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REPRODUCTIVE CHARACTERISTICS OF TWO KOKANEE STOCKS IN TRIBUTARIES TO FLAMING GORGE RESERVOIR, UTAH AND WYOMING

Bradford G. Parsons¹ and Wayne A. Hubert¹

ABSTRACT.—The characteristics of kokanee (*Oncorhynchus nerka*) spawning stocks in the Green River and Sheep Creek (tributaries to Flaming Gorge Reservoir) are described as observed in fall 1985 and spring 1986: the time of spawning; length, age, and sex structure of the stocks; fecundity and egg retention; density of eggs in redds; and the timing of downstream drift of emerging fry. The time of spawning, length-frequency distributions of spawning fish, and egg density in redds differed between the two stocks, but other differences were not observed.

The kokanee (*Oncorhynchus nerka*), the landlocked form of sockeye salmon, have been widely introduced into reservoirs of the western United States as both a sport and forage fish (Wydoski and Bennett 1981). Despite the widespread stocking of kokanee by fishery managers, there is little published information on the dynamics of spawning stocks that migrate from reservoirs or lakes into streams to spawn. Past studies include descriptions of stocks that migrate from Flathead Lake (Hanzel 1964, Fraley and McMullin 1984) and Lake Kocanusa (Huston 1984) in Montana, Porcupine Reservoir in Utah (Janssen 1983), Priest and Upper Priest lakes in Idaho (Bjorn 1961), Lake Tahoe in California (Cordone et al. 1971), and Nicola Lake in British Columbia (Lory and Northcote 1965).

From 1963 to 1983, 2.2 million kokanee were stocked in Flaming Gorge Reservoir on the Green River in Wyoming and Utah (Wengert 1985). Natural reproduction of kokanee occurred in two tributaries to the reservoir—the Green River in Wyoming and Sheep Creek in Utah. The objective of the present study, from 1 October to 19 November 1985 and from 1 March to 27 May 1986, was to describe the characteristics of the kokanee spawning stocks in these two streams including the time of spawning; length, age, and sex of the spawning fish; fecundity and egg retention; density of eggs in redds; and the time of downstream drift of emerging fry.

STUDY AREA

Flaming Gorge Reservoir is on the Green

River in Sweetwater County, southwest Wyoming, and Daggett County, northeast Utah. The dam was closed and the reservoir began filling in November 1962. At full pool the reservoir is 145 km long and has a surface area of 17,000 ha.

The Green River originates in the Wind River Mountains of Wyoming. Fontenelle Dam, 115 km upstream from Flaming Gorge Reservoir, creates a barrier to upstream fish movement, and its hypolimnetic discharge provides cold water to support a salmonid fishery downstream to Flaming Gorge Reservoir. Kokanee spawning is concentrated over the 3.5-km reach of the Green River immediately downstream from Fontenelle Dam. Over this reach the river had an average wetted width of 68 m (range 33–121 m) and a constant discharge of 24 m³/second during fall 1985.

Sheep Creek is a small, high-gradient stream that enters Flaming Gorge Reservoir from the west in Utah. Most of the discharge originates from a large spring 9.6 km upstream from the reservoir. Kokanee spawning occurs 1–7 km upstream from the creek mouth. Mean wetted width over this reach was 8.4 m (range 2.9–23.9 m) during fall 1985, and average discharge was 1.6 m³/second over the same period.

METHODS

Kokanee adults were collected from both streams to determine the timing of migration; length, age, and sex structure of the stocks; and fecundity and egg retention by females.

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In the Green River, fish were sampled from angler catches and with an electrofishing boat between 0.5 and 3.5 km downstream from Fontenelle Dam during fall 1985. A trap installed across the mouth of Sheep Creek in September prevented fish from passing upstream without being caught. The trap was checked at about 1000 and 1800 hrs each day.

Total lengths were measured to the nearest millimeter. Otoliths were removed by the method of Schneidervin and Hubert (1986), and age was determined by three independent readers using a dissecting scope. Estimated age was the modal value or the median value of the three readings (Hubert et al. 1987). The fish were sexed by morphological differences. Ovaries were removed and placed in Gilson's fluid to break down ovarian tissue and harden the eggs for counting (Snyder 1983). Dead females were collected, and all eggs remaining in the body cavity were removed and counted to determine egg retention.

We used a modified Hess sampler to excavate redds and estimate egg deposition (Usinger 1956). The sampler was placed over a portion of the redd, and rocks were removed and water stirred to lift eggs into the current to be carried into the catch bucket. Excavation continued to a depth of 20–25 cm at different locations until the entire redd had been sampled.

The downstream drift of emergent fry was measured with drift nets (0.25-m² mouth, 4-mm mesh Ace netting), 7.2 km downstream from Fontenelle Dam on the Green River and 50 m upstream from the high-water mark of Flaming Gorge Reservoir on Sheep Creek. Samples were collected about once a week at 1-hr intervals after sundown in spring 1986. Flowmeters (General Oceanics, Miami, Florida) were mounted in the nets to measure the water volume sampled. Stream discharge estimates for the Green River at Fontenelle Dam were obtained from the U.S. Bureau of Reclamation and were made by the float method (Buchanan and Somers 1969) for Sheep Creek.

RESULTS

Time of Migration and Spawning

On the Green River, anglers were first observed snagging kokanee within the initial 1.5

TABLE 1. Length-frequency distributions of kokanee in samples from the Green River and Sheep Creek, fall 1985.

Length (mm)	Green River		Sheep Creek	
	Male	Female	Male	Female
261–280	0	0	2	0
281–300	0	0	2	0
301–320	0	0	1	0
321–340	0	0	1	3
341–360	2	3	0	5
361–380	3	23	6	9
381–400	21	104	15	20
401–420	45	158	24	52
421–440	73	46	42	33
441–460	47	7	48	17
461–480	12	0	21	2
481–500	0	0	6	0
501–520	0	1	2	0

TABLE 2. Age structure for kokanee spawners in samples from the Green River and Sheep Creek, fall 1985.

Estimated age (years)	Green River		Sheep Creek	
	Male	Female	Male	Female
2	1	3	2	2
3	40	35	21	29
4	53	43	50	44
5	2	1	3	4

km downstream from Fontenelle Dam on 1 October 1985. The fish were seen over shallow riffles on 15 October, and the first redd was observed on 22 October. Intensive spawning continued over the next two weeks. Water temperatures during the spawning period ranged from 4 to 7 C. Moribund kokanee were observed until 19 November, when sampling was terminated.

Mature, reddish orange kokanee were observed jumping in Sheep Creek Bay of Flaming Gorge Reservoir on 27 August. The first kokanee was observed in Sheep Creek on 5 September and migration peaked on 12 September 1985. The first redd was observed on 13 September; new redds were found over the following nine days. Water temperatures ranged from 7 to 15 C during the spawning period.

Spawning Stock Structure

Length frequencies of 545 kokanee (204 males, 341 females) from the spawning run in the Green River and 311 (170 males, 141 females) from the run in Sheep Creek are shown in Table 1. Length-frequency distributions

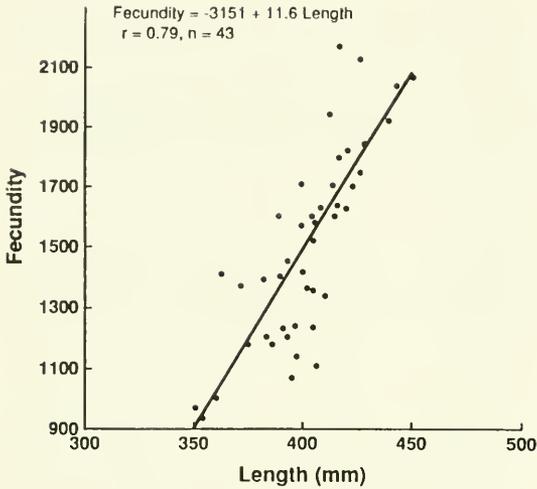


Fig. 1. Absolute fecundity versus total length of female kokanee from the Green River, fall 1985.

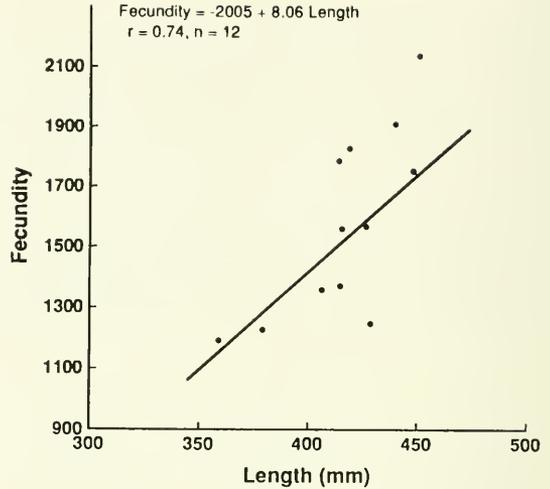


Fig. 2. Absolute fecundity versus total length of female kokanee from Sheep Creek, fall 1985.

differed significantly between the Green River and Sheep Creek for both males (Kolmogorov-Smernov test, $p = .015$) and females ($p = .001$). Average total length of male kokanee was 427 mm in Green River and 431 mm in Sheep Creek. Females averaged 405 mm in Green River and 412 mm in Sheep Creek.

Age structure of both male and female kokanee was similar in the two streams (Table 2). Fish of age 4 made up more than 50% of the fish of both sexes in both streams. The male to female ratio was 1.5:1 (not determined for the Green River).

Fecundity and Egg Retention

Absolute fecundity—the number of ripening eggs in the female before spawning—was estimated for fish from both the Green River and Sheep Creek (Figs. 1, 2). Log transformations and multiple regressions based on both length and age as independent variables did not significantly increase the variance accounted for in either stream sample. Regression equations were not significantly different between streams.

An average of 1,370 eggs per female ($n = 328$) were stripped from Sheep Creek fish by Wyoming Game and Fish Department personnel in 1985. Examination revealed an average of 136 (SD = 43) eggs remained in the body cavity of artificially spawned fish ($n = 12$). The average number of residual eggs in 83 dead females from Sheep Creek was 71 (SD = 136).

Egg Deposition

Excavations of redds yielded an average of 406 (SD = 303, range 0–1,058) eggs in 16 redds in the Green River and 113 (SD = 153, range 0–447) eggs in 12 redds in Sheep Creek. A Mann-Whitney test indicated that the Green River redds contained significantly more eggs than Sheep Creek redds.

Downstream Drift of Emergent Fry

Drifting kokanee fry were sampled in the Green River from 22 March to 22 May 1986 (when sampling was terminated due to high discharges of 250 m³/second). Discharges during the sampling period were 41–160 m³/second. A total of 65 kokanee fry were captured during 16 sampling nights; the largest number (13) was taken on 22 May, when an estimated 1,800 fry drifted past the sampling site during the four-hour sampling period. Total estimated fry drift between 22 March and 27 May was 31,000.

Kokanee fry sampling in Sheep Creek was conducted from 1 March to 17 May, when discharge increased to over 2.5 m³/second. During the sampling interval discharge was 0.8–2.4 m³/second. A total of 658 kokanee fry were captured during 32 sampling nights. The peak catch of 164 fry was made on 24 April. An estimated 6,800 fry drifted past the sampling site between 1 March and 17 May.

On five dates we collected samples in Sheep Creek for 24-hour periods. Fry were

TABLE 3. Comparison of predicted kokanee fecundity from length-fecundity equations for four waters.

Length (mm)	Green River	Sheep Creek	Lake Huron ^a	Lake Stevens ^b
300	329*	413*	590	1024
325	619*	615*	753	1163*
350	909	816	943	1321*
375	1199	1018	1162	—
400	1489	1219	1414	—
425	1779	1420	1700	—
450	2069	1622	2022	—
475	2359*	1823*	2382	—

*Predicted fecundity outside the range of lengths used to develop the equations.

^aCollins (1971)

^bPfeifer (1978)

captured exclusively between sunset and 0200 hrs, except that two fry were taken between 1400 and 1700 hrs on 20 March. Fry catch was not related to either discharge or water temperature in either stream during the sampling period.

DISCUSSION

Coloration of kokanee spawners differed distinctly between the Green River and Sheep Creek. Green River fish were drab, whereas Sheep Creek fish were bright reddish orange. Information on various kokanee strains suggests that the Green River fish were descendants of the Flathead Lake, Montana, strain, and the brightly colored Sheep Creek fish were descendants of the Kootenay Lake, British Columbia, strain.

Kokanee generally spawn between August and January, the exact timing depending upon the genetic background of the stock and the lake environment (Seeley and McCammon 1966). The differences in spawning time between the Green River (late October and early November) and Sheep Creek (September) further suggested that the stocks had differing genetic backgrounds.

Population structure was similar in the Green River and Sheep Creek. Age at maturity in Kokanee ranges from 2 to 7 years (Seeley and McCammon 1966). A 4-year life cycle tended to predominate in the present study. Most of the kokanee spawners in both streams were estimated to be 4 years old (range 2–5 years). The frequency of aging errors was unknown, but some errors were likely.

As shown in Table 3, the fecundity of females from the Green River and Sheep Creek was similar to that of fish migrating from Lake

Huron (Collins 1971) and Lake Stevens, Washington (Pfeifer 1978). Kokanee from Sheep Creek retained an average of 4.5% of their eggs; elsewhere retention rates were 1.5% (Pfeifer 1978) and 6.2% (Janssen 1983).

The density of eggs in redds differed between the Green River and Sheep Creek. Access to spawning sites in Sheep Creek was generally blocked by the trap across the creek, but 328 females were released after being stripped of eggs and allowed to move upstream. Redd building after being stripped of eggs has been reported in other salmon (Belding 1934, Hoover 1936) and could explain the lower egg densities observed in Sheep Creek.

Despite probable genetic differences, as well as differences in the timing of migration, length-frequency distributions, and egg density in redds, between the Green River and Sheep Creek kokanee, the two stocks showed little difference in such adult population features as age composition, fecundity, and egg retention.

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