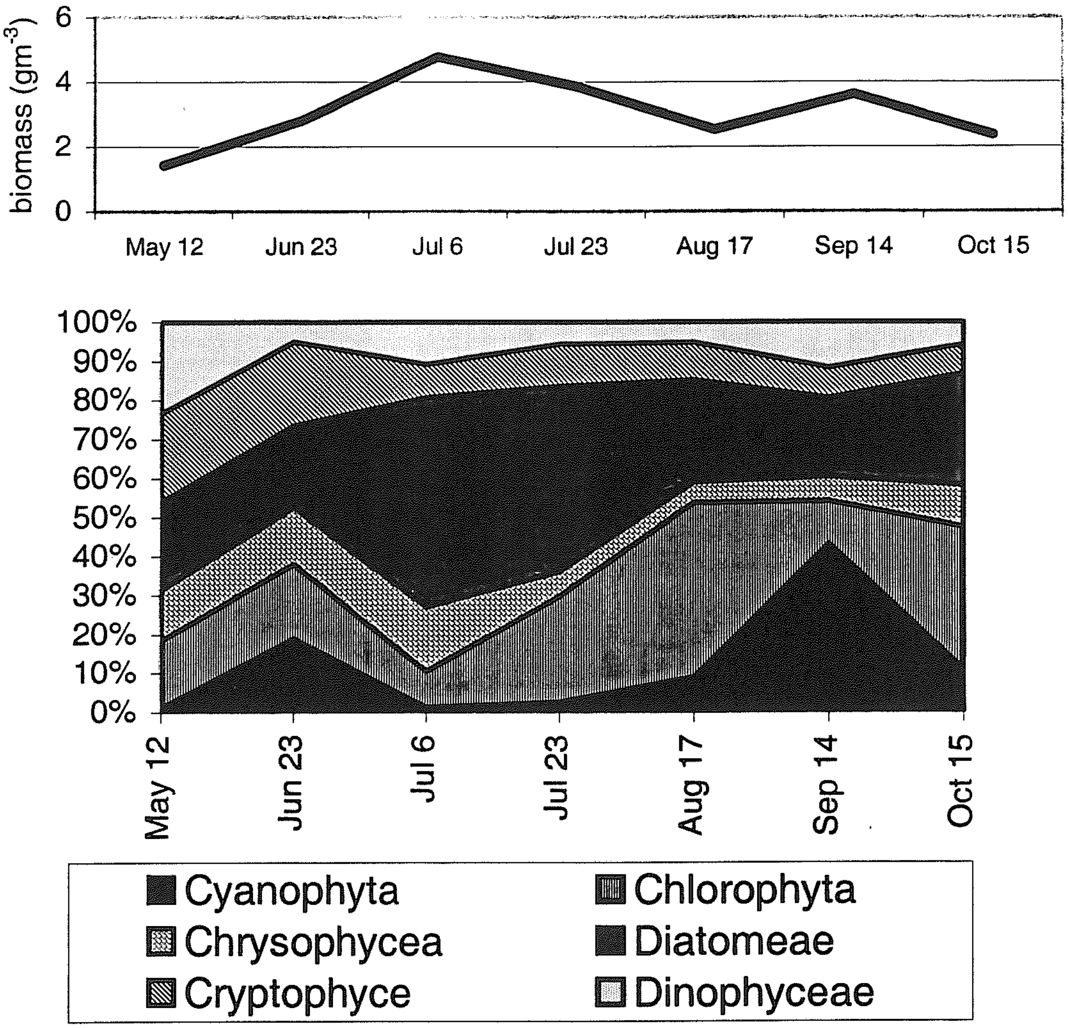


Figure 9. Seasonal distribution of phytoplankton biomass and taxonomic composition at station WC2 during 1998.

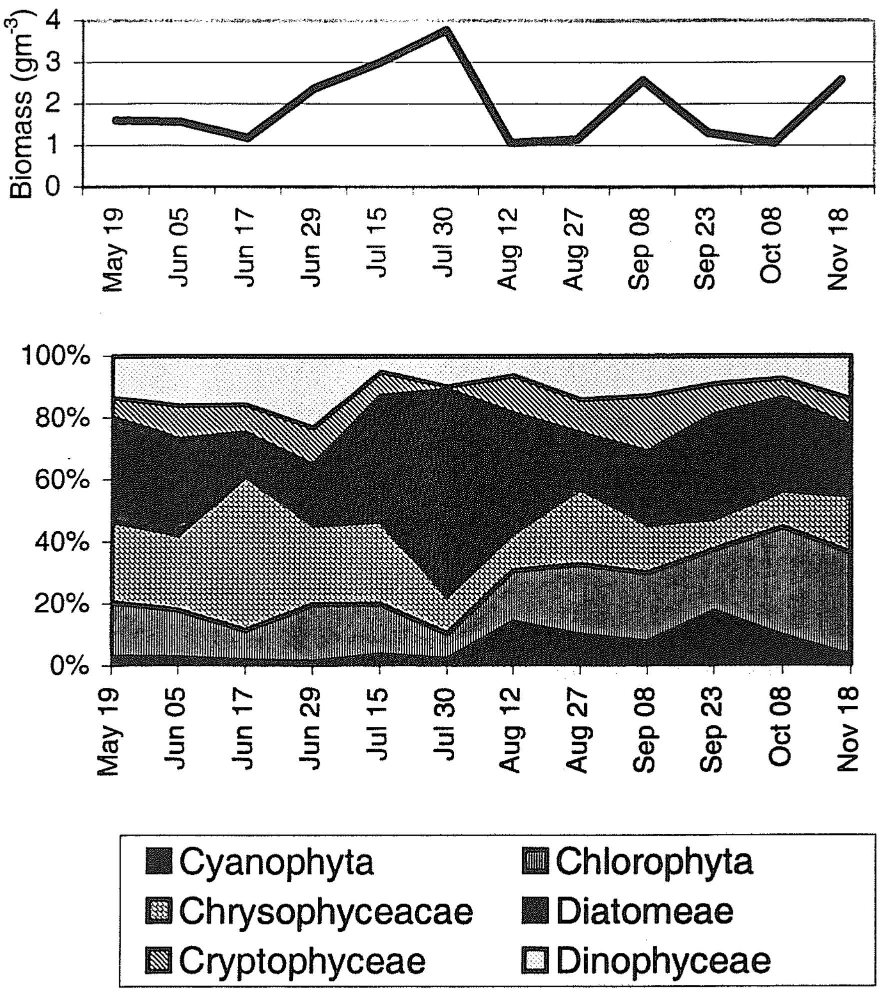


Figure 10. Seasonal distribution of phytoplankton biomass and taxonomic composition at station E2 during 1998.

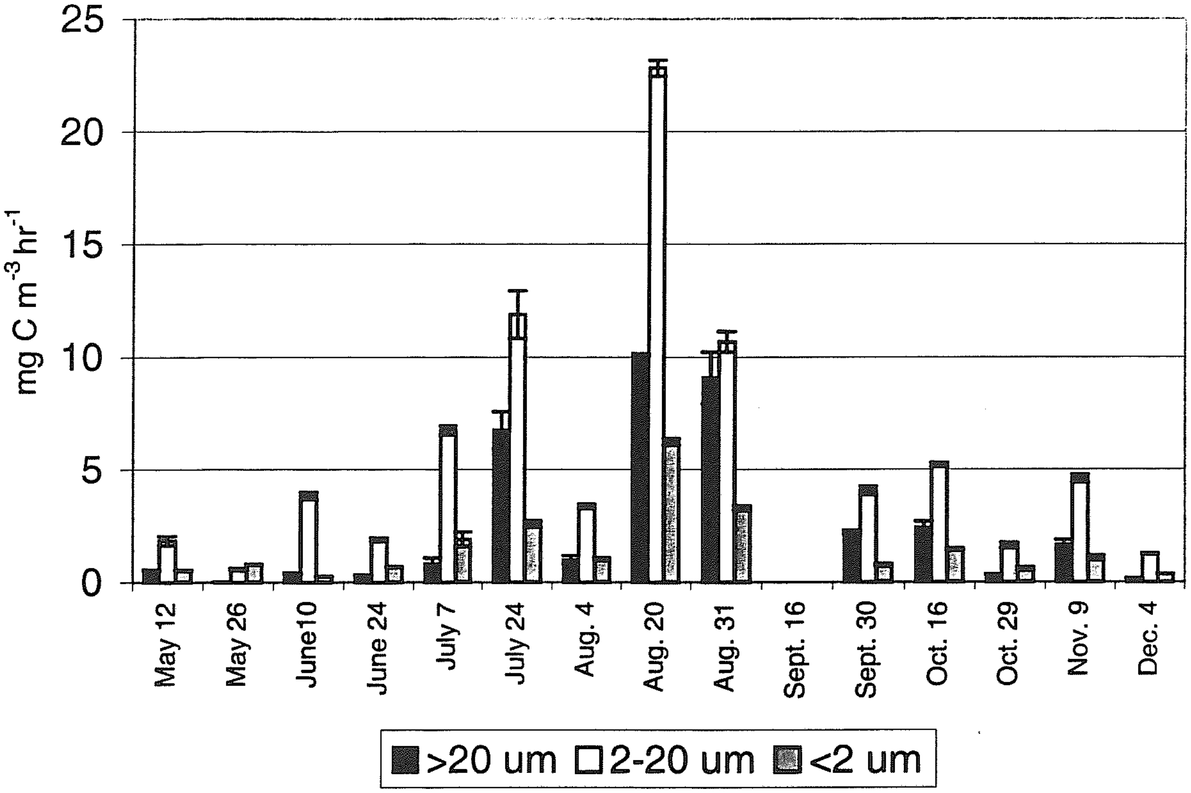


Figure 11. Seasonal variation in size-fractionated primary productivity at station W3 during 1998.

a)

b)

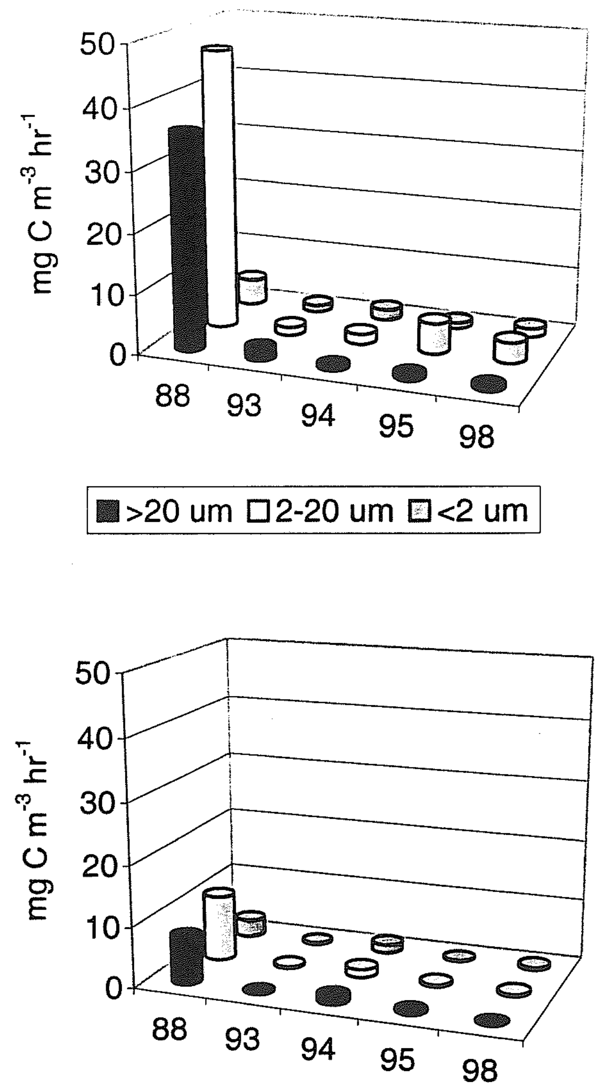


Figure 12. Long term variation in mean spring size-fractionated primary productivity in 1988, 1993, 1994, 1995 and 1998 at a) station W3 and b) station E2.

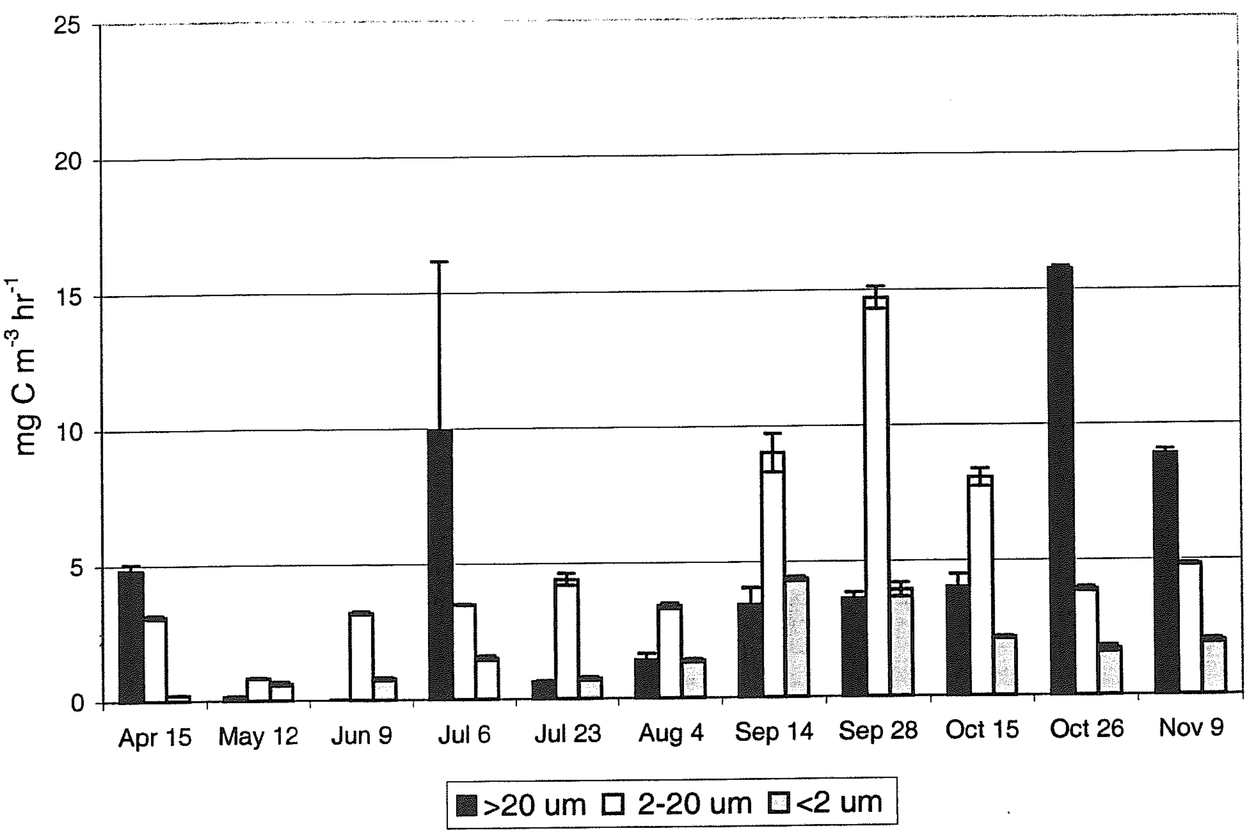


Figure 13. Seasonal variation in size-fractionated primary productivity at station WC2 during 1998.

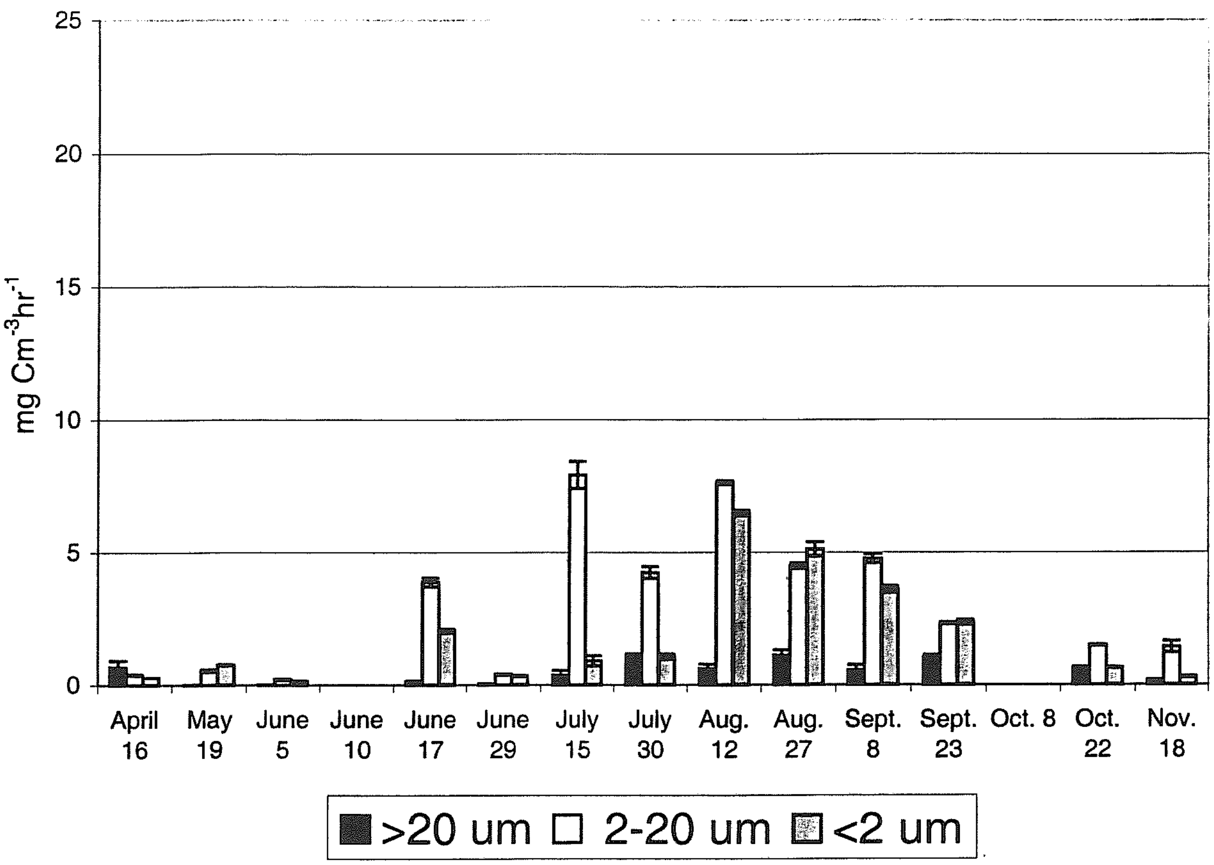


Figure 14. Seasonal variation in size-fractionated primary productivity at station E2 during 1998.

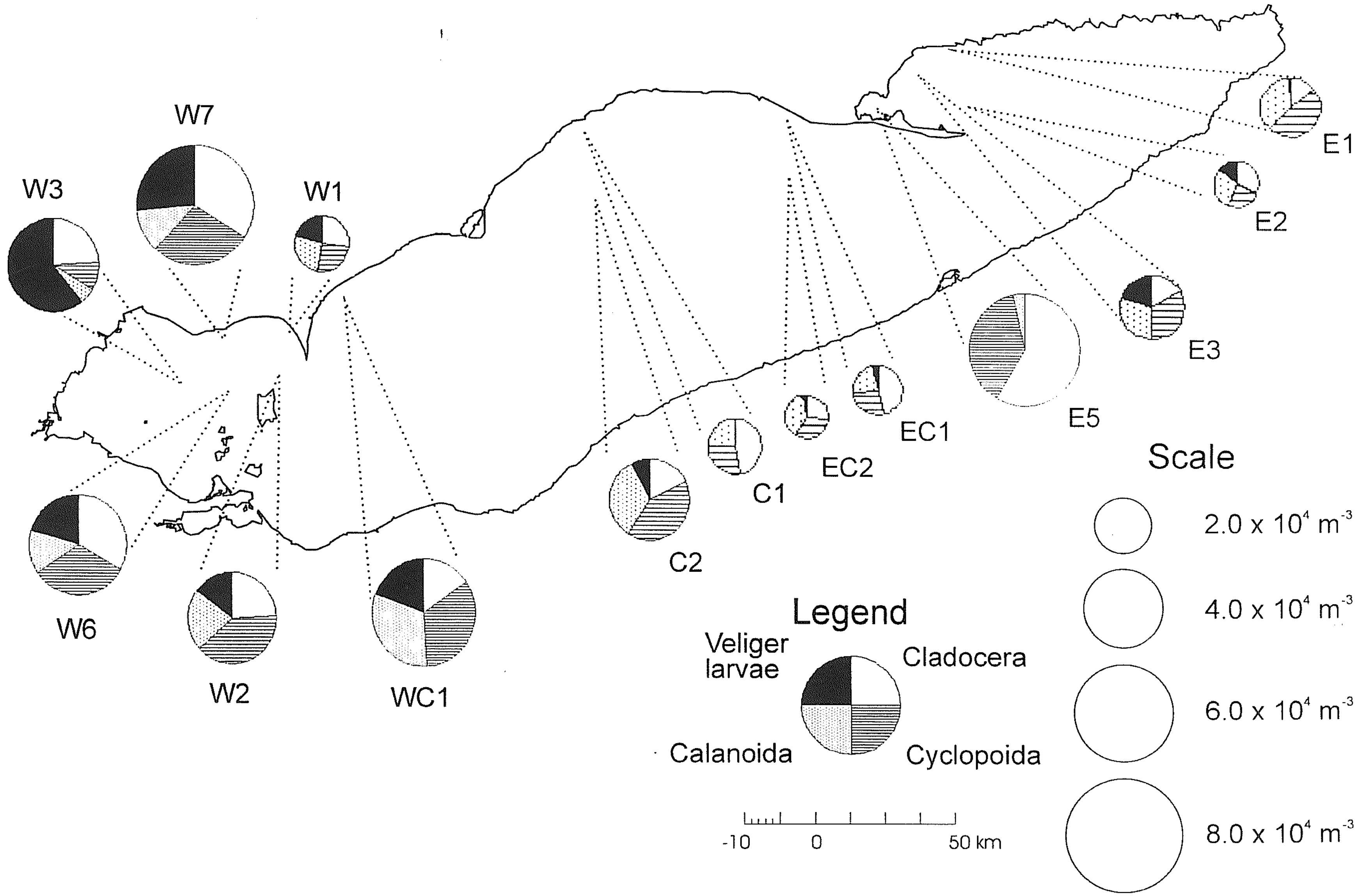


Figure 15. Seasonal-weighted mean abundance (no. m^3) of zooplankton at each LEB station in 1998. Note that this measure of abundance is an average for the entire water column, and consequently deeper stations will tend to have lower values.

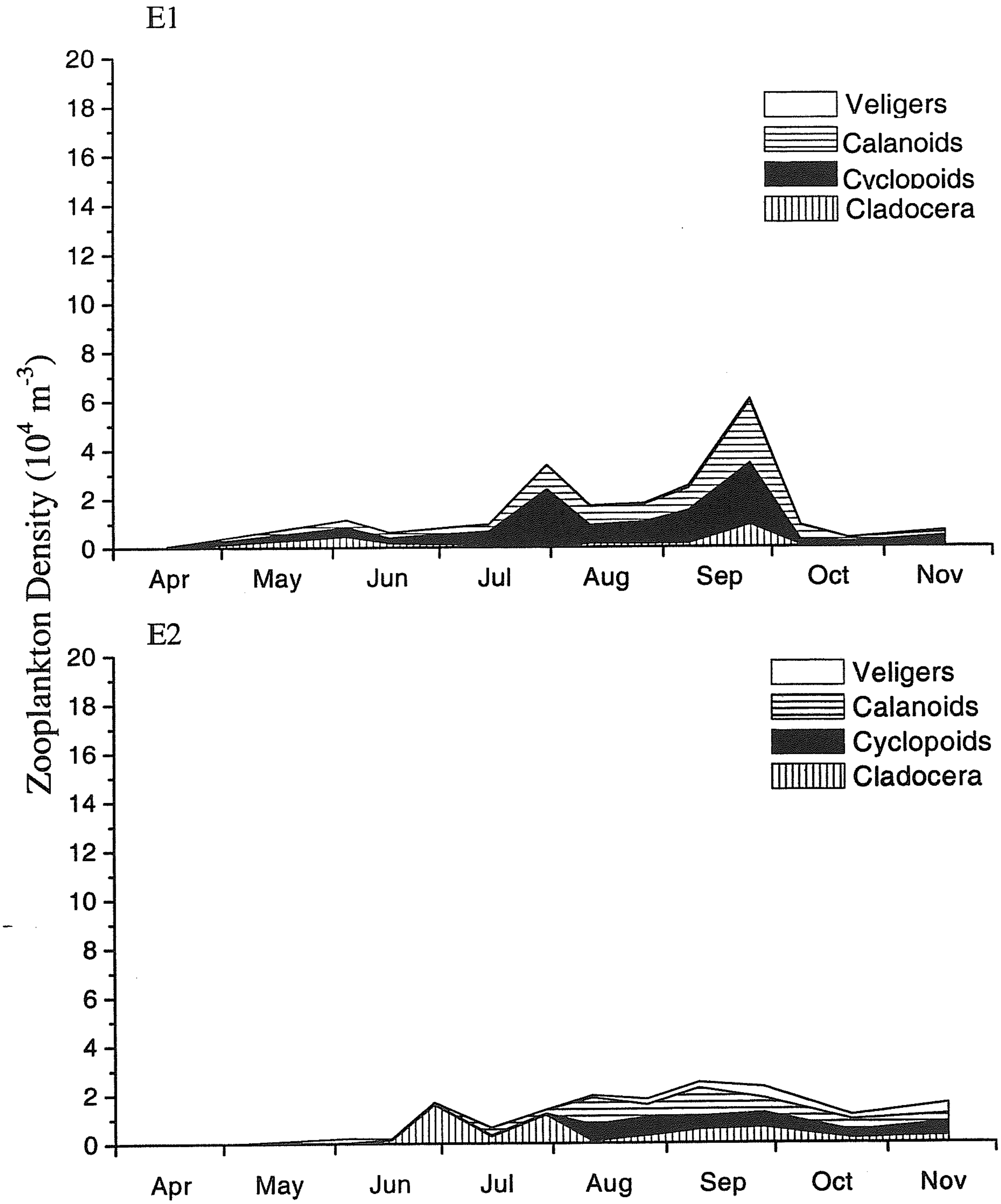


Figure 16. Seasonal trends in macrozooplankton and veliger densities at a nearshore (E1) and offshore (E2) station in the eastern basin of Lake Erie, 1998.

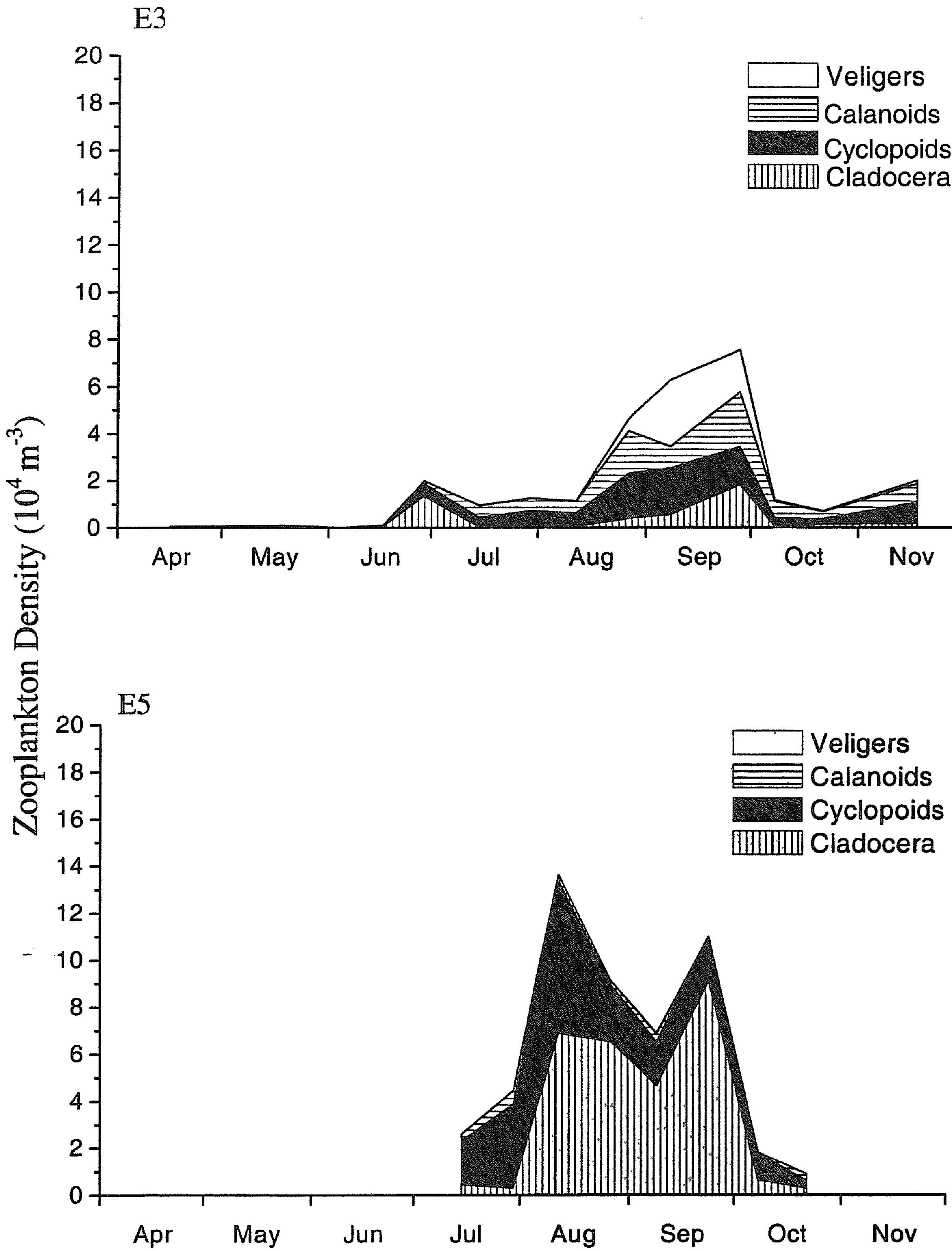


Figure 17. Seasonal trends in macrozooplankton and veliger densities at a nearshore (E3) and shallow embayment (E5) station in the eastern basin of Lake Erie, 1998.

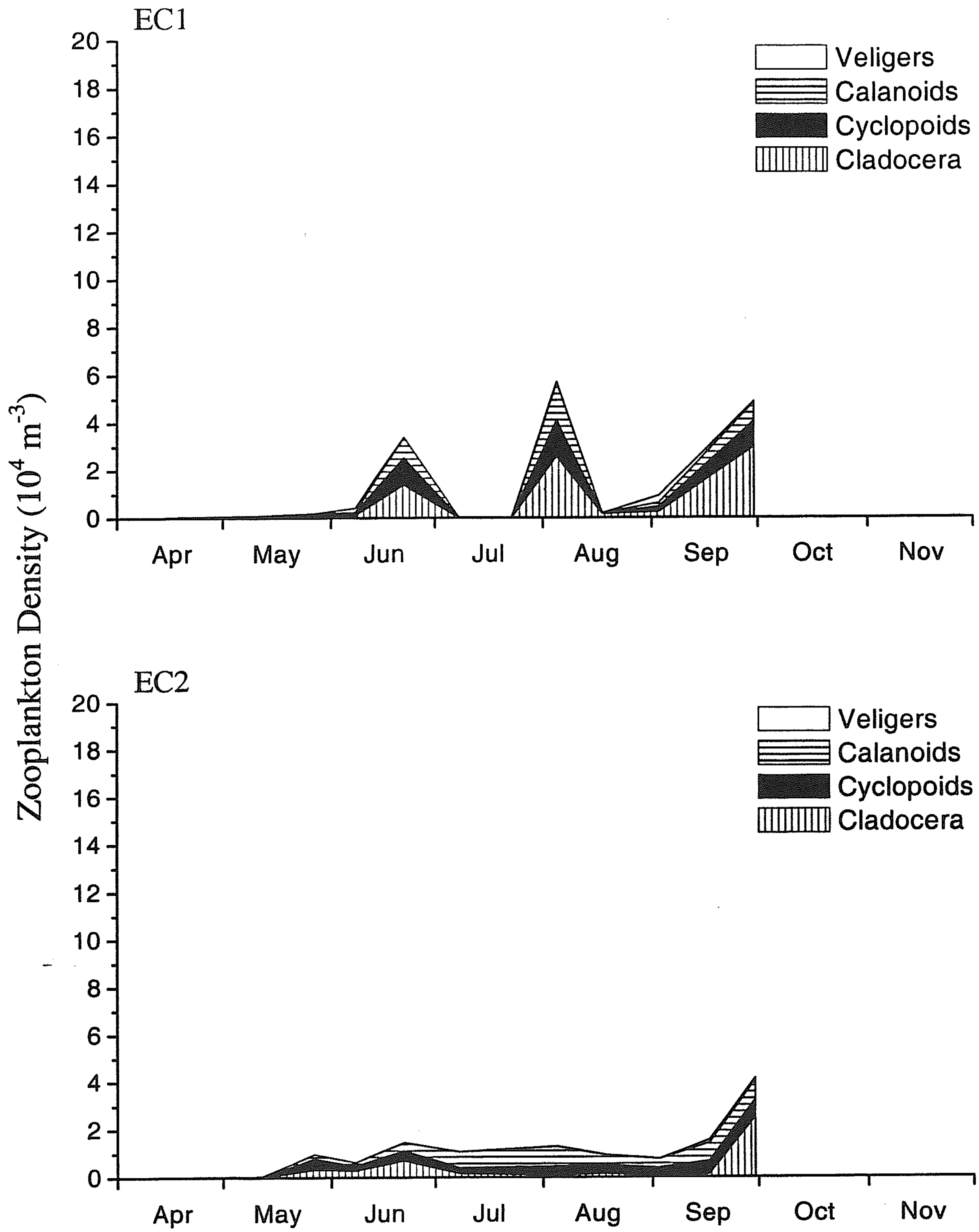


Figure 18. Seasonal trends in macrozooplankton and veliger densities at a nearshore (EC1) and offshore (EC2) station in the east-central basin of Lake Erie, 1998.

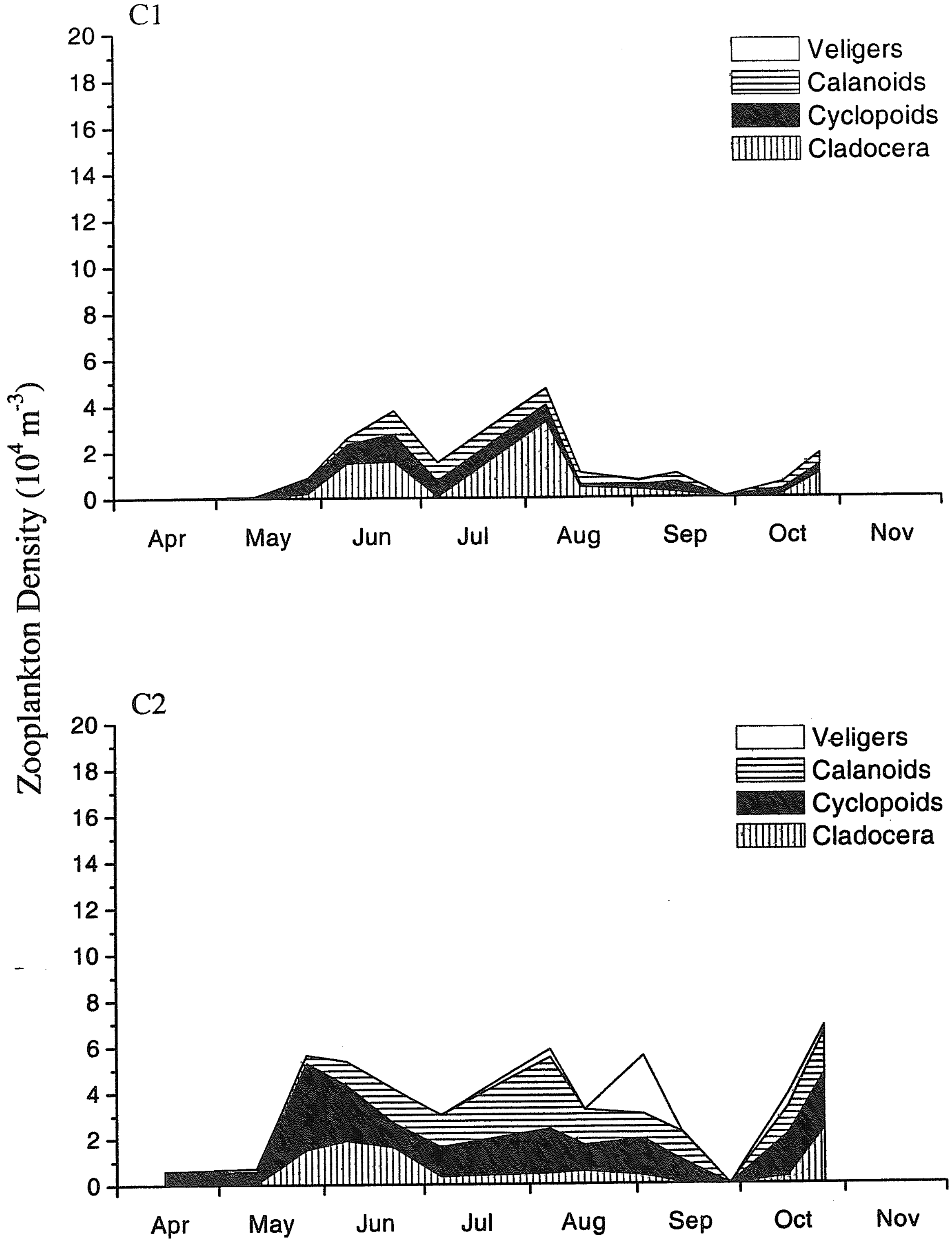


Figure 19. Season trends in macrozooplankton and veliger densities at a nearshore (C1) and offshore (C2) station in the central basin of Lake Erie, 1998.

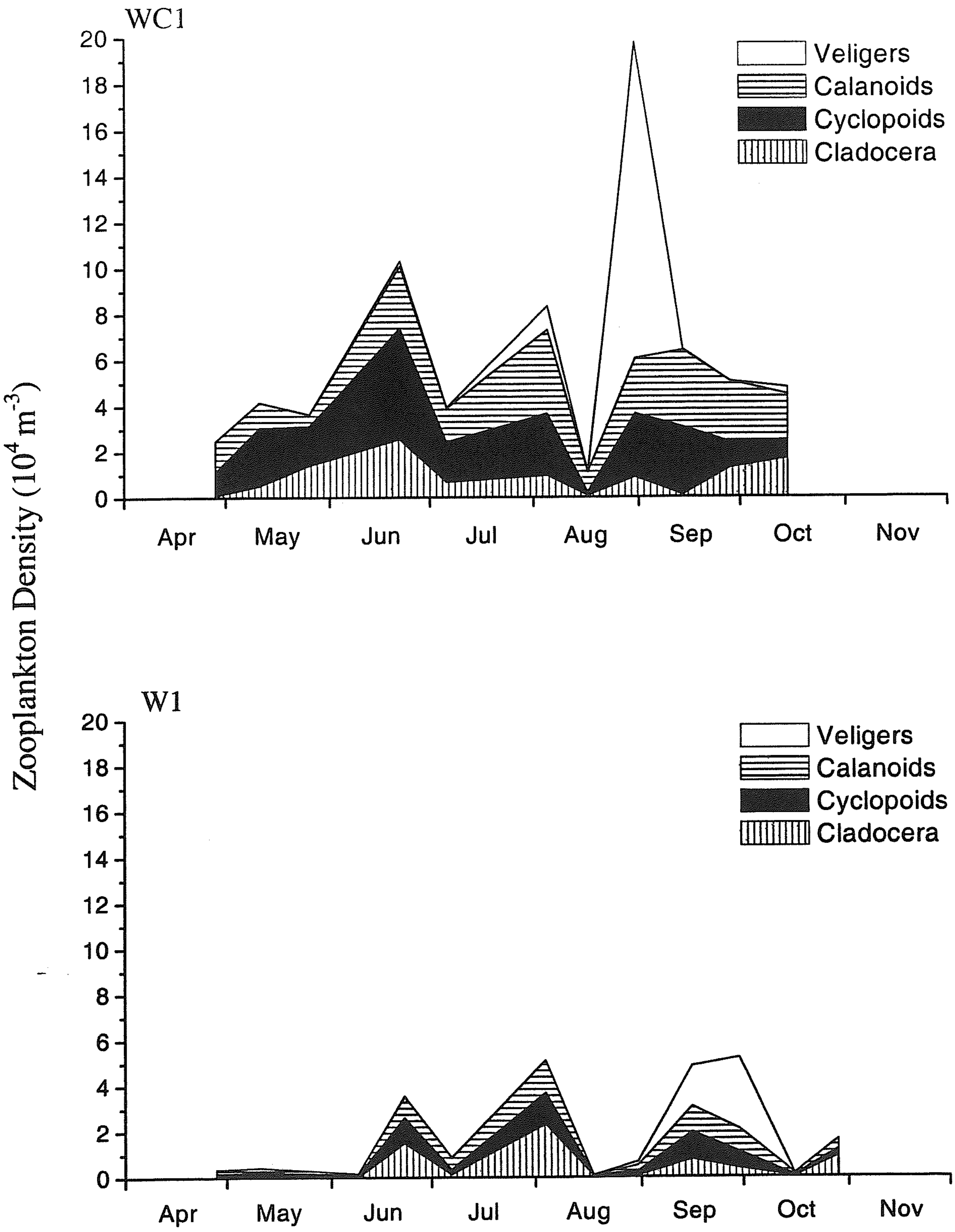


Figure 20. Seasonal trends in macrozooplankton and veliger densities at nearshore stations in the west-central (WC1) and western (W1) basins of Lake Erie, 1998.

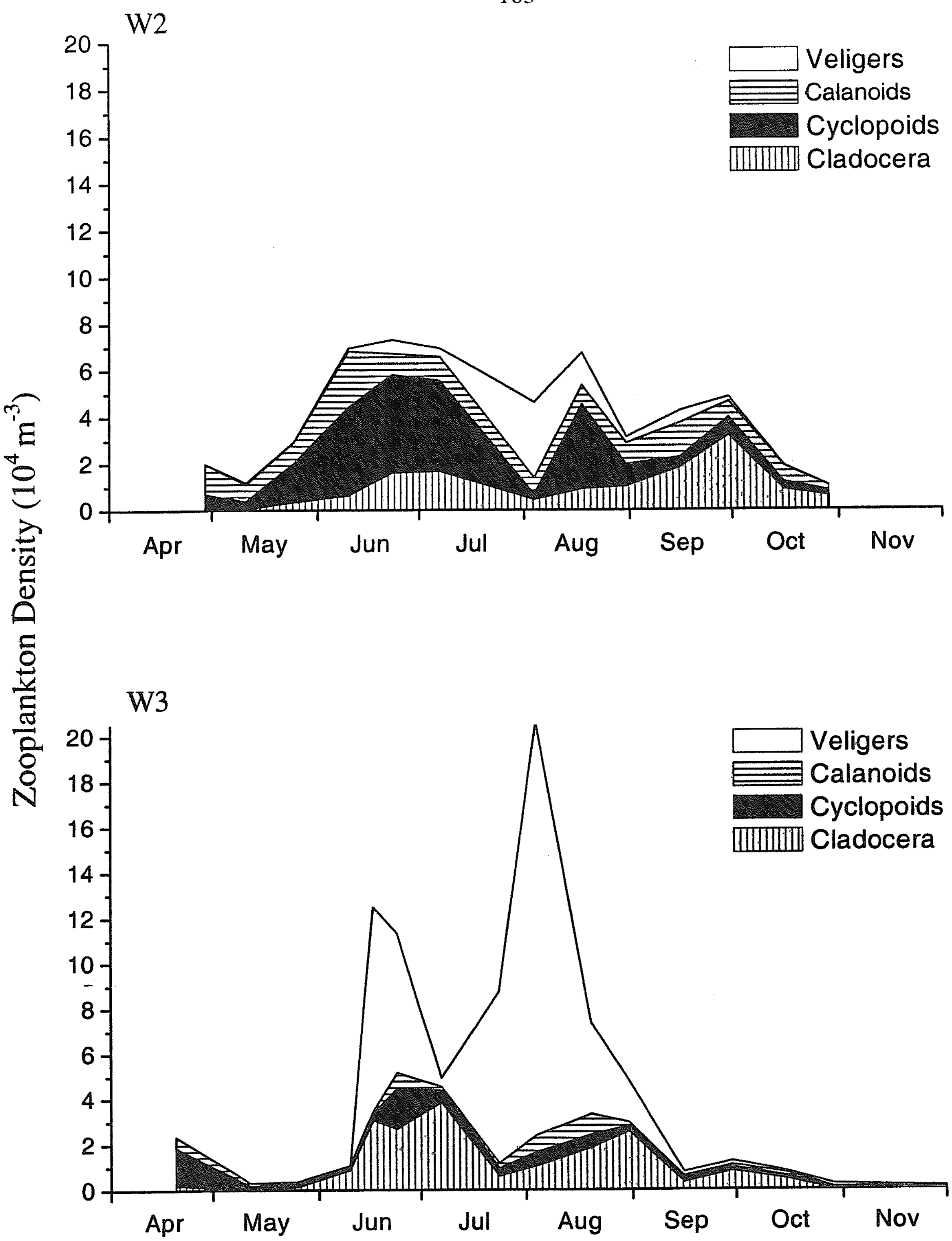


Figure 21. Seasonal trends in macrozooplankton and veliger densities at a nearshore (W2) and offshore (W3) station in the western basin on Lake Erie, 1998.

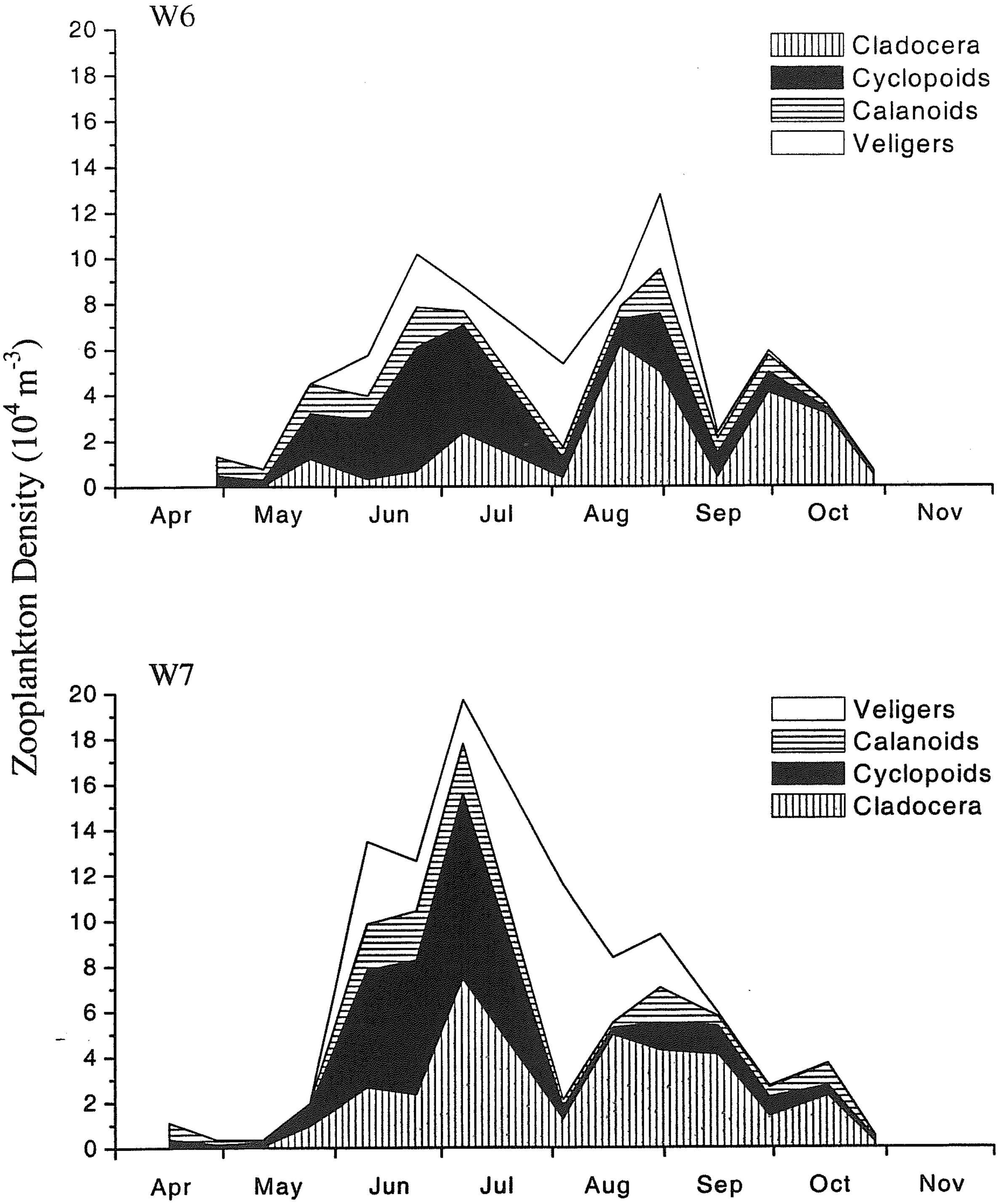


Figure 22. Seasonal trends in macrozooplankton and veliger densities at an offshore (W6) and nearshore (W7) station in the western basin of Lake Erie, 1998.

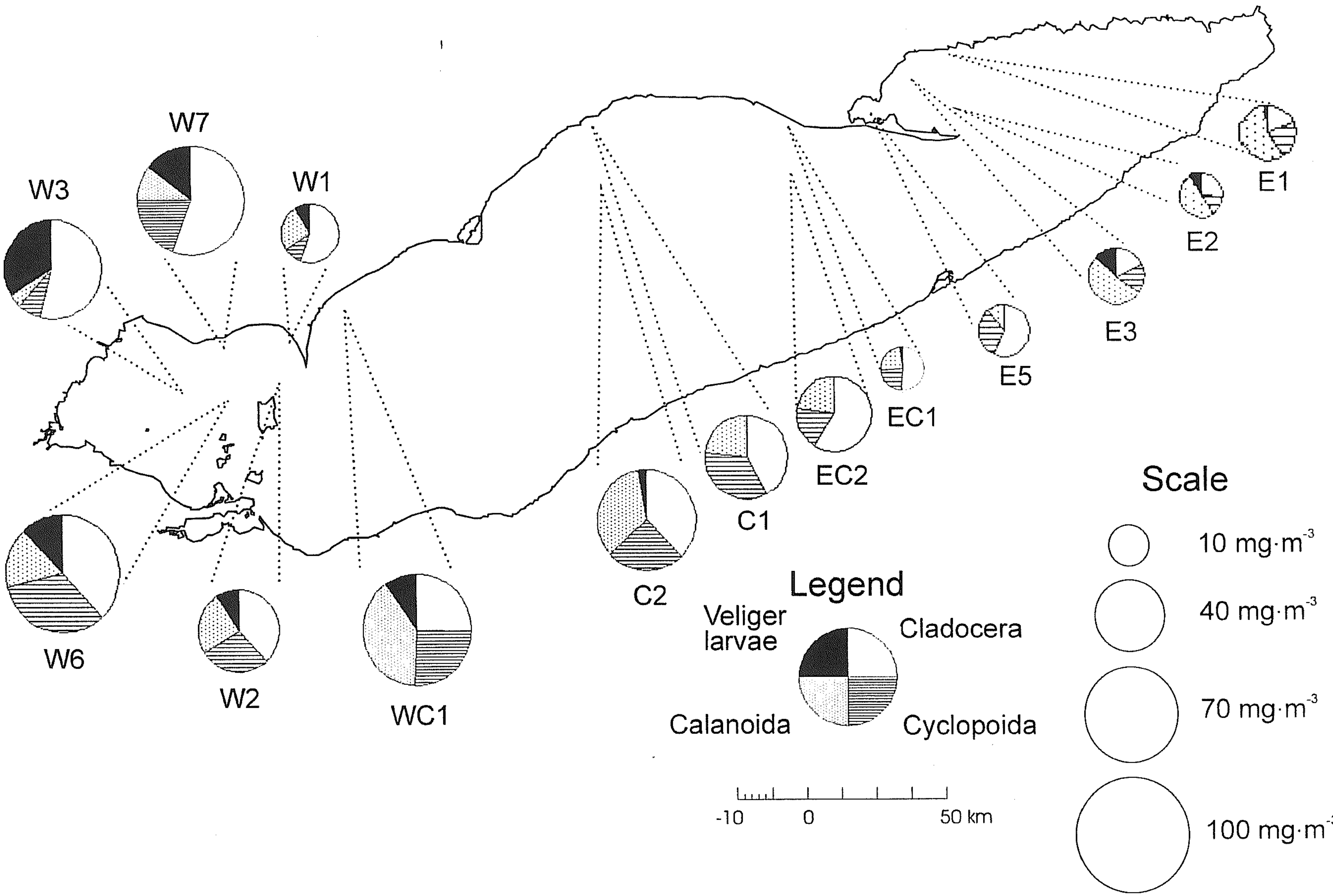


Figure 23. Seasonal-weighted mean biomass (mg m^{-3}) of zooplankton at each LEB station in 1998. Note that this measure of biomass is an average for the entire water column, and consequently deeper stations will tend to have lower values.

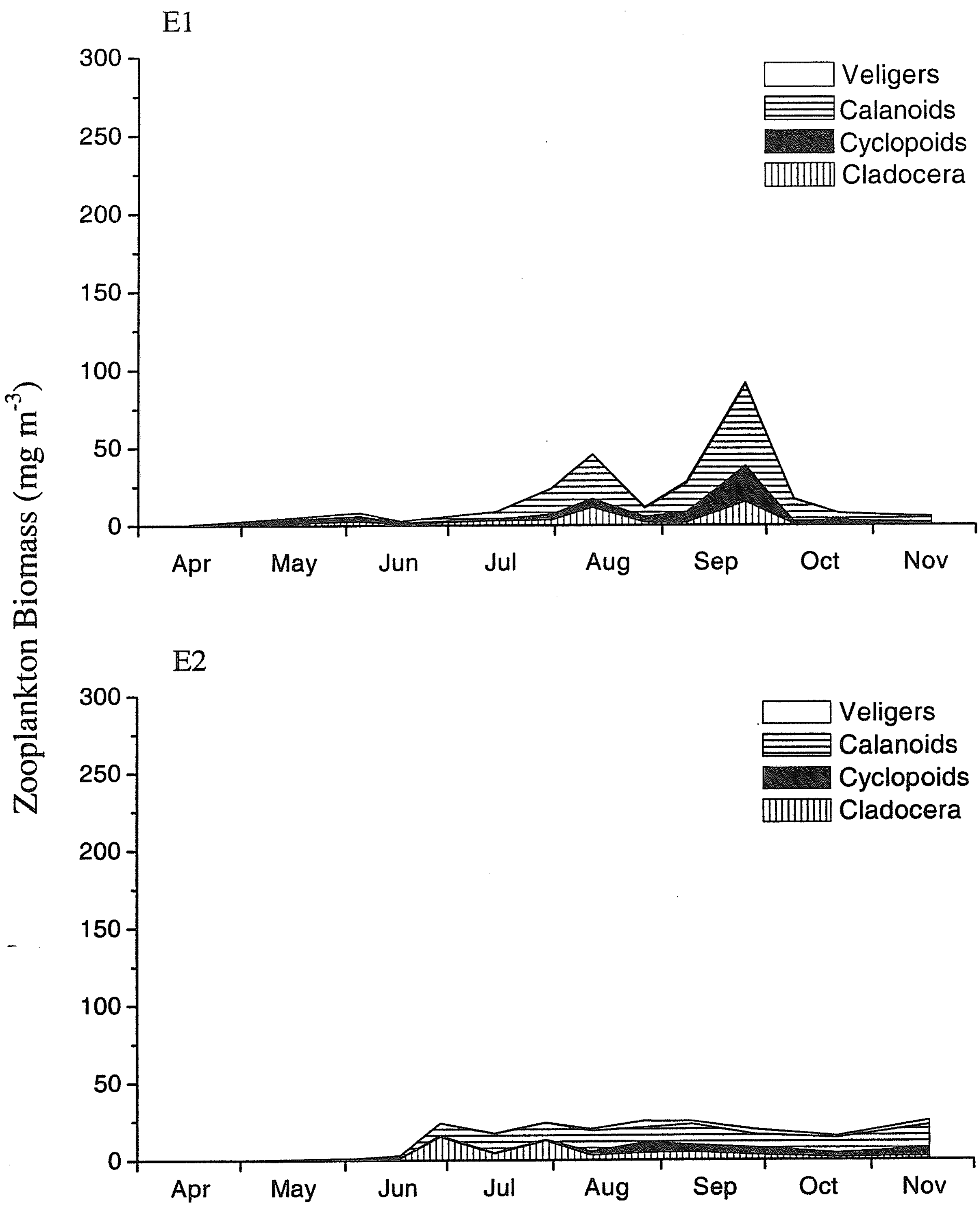


Figure 24. Seasonal trends in zooplankton and veliger biomass at a nearshore (E1) and offshore (E2) station in the eastern basin of Lake Erie, 1998.

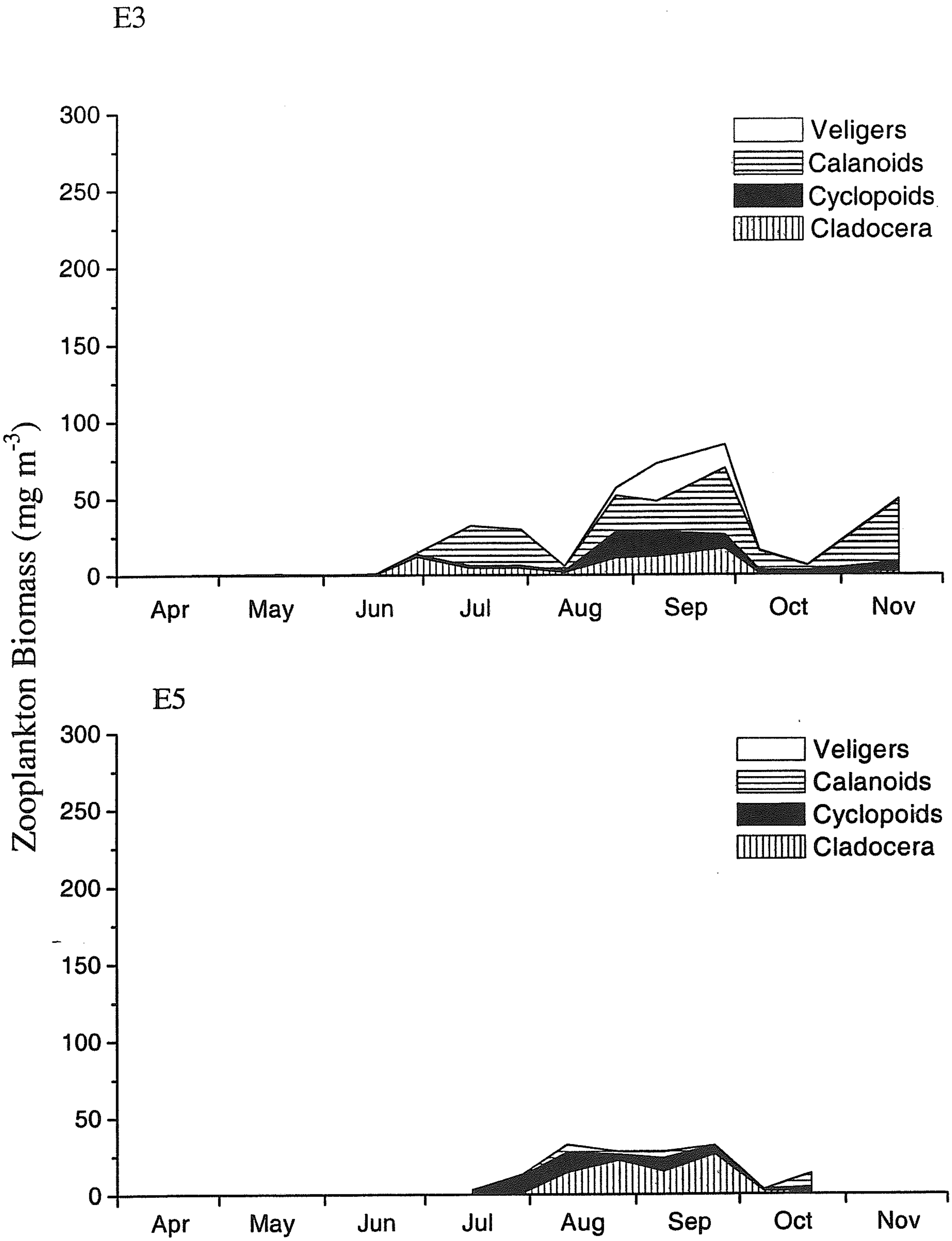


Figure 25. Seasonal trends in zooplankton and veliger biomass at a nearshore (E2) and shallow embayment (E5) station in the eastern basin of Lake Erie, 1998.

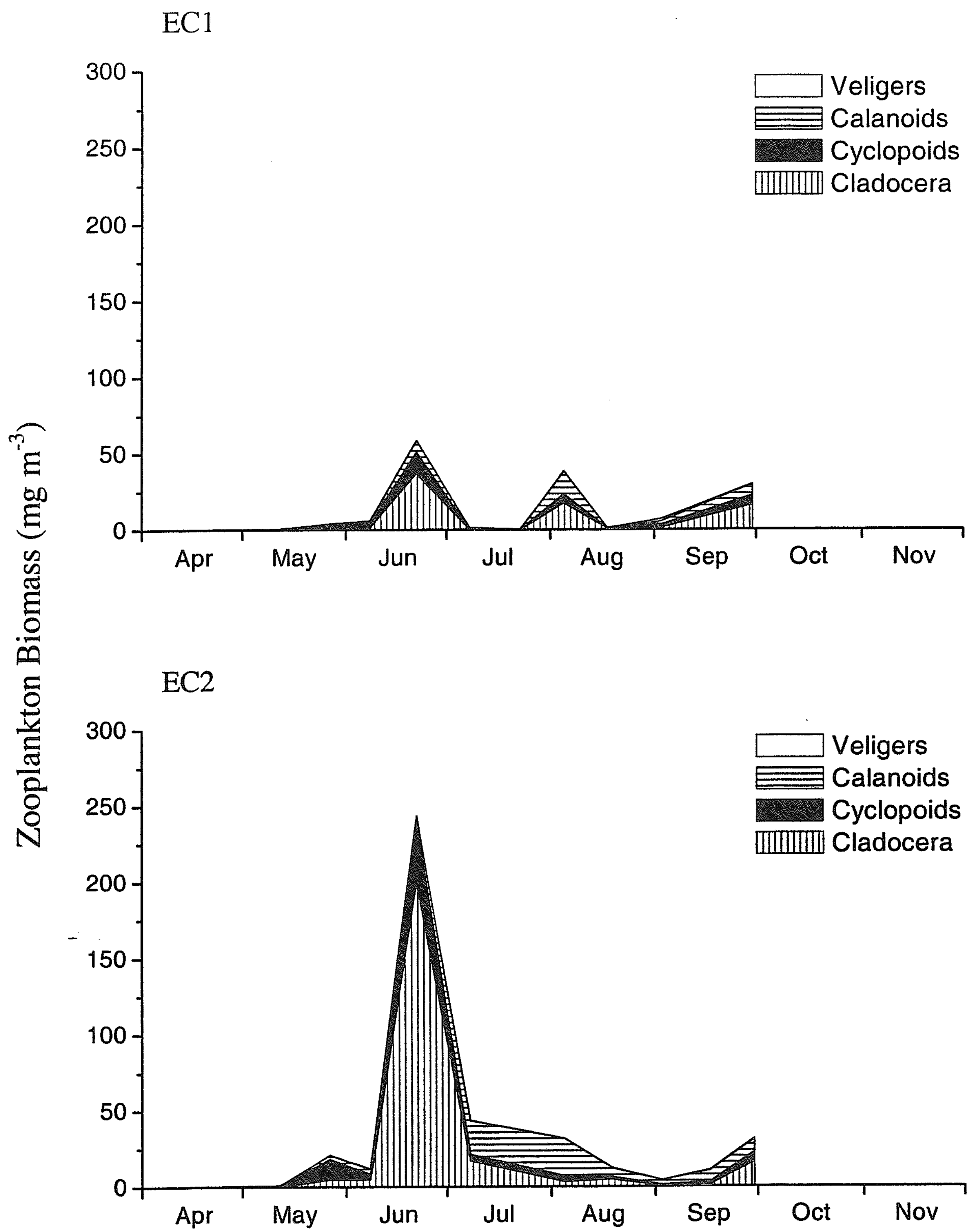


Figure 26. Season trends in zooplankton and veliger biomass at a nearshore (EC1) and offshore (EC2) station in the east-central basin of Lake Erie, 1998.

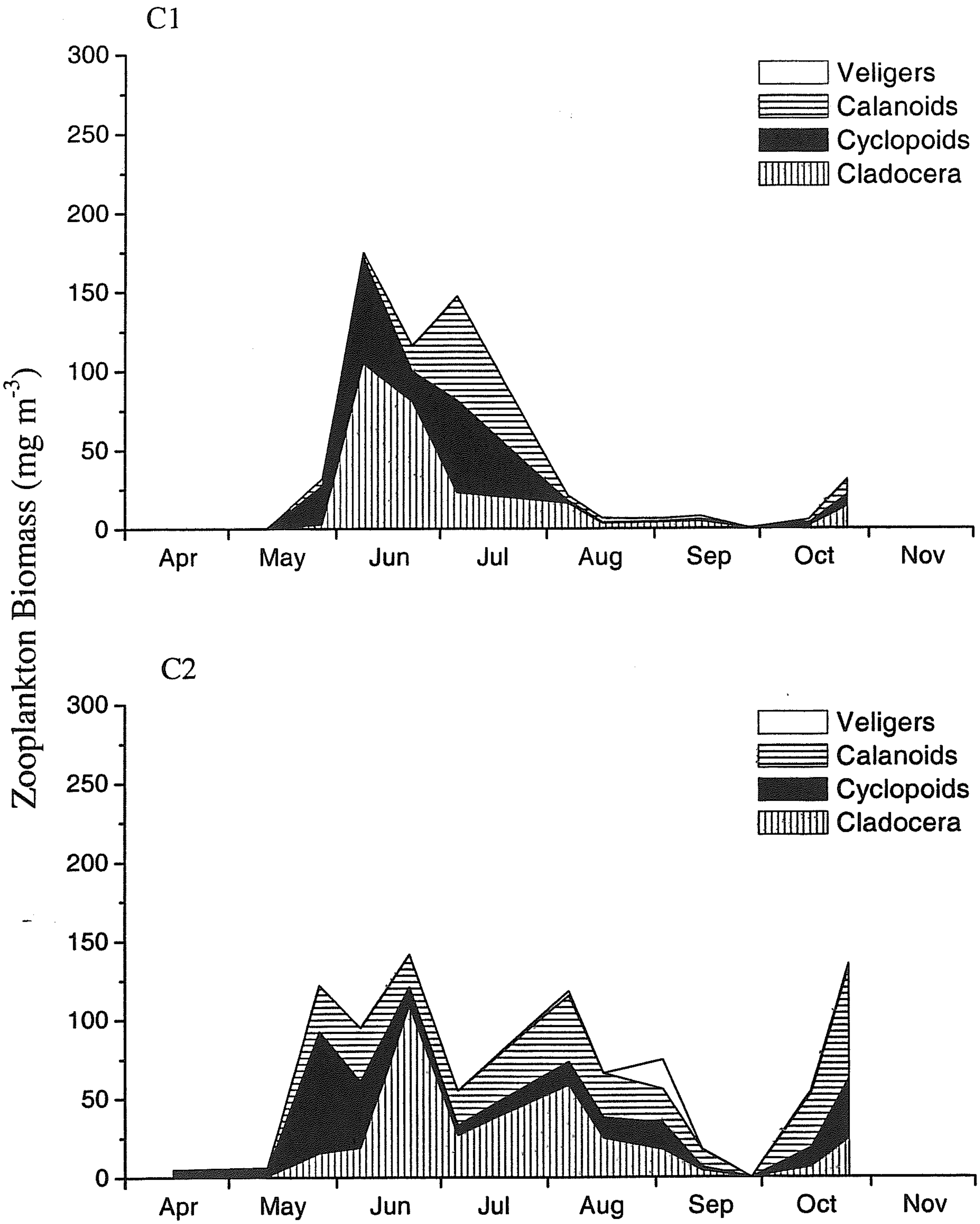


Figure 27. Seasonal trends in zooplankton and veliger biomass at a nearshore (C1) and offshore (C2) station in the central basin of Lake Erie, 1998.

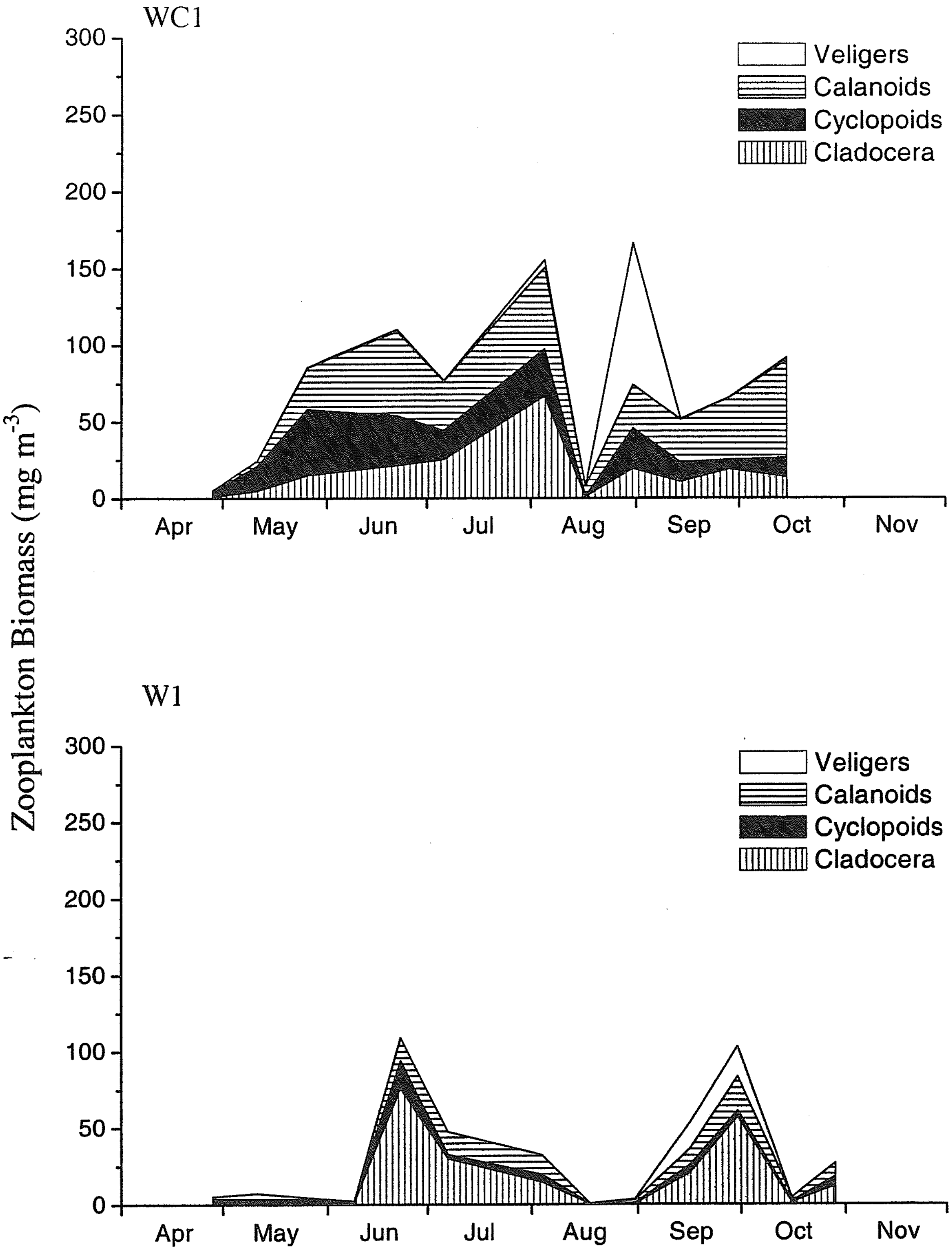


Figure 28. Seasonal trends in zooplankton and veliger biomass at nearshore stations in the west-central (WC1) and western (W1) basins of Lake Erie, 1998.

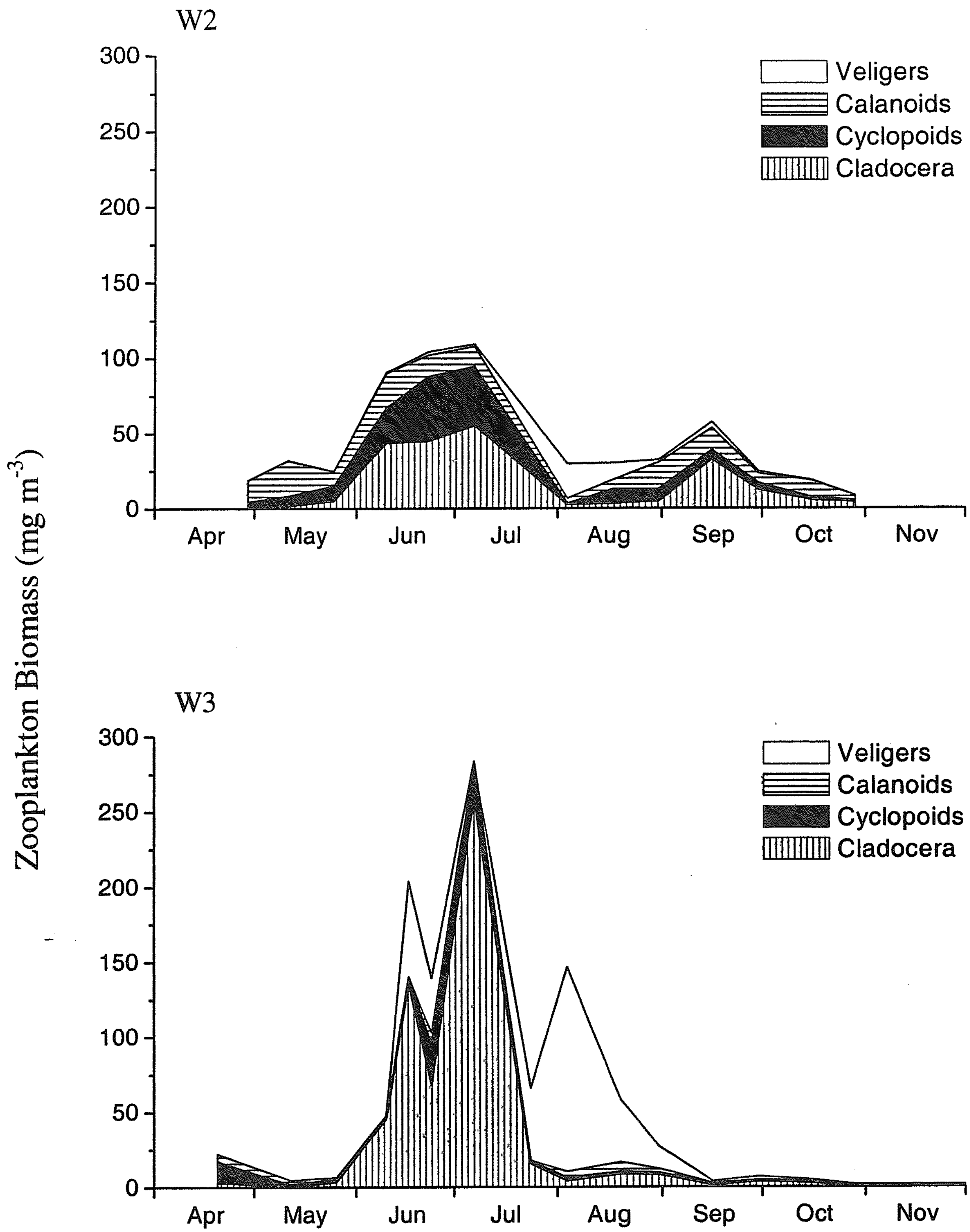


Figure 29. Seasonal trends in zooplankton and veliger biomass at offshore stations in the western basin of Lake Erie, 1998.

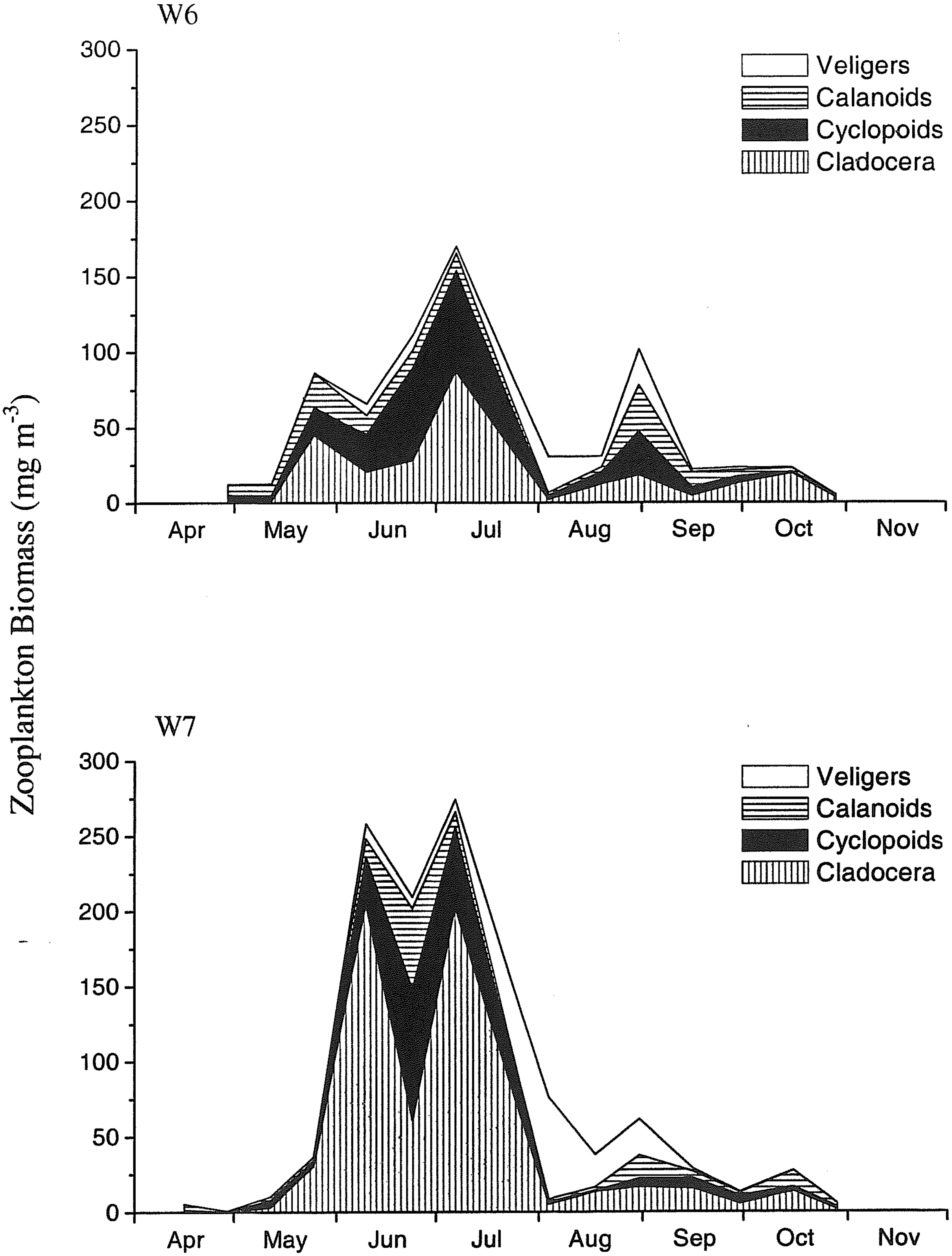


Figure 30. Seasonal trends in zooplankton and veliger biomass at an offshore (W6) and a nearshore (W7) station in the western basin of Lake Erie, 1998

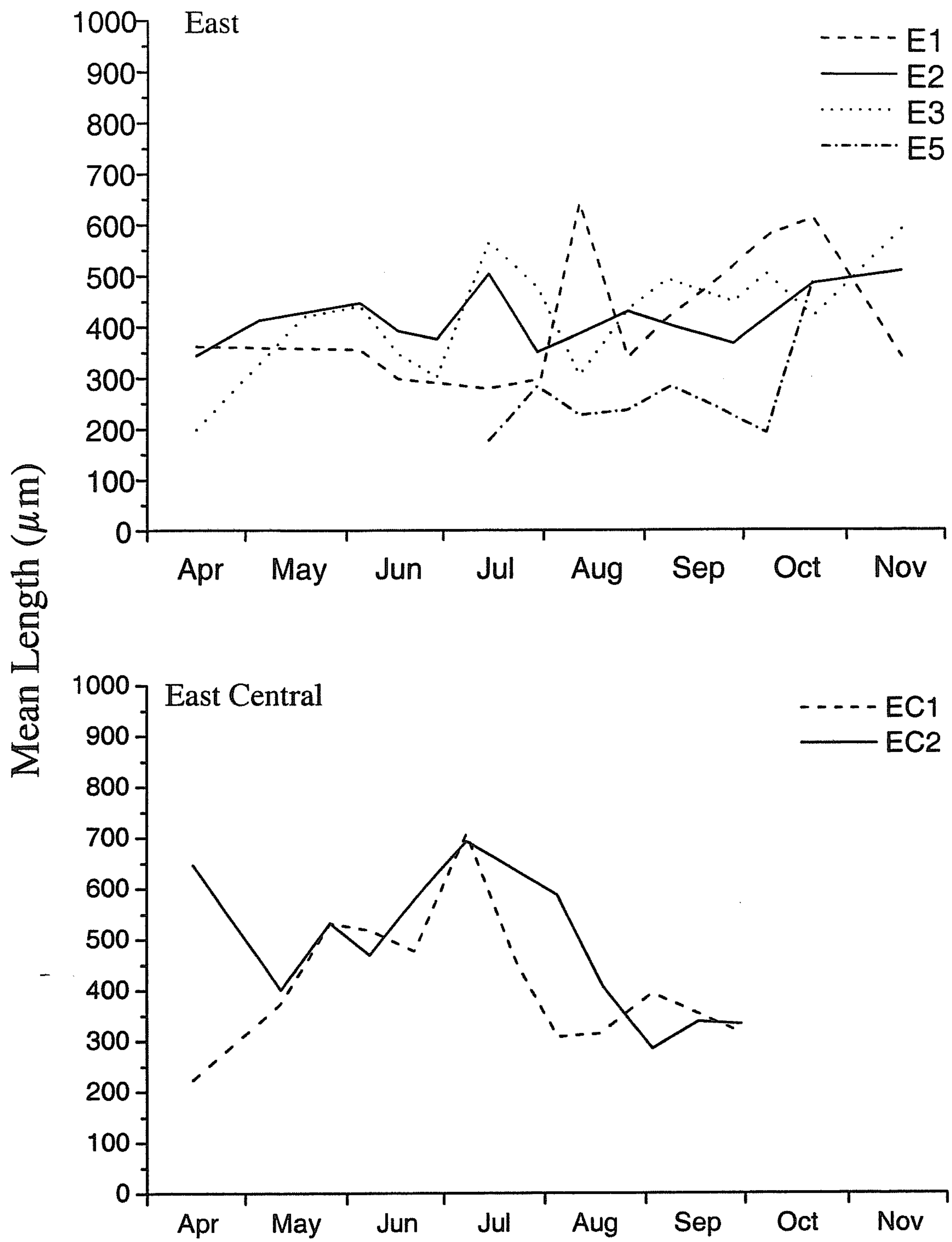


Figure 31. Seasonal zooplankton community size at nearshore (broken lines) and offshore (solid line) stations in the eastern and east-central basins of Lake Erie, 1998. Samples were collected with a 64-μm mesh net.

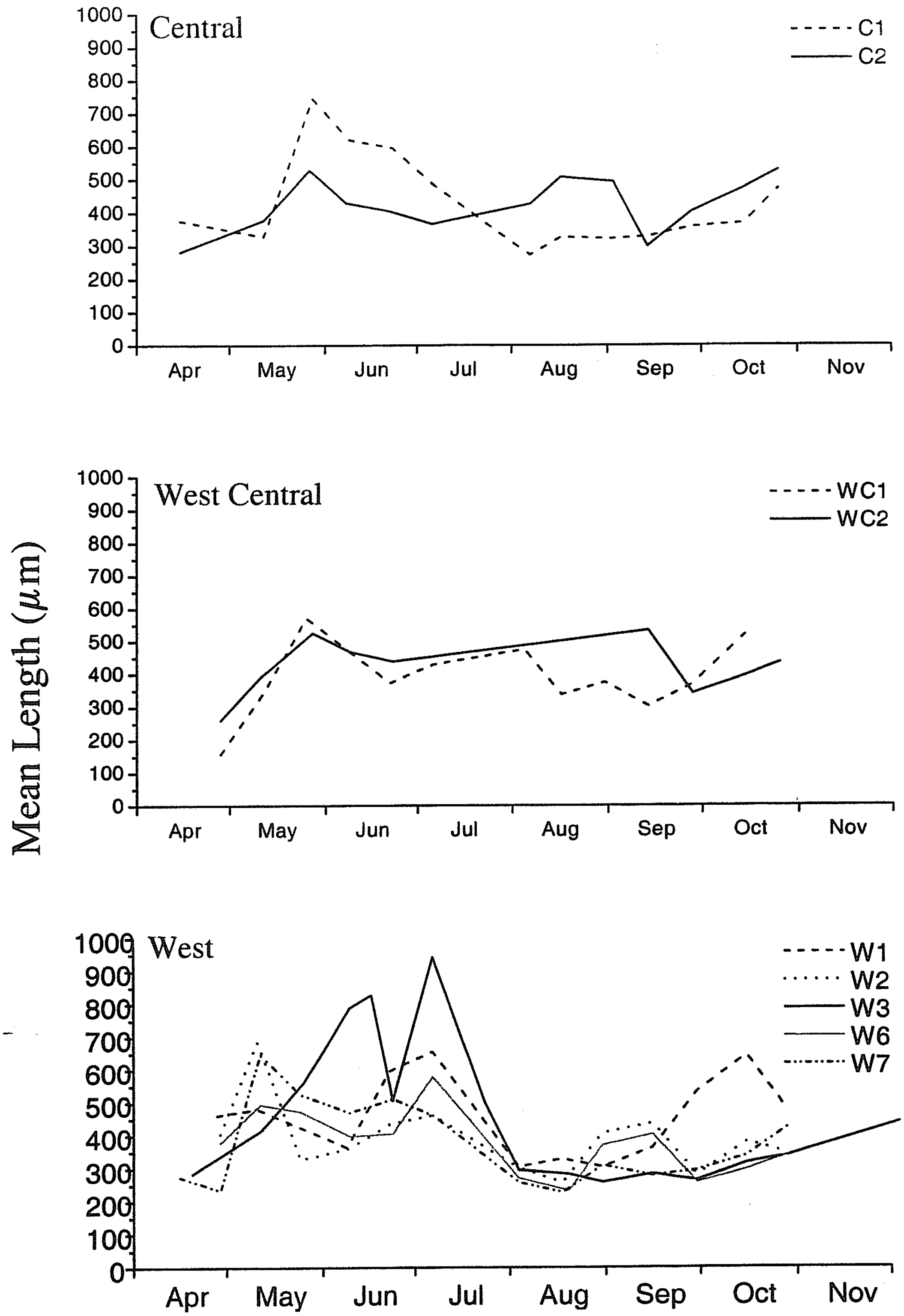


Figure 32. Seasonal zooplankton community size at nearshore (broken lines) and offshore (solid line) stations in the central, west-central and western basins of Lake Erie, 1998. Samples were collected with a 64-μm mesh net.

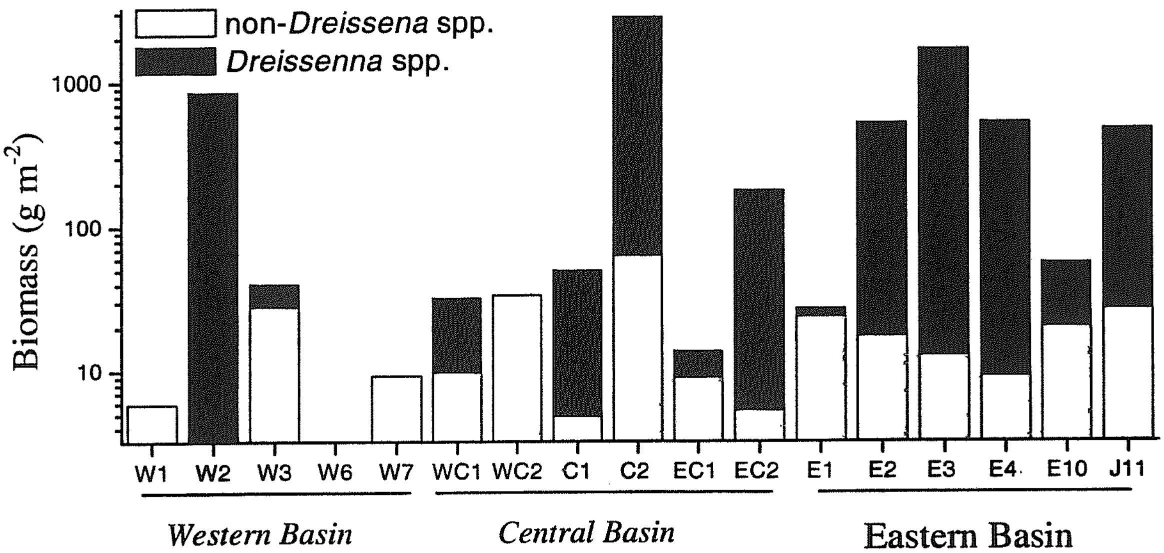
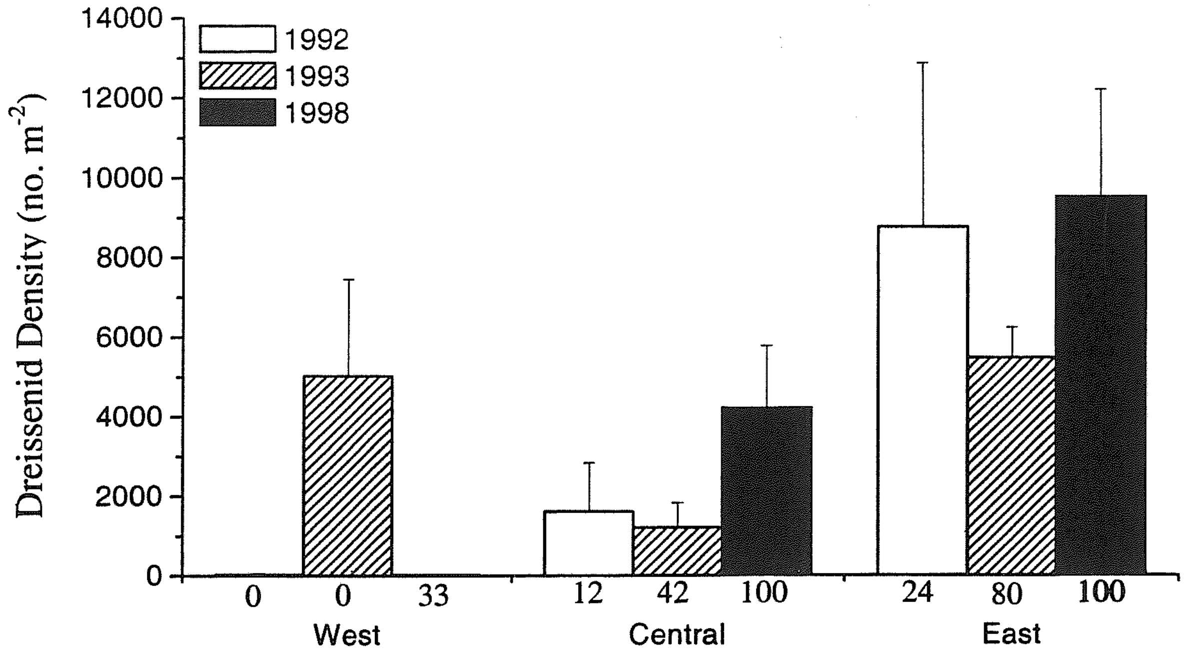


Figure 33. Mean total biomass (shell-free wet weight, g m^{-2}) of benthic fauna at stations in each basin of Lake Erie, 1998.



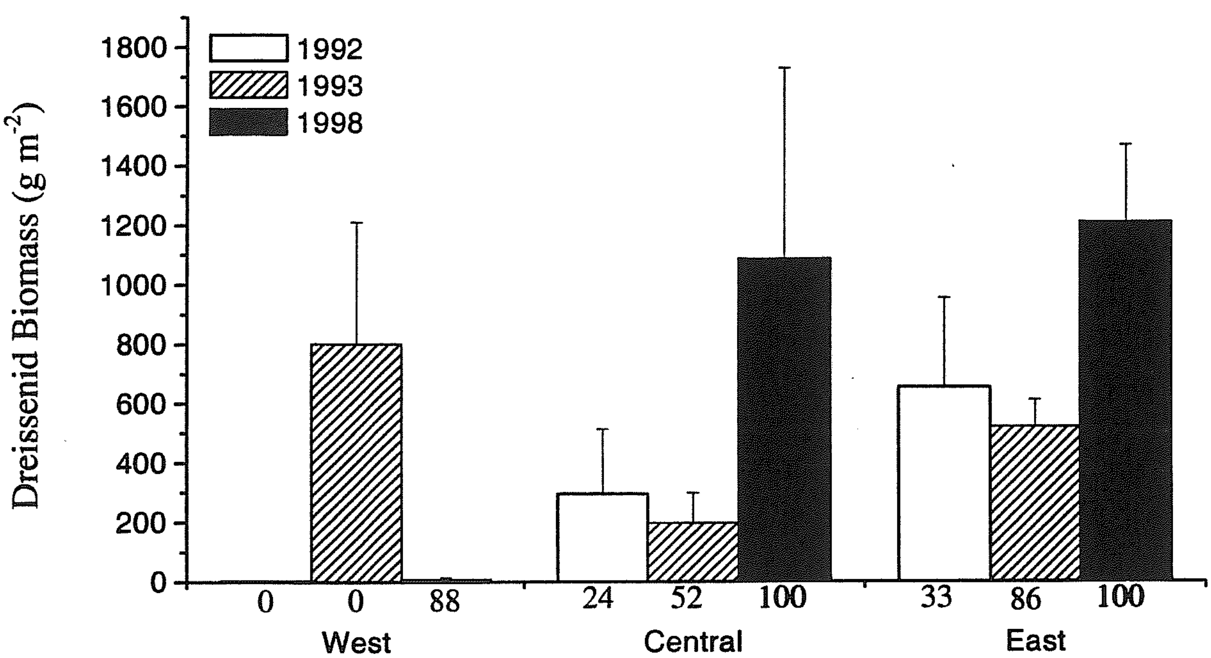


Figure 34. Mean (± 1 S.E.) Dreissena spp. density (>1mm length) and wet biomass (including shells) by basin at 16 sites sampled in 1992, 1993 and 1998. The contribution of D. bugensis as a percentage of the total is indicated below each bar.

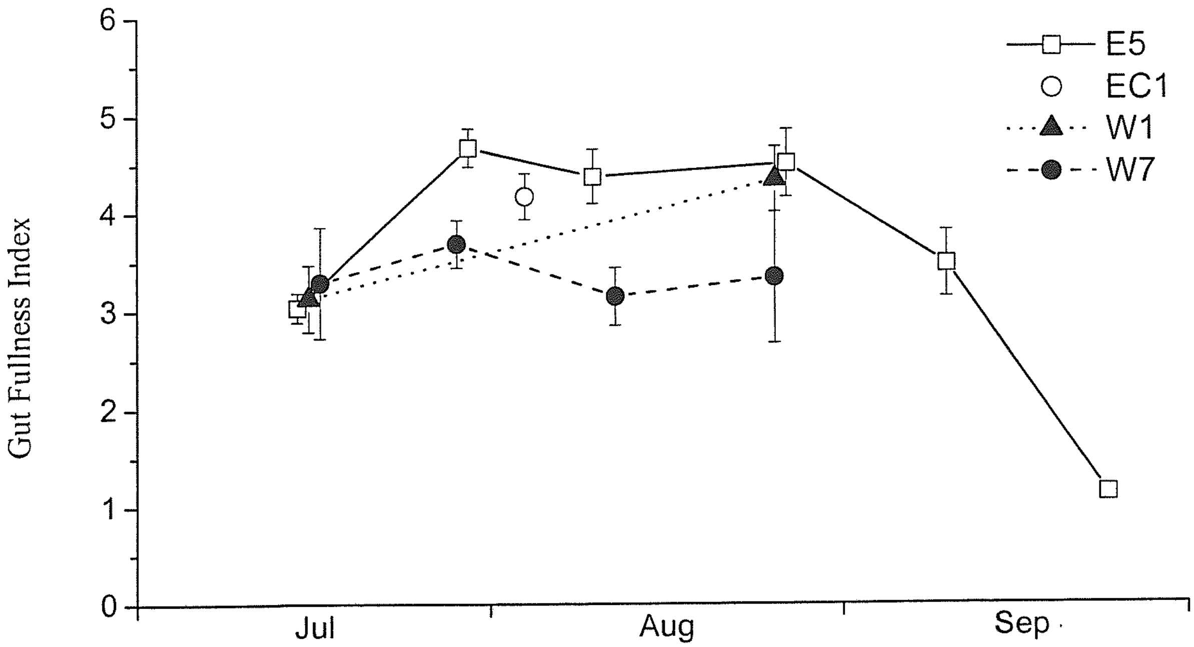


Figure 35. Mean gut fullness index (± 1 S.E.) for young-of-the-year yellow perch collected from the eastern, east-central, and western basins of Lake Erie, 1998. Subjective ratings were given to each fish stomach based on the following scale: 0-empty, 1- near empty, 2- ¼ full, 3- ½ full, 4- ¾ full, 5-full, 6-very full (see Methods for more detailed descriptions).

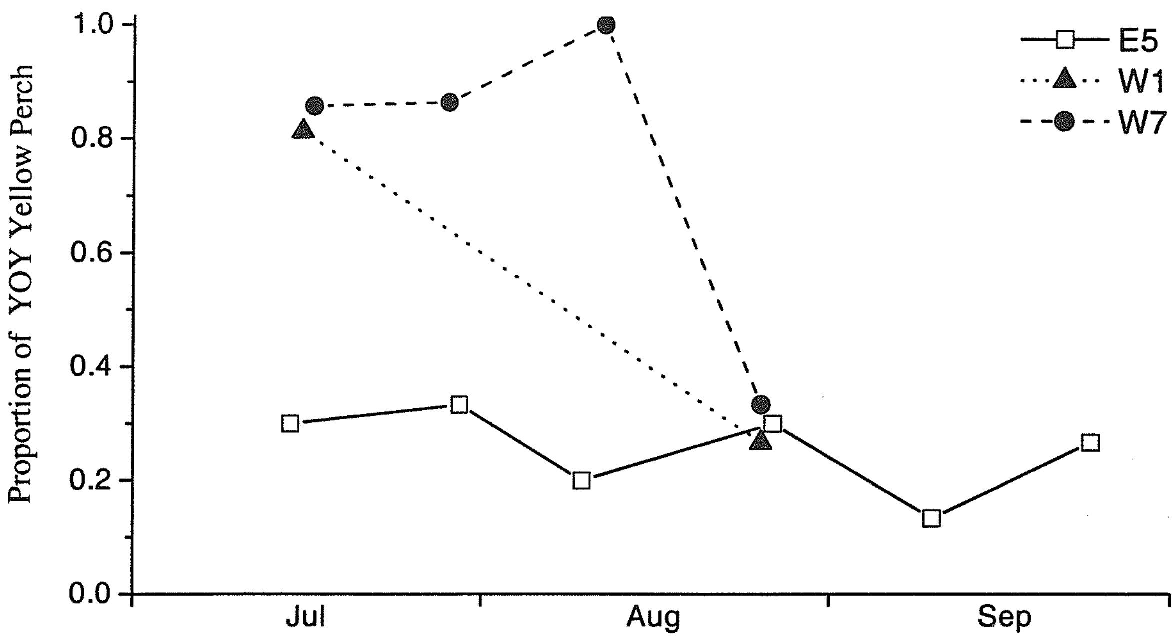


Figure 36. Proportion of young-of-the-year yellow perch stomachs containing only zooplankton prey. Fish were collected at various times from July to September from sites in the eastern (E1) and western (W1, W7) basins of Lake Erie, 1998.

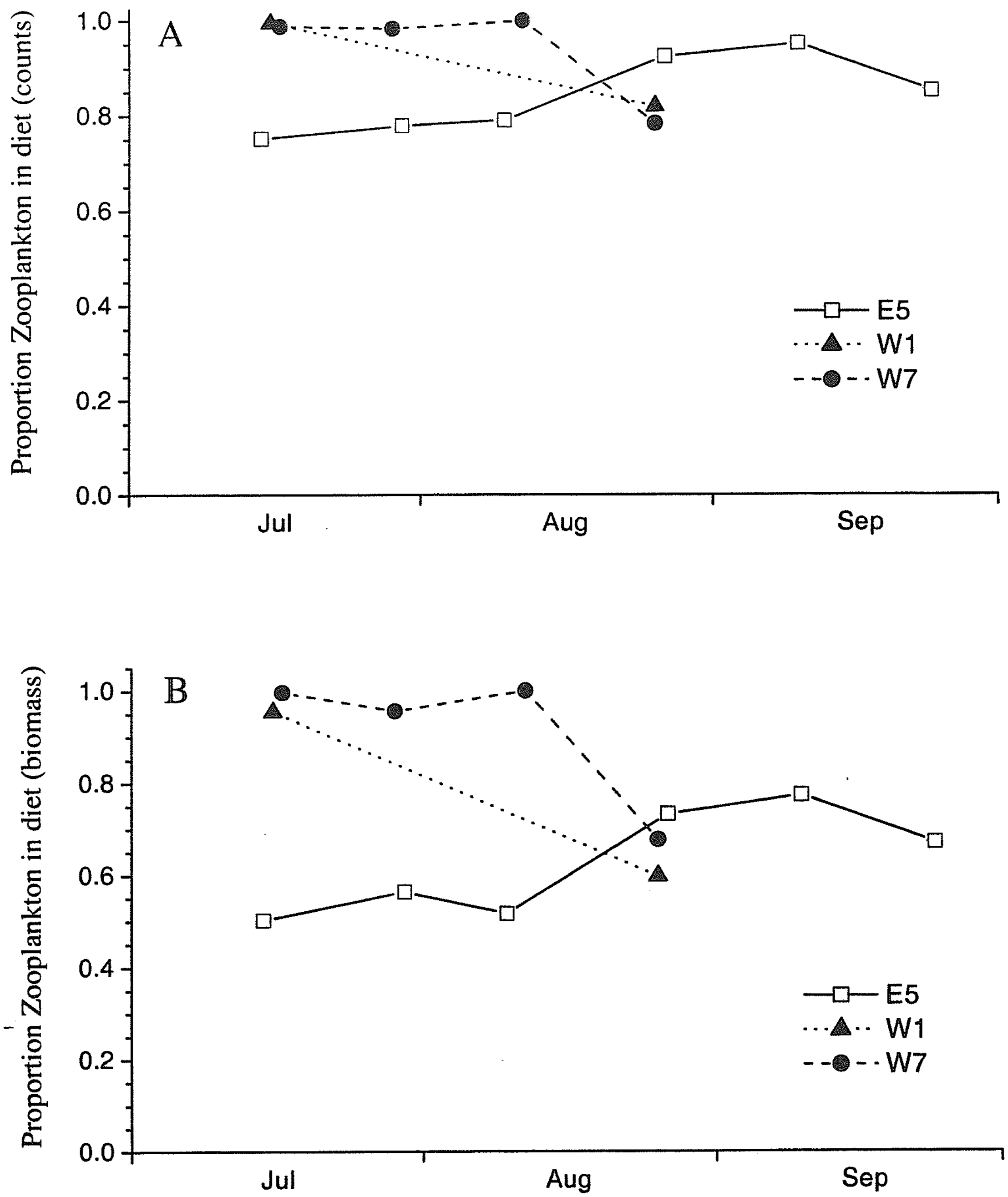


Figure 37. Mean proportion of zooplankton prey items in young-of-the-year yellow perch stomachs from nearshore stations in the eastern (E1) and western (W1, W7) basins of Lake Erie, 1998. A- proportion of diet based on number of diet items. B- proportion of diet based on mass of diet items.

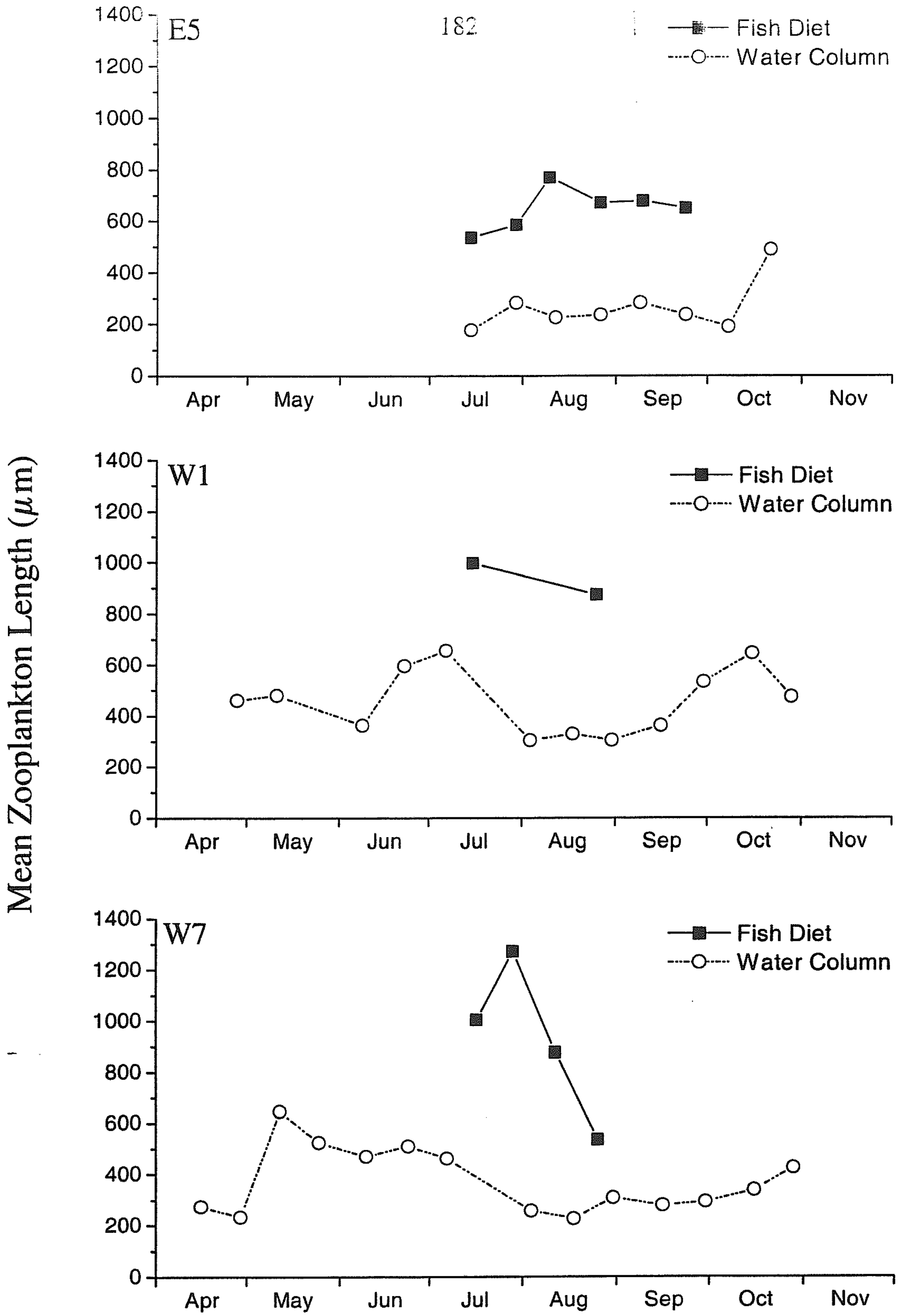


Figure 38. Mean length of the zooplankton community (water column) compared to mean size of zooplankton prey in young-of-the-year yellow perch stomachs (Fish diet) for three stations in Lake Erie, 1998.

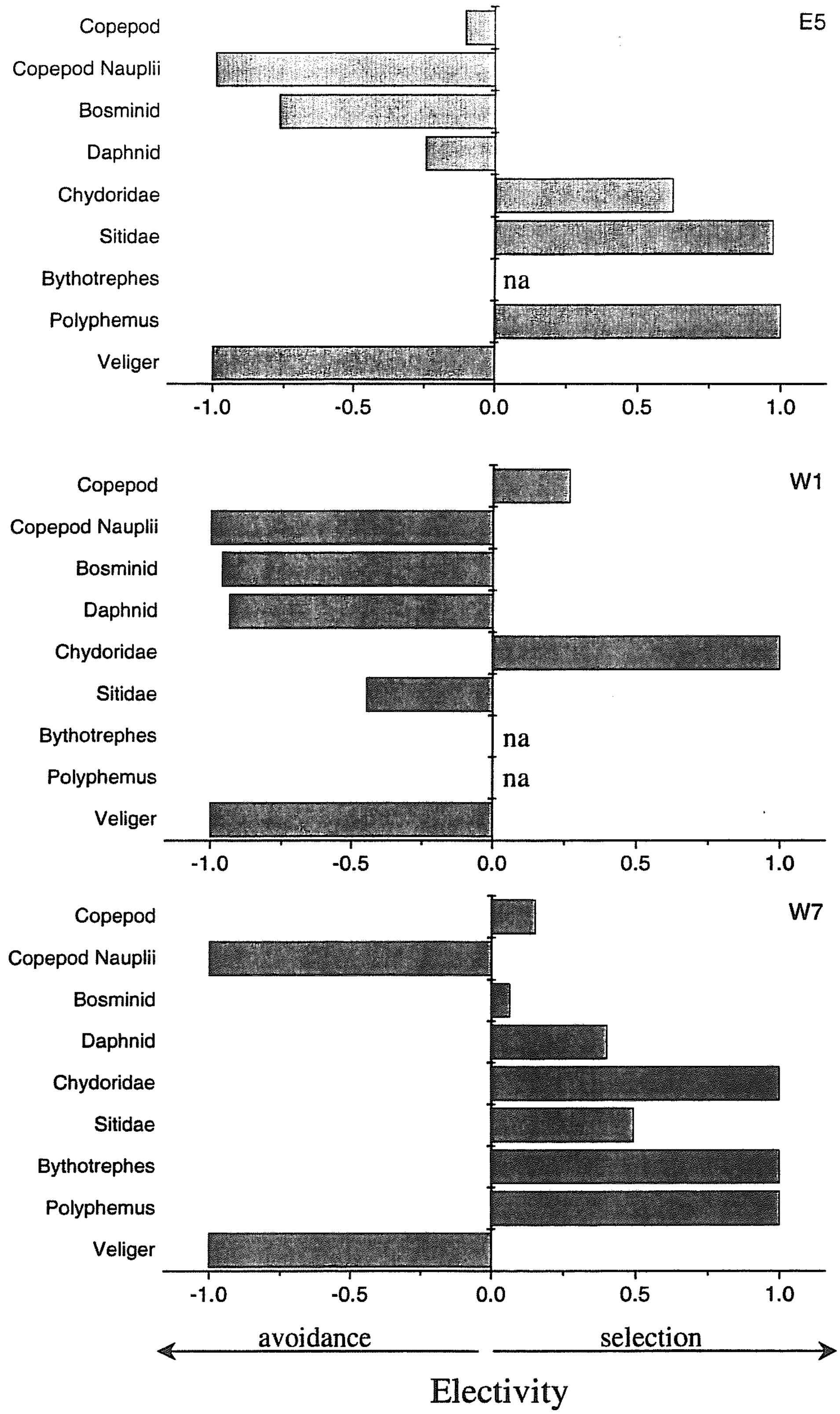


Figure 39. Average electivity (Ivlev, 1961) values for young-of-the-year yellow perch from stations in the eastern (E5) and western (W1, W7) basins of Lake Erie, 1998. "na" indicates that the food category was absent from the environment at that station.

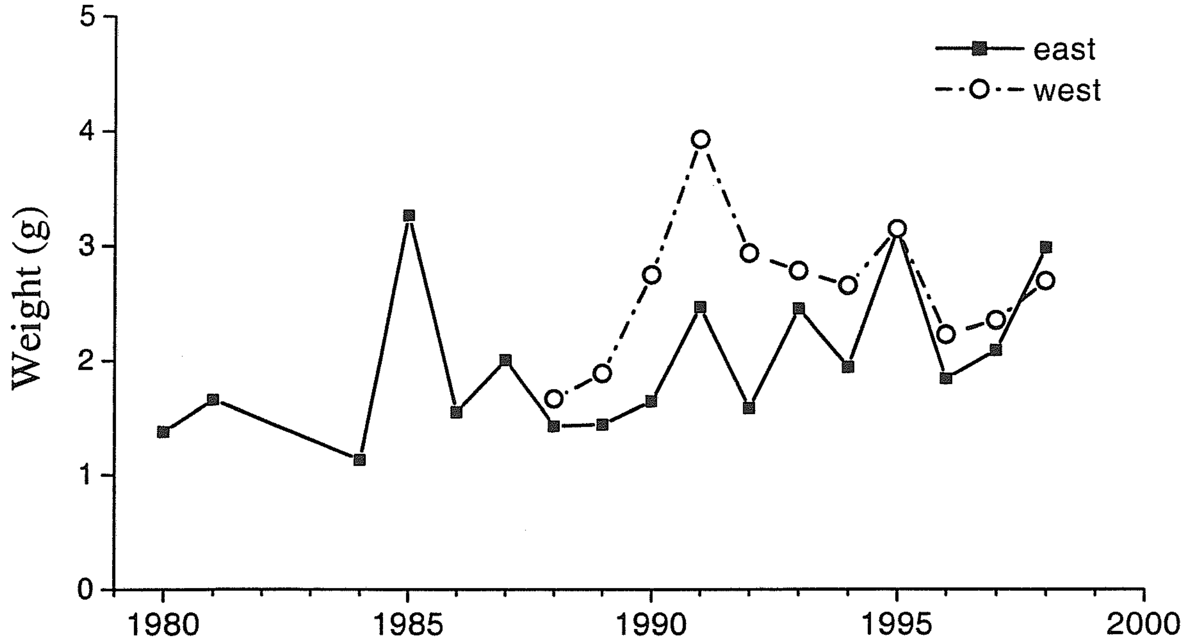


Figure 40. Predicted weight of young-of-the-year yellow perch (Aug 15) from the eastern and western basins of Lake Erie.

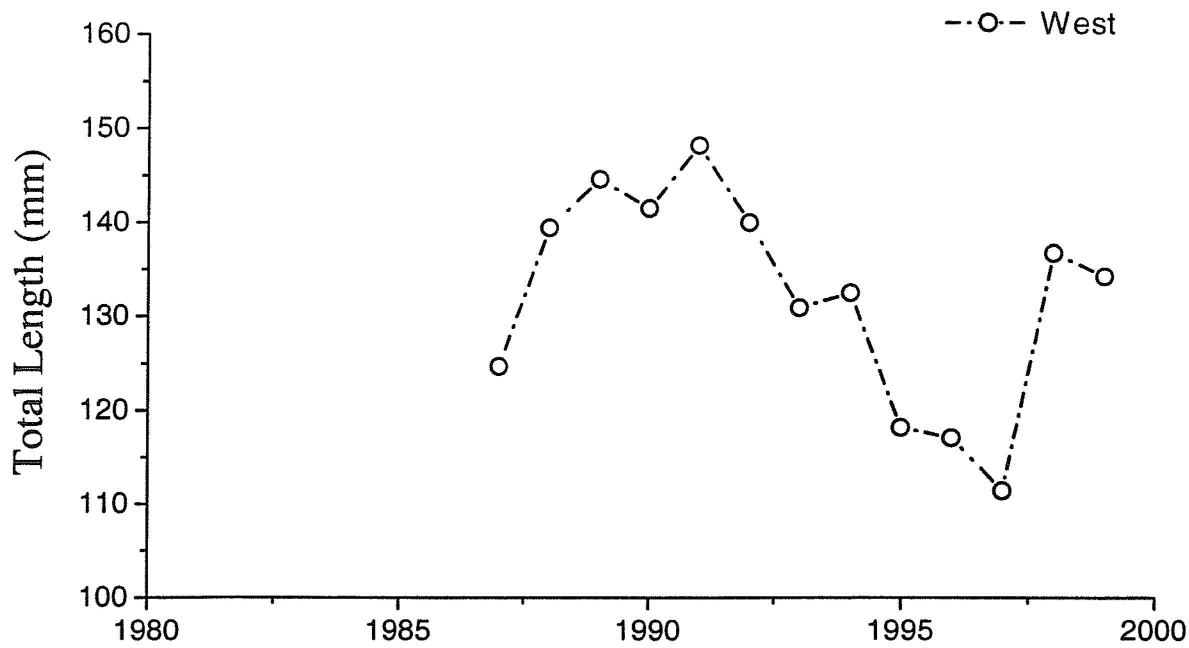


Figure 41. Mean total length of young-of-the-year walleye caught by trawls during August in the west basin of Lake Erie.

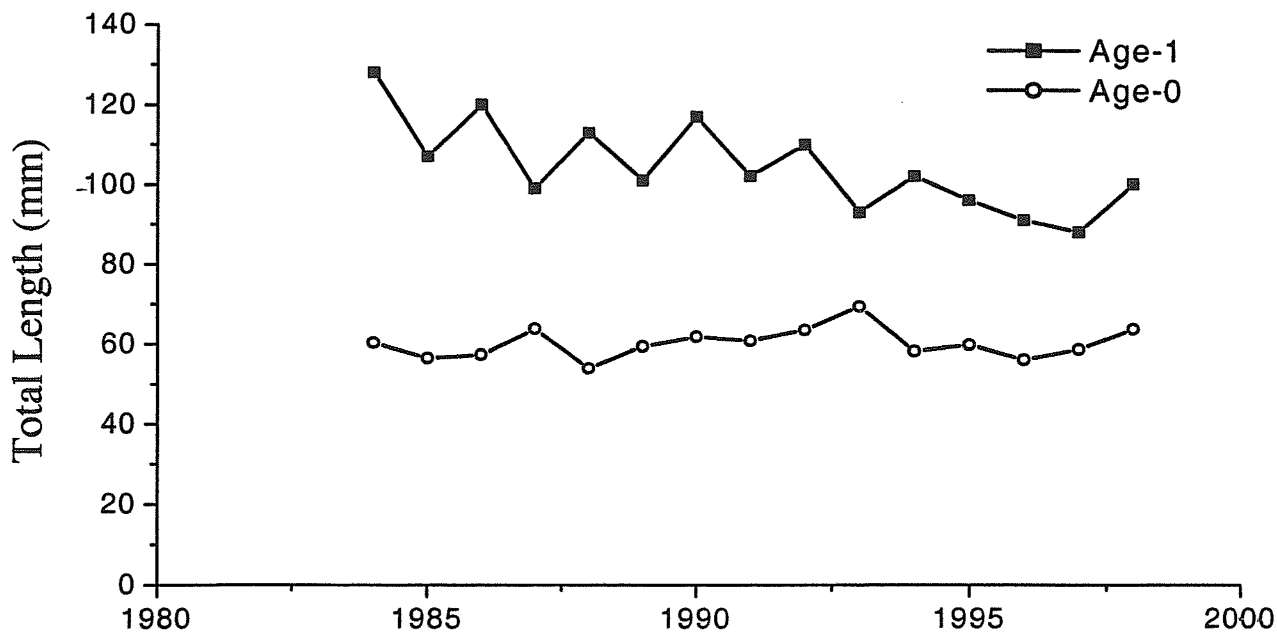


Figure 42. Total length of young-of-the-year and yearling smelt caught by trawl in the east basin (outer Long Point Bay) of Lake Erie.

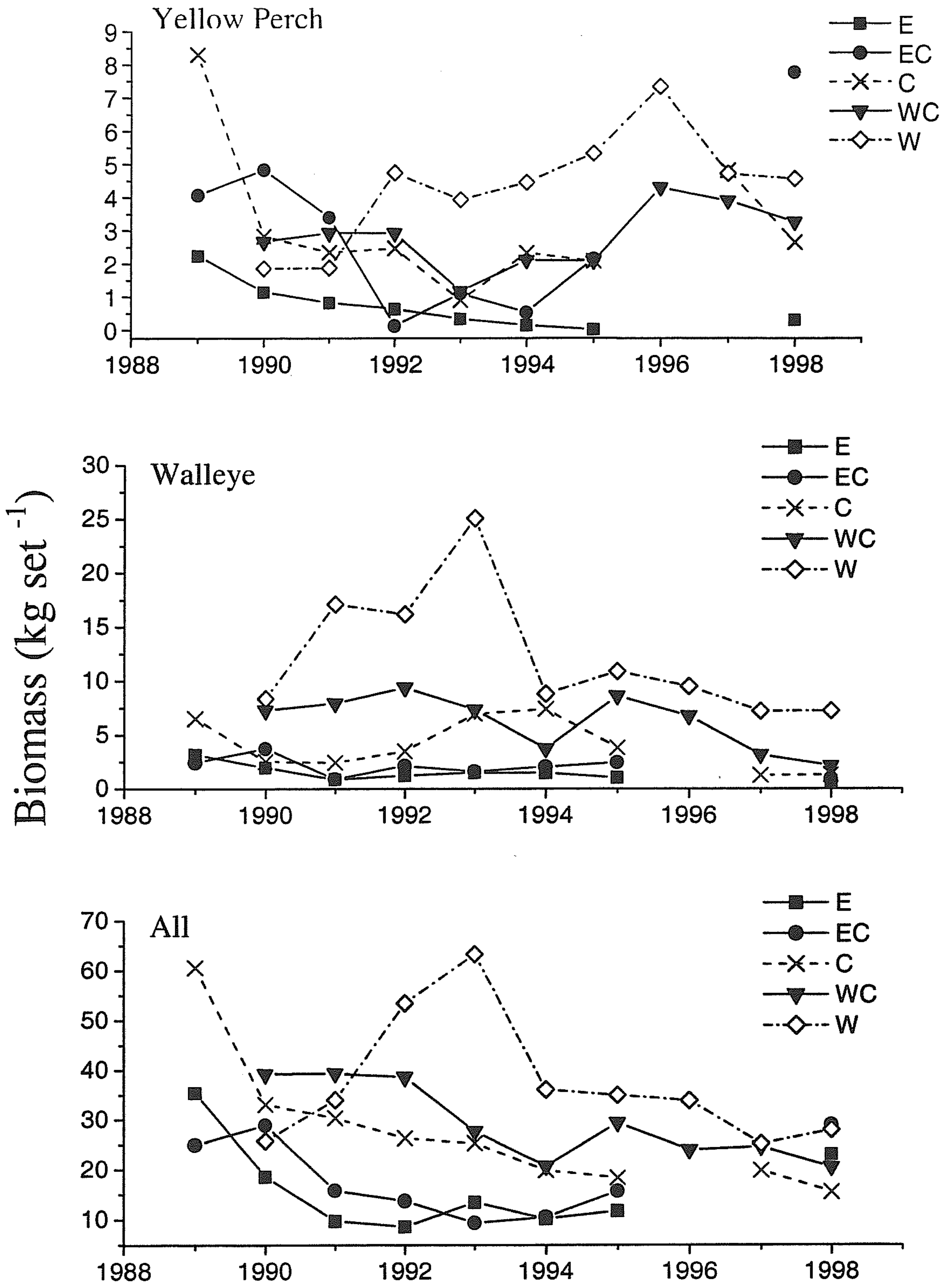


Figure 43. Catch-per-unit-effort for yellow perch, walleye and all fish caught by the OMNR / OCFA Partnership Gillnet program in Lake Erie, 1989-1998.

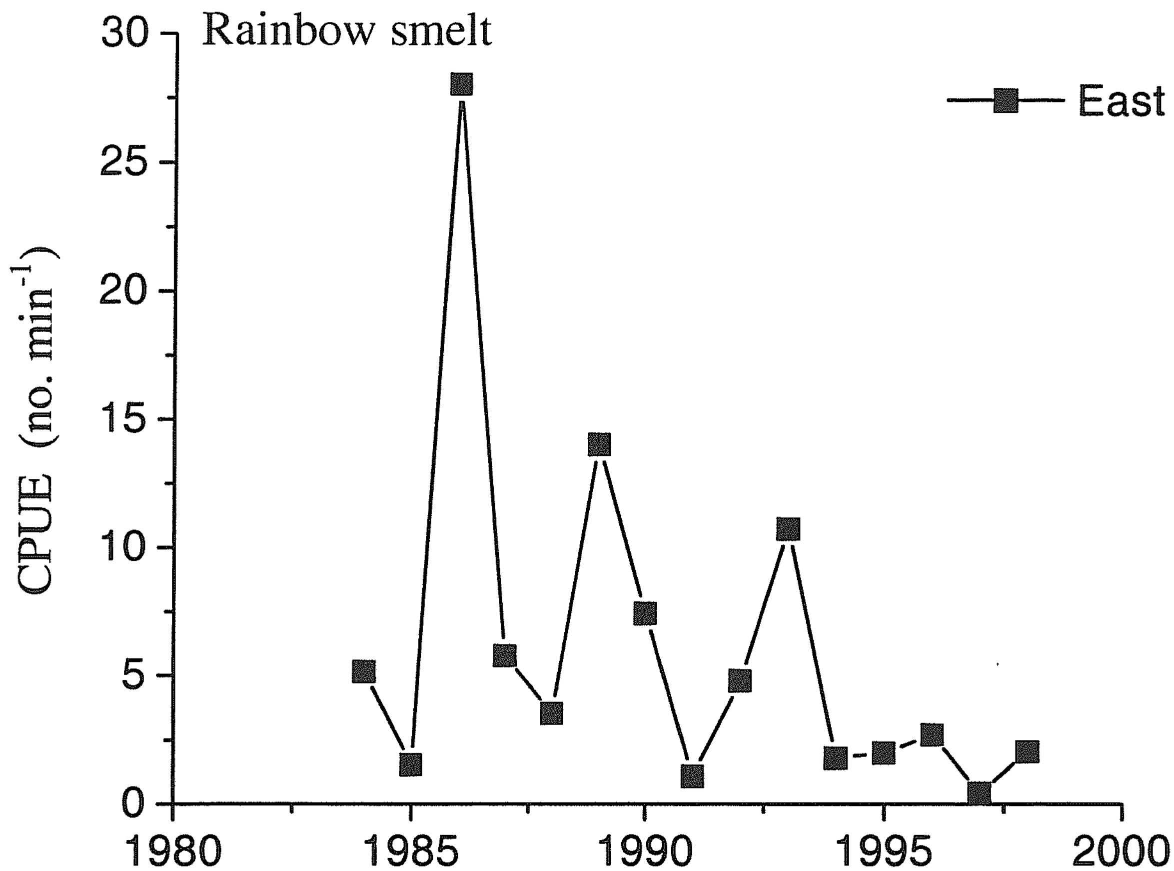
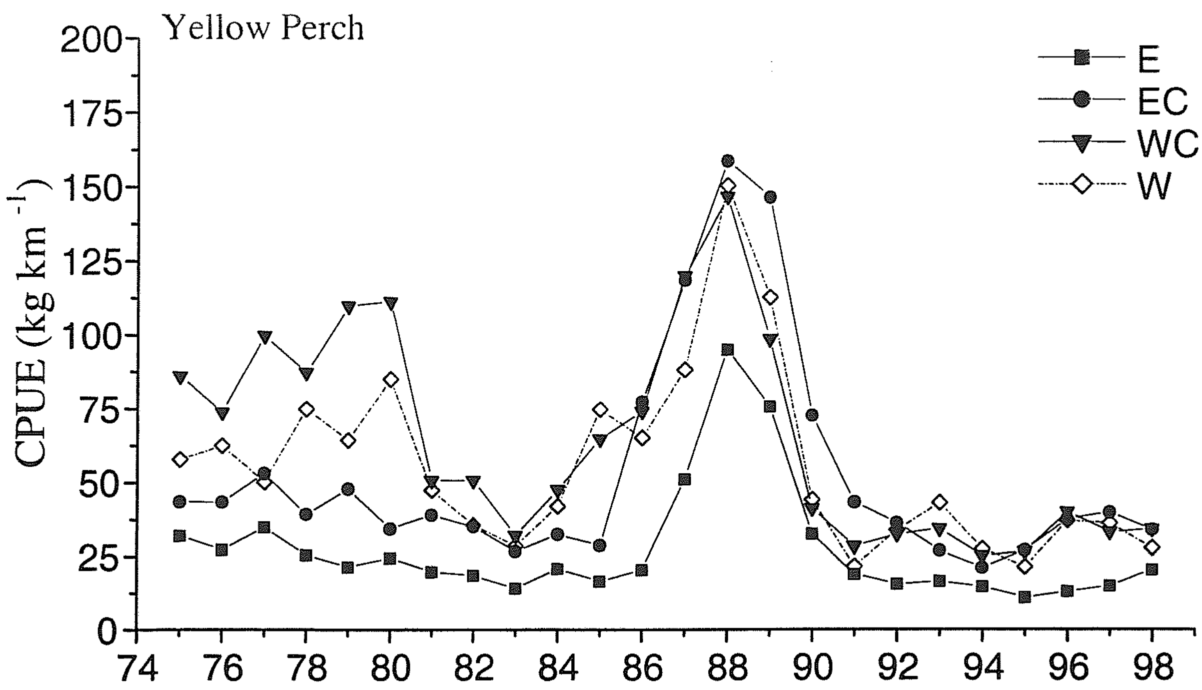


Figure 44. Catch-per-unit-effort for rainbow smelt caught by bottom trawl during October in the eastern basin (outer Long Point Bay) of Lake Erie, 1984 – 1998.



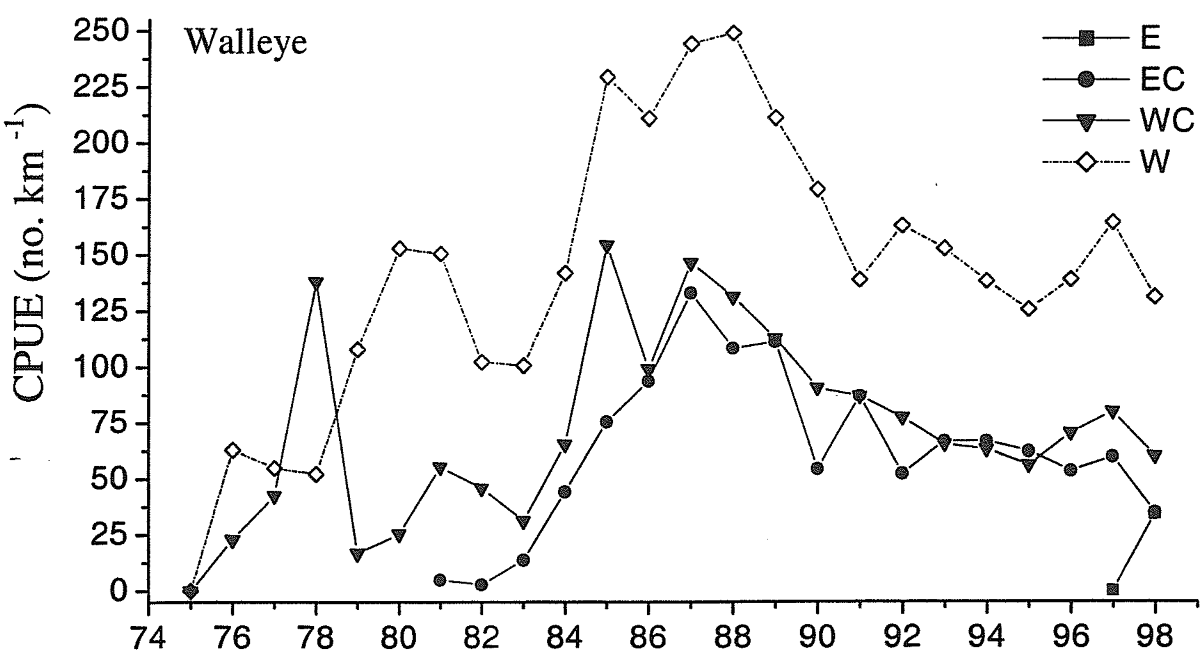


Figure 45. Catch-per-unit-effort for the commercial harvest of yellow perch and walleye in the eastern (E), east-central (EC), west-central (WC) and western (W) basins of Lake Erie between 1976 and 1998.

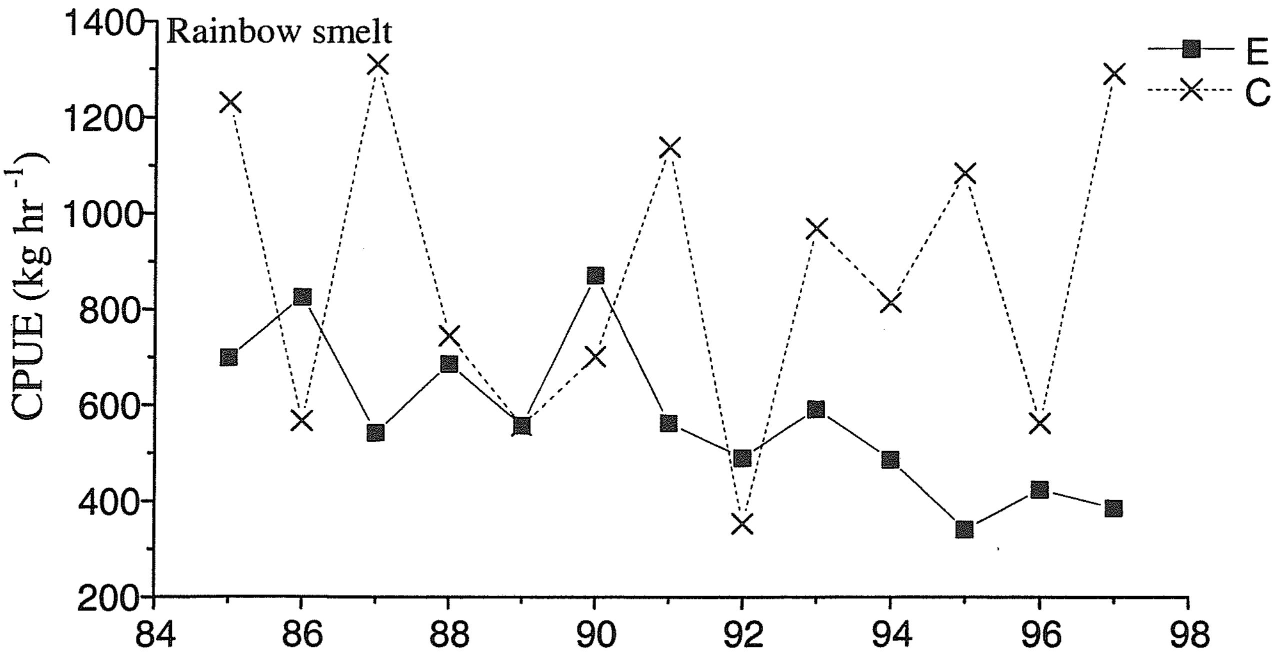


Figure 46. Catch-per-unit-effort for the commercial harvest of rainbow smelt in the eastern (E), and central (C) basins of Lake Erie between 1985 and 1998.

Appendix 1. Length-weight relationships used to estimate zooplankton biomass in Lake Erie. W= aL^b, where length is in mm and weight is in µg dry weight. Biomass of *Dreissena* was determined using W= a-bL+$c$$L^2$, where length is in mm and weight is in µg dry weight.

Taxon	a	b	c	Source
CLADOCERA				
Bosmina sp.	26.6	3.13		Bottrell et al. 1976
Daphnia longiremis	5.00	2.84		Bottrell et al. 1976 (Dumont et al. 1975)
Daphnia retrocurva	5.00	2.84		Bottrell et al. 1976(Dumont et al. 1975)
Daphnia galeata mendotae	5.00	2.84		Bottrell et al. 1976(Dumont et al. 1975)
Diaphanosoma sp.	5.00	2.84		Bottrell et al. 1976
Eubosmina sp.	26.6	3.13		Bottrell et al. 1976
Polyphemus pediculus	6.93	2.15		Dumont et al. 1975
Holopedium gibberum	11.21	3.04		Yan (pers. comm.)
Sida crystallina	5.00	2.84		Bottrell et al. 1976
Chydorus sphaericus	33.23	3.21		Malley et al. 1989
Alona sp.	29.70	3.48		Dumont et al. 19751
Bythothrephes cederstroemi	11.13	2.77		Yan (pers. comm)
Leptodora kindti	0.44	2.67		Rosen 1981
COPEPODA				
Calanoida				
Leptodiaptomus ashlandi	5.50	2.46		Sprules (derived from lit., pers. com.)
Leptodiaptomus minutus	5.50	2.46		"
Leptodiaptomus sicilis	5.50	2.46		"
Leptodiaptomus siciloides	5.50	2.46		"
Skistodiaptomus reighardi	5.50	2.46		"
Skistodiaptomus oregonensis	5.50	2.46		"
Epischura lacustris	6.50	2.63		Culver et al. 1985
Epischura lacustris cop.	6.50	2.63		Culver et al. 1985
Eurytemora affinis	5.50	2.46		Sprules (derived from lit., pers. com.)
-*Limnocalanus macrurus*	5.50	2.46		"
Senecella calanoides cop.	7.70	2.33		"
Calanoid copepodid	5.50	2.46		"
Calanoid nauplii	4.20	2.48		Sprules(derived from Lewis 1979, pers. com.)
Cyclopoida				Sprules (derived from lit., pers. com.)
Diacyclops thomasi	5.50	2.46		"
Cyclops vernalis	5.50	2.46		"
Mesocyclops edax	6.66	2.89		Culver et al. 1985
Tropocyclops extensus	5.50	2.46		Sprules (derived from lit., pers. com.)
Eucyclops agilus	5.50	2.46		"
Eucyclops speratus	5.50	2.46		"
Cyclopoid copepodid	5.50	2.46		"
Cyclopoid nauplii	4.20	2.48		Sprules(derived from Lewis 1979, pers. com.)
Harpactacoida	4.20	2.48		Sprules(derived from Lewis 1979, pers. com.)
DREISSENA VELIGERS	58.207	-2.636	0.037	Hillbricht-Ilkowska and Stanczykowska, 1969