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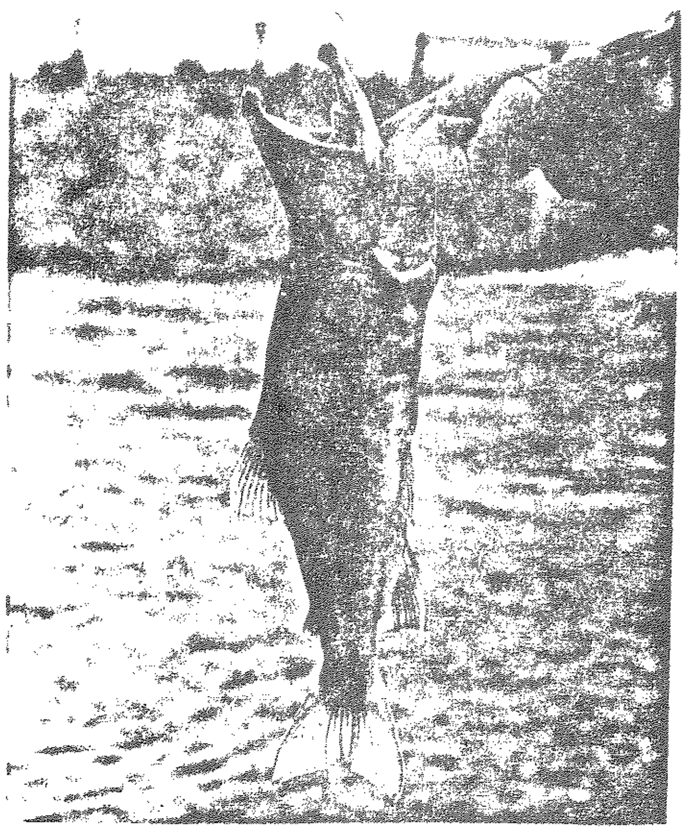
FISH POPULATION STUDY IN THE HELENA VALLEY RESERVOIR AND ADJOINING CANALS WITH EMPHASIS UPON THE KOKANEE (*Oncorhynchus nerka*)



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April 2, 1971
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PRESENTED IN PARTIAL FULLFILLMENT OF GRADUATION

WITH HONORS TO THE BIOLOGY DEPARTMENT

OF CARROLL COLLEGE, HELENA, MONTANA

ABSTRACT

Using otolith and scale methods, age and growth characteristics of kokanee (*Oncorhynchus nerka*) obtained in 1969 and 1970 from the Helena Valley Reservoir, near Helena, Montana, were calculated. Record kokanee have been observed in these waters. An investigation of migration into and out of the reservoir was made. A brief analysis of kokanee distribution in the lake was included. Creel census data from 1969 and 1970 was incorporated into the study.

ACKNOWLEDGEMENTS

We wish to express our appreciation to all who aided us during this study. The major portion of the equipment used was provided by the Montana Fish and Game Department. George Holton of the Montana Fish and Game Department provided technical and professional advice. Robert Green, project manager of the Helena Valley Ditch Unit, Bureau of Reclamation, provided valuable information concerning the structure and physical operations of the irrigation system.

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INTRODUCTION

The kokanee fishery in the Helena Valley Reservoir began in 1968 when the first kokanee were observed. This population is believed to be due to a plant of kokanee introduced in Canyon Ferry Reservoir in 1966. Isolated reports of kokanee in the reservoir prior to this time can perhaps be explained by previous plants in the Missouri River drainage above Canyon Ferry Reservoir.

The Helena Valley Reservoir is currently producing the largest kokanee in Montana. Kokanee of three pounds are not unusual and fish of over five pounds have been caught in the reservoir. The fishery has wide acclaim throughout the state. Fishermen from distant parts of Montana are often found at the reservoir during the snagging season.

The primary objective of this study was to analyze the kokanee population in the Helena Valley Reservoir. Included was an analysis of associated species within the reservoir, analysis of incurrent and excurrent ditches, and a creel census. Field work was conducted from October 1969 to January 1971.

DESCRIPTION OF STUDY AREA

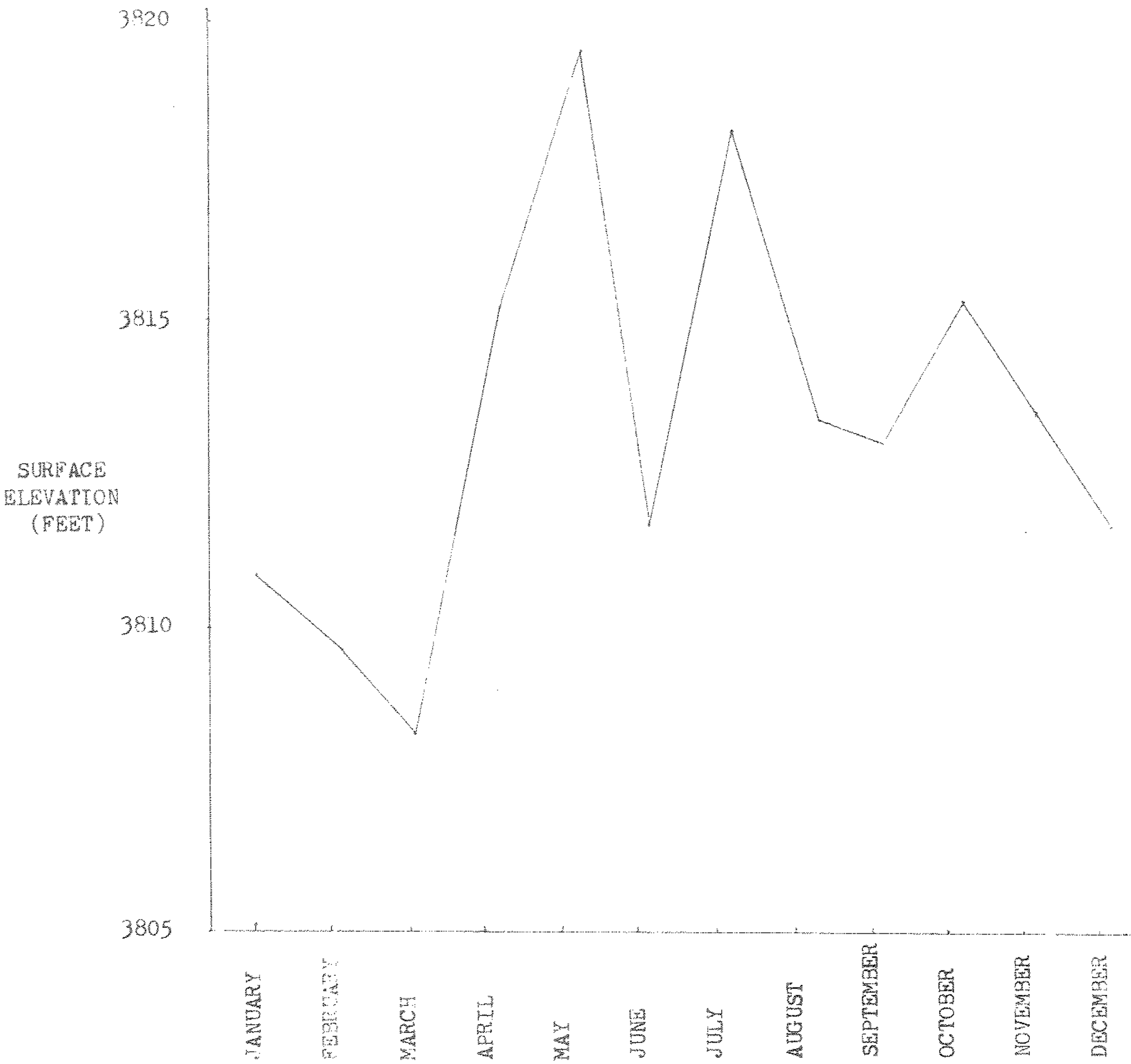
Helena Valley Reservoir is located approximately 10 miles northeast of Helena, Montana ($E\frac{1}{2}$ of Section 8, $W\frac{1}{2}$ of Section 9, Township 10N, Range 2W). Maximum surface area is 518 acres and maximum volume is 10,702 acre-feet. The surface elevation varies between 3805 and 3820 feet. The maximum depth is 70 feet. (Physical descriptions provided by Robert Green.)

Ice cover usually begins in November and continues through March. The ice is uncommonly thick with measurements by the authors of up to 2 feet. This is due in part to a lack of incoming water in the winter months and the resulting poor circultaion.

The lake is at minimum surface elevation in March just previous to the initiation of water pumping from Canyon Ferry Reservoir. The lake is then filled to maximum capacity and held at this point until irrigation usage begins in mid May. A second minimum surface elevation is then reached at the height of the irrigation season when more water is removed than is pumped in. In October, just previous to pump shut off, the reservoir is filled to mid capacity. Through the winter, the surface elevation slowly decreases due to a leak in the dam and municipal use by the City of Helena. Figure 1 shows the 1970 average monthly surface elevations in the reservoir.

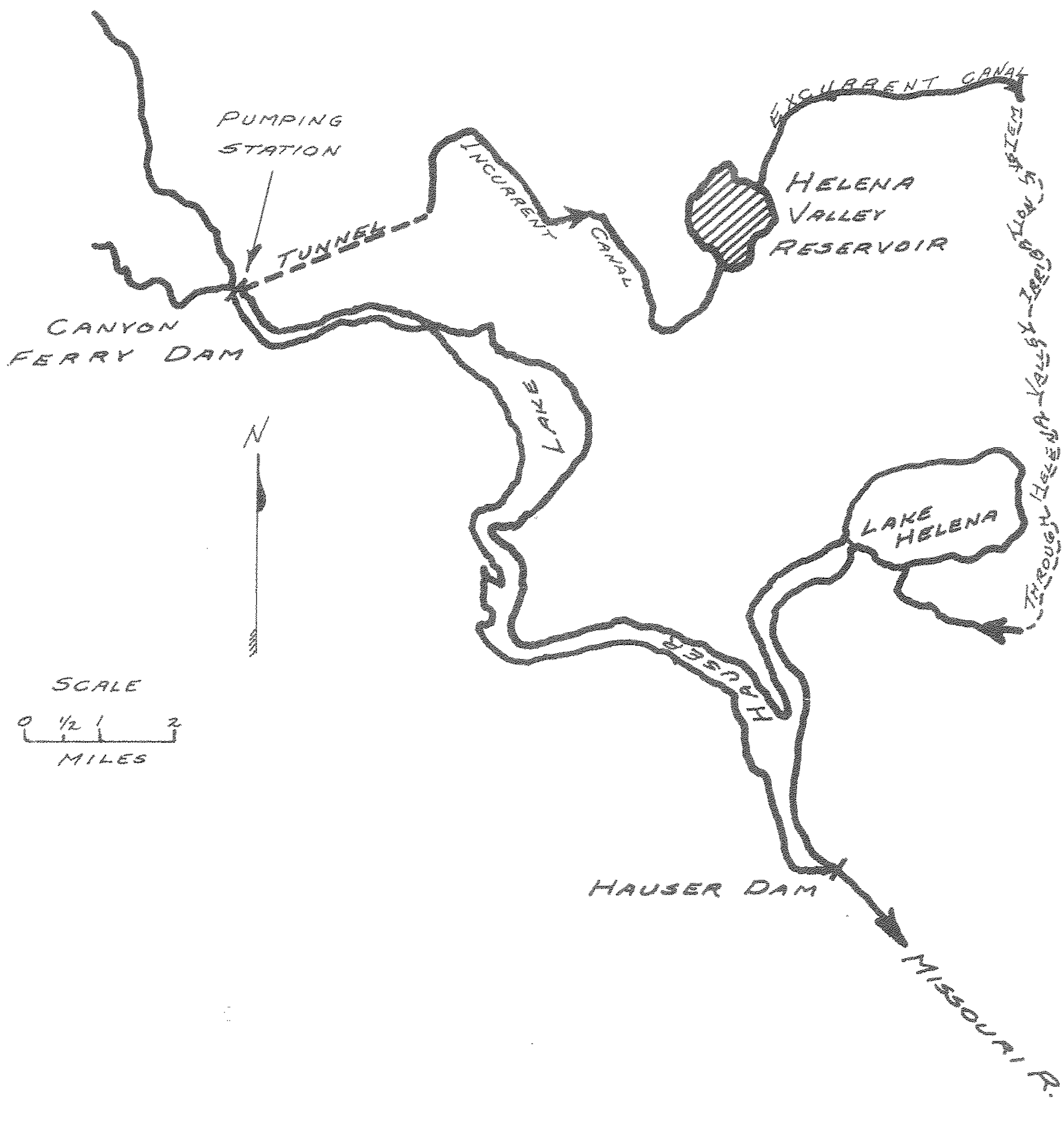
Water is delivered to the Helena Valley Reservoir via a canal 7 miles long which receives water from a tunnel which is 2.6 miles long. Water is pumped into this tunnel by a Bureau of Reclamation pumping station located at the base of the Canyon Ferry Dam (Figures 2 and 3).

FIGURE 1



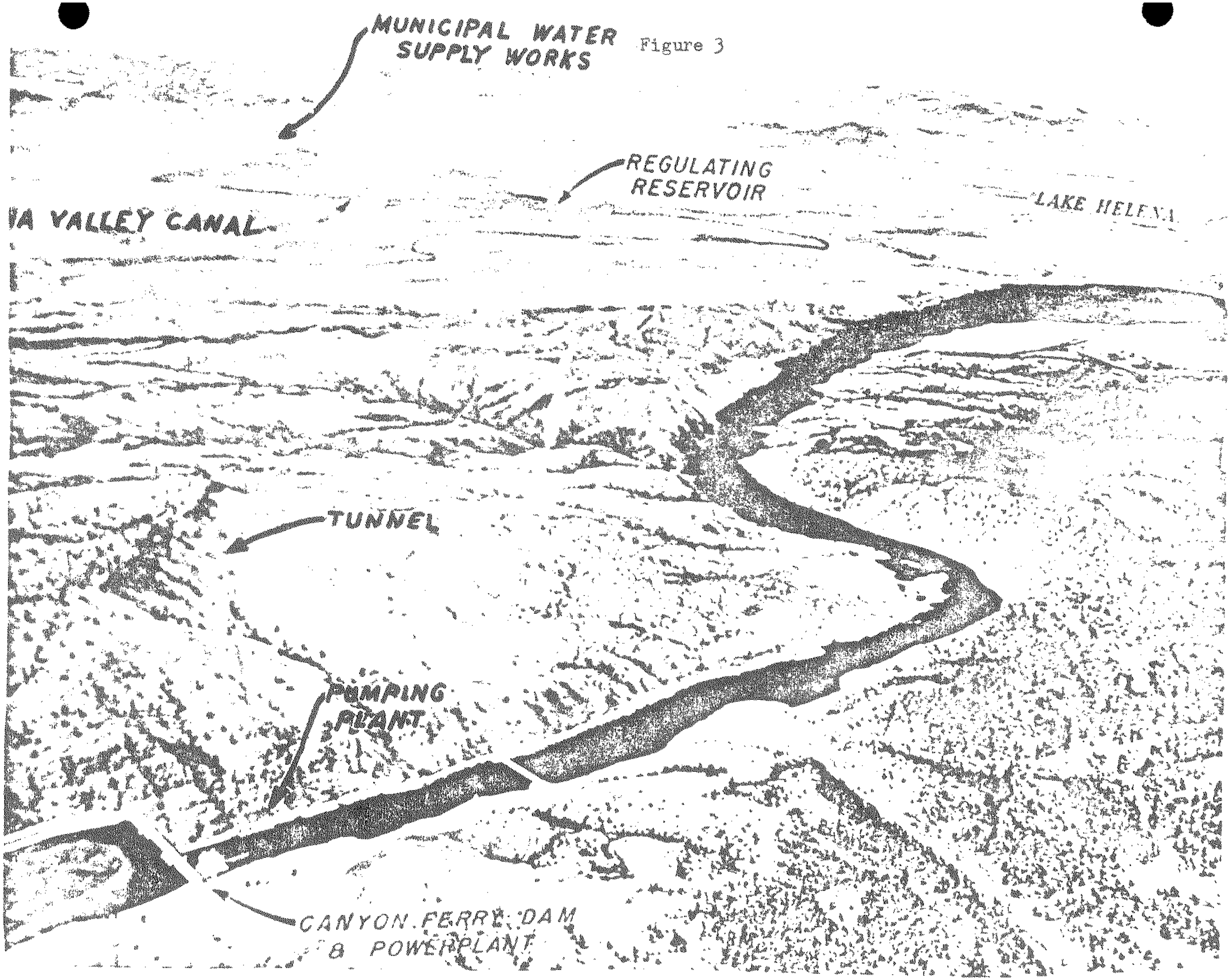
Hydrograph of surface elevation of Helena Valley Reservoir in 1970 (Data obtained from Robert Green, Bureau of Reclamation).

FIGURE 2



MAP OF STUDY AREA

Figure 3



AERIAL PHOTOGRAPH OF STUDY AREA (COURTESY OF ROBERT GREEN)

The pumping station draws water from a depth of 117 feet below maximum water level at the Canyon Ferry Dam. The water is lifted by the pumps 196 feet to where the tunnel begins. Two pumping units are involved in this operation, each pumping 150 cubic feet per second (cfs). The pumps are thus capable of releasing 300 cubic feet of water into the tunnel per second (Table 1).

The incurrent canal consists of the 2.6 mile tunnel and the 7 mile canal. The tunnel is a horseshoe shaped concrete structure seven feet in height. The unlined canal is semicircularly shaped and capable of conducting 300 cfs of water at a velocity of 2.46 feet per second. The maximum depth at the head end of the ditch is 5.5 feet. The canal enters the reservoir via a steep ramp which drops the water 6 to 10 feet to the surface of the reservoir.

The excurrent canal is of a similar structure. It is capable of conducting 350 cfs at a velocity of 2.27 feet per second. The maximum depth of the canal at the head end is 5.6 feet. (Physical characteristics of the Helena Valley Ditch Unit provided by Robert Green.)

Construction of the Helena Valley Reservoir Dam was completed in 1959 and the reservoir was filled with water. Between 1959 and 1963 the dam leaked too severly to allow a fishery of any consequence to develop. In 1964, the reservoir was drained and an attempt was made to seal the leak. Subsequently, the reservoir was filled and there was a substantial decrease in water loss. In 1964, the Montana Fish and Game Department was contacted and requested to develop fish management plans for the reservoir. It was decided that small-

TABLE 1

VOLUME OF FLOW

OF WATER PUMPED INTO THE INCURRENT CANAL DURING 1970[a]

DATE	PUMPING UNITS IN OPERATION	VOLUME OF FLOW OF WATER PUMPED[b]
January 1 to April 6	0	0 cfs
April 6 to April 27	1	150 cfs
April 27 to September 15	2	300 cfs
September 15 to October 1	1	140 cfs
October 1 to December 31	0	0 cfs

[a]Data obtained during a personal interview with Mr. Robert Green, Helena Valley Ditch Unit, Bureau of Reclamation, March 4, 1971.

[b]Volume measured in cubic feet per second (cfs).

mouth bass would be well suited to the reservoir's conditions. In 1967, 11,312 smallmouth bass were planted in the reservoir (Art Whitney, personal communication). In 1968, a population of kokanee was found in the reservoir and fishermen were allowed to snag for spawning fish that fall. The kokanee fishery within the reservoir has continued from this time. A considerable fishery has also developed for yellow perch. Extremely large perch are often caught in the reservoir. A perch caught by the authors in a gill net was 13 inches long and weighted 1.44 pounds (see Figure 4). A limited fishery has also developed for large brown trout (see Figure 5). Brown trout weighing up to 13.5 pounds have been caught in the reservoir. A small mouth bass fishery has not developed in the reservoir.

Fish frequently observed by the authors in the reservoir and canal system include kokanee (Oncorhynchus nerka), brown trout (Salmo trutta), yellow perch (Perca flavescens), white sucker (Catostomus commersoni), and longnose sucker (Catostomus catostomus). Fish observed less frequently included rainbow trout (Salmo gairdneri), mountain whitefish (Prosopium williamsoni), smallmouth bass (Micropterus dolomieui), carp (Cyprinus carpio), flathead chub (Hybopsis gracilis), burbot (Lota lota), and mottled sculpin (Cottus bairdi). Theoretically any fish found in Canyon Ferry could be found in the Helena Valley Reservoir.

FIGURE 4

13 inch yellow perch caught in gill net, January 1970.

FIGURE 5

Female Brown Trout caught in the Helena Valley Reservoir on July 26, 1969. The fish measured 27.5 inches and weighed 10 pounds.

INCURRENT CANAL STUDY

Purpose

The initial purpose of the incurrent canal study was to determine the method of kokanee recruitment into the lake. We were interested in when, in what size, and in what numbers the kokanee enter the reservoir. As the study progressed we became interested in the relationship between the pumping station and fish mortality induced by the pump. Information on species composition in the canal was obtained.

Methods

We felt that a study of the pumping station was necessary for a complete understanding of the incurrent canal system. Through the cooperation of Mr. Robert Green, an inspection of the pumping station was made by the authors. This excursion was made during the winter months when the pumps were not in operation and thus an examination of the internal workings of the pump was possible. We entered the pipe system at the pumping station through a hatch and traced the route taken by the fish from the foot of Canyon Ferry Dam to the entrance of the tunnel. Of major interest to us was the internal workings of the pump where damage to fish could occur. Each unit had a circular shaped piece of metal with seven aperatures in it through which water was pulled (see Figure 6). During the pumping

FIGURE 6

Pumping device with apertures through which water and fish must pass to enter canal system. The blades often injure fish.

operation this device revolves at 200 rpm and fish can actually be chopped to pieces. Water is pushed up to the head end of the tunnel by power generated within the pumping station.

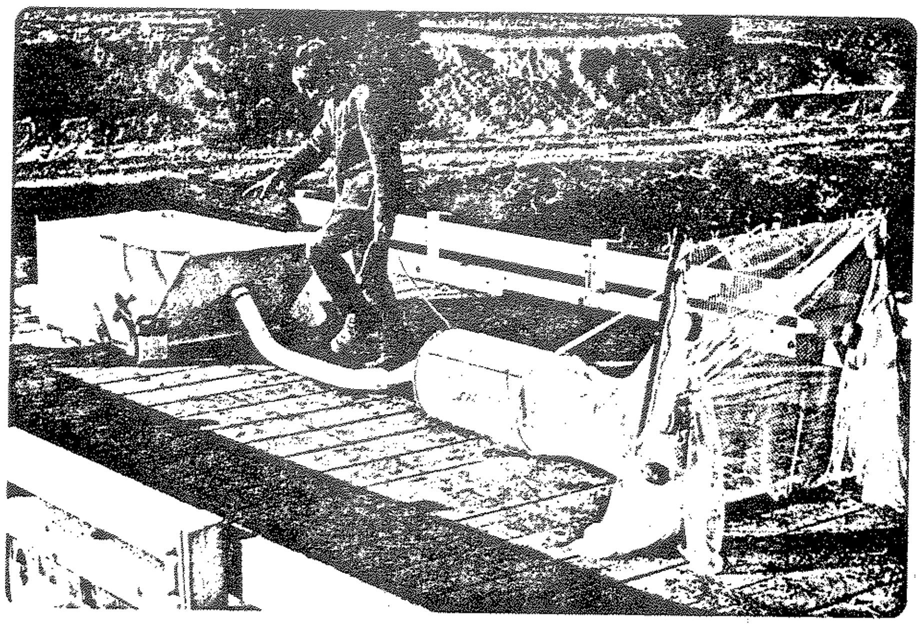
The first place where fish are accessible for trapping purposes is located immediately after the termination of the tunnel. A bridge is located approximately 100 yards from the tunnel mouth and crosses the ditch about 3 feet above water level. This was the area picked by us to do our trapping.

After consultation with personnel from the Montana Fish and Game Department, we decided to construct a modified fyke net designed by Craddock (1961). The trap was completed in March, 1970 and placed into the canal on April 10 of that year, immediately after the pumping operations were initiated (Figure 7). The trap was emptied and cleaned daily until mid May. Trapping was not attempted in the period from mid May to mid June. During the last two weeks in June the trap was again placed in the canal. At this time, algae accumulation on the netting surfaces made operation of the trap impractical.

Graduated gill nets (3/4" to 2" mesh) were used from the beginning of July throughout the irrigation season intermittedly in an attempt to capture fish. Often, the gill nets were placed across the canal to act as a blocking device for dead fish. At times, the gill nets were placed lengthwise (parallel to the current) in an attempt to capture fish which might be living in the canal.

In mid July we designed and constructed a fyke net which we felt would be more operable in the algae-filled water than the modified

FIGURE 7



Modified fyke net constructed in 1970.

fyke net used earlier (Figure 8). It was used throughout the summer but few fish were captured.

On August 1, we obtained a block net from the Montana Fish and Game Department. This net was attached at each end of the bridge in a manner which kept the top of the net out of the water. It was then weighted down with approximately 10 sash weights. Thus as much of the canal as practical was blocked by the net (Figure 9). This net primarily collected dead fish which showed evidence of damage from the pump (see Figure 10).

The final method of capture of fish in the incurrent canal occurred when the pumping operations were halted for the year on October 1, 1970. Fish were captured with a dip net from small pools of water which remained after the main body of water had moved down the canal. The same day the majority of the fish residing in the tunnel were captured by placing a net over the tunnel drain.

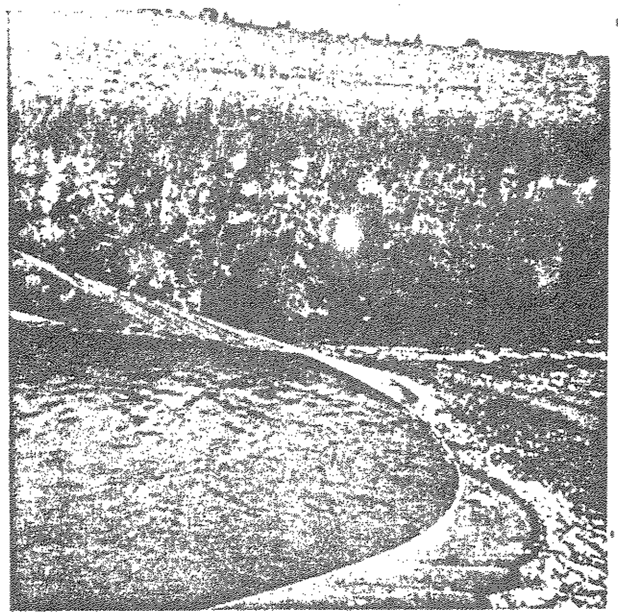
Results

Only two kokanee were trapped by us in the incurrent canal system. On May 4, 1970 a 133 mm kokanee was observed in the modified fyke net. Identification of this kokanee was keyed by the use of How to Know the Freshwater Fishes by Samuel Eddy (1957). Another kokanee was found in the block net in the incurrent canal on August 12, 1970. It was 73 mm in length. Positive identification was made by C. J. D. Brown, Montana State University.

FIGURE 8

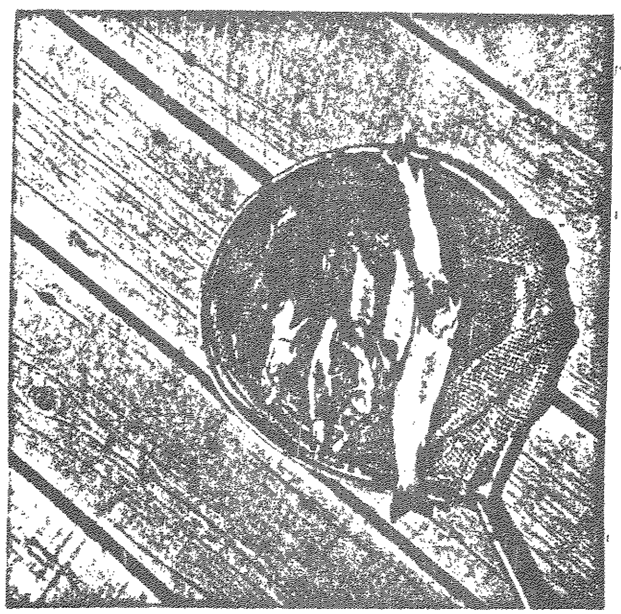
Fyke net built in July 1970.

FIGURE 9



Block Net in Incurrent Canal

FIGURE 10



Example of fish catch in block net. Notice damage to fish by pump.

The data on species other than kokanee were entered into a computer program (see Appendix I) and the mean lengths, standard deviations of the lengths, and numbers of fish in each frequency class were determined (Table 2).

TABLE 2

ANALYSIS OF FISH CAPTURED IN THE INCURRENT CANAL SYSTEM

SPECIES	TIME OF CAPTURE	MORTALITY[b]	NUMBER OF FISH IN CLASSIFICATION	MEAN LENGTH [a]	STANDARD DEVIATION OF LENGTH	RANGE OF LENGTH	METHOD OF CAPTURE
Yellow Perch	April - June	Alive	123	137.7	32.2	51 - 208	Modified Fyke net
Yellow Perch	April - June	Dead	194	132.1	28.5	51 - 208	Modified Fyke net
Yellow Perch	October	Alive	14	171.4	43.2	76 - 208	Dip Net
Yellow Perch	July - August	Dead	32	150.7	55.2	51-251	Block Net
Rainbow Trout Brown Trout	July - August	Dead	27	352.0	83.7	203 - 658	Block Net
Rainbow Trout Brown Trout	October	Alive	14	296.3	106.4	102 - 480	Dip Net
White Sucker	July - August	Dead	40	314.4	54.6	152 - 429	Block Net
White Sucker	October	Alive	16	294.1	48.2	178 - 404	Dip Net
Longnose Sucker	July - August	Dead	53	281.3	43.1	203 - 404	Block Net
Longnose Sucker	October	Alive	11	274.7	34.6	229 - 378	Dip Net

[a] All length values are in millimeters.

[b] Lengths of some dead fish were estimated due to missing body parts.

Discussion

Although no conclusive evidence was obtained as to the origin of the Helena Valley Reservoir kokanee, we believe that we have a plausible explanation. It is our contention that the majority of the kokanee are derived from the annual Canyon Ferry Reservoir plants (see Tables 3 & 4). Kokanee are annually planted during the months of April and May in the vicinity of the Beaver Creek Bay area near Winston (see Figure 11). Between 780,000 and 1,000,000 kokanee fry have been planted each year. The first plant of kokanee occurred in April of 1966 (see Table 3). It is plausible that fish travel from the area of this bay down the lake approximately 15 miles and upon reaching the vicinity of the dam, enter the Helena Valley irrigation system via the pumping station which draws water from a depth of 117 feet below maximum water level in Canyon Ferry. It is also possible that some of the initial kokanee which entered the reservoir were derived from a series of kokanee plants in Willow Creek Reservoir in 1965, 1966 and 1967. Willow Creek Reservoir is located on the Missouri River drainage about seventy miles above Canyon Ferry near Harrison, Montana. These fish would enter the Helena Valley Reservoir in a similiar manner after first arriving in Canyon Ferry.

Foerster (1968) indicates that young O. nerka start their migration soon after loss of egg sac. The fish planted at Canyon Ferry Reservoir have lost their egg sac and are about 1 inch in length. One would assume that these fry would start their migration immediately upon release. However, our data indicates that no large migration into

TABLE 3

A SUMMARY OF KOKANEE[a] PLANTINGS

IN THE VICINITY OF THE HELENA VALLEY RESERVOIR[d]

LOCATION	DATE	NUMBER PLANTED
Hauser Lake[b]	June 17, 1955	118261
Hauser Lake	June 11, 1954	118272
Hauser Lake	May 14, 1953	56800
Hauser Lake	June 2, 1953	56800
Hauser Lake	June 13, 1953	56800
Hauser Lake	June 12, 1953	56800
Willow Creek Resevoir[c]	April 4, 1967	86868
Willow Creek Reservoir	May 3, 1966	127380
Willow Creek Reservoir	May 6, 1965	114240
Canyon Ferry Reservoir	May 5, 1969	264138
Canyon Ferry Reservoir	May 22, 1969	226904
Canyon Ferry Reservoir	May 23, 1969	226404
Canyon Ferry Reservoir	May 28, 1969	226400
Canyon Ferry Reservoir	April 8, 1968	276864
Canyon Ferry Reservoir	April 15, 1968	254340
Canyon Ferry Reservoir	April 25, 1968	254340
Canyon Ferry Reservoir	May 19, 1967	268800
Canyon Ferry Reservoir	May 22, 1967	537600
Canyon Ferry Reservoir	April 24, 1966	259380
Canyon Ferry Reservoir	April 29, 1966	272124
Canyon Ferry Reservoir	April 30, 1966	272124

[a]All fish were planted as fry.
[b]Hauser Lake kokanee were obtained from the Polson Hatchery.
[c]Canyon Ferry and Willow Creek Reservoir kokanee were obtained from Somers Hatchery.
[d]Data obtained from planting records of the Montana Fish & Game Department.

TABLE 4

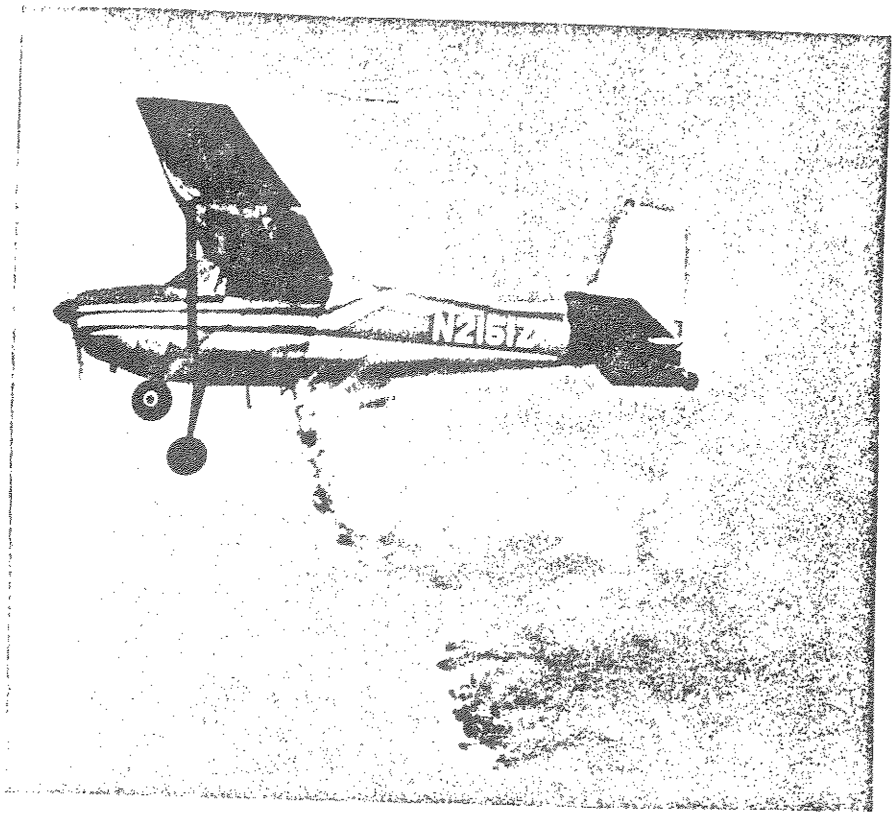
A SUMMARY OF KOKANEE[a] PLANTINGS IN CANYON FERRY RESERVOIR[b]

DATE	NUMBER	HOW PLANTED	LOCATION OF PLANT
April 25, 1966	259,380	Air Dropped	Beaver Creek Bay
April 29, 1966	272,124	Air Dropped	Beaver Creek Bay
April 30, 1966	272,124	Air Dropped	Beaver Creek Bay
1966 TOTAL - - -	863,628		
May 19, 1967	268,800	Air Dropped	Beaver Creek Bay
May 22, 1967	268,800	Air Dropped	Beaver Creek Bay
May 22, 1967	268,800	Air Dropped	Townsend boat docks
1967 TOTAL - - -	806,400		
April 8, 1968	276,864	Truck - Shore plant	Beaver Creek (Davis Ranch)
April 15, 1968	254,340	Truck - Shore Plant	Beaver Creek (Davis Ranch)
April 24, 1968	254,340	Truck - Shore plant	Beaver Creek (Davis Ranch)
1968 TOTAL - - -	785,544		
May 5, 1969	264,138	Truck - shore plant	Mouth - Beaver Creek
May 22, 1969	226,904	Truck - shore plant	Above mouth of Beaver Creek
May 23, 1969	226,404	Truck - shore plant	Beaver Creek (Davis Ranch)
May 28, 1969	226,400	Truck - shore plant	Access area below Beaver Creek
1969 TOTAL - - -	943,846		
April 2, 1970	258,660	Truck - shore plant	Beaver Creek (Davis Ranch)
April 3, 1970	261,270	Truck - shore plant	Beaver Creek (Davis Ranch)
April 6, 1970	256,550	Truck - shore plant	Beaver Creek (Davis Ranch)
April 21, 1970	224,172	Air Dropped	Beaver Creek Bay
1970 TOTAL - -	1,000,652		

[a]All fish planted as fry.

[b]Data obtained from planting records of the Montana Fish & Game Department.

FIGURE 11



Aerial kokanee plant in Canyon Ferry Reservoir near Townsend boat docks. (Photo by Hector LaCasse, Montana Fish and Game) the irrigation system took place before mid May. The modified fyke net blocked approximately 75% of the incurrent canal. It would seem that if any large migration of kokanee had occurred we would have captured some of them. This does not preclude the possibility of migration at another time.

The presence of kokanee in the Helena Valley Reservoir was noticed first by fishermen in 1968. Numbers of immature kokanee were taken in July. Kokanee on their spawning run were taken in September (George Holton, personal communication). The first Canyon Ferry plant in 1966 could account for this as kokanee often spawn at an age of two years (Seeley and McCammon, 1966). Evidence that the Willow Creek Reservoir plants contributed somewhat to the Helena Valley Reservoir population is twofold. Gill netting records for 1968 obtained from the Montana Fish and Game show a kokanee which was 20.5 inches long and weighed 4.60 pounds. Our experiences with age analysis of kokanee in the reservoir would indicate that this is at least a three year old fish. This would make the fish older than any fish planted in Canyon Ferry. Willow Creek Reservoir is the closest upstream area where kokanee were previously planted (see Table 3). Secondly, sightings of spawning kokanee in the incurrent canal have been reported prior to 1968 (Robert Green, personal communication.) This would indicate again that kokanee older than the Canyon Ferry plants were in the reservoir at this time.

The effect of the pumping device on fish mortality was analyzed. As the live and dead perch caught in the modified fyke net in April, May and June of 1970 showed no significant statistical differences in length, we assume that the pumping device is not selective as to mortality with regard to length of fish within this range. We found that 38.8% of the perch caught in the modified fyke net were alive while 61.2% were dead. We can therefore assume that the pump is causing a high mortality. An additional cause of mortality was seen to be the changing pressures encountered by the fish as they go from high pressure at the 117 foot depth to the relatively low pressure found in the canal. Damage to the air bladder was frequently observed with the organ protruding from the mouth. It is our contention that larger fish would probably be more susceptible to damage in the pump, however, our data is biased in regard to this, as the larger fish which were alive, could avoid our traps.

In April, May and June it was noted that practically 100% of the fish caught were yellow perch. From July to October trout and suckers comprised a large portion of the fish caught. We believe that this is due to the changing fish populations in Canyon Ferry Reservoir near the pump outlet. In the period from July through October we found that the fish caught by us in the incurrent canal was composed of 19.8% trout, 22.2% yellow perch, 27.1% white suckers, and 30,9% longnose suckers.

EXCURRENT CANAL STUDY

Purpose

The purpose of the excurrent canal study was to determine the kokanee loss from the reservoir via the canal. We were only partly successful in this effort. Also, a study of the dynamics of the fish population in the canal and adjoining ditches was undertaken.

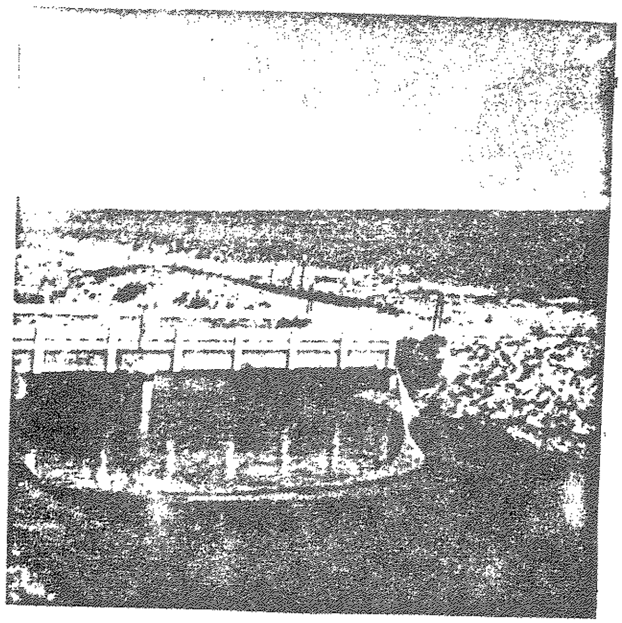
Methods

Water enters the excurrent canal from the reservoir. It is regulated by a hydraulic lifting device which operates the water gates. Fish are able to traverse this gate and thus are able to enter the canal system. It is also possible for fish to enter the ditches draining into Lake Helena which is subsequently connected to Hauser Lake (see Figure 2).

Approximately 300 yards below the dam, a bridge crosses the ditch about three feet above the water level. This location was picked by us as a trapping area (see Figure 12). We also trapped in the first ditch which exits from the canal. This ditch travels down a concrete spillway and enters a concrete receptacle which is the beginning of an irrigation ditch. We set traps at the point where the water enters the receptacle (see Figure 13).

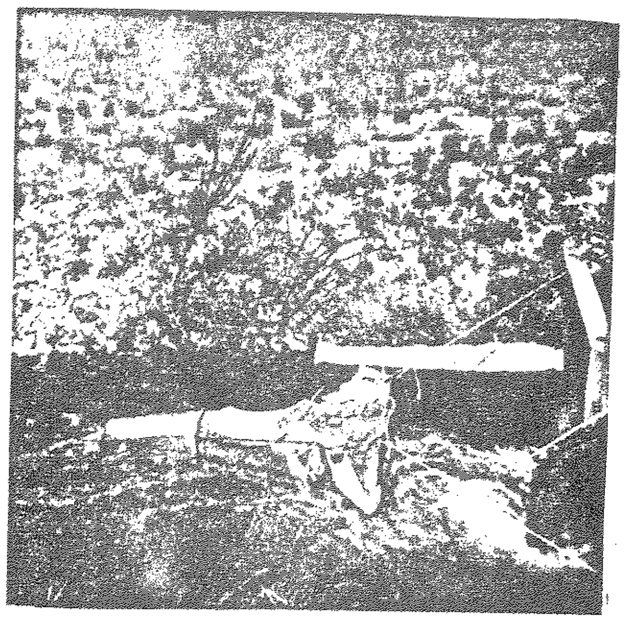
All the methods for fish capture outlined in the incurrent

FIGURE 12



Excurrent Canal Study Area

FIGURE 13



Modified Fyke Net in first off-
shoot of excurrent canal.

canal study were also used in this canal system. In addition we used a Roberts Pied Piper fish shocker run with DC power from a 110 volt, 150 watt Homelite generator, to gather additional fish in the canal after the regulating gates had stopped the water flow in the excurrent canal for the winter.

Results

We trapped kokanee, perch, and longnose suckers in the excurrent canal system. Each species was entered into a frequency distribution to facilitate computations. The frequency distribution data was then entered into a computer program and mean lengths, standard deviations of length, and numbers of fish in each classification was determined (see Table 5).

A relatively unbiased population analysis was accomplished by us after the incoming water from the reservoir was shut off. The water in the ditch at this time was collected in small pools and the fish within these pools were shocked or dip netted. We found that the ditch contained 2.5% kokanee, 18.1% perch, and 79.4% white suckers at this time. Large quantities of young of the year white suckers and yellow perch less than 76 mm in length were observed but not counted. Random analysis of these fry indicated that they consisted of 80.9% white suckers and 19.1% yellow perch.

TABLE 5

ANALYSIS OF FISH CAPTURED IN THE EXCURRENT CANAL SYSTEM

SPECIES	TIME OF CAPTURE	NUMBER OF FISH IN CLASSIFICATION	MEAN LENGTH[a]	STANDARD DEVIATION OF LENGTH	RANGE OF LENGTH	METHOD OF CAPTURE
Kokanee	August - September	19	528	107	483 - 610	Snagged by Fishermen
Kokanee	October	8	284	13	269 - 297	Dip net & Shocking
Yellow perch	October	59	141	36	76-271	Dip net & Shocking
White sucker	October	259	246	63	76 - 455	Dip net & Shocking

[a]All length values are in millimeters.

Discussion

There are two possibilities which would explain the presence of kokanee in the excurrent canal system. It seems probable that the majority of the kokanee population in the canal enter from the reservoir through the gates in the dam. Another explanation is that some kokanee might enter the canal from Lake Helena. Plants of kokanee in Hauser Lake were made in 1953, 1954 and 1955 (see Table 3). Hauser Lake is connected to Lake Helena by a narrow neck which contains water control structures. This area is frequently referred to as the causeway (see Figure 2). Reproduction from these plants might enter the excurrent canal system by this route.

We feel that there is a loss of kokanee from the reservoir into the excurrent canal. In the fall, spawning kokanee congregate at the head end of the canal system directly below the Helena Valley Reservoir Dam. This area is heavily fished during the snagging season and creel data was collected (see Table 5). A natural instinct of the kokanee is to return to the area in which it lived as a fry (Vernon, 1957), (Seeley and McCammon, 1966). If the fish travelled through the reservoir earlier in its life cycle, this instinct would explain the observed congregation. Other evidence of the existence of a kokanee population in the excurrent canal system was the kokanee obtained through the use of a fish shocker and dip net in October of 1970 after the reservoir gates were closed (see Table 5).

DISTRIBUTION OF FISH IN HELENA VALLEY RESERVOIR

Purpose

The purpose of this portion of our research was to get a preliminary idea of the distribution of fish in the Helena Valley Reservoir. Our primary interest was to determine where the majority of the kokanee reside during the different parts of their life cycle. We were somewhat interested in the vertical distribution of kokanee, however, time did not allow us to completely explore this subject. We were also interested in the distribution and relative abundance of other fish in the reservoir.

Methods

The primary method used to determine the distribution of fish in the reservoir was to analyze the numbers of fish caught with gill nets set at various locations and different depths.

A limited amount of trapping in the lake was accomplished with frame nets obtained from the Montana Fish and Game Department. These nets consist of a live trap attached to a perpendicular lead ($\frac{1}{4}$ and $\frac{1}{2}$" mesh, seine material) approximately 50 feet in length. The free end of the lead is attached to the shore with a stake and the live trap is placed in about 5 feet of water. Fish travelling around the lake are detoured by the lead into the trap. We found the frame nets to be quite effective for trapping part of the reservoir's large white sucker population.

During August, 1970, we did some dip netting for smaller fish in the reservoir's shallow bays. The fish obtained by this method were not measured, however, we did keep track of relative numbers of the young fish.

Results

An analysis of the distribution of kokanee is given in Tables 6 & 7. This data is not meant to represent the absolute distribution as it is relative only to the locality where gill netting was done. An aerial photograph of study area is given in Figure 14.

The fish taken by frame nets (Table 8) were predominantely white suckers. These collections were made in June and most of these fish over 12 inches were in the spawning condition. The sizes of the suckers ranged from 2 inches to 2 feet.

The fish which we dip netted in shallow water were approximately 90% sucker and 10% perch fry.

TABLE 6

DISTRIBUTION AS TO LOCALITY OF GILL

NETTED KOKANEE

(1969 and 1970)

LOCATION	GILL NETS SET	NO. OF FISH OBTAINED BY GILL NETTING	NO. FISH PER GILL NET
Area where incurrent canal enters reservoir	2	39	19.5
Northern portion of lake	1	1	1.0
Western portion of lake	14	216	15.4
Northwestern portion of lake	2	2	1.0

Note: Gill nets were in water for about 24 hours

TABLE 7

VERTICAL DISTRIBUTION OF GILL NETTED KOKANEE

(1969 and 1970)

DEPTH OF GILL NET SETTING	NO. OF GILL NETS SET	NO. OF FISH OBTAINED BY GILL NETTING	NO. FISH PER GILL NET
Bottom set	5	6	1.2
3 foot below surface set	5	83	16.6
Surface set	9	169	18.8

Note: Gill nets were in water for about 24 hours.

TABLE 8

FISH CAPTURED IN FRAME NETS IN
HELENA VALLEY RESERVOIR

DATE	LOCATION	FISH TAKEN	
		YELLOW PERCH	SUCKER
June 3, 1970	East shore of lake in shallow bay	0	231
June 3, 1970	Southeast shore of lake in shallow bay	0	31
June 4, 1970	East shore of lake in shallow bay	0	85
June 4, 1970	East shore of lake in shallow bay	2	326
June 5, 1970	East shore of lake in shallow bay	7	432
June 5, 1970	East shore of lake in shallow bay	9	202
June 12, 1970	West shore of lake near island	13	505
June 12, 1970	West shore of lake near island	4	102

FIGURE 14

Aerial Photograph of Study Area

— gill net settings in 1969 and 1970

■— frame net settings in 1970

Discussion

The bulk of the gill netting was done in October and November 1969. Kokanee seem to be most abundant in the western portion of the reservoir and in the area where the incurrent canal enters the lake. Approximately 80% of the kokanee obtained in the nettings in the western portion of the lake were immature. All the kokanee obtained in the nettings which were located at the entrance of the incurrent canal were in spawning condition. It seems that the immature fish prefer the western area of the lake whereas the mature fish seem to be congregating near the incoming water.

Almost all of the kokanee obtained in our study were gill netted in surface type settings. It would therefore appear that the kokanee prefer the upper layers of water in the reservoir. Kokanee have a narrow tolerance range with regard to temperature. (Seeley and McCammon, 1966). A large volume of cool water (approximately 42° F, as given by Robert Green, Bureau of Reclamation) enters the reservoir from the depths of Canyon Ferry and does not allow for great temperature fluctuations. This buffering effect on temperature during the irrigation season might provide a very suitable temperature range for kokanee, which prefer water of about 50° F (Seeley and McCammon, 1966). Normally plankton populations show great fluctuations in a lake due to availability of nutrients (Smith, 1966). The constant input of nutrients from Canyon Ferry could keep the plankton at a relatively high concentration. Thus the cool water and the stable plankton populations (Personal Communication, Terry Beaver, Helena Senior High School) in the eutrophic zone of the lake would provide an optimal area for the kokanee which live primarily upon plankton.

Our collections indicate there is a large population of white suckers in the Helena Valley Reservoir. They appeared to be evenly distributed along the lake shore. This could possibly be due to the spawning activities of the fish at time of capture.

It was noticed by us during our creel census that the smallmouth bass population resides predominantly in the vicinity of the dam. This is a deep rocky area with an abundance of fresh-water shrimp. No smallmouth bass were obtained by our trapping methods.

KOKANEE AGE AND GROWTH STUDY

PURPOSE

Because of the extraordinary size of the Helena Valley Reservoir kokanee, we decided to put our major effort into an age and growth study. A determination of age structure was undertaken, using otoliths and scale samples. A comparison between the reliability of data obtained from scale radius readings and scale diameter readings was attempted. Body-scale and length-weight relationships were also calculated.

Methods

The majority of the kokanee obtained for this portion of our study were gill netted in 1969 and 1970 (see Figure 14). After removal from gill nets (see Figure 15) the kokanee were measured to the nearest tenth of an inch and weighed to the nearest hundreth of a pound. Sex and maturity were determined by visual and viscera examination of each fish. Some lengths, weights, and otolith samples of mature kokanee were gathered from fishermen during the 1969 snagging season.

FIGURE 15

Gill netting in January 1970 through the ice at the Helena Valley Reservoir.

FIGURE 16

Picking the gill nets.

Otolith method of age determination

Examination of the otoliths (ear bones) has been shown to be a valid method of age determination in O. nerka (Kim and Robertson, 1968).

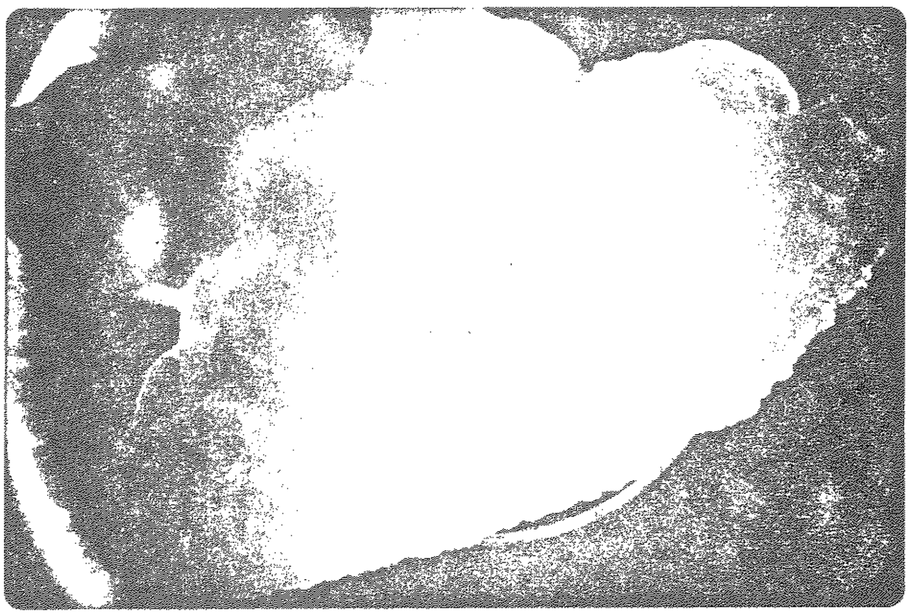
We cut the skull and removed the sacculus with enclosed otolith bones from each of the kokanee. Only the largest of the three otoliths, the sagitta, was used for age analysis. Most of the samples were stored in vials of water. Some were stored dry in scale envelopes. All were set aside for examination at a later date.

When the otoliths were analysed each pair was placed in a water-filled black watchglass and read under a binocular microscope with a magnification of 20 (see Figure 16). Some were viewed through a phase-contrast microscope with transmitted light (see Figure 17). A strong reflected light source was used and annuli were counted. Theoretically in the temperate zones, annual fluctuations in growth rates are reflected in the otoliths (McEachran and Davis, 1970). The otolith is composed of calcium carbonate and protein (Hichling, 1931). Calcium carbonate is primarily deposited in the summer and autumn, when growth rates are high. In the winter months, when the growth rates are low, protein is the major deposition (Irie, 1957 and 1960). The protein band is interpreted as the annulus. In our observations, the protein band appeared as a clear area in the otolith, whereas the calcium carbonate layer was opaque. The age of the kokanee aged in this portion of our study was interpreted as being the number of completed annuli on the otolith.

Figure 17

Typical otolith.

Figure 18



Otolith observed thru phase-contrast microscope. This otolith was removed from an age 3 kokanee.

Scale method of age analysis

Different seasonal temperatures in the temperate zone cause different growth rates to occur in fishes. These differential growth rates are reflected in the structure of the scale samples. Fish develop several growth rings, or circuli, each year. In the summer months, when growth is rapid, the circuli are widely spaced. In the winter months the growth rates are decreased, and the circuli are more closely spaced (Rayner,1965). The annulus occurs at the transition between the winter and summer growth (Tesch, 1968).

The best position to obtain the scale sample is from two rows above the lateral line and immediately below the posterior margin of the dorsal fin (Mosher, 1969), (Clutter and Whitesel, 1956). All our scale samples were obtained from this general area. All scale samples were stored in scale envelopes and examined at a later date.

Collected scales were washed and mounted between two glass slides with no mounting medium. The scale samples were read using bioscope which projected the scale's image onto white paper at a magnification of 33 (see Figures 18, 19 and 20). Determination of age was made using the following criteria for annulus ennumeration (Tesch, 1968):

a. An area of closely spaced circuli followed by an area of widely spaced circuli constitute a years growth, with the annulus interpreted as the border between.

b. Circuli become markedly discontinuous.

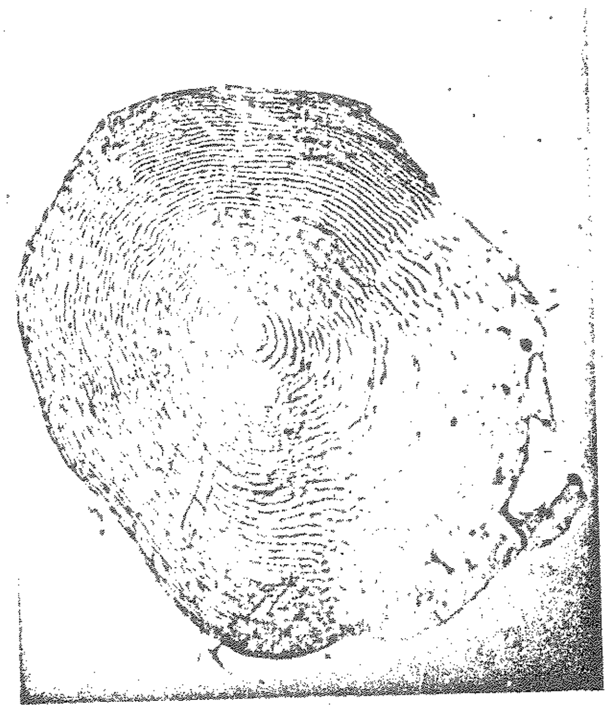
c. "Cutting over" occurs with two or more circuli running together.

Scale measurements used included radius and diameter readings. Diameter readings were made on the dorsal-ventral axis (Clutter and

Figure 19

Scale of a kokanee less than
1 year old.

Figure 20



Scale of a kokanee 1 year of age.

Figure 21

Scale of a kokanee 2 years old.

Whitesel, 1956). Radius measurements were taken from the 17.5 degree radial line as suggested by Narver (1968). Radius and diameter lengths were made on each magnified scale image. Scale lengths were also recorded at each annulus using both axis.

<u>Age and growth calculations</u>

All of the calculations used in this portion of our study were computed using Fortran IV and IBM 360 system. Most of our information was calculated using a program written by Hogman, (1969). Another program (see Appendix II) was used for the computation of frequency distribution, coefficients of the body scale equation, and coefficients of the body scale data.

Information calculated on groups of fish without scale readings included the following:

1. average total length in millimeters and weight in grams,
2. percentage of females,
3. average age,
4. log of the constant in the length-weight equation,
5. coefficients of the length-weight equation,
6. frequency distribution of length,
7. frequency distribution of weight.

In addition to the above we calculated for the fish with scale data the following information:

1. average calculated lengths at each annulus,
2. average length at time of capture,
3. number of fish in each age group,

4. weighted mean length of each annulus for each group,
5. average weight at time of capture,
6. average calculated weights at each annulus,
7. weighted mean of weight at each annulus for each group,
8. coefficients of body scale data,
9. coefficients of correlation of body scale data.

Information was then computed for males only and females only.

Results

Calculation not needing scale readings were made on the following groups of fish (see Tables 9, 10 and 11):

1. total kokanee caught in November and October 1969,
2. total kokanee caught in March 1970,
3. total kokanee caught in September 1970,
4. total immature kokanee caught in 1969 and 1970,
5. total mature kokanee caught in 1969 and 1970,
6. total kokanee obtained in creel census 1969 and 1970.

Calculations on males only and females only were then computed. Calculations requiring scale readings were made on the following groups of fish (see Tables 12, 13, 14 and 15):

1. total kokanee caught in October and November 1969,
2. total kokanee caught in March 1970,
3. total kokanee caught in September 1970.

TABLE 9

SEX, AGE AND SIZE ANALYSIS OF KOKANEE GILL NETTED IN 1969 AND 1970

KOKANEE CLASSIFICATION	NO. OF FISH IN CLASSIFICATION	% OF TOTAL	% MATURE FISH	MEAN TOTAL LENGTH[a]	MEAN WEIGHT[b]	MEAN AGE (COMPLETED ANNULI)	LENGTH WEIGHT EQUATION	LOG OF C IN LEN-WT EQUATION
Total Kokanee caught in October and November 1969	202	100.0 %	35.1%	432.1	800.07	2.1	$W = .0029 \times L^{2.0577}$	-2.5334
Male Kokanee caught in October and November 1969	107	53.0 %	34.6%	430.2	776.02	2.1	$W = .0017 \times L^{2.1476}$	-2.7785
Female Kokanee caught in October and November 1969	95	47.0 %	35.8%	434.3	827.16	2.2	$W = .0025 \times L^{2.0905}$	-2.6095
Total Kokanee caught in March 1970	18	100.0 %	0.0%	358.0	610.39	1.4	$W = .0001 \times L^{2.6587}$	-4.0900
Male Kokanee caught in March 1970	10	55.6 %	0.0%	335.8	571.60	1.1	$W = .0001 \times L^{2.6041}$	-3.9375
Female Kokanee caught in March 1970	8	44.4 %	0.0%	385.8	658.88	1.8	$W = .0001 \times L^{2.9082}$	-4.7521
Total Kokanee caught in September 1970	31	100.0 %	9.7%	312.4	384.94	1.2	$W = .0001 \times L^{2.6340}$	-4.0485
Male Kokanee caught in September 1970	19	41.3 %	15.8%	327.2	449.84	1.3	$W = .0001 \times L^{2.5709}$	-3.8839
Female Kokanee caught in September 1970	12	38.7 %	0.0%	289.0	282.17	1.1	$W = .0001 \times L^{2.8619}$	-4.6194

[a]Length measured in millimeters.

[b]Weight measured in grams.

TABLE 10

MATURE vs IMMATURE KOKANEE GILL NETTED IN 1969 AND 1970 AS TO ANALYSIS OF SEX, AGE AND SIZE

KOKANEE CLASSIFICATION	NO. OF FISH IN CLASSIFICATION	% OF TOTAL	MEAN TOTAL LENGTH[a]	MEAN WEIGHT[b]	MEAN AGE (COMPLETED ANNULI)	LENGTH WEIGHT EQUATION	LOG OF C IN LEN-WT EQUATION
Total immature kokanee caught in 1969 & 1970	177	100.0%	372.1	598.42	1.7	$.0001 \times L^{2.6822}$	-4.1465
Male immature kokanee caught in 1969 & 1970	96	54.2%	368.2	581.28	1.7	$.0001 \times L^{2.6479}$	-4.0610
Female immature kokanee caught in 1969 & 1970	81	45.8%	376.7	618.73	1.8	$.0001 \times L^{2.9176}$	-4.7489
Total mature kokanee caught in 1969 & 1970	74	100.0%	507.5	1062.35	2.5	$.0007 \times L^{2.2900}$	-3.1758
Male mature kokanee caught in 1969 & 1970	40	54.1%	506.4	1037.35	2.4	$.0004 \times L^{2.3741}$	-3.4110
Female mature kokanee caught in 1969 & 1970	34	45.9%	508.9	1091.76	2.6	$.0018 \times L^{2.1325}$	-2.7409

[a]Length measured in millimeters.

[b]Weight measured in grams.

TABLE 11

SEX, AGE AND SIZE ANALYSIS OF KOKANEE OBTAINED
IN CREEL CENSUS IN 1969 AND 1970

KOKANEE CLASSIFICATION	NO. OF FISH IN CLASSIFICATION	% OF TOTAL	% MATURE FISH	MEAN TOTAL LENGTH[a]	MEAN WEIGHT[b]	MEAN AGE (COMPLETED ANNULI)	LENGTH WEIGHT EQUATION	LOG OF C IN LEN-WT EQUATION
Male Kokanee snagged by fishermen in 1969 & 1970	6	31.6%	100.0%	559.8	1475.00	3.0	$W=.1997 \times L^{1.4045}$	-.6997
Female Kokanee snagged by fishermen in 1969 & 1970	13	68.4%	100.0%	491.2	1122.15	2.6	$W=.9819 \times L^{1.1315}$	-.0079
Total Kokanee snagged by fishermen in 1969 & 1970	19	100.0%	100.0%	512.9	1233.58	2.7	$W=.9752 \times L^{1.1397}$	-.0109

[a]Length measured in millimeters.

[b]Weight measured in grams.

TABLE 12

AVERAGE BACK CALCULATED LENGTHS AND WEIGHTS OF KOKANEE GILL NETTED IN OCTOBER AND NOVEMBER 1969

KOKANEE CLASSIFICATION AS TO SEX AND METHOD OF SCALE MEASUREMENT	AGE	NUMBER	LENGTH AT TIME OF CAPTURE[a]	CALCULATED LENGTH AT ANNULUS I	CALCULATED LENGTH AT ANNULUS 2	WEIGHT AT TIME OF CAPTURE[b]	CALCULATED WEIGHT AT ANNULUS 1	CALCULATED WEIGHT AT ANNULUS 2
Total Kokanee using scale radius readings	1	9	319.0	151.4		374	50	
	2	62	396.9	158.4	314.1	673	57	359
Weighted means	1.9	71	387.1	157.5	314.1	635	56	359
Male Kokanee using scale radius readings	1	5	326.2	154.3		392	54	
	2	35	398.1	157.7	321.1	663	57	376
Weighted means	1.9	40	389.1	157.3	321.1	629	57	376
Female Kokanee using scale radius readings	1	4	310.0	147.8		353	46	
	2	27	395.4	159.4	305.0	686	57	338
Weighted means	1.9	31	384.4	157.9	305.0	643	56	338
Total Kokanee using scale diameter readings	1	9	319.0	157.3		374	56	
	2	63	396.9	156.0	316.2	673	55	366
Weighted means	1.9	72	387.2	156.2	316.2	635	55	366
Male Kokanee using scale diameter readings	1	5	326.2	163.0		392	63	
	2	36	398.0	157.6	323.6	663	57	384
Weighted means	1.9	41	389.2	158.2	323.6	629	58	384
Female Kokanee using scale diameter readings	1	4	310.0	150.2		353	49	
	2	27	395.4	153.9	306.4	686	52	342
Weighted means	1.9	31	384.4	153.4	306.4	643	52	342

[a]Length measured in millimeters.

[b]Weight measured in grams.

TABLE 13

AVERAGE BACK CALCULATED LENGTHS AND WEIGHTS OF KOKANEE GILL NETTED IN MARCH 1970

KOKANEE CLASSIFICATION AS TO SEX AND METHOD OF SCALE MEASUREMENT	AGE	NUMBER	LENGTH AT TIME OF CAPTURE[a]	CALCULATED LENGTH AT ANNULUS I	CALCULATED LENGTH AT ANNULUS 2	WEIGHT AT TIME OF CAPTURE[b]	CALCULATED WEIGHT AT ANNULUS I	CALCULATED WEIGHT AT ANNULUS 2
Total Kokanee using scale radius readings	1	1	355.0	111.7		420	22	
	2	12	434.0	169.1	337.1	836	68	427
Weighted means	1.9	13	426.4	164.6	337.1	804	63	427
Male Kokanee using scale radius readings	1	1	335.0	111.7		434	24	
	2	5	458.4	176.5	367.7	983	81	553
Weighted means	1.8	6	437.8	165.7	367.7	891	69	553
Female Kokanee using scale radius readings	1	0						
	2	7	416.6	163.8	315.3	735	48	327
Weighted means	2.0	7	416.6	163.8	315.3	735	48	327
Total Kokanee using scale diameter readings	1	1	335.0	160.8		420	59	
	2	12	434.0	169.5	345.1	836	68	454
Weighted means	1.9	13	426.4	168.8	345.1	804	67	454
Male Kokanee using scale diameter readings	1	1	335.0	160.8		434	64	
	2	5	458.4	178.4	367.8	983	84	554
Weighted means	1.8	6	437.8	175.5	367.8	891	80	554
Female Kokanee using scale diameter readings	1	0						
	2	7	416.6	163.1	328.9	735	48	370
	2.0	7	416.6	163.1	328.9	735	48	370

[a]Length measured in milimeters.

[b]Weight measured in grams.

TABLE 14

AVERAGE BACK CALCULATED LENGTHS AND WEIGHTS OF KOKANEE GILL NETTED IN SEPTEMBER OF 1970

KOKANEE CLASSIFICATION AS TO SEX AND METHOD OF SCALE MEASUREMENT	AGE	NUMBER	LENGTH AT TIME OF CAPTURE[a]	CALCULATED LENGTH AT ANNULUS I	CALCULATED LENGTH AT ANNULUS 2	WEIGHT AT TIME OF CAPTURE[b]	CALCULATED WEIGHT AT ANNULUS I	CALCULATED WEIGHT AT ANNULUS 2
Total Kokanee using scale radius readings	1	27	283.7	142.2		264	37	
	2	1	414.0	165.6	337.1	385	53	314
Weighted means	1	28	288.4	143.0	337.1	268	37	314
Male Kokanee using scale radius readings	1	16	287.9	146.0		275	41	
	2							
Weighted means	1	16	287.9	146.0		275	41	
Female Kokanee using scale radius readings	1	11	277.6	136.6		236	31	
	2	1	414.0	165.6	337.1	741	53	411
Weighted means	1.1	12	289.0	139.0	337.1	278	32	411
Total Kokanee using scale diameter readings	1	27	283.7	155.8		258	47	
	2	1	414.0	148.3	320.8	753	41	366
Weighted means	1.0	28	288.4	155.6	320.8	275	47	366
Male Kokanee using scale diameter readings	1	16	287.9	160.5		275	53	
	2	0						
Weighted means	1.0	16	287.9	160.5		235	53	
Female Kokanee using scale diameter readings	1	11	277.6	149.1		236	39	
	2	1	414.0	148.3	320.8	743	39	357
Weighted means	1.1	12	289.0	149.0	320.8	278	39	357

[a]Length measured in millimeters.

[b]Weight measured in grams.

TABLE 15

BODY-SCALE RELATIONSHIPS FOR KOKANEE GILL NETTED IN 1969 AND 1970

KOKANEE CLASSIFICATION AS TO METHOD OF SCALE MEASUREMENT AND TIME OF CAPTURE	BODY-SCALE[a] RELATIONSHIPS ($Y = a + b X$)	COEFFICIENT OF CORRELATION
Kokanee caught in October and November, 1969		
a) radius readings	$Y = 204.0 + 3.179 X$	.549
b) diameter readings	$Y = 167.2 + 2.047 X$	.612
Kokanee caught in March, 1970		
a) radius readings	$Y = -32.3 + 7.506 X$	.947
b) diameter readings	$Y = 2.4 + 3.620 X$	.964
Kokanee caught in September, 1970		
a) radius readings	$Y = 159.2 + 2.891 X$	.650
b) diameter readings	$Y = 94.1 + 2.403 X$	.744

[a] Y = length in mm, X = scale readings in mm.

Frequency distribution as to length of kokanee gill netted in 1969 and 1970 is given in two forms. Analysis as to length at time of capture is given on Table 16. Analysis as to length at time of capture per age group is given on Figure 21.

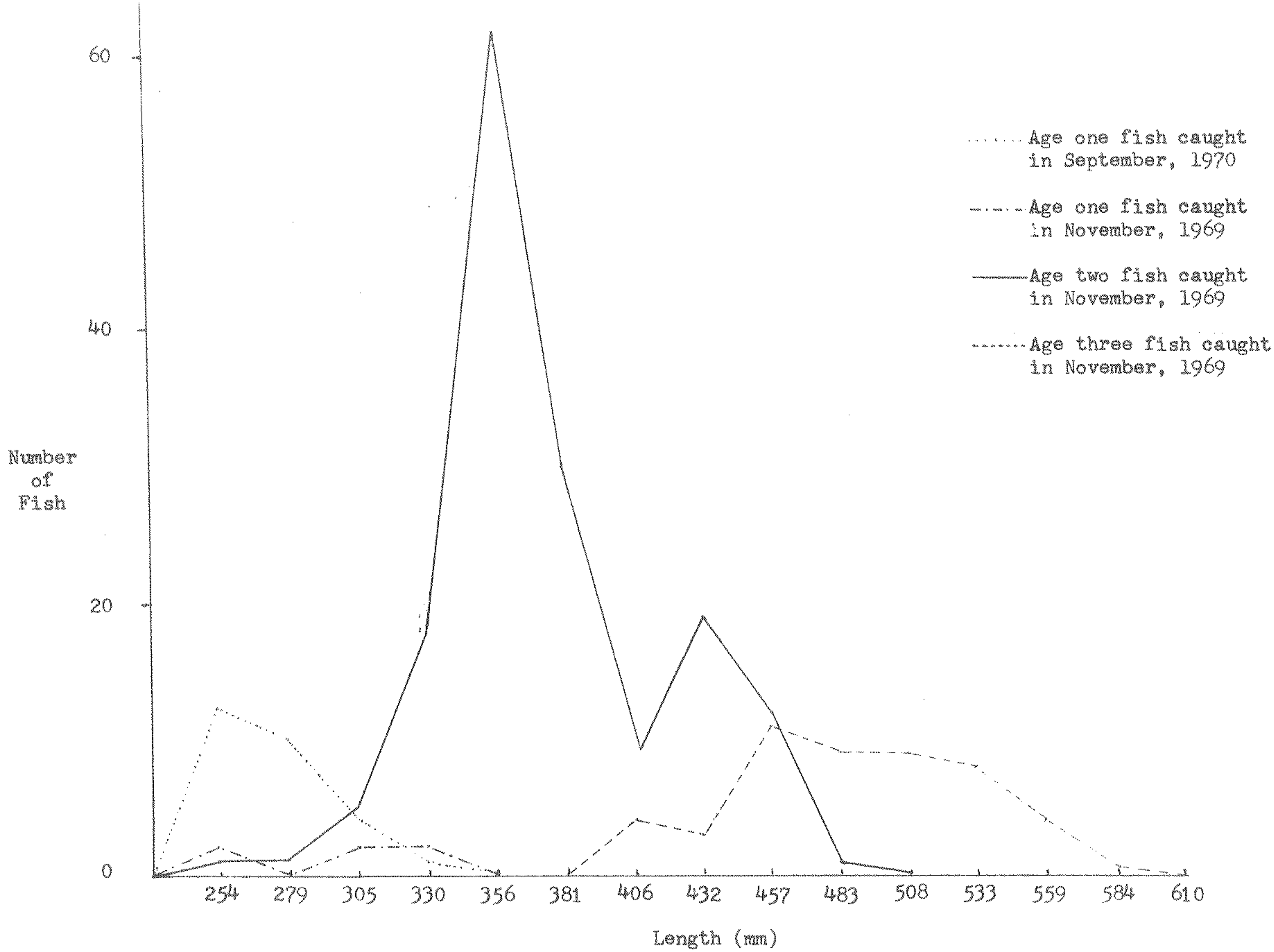
TABLE 16

FREQUENCY DISTIBUTION OF LENGTHS OF KOKANEE GILL NETTED IN 1969 AND 1970

MIDPOINTS OF LENGTH[a] CLASSES	KOKANEE CAPTURED IN OCT. AND NOV. 1969	KOKANEE CAPTURED IN MARCH 1970	KOKANEE CAPTURED IN SEPTEMBER 1970
158.7			
171.4		3	
185.1	1	1	
196.8			
209.5		1	
222.2			
234.9			
247.6			
260.3			4
273.0	2		10
285.7	1		7
298.3			1 1969 year class
311.2	2		3
323.8	2		1
336.4	3	1	
349.1	4		1
361.8	7		
374.5	11	1	
387.2	21		
399.9	35 1967 year class	2	
412.6	25	2	1
425.3	11		
438.0	1		
450.7	12	4	
463.4	2	1	
476.1	14	1	
488.8	5	1	
501.5	19		
514.2	1		1
526.9	7		1968 year class
539.6	2		
552.3	4		2
565.0			
577.7	7		
590.4			
603.1	1		
615.8	2		
628.5			

[a]Lengths measured in millimeters.

FIGURE 22



Frequency distribution of year classes of kokanee used in age and growth study.

Discussion

Carlander (1969), says the record weight for kokanee in the United States and Canada is 1814 grams. On three occasions kokanee larger than this have been observed from the Helena Valley Reservoir. Gill netting records of the Montana Fish and Game show that, on June 25, 1968, a kokanee weighing 2087 grams was taken (George Holton, personnel communication). We observed in a creel check in October 1969 a kokanee weighing 1865 grams. A kokanee weighed with a DeLiar scale in June of 1969 was found to be 2382 grams (George Holton, personnel communication). According to these observations, the Helena Valley Reservoir is producing record kokanee.

It appears that the kokanee of the Helena Valley Reservoir are maturing at an earlier age than kokanee of other locations. Our calculations show that the average age of the mature kokanee was 2.5 years of age. Hanzel (1964), shows an average age of 4.9 in 1954 and an average age of 3.8 in 1961 of spawning kokanee in Flathead Lake. Jeppson (1960) reports that in Lake Pend Oreille, almost the entire spawning run of kokanee in 1959 were in the four year old class. An early maturity might result from an abundance of food during the early stages of a populations growth. (Seeley and McCammon 1966).

In general we found that more males were caught than females. They had a mean age which was slightly less than that of the females. This agrees with reports from California (Seeley and McCammon, 1966) where males often spawn earlier than females.

Growth on a yearly basis appears to be linear with regard to length. Yearly increases in length between annuli are very close (see Tables 12, 13, and 14). It appears from Table 16 that growth from the October-November to March period is minimal and the growth from March to September is substantial. Length frequency distributions of specific age classes changed little in the former period whereas they changed considerably in the latter.

Table 16 indicates, perhaps, that the plant of 1967 was more successful than that of 1968. If we compare the age 1 and age 2 kokanee captured in the October-November 1969 period we see that the 1967 (2 year olds) year class is much stronger in number. Although some bias might have resulted from capture method, we never the less will attempt to explain this observation. All Canyon Ferry kokanee plants of 1967 were air dropped whereas in 1968 the kokanee were planted by truck along the shore. Perhaps, the observed differences in strength of year classes can be explained by differences in success of reaching the reservoir of fry planted by each method.

Our data indicates that the body-scale relationships obtained from scale diameter readings are more reliable than those obtained from scale radius readings. The coefficient of correlation for diameter readings were consistantly higher than those of radius readings (see Table 15).

CREEL CENSUS STUDY

Purpose

An attempt was made to determine the fishermen success in and the use of the Helena Valley Reservoir. We were interested in the creel composition, catch per hour, size of catch, and relative abundance of fishermen.

Methods

We employed a "catch as catch can" creel census due to time limitations. Most of our creel data was obtained from weekend creel checks, but some data was obtained on week days. No attempt was made to separate the creel data as to these considerations. Interviews conducted with fishermen included the following information:

a. Number of fishermen in the party.

b. Total fishing hours.

c. Total fish of each species in creel.

Lengths and weights of game fish were recorded whenever possible. The majority of the creel census data was obtained during the snagging season when large numbers of fishermen were observed at the reservoir.

The data was classified with regard to location and time of year. Data was separated into excurrent canal area, lake shore area, and the immediate area where the incurrent canal enters the lake. Time of year separations included pre-snagging season, snagging season previous to ice cover on the reservoir, and snagging season after ice cover.

An indication of fisherman success is the number of fish one person takes in one hour. We therefore entered the data for the total catch and total hours of each party of fishermen into a computer program (see Appendix III), using a formula given by Cochran (1963). The formula is used to compute the variance of a ratio. The mean and variance of the catch per hour for each creel area was computed in this manner (see Table 17). We also computed the mean and standard deviation of the lengths of kokanee obtained from each of our creel study areas (Table 18).

During our creel census we also kept track of the different species of fish caught by fishermen in the census areas. We felt this would help give an indication of species diversity in the lake and canal system.

Results

We computed an average fisherman use of the reservoir during three time periods. The averages and time periods are given below.

Time Period	Fishermen Observed Per Day [1]
June 2 to August 29, 1970	.67
September 2 to October 4, 1970	4.38
December 11 to December 24, 1970	1.00

This data does not represent absolute fishermen densities, but a record of observations and interviews with fishermen. Fish caught by fishermen during 1969 and 1970 creel census included the following: kokanee, smallmouth bass, brown trout, yellow perch, carp, longnose sucker, and white sucker.

[1]This data represents approximately one hour of observation by creel census taker per day.

TABLE 17

ANALYSIS OF 1970 CREEL CENSUS

LOCATION	TIME OF YEAR	NUMBER OF FISHERMEN	TOTAL CATCH	CATCH PER HOUR	VARIANCE OF CATCH PER HOUR	% MATURE FISH OF TOTAL KOKANEE CATCH
Lake shore	June 2, 1970 to August 29, 1970	46	3 kokanee 14 bass	.34	.30	0%
Trolling in lake	June 2, 1970 to August 21, 1970	18	27 kokanee	.28	5.70	0%
Lake shore	September 2, 1970 to October 4, 1970	5	0	0	b	
Incurrent canal area[a]	September 2, 1970 to October 4, 1970	80	27 kokanee	.15	.35	100%
Excurrent canal area	September 2, 1970 to October 4, 1970	55	34 kokanee	.20	.95	100%
Incurrent canal area (thru ice)	December 11, 1970 to December 24, 1970	13	13 kokanee	.79	.16	100%

[a]Area refers to location where canal empties into Reservoir and is the place where most of the snagging is done.
[b]Data not computable.

TABLE 18

SIZE ANALYSIS OF KOKANEE TAKEN IN CREEL CENSUS 1969 AND 1970

LOCATION	TIME OF YEAR	SEX	TOTAL CATCH	MEAN LENGTH[a]	STANDARD DEVIATION OF LENGTH
Incurrent canal area	1969 snagging season	male	6	561	58
Incurrent canal area	1969 snagging season	female	12	533	46
Lake shore	June thru August 1970	male & female	3	b	
Trolling in lake	June thru August 1970	male & female	27	505	43
Incurrent canal area	1970 snagging season	male	8	538	38
Incurrent canal area	1970 snagging season	female	9	531	38
Excurrent canal area	1970 snagging season	male	14	526	38
Excurrent canal area	1970 snagging season	female	5	528	18
Incurrent canal area	Snagging thru ice - December	male	6	584	18
Incurrent canal area	Snagging thru ice - December	female	10	533	15

[a]Lengths are given in millimeters.

[b]Data not available.

Discussion

Obviously, the reservoir attracts fishermen much more during the kokanee snagging season that at any other time of the year. During the snagging season, which began on September 1 and ended on December 31 of 1970, an average of 2.7 fishermen were observed per day[1], whereas the summer months, June 2 to August 29, showed an average of only .67 fishermen per day. 69 fishermen were observed during the summer months. During the snagging season 148 fishermen were observed.

Fishing success was seen to be at a maximum during the snagging season when kokanee were caught through the ice at a rate of .79 fish per hour. The average catch per hour was .35 in the total creel census. Although this harvest is low if compared with other kokanee fisheries (Robbins, 1966) (Jeppson, 1960), the average size of the kokanee in the reservoir is larger than the kokanee of these other areas. Our analysis indicated an average kokanee length of 513 mm. The average age of the kokanee in our creel census study was 2.7 years. The length of these spawning kokanee compare to an average of 272 mm for spawning kokanee in 1959 in Lake Pend Oreille in Idaho. The mean age of these fish was somewhat less than five years (Jeppson, 1960). Flathead lake showed a spawning kokanee average of 343 mm in 1963, with the largest fish being only 373 mm in length (Robbins, 1966). In our estimation, the Helena Valley Reservoir lacks in quantity, but certainly compensates in quality.

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[1]This data represents approximately one hour of observation by creel census taken per day.

SUMMARY AND CONCLUSIONS

Mortality induced by the pumping device which provides water to the incurrent canal system is substantial. This route appears to be the primary path by which kokanee enter the Helena Valley Reservoir.

Distribution of kokanee appears to be centered in the upper portions of the reservoir. We feel this is due to optimal plankton concentrations and water temperatures in this region during the study period.

Record kokanee are found in the reservoir. The population of kokanee mature at an early age and growth on a yearly basis appears to be linear with regard to length.

The reservoir is heavily fished. Although large numbers of kokanee are not caught by individual fishermen, the average size is extraordinarily large.

Our data indicates that air planting methods allow more successful recruitment into the reservoir than truck planting methods. We, therefore, recommend that air planting methods be employed in future Canyon Ferry plants. We feel that further investigation of this fishery is necessary for proper management.

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APPENDIX I

Standard Deviation Determination

by Jim Traynor

```
      DIMENSION TITLE(20),F(16),X(16)
      Y=0
      READ(1,15)K
   15 FORMAT(I2)
   10 READ(1,11)TITLE
   11 FORMAT(20A4)
      READ(1,12)M,F
   12 FORMAT(I6,16F2,0)
      READ(1,14)X
   14 FORMAT(16F5.2)
      FTOT=0
      DO 100 J=1,M,1
      FTOT=FTOT+F(J)
  100 CONTINUE
      XTOT=0
      DO 200 J=1,M,1
      XTOT=XTOT+X(J)*F(J)
  200 CONTINUE
      XAVG=XTOT/FTOT
      XSUM=0
      DO 300 J=1,M,1
      XSQ=(X(J)-XAVG)*(X(J)-XAVG)*(F(J))
      XSUM=XSUM+XSQ
  300 CONTINUE
   16 STDEV=SQRT(XSUM/FTOT)
      IF(30-FTOT)18,17,17
   17 STDEV=SQRT(FTOT/(FTOT-1))*STDEV
   18 WRITE(3,33)TITLE
   33 FORMAT(1X,20A4)
      WRITE(3,37)
   37 FORMAT(2X,4HXAVG,5X,4HFTOT,5X,5HSTDEV)
      WRITE(3,34)XAVG,FTOT,STDEV
   34 FORMAT(1X,F7.2,2X,F4.0,2X,F7.3)
      Y=Y+1
      IF(K-Y)35,35,10
   35 WRITE(3,36)
   36 FORMAT(1X,19HEND OF COMPUTATIONS)
      CALL EXIT
      END
```

APPENDIX II

Calculation of Body-Scale Relationships With Their Coefficient of Correlation and Frequency Distribution With Regard to Length and Weight

by Jim Traynor

```
      DIMENSION WIDTHL(50),WIDTHW(50),SPEC(21),SEX(210),
     1TLEN(210),WT(210),KSCD(210),          FREQW(50),FREQL(50)
   88 READ(1,99)N
   99 FORMAT(I3)
      READ(1,11)S
   11 FORMAT(I1)
      SUMX=0
      SUMY=0
      SUMXSQ=0
      SUMYSQ=0
      SUMXPY=0
   75 IF(N)80,80,76
   76 IF(S)16,16,12
   12 DO 15 J=1,N
      READ(1,14)SPEC(J),SEX(J),          TLEN(J),WT(J)
   14 FORMAT(A8,A1,1X,F3.0,F4.0,63X)
   15 CONTINUE
      GO TO 39
   16 DO 20 J=1,N
   13 READ(1,10)SPEC(J),SEX(J).          TLEN(J),WT(J),KSCD(J)
   10 FORMAT(A8,A1,1X,F3.0,F4.0,I3,60X)
      X=KSCD(J)
      Y=TLEN(J)
      SUMX=SUMX+X
      SUMY=SUMY+Y
      SUMXSQ=SUMXSQ+X*X
      SUMYSQ=SUMYSQ+Y*Y
      SUMXPY=SUMXPY+X*Y
   20 CONTINUE
      TALY=N
      A=((SUMY*SUMXSQ)-(SUMX*SUMXPY))/((TALY*SUMXSQ)-
     1(SUMX**2))
      B=((TALY*SUMXPY)-(SUMX*SUMY))/((TALY*SUMXSQ)-
     1(SUMX**2))
      R=((TALY*SUMXPY)-(SUMX*SUMY))/SQRT(((TALY*SUMXSQ)-
     1SUMX**2)*((TALY*SUMYSQ)-(SUMY**2)))
      WRITE(3,29)SPEC(1)
   29 FORMAT(1X,A4)
      WRITE(3,30)A,B,R
   30 FORMAT(1X,3HABR,3(1X,F6.3))
```

```
39 WIDTHL(1)=0
   WIDTHW(1)=0
   FREQL(1)=0
   FREQW(1)=0
   DO 40 I=2,50
   WIDTHL(I)=WIDTHL(I-1)+12.7
   WIDTHW(I)=WIDTHW(I-1)+.1
   FREQL(I)=0
   FREQW(I)=0
40 CONTINUE
   DO 50 I=1,50
   DO 60 J=1,N
   A=I
   IF(A*(12.7)-TLEN(J))64,64,62
62 B=I-1
   IF(TLEN(J)-B*(12.7))64,63,63
63 FREQL(I)=FREQL(I)+1
64 IF (A*(0.1)-(WT(J)/1000))60,60,65
65 IF((WT(J)/1000)-B*(0.1))60,66,66
66 FREQW(I)=FREQW(I)+1
60 CONTINUE
50 CONTINUE
   WRITE(3,70)(WIDTHL(I),FREQL(I),WIDTHW(I),FREQW(I), I=1,50)
70 FORMAT(1X,F8.3,10X,F3.0,10X,F8.3,10X,F3.0)
   GO TO 88
80 CONTINUE
   CALL EXIT
   END
```

Calculation of the Variance of a Ratio

by Jim Traynor written in Cobol

```
IDENTIFICATION DIVISION
PROGRAM-ID. 'CREEL'.
AUTHOR. TRAYNOR.
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL
    SELECT VARIANCE ASSIGN TO 'SYS005' UNIT-RECORD 1403.
     SELECT INPUT-FILE ASSIGN TO 'SYS004' UNIT-RECORD 1442R.
DATA DIVISION.
FILE SECTION.
FD INPUT-FILE
    LABEL RECORDS ARE OMITTED RECORDING MODE IS F
    DATA RECORD IS VARCREEL.
01 VARCREEL.
    02 CI          PICTURE 999.
    02 HI          PICTURE 999.
    02 RBAR        PICTURE 9V999.
    02 FILLER      PICTURE X(70).
01 TITLE.
    02 NAME        PICTURE X(80).
FD VARIANCE
    LABEL RECORDS ARE OMITTED RECORDING MODE IS F
    DATA RECORD IS OUTCREEL.
01 OUTCREEL          PICTURE X(121).
WORKING-STORAGE SECTION.
77 VR PICTURE 9(5)V9(5) VALUE IS ZERO.
77 N  PICTURE 999 VALUE IS ZERO.
77 SUM1 PICTURE 9(5)V9(5) VALUE IS ZERO.
77 SUM2 PICTURE 9(5)V9(5) VALUE IS ZERO.
01 TITLE-OUT.
    02 FILLER PICTURE X VALUE SPACE.
    02 NAME-OUT PICTURE X(80).
    02 FILLER X(40) VALUE SPACE.
01 VR-LINE.
    02 FILLER            PICTURE Z(19) VALUE ' VARIANCE OF GROUP-'
    .
    02 VROUT             PICTURE 99.999.
    02 FILLER            PICTURE X(96)VALUE SPACE.
PROCEDURE DIVISION.
P1. OPEN INPUT INPUT-FILE OUTPUT VARIANCE.
P2. READ INPUT-FILE AT END GO TO CLOSE -UP.
P3. MOVE NAME TO NAME-OUT.
    WRITE OUTCREEL FROM TITLE-OUT AFTER ADVANCING 3LINES.
P4. READ INPUT-FILE AT END GO TO CLOSE-UP.
    IF CI = 999 GO TO P5 ELSE GO TO PA.
PA. MULTIPLY RBAR BY HI GIVING SUM1.
    SUBTRACT SUM1 FROM CI GIVING SUM2.
    ADD 1 TO N.
    ADD SUM2 TO VR.
    GO TO P4.
P5. SUBTRACT 1 FROM N.
    DIVIDE N INTO VR.
    MOVE VR TO VROUT.
    WRITE OUTCREEL FROM VR-LINE AFTER ADVANCING 2 LINES.
```

```
    GO TO P2.
CLOSE-UP.
    CLOSE INPUT-FILE VARIANCE.
    STOP RUN.
```