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LIMNOLOGY OF CLARK CANYON RESERVOIR, MONTANA

by

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VITA

The author, Rodney Kent Berg, was born in Waukon, Iowa, on April 21, 1949, to Rodney Karl and Marlys Lucille Berg. He graduated from Waukon High School, Waukon, Iowa in 1967. In January, 1968, he entered Upper Iowa College at Fayette, Iowa. In September, 1969, he transferred to Wisconsin State University at Stevens Point where he graduated in June of 1971 with a Bachelor of Science degree in Wildlife Management. He began graduate studies in June of 1971 at Montana State University.

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ABSTRACT

A limnological study was conducted on Clark Canyon Reservoir during 1971 and 1972 with particular efforts being made to determine the relationships between primary and secondary productivity and selected chemical and physical factors.

Runoff at 159% of normal reduced the average retention time. Turbidity never exceeded 10 JTU. Euphotic zone depth varied from 5 to 15½ meters. Storage of advected and solar heat during summer in the reservoir was attributed to deep water withdrawal. Conductivity ranged from 420 to 650 micromhos. Pronounced vertical conductivity gradients were not observed. Levels of DO in the deep zone decreased with time following each of the three observed overturn periods. pH ranged from 7.80 to 8.63 with highs and lows occurring during overturn and severest stagnation periods, respectively. Ranges of total alkalinity and total hardness, respectively, were 177 to 222 ppm and 157 to 230 ppm. Reductions in the levels of euphotic zone plant nutrients following vernal and autumnal overturn were attributed to uptake by phytoplankton and transfer to the deep water zone by sinking.

Thirty-one algal genera were observed in the euphotic zone during the study period. The five genera with the largest mean annual standing crops were, in descending order of abundance, *Asterionella*, *Aphanizomenon*, *Cryptomonas*, *Rhodomonas* and *Synedra*. Mean total phytoplankton standing crops during winter, spring, summer and fall, respectively, were 2.67, 3.34, 4.05 and 4.10 mm^3/l. Water temperature was the most significant variable measured influencing phytoplankton standing crop. Mean euphotic zone chlorophyll a concentrations during winter, spring, summer and fall, respectively, were 3.36, 9.86, 5.57 and 8.03 ug/l. The small correlation coefficient, 0.34, between chlorophyll a concentration and phytoplankton standing crop was attributed to seasonal variation in the taxonomic composition of the phytoplankton community.

Daphnia schodleri and *Cyclops bicuspidatus thomasii* were the dominant zooplankters during all seasons and averaged 11.86 and 6.18 organisms/l, respectively, on an annual basis. Regression analyses revealed that *Asterionella*, *Cryptomonas* and *Rhodomonas* may have been used as food by herbivorous zooplankton. Instantaneous birth and mortality rates of *D. schodleri* averaged near 0.06 annually. Water temperature and chlorophyll a concentration were the only measured variables significantly affecting *D. schodleri* population dynamics.

DESCRIPTION OF THE STUDY AREA

Clark Canyon Reservoir (Figure 1) is an artificial impoundment of the Beaverhead River located approximately 32.2 kilometers (20 miles) upstream from Dillon, Montana. The reservoir is formed behind a 40.08 meter (131.5 ft) high zoned earthfill dam with concrete control works and spillway. The impoundment covers the lower portions of Red Rock River and Horse Prairie Creek which previously had joined to form the Beaverhead River 396 meters upstream from the present damsite.

Water storage began on August 28, 1964. The reservoir has a useable storage capacity of 405.721 X 10^6 m^3 between the inverted outlet works and the maximum water surface (Table 1). Dead storage capacity below the inverted outlet works amounts to 0.075 X 10^6 m^3. Morphometric characteristics of the reservoir at the average operating level of 1688.6 m (5540 ft) are given in Table 2.

Water can be discharged from the reservoir through two outlets; (1) the spillway (uncontrolled)-- elevation 1694.8 m and (2) the inverted outlet works-- elevation 1662.7 m. Normally, all water is discharged through the inverted outlet works which is located 2.6 m above the old streambed. Discharge consequently comes from the deepest water of the reservoir; 25.9 m at the average operating level.

The major inlet streams to the reservoir are Red Rock River and Horse Prairie Creek which drain largely from the Centennial and Tendoy Mountains. According to Alt and Hyndman (1972) the Centennial

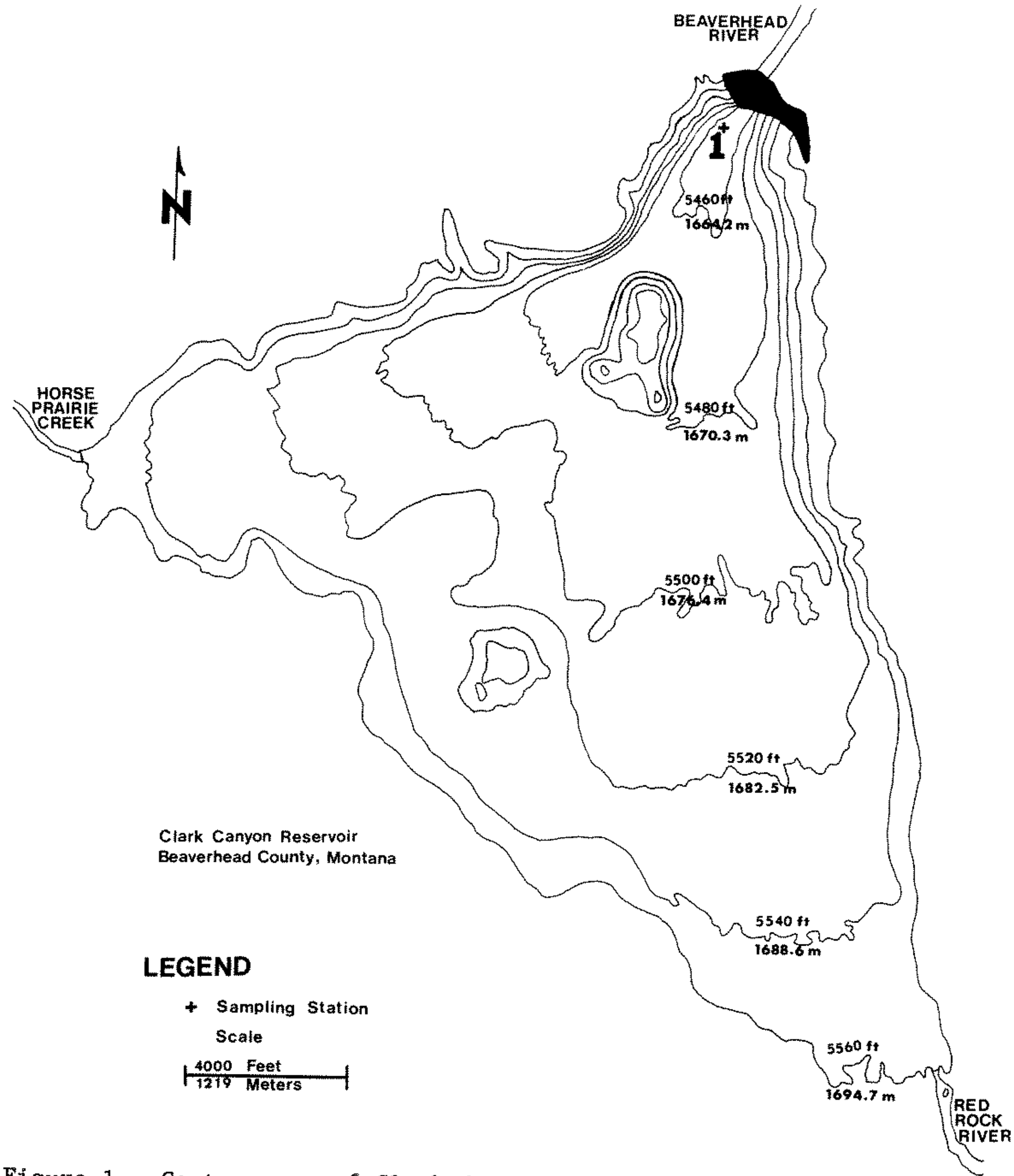

Figure 1. Contour map of Clark Canyon Reservoir showing the location of the sampling station.

Table 1. Surface area and capacity of Clark Canyon Reservoir at various defined operating levels. (Bureau of Reclamation data)

	Elevation - meters (feet)	Surface Area - $m^2 \times 10^6$ (acres $\times 10^3$)	Capacity - $m^3 \times 10^6$ (acre-ft $\times 10^3$)
Top of Dam	1700.2 (5578.0)	------	------
Maximum Water Surface	1698.3 (5571.9)	26.710 (6.600)	405.796 (328.979)
Top of Flood Control Storage (Uncontrolled Spillway Crest)	1694.8 (5560.4)	23.889 (5.903)	317.197 (257.152)
Top of Joint Use Storage	1689.2 (5542.1)	19.971 (4.935)	194.724 (157.863)
Top of Active Conservation Storage	1687.3 (5535.7)	18.195 (4.496)	157.427 (127.626)
Top of Inactive Storage	1667.4 (5470.6)	0.846 (0.209)	1.861 (1.509)
Top of Dead Storage (Inverted Outlet Works)	1662.7 (5455.0)	0.093 (0.023)	0.075 (0.061)
Old Streambed	1660.1 (5446.5)	------	------

Table 2. Morphometric data for Clark Canyon Reservoir at the average operating level--elevation 1688.6 m (5540 ft).

Maximum Depth	28.5 m (93.5 ft)
Mean Depth	9.35 m (30.68 ft)
Maximum Length	6.47 km (4.02 mi)
Maximum Breadth	5.01 km (3.11 mi)
Mean Breadth	3.06 km (1.90 mi)
Area	19.789 X 10^6 m^2 (4.890 X 10^3 acres)
Volume	185 X 10^6 m^3 (150 X 10^3 acre-ft)
Length of Shoreline	26.01 km (16.16 mi)
Shoreline Development	1.65

Mountains are composed of complexly folded Paleozoic and Mesozoic sedimentary rocks covered by much younger light colored volcanic rocks, while the Tendoy Mountains contain Precambrian igneous and metamorphic basement rocks overlain by Paleozoic sedimentary rocks. The drainage area of Red Rock River is approximately 4092 km^2 while Horse Prairie Creek drains approximately 1765 km^2. Minor basins which drain into the reservoir account for an additional drainage area of 154 km^2. Thus the entire drainage area of Clark Canyon Reservoir is approximately 6011 km^2.

METHODS

Monthly reservoir elevation and volume data were obtained from the Bureau of Reclamation, Upper Missouri Region, Billings, Montana. Discharge data were obtained from the United States Geological Survey in Helena, Montana. The data were recorded at the Grant gaging station which is located on the Beaverhead River 0.64 km downstream from Clark Canyon Dam.

A sampling station was established near the dam site where, at the average operating level of the reservoir, the depth was 25.0 m. Water samples and field measurements were taken at near biweekly intervals during the summer (mid June-mid September) and at near monthly intervals during the remainder of the year except when hazardous ice conditions prevailed in the spring and fall.

Water samples were taken during early morning from the surface and at 5 meter intervals to the bottom of the reservoir. These samples were used for chemical and physical determinations. A composite euphotic zone sample, consisting of equal amounts of water taken at one meter intervals from the surface of the reservoir to a depth of eight meters was collected. This sample was used for chlorophyll analysis and phytoplankton counts. A 3.0 liter Van Doren water bottle was used to obtain the samples.

Measurements of temperature, conductivity and turbidity were made at one, five and five meter intervals, respectively, from the surface of the reservoir to the bottom using an ARA Model FT3 All-Weather Hydrographic Thermometer, a Solu-Bridge Model RB3-338-Y147 Conductivity Meter, and a Hach DR Colorimeter contained in a Hach Field Kit.

Secchi disc depth was determined using a standard Secchi disc in accordance with the procedure outlined in Welch (1948). It has been estimated that the Secchi disc disappears at approximately the zone of 10% transmission of total surface radiation (Wright, personal communication). The compensation point for most phytoplankton organisms is reached at light intensities of about 1% of total surface radiation (Verduin, 1964). Thus, the depth of the euphotic zone was defined as that region where there was 1% light transmission. Euphotic zone depth was approximated using the following formula derived by Wright (personal communication):

Depth of Euphotic Zone = 2.7 X Secchi Disc Depth.

The method used for dissolved oxygen analysis was the Alsterberg modification of the Winkler technique using phenylarsene oxide (PAO) instead of sodium thiosulfate as the titrant solution. The pH was measured with an Orion Ionalyzer (Model 407) using a Sargent combination pH electrode. Analyses for total alkalinity, total hardness and ammonia followed procedures outlined in Standard Methods for the Examination of Water and Wastewater (APHA, 1965). Orthophosphate, nitrate and nitrite determinations were made according to methods outlined by Hach (1969). A Bausch & Lomb Spectronic 20 Spectrophotometer was used whenever colorimetric procedures were required.

Dissolved oxygen, pH, and total alkalinity determinations were made within 2-6 hours after field collection, and the remainder of the chemical determinations were made within 48 hours of collection.

The chemical analyses described above were made throughout the course of the study. A more extensive chemical analysis was done on a water sample collected from the euphotic zone of the primary station on September 23, 1972. Colorimetric or titrimetric procedures as outlined in Standard Methods for the Examination of Water and Wastewater (APHA, 1965) were used for all determinations except sodium and potassium were analyzed using a Beckman Atomic Absorption Flame Spectrophotometer, and carbonaceous components were measured using a Beckman Carbonaceous Analyzer.

For phytoplankton analyses 125 ml was taken from the composite euphotic zone water sample. This water was placed in a French square bottle and preserved with 1 ml of Lugol's solution. Phytoplankton were identified, counted, and measured in a Sedgewick-Rafter cell, and standing crop (mm^3/l) was calculated for each taxon.

Chlorophyll a concentrations were determined by filtering (0.45 micron Millipore* filters) a known volume of the euphotic zone

*Registered Trademark, Millipore Filter Corporation, Bedford, Massachusetts.

composite water sample. The filter was then dissolved in 5 ml of 90% acetone and allowed to stand in the dark for 24 hours. The solution was then centrifuged, and the optical density of the supernatant was measured at 665 millimicrons using a Bausch & Lomb Spectronic 20 Spectrophotometer. The micrograms of chlorophyll a per liter were calculated according to the method of Odum *et al.* (1958).

Zooplankton samples were collected by making an oblique tow from the bottom of the reservoir to the surface with a Clark-Bumpus plankton sampler. A #20 plankton net was used, and the collection was preserved in the field using 95% ethanol.

In the laboratory the total volume of the zooplankton sample was measured, and upon uniformly suspending the organisms in the sample by shaking, 1 to 5 ml aliquots were removed and placed in a modified circular counting cell of the type described by Ward (1955). Successive aliquots were examined with a 30X binocular microscope until at least 150 individuals of the most common taxon had been counted. From the data collected population density (number/liter) was calculated for each taxon in the zooplankton community. Population dynamics of *Daphnia schodleri* were estimated following the methods described by Edmonson (1960), Hall (1964) and Wright (1965) except instantaneous birth rates were calculated using Casewell's (1972) correction.

RESULTS

Hydrology

Due to excessive runoff Clark Canyon Reservoir and Dam handled an abnormal volume of water throughout 1971 and 1972 (Figure 2). In 1971 the January-March inflow was high at 68.743 X 10^6 m^3, 123% of normal based on a 1963-1970 average (Table 3). On April 1, the April-July runoff was forecast to be well above normal, and consequently the discharge rate was gradually increased to 28.317 m^3/sec (1000 ft^3/sec) on May 12 and maintained at this level through July 26. This is the maximum rate desired to meet established flood control objectives in the Beaverhead River below Clark Canyon Dam. In spite of maximum release rates, the reservoir was in the flood pool (above elevation 1690.5 m) between June 12 and July 26 reaching a record high storage of 228.198 X 10^6 m^3 (185.000 X 10^3 acre-ft) at elevation 1690.86 m on July 2 (Figure 3). The realized April-July inflow was 280.511 X 10^6 m^3, 190% of normal. Fifty-one percent of the total net inflow for 1971 occurred during this 4 month period. Inflows during the intervening fall and winter period remained unusually high at 196.052 X 10^6 m^3, 159% of normal during August-December, 1971, and 97.323 X 10^6 m^3, 178% of normal during January-March, 1972. During this period, reservoir releases were necessarily higher than normal to maintain the reservoir at no higher than the maximum winter operating level. The accumulation of snow in the reservoir's watershed was at near

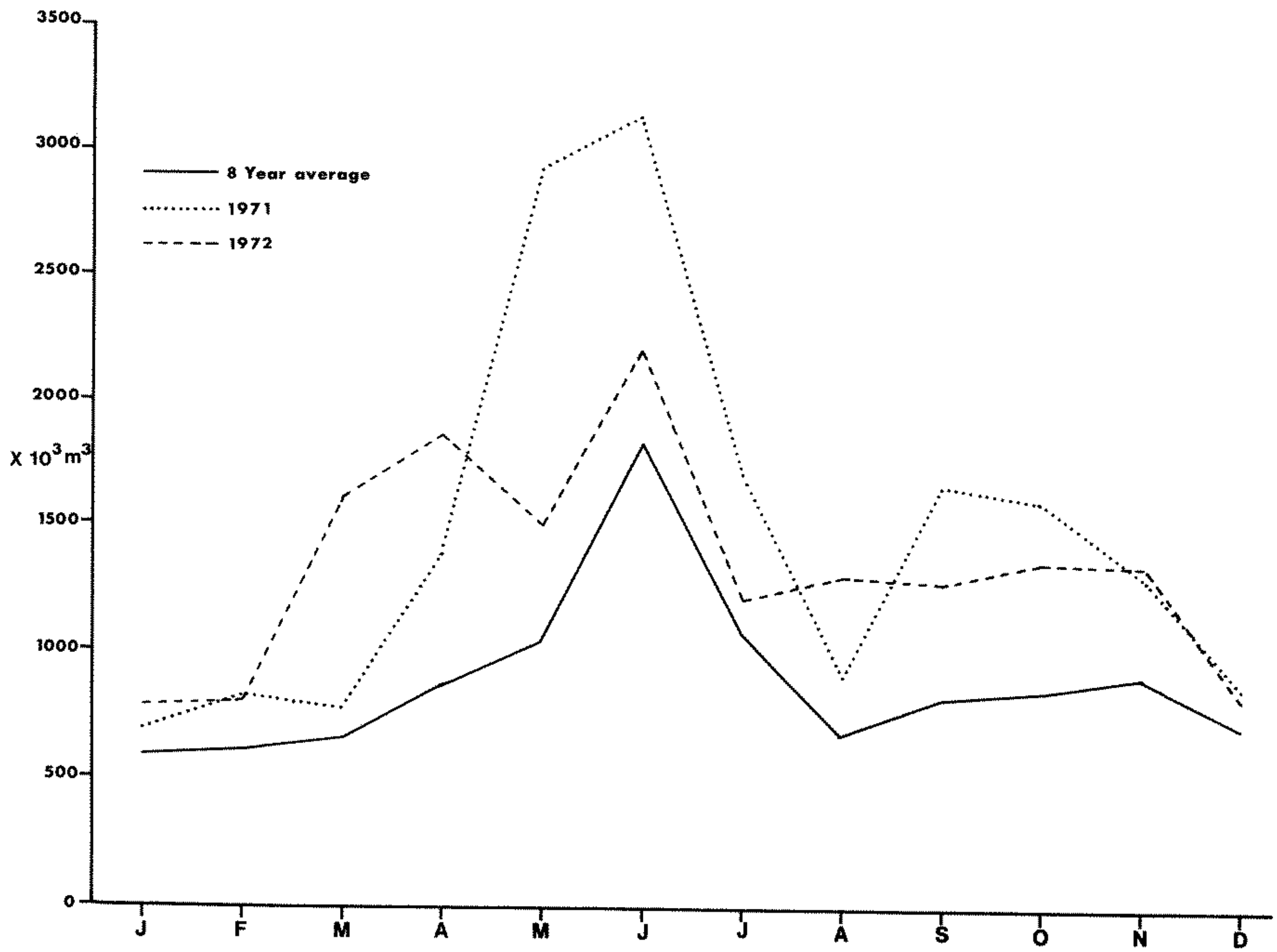

Figure 2. Mean daily inflow at Clark Canyon Reservoir during 1971 and 1972 compared to normal daily inflow based on an 8 year (1963-1970) average.

Table 3. Monthly inflow, discharge and storage change (X 10^3 m^3) at Clark Canyon Reservoir during 1971 and 1972 compared to normal monthly inflow based on an 8 year (1963-1970) average.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1971													
Net Inflow	21,512	23,079	24,152	41,939	90,835	94,326	53,411	28,691	50,290	50,006	39,756	27,310	545,307
Total Discharge	21,636	24,929	24,769	34,415	64,191	69,779	67,102	62,489	61,391	46,676	34,328	33,847	545,552
Storage Change	-124	-1,850	-617	+7,524	+26,644	+24,547	-13,691	-33,798	-11,101	+3,330	+5,428	-6,537	-245
1972													
Net Inflow	24,608	22,869	49,846	55,890	46,848	66,510	38,041	40,644	38,720	42,432	40,459	25,978	492,845
Total Discharge	22,758	21,512	33,440	56,013	56,593	48,748	56,790	63,340	34,156	26,890	32,811	24,991	478,042
Storage Change	+1,850	+1,357	+16,406	-123	-9,745	+17,762	-18,749	-22,696	+4,564	+15,542	+7,648	+987	+14,803
1963-1970 Average													
Net Inflow	18,315	17,250	20,437	26,372	32,526	55,145	33,545	21,309	24,832	26,760	27,685	22,543	326,719

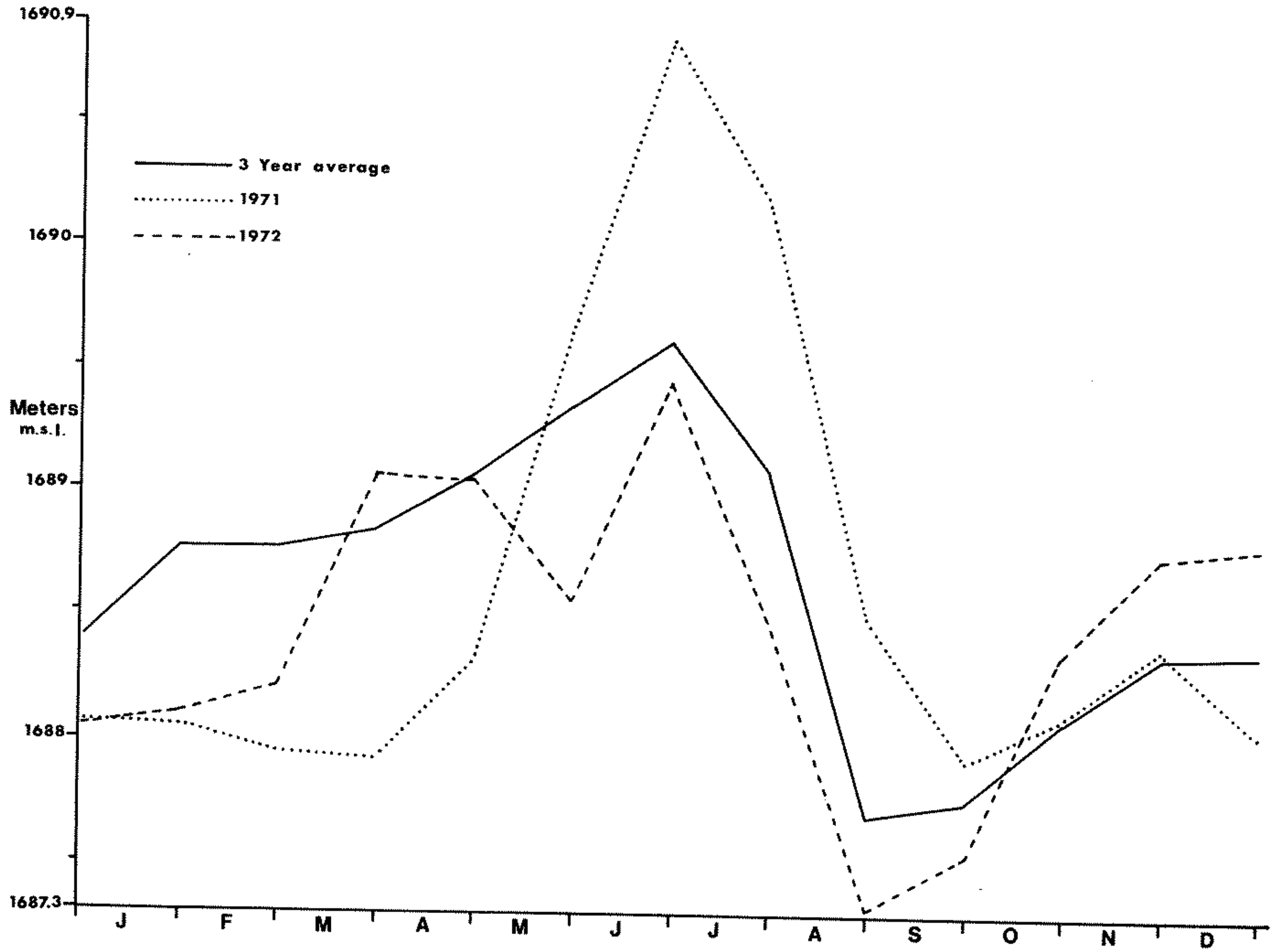

Figure 3. Water levels of Clark Canyon Reservoir during 1971 and 1972 compared to normal reservoir levels based on a 3 year (1968-1970) average.

record high levels during the 1971-1972 winter, and the spring (April-July) runoff was again forecast to be well above normal. Consequently, the discharge was gradually increased to 22.654 m^3/sec (800 ft^3/sec) and maintained at this level through May 22 when it appeared that the major portion of the spring runoff had occurred. This abnormally high discharge rate coupled with a realized spring runoff which was well below the anticipated amount led to an abnormal spring water storage pattern where, in contrast to normal years, the reservoir water level declined from April through May, 1972 (Figure 3). Peak storage of 199.210 X 10^6 m^3 at elevation 1689.46 m occurred on June 30. The realized April-July inflow was 207.290 X 10^6 m^3, 140% of normal. Forty-two percent of the net inflow for 1972 occurred during this 4 month period. Inflow remained high at 188.232 X 10^6 m^3, 153%of normal during August-December, 1972.

On an annual basis, the normal net inflow for eight years prior to this study was 326.719 X 10^6 m^3 per year. Net inflow was 167% of normal and 151% of normal during 1971 and 1972, respectively. The excessive runoff was accommodated largely by increased discharge rates and, except during the above mentioned periods, it had little effect upon reservoir storage patterns (Figure 3).

Light Conditions and Turbidity

Approximated euphotic zone depths on each sampling date during 1971 and 1972 are given in Table 4. In general, it appears that

Table 4. Euphotic zone depths at Clark Canyon Reservoir during 1971 and 1972.

Date	Euphotic Zone Depth (meters)	Date	Euphotic Zone Depth (meters)
6/23/71	6.75	5/12	13.91
6/29	7.16	5/20	12.83
7/7	9.05	6/15	11.21
7/14	10.80	7/5	9.18
7/21	9.59	7/15	15.39
8/18	6.35	7/26	9.45
9/1	6.35	8/6	7.56
9/15	5.00	8/19	9.45
10/9	15.53	8/26	9.66
12/15	13.23	9/10	8.64
1/8/72	12.02	9/23	6.48
2/5	11.88	10/8	9.18
4/21	5.00	10/21	12.56
4/28	7.16	11/4	13.50

euphotic zone depths in Clark Canyon Reservoir were erratic with spring (April) and fall (August-September) lows possibly due to turbid spring runoff and *Aphanizomenon flos-aquae* phytoplankton blooms, respectively. Specifically, the euphotic zone depth varied from a low of 5.00 meters on September 15, 1971 and April 21, 1972, to highs exceeding 12 meters on 8 of the 28 sampling dates.

Turbidity ranged from a maximum of 10 Jackson Turbidity Units (JTU) to a minimum of zero JTU (Appendix Table 9). Vertical turbidity gradients were not well defined but, it was noted on several sampling dates that the lowest turbidity occurred at the reservoir's mid-depths. Turbidity was higher in 1972 than on comparable sampling dates in 1971.

Temperature and Conductivity

All profiles of temperature are given in Table 10 of the Appendix. The data indicated that the reservoir was stratified into well defined thermal zones from late June through early September each year. Spring data available in 1972 suggested that a less pronounced thermocline began to form in late April at a depth of 3 meters (Figure 4a). As the season progressed the thermocline was driven deeper until it reached a maximum depth of 22.0 meters on July 5. Thereafter, it fluctuated erratically between 9.5 and 22.5 meters until the reservoir overturned in mid September. In 1971 sampling began on June 23 when the thermocline was at 8.0 meters. Thereafter, it fluctuated erratically between 4.5 and 22.0 meters until the reservoir overturned, again in mid September. The surface temperature at the onset of the fall overturn was around 14° to 15° C each year. The thermocline was consistently deeper in 1972 than on comparable sampling dates in 1971.

Yearly reservoir bottom temperature regimes showed close similarities on all comparable sampling dates during 1971 and 1972 (Figure 5). Surface temperature regimes were similar except from late June through mid July. In late June, 1971, the epilimnion was warmer than in 1972. However, a prolonged cold spell during the last week of June

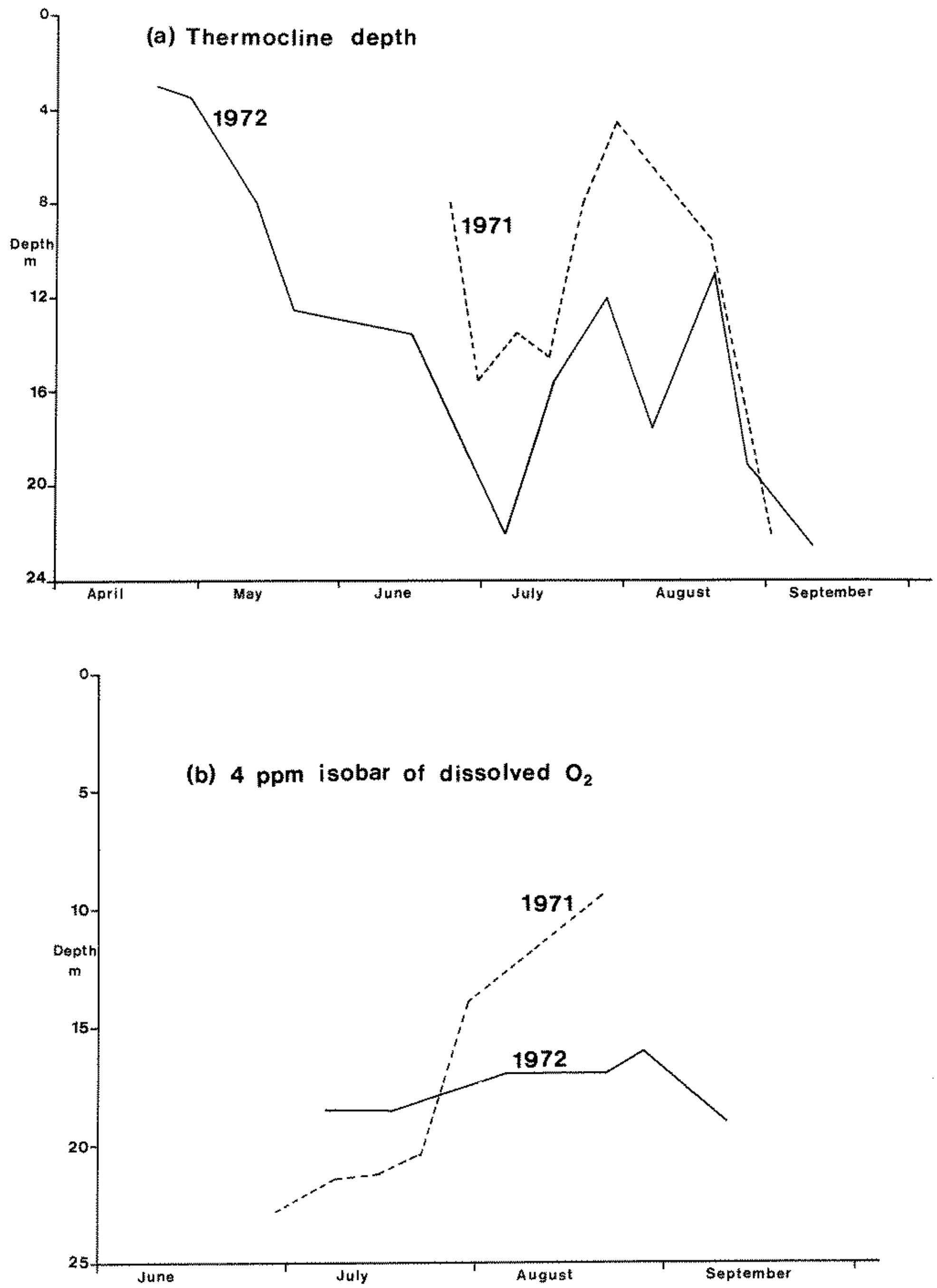

Figure 4. Depth to middle of thermocline (a) compared to depth of 4 ppm dissolved oxygen isobar (b) in Clark Canyon Reservoir during 1971 and 1972.

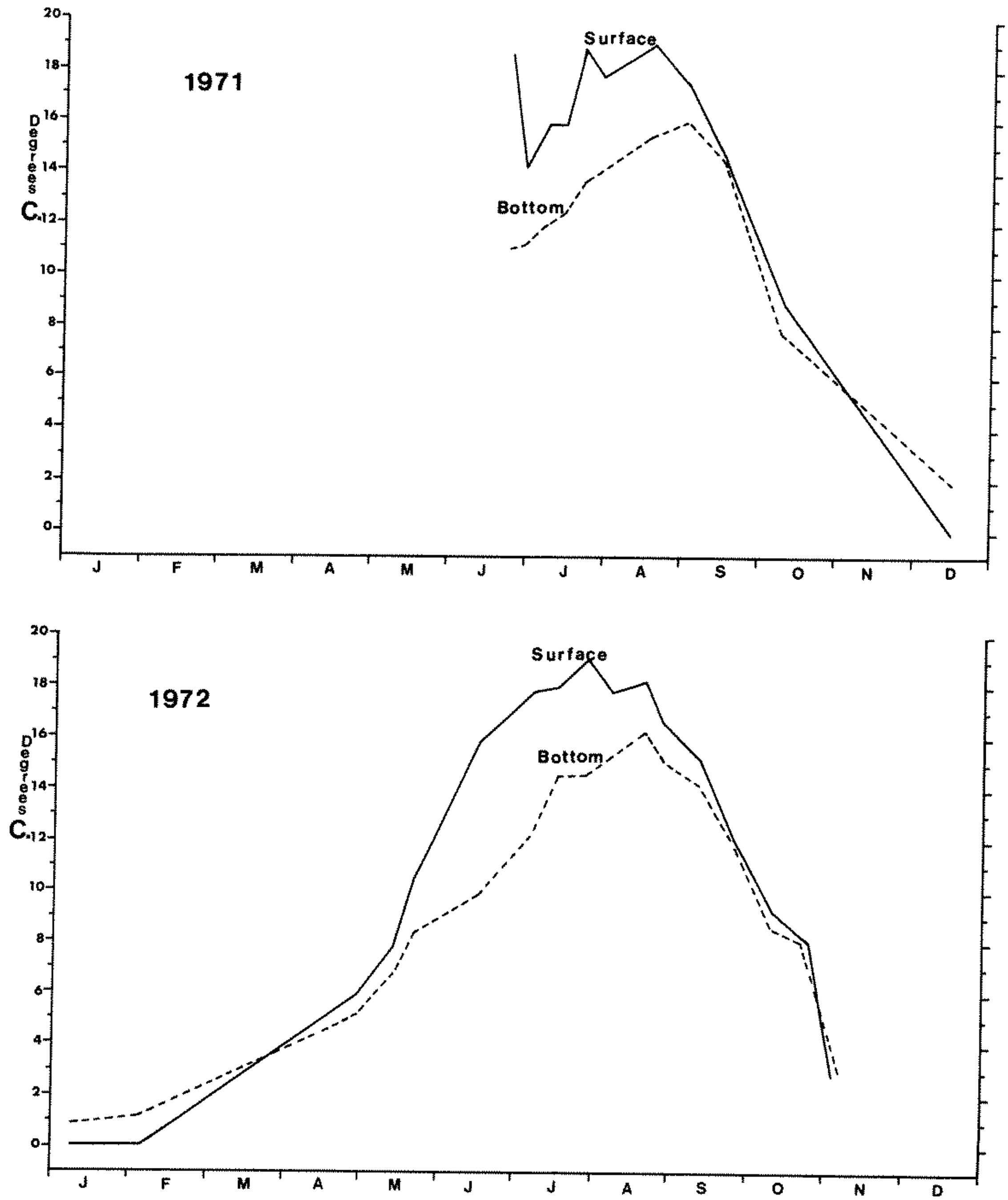

Figure 5. Surface and bottom temperature regimes in Clark Canyon Reservoir during 1971 and 1972.

through mid July, 1971, led to a cooler early July epilimnion than was found in 1972.

Vertical and seasonal changes in temperature are illustrated in Figure 6. The successive temperature profiles illustrate the effectiveness of Clark Canyon Reservoir as a heat trap. Because of deep water withdrawal, the reservoir stores advected heat during the summer in addition to heat absorbed from solar radiation. Martin (1967) and Wright and Soltero (1973) also report storage of heat during the summer in other Montana reservoirs with deep zone discharges.

The conductivity in the reservoir ranged from a low reading of 420 to a high of 650 micromhos (Appendix Table 11). Pronounced vertical gradients of conductivity were not observed in Clark Canyon Reservoir in contrast to the findings of Martin (1967), Arneson (1969) and Wright and Soltero (1973) on other Montana reservoirs. A slight vertical profile with conductivity increasing from 521.62 micromhos on the surface of the reservoir to 539.79 micromhos on the bottom is detectable if the mean readings of each strata over all the sampling dates are considered (Appendix Table 11).

In Figure 7 seasonal and yearly differences in mean conductivity for the complete strata of water sampled are illustrated. In general it appears that the lowest concentration of electrolytes occurred during the spring runoff period, April through June, with increasing amounts through the remainder of each calendar year. On all comparable

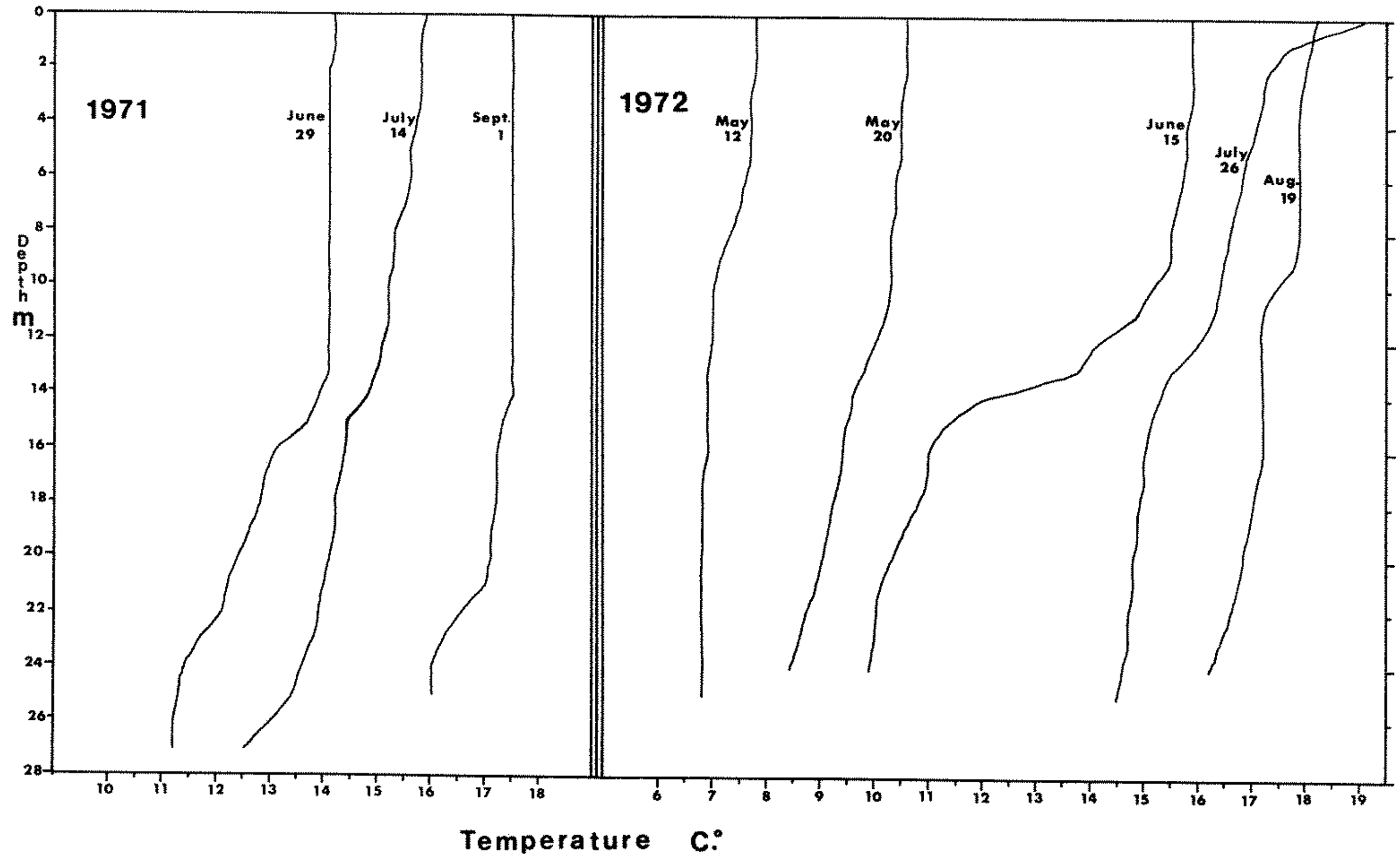

Figure 6. Seasonal temperature profiles in Clark Canyon Reservoir during 1971 and 1972.

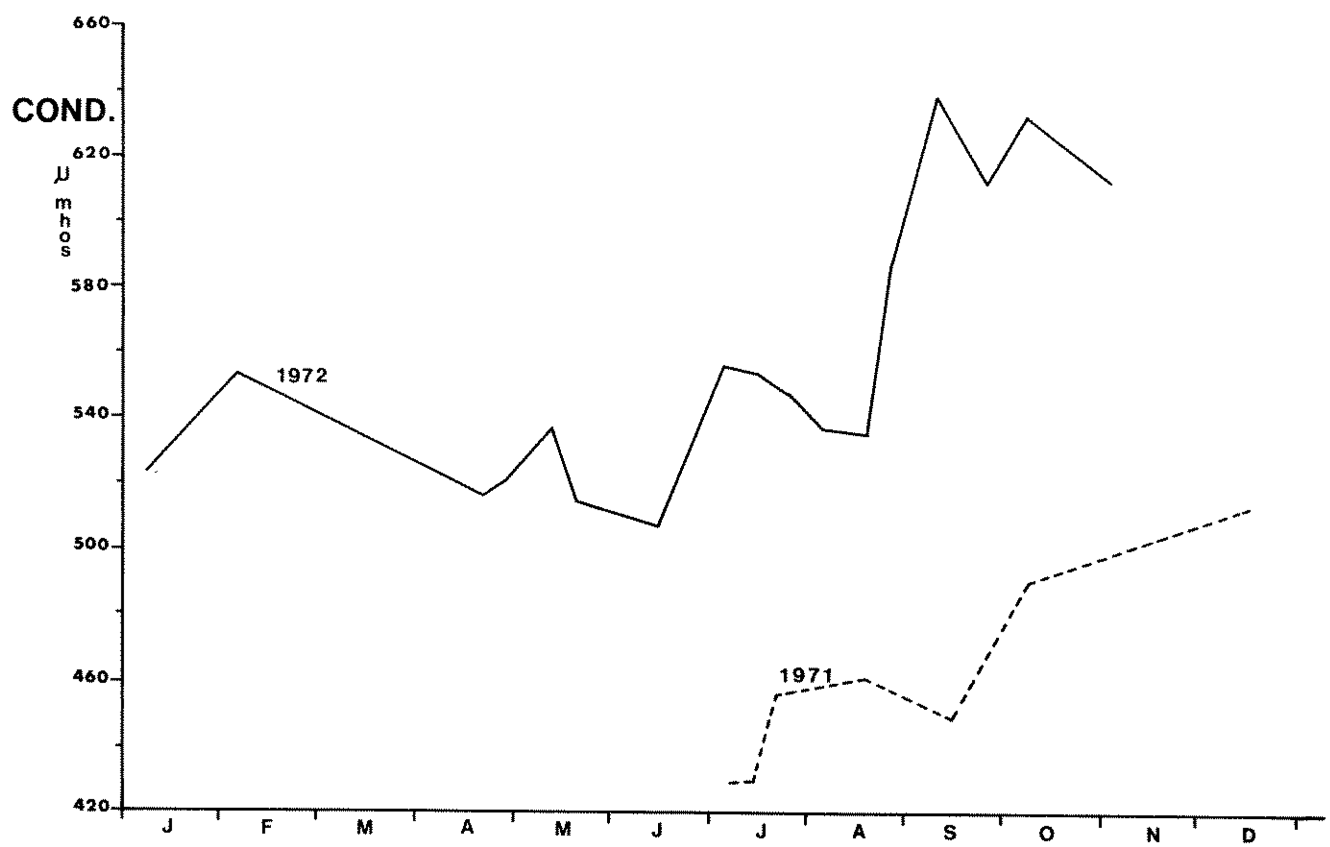

Figure 7. Mean conductivity for the entire strata of water sampled in Clark Canyon Reservoir during 1971 and 1972.

sampling dates the mean conductance was higher in 1972 than in 1971. This may be due in part to decreased surface runoff during 1972.

Water Chemistry

Dissolved oxygen (DO) ranged from 6.46 to 10.80 ppm and from 0.20 to 11.08 ppm in the water near the surface and on the bottom, respectively (Appendix Table 12). The data reveal the presence of a strong clinograde DO curve during each summer and a less pronounced clinograde curve during the intervening winter. DO depletion on the reservoir bottom became progressively more pronounced with time following the overturn periods with the most severe depletion occurring immediately prior to each of the three observed overturn periods. Lows of 0.20 and 0.36 ppm were recorded on the reservoir bottom prior to fall overturn in 1971 and 1972, respectively, while a low of 3.98 ppm was recorded on the nearest sampling date preceding the 1972 spring overturn. Thus, on a seasonal basis, the highest DO budgets occur during the overturn periods and during early winter, while lowest budgets occur during winter and summer stagnation, especially during the latter. On an annual basis, mean DO concentrations for the entire strata of water sampled were higher during 1972 than in 1971 except from late August through mid September (Figure 8a).

Results of numerous studies which have been made pertaining to the minimum DO concentration required to sustain a healthy trout population seem to indicate that 4 ppm or less will affect trout growth and/or

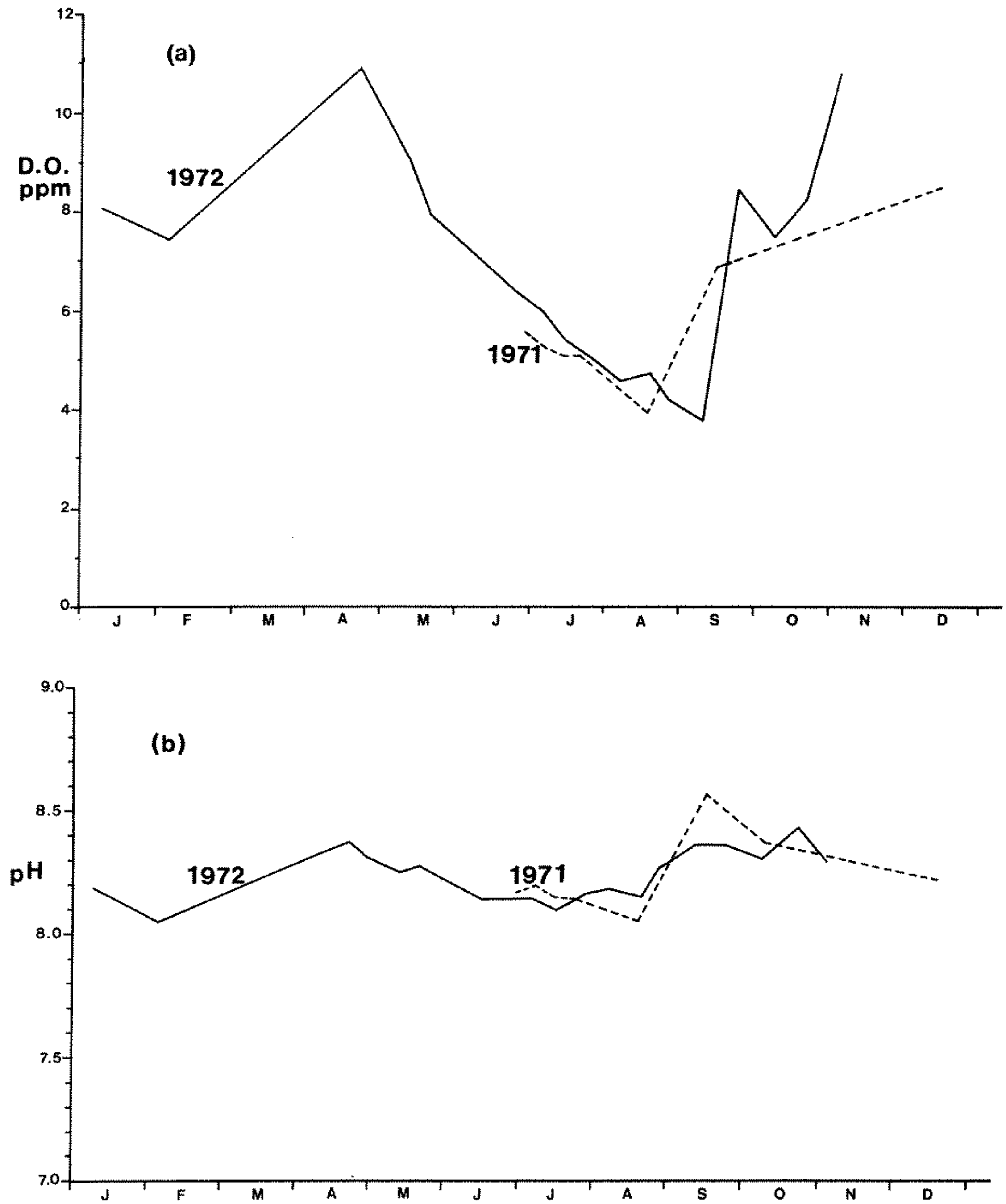

Figure 8. Mean dissolved oxygen (a) and pH (b) for the entire strata of water sampled in Clark Canyon Reservoir during 1971 and 1972.

distribution (National Technical Advisory Committee, 1968; Needham, 1969). Marcoux (1969) reported that DO reduction to 2-4 ppm in the deeper water (17 to 21 m) of Clark Canyon Reservoir limited the use of this portion of the reservoir by all fish species. In my study during 1971 the 4 ppm isoline was first detected on June 29 at a depth of 22.75 meters (Figure 4b). As the season progressed the isoline crept gradually upward until it reached 9.50 meters on August 18. The isoline disappeared from the reservoir by September 15 when a low of 5.20 ppm DO was recorded near the bottom. In 1972 the isoline was first detected on July 5 at a depth of 18.50 meters. As the season progressed the isoline again crept gradually upward, but to a lesser extent than in 1971, reaching a depth of 16.00 meters on August 26. The isoline disappeared by September 23 when the reservoir had overturned. During both years the isoline's location appeared to be largely dependent upon thermocline depth (Figure 4). Consequently, the severest depletion occurred from mid July through late August. This is in contrast to depletion on the reservoir bottom which, as previously explained, was severest immediately prior to overturn in early September.

The pH readings ranged from 7.80 to 8.63, and, in general, the curve of vertical distribution of the pH followed that of dissolved oxygen (Appendix Table 13). Thus, in both years the highest mean pH occurred during the overturn periods while lowest means coincided with periods of severest stagnation (Figure 8b). Lowest pH occurred near the bottom during the stagnation periods.

Previous studies have shown that total alkalinity and total hardness act in a relatively conservative manner. Data at Clark Canyon Reservoir strongly support this contention. Ranges of total alkalinity and total hardness, respectively, were 177 to 222 ppm and 157 to 230 ppm (Appendix Tables 14 and 15). The vertical distribution was relatively homogenous. On comparable sampling dates mean readings were slightly higher in 1972 than in 1971 (Figure 9). This is largely attributable to lower inflows during 1972. On a seasonal basis, the lowest mean total alkalinity occurred from June through mid August while highs were recorded during the winter months. With respect to total hardness, it appeared that the highest concentration of polyvalent cations occurred during the fall overturn periods while lows occurred during summer.

Orthophosphate concentrations ranged from 0.00 to 0.54 ppm (Appendix Table 16). In general the values found were quite high in comparison to average natural waters. Vertical homogeneity was observed during the overturn periods with concentrations ranging between 0.05-0.12 ppm (Table 5). Phosphate reduction to 0.02 ppm was observed in the euphotic zone during the winter period. The deep zone concentration remained essentially unchanged from that observed during the preceding autumnal overturn. As summer stratification progressed following the 1972 vernal overturn, phosphate accumulation in the hypolimnion was observed, reaching a maximum of 0.20 ppm or 3 times the

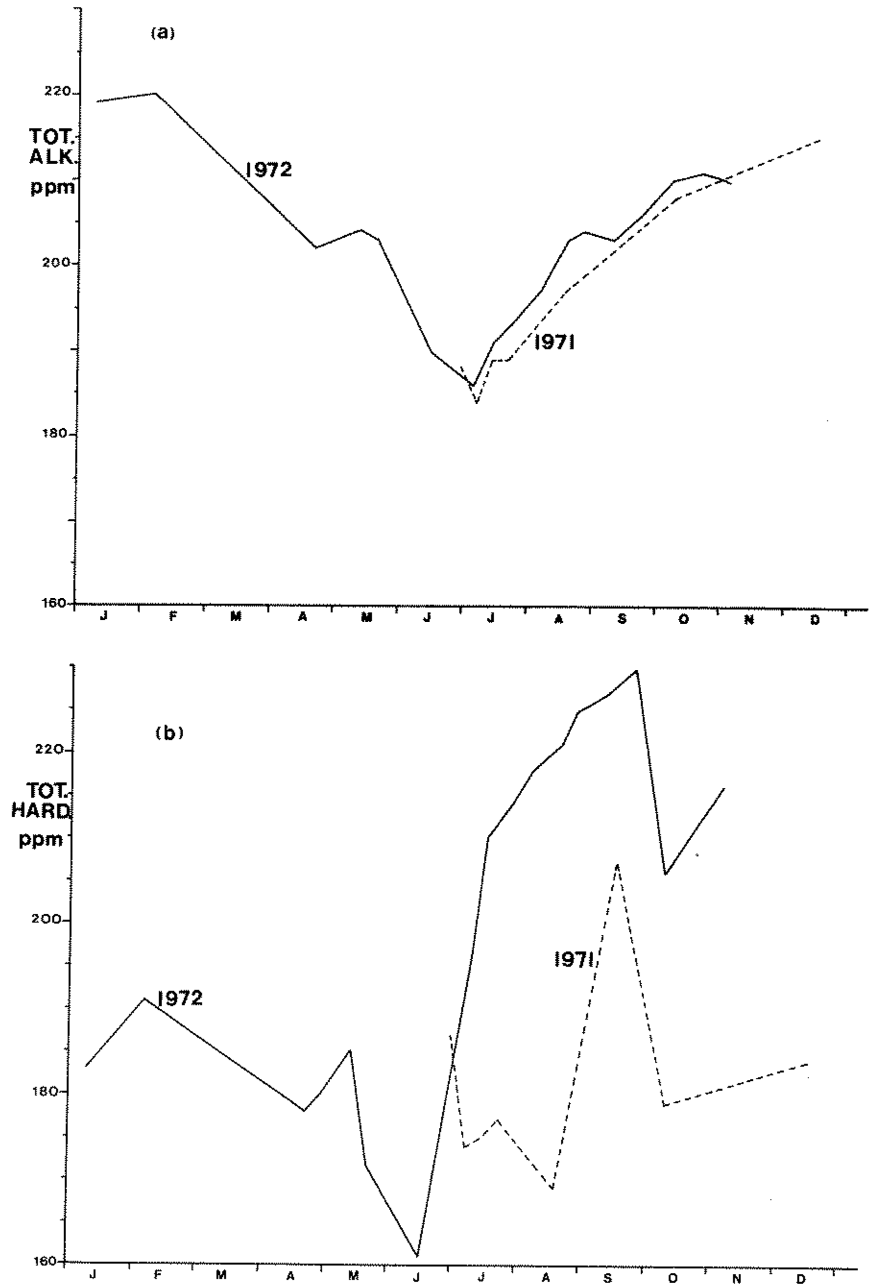

Figure 9. Mean total alkalinity (a) and total hardness (b) for the entire strata of water sampled in Clark Canyon Reservoir during 1971 and 1972.

Table 5. Plant nutrient concentrations in the euphotic zone (0-8 m) and in the deep zone (15-bottom m) during 1971 and 1972.

Date	Phosphate ppm 0-8	Phosphate ppm 15-b	Nitrate ppm 0-8	Nitrate ppm 15-b	Nitrite ppm 0-8	Nitrite ppm 15-b	Ammonia ppm 0-8	Ammonia ppm 15-b
8/18/71	0.29	0.11	--	--	--	--	--	--
9/15	0.07	0.07	--	--	--	--	--	--
10/9	--	--	0.03	0.04	.001	.002	--	--
1/8/72	0.03	0.07	0.24	0.31	.005	.006	--	--
2/5	0.02	0.06	0.15	0.21	.005	.005	--	--
4/21	0.06	0.07	0.03	0.03	Zero	Zero	Zero	Trace
4/28	0.06	0.06	0.03	0.03	Zero	Zero	Trace	0.02
5/12	0.04	0.05	0.01	0.02	.001	.001	0.01	0.05
5/20	0.03	0.05	0.02	0.02	.001	.001	0.02	0.11
6/15	0.06	0.10	Trace	0.02	Zero	.003	0.03	0.12
7/5	0.07	0.20	0.01	0.05	.003	.012	0.01	0.27
7/15	0.04	0.16	0.01	0.06	.002	.012	0.06	0.19
7/26	0.10	0.17	0.01	0.06	.005	.012	0.06	0.24
8/6	0.05	0.14	Trace	0.03	.005	.014	0.03	0.25
8/19	0.04	0.11	--	--	--	--	Trace	0.03
8/26	0.35	0.11	0.01	0.03	.008	.010	0.02	0.07
9/10	0.05	0.05	0.01	0.01	.003	.002	Zero	0.01
9/23	0.11	0.12	0.01	Trace	Trace	Trace	0.01	0.03
10/8	0.11	0.11	Trace	0.02	Zero	Zero	0.22	0.08
10/21	0.06	0.07	0.01	0.02	Zero	Zero	0.17	0.20
11/4	0.03	0.03	0.01	0.02	Zero	Zero	0.05	0.07

euphotic zone concentration on July 5. Subsequent reductions in the hypolimnetic phosphate concentration may be attributable to reservoir drawdown during July and August due to irrigation releases. Euphotic zone phosphate concentrations during the summer stratification period were erratic with values ranging between 0.03-0.35 ppm. Phosphate reduction was observed in both the euphotic and deep zones as autumnal circulation progressed in 1972.

Nitrate concentrations ranged between 0.00-0.36 ppm (Appendix Table 17). Vertical uniformity of nitrate concentration at 0.01 to 0.03 ppm was observed during overturn periods (Table 5). Highest nitrate concentrations, 0.15-0.36 ppm, were observed during the winter months. Nitrate reduction between January and February was observed in both the euphotic and dysphotic zones. Dysphotic zone concentrations during winter exceeded euphotic zone values by one-third. With the advent of summer stratification following the 1972 spring overturn and throughout the summer stagnation and fall mixing periods, nitrate in the euphotic zone remained at a low concentration, averaging 0.01 ppm. As time advanced following the vernal overturn, nitrate accumulation in the hypolimnion occurred, reaching a maximum of 0.06 ppm or 6 times the euphotic zone concentration during July. The subsequent reduction in hypolimnetic nitrate concentrations may again be attributable to reservoir drawdown.

Nitrite concentrations ranged between 0.000-0.020 ppm (Appendix Table 18). The vertical distribution of nitrite generally followed the pattern of nitrate, with increased concentrations deeper in the reservoir. Seasonal trends were also similar except during overturn periods when, in the presence of an increased DO budget, the nitrite was effectively eliminated (Table 5).

Ammonia analyses were conducted from April 21-November 4, 1972. Concentrations ranged between 0.00-0.56 ppm (Appendix Table 19). A near uniform vertical profile with concentrations ranging between 0.00-0.01 ppm was observed during the vernal overturn. As summer stratification progressed, hypolimnetic concentrations increased, reaching a maximum of 0.27 ppm or 27 times the euphotic zone concentration on July 5 (Table 5). Euphotic zone ammonia concentrations during the summer were erratic, but generally increased to a late July maximum of 0.06 ppm and subsequently declined. Vertical homogeniety of ammonia was restored with the advent of the fall overturn. The increased ammonia concentrations during October may be attributable to the nature of the autumnal circulation period (Hutchinson, 1957).

Results of a more thorough chemical analysis of a euphotic zone water sample taken from the reservoir on September 23, 1972, are shown in Table 6. Similar euphotic zone analyses conducted during the 1965 fall overturn on Hebgen Lake and Quake Lake by Martin (1967) and Arneson (1969), respectively, are also presented along with the mean

Table 6. Euphotic zone chemical characteristics during fall overturn in 3 Montana reservoirs compared to the mean composition of river water of the world.

Measurement	1	2	3	4
pH	8.47	8.35	7.79	---
Total Alkalinity (me/1)	4.13	1.47	1.50	---
Total Hardness (ppm)	232.8	---	---	55
Calcium Hardness (ppm)	149.6	---	---	---
Magnesium Hardness (ppm)	83.2	---	---	---
Ca^{++} (me/1)	2.99	0.21	0.73	0.750
Mg^{++} (me/1)	1.66	0.18	0.23	0.342
Na^{+} (me/1)	0.90	1.48	1.02	0.274
K^{+} (me/1)	0.10	0.11	0.11	0.059
HCO_3^{-} (me/1)	3.95	---	---	0.958
$SO_4^{=}$ (me/1)	1.22	0.23	0.14	0.233
Cl^{-} (me/1)	0.27	0.58	0.38	0.220
$CO_3^{=}$ (me/1)	0.18	---	---	---
Fl^{-} (me/1)	0.02	---	0.11	---
Silica as SiO_2 (ppm)	18.8	45	31	13
Total Carbon (ppm)	59.5	---	---	---
Organic Carbon (ppm)	5.0	---	---	---
Inorganic Carbon (ppm)	54.5	17.6	---	---
Total Iron (ppm)	0.00	0.13	0.07	0.67

1. Clark Canyon Reservoir, 9/23/72 (present study).
2. Hebgen Lake, 9/23/65 (Martin, 1967).
3. Quake Lake, 9/14/65 (Arneson, 1969).
4. Mean composition of river water of the world (Livingstone, 1963).

composition of river water of the world as computed by Livingstone (1963). In general it appears that Clark Canyon Reservoir contains 2 or 3 times more total dissolved solids (TDS) than either Hebgen Lake or Quake Lake and 4 times more TDS than "average" river water. Reid (1961) presents a classification scheme for biological productivity based on calcium ion concentration as follows:

Ca^{++} concentration	Biological productivity
Less than 0.50 me/l	"Poor"
0.50 - 1.25 me/l	"Medium"
Greater than 1.25 me/l	"Rich"

By this criterion Clark Canyon Reservoir must be regarded as a very "rich" reservoir. The order of abundance of specific ions in Clark Canyon Reservoir is in accordance with typical North American fresh waters.

Phytoplankton Standing Crop and Chlorophyll

A total of 31 algal genera (6 classes) were observed in the euphotic zone of Clark Canyon Reservoir from December 15, 1971 to November 4, 1972 (Appendix Table 20). Thirty-two genera (7 classes), 28 genera (8 classes), and 50 genera (7 classes) were reported by Martin (1967), Arneson (1969) and Wright and Soltero (1973) respectively, in studies of other Montana reservoirs. Smith (1973) observed 43 genera (5 classes) in Clark Canyon Reservoir's inlet streams and outlet river.

For seasonal analysis, all biological data were divided into four groups: (1) winter, contained three sampling dates from December 15, 1971 through February 5, 1972; (2) spring, contained four sampling dates from April 21 through May 20, 1972; (3) summer, contained seven sampling dates from June 15 through August 26, 1972; (4) fall, contained five sampling dates from September 10 through November 4, 1972.

The five genera with the largest mean annual standing crops were, in descending order of abundance, *Asterionella*, *Aphanizomenon*, *Cryptomonas*, *Rhodomonas* and *Synedra*. The seasonal abundance of these genera is shown in Figure 10.

The dominant genus during winter was *Asterionella* (Table 7). Its standing crop ranged from 1.00 mm^3/l to 1.14 mm^3/l and averaged 1.053 mm^3/l. *Synedra*, *Cocconeis*, *Rhodomonas*, *Cryptomonas*, *Chlamydomonas* and *Cymbella* each achieved mean winter standing crops of between 0.11 and 0.30 mm^3/l. The remaining winter genera averaged less than 0.10 mm^3/l. Alga, whose mean biomass during winter was at least two times that observed during any other season, included *Pediastrum*, *Cocconeis*, *Cymbella*, *Gomphonema* and *Dinobryon*. Blue-green and dinoflagellate genera were conspicuously absent during winter.

During spring *Asterionella* remained the most abundant genus with a mean density of 1.105 mm^3/l. The peak annual standing crop of *Asterionella* at 1.46 mm^3/l was reached on April 21. A gradual decline in its abundance was observed throughout the spring and summer until

Table 7. Seasonal rank order of abundance of algal genera in Clark Canyon Reservoir during 1971 and 1972

	Winter	mm^3/l	Spring	mm^3/l	Summer	mm^3/l	Fall	mm^3/l	Annual Avg.	mm^3/l
1.	*Asterionella*	1.053	*Asterionella*	1.105	*Aphanizomenon*	1.003	*Aphanizomenon*	1.486	*Asterionella*	0.732
2.	*Synedra*	0.293	*Cryptomonas*	0.537	*Cryptomonas*	0.767	*Cryptomonas*	0.516	*Aphanizomenon*	0.622
3.	*Cocconeis*	0.257	*Rhodomonas*	0.265	*Asterionella*	0.443	*Synedra*	0.422	*Cryptomonas*	0.516
4.	*Rhodomonas*	0.257	*Synedra*	0.258	*Rhodomonas*	0.330	*Fragillaria*	0.390	*Rhodomonas*	0.280
5.	*Cryptomonas*	0.223	*Chlamydomonas*	0.258	*Ceratium*	0.327	*Asterionella*	0.328	*Synedra*	0.245
6.	*Chlamydomonas*	0.123	*Diatoma*	0.200	*Diatoma*	0.261	*Rhodomonas*	0.266	*Fragillaria*	0.197
7.	*Cymbella*	0.117	*Staurastrum*	0.155	*Fragillaria*	0.226	*Ceratium*	0.184	*Ceratium*	0.128
8.	*Chlorella*	0.093	*Chlorella*	0.105	*Anabaena*	0.226	*Uroglenopsis*	0.102	*Diatoma*	0.118
9.	*Fragillaria*	0.087	*Stephanodiscus*	0.088	*Schroederia*	0.080	*Staurastrum*	0.072	*Chlamydomonas*	0.115
10.	*Gomphonema*	0.050	*Fragillaria*	0.083	*Staurastrum*	0.070	*Melosira*	0.060	*Cocconeis*	0.087
11.	*Pediastrum*	0.043	*Cyclotella*	0.075	*Uroglenopsis*	0.046	*Chlamydomonas*	0.048	*Staurastrum*	0.074
12.	*Hannaea*	0.023	*Uroglenopsis*	0.048	*Cocconeis*	0.037	*Rhoicosphenia*	0.030	*Chlorella*	0.059
13.	*Dinobryon*	0.023	*Cocconeis*	0.040	*Chlamydomonas*	0.031	*Hannaea*	0.024	*Anabaena*	0.057
14.	*Navicula*	0.015	*Navicula*	0.020	*Navicula*	0.024	*Chlorella*	0.022	*Uroglenopsis*	0.049
15.	*Scenedesmus*	0.012	*Rhoicosphenia*	0.020	*Stephanodiscus*	0.024	*Cymbella*	0.016	*Cymbella*	0.036

the annual minimum of 0.09 mm^3/1 was observed on August 26. *Cryptomonas* accounted for the second largest mean volume during spring. In contrast to *Asterionella*, a gradual increase in its standing crop from 0.29 mm^3/1 on April 21 to 0.80 mm^3/1 on May 20 was noted. The mean volume of *Cryptomonas* for the spring was 0.537 mm^3/1. *Rhodomonas, Synedra, Chlamydomonas, Diatoma, Straurastrum* and *Chlorella* attained mean spring standing crops ranging between 0.10 and 0.27 mm^3/1. The remaining spring genera averaged less than 0.10 mm^3/1. Alga whose mean biomass during spring was at least two times that observed during any other season included *Ankistrodesmus, Chlamydomonas, Staurastrum, Cyclotella, Nitzschia* and *Stephanodiscus*. As was the case during winter, blue-green and dinoflagellate genera were not present in the spring samples.

Aphanizomenon was dominant during the summer season with a mean standing crop of 1.003 mm^3/1. It first appeared on July 5 at a density of 0.03 mm^3/1 and sharply increased thereafter until a peak was observed on August 19 at 2.99 mm^3/1. A slight decline in its abundance in late August was followed by the annual peak of 4.04 mm^3/1 on September 10. With the demise of this second peak, a gradual decline in the abundance of *Aphanizomenon* followed, and on October 21 its presence was no longer detectable. *Cryptomonas, Asterionella, Rhodomonas, Ceratium, Diatoma, Fragillaria* and *Anabaena* each achieved mean summer standing crops of between 0.22 and 0.77 mm^3/1. The remaining summer genera averaged less than 0.10 mm^3/1. A "bloom" of the blue-green algae, *Anabaena*, was recorded in early July when its biomass reached 1.24 mm^3/l. Alga whose mean biomass during summer was at least two times that observed during any other season included *Schroederia* and *Anabaena*.

In the fall season *Aphanizomenon* remained the dominant algae averaging 1.486 mm^3/l. *Cryptomonas, Synedra, Fragillaria, Asterionella, Rhodomonas, Ceratium* and *Uroglenopsis* attained mean fall standing crops ranging between 0.10 and 0.52 mm^3/l. The remaining fall genera averaged less than 0.10 mm^3/l. Alga whose mean biomass during fall was at least two times that observed during any other season included *Melosira* and *Uroglenopsis*.

The seasonal abundance of Clark Canyon algae by class is shown in Figure 11. The Bacillariophyceae were the dominant class during all seasons comprising 71.2, 57.3, 31.9 and 40.8% of the total cell volume during winter, spring, summer and fall, respectively. Myxophyceae were present only during the summer and fall when they contributed 25.8 and 26.9%, respectively, to the total standing crop. The standing crops of Bacillariophytes and Chlorophytes were depressed during Myxophyton "blooms". The Cryptophyceae occurred with notable consistency during all seasons, comprising 17.8, 24.4, 27.2 and 19.4% of the total cell volume during winter, spring, summer and fall, respectively. The Chlorophyceae were not an important class on a cell volume basis as they contributed only 10.1, 16.6, 6.1 and 4.8% of the total cell volume

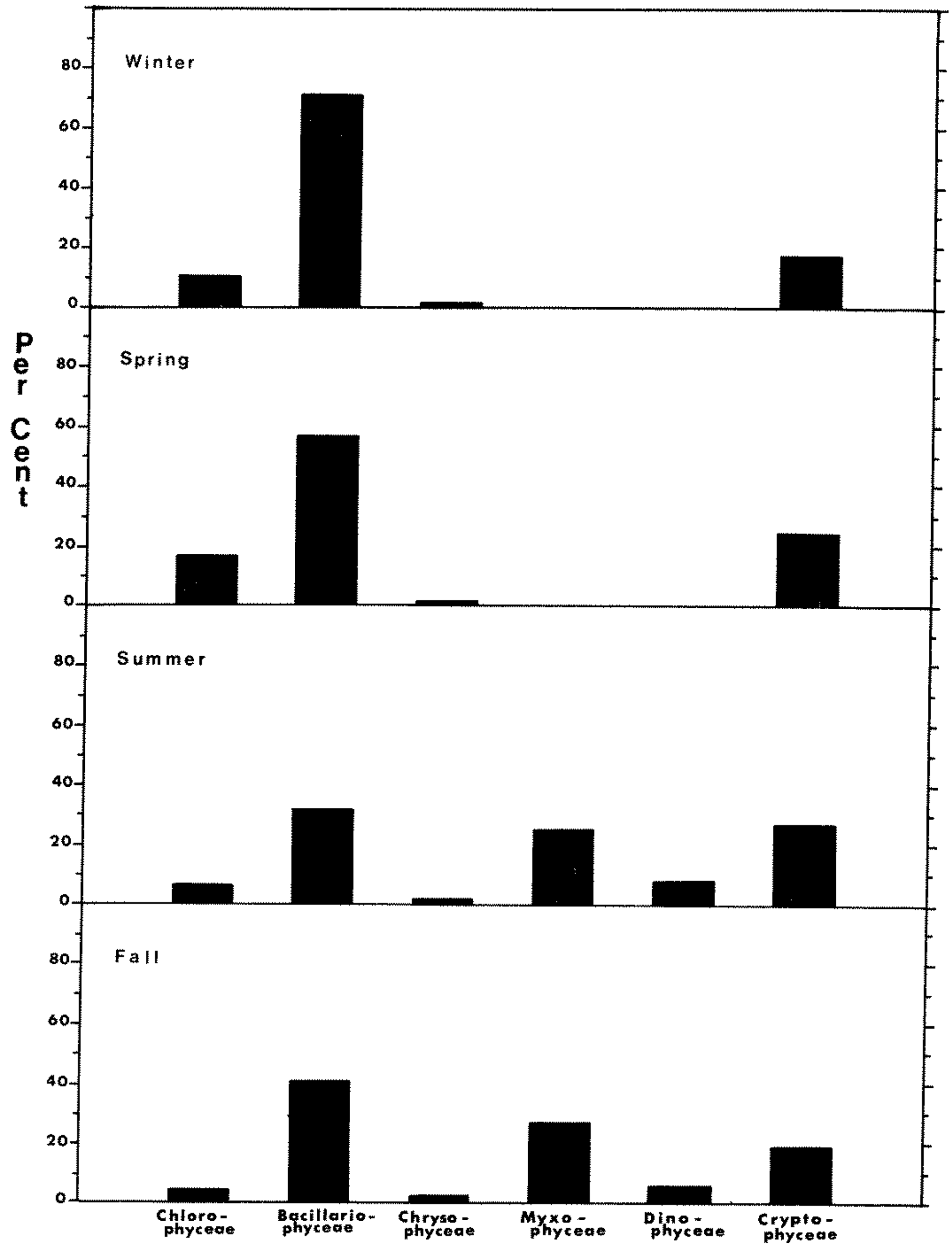

Figure 11. Seasonal percentages of the total standing crop for each algal class in Clark Canyon Reservoir.

during winter, spring, summer and fall, respectively. Chrysophyceae were present in insignificant amounts during all seasons. Dinophyceae were present only during the summer and fall seasons when they contributed 7.8 and 6.0%, respectively, to the total standing crops.

Euphotic zone chlorophyll a concentrations ranged from a maximum of 14.43 ug/l on September 10, 1972, to a minimum of 1.19 ug/l on July 26, 1972 (Appendix Table 21). The highest quantities reported for Hebgen Lake (Martin, 1967), Quake Lake (Arneson, 1969) and Bighorn Lake (Wright and Soltero, 1973), respectively, were 6.47, 13.84 and 77.0 ug/l. The three peak concentrations of chlorophyll a observed in Clark Canyon Reservoir during late April, early July and early September were due, respectively, to a spring diatom- green algae "bloom", an *Anabaena* spp. (blue-green algae) "bloom" and an *Aphanizomenon flos-aquae* (blue-green algae) "bloom". On a seasonal basis, mean euphotic zone chlorophyll a concentrations during winter, spring, summer, and fall, respectively, were 3.36, 9.86, 5.57 and 8.03 ug/l. The annual average was 6.71 ug chlorophyll a/l.

The relationship between euphotic zone chlorophyll a concentration and phytoplankton standing crop is shown in Figure 12. A simple correlation coefficient of 0.34 (P=.16) was obtained by a regression analysis of all simultaneous measurements of chlorophyll a and phytoplankton standing crop. On a seasonal basis, the chlorophyll a/ cell volume ratios during winter, spring, summer and fall, respectively, were 1.26,

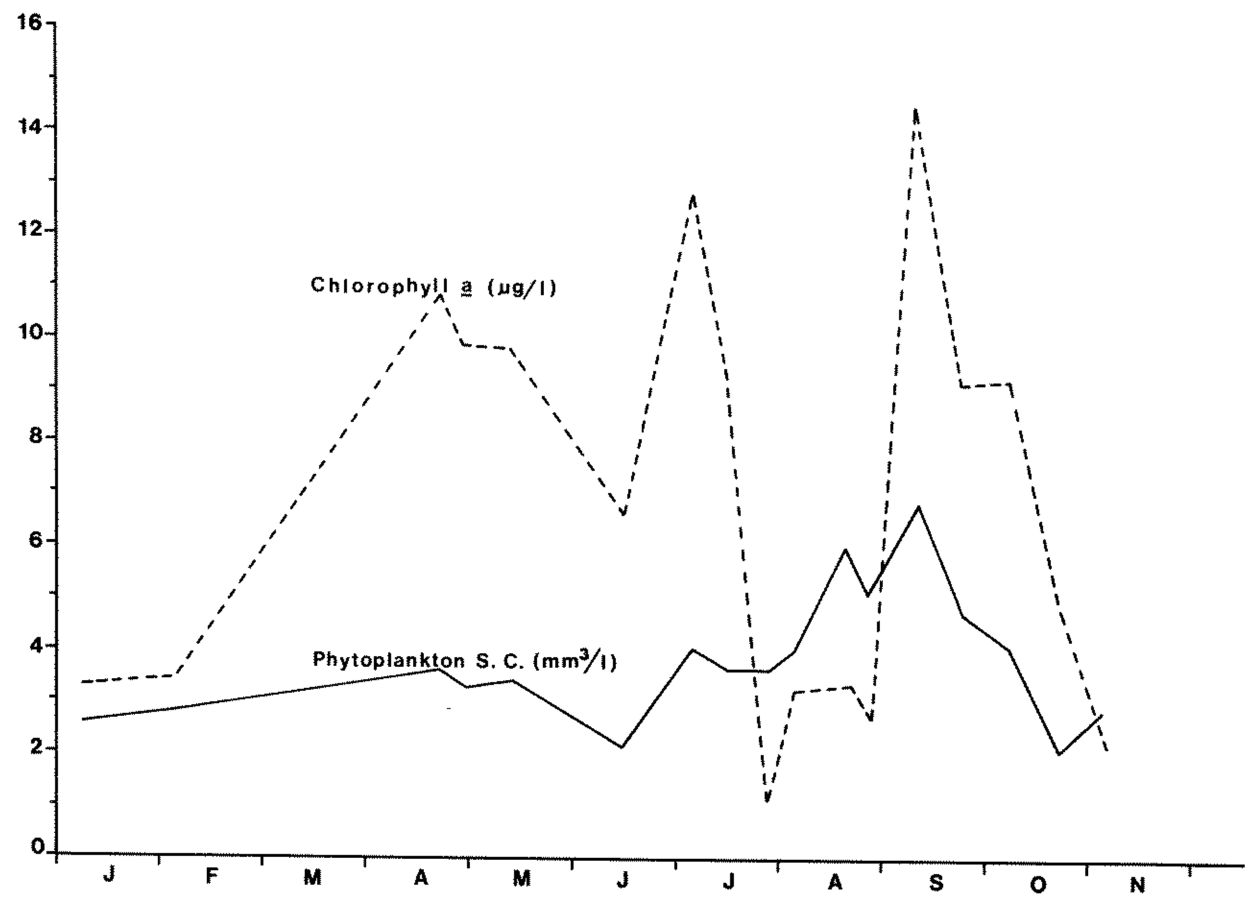

Figure 12. Relationship between euphotic zone chlorophyll _a_ concentration and phytoplankton standing crop in Clark Canyon Reservoir during 1972.

2.95, 1.38 and 1.96 (Appendix Table 21). This yields an annual average ratio of 1.89 ug chlorophyll a/ mm^3 of phytoplankton cells. Similar values were reported by Martin (1967), while Wright and Soltero (1973) found slightly higher ratios averaging 3.4 ug chlorophyll a/mm^3 of phytoplankton cells from April through November at Bighorn Lake.

Zooplankton Standing Crop and *Daphnia schodleri* Population Dynamics

The major zooplankton taxa encountered during the study, excluding rotifers, were *Daphnia schodleri*, *Cyclops bicuspidatus thomasii* and *Diaptomus* spp. *Bosmina* sp. and *Macrothrix* sp. were found rarely in some samples, especially from December through mid July. The mean annual numerical densities of *D. schodleri*, *C. bicuspidatus*, *D.* spp. and copepod nauplii, respectively, were 11.86, 6.18, 1.10 and 7.87 organisms/l (Appendix Table 22). Wright (1965) found similar numerical densities of *D. schodleri* on comparable sampling dates at Canyon Ferry Reservoir, but the *C. bicuspidatus* population densities which he encountered were much higher than those found in Clark Canyon Reservoir. In Quake Lake from late spring through early fall, Arneson (1969) reported mean numerical densities of *D. schodleri*, *C. bicuspidatus* and *D.* spp., respectively, of 3.63, 0.14 and 0.29 organisms/l.

D. schodleri was the dominant zooplankter during all seasons, averaging 10.69, 13.94, 18.47 and 4.32 organisms/l during winter, spring, summer and fall, respectively. The *D. schodleri* population ranged from a low of 3.10 organisms/l on October 8, 1972, to a peak annual density of 33.28 on July 15, 1972 (Figure 13a).

C. bicuspidatus was the second most abundant zooplankter during all seasons, averaging 3.77, 11.42, 8.55 and 0.92 organisms/l during winter, spring, summer and fall, respectively. The *C. bicuspidatus* population ranged from a low of 0.26 organisms/l on October 21, 1972, to a peak annual density of 21.62 on April 21, 1972. Unlike *D. schodleri* and *D.* spp. which achieved their highest annual population densities during the summer, *C. bicuspidatus* was most abundant during the spring.

D. spp. ranked as the third most abundant zooplankter during all seasons, averaging 0.23, 0.00, 4.01 and 0.14 organisms/l during winter, spring, summer and fall, respectively. The *D.* spp. population ranged from a low of zero organisms/l during the entire spring to a peak annual density of 10.78 on July 15, 1972, coincident with the peak annual concentration of *D. schodleri*.

The copepod nauplii were most abundant during the spring when they averaged 23.31 organisms/l. Mean numerical densities during winter, summer and fall, respectively, were 0.14, 7.64 and 0.37 nauplii/l.

Instantaneous birth rates of *D. schodleri* ranged from 0.004 on May 20, 1972, to a peak annual rate of 0.141 on December 15, 1971 (Table 8). Average birth rates during winter, spring, summer and fall, respectively, were 0.128, 0.031, 0.030 and 0.038. The high birth rates

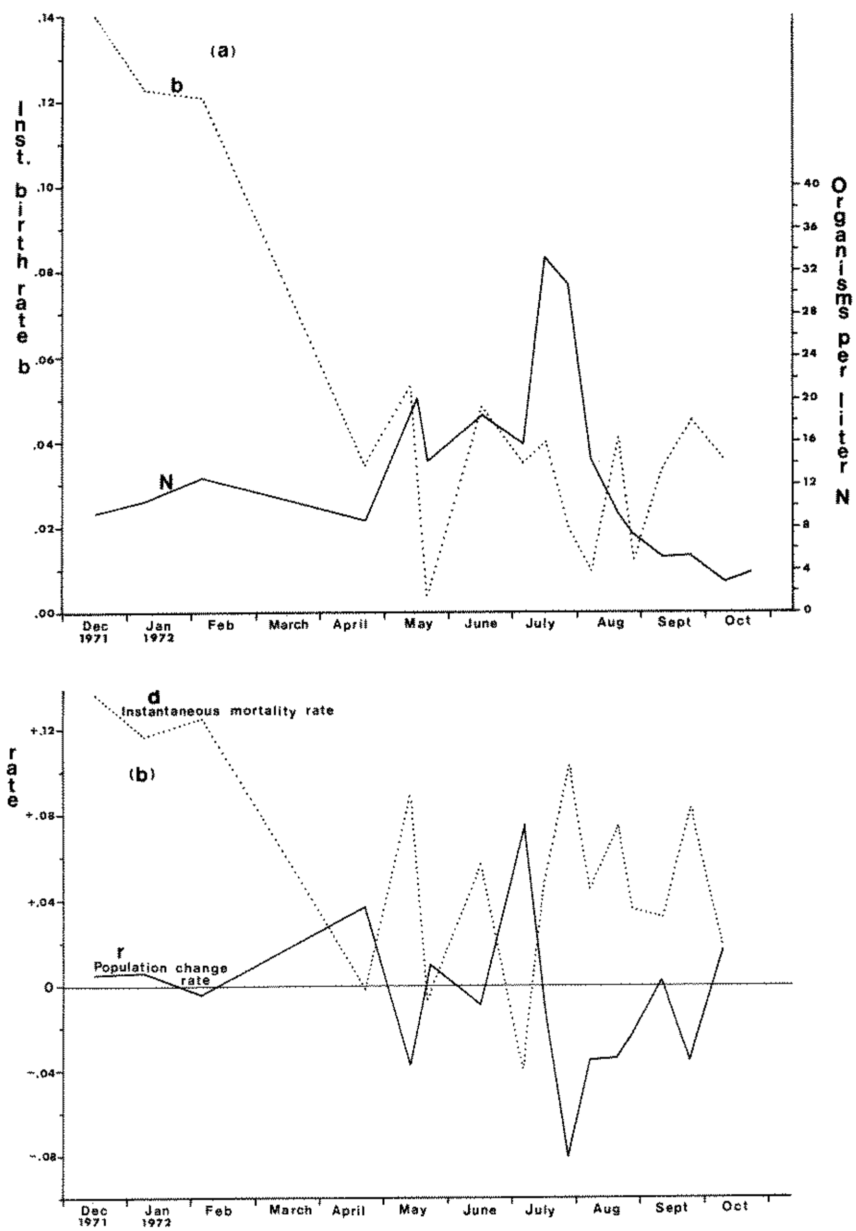

Figure 13. *Daphnia schodleri* standing crop and population dynamics in Clark Canyon Reservoir.

Table 8. Population data for *Daphnia schodleri* in Clark Canyon Reservoir.

Date	Egg Duration*	Finite Birth Rate	Instantaneous Birth Rate	Population Change Rate	Instantaneous Mortality Rate
12/15/71	28.4	0.141	0.141	+0.005	+0.136
1/8/72	28.4	0.123	0.123	+0.006	+0.117
2/5/72	27.8	0.121	0.121	-0.004	+0.125
4/21/72	18.2	0.036	0.035	+0.037	-0.001
5/12/72	13.6	0.054	0.053	-0.037	+0.089
5/20/72	9.2	0.004	0.004	+0.011	-0.007
6/15/72	5.8	0.048	0.048	-0.009	+0.057
7/5/72	3.4	0.037	0.035	+0.077	-0.039
7/15/72	3.8	0.041	0.040	-0.007	+0.047
7/26/72	4.0	0.019	0.020	-0.080	+0.103
8/6/72	3.6	0.010	0.010	-0.035	+0.045
8/19/72	3.4	0.041	0.041	-0.034	+0.075
8/26/72	4.2	0.013	0.013	-0.023	+0.036
9/10/72	4.6	0.034	0.034	+0.002	+0.032
9/23/72	6.6	0.045	0.045	-0.035	+0.080
10/8/72	10.4	0.036	0.036	+0.017	+0.019
10/21/72	12.0	--	--	--	--

*From data reported by Hall (1964).

during winter are attributable to high egg densities. The mean annual birth rate of *D. schodleri* was 0.057. Wright (1965) found a mean birth rate of 0.152 from April through early September, 1958, in Canyon Ferry Reservoir. Extremes ranged from 0.59 to 0.01.

On an annual basis, instantaneous mortality rates of *D. schodleri* averaged 0.061 and ranged from less than zero on several sampling dates to a peak annual rate of 0.136 on December 15, 1971, coincident with the peak annual instantaneous birth rate (Figure 13). The occurrence of negative mortality on several occasions reveals that birth rates were sometimes underestimated. Wright (1965) and Martin (1967) also report negative mortality rates as a result of problems encountered in the processing of zooplankton samples and data. Average mortality rates during winter, spring, summer and fall, respectively, were 0.126, 0.027, 0.046 and 0.044.

The instantaneous rates of population change for *D. schodleri* ranged from -0.080 on July 26, 1972, to +0.077 on July 5, 1972 (Table 8). Mean population change rates during winter, spring, summer and fall, respectively, were +0.002, +0.004, -0.016 and -0.005. Positive "r" values indicative of an increasing population were generally characteristic of *D. schodleri* from December 1971 through July 1972 (Figure 13b). Negative population change rates characteristic of declining populations were prevalent from mid July through late September. By early October the *D. schodleri* population had recovered and was characterized by a positive population change rate. Wright (1965) found population change rates ranging from -0.21 to +0.15 at Canyon Ferry Reservoir.

Relationships Among Physical, Chemical and Biological Parameters

Statistical analyses were used to quantitatively evaluate relationships among fifteen variables listed in Appendix Table 23. Simple correlation coefficients between the variables are given in Appendix Table 24. Significant multiple linear regression analyses are shown in Appendix Table 25.

A total of sixty-three multiple linear regressions were performed using various combinations of independent variables in an attempt to describe or explain eleven different dependent variables. Seventeen which were most plausible and/or most significant based on F-tests were selected for presentation in this report. To facilitate interpretation the multiple linear regression analyses were classified into "descriptive" and "explainative" types. A "descriptive" analysis includes independent variables which are correlated with the dependent variable by cause and effect, interaction, reaction to an extraneous variable and/or coincidence. "Explainative" models include only cause and effect and/or interactive variables. Thus the "explainative" models include only independent variables which have a plausible direct or indirect influence upon the dependent variable based on results of other studies. The "descriptive" models include additional significantly correlated but non influential variables whose levels, if known, will aid in predicting the level of the dependent variable.

Simple correlation revealed a significant positive relationship between water temperature and total phytoplankton standing crop. With regard to the four major phytoplankton genera, water temperature was positively correlated with the standing crops of *Aphanizomenon* and *Cryptomonas*, negatively correlated with the standing crop of *Asterionella*, and not significantly correlated with the standing crop of *Rhodomonas*. Water temperature was not significantly correlated with any zooplankton standing crop measurement (*Daphnia*, *Cyclops*, and/or total zooplankton standing crop), but significant negative correlations existed between water temperature and the instantaneous birth and death rates of *Daphnia*. *Aphanizomenon* standing crop was negatively correlated with all zooplankton standing crop measurements. Chlorophyll a concentration was negatively correlated with the instantaneous death rate of *Daphnia* and positively correlated with its population change rate.

The multiple linear regression analysis of the variables affecting chlorophyll a concentration is not presented because of the low R^2 value (0.09) obtained. This is explainable by the exclusion of one or several influential, but unmeasured, variables, such as light intensity, from the regression. This also accounts for the relatively low R^2 values obtained by regression on all phytoplankton measurements (total standing crop and standing crops of the four major phytoplankton genera). R^2, the square of the multiple correlation coefficient, is the proportion of the variation of the dependent variable measurements removed by the multiple regression.

The multiple linear regression equation best "explaining" the observed variation in phytoplankton standing crop is:

$$P = 2.383 + 0.116W + 1.937Po \qquad R^2 = 0.34 \qquad (1)$$

where P = phytoplankton standing crop ($mm^3/1$)
W = water temperature (Centigrade degrees)
Po = orthophosphate concentration (ppm)

Water temperature was the most significant measured "explainative" variable affecting phytoplankton standing crop ($r = 0.53$, $P = .01$). The partial correlation coefficient, r, is the correlation between the dependent variable and the named independent variable when the other independent variables are held constant. P is its level of significance. Orthophosphate concentration was insignificant ($r = 0.13$, $P = .31$). Removing orthophosphate concentration from the regression equation decreased the R^2 value to 0.33. Wright and Soltero (1973) found that the most significant variables explaining the observed variation in phytoplankton standing crop in Bighorn Lake were, in decreasing order of significance, solar radiation, euphotic zone depth, and ammonia nitrogen.

"Descriptive" and "explainative" regression analyses for the four major phytoplankton genera are included in Appendix Table 25. The "explainative" regression models reveal that water temperature was the only significant measured variable affecting the standing crops of *Asterionella*, *Aphanizomenon*, and *Rhodomonas*. Both water temperature and orthophosphate concentration had a significant influence upon the standing crop of *Cryptomonas*.

The best "descriptive" model for zooplankton standing crop is:

$$Z = -13.46 + 2.376W - 0.649C - 7.767P + 31.70As + 17.36Cr + 41.95Rh \qquad R^2 = 0.86 \qquad (2)$$

where Z = zooplankton standing crop (organisms/1)
W = water temperature (Centigrade degrees)
C = chlorophyll a concentration (ug/1)
P = phytoplankton standing crop ($mm^3/1$)
As = *Asterionella* standing crop ($mm^3/1$)
Cr = *Cryptomonas* standing crop ($mm^3/1$)
Rh = *Rhodomonas* standing crop ($mm^3/1$)

The most important variables, in decreasing order of significance, were water temperature ($r = 0.81$, $P < .005$), *Asterionella* standing crop ($r = 0.78$, $P < .005$), phytoplankton standing crop ($r = -0.69$, $P = .01$), *Rhodomonas* standing crop ($r = 0.61$, $P = .02$), *Cryptomonas* standing crop ($r = 0.55$, $P = .04$), and chlorophyll a concentration ($r = -0.36$, $P = .14$). Removal of chlorophyll a concentration from the regression reduced the R^2 value to 0.83.

The best "explainative" model for zooplankton standing crop is:

$$Z = -37.08 + 2.479W + 41.17As + 9.690Cr \qquad R^2 = 0.63 \qquad (3)$$

where Z = zooplankton standing crop (organisms/1)
W = water temperature (Centigrade degrees)
As = *Asterionella* standing crop ($mm^3/1$)
Cr = *Cryptomonas* standing crop ($mm^3/1$)

The most important variables, in decreasing order of significance, were *Asterionella* standing crop ($r = 0.77$, $P < .005$), water temperature ($r = 0.71$, $P < .005$) and *Cryptomonas* standing crop ($r = 0.25$, $P = .18$). Removal of *Cryptomonas* standing crop from the regression reduced the

R^2 value to 0.60.

The best "descriptive" model for *Daphnia* standing crop is:

$$D = 4.910 + 1.121W - 6.184P + 10.76As + 11.41Cr + 20.59Rh \qquad R^2 = 0.75 \qquad (4)$$

where D = *Daphnia* standing crop (organisms/1)
W = water temperature (Centigrade degrees)
P = phytoplankton standing crop ($mm^3/1$)
As = *Asterionella* standing crop ($mm^3/1$)
Cr = *Cryptomonas* standing crop ($mm^3/1$)
Rh = *Rhodomonas* standing crop ($mm^3/1$)

The most important variables, in decreasing order of significance, were phytoplankton standing crop ($r = -0.74$, $P < .005$), water temperature ($r = 0.67$, $P = .01$), *Cryptomonas* standing crop ($r = 0.52$, $P = .04$), *Asterionella* standing crop ($r = 0.51$, $P = .04$) and *Rhodomonas* standing crop ($r = 0.45$, $P = .07$). Removal of *Rhodomonas* standing crop from the regression reduced the R^2 value to 0.69.

The best "explainative" model for *Daphnia* standing crop is:

$$D = -15.22 + 1.233W + 19.49As + 4.686Cr \qquad R^2 = 0.45 \qquad (5)$$

where D = *Daphnia* standing crop (organisms/1)
W = water temperature (Centigrade degrees)
As = *Asterionella* standing crop ($mm^3/1$)
Cr = *Cryptomonas* standing crop ($mm^3/1$)

The most important variables, in decreasing order of significance, were *Asterionella* standing crop ($r = 0.63$, $P = .01$), water temperature ($r = 0.58$, $P = .02$) and *Cryptomonas* standing crop ($r = 0.18$, $P = .27$). Removal of *Cryptomonas* standing crop from the regression reduced the R^2 value to 0.43.

"Descriptive" and "explainative" regression analyses for *Daphnia* population dynamics parameters are included in Appendix Table 25. An "explainative" regression model reveals that water temperature was the only significant measured variable influencing the instantaneous birth rate. Chlorophyll a concentration was the only significant measured variable affecting the instantaneous death and population change rates.

DISCUSSION

Above normal runoff and discharge rates during the study period led to a relatively high rate of water flow through the reservoir. This effectively reduced the average retention time of a given segment of water.

The low turbidity readings encountered may be explained partly by the down reservoir location of the sampling station. The increased annual turbidity in 1972 may be attributable to reduced and therefore more "concentrated" inflow compared to 1971. Smith (1973) believes that turbidity in the Beaverhead River below Clark Canyon Dam is decreased somewhat by the presence of Clark Canyon Reservoir.

Thermocline depth fluctuations in Clark Canyon Reservoir were greater than those normally encountered in lakes and reservoirs. This was probably due largely to the reservoir's unprotected, "windswept" location and its relatively small surface area. Vertical eddys caused by the bottom zone withdrawal and above normal turnover rates may also have been influential.

Heat storage during summer due to deep water withdrawal probably has a significant effect on the taxonomic composition of the phytoplankton community of Clark Canyon Reservoir. Studies conducted on Hebgen Lake (Martin, 1967) and Quake Lake (Arneson, 1969) which have bottom and surface water withdrawal, respectively, demonstrate the effect of stored heat on phytoplankton. These lakes are located only three miles apart on the upper Madison River drainage in Montana, but the higher surface temperature in Hebgen Lake caused by deep zone withdrawal, was considered the primary causitive agent effecting a late summer blue-green algae "bloom". A diatom- flagellate phytoplankton community was associated with the lower epilimnion temperatures in Quake Lake. If Clark Canyon Reservoir had surface water withdrawal, the resultant cooler epilimnion temperature might retard or entirely inhibit the now characteristic late summer- early fall *Aphanizomenon* "blooms".

Numerous investigators have reported additional limnological effects of dams with deep water withdrawal. Wright (1967), Martin (1967) and Wright and Soltero (1973) believe that the discharge of nutrient rich bottom water may effect downstream eutrophication while at the same time depleting the reservoir system of essential nutrients. My data suggest that the reservoir system was not fully depleted of essential nutrients by the deep water withdrawal. Other studies have shown that the downstream BOD could not be satisfied due to the release of deep water with a low DO content. DO near the bottom of Clark Canyon Reservoir was below 4 ppm from late June through early September during my study, but Smith (1973) found DO concentrations above saturation in the Beaverhead River immediately below Clark Canyon Dam due to the "hydrolic ram" type outlet works. Marcoux (1969) reported fish kills in a two mile section of the Beaverhead River immediately below Clark Canyon Dam due to the release of hydrogen sulfide laden hypolimnial water. Subsequent analyses conducted during the present study and by Peterson (1971) and Smith (1973) revealed that hydrogen sulfide was not present in measurable quantities in the reservoir's epilimnion or in the Beaverhead River below Clark Canyon Dam. Apparently the conditions conducive to the formation of hydrogen sulfide existed only in the early history of the reservoir, probably in response to newly decomposed organic matter.

A beneficial effect of deep water withdrawal, which alone may outweigh all the detrimental effects, is the maintenance of water temperatures in the Beaverhead River below Clark Canyon Dam during summer which are suitable for coldwater biota. Surface water withdrawal could raise the downstream temperature during summer to levels above those found before impoundment. Trout populations could be depressed and rough fish encouraged by the resultant warmer temperature. A second beneficial effect of deep water withdrawal relates to the plausible use of zooplankton, especially *D. schodleri*, as food by small fish in the Beaverhead River immediately below Clark Canyon Dam (Smith, 1973).

Euphotic zone depths could not be correlated with phytoplankton standing crops in Clark Canyon Reservoir because the phytoplankton samples were taken from a "fixed" euphotic zone. Some studies have described an inverse correlation between phytoplankton density and light penetration due to self shading. Wright and Soltero (1973) believed that *Aphanizomenon* in Bighorn Lake may have limited the growth of other algae due to its characteristic water bloom and shading effect. Conversely, Martin (1967) and Arneson (1969) found no correlation between extinction coefficients of light and phytoplankton standing crop measurements in Hebgen Lake and Quake Lake, respectively.

Plant nutrient reduction in the euphotic zone of the reservoir following vernal and autumnal overturn may be attributable to uptake by phytoplankton and transfer to the deep water zone by sinking of plankton. Epilimnion orthophosphate and nitrogen regeneration by zooplankton probably prevented full depletion by phytoplankton of their nutrients.

There are several plausible operative factors leading to seasonal changes in the taxonomic composition of the phytoplankton community in Clark Canyon Reservoir. Temperature has been reported as the primary causitive agent in phytoplankton "succession" by Martin (1967) and Wright and Soltero (1973). Different species predominate at different times because of the interaction between prevailing temperature and other environmental factors. The Myxophycean "blooms" in Clark Canyon Reservoir provided the clearest example of temperature's effect on phytoplankton "succession". *Anabaena* did not appear in the reservoir until the euphotic zone temperature reached 15.5 to 15.9° C. *Aphanizomenon* was not encountered until the temperature rose to 17.4 to 17.8° C. Wright and Soltero (1973) observed *Aphanizomenon* development in Bighorn Lake when water temperatures were about 18° C, with blooms appearing shortly thereafter. Algal "succession" may also be effected by seasonal variability in the concentrations of single inorganic nutrients and/or combinations of nutrients. The highest annual diatom standing crops in Clark Canyon Reservoir were observed during the spring season. Martin (1967) explains that the main occurrence of diatoms usually coincides with the higher levels of inorganic nutrients present in spring. Blue-green algae were encountered in Clark Canyon Reservoir from mid June through early October. This time period coincides with the lowest annual nitrate nitrogen levels and the peak annual phosphate/nitrate ratios. Hutchinson (1957) says that the position of blue-green algae in the "successional" pattern is usually accompanied by low levels of nitrate nitrogen and/or high phosphate/nitrate ratios. Other factors in algal "succession" which were beyond the scope of this study include organic chemical environment, the production of growth inhibiting substances and the concentrations of "trace" elements.

The poor correlation between euphotic zone chlorophyll a concentration and phytoplankton standing crop is explainable largely by seasonal variation in the taxonomic composition of the algal community. Certain phytoplankton species would attenuate more chlorophyll a per unit volume than others. Heavy cell walls and/or sheaths around certain algae could make chlorophyll extraction more difficult and possibly incomplete.

Numerous investigators have measured phytoplankton standing crops in an attempt to explain observed variation in zooplankton standing crops. At Clark Canyon Reservoir multiple linear regression analyses revealed that *Asterionella*, *Cryptomonas* and *Rhodomonas* standing crops were positively correlated with zooplankton standing crops, suggesting that these three phytoplankters may have been used as food by herbivorous zooplankters. Martin (1967) believed that *Cryptomonas*, *Rhodomonas*, *Asterionella*, *Chlamydomonas*, *Chlorella*, and *Chrysococcus* constituted the most important food species in Hebgen Lake. Wright and Soltero (1973) suggest that organisms such as *Cryptomonas* and *Rhodomonas* and other microplankton may be heavily grazed as food species in Bighorn Lake, but the food value of such organisms as *Aphanizomenon* which comprise the bulk of the phytoplankton standing crop in late summer and early fall was questionable. Hall (1964) says, "filamentous green or blue-green algae may be abundant but are considered unavailable as food for the zooplankton, resulting in low zooplankton densities." Data collected at Clark Canyon Reservoir lend support to this contention because low zooplankton standing crops were encountered during the blue-green algae "blooms".

"Explainative" multiple linear regression analyses revealed that water temperature and chlorophyll a concentration were the only significant measured variables influencing the population dynamics of

Daphnia schodleri in Clark Canyon Reservoir. Hall (1964) indicated that food and temperature strongly influenced the instantaneous population change rate of *Daphnia galeata mendotae* in Base Line Lake, Michigan. He concluded that other variables either tended to remain relatively constant in the zone of the lakes inhabited by *Daphnia* or seemed to be of little importance. Because of the low R^2 values obtained in my regression analyses, it is believed that food and temperature alone do not regulate the population dynamics and subsequent standing crops of *Daphnia schodleri* in Clark Canyon Reservoir. Other significant, but unmeasured, variables such as predation by fish must be influential.

APPENDIX

Table 9. Turbidity (Jackson Turbidity Units) of Clark Canyon Reservoir during 1971 and 1972.

Date	Depth (meters)						
	0	5	10	15	20	Bottom	0-8
7/7/71	1	1	2	2	3	3	1
7/14	1	2	2	1	2	3	2
7/21	2	2	2	2	2	3	2
8/18	2	3	4	4	4	5	2
9/15	2	2	2	1	2	2	2
10/9	0	0	0	0	0	0	0
12/15	0	0	0	1	0	2	0
1/8/72	1	0	1	1	1	2	1
2/5	1	1	1	1	1	1	1
4/21	7	7	8	5	8	8	7
4/28	7	7	7	4	8	8	7
5/12	6	7	5	3	8	10	6
5/20	6	5	5	4	7	9	6
6/15	6	4	2	2	3	6	6
7/5	5	5	5	5	9	10	5
7/15	3	4	3	2	4	6	3
7/26	5	5	4	3	5	6	5
8/6	8	7	6	5	7	8	7
8/19	6	5	4	3	4	5	5
8/26	1	2	2	3	4	4	2
9/10	2	3	3	4	4	4	3
9/23	6	6	6	6	8	8	6
10/8	4	3	3	2	3	5	3
10/21	2	2	2	1	1	2	2
11/4	2	2	2	2	2	2	2

Table 10. Temperature (Centigrade degrees) of Clark Canyon Reservoir during 1971 and 1972.

Meters Depth	6-23 -71	6/29	7/7	7/14	7/21	7/28	8/18	9/1	9/15	10/9	12/15	1-8 -72	2/5	4/21	4/28	5/12	5/20	6/15	7/5	7/15	7/26	8/6	8/19	8/26	9/10	9/23	10/8	10/21	11/4
0	18.6	14.2	15.9	15.9	18.8	17.8	19.0	17.5	14.8	9.0	0.0	0.0	0.0	5.4	5.9	7.8	10.6	15.9	17.8	18.0	19.1	17.8	18.2	16.6	15.2	12.2	9.3	8.2	2.9
1	18.3	14.2	15.9	15.8	18.8	17.8	19.0	17.5	14.8	9.0	0.4	0.4	0.2	5.4	5.9	7.8	10.6	15.9	17.8	17.7	17.7	17.8	18.1	16.6	15.2	12.2	9.2	8.2	2.9
2	18.1	14.1	15.9	15.8	18.8	17.5	19.0	17.5	14.8	9.0	0.6	0.7	0.9	5.3	5.9	7.8	10.6	15.9	17.8	17.4	17.3	17.8	18.0	16.6	15.2	12.2	9.2	8.2	2.9
3	18.0	14.1	15.9	15.8	18.8	16.9	19.0	17.5	14.8	9.0	0.8	0.8	1.0	5.2	5.8	7.7	10.5	15.9	17.7	17.3	17.2	17.7	17.9	16.6	15.2	12.2	9.2	8.2	2.9
4	17.8	14.1	15.9	15.7	18.8	16.3	19.0	17.5	14.8	9.0	0.9	0.9	1.1	5.1	5.6	7.7	10.5	15.8	17.6	17.2	17.1	17.6	17.9	16.6	15.2	12.2	9.2	8.2	2.9
5	17.2	14.1	15.9	15.6	18.8	15.5	19.0	17.5	14.8	9.0	1.0	1.0	1.2	5.0	5.5	7.7	10.5	15.8	17.5	17.2	16.9	17.5	17.9	16.6	15.2	12.2	9.2	8.2	2.9
6	17.0	14.1	15.8	15.6	18.7	15.1	19.0	17.5	14.8	9.0	1.0	1.0	1.2	5.0	5.4	7.6	10.4	15.7	17.5	17.2	16.8	17.4	17.9	16.6	15.2	12.2	9.2	8.2	2.9
7	16.8	14.1	15.8	15.5	18.2	15.0	19.0	17.5	14.8	9.0	1.1	1.1	1.2	5.0	5.3	7.5	10.4	15.6	17.4	17.2	16.7	17.3	17.9	16.6	15.2	12.2	9.2	8.2	2.9
8	15.8	14.1	15.7	15.3	17.0	15.0	18.6	17.5	14.8	9.0	1.1	1.1	1.2	5.0	5.2	7.3	10.3	15.5	17.4	17.2	16.6	17.3	17.9	16.6	15.2	12.2	9.2	8.2	2.9
9	14.3	14.1	15.3	15.3	15.9	15.0	18.2	17.5	14.8	9.0	1.1	1.1	1.2	5.0	5.2	7.1	10.3	15.5	17.4	17.2	16.5	17.3	17.8	16.6	15.2	12.2	9.2	8.2	2.9
10	13.8	14.1	15.1	15.2	15.5	14.9	17.7	17.5	14.8	9.0	1.1	1.1	1.3	4.9	5.2	7.0	10.3	15.1	17.3	17.2	16.4	17.2	17.4	16.6	15.1	12.2	9.1	8.2	2.9
11	13.6	14.1	14.9	15.2	15.2	14.9	17.4	17.5	14.8	9.0	1.2	1.2	1.3	4.9	5.2	7.0	10.2	14.8	17.3	17.2	16.3	17.2	17.2	16.6	15.1	12.2	9.1	8.2	2.9
12	13.5	14.1	14.7	15.1	15.1	14.8	17.1	17.5	14.8	9.0	1.2	1.2	1.4	4.9	5.2	7.0	10.0	14.1	17.3	17.2	16.0	17.2	17.2	16.6	15.1	12.2	9.1	8.2	2.9
13	13.3	14.1	14.6	15.0	15.0	14.8	17.0	17.5	14.8	8.8	1.2	1.2	1.6	4.9	5.2	6.9	9.8	13.8	17.3	17.1	15.5	17.2	17.2	16.6	15.1	12.2	9.0	8.1	2.9
14	13.0	13.9	14.2	14.8	15.0	14.8	16.9	17.5	14.8	8.6	1.3	1.3	1.8	4.9	5.2	6.9	9.6	12.0	17.3	17.0	15.3	17.2	17.2	16.6	15.0	12.2	9.0	8.1	2.9
15	12.8	13.7	14.0	14.4	15.0	14.8	16.8	17.3	14.8	8.5	1.4	1.4	1.9	4.9	5.2	6.9	9.5	11.3	17.3	16.6	15.1	17.2	17.2	16.5	15.0	12.2	8.9	8.1	3.0
16	12.8	13.1	14.0	14.4	14.9	14.8	16.6	17.2	14.8	8.3	1.5	1.5	1.9	4.9	5.2	6.9	9.4	11.0	17.2	15.8	15.0	17.1	17.2	16.5	14.9	12.1	8.9	8.1	3.0
17	12.4	12.9	13.9	14.3	14.8	14.8	16.4	17.2	14.8	8.2	1.6	1.6	1.9	4.8	5.2	6.8	9.3	11.0	17.2	15.5	15.0	16.9	17.1	16.3	14.9	12.1	8.9	8.1	3.0
18	12.4	12.8	13.9	14.2	14.8	14.5	16.2	17.2	14.6	8.1	1.7	1.7	1.9	4.8	5.2	6.8	9.2	10.8	17.2	15.2	14.9	16.2	17.0	16.2	14.8	12.1	8.9	8.1	3.0
19	12.2	12.6	13.8	14.2	14.8	14.5	16.1	17.1	14.6	8.0	1.7	1.8	1.9	4.8	5.2	6.8	9.1	10.5	17.1	15.0	14.9	16.0	16.9	15.9	14.8	12.1	8.8	8.1	3.0
20	12.1	12.4	13.6	14.1	14.7	14.5	16.0	17.1	14.5	8.0	1.8	1.8	2.0	4.8	5.2	6.8	9.0	10.3	17.0	14.8	14.8	15.9	16.8	15.4	14.8	12.1	8.8	8.1	3.0
21	12.0	12.2	13.2	14.0	14.7	14.5	15.8	17.0	14.5	7.9	1.9	1.9	2.0	4.8	5.2	6.8	8.9	10.1	16.7	14.7	14.8	15.8	16.7	15.2	14.8	12.1	8.8	8.1	3.0
22	11.9	12.1	12.9	13.9	14.7	14.4	15.8	16.5	14.5	7.8	1.9	1.9	2.1	4.8	5.2	6.8	8.7	10.0	15.6	14.6	14.7	15.7	16.6	15.2	14.7	12.1	8.8	8.1	3.0
23	11.7	11.7	12.8	13.8	14.6	14.4	15.5	16.2	14.5	7.8	1.9	1.9	2.1	4.8	5.2	6.8	8.6	10.0	14.4	14.5	14.7	15.6	16.4	15.2	14.2	12.1	8.8	8.1	3.0
24	11.4	11.4	12.5	13.6	14.3	14.3	15.5	16.0	14.5	7.8	2.0	1.9	2.2	4.8	5.2	6.8	8.4	9.9	13.3	14.5	14.6	15.5	16.2	15.1	14.2	12.1	8.7	8.1	3.0
25	11.1	11.3	12.2	13.4	14.1	14.2		16.0					2.2	4.8	5.2	6.8			12.8	14.5	14.5	15.3					8.7	8.1	
26	11.0	11.2	12.1	13.0	13.9	14.2													12.2										
27	11.0	11.2	12.0	12.5	13.6	14.1																							
28			12.0																										

Table 11. Conductivity (umhos @ 25° C) of Clark Canyon Reservoir during 1971 and 1972.

	Depth (meters)							
Date	0	5	10	15	20	Bottom	0-8	Mean
7/7/71	423	423	420	420	442	450	422	429.7
7/14	423	422	422	432	430	450	422	429.8
7/21	438	438	445	450	483	475	440	456.5
8/18	450	445	460	468	468	475	450	461.0
9/15	440	440	450	450	455	460	440	449.2
10/9	495	495	475	495	480	500	495	490.0
12/15	515	500	515	515	520	520	515	513.3
1/8/72	525	525	510	525	525	530	525	523.3
2/5	525	535	545	560	575	580	530	553.3
4/21	520	515	515	515	515	520	515	516.7
4/28	525	520	520	520	520	525	520	521.7
5/12	540	540	535	535	535	540	540	537.5
5/20	515	515	515	515	515	515	515	515.0
6/15	450	470	495	530	530	570	470	507.5
7/5	560	560	560	560	555	545	560	556.7
7/15	560	560	560	560	545	540	560	554.2
7/26	550	550	550	550	545	540	550	547.5
8/6	535	540	540	540	535	535	540	537.5
8/19	530	535	535	535	535	545	535	535.8
8/26	560	580	580	590	600	610	575	586.7
9/10	620	635	640	645	645	650	630	639.2
9/23	600	610	615	615	615	620	610	612.5
10/8	620	630	635	635	635	640	630	632.5
11/4	600	610	615	615	620	620	610	613.3
Mean	521.6	525.3	526.5	532.7	534.1	539.8		

Table 12. Dissolved oxygen (ppm) in Clark Canyon Reservoir during 1971 and 1972.

Date	Depth (meters)					
	0	5	10	15	20	Bottom
6/29/71	6.64	6.58	6.32	6.01	5.02	2.54
7/7	6.74	6.66	6.20	5.60	4.58	1.60
7/14	6.46	6.40	6.22	5.48	4.58	1.30
7/21	7.04	6.72	6.16	5.16	4.20	1.22
7/28	7.48	7.22	5.04	3.76	2.60	1.02
8/18	8.34	7.80	3.64	2.36	1.09	0.20
9/15	7.40	7.38	7.36	7.18	6.58	5.20
12/15	10.18	10.07	8.52	8.40	7.60	6.00
1/8/72	10.05	9.90	8.20	8.02	7.18	5.12
2/5	10.02	8.52	7.98	7.22	6.84	3.98
4/21	10.80	10.87	10.72	10.84	11.00	11.08
4/28	10.42	10.40	10.40	10.36	10.22	10.12
5/12	9.10	9.04	9.04	9.02	8.98	8.68
5/20	8.50	8.24	8.10	8.00	7.84	6.78
6/15	7.56	7.46	7.00	6.04	5.62	4.40
7/5	9.22	7.84	7.10	6.46	3.04	2.20
7/15	6.98	6.60	6.58	6.24	3.06	2.04
7/26	7.20	6.58	5.76	5.32	2.92	2.00
8/6	6.90	6.52	5.51	5.23	2.13	1.08
8/19	7.16	6.98	5.44	5.18	2.58	0.80
8/26	6.96	6.80	5.60	4.24	2.10	0.41
9/10	6.81	6.59	6.05	5.03	3.72	0.36
9/23	8.60	8.58	8.56	8.36	8.22	8.16
10/8	6.84	6.84	6.84	8.04	8.02	8.02
10/21	8.40	8.36	8.34	8.18	8.04	8.02
11/4	10.78	10.78	10.74	10.72	10.68	10.66

Table 13. pH in Clark Canyon Reservoir during 1971 and 1972.

Date	Depth (meters) 0	5	10	15	20	Bottom	0-8	Mean
6/29/71	8.26	8.25	8.24	8.19	8.07	8.00	8.25	8.17
7/7	8.30	8.26	8.24	8.24	8.10	8.02	8.28	8.19
7/14	8.26	8.20	8.20	8.20	8.12	7.90	8.22	8.15
7/21	8.21	8.20	8.20	8.19	8.12	7.91	8.20	8.14
8/18	8.23	8.18	8.12	7.96	8.00	7.80	8.19	8.05
9/15	8.56	8.59	8.60	8.63	8.51	8.48	8.60	8.56
10/9	8.44	8.41	8.40	8.37	8.31	8.29	8.39	8.37
12/15	8.33	8.32	8.32	8.30	8.20	7.92	8.32	8.23
1/8/72	8.30	8.28	8.27	8.24	8.16	7.90	8.30	8.19
2/5	8.23	8.14	8.08	8.04	8.00	7.81	8.21	8.05
4/21	8.36	8.34	8.38	8.36	8.38	8.38	8.35	8.37
4/28	8.28	8.30	8.32	8.32	8.32	8.33	8.30	8.31
5/12	8.19	8.24	8.26	8.26	8.26	8.26	8.24	8.25
5/20	8.26	8.28	8.29	8.30	8.31	8.15	8.28	8.27
6/15	8.20	8.20	8.18	8.12	8.10	8.04	8.20	8.14
7/5	8.38	8.30	8.30	8.14	7.91	7.81	8.35	8.14
7/15	8.20	8.20	8.22	8.20	7.94	7.86	8.22	8.10
7/26	8.30	8.28	8.28	8.22	8.00	7.88	8.28	8.16
8/6	8.34	8.30	8.28	8.24	8.02	7.89	8.31	8.18
8/19	8.31	8.28	8.23	8.19	8.05	7.83	8.28	8.15
8/26	8.29	8.29	8.27	8.26	8.23	8.20	8.27	8.26
9/10	8.44	8.43	8.44	8.38	8.36	8.27	8.44	8.37
9/23	8.38	8.38	8.38	8.36	8.34	8.30	8.38	8.36
10/8	8.30	8.30	8.30	8.32	8.32	8.32	8.30	8.31
10/21	8.40	8.42	8.42	8.42	8.42	8.44	8.42	8.42
11/4	8.29	8.29	8.29	8.29	8.29	8.29	8.29	8.29

Table 15. Total hardness (ppm $CaCO_3$) in Clark Canyon Reservoir during 1971 and 1972.

Date	Depth (meters) 0	5	10	15	20	Bottom	0-8	Mean
6/29/71	195	191	184	186	186	181	190	187
7/7	191	186	174	168	165	160	187	174
7/14	186	180	172	168	168	176	181	175
7/21	183	178	176	184	174	168	177	177
8/18	167	165	169	174	171	170	167	169
9/15	208	209	208	208	206	204	209	207
10/9	183	185	188	180	174	161	188	179
12/15	190	189	188	183	181	170	188	184
1/8/72	194	190	185	184	181	166	190	183
2/5	204	200	196	184	178	181	196	191
4/21	168	177	189	182	181	157	175	176
4/28	180	180	188	183	183	165	179	180
5/12	194	187	185	186	185	173	188	185
5/20	179	178	166	175	174	161	172	172
6/15	160	157	163	164	162	158	158	161
7/5	192	186	190	191	192	192	189	191
7/15	212	206	207	208	212	212	208	210
7/26	215	211	213	213	216	218	213	214
8/6	217	216	217	217	220	222	217	218
8/19	220	220	221	221	222	223	221	221
8/26	224	224	223	224	225	228	223	225
9/10	226	225	225	227	227	229	226	227
9/23	230	230	230	230	230	230	230	230
10/8	226	218	210	205	196	182	219	206
10/21	228	221	220	218	210	203	222	217
11/4	226	222	218	218	212	200	222	216

Table 16. Orthophosphate (ppm $PO_4^{\equiv}$) in Clark Canyon Reservoir during 1971 and 1972.

Date	Depth (meters) 0	5	10	15	20	Bottom	0-8
8/18/71	.36	.32	.16	.14	.09	.09	.29
9/15	.08	.08	.07	.07	.07	.07	.07
1/18/72	.02	.03	.03	.04	.05	.12	.03
2/5	.01	.02	.02	.03	.04	.10	.02
4/21	.06	.06	.07	.07	.07	.07	.06
4/28	.06	.06	.06	.06	.06	.06	.06
5/12	.04	.04	.04	.04	.05	.06	.04
5/20	.03	.03	.03	.04	.04	.08	.03
6/15	.06	.07	.05	.07	.10	.12	.16
7/5	.08	.04	.05	.09	.20	.32	.07
7/15	.03	.04	.03	.09	.15	.23	.04
7/26	.10	.11	.12	.12	.16	.24	.10
8/6	.00	.06	.07	.10	.12	.19	.05
8/19	.02	.06	.04	.06	.09	.18	.04
8/26	.54	.33	.17	.13	.09	.12	.35
9/10	.05	.04	.04	.05	.04	.07	.05
9/23	.12	.11	.11	.11	.12	.14	.11
10/8	.11	.11	.11	.11	.11	.11	.11
10/21	.06	.06	.06	.07	.07	.06	.06
11/4	.03	.03	.03	.03	.03	.03	.03

Table 17. Nitrate (ppm NO_3-N) in Clark Canyon Reservoir during 1971 and 1972.

Date	Depth (meters)						
	0	5	10	15	20	Bottom	0-8
10/9/71	.03	.04	.05	.05	.04	.04	.03
1/8/72	.21	.23	.25	.25	.32	.36	.24
2/5	.15	.17	.20	.20	.20	.23	.15
4/21	.03	.03	.03	.03	.03	.03	.03
4/28	.03	.03	.03	.03	.03	.03	.03
5/12	Trace	.01	.01	.01	.01	.03	.01
5/20	.01	.03	.02	.03	.01	.01	.02
6/15	Trace	.01	.01	.01	.02	.02	Trace
7/5	.01	.01	.01	.01	.09	.06	.01
7/15	.01	.01	.01	.01	.07	.09	.01
7/26	.01	.01	.02	.02	.08	.09	.01
8.6	Trace	Trace	Trace	Trace	Trace	.10	Trace
8/26	.01	.02	.04	.04	.03	.01	.01
9/10	.01	.01	.01	.01	.03	.00	.01
9/23	.02	.01	.00	Trace	.01	Trace	.01
10/8	.00	Trace	.01	.02	.03	.01	Trace
10/21	.01	.01	.03	.03	.02	.01	.01
11/4	.01	.02	.04	.04	.02	.01	.01

Table 18. Nitrite (ppm NO_2^--N) in Clark Canyon Reservoir during 1971 and 1972.

Date	Depth (meters) 0	5	10	15	20	Bottom	0-8
10/9/71	.001	.001	.001	.001	.001	.003	.001
1/8/72	.006	.006	.006	.006	.006	.006	.005
2/5	.005	.005	.005	.005	.005	.005	.005
4/21	0	0	0	0	0	0	0
4/28	0	0	0	0	0	0	0
5/12	.001	.001	.001	.001	.001	.001	.001
5/20	.001	.001	.001	.001	.001	.001	.001
6/15	0	0	.001	.002	.003	.005	0
7/5	.001	.003	.004	.005	.013	.018	.003
7/15	0	.002	.001	.003	.014	.019	.002
7/26	.005	.005	.006	.007	.013	.015	.005
8/6	.005	.005	.006	.007	.016	.020	.005
8/26	.008	.008	.010	.010	.010	.011	.008
9/10	.005	.003	.001	.001	.003	.003	.003
9/23	.001	Trace	0	0	0	.001	Trace
10/8	0	0	0	0	0	0	0
10/21	0	0	0	0	0	0	0
11/4	0	0	0	0	0	0	0

Table 19. Ammonia (ppm NH_3-N) in Clark Canyon Reservoir during 1972.

Date	Depth (meters) 0	5	10	15	20	Bottom	0-8
4/21/72	0	Trace	Trace	0	Trace	.01	0
4/28	Trace	Trace	Trace	.01	.02	.03	Trace
5/12	.01	.01	.01	.02	.03	.10	.01
5/20	.03	.02	.02	.03	.03	.26	.02
6/15	.01	.02	.04	.07	.08	.21	.03
7/5	.03	.01	Trace	.05	.21	.56	.01
7/15	.05	.05	.05	.04	.21	.31	.06
7/26	.05	.06	.07	.09	.26	.38	.06
8/6	Trace	.03	.07	.11	.27	.38	.03
8/19	0	0	Trace	.02	.03	.03	Trace
8/26	.01	.02	.02	.03	.04	.13	.02
9/10	0	0	Trace	.01	.01	.02	0
9/23	.01	.01	.01	.02	.03	.04	.01
10/8	.23	.23	.20	.12	.06	.05	.22
10/21	.17	.17	.18	.18	.21	.20	.17
11/4	.05	.05	.06	.06	.08	.08	.05

Table 20. Phycoplankton standing crop (mm^3/l) in Clark Canyon Reservoir during 1971 and 1972.

Date	*Ankistrodesmus falcatus*	*Chlamydomonas* spp.	*Chlorella* spp.	*Coenocystis* spp.	*Pandorina morum*	*Pediastrum* spp.	*Scenedesmus* spp.	*Schroederia* spp.	*Staurastrum* spp.	Total Chlorophyceae	*Asterionella* spp.	*Cocconeis* spp.	*Cyclotella* spp.
12/15/71	0	0.13	0.08	0	0	0.03	0.01	0	0	0.25	1.02	0.26	0
1/8/72	0	0.10	0.04	0	0	0.10	0.02	0	0	0.26	1.14	0.27	0
2/5	0	0.14	0.16	0	0	0	Trace	0	0	0.30	1.00	0.24	0
Winter Mean	0	0.123	0.093	0	0	0.043	0.012	0	0	0.270	1.053	0.257	0
4/21	0.01	0.35	0.18	0.01	Trace	0	Trace	0	0.11	0.66	1.46	0.07	0.20
4/28	0.02	0.28	0.20	0.01	Trace	0	0	0	0.16	0.67	1.36	0.09	0.08
5/17	0.07	0.13	0.02	0	Trace	0	Trace	0	0.20	0.37	1.16	0	0.02
5/20	0	0.27	0.02	0.02	Trace	0.06	0	0	0.15	0.32	0.56	0	0
Spring Mean	0.011	0.258	0.105	0.010	Trace	0.015	Trace	0	0.155	0.355	1.105	0.040	0.075
6/15	0.01	0.09	0.01	0	0.01	0	0	0.16	0	0.28	0.69	0.07	0
7/5	0	0.01	0.01	0.02	0	0	0	0.02	0	0.06	0.69	0.10	0
7/15	0.01	0.02	0.02	0.01	Trace	0	0	0.04	0	0.10	0.71	0	0
7/26	0.01	0.01	0.03	0.01	0	0	0	0.08	0	0.14	0.52	0	0
8/6	0.01	0.04	0.02	0	0.01	0.03	Trace	0.05	0.17	0.33	0.61	0	0
8/19	0	0.03	0.01	0	0	0.11	0	0.06	0.32	0.35	0.29	0	0
8/26	0	0.02	0.01	0.01	0	0	0	0.15	0	0.19	0.09	0.09	0
Summer Mean	0.006	0.031	0.016	0.007	Trace	0.023	Trace	0.080	0.070	0.236	0.443	0.037	0
9/10	0.02	0.06	0.03	0.02	Trace	0	Trace	0.04	0	0.15	0.17	0	0
9/23	0	0.01	0.02	0	Trace	0	0	0	0.36	0.39	0.20	0	0
10/8	0.01	0.04	0.01	0.04	0	0.03	0	0.01	0	0.14	0.45	0.03	0.02
10/21	0	0.08	0.01	0.01	Trace	0	0	0	0	0.12	0.19	0	0.03
11/4	0	0.05	0.04	0	Trace	0.03	0	0	0	0.17	0.63	0.04	0.01
Fall Mean	0.006	0.048	0.022	0.014	Trace	0.012	Trace	0.010	0.072	0.184	0.328	0.014	0.012
Annual Mean	0.006	0.115	0.059	0.008	Trace	0.023	0.007	0.023	0.074	0.311	0.732	0.087	0.022

Date	*Cymbella* spp.	*Diatoma* spp.	*Fragilaria* spp.	*Gomphonema* spp.	*Hannaea arcus*	*Melosira* spp.	*Navicula* spp.	*Nitzschia* spp.	*Rhoicosphenia curvata*	*Stephanodiscus* spp.	*Synedra* spp.	*Tabellaria* spp.	Total Bacillariophyceae
12/15/71	0.10	0	0.08	0.05	0.02	0	0.03	0	0	0	0.39	0	1.93
1/8/72	0.11	0	0.16	0.05	0.04	0	0.01	0	0	0	0.10	0.01	1.89
2/5	0.14	0	0.02	0.05	0.01	0	Trace	0.01	0	0	0.39	0	1.86
Winter Mean	0.117	0	0.087	0.050	0.023	0	0.015	Trace	0	0	0.293	Trace	1.900
4/21	0	0.10	0.15	0	0.02	0	0.01	0.02	0	0.06	0.15	0.03	2.27
4/28	0	0.09	0.07	0.03	0	0	0.04	0	0	0.04	0.34	0	2.02
5/17	0	0.38	0.06	0	0	0	0.01	0.04	0.05	0.09	0.39	0	2.20
5/20	0	0.23	0.05	0	0.03	0	0.02	0	0.03	0.16	0.15	0	1.23
Spring Mean	0	0.200	0.083	0.008	0.013	0	0.020	0.015	0.020	0.088	0.258	0.008	1.930
6/15	0	0.48	0.09	0	0.11	0	0.02	0.01	0.01	0	0.05	0	1.33
7/5	0	0.16	0.42	0.08	0	0	0.01	0.01	0	0.02	0	0	1.49
7/15	0	0.68	0.38	0	0.02	0	0.01	0	0	0	0	0.03	1.83
7/26	0	0.30	0.19	0	0.02	0	0.01	0	0	0.01	0	0.05	1.11
8/6	0.06	0.17	0.17	0.06	0	0	0.05	Trace	0	0	0	0.01	0.93
8/19	0	0.02	0.16	0.01	0	0	0.05	0	0	0.10	0	0	0.33
8/26	0	0.02	0.17	0.01	0.03	0	0.01	0	0.07	0.03	0	0.03	0.55
Summer Mean	0.009	0.261	0.226	0.023	0.026	0	0.024	Trace	0.011	0.024	0.007	0.017	1.110
9/10	0	0	0.40	0	0.02	0.08	0.02	0.02	0.05	0.01	0.20	0	0.96
9/23	0.04	0	0.21	0	0.02	0.06	0.01	0	0.05	0.02	0.49	0	1.10
10/8	0.04	0.02	0.25	0	0.03	0.09	0.01	0	0.05	0	0.44	0.02	1.65
10/21	0	0	0.41	0.01	0	0.05	0.01	0	0	0.02	0.44	0.02	1.19
11/4	0	0.03	0.68	0	0.05	0.02	0.02	0	0	0.01	0.54	0.03	2.06
Fall Mean	0.016	0.010	0.390	Trace	0.024	0.060	0.014	Trace	0.030	0.012	0.442	0.014	1.352
Annual Mean	0.036	0.118	0.197	0.022	0.022	0.015	0.018	0.008	0.015	0.031	0.245	0.011	1.573

Date	*Dinobryon* spp.	*Uroglenopsis* spp.	Total Chrysophyceae	*Anabaena* spp.	*Aphanizomenon flos-aquae*	Total Myxophyceae	*Ceratium hirundinella*	Total Dinophyceae	*Cryptomonas* spp.	*Rhodomonas lacustris*	Total Cryptophyceae	Total Phytoplankton
12/15/71	0.03	0	0.03	0	0	0	0	0	0.14	0.28	0.42	2.63
1/8/72	0.02	0	0.02	0	0	0	0	0	0.28	0.22	0.40	2.57
2/5	0.02	0	0.02	0	0	0	0	0	0.35	0.27	0.62	2.80
Winter Mean	0.023	0	0.023	0	0	0	0	0	0.223	0.257	0.480	2.673
4/21	0	0	0	0	0	0	0	0	0.29	0.40	0.69	3.47
4/28	0.01	0	0.01	0	0	0	0	0	0.43	0.18	0.59	3.29
5/17	0	0	0	0	0	0	0	0	0.65	0.16	0.81	3.38
5/20	0.02	0.19	0.21	0	0	0	0	0	0.80	0.32	1.12	3.08
Spring Mean	0.008	0.048	0.055	0	0	0	0	0	0.537	0.265	0.803	3.343
6/15	0.03	0	0.03	0.03	0	0.03	0	0	0.27	0.20	0.47	2.14
7/5	0	0	0	1.24	0.03	1.27	0.46	0.46	0.42	0.31	0.73	4.03
7/15	0	0	0	0.18	0.32	0.30	0	0	0.97	0.46	1.43	3.66
7/26	0	0.13	0.13	0.05	0.39	0.44	0.69	0.69	0.77	0.37	1.14	3.65
8/6	0	0	0	0.03	1.01	1.04	0.57	0.57	0.62	0.69	1.11	3.98
8/19	0	0	0	0.04	2.99	3.03	0.57	0.57	0.92	0.32	1.24	5.92
8/26	0.01	0.19	0.20	0.01	2.48	2.49	0	0	1.40	0.16	1.56	4.89
Summer Mean	0.006	0.046	0.051	0.226	1.003	1.229	0.327	0.327	0.767	0.330	1.097	4.050
9/10	0	0.32	0.32	0	4.04	4.04	0	0	0.68	0.70	1.38	6.85
9/23	0.02	0	0.02	0	2.33	2.33	0.12	0.12	0.49	0.26	0.75	4.71
10/8	0.01	0.19	0.20	0	1.06	1.06	0.46	0.46	0.43	0.32	0.75	4.06
10/21	0	0	0	0	0	0	0.34	0.34	0.42	0.02	0.44	2.09
11/4	0.01	0	0.01	0	0	0	0	0	0.56	0.03	0.59	2.78
Fall Mean	0.008	0.102	0.110	0	1.486	1.486	0.184	0.184	0.516	0.266	0.782	4.098
Annual Mean	0.015	0.049	0.060	0.057	0.622	0.679	0.128	0.128	0.511	0.260	0.791	3.541

Table 21. Chlorophyll *a* concentration (ug/l) and chlorophyll *a*/cell volume ratios in Clark Canyon Reservoir during 1972.

Date	Chlorophyll *a* ug/l	Chlorophyll *a*/ cell volume
1/8/72	3.29	1.28
2/5	3.43	1.23
Winter Mean	3.36	1.26
4/21	10.79	2.98
4/28	9.86	3.00
5/12	9.80	2.90
5/20	8.98	2.92
Spring Mean	9.86	2.95
6/15	6.61	3.09
7/5	12.72	3.17
7/15	9.21	2.52
7/26	1.19	0.33
8/6	3.24	0.81
8/19	3.34	0.56
8/26	2.70	0.54
Summer Mean	5.57	1.38
9/10	14.43	2.11
9/23	9.13	1.94
10/8	9.19	2.26
10/21	4.84	2.32
11/4	2.54	0.91
Fall Mean	8.03	1.96
Annual Mean	6.71	1.89

Table 22. Zooplankton standing crop (organisms/1) in Clark Canyon Reservoir during 1971 and 1972.

Date	*Cyclops bicuspidatus thomasii*	*Diaptomus* spp.	Copepod nauplii	*Daphnia schodleri*	Total Adult Zooplankton Standing Crop
12/15/71	4.09	0.23	0.11	9.20	13.52
1/8/72	4.29	0.21	0.14	10.40	14.90
2/5	2.94	0.24	0.18	12.46	15.64
4/21	21.62	0	1.85	8.83	30.45
5/12	8.20	0	0.40	18.83	27.03
5/20	4.44	0	67.69	14.16	18.60
6/15	10.53	0.28	11.64	18.77	29.58
7/5	7.74	0	3.50	15.87	23.61
7/15	14.31	10.78	14.31	33.28	58.37
7/26	14.05	4.97	11.49	30.58	49.60
8/6	3.72	8.14	1.40	14.49	26.35
8/19	5.30	1.37	6.87	9.14	15.81
8/26	4.26	2.51	4.26	7.19	13.96
9/10	2.31	0.32	1.21	5.10	7.73
9/23	0.87	0.08	0.13	5.25	6.20
10/8	0.47	0.13	0.13	3.10	3.70
10/21	0.26	0.04	0.02	3.86	4.16

Table 23. Variables used for statistical analyses of data collected at Clark Canyon Reservoir during 1971 and 1972.

1. Water temperature (Centigrade degrees)
2. Orthophosphate (ppm $PO_4^{\equiv}$)
3. Nitrate nitrogen (ppm NO_3^--N)
4. Chlorophyll a (ug/l)
5. Total phytoplankton standing crop (mm^3/l)
6. *Asterionella* standing crop (mm^3/l)
7. *Aphanizomenon* standing crop (mm^3/l)
8. *Cryptomonas* standing crop (mm^3/l)
9. *Rhodomonas* standing crop (mm^3/l)
10. Total zooplankton standing crop (organisms/l)
11. *Daphnia schodleri* standing crop (organisms/l)
12. *D. schodleri* instantaneous birth rate
13. *D. schodleri* instantaneous death rate
14. *D. schodleri* population change rate
15. *Cyclops bicuspidatus thomasii* standing crop (organisms/l)

Table 24. Simple correlation coefficients (r) relating some parameters measured at Clark Canyon Reservoir during 1971 and 1972.

Variable[1]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	1.000														
2.	.381	1.000													
3.	-.574**	-.212	1.000												
4.	.164	-.116	-.239	1.000											
5.	.582**	.320	-.308	.326	1.000										
6.	-.708***	-.444*	.421*	.084	---	1.000									
7.	.507**	.386	-.245	.140	---	-.677***	1.000								
8.	.671***	.629***	-.357	-.044	---	-.538**	.496**	1.000							
9.	.377	-.214	-.151	.338	---	-.118	.447*	.151	1.000						
10.	.302	-.183	-.185	-.102	-.296	.243	-.460*	.217	.140	1.000					
11.	.292	-.238	-.127	-.149	-.361	.166	-.491*	.210	.042	---	1.000				
12.	-.785***	-.362	.875***	-.297	-.453*	.541**	-.320	-.633***	-.296	---	-.157	1.000			
13.	-.478*	-.144	.534**	-.653***	-.286	.203	-.087	-.236	-.289	---	.170	.640**	1.000		
14.	-.228	-.156	.137	.576**	-.123	.343	-.256	-.404	.068	---	-.299	.116	-.568**	1.000	
15.	.063	-.138	-.195	.100	-.253	.489*	-.433*	.011	.084	---	.578**	-.198	-.195	.057	1.000

[1]/ Variables named on Table 23.

*Significant at .05 level (one tailed test)

**Significant at .025 level (one tailed test)

***Significant at .005 level (one tailed test)

Table 25. Multiple linear regression analyses of some parameters measured at Clark Canyon Reservoir during 1971 and 1972.

Independent Variables	Partial Corr.	Regression Coef.	T	F	R^2	Intercept
(1) Explainative analysis for total phytoplankton standing crop						
Water temperature	.527	0.116	2.40**	3.93*	0.34	2.383
Orthophosphate	.132	1.937	0.52			
(2) Descriptive analysis for *Asterionella* standing crop						
Water temperature	-.650	-0.041	-3.20**	11.07**	0.70	0.898
Aphanizomenon s. c.	-.653	-0.187	-3.22**			
Rhodomonas s. c.	.555	1.093	2.50**			
(3) Explainative analysis for *Asterionella* standing crop						
Water temperature	-.599	-0.042	-2.90**	6.55**	0.47	1.158
Orthophosphate	-.256	-1.155	-1.02			
(4) Descriptive analysis for *Aphanizomenon* standing crop						
Water temperature	-.337	-0.073	-1.29	6.90**	0.68	1.187
Orthophosphate	.416	5.200	1.65			
Asterionella s. c.	-.654	-2.109	-3.12**			
Rhodomonas s. c.	.642	4.639	3.02**			
(5) Explainative analysis for *Aphanizomenon* standing crop						
Water temperature	.434	0.095	1.87*	3.29	0.30	-0.489
Orthophosphate	.248	3.916	0.99			
(6) Explainative analysis for *Cryptomonas* standing crop						
Water temperature	.516	0.023	2.33*	8.40**	0.53	0.215
Orthophosphate	.518	1.802	2.34*			
(7) Descriptive analysis for *Rhodomonas* standing crop						
Water temperature	.636	0.019	2.97**	5.59**	0.63	-0.079
Orthophosphate	-.499	-0.863	-2.08*			
Asterionella s. c.	.557	0.248	2.42*			
Aphanizomenon s. c.	.642	0.089	3.02**			
(8) Explainative analysis for *Rhodomonas* standing crop						
Water temperature	.568	0.017	2.67**	3.83*	0.34	0.165
Orthophosphate	-.385	-0.802	-1.61			

Table 25. Continued.

Independent Variables	Partial Corr.	Regression Coef.	T	F	R^2	Intercept
(9) Descriptive analysis for total zooplankton standing crop						
Water temperature	.810	2.376	4.15**	8.85**	0.86	-13.46
Chlorophyll a	-.357	-0.649	-1.15			
Total phytoplankton s. c.	-.694	-7.767	-2.89**			
Asterionella s. c.	.781	31.700	3.75**			
Cryptomonas s. c.	.552	17.360	1.99*			
Rhodomonas s. c.	.610	41.950	2.31*			
(10) Explainative analysis for total zooplankton standing crop						
Water temperature	.706	2.479	3.46**	6.76**	0.63	-37.08
Asterionella s. c.	.769	41.170	4.16**			
Cryptomonas s. c.	.255	9.690	0.91			
(11) Descriptive analysis for *D. schodleri* standing crop						
Water temperature	.668	1.121	2.84**	6.04**	0.75	4.910
Total phytoplankton s. c.	-.738	-6.184	-3.46**			
Asterionella s. c.	.512	10.760	1.89*			
Cryptomonas s. c.	.518	11.410	1.92*			
Rhodomonas s. c.	.449	20.590	1.59			
(12) Explainative analysis for *D. schodleri* standing crop						
Water temperature	.577	1.233	2.45*	3.25	0.45	-15.22
Asterionella s. c.	.630	19.490	2.81**			
Cryptomonas s. c.	.179	4.686	0.63			
(13) Descriptive analysis for *D. schodleri* instantaneous birth rate						
Water temperature	-.593	-0.004	-2.55**	9.31**	0.70	0.131
Chlorophyll a	-.408	-0.003	-1.55			
Cryptomonas s. c.	-.360	-0.036	-1.34			
(14) Explainative analysis for *D. schodleri* instantaneous birth rate						
Water temperature	-.785	-0.005	-4.74**	22.47**	0.62	0.109

Table 25. Continued.

Independent Variables	Partial Corr.	Regression Coef.	T	F	R^2	Inter-cept
(15) Descriptive analysis for *D. schodleri* instantaneous death rate						
Chlorophyll a	-.634	-0.007	-2.72**	5.29**	0.66	0.164
Total phyto-plankton s. c.	-.479	-0.040	-1.81*			
Asterionella s. c.	.562	0.077	2.25*			
Aphanizomenon s. c.	.575	0.053	2.33*			
(16) Explainative analysis for *D. schodleri* instantaneous death rate						
Chlorophyll a	-.520	-0.006	-2.11*	4.00*	0.50	0.205
Total phyto-plankton s. c.	-.358	-0.034	-1.33			
Aphanizomenon s. c.	.340	0.029	1.25			
(17) Explainative analysis for *D. schodleri* population change rate						
Chlorophyll a	.636	0.005	2.97**	5.19*	0.44	-0.036
Aphanizomenon s. c.	-.410	-0.009	-1.62			

*Significant at .05 level (one tailed test)
**Significant at .01 level (one tailed test)