LAKE WENTWORTH

LAKE LAY MONITORING PROGRAM

1984

Freshwater Biology Group (FBG)

University of New Hampshire

Durham

by

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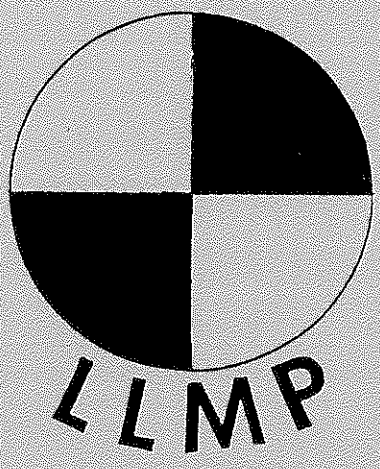

To obtain more information about the Lake Lay Monitoring Program (LLMP) please contact Dr. Baker at (603)-862-2060 or Dr. Haney at (603)-862-2100.

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ACKNOWLEDGMENTS

This is the first year that Lake Wentworth has been a part of the Lake Lay Monitoring Program (LLMP). Through the efforts of Mr. Mal Blodget and dedicated monitors, the program got off toan excellent start. One site, "Fullers Deep," was monitored throughout the entire season, and a second site, on Crescent Lake, was added in July. Lay monitors on Lake Wentworth were: Mal Blodget, Laura Connors, Lawrence Goldthwait, Richard Goldthwait and Fredrick Pflueger.

We congratulate the lay monitors on the quality of their work and anticipate that the monitors will continue their efforts next year. We wish to thank Mr. Blodget and all the members of the Lake Wentworth Association for their time and effort in organizing the LLMP on Lake Wentworth. We would also like to thank Fredrick Pflueger for providing a boat to our visiting team.

Members of our Freshwater Biology Group included Kim Babbitt, Matt Boyle, Chris Brown, Emily LeViness, Deb Thunberg and Jennifer Turner. Kim was team leader, and was responsible for coordination of field trips and data analysis and interpretation. Matt was responsible for phosphorus analysis, Chris for chlorophyll *a* analysis, Emily for phytoplankton, and Deb for zooplankton. All team members helped with data organization and filing, and also with field trips throughout the summer. In the fall, Sara Hubner helped with word processing and report organization.

The Office of Computer Services kindly provided computer timeand storage space for the Lake Lay Monitoring Program. The final text was set with Wordstar on Northstar and Zenith microcomputers, and printed on a letter-quality Spinwriter.

Summary for Wentworth Lake 1984

1) Wentworth lake is oligotrophic based on deep average Secchi disk depth (6.9 meters), low chlorophyll average *a* concentrations (1.3 milligrams per cubic meter), and low total phosphorus concentrations from lay monitor samples (2.0-10.4 micrograms per liter). The total phosphorus value found on June 15 by the FBG was very high (53.5 micrograms per liter). This high value is probably due to higher amounts of phosphorus entering the lake due to high lakewater levels as well as higher inputs from lake inlets.

2) The density of phytoplankton was low, 1662 cells/liter. The dominant groups included the Chlorophyceae, Chrysophyceae, Cryptomonads and Diatoms. The density of herbivorous crustacean zooplankton was also low, 6 animals per liter. The dominant group was the calanoid copepods. The species composition of phytoplankton and zooplankton indicate oligotrophic conditions.

3) The pH of near-surface water was low, 5.7. pH values throughout the entire water column ranged from 5.7-5.9. These values, though low, reflect only one day in the year. pH values are changeable throughout the season, and thus readings from more than one day are needed to determine the condition of the lake in terms of pH. The Alkalinity was also low; 3.75 milligrams calcium carbonate. The low level of alkalinity indicates that Wentworth Lake has a low capacity to resist the effects of acid precipitation.

4) The dissolved oxygen concentration was above 8.0 ppm throughout most of the water column. Oxygen concentrations below 15.0 meters were lower, (6.4-7.4 ppm), indicating that oxygen depletion may be more extensive as the summer progresses.

5) The specific conductivity was low, with an average of 45.5 micromhos per centimeter. The chloride ion concentration was also low (1.2 parts per million). These values indicate low inputs of road salt and/or raw sewage.

Comments and Recommendations for Wentworth Lake 1984

1) The consistency of data collection by the lay monitors was excellent throughout the 1984 season. The data collected represent a good data base for Wentworth Lake. Continued monitoring will serve to add to this data base, and provide a valuable record of water quality from year to year. Sampling should be continued next year, and should begin as early as possible. Variations in trophic indicators (Secchi disk depth, total phosphorus and chlorophyll a) occur throughout the summer sampling period. In order to monitor these variations properly, data should be collected throughout the entire summer, and if possible, in the spring after ice-out. If feasible, more sampling stations should be established to provide better spatial coverage of the lake.

2) Sampling for total phosphorus sampling should be continued next year. It is especially important that samples be taken in the spring and early summer when inputs of phosphorus may be high. A phosphorus sample taken by the FBG in June had concentrations in the eutrophic range (53.5 micrograms per liter).

3) The extent of oxygen depletion in the hypolimnion was low on the FBG test date, however it is likely that oxygen depletion was more extensive during mid-late summer. The extent of oxygen depletion during the latter part of the summer should be determined, as oxygen concentrations below 4.0 ppm (which may occur in Wentworth during mid to late summer) may limit the growth and distribution of cold-water fish such as lake trout and land-locked salmon.

4) A program of lay monitor alkalinity (buffering capacity) and pH testing should be initiated to assess the effects of acid precipitation on the lake. It is important to establish a data base for alkalinity and pH in order to detect changes in these parameters as early as possible, especially in lakes such as Wentworth that already have an extremely low buffering capacity. This could be accomplished by training at least one lay monitor on the use of the pH meter and the chemical test for alkalinity. A workshop on "Testing for the Effects of Acid Precipitation" will be offered by the Freshwater Biology Group at the University of New Hampshire in late May or early June.

5) Data obtained by the FBG indicate that the dissolved water color in Lake Wentworth is relatively low. This is important to know for water color decreases the water transparency, and thus effects the Secchi disk depth. A more accurate assessment of water quality based on Secchi disk depth can be made by knowing both the chlorophyll *a* concentration and the amount of dissolved water color. To provide data on changes in water color we suggest the lay monitors collect samples for dissolved water color. These samples consist of the filtrate from the chlorophyll *a* sample and the data could be collected with essentially no additional cost. Details on the method for collection of dissolved water color samples will be provided on request.

6) If feasible, one or more trips should be made by the LLMP next year to verify and therefore strengthen lay monitor data. The LLMP, by providing a wider range of tests, may also be able to detect early signs of changes in lakewater quality that the lay monitors cannot pick up in their sampling.

METHODS OF LAY MONITORS

Lay monitors collected data on four parameters: thermal stratification, water clarity, chlorophyll *a* concentration and total phosphorus. Data on thermal stratification, chlorophyll and water clarity were collected at weekly intervals whenever possible.

Thermal profiles were obtained by collecting lakewater samples at several depths with a modified Meyer bottle (Lind, 1979). Samples were obtained by lowering the empty but weighted bottle and sampling (by pulling out the stopper) at 1-meter intervals. The temperature of the samples was measured with Taylor pocket thermometers, and recorded in degrees Celsius.

Water clarity was measured while lowering an 8-inch (20 cm) Secchi disk and holding a view-scope just below the surface to eliminate the effects of surface reflection and wave-action. When the Secchi Disk disappeared the depth mark on the plastic suspension line was noted. The disk was raised until it just came into sight, and again the depth on the line was noted. The process was repeated two to three times, and an average between the two marks on the line (the point of disappearance and the point of re-appearance) was considered to be the Secchi Disk Depth (SDD), measured to the nearest one-tenth meter (0.1 meter) -- as for example, 5.2 meters. Readings were generally taken between 9 a.m. and 3 p.m., the period of maximum light penetration.

Chlorophyll *a* concentration was used as an estimator of algal biomass. A weighted tube 33 feet (10 meters) in length was used to collect an integrated water sample from the 'upper-lake' (epilimnion). The weighted end of the tube was slowly lowered to the interface of the epilimnion and the 'middle-lake' (metalimnion). The end of the tube was then bent double to shut off flow of air and water, and the weighted end of the tube (presently at the base of the epilimnion) was pulled up to the surface with a plastic line attached to it. The water in the tube (epilimnetic lakewater sample) was poured into a plastic bottle by placing the weighted end of the tube into the neck of the bottle and, while keeping the bent-off end above the weighted end, unbending the upper end (allowing the sample to discharge into the bottle).

Water samples were filtered through a membrane filter with a porosity of 0.45 microns. The damp filters containing chlorophyll-bearing algae were air dried for at least 15 minutes to prevent decomposition. Filtration and drying were done in the shade to minimize destruction (by bleaching) of chlorophyll. The dried filters were then sent to UNH for analysis. [In Durham, members of the Freshwater Biology Group extracted chlorophyll in 90% acetone saturated with magnesium carbonate, and read the absorbance of the sample at standard wavelengths (663 and 750 nanometers).

Samples for total phosphorus were collected with an integrated tube sampler, in the same manner as chlorophyll *a* wherever possible, or by dipping an acid-washed bottle in the water at inlet and outlet streams.

Total phosphorus samples were stored on ice in acid-washed 250 ml polyethylene bottles, and were fixed within 1 to 2 hours with 1.0 ml concentrated sulfuric acid. In Durham, the FBG members digested the total-phosphorus by adding ammonium persulfate and auto-claving the samples for at least 45 minutes. Finally, the phosphorus content of the samples was analyzed with the single-reagent method that included a fresh solution of ascorbic acid and potassium antimony tartrate (E.P.A., 1979). Absorbance of the blue phosphorus complex was measured spectrophotometrically at 650 nm.

METHODS OF FRESHWATER BIOLOGY GROUP (FBG) TEAM

The same as well as additional parameters were investigated by the FBG research team. The additional factors were primarily measurements of sunlight penetration into the lakewater, and water chemistry. The latter included dissolved oxygen, 'free' (unbound) carbon dioxide, pH, specific conductivity, and chloride ion. In addition, the microscopic plants (phytoplanktonic algae) and animals (zooplanktonic invertebrates) were identified. Relative or absolute counts were made.

Dissolved oxygen and temperature were measured with a Yellow Springs Instruments Model 54A Oxygen/Temperature meter with a submersible probe. Readings were taken at 1-meter intervals throughout the 'upper-lake' (epilimnion) and 'lower-lake'(hypolimnion), and at half-meter intervals through the 'middle-lake' (metalimnion).

Sun- and skylight penetration into the lakewater was measured at 1-meter intervals with a Whitney submersible photometer model LYA-8A, and the relative light intensity was recorded. Measurements were taken on the sunny side of the boat.

Dissolved water color was measured by reading the absorbance of filtered lakewater (0.45 micron) at 440 and 493 nanometers, in a Bausch and Lomb Spectronic 710 with a 15 cm path length.

Water chemistry (alkalinity, 'free' (unbound) carbon dioxide, pH, and specific conductivity and chloride ion) samples were collected with a 3-liter Van Dorn bottle. Alkalinity, free carbon dioxide and pH samples were stored on ice in 250 ml polyethylene bottles, and were analyzed in the field within 1 to 2 hours. Specific conductivity and chloride ion samples were analyzed in the lab, at room temperature.

Alkalinity was determined titrimetrically with 0.002 N sulfuric acid to a final pH of 4.5, with a combination solution of the two dyes bromocresol green and methyl red as the end-point indicator (E.P.A.,1979). Alkalinity is expressed as equivalents of calcium carbonate.

Free (unbound) carbon dioxide concentration was determined by titrating the fresh lakewater samples with 0.0027 N NaOH to a final pH of 8.3, and with the dye phenolphthalein as the end-point indicator.

Lakewater pH was measured with a digital pH meter (Orion model 231) equipped with a combination probe (Orion Co.).

Specific conductivity was measured with a Barnstead Conductivity Bridge Model PM-70CB equipped with model B-10 probe (cell constant = 1.0). Correction for sample temperature was made with a standard curve.

Chloride ion concentration was measured with a pH meter (Corning Model 10) equipped with a chloride electrode (Orion model 94-17B) and a double junction reference electrode (Orion Model 90-02). Standard curves were prepared every 2 hours during laboratory analysis.

Samples to be analyzed for phytoplankton, and chlorophyll *a* were collected with a vertical 'tube' sampler. Chlorophyll *a* samples were filtered, dried and analysed in the same manner as those collected by lay monitors.

Phytoplankton samples were fixed with iodine (Lugol's Solution) in the field, within 1 to 2 hours after collection. Phytoplankton were counted with a Unitron 'inverted' microscope after settling the samples for 24 hours in counting chambers. At least 200 individual algal 'units' were counted with a modified scan technique (Baker 1973).

Zooplankton density was estimated in samples collected by towing up a plankton net (30 cm diameter, 150 micron porosity) through the oxygenated (>0.5 ppm) portion of the lake. Samples were fixed after collection with a 4% formalin-sucrose solution (Haney and Hall,1973), and subsampled with a 1-ml Hensen-Stemple pipet. Sufficient subsamples were taken to insure that at least 100 microcrustaceans were counted.

RESULTS AND DISCUSSION OF LAY MONITOR DATA

Lay monitor research was conducted separately from Freshwater Biology Group (FBG) research, thus the results are presented separately. One sampling site was active on Wentworth Lake, and one on Crescent Lake in 1984. The lay monitor data for 1984 are presented in Appendix A.

Lay monitors collected information on four parameters: water transparency (Secchi disk depth), productivity (chlorophyll a), total phosphorus and thermal stratification. Information on thermal stratification is used primarily to determine the sampling depth of the chlorophyll a sample.

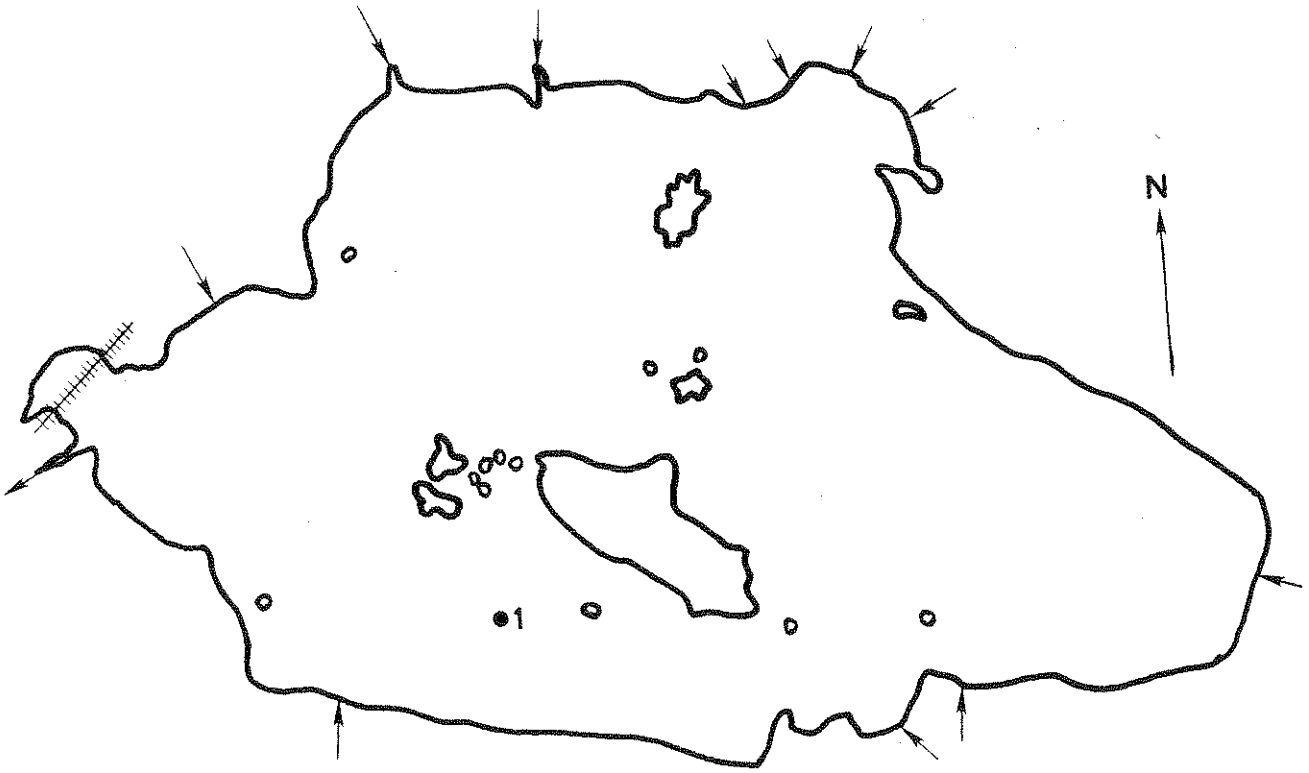

Figure 1. Lake Wentworth, Town of Wolfboro, New Hampshire. Outline map and location of 1984 sampling sites.

Secchi Disk Depth and Chlorophyll a Concentration (Lay monitor)

The water clarity on Wentworth Lake was high, with a Secchi disk average of 6.9 meters for the entire summer and a range 6.2-7.5 meters. Secchi disk depths were generally lowest in June and July and increased in August (Table 1). Chlorophyll a concentrations were low, with an average of 1.3 milligrams per cubic meter, and a range 0.8-1.9 milligrams per cubic meter. Seasonally, chlorophyll a values were highest in June and July and lowest in August and September (Table 1). Crescent Lake was sampled four times in 1984. A Secchi disk depth of 5.5 meters was found on July 21 and 5.0 meters on August 4. The Secchi disk bottomed out on the other two sampling dates. Chlorophyll a values averaged 0.8 milligrams per cubic meter, with a range of 0.5-1.0 milligrams per cubic meter. Based on Secchi disk depth and chlorophyll a concentrations Wentworth and Crescent Lakes would be classed as oligotrophic.

Table 1. Monthly comparison of Secchi disk depth (SDD) and chlorophyll a (chl a) for Wentworth Lake in 1984.

	SDD (meters)	Chl a (mg/cubic m)
June	6.6	1.5
July	6.6	1.6
Aug	7.1	1.1
Sept	7.5	0.9

The New Hampshire Water Supply and Pollution Control Commission found a Secchi disk depth of 5.4 meters and a chlorophyll a concentration of 1.7 milligrams per cubic meter on August 28, 1975. On August 19, 1978, the Brewster Academy found a Secchi disk depth of 6.0 meters and a chlorophyll a concentration of 1.3 milligrams per cubic meter at 1.5 meters. Secchi disk depths were deeper (7.3 meters) and chlorophyll a concentrations lower (0.8-1.1 milligrams per cubic meter) in 1984, during mid-late August. From these data it appears that Wentworth Lake has become more oligotrophic in terms of water clarity and chlorophyll a concentration in the past 10 years. However, the data from the NHWSPCC and Brewster Academy represent only two sampling dates and thus real trends in lake water quality cannot be determined as such. These data do, however, demonstrate the need for long-term seasonal monitoring.

Total Phosphorus

Total phosphorus samples collected by the lay monitors indicate low concentrations of phosphorus in Wentworth and Crescent Lakes (Table 2). Most of the phosphorus values were below 8.0 micrograms per liter. The two highest concentrations (10.4 and 8.1 micrograms per liter) were found at Willey Brook. These data indicate that the Willey Brook may be a major source of phosphorus for Wentworth Lake. The low total phosphorus concentrations indicate oligotrophic conditions.

Table 2. Total phosphorus (TP) data from Wentworth Lake for 1984. (TP=micrograms/liter)

Site	Date	TP
Fullers Deep	July 29	2.5
State Park	July 29	2.0
Fernald Brook	July 29	4.8
Willey Brook	July 29	8.1
Fullers Deep	Sept 16	3.1
State Park	Sept 16	7.1
Fernald Brook	Sept 16	5.6
Willey Brook	Sept 16	10.4
Hooper Brook	Sept 16	7.6
Crescent Outlet	Nov 05	5.6

RESULTS AND DISCUSSION OF FRESHWATER BIOLOGY GROUP DATA

Temperature and Dissolved Oxygen (FBG)

Wentworth Lake was thermally stratified on June 15, the FBG test date. Dissolved oxygen concentrations were above 8.0 ppm throughout most of the water column. Oxygen concentrations less than 8.0 ppm (6.4-7.4 ppm) occurred below 15 meters. Lower oxygen concentrations in the deep water in June may indicate the occurrence of more extensive oxygen depletion as the summer progresses. Studies conducted by the New Hampshire Water Supply and Pollution Control Commission on August 28, 1975, and Brewster Academy on August 19, 1978, showed oxygen concentrations below 4.0 ppm in the deep water. Oxygen concentrations below 4.0 ppm may limit the distribution and growth of cold-water fish such as lake trout and land-locked salmon.

Water Clarity and Dissolved Color (FBG)

The FBG measured a Secchi disk depth of 6.5 meters on June 15, comparable to values found by the lay monitors. Dissolved water color (absorbance per 15 cm at 440 nm), primarily due to humic acids, was .028 on June 15. This value is relatively low compared to other lakes in the LLMP. The result of having low dissolved water color in the lake is to increase light penetration in the water column. This in turn increases water clarity, and thus Secchi disk depth.

Chlorophyll a (FBG)

The chlorophyll a concentration measured by the FBG was 1.9 milligrams per cubic meter. This value is in the oligotrophic range, and is comparable to the value found by the lay monitors on that day.

Total Phosphorus (FBG)

Total phosphorus is usually the most limiting (least abundant) nutrient to algae in freshwater systems. Increases in algal growth may occur with increases of phosphorus loading. The total phosphorus concentration found on June 15 was 53.5 micrograms per liter. This value is in the eutrophic range, and is surprising considering the low chlorophyll a values. This high value is probably due to the high lakewater level at that time. More nutrients are likely to enter from around the lakeshore as well as from the lake inlets streams. Considering lay monitor phosphorus data, this is probably the case.

Alkalinity, pH, and Free Carbon Dioxide

The pH of near-surface water was 5.7, with a range 5.7-5.9 throughout the entire water column. The alkalinity for near-surface waters was 3.75 milligrams calcium carbonate. Both pH and alkalinity values are low. pH values are highly variable throughout the season, and even from day to day, and thus conclusions about lake water quality, based on pH, cannot be made from only one reading. pH values are likely to be lower during the early part of the season when the effects of spring run-off are felt by the lake. On the other hand, changes in alkalinity may show a more accurate picture of the effects of acid precipitation.

The New Hampshire Water Supply and Pollution Control Commission found an alkalinity value of 6.8 milligrams calcium carbonate in 1975. These data indicate that the alkalinity has decreased in the last five years. If this trend continues, Wentworth Lake may be in danger of losing its ability to buffer against pH depression due to acid precipitation

Free carbon dioxide accumulated in the hypolimnion. The low amount of accumulated free carbon dioxide indicates low productivity, without data from the latter part of the season it is impossible to know how much of an accumulation occurred over the summer months.

Specific Conductivity and Chloride Ion

The specific conductivity at Lake Wentworth was low, with an average of 45.5 micromhos/cm for all depths. The chloride ion concentration was also low (1.2 parts per million). These values indicate low inputs of road salt and/or raw sewage.

Phytoplankton

The density of phytoplankton on June 15 was 1662 cells/liter. The dominant phytoplankton groups on June 15 were the Chlorophyceae (*Polytoma*), the Chrysophyceae (*Kephyrion*), the Cryptomonads (*Chroomonas*) and the Diatoms (*Cyclotella*). The density and species composition of phytoplankton indicates oligotrophic conditions.

Zooplankton

The density of herbivorous crustacean zooplankton was low (6 animals per liter). The dominant group was calanoid copepods. The density of predatory zooplankters, mainly *Holopedium* and cyclopoid copepods was also low (0.3 animals per liter).

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APPENDIX A

LLMP 1984 -- Lay Monitor Data: Wentworth and Cresecent

Date	Lake	Site	SDD	Chl
Jun-15-84	Wentworth	1 Fullers	6.20	1.93
Jun-23-84	Wentworth	1 Fullers	7.30	.93
Jun-30-84	Wentworth	1 Fullers	6.40	1.79
Jul-08-84	Wentworth	1 Fullers	6.50	1.86
Jul-14-84	Wentworth	1 Fullers	6.70	1.57
Jul-21-84	Wentworth	1 Fullers	6.50	1.14
Jul-28-84	Wentworth	1 Fullers	6.50	1.86
Aug-04-84	Wentworth	1 Fullers	6.50	1.29
Aug-11-84	Wentworth	1 Fullers	7.40	1.21
Aug-16-84	Wentworth	1 Fullers	7.25	.79
Aug-26-84	Wentworth	1 Fullers	7.30	1.14
Sep-01-84	Wentworth	1 Fullers	7.50	.79
Sep-08-84	Wentworth	1 Fullers	7.40	1.07
Jul-21-84	Crescent	2 Deep	5.50	.93
Aug-04-84	Crescent	2 Deep	5.00	1.00
Aug-16-84	Crescent	2 Deep	-2	.86
Sep-01-84	Crescent	2 Deep	-2	.50