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HYDROELECTRIC PEAKING AND KOKANEE SALMON YEAR-CLASS STRENGTH - HISTORIC RELATIONSHIPS IN THE FLATHEAD

BY

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Kokanee (*Oncorhynchus nerka*) provide more angling opportunity and comprise more of the total harvest than any other game fish in the Flathead River drainage (Hanzel 1977). All fish that reside in or migrate through the main stem Flathead River above Flathead Lake are affected by operation of Hungry Horse Dam (South Fork Flathead River). However, kokanee are more directly affected than other major game species.

Most Flathead Lake kokanee spawn in three areas of the drainage. Upper drainage spawners utilize McDonald Creek and the lower Middle Fork Flathead River. Other kokanee spawners utilize the shoreline of Flathead Lake and several areas of the main stem river.

More kokanee spawn in the upper drainage than in any other river area. We estimated approximately 50,000 spawners in McDonald Creek and 8,000 spawners in the lower Middle Fork in 1979 (Graham et al. 1980). Upper drainage spawners are unaffected by Hungry Horse Dam operations. Virtually all available spawning gravel is used even in years when poor runs occur. Consequently, we feel the contribution from upper drainage areas to total recruitment to Flathead Lake is relatively constant from year-to-year.

An undetermined number of kokanee spawn along the shore of Flathead Lake. Prior to construction of Hungry Horse Dam, the lakeshore was the principle spawning area (Stefanich 1954). Hypolimnial water released from Hungry Horse resulted in warmer winter water temperatures in the main stem river and a subsequent shift toward river spawners was noted (Hanzel 1964).

Main stem spawners are directly affected by Hungry Horse operations. Kokanee prefer shallow areas of moderate velocity for spawning. Consequently, most redds are located in areas impacted by fluctuations in water level caused by changes in discharge at Hungry Horse Dam. We feel operation of Hungry Horse Dam may be the over-riding factor involved in survival of kokanee eggs in the main stem river.

One of the objectives of our studies is to evaluate the impact of Hungry Horse operations on kokanee spawning and incubation mortality. In addition to our field studies, we investigated theoretical relationships between Flathead River flows and kokanee year-class strength. Several assumptions were made including the following:

1. Growth of kokanee is inversely density dependent, i.e., large populations result in slower growth and vice versa.

2. Poor or average year-classes of kokanee are produced when recruitment to the lake is limited to fish produced in the upper drainage and the lakeshore i.e., few kokanee are produced in the main stem.

3. Strong year-classes are produced when flow conditions in the main stem are favorable for incubation and consequently the main stem makes a substantial contribution to total recruitment.

Kokanee year-classes do not exist as discrete units within Flathead Lake but interact with other year-classes of kokanee as well as with their cohorts. Based on our best estimate of year-class interactions, we made the following assumptions.

1. Fry or age 0+ fish interact primarily with their cohorts and the previous year-class, or age I+ fish but little if at all with older fish.

2. In subsequent years, interactions occur primarily within cohorts and between a cohort and adjacent year-classes.

Most kokanee mature and spawn at age III+, thus leaving the fishery. The sum total of the interactions for an individual fish is, three years of interaction with the previous year-class, four years of interaction with its cohorts and three years of interaction with the following year-class.

Total years of interaction were used as weighting factors in calculating weighted, three-year moving average flow conditions in the main stem Flathead River (Table 1). Average flow conditions were correlated with the length of male kokanee spawners produced by those flows. For example, 1979 spawners resulted from eggs deposited in fall 1975 (water year 1976). Flow conditions in water year 1976 were poor for egg and fry survival. November flows (when most main stem spawning occurs) averaged 271.2m3/s (9,576 cfs). Mean daily December to March (incubation period) flow was 128.7m^3/s (7,396 cfs). The ratio of December to March flow versus November flow is 0.77 indicating eggs were frequently dewatered. Air temperature during the incubation period is nearly always at or

Table 1. Water conditions during the kokanee spawning (November) and incubation period (December - March) for Water Years 1962-78. Mean length of male kokanee spawners and weighted three-year moving average water conditions are also given. All water data from USGS gauge on Flathead River at Columbia Falls, Montana

Water Year	Mean November flow (m^3/s)	Mean December-to March flow (m^3/s)	Mean December-March to November	Spawn Year	Male Kokanee Length (mm)	Water Years producing Interacting year classes	Weighted 3-year moving average: November flow (m^3/s)	Weighted 3-year moving average: flow ratio
1962	62.4	197.3	3.16					
1963	123.7	180.7	1.46	1966	290	1962-64	81.4	2.89
1964	44.1	200.1	4.54	1967	277	1963-65	91.6	3.02
1965	122.9	314.1	2.56	1968	291	1964-66	98.5	2.88
1966	120.3	195.7	1.63	1969	315	1965-67	166.4	1.60
1967	271.5	162.7	0.60	1970	328	1966-68	196.0	1.02
1968	171.1	168.2	0.98	1971	340	1967-69	199.7	0.98
1969	165.9	227.0	1.37	1972	345	1968-70	161.2	1.03
1970	144.9	92.1	0.64	1973	312	1969-71	131.7	1.39
1971	80.0	193.4	2.42	1974	328	1970-72	150.4	1.45
1972	249.8	241.6	0.97	1975	330	1971-73	170.8	1.43
1973	156.1	164.6	1.05	1976	321	1972-74	188.1	1.12
1974	169.2	228.9	1.35	1977	333	1973-75	194.6	1.00
1975	266.9	128.7	0.48	1978	348	1974-76	238.9	0.83
1976	271.2	209.5	0.77	1979	361	1975-77	218.5	0.88
1977	99.7	141.8	1.42					
1978	180.5	114.8	0.64					

below freezing. Consequently, dewatering of eggs soon results in mortality due to dessication and/or freezing.

A weak year-class was produced in water year 1976 due to frequent dewatering of eggs. During their residence in the lake, the 1979 spawners interacted with the 1975 and 1977 year-classes as well as their cohorts. Flow conditions in water year 1975 were even more unfavorable than water year 1976, thus an even weaker year-class was produced. Water year 1977 was much more favorable thus, a member of the weak 1976 year-class interacted four years with its cohorts, three years with an even weaker 1975 year-class and three years with a stronger 1977 year-class. The 1979 spawners averaged 361 mm total length - the largest fish for the period of record.

Each of two correlations indicated a strong relationship between main stem Flathead River flows and kokanee year-class strength (Figure 1). The relationship between November (spawning) flows and fish length (r= -0.89) indicates weaker year-classes are produced at successively higher flows. Egg mortality increases as spawning flow increases because more eggs are deposited in areas subject to dewatering. The relationship between the ratio of incubation flows to spawning flows and fish length (r=0.92) indicates stronger year-classes are produced as the ratio increases (eggs are dewatered less frequently).

SUMMARY

Year-class strength of Flathead Lake kokanee is directly affected by operation of Hungry Horse Dam. Weak year-classes are produced when Flathead River flows are high (due to generation at Hungry Horse) during the November spawning period. The ratio of incubation period river flows to spawning period river flows is also important in determining year-class strength.

The correlations presented were based upon the assumption that total length of kokanee spawners was inversely related to year-class strength. Total length was also affected by interactions within cohorts and between cohorts and adjacent year-classes.

The correlations suggest river flows could be managed to produce optimum yield. We estimate optimum yield would be produced when male kokanee spanwers average 315 mm to 320 mm total length. From the regression equations, our goal could be achieved with November flows of 146-157 m^3/s (5,155-5,554 cfs) and/or a flow ratio of 1.64 to 1.82.

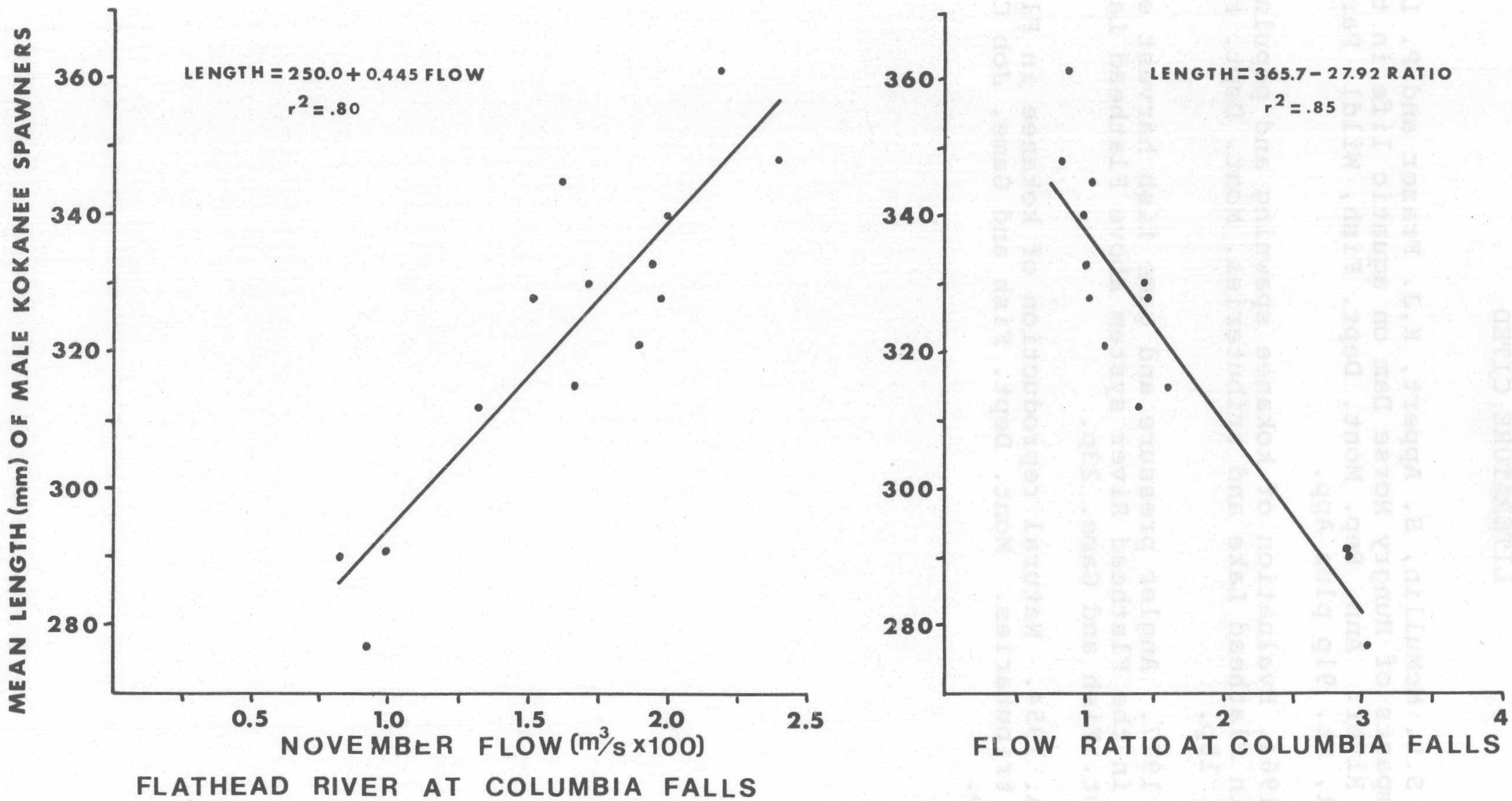

Figure 1. Relationships between length of male kokanee spawners and mean daily flow of the Flathead River at Columbia Falls during November (left) and the ratio of mean daily flows for the period Dec. - March to mean daily flows for November (right). Flow data are from water years 1962-77. Kokanee length data are from spawn years 1966-79.

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