5-1983

Investigation of Selected Aspects of Kokanee (Onchorhynchus nerka) Ecology in Porcupine Reservoir, Utah, With Management Implications

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INVESTIGATION OF SELECTED ASPECTS OF KOKANEE (*ONCHORHYNCHUS NERKA*) ECOLOGY IN PORCUPINE RESERVOIR, UTAH, WITH MANAGEMENT IMPLICATIONS

by

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A thesis submitted in partial fulfilment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Fisheries and Wildlife

UTAH STATE UNIVERSITY
Logan, Utah

1983

ACKNOWLEDGEMENTS

I would like to thank the Utah Division of Wildlife Resources for the logistic support that made this study possible. The use of equipment and time off from my summer position was invaluable. Additional equipment was supplied by Utah State University for which I am very grateful for.

I owe special thanks to Dr. John Neuhold for his moral and physical support and guidance throughout this study. His ideas and suggestions were invaluable. I would like to extend my appreciation to Drs. William Helm and Willford Hanson for their expert technical advise and for their review, critique and suggestions for my thesis and research program.

I would like to thank all the people that assisted me throughout my research in the field. I would like to list all of their names but for fear of missing someone I will just say thanks to all of you. It would have been literally impossible for me to accomplish what I did without your help.

I am particularly grateful to my father for his love and support. I owe this degree as well as all my education to him for all his support and special understanding.

I would like to thank two men for all the special help that they have given me in the last six years; Dexter Pitman and George Wilson. They have always been there when needed.

Finally to my wife Laurie, for all her love and support and especially all of the time she spent helping me both in the field, in the office and at home, I give her all my Love.

Paul Janssen

Paul J. Janssen

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ABSTRACT

Investigation of Selected Aspects of Kokanee (Onchorhynchus nerka) Ecology in Porcupine Reservoir, Utah, with Management Implications

by

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Utah State University, 1983

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Several aspects of kokanee (Onchorhynchus nerka) ecology were studied in the fluctuating, 80ha Porcupine Reservoir, Utah in order to determine optimum management strategies. In 1981, escapement was enumerated and estimates of egg deposition were made. An estimate of the resulting fry recruitment was also attempted and was successful up to the arrival of spring runoff. In 1982, escapement was enumerated and estimates of egg deposition were made, with subsequent estimates of egg deposition and percent survival to the advanced eyed stage. Age and growth rates were determined and survival rates estimated.

Escapement for 1981 and 1982 was 5,463 and 7,113 kokanee, respectively, depositing an estimated 1,843,955 and 2,393,757 eggs, respectively. The estimated fry recruitment to the reservoir for the 1981 spawning run was 57,000 fish up to the arrival of spring runoff and appeared to be only a fraction of the total number of fry in the river. From the 1982 spawning run, an estimated 2,265,507 eggs were actually deposited, of these an estimated 64.2% or 1,457,599 eggs were fertilized and survived to the advanced eyed stage. Kokanee growth rates were good. Fish mature and spawn at 34 months of age at an average total length of 364mm. Twelve month old kokanee average 124mm and 24 month old fish 257mm. The kokanee population continues to grow but at a decreasing rate and survival rates are declining. For every kokanee that spawned in 1972, an estimated 8.2 progeny survived to spawn in 1975 and for every spawning kokanee in 1979 an estimated 3.0 progeny survived to spawn in 1982.

The kokanee is presently underharvested and appears to be at or near the carrying capacity of the reservoir. In order to acheive an optimum sustainable yield the spawning population should be reduced and maintained at approximately 2,000 fish (1,000 redds).

(68 pages)

INTRODUCTION

Study Area

Porcupine Reservoir, a multiple purpose, medium elevation, drawdown water storage reservoir, on the East Fork Little Bear River was completed and filled in 1962. The earth fill dam has a maximum storage capacity of $15.419 \times 10^6 m^3$. At spillway level the reservoir covers 80 hectares with a maximum depth of 42.4m, an average depth of 20.1m and an elevation of 1,615m.

Limnological data taken in 1979 by the Utah State Department of Health (USDH) describes Porcupine Reservoir as a hard water reservoir with total alkalinity ranging from 164 - 188mg/L. The reservoir is classified as mesotrophic with no true thermocline but exhibiting a decline in temperature from 20^oC (surface) to 7.5^oC (bottom). DO levels in mid July range from a high of 9.4mg/L (surface) to a low of 5.8mg/L (bottom)(Denton 1980). The growing season, measured in number of frost free days, is 150 - 200 days.

The EPA (1972) during a national eutrophication survey (NES) recorded secchi disk readings that ranged from 0.7m in May to 2.1m in the fall. The EPA also found that phosphorous is the limiting nutrient during all months of the year with the single exception of August when nitrogen is limiting. The reservoir is subject to significant levels of nutient loading (EPA 1972). Livestock and recreational use of riparian zones of the East Fork Little Bear

River above the reservoir are the two non point nutrient loading sources (Denton 1980).

Water sources for the reservoir include two minor ones; Porcupine Cr. and a large spring, and one major; the East Fork Little Bear River. The East Fork Little Bear River ia a medium size stream with an average annual flow of $1.02m^3$/sec and minimum and maximum flows of $0.062m^3$/sec and $21m^3$/sec respectively. The stream has a drainage area of $91.25km^2$, all of which is high mountainous range.

Extreme reservoir drawdowns are an annual occurrence. Spillway level waters are reached in a normal water year followed by a vertical drawdown of 28.3m to the conservation pool with surface area fluctuations from 79 to 26ha. The conservation pool of $1.85x10^6m^3$ is owned by the Utah State Division of Wildlife Resources(DWR). Of the $1.85x10^6m^3$, $1.2335x10^6m^3$ is dead storage, the remaining $6.167x10^5m^3$ is used to the Divisions direction. Historically the $6.167x10^5m^3$ have been used to keep a minimum flow of $0.056m^3$/sec in the East Fork Little Bear River below the reservoir after the irrigation season is terminated and water is no longer released from the dam (Personal communication, D. Pitman, DWR Regional fisheries manager). Water levels at or near the conservation pool occur annually from sometime in September and continue through the winter, when levels slowly rise until spring runoff when the lake is filled rapidly.

There are several fish species present in Porcupine, these include: kokanee (*Onchorhynchus nerka*), brown trout (*Salmo trutta*), cutthroat trout (*Salmo clarki*), rainbow trout (*Salmo gairdneri*), mountain sucker (*Pantosteus platyrhynchus*) and speckled dace (*Rhinichthys osculus*).

Management Practice

The Utah Division of Wildlife Resources presently sets management objectives for a given body of water. These objectives have as a goal the optimization of fishing quality and quantity that would satisfy the majority of fishermen. Two such goals have been adopted for Porcupine Reservoir: 1) a catch rate of 0.75 fish/hour on the fishing season opening weekend and 0.5 fish/hour for the remainder of the season; and 2) a minimum fish length of 228.6mm (Personal communication, D. Pitman, DWR Regional Fisheries Manager).

Techniques employed to meet the above stated objectives vary with location. At Porcupine Reservoir, as is the case with most Utah waters, the rainbow trout was selected as the species to meet these objectives. Since the first year of the reservoir's existence, rainbow trout have been stocked annually in various numbers and sizes. A low of 9,298 76mm to 152mm fish to a high of 69,224 63.5mm fish have been stocked annually, with the average stocking being 37,474 fish. The majority of the stockings were made during the months of May, June, August and September. The fish live and grow in the reservoir until the following year's opening of the fishing season. They then begin to enter the creel, ideally at a quality and quantity suitable to meet the preset objectives.

A number of lakes, including Porcupine, lend themselves to a third objective of fisheries management. A multiple species creel is often very attractive. Porcupine has lent itself to this objective. Brown trout were present in the East Fork Little Bear River drainage system prior to dam closure and have persisted. No direct population manipulation or recruitment augmentation has been employed to manage this species in Porcupine Reservoir. The cutthroat trout are endemic to the East Fork Little Bear River drainage system. Although it was present in the system, the cutthroat was stocked in 1974 and has been annually up to the present time. An average of 48,746 fry were stocked annually until 1975, when the average stocking was reduced 70% to 15,000 fry and has continued at this level until the present.

In May, 1963, 48,384 kokanee fry at 5004/kg were stocked in Porcupine. In May, 1967 another stocking of 213,910 fingerlings at 419/kg was made due to the limited success of the first introduction. A small spawning run was recorded during the last week of September, 1966 with only 20 to 30 fish seen. Since the last stocking in 1967 the kokanee have established themselves and grown in numbers with large annual spawning runs up the East Fork

Little Bear River. The extent of kokanee management up to the present time involves an annual estimate of spawning redds after the majority of spawning has been completed in an effort to monitor inferred year class strengths.

Fisheries management on the reservoir also includes inferred population abundance from gill net catch data preceding the fishing season opening and an opening weekend creel census to monitor actual fishing success.

Management Practice Results

In the last six years management results have been mixed. The fish/hour objective has been met infrequently (Table 1). The rainbow trout, the most intensely managed species in Porcupine Reservoir, have not returned to the creel with the success expected. Of the four salmonid species represented in the creel rainbow trout numbers have fluctuated most radically. In 1976, 77, 78 and 81, rainbow trout represented 97%, 78%, 56%, and 98% respectively, of the creel for the opening weekends and for 1979 and 1980 for the month of June, 70% and 7%, respectively. The lack of complete, year long data for determining success of management objectives for the years 1976, 77, 78 and 81 could be misleading. However, during a 1979 and 1980 research project an intensive creel census was conducted on Porcupine Reservoir. Results of that study indicate that catch rates vary significantly during the summer and fall

Table 1. Opening weekend and June average catch rates, average fish size and species composition of the creel for rainbow trout and kokanee for the past six years (1976-1981), Porcupine Reservoir, Utah.

YEAR	Opening weekend catch rates (fish/hour)		June ave. catch rates	Ave. fish size (mm)		Species composition % (no. harvested)	
	Sat.	Sun.		RBT	KOK	RBT	KOK
1981	1.03	0.60	----	258	310	98 (6263)	1 (15)
1980	----	----	0.51	---	---	7 *(493)	88 *(6307)
1979	----	----	0.33	250	310	70 *(1673)	26 *(343)
**1978	0.44	0.35	----	236	259	56 (1075)	36 (650)
1977	0.71	0.34	----	---	---	78 (2278)	17 (496)
1976	0.77	0.39	----	258	315	97 (6631)	2 (137)

* total harvest for the month of June

** catchables planted due to drought during the summer of 1976 months (Hudy 1980). Although success for other months may meet management objectives, the month of June was the most critical having 49.2% of the fishing pressure and 36.5% of the total harvest for the entire year (June - November).

Hudy (1980) also revealed that in 1979, angler satisfaction was poor. Only 31.4% of the anglers were satisfied with the number of fish caught, and 26.4% with the size of fish caught. In 1980 anglers were more satisfied with the fishery. Angler satisfaction increased to 58.9% with the numbers caught and 50.0% with the size of fish caught. Significant in the 1980 season was the change in species composition when kokanee comprised 88.0% of the creel while rainbow trout made up only 6.9%. The cause of this dramatic and unexpected change in species composition is unclear.

There are several possible reasons for the fluctuating success of the rainbow trout returning to the creel. Inter- and intraspecific competition, predation, and unsuitability of rainbow trout, for any number of reasons, to the present reservoir system, are all possible reasons. Changes in species composition in the creel and in satisfaction with the fishery suggest that a modification of the management plan is needed.

The cutthroat trout and brown trout have added occasional variety to the Porcupine Reservoir anglers' creel. Both species contribute to the uniqueness of the fishery by their mere existence, and also as a trophy fish. Brown trout greater than 0.91 kg are common and fish up to 6.35kg are known to exist.

Management Alternatives

The limited success of present management techniques in meeting the management objectives suggests that an examination of management alternatives be made. Several management alternatives are at the disposal of the fishery manager. Many of the alternatives are geared toward the objectives of fisheries quality and/or variety, with the quantity objective the most difficult to meet. A policy change may have to be considered as a result of a choice of any of three management alternatives. These include: 1) a quality or trophy fishery, 2) an alternative species fishery where the means to obtain management objectives are met with species other than the rainbow trout and 3) a multiple species fishery with different species contributing in various ways to each of the objectives.

The establishment of a trophy fishery would probably be centered around two species that are already present in Porcupine Reservoir, the brown trout and the cutthroat trout. Problems facing a trophy fishery are significantly lower catch rates and the neccessary forage base to support and grow such fish.

Cutthroat trout or kokanee are the most likely alternative species choices. Both have been used elsewhere as the primary fishery, eg., the cuttroat in Bear Lake, Utah and the kokanee in Odell Lake, Oregon and Couer d' Alene Lake, Idaho.

A multiple species fishery would include the combination and specific management of from any two to all four of the salmonids that are currently present in the reservoir. Successful implementation of any of these combinations should be preceded by an investigation into intra- and interspecific competition. The documentation and demonstration of such competitive interactions is very difficult, as pointed out by Sale (1979) and Larkin (1956). Using habitat utilization of each species as an indication and confirmation of competition can be a very dangerous practice (Andrusak and Northcote 1971). Studies of habitat partitioning do not lend themselves to determining and examining the extent of competition (Sale 1979).

The state of Utah along with the other Intermountain states is experiencing rapid and massive population growth. The consequent rising demand for hydropower, irrigation and culinary water is stressing existing systems creating a demand for the construction of additional dams to impound small, coldwater reservoirs. Among the uses to which these reservoirs are put is an increasing fishing pressure. The increased number of anglers demands that fishery managers develop management plans that maximize the sustainable yield of a given body of water while contending with constant or shrinking budgets. The development and specific management of self perpetuating populations of kokanee as seperate entities or as a part of a multiple species management plan could have significant impacts in helping to ease the burden, monetarily as well as logistically, of providing a quality and quantity fishery in the future.

Kokanee Potential

The kokanee appears to have great potential in an alternative management plan when one examines the performance of the species in several western U.S. waters.

The kokanee (Onchorhynchus nerka) originated in the Pacific coast drainage lakes from sockeye salmon that failed to continue their life cycle of entering the ocean but instead remained and completed the cycle in freshwater lakes (Ricker 1959). The kokanee has been introduced in many western states and some eastern states as well as in Europe since 1941 (Seeley and McCammon 1963).

Successful introductions of kokanee are wide spread and well documented. In Colorado the kokanee has become well established as an important game fish adding significantly to the anglers' creel in high alpine lakes near timberline, in high elevation reservoirs with fluctuating water levels and even in small eutrophic lakes (Klein 1979). The introduction of kokanee in Priest Lake, Idaho brought on dramatic growth increases of lake trout (Salvelinus namaycush). A trophy fishery developed for both the lake trout and dolly varden

(Salvelinus malma) as a result of the kokanee forage base. In addition to creating a trophy fishery the kokanee flourished in Priest Lake, contributing 95% of the game fish harvest in the mid 1950's (Rieman et al. 1979). In Cour d'Alene Lake, Idaho 247,939 angler hours were expended to harvest 465,034 kokanee for an average catch rate of 1.89 fish/hour for 1981 (Rieman and Ward 1981). In Flathead Lake, Montana the kokanee has become one of the most important game fish. Both a trolling fishery in the lake and a popular snagging fishery in the Flathead River are supported by large kokanee populations (Graham et al. 1980). Hanzel (1977) reported that kokanee made up 80% of the game fish harvest in the main stem of the Flathead River between May and October of 1975. Liberal daily catch rates are also associated with kokanee fisheries. Daily limits in Idaho range from 25 to 50 fish/day.

A very important aspect of the kokanee in all of the above mentioned cases is self perpetuation. Literally thousands of dollars are saved with the elimination of the use of hatchery reared fish. In each case the single mode of recruitment is natural reproduction. The impacts of such a program are substantial during the present day situation of rising costs and shrinking budgets. In Preist Lake, Idaho in 1981 465,034 kokanee were harvested. If these kokanee were replaced by hatchery reared five inch rainbow trout, with a 50% survival rate to catchable size at a cost of $0.064 a fish (Kamas hatchery, Personal communication, Dexter Pitman, DWR

Regional Fisheries Manager, 1982), it would cost the state 930,068 fish at a total cost of $59,524.

Objectives: To assess the value and place of the kokanee in these small, coldwater reservoirs, the established population of kokanee in Porcupine Reservoir was studied to help gain insight into the type of management plan the kokanee would most effectively fit, and the cause of generally low catch rates of Porcupine kokanee. Specifically I propose to:

1. determine kokanee spawning success, indicating extent of annual recruitment to the reservoir.
2. determine rates of growth, giving insight into when and for how long the kokanee is vulnerable to the reservoir angler.
3. determine survival rates, indicating population stability and extent if any, of a maximum sustainable yield.
4. to make management recommendations optimizing quality and quantity objectives.

METHODS AND MATERIALS

Evaluation of Spawning Success

Enumeration of kokanee escapement

The monitoring and enumeration of spawning salmon escapement was accomplished through the use of a fish trap constructed and operated for the duration of the 1981 and 1982 spawning runs. The trap was of a V-entrance construction utilizing 1/2 inch stainless steel pipe set vertically through two parallel 2x4's. Holes were drilled in the 2x4's in a manner such that the spacing between pipes was approximately 12mm, which was sufficiently small to hold precocial salmon that ranged as small as 230mm. Steel fence posts, 1.5m long were driven into the stream bed and the 2x4's were then secured to the posts with wire. The pipes were then placed into the holes in the 2x4's and driven approximately six inches into the stream bed. Large rocks had to be placed on the downstream side of the upstream barrier to prevent the salmon from digging under the pipe and escaping the trap. Distance between the upstream barrier and downstream V entrance was approximately 3m for both years of operation and proved to be sufficient for holding as many as 700, 15 inch fish.

The trap was installed on August 26, 1981 and again on August 15, 1982. Upon installation the trap was checked daily for the arrival of the first spawning salmon. Upon arrival, the trap was checked a minimum of twice a day. In order to control the incidence of fish molestation and predation by humans it was desirable to keep someone on hand constantly on the weekends and as often as possible during the week.

Subsequent to the arrival of spawning salmon, various matters of direct observation were recorded. In 1981 and 1982 the trap was serviced twice daily during the spawning runs. Each trapped fish was sexed, aged, counted and released upstream. Determination of sex and age was made by visual observation. Morphological differences between the male and female kokanee were used to ascertain sex.

Age determinations were made in 1981 with length-frequency histograms and in 1982 with calculated age/length distributions of Porcupine Reservoir kokanee which exhibit virtually no overlap between age and length. (Salmon 22 months old ranged from 230mm to 309mm while 34 month old salmon ranged 346mm to 408mm). During the course of the spawning run a minimum sample of 20 fish of each sex and age class was measured for total lengths and weighed to the nearest 5 grams. The fish trap was operated until less than 1% of the total cumulative % of spawners were caught/day for five consecutive days.

Estimation of potential egg deposition

Fecundity rates were determined for each spawning age class. A minimum sample of 20 females containing green eggs was collected from the trap. The fish were weighed and total lengths measured. An incision was then made beginning at the vent and terminating at the isthmus, anterior to the pectoral fins, allowing the removal of the two laterally paired ovaries without damage to any of the eggs. The eggs were teased from the ovary and counted.

As the majority of fish completed their spawning activity and began to die, a minimum sample of 20 moribund fish was collected for egg retention estimates. The entire length of the stream utilized by spawning fish was walked. When a moribund fish was encountered it was measured for standard length, and an incision was made from the vent to the isthmus exposing any eggs which the fish had failed to expel during the spawning act. All eggs found were counted. The potential egg deposition was determined by multiplying the number of females trapped by the estimate of fecundity, and then subtracting the estimated percent egg retention.

Estimates of fry recruitment

In 1981 an attempt was made to estimate the number of fry that survived the instream stage of their life cycle to enter the lake dwelling stage. Upon the completion of the 1981 spawning run, eggs were excavated from the stream on a biweekly schedule in order to monitor the development of the recently deposited eggs. A weir trap was constructed and installed in the stream below any known redds. The weir trap consisted of a small, 1m high dam with a rectangular weir overflow. A known volume of water was diverted from the weir into a large live cage lined with 1.6mm mesh screen. The trap was checked for fry and cleaned daily. The weir trap was effective for approximately 51 days, until temperatures in excess of 5^{o}C caused ice to dam the weir and wash out the dam. A drift net was then constructed and used for fry recruitment estimation. A straight, steep gradient run of the stream with a monotypic, gravel bottom was selected for the placement of the net. Water flow measurements (cubic meters per second) for the entire stream flow were recorded hourly by a U.S. Geological Survey gauging station and measurements of water flow through the drift net were made weekly with a Pygmy water velocity meter. The drift net worked effectively for three months, to April 12, 1982, when the arrival of spring runoff washed the net out.

Estimates of fry recruitment for the time period prior to spring runoff was equal to the sum of daily recruitment estimates. Daily recruitment estimates were determined by multiplying the number of fry trapped by the ratio of the total volume of stream/volume of stream trapped.

Estimates of % egg fertilization and survival

The fry traps in 1981 were successful only up to the arrival of spring runoff. It appeared, as a result of data analysis, that the daily fry emergence trend just prior to spring runoff was still on the rise. It was obvious that the fry recruitment estimates had little or no value as a total fry recruitment estimate. The decision was then made to estimate fry numbers in the stream before emergence and recruitment took place.

Following the end of the 1982 spawning run, eggs were monitored on a biweekly basis to trace their development. Sampling was initiated when egg development had reached the advanced eyed stage. This stage of development was chosen for several reasons: 1) the eyed stage of development is the most robust stage and the only stage which could survive the excavation proccess, 2) fry could conceivably avoid the egg excavation equiptment and 3) viable eggs and dead eggs appear identical until the viable eggs reach the eyed stage.

Actual sampling of eyed eggs was accomplished with an hydrolic egg sampling device fashioned after a design developed and described by McNeil (1964) and Magee and Heiser (1971).

The entire section of stream utilized by the spawning kokanee was divided into four sections. Morphology of the sections alternated from low gradient with a large amount of available spawning substrate to steep, high gradient canyon stretches dominated by boulders and large rubble with little available spawning substrate present. Sections 1,2 and 4 were of the low gradient type and morphologically similar. Section 3 was a canyon stretch.

Several samples were taken randomly from each of the four sections. A $30.48cm^2$ Surber sampler was used to encompass the area to be sampled and a small seine was used as a back up to catch any eggs that were missed by the Surber net due to the presence of eddies, deep water, slow currents, etc..

In order to determine the efficiency of spawners and habitat to produce sac fry and cosequently give insight into fry recruitment numbers, the following estimates were made from the egg sampling data:

1. estimate of total egg deposition= sum of (mean no. eggs per $30.48cm^2$)x (surface area per section)
2. estimate of total number of eyed eggs in stream= sum of all section estimates
3. % survival to eyed stage= two methods
   a) total no. eyed eggs excavated/no. eggs excavated
   b) no. eyed eggs excavated/potential egg deposition(from escapement data)

Kokanee Age and Growth

In the spring and fall of 1982 a minimum sample of 20 fish of each age class was collected with experimental gill nets and midwater trawl to determine age and growth rates. Total lengths and weights of each fish were recorded. Five to ten scales were removed from the area between the lateral line and the anterior base of the dorsal fin and positioned on adhesive scale paper. Scale impressions were made on cellulose acetate with a heated press. A scale projector was used to read the scales for age determinations and measure annuli. A computer program "SHADII", developed by Nelson (1976) from an earlier program developed by Mayhew (1973), was utilized for analysis of age and growth data. "SHADII" contains routines for length grouping and condition factor calculation, length weight regression, body scale regression and back calculation of length. It also gives a choice of three regression models: 1) log-log, 2) linear and 3) quadratic all of which were used. Back-calculated total lengths of Porcupine Reservoir were compared with several other western U.S. waters from which back-calculated total length data have been compiled by Carlander (1969).

Survival Rate Estimations

Survival rate estimations were obtained by way of annual redd counts carried out by the Utah State Division of Wildlife Resources (UDWR) since 1970. Immediately following the completion of the spawning run of a given year, personnel from the UDWR walked the entire length of the East Fork Little Bear River utilized by spawning kokanee. All redds as well as all live and dead fish encountered were counted. In order to determine the accuracy and meaning of the annual redd counts, 1981 values for both redd counts and actual spawning escapement were compared. Data from the redd counts were used to construct a reproduction curve and to make estimations of optimum yield.

The reproduction or equilibrium curve was developed by W.E. Ricker (1958) and is used to graphically display changing cohort survival rates as population densities change. Dependent and independent variables include the total number of progeny redds and the total number of redds, respectively. Also plotted on the graph is a 45^{o}, equilibrium line. The location of data points in relation to this equilibrium line indicate various population characteristics. Data points above the equilibrium line indicate a population increasing in numbers. Points below the line indicate a declining population size and points on the line indicate a population in equilibrium. A given population has the potential to increase its size above the equilibrium line but cannot continue to do so indefinitely. When the population becomes too large for its environment, density dependent, feed-back mechanisms will decrease the populations reproduction rate below the equilibrium line in order to compensate for its excessive size. This set of data points, when connected by a line produces the reproduction curve for that give population, expressing all of the above concepts. The peak of the curve is the population's optimum reproduction rate, and the point of the curve that is the greatest vertical distance above the equilibrium line is the population size giving an optimum sustainable yield. The Ricker curve is a reflection of progeny survival rates (number of progeny surviving to spawning age/spawner). The Ricker curve assumes that population growth is logistic in nature.

RESULTS

Evaluation of Spawning Success

Enumeration of kokanee escapement

In 1981, 5,463 kokanee were trapped and released. In 1982, 7,113 kokanee were trapped and released. The age-frequency distribution of spawning fish was similar for both years, 44% of all the fish were 2+ (34 months) females and 30%-36% were 2+ males. A similarly consistant pattern existed for the 1+ (22 months) fish. Females represented 1% of the total escapement numbers for both years and males 19%-25% (Table 2).

The daily pattern of spawner escapement was similar for both years. Daily escapement totals began and remained quite high (150-450 fish) until a large peak was reached. After peaking, daily totals dropped quickly.

In 1981, two major peaks were recorded on the 9th and 12th days of the run, with 588 and 653 fish, respectively, each day (Figure 1). In 1982, three peaks on the 6th, 12th and 16th days were recorded with 550, 1,487 and 667 fish, respectively, trapped each day (Figure 2). Overall age and sex composition of the 1982 spawning run changed as the run progressed. One year old, precocial males dominated the first 11 days with their numbers representing 52% of the total count for these days. After 11 days 1+ male numbers dropped dramatically and 2+ females and 2+ males dominated

Table 2. 1981 and 1982 spawning kokanee age and sex escapement totals, Porcupine Reservoir, Utah.

Item	1981			1982		
	AGE		Total	AGE		Total
	1+	2+		1+	2+	
No. female spawners	49	2396	2445	110	3133	3243
No. male spawners	1027	1991	3018	1759	2111	3870
Total no. spawners	1049	4279	5463	1869	5244	7113
% females	1	44	45	1	44	45
% males	19	36	55	25	30	55
male:female ratio	21:1	1:1.2	1.2:1	16:1	1:1.5	1.2:1

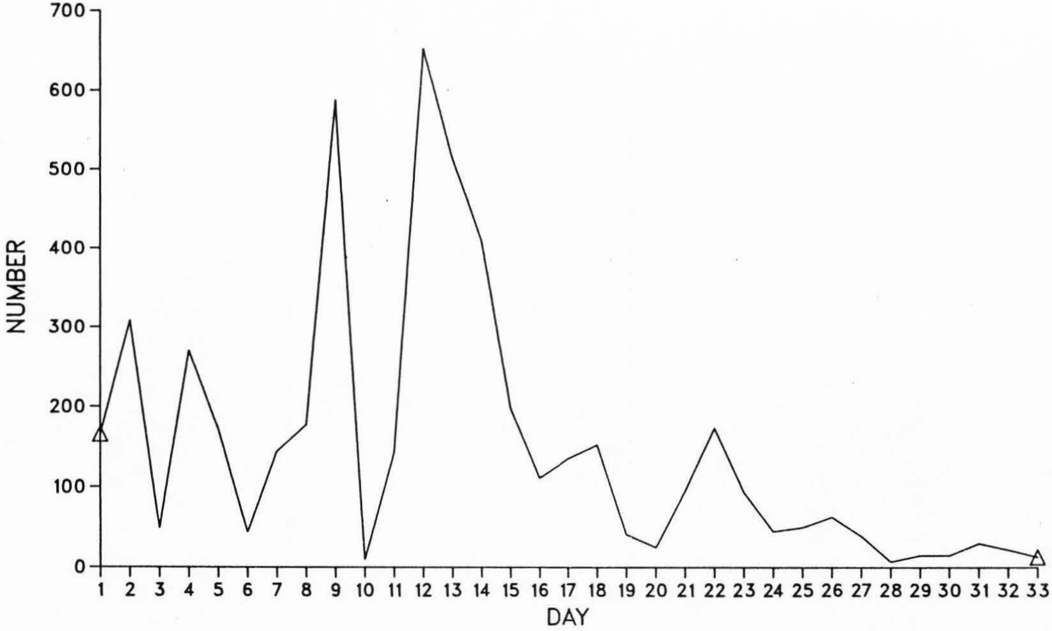

Figure 1. 1981 daily escapement pattern of spawning kokanee, Porcupine Reservoir, Utah.

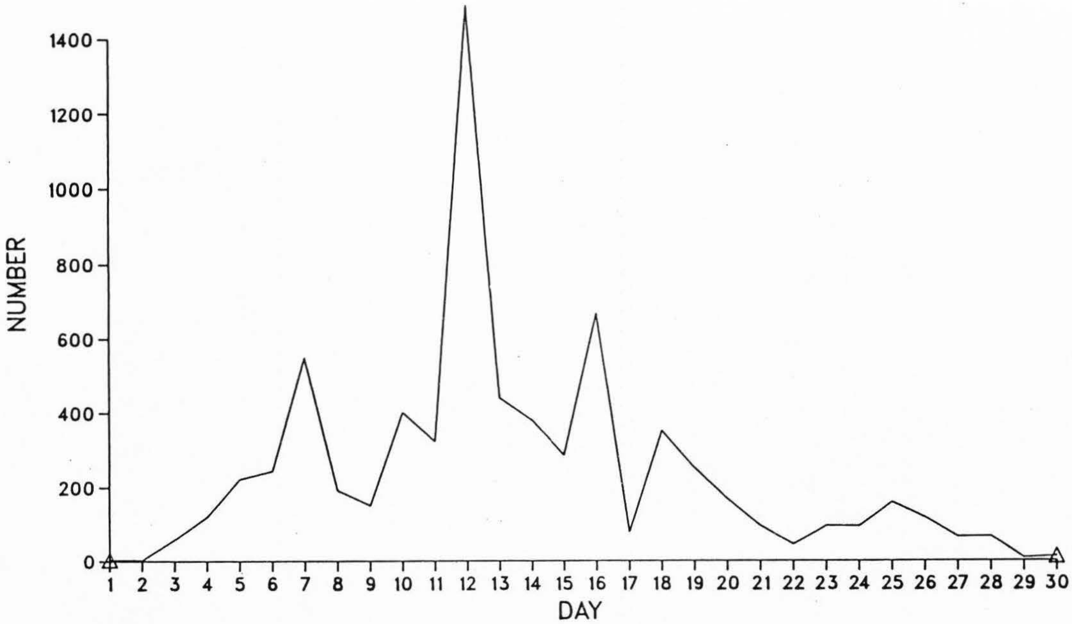

Figure 2. 1982 daily escapement pattern of spawning kokanee, Porcupine Reservoir, Utah.

the daily totals comprising 51% and 35%, respectively, of the total count for the remaining 19 days of the run. Precocial females (1+) were not significant, with never more than 20 trapped in a given day (Figure 3).

Cum ulative escapement was also similar for both years. In 1981 the trap was operated for 35 days, by the 14th day, 76% of the total escapement was in the river (Figure 4). In 1982 the trap was operated for 30 days, with 66% of the fish in the river by the 14th day (Figure 5). In 1981 and 1982 it took 16 and 18 days, respectively, for 80% of the fish to enter the river and 21 days, both years, for 90% of the fish to enter the river. The second and third weeks of the run were the strongest for the 2+ females. During this time 76.9% of all the females entered the stream (Figures 4 and 5).

Total lengths of spawning fish varied significantly between the two years (Table 3). In 1981 2+ fish averaged 370.5mm, with males averaging 7mm longer than females, and 1+ fish averaged 283mm with the males averaging 4mm longer than females. In 1982, both males and females of both age classes were significantly smaller than the 1981 spawning fish (t test, $P<.05$). Two year old fish averaged 355.5mm, with the males averaging 15mm longer than females. One year olds averaged 253.5mm, with the males 13mm longer than females. Weight differences between 1981 and 1982 fish were also significant (Table 4). For each age class and sex, the 1981 fish were significantly smaller.

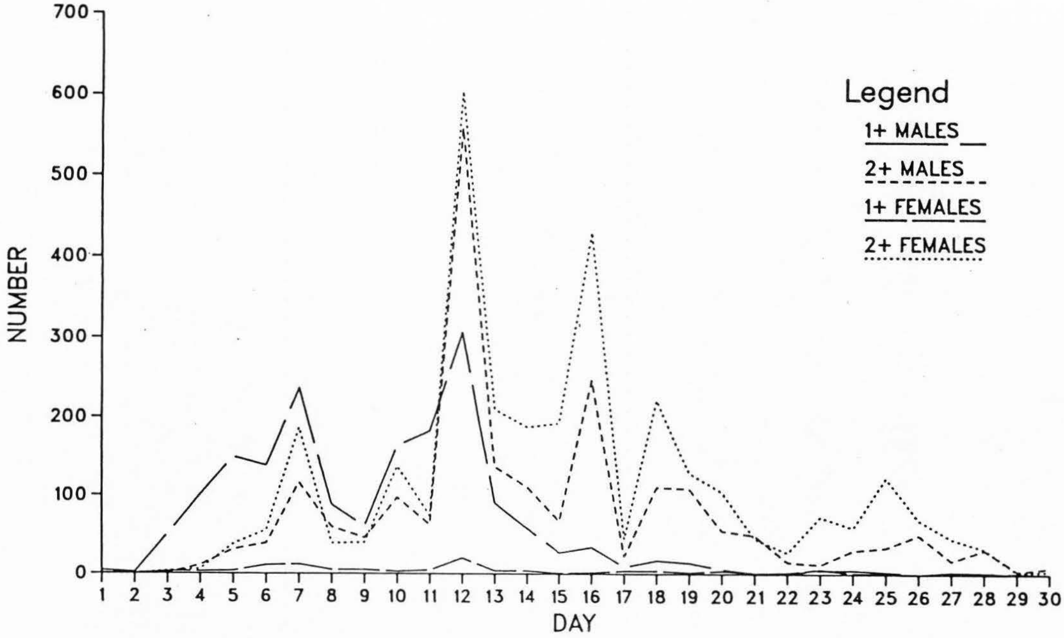

Figure 3. 1981 daily escapement pattern of each sex and age class of spawning kokanee, Porcupine Reservoir, Utah.

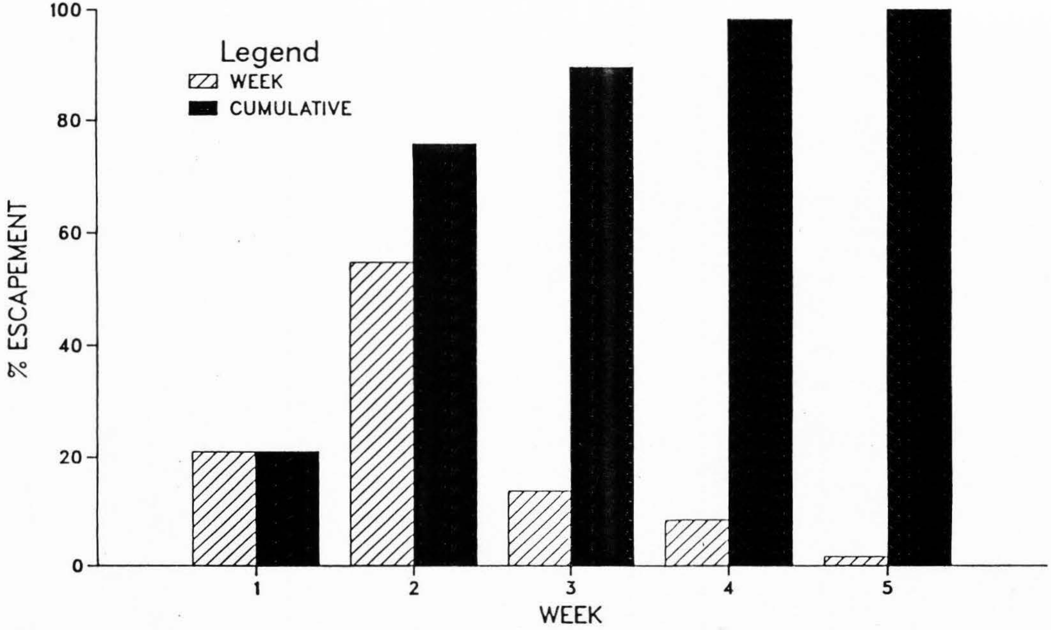

Figure 4. 1981 cumulative and weekly escapement of spawning kokanee, Porcupine Reservoir, Utah.

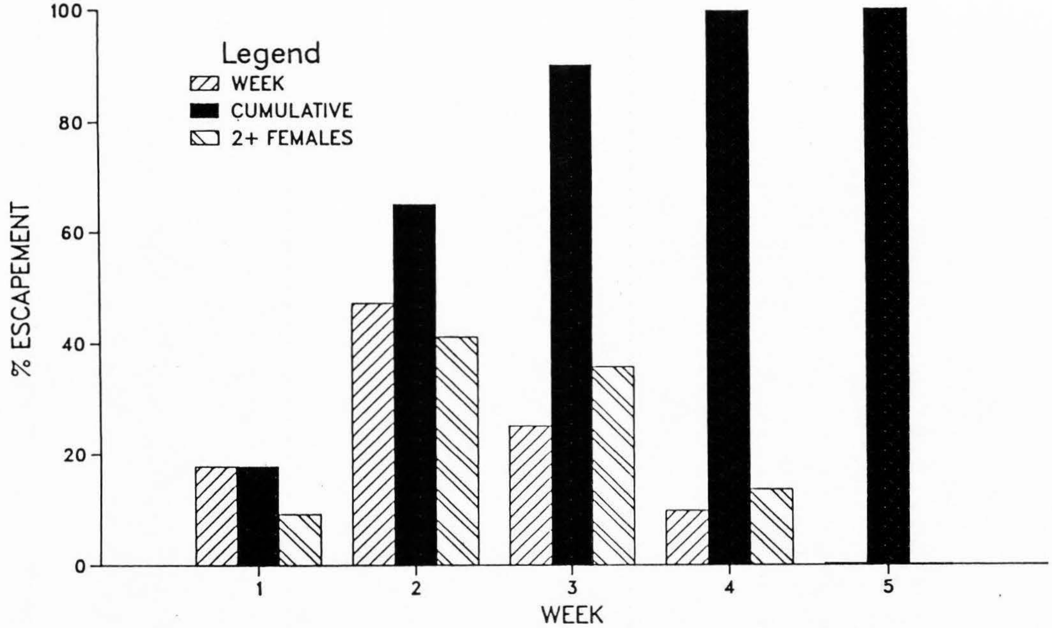

Figure 5. 1982 cumulative, weekly and 2+ (age) female weekly escapement of spawning kokanee, Porcupine Reservoir, Utah.

Table 3. Total lengths (mm) of 1981 and 1982 spawning kokanee in Porcupine Reservoir with 95% confidence intervals.

Spawning Year	Females		Males	
	age(months)		age(months)	
	22	34	22	34
1981	281 ± 13	367 ± 2	285 ± 9	374 ± 1
1982	247 ± 27	348 ± 7	260 ± 5	363 ± 4

Table 4. Weights (g) of 1981 and 1982 spawning kokanee in Porcupine Reservoir with 95% confidence intervals.

Spawning Year	Females		Males	
	age(months)		age(months)	
	22	34	22	34
1981	235 ± 38	442 ± 8	257 ± 12	493 ± 5
1982	171 ± 55	397 ± 13	185 ± 6	453 ± 11

Estimations of potential egg deposition

In 1981, 2+ females averaged 934 eggs/fish, with 58 or 6.2% of the eggs retained after spawning was complete (Table 5). One year old females averaged 556 eggs/fish, accounting for only 1.1% of the total estimate of eggs carried upstream. Egg retention was not calculated for 1+ females in 1981 or 1982 because of the difficulty encountered in finding these fish after they had completed spawning.

In 1982 2+ females averaged 740 eggs/fish, which was significantly fewer than in 1981 (t test, $P<.05$). Average retention was 7 eggs or 0.95% and was also significantly fewer than in 1981 (t test, $P<.05$)(Table 6). Twenty-two-month-old females averaged 528 eggs/fish, accounting for 2.5% of the total estimate of eggs carried upstream. Due to the small sample size of 1+ female egg counts, no significant difference could be shown (t test, $P<.05$).

In 1981, an estimated 1,964,404 eggs were carried upstream and 1,834,955 eggs were estimated actually deposited in redds. In 1982, an estimated 2,416,179 eggs were carried upstream, with an estimated 2,393,757 eggs deposited in redds, an increase of 30.5% over 1981.

Estimates of fry recruitment

While the weir fry trap was in operation (November 15, 1981-January 9, 1982), the fry recruitment estimate was 1,236 fish. The first fry was trapped December 1, 1981. The fry trapped during the

Table 5. Estimates with 95% confidence intervals of fecundity, egg retention and total number of eggs deposited in the East Fork Little Bear River by spawning kokanee in 1981, Porcupine Reservoir, Utah.

ITEM	AGE		TOTAL
	1+	2+	
No. female spawners**	39	2080	2119
Ave no. eggs/female	556 ± 111	934 ± 39	----
Total no. eggs carried upstream	21,684 ± 4,329	1,942,720 ± 81,120	1,964,404 ± 85,449
No. eggs retained/ female	---	58 ± 40	----
% eggs retained	---	6.2 ± 4.3	----
No. eggs deposited	21,684 ± 4,329	1,822,271 ± 161,092	1,843,955 ± 165,421

** does not include fish taken for fecundity estimates.

Table 6. Estimates with 95% confidence intervals of fecundity, egg retention and total number of eggs deposited in the East Fork Little Bear River by spawning kokanee in 1982, Porcupine Reservoir, Utah.

ITEM	AGE		TOTAL
	1+	2+	
No. female spawners**	106	3113	3219
Ave. no. eggs/female	528 ± 112	740.2 ± 48.8	----
Total no. eggs carried upstream	55,968 ± 11,872	2,360,211 ± 95,946	2,416,179 ± 107,818
No. eggs retained/ female	---	7 ± 3	----
% eggs retained	---	0.95 ± 0.40	----
No. eggs deposited	55,968 ± 11,872	2,337,789 ± 105,105	2,393,757 ± 116,977

** does not include fish taken for fecundity estimates.

first 20 days were sac fry and were probably caught as a result of brown trout spawning and inadvertently excavating these fry. After approximately 20 days the yolk sac had been absorbed and the fry had reached the swim-up stage of development. The fry recruitment estimate during the time when a drift net was utilized (January 10, 1982 - April 11, 1982) was 55,764 fish.

The daily recruitment of fry increased throughout the period of trapping, with a sharp increase noted 90 days after hatching (Figure 6). Just prior to the arrival of spring runoff and the termination of fry recruitment estimates, daily fry estimates were still increasing. The day before the spring runoff arrived (April 11, 1982) 4,054 fry were estimated to have entered the lake, the highest daily figure. Thus it is probable that the majority of fry entered the lake during the spring runoff. Between December 1, 1981 and April 12, 1982 an estimated 57,000 fry entered the lake.

Estimates of % egg fertilization and survival

By November 3, 1982, eggs had reached the advanced eyed stage required for sampling. Sampling took five working days and was completed November 21, 1982. Sections #1 and #2 were found to be the most important in respect to the average number of eggs/m^2, with 249.7 and 215.3 eggs, respectively, and to the total number of eggs deposited with 1,393,326 and 837,948 eggs, respectively (Table 7). Section #4 had the largest percentage of eyed eggs with 96.7%. No eggs were found in the canyon section #3, where the bottom substrate

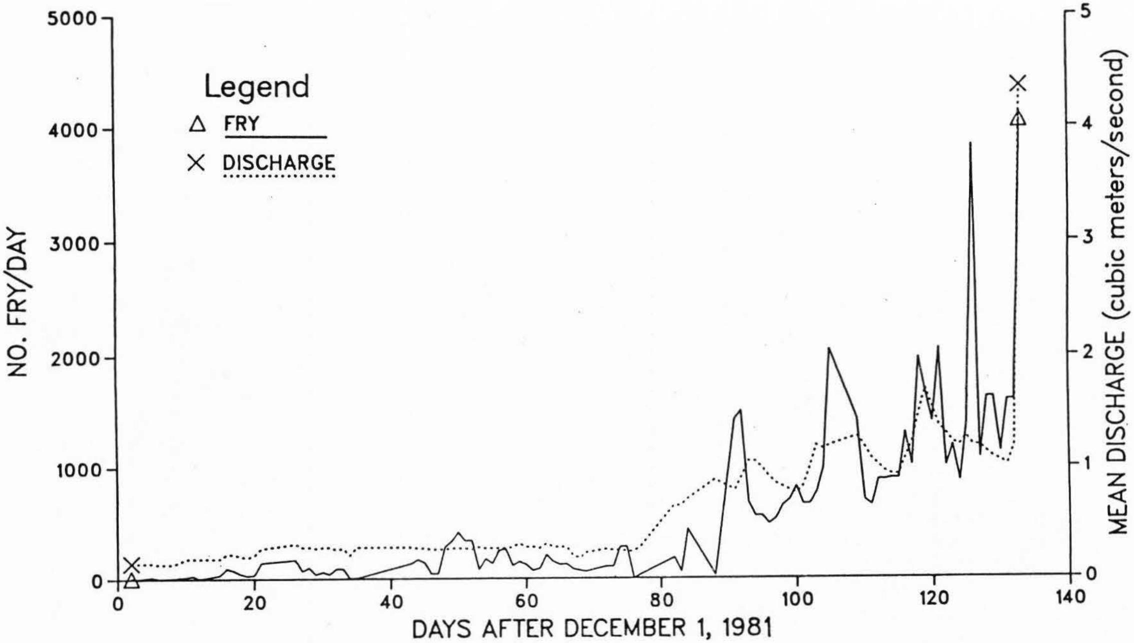

Figure 6. 1981 daily estimates of kokanee fry recruitment to Porcupine Reservoir, Utah and daily discharge measurements of the East Fork Little Bear River, recorded by the U.S. Geological Survey gauging station.

Table 7. 1982 estimates and 95% confidence intervals of % egg fertilization and survival to the advanced eyed stage of development of eggs deposited in the East Fork Little Bear River by spawning kokanee, Porcupine Reservoir, Utah.

ITEM	SECTION				TOTAL
	1	2	3	4	
AREA (m^2)	5,580	3,892	1,017	2,806	13,295
Ave. no. eggs/m^2	249.7 $\pm$ 180.5	215.3 $\pm$ 238.1	0.00	12.2 $\pm$ 26.0	171.1 $\pm$ 150.9
Ave. no. eyed eggs/m^2	178.7 $\pm$ 143.6	109.8 $\pm$ 122.5	0.00	11.8 $\pm$ 24.4	109.8 $\pm$ 101.3
% eyed	71.6	51.0	0.00	96.7	64.2
Total no. eggs	1,393,326 $\pm$ 1,007,190	837,948 $\pm$ 926,685	0.00	34,233 $\pm$ 72,956	2,265,507 $\pm$ 2,006,831
Total no. eyed eggs	997,146 $\pm$ 801,288	427,342 $\pm$ 476,770	0.00	33,111 $\pm$ 68,466	1,457,599 $\pm$ 1,346,524
Section length (km)	0.71	0.68	0.14	0.48	2.01

was predominantly boulders.

Average egg survival in the entire stream was 64.2%. The estimated total number of eggs deposited was 2,265,507, with 1,457,599 eggs estimated surviving to the advanced eyed stage. It was also found that 1+ females were unsuccessful spawners. Egg sampling uncovered 106 1+ eggs, all of which were dead. Eggs of 1+ females were approximately 3.2mm in diameter and 2+ female eggs were approximately 4.8mm in diameter.

Confidence intervals of 95% were extremely broad, due to the sampling technique and behavior of the fish with their building of redds. A sample was either in a redd or out of it, resulting in many zeros and many numbers in the hundreds (100-350). It was felt, however, that the estimates were good due to the similarities in the two seperate estimates of egg deposition: 1) estimated number of eggs deposited, calculated from escapement, fecundity and retention rates, was 2,393,757, and 2) estimated number of eggs deposited, figured from the sampling of eggs in redds, was 2,265,507.

Kokanee Age and Growth

Kokanee in Porcupine Reservoir grow an average of 120mm annually (Figure 7). At the end of the first and second growing season the fish average 124mm and 257mm, respectively. Fish reach the management goal of 228mm (9 inches) in August of their second year of growth, or at about 20 months of age. It is apparent in Figure 7 that only one age class is vulnerable (> 228mm) to the

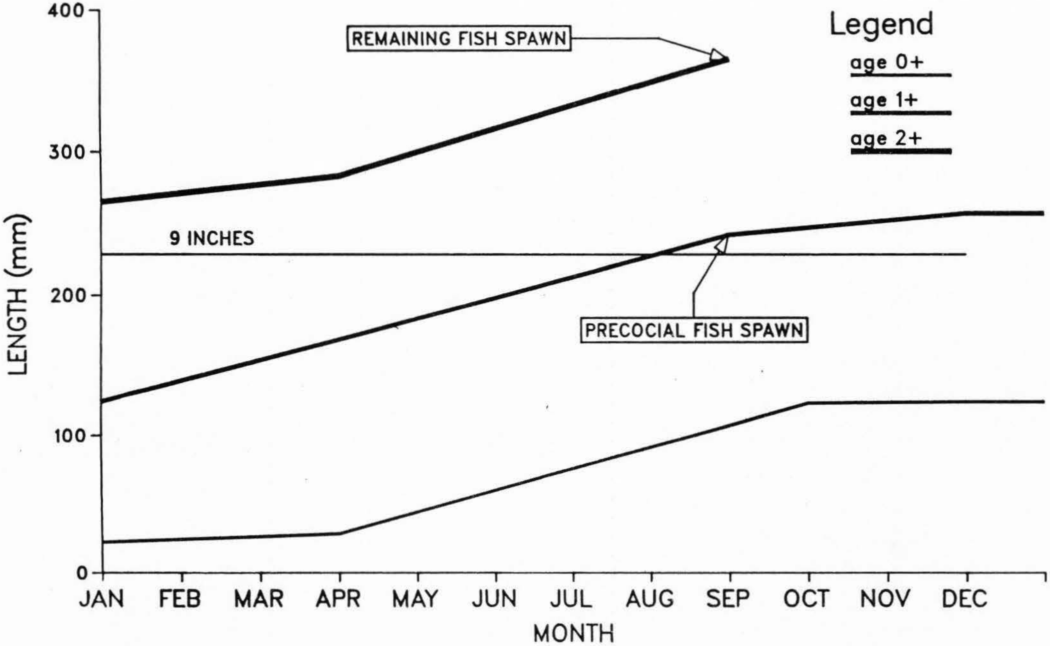

Figure 7. Growth curves for the three age classes of kokanee present in Porcupine Reservoir, Utah.

creel at any given time during the year. A few larger "residual" fish (which do not mature and spawn) are present and averaged 375mm in October 1982. Average weights for 0+, 1+ and 2+ fish in October 1982 were 13gm, 157gm and 402gm, respectively. Two year old kokanee in April 1982, averaged 182 gm, and the "residual" fish averaged 470 gm.

Back calculated total lengths of Porcupine Reservoir kokanee compare favorably to other western U.S. kokanee stocks (Figure 8). Growth characteristics are similar for all lakes represented for the first two years of growth. After two years, the growth of "residual" fish in Porcupine Reservoir exceed the growth of all the other lakes represented (Table 8).

Table 8. Back calculated total lengths with 95% confidence intervals of Porcupine Reservoir kokanee collected in 1982.

AGE	NO.	ANNULUS		
		1	2	3
1	16	124.75 ± 6.7		
2	20	118.96 ± 5.1	246.25 ± 8.9	
3[a]	2	129.49 ± 218.5	245.06 ± 27.9	361.54 ± 152.7

a) "residual" fish (fish that do not mature and spawn)

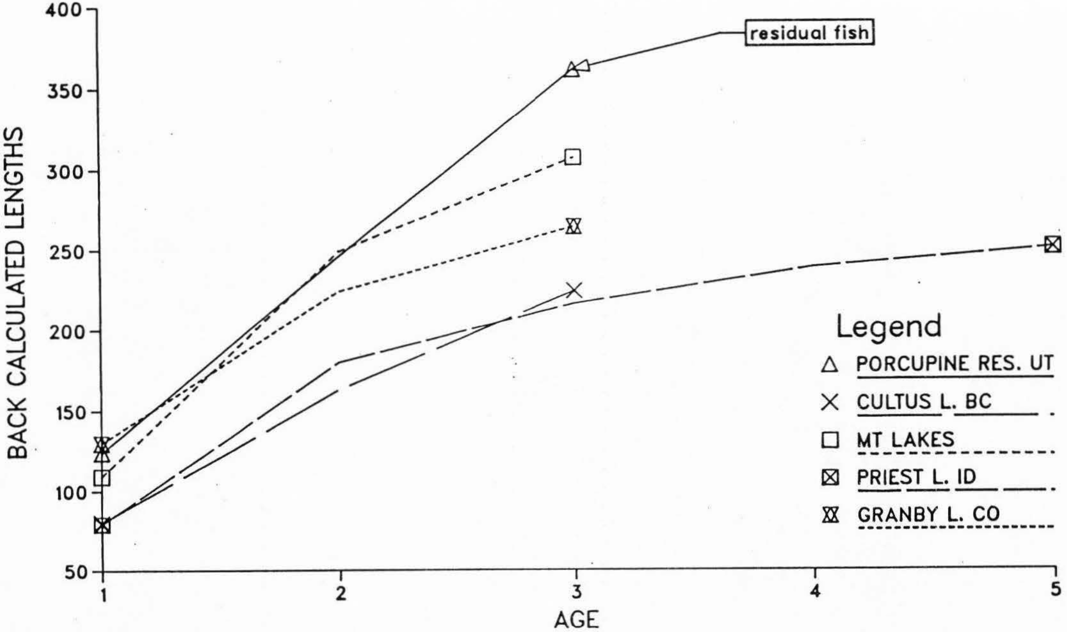

Figure 8. Back calculated total lengths of several western U.S. kokanee stocks including Porcupine Reservoir, Utah.

The log-log relationship of the "SHADII" program gave the most favorable results, with a length-weight regression r^2 value of .984 and a body-scale regression r^2 value of .974.

Survival Rate Estimations

Since 1970, kokanee redds in the East Fork Little Bear River have increased from a low of 35 redds in 1970 to a high of 3,133 redds in 1982, and are assumed to indicate a similar increase in actual numbers of kokanee in the reservoir (Figure 9). Since 1979, the number of redds has increased sharply from 1,048 to 3,133 in 1982. It was found from the analysis of escapement counts and redd counts that the number of redds counted was directly proportional to the number of 2+ females spawning or approximately 50% of the total number of fish spawning.

The Ricker (1958) reproduction curve in figure 10 illustrates the stability of the Porcupine Reservoir kokanee population. The reproduction curve leaps immediately and strongly above the equilibrium line, with a optimum sustainable yield and population size, attained rapidly. Approximately 4,000 surplus catchable progeny were produced each year after the spawning population attained a size of 2,000 fish (1,000 redds). This surplus of fish is in addition to the fish lost to the anglers creel before the spawning run. (In 1979, when the last intensive creel was conducted by Hudy (1980), 1,580 kokaneee were harvested, Table 9)

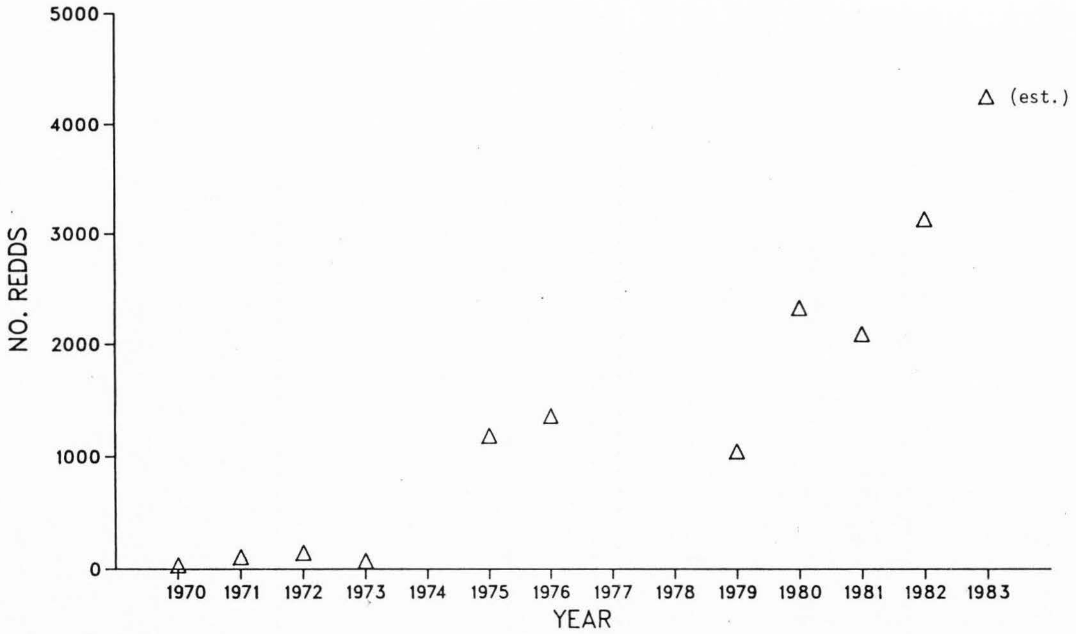

Figure 9. Annual spawning kokanee redd counts in the East Fork Little Bear River, Utah (1970-1982).

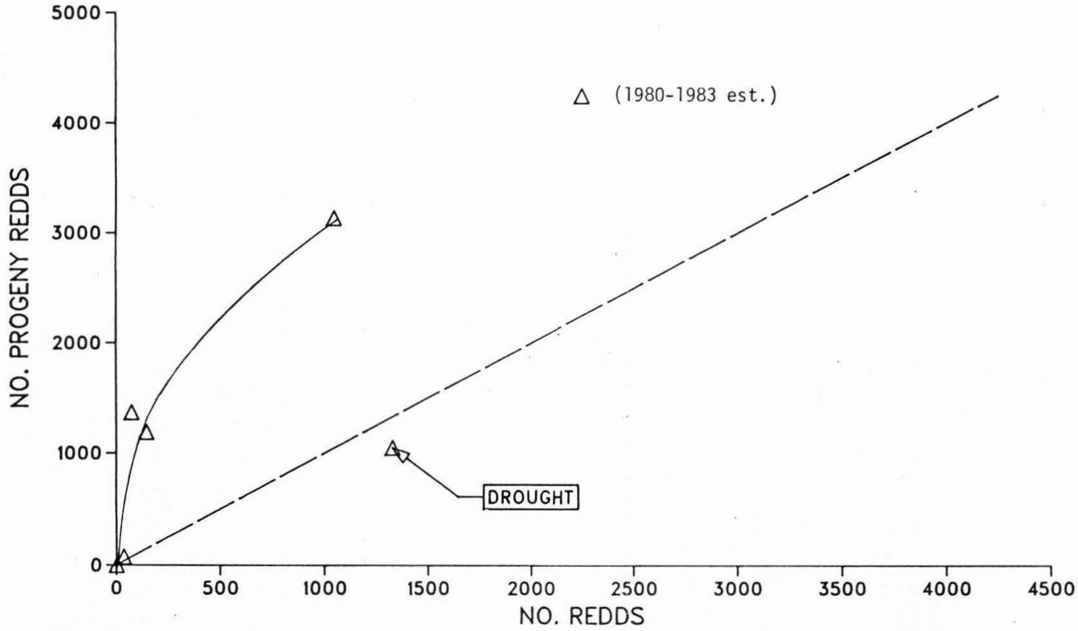

Figure 10. Ricker equilibrium curve (Ricker 1958) constructed from annual counts of spawning kokanee redds (1970-1982) Porcupine Reservoir, Utah. Time period from spawner to progeny spawner is three years.

Table 9. Expanded fishing pressure and harvest with 95% confidence intervals on Porcupine Reservoir for the 1979 fishing season (Hudy 1980).

	Method	Number of Fishermen	Hours Fished	Number of Fish Caught[1]			
				RBT	CTT	BRW	KOK
June	Boat	619 ± 60	2,211 ± 261	323 ± 72	71 ± 15	57 ± 10	318 ± 75
	Shore	1,637 ± 126	4,996 ± 352	1,350 ± 134	148 ± 36	96 ± 16	25 ± 5
July	Boat	232 ± 39	1,053 ± 230	49 ± 39	10 ± 0	10 ± 0	372 ± 143
	Shore	457 ± 40	1,444 ± 376	259 ± 118	21 ± 20	6 ± 0	10 ± 0
August	Boat	185 ± 112	606 ± 225	35 ± 66	8 ± 0	11 ± 16	470 ± 450
	Shore	338 ± 89	818 ± 260	191 ± 66	13 ± 16	8 ± 16	34 ± 18
September	Boat	140 ± 52	673 ± 243	345 ± 91	31 ± 41	3 ± 0	305 ± 183
	Shore	407 ± 155	1,219 ± 450	964 ± 552	30 ± 35	7 ± 12	17 ± 12
October	Boat	44 ± 109	147 ± 269	36 ± 51	12 ± 0	18 ± 31	0 ± 0
	Shore	282 ± 274	908 ± 873	450 ± 654	46 ± 67	32 ± 67	6 ± 5
November	Boat	65 ± 74	285 ± 450	55 ± 157	19 ± 31	11 ± 16	6 ± 15
	Shore	86 ± 64	299 ± 272	197 ± 388	2 ± 0	26 ± 47	17 ± 47
Total	Boat	1,285 ± 158	4,475 ± 711	843 ± 216	151 ± 54	110 ± 40	1,471 ± 512
	Shore	3,207 ± 358	9,684 ± 1,171	3,411 ± 959	260 ± 124	175 ± 86	109 ± 52
Grand Total		4,492 ± 391	14,659 ± 1,370	4,254 ± 983	411 ± 135	285 ± 95	1,580 ± 515

[1] RBT = rainbow trout; CTT = cutthroat trout; BRW = brown trout; KOK = kokanee salmon

Survival rates have steadily declined since 1972, as the number of redds have increased. For every spawner in 1972, 8.2 progeny survived to spawn in 1975. For every spawner in 1979, 3.0 progeny survived to spawn in 1982.

DISCUSSION AND CONCLUSIONS

The Porcupine Reservoir kokanee is a well established, highly stable, growing population. It is a strain of kokanee that has settled into a three year spawning cycle. This particular race of kokanee spawns early in the fall months (end of August through September) in the East Fork Little Bear River as opposed to other races of kokanee that spawn within the boundaries of a lake and/or spawns later in the fall or early winter. It is similar to, and may well have come from, a race of kokanee found in lakes of the Upper British Columbia Trench in southeastern British Columbia and described by Seeley and McCammon (1966) as a race maturing at three years of age with some precocial males maturing at two years of age.

The annual spawning run of Porcupine Reservoir kokanee appears to be very consistent from year to year. Age classes and sexes are similar proportionately, and the dates of the start of the run and the daily pattern of escapement throughout the run vary little from year to year. Competition for spawning areas is minimal and is not a factor in egg survival. Foerster (1938) and Mathisen (1955) suggested that egg retention rates of sockeye salmon were low (< 10%) unless competition for spawning substrate was excessive, which increased egg retention percentages. Egg retention rates for Porcupine Reservoir kokanee were less than 7% for both years. Presently, kokanee egg survival in the East Fork Little Bear River is excellent. Section #1 is the most valuable section in respect to the number of fry hatched/m^2 but is also the most vulnerable to perturbations. This section is affected by man and cattle activities in riparian zones, and silt loading was apparent in this section after heavy rains. It has the potential in the future to be impacted severely if human and/or cattle activities are increased greatly in this and other sections. Sections further upstream are less vulnerable but the spawning run population size is insufficient to push substantial numbers of fish up into these more stable sections.

From the time of fertilization it takes approximately three months for the Porcupine Reservoir kokanee to hatch. From time of hatching, approximately 20 days are needed for the fry to absorb the yolk sac. Approximately six months from fertilization the fry begin entering the reservoir. The arrival of spring runoff is a key time for the fry, when the majority of them enter the lake. Downstream migration during spring runoff is to the advantage of the fry and probably increases survival greatly. Spring runoff and the silt load it carries provides an effective source of cover from predators. The long residence time in the stream is also an advantage to the fry in terms of food availability. Kokanee fry in streams feed on insects (Platts 1958), a plentiful food source, but change to plankton upon entering the lake. Foerster (1968) suggested that this transition from stream insects to lake plankton was very critical to fry survival and that the absence of small food organisms in the lake could result in high mortalities. The longer into spring the fry remain in the stream the more time the lake has to warm up and receive nutrients from the spring runoff, which enables plankton to bloom and provide an adequate food source for the fry. In Flathead Lake, Montana, Graham and Leathe (1981) found that Daphnia thorata was the dominant food item in the diet of 0+ kokanee. Cyclops was an important food item for kokanee fry in Odell Lake, Oregon through July (Lindsay and Lewis 1978).

Growth of Porcupine Reservoir kokanee is good and sufficiently meets the quality objective. A problem with the kokanee fishery, however, is the fact that 2+ kokanee are vulnerable to the angler for only two and one half months out of the six month fishing season. Although 1+ kokanee are available to anglers beginning in September when they reach 228mm in length, angling pressure is minimal after August. In 1979, only 22% of the total angler hours were exerted during the last three months of the season. Similarly, only 22% of the total number of kokanee harvested were taken in the last three months of the season. It is apparent that the kokanee in Porcupine Reservoir are not represented in the creel in proportion to their population size. Redd counts have increased steadily in the past ten years while the kokanee harvest has fluctuated randomly from year to year.

The stability of the Porcupine Reservoir kokanee is excellent. A optimum sustainable yield (osy) of approximately 4,000 fish is possible with spawning populations in excess of 2,000 redds (1000 redds or 2+ females) (precocial 1+ females were found to be unsuccessful spawners as well as insignificant in numbers). Effects of an overharvest would be minimal and recovery would be rapid. At present a large number (> 4,000) of harvestable kokanee escape capture and manage to spawn, and thus are not utilized by the angler. These excess fish may be detrimental to the kokanee population as a whole by increasing intraspecific competition. A reduction in the number of spawning kokanee might reduce the number of harvestable kokanee but at the same time result in an increase in average size by reducing intraspecific competition.

Intraspecific competition appears to be a limiting factor in Porcupine Reservoir. In June, 1980 an estimated 6,307 kokanee were harvested by anglers, which exceeds the total number of 1981 spawners and nearly equals the total number of spawners in 1982. The reason for such an exceptionally strong year class is felt to be intraspecific competition or in this case the lack thereof. In 1976, a severe water drought limited the spawning success of kokanee and the result was a weak "76" year class. This "76" year class matured and spawned in 1979 with numbers less than that which had produced it in 1976. The assumption is that the absence of large numbers of this "76" year class allowed unusually high survival of the following "77" year class. The biomass not represented by the "76" year class was compensated for by the large numbers of the "77" year class.

Intraspecific competition may also be the cause for the significant differences in lengths, weights and fecundity rates between 1981 and 1982 spawning fish. The 1982 spawning run was 30% larger in numbers than the 1981 spawning run and appropriately the 1982 fish were 2% to 12% shorter in length and 20% lower in fecundity rates than the 1981 fish. Obviously the critical time for any type of competitive interactions would be during long periods of low water levels in the reservoir. Such conditions are present in Porcupine Reservoir nearly annually from mid September, through the winter, until the arrival of spring runoff. In the winter of 1981-1982 a number in excess of 6,000 2+ kokanee at an average weight of 182gm is estimated to have overwintered in the reservoir. Thus, at conservation pool level (overwinter) there were 231 2+ kokanee/ha or 42kg 2+ kokanee/ha. While this figure is meaningless in making comparisons with other waters, it is important as a productivity index for Porcupine Reservoir, since 2+ kokanee appear to constitute the major biomass of the reservoir. In 1981 an estimated 165 2+ kokanee/ha or 39kg 2+ kokanee/ha were overwintered. Variations in biomass from year to year may fluctuate in response to annual fluctuations in water levels and weather (temperatures). Another factor to consider is the other fish in the reservoir. The 0+, 1+, and "residual" kokanee, the rainbow trout, cutthroat trout and large browns that also overwinter in the reservoir must exert some impacts on the biomass of 2+ kokanee.

With respect to rainbow trout/kokanee interaction and competition, the overwinter period is the most critical. It has been suggested in the literature that under conditions of limited food supply the kokanee will out-compete the rainbow trout for these limiting resources (Seeley and McCammon 1966). Such interactions may be responsible for the varied success of the basic yield, rainbow trout fishery, in the reservoir. Substantial increases in the kokanee harvest, in addition to being advantageous to the kokanee themselves, as mentioned previously, may also improve the success of the rainbow trout fishery.

While competition in Porcupine Reservoir has neither been substantiated nor disproved by this study, the data that have been produced certainly warrant consideration as indicators of such implied interactions. The factor limiting kokanee population size appears to be the lake environment, as oppossed to spawning habitat and success. Such factors as high egg survival, low egg retention rates and the availability of additional, presently unutilized, spawning substrate indicate that recruitment to the reservoir is excellent and provides ample potential for large population growth if the reservoir was capable of sustaining such large numbers. It is apparent that the present high quality of the stream is responsible for the exceptional spawning success of the kokanee. In order to maintain a robust kokanee population in Porcupine Reservoir, the East Fork Little Bear River must be protected against any perterbations that would decrease water quality. Significant increases in silt loading would no doubt limit the success of the kokanee if not eliminate the species completly.

RECOMMENDATIONS

1) Results from this study of kokanee in Porcupine Reservoir, suggest a minimum or optimum spawning population size of 2,000 fish (1,000 2+ females or 1,000 redds). Consequently, the harvest of kokanee should be increased substantially to meet this requirement. Several options exist which include: A) an information and education program to enlighten anglers on proper and effective techniques needed to harvest kokanee, B) increased creel limits, C) increased length of season and D) a snagging fishery during periods of spawner escapement.

2) To monitor the effects of any management plan, specific data must be collected annually. Annual escapement counts and an intensive creel census would be most effective in determining more precisely the number of spawning fish needed for anosy. However, the number of angler hours and fish harvested from Porcupine Reservoir in proportion to other major fishery waters in the region does not justify such an investment. A second and more feasable alternative is to collect data on a few key parameters. The number of fish harvested in a given year is less useful to know than the numbers of fish left unharvested and thus allowed to mature and spawn. Since kokanee have a three year cycle of spawner to progeny spawner, the goal of a management plan is to reduce the spawning population size to 1,000 redds for three consecutive years. The following 4th, 5th and 6th years will determine management success. Ideally, there

would be 2,000 fish (1,000 2+ females) surviving to spawn in these years. A count in excess of 1,000 redds would indicate that still more kokanee could be harvested and a count below 1,000 redds would indicate that the harvest was excessive and should be reduced.

To gather such data, annual redd counts are mandatory. Such counts should be done during the fourth week of spawner escapement. By then over 95% of the escapement is complete and the majority of fish have completed spawning. Counts made later would be low because redds do not remain visable for long periods of time, as algae and silt quickly cover freshly cleaned and/or excavated gravel. Fish present also help with locating redds. The count can be completed in one day.

There is a suggestion that the number of precocial (1+) fish spawning in a given year is an indicator of that years 1+ age class strength. This kind of information would be valuable in predicting potential under or overharvests the following year. Such data can be collected simultaneously with the redd counts by simply counting all 1+ fish, dead or alive, encountered. These fish are easily distinquished because of their size. Analysis of trend data of numbers of precocial spawners and the following years redd counts should show any exsisting correlation.

3) The basic yield, rainbow trout fishery, should be evaluated after the kokanee harvest has been increased to the above mentioned level.

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