PRELIMINARY EVALUATION OF SPAWNING GRAVEL PLACEMENT BELOW BIGFORK DAM

Prepared by

Scott Rumsey, Fisheries Biologist
Montana Department Fish, Wildlife and Parks
Kalispell, Montana

Funded by

Federal Aid in Fish Restoration F-33-R

March, 1983

ACKNOWLEDGEMENTS

Pacific Power and Light Company should be commended for their cooperation and expenditures relating to the fishery enhancement of Bigfork Dam. Thanks goes to Fish, Wildlife and Parks personnel contributing time and effort to the project.

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Introduction

Kokanee salmon (Oncorhynchus nerka) historically and presently migrate up the Swan River in the fall as spawning adults. In the past, annual concentrations of kokanee gathered below Bigfork Dam and spawned in large, coarse (8" plus) rock substrate.

In an attempt to increase salmon production and sustain a local kokanee population, Pacific Power & Light Company (PP&L) and the Department of Fish, Wildlife and Parks (DFWP) cooperated in an effort to place lost spawning gravel below the dam in 1978 and 1981. A fishery closure was also enacted in 1982 to protect spawning fish within 300 feet of the dam.

Objectives

The primary objective of this project is to conduct an evaluation on the gravel placement for kokanee salmon below Bigfork Dam. A secondary objective will design a strategy for future gravel placement and management in the area.

Area Description

Bigfork Dam is a hydro-generating facility located on the Swan River approximately 1.5 miles above its mouth at Flathead Lake and 14 miles downstream from Swan Lake. The Swan River has a drainage area of about 700 square miles and a mean annual discharge of 1,144 cubic feet per second (cfs). The dam was constructed in 1902 and has a generation capacity of 4,150 kw and impounds approximately 109 acre-feet of water. The concrete dam is 12 feet high and 300 feet wide, and includes a fish passage structure. The dam and powerhouse is owned and operated by Pacific Power and Light Company of Portland, Oregon. The powerhouse is served by a mile-long pipeline and canal with a capacity of 500 cfs controlled by headgates. The forebay is a run of the river type impoundment with a short flow through time. It is approximately 12 feet deep and not expected to alter water chemistry, temperature, and gas saturation downstream.

A multi-step fish ladder constructed at the dam in the early 1930's, was modified in 1960 to improve upstream passage for westslope cutthroat trout (Salmo clarki), and bull trout (Salvelinus confluentus). Trapping of the fish ladder in the 1950's, 1960's and 1970's by PP&L and DFWP personnel revealed limited use of the fish ladder by native trout. Incidental use of the ladder by kokanee salmon was also minimal. Kokanee populations exist above and below the dam, therefore, management and manipulation of the ladder was not directed toward this species.

Spawning gravel was first placed below the dam in 1978 in an effort to replace bedload gravels interrupted by the impoundment. Rubber-tired loaders dumped 100 yards of clean, 2-inch minus, round rock directly below the sill of the dam. By 1980, the majority of the previously placed gravel

had been scoured away and transported downstream by turbulent spring flows. In 1981, 300 cubic yards of oversize (6" minus), clean rock was again replaced by PP&L at the request of the DFWP. It was presumed that the larger material would remain in place for a longer period. The area covered in 1981 was increased to take advantage of areas not adversely affected by scour.

Methods

Kokanee Estimates

Visual observations of mature kokanee salmon were made in the fall of 1982 by DFWP creel census personnel (Graham and Fredenberg 1982; Decker-Hess and Graham 1982). Historically and presently, two runs of kokanee spawn below the dam; an early September-October group and a late November-December group.

Spawning Gravel Mapping

Survey techniques were used to map the gravel suitable for kokanee spawning in February-March, 1983. Suitable spawning gravel was defined as having a composition of 40 percent two-inch plus material and 60 percent two-inch minus rock. Suitable gravel was easily separated from other substrate which was much larger and contained no small (2" approximate) rock. Water depths over the spawning gravel were also recorded.

Egg Sampling

A hydraulic egg sampler (McNeil 1963) and a kick net were used to sample eggs in the spawning gravel in February and March of 1983. The kick net was used to sample eggs when large substrate (>6") did not allow adequate penetration of the hydraulic sampler. Random sampling of the spawning gravel was used because individual redds were not discernible. Egg viability was determined immediately after extraction from the gravel.

Dissolved Oxygen, Water Temperatures

Dissolved oxygen samples were collected in March, 1983 with an intergravel water sampler (Decker-Hess and Graham 1982). These samples were taken in close proximity to the hydraulic sampler locations. Samples were extracted eight inches below the surface of the gravel and examined in the field by the modified Winkler method (Decker-Hess and Graham 1982; Environmental Protection Agency 1974).

Temperature records were collected with a Foxboro 31-day thermograph two miles upstream from the dam. Data was extracted for a period from September to December of 1982 on the Swan River. Information from two successful kokanee spawning streams was included for comparison. These were thermograph records for a lake-outlet stream (McDonald Creek) and a nonlake-outlet stream (Middle Fork Flathead River).

Spawning Area Water Elevations

To evaluate the potential for dewatering of the spawning area, water levels over the dam were recorded by PP&L personnel. These measurements were vertical water elevations above the crest of the dam.

Results

Kokanee Estimates and Spawning Times

Adult kokanee were observed below the dam from October 8, 1982 until November 5, 1982. On November 5, a visual count was made where 300-500 individual spawners were estimated. On October 24, 1982, dead kokanee were observed below the dam indicating that some spawning occurred prior to this time. These fish represented the early spawner (September-October) group. No later observations were made at the site, therefore the second groups of spawners (November-December) was not quantified in 1982. From historic observations and hatchery egg taking operations, the later groups spawned some time in November and December.

Spawning Gravel Retention and Mapping

Survey of the entire spawning gravel revealed three distinct areas totalling 1,770 square feet with an average gravel depth of six inches (Figure 1). Assuming this gravel depth over the total area, 33 cubic yards or 11 percent of the original 300 cubic yards remains.

Egg Sampling

A total of 523 kokanee eggs were collected by seven hydraulic and five kick net samples (Figure 2). Overall mortality of the samples was 89 percent or 465 eggs (Table 1). Individual samples had mortalities ranging from 62 to 100 percent. Less than half (43 percent) of the live eggs collected had reached the eyed stage, while the remaining were uneyed. Kokanee egg mortality was significantly less in McDonald Creek by February of 1982 averaging only 28 percent (Fraley and Graham 1982).

Whitefish eggs were also collected during the hydraulic and kick net sampling (species unknown). Mortality on the 452 whitefish eggs was one percent (Table 1). Nearly all of the live whitefish eggs had reached the late-eyed stage of development and were near hatching.

Dissolved Oxygen Water Temperatures

Dissolved oxygen concentrations in the area should not adversely affect the development of kokanee embryos. Four samples were collected and concentrations averaged 10.65 mg/l with a range from 8.2 mg/l to 11.6 mg/l (Figure 2).

Temperature records were analyzed weekly for ease of comparison (Figure 3). Combs (1965) established a lower temperature threshold for normal sockeye salmon egg development of 42.5 degrees fahrenheit. When eggs were subjected to temperatures below this threshold at deposition (spawning) higher than average mortality resulted. If egg deposition took place below Bigfork Dam later than the third week of November in 1982,

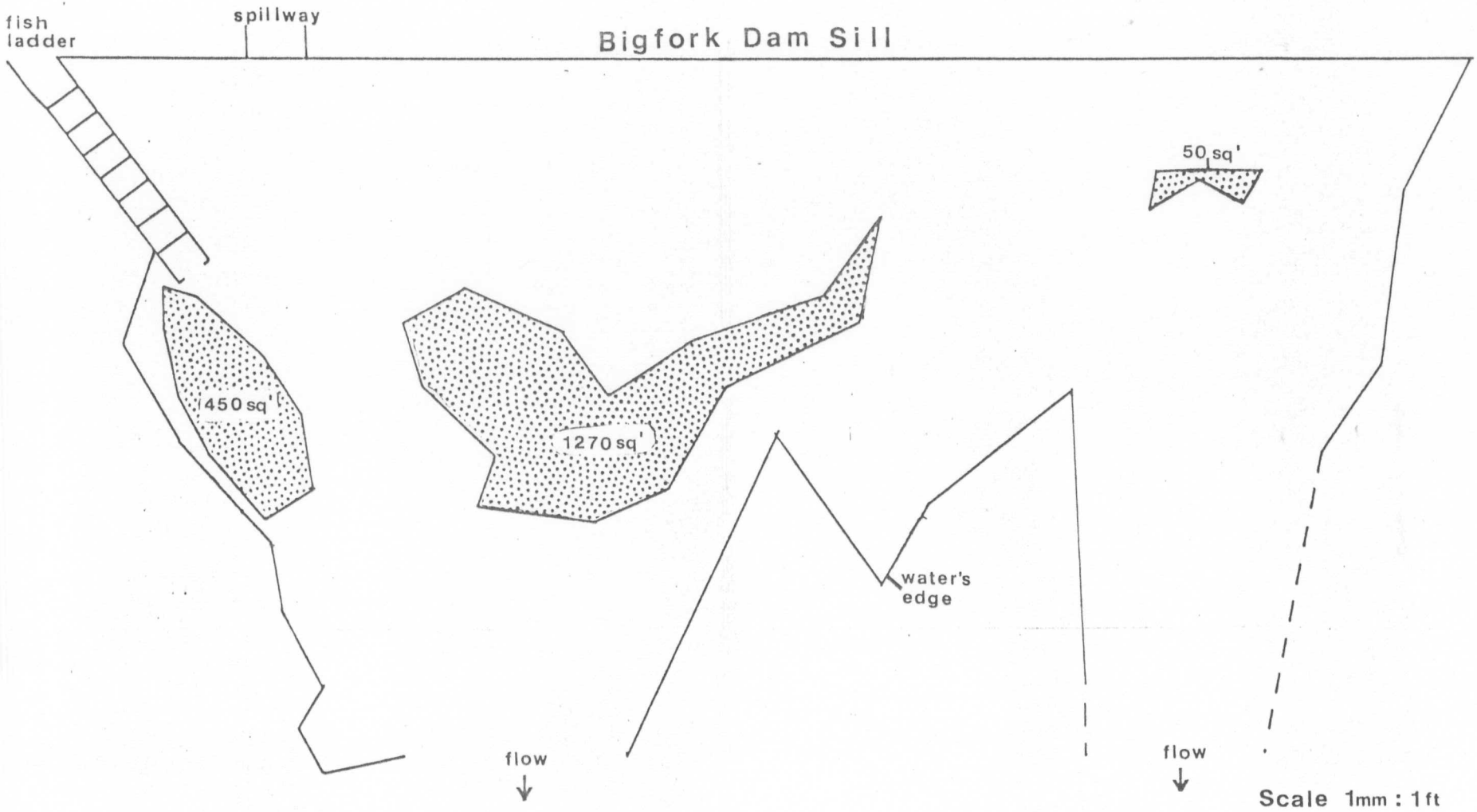

Figure 1. Spawning gravel areas and channel configuration below Bigfork Dam (2/28/83).

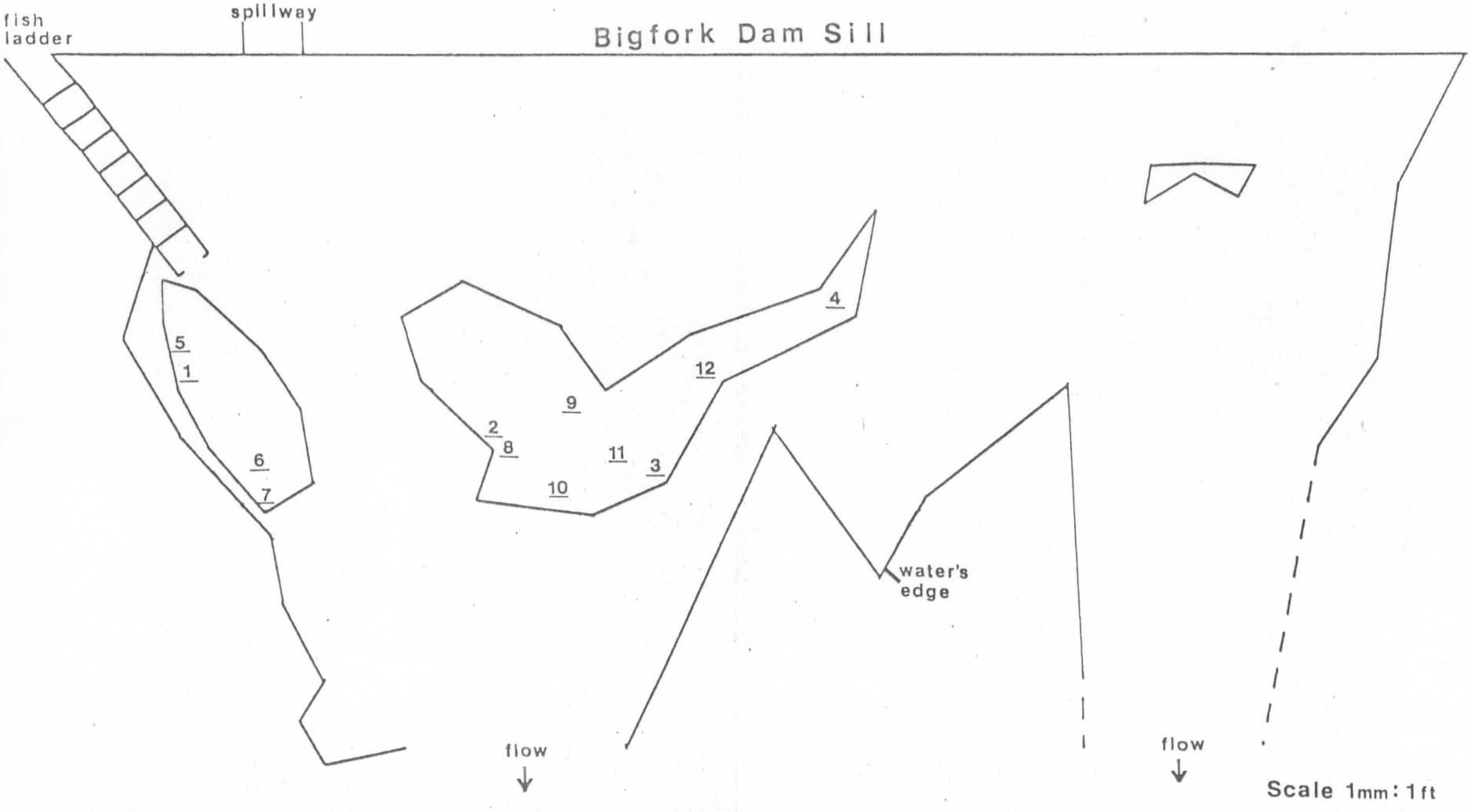

Figure 2. Egg and dissolved oxygen (DO) sampling location below Bigfork Dam (2/28/83, 3/3/83). The first four numbers (1-4) represent both egg and DO sampling sites.

Table 1. Kokanee and whitefish egg mortalities below Bigfork Dam.

Sample number	Kokanee		Whitefish		% mortality	
	Live	Dead	Live	Dead	Kokanee	Whitefish
1H[1/]	--	--	1	1	--	50
2H	0	4	--	--	100	--
3H	6	179	--	--	97	--
4K[2/]	8	45	--	--	85	--
5H	--	--	360	4	--	1
6K	4	12	--	--	75	--
7K	31	51	82	4	62	5
8H	0	12	--	--	100	--
9H	1	5	--	--	83	--
10K	1	49	--	--	98	--
11H	2	28	--	--	93	--
12K	5	80	--	--	94	--
TOTALS	58	465	443	9	89	1

1/ H = Hydraulic
2/ K = Kick

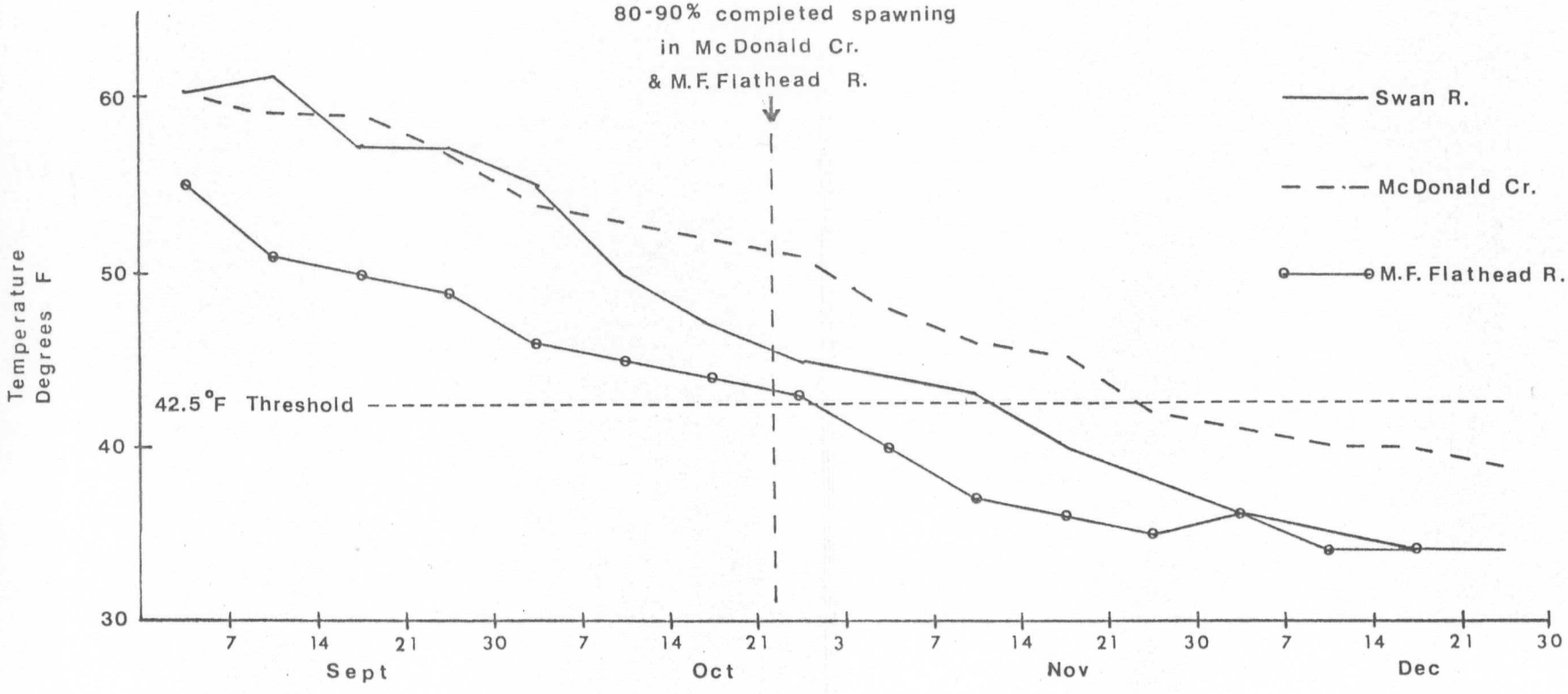

Figure 3. Mean weekly temperatures in the Swan River, McDonald Creek, and Middle Fork of the Flathead River during the kokanee spawning period in 1982.

then higher than average mortalities would also result (Figure 2).

Kokanee spawning in McDonald Creek and the Middle Fork of the Flathead River was 80-90 percent complete by 22 October, 1982 (Fraley and Graham 1982) (Figure 3). Temperatures in these streams at this time were above threshold level.

Spawning Area Water Elevations

During the spawning and incubation period below the dam, water elevations were adequate and dewatering of eggs should not have occurred in 1982-83. Ice scour was also not evident due to a mild winter.

Discussion

Kokanee runs returning annually below Bigfork Dam suggest production from the local spawning area. Gravel recently placed below the dam was used by these spawning salmon. The source of these returning fish may not solely be from this spawning area. It may be due to straying from other spawning areas or fry drift from Swan Lake populations that home as adults and are blocked by the dam.

Future placement of spawning gravel below the dam should be considered as a viable management tool to aid in salmon production in the Flathead drainage. However, the successful production of fry within this gravel may be limited.

Potentially, early spawning fish deposit their eggs in the gravel areas in September and October. In November and December another group of fish spawn in the same limited areas, destroying the earlier-laid eggs by superimposition. These late eggs are subsequently deposited when cold water temperatures are below threshold level resulting in abnormally high mortality (Figure 3).

Recommendations

The following fieldwork is recommended to further evaluate the success of the spawning area below Bigfork Dam for a period of four years to complete a kokanee life cycle.

1. Estimate number of spawners in the area weekly from September to December.

2. Monitor dates of egg deposition by spawner groups (early vs late) using redd counts or other applicable methods.

3. Monitor temperature, water levels, intergravel dissolved oxygen concentrations, and gravel displacement from the area during the spawning and incubation periods.

4. Monitor egg mortality and development of both early and late spawners following the eyed stage of development. Egg plants could be used to determine specific causes of mortality.

5. Monitor the total production of the area to evaluate the contribution to the drainages. Fry nets set above and below the site would separate upstream drift from area escapement.

6. Use the above information to devise a management scheme compatible with the system.

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