Periphyton in Freshwater Ecosystems and their Response to Environmental Conditions

Bios 569 - Practicum in Aquatic Biology

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Periphyton in Aquatic Ecosystems

Abstract

This study focuses on the oxygen productivity of epipelic periphyton. Light intensity and nutrient concentration were varied to show the effect each had on oxygen productivity. Nutrients added were NO_3^-, Urea, P_2O_5, and K_2O. The study took place at the University of Notre Dame Environmental Research Center (UNDERC). All data was collected from the bottom of Crampton Lake, a 72 acre freshwater lake on the property. The results of the study showed that the oxygen concentration within Crampton lake is approximately constant throughout a test period. Plexiglas chambers inserted at the sediment water interface showed little change in oxygen concentration throughout a four or six hour test period. This led to the conclusion that the oxygen production rate of epipelic periphyton in Crampton Lake is equal to the loss of oxygen through respiration, absorption, and diffusion.

INTRODUCTION

Periphyton is algal communities which live upon the surfaces of submersed objects. This project will concern epipelic periphyton, i.e. the communities growing on the surfaces of sediments in aquatic ecosystems.

Different algal species present in periphyton react differently to variable environmental stimuli (Jones and Mayer 1983). Light intensity, dissolved inorganic nitrogen, and phosphorous compounds in the sediment can all have an affect on the algal species composition in periphytic communities of an ecosystem. Light supplied from above and nutrients supplied through the sediments can effect oxygen productivity, species composition and biomass. Light intensity is the dominant influence in changes in periphyton (Wetzel 1983). The site of this project was characterized by drastic variation in light and temperature. When the ice retreats in the spring the light intensity and temperature of the lakes drastically increase. This sudden increase in temperature and light can cause higher than normal production in the periphyton.

It is unknown what effects light intensity and nutrient concentration may have on periphyton (Roos 1983). Studies have shown that light reduction may result in lower periphytic biomasses (Roos 1983). Various studies have also shown that variation in nutrient concentration in the sediments may have an effect on the species composition of periphyton (Roos 1983).

The following hypotheses were developed:

H_1: Increased light intensity increases the oxygen productivity of a periphyton community.

H_2: An increase in the concentration of dissolved inorganic nitrogen and phosphorous compounds within the sediments will cause an increase in the daily oxygen production of a periphyton community.

MATERIALS AND METHODS

Site Description

This study took place at the University of Notre Dame Environmental Research Center (UNDERC). UNDERC is a 7345 acre site which straddles the border between Wisconsin and the upper peninsula of Michigan. Thirty freshwater lakes are located on the property, 26 of which are entirely on the center grounds.

The sampling site for this project was Crampton Lake. Crampton Lake is the most easterly lake on the UNDERC property. It has a surface area of 72 acres and a maximum depth of 14 meters. This study took place in the northwest corner of the lake at a depth of 2.5 meters. The aquatic macrophyte *isoetes* was abundant at the site.

On May 28, 1992 a sheet of plywood was inserted vertically into the sediments. This sheet of plywood was painted white on one side and black on the other. When inserting the board into the sediments the white side was oriented south so as to reflect the most light onto the sediments and cast a shadow on the north side sediments. The insertion of the board into the sediments required two people.

On May 29, 1992 Jobes brand nutrient sticks were inserted into the western half of the sediments on each side of the board. Twenty five sticks were used on each side of the board. The composition of the sticks was:

1) 2% NO_3^-
2) 2% Urea
3) 2% other water soluble nitrogen compounds
4) 7% non water soluble nitrogen compounds
5) 4% P_2O_5
6) %5 K_2O

Field Methods

When sampling six cylindrical plexiglas chambers were used to collect oxygen produced during the test period. One chamber was inserted into each area which was manipulated, i.e. increased light and nutrients, increased light only, decreased light with increased nutrients, and decreased light only. One chamber was also inserted east of the board as a control. One chamber was covered with black plastic and was also inserted into the sediments east of the board to measure respiration rates. These chambers were inserted at 10:00am at which time a sample was taken from the surrounding water using a 30cc plastic syringe. This sample was used as time zero for all the samples that day.

Each of these chambers were fitted with a rubber septum through which the two-hour and four-hour samples were drawn. These samples were drawn by using a 30cc plastic syringe fitted with a 16 gauge needle. Once a sample was taken from the chamber a septum was fitted to the end of the syringe to seal the sample. The Winkler determination of dissolved oxygen (Wetzel and Likens 1979) was then run on the sample to determine dissolved oxygen concentration in the sample. For this experiment the Winkler method was modified to allow for

smaller sample size and accuracy necessary for this analysis.

Modified Winkler Method

The Winkler reagents (Wetzel and Likens 1979) were added to the sample as soon as possible after drawing the sample from the chamber. Using a 1-cc syringe 0.2 ml of $MnSO_4$ were injected into the sample through the rubber septum. Immediately following that 0.2 ml of KOH/KI solution was added to the syringe in the same manner. The syringe was then shaken slightly to mix the chemicals. A brown precipitate formed which was allowed to settle before once again shaking the syringe. After allowing the precipitate to settle again 0.2 ml of concentrated H_2SO_4 was added to the sample in the same manner as the previous reagents. This dissolved the precipitate creating a browning solution of iodine.

Once the iodine solution was prepared the samples were stored in darkness until titrated. The iodine was titrated using a 10 ml buret filled with a solution of .005N sodium thiosulfate ($Na_2S_2O_3$). The following formula was used to determine dissolved oxygen concentration in mg O_2/l.

$$\frac{(\text{ml titrant})(.005\ \text{N})(8000)}{(\text{Sample Size in ml})}$$

RESULTS

All data collected were recorded in mg O_2/l within the chamber. No data were collected from the surrounding water column during the day. Dissolved oxygen data was collected on June 27, July 8, and July 9, 1992. Due to poor weather and light conditions more replicates were not attempted. The data from these three days are presented in tables 1,2 and 3. The data are also presented graphically in figures 1,2 and 3.

Oxygen production was largely unaffected by light intensity or nutrient addition over the four or six hour periods on these three days. However, June 27 data shows a lower oxygen level in the dark chambers than in any of the other chambers. This effect is not as pronounced in any other site on the other two days.

Oxygen production data was also collected from an area off the main research site on June 11 and June 12, 1992. This data is shown in Table 4 and is graphically represented in figure 4.

Table1. Oxygen concentration in mg/l for June 27, 1992.

	Time O	2 Hrs	4 Hrs
Control:	6.45	7.76	6.94
Lt w/Nuts:	6.45	7.6	6.69
Lt w/o Nuts:	6.45	7.6	7.09
Dk w/Nuts:	6.45	6.96	4.72
Dk w/o Nuts:	6.45	6.35	4.64

Table 2. Oxygen concentration in mg/l for July 8, 1992.

	Time 0	2 Hrs	4 Hrs
Control:	7.47	7.76	6.94
Lt w/nuts:	7.47	5.41	7.47
Lt w/o Nuts:	7.47	7.04	8.68
Dk w/Nuts:	7.47	7.17	8.59
Dk w/o Nuts:	7.47	6.8	7.57

Table 3. Oxygen concentration in mg/l for July 9, 1992.

	Time 0	2 Hrs	4 Hrs	6 Hrs
Control:	9.47	9.47	7.6	9.33
Lt w/Nuts:	9.47	9.31	8.45	7.81
Lt w/o Nuts:	9.47	9.49	8.96	8.85
Dk w/Nuts:	9.47	9.12	8.08	8.56
Dk w/o Nuts:	9.47	8.48	9.17	7.76

Table 4. Dissolved Oxygen in mg/l for off site sample on June 11 and 12, 1992. Also oxygen concentration in water column during the day. Time 0 is 10:00 am.

	Time 0	2 Hrs	4 Hrs
June 11	7.09	5.76	6.69
June 12	6.69	5.12	7.23
June 12 (Water Column)	6.69	7.23	7.80

In each of these samples there was no experimental manipulation. On June 11 and 12 the oxygen concentration first decreased and then increased. Also, on June 12 water column data was collected. This showed a steady increase of dissolved oxygen present in the water column during the day.

DISCUSSION

Data collected showed no apparent relationship between oxygen production and light intensity or nutrient concentration. Oxygen production did not change in the sites where light intensity was increased or where nutrient concentrations were raised.

As shown in figures 1, 2 and 3, the fluctuation in oxygen concentration over time is minimal. Also, the differences caused by varied light or nutrients is insignificant. The data is very consistent in showing this over the three days. Due to time restrictions replicates of each day's oxygen concentration were neglected. Since the experiment relied on intense sunlight, poor weather did not allow more collection days.

Data in figure 4 shows largely the same result. The data collected from these samples at a random site shows that oxygen concentration is constant through a four hour period.

At the sediment water interface in Crampton Lake oxygen productivity is about equal to the respiration rate. In order for the oxygen concentration not to increase within the chambers during a four or six hour test period one of three things must be true: 1) Oxygen is diffusing into the surrounding water at a rate equal to oxygen production. 2) Rate of respiration in the sediments is equal to the oxygen production rate. Or 3) Photosynthesis is shut off or does not occur in the sediments of crampton lake.

Respiration rates shown in figure 5 vary during the day, however this data is questionable due to the calculation of negative respiration rates. July 9 respiration data shows a level of respiration which is high in the morning tapers during midday and then rises again during the afternoon. The data which was taken on June 27 and July 8 also shows the initial positive respiration rate which tapers to a lower, negative rate at midday. A third, afternoon, sample was not taken on those days.

CONCLUSIONS

The results of this experiment seem to clearly show that the oxygen production rate is equal to the loss of oxygen through respiration, absorption, and diffusion. Also, the respiration rate was shown to vary over time. The data collected during the three days show that the rate of respiration was higher after two hours than four hours. On the day collected the rate again rose at 6 hours. The large part of the experiment showed that oxygen concentration in Crampton lake is constant throughout the day.

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This project is dedicated to the memory of Donald Chamberlain.

CAPTIONS

Figure 1. Dissolved oxygen concentration in mg/l for June 27, 1992 showing effects of increased light and nutrients on algal productivity.

Figure 2. Dissolved oxygen concentration in mg/l for July 8, 1992 showing effects of increased light and nutrients on algal productivity.

Figure 3. Dissolved oxygen concentration in mg/l for July 9, 1992 showing effects of increased light and nutrients on algal productivity.

Figure 4. Dissolved oxygen concentration in mg/l for June 11 and 12 in a non-manipulated environment. Also shows change of oxygen concentration in the water column on June 12.

Figure 5. Respiration rates in mg $O_2(cm^2)^{-1}(hr)^{-1}$ for an off site sample on June 27, July 8 and July 9, 1992.

Crampton Lake

June 27

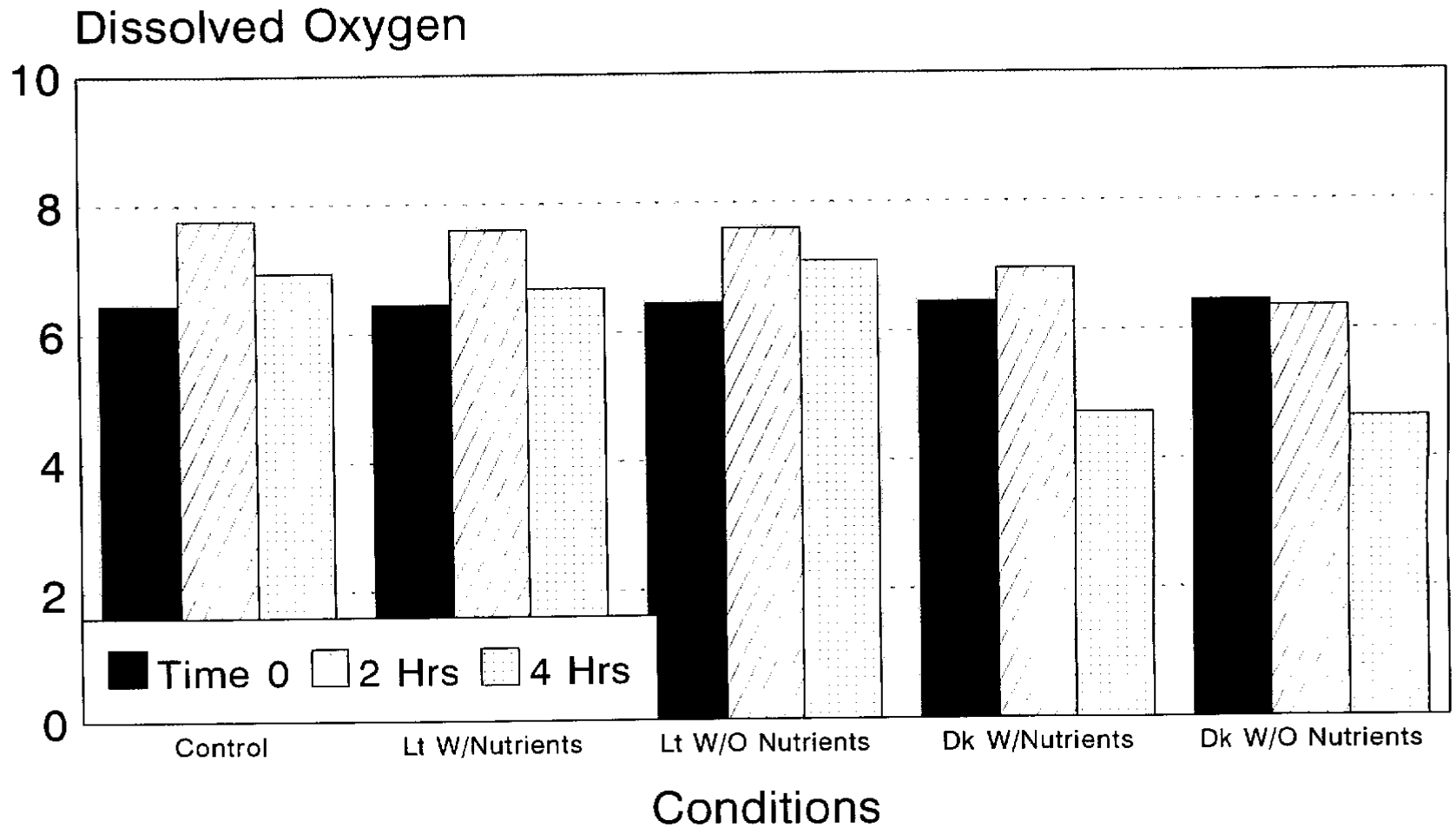

Figure 1.

Crampton Lake

July 8

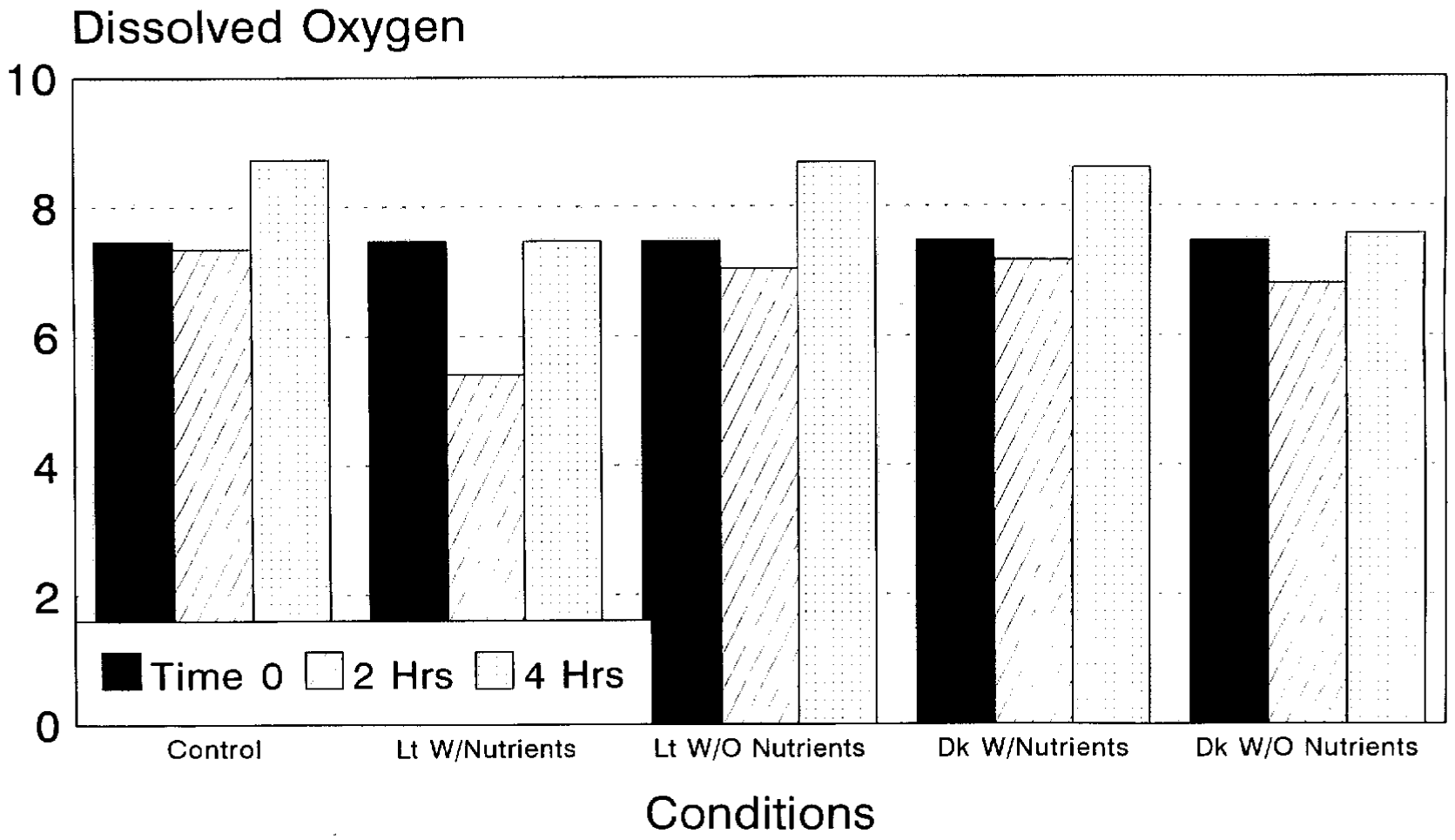

Figure 2.

Crampton Lake

July 9

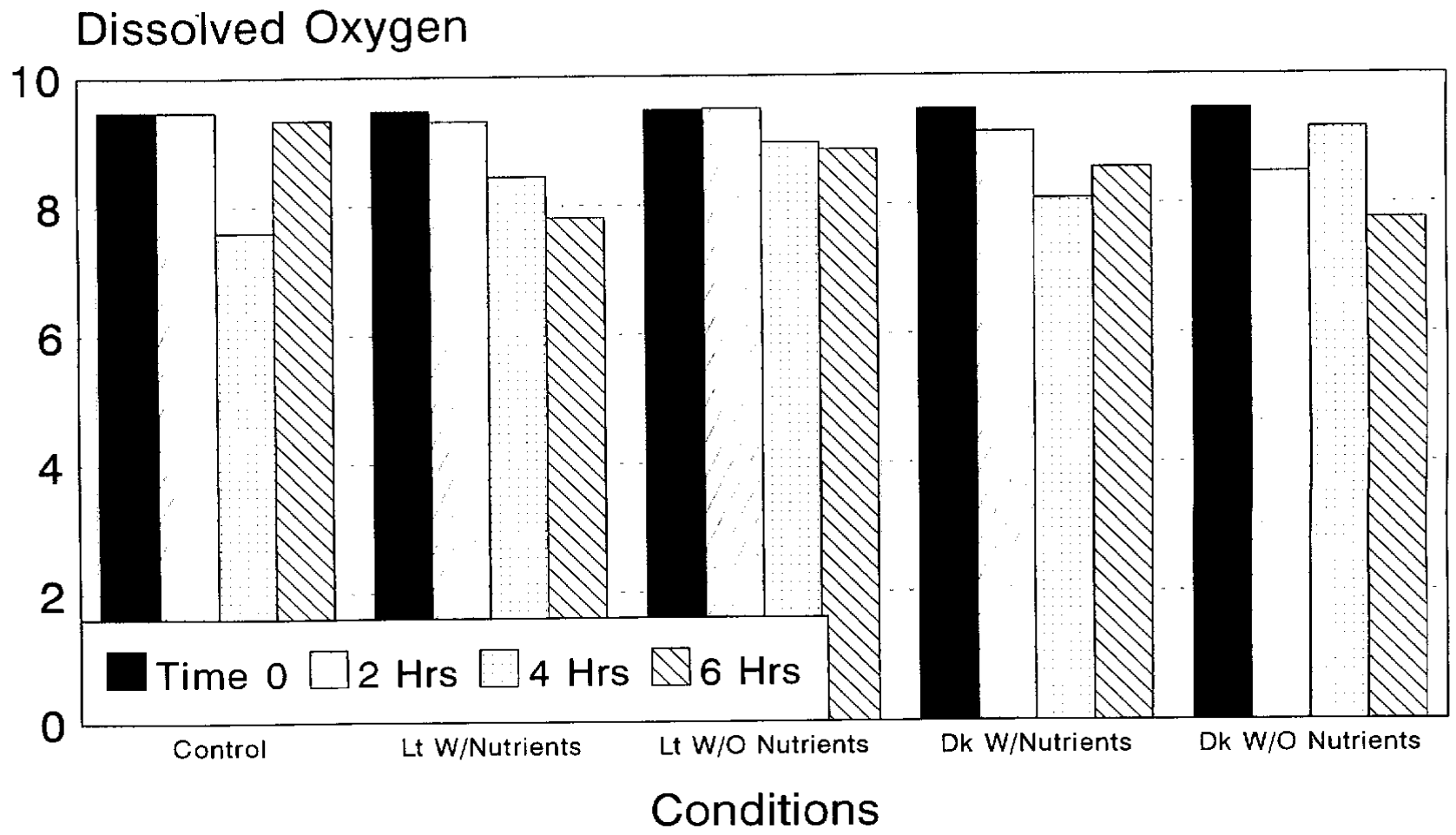

Figure 3.

Crampton Lake

Off Site and Water Column Samples

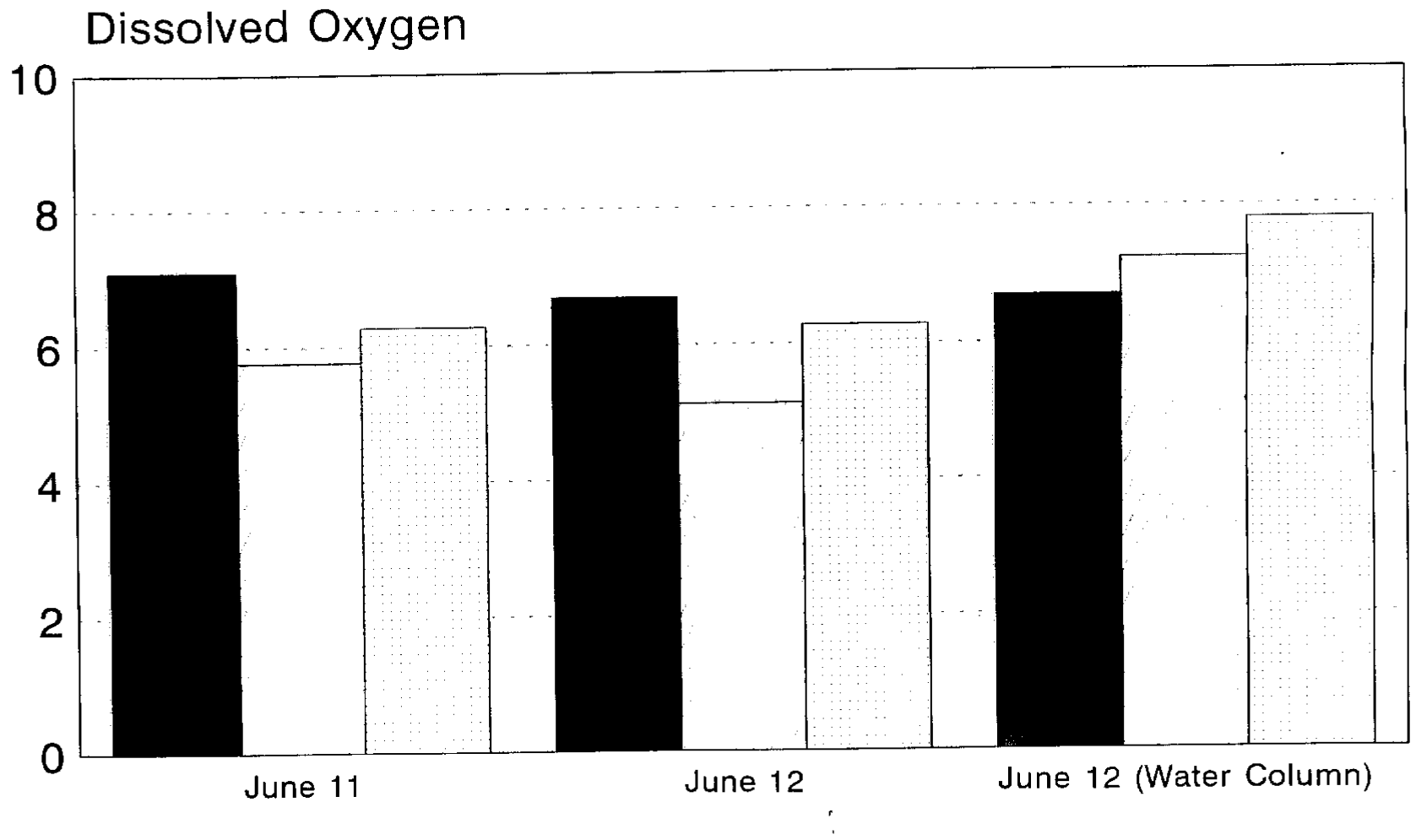

Figure 4.

Crampton Lake

Respiration Rates

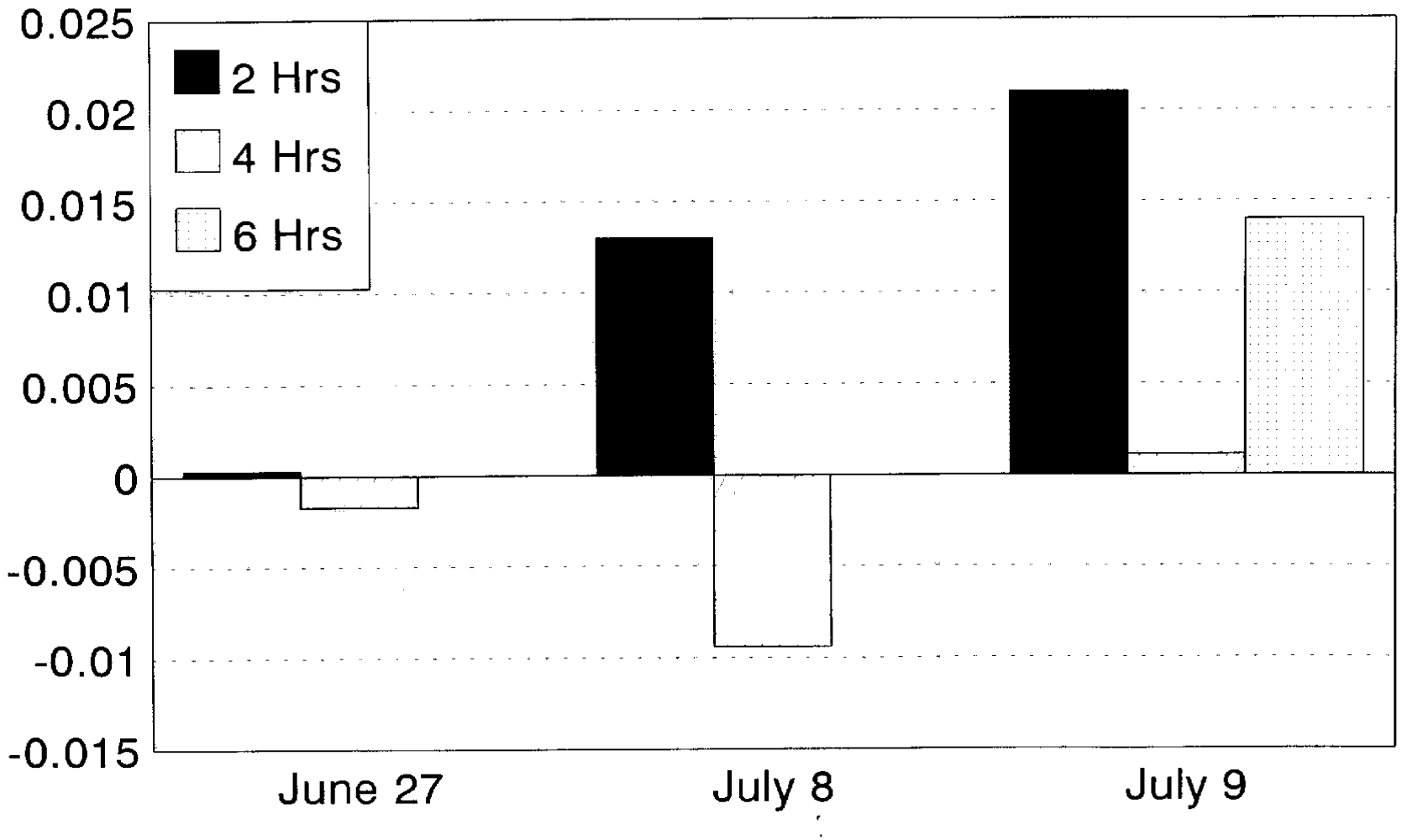

Figure 5.

File Listing

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File	File Name	Suffix	Program	Format
Text	TOC	- - - -	Wordperfect	Macintosh
Cover	Title Page	- - - -	Wordperfect	Macintosh
Figure 1	June27	.CH3	Harvard Graphics	DOS
Figure 2	July8	.CH3	Harvard Graphics	DOS
Figure 3	July9	.CH3	Harvard Graphics	DOS
Figure 4	Offsite	.CH3	Harvard Graphics	DOS
Figure 5	Respire	.CH3	Harvard Graphics	DOS
Raw Data	July8	.WQ1	Quattro	DOS
Raw Data	July9	.WQ1	Quattro	DOS
Raw Data	June11	.WQ1	Quattro	DOS
Raw Data	June12	.WQ1	Quattro	DOS
Raw Data	June18	.WQ1	Quattro	DOS
Raw Data	June27	.WQ1	Quattro	DOS
Raw Data	June9	.WQ1	Quattro	DOS