IOWA CONSERVATION COMMISSION

FISHERIES SECTION

FEDERAL AID TO FISH RESTORATION

ANNUAL PERFORMANCE REPORT

RESERVOIR INVESTIGATIONS

PROJECT NO. F-94-R-6

Study No. 3: Assessment of the Relationships Between Nutrients, Blue-Green Algae, Zooplankton and Fish Planktivores

- Job 1. Relationship between water quality, plankton density and species composition of plankton
- Job 2. In-lake rehabilitation techniques

Study No. 4: Assessment of Population Dynamics and Fish Stocking Methods of Walleye at Rathbun Lake

- Job 1. Assessment of stocking methods
- Job 2. Walleye stock assessment

Study No. 5: Microcomputer Technical Support and Assistance

- Job 1. Fisheries microcomputer programs
- Job 2. Development of state-wide microcomputer fisheries data storage/retrieval systems

PERIOD COVERED : 1 JULY 1985 - 31 MARCH 1986

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Date Prepared: April 1986

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Don Bonneau by MC 6-26-86

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE:	Iowa	NAME:	Assessment of the Relationships Between Nutrients, Blue-Green Algae, Zooplankton and Fish Planktivores
PROJECT NO.:	F-94-R-6		
STUDY NO.:	3		
JOB NO.:	1		
		TITLE:	Relationship betweeen water quality, plankton density and species composition of plankton

Period Covered: 1 July 1985 through 31 March 1986

ABSTRACT: Water quality, phytoplankton and zooplankton were measured at Green Valley Lake to determine the mechanisms involved in development of nuisance levels of blue-green algae. Correlation and regression analysis showed levels of chlorophyll(a) could be predicted from concentrations of organic Nitrogen, ammonia, turbidity and pH, with organic Nitrogen the single most important and reliable predicter. Further examination of the data showed the accelerated growth phase of blue-green algae, primarily Microcystis and Aphamozomenon, was preceeded by a precipitous drop in inorganic Nitrogen. Concentrations of ammonia less than .2 mg/l and nitrate-nitrite values less than 1 mg/l preceeded major blue-green blooms, those in the order of 14,000 colonies per liter. Blue-green populations in 1985 attained concentrations of about 3,500 per liter in late August. Green and yellow-green population density peaked in September at about 4,000 per liter. Zooplankton densities were lower than previous years of investigation and attained a maximum of 60 individuals per liter.

STUDY OBJECTIVE

To determine methods for control of nuisance blue-green algae and provide strategies for management of fish populations.

JOB 1 OBJECTIVE

To determine the influence of water quality on the phyto- and zooplankton community.

INTRODUCTION

Nutrient loading from the intensively farmed watershed at Green Valley Lake has resulted in high phytoplankton populations, primarily blue-green algae. Nuisance blue-green is a sympton of many Iowa waters with inflow from heavily fertilized, rowcropped land. These blooms deter water contact sports and adversely affect fish populations. The blue-green assemblage is rarely used by zooplankton as food, but instead the trophic component is transferred to bacterial decomposers and benthic invertebrates. Shunting of this energy away from zooplankton exerts a deleterious impact upon larval and juvenile fishes. Summer fish kills are another serious problem caused by dense algal blooms. High plankton respiration and decomposition on hot, windless nights can reduce dissolved oxygen levels to critical levels.

Bachman (1980) clearly defined the problem in an investigation that classified 107 Iowa lakes. The primary problem was nutrient loading which resulted in high phytoplankton populations as measured by chlorophyll(a) concentrations.

Previous investigations summarized by Dunst (1974), showed a multitude of remedial lake rehabilitation strategies. In-lake rehabilitation tehniques which show promise are nutrient inactivation (Cooke, 1981) and alteration of the Nigrogen and Phosphorous ratio. N:P ratios may be critical in establishing algal species composition (Barica, 1980). Far more important in terms of long-lasting effects, however, is control of nutrient loading, the source of the problem.

The investigation at Green Valley Lake was designed to pursue three primary areas of endeavor including 1) control of blue-green algae in experimental, confined areas, 2) monitoring the effect of watershed and in-lake rehabilitation structures on water quality, and 3) defining the relationship between water quality and lake biota, the latter including zooplankton and fish planktivores. Segment 3 was accomplished in 1982 and 1983, while the objectives for Segment 1 were attained during the summers of 1983 and 1984.

Monitoring the effect of improved soil conservation practices and two silt retention dams (Segment 2) was initiated in 1981. Pre-remedial monitoring was accomplished in 1981-1983, with watershed improvements and silt dam construction accomplished in 1984. A second silt dam will be constructed in 1986-87. Post-remedial assessment will continue through 1988. This report will focus on water quality and plankton communities in the lake, as a whole, but more importantly conditions were monitored directly above and below the silt retention dam.

DESCRIPTION OF THE STUDY AREA

Green Valley Lake is a 428 ac man-made impoundment located near Creston in Union County (Table 1). The lake is located in Green Valley State Park, however, much of the watershed lies outside the park and is subject to intensive rowcropping. The lake is situated high in the watershed with little wind protection, resulting in ephemeral stratification during calm periods.

Table 1. Physical description of Green Valley Lake and watershed.

Area	428 ac	Shoreline development	4.27
Maximum depth	26 ft	Volume development	1.13
Mean depth	10 ft	Watershed/lake area	11.6/1

Watershed use:

Cropland 77%	Pasture 18%	Timbered 2%

The lake was renovated of scale-fish, primarily carp, in 1974 and restocked with largemouth bass, black crappie and bluegill. The fishery is now dominated by crappie, channel catfish and bullhead.

METHODS AND PROCEDURES

Water samples were collected by the park officer and transferred to the State Hygienic Laboratory for analysis. Field measurements included dissolved oxygen, air temperature, surface water temperature, wind speed-direction and Secchi disc visibility. Laboratory analysis consisted of pH, turbidity, chlorophyll(a), organic Nitrogen, ammonia, nitrate-nitrite complex, filterable phosphate and total phosphate. Analysis was completed according to EPA methods and standards. Sampling commenced in early May and continued through mid-September on a bi-weekly regimen. Two sampling locations were established at the lake, designated as site 1 and site 2 (Figure 1). Sampling at site 1 was stratified at 2, 4 and 6 meters and designated as 1A, 1C and 1E, respectively. The depth at site 2 was approximately 1 meter and the samples were taken at mid-depth. Samples were also taken in 1985 above and below the silt retention dam.

Plankton sampling commenced on June 7, 1985 and continued biweekly through September. Three stations were sampled with two hauls at each station, one at the surface and one a meter below surface (Figure 1). In addition to these tows, plankton was also sampled directly above and below the silt retention dam. At these sites the net was lifted 6 feet, vertically, through the water column with lifts duplicated both above and below the structure. Net orifice was 104 cm^2 with a cod of 45 cm; mesh size was 80 microns. Tows were made over a known distance, thus total samples volume was determined. Samples were preserved in 5% buffered formalin for later processing. At station 1, one gallon of surface water was taken to estimate quantity of phytoplankton passing through the mesh.

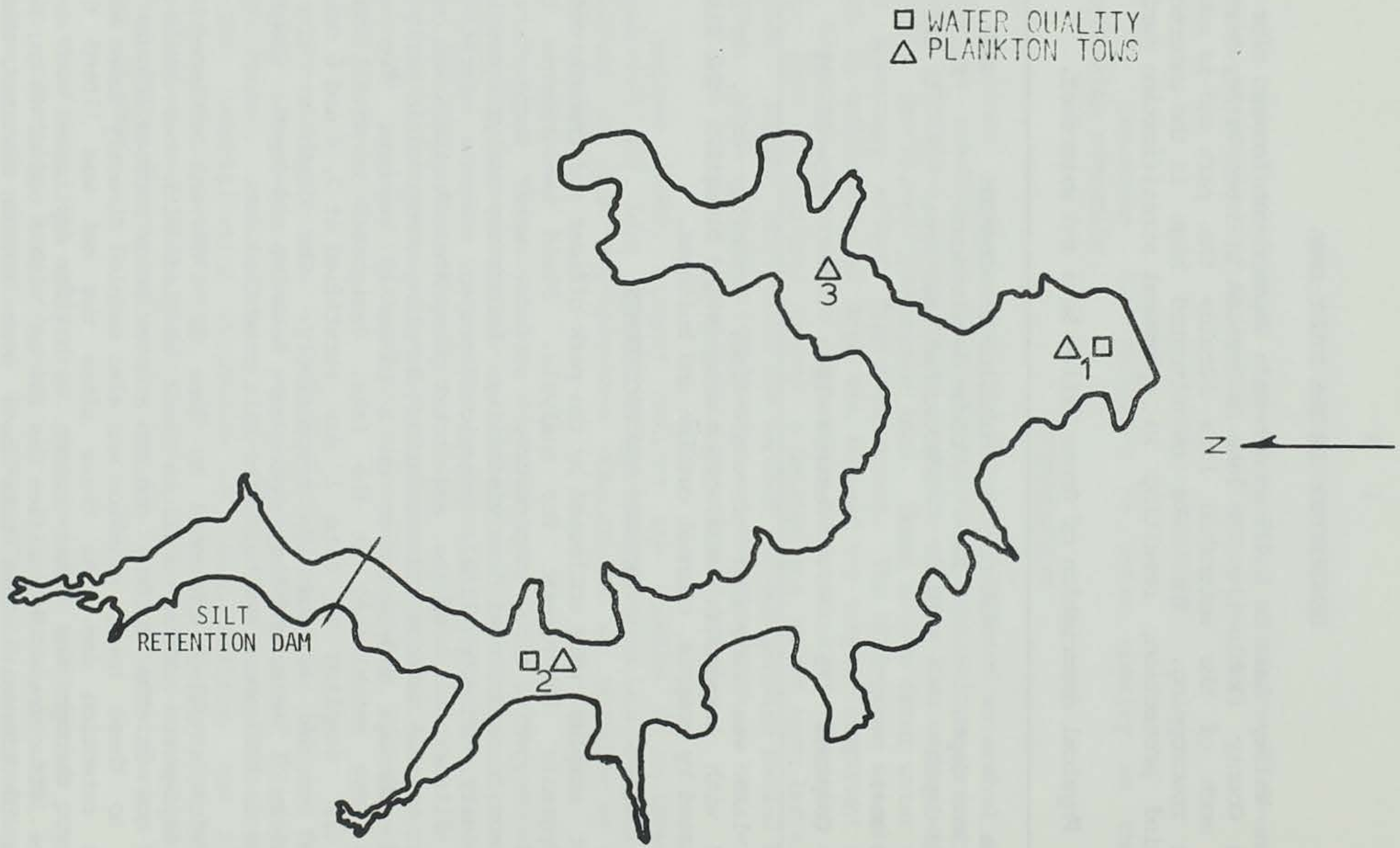

Figure 1. Green Valley Lake showing locations of water quality and plankton tow stations.

Each sample was poured into a 100 cc graduated cylinder and allowed to settle 7 days, then the volume of phytoplankton and zooplankton in the cylinder was recorded; in addition, blue-green algae volume floating on the surface of the cylinder was recorded. Following the volumetric measurements, the sample was thouroughly mixed and a one ml aliquot was introduced into a Palmer counting cell. Identification and enumeration of the biota was made at 45X. Two replicate slides were prepared and three fields examined within each slide. Phytotaxa were identified to at least subclass.

One gallon of unfiltered water was allowed to settle for 7 days and concentrated to 200 ml by siphoning off the supernatant. One drop was placed on a slide and 10 fields were examined. Triplicate slides were prepared.

FINDINGS

Water Quality

Organic and inorganic phosphorous ions are considered one of the primary factors in biological productivity in Iowa lakes (Bachmann, 1980). During 1985, total phosphorous at Green Valley Lake ranged from .02 mg/l at station 1A in early September to 1.1 mg/l at station 2A on June 25 (Table 2). Average for the sampling season was .25 mg/l with highest concentations at the upper station (2A). The average for that station was .37 mg/l. Overall, concentrations at the dam were much less with an average value of .20 mg/l at both the surface (1A) and mid-depth (1C) locations. Seasonal occurrance of total phosphates showed a trimodal distribution with greatest levels occurring on May 6, June 25 and August 5. Values on these dates were greater than 30 mg/l; during the remainder of the year concentrations averaged less than 20 mg/l.

Table 2. Total phosphate concentrations (mg/l) at Green Valley Lake, 1985.

Date	Station 1A	1C	1E	2A
May 6	.28	.29	.33	.32
May 20	.13	.15	.21	.20
June 10	.16	.14	.20	.15
June 25	.33	.16	.20	1.10
July 8	.14	.20	.28	.19
July 22	.23	.21	.22	.27
August 5	.36	.32	.37	.32
August 19	.21	.19	.22	.26
September 9	.02	.24	.24	.72
September 24	.13	.13	.15	.17
Mean	.20	.20	.24	.37

Filterable phosphate, a form more readily useable for plant respiration, likewise showed higher concentrations at 2A where the average for the season was .17 mg/l (Table 3). Values at 1A averaged .08 mg/l with readings at the deeper levels (1C and 1E) of .07 mg/l and .11 mg/l, respectively. Seasonal distribution of filterable phosphate showed a maximum concentration of .16 mg/l was attaind on June 25, while concentrations of less than .10 mg/l were dominant before and after that date.

Table 3. Filterable phosphate concentrations (mg/l) at Green Valley Lake, 1985.

Date	Station 1A	1C	1E	2A
May 6	.08	.08	.11	.11
May 20	.09	.02	.11	.13
June 10	.10	.11	.17	.15
June 25	.14	.15	.18	.17
July 8	.04	.05	.08	.06
July 22	.05	.05	.08	.11
August 5	.08	.07	.14	.09
August 19	.06	.07	.09	.11
September 9	.01	.01	.01	.67
September 24	.13	.13	.15	.12
Mean	.08	.07	.11	.17

Nitrogen, in its various forms, is also important to plant production. Unlike phosphorous, however, it is not normally a limiting factor. Organic nitrogen, incorporated into plant mass, was greater by far than any of the other Nitrogen forms. Overall average for the season was .94 mg/l with a range of .71 mg/l to 1.50 mg/l (Table 4). Concentrations at station 2A were reflective of the higher algae biomass; average concentration at 2A in 1895 was 1.08 mg/l. Locations at the dam were .88-.94 mg/l. Seasonal occurrance of organic Nitrogen was fairly uniform ranging from .77 mg/l on May 20 to 1.14 mg/l on August 5.

Ammonia concentrations ranged from .01 mg/l to .40 mg/l with an overall average of .18 mg/l (Table 5). Generally the highest concentrations were found at the deepest station (1E) where the annual average was .22 mg/l. Values at the surface stations were .15-.19 mg/l. Maximum ammonia concentration occurred on May 6 at .34 mg/l. Values during the remainder of the season were usually less than .20 mg/l.

The nitrate-nitrite complex is the most readily assimilated form of Nitrogen. The overall concentration during the season was .30 mg/l with greatest concentrations in May of .6-.8 mg/l (Table 6). Later in July-September nitrate-nitrite decreased to .1 mg/l at all stations. Distribution of these nitrogen ions was uniform between stations.

Table 4. Organic Nitrogen concentrations (mg/l) at Green Valley Lake, 1985.

Date	Station 1A	1C	1E	2A
May 6	.93	.95	.95	1.20
May 20	.79	.77	.71	.79
June 10	.81	.75	1.10	.92
June 25	.82	.91	.97	.83
July 8	.87	.87	.91	1.40
July 22	.86	.74	.80	.92
August 5	.86	.98	1.20	1.50
August 19	1.20	.85	1.00	1.10
September 9	.95	.97	.96	1.30
September 24	.72	.79	.78	.85
Mean	.88	.86	.94	1.08

Table 5. Ammonia concentrations (mg/l) at Green Valley Lake, 1985.

Date	Station 1A	1C	1E	2A
May 6	.32	.32	.33	.40
May 20	.07	.01	.07	.10
June 10	.15	.15	.38	.26
June 25	.17	.18	.21	.13
July 8	.13	.13	.29	.06
July 22	.03	.05	.12	.20
August 5	.23	.22	.31	.07
August 19	.01	.11	.14	.30
September 9	.04	.03	.05	.04
September 24	.35	.33	.32	.32
Mean	.15	.15	.22	.19

Table 6. Nitrate-nitrite Nitrogen concentrations (mg/l) at Green Valley Lake, 1985.

Date	Station 1A	1C	1E	2A
May 6	.6	.6	.6	.6
May 20	1.1	.8	.8	.8
June 10	.6	.5	.4	.5
June 25	.4	.4	.4	.4
July 8	.2	.1	.1	.1
July 22	.1	.1	.1	.1
August 5	.1	.1	.1	.1
August 19	.1	.1	.1	.1
September 9	.1	.1	.1	.1
September 24	.1	.1	.1	.1
Mean	.3	.3	.3	.3

Hydrogen ion concentration was indicative of plant production where highest values were found at locations and periods with highest algal populations. For example, greatest pH values (9.0) were found at the surface stations in July and August (Table 7). Values were all less than 7.5 until June 25, regardless of depth or location. High pH levels of about 8.5 continued until sampling ceased in late September.

Table 7. Hydrogen ion concentrations at Green Valley Lake, 1985.

Date	Station 1A	1C	1E	2A
May 6	7.2	7.4	7.4	7.3
May 20	7.3	7.4	7.4	7.4
June 10	7.4	6.9	7.4	7.3
June 25	7.4	7.5	7.4	9.2
July 8	9.0	9.2	9.0	8.7
July 22	9.0	9.0	8.5	9.3
August 5	8.5	8.5	8.5	9.0
August 19	9.0	8.5	8.5	8.0
September 9	8.5	8.5	8.5	9.0
September 24	8.5	8.5	8.5	7.5
Mean	8.2	8.1	8.1	8.3

Turbidity in 1985 averaged 20 JTU and ranged from 10-44 JTU. The deep station (1E) and the station in the upper west arm (2A) were consistently more turbid than the other stations (Table 8); yearly averages for these stations were 26 JTU and 24 JTU, respectively. There was no particular trend in water clarity as the season progressed. Sometimes high turbidity was caused by silt-laden runoff, at other times water clarity was a function of algal density.

Table 8. Turbidity (JTU) at Green Valley Lake, 1985.

Date	Station 1A	1C	1E	2A
May 6	21	22	39	31
May 20	17	16	21	24
June 10	12	11	44	22
June 25	15	13	30	16
July 8	10	11	24	22
July 22	14	15	18	22
August 5	11	11	39	23
August 19	11	11	16	27
September 9	14	13	14	28
September 24	18	19	19	29
Mean	14	14	26	24

Chlorophyll(a) is an indirect measure of primary production and phytoplankton density. Concentrations of chlorophyll(a) in 1985 were considerably lower than previous years, particularly those in 1981-83. The average in 1985 was 30 mg/l, while the average for earlier years was 50 mg/l. Likewise, the variance was much reduced in 1985 with values ranging from 7-78 mg/l; one standard deviation was 18 mg/l. Levels of chlorophyll(a) were usually greatest at station 2A where the average was 42 mg/l (Table 9). Stations 1A and 1C yielded chlorophyll(a) levels of 26 mg/l, while the concentration at 1E was 31 mg/l. Seasonal distribution of chlorophyll(a) showed highest levels were attained in July, August and early September. For example, the highest readings of 53 and 51 mg/l were obtained on August 5 and September 9, respectively. July values yielded an average of 44 mg/l.

Relationships between water quality parameters were assessed by multiple correlation and regression analysis. The data set consisted of 160 observations of each parameter and included 5 years, 4 stations and 8 periods. The correlation matrix is shown in Table 10. Chlorophyll(a) concentrations were most closely and positively associated with organic Nitrogen, pH and total phosphate concentrations. There was also a significant, but negative relationship with ammonia.

Table 9. Chlorophyll(a) concentations (mg/l) at Green Valley Lake, 1985.

Date	Station 1A	1C	1E	2A
May 6	9	7	10	8
May 20	19	25	26	46
June 10	11	9	22	17
June 25	24	28	34	24
July 8	35	37	37	72
July 22	37	35	34	65
August 5	39	37	51	78
August 19	20	13	29	17
September 9	49	49	50	64
September 24	18	18	17	24
Mean	26	26	31	42

Table 10. Intraclass correlations of water quality parameters at Green Valley Lake, 1981-1985.

	Chlor(a)	pH	Turb	Org N	NH_3-NH_4	NO_2-NO_3	Filtered P	Total P
Chlorophyll(a)	1.00	.40**	.07	.58**	-.17*	-.15	-.003	.19*
pH		1.00	-.07	.17*	-.15	-.29**	-.04	.16*
Turbidity			1.00	.65**	.05	.38**	.31**	.49**
Organic Nitrogen				1.00	.05	.10	.32**	.58**
NH_3-NH_4					1.00	-.07	.55**	.36**
NO_2-NO_3						1.00	.06	.11
Filtered Phosphate							1.00	.80**
Total Phosphate								1.00

*Significant at the .05 level.
**Significant at the .01 level.

Stepwise regression analysis yielded a model whereby chlorophyll(a) levels could be predicted using pH, tubidity, ammonia and organic Nitrogen, all of which had significant b-values ($p < .10$). The regression was best described by the following:

$$Y = -139 + 17X_1 - .5X_2 + 47X_3 - 22X_4$$

where Y = chlorophyll(a) in mg/l
X_1 = pH
X_2 = turbidity in JTU
X_3 = organic Nitrogen in mg/l and
X_4 = ammonia in mg/l.

Organic Nitrogen was by far the most reliable predictor, followed in order of importance by turbidity, pH and ammonia. Other variables, although the r-value may have been significant, did not contribute significantly as a predictor ($\beta = 0$).

Interclass correlations showed a multitude of significant relationships (Table 10). In fact, of the remaining 21 comparisons, 12 were significant and ranged in magnitude from r = .16 for ph and total phosphate to r = .80 for filtered phosphate and total phosphate.

Phytoplankton

Blue-green algae dominated the phytoplankton community particularly early in the season, while green and yellow-green algae became more prevalent in September. The blue-green complex was dominated by *Aphanozomenon*, *Microcystis* and to a lesser extent, *Oscillatoria*. Blue-green density was nil in early June, increased gradually until mid-July and then rapidly reached maximum density of 3,330 per liter on July 31 (Figure 2). September blue-green populations decreased rapidly and by October the density was less than 1,000 per liter.

Abundance of green and yellow-green algae, consisting of desmids, diatoms and flagelate chrysophytes, remained low through mid-August at densities less than 200 per liter. By September 12, however, abundance had attained a maximum of 4,220 per liter. When sampling ceased on September 27 density was at about 2,000 per liter.

As expected, phytoplankton density was related to chlorophyll(a) concentration. Examination of Figure 2 and Table 9 showed peak phytoplankton blooms were associated with maximum chlorophyll(a) concentrations which occurred on August 5 and September 9. Similarly, low plankton density in mid-August and later in September were associated with significant decreases in chlorophyll(a) levels for those dates.

Zooplankton

Maximum zooplankton density at Green Valley Lake was 63 per liter on June 7. This was followed by a precipitous decline to 8 per liter on July 6 (Figure 3). There was a second pulse which peaked on August 3 at a density of 25 per liter. When sampling ceased on August 29 zooplankton population had decreased to a concentration of 11 per liter.

No particular group dominated the zooplankton community in 1985. Copepods were slightly more abundant than other taxa in early June at 21 per liter (Table 11). If a dominant taxa occurred during the season it was Cladocera; on July 31 it comprised 54 percent of the zooplankton. Copepod nauplii and rotifers were abundant in June but became relatively unimportant during the remainder of the study.

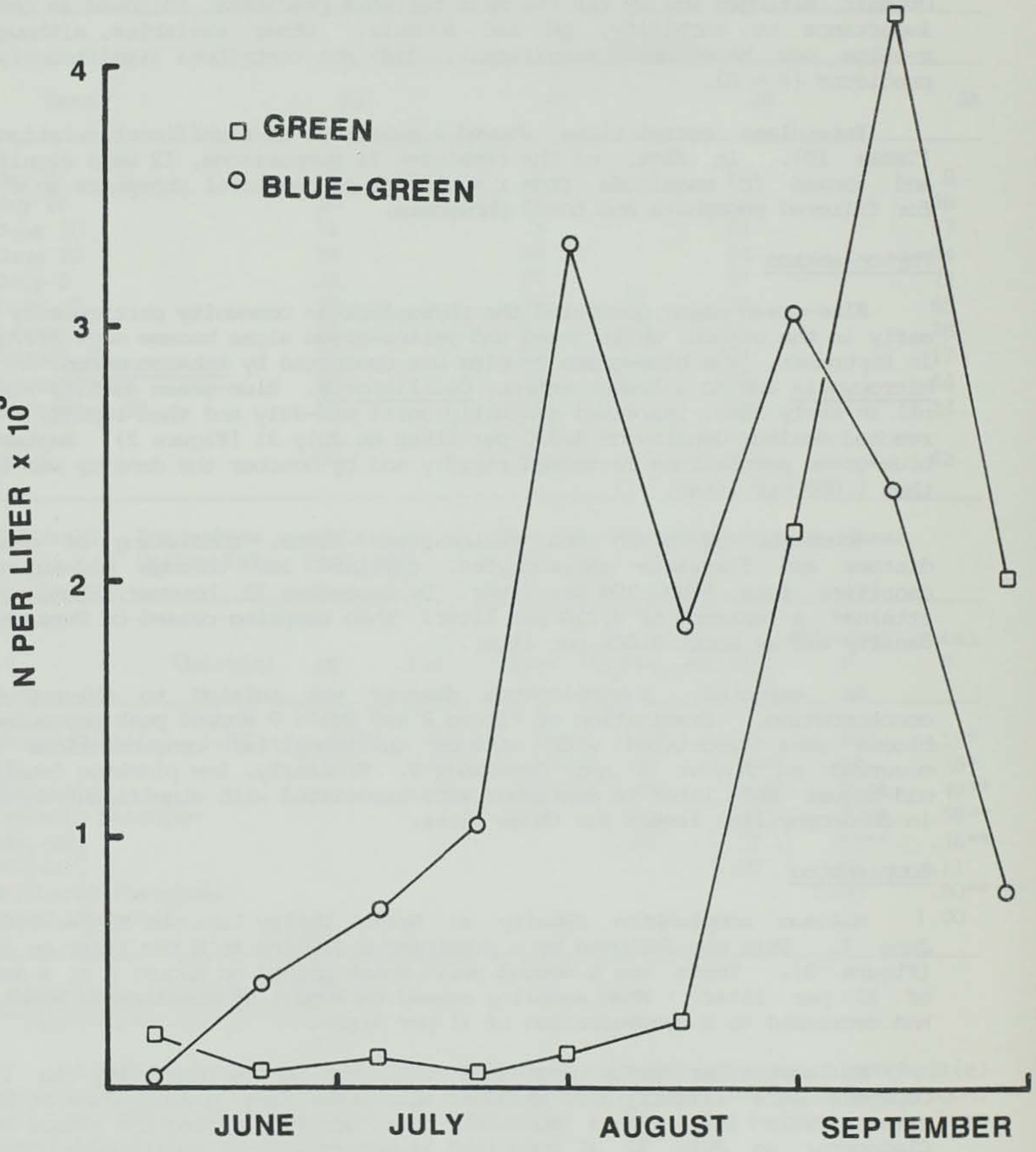

Figure 2. Numerical abundance of phytoplankton in plankton net tows at Green Valley Lake, 1985.

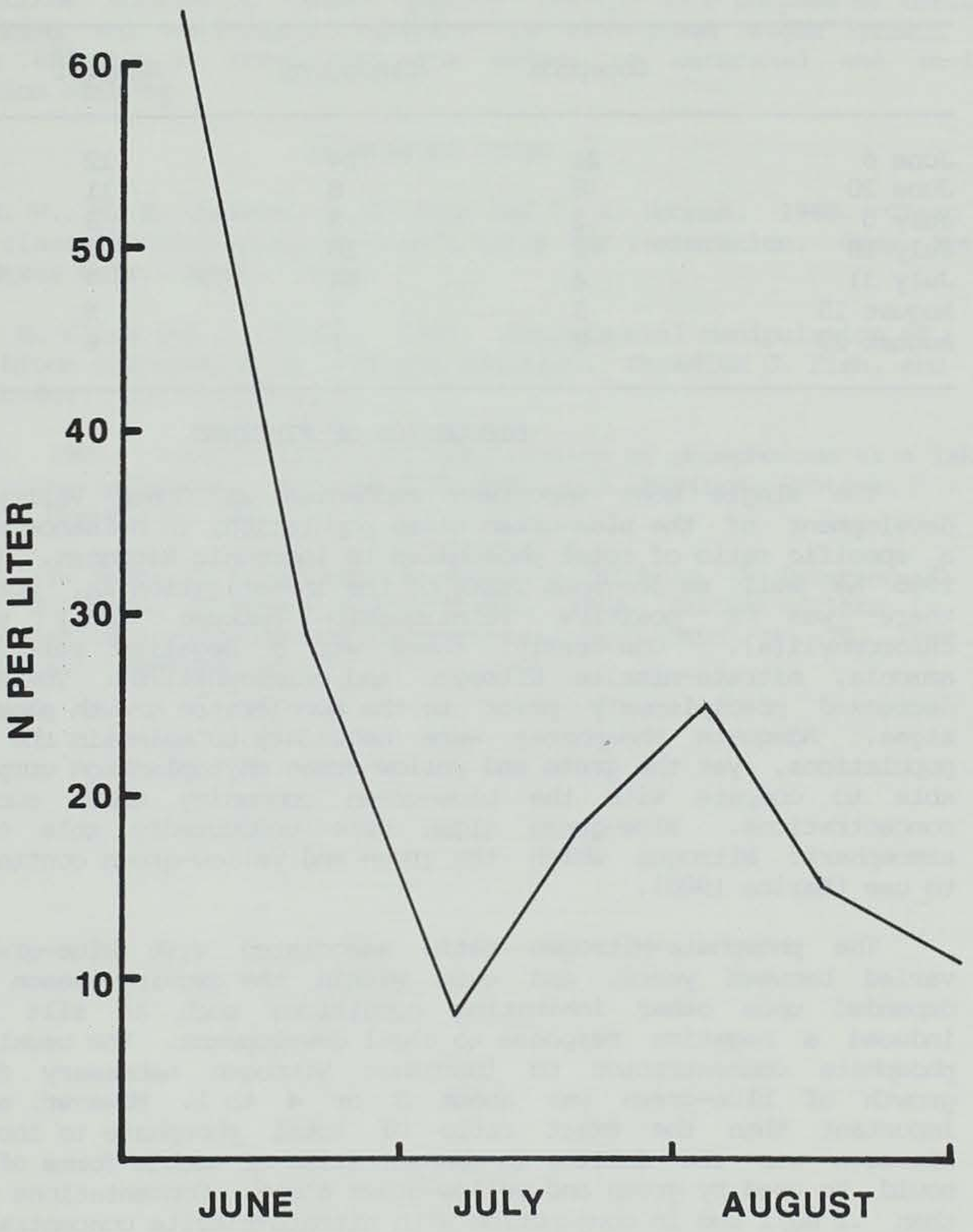

Figure 3. Density of zooplankton at Green Valley Lake, 1985.

Table 11. Density of major zooplankton taxa at Green Valley Lake, 1985, in number per liter.

	Copepoda	Cladocera	Nauplii	Rotifera
June 6	21	14	12	14
June 20	8	8	11	<1
July 5	2	3	3	1
July 18	2	10	7	1
July 31	4	14	7	<1
August 15	3	3	5	3
August 29	2	1	6	2

DISCUSSION OF FINDINGS

The single most important mechanism at Green Valley Lake in the development of the blue-green algae population, in nuisance proportions, was a specific ratio of total phosphates to inorganic Nitrogen. This was true in 1985 as well as previous years of the investigation in. Correlation showed there was a positive relationship between total phosphates and chlorophyll(a). Conversely, there was a negative relationship between ammonia, nitrate-nitrite Nitrogen and chlorophyll(a). These inorganic ions decreased precipitously prior to the accelerated growth phase of blue-green algae. Adequate phosphates were necessary to maintain the rapidly growing populations, yet the green and yellow-green phytoplankton components were not able to compete with the blue-green community under such low Nitrogen concentrations. Blue-green algae were undoubtedly able to use and fix atmospheric Nitrogen which the green and yellow-green contingent was unable to use (Barica 1980).

The phosphate-Nitrogen ratio associated with blue-green algal blooms varied between years, and even within the growing season the exact ratio depended upon other inhibiting conditions such as silt turbidity which induced a negative response to algal development. The usual ratio of total phosphate concentration to inorganic Nitrogen necessary for accelerated growth of blue-green was about 3 or 4 to 1. However, and perhaps more important than the exact ratio of total phosphate to inorganic forms of Nitrogen was the decline in concentration of usable forms of Nitrogen which could be used by green and yellow-green algae. Concentations of ammonia less than .2 mg/l and in conjunction with nitrate-nitrite concentrations less than 1 mg/l were usually prequisite for a major blue-green bloom with a density of greater than 14,000 colonies per liter.

Once the accelerated growth phase was initiated, regardless of algae type, changes in several water quality parameters could be predicted. Photosynthetic activity and assimilation produced significant increases in pH and organic Nitrogen along with significant decreases in ammonia and turbidity. These changes, at least for pH and organic Nitrogen, were a result of algae growth and not the mechanism responsible for growth.

RECOMMENDATIONS

Discontinue monitoring water quality for the sole purpose of defining and describing the mechanisms inherent in blue-green algae growth and concentrate efforts on monitoring the effect of watershed and in-lake rehabilitation efforts.

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE:	Iowa	NAME:	Assessment of the Relationships Between Nutrients, Blue-Green Algae, Zooplankton and Fish Planktivores
PROJECT NO.:	F-94-R-6		
STUDY NO.:	3		
JOB NO.:	2		
		TITLE:	In-lake rehabilitation techniques

Period Covered: 1 July 1985 through 31 March 1986

ABSTRACT: Lake rehabilitation at Green Valley is continuing in the watershed with improved soil conservation practices and at the lake with construction of a silt retention dam (1983-84) in the west arm. Examination of water quality and plankton data sets from 1981 to 1985 showed water quality at the lake has improved significantly for ammonia, chlorophyll(a) and organic Nitrogen. Ammonia decreased from .64 mg/l to .18 mg/l. Chlorophyll(a), likewise, decreased from 60 mg/l in 1981 to 22 mg/l in 1984. Average organic Nitrogen concentration was 1.87 mg/l in 1981, while the average was .95 mg/l in 1985. The most significant biological development at Green Valley was a 60-fold decrease in blue-green algae density since 1982. More useful forms of phytoplankton such as greens, and yellow-greens were stable during the investigation at about 1,000 per liter. Zooplankton, however, decreased from 300 per liter in 1982 to 24 per liter in 1985. Water quality comparisons above and below the silt dam in 1985 showed significantly better quality for turbidity, pH, nitrate-nitrite, and phosphates below the silt dam.

JOB 2 OBJECTIVE

To determine the feasibility of in-lake rehabilitation techniques to reduce or eliminate the problem of nuisance blooms of blue-green algae.

INTRODUCTION

In-lake rehabilitation efforts were confined to limnocorral experiments in 1983 and blocked-off cove experiments in 1984. Experimental efforts focused on alum treatment, and adjustment of N:P ratio with ammonium nitrate to control blue-green algae blooms (Mitzner 1984). Findings showed initial control was positive; however, the effects were short-lived and within two weeks water quality and plankton populations were at pre-treatment levels. Further efforts were discontinued.

Improved soil conservation practices in the watershed and construction of a silt retention dam and erosion control structures in the west arm were completed in 1983-84. The second phase of the investigation was to monitor the effectiveness of these remedial practices. Water quality was measured before and after remedial work with a secondary objective of monitoring parameters above and below the silt retention dam to determine effectiveness of nutrient loading to the lake.

FINDINGS

Analysis of water quality data before (1981-83) and after (1984-85) rehabilitation work showed a significant decrease ($p < .05$) in ammonia, chlorophyll(a) and organic Nitrogen (Table 12). Ammonia was highest in 1982 with mean concentration of .64 mg/l, but by 1985 it had decreased to .18 mg/l. Chlorophyll(a) had a maximum of 60.1 mg/l in 1981 which decreased to 22 and 30 mg/l in 1984 and 1985, respectively. Organic nitrogen, because it was so closely allied to chlorophyll(a) followed the same trend. Maximum concentrations of 1.87 mg/l in 1981 decreased to .95 mg/l in 1985. The remaining parameters including the various phosphates, pH and nitrate-nitrite were also significantly different ($p < .05$) between years; however, the differences were not significant when before-and-after analysis was completed.

Table 12. Mean annual water quality parameter measurements at Green Valley Lake, 1981-1985, in mg/l unless otherwise specified.

	1981	1982	1983	1984	1985
Chlorophyll(a)	60.1	44.2	47.1	22.4	29.8
Organic Nitrogen	1.87	1.81	1.34	1.20	.95
Nitrate-Nitrite Nitrogen	.54	1.23	1.40	2.75	.35
Ammonia	.52	.64	.44	.23	.18
Filterable Phosphate	.09	.15	.18	.12	.10
Total Phosphate	.22	.31	.41	.25	.26
pH	7.91	7.72	8.03	7.53	8.11
Turbidity (JTU)	29.7	19.5	13.0	54.5	20.0

Comparison of water quality parameters above and below the silt retention structure showed turbidity, organic Nitrogen, nitrate-nitrite, filterable phosphate and total phosphate were all significantly ($p < .05$) less below the structure (Table 13). Chlorophyll(a) was 32 mg/l above and 27 mg/l below the structure, but the difference was not significant. Similarly, ammonia concentrations were .53 mg/l and .21 mg/l above and below, respectively, yet the values were not significantly different. Hydrogen ion concentration increased slightly from 7.37 above to 7.94 below the silt dam. Again the difference was not significant.

Table 13. Mean concentration of water quality parameters above and below the silt retention dam at Green Valley Lake, 1985, expressed as mg/l unless otherwise indicated.

	Above	Below	p < .05
Chlorophyll(a)	32	27	
Turbidity (JTU)	61	24	*
pH	7.37	7.94	
Organic Nitrogen	1.7	1.0	*
Ammonia	.53	.21	
Nitrate-Nitrite	3.9	.4	*
Filterable Phosphate	.24	.12	*
Total Phosphate	.51	.34	*

Phytoplankton populations changed greatly since 1982 when sampling commenced. Foremost was the 61-fold decrease in blue-green density from an average of 93,140 per liter in 1982 to 1,524 per liter in 1985. Concentrations in 1983 and 1984 were 19,700 and 5,880 per liter, respectively. The decline was statistically significant ($p < .05$).

Green and yellow-green populations increased, but only slightly. Average density in 1982 was 930 per liter followed by gradual increases in 1983 and 1984 of 1,190 and 1,220 per liter, respectively. Average concentration decreased slightly in 1985 to 1,040.

Zooplankton showed a steady decrese in abundance form 302 per liter in 1982 to 24 per liter in 1985. Values for 1983 and 1984, respectively, were 201 and 48 per liter. This decrease was undoubtedly due to the ever increasing number of grazing planktivores such as the abundant crappie population.

Density of plankton in 1985 above and below the silt retention dam was nearly identical. For example, abundance of blue-green phytoplankton averaged 1,520 per liter above and 1,630 per liter below the structure. Greens and yellow-greens showed a greater difference above and below the dam where the average above was 2.3 times greater than below the dam. These differences, however, were not significantly different.

Zooplankton populations, likewise, were nearly identical with an average density above the dam of 1,970 per liter. Below the average was 1,610 per liter. Again, these values were not significant.

DISCUSSION OF FINDINGS

The most significant biological development at Green Valley Lake during the investigation was a 60-fold decrease in blue-green algae density since 1982. It is not clear what caused a decrease of such magnitude particularly since water quality parameter concentrations decreased, but not nearly of a 60-fold magnitude. Several inferences were possible. First, relatively small improvements in water quality during the investigation may have been enough to drastically change the algal species complex at the lake. Second the subtle, relative changes between parameter concentrations may have caused a shift in species composition in the algae community. Mechanisms such as this and particularly those between Phosphorous and Nitrogen could have provided a competetive advantage for green and yellow-green algae. There was evidence of this occurring at Green Valley within each season, but such a trend over the investigation was less clear. In other words accelerated blue-green growth could be anticipated during the season as inorganic Nitrogen forms were being depleted. It was more difficult to explain the 60-fold decrease in blue-green algae over the investigation using this rationale. Regardless of the exact mechanisms involved, water quality improved and the blue-green algae population, although still a nuisance, became less of a problem.

RECOMMENDATIONS

In-lake rehabilitation and watershed improvement work should continue. Construction of a second silt retention dam in the east arm of the lake and fishing jetties will help improve water quality. The silt dams and fishing jetties will impede wind, thus thermal stratification may develop and provide a nutrient sink for the critical growth compounds of Nitrogen and Phosphorous.

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE:	Iowa	NAME:	Assessment of Population
PROJECT NO.:	F-94-R-6		Dynamics and Fish Stocking
STUDY NO.:	4		Methods at Rathbun Lake
JOB NO.:	1	TITLE:	Assessment of stocking methods

Period Covered: 1 July 1985 through 31 March 1986

ABSTRACT: Walleye fry stocking rate at Rathbun Lake in 1985 was 2,580 per acre, which resulted in a population on October 31 of 101,240 or 9.2 per acre. Instantaneous mortality (Z) from April 29 to May 17 was .081 with a corresponding daily rate of 8% per day. Mortality from mid May to mid August to November was .15% per day. Growth of juvenile walleye was greatest during July; and, by October, average length was 147 mm (5.8 in). Larval walleye commenced feeding at 9 mm with Daphnia and copepods comprising most of the diet. Gizzard shad became important to juvenile walleye as food by early June and continued through mid August. From August through October cyprinids dominated the diet. Fingerling walleye were stocked in October at a rate of 5.7 per acre; thus, the 1985 year class, on October 31, was estimated at 15 per acre.

STUDY OBJECTIVE

To develop management guidelines for walleye at Rathbun Lake by assessing population dynamics and delineating the contribution of stocked fish (1984-1988) to the fishery such that the population biomass of fish > 14 inches will be tripled.

JOB 1 OBJECTIVE

To delineate the contribution of stocked fry and fingerling to the walleye population by measuring abundance after one year, growth, condition and predator-prey relationships during that time period.

INTRODUCTION AND BACKGROUND

Walleye management in Iowa waters is accomplished primarily through stocking where, annually, about 125 million fry and 100,000-200,000 fingerlings are stocked into natural lakes, streams and man-made impoundments. Stocking rates have been established primarily from research investigations conducted at natural lakes (Jennings 1968, 1969, 1970, 1971; Rose 1955; Payne 1975; McWilliams 1976). Investigations on man-made impoundments < 1,000 ac were reported by Mayhew (1959, 1962, 1963) and Mitzner (1969, 1971). Assessment of stocking regimes at large flood control reservoirs in Iowa is lacking. Thus, the impetus for this investigation was to assess walleye stocking at Rathbun Lake and use the findings in management-oriented stocking strategies in flood control reservoirs.

Findings in 1984 showed stocking rates of 2,600 fry and 4.6 fingerling per acre resulted in a population density of 6.6 0-age walleye per acre on November 1. Instantaneous mortality of larval walleye from May 5 to June 11 was .12 with a corresponding daily rate of 11%. Mortality from June 11 to October 31 was 2% per day. Larval walleye commenced feeding at 9-10 mm (13 days old) on a diet composed primarily of <u>Daphnia</u> and copepods. Gizzard shad became important in the diet by mid-June and continued as the dominant food item through July when 95% of the gut contents, by weight, were juvenile gizzard shad. Young walleye fed primarily on cyprinids during August-October. Growth rate of 0-age walleye was greatest during July when they were feeding primarily on gizzard shad. Average walleye length at the end of the growing season was 130 mm (5.1 in).

DESCRIPTION OF THE STUDY AREA

Rathbun Lake is an 11,000 ac impoundment and receives run-off from the Chariton River and its tributaries in Appanoose, Wayne, Lucas and Monroe Counties. The project was built and operated for flood control, recreation and navigational benefits. Normal reservoir operation discharge rates range from 10 to 1,200 cfs; however, the maximum discharge is 5,000 cfs. Storage at conservation pool (904 ft MSL) is 205,400 ac-ft and maximum volume is 551,600 ac-ft at crest elevation (926 ft MSL). The watershed to lake surface area ratio is 32:1 at conservation pool and 17:1 at spillway elevation.

METHODS AND PROCEDURES

Experimental design for assessment of sac fry stocking was to increase the stocking rate to 2,000 fry per acre during a four-year period and measure the survival and contribution of each year class at least through the first summer. Food habits of newly-stocked fry were also followed through the first summer to examine the relationships between juvenile walleye survival and abundance of such major food groups as zooplankton, gizzard shad and cyprinids.

Walleye young were sampled with a meter net, a conical-shaped net with a circular bridal, one meter in diameter. The net was towed at 4 ft/sec at each station for 10 minutes. Larval fish were removed from the net and preserved in 5% buffered formalin for laboratory analyses. Stocked walleye fry were sampled weekly using meter net tows at six stations. Sampling commenced on April 29 and continued through May 17. Three tow net stations were located in open water. These were further stratified into two depths -- surface (A) and 5 meters (B). Embayment stations were located in Honey Creek and Buck Creek, while a shoreline station was located about midway in the reservoir on the northeast shore (Figure 1).

Fingerling walleye were sampled with 1/4-inch mesh seine (July-September) and electrofishing (September-October). Thirty-two hours of electrofishing effort (230 V AC) at night over a 12-day period were used to complete the fingerling population estimate. Finclipped, hatchery-reared fingerlings were stocked from October 4-18. Sampling for recaptured fish commenced October 24 and continued through November 4.

Cove rotenone sampling occurred in August to estimate population abundance and biomass of 0-age walleye. All species, however, were picked up, enumerated, weighed and processed such that population statistics of both predator and prey populations were described. Six coves were sampled at identical locations from previous studies. Sites are shown in Figure 1. Coves ranged in size from .44 ha (1.08 ac) to 1.46 ha (3.60 ac). These coves had a combined surface area of 4.88 ha (12.06 ac). Rotenone was applied through a weighted, perforated hose to assure even distribution. Rate was approximately 3 ppm (1 gallon per ac-ft). All fish were picked up for three consecutive days. During the first day fish were weighed in aggregate by species; total lengths were measured to the nearest cm from random subsamples. Fish picked up during the second and third days were enumerated by species. The composite sample for all coves were adjusted to account for species and size selectivity, distribution within the lake and the probability of successfully recovering dead fish within a three-day period as determined by Hayne (1967).

Zooplankton were sampled with a one-half meter plankton net; mesh size was 116 microns. The net had an orifice of 0.2 m^2 and a length of 2.4 m. Tows were made at the same stations as meter net tows using identical procedures as meter netting. Gizzard shad and other forage fish were sampled with meter net, tucker trawl and seine, May-September.

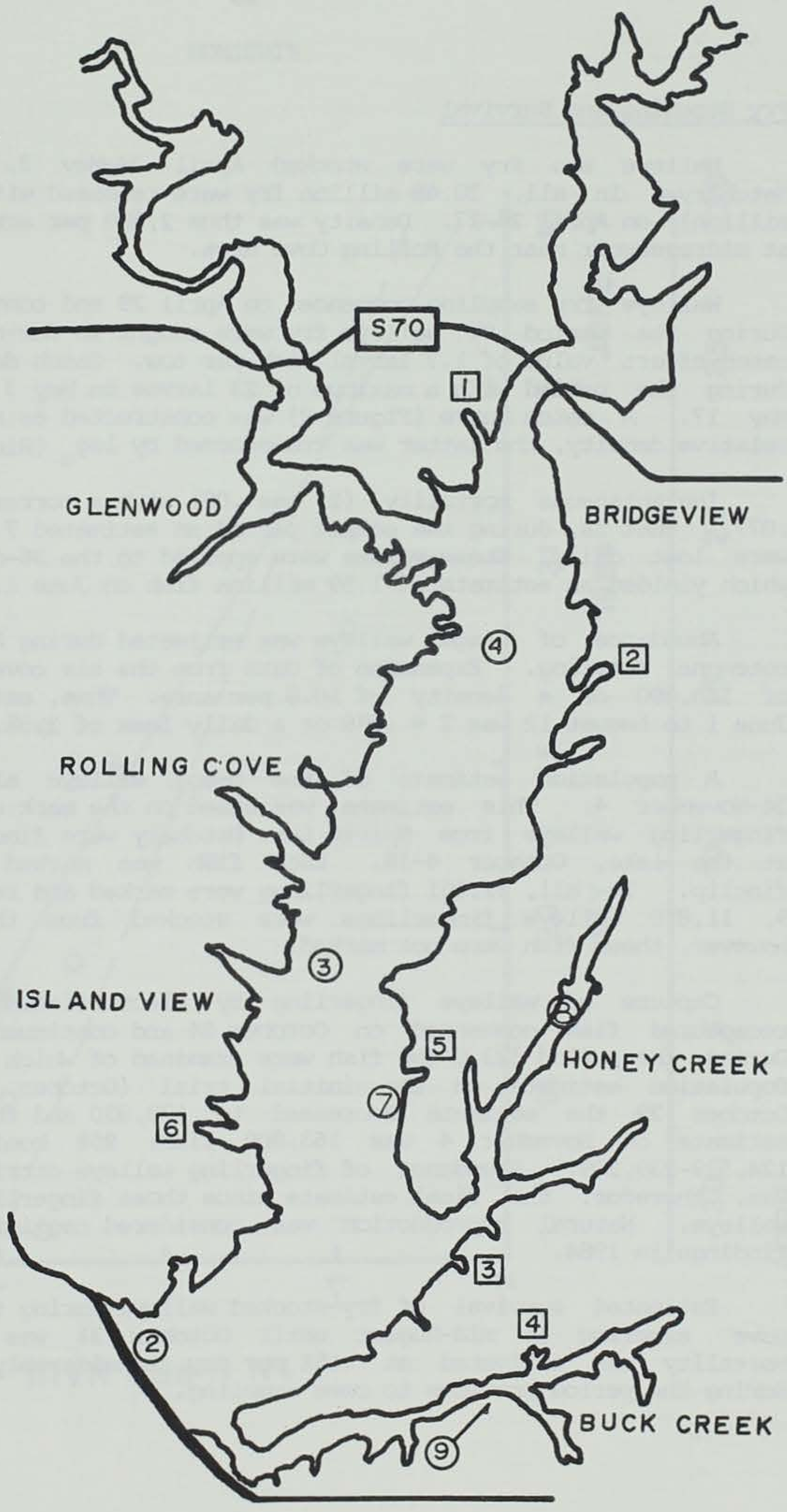

Figure 1. Stations sampled with trawl and rotenone at Rathbun Lake, where circles denote trawl stations and squares denote coves.

FINDINGS

Fry Stocking and Survival

Walleye sac fry were stocked April 24-May 3, 1985, from Rathbun Hatchery. In all, 28.4 million fry were released with peak stocking (17.5 million) on April 26-27. Density was thus 2,580 per acre. Fry were released at midreservoir near the Rolling Cove area.

Walleye fry sampling commenced on April 29 and continued through May 17. During the period 87 walleye fry were caught in tow-net samples yielding a catch-effort value of 1.7 larval fish per tow. Catch decreased geometrically during the period with a maximum of 23 larvae on May 3 to a low of 3 fish on May 17. A catch curve (Figure 2) was constructed as a function of date and relative density, the latter was transformed by $\log_e$ (Ricker, 1975).

Instantaneous mortality (Z) was .081 with a corresponding daily rate of .077. That is, during the sample period an estimated 7.7% of the stocked fry were lost daily. These values were applied to the 36-day post-larval period which yielded an estimate of 1.59 million fish on June 1.

Abundance of 0-age walleye was estimated during August 5-22 using cove rotenone sampling. Expansion of data from the six coves yielded an estimate of 118,800 or a density of 10.8 per acre. Thus, estimated mortality from June 1 to August 12 was Z = .036 or a daily loss of 3.5%.

A population estimate of the 0-age walleye also occurred October 24-November 4. This estimate was based on the mark and recapture method. Fingerling walleye from Spirit Lake Hatchery were finclipped and introduced at the lake, October 4-18. Each fish was marked with a left pectoral finclip. In all, 51,061 fingerlings were marked and released. On September 9, 11,820 walleye fingerlings were stocked from the Rathbun Hatchery; however, these fish were not marked.

Capture of walleye fingerling by electrofishing for examination of recaptured fish commenced on October 24 and continued through November 4. During the period 323 0-age fish were examined of which 101 were finclipped. Population estimate on the initial trial (October 24) was 293,600. On October 29 the estimate decreased to 179,930 and then stabilized. Final estimate on November 4 was 163,800 fish; 95% confidence interval was 124,539-239,209. Abundance of fingerling walleye attributed to fry stocking was, therefor, the final estimate minus those fingerling stocked or 101,243 walleye. Natural reproduction was considered negligible, as described for findings in 1984.

Estimated survival of fry-stocked walleye during the 80-day period from cove sampling in mid-August until October 31 was 85.9%. Conversely, mortality was estimated at .15% per day, considerably lower than mortality during the period previous to cove sampling.

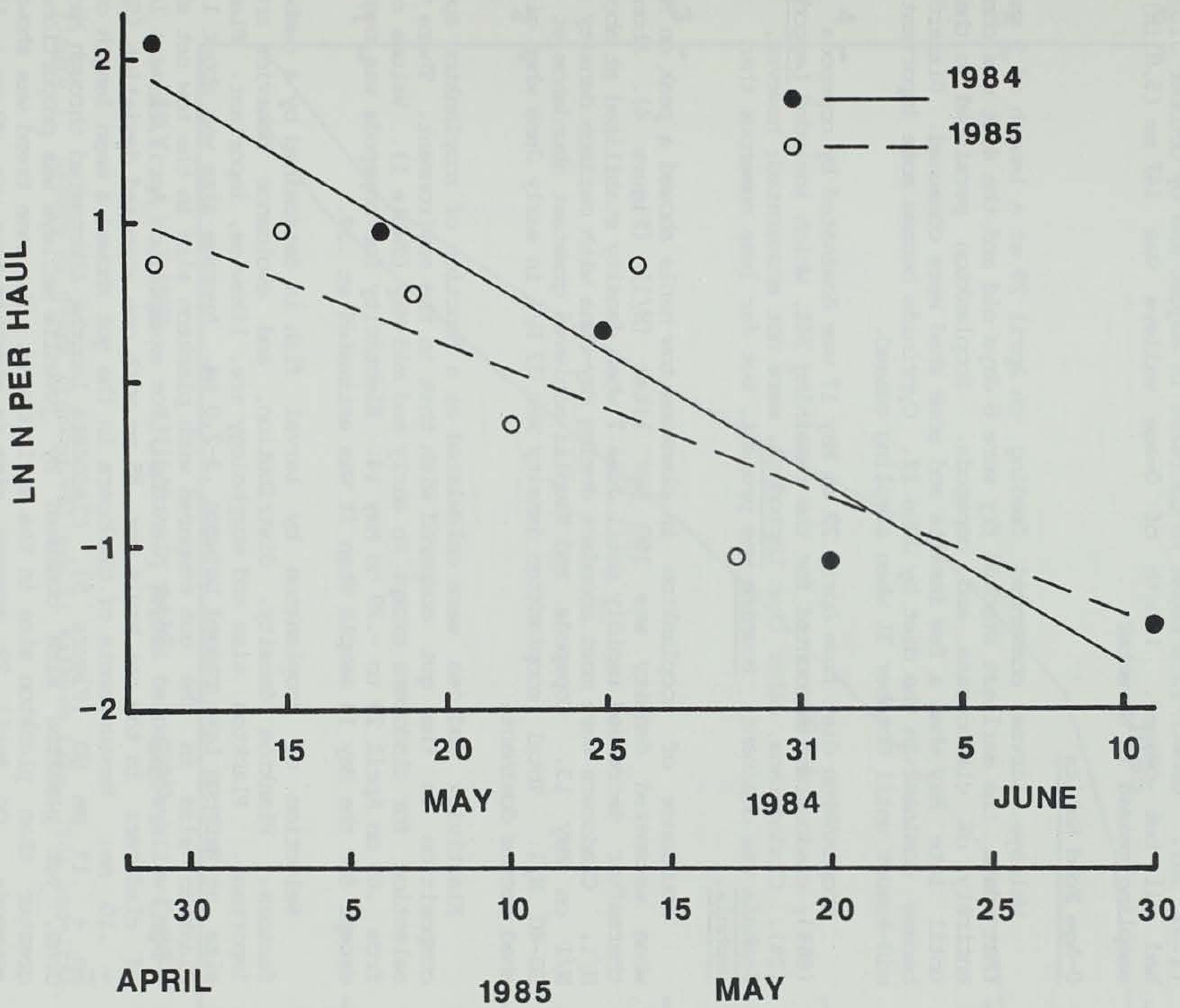

Figure 2. Catch curve of larval walleye from meter net tows at Rathbun Lake, 1984 and 1985.

0-Age Growth

Juvenile walleye grew most rapidly in July with an increment of 44 mm (1.75 in) (Figure 3). Growth increment in June was, likewise, high at 39 mm (1.55 in). Growth rate began to decrease in August and by October 31 growth had all but ceased. Length of 0-age walleye was 147 mm (5.8 in) when sampling ceased in November.

0-Age Food Habits

Walleye larvae commenced feeding on April 29 at a length of 9 mm. On that date the earliest stocked fry were 8 days old and the diet was composed entirely of cladocerans and copepods. Zooplankton persisted in the diet until late May when a few insects and some shad were consumed. Gizzard shad became dominant in the diet by June 12. Cyprinids became more important from mid-August until October 31 when sampling ceased.

Zooplankton diet from April 29 to May 17 was dominated by copepods (66%); cladocerans accounted for the remaining 34%, which included Leptodora (2%). Cladocerans, other than Leptodora, were not enumerated; however, Daphnia was dominant. Bosmina was present, but far less numerous than Daphnia.

Abundance of zooplankton in plankton tow hauls showed a peak on May 13 when estimated density was 150 per liter (N/l) (Figure 4). Abundance thereafter decreased rapidly until June 7 when density stabilized at about 10 N/l. Cladocera were most abundant during May-June with maximum density of 78 N/l on May 13. Copepods and Nauplii achieved greatest abundance at about 30-40 N/l. Total zooplankton density was 32 N/l in early June when gizzard shad became dominant.

Electivity indices were calculated as a function of zooplankton species composition in the gut compared with that in the environment. There was a selection for cladocera except in early and mid-May (Table 1). Values ranged from .65 on April 29 to -.39 on May 14. Electivity for copepods was negative except for the May 14 sample when it was estimated at .39.

Selection of zooplankton by larval fish is determined by a number of factors. Plankton density, distribution, and avoidance behavior are all important. Plankton size and morphology are, likewise, important. Plankton size at Rathbun Lake ranged between .3-2.0 mm. Average size was about 1 mm. Plankton size in the gut compared with plankton size in the tow net showed 0-age walleye selected larger plankton. For example, on April 29 mean length of cladocera in tow net hauls was .55 mm with one standard deviation (SD) of ± .10 mm. Measurements of cladocera in the gut showed a mean length of .83 mm ± .17 mm SD (Figure 5). Cladocera lengths fluctuated through May and June, yet plankton size consumed by juvenile walleye was proportionately greater than plankton size in the environment. The same trend was shown for copepods. On April 29 average size in plankton tows was .48 mm ± .15 SD, while mean length in the juvenile walleye ration was .88 mm ± .51 mm SD.

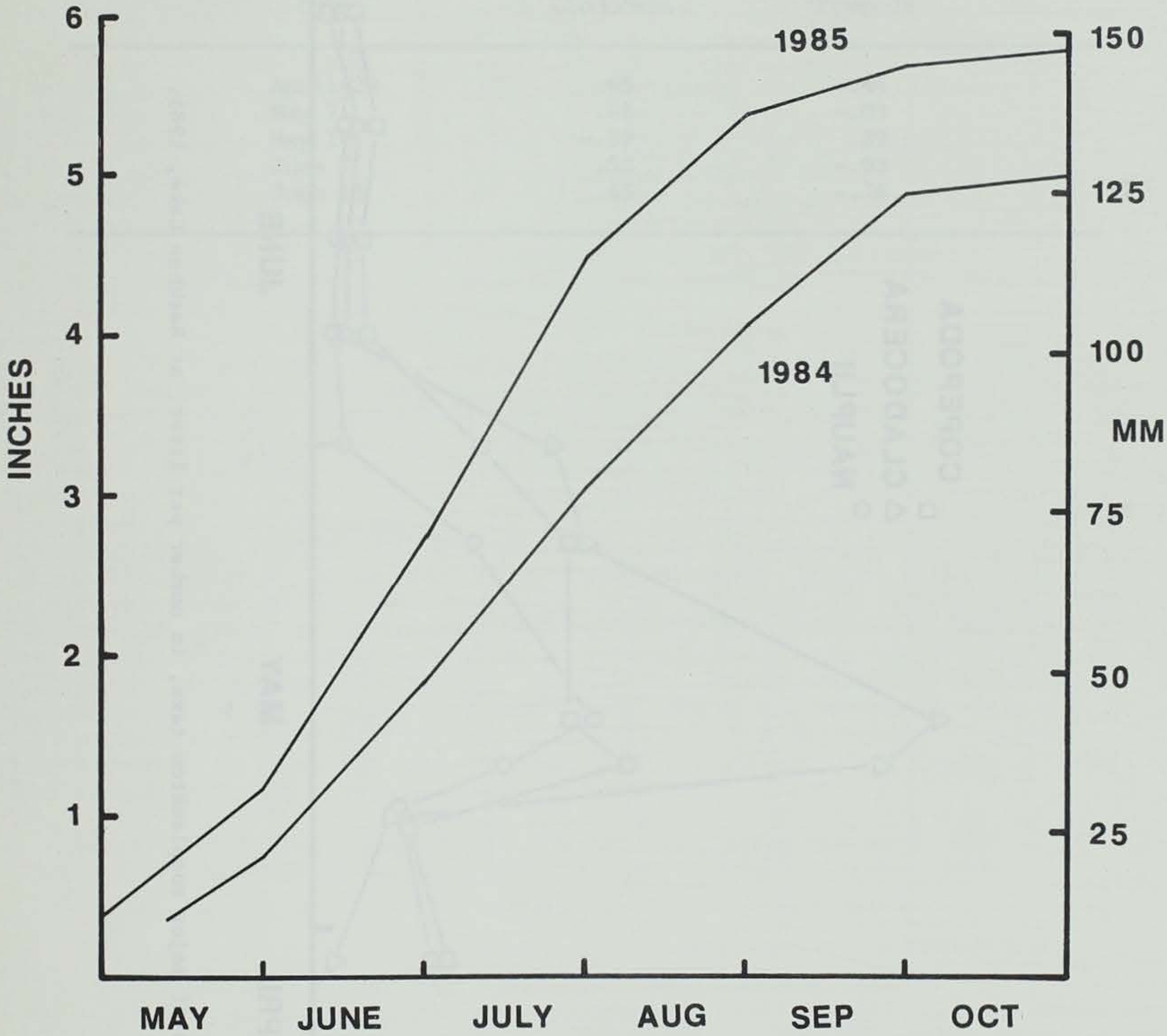

Figure 3. Growth of 0-age stocked walleye at Rathbun Lake, 1984 and 1985.

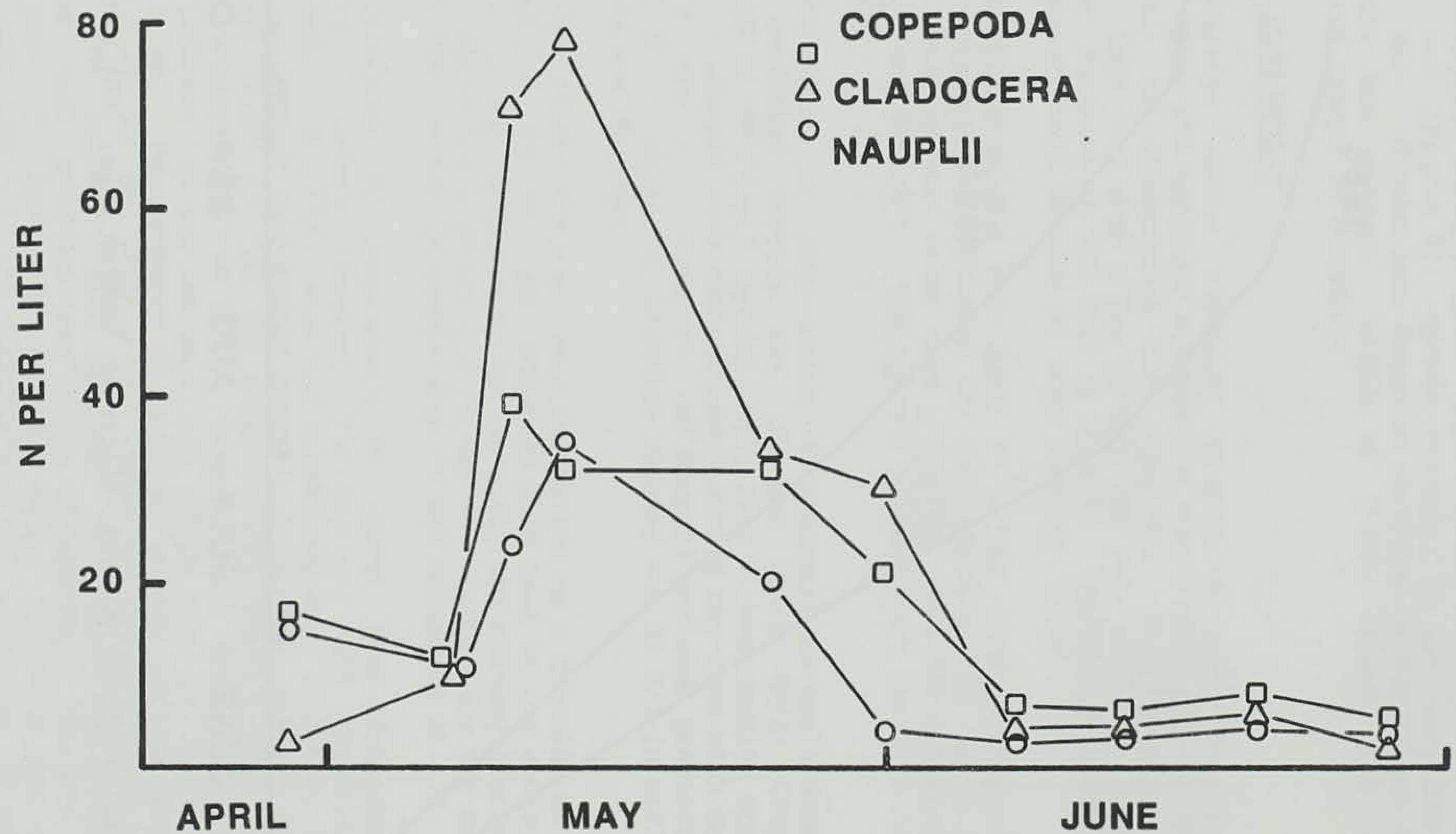

Figure 4. Abundance of major zooplankton taxa, in number per liter, at Rathbun Lake, 1985.

Table 1. Electivity indices of major taxa of zooplankton consumed by 0-age walleye at Rathbun Lake, 1985.

Date	Cladocera	Copepoda
April 29	.65	-.44
May 7	.03	-.03
May 14	-.39	.39
June 7	.50	-.93
June 13	.45	-.76

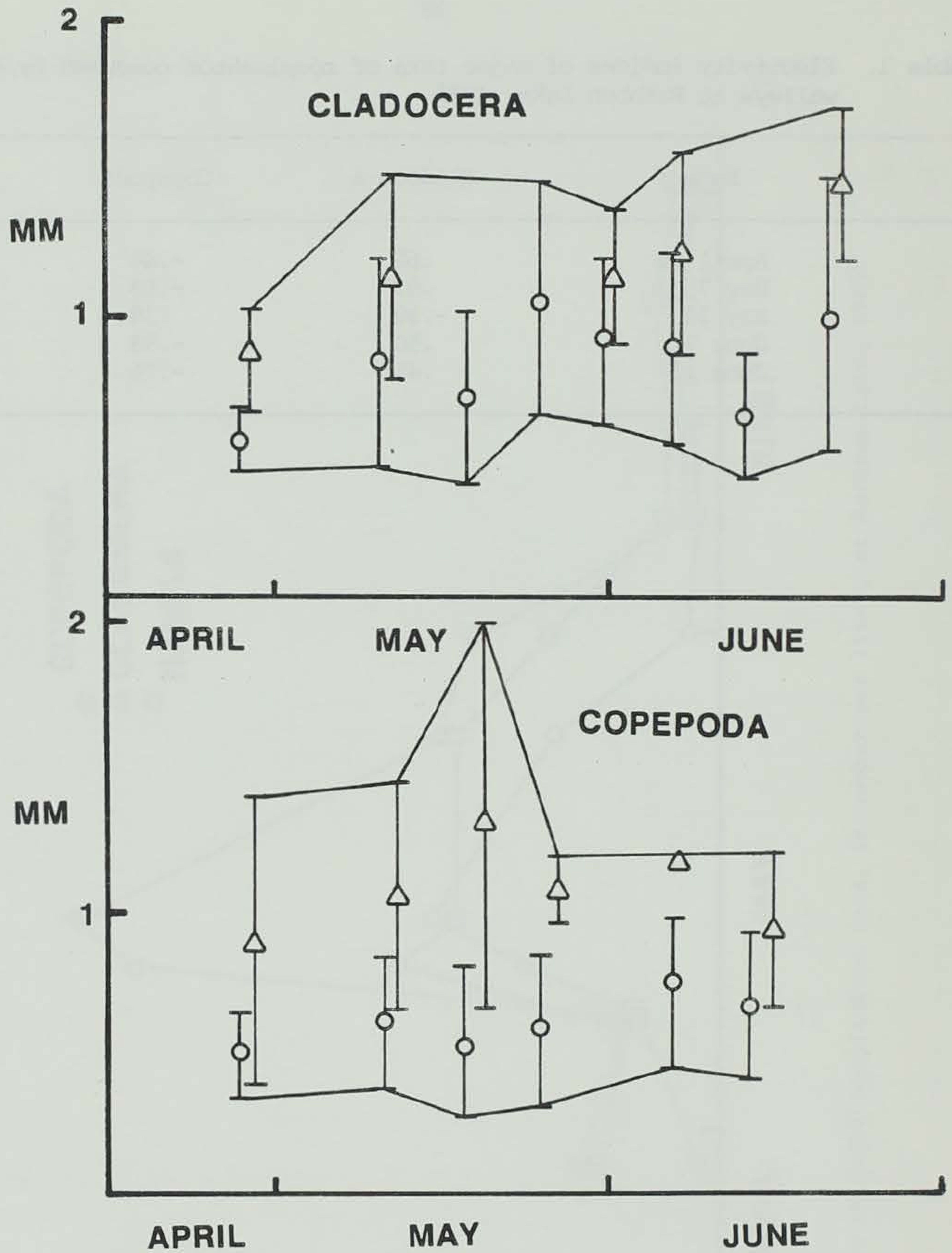

Figure 5. Length distribution of zooplankton in 0-age walleye diet (Δ) and in Rathbun Lake (o), 1985. Vertical bars denote ± one standard deviation.

The diet of juvenile walleye was fully piscivorous by early June when mean length was 33 mm (1.3 in). From May 18-June 12, 56% of the ration, by weight, was identified as gizzard shad, while 39% were unidentified fish. Examination of samples from meter net tows showed at least 95% of the larval fish of a size consumed by 0-age walleye, were gizzard shad. Thus, by inference a majority of the unidentified fish in the gut were shad meaning 90-95% of the ration was gizzard shad. The remaining 5% of the diet consisted of zooplankton (4%) and insects (1%).

From June 13 through August 15, shad continued to dominate the diet of young walleye; however, cyprinids began to become evident in the samples. Shad contributed 68%, unknown fish 26% and cyprinids 5% during this period. It could not be estimated what fraction of the unknown group were cyprinids or shad. From August 15 through October cyprinids dominanted the diet at 35%, shad at 32%, white bass at 21% and unknown at 10%. The remaining 2% consisted of drum, insects and zooplankton.

The upper and lower limit of forage fish size available to 0-age walleye at Rathbun were established based upon walleye growth and fish length in the gut at various walleye lengths during the growing season. The method was similar to that used by Parsons (1971). Upper limits of forage fish size were of importance, particularly with reference to growth and availability of gizzard shad. Decrease of gizzard shad in the ration accompanied by an increased use of cyprinids by juvenile walleye was primarily a function of availability. That is, gizzard shad grew rapidly during July and became morphologically unavailable to walleye by early August. Cyprinids were abundant enough to fill the void created by the rapidly growing shad. For example, 100% of the gizzard shad population was available to 0-age walleye through June 1 (Table 2). By July 15 only 74% of the shad population, by size, was available to the juvenile walleye. This decreased to 51% and 9% on July 1 and 15, respectively. Conversely 100% of the juvenile emerald shiner population were available to 0-age walleye through August 1; however, by September 1, only 13% were available to 0-age walleye. Red shiners provided available forage from July 15 through September.

Table 2. Percent of gizzard shad and cyprinid populations which were morphologically available to 0-age walleye at Rathbun, 1985.

Date	Juvenile Gizzard Shad	Juvenile Emerald Shiner	Red Shiner All Ages
May 15	100	---	0
June 1	100	---	0
June 15	74	100	0
July 1	51	100	2
July 15	9	100	100
August 1	4	100	100
August 15	2	51	100
September 1	0	13	100
September 15	0	0	100
October 1	0	0	100

Fingerling Stocking

Fingerling walleye were stocked at the rate of 5.7 per acre with 51,061 fish coming from the Spirit Lake Hatchery and the remaining 11,495 from the Rathbun Hatchery. Electrofishing gear was used to measure catch-effort of fingerling walleye, including fall-stocked fish and the contribution of spring-stocked fry to the population of 0-age fish.

Success of 0-age walleye stocked in 1984 was evaluated by comparing the number of I-age fish alive in 1985 to the initial stock. Electrofishing effort in October, 1985 yielded 75 I-age walleye of which 17 had been fin clipped the previous year. Thus, 22.7% were marked. In 1984, 53.2% of the year class had been marked. This was based upon known number of fingerlings marked and population estimate of unmarked fingerlings in October, 1984. The difference between 53% marked walleye in 1984 and 23% marked in 1985 was due to differential mortality between fingerling-stocked fish and fry-stocked fish between October, 1984 and October, 1985. Actual mortality of the 1984 year class was unknown because a population estimate was not made. However, the mortality rate of fry-stocked 0-age fish between August 12 and October 31 in 1985 (.19% per day) was applied to the 1984 fry-stocked walleye segment during the November 1984-November 1985 period. The daily rate was extrapolated to an annual rate of 50.1%. Based on this premise, the annual mortality rate for the hatchery-stocked fingerling segment of the 1984 year class was calcuated at 91% as I-age fish.

DISCUSSION

Good survival of fry-stocked walleye in 1985, combined with fingerling-stocked fish, produced an estimated year class strength of 14.9 0-age walleye per acre in November. In November, 1984, the value was 6.6 per acre. Average stocking rate of fingerling walleye from 1975-1983 was 5.2 per acre with a maximum of 10.8 per acre in 1979 and a minimum of 2.4 per acre in 1978 and 1982. Contribution of the 1985 year class to the fishery should be considerably greater than any of the previous year classes, provided survival continues to be greater than 50%

Increased survival of fry-stocked walleye may be attributed to at least two influences. First, stocking method was changed such that fry were introduced offshore in midreservoir where plankton populations were most dense and littoral predation was minimum. Second, the plankton population in 1985 included the large species, Leptodora, which was more important in the diet than the previous year. Regardless of the mechanism for increased survival there was a 2.3-fold difference in autumn density of 0-age walleye between 1984 and 1985.

Growth was also accelerated in 1985 where mean length in October was 17% greater compared to 1984. Food habits in both years showed cyprinids, mainly emerald and red shiners, provided a major portion of the diet when gizzard shad became unavailable. These cyprinids should continue to be important as a food source for juvenile walleye during August-October.

RECOMMENDATIONS

Hatchery-reared and nursery lake-reared walleye will be tagged with a binary coded wire tagger instead of finclipping. Different fingerling sizes will receive different codes to differentiate survival between size groups.

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE:	Iowa	NAME:	Assessment of Population
PROJECT NO.:	F-94-R-6		Dynamics and Fish Stocking
STUDY NO.:	4		Methods at Rathbun Lake
JOB NO.:	2	TITLE:	Walleye stock assessment

Period Covered: 1 July 1985 through 31 March 1986

ABSTRACT: Stock assessment of walleye > 45 cm (17.5 in) at Rathbun Lake yielded an estimate of 6,141 with a biomass of 3.03 kg/ha (2.70 lb/ac). Females began maturing at age IV, while males began recruiting to the reproducing population at age III. The mode for brood females was age VI, while that for males was age VII. Growth rate showed females were 68 cm (27 in) at age VIII; males at the same age averaged 57 cm (22.5 in). Length-weight relationships were determined separately for males and females; however, the regressions were not significantly different ($p > .05$). W_r for males and females was 100 and 104, respectively. Walleye harvest in 1985 was 1,317 of which 645 were greater than 45 cm (17.5 in). Thus, exploitation rate was estimated at 10.5% compared to an exploitation rate in 1984 of 14.8%.

JOB 2 OBJECTIVE

To estimate abundance, biomass, natural mortality, fishing mortality and growth of walleye at Rathbun Lake.

INTRODUCTION

Walleye stock assessment at Rathbun Lake is based upon two needs. First, optimum yield should be sustained in the fishery. Second, the source of brood fish should be maintained at levels adequate to meet state-wide stocking requests. Approximately 45 million walleye fry are produced annually at Rathbun Hatchery requiring eggs from approximately 600-1,000 female walleye.

Sportfish census at Rathbun Lake has shown a systematic decrease in adult walleye since 1972. Walleye harvest that year was 13,600 fish. Catch of walleye in 1978 was 2,900 fish and harvest decreased to 1,300 and 1,600 in 1981 and 1984, respectively. Gill netting statistics during brood fish taking efforts also showed a downward trend in catch-effort. Of primary concern, however, was the lack of young brood fish entering the hatchery. This indicated inadequate stocking, poor survival, overharvest, or a combination of these factors. Goals of Job 1 will address stocking density and success, while this segment will determine optimum sustained harvest of the population.

METHODS AND PROCEDURES

Population estimation was determined by mark-recapture using the Schumacher-Eschmeyer method. All fish brought into the hatchery in April were marked with a partial anal fin-clip and then returned to the lake after they were stripped. In all, 998 fish were marked; 399 were males, while 599 were females. Recapture effort with fyke nets commenced May 21, assuring adequate time for redistribution of marked fish in the reservoir. Sampling continued through July 12 with a total effort of 532 net-days. In addition the creel clerk examined all walleye for marks. Biomass of the population was computed as a function of the population estimate, length-frequency distribution and length-weight regression.

An expandable creel census occurred from April 8 to October 3. The daily survey period was from 7:00 A.M. to 7:00 P.M. during April, May and September, and from 6:00 A.M. to 10:00 P.M. during June, July and August. The survey day was stratified and the first or last half of the above hours were designated as A- or B-days, respectively. Further stratificaton occurred between weekend and weekdays.

The lake was subdivided into four survey areas including the main pool, southfork area, headwaters area and the Honey Creek-Buck Creek complex. Angler counts were made hourly, or every two hours, if hourly counts were impractical because of weather or a large number of anglers. Anglers were interviewed between and during the counts to determine catch by species and size. Fishing pressure (angler hours) was expanded seperately for boat and shore anglers as a function of average counts, fishing days in the period and fishing day length. Total catch was a function of pressure and catch-effort for each period, area, weekday-weekend day, and boat-shore segments.

FINDINGS

Population Abundance and Biomass

Population abundance of walleye $\geq$ 45 cm (17.7 in) was estimated at 6,141 and based upon examination of 80 fish of which 12 were recaptured. Lower and upper confidence intervals at the 95% level were 3,855 and 15,080, respectively. The estimate commenced in late May at about 1,000 which increased steadily through July when it peaked at 8,815 (Figure 6). Thereafter the estimate decreased until mid-August when it stabilized at about 6,000. Abundance of male and female walleye were also estimated independently. Fish could not be sexed when fish were being caught for examination of recaptures; however, April length-frequencies for male and female were markedly different with males significantly smaller than females (Figure 7). The number of marked males and females was also known. Thus, fish which were captured late in May-July were measured and the sample proportionately divided between male and female by comparing with April length-frequencies. This method yielded estimates of 3,564 and 3,035 for male and female walleye, respectively. The sum (6,599) was about 7% greater than the estimate when sexes were combined.

Length-frequency distribution of walleye in 2.5-inch bar mesh gill nets in April ranged from 14 to 30 inches. Size of males was smaller than females with a mode at 22 inches (Figure 7). Size ranged from 14 to 26 inches. Mode in the female size distribution was 27 inches with a range of 19 to 30 inches. Eighty-two percent of the females were > 24 inches.

Walleye biomass was determined as a function of abundance at each centimeter size group, length-frequency distribution and length-weight relationships. Male biomass was computed for fish > 40 cm (> 15.8 in) at 6,190 kg (13,635 lb) or 1.54 kg/ha (1.24 lb/ac). Biomass for females was determined for fish > 47 cm (> 18.5 in) with an estimate of 9,987 kg (21,998 lb) or 2.24 kg/ha (2.00 lb/ac). Combined biomass of male and female populations yielded an estimate of 3.03 kg/ha (2.70 lb/ac).

Body Condition

Length-weight relationships of walleye were best described by the functions

1985: $\log Y = -4.6938 + 2.8916 \log X$, male
1985: $\log Y = -5.1823 + 3.0861 \log X$, female
1984: $\log Y = -5.0289 + 3.0206 \log X$, male
1984: $\log Y = -5.0639 + 3.0373 \log X$, female

where Y was weight in grams and X was length in millimeters.

Body condition in 1985, as measured by k-factor, showed male walleye averaged 1.03 with a standard deviation of $\pm$ .07. In 1984 mean k-factor was 1.07 $\pm$ .07. Female body condition factors in 1984 and 1985 were 1.10 $\pm$ .12 and 1.15 $\pm$ .10, respectively.

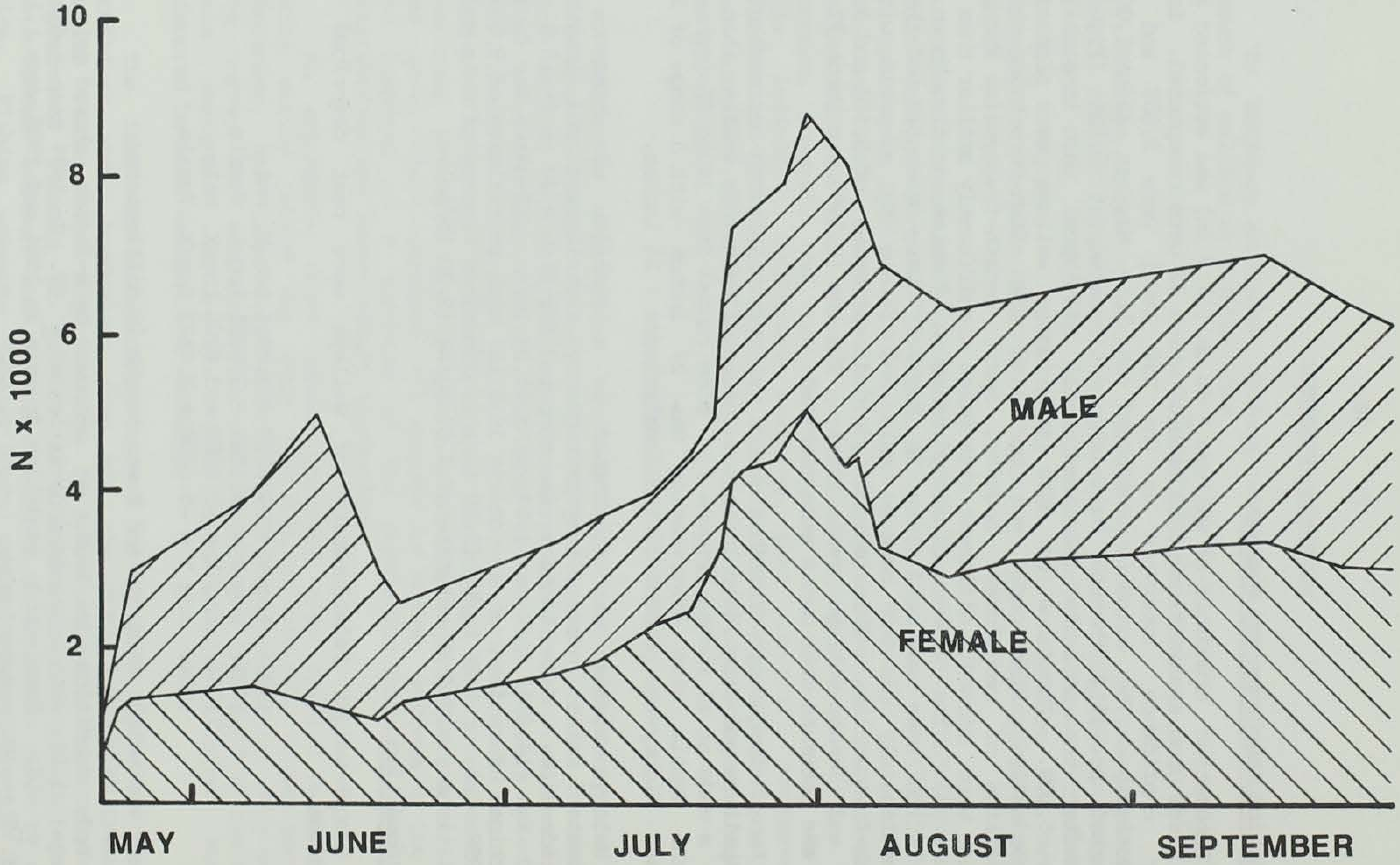

Figure 6. Population abundance of walleye > 45 cm at Rathbun Lake, 1985.

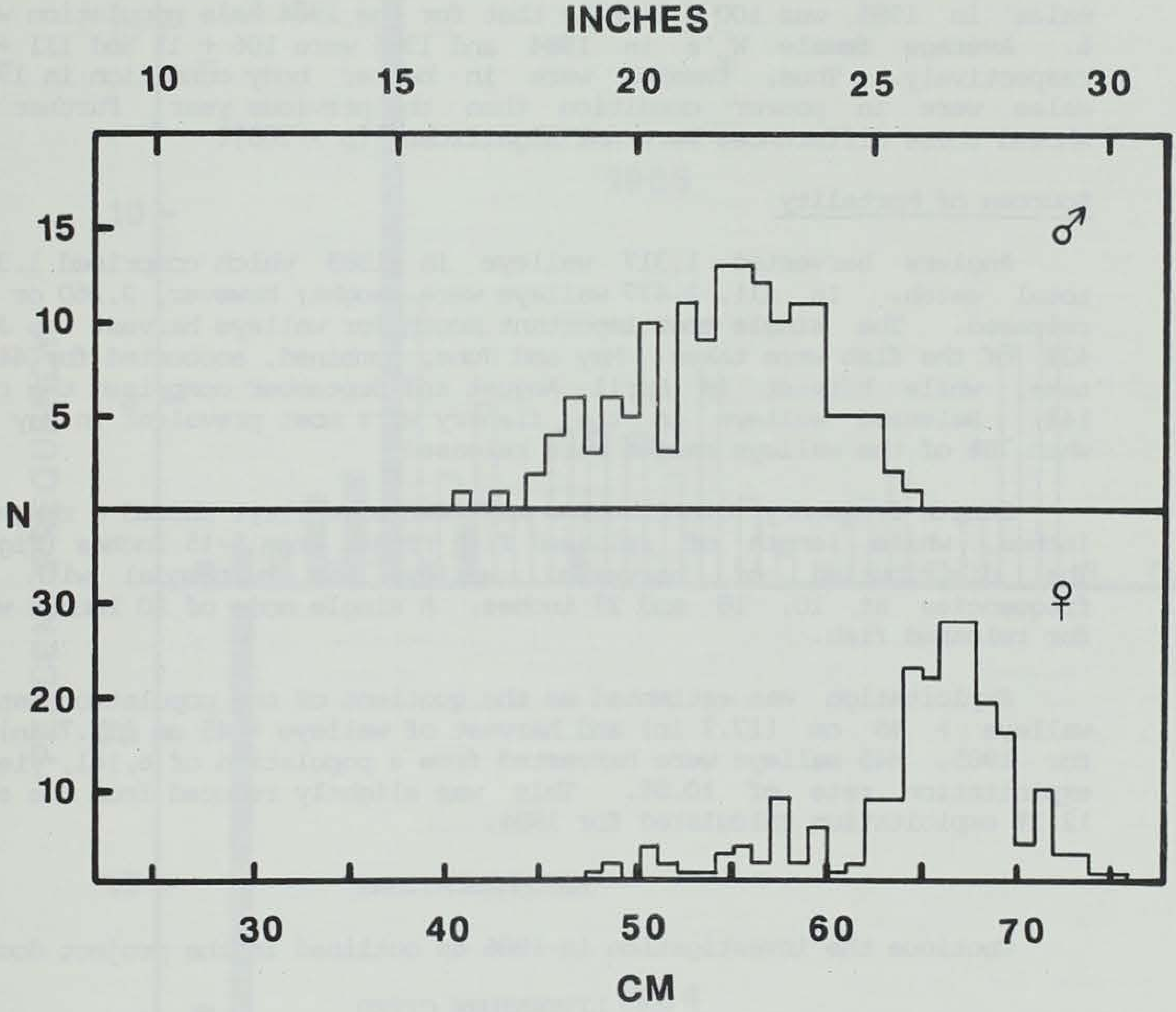

Figure 7. Length-frequency distribution of male and female walleye in April, 1985.

A tentative length-weight relationship standard was developed from Colby et al. (1979). The function was described by

$$\text{Log } Y = -5.1385 + 3.0548 \text{ Log } X$$

where parameters were the same as before. Mean W_r for Rathbun walleye males in 1985 was 100 $\pm$ 7 while that for the 1984 male population was 104 $\pm$ 6. Average female W_r's in 1984 and 1985 were 106 $\pm$ 11 and 111 $\pm$ 10, respectively. Thus, females were in better body condition in 1985 while males were in poorer condition than the previous year. Further analysis showed these differences were not significant ($p > .05$).

Sources of Mortality

Anglers harvested 1,317 walleye in 1985 which comprised 1.3% of the total catch. In all, 3,477 walleye were caught; however, 2,160 or 62% were released. The single most important month for walleye harvest was July when 42% of the fish were taken. May and June, combined, accounted for 44% of the take, while harvest in April, August and September comprised the remaining 14%. Released walleye in the fishery were most prevalent in May and June when 70% of the walleye caught were released.

Length-frequency distribution of creeled walleye showed a range of 8-31 inches, while length of released fish ranged from 5-15 inches (Figure 8). The distribution of harvested walleye was multimodal with greatest frequencies at 10, 18 and 27 inches. A single mode of 10 inches was shown for released fish.

Exploitation was estimated as the quotient of the population estimate of walleye > 45 cm (17.7 in) and harvest of walleye > 45 cm (17.7 in). Thus, for 1985, 645 walleye were harvested from a population of 6,141, yielding an exploitation rate of 10.5%. This was slightly reduced from the estimated 12.2% exploitation calculated for 1984.

RECOMMENDATIONS

Continue the investigation in 1986 as outlined in the project documents.

LITERATURE CITED

Colby, P. J., R. E. McNicol and R. A. Ryder. 1979. Synopsis of biological data on the walleye Stizostedion v. vitreum (Mitchill 1818). FAO Fisheries Synopsis No. 119. United Nations, Food and Agriculture Organization. Rome.

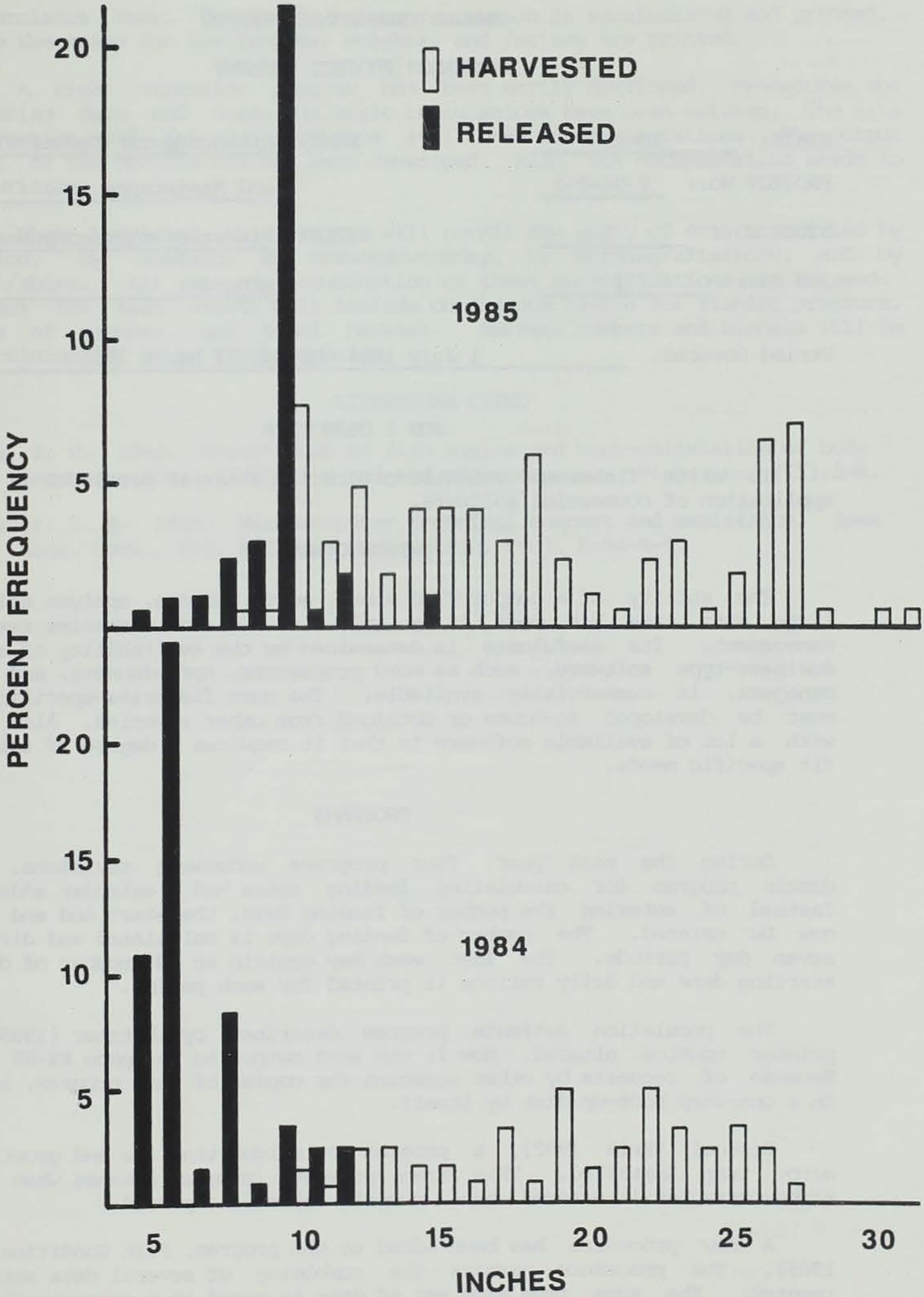

Figure 8. Length-frequency distribution of walleye in the sport fishery at Rathbun, 1984 and 1985.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE:	Iowa	NAME:	Microcomputer Technical Support and Assistance
PROJECT NO.:	F-94-R-6		
STUDY NO.:	5	TITLE:	Fisheries microcomputer programs
JOB NO.:	1		

Period Covered: 1 July 1985 through 31 March 1986

JOB 1 OBJECTIVE

To write fisheries oriented programs and assist personnel in fisheries application of commercial software.

INTRODUCTION

The ability of a computer to store, sort, arrange, analyze and retrieve large data sets has made it a valuable tool for fisheries research and management. Its usefulness is determined by the availability of software. Business-type software, such as word processors, spreadsheets, and data base managers, is commercially available. The more fisheries-specific software must be developed in-house or obtained from other agencies. Also a problem with a lot of available software is that it requires a degree of tailoring to fit specific needs.

PROGRAMS

During the past year, four programs underwent revisions. A public domain program for calculating feeding rates had a calendar added to it. Instead of entering the number of feeding days, the start and end dates can now be entered. The number of feeding days is calculated and divided into seven day periods. The last week may contain an odd number of days. The starting date and daily rations is printed for each period.

The population estimate program described by Mitzner (1985) had its printer routine altered. Now it can send output to an Epson FX-85 printer. Because of requests by other agencies for copies of this program, it was put on a one-step boot-up disk by itself.

Disbcal (Frie 1982), a program for calculating age and growth, had an error trap installed. This trap prevents program crashes when a null or alpha-character is entered when a numeric value is expected.

A new procedure has been added to the program, Fish Condition (Mitzner 1985). The procedure permits the combining of several data sets without reentry. The sums from each set of data is saved to a separate file at the time each set is analyzed. The new procedure accesses these files and accumulates them. The length-weight regression is recalculated and printed. Also the means for the lengths, weights, and factors are printed.

A creel expansion program has been partly developed. Procedures for entering data and doing the basic calculations have been written. The data correction and deletion routines still need minor alterations. The output part of the program has not been developed. Also, the documentation needs to be written.

When completed, this program will permit the entry of data stratified by period, by section, by weekend/weekday, by morning/afternoon, and by boat/shore. All or any combination of these stratifications may be used. Output for each strata will include confidence limits for fishing pressure, rate of success, and total harvest. Harvest numbers and biomass will be calculated for up to twenty species.

LITERATURE CITED

Frie, R. V. 1982. Measurement of fish scales and back-calculation of body lengths using a digitizing pad and microcomputer. Fisheries, 7(5):5-8.

Mitzner, L. R. 1985. Microcomputer technical support and assistance. Iowa Cons. Comm., Fed. Aid Fish Restoration, Proj. F-94-R-5.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE:	Iowa	NAME:	Microcomputer Technical Support and Assistance
PROJECT NO.:	F-94-R-6		
STUDY NO.:	5	TITLE:	Development of state-wide fisheries data storage/ retrieval systems
JOB NO.:	2		

Period Covered: 1 July 1985 through 31 March 1986

JOB 2 OBJECTIVE

To provide technical assistance for developing and updating file systems and provide continuity among systems and users.

INTRODUCTION

The use of computers is nothing new to the Fisheries Section. Since the mid 1960's, a main-frame computer at Iowa State University has been used for analysis of large data blocks. The development of desk-top computers has made it an important tool for fisheries research and management.

In 1982, a 128K RAM Apple III micro-computer was purchased and located at Chariton. Since then eight additional field stations have been equipped with compatable computers. These stations are the four district offices, Rathbun and Fairport hatcheries, Clear Lake management station, and the Bellevue Research Station. The distribution of computers to field stations has created the need for technical support. This support maintains continuity among users and systems.

TECHNICAL ASSISTANCE

Three new micro-computer systems were installed this year. Personnel at the newly equipped stations were given informal training on the use and care of both hardware and software. This included an introduction to the operating systems. They were also instructed on how to format, copy, and catalog disks. Methods for developing, organizing and maintaining files were also presented.

As new software was purchased or developed it was demonstrated to future users. Also, a hot line was provided at Chariton to answer questions about the operation of both hardware and software.