A HISTORY OF THE KOKANEE IN DETROIT RESERVOIR

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I INTRODUCTION

Kokanee were originally stocked in Detroit Reservoir in 1959. This species was introduced in hopes that it would utilize pelagic zoo plankton and provide a more varied sport fishery. The trout fishery in the reservoir depends primarily on heavy plants of legal-sized rainbow trout, supplemented by stocking fingerling rainbow.

As the introduction of the kokanee has been somewhat successful in this fluctuating impoundment, a compilation of all known biological data would be of interest and aid in the future management of this species.

II ENVIRONMENT AND FOOD HABITS

Detroit is a multi-purpose reservoir maintained by the Corps of Engineers and contains 3,580 surface acres at full pool and 1,250 acres at minimum pool. Elevation is 1,569 feet at full pool. An annual drawdown of about 140 feet is usually accomplished by December 1. The reservoir is normally maintained at full pool from May to September.

As Detroit is subjected to extreme fluctuations and is characterized by a steeply sloping shoreline, it cannot be classed as a productive water. The reservoir does, however, contain ample quantities of plankton. It has been found in the summer months through stomach samples that zoo plankton serves as the primary food organism for rainbow trout. Rainbow trout examined in the spring have contained mostly nonorganic matter.

Kokanee taken by anglers in April were in good condition as they were feeding extensively on the copepod, Cyclops. In the summer and fall months, the main diet is the water flea, Daphnia.

In late August of 1963, 67 stomachs were examined from maturing kokanee collected as they moved near shore prior to migrating into tributaries. It was found that 48 stomachs contained Daphnia and 19 were empty. This would indicate that a majority were actively feeding until the fish moved into the tributaries. A sample of 22 stomachs from maturing kokanee was taken August 21, 1964 just below the mouth of the Breitenbush River. Only 1 stomach contained Daphnia, while the others were empty.

Anglers readily caught kokanee after the fish had moved into the tributaries. They were most susceptible to small wobblers, but some anglers were able to catch them on worms and flies drifted to individual fish.

Temperature Preference:

A temperature preference has not been determined for kokanee in the reservoir. Studies in California indicate kokanee adhere closely to a temperature of 50° Fahrenheit. In the 1963 Research Division Annual Report of the Game Commission, it states only that kokanee in Odell and Elk Lakes were most abundant in midsummer at Depths where the temperature was below 60° Fahrenheit. It is assumed that kokanee in Detroit would probably reside at levels where the temperature ranged from 50° to 60° Fahrenheit in the summer months.

Using data from weekly temperature series recorded at Detroit Dam, a theoretical vertical distribution of kokanee is presented in Table 1. The temperature series was recorded in 1961 and is resonably representative. Readings were available only in 25-foot intervals.

Table 1

Theoretical Vertical Distribution of Kokanee

in Detroit Reservoir

1964

Period	Approximate Depth Range*
January through June 5	Temperatures all below 50° F.
June 26	40 to 65 feet
July 10	50 to 80 feet
July 24	67 to 92 feet
August 8	85 to 105 feet
August 22 to September 4	105 to 130 feet
September 18	124 to 145 feet
September 29	140 to 160 feet
October 15	110 to 148 feet
October 23	94 to 130 feet
October 31	0 to 115 feet
November 7 to December	50° F. and less

* Using a temperature range of 50° to 55° Fahrenheit as a theoretical temperature preference.

The vertical distribution of kokanee is demonstrated by anglers readily taking them in relatively shallow depths in the early part of the season and trolling at greater depths to successfully take fish later in the summer.

III STOCKING

Kokanee were stocked as unfed fry for the first three years from 1959 to 1961. Kokanee were reared to fingerling size in 1962, when only a limited number of eggs were available. The 1963 supplement was also reared to fingerling size. As the fall 1963 spawning run appeared highly successful, the 1964 stocking was omitted.

The 1964 spawning run was considerably lower than the 1963 escapement, with doubt as to whether kokanee eggs survived the December flood. For this reason, it was decided to stock the reservoir with fry in 1965 from eggs taken in the Breitenbush River in September of 1964. Some 400,000 fry were retained for this purpose.

It was originally planned to stock the Breitenbush River to establish spawning population for egg-taking purposes. It was decided later to experiment and take advantage of the kokanee's strong homing instinct by stocking a smaller tributary that would be easier to install a weir for trapping kokanee. Advanced fry (205,000), averaging 2,420 per pound, were liberated in French Creek on February 16.

There was some concern when this mass of fry remained in the release area throughout the first day. The next morning, a few fry were observed in the area. Observations were made along the edge of the stream for a mile down to the reservoir. The fry were well scattered and appeared most abundant in the lower section of the stream. Many fry were flushed from under rocks and those in open water were easily "spooked" when approached. No fry could be observed in the stream one week after the release, indicating their migration is quite rapid. The large, deep holes in the stream made observation of fry difficult, with the conclusions based only on fry that could be seen along the edge of the stream.

Another 160,000 fry, averaging 2,205 per pound, were released on March 2 in the North Santiam River about 8 miles above the reservoir. Fry were stocked primarily to establish a spawning run in this stream.

Stocking records for kokanee in Detroit Reservoir are listed in Table 2.

Table 2

Stocking Records of Kokanee, Detroit Reservoir
1959 to 1965

Date Stocked	Source	Number	Pounds	Size	Hatchery
4/6/59	Montana	484,260	126.25	Unfed fry	Leaburg
2/29/60	Washington	541,404	94.7	" "	Wizard Falls
2/22/61	"	430,916	80.6	" "	" "
5/2/62	Brit. Col.	150,025	434.9	2 inches	" "
7/9/63	Drews (B.C.)	215,380	673.0	320 per pound	Leaburg
8/9/63	Washington	99,589	295.0	2 inches	Fall River
2/16/65	Detroit Res.	205,426	84.9	2,420 per pound	Roaring River
3/2/65	" "	160,000	73.0	2,205 per pound	" "

IV SPORT FISHERY

A desirable sport fishery was slow to materialize after the initial plant in 1959. The first kokanee appeared in the catch in August of 1960. The fishery appeared promising, as later in the fall of 1960, several males were checked ranging from 11 to 13 inches. These fish were maturing as jacks. Immature females ranged in size from 8 to 10 inches.

In 1961, only 37 kokanee were observed in a catch of 2,269 fish recorded for the season. Of these, 20 were taken in late April and the rest entered the creel throughout the season. Good catches of kokanee were reported but apparently escaped routine creel census. By September, kokanee were checked ranging to 14 inches in length. Two females examined with maturing eggs indicated some fish were spawning as three-year-olds.

Anglers were still unable to take kokanee in numbers during the 1962 season. Only 53 were checked of 2,512 fish censused. Fish sampled in September (10) were 14 to 16 inches in length. It was not until late October that the magnitude of the population was apparent. Several thousand fish accumulated below a falls in the lower North Santiam River, but they apparently had not been susceptible to the ordinary methods of angling.

The sport fishery for kokanee remained dormant as the 1963 season opened. From April 20 to May 15, only 9 kokanee were checked of 1,546 fish examined. In late May, kokanee appeared regularly in the creels. They comprised about 10 percent of the catch in late May, and 81 kokanee out of 313 fish were taken from June 1 to 15. The first half of August was the most productive period, with one-third of the total catch being kokanee. Anglers became more adept in their technique to catch kokanee as they gained experience.

Once the kokanee left the reservoir in early September, the sport fishery on this species was over. Of 324 fish checked in September and October, only 9 were kokanee. Creel census records for the season revealed 585 kokanee (12 percent) were checked. It was estimated that about 56,000 kokanee were harvested in 1963. The majority of this run ranged from $10\frac{1}{2}$ to $12\frac{1}{2}$ inches in length.

The 1964 fishery was a complete reversal of the 1963 season. At the start of the season, one-third of the anglers' catch was comprised of kokanee. Bank anglers on opening day caught kokanee on bait. Fair success prevailed through May, was variable through July, and declined considerably by August. A total of 1,064 (15 percent) kokanee was checked for the season of 6,965 fish examined. Most of the sport-caught fish earlier in the season varied from 10 to 12 inches in length. The majority of fish in the September spawning run exceeded 12 inches. Table 3 compares size groups for the sport catch from 1962 to 1964.

Table 3

A Comparison of Size Groups of Sport-Caught Kokanee

Detroit Reservoir, 1962 - 1964

	Size-Groups in Inches					
Year	6-8	8-10	10-12	12-14	14-16	Total
1962	1	9	19	14	10	53
1963	13	130	404	35	3	585
1964	18	160	744	142	0	1,064

V SPAWNING RUNS

Kokanee from the original fry plant in 1959 matured in October of 1962. Success of their spawning is questionable. When the fish migrated from the reservoir in late October, the reservoir was drawn down, exposing Hoover Falls in the lower part of the North Santiam River. From all observation, it appeared that kokanee were unable

to negotiate the falls. Falls also limited their migration in the Breitenbush River and Blowout Creek, the two streams containing kokanee in 1962. Considerable spawning activity occurred below these barriers. The success of the spawning was questionable since an extreme freshet occurred shortly after the eggs were deposited in the gravel.

The 1962 run of fish matured as four-year-olds, spawning in late October and November. This may be related to the origin of the eggs obtained from Montana. As two maturing females were checked in September 1961, there was undoubtedly a small number of these fish that spawned as three-year-olds. Observations of likely spawning areas in October and November of 1961 failed to locate mature kokanee.

The accelerated sport fishery in 1963 indicated that a substantial spawning population of kokanee was in the offing. The potential run was suggested when over 200 maturing kokanee were collected in shoreline gill net sets made while evaluating a marked rainbow study in late August. Kokanee at this stage appeared light pinkish in color. A survey by boat on September 4 found large schools of kokanee, now bright red, concentrating at the mouth of every tributary of any consequence. By September 9, kokanee were observed 20 miles above the reservoir in the North Santiam River. It was interesting to note that about 300 kokanee had moved into Downing Creek, a North Santiam tributary, with a water temperature of 40° Fahrenheit. The North Santiam temperature was 54° Fahrenheit.

Migration into smaller tributaries of the reservoir was accelerated after a mid-September freshet. On September 20 and 22, spawning counts were made in three tributaries and three sections of the North Santiam. Results of the survey are shown in Table 4.

Table 4

Spawning Ground Counts of Kokanee in
Detroit Reservoir Tributaries, September 20 and 22, 1963

Stream	Miles from Mouth	Length of Survey	Number of Kokanee	Kokanee per Mile
Tumble Creek	Mouth Upstream	0.25	430	1,720
French Creek	Mouth Upstream	0.8	1,678	2,097
Blowout Creek	Mouth Upstream	1.5	1,509	1,006
North Santiam	12	0.25	450	1,800
North Santiam	20	0.25	98	392
North Santiam	23	0.7	838	1,197
Totals		3.75	5,003	1,369 average

Counts made in the North Santiam at 12 and 23 miles above the reservoir were in areas where kokanee were concentrated. Surveys in Tumble, French, and Blowout Creeks were ended at impassable falls. Another falls, about 1 mile up the Breitenbush River, blocked the spawning migration in this stream. A concentration of at least 5,000 kokanee was observed in the first two pools below the falls.

The North Santiam was the only stream in which kokanee were able to migrate a great distance, moving 25 miles above the reservoir.

Approximately 1,000 kokanee were still spawning in French Creek on October 2. Dead fish were quite numerous at this time. A few fish were still spawning in this stream on October 14, indicating the overall spawning period lasted about one month.

The 1964 spawning run was similar to that of 1963 in that fish migrated out of the reservoir in early September. Two gill nets were

set in the Breitenbush Arm just below the stream mouth on August 20. A total of 30 maturing kokanee was caught. Five had already turned red and the others had a pinkish cast. Kokanee apparently wait at the mouths of tributaries until maturing before moving upstream. The first fish entered the weir two weeks after the gill net sample was obtained.

The magnitude of the 1964 spawning run was considerably less than the 1963 escapement. Few kokanee were observed in Blowout and French Creeks, and numbers of fish in the North Santiam were far below those observed in 1963. Only a few dozen fish were observed in the upper North Santiam where several hundred were present in the same areas in 1963. In the Breitenbush River, 5,269 kokanee were handled at the weir and another 2,000 were estimated holding below.

The vanguard of the spawning runs in both 1963 and 1964 was predominately males. Gill net samples in August of both years were comprised of 70 percent males. Of the fish arriving at the Breitenbush weir, 57 percent handled were males.

VI EGG-TAKE OPERATION

An attempt to trap mature kokanee for egg-taking purposes in 1963 was unsuccessful. By the time it was realized the spawning run was of sufficient size to provide an egg source, kokanee had already moved into the tributary streams. Since a concentration of kokanee occurred below an impassable falls on the Breitenbush River, an attempt was made to collect spawners by use of a trap net fished in a large pool. A mid-September freshet made it impossible to properly operate the net, and most kokanee were through migrating. A small number of eggs were taken, primarily to test their quality.

With the 1964 sport fishery indicating another sizeable population of kokanee, plans were made for an egg-taking operation. It was decided that the only way to successfully trap kokanee was to weir off a stream in advance of any migration. As the Breitenbush River had an impassable falls and contained a good run of fish in 1963, it was selected as the best stream for trapping.

Construction of the weir:

Considerable thought was given to the construction of the weir. As the stream flow is usually low in September, it was decided to try a heavy guage, one-inch mesh chicken wire. Three strands of cable were used as a base with steel fence posts attached every few feet for better support to the cables and chicken wire. Two rock jacks were constructed in the center of the stream to anchor cables. An additional rock jack was necessary on one bank as nothing was available to serve as an anchor. Fixed winches were used to fasten and tighten cables at one side. The bottom of the chicken wire was angled with the stream bottom and covered with rock and gravel to seal the bottom of the weir.

Rather than use the conventional type of weir installed straight across the stream, the weir was constructed diagonally from either bank forming a "V" shape. It was anticipated that a portion of the run would have to be held for some time before ripening. It was for this reason that a large holding pen was built above the weir rather than a smaller trap or live box. One-half of the stream was fenced off for some 50 feet above the weir. This allowed a holding area capable of accommodating 4,000 or more kokanee. Kokanee were then seined into a live box for spawning. The weir was designed and constructed by the Roaring River Hatchery crew and other Game Commission personnel.

This type of weir construction proved to be quite successful for trapping kokanee. No estimate was made of the stream flow during trapping operations; however, a 20-year mean average flow for the month of September is 146 cfs. Some difficulty was experienced when a windstorm produced an early leaf drop. Wire brushes were used to grind the leaves through the mesh of the chicken wire.

Spawning:

Prior to the migration of kokanee into the Breitenbush weir, trap nets were fished for several days in the upper North Santiam Arm of the reservoir in an attempt to collect spawners. Although kokanee appeared to be numerous and were moving upstream to some extent, they were reluctant to enter trap nets; and this phase was abandoned.

The first kokanee entered the Breitenbush weir on September 4. Two thousand fish had entered the holding pen by September 7. As there was some concern the holding pen could become overcrowded, green kokanee were transferred to the Roaring River Hatchery to be spawned later. From September 8 to 17, 874 females and 204 males were transported to the hatchery.

The first spawning at the weir took place on September 10 when 238 females produced 110,080 eggs. Spawning at the hatchery commenced on September 13. Table 5 lists the kokanee egg-take data.

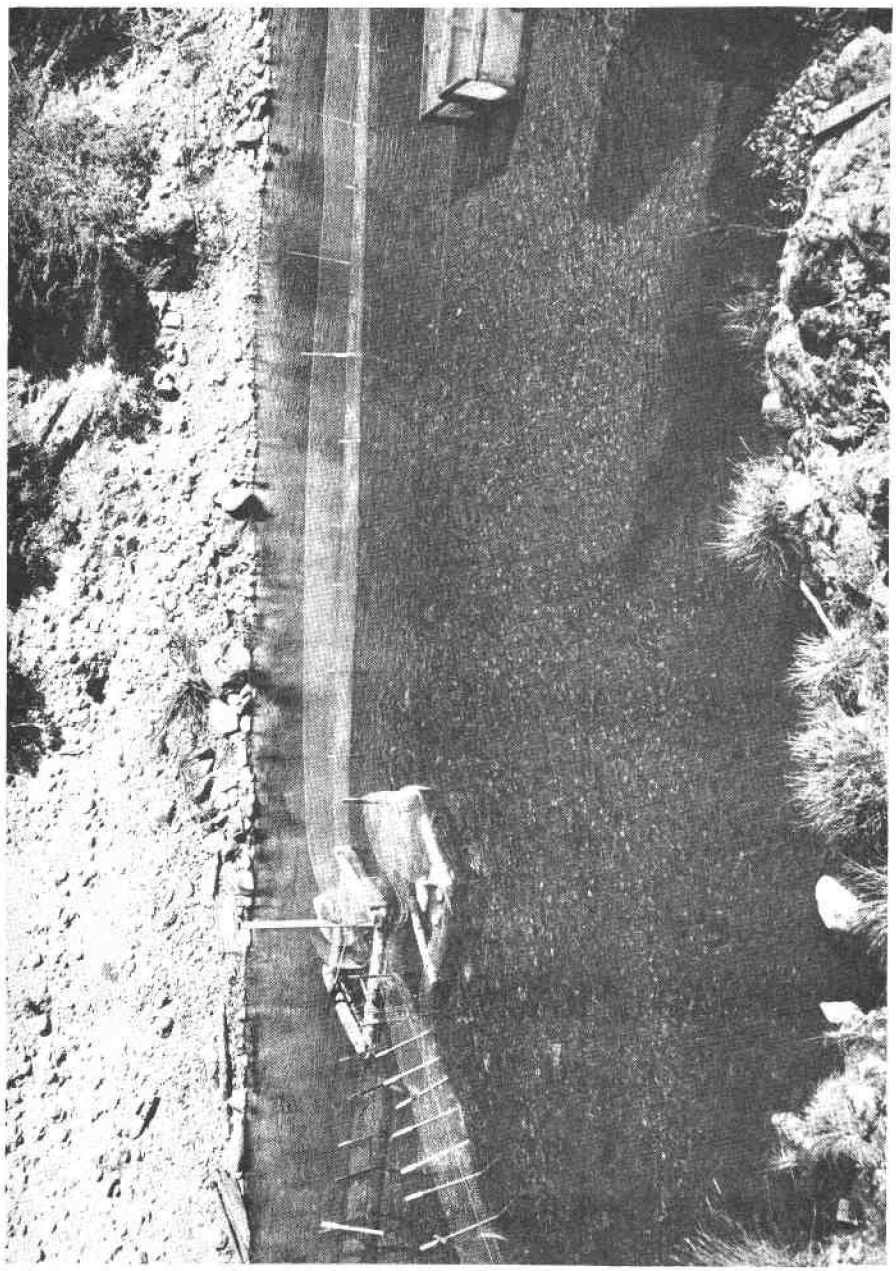

Fig. 1 Weir layout with holding pen in foreground.

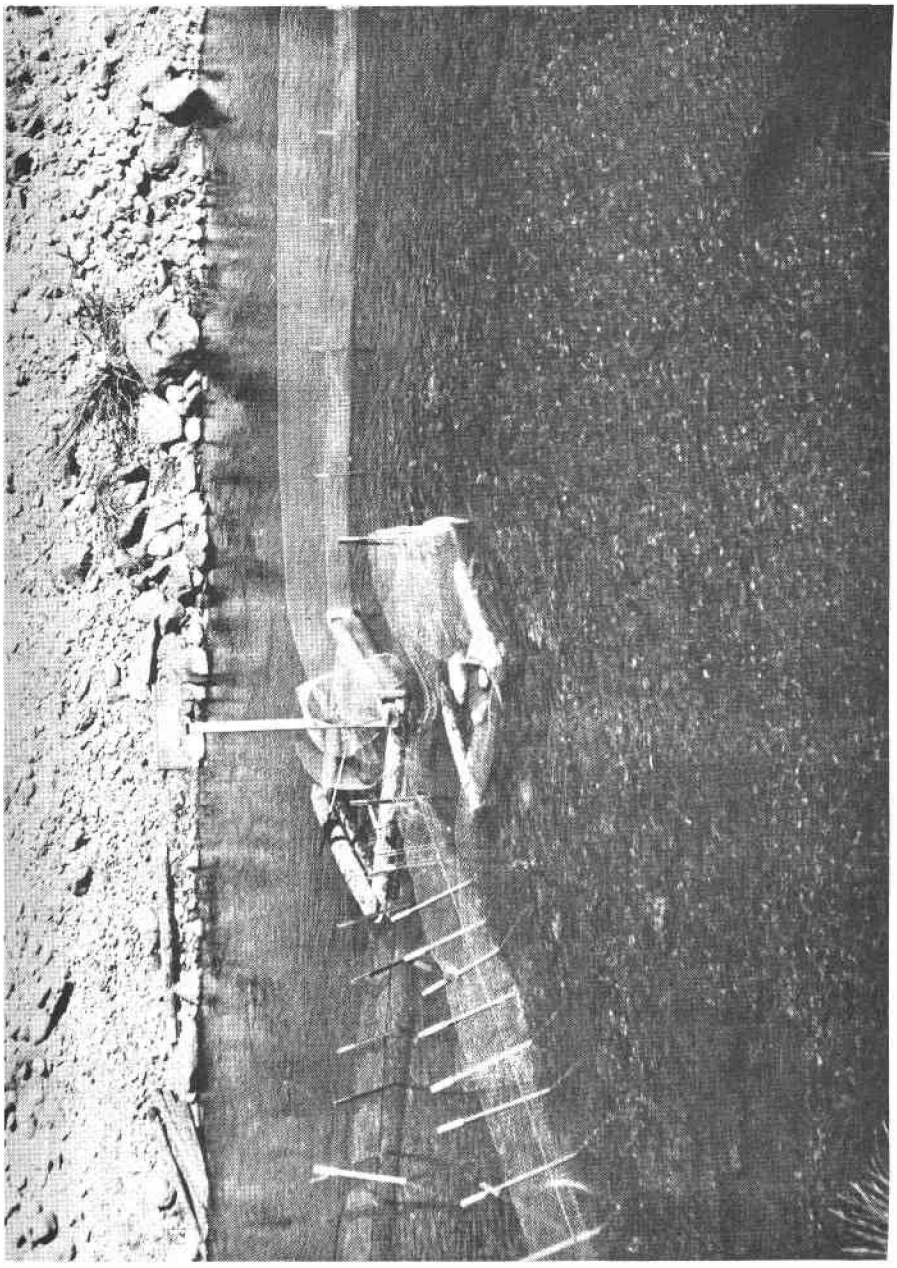

Fig. 2 Closeup of weir construction.

Table 5

Kokanee Egg-Take, September, 1964

Date	Number of Females	Number of Eggs Taken	Average per Fish
Breitenbush weir:			
9/10/64	238	110,080	462
9/11/64	358	178,880	499
9/14/64	292	137,600	471
9/15/64	166	86,000	518
9/17,18/64	63	34,400	546
9/22/64	48	24,080	502
Totals	1,165	571,040	490
Roaring River Hatchery:			
9/13/64	319	180,000	564
9/16/64	179	84,600	473
9/21/64	222	111,600	503
9/25/64	92	46,800	509
10/5/64	5	2,150	430
Totals	817	425,150	520
GRAND TOTALS	1,982	996,190	Average: 502

At the weir 1,165 females and 703 males were spawned. After spawning, these fish were placed above the weir. In addition, unspawned kokanee totaling 216 females and 2,102 males were released above the weir. The fish handled at the weir, including the 1,078 kokanee transferred to the hatchery, totaled 5,264. It was estimated another 2,000 fish were spawning below the weir.

Although the spawning period covered nearly one month, the majority of eggs were taken in a period from September 10 to 21.

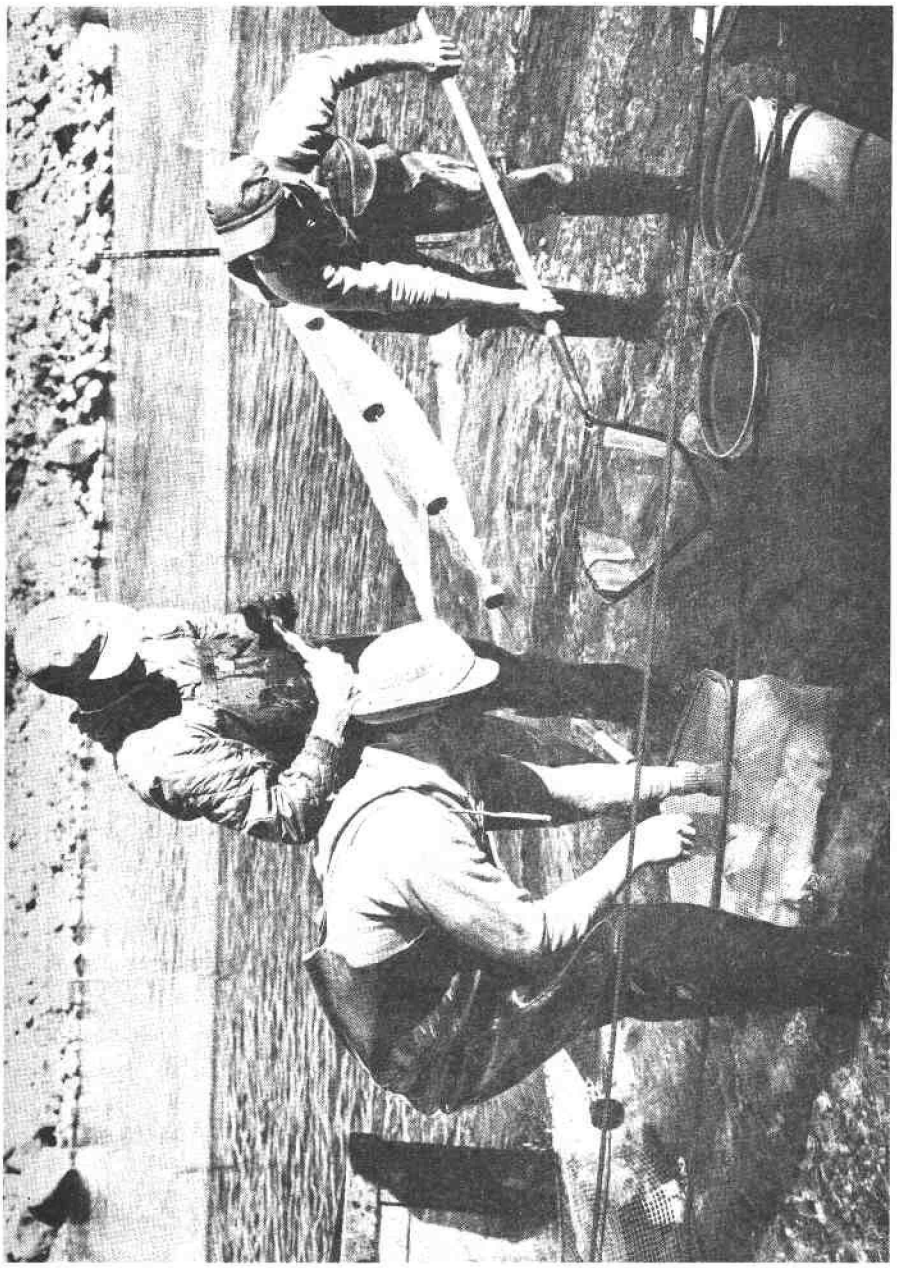

Fig. 3 Kokanee being sorted for spawning after seining the holding pen.

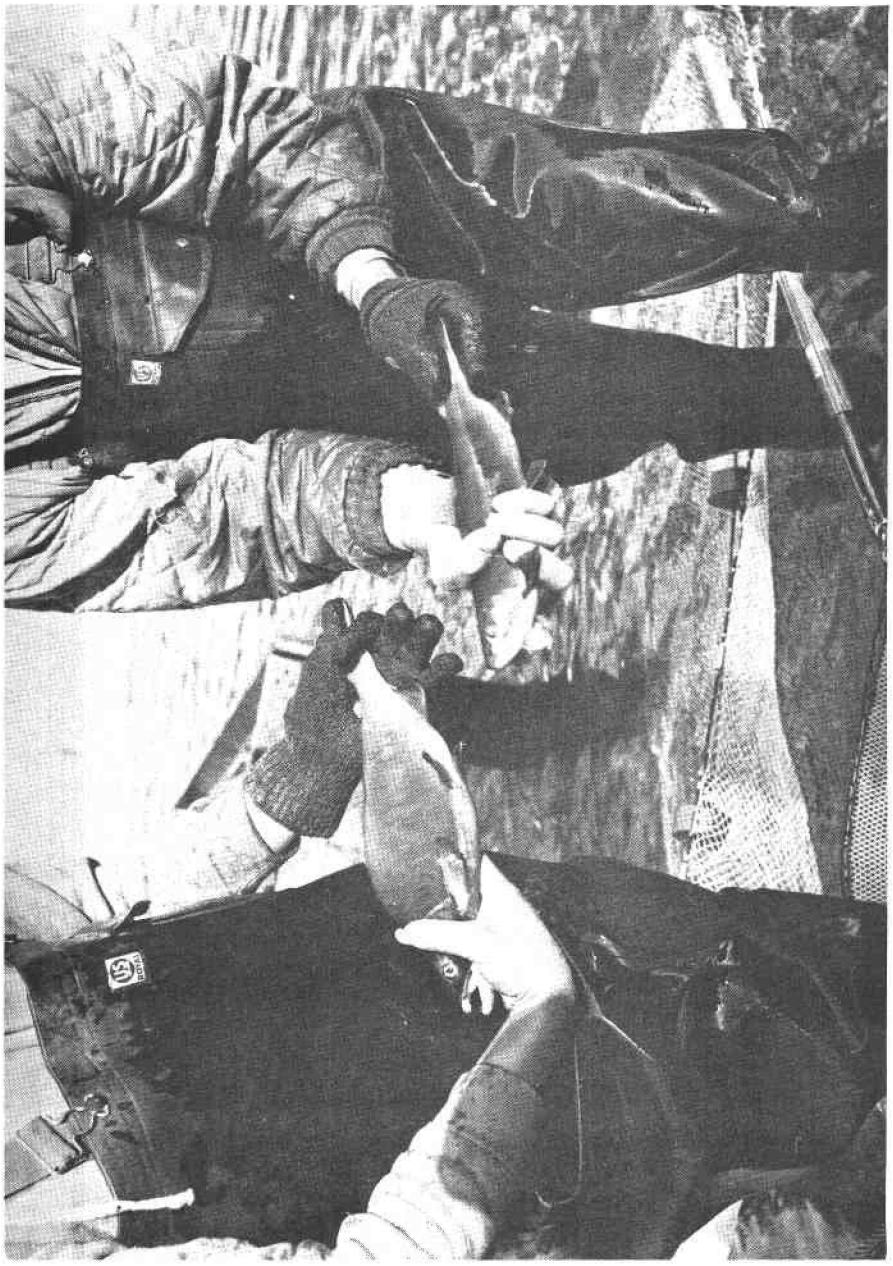

Fig. 4 Pair of kokanee showing typical body conformity of male on left and female on right.

Fecundity:

Nineteen females, spawned in 1963, produced 7,400 eggs, an average of 389 eggs per fish. These females averaged 11.38 inches, 1.3 inches less than the females recorded in the 1964 run.

Females spawned in 1964 were divided into two groups. Females spawned at the weir were stripped and produced an average of 490 eggs each. Females spawned at the hatchery were killed and cut open to remove the eggs. This group averaged 520 eggs per female. It was felt that some loss of eggs occurred from injury when the females were cut open. The number of good eggs obtained by cutting fish open was probably not sufficient to justify this method over spawning by stripping.

Size and Quality of Eggs:

The kokanee eggs taken in 1964 were considered to be of good quality and were judged comparable to good rainbow eggs. A fertility of 96 percent was estimated from a sample of eggs examined. There was a tendency for some eggs to be soft shelled.

In the green stage, kokanee eggs averaged 225 per ounce. Eyed eggs averaged 208 eggs per ounce.

VII SPAWNING HABITS AND PROPAGATION

Natural Propagation:

Spawning ground counts conducted in September of 1963 provided an excellent opportunity to observe the spawning habits of kokanee. Spawning densities varied from several hundred fish on a single-gravel bar to a pair utilizing a gravel pocket one foot square. The heaviest spawning concentrations were below natural falls and on the good gravel

bars. In many cases, some of the better spawning gravel in the lower section of streams was under-utilized, as the majority of fish migrated higher into the stream basins. Vertical drops of 3 to 4 feet proved to be complete blocks to kokanee migration.

Gravel used by spawning kokanee varied in size from fine materials of sand and pea gravel to rocks 4 inches in diameter. Numerous redds were examined to verify egg deposition. Eggs were recovered from redds in the North Santiam, Breitenbush, and French Creek. Eggs were found buried at depths varying from 4 to 7 inches.

Data on incubation and hatching in the wild were obtained while evaluating the spawning success of the 1963 run. Redds in the upper North Santiam River were examined on several occasions to determine hatching time. Eggs were deposited in these redds about September 20. On December 23, eyed eggs were recovered from the same redds. The water was 37° Fahrenheit at this time. Redds were reexamined on January 10, and about one-half of the eggs had started to hatch. Small fyke nets were fished periodically during the next few months, but no kokanee fry were collected. On May 6, several redds were examined again in the same area. A substantial number of fry were still in the gravel. Nearly 8 months had elapsed from the time the eggs had been deposited. The average mean water temperature for the North Santiam varies from 37° to 41° Fahrenheit from November through April.

About the time it was anticipated fry would be emerging from the gravel, a heavy snow runoff occurred. The runoff spoiled plans to collect and evaluate the emergence and downstream movement of fry. No observations or collections of fry were ever recorded. The only good indication that fry did successfully emerge and migrate into the

reservoir originated from reports by resort owners who observed large schools of fry around their boat docks the first week in June. These schools of fry were not definitely varified as kokanee, but it appears reasonable to assume they were. A true evaluation of the spawning success of this run cannot be determined until the fall of 1966 when the progeny will mature.

Hatchery Propagation:

An egg loss of 9 percent was experienced at the Roaring River Hatchery with eggs from the 1964 egg-take. This included a number of prematurely hatched kokanee which died soon after hatching. It was estimated that premature hatches comprised less than one percent of the total eggs.

Premature hatches occurred after about 40 days' incubation. Approximately 60 days were required to hatch the remainder of the eggs. The water temperature in the hatchery ranged from 41° to 52° Fahrenheit during the hatching period from mid-September to mid-November. Average temperatures for each month was 50° Fahrenheit for September, 48° Fahrenheit for October, and 45° Fahrenheit in November. The water averaged about 44° to 45° Fahrenheit during the sac stage, and 43° Fahrenheit during the period when the fry commenced feeding.

The elapsed time from hatching to the swimup stage was approximately 30 days. A loss of 2.8 percent was measured for fry in baskets up to the time feeding started. Fry were started on Clark's chinook mash, later supplemented with Clark's swimup feed.

The number of fry in the swimup stage averaged 3,640 fish per pound. After 14 days of feeding, fry averaged only 3,950 per pound. Fry were moved from baskets to open troughs where feeding was better

accomplished. When fry were liberated on February 16 and March 2, they averaged 2,420 and 2,205 fish per pound, respectively.

VIII AGE AND GROWTH

Kokanee from the original 1959 fry plant exhibited good growth during their first two summers in the reservoir. Males maturing as jacks varied in length from 11 to 13 inches. Immature females ranged from 8 to 10 inches. By the end of the third summer, these fish were approaching 14 inches in length. As a four-year-old, an average size of 14 to 16 inches was attained. A small number of maturing females were recorded about 15 inches fork length.

The large spawning run of 1963 contained kokanee maturing at a size range of $10\frac{1}{2}$ to $12\frac{1}{2}$ inches. Adequate scale samples were not obtained from these fish to determine the year class. A sample of 66 females maturing in late August averaged 11.4 inches fork length, and 100 males 11.39 inches.

Scale analyses from kokanee spawned in 1964 indicated that these fish were in their third year. This would mean they were from the May 1962 liberation of 150,000 two-inch fingerling. The egg source was British Columbia. Maturing kokanee in the 1964 run generally ranged between 12 and 14 inches. A total of 172 spent females was measured averaging 12.7 inches fork length. A sample of 28 males averaged 13.0 inches. Females ranged from 10.4 to 13.6 inches, and the males 12.4 to 13.6 inches.

Scale samples were taken from 11 immature kokanee caught by anglers in August and September. The fish varied in length from 8.0 to 9.7 inches fork length and averaged 8.8 inches. Scale analysis

revealed they were in their second year and would have been from one of two groups of fingerling liberated in 1963. It is assumed that the majority of these fish will be maturing in the fall of 1965 since they are of British Columbia stock. It is estimated that they will range between 10 and 12 inches upon maturity.

In comparing the growth rate from scale analysis, it is interesting to note that the 11 immature two-year-olds averaged only 3.78 inches at the first annulus. At the end of their first year, 30 mature three-year-old fish from the 1964 run averaged 5.86 inches. Both groups of fish revealed a similar growth rate of just over 5 inches from the first to second annuli. The difference in size at the first annulus probably results from the time of liberation with the three-year fish released on May 2 and the two-year fish released on either July 9 or August 9. This is theorizing that kokanee planted as fingerling made better growth feeding on their natural diet of plankton in the reservoir than they would have made at the hatchery. There was also a difference in seasons as the three-year fish made their growth in 1962 and the two-year group in 1963.

Scale analysis of the 30 mature three-year fish indicates an average growth of 1.2 inches was made from the second annulus to the spawning period in September. The same growth pattern was apparent in the sport fishery. Kokanee in 1962, 1963 and 1964 all gained only an average of 2 inches during the maturation year.

Growth rates of 2 age classes of kokanee are compared in Table 6.

Table 6

A Comparison of Two Age Classes of Kokanee from Scale Analysis

Group	No. in Sample	Average Size at Annulus 1	Range in Size at Annulus 1	Average Size at Annulus 2	Range in Size at Annulus 2	Size at Maturity
2-year	11	3.78	2.8 to 4.7	8.81*	8.0 to 9.7	Immature
3-year	30	5.86	4.0 to 7.9	10.97	8.8 to 12.6	12.18**

* Collected in August and September and had not actually reached their second annulus.

** Collected in September after spawning.

IX FUTURE OUTLOOK FOR KOKANEE POPULATIONS IN DETROIT RESERVOIR

Spawning runs for the next few years will come from a variety of sources, including a fingerling plant, natural reproduction, and an advanced fry plant. The possibility exists that natural reproduction could support kokanee populations in the reservoir after the 1965 fry stocking. Hypothetical kokanee populations are predicted for the next five years as follows:

1965: The majority of this run should originate from a plant of 215,380 fingerling of British Columbia strain which should be maturing in September in their third year. A second group of 99,589 fingerling was stocked in 1963 from a Washington source. Whether their maturation will occur in their third or fourth year or both is unknown. It may prove impossible to distinguish between the two plants unless the Washington race of fish matures later in the year as normally occurs.

1966: An interesting year is indicated since the progeny of the phenominal 1963 spawning run should be maturing in their third year (1966). The success from natural spawning in 1963 will be determined. The possibility exists that progeny from the 1962 spawning run will enter the catch in 1966. These fish should mature as four-year-olds and spawn in late October or early November.

1967: The age class of kokanee entering the fishery in 1967 should originate from a plant of 365,000 advanced fry liberated in French Creek and the North Santiam River. An evaluation of homing instinct will be possible since these will be the first returns of plants made in tributaries of the reservoir.

1968: This age class will need hatchery supplementation because of a low spawning escapement.

1969: This year's run should be the second generation from the 1963 spawning run, depending on the previous success of runs in 1963 and 1966.

X CONSIDERATIONS FOR FUTURE MANAGEMENT OF KOKANEE

1. The question often arises--What race or strain of kokanee is desirable for Detroit Reservoir?

The advantage of the British Columbia race (third year, September spawners) primarily spawning in September enables kokanee to ascend tributaries that would be impassable later in the fall when the reservoir is drawn down. A September migration is desirable for trapping mature fish in tributaries for egg-taking purposes. Arguments against this race are--The fish normally are of a smaller size when reaching

maturity in their third year and since the migration from the reservoir occurs in early September, the fish are no longer available to the reservoir fishery.

A four-year fish spawning later in the fall would not only be available for an additional year in the reservoir, but would also inhabit the impoundment about two months longer prior to the spawning migration. The possibility exists that this race of fish would have difficulty in propagating naturally. Other states have experienced instances of no natural reproduction from the later spawning kokanee because of the colder water temperatures killing the eggs in the green stage. This could be beneficial if overpopulating was feared.

2. Future egg-take operations:

Kokanee populations in 1963 and 1964 were large enough to provide an egg source; however, problems do occur in trying to collect fish for this purpose. Experience gained in the trapping operation on the Breitenbush River in 1964 in weiring off a stream prior to migration should prove helpful in future operations.

Runs of the last three years reveal that kokanee normally are most abundant in the two main tributaries of the reservoir--the Breitenbush and the North Santiam Rivers. This will probably continue to hold true in 1965 and 1966. Trapping operations for the next two years should be confined to one of the two streams. Although both streams maintain considerable flows, the 1964 trapping operation proved that a weir can be successfully maintained on a larger stream in September.

It is anticipated that the 1967 egg-taking station can be established in French Creek, a smaller tributary. A liberation of 205,000 advanced fry was made in this stream in 1965 in hopes of developing

a spawning run for 1967. There is no assurance this will be accomplished, but it is a well-known fact that kokanee exhibit a high degree of homing instinct.

It is recommended in the future that an experimental plant of kokanee of the Montana race be stocked in a smaller tributary of the reservoir. The objective of this plant would be an attempt in establishing a run for an egg source as well as providing a race of kokanee that would be available over a longer period to the anglers. By stocking a small tributary, it is anticipated an egg-take could still be accomplished even in November under normal circumstances.

3. Is overpopulating a serious threat?

Kokanee would probably have to be less than 9 inches long to be undesirable to the angler. The possibility of additional fish in the creel may offset the lack of size. Judging from the tremendous population of kokanee in Detroit in 1963 attaining a size of $10\frac{1}{2}$ to $12\frac{1}{2}$ inches, it would appear that an extremely high population would have to exist to cause stunting. When the progeny of the 1963 run mature in 1966, we should be able to evaluate the success of natural reproduction.

If an overpopulation was apparent, this would provide an excellent opportunity to weir off key streams, to take eggs if required, and to reduce the available spawning area for natural reproduction. Most tributaries, except the North Santiam, have natural barriers which limit the amount of spawning area. Plans to improve the passage over these barriers are dependent upon the success of the 1963 run to reproduce naturally.

4. An accelerated program of biological investigations is necessary to evaluate the next three to four years' kokanee populations in the reservoir.

The future kokanee runs will originate from fingerling releases in the reservoir, fry stocked in tributaries, and natural reproduction. To properly study the results of the program, data should be collected and analyzed to evaluate the runs. Such data should include:

a. Creel census from which average lengths, scale samples, and stomach samples can be obtained throughout the summer. An indices of the coming fall's spawning run can be obtained by examining sport-caught fish in midsummer when the maturity can be determined. An indication of the average size, age, and abundance can also be assessed from the maturing females.

b. Spawning surveys should include time of migration, streams utilized, spawning numbers, and other incidental data of relative importance and interest.

c. Food habits should be studied thoroughly to determine what plankton species are available throughout the year and at what levels of abundance.

d. An egg-take should be attempted if the population appears sufficient to support this phase of the program. This also provides an opportunity to obtain a cross-section of the spawning run; i.e., average size of maturing females, average number of eggs produced, and determine age and growth patterns from scale samples.

e. It would be desirable to determine the vertical distribution of kokanee in midsummer, if proper equipment and methods can be used to obtain this data. Anglers would certainly benefit from this data. It is very possible that kokanee reside at such depths in the summer months that they are no longer available to the average troller. This could be a key factor in the harvest of the species.

5. All biological data obtained on the kokanee in Detroit Reservoir should be applicable to other similar impoundments of the present and future.

An evaluation of the success of kokanee spawning escapement in Detroit during the last two years could be of value when considering use of the species in other fluctuating reservoirs of similar status.

In Detroit Reservoir, the kokanee appears to be a highly desirable species with the ability to utilize plankton and attain reasonable growth. Rainbow growth studies in Detroit reveal that the species is restricted to a short growing season in the summer months and is largely dependent upon the water flea (Daphnia) as a source of food.

It seems apparent that the kokanee could well be the key species in many established and future impoundments--especially those incapable of sufficient trout production.

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