EVALUATION OF SPAWNING GRAVEL PLACEMENT IN THE SWAN RIVER BELOW BIGFORK DAM - 1984-1985 SPAWN YEARS

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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

Peak counts for spawning kokanee (Oncorhynchus nerka) during the 1984 and 1985 spawn years were 800 and 1,300 fish respectively in the Swan River below Bigfork Dam. Gravel added during 1978 and 1981 to increase spawning habitat contributed little to the area due to near total removal by turbulent spring flows. Mortality of green egg plants during the 1984 spawn year increased from 65 percent during January to 91 percent in April. Egg mortality in natural redds averaged 75 percent during March and April of 1985. Suspected causes of those high mortalities include redd superimposition and egg deposition when water temperatures were below 42.5 degrees F.

INTRODUCTION

Kokanee salmon consistently migrate into the Swan River to spawn immediately below Bigfork Dam. In the past, annual concentrations of kokanee spawned in large (8-inch 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 placing 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. In 1983, salmon snagging was closed below the dam, in Flathead Lake, and in the upper Flathead river system. Sampling and evaluation of the spawning areas was continued during the 1983, 1984, and 1985 spawn years (spawn year includes the spawning, egg incubation, fry hatching, and emergence period which typically extends from September until March of the following year) as described by Rumsey (1984, 1985).

OBJECTIVES

The primary objective of this project is to estimate the relative abundance of spawning salmon below Bigfork Dam. A secondary objective will evaluate the effectiveness of gravel placed below Bigfork Dam and the environmental factors affecting population changes.

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

concrete dam was constructed in 1902, has a generation capacity of 4,150 kw, and impounds approximately 109 acre-feet of water. The dam is 12 feet high, 300 feet wide, and includes a fish ladder. The dam and powerhouse are owned and operated by PP&L of Portland, Oregon. The powerhouse is served by a mile long pipeline and controlled by headgates that have a capacity of 500 cfs. 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.

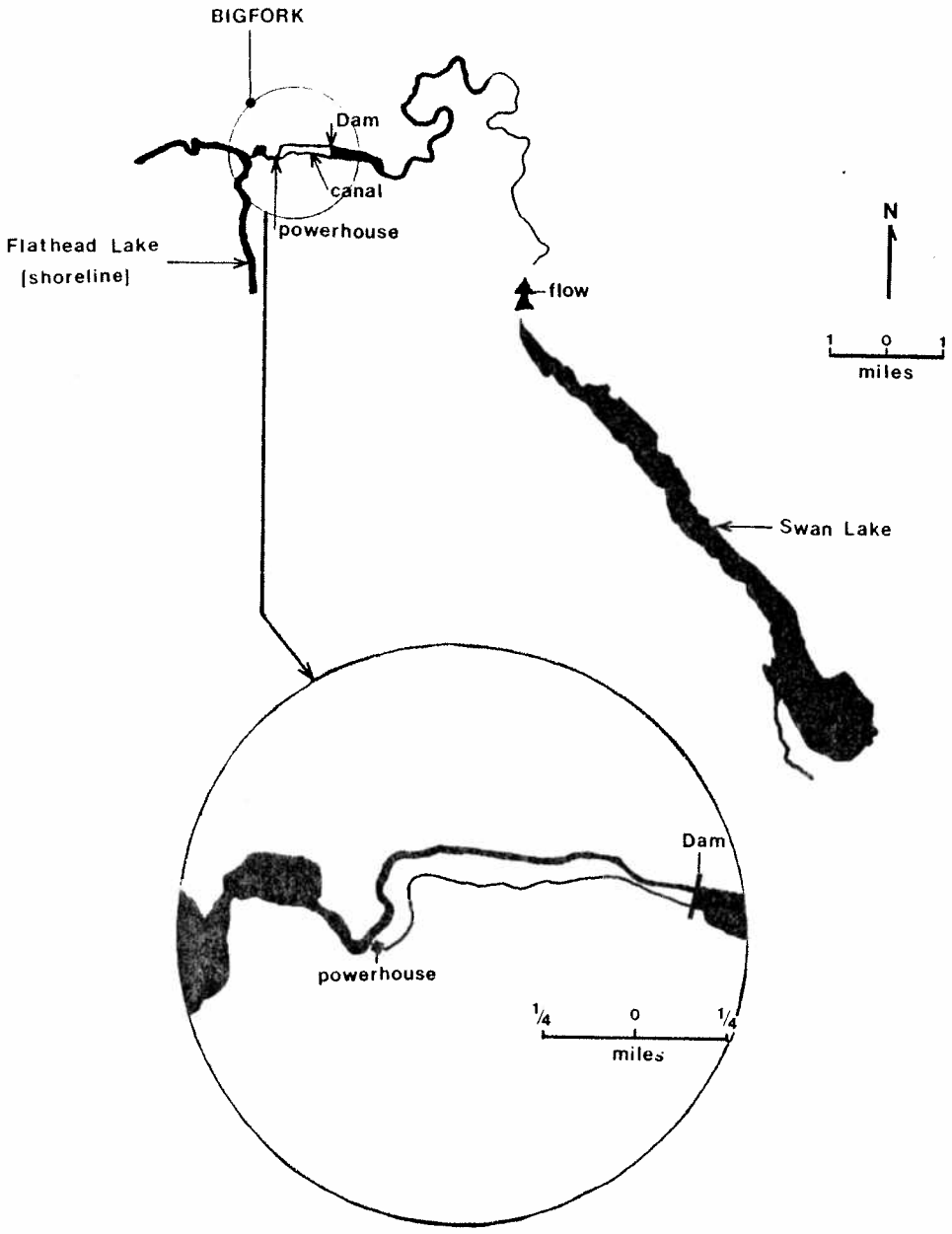

Figure 1. Project vicinity map.

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 at 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 these native trout. Use of the ladder by kokanee was also limited. Since the late 1970's, the ladder has not been manipulated during the fall because kokanee populations exist above and below the dam and passage was not a concern.

Spawning gravel was first placed below the dam in 1978 in an effort to replace bedload gravel deposition interrupted by the impoundment. Rubber-tired loaders dumped 100 cubic yards of clean, round rock with a nominal diameter of two inches directly below the sill of the dam. By 1980, the majority of the 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. In 1981, 300 cubic yards of clean 6-inch 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. Analysis of salmon redds below the dam showed that the majority of the substrate utilized for spawning ranged from 0.08 to 0.63 inches in size (Rumsey 1985).

METHODS

Kokanee Estimates

Snorkel counts of mature kokanee were made weekly from September until December during the 1984 and 1985 spawn years. Counts were conducted by two snorkelers drifting downstream, one on each 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 swim back upstream between the snorkelers. Both individuals would then count independently and compare numbers. If discrepancies between the two counters exceeded 10 percent of the total, the count was repeated. This method was adequate in Swan River during daylight because fish held in either deep runs or pools. Counts were at two locations: below Bigfork Dam and below the powerhouse, which were the major areas of fish concentration. In order for Flathead Lake kokanee to reach the spawning area below Bigfork Dam, they must pass through the powerhouse section (Figure 1).

Embryo Mortality

During the 1984 spawn year, kokanee embryo mortality was assessed through experimental egg plants and kick-net sampling of natural redds. These plants were conducted using water hardened, green eggs spawned at the site. Fifty eggs were placed in each 5" x 8" fiberglass window screen bag, and combined with a small quantity of randomly sized gravel substrate. Ten bags were placed below Bigfork Dam on 27 November and 13 December and six were placed below the powerhouse on 13 December. The bags were placed in the gravel in parallel lines in areas where kokanee were known to have spawned in previous years (Rumsey 1985). Controls were placed in the Flathead Lake Salmon Hatchery at Somers. Bags were then retrieved at random intervals and live and dead eggs counted.

Dissolved Oxygen, Water Temperatures

Dissolved oxygen measurements were made at the egg bag sites during bag placement and on sampling dates. Water for the oxygen determination was extracted 8 inches below the gravel surface with an inter-gravel water sampler (Decker-Hess and Graham 1982). During the 1984 spawn year, water temperatures immediately below the dam were continuously recorded with a Foxboro 31-day thermograph. Due to maintenance problems, thermograph use was discontinued during 1985 and random temperatures were recorded with a pocket thermometer.

Spawner Residence Time

During the 1985 spawn year, efforts were made to determine the time individual kokanee remained in the Swan River. This residence time estimate would enable more accurate estimates of total spawner numbers when fish enter and remain in an area over a prolonged period. In the Swan River fish typically begin entering the spawning area in early September and are observed through December. During this period new groups of fish periodically enter the area, as evidenced by individual fish coloration, condition, and increasing numbers.

To determine residence time below the dam, fish were tagged in the powerhouse section prior to their ascent to the spawning area, one mile upstream. Fish were collected for tagging by the use of a fyke net and boat electroshocker. Observations of both tagged fish and of residence time of fish on the spawning area were accomplished through beach seining and snorkeling. Colored floy tags and Peterson disc tags were used to mark fish with colors keyed to each marking date. Sex of tagged fish were recorded at time of capture.

Spawning Area Water Elevations

Water levels over the dam were recorded by PP&L personnel to evaluate flow conditions and the potential for dewatering of the spawning area. These measurements were vertical water elevations above the crest of the dam. A 40 cfs minimum flow is provided by PP&L under their Federal Energy Regulatory Commission license agreement.

RESULTS

Kokanee Estimates

Spawner counts during the 1984 and 1985 spawn years were first conducted during the second week of September. Final counts for both years were during the first week of December when salmon numbers declined sharply and ice formation also hampered snorkeling in 1985. Peak counts both below the dam and powerhouse during the 1984 spawn year occurred on 19 November. These two figures were then combined to estimate total spawner escapement for the areas. The total estimate for 1984 was 1,250 fish (Figure 2). The same method for the 1985 spawn year resulted in an estimate of 1,350 salmon using the area. However, the 1985 peak occurred on 21 October, nearly a month earlier than the previous year. Fish counts in the powerhouse area were very low during 1985, indicating a rapid ascent to the dam (Figure 2).

Some kokanee used the fish ladder at the dam during 1985 when higher fall flows allowed passage. During one count on 5 November, 100 kokanee were observed in the ladder. A fish tagged in Flathead Lake (from Skidoo Bay, March, 1985) was also captured during routine fish sampling at a shoreline spawning area in Swan Lake (approximately 22 miles upstream from Bigfork Dam).

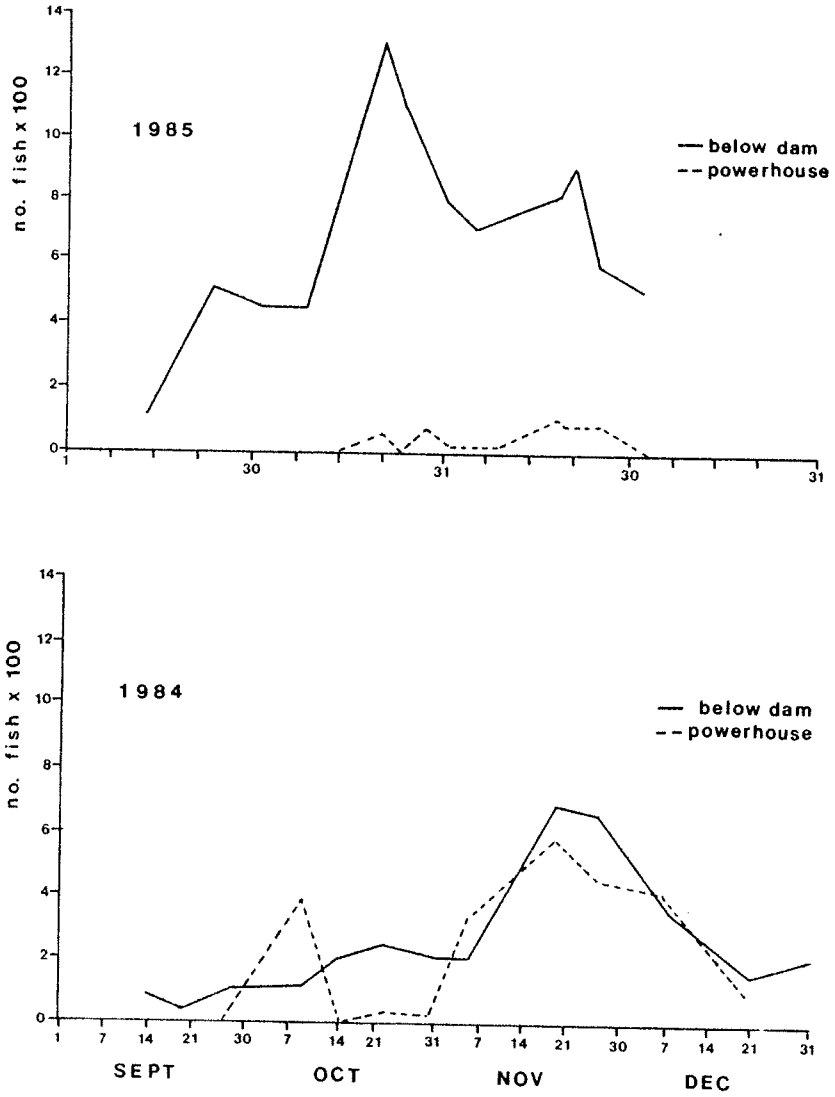

Figure 2. Swan kokanee spawner counts below Bigfork Dam and powerhouse, 1984 and 1985.

Spawner Residence Time

Fifty-two kokanee were captured, tagged, and released on three different days with four corresponding colors (33 yellow floy, 13 red floy, 2 blue floy, and 4 orange discs). On 16 October, two colors were used--red on males and blue on females. The subsequent observations of these fish are shown in Figure 3. Relatively high densities of fish in the spawning area, combined with fluctuating flow conditions from fall rains generally made tag observations difficult. Ice formation occurred in the spawning area on 2 December, concluding all snorkel observations. Due to the great fluctuation in the number and time of tag

observations, it is difficult to derive an accurate residence time estimate. An effort to develop a residence time estimate will again be attempted during the 1986 spawn year.

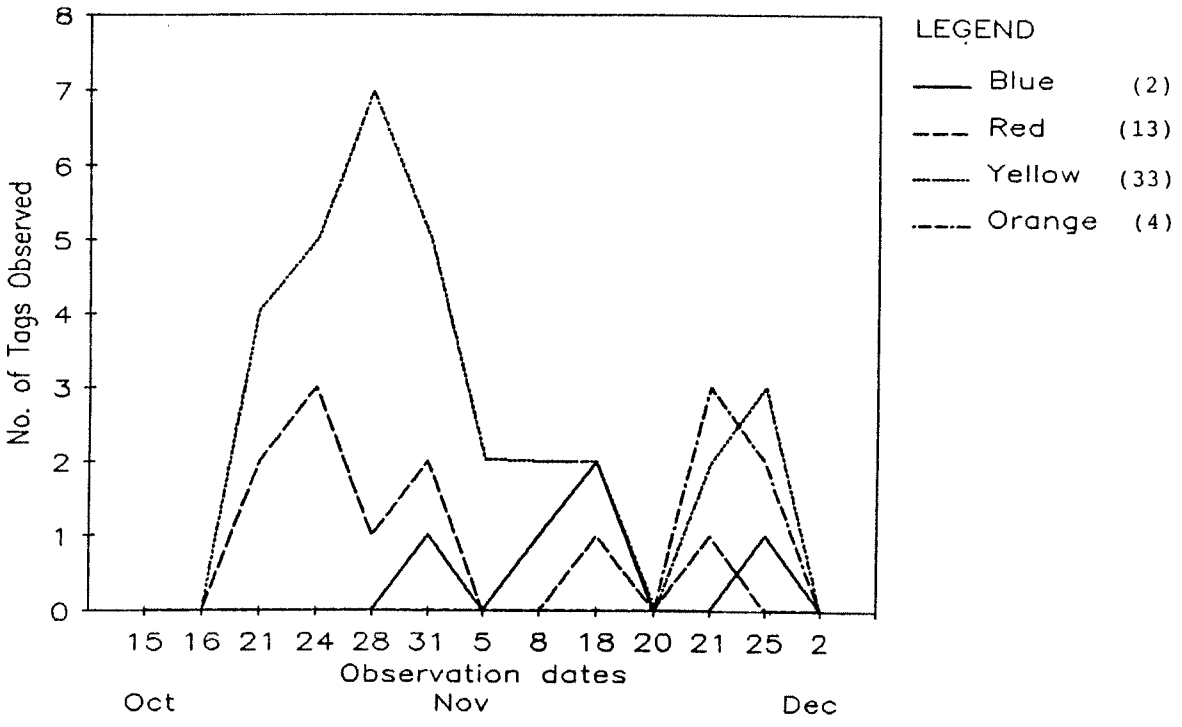

Figure 3. Tag observations on specified days immediately below Bigfork Dam during 1985. Marking dates are line origins and numbers in parenthesis indicate total number of fish marked per color. Ice formation occurred on 2 December, concluding all observations.

Embryo Mortality

Results from experimental egg bag plants below the dam during the 1984 spawn year are shown in Table 1. Eggs that were in the water for only 11 days exhibited no mortality. Once eggs reached 50 days of incubation, mortality increased to 65 percent. Eggs accumulating more than 50 incubation days consistently had mortalities of 85 percent or greater.

Table 1. Results of experimental egg plants below Bigfork Dam on the Swan River, Montana, 1984.

Plant Date	Sample Date	Percent Mortality
1st plant		
11/27	12/07	0
	01/16	65
	03/19	90
	04/08	85
2nd plant		
12/13	03/19	85
	04/08	99

Mortality of naturally spawned eggs as measured by kick net sampling below the dam was not as high as planted eggs, with maximums reaching 76 percent (Table 2). The majority of eggs sampled had reached the eyed stage of development. Lower mortality of naturally spawned eggs may be due to the decomposition of dead eggs before sampling and egg deposition during warmer river temperatures.

Table 2. Results of kick net samples below Bigfork Dam on the Swan River, Montana, 1985.

Sample Date	Live	Dead	Percent Mortality
03/19	174	562	76
04/09	102	222	69

Mortality in egg bag plants below the powerhouse exceeded 95 percent during the entire sampling period (Table 3).

Table 3. Results of experimental egg plants below PP&L powerhouse on the Swan River, Montana, 1984.

Plant Date	Sample Date	Percent Mortality
12/13	03/19	99
	04/08	96
	04/24	100

Egg bag controls at the Flathead Lake Salmon Hatchery were sampled on the same days as Swan River egg bag plants. Mortalities in these controls never exceeded 2 percent during the sampling period. Incubation water at the hatchery is spring influenced and therefore much warmer than that of the Swan River.

Dissolved Oxygen

Intergravel dissolved oxygen concentration below the dam was high enough so it should not have adversely affected the development of kokanee embryos. Concentrations ranged between 11.7 mg/1 and 14.2 mg/1 throughout the experimental egg bag sampling period.

Below the powerhouse, dissolved oxygen concentrations decreased from 8.4 mg/1 to 5.2 mg/1 for the period and may have limited embryo development. Davis (1975) established a concentration of 6.5 mg/1 and above that will protect a large portion of salmon eggs.

The oxygen concentration at the Flathead Lake Salmon Hatchery during the incubation of experimental egg bag controls was approximately 11.7 mg/1.

Water Temperature

Temperature records were plotted weekly during the 1984 spawn year. The largest concentration of fish moved upstream during the first and second week of November when temperatures were approaching 42 degrees F.

During the 1985 spawn year the major upstream migration occurred during the second week of October when temperatures declined below 50 degrees F.

Spawning Area Water Flows

Water flows below Bigfork Dam during 1984 and 1985 did not limit embryo development. The 40-cubic-foot-per-second minimum flow appears to be adequate. There is little evidence of channel margin spawning by salmon which would be affected by flow fluctuations. During spawner migration in 1984, flows remained quite constant with little contribution from fall precipitation. Upstream movement by salmon steadily increased until 19 November, the date peak counts occurred (Figure 2).

Flows were very different during the 1985 salmon run. Fall rains began during the second week of September and corresponding

river flows increased. Flows remained high and fluctuated until the third week of October and then receded until the first week of November. High flows prevailed from then for two weeks until the river stabilized in latter November. The majority of the fish moved upstream to the spawning area in late October during declines in the abnormally high river flows. Fish also did not accumulate in the lower river section (powerhouse) as in past years, but moved directly upstream to the dam.

DISCUSSION

Factors such as substrate compositions, dissolved oxygen concentrations, and flows appear more than adequate to provide good embryo development below Bigfork Dam. However, embryo mortalities have been substantial each year of the present study and also substantial when compared to results of work during the 1982, 1983, and 1984 spawn years. During these years the average overall mortality determined from kick samples of naturally spawned eggs was 89 percent, 52 percent, and 74 percent respectively (Rumsey 1984, 1985). Experimental egg bag plants in 1984 showed mortalities approaching 90 percent. Similar experiments in Flathead River spawning areas found that embryo mortality did not exceed 23 percent during 1983. High egg mortalities in the Swan River below the dam may be partially due to exposure to cold water temperatures (less than 42.5 degrees F) at time of egg deposition and early development (Combs 1965).

Redd superimposition below the dam may also contribute to the high egg mortality below the dam. Survey of available spawning gravel (Rumsey 1985) showed approximately 180m^2 of suitable habitat. Applying a mean redd density of 0.35 redds per m^2 (Fraley and McMullin 1983) of spawning gravel yields an area capacity of 63 redds. Estimating a three fish per redd ratio (Fraley and McMullin 1983) suggests that 189 spawners would suitably spawn this area. The peak 1985 count of 1,350 fish shows that fish exceeded the area optimum by nearly seven times.

Below the powerhouse in the Swan River, mortality of salmon embryos is even higher, exceeding 95 percent during egg bag sampling. Cold water temperatures, compounded by low dissolved oxygen levels, may be impacting these eggs.

The number of kokanee spawning below Bigfork Dam has averaged 1,120 fish annually over the last three-year period. It is possible that enough eggs ultimately survive in the area each year to produce this number of fish spawning below the dam. However, some fish probably come from other origins. Five, one-year old kokanee were collected in drift nets above Bigfork Dam during the spring of 1983 and 1984 (Rumsey 1984). Presumably, these fish were spawned and hatched in Swan Lake and drifted

downstream. The collection of a Flathead Lake tagged fish in Swan Lake during the fall of 1985 further supports this presumption. At the same time, some abnormally large kokanee were collected from Swan Lake. These large fish apparently reached Swan Lake by passing through the fish ladder at Bigfork Dam after leaving Flathead Lake. Kokanee spawners from Swan Lake have consistently been 4-5 inches smaller than those from Flathead Lake.

The Swan River provides genetic diversity to the spawning salmon populations of Flathead Lake. In total, its contribution to the Flathead River-Lake system averages approximately 1 percent for the period of 1979-1985.

RECOMMENDATIONS

The following are management options for maximizing fry production in the spawning area below Bigfork Dam.

1. Limit the number of spawners using the area below the dam. Two hundred to 300 fish should adequately spawn the available habitat without undue superimposition. Early spawning fish (September-October) should only be allowed entry when water temperatures are above 42.5 degrees F. This could be controlled through harvest or by blocking fish access to the spawning area.

2. Enhance spring or "off channel" areas below the dam to accommodate spawning kokanee and increase production. This may include future construction of a spawning channel.

If spawning area enhancement is undertaken, the following procedures will facilitate evaluation of the results:

1. Conduct drift netting below the spawning area to estimate total fry recruitment during spring outmigration. Netting should start in March and continue throughout the period.

2. Monitor egg mortality before and after water temperatures reach 42.5 degrees F through the use of experimental egg bag plants in the river and adjacent spring area below the dam.

3. Monitor temperature and flows of spring area adjacent to the dam during spawning and incubation period.

4. Conduct snorkel counts on a biweekly schedule to estimate total spawner escapement.

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Waters referred to: Swan River 07-4560