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EVALUATION OF SPAWNING GRAVEL PLACEMENT BELOW BIGFORK DAM - 1983 SPAWN YEAR

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Job Title:
Measure annual trends in recruitment and migration of kokanee populations and identify major factors affecting trends.

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ABSTRACT

A total of 750 kokanee salmon (Oncorhynchus nerka) spawned below Bigfork Dam during 1983 in 1,938 ft2 of substrate placed during 1981. Turbulent spring flows over a period of two years have removed nearly 95 percent of the added gravel. Egg mortality within the area was relatively high (52 percent) with suspected causes being superimposition and egg deposition when water temperatures were below 42.5° F.

INTRODUCTION

Kokanee salmon (Oncorhunchus 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. Sampling and evaluation of the spawning areas was continued during the 1983 spawn year (includes spawning and egg incubation period from September 1983 until March 1984) as described by Rumsey (1984).

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 (Figure 1). The Swan River has a drainage area of about 700 square miles and a mean annual discharge of 1,444 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 PP&L 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, or 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

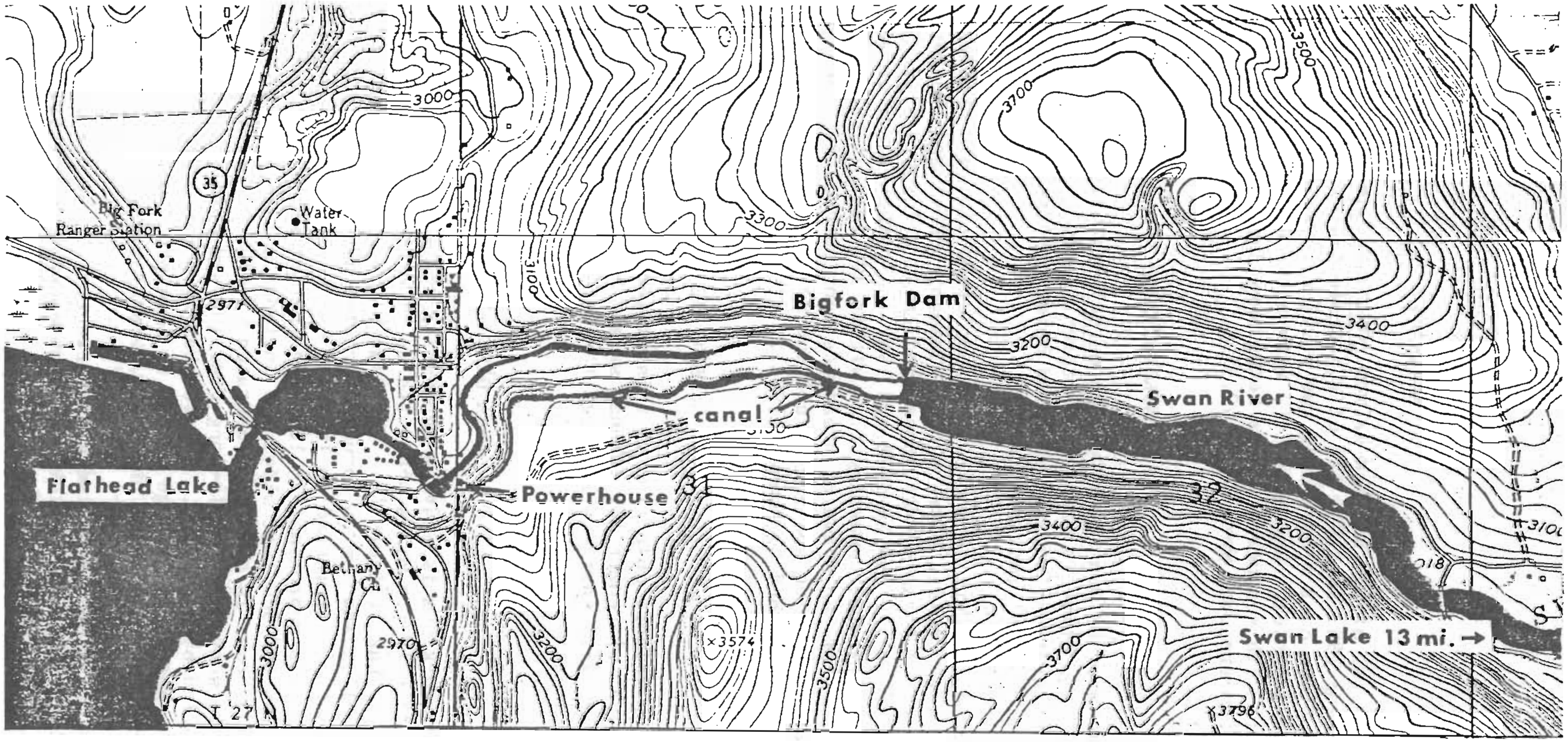

Figure 1. Project vicinity map.

(*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. 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 (Schumacher, personal communication). Turbulent spring flows are characteristic of the channel below Bigfork Dam where stream gradient is nearly 120 feet per mile (2.3 percent). In 1981, 300 cubic yards of oversize (6-inch minus), clean rock was again placed 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

Techniques were modified from work done during 1982-83 to provide more accurate information (Rumsey, 1984).

Kokanee Estimates and Spawning Times

Snorkel counts of mature kokanee were made weekly from October until December in 1983. Counts were conducted by two snorkelers drifting downstream on either side of a school of fish. During a count, the school would typically move downstream to the end of a pool or channel constriction, congregate, and then filter back upstream between the swimmers. Both individuals would then count independently and compare numbers following the section. If discrepancies between the two counters exceeded 10 percent of the total, then the count was repeated. This method was adequate in the Swan River during daylight hours because fish held in either deep runs or pools. Similar methods were used by Fraley and McMullin (1983) in the Flathead River and its tributaries. Counts were separated into two locations--below Bigfork Dam and below the powerhouse, which were the major areas of fish concentration. In order for kokanee to reach the spawning area below Bigfork Dam, they must pass through the powerhouse section (Figure 1).

Spawning times were observations during snorkel counts. They included redd excavation or gravel cleaning dates, fish condition, and dead fish.

Spawning Gravel Mapping

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

Substrate Composition

Substrate samples were collected from the spawning areas below the dam for compositional analysis in January and April of 1984. Five and 10 kilogram samples were taken with a shovel and placed in 19 liter plastic buckets for further analysis. Samples were dried and sieved through 76.2mm, 50.6mm, 16mm, 6.35mm, 2mm, and 0.63mm mesh and percent dry weight calculated (Shirazi and Seim, 1979, Decker-Hess and McMullin 1983).

Egg Sampling

A one meter square kick net containing 1.35mm mesh was used to sample kokanee salmon eggs below Bigfork Dam in January, February, and March of 1984. Random sampling of the spawning gravel was used because individual redds were not discernible. A hydraulic sampler (McNeil 1963) used in 1982 was not used in the 1983 spawn year due to inefficiency in shallow gravel underlaid by large cobble.

Below the powerhouse a hydraulic sampler (Decker-Hess and McMullin 1983) was used with scuba in deep water to randomly sample the substrate for eggs. Egg viability and development was determined visually immediately after extraction from the water.

Dissolved Oxygen, Water Temperatures

Dissolved oxygen samples were collected in April of 1984 with an intergravel water sampler (Decker-Hess and Graham 1982). Samples were extracted 8 inches below the gravel surface and field examined using the Modified Winkler Method (Decker-Hess and Graham 1982, Environmental Protection Agency 1974).

Temperature records were recorded with a Foxboro 31-day thermograph 2 miles upstream from the dam.

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.

Fry Netting

One-half meter drift nets were set overnight in April and May during 1984 above Bigfork Dam to investigate the possibility of kokanee fry drift from Swan Lake. Netting below the dam and powerhouse was not conducted during 1984 because of turbulent spring flows.

RESULTS

Kokanee Estimates and Spawning Times

Adult kokanee were first observed and counted by snorkeling below the dam and powerhouse on October 7, 1983. Snorkeling of both areas was continued every 11 to 14 days until December 19 when the count dropped below 100 individuals. To derive an estimate for total spawner escapement during 1983, numbers were combined from the two areas when the peak occurred below the dam. A peak count of 550 fish occurred below Bigfork Dam on November 11 (Figure 2). The total spawner escapement for 1983 was estimated to be 750 fish.

Spawning had begun below the dam when the October 18 count was conducted. Gravel had been cleaned, but individual redds were not discernible (Rumsey 1984). The amount of area used continually increased throughout the counting period. The condition and appearance of some dead fish by November 11 suggested an early September-October spawning group, followed by a later November-December group.

Spawning Gravel Mapping

Survey of the spawning area below Bigfork Dam identified two predominant areas and four smaller areas (Figure 3) totaling 1938 square feet (180 sq. mtr.). This represents a 9 percent increase of the area utilized over the previous year where only 1770 square feet (164 sq. mtr.) was used.

The gravel suitable for spawning averaged approximately 4 inches thick during the December, 1983, survey leaving 18 yards (6 percent) of the original 300 placed in 1981. Fifteen yards of material were presumably lost or displaced by spring flows since the previous year's survey when the gravel averaged 6 inches in depth and totaled 33 yards (Rumsey, 1984).

Substrate Composition

Substrate compositions collected are shown in Figure 4. The average percent of fine materials less than 6.35mm in diameter from all samples was 9 percent.

Egg Sampling

A total of 1380 kokanee eggs were collected by four kick net samples over a 3-month period. The average mortality for the period was 52 percent with a low of 9 and high of 63 percent (Table 1). The two January samples exhibited relatively low mortalities (0 and 10 percent) where the February and March samples were abnormally high (63 and 62 percent) when compared with other local spawning areas (Rumsey, 1984). Until the March sampling, 80 percent or more of the eggs sampled were classified "green" relative to development. During March, only 30 percent of the surviving eggs were "green" with the remainder being "eyed".

Table 1.--Kokanee egg mortalities below Bigfork Dam.

Sample Date	Live	Dead		Percent Mortality
1/26/84	25	0		0%
1/26/84	222	26		10%
2/09/84	202	343		63%
3/07/84	216	346		62%
TOTALS	665	715	Avg.	52%

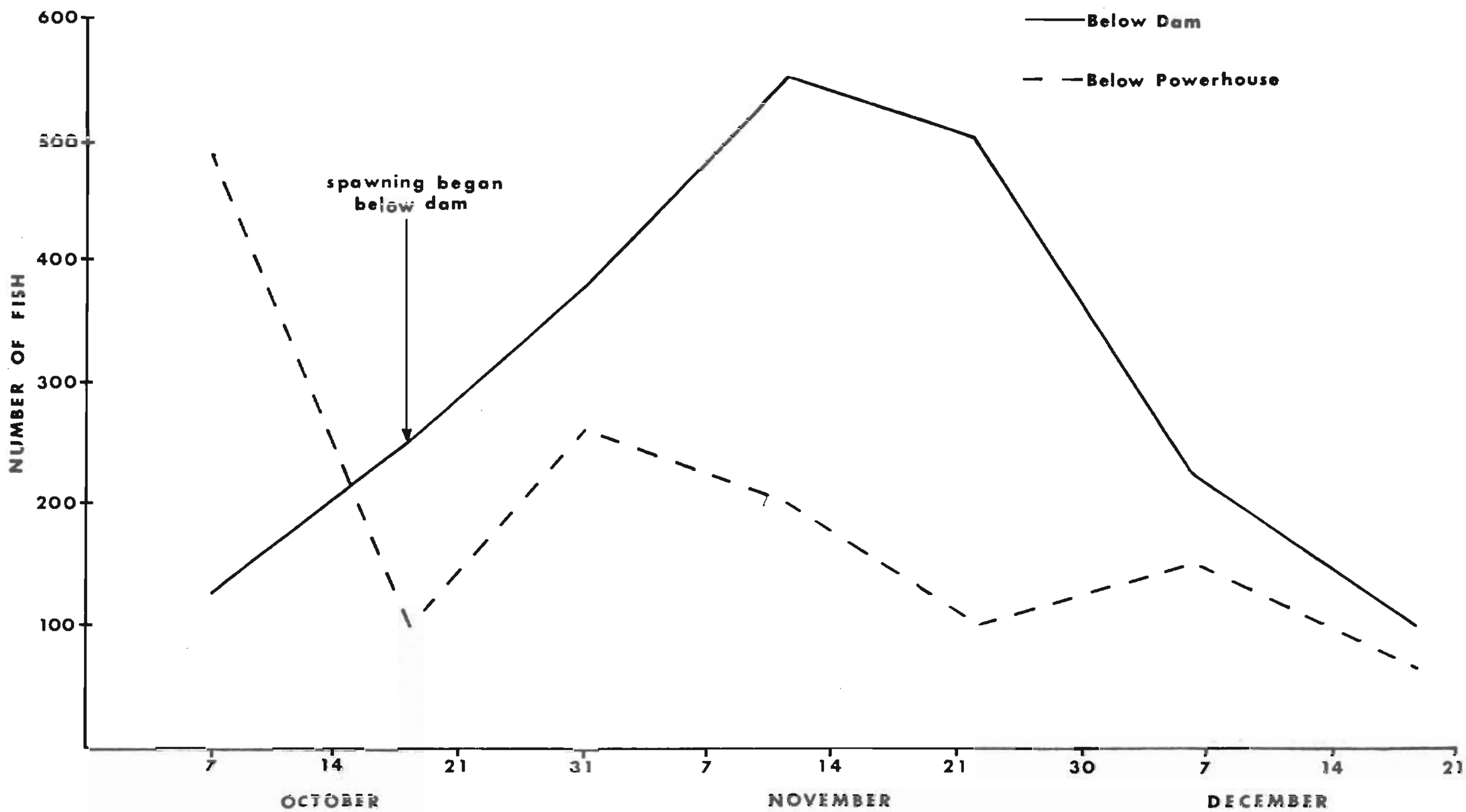

Figure 2. Number of kokanee spawners below Bigfork Dam and powerhouse during 1983.

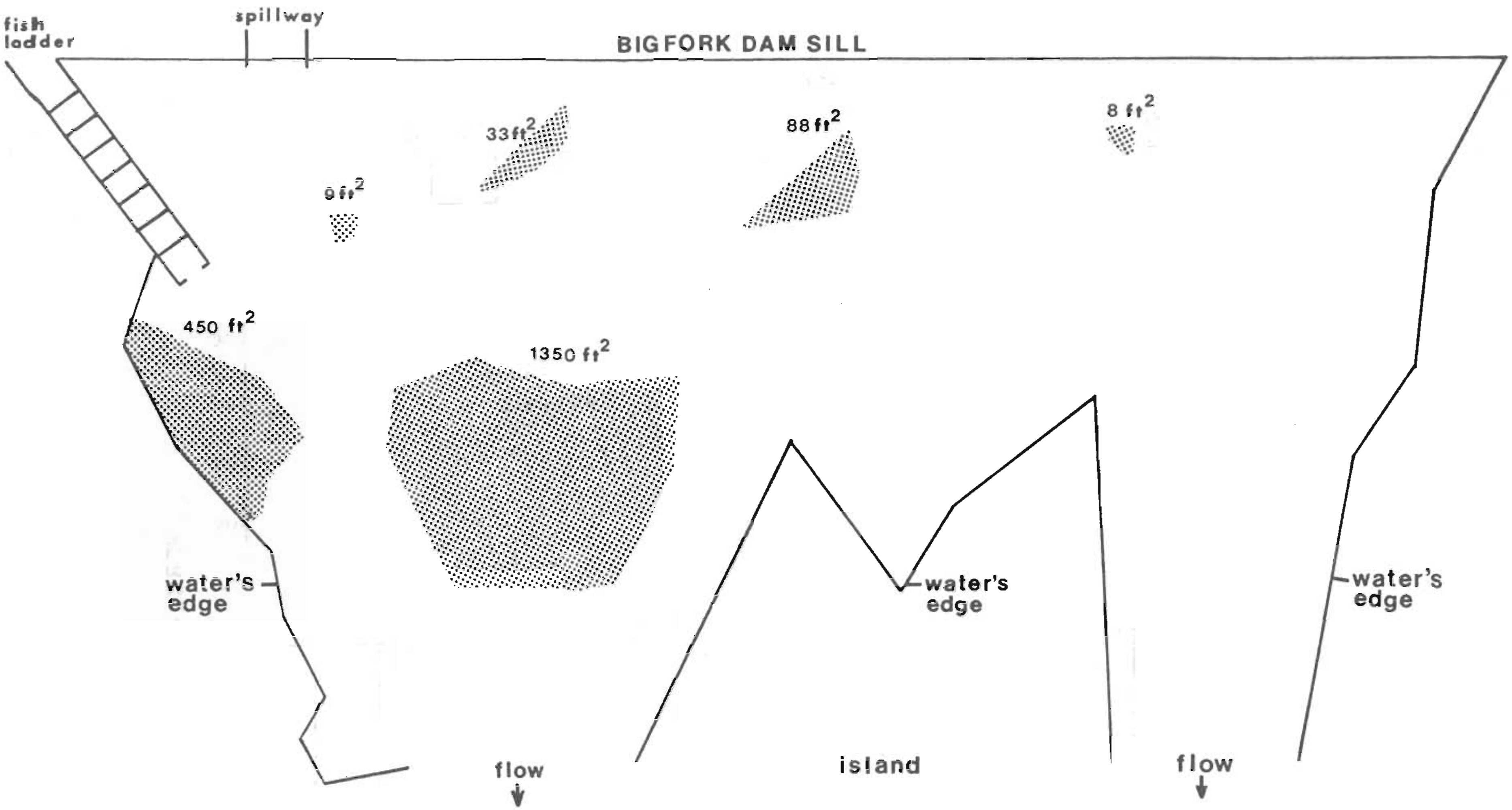

Figure 3. Area spawned below Bigfork Dam by kokanee salmon (12/6/83).

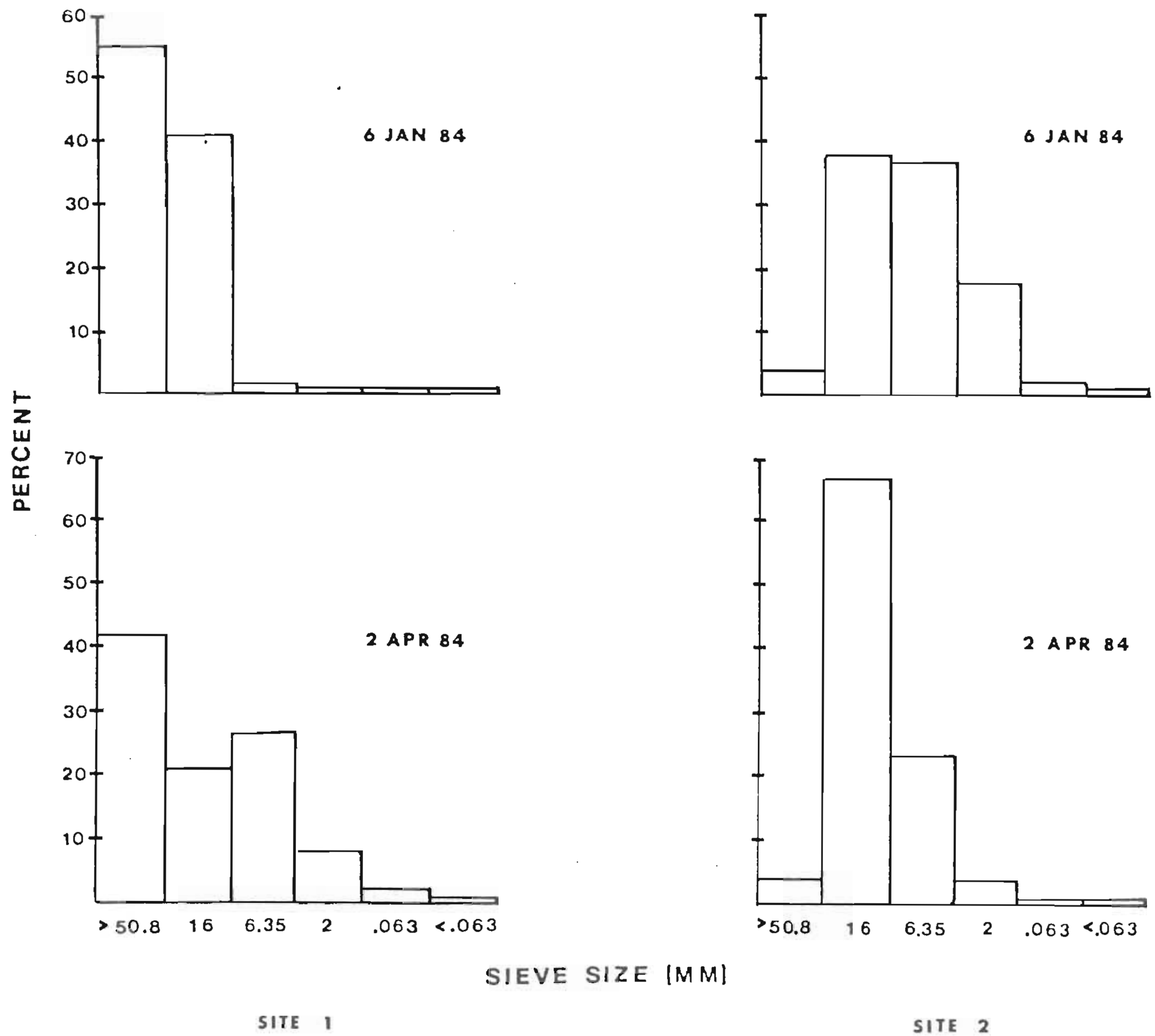

Figure 4. Substrate composition below Bigfork Dam from two spawning sites during January and April, 1984.

Hydraulic sampling below the powerhouse collected 644 eggs in the "green" stages of development. Many eggs died prior to extraction from the water and a natural mortality estimate could not be made. Further egg sampling should be conducted only after eggs become "eyed".

Dissolved Oxygen, Water Temperatures

Dissolved oxygen concentrations in the area should not adversely affect the development of kokanee embryos. April samples collected within the two large areas (Figure 4) had concentrations of 11.0 and 11.2 milligrams per liter.

Temperature records were plotted weekly for ease of comparison (Figure 5). Combs (1965) established a lower temperature threshold for normal sockeye salmon egg development of 42.5° F. When eggs were subjected to temperatures below this threshold at time of deposition, then higher than average mortality resulted. From observations, it was determined that the majority of spawning occurred prior to November 21, the date when this temperature was reached. However, some fish did spawn after this date.

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 during the 1983 spawn year. Ice scour was also not evident.

Fry Netting

Net sets above Bigfork Dam caught no kokanee fry during the period. Juvenile whitefish and squawfish fry were captured in nearly every set.

DISCUSSION

Physical factors such as substrate composition, dissolved oxygen concentration, and water levels are more than adequate to provide good embryo survival below Bigfork Dam. However, mortality is very high (52 percent) when compared to areas of McDonald Creek (22 percent) and the Middle Fork of the Flathead River (23 percent) (Fraley and McMullin, 1983). Possible factors limiting survival are spawning superimposition and egg deposition during cold water temperatures.

Fraley and McMullin (1983) established a mean redd density from four Flathead River areas of 0.35 redds per cubic meter of spawning gravel with a three fish per redd ratio. In the Swan River 0.35 redds per cubic meter yields an area capacity of 63 redds providing they are continuous and no superimpostion has occurred. Using a three fish per redd ratio leaves 189 spawners to occupy these redds. The peak count below the dam of 550 fish exceeds this optimum number by nearly 200 percent. Therefore, it is presumed that superimposition is having a major affect on egg survival below Bigfork Dam. Egg deposition below 42.5° F. may further compound mortality in the spawning area.

The Flathead Lake Salmon Hatchery periodically collected spawn and planted fry below Bigfork Dam. The last egg collection occurred during 1981 and the

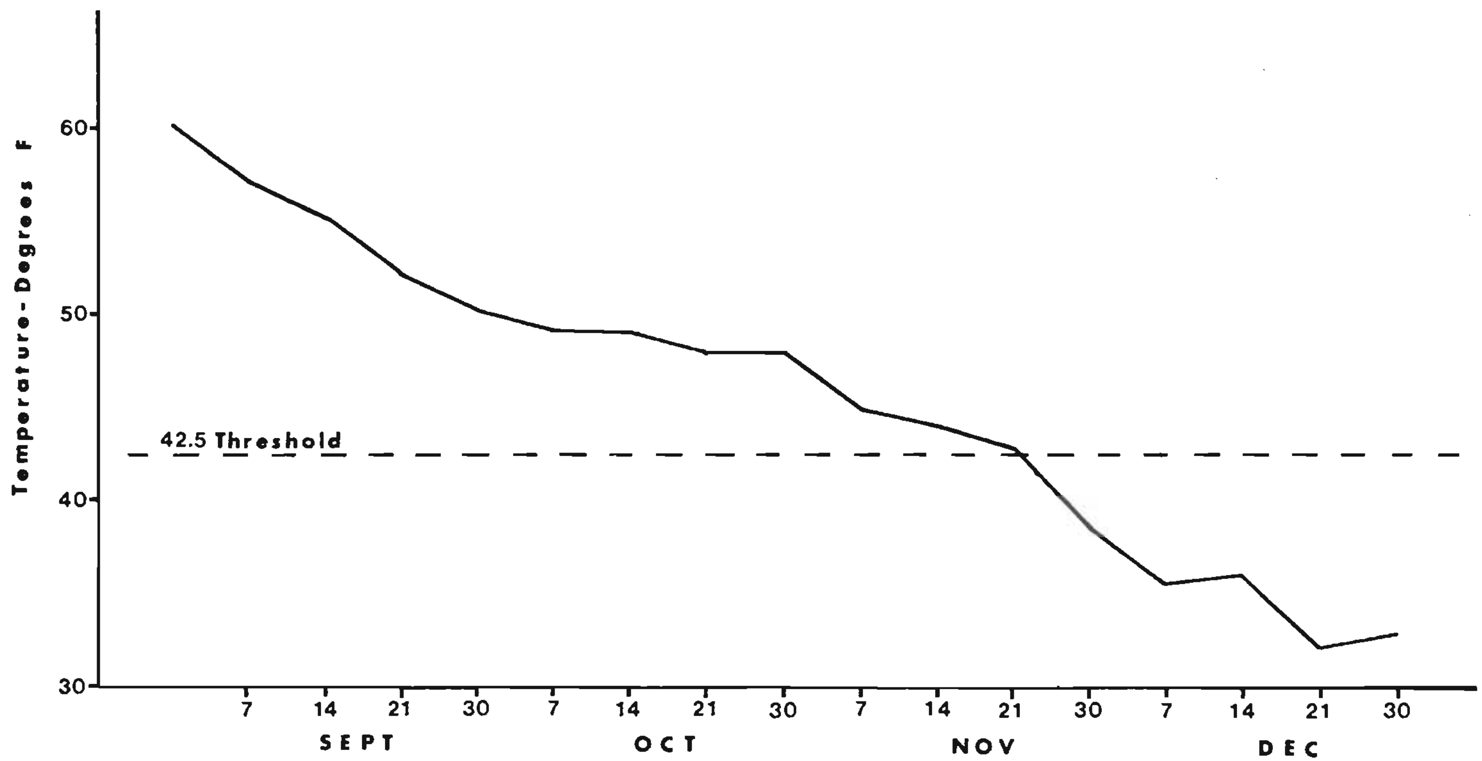

Figure 5. Weekly temperatures in the Swan River during the kokanee spawning period in 1983.

last fry plant during the spring of 1979. Returning adults as a result of this plant may carry into 1983 with five-year old spawners present. This may quantify the number of fish returning to the Swan to spawn when considering high egg mortality. Another possibility is the straying of fish from other spawning areas and their attraction to substantial flows of the Swan River.

Future gravel placement directly below the dam is not recommended. Placement in other areas such as below the powerhouse may be feasible with designed structures incorporated to accomplish gravel retention.

RECOMMENDATIONS

The following is recommended to further evaluate the success of the spawning area below Bigfork Dam:

1. Estimate the number of spawners throughout the spawning period.

2. Monitor dates of egg deposition by spawner groups.

3. Determine the average residence time of spawners to derive a more accurate total estimate of kokanee using area.

4. Monitor temperature, water levels, intergravel dissolved oxygen concentrations, and gravel displacement during spawning and egg incubation.

5. Monitor egg mortality and development. Egg plants could be used to help determine specific causes of mortality.

6. Monitor the total production of the area to evaluate the contribution to the drainage.

7. Invesitgate the potential of future gravel placement in key areas or consider possible development of new areas.

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