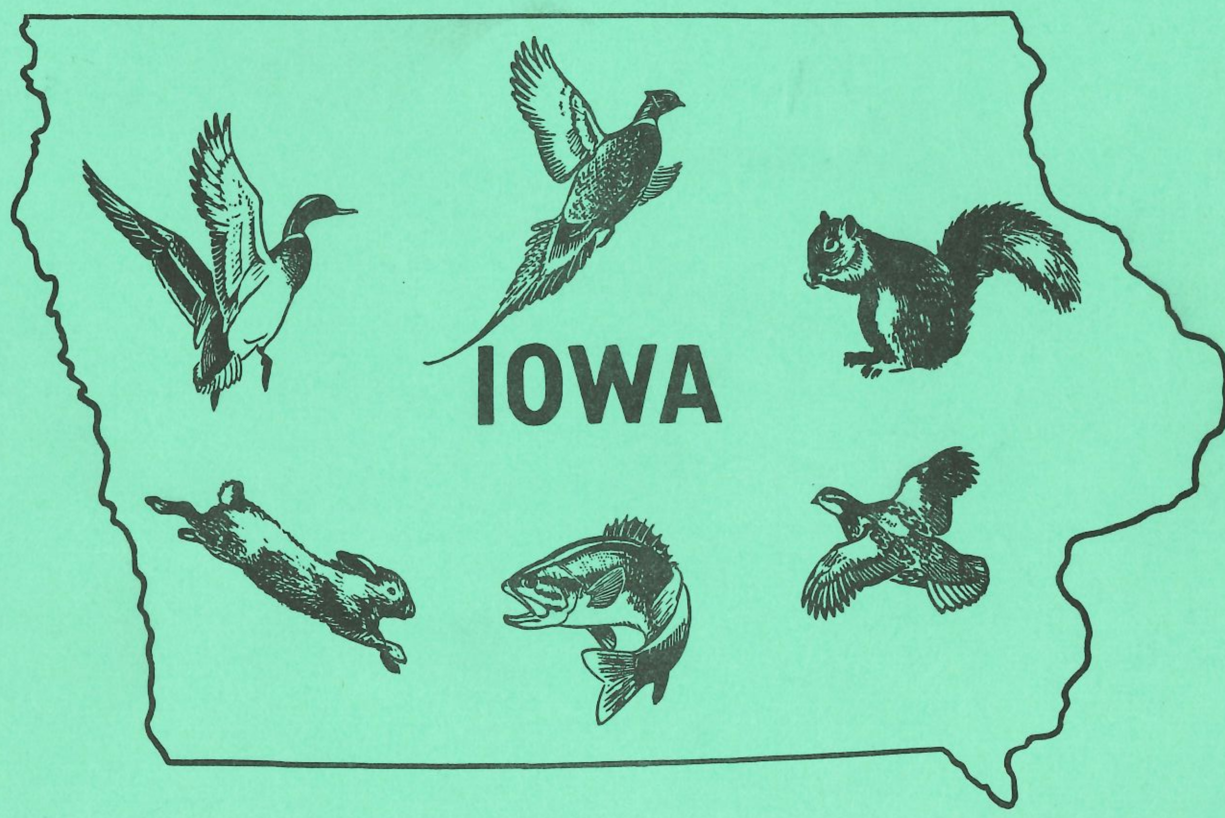
1966

QUARTERLY BIOLOGY REPORTS



FISH AND GAME DIVISION — BIOLOGY SECTION

STATE CONSERVATION COMMISSION

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QUAIL STUDIES ON TWO AREAS IN SOUTHERN IOWA, 1966

M. E. Stempel
Game Biologist

Gene Hlavka
Game Biologist

Quail counts on the two study areas in southern Iowa were continued in 1966. The Wapello Area is situated southwest of Ottumwa; the Decatur-Wayne Area, about 8 miles north of the Iowa-Missouri boundary. Coveys are located with the aid of dogs and by "sign" in both autumn and winter. The standard roadside quail whistling cock counts are conducted from May through August.

The 1966 brood stock on both areas totaled 32 coveys --- an increase of 12 coveys over the 1965 winter counts. More than 14 weeks of quail calling indicated good production in 1966. The fall 1966 covey counts on both areas totaled 60 --- an increase of 7 coveys over the counts of 1965 and 19 more coveys than the average for the preceding 2 years. It took 0.86 hours to flush a covey during the fall count in 1966. Quail sighted per 100 miles driven on combined census routes increased from 1 in 1965 to 14 in 1966. Farmers' estimates of the number of coveys were also up in 1966. Nearly 20 percent of the hunting activity was in October (10 hunting days available). Hunting activity was evenly distributed in November, December and January with 27 percent for each month.

RESULTS OF 1966 IOWA WATERFOWL BANDING PROGRAM

Richard Bishop
Game Biologist

The banding of waterfowl was carried on in Iowa during 1966 much as it has been in preceding years. The banding of migratory birds supplies data on migrations, populations, distributions, and mortality. Such information is necessary for the better management of the species concerned. Iowa's banding program is based on drive-trapping and night-lighting young birds on the breeding grounds and bait-trapping flying birds prior to the hunting season. A total of 4,880 birds were banded and released in 1966 - 2,588 by night-lighting and 2,292 by bait-trapping. The birds banded consisted of 12 species of ducks and 8 species of other marsh birds. Blue-winged teal and wood ducks were the two most important and abundant species banded. Of the blue-winged teal banded, about 94 per cent were young birds.

A COMPARISON OF THE AGE STRUCTURE OF TWO RED FOX POPULATIONS

Robert Phillips
Game Biologist

Two study areas, northeast Iowa and central Iowa, were selected for comparing age ratios of red foxes. Eye lenses from 162 foxes were collected in the fall of 1966. Dried lens weights were used to separate juvenile from adults. The eye lens data showed a 2.6 young per adult ratio for northeast Iowa as compared to 6.6 young per adult for central Iowa. The high percent of juvenile foxes in the central Iowa sample is believed to reflect the results of long-term intensive trapping on a limited area. The smaller young per adult ratio for northeast Iowa is believed to be the more normal age ratio.

THE RELATIONSHIP OF LAKE MORPHOMETRY AND THERMAL STRATIFICATION

Jim Mayhew
Fisheries Biologist

Comparison of lake basin characteristics in relation to thermal stratification is made for five southern Iowa recreational lakes. Slope of the basin, area development, and volume development were used to make these studies. Those lakes with similar basin development also had similar stratification characteristics. Lakes with a mean slope of 0.05 and volume development of less than 1.15 were stratified and had dissolved oxygen depletion in the hypolmnion. Impoundments with mean slope of 0.035 and volume development of 1.25 had limited or temporary thermal layering. When basin slope was less than 0.02 and volume development more than 1.4, the lake did not stratify. There was intensification of thermal layering with declining volume and area development and increasing basin slope. Comparison of basin characteristics and predictions of thermal layering in an incomplete recreational lake and a hypothetical cone-shaped basin are also presented.

THE IOWA TROUT PROGRAM ---WITH SPECIAL REFERENCE TO THE YEARS 1956 THROUGH 1966

Robert Schacht
Fisheries Biologist

A short history of trout culture in Iowa is presented. During the years 1956 through 1966 approximately 2,000,000 trout were stocked in Iowa streams. Rainbow trout made up 74 per cent of the fish planted in the 11 year period. These fish were 8 to 10 inches in length and weighed one-half pound. According to creel census data the trout catch and rate of angler success has increased greatly. In 1965 the average trout fisherman caught 2 fish compared to one fish in 1960.

RESULTS OF EXPERIMENTAL CHANNEL CATFISH STOCKING IN TWO IOWA LAKES

Robert Hollingsworth
Fisheries Biologist

Channel catfish stocking programs were initiated on Spirit and East Okoboji Lakes in 1961. Fingerlings were stocked at varying rates in Spirit Lake for five successive years. Small adults were stocked in East Okoboji for four years at 5,000 per year. Creel census and lake survey data indicate that fishable catfish population has been established in East Okoboji. There is little evidence of survival of Spirit Lake stockings

WESTERN IOWA CREEL CENSUS DATA, 1962 - 1965

Bill Welker
Fisheries Biologist

Data from officer angler contacts at the major streams in western Iowa are summarized for the years 1962 through 1965. Bullheads, channel catfish, and carp were the most frequently caught fish in 1962, 1964 and 1965, and in most cases comprised over 75 per cent of the harvest. Crappie replaced carp among the top three species caught in 1963. Less important fish in the creel include walleye, sauger, largemouth bass, northern pike, bluegill, yellow perch, freshwater drum, sturgeon, buffalo, and suckers.

Catch rates were low ranging up to 1.8 fish per hour. Streams which had highest catch rates were the Little Sioux River 0.7 to 1.2 fish per hour, Missouri River 0.4 to 1.2 fish per hour, Rock 0.7 to 1.3 fish per hour, and Floyd River 0.7 to 1.8 fish per hour.

AGE AND GROWTH OF BIGMOUTH BUFFALO IN CORALVILLE RESERVOIR

Larry Mitzner
Fisheries Biologist

Scale samples were taken from 236 bigmouth buffalo from June 18 through October 7, 1966. Grand average calculated length and weight was determined for 10 age groups with considerable variation in growth for individual year classes. Growth during 1966 was from 92 to 105 days in length with growth terminating by September 16. Growth during different calendar years varied from +40.15 per cent deviation in 1960 to -37.85 per cent deviation from the mean in 1964. Age distribution indicated weak 1963 and 1964 year classes.

ESTIMATED FISH POPULATION IN STRAIGHTENED AND UNSTRAIGHTENED SECTIONS OF A STREAM

Terry Jennings
Fisheries Biologist

During August, 1966 approximately 6.0 miles of Bluff Creek in Boone County was treated with 2.0 ppm rotenone to eliminate all fish within this portion of the stream. A complete eradication of all fish within the project area was accomplished. Complete elimination of fish in this stream presented a unique biological opportunity to estimate fish populations from straightened and unstraightened sections. It was found the straightened section contained an estimated 33,415 fish weighing 242 pounds per acre. The unchanneled segment sustained approximately 40,068 fish weighing 322 pounds per acre.

1965 - OFFICER CONTACT CREEL CENSUS FOR THE MISSISSIPPI RIVER

Don R. Helms
Fisheries Biologist

In 1965, Iowa Conservation Officers collected creel data from 1,679 parties of anglers fishing in the Mississippi River. These contacts, representing a sample of 3,552 man hours of fishing, indicated that the average fisherman caught 1.60 fish per hour. Harvest consisted of 34.9 percent bluegill, 27.0 percent crappie, 9.3 percent bullhead, 8.1 percent bass, 7.9 percent drum, 5.3 percent catfish and 4.7 percent walleye and sauger.

STATUS AND ANALYSIS REPORT OF SQUIRREL PROJECT

Richard John McCloskey, Graduate
Assistant, Iowa State University

Squirrels rank third in importance behind pheasants and cottontails as a hunting resource in Iowa (Kline 1964, Klonglan 1965), and approximately 45 percent of the individuals purchasing licenses hunt squirrels. A cooperative project between Iowa State University and Biology Section, State Conservation Commission was initiated in June, 1966, to determine chronology of production of "spring" and "fall" litters of fox squirrels and the relative importance of each as contributors to fall population. In addition, data were to be obtained with the long range objective of relating chronology and success of production to climate and mast abundance.

Hunting of squirrels has been a fall sport in Iowa for a number of years. Squirrels represent one of the few species that the sportsman may bag at the same rate per hunting hour at the beginning of the season as at the end of the season (Uhlig 1956). Squirrels are apparently underharvested in relation to their numbers and reproductive potential. Biological information is needed in order to make sound recommendations for adjustments in harvest regulations.

Some specific accomplishments of the current study include the following:

1. Two study areas have been established near the Wildlife Research Station, Boone. One is on private land open to hunting and the other is on the Research Farm adjacent to the Research Station. Both areas have been cover mapped.

2. A method of applying back-tags to squirrels for individual recognition has been developed. Certain flaws in the technique have been corrected, and it is hoped that the period of retention will increase from the current 6-weeks.

3. A total of 126 fox squirrels have been examined for reproductive status. Twenty-three were adult females. Uterine scars averaged 3.7. Average numbers of uterine scars identified in other studies were below those found during the current study. Brown & Yeager (1945) reported an average of 2.4 in Illinois; Nixon (1965) found 2.9 as average in Ohio while Packard (1956) reported 2.9 in Kansas.

4. Each of the five pregnant females examined had 3 embryos showing normal development. One female had, in addition to the three normal embryos, four embryos in the process of being reabsorbed.

5. Available information concerning the timing of reproductive events is summarized in Table 1. Some form of reproductive occurs each month within the Iowa populations. Both August and September show peak occurrences of lactating females in the sample. April and June show the highest frequency of births. No incidences of birth were recorded for September and October and apparently little conception takes place during August, September and October. One pregnant female was found during August.

6. Weights of 66 juvenile squirrels examined are summarized in Table 2. Average weights for the juveniles have been calculated for each month. An arbitrary minimum standard of hunter acceptability was set at 75 percent of the average weight of adult squirrels (567 grams) examined during the hunting season (September-January). Actual weights of the individual juveniles were compared to the arbitrary standard. The percentage of individuals of the monthly sample classified as acceptable is listed in the right hand column of Table 2.

7. Study of activity cycles of squirrels on the study areas has been conducted to relate reproductive behavior to chronology of production and to determine what periods of time and weather conditions might be optimal for hunting. Activity observations were conducted in conjunction with general field work required for the project. Observations were accomplished by remaining at a particular spot for a predetermined period of time (ususally 15 minutes). A total of 1,538 spot counts of 15 minute duration have been made during 1966-67 (Table 3).

   Fox squirrel activity seems greatest from 5:00 to 11:00 A.M.. An apparent peak of activity occurs between 6:00 and 7:00 A.M., but a plateau extends from 5:00 A.M. until 8:00 A. M. Afternoon activity is less than that recorded for the morning. A limited increase in activity was noted between 5:00 and 6:00 P.M. with a drastic reduction occurrring within the next hour. The time periods of peak activity do not agree in all cases with published studies of Hicks (1949).

8. Monthly relationships of activity are expressed in Table 4. Peaks of activity occurred in April, July and August. Minimum activity was noted for May, June, December and January.

9. A total of 802 forefeet of fox squirrels was x-rayed to determine age ratios. Squirrels were classified on the basis of degree of calcification of epiphyseal cartilage and the ulna as juvenile (18 weeks or less), subadulat (19 weeks to 12 months), and adult (over 12 months) (Carson 1961). The total ratio for 1966 was 249:253:300 juveniles to sub-adults. The young-adult ratio was 1.66:1.

Management implications as currently viewed from preliminary data might include the following:

1. Fox squirrels are apparently more productive in Iowa than in some of the surrounding states. Adult females exhibit higher placental scar counts and have larger numbers of embryos. The adult:juvenile ratio of squirrels in the hunter's bag generally shows a higher proportion of juveniles, and generally reflects a higher percentage of juveniles in the Iowa population as compared with surrounding states. A "healthy" squirrel population is indicated by all measures of population status currently available.

2. Fox squirrels are not overharvested in Iowa according to presently used measuring devices. Reproductive information is interpreted to indicate that an opening of the squirrel season in August (presently not possible because of legislative restriction) would not adversely affect the population. However, if the arbitrary assumption of hunters desiring young squirrels to weigh a minimum of 75 percent of average adult weight is valid, opening of the season in August would result in most juvenile squirrels being of insufficient weight. An experimental season during August would provide additional data of sufficient magnitude to determine the relative validity of these data.

3. Opening of the season on September 1, appears to be biologically feasible. Extension into late January would allow hunting during one of the peak periods of birth. Insufficient data are presently available to determine the effect of an extension of the season.

4. It apperas that the key to increased utilization of the resource may well lie with assistance in increasing the efficiency of the hunter. More detailed information concerning squirrel behavior, peak periods of activity, response to hunter activity, effect of weather patterns on activity and methods of appraising squirrel populations of individual woodlots would benefit the hunters.

Items that need further investigation and study.

1. Additional reproductive information is needed to increase the validity of the information presented in Table 1. Information concerning the reproductive status of males will be available upon completion of sectioning of testes currently available. Additional information will be gathered during the coming summer and fall.

2. Additional work with squirrel behavior is needed to identify activity patterns in relation to time of day, season and response to disturbance. Behavioral observations related to foraging during the late winter and early spring are needed to determine the relationship of fox squirrels and agricultural practices. How dependent are squirrel populations on agricultural crops and does the relative nearness of cultivated crops allow for greater reproductive output? The Research Farm adjacent to the Research Station, Boone, would provide an excellent research area to study this relationship. The cultivated fields are dispersed in a way that would facilitate a study of this kind. Additional preliminary study on the population and movements of squirrels in that area would be needed prior to changing the crop patterns.

3. New methods of population analysis are needed to be able to determine the status of reproduction in relation to setting harvest regulations. Both extensive and intensive methods are needed. Statewide information is needed to facilitate management decisions and intensive studies are important in assisting the hunter in increasing harvest

4. Population dynamics of the species is not well understood and only long-range studies of population parameters can provide information concerning underlying causes of shifts in population density.

This report is to be considered preliminary in nature. Complete analysis of data gathered in the current study will be available in thesis form by Spring 1968. Current status reports are available in the Biology Quarterly Reports and Quarterly Reports, Iowa Cooperative Wildlife Research Unit.

Submitted by,

Paul A. Vohs Jr. and
Richard J. McCloskey

Table 1. Composite of information gathered on reproduction of fox squirrels in Iowa during 1962, 1963, 1964, 1966 and 1967

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Males in active reproductive state			4	1		2		1	2	1	3	
Reproductive Chases				1		2	1	2	1	1	5	
Matings observed				1		1	1			1		
Embryos present (pregnant)			2			1	1	1				
Females lactating			2			1	4	5	5	2	1	
Date of Birth (backdating)		2		6	2	4	2	1				
Date of birth by behavior (backdating)	3			1								3
Date of conception (backdating)	4	4	3	4	1	2	1				3	2

Table 2. Juvenile squirrel weights interpreted as a percent of average adult weight during hunting season and percent of those over 75 percent adult weight deemed acceptable to the hunter

MONTH	NUMBER OF JUVENILES	AVERAGE WEIGHT OF JUVENILES (GRAMS)	PERCENTAGE ACCEPTABLE OF THOSE HANDLED
April	2	373	50
May	1	540	0
June	9	481	22
July	6	619	83
August	9	483	22
September	14	555	70
October	9	590	66
November	13	590	62
December	2	687	100
January			
February	1	757	100

Table 3. Time of day relationship between number of observation periods and number of fox squirrels seen

TIME	NUMBER OF 15 MINUTE OBSERVATION PERIODS	NUMBER OF SQUIRRELS SEEN	SQUIRRELS PER OBSERVATION PERIOD
4 - 5	35	1	0.03
5 - 6	56	65	1.16
6 - 7	136	195	1.43
7 - 8	224	241	1.08
8 - 9	184	97	0.53
9 - 10	128	119	0.93
10 - 11	136	90	0.66
11 - 12	160	75	0.47
12 - 1	104	63	0.61
1 - 2	96	47	0.49
2 - 3	104	47	0.45
3 - 4	56	23	0.41
4 - 5	32	15	0.47
5 - 6	32	19	0.60
6 - 7	35	6	0.17
7 - 8	20	3	0.15

Table 4. Monthly relationship among observation periods and squirrels seen, March 1966 through March 1967

MONTH	NUMBER OF 15 MINUTE PERIODS	NUMBER OF SQUIRRELS	NUMBER OF SQUIRRELS PER PERIOD
March, 1966	52	33	0.64
April	62	114	1.84
May	85	17	0.20
June	158	50	0.31
July	250	315	1.22
August	255	240	0.94
September	192	110	0.71
October	173	117	0.68
November	92	52	0.57
December	103	33	0.32
January	48	12	0.25
February	40	5	0.80
March, 1967	28	8	0.26

A COMPARISON OF THE AGE STRUCTURE OF TWO RED FOX POPULATIONS

Robert Phillips
Game Biologist

In order to properly manage the red fox (Vulpes fulva) as a game animal and predator in Iowa, it is necessary that we have current knowledge of it's population status, productivity, movements and food habits. This paper presents a progress report on the population phase of the fox investigation.

One tool a wildlife manager uses to determine the productivity of a game population is the fall age ratio. In this particular study it was of interest to know if the age ratio for red foxes in Iowa varied from one geographical area of the state to another.

For this study, two areas were selected for comparative purposes. One area was located in Central Iowa, including a portion of southern Hamilton County and northern Story County. This area is trapped each year by George Good of Randall. The other study area was in northeast Iowa, including Allamakee, Winneshiek and Fayette counties. The priniciple trapper for this area is Marvin Hall of Nashua. I am indebted to the above trappers for cooperation in assisting in the data collection.

METHODS AND MATERIALS

There are two principle aging techniques for separating young from adult foxes. Sullinvan and Haugen (1956) used the degree of ossification of the proximal epiphysis of the humerus and Friend and Linhart (1964) developed the eye lens technique to age red foxes in New York State. The data presented in this paper is based on the results of the New York study.

Eye balls were collected from 162 trapped red foxes in the fall of 1966. Sixty-eight of theses were from the central Iowa study area and the remainder from the northeastern counties.

All eyes were preserved in 10 percent formalin. The lenses were separated from the eyes, rolled in paper toweling to remove excess moisture, and placed in uncapped shell vials in a drying oven. Drying time was 48 hours at 80° C. Weighing was done on a Mettier, single pan, direct reading-balance.

Four known age foxes were available for this study. They were juvenile animals which were tagged as pups in the spring and recovered by trapper George Good in October and November.

RESULTS

Age determination by the lens method as used in the New York study was based on 210 milligrams as the point of separation between juveniles and adults. This same breaking point was used to analyse the data in this study.

The mean lens weight for female red foxes was lighter than that for males (Table I). These findings agree with those of Friend and Linhart (1964).

Frequency distributions of the lens weights are presented in Figure I. According to these data, adults make up 27.6 percent (2.6 young per adult) of northeast Iowa fall fox population as compared to 13.2 percent (6.6 young per adult) for the central Iowa area.

DISCUSSION

The high percent of juvenile foxes in the central Iowa sample is believed to reflect the results of long-term intensive trapping on an area. Since 1960, George Good has removed over 600 fox from a small area encompassed by a 9-mile radius from his home.

In my opinion, after Good finishes trapping in late January of each year there are very few breeding pairs left in the area. Each fall, however, more foxes begin showing up. The eye lens data indicated that practically all of these animals trapped in the fall are young of the year. Most likely they are individuals that are dispersing from denning areas which are outside the intensively trapped area. The lack of resident foxes in the intensively trapped area may be the attraction causing many young animals to move through the vacant habitat.

The smaller young per adult figure for northeast Iowa is believed to reflect a more normal fall age ratio. In a Wisconsin study during the period 1946-1950, the fox age ratio was 27 percent adults to 73 percent immatures (Richards and Hine, 1953).

Many thousands of fox are harvested annually from the northeastern counties, but good breeding populations have always been present. Good habitat combined with a successful reproductive and survival rate probably accounts for the high fox population in the northeastern part of Iowa.

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Figure 1. Distribution, for each study area, of dried weights of eye lenses from red foxes trapped during October, November and December, including mean weights and numbers of specimens according to sex and age

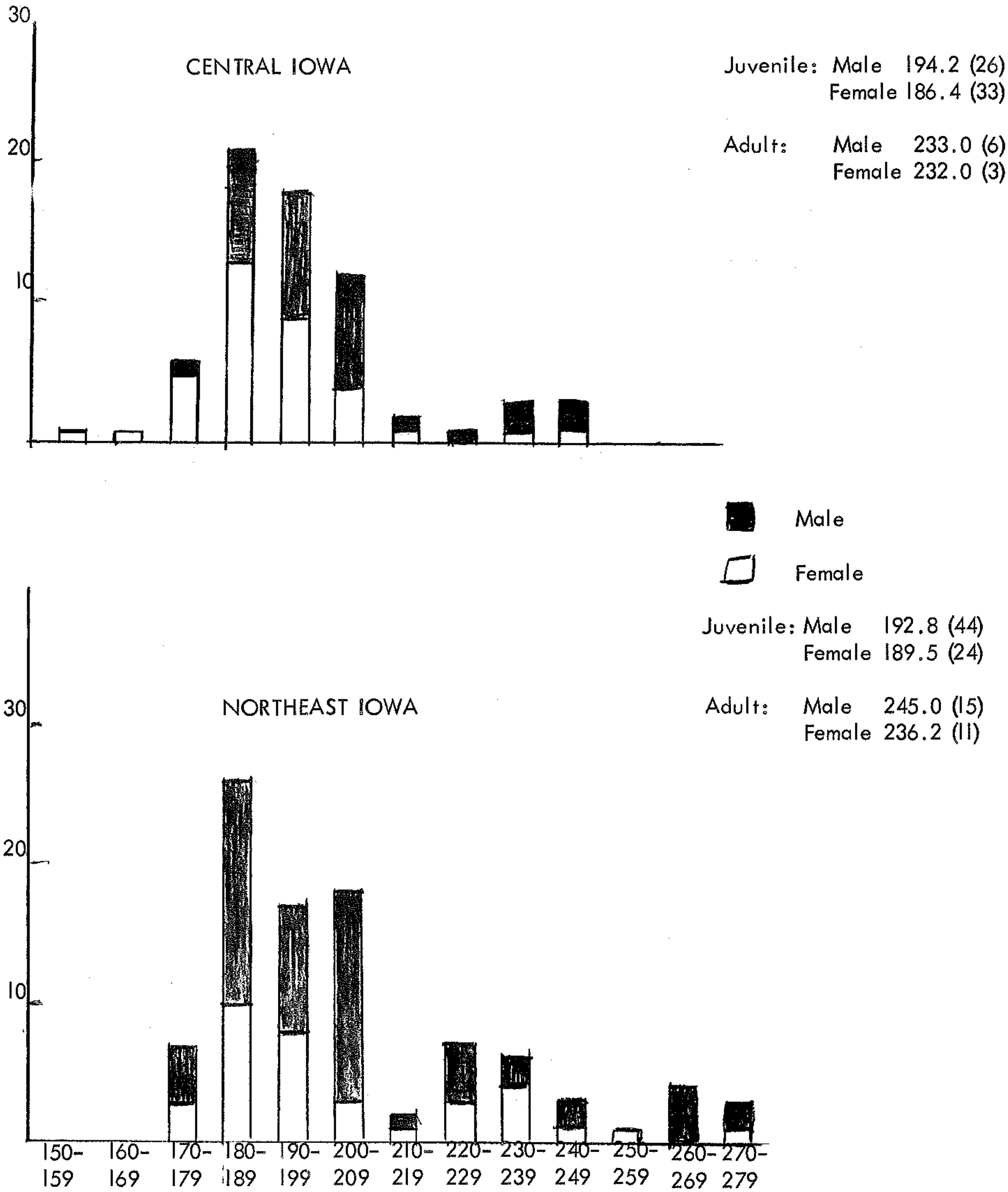

Table I. Differences between the sexes with respect to eye lens weight for 162 red foxes trapped in October, November and December, 1966

Location	Number	Sex	Weight in milligrams Mean	Difference*	Range
			Juveniles		
	26	Male	194.2		176-209
Central Iowa	33	Female	186.4	- 7.8	158-209
Northeast Iowa	44	Male	192.8		173-209
	24	Female	189.5	- 3.3	178-205
Combined Areas	70	Male	193.3		
	57	Female	187.7	- 5.6	
			Adults		
Central Iowa	6	Male	233.0		224-247
	3	Female	232.0	- 1.0	215-242
Northeast Iowa	15	Male	245.0		210-278
	11	Female	236.2	- 8.8	217-279
Combined Areas	21	Male	241.7		
	14	Female	235.3	- 5.6	

* Mean weight of females compared with that of males.

QUAIL STUDIES ON TWO AREAS IN SOUTHERN IOWA, 1966

M. E. Stempel
Game Biologist
and
Gene Hlavka
Game Biologist

INTRODUCTION

Two quail study areas are located south of Highway 34 in Iowa's "banana belt" (Stempel and Hlavka, 1966). The Wapello Area is situated southwest of Ottumwa in Adams, Green and Center Townships of Wapello County. Little Soap Creek drains this study area. Bottomlands and ridgetops are in grain and hay. Slopes are in brush or timber. The Decatur-Wayne Area comprises parts of Clay and Jefferson Townships in western Wayne County in addition to parts of High Point and Woodland Townships in eastern Decatur County. This former Iowa State University quail study area is located about 8 miles north of the Iowa-Missouri boundary in south central Iowa. Steele's Creek drainage ditch drains this area. Grain crops are raised in the floodplain of Steele's Creek. For the most part the terrain in both areas is sloping to hilly. The soils are somewhat acid. There are numerous small ponds. Up and downhill farming still continues, and many gullies are caused by erosion.

METHODS OF CENSUSING

Game biologists conduct the early fall and late winter quail counts with the aid of dogs. When there is snow cover, the coveys can be located by their trails. Quail sign (roosts, tracks, feathers or droppings) are recorded. Data from these counts are used in estimating the number of quail on each area. Covey searches are confined primarily to grain field edges and adjoining or nearby travel lanes. Abandoned farmstead grounds are also examined. The actual walking time of the census is recorded. In addition, farmers are asked for their estimates of the number of coveys on their farms.

From May through August at two-week intervals standard whistling cock counts are conducted. A record is kept of the number of different cock quail heard calling at each of 10 stops (listening points) on a pre-selected route through each study area. All sightings of quail are noted.

Five farmers on each study area are interviewed about hunting activity. Questions were asked about the number of parties, the number of hunters in those parties using the farm and the farmer's opinion of the quail population.

RESULTS OF STUDIES

Winter Studies

Late February-early March quail counts were conducted without the benefit of snow cover in 1966. Thirty-two coveys were located on the two areas. This was an increase of 12 coveys over the 20 coveys found on both areas in 1965.

Spring and Summer Studies

The 1966 growing season turned out to be much better than expected. Iowa produced a record corn crop of over 900 million bushels (Annual Crop Summary - 1966, Iowa Crop and Livestock Reporting Service). Cool, wet weather in May and early June slowed early crop growth. This was followed by above normal temperatures after mid-June and hot, dry weather in July. August was pleasantly cool - the coolest August since 1950. Timely rains occurred in August. September had many bright days and little rainfall. (Climatological Data - Iowa, for months concerned).

Quail calling on the two study areas seemed to reflect the favorable growing season. Calling was well under way in May, peaked in July, and continued through August (Figure 1). A long calling period, rather than a high peak of calling, indicates an abundant quail crop. This 14-week calling period of 1966 "predicted" high quail production.

Another indictor of high quail production in 1966 was the number of quail sighted per 100 miles driven on the combined study area census routes. In 1966, 14 quail were observed per 100 miles driven; in 1965, one quail was observed per 100 miles. One quail chick about one quarter grown was sighted on June 27 on the Decatur-Wayne census route.

Autumn Studies

The fall 1966 quail census was completed on the Wapello Area prior to the opening of the quail season on October 22. On the Decatur-Wayne Area this census started on October 25 and was completed on November 9 after eight days of field work. Hot weather and dry, dusty ground conditions prevailed during the last week in October. Unseasonable highs were reached on October 26 when the temperature rose to 78 at 11:30 a.m. and on October 27 with a temperature of 85 about 1:00 p.m.. On November 2 a hard freeze occurred; the morning's low was 14°. Cool weather prevailed for the remaining days of the census.

Sixty quail coveys were located in 1966 on both areas (Table 1). Compared to the 1964-65 average of 41 coveys, this was an increase of 19 coveys. In 1966, it took only 0.86 hours to flush a covey. This was less than half the time for 1965. Also in 1966, the farmer's estimate of 41 coveys was 13 more coveys than the 1964-65 average of 28 coveys.

HUNTING ACTIVITY

The 1966-67 quail season of 102 days commenced on October 22 and terminated on January 31. Nearly 20 percent of the hunting activity was in October (Table 2). Hunting activity was evenly distributed in November, December and January with 27 percent for each month. October had 10 quail hunting days. On the Decatur-Wayne Area the presence of ringneck pheasants may have been an added incentive to hunting. Some hunting without permission was reported on both areas.

SUMMARY

1. Quail counts were continued on two study areas, Wapello and Decatur-Wayne in 1966.

2. The brood stock on both areas increased by 12 coveys over the 1965 combined counts.

3. More than 14 weeks of quail calling indicated good production in 1966.

4. The fall 1966 counts of coveys for both areas totaled 60 - an increase of 19 coveys over the 1964-65 average.

5. It took 0.86 hours to flush a covey during fall 1966.

6. Quail sighted per 100 miles driven on census routes increased from 1 in 1965 to 14 in 1966.

7. Nearly 20 percent of the hunting activity was in October (10 hunting days). Hunting activity was evenly distributed in November, December and Juanuary with 27 percent for each month.

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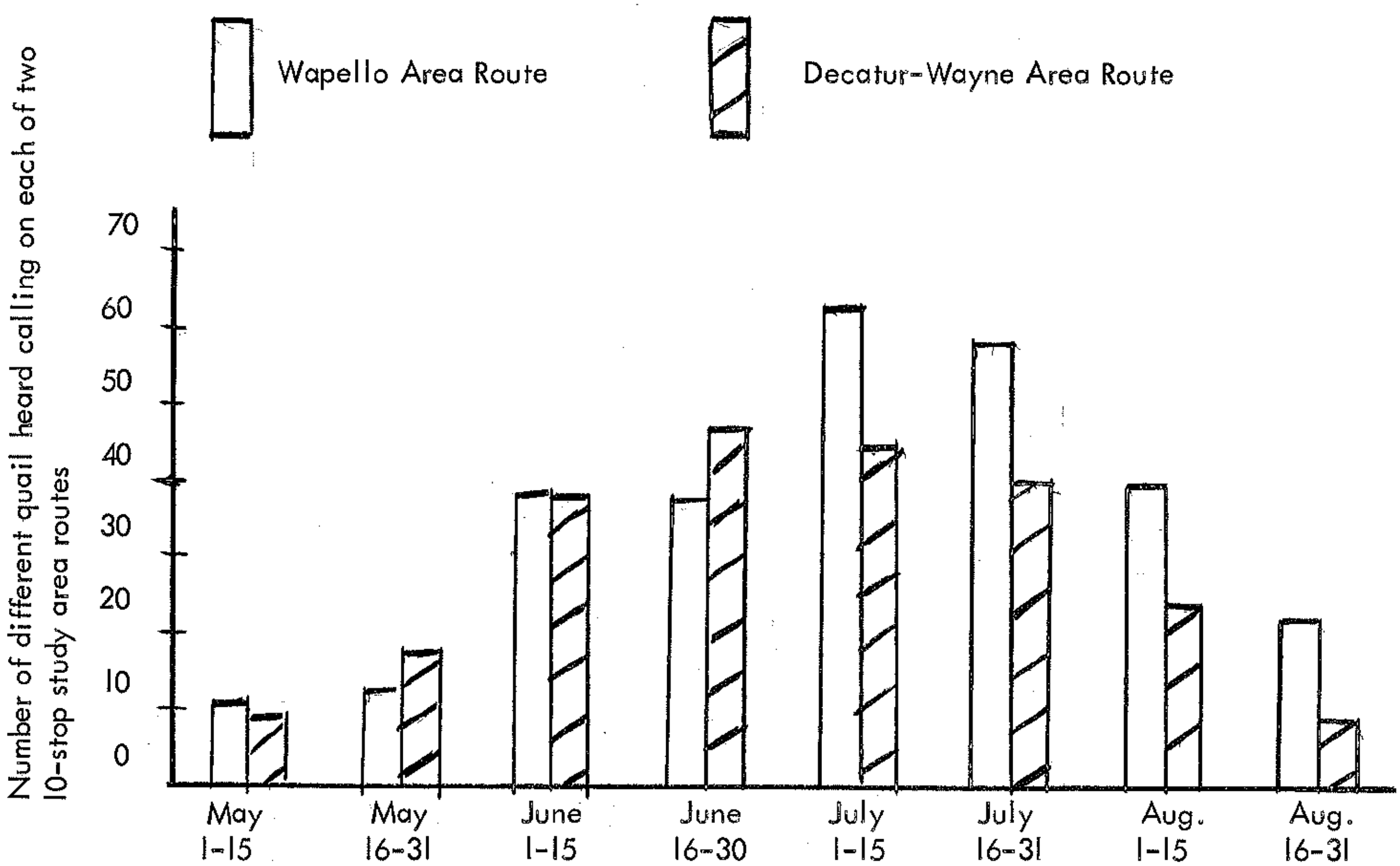

Figure 1. The length and peak of the quail calling period on two study areas in southern Iowa, 1966

Table 1. Results of fall 1966 quail counts on the Wapello and Decatur-Wayne Areas compared to the 1964-65 average of both areas.

	1966			1964-65 Avg.
	Wapello Area	Decatur-Wayne Area	Both Areas	Both Areas
No. of coveys located	28	32	60	41
Flush	7	25	32	
Sign	21	7	28	
No. of quail estimated	310	422	732	614
Flush	58	335	393	
Sign	252	87	339	
No. of hrs. spent walking	6.5	32.17	38.67	
Hrs. per covey flush	0.93	0.78	0.86	
Farmer estimate of no. of coveys	23	18	41	28

Table 2. Summary of quail hunting activity reported by farmers during October, November, December, and January on five farms on each of two areas, Wapello and Decatur-Wayne, 1966-67

	Wapello Area		Decatur-Wayne Area		Both Areas		Percent of Total Hunting Activity on Both Areas	
	No. of Parties	No. of Hunters	No. of Parties	No. of Hunters	No. of Parties	No. of Hunters	Parties 1966-67	Parties 1965-66
October*	1	2.3	4	6	5	8.3	19	-
November	0	0	7	13	7	13	27	53
December	1	1	6	14	7	15	27	26
January	1	3	6	15	7	18	27	21
TOTALS	3	6.3	23	48	26	54.3	100	100

* October had 10 quail hunting days

PESTICIDE CONCENTRATION LEVELS IN IOWA FISH

L. G. Johnson
State Hygienic Lab.

Studies on the concentration of pesticides in a number of the larger rivers of Iowa have indicated relatively low concentrations of the chlorinated hydrocarbons in these flowing streams. Similar investigations performed in other states around the Midwest have also shown relatively low levels of chlorinated hydrocarbon pesticides in surface waters. However, there have been published in the last year or so a number of statements indicating that large amounts of chlorinated hydrocarbon pesticides have been found in fish from both rivers and lakes. We felt that the fish population serving as a food source to our citizens should be studied to see if the chlorinated hydrocarbons were aggregating in Iowa fish. Representative analytical data collected on Iowa streams is attached in Table I showing the low concentrations delineated in a number of Iowa rivers.

Previous studies made by this laboratory in conjunction with the State Conservation Commission staff have shown that pesticides of various types collect in certain specific organs of pheasants. Because we are interested in fish as a food source, we felt that our first investigations should be restricted to measurement of pesticide concentrations in the filet portion of a variety of fish caught at selected locations. Working with Mr. Harry M. Harrison, Supt. of Biology, State Conservation Commission, we arranged to procure filets of fish from the five following locations: Mississippi River at Guttenberg, Des Moines River near the site of the Red Rock Reservoir, Missouri River, Allerton Reservoir, and Spirit Lake. Three specimens of important species were taken at each point. Table II gives the species, size, and age of the samples. Frozen filets from each specimen were sent to the laboratory except for those from the Des Moines and Allerton sites, which were submitted as whole frozen fish. Ten gram samples were taken from each specimen and analyzed by the following procedure.

The sample was ground in an Omni-Mixer for about one minute. Anhydrous sodium sulfate was added and the mixture reground. To this was added 150 ml of pesticide grade petroleum ether and the mixture blended for one minute. The extract was decanted through a 2"column of anhydrous Na_2SO_4 and collected in a Kuderna-Danish evaporative concentrator. The fish mixture was twice re-extracted with 100 ml portions of pet. ether. These were also passed into the Kuderna-Danish apparatus. The combined extract was concentrated to about 10 ml. This was added to a 4" column of Florsil topped with 1/2" of anhyd. Na_2SO_4 which was prewashed with 30-40 ml of pet. ether. Following the addition of the sample, the column was eluted into a Kuderna-Danish apparatus with 200 ml of 6% ethyl ether in pet. ether. A second elution with 200 ml of 15% ethyl ether in pet. ether was received in a second Kuderna-Danish. Both extracts were concentrated to approximately 10 ml and then 5 microliter portions were injected into the gas chromatograph. The operating conditions for the gas chromatograph were as follows:

> Instrument: F & M Model 400 with 200 millicurie tritium
> Parallel plate electron capture detector operated in the
> pulsed mode.

Column: 4' x 1/4" OD Pyrex U-shaped column packed with 3.8% SE-30 on 80/100 mesh Diatoport S.

Carrier Gas: 90% argon-10% methane at 40 ml/min.

Temperature: Oven 200°
Flash Heater-245°
Detector-210°

Instrument Settings:

Pulse interval:	50 microseconds
Attenuation:	X16
Range:	X10

The heights of possible pesticide peaks were compared to those of appropriate standards. High backgrounds permitted by this limited cleanup prevented using a cut-off point below 1 part per million without extensive further analytical cleanup. We feel that the lower sensitivity level of one part per million is logical in this study because we are interested in comparing the amounts of chlorinated hydrocarbon pesticides in the edible portion of fish with the amount tolerated in various types of edible flesh from other food stuff animals. Federal standards for DDT in the fat of meat from cattle, goats, hogs, horses and sheep have been set at 7 perts per million. Methoxychlor in the same animals has been established at 3 parts per million. Malathion, one of the organo phosphates has been set at 4 parts per million in or on meat and meat by-products from the same animals but additionally in poultry. Obviously, there is no such thing as a single maximum permissible concentration for all pesticides viewed indiscriminately in or on food stuffs. In many cases, an inadequate understanding of the low level toxicological effects of pesticides on man, animals and fishes has resulted in a very cautious approach to the setting of tolerable limits. This has been extended all the way down to the "zero tolerance concept" in the case of milk and dairy products. Milk is viewed with extreme caution because it is a primary food for very young infants which are usually accepted as the most sensitive group with respect to most toxic effects.

Zero tolerance usually means the lowest level to which a constituent can be detected. For your information, the analytical chemist has improved his ability to detect many of the chlorinated hydrocarbon pesticides about one million times over the last five years. Therefore, a zero tolerance a few years ago meant one part per million, NOW it can mean one millionth of that level or a part per trillion. The toxicological effect to the organism has not changed in five years, but our ability to detect the constituent has improved so much that we are in an area of legal difficulty at the very least.

You will note the results of the fish filets analyzed show that none of the specimens submitted to us evidenced chlorinated hydrocarbon pesticide levels above one part per million. Compared against the levels in flesh of food stuff animals, this indicates that the human consumption of the edible portions of fish does not pose a problem on the basis of this study. It must not be construed by these data that little or no pesticides exist in fish of Iowa but it does indicate that the edible portions appear to be a safe source of food based on comparative maximum permissible limits established for other protein of animal nature

One must consider the method of common cooking with respect to fish and other flesh products. If the pesticides aggregate or concentrate in the lipid or oily fractions of the animal flesh, the common cooking process can determine the amount of oil removed during the heating period. I would assume that most Iowans cook fish relatively well compared to the way they cook other meats with the exception of pork products. If the flesh is raised to a high temperature the fat incorporated pesticide will have a greater tendency to leave the flesh being cooked and should reduce the amount ingested by the individual. Also, the temperature degradation during cooking might further reduce pesticide levels in well cooked products.

We intend to continue our study of pesticide aggregation in fish by disecting out different organs as well as analysis of the oil extracts retained in the edible filet. It is quite possible that we will find significant amounts of pesticides in the other organs and at concentrations which could be significant to propogation and growth rate factors which are so important to fish conservationists. We will probably collect in much the same location as shown in this study but we will probably adapt our "clean-up procedures" so that we can determine pesticide concentrations at levels down to approximately a part per billion.

The State Hygienic Laboratory appreciates the excellent cooperation which we received from the conservation officers in the collection of these fish specimens and their submission to the laboratory. Without the hard work and interest which you people put into the field aspects of these studies, the laboratory would be severely handicapped in many of our research and surveillance programs in the pesticide field.

Table I. Survey of chlorinated hydrocarbon pesticide levels in selected Iowa rivers

Sampling points:

Mississippi River:	Dubuque
	Davenport
Cedar River:	Cedar Rapids
Iowa River:	Iowa City
Raccoon River:	Des Moines
Missouri River:	Council Bluffs

Results to date:

	Feb.	March	April	May	June	July	Aug.	Sept.
Dubuque:	*	*	-	*	*	*	*	*
Davenport	*	*	-	*	*	*	*	-
Cedar Rapids:	*	*	-	*	*	*	*	*
Iowa City:	*	**	-	DDT 0.4 ppb DDE 0.1 ppb	*	*	*	Inc.
Des Moines	*	-	*	*	*	*	Inc	Inc.
Council Bluffs	*	*	-	*	*	*	*	*

* No pesticides found in concentrations as high as 0.1 ppb
** No pesticides found in concentrations as high as 0.3 ppb
Inc. Received but not completed

Table II.

SOURCE	SPECIES	WT.	LENGTH	AGE (YRS)	COLLECTION DATE
Mississippi River	Walleye	3# 15 oz.	20 1/2"	5	11/10/66
Mississippi River	Walleye	5# 4 oz.	22 1/4"	7	11/14/66
Mississippi River	Walleye	11#	27 1/2"	8	11/14/66
Missouri River	Carp	1#	13.6"		11/15/66
Missouri River	Carp	3# 2 oz.	19.5"		11/15/66
Missouri River	Carp	4# 7 oz.	24"		11/15/66
Des Moines River	Chan Cat	0.5#	12.2"	4	11/16/66
Des Moines River	Chan Cat	1.0#	15.2"	5	11/15/66
Des Moines River	Chan Cat	2.0#	17.2"	6	11/15/66
Allerton Reservoir	L.M. Bass	1.0#	12.5"	4	11/14/66
Allerton Reservoir	L. M. Bass	1.8#	15.0"	5	11/14/66
Allerton Reservoir	L. M. Bass	2.8#	17.0"	6	11/14/66
Spirit Lake	Walleye	436 g	14.1"		12/3/66
Spirit Lake	Walleye	2.53#	18.6"	6	12/8/66
Spirit Lake	Walleye	10.9#	28.9"	12 (or up to 20 yrs)	12/8/66

RESULTS OF 1966 IOWA WATERFOWL BANDING PROGRAM

Richard Bishop
Game Biologist

INTRODUCTION

The past several years Iowa has been engaged in a waterfowl banding program in conjunction with the other 13 states in the Mississippi Flyway and the Fish and Wildlife Service. Banding migratory birds supplies data on migrations, populations, distribution, and mortality, which are necessary for the better management of the concerned species. Iowa's banding program in t he past involved drive trapping and some nightlighting of young birds on the breeding grounds and bait trapping flying birds prior to the season. In addition, an attempt was made to band mallards wintering in Iowa.

Game Section personnel have the primary responsibility of the banding of waterfowl in Iowa. Their efforts are directed toward the three major nesting species in Iowa - bluewinged teal, wood ducks, and mallards. Nine other species of ducks were banded, plus eight species of marsh birds. Table I shows the species and numbers of birds banded on the breeding grounds. Table II gives the species and number of birds banded by bait trapping. Table IV gives the total birds banded during 1966.

RESULTS AND DISCUSSION

The majority of the effort of banding birds on the breeding grounds fell into the hands of drive banders. In 1965, 12 men devoted 2 weeks during the middle of July to banding 880 birds. During the same time period, three two-man crews banded 1,351 birds night-lighting. The expense of 24 men away from home coupled with the lack of manpower for other projects during the same period has caused some criticism. It was pointed out that a sizable portion of the budget and time was devoted to waterfowl banding and that more work and attention should be given to other projects and other game species. This feeling was taken into consideration and the past year's data were reviewed. It appeared that several two-man night-lighting crews working in their own units could band about the same number of ducks at a minimal cost.

In 1966, four two-man crews, operating for the most part in their own areas, banded the majority of 2,588 birds in about 3 weeks. About 100 birds were banded on a few drives between night-lighting work. Two crews banded the majority of the 2,588 birds. Total banding operations during July of 1965 consisting of 28 men who banded only 2,231 birds. From these data it appears that more birds can be banded at considerably less effort and expense. Expense of summer banding has been reduced roughly two-thirds by the change of banding operations.

Night-lighting operations netted 2,588 birds of which 1,691 were blue-winged teal, 454 wood ducks, and 216 mallards. Sex and age data are presented in Table III.

Pre-season bait trapping was carried out as in the past on most unit game areas during August and September. As in 1965, bait trapping was terminated early for the teal season which began September 17. Bait trapping success was down in certain areas, which resulted in a reduction in the overall number of teal banded. A total of 2,292 birds were banded of which 2,145 were blue-winged teal. In 1965 a total of 3,417 birds were banded, of which 2,953 were blue-winged teal. Blue-winged captured in bait traps were 94 per cent young in 1966 compared with 86 per cent in 1965.

Post-season banding of wintering populations of mallards was attempted but was not successful. More carefully laid plans are scheduled for 1967.

After analyzing the total banding program in regard to expense, effort, and results, it looks as if the decision to reduce the drive banding efforts and increase the night-lighting activities paid off. Bait trapping activities were similar to last years; however, low water levels and different concentration areas of teal reduced the pre-season catch.

SUMMARY

1. Banding operations consisted of two major operations.

    a. Night-lighting - 2,588

    b. Bait trapping - 2,292

2. A total of 4,880 wild birds were banded and released.

3. Birds banded consisted of 12 species of ducks and 8 species of marsh birds. Blue-winged teal and wood ducks were the two most important and abundant species.

4. Of the blue-winged teal banded, about 94 per cent were young birds.

5. Drive banding operations were reduced this year and night-lighting crews were increased. This reduced the cost of summer banding and manpower tied up during July.

TABLE I. TOTAL BIRDS BANDED DURING BREEDING GROUNDS WATERFOWL BANDING OPERATIONS - 1966

COUNTY	NAME OF AREA	Mallard	G.W. Teal	B. W. Teal	Shoveler	Pintail	Wood Duck	Redhead	Ring-neck	Ruddy	L. Scaup	Coot	Common Gallinule	Hooded Merganser	Eared Grebe	Red-necked Grebe	TOTALS
Bremer	Sweet Marsh	26		3	1		35										65
Calhoun	South Twin Lake	5	1	29			17	4			2	22					80
Cerro Gordo	Ventura Marsh	2		6			13	5		5							31
Clay	Dan Green Sl.	9		29			9	4			1	1					53
Clay	Mud Lake	2	1	92			5										100
Clinton	Goose Lake			14			6										20
Dickinson	Hottess Lake			15			14										29
Dickinson	Lily Lake	11		40			12	11									74
Dickinson	Private Pond			25			2										27
Dickinson	Jemmerson Sl.	12		171			27	4						1			215
Dickinson	Grover's Lake	5	1	144	3		8	4	2	1							168
Dickinson	Marble Lake			13			10										23
Dickinson	Center Lake	5		18			11										34
Dickinson	E. Okoboji Sl.	9	1	84		5	32										131
Emmet	West Swan Lake		3	42			8								19		72
Emmet	Ingham Lake	36	26	601	3		81	2		14	1						764
Emmet	High Lake	1					9										10
Emmet	Twelve Mile Lake						1										1
Emmet	Cheever Lake	3		14		3	11	4		3	1					1	40
Emmet	Unk. Area	30								2							32
Hancock	E. Twin Lake	15		17			8										40
Hancock	Eagle Lake			3						2							5
Jackson	Sabula Sl.						2										2
Jones	Muskrat Sl.						3										3
Kossuth	Iowa Lake Marsh			10			2										12
Lucas	Colyn Area	3					15										18
Monona	Badger Lake	4	6	28	1		15										54
Osceola	Rush Lake	6	1	46			2			15	1						71
Pocahontas	Lizard Lake			3			13					5					21
Pocahontas	Little Clear Lake	4	1	23			6					4					38
Palo Alto	Virgin Lake						1										1
Palo Alto	Silver Lake	2		14			45										61
Palo Alto	Rush Lake						2					15					17
Winnebago	Harmon Lake		6	85			8	1	1		1						101
Wright	Big Wall Lake										1						1
Wright	Morse Lake	8		13													21
Wright	Elm Lake	3		1			1										5
Worth	Silver Lake	16	1	108			20			1	1		1				148
TOTALS		216	48	1691	8	8	454	39	3	43	9	47	1	1	19	1	2,588

TABLE 11 . - TOTAL BIRDS BANDED DURING PRE-SEASON WATERFOWL BANDING OPERATIONS - 1966

COUNTY	NAME OF AREA	Mallard	G. W. Teal	B. W. Teal	Wood Duck	Pintail	Widgeon	Gadwall	Coot	Sora Rail	King Rail	P. B. Grebe	TOTALS
Calhoun	South Twin L.	6		24	68								98
Cerro Gordo	Ventural Marsh			228									228
Clay	Dan Green Sl.	3		61	7	2							73
Clay	Trumbull Lake			510	1								511
Green	Goose Lake	6		650	4			1	3		4	1	669
Lucas	Colyn Area		7	103	17								127
Tama	Otter Creek				2								2
Worth	Rice Lake		1	430	5								436
Worth	Elk Creek		1	139	6		1			1			148
TOTALS		15	9	2145	110	2	1	1	3	1	4	1	2,292

TABLE III. - AGE AND SEX COMPOSITION BY SPECIES - ALL AREAS - BREEDING GROUNDS BANDING

SPECIES	AM	AF	IM	IF	LM	LF	LU	TOTAL
Mallard	7	16	12	27	74	80		216
G. W. Teal	3	12	18	11	2	2		48
B. W. Teal	123	90	397	301	412	368		1691
Shoveler	1	3		2	2			8
Pintail					3	5		8
Wood Duck	43	19	40	38	154	160		454
Redhead	2	2	2	1	16	16		39
Ring-neck	3							3
Ruddy	3	5			15	20		43
L. Scaup	8	1						9
Coot	12 Adult Unk.						35	47
Eared Grebe	2 Adult Unk.						17	19
Red-necked Grebe	1 Adult Unk.							1
Hooded Merganser	1 Adult Unk.							1
Common Galinule							1	1

TABLE IV. - TOTAL BIRDS BANDED - 1966

SPECIES	BREEDING GROUNDS	PRE-SEASON	TOTAL
Mallard	216	15	231
G. W. Teal	48	9	57
B. W. Teal	1691	2145	3836
Shoveler	8		8
Pintail	8	2	10
Wood Duck	454	110	564
Gadwall		1	1
Widgeon		1	1
Redhead	39		39
Ring-neck	3		3
Ruddy	43		43
L. Scaup	9		9
Coot	47	3	50
Eared Grebe	19	3	50
P. B. Grebe		1	1
Red-necked Grebe	1		1
Gallinule	1		1
Hooded Merganser	1		1
Sora Rail		1	1
King Rail		4	4
Mourning Dove	19	1143	1162
SUB TOTAL	2607	3435	6042
Mallard, Exp.			273
Canada Goose, Exp.			61
TOTAL			6376

STATUS AND ANALYSIS REPORT OF GROUSE PROJECT

Wayne Porath, Graduate Assistant, I.S.U.
Paul A. Vohs Jr.

Ruffed grouse inhabit the forested areas of eastcentral and northeast Iowa along the fringe of the current range of the species in North America. Hunting of ruffed grouse in Iowa has not been permitted in recent years but a request for permission to extend the regulatory authority of the State Conservation to include open seasons is before the Iowa Legislature. Information concerning general life history and population dynamics are little known for the Iowa grouse. Efforts of Emmet Polder (Polderboer) during 1938 and 1939, whose master's thesis and publications concerned cover requirements and food habits of ruffed grouse in northeast Iowa; efforts of Conservation Commission personnel during the past several years in trapping grouse; extended spring drumming counts from 1961-65 and Gerald Kaufman's (1965) study of the distribution of grouse in northern Dubuque County constitute most of the available knowledge concerning ruffed grouse in Iowa.

Studies conducted in surrounding states on ruffed grouse may be used as guides once the details of similarities and differences of population turnover, predation, disease, nesting and brooding sites, wintering areas, food habits etc. have been detected. Insufficient information is available concerning the Iowa birds to make full and confident parallels of findings of other states to the management of Iowa grouse. The work of Wayne Porath since June, 1966 on a cooperative program between Iowa State University and Biology Section, State Conservation Commission represents the most intensive investigation of ruffed grouse conducted in Iowa. The investigation is not complete and the current spring represents the first opportunity for field work during that season. It is hoped, upon completion of Wayne's study, that general information concerning the life history and ecology of Iowa grouse will be available. It will then be possible to interpret the relationship and relative usefulness of other studies to the Iowa population. If a hunting season is permitted by law, the preliminary investigation coupled with continued investigation will make possible pre- and post-hunting evaluation of the effects of hunting on the Iowa population and allow biologically based value judgments to be made concerning liberalizing or strengthening current regulations. Further, biological information will be available for presentation to the public regarding the effect of hunting on ruffed grouse and reasons for any proposed changes in the regulations.

Some specific accomplishments of the current study include:

1. Establishment of a 409-acre intensive study area in Yellow River State Forest, Allamakee County, Iowa.

2. Preparation of a suitable field map including existing cover.

3. Identification and classification of 29 drumming logs within the research area, including tagging each log with semi-permanent identification.

4. Delimitation of 10 (or so) activity centers of male ruffed grouse and determining 8 to be occupied in early summer 1966 and 8 (possibly 9) occupied in February, 1967.

5. Location of a minimum of 11 broods of grouse and determination of hatching dates for 10 broods.

6. Captured a total of 41 individual grouse and had 21 back-tagged grouse on the study area on September 1, 1966.

7. Estimated the minimal study area population to be 48 grouse on July 15, 1966 or 1 grouse per 8.5 acres of total area or 1 grouse per 7.5 acres of ecological habitat (bottomland and cultivated fields excluded). This is considerably higher than Polder estimated for his study area north of Lansing, Iowa.

8. Recorded 51 encounters (brood flushes) with 11 broods and devised an index of utilization calculated by dividing number of brood flushes in a cover type by acreage of cover type. Greatest utilization of cover type by broods occurred in maple-oak-birch and basswood type, 20-35 years old. Second was oak-hickory, 20-35 years old. Third was oak-hickory, 35-80 years old. No use by broods was observed in valleys and crop fields.

9. Utilization of cover types by young broods in June and July was generally restricted to oak-hickory. Broods were flushed from all cover types in August with exception of bottomland, valleys and croplands.

10. Extended fall movements of two young female grouse were noted 5 and 6 miles south of where marked in late October and early November.

11. Birds of all ages were found to be heavily infected with protozoan parasites of the genera Leucocytozoan and Haemoproteus by Dr. David Roslien, Luther College.

12. Preliminary examination of droppings of grouse collected in winter show considerable bud scales of hop-hornbeam, a species not mentioned in Polder's work. Grouse were observed budding on hop-hornbeam on two mornings near study area in December, 1966.

Management implications as currently viewed from preliminary data might include the following:

1. The most important specific management information coming from the project will be suggestions for improving production of the species within the limited habitat available. Justification for habitat manipulation and management of grouse as a game species will occur with the establishment of an open season.

2. It is important to know the details of production (as with pheasants and quail) in order to better predict and measure annual fluctuations. Suggestions for season opening, length and bag hinge on production.

3. Molting os male ruffed grouse occurred during August. Timing of hunting season would be of necessity later than the period of molt. Hunting season during the period of fall shuffle might enhance the movement of grouse to adjacent coverts and cause some expansion of the range. An open season might "benefit" the species by assisting in range extension.

4. Very little utilization of grouse of any age group was observed in mature timber stands on the southwest corner of the study area. What is the relationship of the stands to the forestry practices on the area? Little, if any, evidence of cutting (except on the lowlands) during the past 20 years exist on the study area.

5. Broods have been observed to make intensive utilization of lowlands as reported in a number of studies from other states and by Polder. The absence of use of these areas on the study area may be related to management of stream valleys and retarding of plant succession to facilitate fishing and camping.

6. Broods of ruffed grouse began to range over large areas between July 15, and August 1, 1966. Relationship of broods to original brooding areas may be identified prior to this time but difficulty will be encountered in identifying production areas after August 1.

7. The majority (7) of the recorded hatches of broods occurred in late May and early June and three were grouped closely approximately 24 days from the early group. Renesting appears to be a possible explanation for the timing of the second group but renesting has never been shown positively to occur in this species.

8. Occupation of activity centers by male grouse appeared to remain constant at 8 from early summer through the winter. All apparent centers are not occupied (2 may be vacant) but the same number of occupied centers were noted.

Items that need further investigation and study.

1. Ruffed grouse are "cyclic". What is the relationship of the Iowa population on the fringe of the total range to population dynamics of grouse in the center of the range?

2. The current extensive method of population estimation or index of the Iowa population is the drumming count. Investigation of intensity of drumming in relation to known population levels is needed to interpret the drumming counts and the meaning of changes that occur.

3. Additional information is needed concerning natural mortality of the species, especially the development of protozoan infections and the possible effects

of the infections. Continued cooperation with Dr. David J. Roslien in this area is recommended. Information on avian predation and possible effects on the population is warranted, particularly in the light of Gordon Gullion's findings in Minnesota that birds in the vicinity of conifers may be subject to intense predation.

4. What does the fall shuffle consist of in Iowa? Reported observations of sighting of two tagged birds (of 2l in September) on the study area, two juvenile females 5 and 6 miles from the area and eight occupied activity centers on the study area indicate the need for study of the shuffle. Where do the birds go? Do all of the males remain on the area? If so, what happens to them. Which females remain and which leave? What would the effect of an open season be on this phenomenon?

5. The effect of a hunting season on the resident population could be compared to pre-hunting conditions using the information gathered in the current study as a measure of the latter. In order to make the information most meaningful we should continue to gather information without lapse through an initial open season (if allowed) and a minimum of 2 years beyond.

6. The mass of material made available from a hunting season would be valuable for determining sex ratios, age ratios, molting patterns, dispersal of marked birds, parasite infestations and other life history information on a more extensive basis. Gathering of this extensive information may or may not be a part of the intensive study and would depend upon the desires of the Commission. We would feel that maximum effectiveness would result if the extensive information could be part of the study. We would certainly desire access to information related to the intensive study.

This report is to be considered preliminary in nature. Complete analysis of the data gathered in the current study will be available in thesis form by Spring 1968. Current status reports are available in the Biology Quarterly Reports, Iowa Conservation Commission; and Quarterly Reports, Iowa Cooperative Wildlife Research Unit.

Submitted by:

Paul A. Vohs Jr. and
Wayne R. Porath

1965 - OFFICER CONTACT CREEL CENSUS FOR THE MISSISSIPPI RIVER

Don R. Helms
Fisheries Biologist

Beginning in 1960 all Conservation Officers were instructed to obtain basic information on catch statistics from Iowa anglers during routine patrol. As the Officers interviewed anglers a small card was filled out for the number of anglers in the party, hours fished, and number and species of fish caught. These data are returned to the Biology Section for compilation and reported in Quarterly Biology Reports.

The following is a presentation of the material collected in 1965 on the Mississippi River.

Due to the manner in which the data were collected, a breakdown by counties is the most convenient. There are 10 counties bordering the Mississippi River. Each contributes from 20.8 to 37.5 river miles of shoreline, which with the exception of Scott County, lies adjacent to one navigation dam and parts of two navigation pools. Scott County is bordered by parts of two pools and all of a third. A total of 1,679 contacts were made representing a sample of 3,552 man hours of fishing.

Catch rate varied from a high of 2.5 fish per hour in Allamakee County to 0.49 fish per hour in Des Moines County with an average of 1.60 per hour (Table I). There was a general trend for the catch to decrease progressively from north to south. Extreme exceptions are probably due to insufficient data.

Bluegill, crappie, bass, walleye and sauger were comparatively more abundant in northern counties; whereas, catfish, bullhead, drum and carp were more prominent in southern counties. The high percentages of crappie and bluegill in Allamakee and Clayton counties is magnified by the inclusion of ice fishing contacts made in this area. Bluegill, crappie and bass were the only species reported for this type of contact.

Table I. Angler success and harvest by county on the Mississippi River in 1965

County	Total Contacts	Total Hours	Fish /hr.	Percent of catch by Species									
				Blue-gill	Crappie	Bull-head	Bass	Drum	Cat-Fish	Walleye Sauger	Carp	W. & Y. Bass	Misc.
Allamakee	338	1,019	2.50	41.6	31.6	6.4	10.6	4.4	1.7	2.4	0.4		0.9
Clayton	391	1,155	1.14	56.5	24.0	1.3	6.0	2.1	0.3	9.3			0.5
Dubuque	278	296	1.47	4.8	31.3	10.1	4.4	34.3	8.0	3.0	3.0	1.1	
Jackson	242	428	1.50	13.3	29.8	23.6	13.3	11.7	3.1	3.6	1.6		
Clinton	37	67	0.88	8.5	54.2			11.9	18.6		6.8		
Scott	56	112	0.78	9.2	3.4	51.7	1.1	12.6	8.0	8.0	1.1	2.3	2.6
Muscatine	33	58	1.74	14.9	4.0	4.0		5.0	4.0	38.6		14.9	14.6
Louisa	19	49	2.02	33.3	26.3	28.3	3.0	5.1	2.0		1.0	1.0	
Des Moines	68	100	0.49			57.1	4.1	10.2	10.2		18.4		
Lee	217	268	1.28	3.8	6.7	12.8		14.2	49.4		12.8	0.3	
Combined	1,679	3,552	1.60	34.9	27.0	9.3	8.1	7.9	5.3	4.7	1.6	0.4	0.8

RESULTS OF EXPERIMENTAL CHANNEL CATFISH STOCKING IN TWO IOWA LAKES

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INTRODUCTION

In 1961, two Dickinson County lakes, Spirit and East Okoboji, were selected for a channel catfish stocking study. The study was intended to determine the difference in stocking success between fingerling and small adult catfish. A second objective was to establish catfish populations in either or both lakes. Spirit Lake received from 50,000 to 150,000 catfish fingerlings annually for 5 years. East Okoboji Lake received an annual planting of 5,000 small adults for 4 successive years. The results of these stockings were followed through a creel census described by Rose (1956). This census has been used on both lakes since 1957. A limited amount of data on the progress of the catfish populations was collected by annual test netting surveys conducted by the Biology Section.

Spirit Lake

Spirit Lake, Iowa's largest natural lake, has a surface area of 5,660 acres. It is a eutrophic lake of glacial origin with a maximum depth of about 26 feet. It has rocky points, bars, and reefs as well as mud bottom.

Prior to 1961, channel catfish were not important to the fishery or fish population density. No catfish have been taken in surveys of the lake since 1943. From 1961 through 1965, 430,000 fingerling catfish were stocked in Spirit Lake. They were stocked at rates of 50,000 to 150,000 per year, varying from 8.8 to 26.5 fingerlings per acre (Table I).

Table I. Channel catfish stocking record - Spirit and East Okoboji Lakes

	Spirit Lake (fingerlings)		East Okoboji (small adults)	
	Total	Per Acre	Total	Per Acre
1961	50,000	8.8	5,000	2.6
1962	150,000	26.5	5,000	2.6
1963	110,000	19.4	5,000	2.6
1964	70,000	12.4	5,000	2.6
1965	50,000	8.8		

To date, no evidence of these stockings has been found in lake surveys. In reporting his 1963 survey of Spirit Lake, Tom Moen, Fisheries Biologist, stated, "It would appear that our stocking success is quite low in this case....... the catfish fingerling stocking has not shown definite results after three years of stocking.

The creel census conducted on Spirit Lake shows very limited results which can probably be attributed directly to stocking (Table 2).

Table 2. Creel Census results - channel catfish

	Spirit Lake		East Okoboji	
	Fish Creeled	Mean Weight	Fish Creeled	Mean Weight
1966	10	4.5 lb	938	1.47 lb
1965	11	5.0	259	1.57
1964	28	2.7	117	1.61
1963			14	1.57
1957			38	

East Okoboji

East Okoboji is a long and narrow, 1,875 acre lake. The bottom is composed of mud. It is a eutrophic lake with a maximum depth of about 22 feet. The upper half of the lake is less than eight feet deep and is subject to occassional winter kill.

In past years, East Okoboji yielded an occasional channel catfish to anglers. However, none were taken in lake surveys from 1942 until 1963, after stocking had begun.

Annually, from 1961 through 1964, 5,000 small adult catfish (2.8 fish per acre) were stocked in East Okoboji (Table 1). These fish, taken from the Mississippi River, averaged about 10 inches total length. The 1963 lake survey provided the first evidence of catfish when five individuals were taken. None were observed in 1964, but a few were recorded in 1965 and 1966 surveys. Referring to East Okoboji in 1963, Moen stated, "Channel catfish stockings of 'fiddler' size appears to be paying off in this lake as opposed to fingerlings in Spirit Lake. Reports from fishermen indicate their presence as well as the limited number found in the seine hauls."

More tangible evidence of an established catfish population appears in East Okoboji's creel census. Table 2 shows a definite trend toward increasing harvest. Though young-of-the-year catfish have not been observed, natural reproduction is expected to occur. East Okoboji is similar to other lakes which support natural propagation in catfish populations.

DISCUSSION

Stocking fingerlings at a rate of 50,000 to 150,000 per year from 1961 through 1965 has failed to establish a catfish population in Spirit Lake. The fishery population in East Okoboji has been increased by annual stockings 5,000 small adults over a four year period.

Little can be said in comparing the sizes stocked except that survival of the small adults was probably much greater than fingerlings. Small adults have not been stocked in Spirit

Lake nor have fingerlings been stocked in East Okoboji. Stocking rates represent another unknown in this situation. Spirit received an average of 15 fingerlings per acre each year. When stocked in the face of existing fish populations, this rate may not be comparable to the 2.6 small adults per acre that East Okoboji received. Predator species are abundant in both lakes. A higher fingerling stocking rate may have produced much better results in Spirit Lake.

Further investigation of stocking sizes and rates is needed if stocking efficiency is to be improved. In future undertakings of this nature, the number of variables must be held to a minimum so that results from different stocking procedures can be more directly compared.

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WESTERN IOWA CREEL CENSUS DATA, 1962-1965

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Since 1960, Iowa Conservation Officers have gathered angler success information during their routine duties. Each angler contacted is asked the amount of time spent fishing and the number and species of fish caught. This information is important and can be used as an index to general angler success and harvest. Data collected from the major fishing streams in western Iowa from 1962 through 1965 are included in this paper.

There was no major change in the species composition of the creel from each area between 1962 and 1965. Bullhead, channel catfish and carp were the most frequently caught species in 1962, 1964, and 1965. (Tables 1, 3 and 4) In most cases these fish comprised over 75 per cent of the creel. Crappie replaced carp among the top three species in 1963 (Table 2). Less important fish include walleye, sauger, largemouth bass, northern pike, bluegill, yellow perch, freshwater drum, sturgeon, buffalo and sucker.

More fishermen were contacted and more fish were caught at the Little Sioux River each year than at any other area. Between 40 and 80 per cent of the catch from this stream each year was composed of channel catfish. Catch rate was in excess of one catfish per man/day, except in 1962. This river has been one of the finest catfishing areas in Iowa for several years.

All northern pike were caught in the Big Sioux, Little Sioux and Rock rivers. The upper reaches of these streams are located in northwest Iowa and flow through glacial drift areas which contain considerable amounts of rock and gravel. Therefore, these streams are not extremely turbid during much of the year and provide habitat for these sight-feeding fish.

Most crappie and largemouth bass were caught in the Missouri River. Upstream reservoir construction and related channelization work on this stream in recent years has improved the habitat for these fish. Numerous ox-bow lakes have also been formed by channelization which provides a combined lake and river type environment to which these fish have rapidly adapted.

There is considerable variation in the catch rate. Lack of an adequate number of contacts is probably most responsible for this variation. In general, the catch rates ranged up to 1.8 fish per hour. Streams which had the highest range of catch rates were the Little Sioux (0.7 - 1.2) fish per hour, Missouri (0.4 - 1.2) fish per hour, Rock (0.7 - 1.3) and Floyd (0.7 - 1.8) fish per hour.

Table 1. 1962 creel census data from western Iowa streams

River	Bullhead	Channel Catfish	Carp	Walleye	Sauger	Largemouth Bass	Northern Pike	Bluegill	Crappie	Misc.[1]	Total Fish	Total Fishermen	Total hrs Fished	Fish/ Hour
Little Sioux	13	252	18	6	2		16			10	317	278	367	0.9
Big Sioux	57	17	32	1			3			2	112	127	191	0.6
Rock	33	66	56				3				158	99	151	1.0
Missouri	17	41	77			2				1	138	86	117	1.2
Boyer	8	3									11	33	41	0.3
Maple	3	14									17	29	42	0.4
Floyd	95		27							8	130	48	70	1.8
E. Nishnabotna	38	34	4								76	91	135	0.6
W. Nishnabotna	3	34	1								38	70	74	0.5
Nodaway	7	7	4								18	23	25	0.7

1. Includes freshwater drum, buffalo, sucker

Table 3. 1964 Creel census data from western Iowa streams

River	Bullhead	Channel Catfish	Carp	Walleye	Sauger	Largemouth Bass	Northern Pike	Bluegill	Crappie	Misc.[1]	Total Fish	Total Fishermen	Total hrs Fished	Fish/ Hour
Little Sioux	735	657	76	7		1	99		4	19	1598	583	1,359	1.2
Big Sioux	50	22	26							20	118	147	247	0.5
Rock	19	1	3								23	24	17	1.3
Missouri	4	30	30		1	6			64	10	145	99	201	0.7
Boyer	10	5	1								16	16	30	0.5
Maple	5	4									9	18	27	0.3
Floyd	16	7	52							1	76	42	104	0.7
E. Nishnabotna	6	4	5								15	34	42	0.3
W. Nishnabotna	1	5									6	30	37	0.2
Nodaway												4	5	

1. Freshwater drum, bluegill, buffalo, and yellow perch

Table 2. 1963 Creel census data from western Iowa streams.

River	Bullhead	Channel Catfish	Carp	Walleye	Sauger	Largemouth Bass	Northern Pike	Bluegill	Crappie	Misc.[1]	Total Fish	Total Fishermen	Total hrs Fished	Fish/ Hour
Little Sioux	158	531	24	6	1		127			2	849	469	1193	0.7
Big Sioux	25	50	22	3		1	15			8	124	191	225	0.5
Missouri	15	184	146	3	2	4			276	33	663	354	555	1.2
Floyd	6	6	17							1	30	38	41	0.7
E. Nishnabotna	35	38	7								80	51	114	0.7
W. Nishnabotna		4									4	12	33	0.1
Nodaway												2	4	

1. Freshwater drum, gar and sunfish

Table 4. 1965 Creel census data from western Iowa

River	Bullhead	Channel Catfish	Carp	Walleye	Largemouth Bass	Northern	Crappie	Misc.[1]	Total Fish	Total Fishermen	Total hrs. Fished	Fish/ Hour
Little Sioux	305	516	88	14	2	9	3	10	947	460	1,097	0.9
Big Sioux	150	18	18			15		5	206	187	282	0.7
Rock	12	6							18	6	27	0.7
Missouri	66	36	92		1		21	14	230	256	506	0.4
Boyer	67	47	15					9	138	103	255	0.5
Maple	10								10	14	21	0.5
Floyd	13		6						19	23	28	0.7
E. Nishnabotna	1	10							11	8	15	0.7
W. Nishnabotna	1	4	7						12	61	81	0.1
Nodway		2	1						3	6	8	0.4

1. Freshwater drum, mooneye, bluegill, sturgeon, gizzard shad

ESTIMATED FISH POPULATIONS IN STRAIGHTENED AND UNSTRAIGHTENED SECTIONS OF SAME STREAM

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INTRODUCTION

Annually many questions arise as to the expected total population of fish in small Iowa streams. Also, questions are asked as to what effect stream straightening has on the fish populations of these areas. Rarely do fish kills occur of such magnitude necessary to obtain population data on these streams Even less frequently do natural kills occur where straightened and unstraightened sections of the same stream are equally affected. If nature does eliminate fish in a small stream, it is usually at a time when all fish in representative sections can not be counted. Generally, public opinion is such that it would be difficult to justify the elimination of fish from a large section of stream solely to obtain a count of those present. Also, most streams of the type from which total population estimates are desired are on private land thus adding to the difficulty of obtaining such information.

During August, 1966 permission was granted to eliminate all fish from approximately 6.0 miles of Bluff Creek feeding Boone County Conservation lake. The main objective of this treatment was to reduce the chances of carp entering the new lake. Rotenone was used at a concentration of about 2.0 p.p.m. Complete eradication of all fish within the project area was accomplished. Elimination of fish in this stream presented an opportunity to estimate the fish population from straightened and unstraightened sections of the same stream.

STRAIGHTENED SECTION

Stream Description: At the time of the chemical treatment, the straightened portion of this stream averaged 10 feet in width and a maximum depth of 2 feet. Bottom topography was quite uniform with no pronounced pools and few riffles. At this time tile lines feeding the stream were not flowing and the stream was sluggish. Bottom composition was mainly sand and mud. Aquatic vegetation was absent except at the extreme upper end where smartweed was abundant. The stream banks were steeply sloping and weedy. No trees or log piles were present. There is little or no protection for fish during periods of high water. This segment of the stream flows through agriculture and pasture land. Cattle have access to much of this stream causing intermittent periods of high turbidity.

Sampling Methods and Results: To obtain the data necessary to make a total population estimate, all fish within a measured portion of the stream were recovered, counted, and weighed. At the first sampling station a 100 foot section was measured. However, because a large number of dead fish were present, recovery of all was time consuming. Subsequent sampling was done in 50 foot lengths.

The fish population observed in a sample length of 200 feet is presented in Table I. Individual species of small minnows, shiners, etc. was not considered significant enough to warrant listing each separately. Observation of stream sections not sampled, indicates these data are representative of the entire channeled area.

Results of expanding these data to 3 stream miles can be seen in Table 2. As would be expected in a stream of this type minnows and shiners were most abundant, comprising about 90 per cent to the total estimated population of 120,295 fish. Creek chub, carp, and suckers followed in order of abundance. Bullhead and young smallmouth bass were also present. Most of the fish observed were quite small. The straightened area contained approximately 3.6 acres of water. The average acre contained about 242 pounds of fish.

UNSTRAIGHTENED SECTION

Stream Description: This section of stream averaged approximately 15 feet in width. It meandered extensively through a limited amount of pasture land, golf course and timber. Each of the many bends on the stream contained large deep holes, usually in conjunction with a log jam. Maximum depth for each of these holes was about 4.5 feet. There was an abundance of rock riffles throughout this section. Bottom composition except at the riffles was sand and mud. This segment of the stream contained excellent habitat for fish.

Sampling Methods and Results: The methods used to collect data from this section of stream were the same as those previously described.

Results obtained from fish collection in 100 feet of sampling are shown in Table 3. Visual observation of long stream lengths indicated data collected from sample areas were reliable. Only two large adult carp were observed and they were not in the sample areas.

Expanded results for this portion of stream are presented in Table 4. Minnows, shiners and other species were the most abundant, accounting for approximately 91 per cent of the estimated 220,376 fish. Creek chubs were next in abundance followed by suckers and smallmouth bass. Approximately 5.5 acres of stream were contained within this area. Each acre sustained 322 pounds of fish.

DISCUSSION

On a per acre basis the unstraightened segment of this stream contained approximately 16 per cent more fish by number and 25 per cent more fish by weight than the rechanneled section. Even though the channeling was upstream, sample areas in the unchanneled segment were far enough removed that it is doubtful drift of dead or live fish from upstream influenced the data significantly. Habitat was probably the most important factor influencing fish population. A unstraightened stream has considerably more stream length and superior environment per mile than a straightened channel. Thus straightening reduced the number of fish by reducing habitat quality and by reduced stream acreage. The data presented compare fish populations only on a basis of habitat and does not include those from estimated loss of stream length due to straightening.

Table 1. Number and weight of fish observed by species in 200 feet of straightened stream.

Species	Total Fish	Total Weight (pounds)
Creek chub	113	2.28
Carp	20	.18
Smallmouth bass	10	.06
Suckers	13	.91
Minnows, shiners and misc. fish	1,325	7.28
Black bullhead	1	.14

Table 2. Estimated fish population density in 3 miles of straightened stream.

Species	Estimated Total fish	Estimated Total Weight
Creek chub	8,950	180
Carp	1,584	15
Smallmouth bass	792	0.5
Suckers	1,030	71
Minnows, shiners and other fish	107,860	593
Black bullhead	79	11
Total	120,295	870.5

Table 3. Number and weight of fish observed in 100 feet of unstraightened stream

Species	Total Fish	Total Weight
Creek Chub	101	2.58
Carp	1	.45
Smallmouth Bass	9	.09
Suckers	18	.91
Minnows, shiners and misc. fish	1,281	7.38
Black bullhead	1	.33

Table 4. Estimated fish population density (by species) in 3 miles of unstraightened stream

Species	Estimated Total Fish	Estimated Total Weight
Creek Chub	15,840	406
Carp	158	71
Smallmouth bass	1,426	15
Suckers	1,852	83
Minnows, shiners and other fish	200,942	1,158
Black bullheads	158	52
Total	220,376	1,785

Check list of those species recovered from this stream

Big-mouth Shiner	<u>Notropis dorsalis</u> (Agassiz)
Black Bullhead	<u>Ictalurus melas</u> (rafinesque)
Blacknose Dace	<u>Rhinichthys atratulus meleagris</u> (Agassiz)
Brook Stickleback	<u>Eucalia inconstans</u> (Kirtland)
Carp	<u>Cyprinus carpio</u> (Linnaeus)
Common Shiner	<u>Notropis cornutus fontalis</u> (Agassiz)
Creek Chub	<u>Semotilus atromaculatus</u> (Mitchill)
Fathead Minnow	<u>Pimephales promelas</u> (Rafinesque)
Hornyhead Chub	<u>Hybopsis biguttata</u> (Kortland)
Johnny Darter	<u>Etheostoma nigrum</u> (Rafinesque)
Sand Shiner	<u>Notropis deliciosus</u> (Girard)
Slenderhead Darter	<u>Percina phoxocephala</u> (Nelson)
Smallmouth Bass	<u>Micropterus dolomieui</u> (Lacepede)
Stonecat	<u>Noturus flavus</u> (Rafinesque)
Striped Fantail Darter	<u>Etheostoma flabellare lineolatum</u> (Agassiz)
Suckermouth Minnow	<u>Phenacobius mirabilis</u> (Girard)
Stoneroller	<u>Campostoma anomalum</u> (Rafinesque)
White Sucker	<u>Catostomus commersoni</u> (Lacepede)

THE RELATIONSHIP OF LAKE MORPHOMETRY AND THERMAL STRATIFICATION

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In the selection of sites for the construction of small artificial lakes and reservoirs consideration of thermal and chemical stratification is of paramount importance. Investigations by Dendy (1945), Sprugel (1951) and Byrd (1951) revealed thermal stratification was the principle limiting factor of vertical distribution and movement of fish. Studies at Red Haw Lake by Mayhew (1963) verified a profound relationship between thermal stratification and vertical movement, growth, and general well-being of fish. In this investigation thermal stratification was the most important factor controlling fish growth and population magnitude. Failure of many anglers to recognize the presence of this phenomenon was also responsible for most unsuccessful fishing trips.

Thermal layering is the result of physical isothermic isolation by thermal resistance and differential density. Its magnitude is influenced by fluctuationof atmospheric temperature, area hypsography, and basin configuration. Moen (1956) found great variation in severity of thermal stratification in Iowa artificial lakes and reservoirs. The Red Haw Lake studies (Mayhew, op. cit.) also revealed slight difference in the location of the thermocline from year to year. In fact, epilimnion thickness was identical each of the 3 summers studied. Atmospheric temperatures show insignificant annual variation in this region of the state. It appears therefore, atmospheric temperature is important only during initial formation of thermal layering and for maintenance of stratification. Severity of stratification and the location of the thermocline are functions of basin characteristics.

This is a study of variations in morphometry of five different southern Iowa artificial lake basins in relation to their degree of thermal and chemical stratification.

METHOD OF STUDY

The five lakes selected for study varied greatly in intensity of thermal stratification, size, location, and general topographical characteristics. Two exhibit severe thermal and chemical stratification each summer, two stratify temporarily without a well defined hypolimnion, and one has never stratified. The lakes were Red Haw Lake in Lucas County, Lacey-Keosauqua Lake in Van Buren County, Green Valley Lake in Union County, Lake Darling in Washington County, and Lake Keomah in Mahaska County. All are state-owned recreational impoundments for which engineering and limnological data were available.

In order to determine the relationship of thermal stratification and basin development, a series of mathematical relationships were developed for lake morphometry. These indices would express physical characteristics of each lake basin as a multiple dimensional cone whose heighth and area of the base would be identical to the actual form of the water mass. All data were graphically illustrated for individual analysis and comparison with other lake basins.

If these relationships were valid, there would be a direct similarity of one or more basin characteristics in those lakes with similar thermal and chemical stratification characteristics. Further, if these indices were comparable with accuracy, they could be employed to determine the extent and location of thermal layering before construction of impoundments.

The most important physical factors influencing basin development are slope of the basin, area development, and volume development. There are several others that could influence thermal layering in individual impoundments but they were considered of minor imporrance or immeasurable.

Slope of basin walls yielded shape of the water mass in a 2-dimensional plane. Slope of individual isobaths was calculated by using the formula

$$\text{Slope} = \frac{C_1 + C_2}{2} \cdot \frac{I}{A}$$

where

C_1 and C_2 = lengths of the 2 contours involved
I = vertical distance or interval between contours
A = area in acres X 4.356 X 10 -4.

Mean slope was then determined for the entire water basin by the formula

$$\text{Slope} = \left(\frac{1/2\, C_0 + C_1 + C_2 + \text{-----}\ \text{-----}\ (C_n - 1) + 1/2\, C_n}{N}\right) \cdot \frac{D}{A}$$

where

C_o, C_1, C_2 = lengths of contours
n = number of contours
D = maximum depth of the lake
A = surface area of the lake in acres X 4.356 X 10^{-4}.

Changes in basin slope are reflected in both individual and mean slope relationships. As walls of the lake basin become steeper there is a proportional increase in slope of contour and mean slope.

Area development was determined for each impoundment by graphically ploting hypsographic curves of submerged contours and elevation. Area in acres was plotted on the ordinate and depth on the abscissa. The resulting curve represents in 3-dimensional profile certain elements characteristic to the form of the basin. As area development becomes greater, there is an inverse association of depth and area. The slope of the curve becomes progressively greater with increased area development.

Volume development was determined by plotting a series of curves using Δ-volume within individual contours. The form of the water was further expressed as an index figure by using the formula

$$\text{Volume Development} = \frac{3\ (MD)}{MXD}$$

where

MD = mean depth of the lake
MXD = maximum depth.

This expression of volume development represent the ratio of total volume in relation to an infinite nth dimensional cone whose volume development is identical with the lake basin.

When the resulting value is unity, the form of the lake basin is a perfect cone; when the basin walls are essentially convex toward the surface, the index figure is less than unity; when the basin walls are concave toward the surface, the index figure is greater than unity.

RESULTS

Red Haw Lake

The lake is located near Chariton in Lucas County. At spillway crest the lake contains 82 surface acres and a maximum depth of 38 feet. Mean depth is 13.8 feet. The entire irregular shoreline is covered with heavy mature timber that shelters the lake from wind. Each summer, beginning early in May, the lake becomes severely stratified. The thermocline is located from 9 to 20 feet deep with complete absence of dissolved oxygen below 12 feet.

Slope of contours within the basin ranged from 0.036 to 0.186 with a mean slope of 0.086. There is a progressive increase in slope as depth increases. Area development, as illustrated in Figure 1, also revealed similar basin characteristics. As depth increases, there is an inverse association with area. Volume development for Red Haw Lake was calculated at 1.08. These data indicate a lake characterized by steep basin walls, limited shallow water, and accelerated volume and area development as depth increases. Basin walls are slightly concave toward the surface of the water.

Lacey-Keosauqua Lake

This lake is located near Keosauqua in Van Buren County. The dam impounds a surface area of 24.7 acres with a maximum depth of 36 feet. Mean depth is 12.5 feet. The very deep, heavily wooded valley affords maximum shelter to the water surface. Severe thermal stratification occurs annually from early May until late September. Moen (op. cit.) found the lake stratified as early as May 4. Dissolved oxygen is completely utilized at depths in excess of 10 feet. Occasionally a psuedo-thermocline will develop within the epilimnion. Thermal layering is more extensive in this lake than any other Iowa artificial lake.

Basin slope becomes progressively greater as depth inverses. Slope ranged from 0.098 to 0.376. The extreme slope of the latter is due to measurement of the original creek channel where slope would be almost vertical. Mean basin slope was 0.207. The hypsographic curve showed rather unique development. Slope of the line was oblique in shallow water strata, became less abrupt at medium depths, and declined very sharply in the abyss (Figure 3). Volume development was 1.1 for the lake basin. Graphically (Figure 4) there was an inverse association of Δ-volume development and depth. Basin walls are concave toward the water surface.

Green Valley Lake

Green Valley Lake is located near Creston in Union County. The lake has a surface area of 398.2 acres and a maximum depth of 26 feet. Mean depth is 10.1 feet. The lake is located in a long, narrow, unprotected valley. Shoreline development is quite irregular. Temporary or unstable thermal stratification occurs in mid-summer. Only epilimnion and thermocline are present. Dissolved oxygen is found at all depths, but during prolonged thermal layering and low wind velocity it may not be found in sufficient quanity to sustain fish life.

Slope of the basin varied from 0.027 to 0.231 with a mean slope of 0.041. The unusually high figure for the latter was again due to measurement of the original stream bed. Basin slope becomes progressively steeper at deeper contours. The hypsographic curve in Figure 5 reveal rather stable and gentle area development until the 20-foot contour; then a drastic reduction in area development occurs. This in effect represents a cone with a large base and limited heighth that is drastically pinched inward near the apex. Volume development was 1.21 for the entire basin. The Δ-volume curve in Figure 6 shows proportional development within contours until deeper contours are reached. At this point volume development is substantially reduced. Shape of the water mass was concave toward the surface.

Lake Keomah

The lake is located near Oskaloosa in Mahaska County. At spillway crest the impoundment contains 82.6 surface acres and a maximum depth of 22 feet. Mean depth is 10.4 feet. The lake is Y-shaped with the dam forming the base of the figure. Shoreline development is somewhat irregular. Mature woodland around the entire perimeter of the lake offers protection from wind. Thermal layering is present throughout most of the summer. The hypolimnion is not well defined and may disappear frequently during high surface turbulents. Dissolved oxygen concentrations in the hypolimnion are usually below the minimum required for fish life, but this region has never been found anareobic.

Basin slope could not be determined because of the lack of adequate survey contours. From other available data it was estimated to be slightly more severe than in Green Valley Lake and substantially less than Red Haw Lake. Area development almost assumes a straight line relationship. Figure 7 This means area development is constant and directly proportional with increased depth. Volume development was 1.31 for the entire lake basin. Pronounced acceleration of Δ-volume in shallow depths was found, with a greater tendency for the shape of the water mass to be concave toward the surface in the shallows (Figure 8).

Lake Darling

Lake Darling is a shallow, turbid impoundment near Brighton in Washington County. Surface area is 404 acres; maximum depth 21 feet; and mean depth 10.2 feet. The lake is located in a long, narrow valley with several large bays protruding from the main body. There is little shelter along the shoreling. The lake has never thermally stratified in 15 years of routine temperature profiles. Surface water temperature during the summer is usually within 5° F. of those near the bottom. Moen (op. cit.) found psuedo-stratification within 3 feet of the surface on one occasion.

Slope between contours within the basin ranged from 0.004 to 0.062 with a mean slope of 0.019 for the entire lake. There is also a direct association between area development and depth. The hypsographic curve in Figure 9 is almost a straight line relationship with a slight tendency for greater area development in the deeper contours. Volume development in Lake Darling was 1.46. At shallow depths Δ - volume increases slightly because of acceleration of the curvature in the concave basin walls (Figure 10).

DISCUSSION OF RESULTS

The presence of thermal stratification is the most important factor of environmental stress in many Iowa artificial lakes and reservoirs. Stratification is significant because it forms a natural barrier isolating both epilimnion and hypolimnion. The hypolimnion is isolated from the atmosphere because each layer is physically incapable of being mixed due to thermal resistance. Organic decomposition increases rapidly in the hypolimnion until all available dissolved oxygen is utilized and toxic amounts of ammonia nitrogen and hydrogen sulfide are released. This environment is not only undesirable but is essentially hostile to most higher forms of life. The epilimnion is isolated from the bottom of the lake except the portion that is located between the epilimnion and thermocline. This in effect reduces living space and precludes the development of normal bottom fauna which are a very important food chain constituent.

There is substantial evidence that severe thermal layering has a vital influence on fish life by limiting movement and crowding all fish into a narrow oxygenated strata. In severely stratified lakes, such as Red Haw Lake and Lacey-Keosauqua Lake, the epilimnion occupies less than 35 per cent of the entire water volume. The utilization of this controlling capability of thermal layering could make this phenomenon a valuable "tool" in fishery management.

One of the common perplexing problems of fishery management is lack of personnel. Many of the recreational lakes in southern Iowa are located substantial distances from management stations and simply do not receive adequate fish management because of long distance operations. Most successful intensive fish management programs have been located within close proximity of management stations.

Water level reduction for population manipulation has been one of the most successful methods of fish management. In effect this occurs naturally with thermal and chemical stratification except that it assumes an inverted position crowding the entire fish population into the epilimnion. Many severely stratified artificial lakes in southern Iowa receive only limited fish management, such as routine channel catfish fingerling stocking or remedial fingerling largemouth bass stocking to supplement natural reproduction. Yet they rank high in fish production and angler success. Natural population manipulation by severe stratification is thought to be primarily responsible.

Through the use of measurable morphometrical basin characteristics it is possible to accurately predict the intensity and location of thermal layering. Lakes having similarity in basin structure also have similarity in thermal characteristics. Although there are many physical properties applicable to basin shape only area development, volume development, and slope were used in this study.

The shape of the water mass in stratified lakes was quite different from lakes with temporary stratification or none at all. There is a decrease in area and volume development and an increase in basin slope with intensification of thermal layering. Basin shape in all lakes studied was concave toward the surface. Development of the basin also approached unity with increased thermal layering. In general, minimum standards for a lake basin with well-defined thermal and chemical stratification are volume development less than 1.15 and mean basin slope 0.05. Limited or temporary stratification can be expected in lakes with volume development less than 1.25 and mean slope of 0.035. Lake basins with volume development of more than 1.4 and basin slope of less than 0.02 will not stratify. Area development comparison can be made only by graphical direct association in hypsographic curves. Lake basins with greatest area development in relation to depth did not stratify.

Basin development comparison was made with Lake Anita in Cass County using these methods. Construction has been recently completed on this 154-acre recreational lake, and it is yet unfilled with water. Volume development was calculated at 1.18. Slope ranged from 0.03 to 0.198 with mean slope of 0.064. Area development was similar to Green Valley Lake. From this information, Lake Anita is expected to stratify at approximately 18 feet with a well defined hypolimnion. There will be annual depletion of dissolved oxygen below a depth of 24 feet. Temperature and dissolved oxygen profiles will be completed for this lake when water levels reach spillway crest.

Further analysis of thermal characteristics was made by using basin dimensions of Red Haw Lake but assuming the lake basin was a perfect cone. Temperature and dissolved oxygen profiles from the lake were then applied to this hypothetical basin. Volume development would be 1.0; slope, 0.45; and area development would assume straight line regression in the hypsographic curve. Thermal layering would be extremely severe with the thermocline extending from 4.5 to 13 feet. Depletion of dissolved oxygen levels would be in comparable severity.

The magnitude of thermal stratification should be of paramount importance in the selection of sites for recreational lakes in southern Iowa. Lakes without stratification are capable of producing far more fish because there is no crowding of fish into shallow water each summer. However, this crowding is important as a natural population controller not unlike that induced by water level reduction. Lake basins within close proximity to fish management stations should be selected for non-stratification characteristics. Maximum production can be maintained through intensive fish management. Lake sites located considerable distances from fish management stations should be selected for characteristics that will promote severe thermal layering. These lakes will have natural population manipulation by having fish populations crowded into the epilimnion.

ACKNOWLEDGEMENTS

I am indeed grateful for assistance in setting up the mathematical relationships of lake basins from Bill Randolph, Engineer, Engineering Construction and Design Section, State Conservation Commission. His help was instrumental in making valid comparisons of lake basins.

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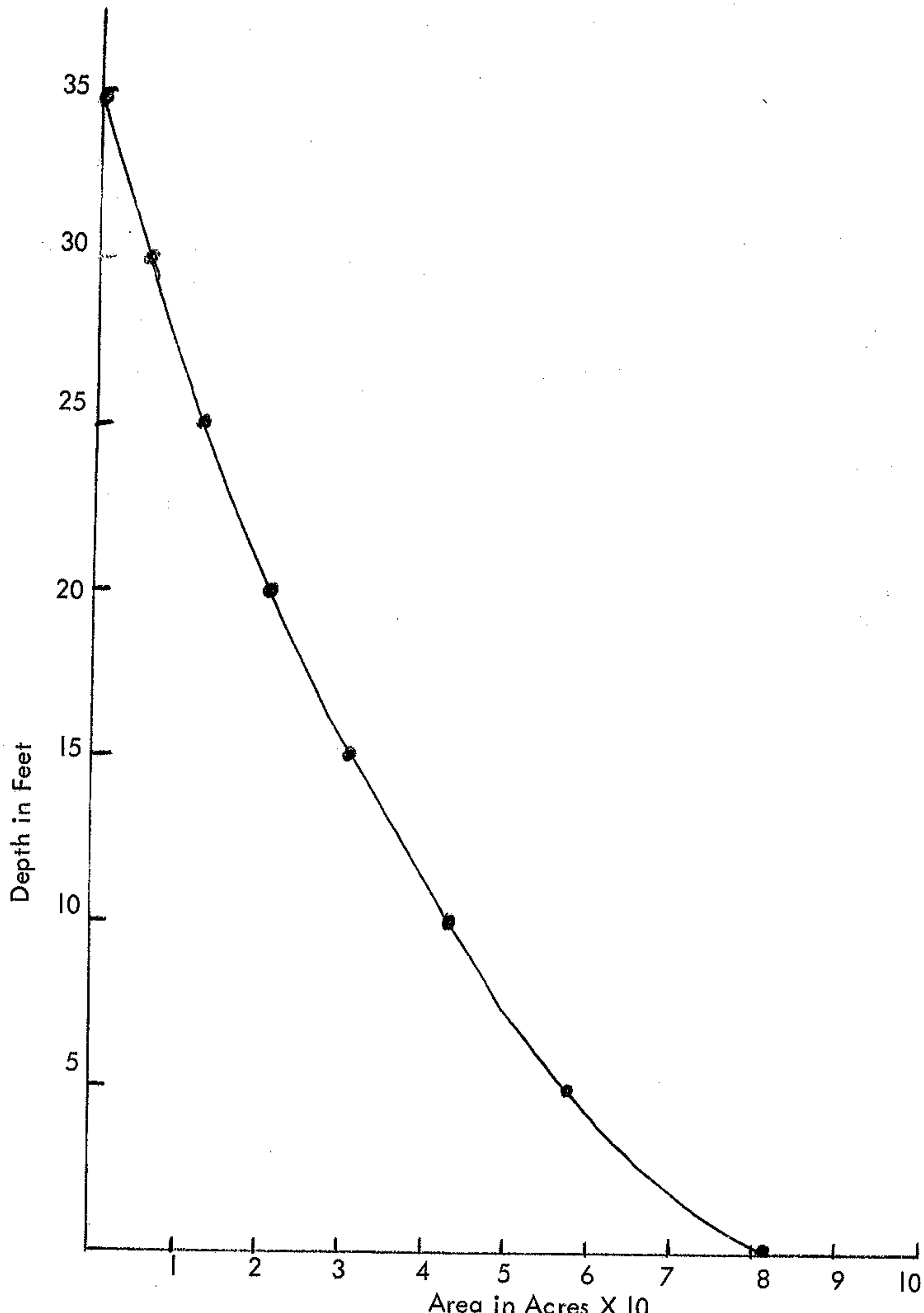


Figure 1. Hypsographic curve of area development in Red Haw Lake.

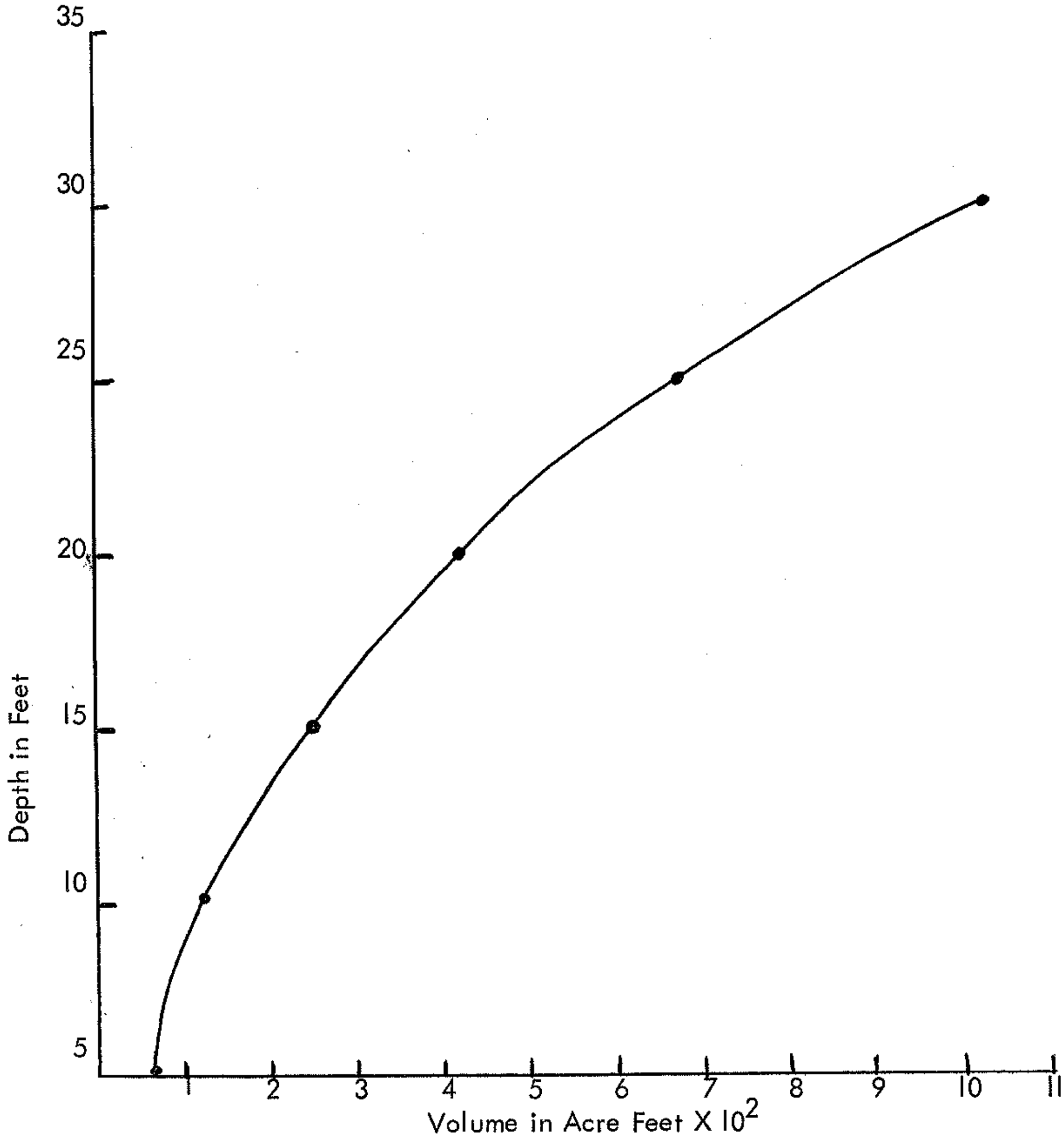


Figure 2. Volume development in Red Haw Lake.

Figure 3

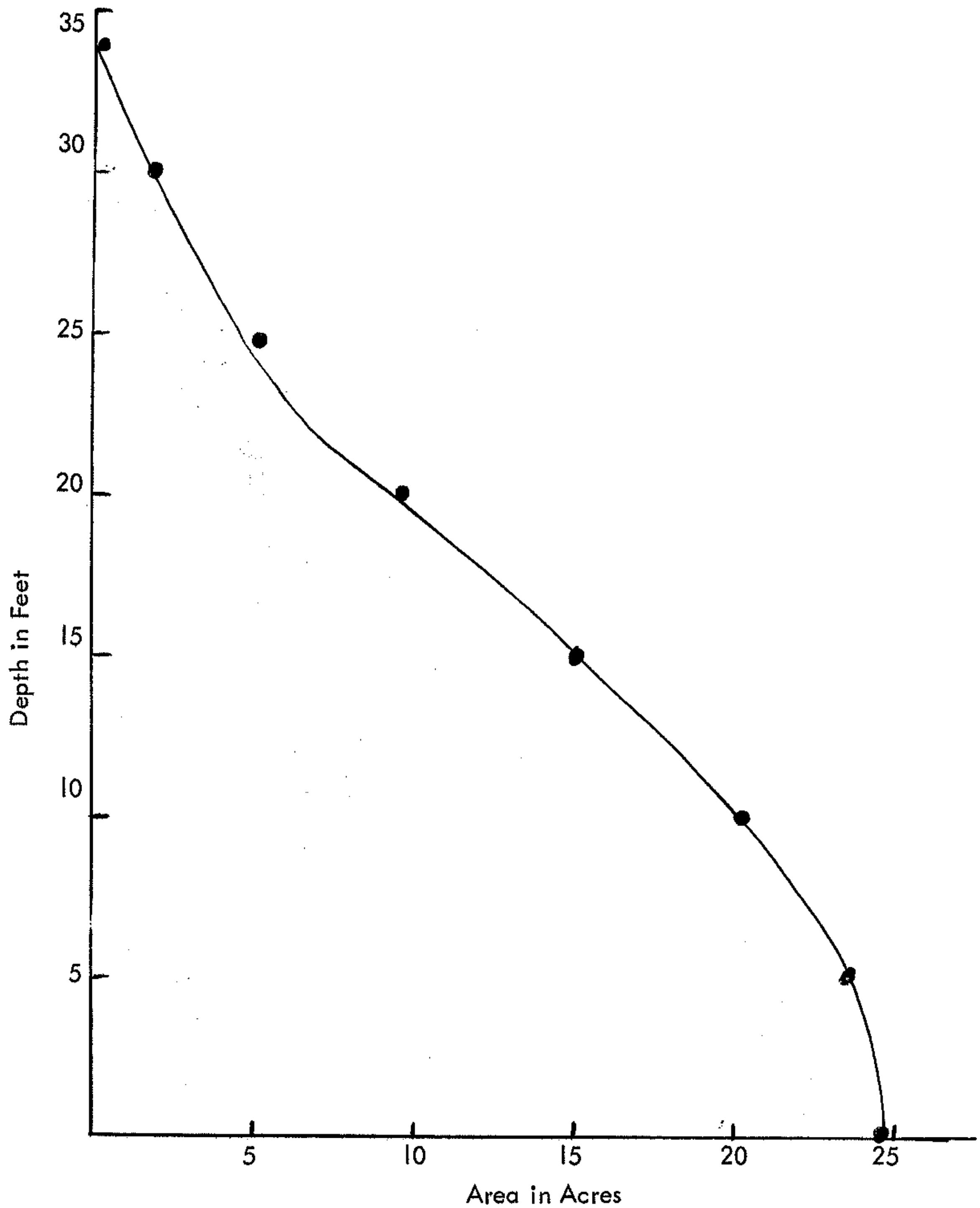


Figure 3. Hypsographic curve of area development in Lacey-Keosauqua Lake.

Figure 4

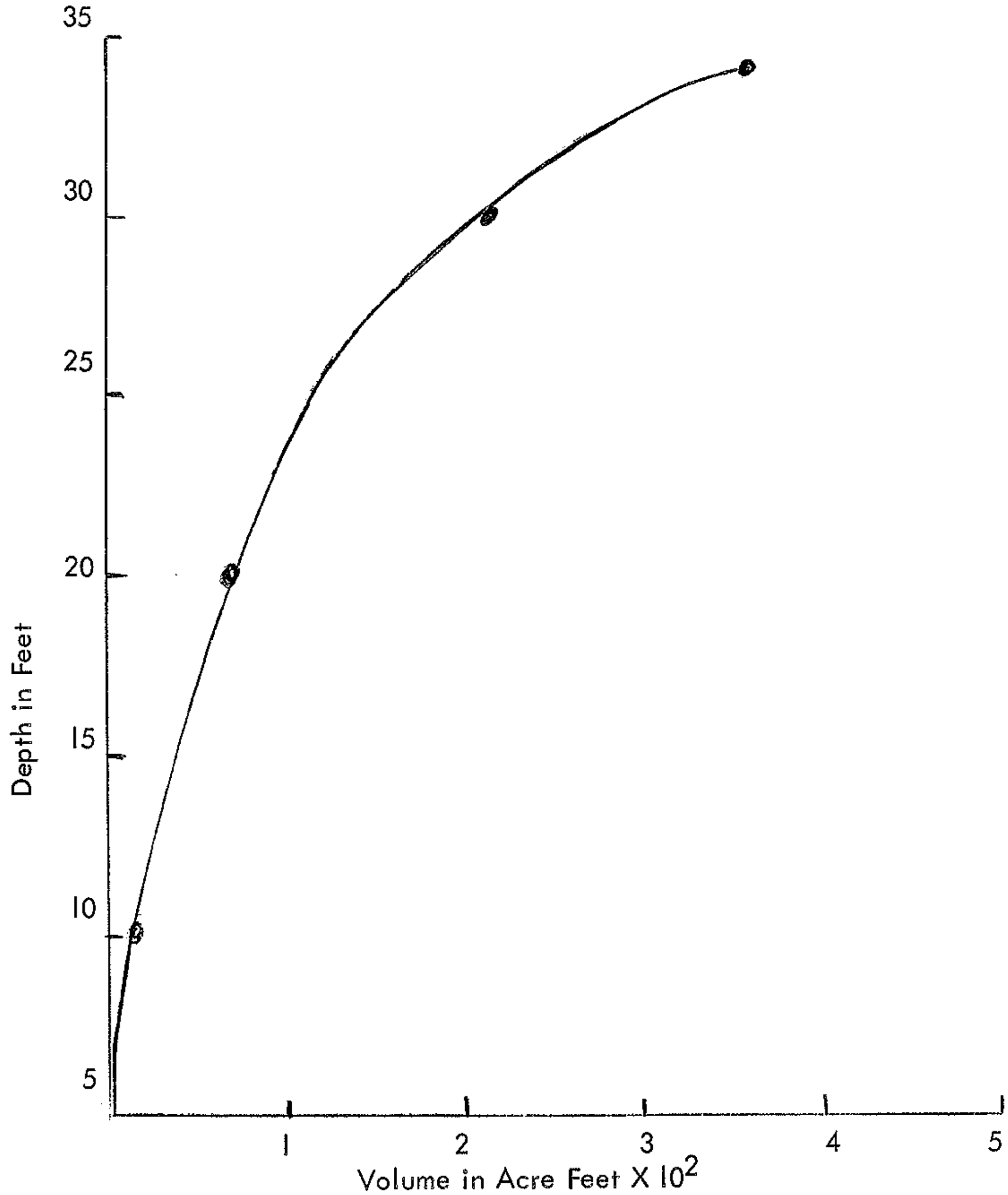


Figure 4. Volume development in Lacey-Keosauqua Lake

Figure 5

Figure 5. Hypsographic curve of area development in Green Valley Lake.

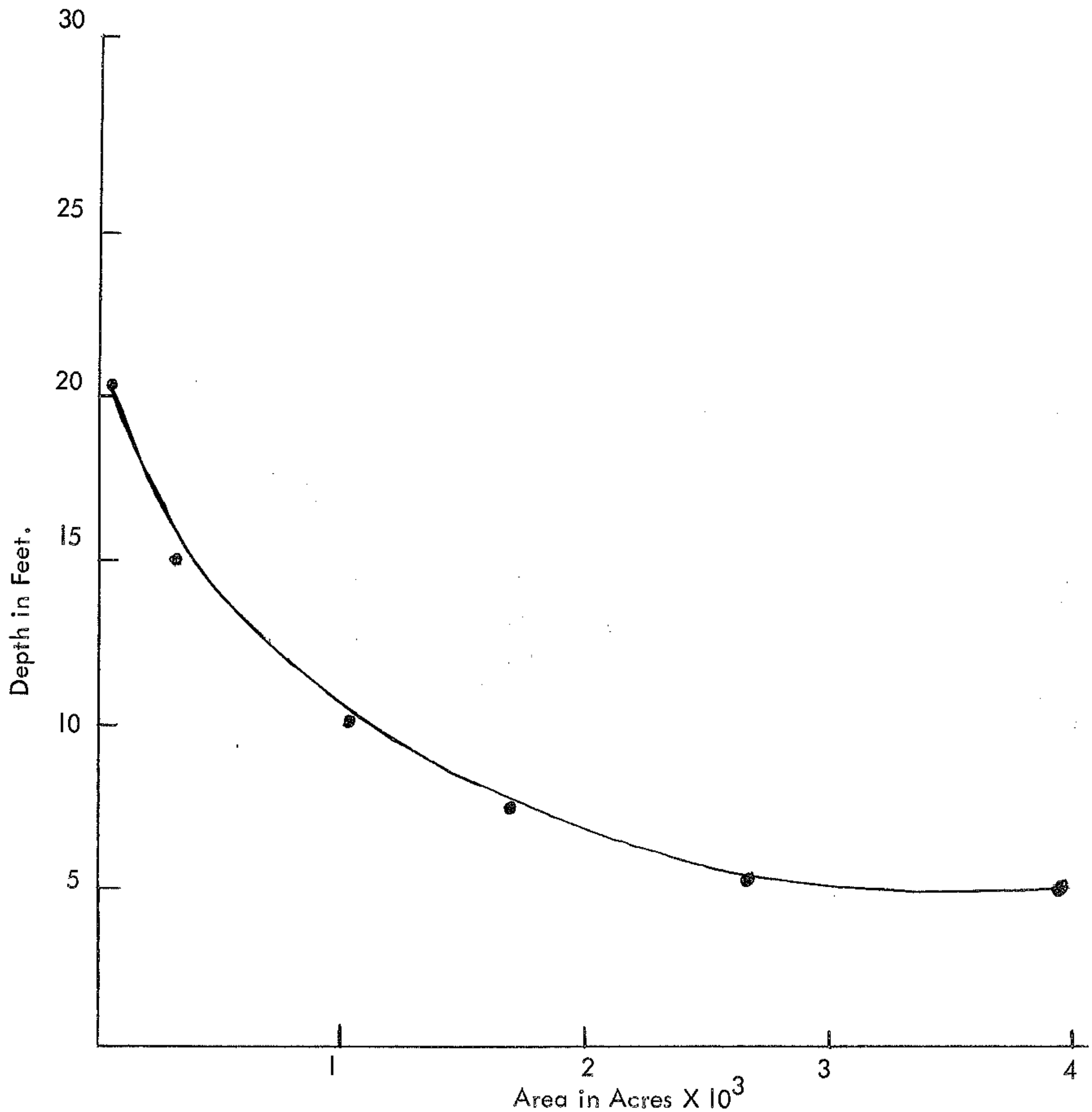


Figure 6

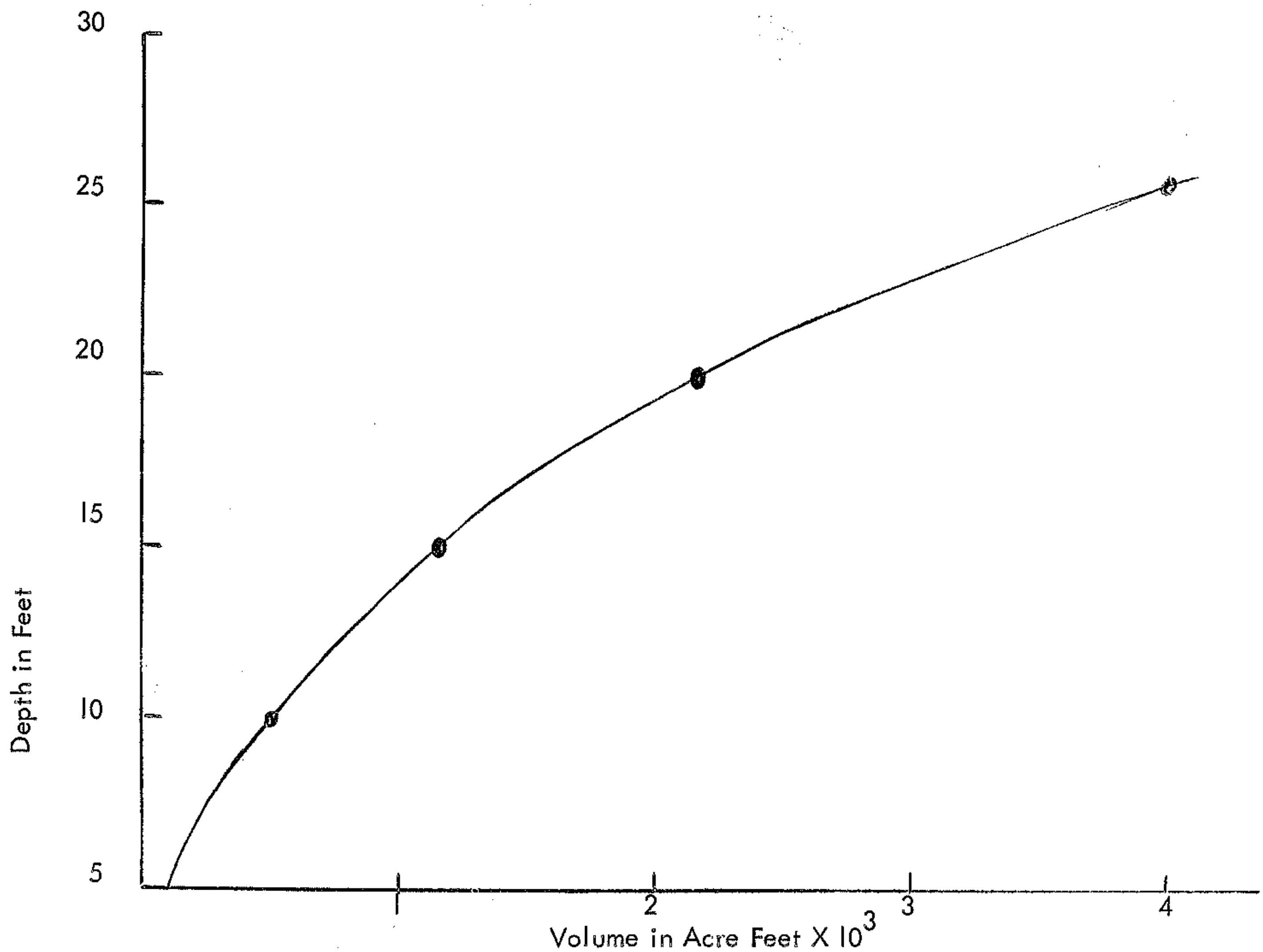


Figure 6. Volume development in Green Valley Lake.

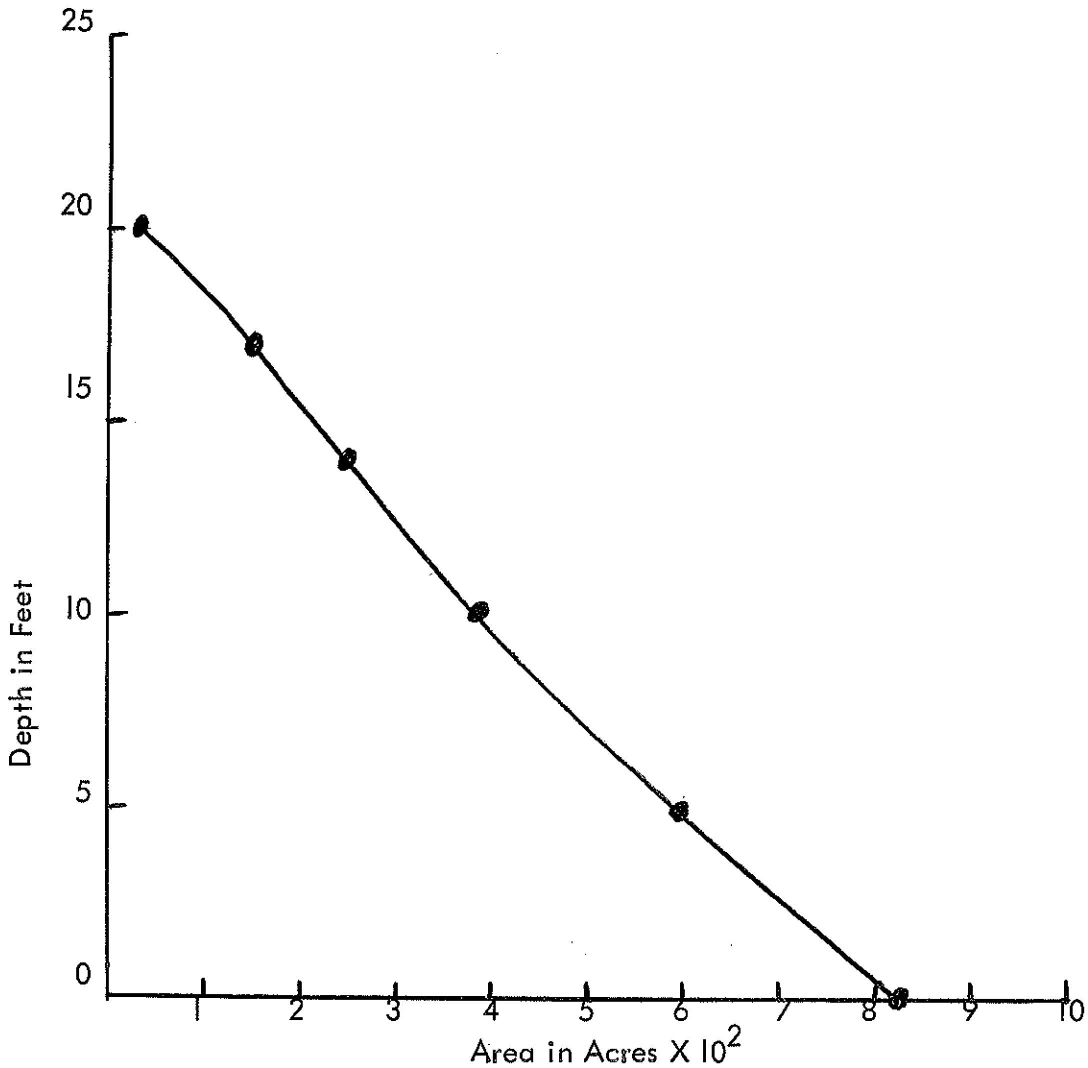


Figure 7. Hypsographic curve of area development in Lake Keomah.

Figure 8

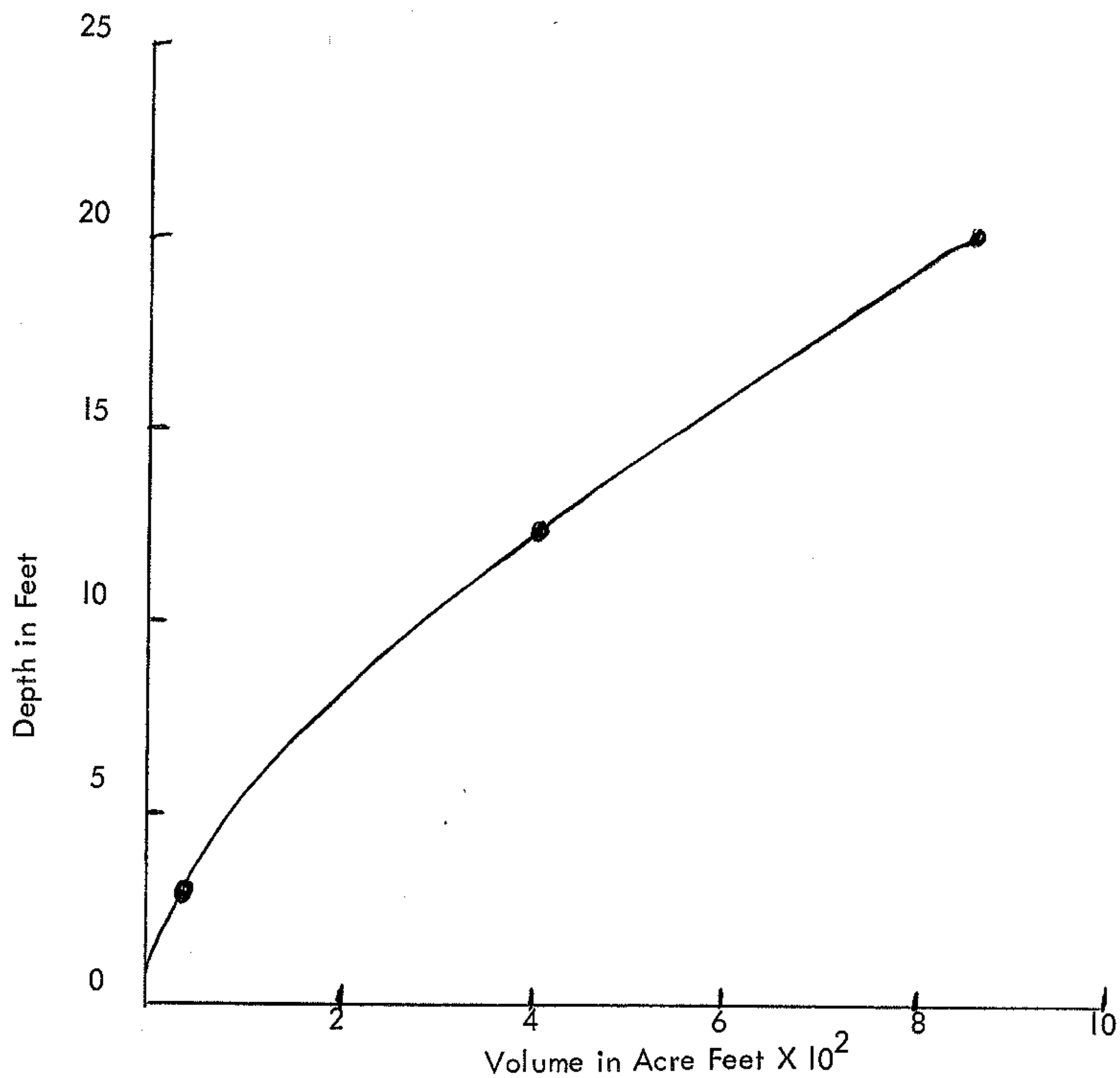


Figure 8. Volume Development in Lake Keomah.

Figure 9

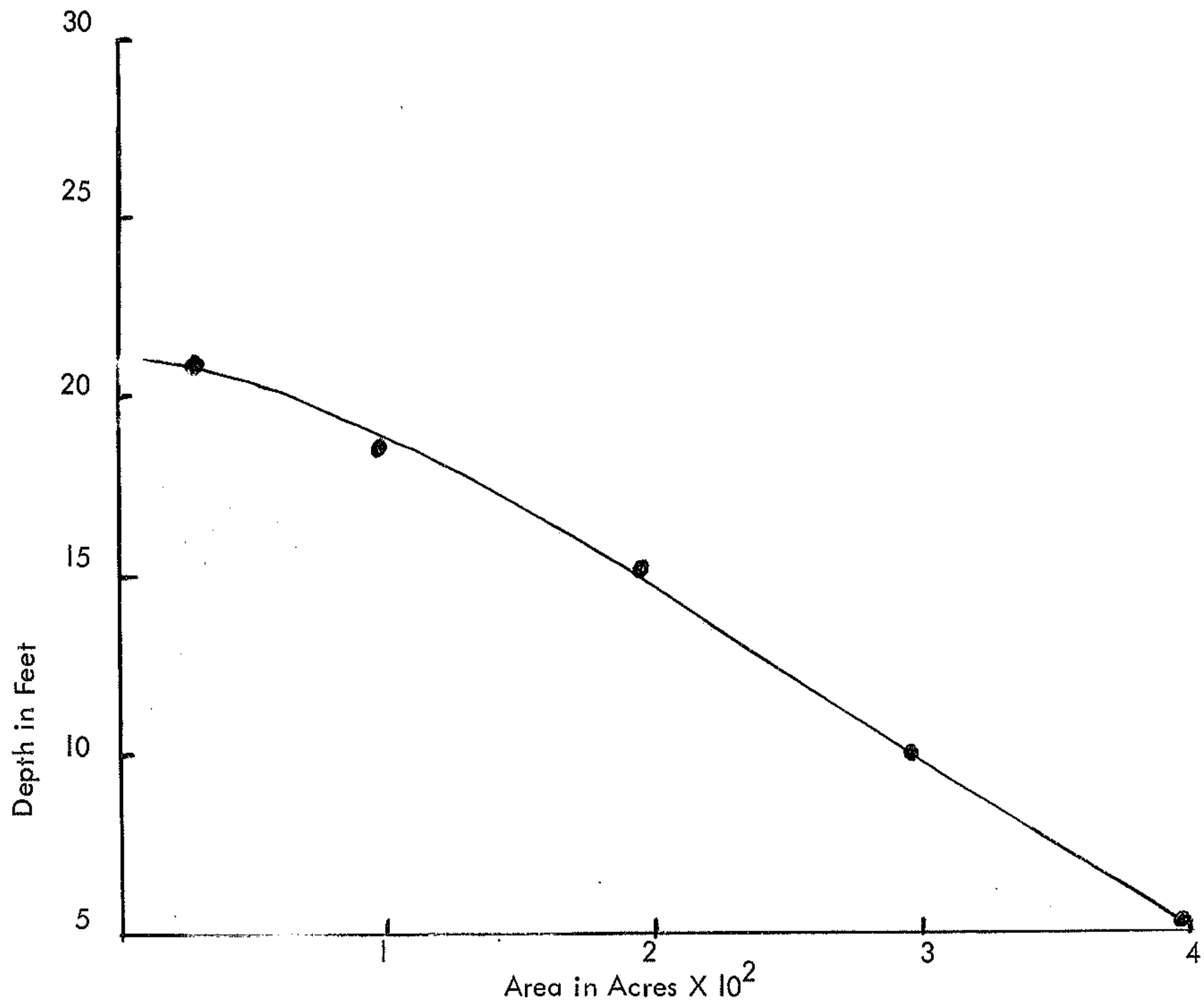


Figure 9. Hypsographic curve of area development in Lake Darling.

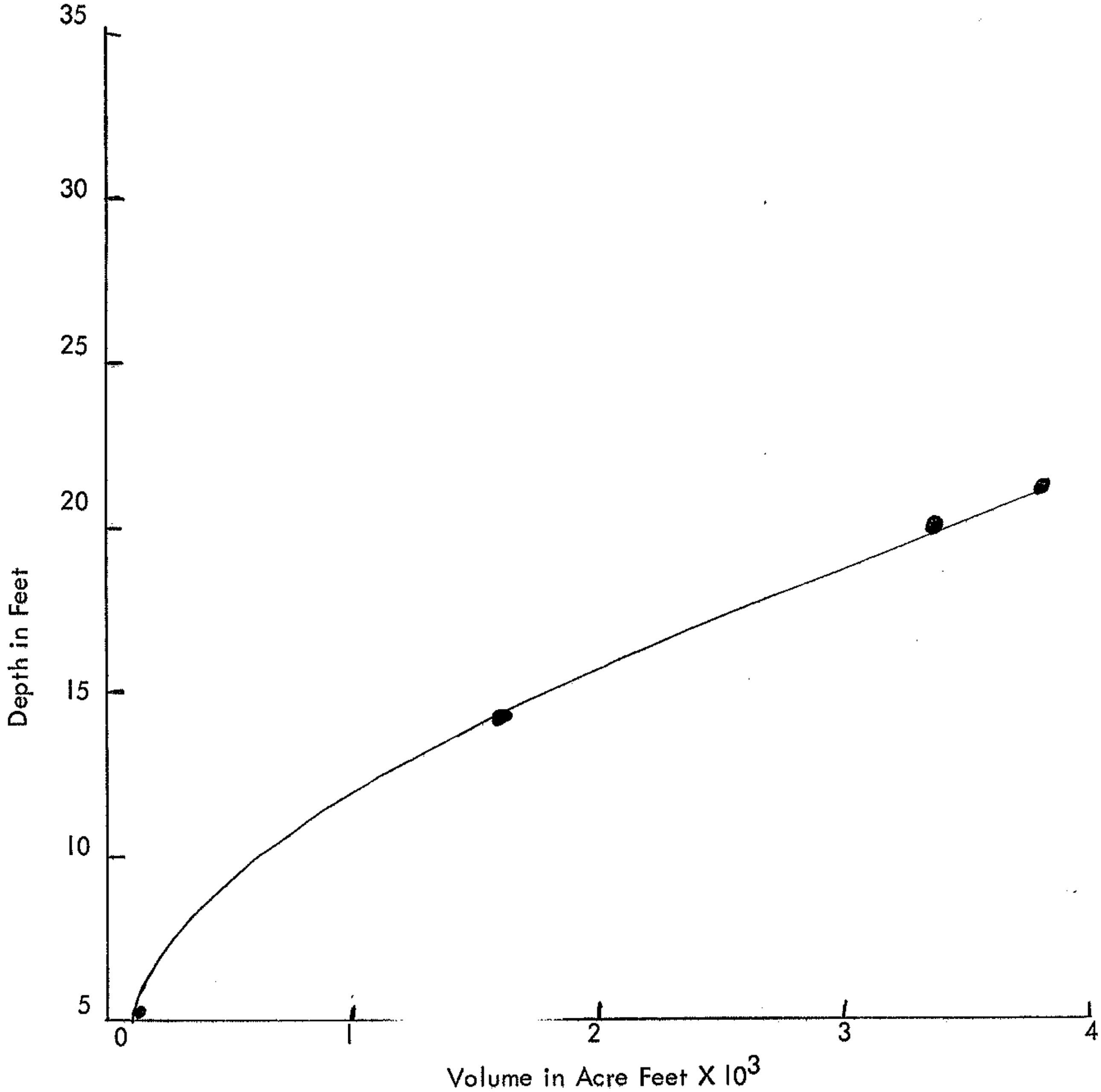


Figure 10. Volume Development in Lake Darling.

AGE AND GROWTH OF BIGMOUTH BUFFALO IN CORALVILLE RESERVOIR

Larry Mitzner
Fisheries Biologist

The biological success of a commercial fisheries program must be based on five important parameters: l) growth of the fish in terms of length and weight, 2) density of the population, 3) density of the population entering the fishery, 4) mortality of the population from natural causes and 5) mortality of the population from fishing. Data for one season is insufficient to estimate the parameters of density and mortality. However, coupled with similar data from future seasons it will lend itself to mortality and density calculations. The data for 1966 were found adequate to calculate growth and determine the age class structure of the bigmouth buffalo.

Financial aid for this study has been given by the Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service.

METHODS

Growth of the bigmouth buffalo in Coralville Reservoir was determined from 236 scale samples collected from June 18 through October 7, 1966. Size range of the sample was 6.25 inches to 23 inches standard length and represented 10 year classes. The scales were taken without regard to sex because fish were fin clipped and returned to the water intact. Samples were collected from representative geographic locations and time intervals throughout the summer.

DESCRIPTION OF GROWTH

Body-Scale Relationship - Body scale relationship was determined from 236 fish taken by pound net and gill net. Also 8 young-of-the-year fish were taken by shore seine. Fish were measured to the nearest 0.25 inch. The scales were magnified 17 times and measured on the anterior radius to the nearest 1/8 inch. The average scale length for each 0.25 inch interval of standard body length was calculated and graphically plotted in relationship to the body length. A rectilinear relationship was evident with a theoretical scale formation at 1/8 inch. Using the formula y=a +bx and emperically solving for a line drawn through the points by sight, this relationship can be expressed

$$y = .125 + 1.328x$$

where y equals the standard body length in inches and x equals the length of the anterior radius of the scale in inches. This relationship was used to back calculate the standard body lengths at all annuli. Because the theoretical length at scale formation was so small it was not used as a correction factor.

Growth of buffalo collected in each of 7 bi-weekly periods was calculated and the values compared. There was very close agreement among the values of each bi-weekly period, hence, calculations were made by combining the bi-weekly periods using a weighted average (Table 1).

Table I. Mean calculated standard lengths of bigmouth buffalo in Coralville Reservoir

Year Class	Age Group	Year of Life 1	2	3	4	5	6	7	8	9	10
1965	I	4.51									
1964	II	5.15	7.85								
1963	III	5.98	9.84	12.11							
1962	IV	6.49	10.23	12.29	13.95						
1961	V	5.53	10.59	12.62	13.76	14.88					
1960	VI	6.58	11.61	12.51	13.71	14.68	16.15				
1959	VII	6.03	9.82	13.03	14.81	15.86	16.53	17.74			
1958	VIII	6.50	11.99	15.18	17.86	19.48	20.41	21.08	21.93		
1957	IX	6.40	9.20	12.20	17.50	19.80	20.70	21.20	21.60	22.20	
1956	X	4.70	8.80	11.80	14.70	17.40	20.00	21.40	21.90	22.20	22.75
Mean		5.79	9.99	12.72	15.21	17.01	18.77	20.38	21.81	22.20	22.75

Growth of Individual Year Classes - The growth rates for individual year classes varied greatly (Figure I). Variation observed in the 1956, 1957 and 1958 year classes may be caused by a small sample. During the early part of the fishes life (years 0 through 3) there is relatively little deviation from the mean growth. Years 4 through 10 have the largest variation in growth. Perhaps in later years these fish are more susceptible to growth stimulants and depressants. Another possibility could be due to growth compensation, or slight deviation from growth potential in younger years of life may cause a much greater deviation in later years.

Standard lengths attained for the first 10 years of life were 5.79, 9.99, 12.72, 15.21, 17.01, 18.77, 20.38, 21.81, 22.20, and 22.75 inches respectively. Growth rate continues at a steady rate until the second annulus is formed, then it declines steadily until the fourth annulus is formed; decreasing slightly for each year of life thereafter.

Growth within the Season. - The growth within the season of 1966 was analyzed by subtracting average length at the last annulus formation from the average length at the time of capture for each age group and each bi-weekly period. Increments were used as a base to determine the percentage of growth completed during each period for each age group. For each period the percentages for each age group were averaged (Figure 3).

By interpolation, 25 per cent of the growth occured by June 27, 50 percent by July 18, 75 percent by August 25 and 100 per cent by September 16. By the same method it was determined that the annulus formation occured between June 4 and June 17. Growth for the 1966 season was accomplished in 92 to 105 days.

Variation of Growth in Different Calendar Years - Factors such as water temperature throughout the growing season, food availability and space determine the growth rate for fish in a given year. It is readily apparent that these factors vary greatly from year to year, thus causing various degrees in growth rate.

Figure 1. Growth of year classes 1956 through 1965 for bigmouth buffalo in Coralville Reservoir.

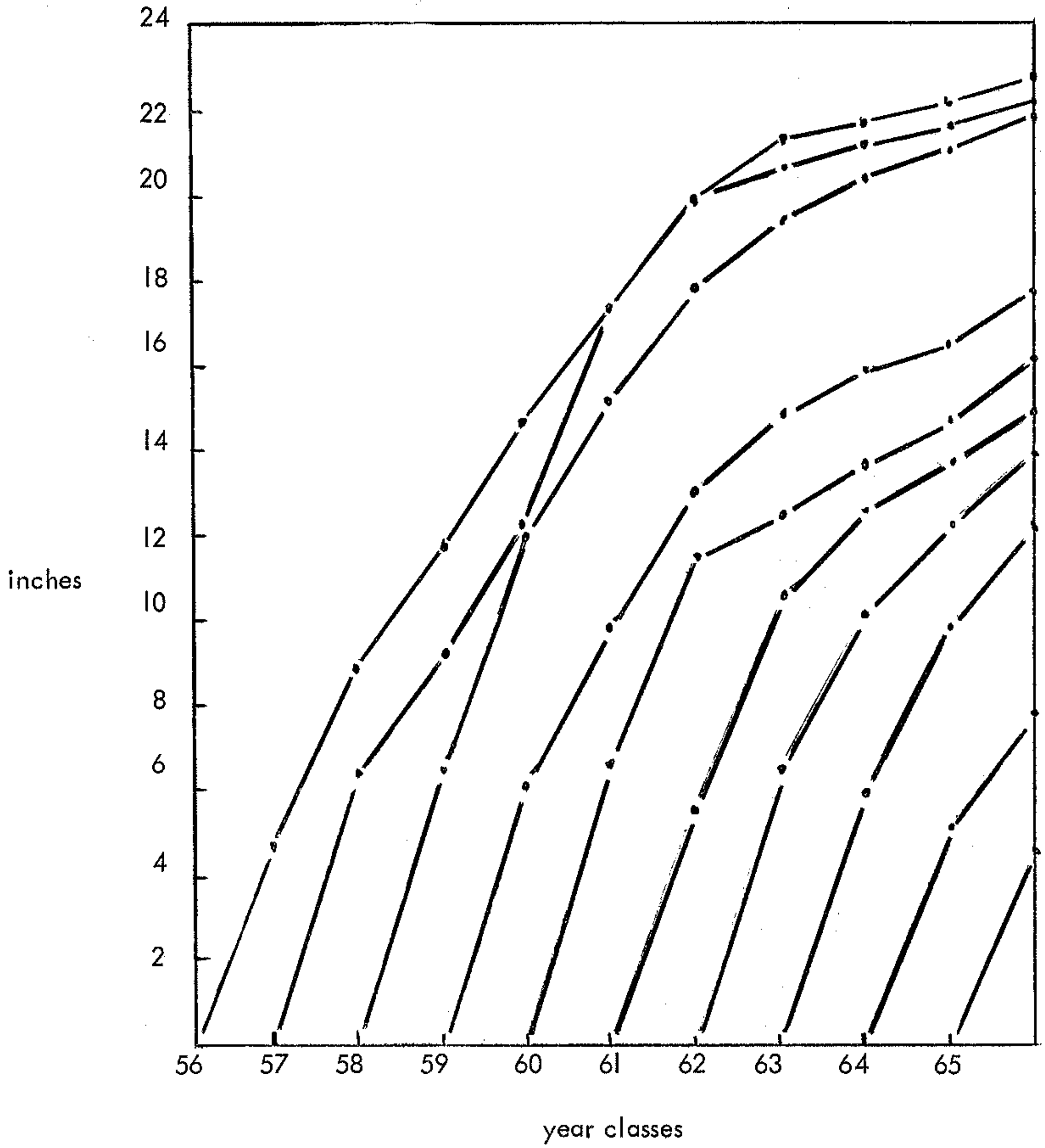


Figure 2. Grand average calculated standard lengths of the bigmouth buffalo in Coralville Reservoir.

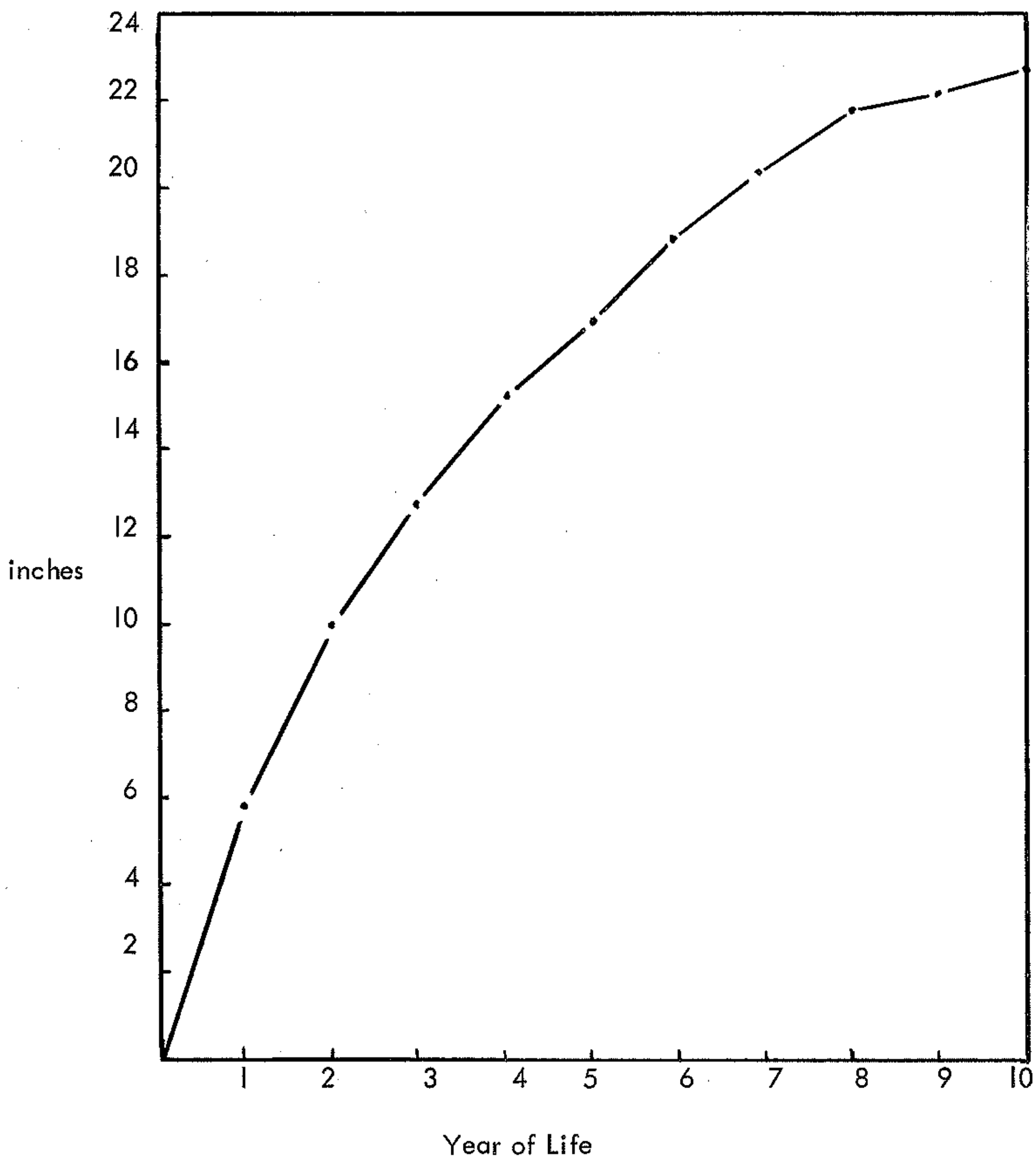
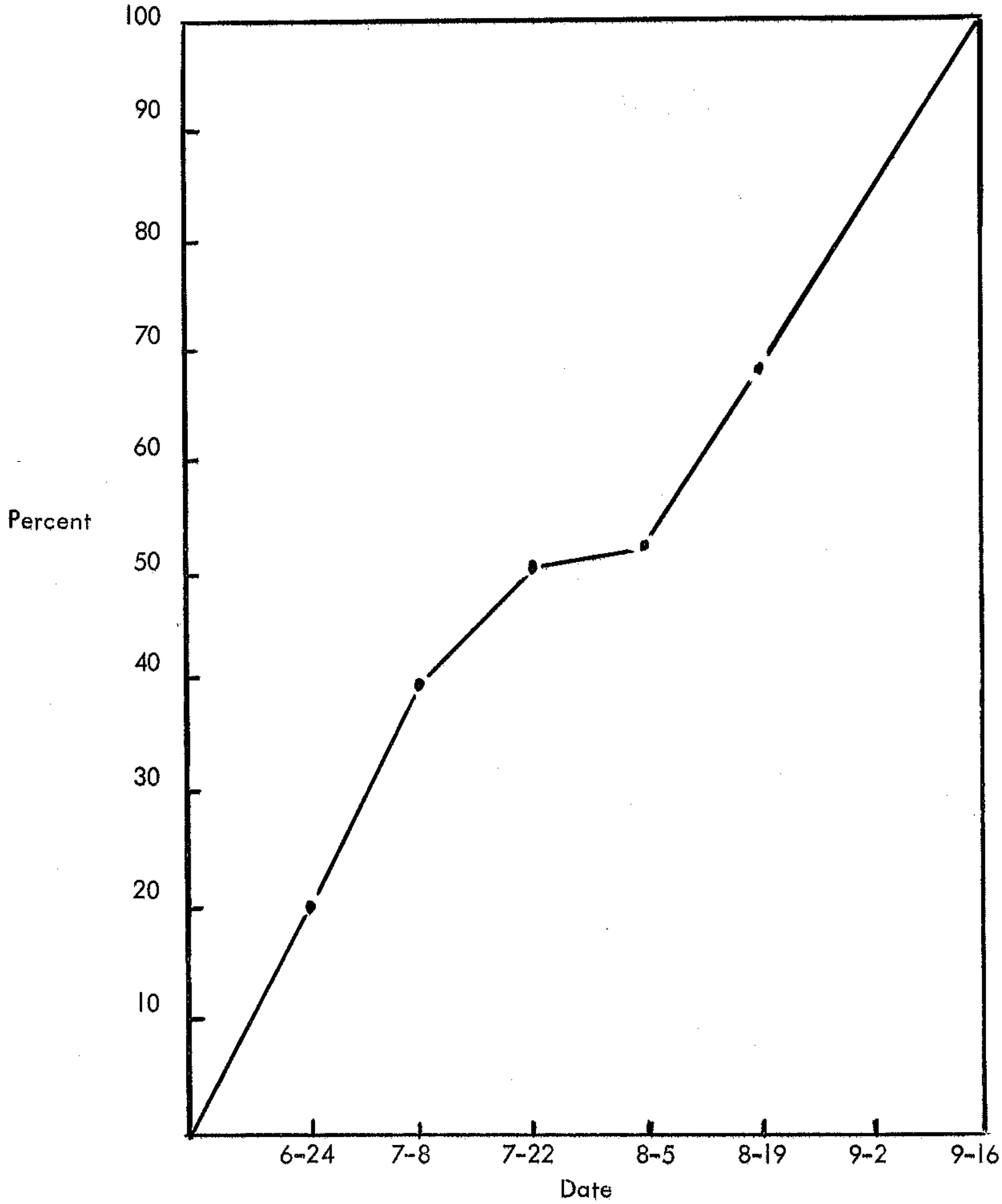


Figure 3. Growth within the season for bigmouth buffalo in Coralville Reservoir.



Growth of the bigmouth buffalo for the calendar years 1956 through 1965 had variations from +40.15 percent deviation in 1960 to -33.85 percent deviation from the mean in 1964 (Table 2 and Figure 4). These values were obtained by calculating the percent deviation of

Table 2. Percent deviation from mean growth for calendar years 1956 through 1965 for bigmouth buffalo in Coralville Reservoir

calendar years	Percent deviation
1956	-21.85
1957	+ 5.65
1958	- 3.85
1959	+17.15
1960	+40.15
1961	+30.15
1962	- 1.85
1963	-27.85
1964	-33.85
1965	- 3.85

growth increments of each year class for each year of life. Increment-percentage deviations were averaged for each calendar year.

During the winter of 1964-1965 a fish kill occured in Coralville Reservoir as described by Helms (1966). It is noted that there was an increase in growth from 1964 to 1965 of 30 percent. It is possible that the fish kill caused a biological void, thereby accelerating the growth rate.

LENGTH-WEIGHT RELATIONSHIP

The length-weight relationship for the buffalo was determined by the least squares method. The average weight for each 0.25 inch standard body length was calculated and the following equation was derived from the data:

$$\log W = -3.199 + 3.1926 \log L$$

where W equals weight in pounds and L equals standard length in inches.

GROWTH IN WEIGHT

The grand average calculated lengths were calculated in terms of length-weight relationship; 0.2, 1.0, 2.1, 3.8, 5.4, 7.4, 9.6, 11.9, 12.6 and 13.3 pounds were the weight values at annuli I through X respectively (Figure 5).

Figure 4. Percent deviation from mean growth for calendar years 1956 through 1965 for bigmouth buffalo in Coralville Reservoir.

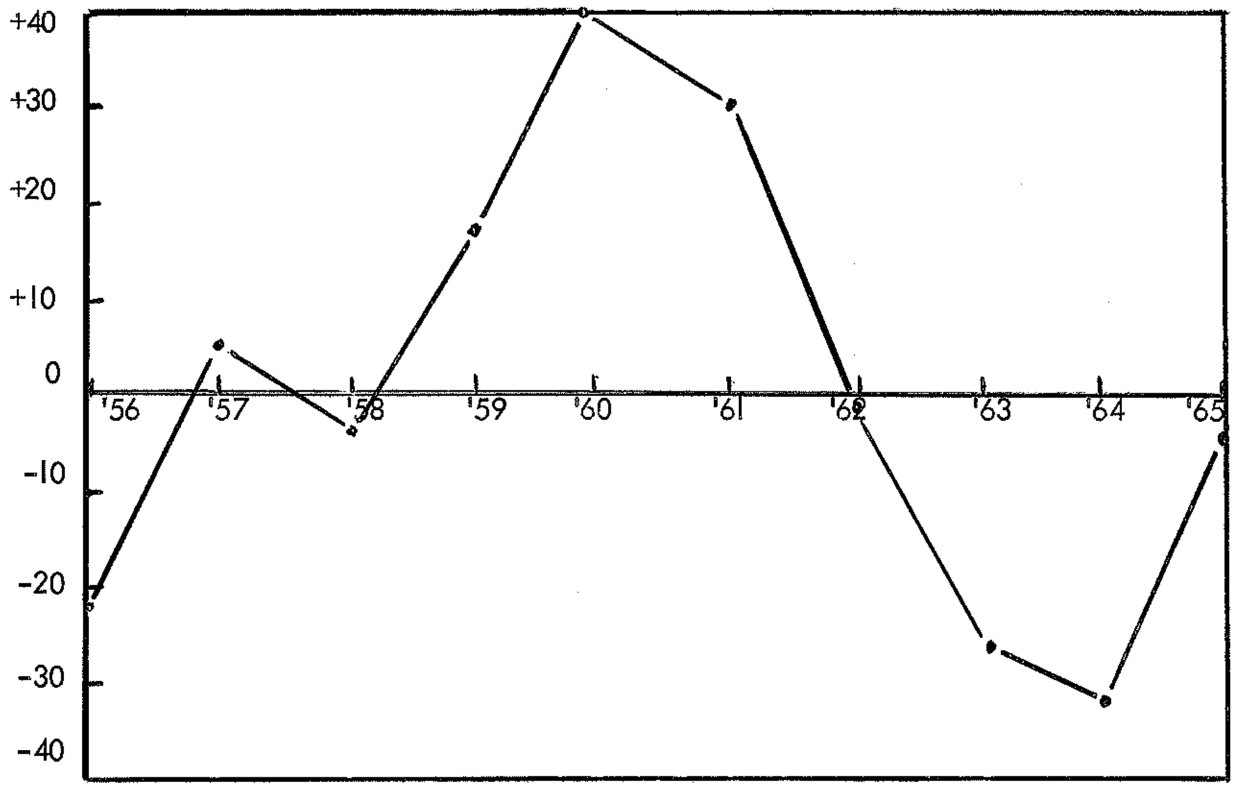
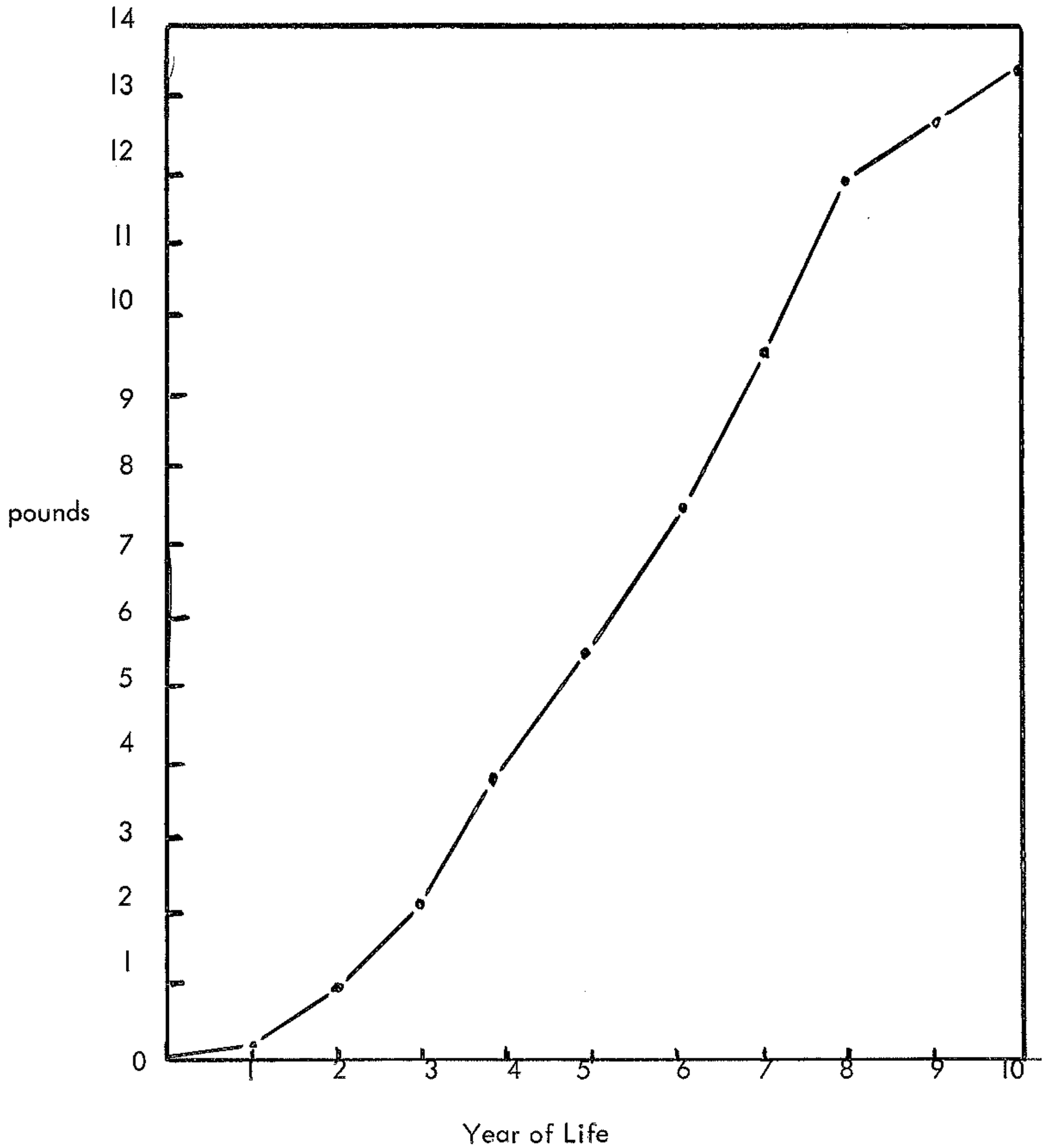


Figure 5. Grand average calculated weights of the bigmouth buffalo in Coralville Reservoir



AGE DISTRIBUTION

Data from pound net catches were used to determine age distribution. The age distribution was 17.2, 3.4, 4.9, 15.7, 28.9, 22.5, 4.9, 1.5, 0.5 and 0.5 percent for age groups I through X respectively (Table 3).

Table 3. 1966 age distribution of bigmouth buffalo in Coralville Reservoir

Year class	Age group	Pound nets	Gill nets	Total gear	Percent of pound net total
1965	I	35	28	63	17.2
1964	II	7	3	10	3.4
1963	III	10	1	11	4.9
1962	IV	32	0	32	15.7
1961	V	59	0	59	28.9
1960	VI	46	0	46	22.5
1959	VII	10	0	10	4.9
1958	VIII	3	0	3	1.5
1957	IX	1	0	1	0.5
1956	X	1	0	1	0.5
	TOTAL	204	32	236	100.0

CONCLUSIONS

1. The growth rates for individual year classes varied greatly.

2. Grand average calculated standard lengths were 5.79, 9.99, 12.72, 15.21, 17.01, 18.77, 20.38, 21.81, 22.20, 22.75 inches for annuli I through X respectively.

3. Growth within the season was accomplished in 92 to 105 days. Growth was accomplished by September 16.

4. Large variation of growth in different calendar years was evident; 1964 was a year of poor growth and 1960 was a year of good growth.

5. Growth of weight was 0.2, 1.0, 2.1, 3.8, 5.4, 7.4, 9.6, 11.9, 12.6, and 13.3 pounds for annuli I through X respectively.

6. 1963 and 1964 were relatively weak year classes compared to 1965.

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THE IOWA TROUT PROGRAM
with special reference to period of 1956-1966

Robert Schacht
Fisheries Biologist

Trout culture in Iowa dates back to 1873 when the first state fish hatchery was established at Anamosa. In 1880, a hatchery was built at Spirit Lake to handle trout and trout eggs transferred from Anamosa. In 1918, the fishery station at Lansing was also equiped to hatch trout. Hatching of trout at Lansing was discontinued in 1931. The Backbone hatchery and Decorah hatchery were established in 1928 and 1934 respectively and produced all the trout for the Iowa program. Starting in 1933 trout were over seven inches in length when stocked. All earlier plantings were fry or fingerling. In 1961, the Conservation Commission perchased Big Springs hatchery, which had operated commercially prior to that date. Presently, all trout are reared at Backbone, Big Springs, and Decorah hatcheries.

Until recently trout eggs were obtained through several sources. State, Federal, and private hatcheries provide the number of eggs needed each year. For the last few years the Federal fish hatchery at Manchester, Iowa provided 350,000 trout eggs each year. This has eliminated the need for extensive egg-taking operations at Backbone and Big Springs hatcheries.

Eggs received from Manchester are taken to Backbone hatchery where they are hatched and reared. As trout reach fingerling size, a number of them are transferred to Big Springs and Decorah to be held until they are of stockable size. Trout stocked over the last eleven years has ranged between 8 and 10 inches. The average weight of each fish has been slightly over one half pound (Table 1).

In the 11 year period, 1956 through 1966, almost 2 million trout have been stocked in suitable streams. A mean of 175,000 trout have been stocked each year during this period. Numbers of trout stocked since 1962 have been nearly 200,000 annually.

Rainbow trout have made up the majority of the stocking during the period. Sixty two to 90 per cent of all fish stocked were rainbows. The reason more rainbows are stocked is they are more economical to produce since they grow faster and have fewer hatchery losses than brown trout. Brown trout made up 13 to 36 per cent of the fish stocked. Brook trout comprised 1 to 10 per cent of the fish stocked in 1956 through 1959 and in 1962. They were not stocked in other years.

Iowa has adjusted its trout program to give the angler the best possible chance for a successful fishing trip. A major change was the opening of the season for trout to year around fishing on March 1, 1954. This extended the season 3 months. Because of the longer season, stocking procedures had to be changed. Before the continuous open season about 75 per cent of the trout were stocked out by July 4th of each year. Today, about 40 per cent of the fish are stocked out after July 4th. Condition of the stream, water temperature, and fishing pressure regulate stocking. More stocking trips are now made each year with smaller lots of fish per trip. These changes have given indications that the present program resulted in increased angler success (Table 2). Creel census data collected since 1960 show an increase in the catch rate based on 1,000 contacts each.

SUMMARY

1. In the period of 1956 through 1966 Iowa trout streams have been stocked with nearly 2,000,000 trout. A yearly average of 175,000 trout was stocked during the period. Since 1962, an average of almost 200,000 trout have been stocked.

2. Seventy-four per cent of the trout stocked in the period were rainbow.

3. The average trout stocked weighed one half pound and was 8 to 10 inches in length.

4. Angling success has increased since 1960. A higher catch rate has yielded more fish to fisherman.

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Table I. Number of trout stocked by species, total trout stocked per year, weight stocked per year, and average weight per fish, of trout stocked in 1956 through 1966

Year	Rainbow	Brown	Brook	Total	Weight (lbs.)	Mean Weight
1956	81,175	35,615	13,225	130,015	-	-
1957	83,265	36,790	13,270	133,325	-	-
1958	102,867	47,255	8,890	159,012	71,561	.45
1959	146,278	24,787	15,618	186,683	90,697	.49
1960	117,172	61,472	-	178,644	-	-
1961	123,478	28,735	-	152,213	79,131	.52
1962	124,535	71,109	2,620	198,264	105,725	.53
1963	138,607	64,428	-	203,035	109,887	.54
1964	149,025	17,123	-	166,148	96,203	.58
1965	202,045	31,280	-	233,325	121,119	.52
1966	157,428	36,945	-	194,373	100,532	.52
	1,425,875	455,539	53,623	1,935,037	775,356	.52

Table 2. Creel census data for the Iowa trout streams 1960 - 1965

Year	Number of Fishermen	Hours Fished	Trout Caught	Fish/ Man	Hours/ Fish
1960	1082	2323	1192	1.1	1.9
1961	1021	2023	1489	1.5	1.4
1962	1095	2120	1607	1.5	1 3
1963	1221	2860	2095	1.7	1.4
1964	1109	2051	1715	1.5	1.2
1965	1124	2247	2172	1.9	1.0