

## INTERNAL REPORT 81

### GRAZING AND PRODUCTION BY ZOOPLANKTON IN LAKES OF CONTRASTING TROPHIC STATUS -- A PROGRESS REPORT

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#### ABSTRACT

Grazing rates and density of the crustacean zooplankton were measured in Findley and Chester Morse Lakes and Lake Sammamish, Washington. Sample analysis is incomplete at reporting time, thus estimates of production from examination of life stage biomass changes was not possible. Maximum density of crustacean zooplankton was about 10/l in the water column of oligotrophic Findley and Chester Morse Lakes and 70/l in mesotrophic-eutrophic Lake Sammamish during 1972. Densities averaged about 10 times greater in Lake Sammamish than in the other lakes. Copepods comprised most of the numbers in all three lakes. Grazing apparently represents a sizable loss to phytoplankton in the three lakes; feeding rates experimentally determined *in situ* from changes in  $^{14}\text{C}$  tagged phytoplankton ranged from nearly one half to over six times the algal biomass per day. However, feeding rate was always less than phytoplankton productivity

#### INTRODUCTION

Zooplankton play an important role in the dynamics of lake systems from at least three standpoints. Their herbivorous grazing activity can represent a significant loss rate to the phytoplankton and a control of their biomass, particularly in oligotrophic lakes. They perform, through consumption and metabolic processes, much of the nutrient regeneration so important to maintaining primary production in the lighted zone of stratified lakes (Johannes 1968). Finally, the energy converted by the zooplankton sustains the production of planktivorous fish.

The objectives of this project are to quantitatively define these roles for the crustacean zooplankton in three lakes of Cedar River drainage, Washington. These lakes are Sammamish, Chester Morse and Findley and have been physically described elsewhere (Taub et al. 1972). Grazing rates are to be determined *in situ* in each lake at least frequently enough to represent seasonal changes. Regeneration rates of nutrients (N and P) in the water column could be estimated from grazing rate measurements with help from experimental data reported in the literature. Production of crustacean plankton are to be estimated in the three lakes by examining the biomass changes in the life history stages of the dominant species. The bulk of this work is not complete, however, highlights of the findings thus far will be presented.

The extent of the research considered desirable and the low level of funding available per year necessitated spreading the work over three years. Following the first year of investigation, the researchers feel that progress toward the objectives is satisfactory.

## MATERIALS AND METHODS

### *Grazing Rates*

Consumption of plankton algae by zooplankton was determined in 41 dark and clear bottles held for about 4 hours at 1 per cent of surface light intensity in the three lakes. Two experiments were conducted in Lake Sammamish and one each in Chester Morse and Findley Lakes. The amount of phytoplankton consumed was determined by measuring the change in radio-carbon activity of the phytoplankton during the four-hour exposure to grazing zooplankton. The phytoplankton were "tagged" by a preliminary exposure of the water samples and contained plankton to 6-30  $\mu\text{C}/\text{l}$  of  $\text{Na}_2^{14}\text{CO}_3$ . To increase the sensitivity of measurements, the zooplankton were concentrated in some instances to 10 times. Experimental controls were set up by removing zooplankton by filtering or inactivating them with a neuro-anesthetic.

Partitioning of the grazing activity into three phytoplankton size groups (ultra, nano and net plankton) was accomplished by filtering subsamples from the four-liter bottles through a series of three pore-size filters--50 $\mu$ , 5 $\mu$  and 0.45 $\mu$ . The grazing results could then be tied to phytoplankton productivity and nutrient response studies where similar partitioning is underway.

### *Production*

Net hauls for zooplankton were collected in the three lakes at frequencies varying from twice weekly to less than once per month with the least frequency occurring in the winter months. Hauls were collected with either a 0.25 m Wisconsin net or a 0.5 m closing net. Concentration of plankton was determined by dividing the total number in the sample by the volume in the cylinder of lake water filtered. Biomass can be calculated from average lengths using length-weight relationships in the literature.

Production can be calculated from biomass increments for life history stages of each species using development times from the literature, or determined in the laboratory as is being done with an unknown species in Findley Lake. Difficulty was encountered in trying to employ the egg ratio method to determine birth rates because important species such as *Limnocalanus* and *Epischura* do not carry their eggs and also since cladocerans tended to lose their eggs when preserved. Data are not sufficiently compiled to calculate secondary production at this time, however some data are available on concentrations.

## RESULTS AND DISCUSSION

### *Grazing*

Several experiments were performed, results of only four are reported here. Grazing rates were determined by first estimating filtering rates or "the volume of ambient medium containing the number of cells eaten by one animal in a given time" (Rigler 1971) according to the following equation:

$$F = V \frac{\log C_o - \log C_t}{0.4343 t} \quad (1)$$

where  $V$  is the volume of water per animal,  $C_o$  is the final  $^{14}\text{C}$  activity of cells in the control bottle, and  $C_t$  the final  $^{14}\text{C}$  activity of cells in the test bottle at time  $t$ . Use of this equation assumes that the feeding rate of zooplankton is proportional to the concentration of phytoplankton and that cell concentration decreases exponentially with time.

The values obtained for feeding rates in the three lakes are shown in Table 1. Grazing apparently represents a sizable loss rate for the phytoplankton in all three lakes. The feeding rates range from nearly one half of the phytoplankton biomass removed per day to over six times. However, loss due to grazing was less than the gain from primary productivity. High loss rates of phytoplankton due to grazing has been commonly observed, particularly in oligotrophic systems. Loss rates may tend to decrease in eutrophic lakes because detritus feeders are favored in these systems.

The August experiment in Lake Sammamish showed the lowest rate and at this time nanoplankton comprised only 70 per cent of the biomass; nanoplankton comprised more than 90 per cent during the other experiments. Since blue green algae are abundant in Lake Sammamish in August one might suspect that the lower grazing rate (0.4/day) was due to these apparently inaccessible large food items. However, the net plankton ( $>50\mu$ ) was heavily grazed.

Although high loss rates of phytoplankton were consistently measured the overall effect of zooplankton grazing on phytoplankton may be positive. The light bottles with zooplankton (at 1 per cent surface intensity) always showed increased  $^{14}\text{C}$  activity over and above the dark bottle with zooplankton. This suggests that zooplankton activity stimulates the growth of phytoplankton to more than compensate for the removal of cells through grazing. This stimulation is suspected to be caused by regeneration of nutrients for which zooplankton are considered by many to be the most important agents in the photic zone (Johannes 1968).

However, analyses of macronutrients nitrogen and phosphorus did not show a clear indication of this process. Nitrogen and phosphorus together have been consistently found to be limiting phytoplankton growth in these lakes so it is reasonable to believe that measurements of these nutrients should demonstrate the effect if the cause is nutrient regeneration. On the other hand, the rapid rate at which phytoplankton absorb nutrients if in short supply makes the observation of a nutrient concentration increases in bottles containing algae and zooplankton remote. The regeneration rate of nutrients by zooplankton may have to be hypothesized from grazing rates to attain reasonable rate estimates for modeling rather than measured directly.

### *Production*

Sample analysis is not complete on any of the lakes to the extent that production can be estimated. Most of the 1972 samples have been analyzed in Lakes Sammamish and Findley with work progressing on Chester Morse samples at present. Although production estimates for 1972 will be forthcoming from the three Lakes, more reliable estimates may require more frequent sampling in winter when larval stages are abundant. These samples are presently being collected.

Concentrations of total copepods and cladocerans range, respectively, from 3 to 10/l and 0 to 1/l in Findley Lake and from 0.5 to 4/l and from 0 to 4.5/l in Chester Morse Lake during 1972. Concentration ranges for the respective groups in Lake Sammamish during 1972 were 10 to 70/l and 0 to 2.5/l. Comparison of similar collections has shown that crustacean zooplankton average about 10 times the density in mesotrophic-eutrophic Lake Sammamish as in oligotrophic Chester Morse and Findley Lakes. A mean growing season biomass of 35 $\mu$ g/l dry weight in the photic zone of Lake Sammamish was estimated for purposes of a phosphorus cycling model.

The principal zooplankton in the three lakes are shown in Table 2. A small *Diatomus* sp. in Findley Lake has not been identified. We plan to seek outside assistance for this.

Table 1. Concentrations of zooplankton and phytoplankton and calculated rates and effects of grazing from dark bottle experiments *in situ* based on changes in  $^{14}\text{C}$  tagged phytoplankton.

Lake	Date (1972)	Zooplankton No/l	Chl $a$ $\mu\text{g/l}$	Feeding Rate	Feeding Rate	Feeding Rate	per cent nano Plankton grazed
				$\mu\text{g chl } a/animal \cdot \text{day}$	primary product	biomass (phytopl)	
Findley	22 Sep	37	0.58	0.103		6.60	80
Chester Morse	9 Jul	6	0.78	0.139	0.73	1.07	99
Sammamish	24 Jul	30	6.1	0.285	0.89	1.40	99
	27 Aug	138	3.0	0.0086	0.17	0.40	0 <sup>a</sup>

<sup>a</sup>Only net plankton were grazed even though nanoplankton comprised 70 per cent of the biomass. In the other experiments nanoplankton comprised more than 90 per cent of the biomass.

Table 2. Principal zooplankton in three lakes of the Cedar River drainage, Washington.

Lake Sammamish

*Diaptomus ashlandi*  
*Cyclops bicuspidatus*  
*Epischura neradensis*  
*Daphnia thorata*  
*D. schodleri*  
*Bosmina* sp.  
*Diaphanosoma leuchtenbergianum*  
*Kellicottia longispina*  
*Polyarthra* sp.  
*Keratella cochlearis*

Chester Morse Lake

*Limnocalanus macrurus*  
*Epischura neradensis*  
*Diaptomus ashlandi*  
*Cyclops bicuspidatus*  
*Daphnia rosea*  
*D. schodleri*  
*Bosmina* sp.  
*Holopedium gibberum*  
*Leptodora kindtii*  
*Polyarthra* sp.  
*Kellicottia longispina*  
*Conochillus unicornis*  
*Collotheca pelagica*  
*C. mutabilis*

Findley Lake

*Diaptomus kenai*  
*D.* sp.  
*Cyclops*  
*Holopedium gibberum*  
*Daphnia rosea*  
*Polyarthra* sp.  
*Kellicottia longispina*  
*Conchillus unicornis*  
*Keratella quadrata*

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