December 1984

EFFECTS OF THE OPERATION OF HUNGRY HORSE DAM ON THE KOKANEE FISHERY IN THE FLATHEAD RIVER SYSTEM

Annual Report 1984

DOE/BP-383

DOE/BP-383

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views of this report are the author's and do r necessarily represent the views of BPA.

This document should be cited as follows:

Fraley,John Project Biologist; Fisheries Research and Special Projects Bureau, Montana Department of Fish, Wildlife and Parks, Thomas Vogel, Project Manager, U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Contract No. DE-AI79-1983BP39641, Project No. 1981-S-5, 86 electronic pages (BPA Report DOE/BP-383)

This report and other BPA Fish and Wildlife Publications are available on the Internet at:

http://www.efw.bpa.gov/cgi-bin/efw/FW/publications.cgi

For other information on electronic documents or other printed media, contact or write to:

Bonneville Power Administration
Environment, Fish and Wildlife Division
P.O. Box 3621
905 N.E. 11th Avenue
Portland, OR 97208-3621

EFFECTS OF THE OPERATION OF HUNGRY HORSE DAM ON THE KOKANEE FISHERY IN THE FLATHEAD RIVER SYSTEM

Annual Progress Report FY 1984

By
John Fraley, Project Biologist
Fisheries Research and Special Projects Bureau
Montana Department of Fish, Wildlife and Parks
Kalispell, Montana 59901

Prepared for

Thomas Vogel, Project Manager

U.S. Department of Energy

Bonneville Power Administration

Division of Fish and Wildlife

Contract No. DE-AI79-83BP39641
Project No. 81-S-5

December 1984

EXECUTIVE SUMMARY

This study was undertaken to assess the effects of the operation of Hungry Horse Dam on the kokanee fishery in the Flathead River system. Studies concerning operation of the dam on Flathead River fisheries began in 1979 and continued to 1982 under Bureau of Reclamation funding. Studies concerned specifically with kokanee salmon continued under Bonneville Power Administration funding in 1982. This annual report covers the 1983-84 field season concerning the effects of Hungry Horse operations on kokanee abundance and reproductive success in the upper Flathead River system. This report also addresses the projected recovery of the main stem kokanee run under the flow regime recommended by the Department of Fish, Wildlife and Parks and implemented by the Bureau of Reclamation and Bonneville Power Administration in 1982.

An estimated 58,775 kokanee reached spawning grounds in the FlatheadRiver Systemin1983. Anaverage of 70,528 kokanee have reached Flathead River system spawning grounds annually over the past five years. An estimated 16,279 kokanee spawned in the main stem Flathead River during 1983, which is the second largest run of any of the last five years. The South Fork of the Flathead supported a very strong spawning run of 5,170 fish. An estimated 1,688 kokanee spawned in the Whitefish River. A trend count of 34,306 spawners was recorded for McDonald Creek.

The length of kokanee in the Flathead system is dependanton the density of the population, so length is a measure of year class strength. Relationships of year class strength and past flow conditions in the main stem were highly significant from 1966-83 ($r=0.93$, $p<.001$). The predicted length of 1983 female spawners from this relationship (363 mm) agreed closely with the actual length of females in the 1983 spawning run (364 mm), demonstrating the strength of the relationship. The 1983 spawning run was composed of 92% age III+ fish, as compared to an average of 80% from 1972-1983.

A total of 6,883 kokanee redds were enumerated in the main stem FlatheadRiver in1983. The timing of spawning was earlier than in previous years of the study, resulting in the dewatering of 857 redds, which were constructed before controlled flows went into effect on15 October.

At Brenneman's slough spawning area, 314 kokanee constructed 174 redds, yielding a ratio of 1.80 fish per redd. The average spawner-redd ratio over the two years this has been studied is 2.4 fish per completed redd. A substantial portion of kokanee spawning occurred in daytime spawning study areas in 1983. Daytime redd construction and egg deposition averaged 26%, with 74% occurring in the night areas.

Atotalof 2,366 man-days of angling pressure was estimated during the 1983 kokanee lure fishery in the Flathead River system.

Anglers harvested an estimated 4,234 kokanee (7% of the spawning run) at a catch rate of 0.61 fish per hour. Most of the harvest occurred in September, and most anglers interviewed were from FlatheadCounty.

Estimated numbers of fry emigrating from McDonald Creek, the Whitefish River and Brenneman's Slough were 13,100,000, 66,254 and 37,198, yielding egg to fry survival rates of 76%, 10.4% and 19.2%. Egg to fry survival rates calculated for eyed eggs planted in two main stem spawning areas averaged 48%.

Kokanee fry movement experiments indicated that fry move rapidly downstream through the river system during nighttime periods after emigrating from McDonald Creek. During lower flow periods most fry reach the Flathead River near Kalispell (55 km downstream) during the second night of travel. During moderate flow levels in early May, fry from McDonald Creek reached Kalispell in one night of travel and passed into Flathead Lake (100 km downstream) from McDonald Creek during their third night of travel.

Timing of the recovery of the main stem kokanee run will be affected by fluctuations in natural reproductive success. Average conditions are estimated to be 20% egg to fry survival, 2.0% fry to adult return, and a l0%-50% shifting harvest rate after the population reaches 50,000 fish. Under these conditions the population would recover to a fishable level by 1993 and to levels approaching the management goal shortly after the year 2000.

ACKNOWLEDGEMENTS

Steve McMullin was the project leader and provided valuable guidance throughout the study. Patrick Graham was the overall supervisor of fisheries research in Montana. Jon Cavigli and Mark Gaub have been invaluable during field activities, data summation, figure preparation and manuscript preparation and review over the past four years. Their efforts are greatly appreciated. Paul Suek did an excellent job during field activities and data summation. Mike Aderhold, Pat Graham, and Elinor Pulcini assisted in the field. Thanks are extended to the Flathead Lake contract kokanee crew for cooperation throughout the study.

Laney Hanzel, Scott Rumsey, Jim Vashro, Bob Domrose, Joe Huston and Gary Anderson of the regional fisheries staff provided eguipment, information and guidance, and critically reviewed the manuscript.

Personnel of the U.S. Park Service were very helpful throughout the study. Thanks are extended to Gary Gregory, Bill Michels, Riley McClelland, Dave Lange, Leo Marnell, Oak Blair, Ellen Seeley and JoeDecker. Ed Blank and Ray Weinberg of the U.S. Geological Survey provided valuable assistance and information. Private landowners in the drainage who have generously cooperated throughout the study include Tom Siderius, Bob and Betty Rose, John Dalimata, Gordon Pouliot and Clifford Brenneman.

Personnel of the Bonneville Power Administration were particularly helpful. Tom Vogel made helpful suggestions in manuscript preparation and critically reviewed the report. Roger Larson of the Bureau of Reclamation performed computer analysis critical in the projection of the main stem kokanee population recovery. Rich Clark and Dick Taylor of the Bureau of Reclamation at Hungry Horse provided flow information and generous cooperation.

Janice Pisano and Jean Blair typed the manuscript.

This study was funded by the Bonneville Power Administration.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Kokanee salmon (*Oncorhynchus nerka*) were first introduced to the Flathead system in 1916 (Montana Fish and Game Commission 1918, Alvord1975) and a thriving kokanee fishery had developed by the early 1930's in Flathead Lake. Kokanee became the most popular gamefish in the drainage, supporting a summer trolling fishery in Flathead Lake and until 1983, an intense fall snagging fishery in the Flathead River system. Kokanee comprised about 90 percent of the total harvest of 719,000 fish in the Flathead Lake-River system during the 1981-82 season (Graham and Fredenberg 1982, Fredenberg and Graham 1982). Over 80 percent of the gamefish harvested in 1975 were kokanee salmon (Hanzel 1977). Anglers from most of the western United States, Alberta and British Columbia have taken part in the Flathead Lake trolling and river snagging fisheries. The river snag fishery was closed in 1983 to protect the reduced spawning population.

Hungry Horse Dam was constructed on the South Fork of the Flathead River from 1948-1953. Located 8 km upstream from the mouth of the South Fork, the dam is operated primarily for flood control and hydroelectric energy production. Electrical energy produced from the operation of Hungry Horse is marketed by BPA. Penstocks are located 75 m below the crest. At present peak capacity, the powerhouse produces 328 Megawatts at a rated flow capacity of 11,417 cfs. Operation of Hungry Horse is determined in concert with the complex network of electricalenergyproducing systems, water consumption needs, and flood control requirements throughout the Pacific Northwest. Water leaving Hungry Horse passes through 19 dams before reaching the Pacific Ocean.

Kokanee spawning in the South Fork and main stem have been affected by operation of Hungry Horse Dam. Kokanee spawn in shallow areas with moderate water velocities. In large rivers like the Flathead, kokanee spawn primarily along stream margins and in side channels. Vertical water level fluctuations of over two meters in the South Fork and up to 1.4 m in the main stem have resulted in alternate wetting and dewatering of eggs when flows were high during the spawning season and low during the incubation season. Eggs deposited in spawning gravels which are dewatered are subject to dessication and freezing mortality. Dewatering of kokanee spawning beds was first recognized in the mid 1970's (Domrose 1975). Heavy incubation mortality resulting from de-watering has probably been the most important factor affecting year class strength in Flathead kokanee (Graham et al. 1980, McMullin and Graham 1981, Fraley and Graham 1982, Fraley and McMullin 1983). The main stem kokanee spawning run has declined from an estimated post-harvest level of over 150,000 fish in 1975 to an average of 9,400 fish during the last five years (Fraley and Graham 1982, Hanzel 1977). The spawning run from 1979-1983 is less than 10% of the management goal, represented by the 1975 run.

Studies conducted by Department of Fish, Wildlife and Parks from 1979 to 1982 under Bureau of Reclamation funding, have resulted in flow recommendations for the main stem of 3500-4500 cfs during the kokanee spawning period (15 October -15 December) and 3500 cfs or more during the remainder of the year (Fraley and Graham 1982). Montana Department of Fish, Wildlife and Parks studies continued under Bonneville Power Administration funding in 1982 and1983 with major emphasis on finetuningthe flow recommendations in the main stem Flathead River, monitoring their effect on kokanee reproduction and recommending management strategies to bring about the recovery of the main stem kokanee spawning population. Major objectives of the study are:

1. Continue to develop the stock recruitment relationship begun in 1979 for kokanee in the river system (Graham et al. 1980b).

2. Quantify effects of the amount and timing of controlled flows on distribution and reproductive success of kokanee in the reregulated portion of the Flathead River. Determine the relative contributions of day and nighttime spawning.

3. Determine relative contributions of major river system spawning areastototalkokanee population.

4. Identify timing and destination of successive runs of kokanee spawners in the Flathead River and their use by fishermen, and determine if timing is affected by discharge from Hungry Horse Dam.

DESCRIPTION OF STUDY AREA

The Flathead River, which drains 21,876 km^2 of southeast British Columbia and northwest Montana, is the northeastern most drainage in the Columbia River basin (Figure l). Three forks of approximately equal size drain the west slope of the Continental Divide.

Kokanee salmon, westslope cutthroat (*Salmo clarki*) and bull trout (*Salvelinus confluentus*) arethethree major sport fish in the Flathead River (Hanzel 1977). Cutthroat and bull trout are native to the Flathead, but kokanee were introduced. In 1916, 500,000 chinook salmon eggs obtained from the Oregon Fish Commission were reared in the Flathead Lake Hatchery and the fry were stocked in several area lakes (Montana Fish and Game Commission 1918). In subsequent years, mature kokanee salmon or "redfish" were netted in Lake Mary Ronan and Flathead Lake: apparently they had been mixed in with the chinook salmon eggs. Kokanee populations became established in Flathead Lake and continued to grow. By 1933, a kokanee trolling fishery was underway on Flathead Lake. That fall an estimated catch of 100 tons of

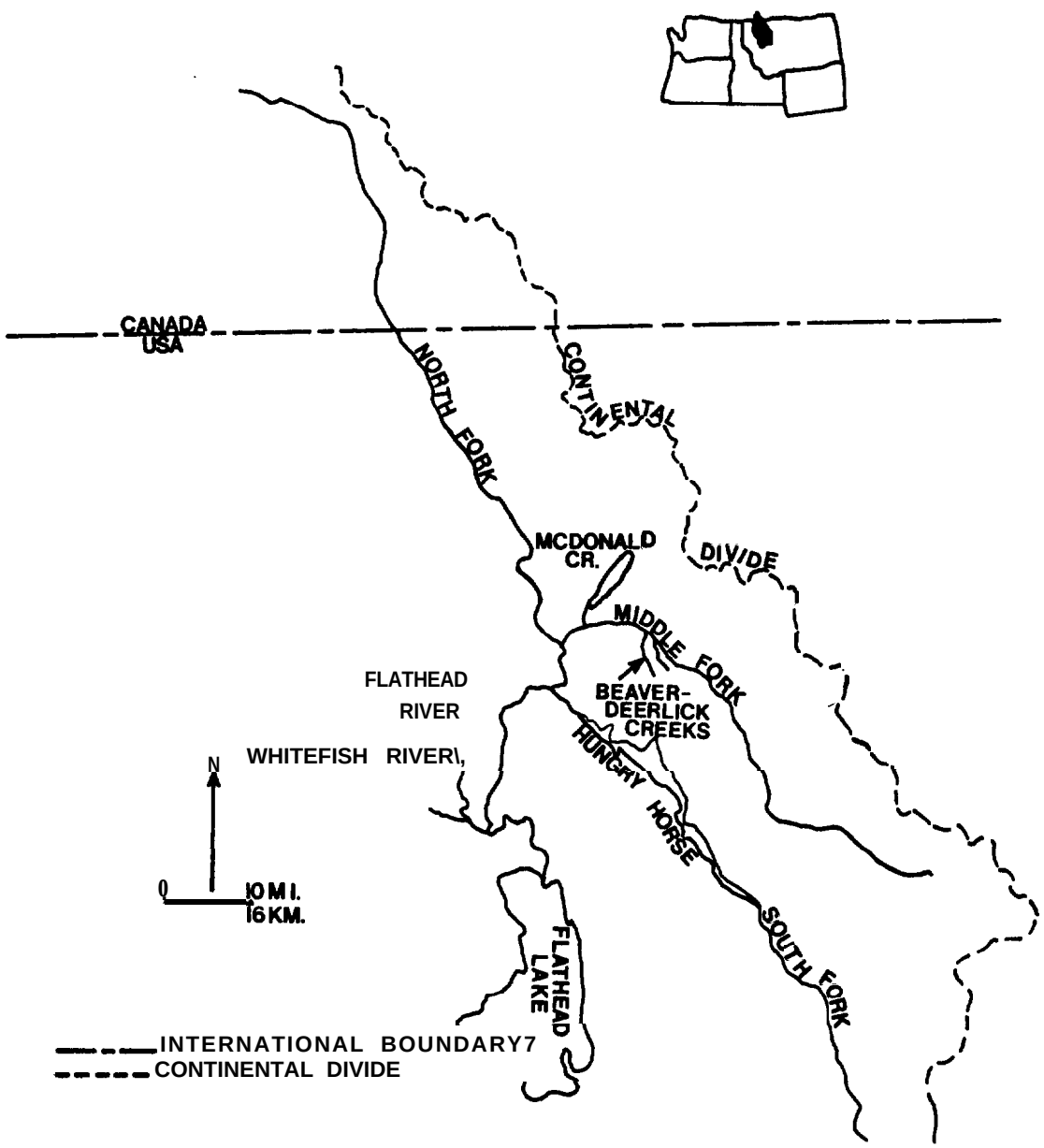

Figure 1. The upper Flathead drainage.

kokanee was canned for the Montana Relief Commission. Thousands of kokanee were spawning alongtheshores of FlatheadLake and runs were ascending the Flathead River System (Alvord 1975, Montana Fish and Game Commission 1934).

By the late 1930's, a run of kokanee had become established in McDonald Creek (Fish and Wildlife Service 1968) and probably in the Whitefish River and spring areas in the main stem Flathead River. The kokanee population in the main stem continued to grow from the 1960's through the early 1970's. This growth was partly associated with flow patterns and modified temperatures of water discharged from Hungry Horse Dam. During the mid-1960's, local residents first noticed large numbers of kokanee in Beaver and Deerlick creeks in the Middle Fork drainage. Department personnel first observed kokanee spawning in the Middle Fork of the Flathead River from McDonald Creek upstream to the mouth of Deerlick Creek in 1981.

Other fish species commonly found in the Flathead River include rainbow trout (**Salmogairdneri**), mountain whitefish (**Prosopium williamsoni**) and largescale sucker (**Catostomus macrocheilus**) Several other species encountered less frequently include brook trout (**Salvelinus fontinalis**), Yellowstone cutthroat trout (**Salmo clarki bouvieri**), lake trout (**Salvelinus namaycush**), lakewhitefish (**Coregonus clupeaformis**), pygmy whitefish (**Prosopium coulteri**) and northern squawfish (**Ptychocheilus oregonensis**) Several m&e species are known to be present in the drainage, but are rarely encountered in the Flathead River.

METHODS

ADULT KOKANEE MIGRATION AND ABUNDANCE

Migration and abundance of kokanee spawners were monitored by snorkeling, aerial census, fisherman tag returns of marked fish, and redd counts. Kokanee were observed by snorkeling in the North and Middle Fork drainages. Aerial census was the major method used in determining spawner distribution in the main stem Flathead and lower Middle Fork.

Snorkeling surveys were conducted in selected areas of the Middle Fork above McDonald Creek in late September and the North Fork from Kintla Creek to Canyon Creek in early October, 1983. Snorkeling counts were made on the entire length of McDonald Creek six times between early September and mid-November, 1983. Two observers snorkeled downstream and forced kokanee schools upstream between them. Each observer reported a count to a data recorder following behind in a canoe. The two counts represented the high and low range for each school of fish.

Aerial counts of kokanee spawners were made as part of a fisherman census on the Flathead River from Flathead Lake upstream

to the confluence of the North and Middle Forks. These aerial counts were also made on the Middle Fork below West Glacier. A small plane carried the observer at an elevation of approximately 150 m over the river channel and counts were made by estimating the size of schools of adult spawners. The counts were made approximately three times weekly from 28 August to 15 October 1983. Other researchers have successfully used aerial counting methods to enumerate salmon. Gibson (1973), Neilson and Geen (1981) and Church and Nelson (1963).

Kokanee spawner abundance was estimated from redd counts in all segments of the river system except McDonald Creek, where redds were too dense to be enumerated individually. Abundance was estimated by multiplying redd counts by an average figure of 2.4 spawners per completed redd. This ratio was determined by comparisons of trap counts of spawners and redd counts in confined areas in 1982 and1983. Areas trapped included a main stem spring site and Beaver Creek.

CENSUS OF THE RIVER SYSTEM KOKANEE FISHERY

A survey of the kokanee fishery was conducted on sections MSl-MS4 of the main stem Flathead River and section MFl of the Middle Fork of the Flathead River from 28 August through 15 October, 1982 (Table 1, Figure 2). The purpose of the survey was to determine catch rates, fishing pressure, harvest, and other information concerning the lure fishery for kokanee salmon in the main stem and Middle Fork from late August through early October.

The fishery or creel census design was a modification of the method described by Neuhold and Lu (1957) and used by Fredenberg and Graham (1982). A complete description of the methods is given in the 1983 annual report.

SPAWNING SITE INVENTORY

An inventory of spawning sites or redds was conducted in five major spawning areas in the Flathead River system, including the main stem Flathead (Figure 2), Middle Fork of the Flathead, Beaver-Deerlick Creeks, Whitefish River and South Fork of the Flathead The inventories were made when spawning was considered at least 90 percent completed in each area, as indicated by the presence of spawners.

Spawning and incubation flows in the Flathead River below the South Fork were provided during the 1983 water year through agreement with the Bureau of Reclamation and the Bonneville Power Administration, as recommendedtothe Northwest Power Planning Council by the Department of Fish, Wildlife and Parks. Spawning

Table 1. Description of angler survey sections on the mainstem Flathead and Middle Fork of the Flathead River.

Description	River section	Section length km	Section length Miles
Flathead River – Flathead Lake to confluence of Stillwater River	MS1	36.0	22.4
Flathead River – Mouth of Stillwater River to Pressentine Fishing Access	MS2	19.0	11.8
Flathead River – Pressentine Access to Highway 40 Bridge at Columbia Falls	MS3	10.6	6.6
Flathead River – State Highway 40 Bridge to confluence of North and Middle Forks	MS4	23.3	14.5
Middle Fork of Flathead – Confluence of North Fork to confluence of Harrison Creek	MF1	21.7	13.5

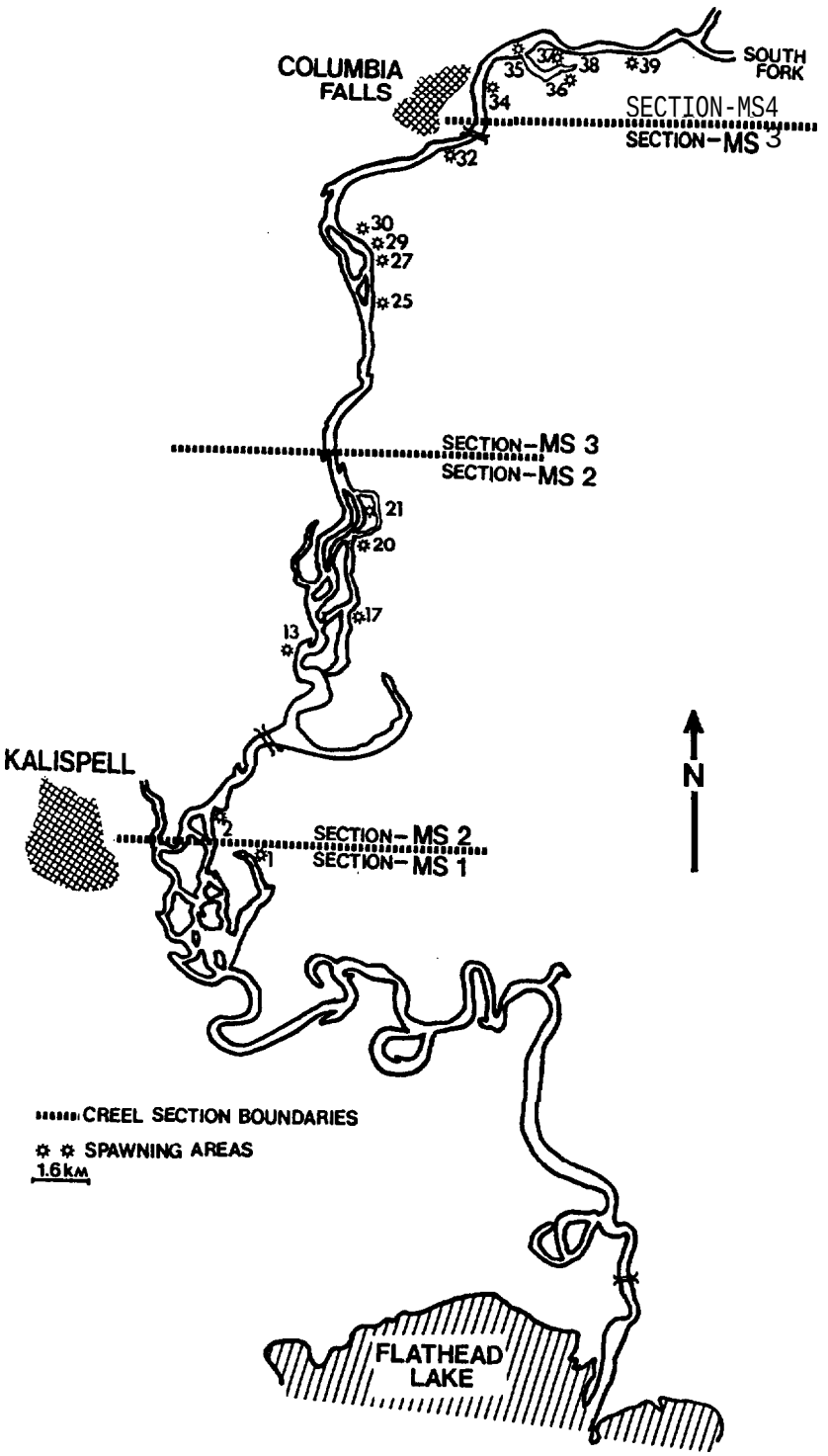

Fig. 2. Map of major kokanee spawning areas and creel survey sections on the Flathead River.

flows of 3,500 to 4,500 cfs (at Columbia Falls) were maintained from 15 October to 15 December. Aminimum flow of 3,500 cfs was maintained from 16 December to 30 April..

Kokanee redd counts were made in mid-October and early and late November in the Flathead River below the South Fork. All areas which had suitable spawning gravel were checked from a jet boat or by wading.

Surveys of spawning activity in McDonald Creek were made while snorkeling from September to November, 1983. Actual counts of redds were not made due to the density of spawners and redd superimposition.

Kokanee redd counts were made in the Middle Fork of the Flathead River above McDonald Creek on 1 November 1983. The Middle Fork below McDonald Creek was surveyedon 20Gctober. Reddcounts were made in both Beaver and Deerlick Creeks on 5 December. The Whitefish River was surveyed for kokanee redds on 24 and 25 October. Redds were countedinthe South Fork of the Flathead on 7November.

Fish traps to enumerate kokanee spawners were placed in Brenneman's Slough (main stem area l), Columbia Falls Slough (main stem area 36), Beaver Creek, and Deerlick Creek. Numbers of spawners enteringtheseareas were compared with the numbers of redds constructed.

Areas of gravel in four main stem kokanee spawning areas, McDonald Creek and Beaver Creek were selected for die1 spawning studies. In areas where sufficient spawners were present, areas of gravel were alternately covered and uncovered during day and night periods. Redd construction and egg deposition were compared in areas available for daytime and nighttime kokanee spawning. Behavioral observations were also made throughout the spawning period in these areas.

EGG INCUBATION AND ALEVIN DEVELOPMENT

Survival and development of kokanee eggs and sac fry alevins was monitored in natural redds throughout the winter in the Flathead River to evaluate the effects of the requested spawning and incubation flows. A hydraulic egg sampler (Graham et al. 1980, McNeil 1963) and kick net were used to sample natural redds.

Survival and development of eggs and alevins were also monitored at spawning areas in the Middle Fork Flathead River, McDonald Creek and the Whitefish River. Two areas of the Middle Fork, one below and one above McDonald Creek, were sampled with the kick net. A 2 km portion of McDonald Creek was sampled with the hydraulic egg sampler and kick net to estimate the density of live eyed eggs and sac fry alevins in the gravel.

Egg to fry survival was monitored for experimental kokanee egg plants at main stem area 13, a spring influenced site near Lybecks Dike, and main stem area 2, a side channel area below Kalispell (Figure 2). These areas were selected for experimental recovery plants because they had been high quality spawning areas in the past, but had been virtually unused by kokanee from 1979-1983. Two methods of planting eggs were tested; wire mesh planting boxes and artificial redds, each supplied with 1000 eggs. Both green and eyed eggs were planted for comparison purposes. Survival in sample redds and boxes was checked monthly. Egg mortality rates for each month until hatching were added for total mortality.

STREAMFLOW — KOKANEE LENGTH RELATIONSHIPS

Relationships between year class strength of kokanee spawners and flows during the spawning and incubation seasons which produced them were analyzed (McMullin and Graham 1981). Length of kokanee spawners was used as the measure of year class strength, assuming fish size was inversely related to fish numbers in Flathead Lake. Other workers have reported this density dependent relationship in sockeye salmon populations (Foerster 1944, Johnson 1965, Goodlad 1974, Stober etal.1978).

The majority of kokanee spawners entering the river system in a particular year are of one age class (Hanzel 1976). However, interactions with other year classes of kokanee can affect their growth. To account for year class interactions, a three-year moving average of flow conditions was used in the calculations (Graham et al. 1980, McMullin and Graham 1981).

FRY EMERGENCE AND MIGRATION

Timing and abundance of emerging fry were evaluated using 0.5 m^2 drift nets suspended in the water column and fry emergence traps placed over the spawning gravel.

Drift nets were used in all river system spawning areas to filter swimming fry from the water column (Fraley and Graham 1982). A fry holding box (Figure 3) was added during 1984 to reduce fry mortality in some areas. Net sets were made weekly from January to mid-June in McDonald Creek. In Brenneman's Slough, samples were takenfrom February to mid-June. Sets were made in the Middle Fork of the Flathead near West Glacier and the main stem near Kalispell from March through May. The Whitefish River was sampled from March to June.

Drift nets were suspended in the water column overnight at each area. Fry were counted, the volume of water filtered by the net was calculated and a total estimate of fry emigration from each area was obtained. These data were used to estimate production and

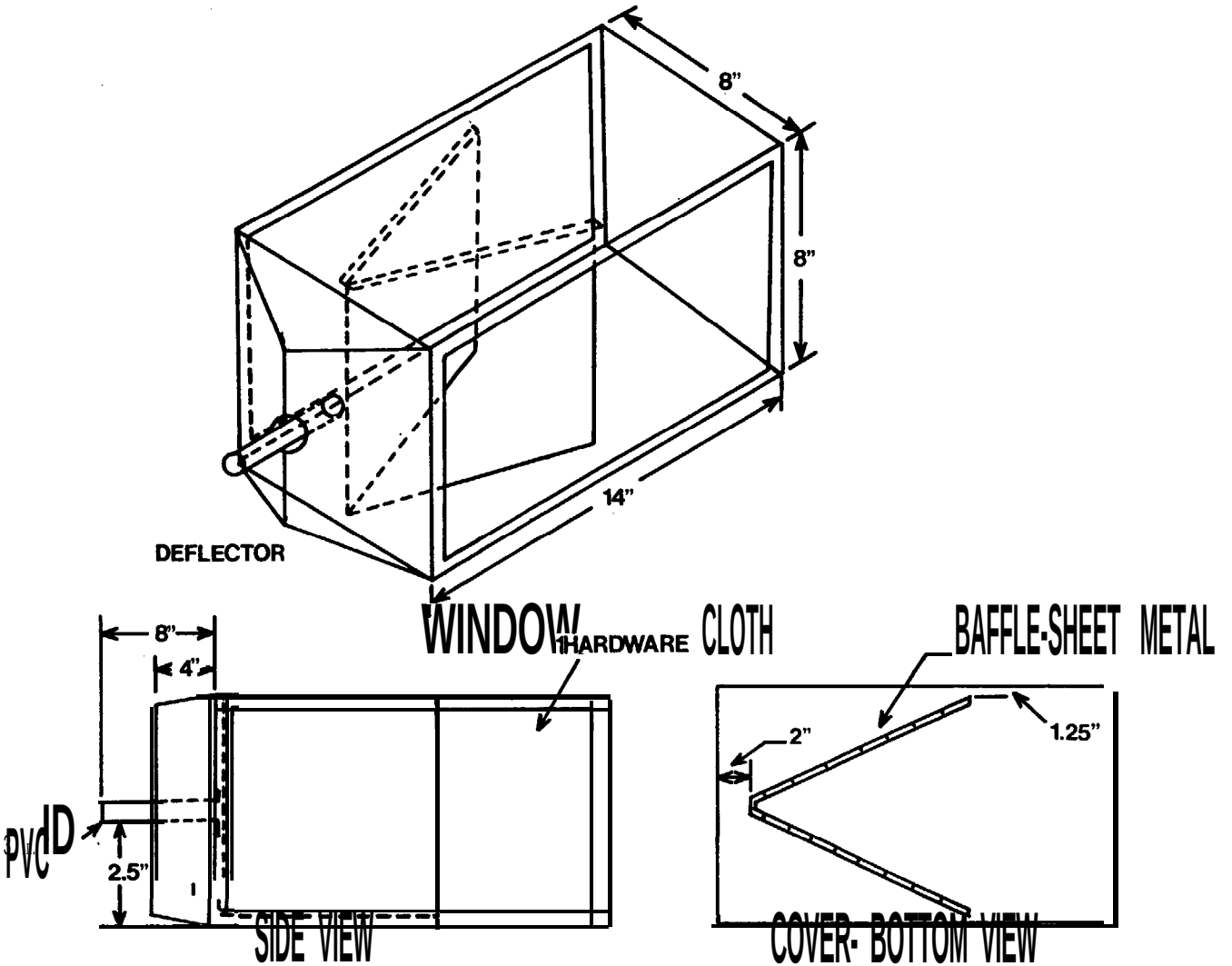

Fig. 3. Fry holding box for drift net. Construction is ½ inch plywood with 1/8 inch hardware cloth windows which were given several coats of paint to reduce mesh size. Hinged top is made of ½ inch plywood, baffle and deflector are sheet metal.

egg to frysurvivalrates from each area. Distribution of fry in the water column was evaluated in overnight experiments using drift nets distributed laterally and vertically in the water column in McDonald Creek.

Two experiments were conducted to monitor fry movements in the river system. Twogroups of fry were captured in McDonald Creek and dyed with Bismark Brown stainata concentration of 1:30,000 (Ward and VerHoeven 1963). Movements of these fry were followed by setting drift nets at the junction of the Middle and Worth Forks of the Flathead River near Blankenship Bridge (8 km downstream), the main stem Flathead River at the County Bridge below Columbia Falls (34 km downstream) the Old Steel Bridge near Kalispell (55 km downstream); and the Sportsman Bridge near Flathead Lake(94 km downstream).

Fry emergence traps (0.12 m^2) were placed in river system spawning areas to help determine emergence timing and abundance of kokanee fry (Fraley and Graham 1982). Phillips and Koski (1969) used similar traps in Oregon river systems to capture salmonid fry. The traps consisted of a nylon net and metal frame with a nylon sock and plastic collecting bucket to capture emerging fry. Frames were attached to the stream bottom with rebar. Ten traps were placed in main stem spawning areas, four were placed in McDonald Creek, and two were placed in the Whitefish River.

RECOVERY OF THE MAINSTEM KOKANEE POPULATION

To project the recovery of the main stem kokanee population, an egg to fry survival rate of 20 percent and various fry to adult survival rates were assumed. A 20 percent overlap of the previous kokanee year class was assumed and the number of returning kokanee spawners was projected for each year from 1983 to 2033. A computer program whichincorporatedtheabove assumptions was writtenby Roger Larson of the Bureau of Reclamation incooperation with the Department of Fish, Wildlife and Parks. The program was calibrated with kokanee escapement estimates made from 1979-1983.

RESULTS AND DISCUSSION

KOKANEE ABUNDANCE AND MIGRATION

Kokanee Abundance

One of the major objectives of the study was the assessment of the relative contribution of various river system segments to total kokanee recruitment to the Flathead Lake population. Monitoring the abundance of kokanee in areas unaffected by Hungry Horse discharges such as McDonald Creek, the Middle Fork of the Flathead River, Beaver Creek, Deerlick Creek, the Whitefish River, and main stem spring areas provides a reference to monitor natural fluc-

tuations in kokanee populations. An estimated 58,775 kokanee spawned in all segments of the Flathead River system in 1983 (Table 2). based on snorkel counts and redd counts.

Mainstem Flathead River

An estimated 16,279 kokanee spawned in the main stem Flathead River in1983, assuming 2.4 kokanee per completed redd (Table 2). More kokanee spawned in the main stem in1983 than inanyyear of the study except 1981.

McDonald Creek

A mean snorkeling trend count of 34,306 kokanee was obtained in lower McDonald Creek on 5 October 1983 (Table 3). Kokanee numbers dropped during later counts, indicating peak kokanee migrationand spawning occurred earlier than in previous years of the study (Table 3). Spawning had begun by mid-September and was virtually completed before 16 November when only 396 live kokanee were present. The total number of kokanee spawning in lower McDonald Creek in 1983 was probably nearer the upper range of the trend count (38,000-40,000) because of turnover of spawners before and after the peak trend count.

Kokanee spawned in upper McDonald Creek (above McDonald Lake) during 1983, as 2,100-2,500 fish were counted on 2 November. It is not known whether these fish were from Flathead Lake, or from a population existing in McDonald Lake. The kokanee in upper McDonald Creek averaged 15mm larger than fish collected from lower McDonald Creek.

Middle Fork of the Flathead

An estimated 1,330 kokanee spawned in the Middle Fork of the Flathead River during 1983 (Table 2), based on redd counts of 120 above McDonald Creek and 434 below McDonald Creek (Appendix A). Snorkel counts of spawners in the Middle Fork below McDonald Creek indicated large numbers of kokanee bound for McDonald Creek were not holding in this river section as they had in previous years. There was virtually no spawning run into Beaver or Deer-lick Creeks in the upper Middle Fork drainage; only one redd was constructed in the lower portion of Deerlick Creek. This compares to a count of 718 redds in Beaver and Deerlick Creeks in 1981, and 42 redds in 1982.

WitefishRiver

An estimate of 1,272 kokanee spawnedinthe Whitefish River above Rose Crossing (Table 2) based on a redd count of 530,

Table 2.. Estimated numbers of post-harvest kokanee spawners in the Flathead River system, 1979-1983. The percent contribution for each area is in parentheses.

Year	McDonald Creek[1]	Mainstem Flathead R.[2]	Whitefish River[2]	South Fork Flathead R.[2]	Beaver-Deerlick Creeks[2]	Middle Fork Flathead R.	Total
1979	65,000 (90)	6,785 (10)	---	--[3]	0	---[3]	**71,785**
1980	49,500 (96)	1,121 (2)	1,022 (2)	---[3]	---[3]	---[3]	**51,643**
1981	103,500 (79)	19,073 (15)	988 (<1)	720 (<1)	1,723 (1)	5,520 (4)	131,534
1982	30,965 (80)	3,720 (10)	1,836 (5)	480 (1)	101 (<1)	1,802 (4)	38,904
1983	34,306 (59)	16,279 (28)	1,272 (3)	5,170 (9)	2 (<1)	1,330 (2)	58,775

1 Mean snorkel count of spawners.
2 **Estimated by multiplying redd counts by 2.4.**
3 **No count.**

Table 3. Snorkel counts of kokanee in McDonald Creek during 1983.

Date	Number of kokanee				Total mean
	Low count	High count	Mean (live)	Dead	
9/7/83	4,845	6,390	5,618	0	5,618
9/21/83	11,092	12,677	11,885	10	11,895
10/5/83	30 ,360	37,995	34,178	128	34 ,306
10/19/83	22,327	25,427	23,877	2,213	26,090
11/2/83	6,370	7,540	6,955	2,870	9,825
11/16/83	377	414	396	---[1]	396

1 **No count due to decomposition.**

(Appendix A). An estimated 326 kokanee spawned in the whitefish River below Rose Crossing. An additional90 spawners were estimated based on a redd count of 37 in the Stillwater River from the confluence of the Whitefish River to Conrad Drive.

South Fork of the Flathead

The South Fork of the Flathead supported a spawning run of 5,170 kokanee (Table 2) based on a count of 2,154 redds (Appendix A). The number of spawners in the South Fork in 1983 was nearly ten times greater than in 1981 or 1982. It is possible that some straying occurred into the South Fork from other river system segments.

Kokanee Migration

The rate of migration and distribution of kokanee spawners may be influenced by river discharge and temperature and may affect the recreation potential of the fishery. Aerial counts of kokanee aided in the assessment of the migration patterns in the river system.

The timing of kokanee migration in the Flathead River in 1983 was about one week earlier than in previous years, as 23 individual schools of fish were observed in an aerial count on 31 August (Figure 4). One school was observed as far upstream as the Middle Fork of the Flathead River, 3 miles below McDonald Creek.

Few kokanee were observed during aerial counts in main stem Section MSl, partly because of water depth. However, the low numbers of fish observed and limited angler success indicated kokanee were not holding in large numbers in this river section. Low numbers of kokanee were seen periodically in aerial counts from late August to mid-October in river section MS2, reflecting periodic upstream migration through this river section. No spawning occurred in Section MS2 in 1983. Electrofishing surveys in this section near Kalispell confirmed the fact that no large numbers of kokanee held in this area of the river during 1983.

Aerial kokanee counts were greater in Section MS3, reflecting upstream movement and moderate numbers of kokanee spawning in this section. Counts were relatively high in main stem Section MS4. Large numbers of kokanee spawned in this section, and migrating kokanee bound for McDonald Creek periodically held in the area. Kokanee numbers peaked in late September. In general, larger numbers of kokanee were observed in the main stem throughout the 1983 spawning and migration period than were observed in 1982, reflecting the stronger 1983 year class. Good survival conditions and lower fishing limits for this year class are probable reasons for the increase in spawner numbers.

Aerial counts of kokanee peaked in mid-September and mid-

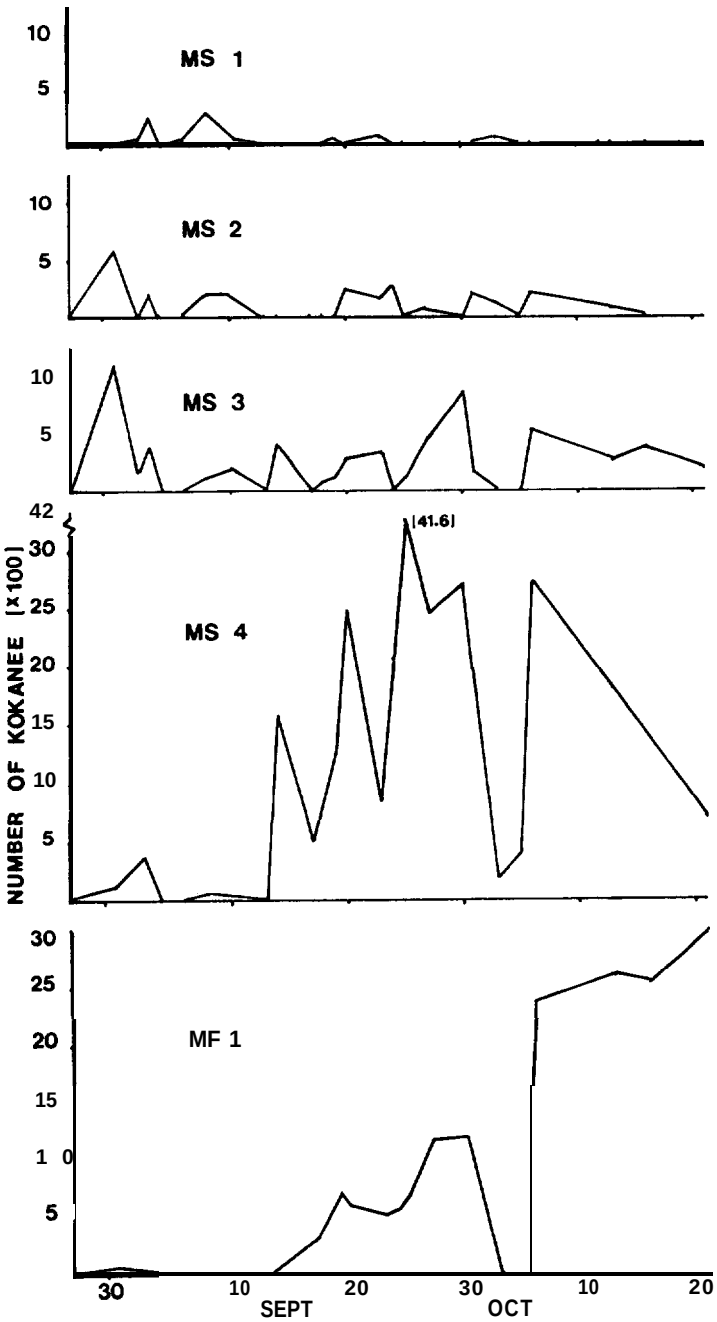

Fig. 4. Aerial counts of Kokanee spawners in sections of the mainstem and Middle Fork of the Flathead River, 1983.

October in the Middle Fork of the Flathead below McDonald Creek (Figure 4). The earlier peak probably represented spawners staging to move into McDonald Creek. The later peak represented some staging kokanee, but was probably composed mainly of fish which were spawning in the Middle Fork.

CENSUS OF THE RIVER SYSTEM KOKANEE FISHERY

Mamsten FLathead **River**

The traditional river system snag fishery was closed during 1983; all kokanee anglers used lures or a combination of lures and corn. The fishery on the main stem began in late August, when kokanee spawners moved upstream from Flathead Lake into the "Salmon Hole" area of the river below Kalispell (Section MSl). A total of 88 angler parties, mostly boat fishermen, were contacted in the Salmon Hole area. The majority of the anglers (94%) were fishing for kokanee (Appendix B).

A total of 998 mandays of fishing pressure was expended by anglers on Section MS1 from 27 August through September. Anglers caught kokanee at a rate of 0.49 fish per hour and harvested an estimated 2,625 fish from this river section (Appendix B).

Anglers had limited success in Sections MS2 and MS3 as the kokanee run progressed upstream. No kokanee were caught by anglers interviewed in Sections MS2 and MS3. Fishing pressure in the two sections totalled724 mandays from 27 August through 15 October. Most of the angling was for cutthroat and whitefish; only 20% of the anglers contacted were fishing for kokanee (Appendix B).

Only273 mandays of anglingpressurewas estimated for main stemSection MS4. The few anglers who fished this section enjoyed a catch rate of 1.5 kokanee per hour and harvested an estimated 1,109 kokanee.

Fishing pressure for the fall kokanee season on the four sections of the main stem totalled 1995 mandays. An estimated 3,734 kokanee were harvested at a rate of 0.56 per hour. Anglers fishing specifically for kokanee comprised 62% of the total pressure, catching kokanee at a rate of 0.72 fish per hour (Appendix B).

The 1983 main stem kokanee fishery attracted few non local anglers because of the low kokanee population level, closure of the snagging season and the reduced limit of 10 fish. Of the 179 parties interviewed, 91% listed their residence as Flathead County.

Middle Fork of the Flathead River

A very limited kokanee fishery existed on the Middle Fork of

the Flathead River in 1983 (Appendix B). A total of 19 angler parties were interviewed from 15 September - 15 October. Fishermen caught kokanee at a rate of 1.1 per hour, using lures or a combination of lures and corn. Fishing pressure was estimated at only 371 hours (63 mandays), concentrated in the last two weeks of September. The limited activity resulted in an estimated harvest of 500 kokanee.

CagerisalofPresentandPastF5sberies

Surveys of the Flathead River System kokanee fishery were conducted in 1975 and 1981 (Hanzel 1977, Fredenberg and Graham 1982), and in1982 and1983. The 1975 and 1981 fisheries reflect kokanee snagging with a 35 fish limit and relatively strong population levels (Table 4). The 1982 figures represent a snag fishery with a 20 fish limit and relatively low population levels. Snagging was not allowed in 1983, and the figures reflect the greatly reduced fishing pressure andharvest, the10 fish limit, and the relatively low population level.

Because of the relatively weak main stem runs of recent years, there has been a shift in angler pressure from these later spawning fish to the "early" runs bound for McDonald Creek and the Middle Fork (Table 5). During 1981, 1982 and 1983, the majority of the kokanee harvest was borne by the "early runs" of fish bound for the Middle Fork drainage. In 1975, however, the majority of the harvest was from the "late runs" of main stem spawners present in the main stem after 1 October. This shift of the harvest from the late runs to the early runs of kokanee reflects the population decline in the main stem spawning run during the late 1970's. The decrease in the percent of the population harvested is due mainly to decreasing limits, elimination of snagging and low kokanee population levels.

SPAWNING SITE INVENTORY

Flathead River Redd Counts

Kokanee spawning in the main stem Flathead River below the South Fork had begun by 25 September 1983 when redds and fish were observed at Area 39. A total of 3,100 redds had been constructed by 18 October. By mid-November, 5,948 redds were counted. A total of 6683 redds had been constructed in 28 spawning areas by late November (Table 6 and Appendix A).

The timing of spawning in the main stem during 1983 resulted in the dewatering of 657 redds before the 15 October flow restrictions went into affect. Of the 6026 wetted redds in the main stem 748 (12.3%) were constructed in spring influenced areas.

Table 4. Comparison of characteristics of the 1983, 1982, 1981 and 1975 river system kokanee fisheries. The 1975 fishery data is for the mainstem only. During the fall of 1975 very little fishing occurred on the Middle Fork.

	Middle Fork			Mainstem			
	1983	1982	1981	1983	1982	1981	1975
Catch rate (kokanee/hour)	**1.10**	**0.93**	2.0	0.56	0.45	2.0	2.0
Fishing pressure (hours)	**371**	17,019	37,870	8,377	25,630	56,602[1/]	69,276
Number of hours per completed trip	**5.9**	3.4	4.7	4.2	3.3	3.2	3.6
Fishing pressure (mandays)	63	5,006	8,040	1,995	7,767	17,688[1/]	19,223
Kokanee harvest	500	18,047	75,117	3,734	12,402	77,000	150,243
Percent of harvest by shore anglers	46	77	79	28	70	73	---
Percent of fisherman hours interviewed	22	19	6.8	8	6	4.8	1.6
Total number of party interviews	19	436	237	177	324	207[2/]	___

1/ Pressure from September and October.

2/ Interviews from September and October only.

Table 5. Estimated distribution of harvest between the Middle Fork "early" runs and the mainstem "late" runs during 1983, 1982, 1981 and 1975. The percent of the estimated population which was harvested is in parentheses. Methods for the estimates are given in Fraley and McMullin (1983).

Year	Middle Fork runs	Mainstem runs	Total
1983	**3,212(8)**	**1,022(6)**	4,234(7.5)
1982	29,999(44)	450(10)	30,449(42)
1981	133,555(53)	18,562(44)	**152,117(52)**
1975	18,450(40-45)	131,793 (40-45)	150,243(40-45)

Table 6. Numbers of redds counted in early and late November in spawning areas utilized by kokanee salmon on the Flathead River below the South Fork in 1983.

Area number	3-14 November	29 November - 2 December
1	8	278
9	3	7
10	19	19
18	2	2
19	6	6
20	130	130
21	18	24
25	124	124
27	311	368
28	60	60
29	197	197
30	103	103
31	25	25
32A	6	10
32	196	199
33	36	36
34	123	123
35	20	25
37	1100	1302
38	260	260
39A	30	30
39B	108	108
39	1851	1852
39C	742	742
40	178	231
41	0	8
42	100	222
42A	192	192
TOTAL	5948	6683

Kokanee spawning in the main stem occurred earlier in1983 than in the previous four years of the study, as 89% of all redds had been constructed by early November. During the previous years of the study, less than 50% of all redd construction had taken place by early November.

Relationship of Redd Counts and Spawner Counts

Kokanee salmon entering the Brenneman's Slough spawning area were monitored by stream trapping for the purpose of comparing spawner numbers and redd counts. Totalkokanee numbers in other spawning areas can then be estimated using a ratio between spawner and redd counts.

A total of 314 kokanee (136 males, 178 females) were passed through the Brenneman's Slough trap by the end of December (Figure 5). These fish constructed 174 redds, yielding a ratio of 1.8 kokanee per redd (0.78 males per redd, 1.02 females per redd).

The spawner - redd ratio during the 1982-83 spawn year was 3.02 in Brenneman's Slough and 3.2 in Beaver Creek (Fraley and McMullin1983). The overall average spawner - redd ratio for the sites studied in 1982 and 1983 was 2.4.

Insufficient numbers of fish entered other spawning areas where traps were in place in 1983 to obtain a relationship.

Residence Time of Spawners

Three groups of kokanee were tagged as they entered Brenneman's Slough to determine length of residence time. Residence time information could be important in determining turn-over rates and total numbers of spawners in McDonald Creek, where periodic snorkel counts are made.

Maximum residence time recorded for the first group of kokanee was 25 days. Kokanee from the second group tagged still remained alive in the spawning area after 32 days. No residence time was determined for the third group of spawners due to ice formation.

Residence time in Brenneman's Slough (approximately one month) may be less than in an area such as McDonald Creek. Kokanee enter Brenneman's Slough in spawning condition, while fish entering McDonald Creek are not fully ripe. Residence time in McDonald Creek is probably closer to one and on-half to two months.

Day-Night Spawning Studies

Determining the die1 timing of kokanee spawning in Flathead River spawning areas is of critical importance in fine tuning flow

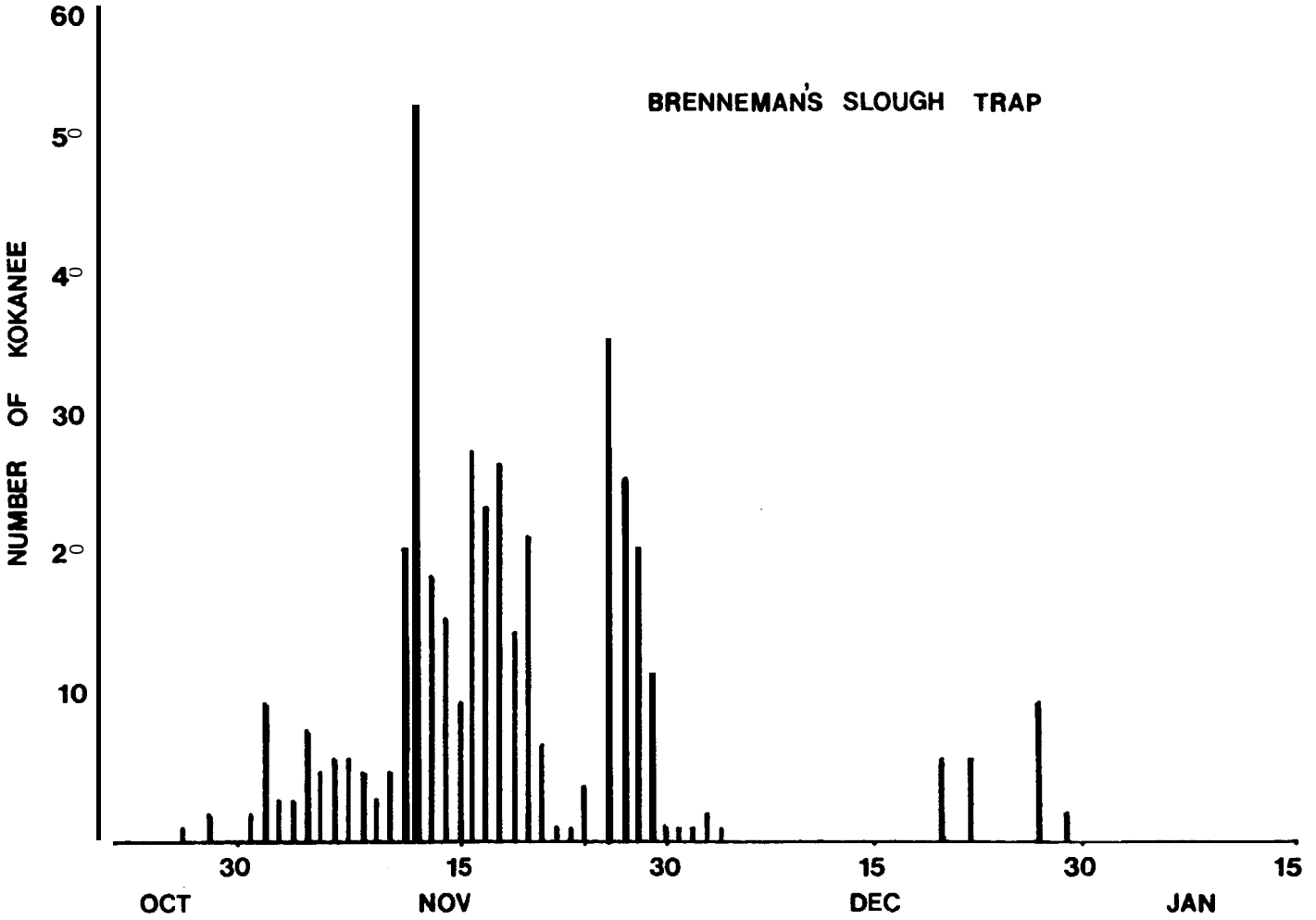

Fig. 5. Number of kokanee spawners entering Brenneman's Slough (Mainstem Area 1) on the lower Flathead River during 1982-83.

recommendations in the main stem below Hungry Horse Dam. Sufficient numbers of spawners entered Brenneman's Slough (main stem Area 1), the House of Mystery (main stem Area 39) and McDonald Creek study sites for day-night spawning studies in 1983.

At main stem Area 1 a total of 582 eggs (43%) of the total deposition were deposited in three redds or parts of redds located in the day portion of the study site (Table 7). In the night portion, 777 eggs (57%) were deposited in six redds or portions of redds. At main stem area 39, the day portion of the site contained 714 eggs (34%) in four redds. In the night area, 1,415 eggs were found in six redds. All egg deposition (70 eggs) and redd construction (5 redds) occurred in the night area on McDonald Creek. The experiment was terminated before much egg deposition had taken place due to the arrival of migrating eagles.

In summary, an average of 26% of both the egg deposition and the redd construction was found in the day portions of the study sites. The night portion of the study sites contained 74% of both egg deposition and redd construction. Kokanee remained above redds constructed in the night areas during daylight hours at all areas, even though the redds were covered with wire blocks. These data indicate that a minimum of one quarter of kokanee spawning in the main stem would be lost if generation occurred during the daylight period.

EGG INCUBATION AND ALEVIN DEVELOPMENT

mggandAlevinsurvival

Egg survival was monitored from mid-December to early January in various river system spawning areas (Table 8). Survival in main stem redds ranged from 27-92% and averaged 62%. During 1982-83, main stem survival ranged from 37-75% and averaged 59% (Fraley and McMullin, 1983). These figures reflect the success of the recommended flows in the river below the South Fork in eliminating excessive incubation mortality in most areas. During years of fall generation such as 1979, survival in shallow spawning areas was near 0%.

Survival in other river system areas ranged from 86% to 97%. Survival figures for these areas may be high due to the later sampling date and the possible decomposition of eggs.

Dissolved oxygen levels at 15 cm gravel depth in main stem area 1 averaged 4.7 ppm, while levels in all other areas were above 8.9 ppm. The low dissolved oxygen levels in Area 1 due to organics and decomposition may have contributed to the relatively low egg survival of 27%.

Table 7. Numbers of kokanee eggs deposited in day and night spawning sites at Flathead River system spawning areas.

	Brenneman's Slough (11/15-11/23/83)		Mainstem Area 39 (10/17-10/25/83)		McDonald Creek (9/26-10/3/83)[1/]	
	Day	Night	Day	Night	Day	Night
Live	165	198	424	698	0	70
Dead	417	579	290	717	0	0
Total	582	777	714	1415	0	70
% Egg deposition	43	57	34	66	0	100

1/ Experiment terminated early due to the eagle concentration.

Table 8. Analysis of green to early eyed kokanee egg samples taken from kokanee redds with a 0.11 m^2 hydraulic sampler and kick net in areas of the mainstem Flathead River, Middle Fork Flathead River, McDonald Creek and Whitefish River during December and January 1983-84.

Location	Date	Total number eggs	Percent survival	Percent eyed	Mean intergravel dissolved oxygen (ppm)	Water temperature
Mainstem Flathead River						
Brenneman's Slough (Area 1	12/14/83	1359[1]	27	0	4.7	45°F[2]
Hoerners (Area 27)	12/15/83	226	46	3	10.2	39°F
Highway 2 Bridge (Area 32)	12/16/83	114	82	0	10.2	36°F
House of Mystery (Area 39)	01/04/84	293	92	100	8.9	41°F
Middle Fork Flathead River	12/19/83	317	96	7	11.5	34°F
South Fork Flathead River	01/05/84	687	94	100	--	39°F
McDonald Creek	12/19/83	491	97	100	11.1	39°F
Whitefish River	12/15/83	118	86	100	10.5	33°F

1/ Eggs sampled on 29 November.

2/ Temperature taken on 30 January 1984.

Egg and Alevin Development

Kokanee egg development was rapid during the 1983-84 incubation period, due to early initiation of spawning and warmer water temperatures. All sampled eggs had reached the eyed stage in McDonald Creek and the Whitefish River by mid-December. By early January eggs in main stem Area 39 and in the South Fork of the Flathead River had reached the eyed stage.

Hatching was earlier during 1983-84 than in previous years in McDonald Creek (Table 9). By mid-January, 29% of all eggs sampled had hatched. The trend of earlier hatching dates of kokanee eggs over the past five years in McDonald Creek reflects the trends of progressively earlier spawning timing and the absence of later spawners.

Experimental Egg Plants

Kokanee eggs were planted in two main stem areas that had supported kokanee spawning before the late 1970's, but have not contained redds during the last four years. These areas were chosen to determine the effectiveness of egg plants in aiding the recovery of the main stem kokanee population.

At Lybeck's Dike (Area 13), a spring influenced site, an estimated 68% of the 23,000 eyed eggs survived to hatching. Emergence trap catches from two plants of 1000 eggs indicated 45-46% egg to emerging fry survival (Figure 6). These figures indicated a survival rate of 67% from hatching to emergence and a production of 10,465 emigrating fry.

At Area 2, a side channel site, an estimated 74% of the 23,000 eyed kokanee eggs planted survived to hatching. Applying the hatching to emergence survival rate determined for Area 13, an estimated 11,403 emigrating fry were produced./ An estimated 67% of the 5,500 green eggs planted survived to hatching at Area 13. Of the 4,500 green eggs planted at Area 2, an estimated 37% survived to hatching. No emergence and emigration information were available for green plants, but based on hatching to emergence survival in the eyed plants, an estimated 24% and 44% of the green eggs survived to emergence at 'Areas 2 and 13, respectively. These survival rates indicate productions of 1080 and 2420 fry from green egg plants in Areas 2 and 13, respectively.

No significant difference in egg survival was noted between planting boxes and artificial redds. Artificial redds required less effort than planting boxes and are recommended for any future plants.

In summary, an estimated 21,868 fry were produced from 46,000 eyed eggs planted in Areas 2 and 13, yielding an egg to emigrating fry survival rate of 48%. The 46,000 eyed eggs survived from

Table 9. Analysis of egg and alevin samples taken in McDonald Creek in the Apgar area from 1980-1984.

Sampling dates	No. Samples	No. Live Eggs and Alevins	% Survival	% Alevins
1/18-1/23/84	18	1,127	92	29
2/1-2/2/83	13	1,181	88	25
2/8-2/9/82	14	1,424	78	12
1/13/81	3	311	94	< 1
1/14/80-2/1/80	10	1,801	85	7

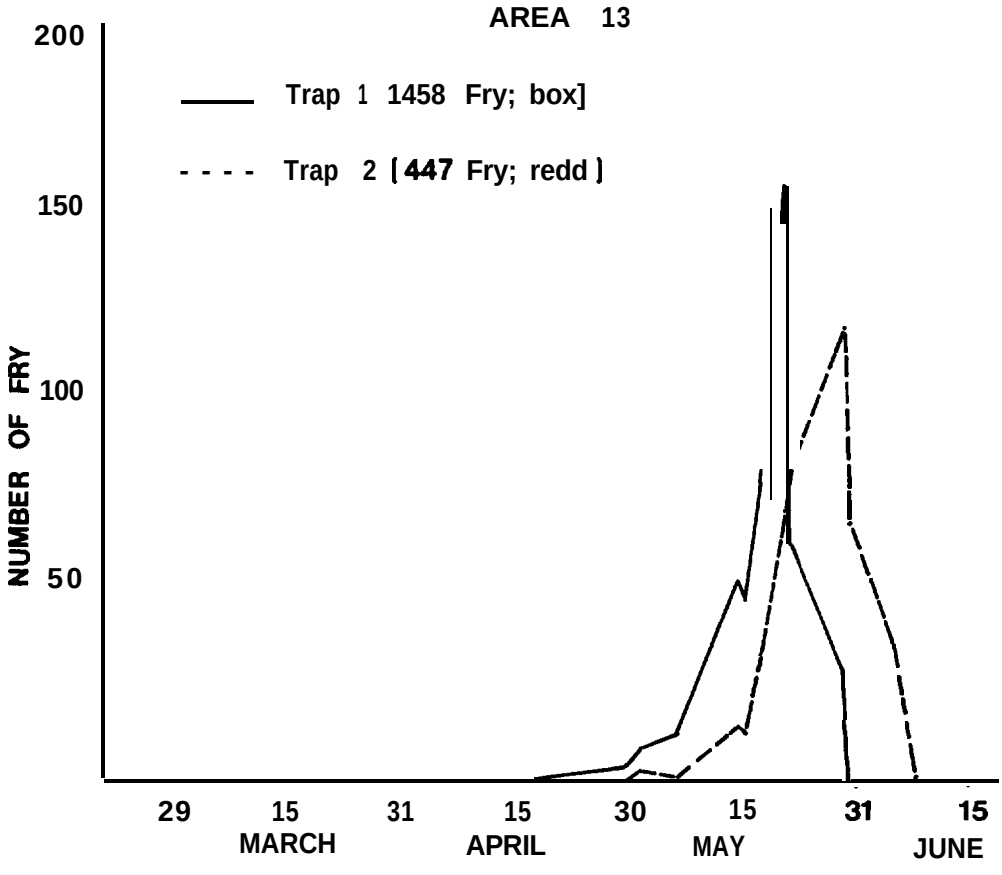

Fig. 6. Emergence trap catches from one planting box and one artificial redd containing 1000 eyed kokanee eggs each at Lybeck's Dike on the Flathead River during 1984.

56,000 green eggs deposited in the hatchery. The egg to fry survival rate was 39% when calculated from the original 56,000 eggs. An estimated 3500 fry were produced from 10,000 green eggs planted yielding an egg to fry survival rate of 35%. Al though the difference between egg to fry survival is not great between the green and eyed egg plants, it may be advantageous to plant eyed eggs because of the earlier emergence times and greater control over environmental variables during the initial stages of development.

STREAM FLOW-KOKANEE LENGTH RELATIONSHIPS

Several models were developed using weighted three year moving average flow conditions to explain variations in kokanee year class strength from the 1966 through the 1982 spawning years (Graham et al. 1980, McMullin and Graham 1981, Fraley and Graham 1982, Fraley and McMullin 1983). Combined male and female spawner length was assumed to be inversely related to population density and was used as the measure of year class strength.

There was a strong relationship between kokanee spawner length and flow conditions from 1966 through 1983 (Table 10, Figure 7). The correlation between female kokanee spawner length and spawning and incubation gauge height differences from 1966 through 1983 was highly significant **($r=-0.93$,** $r^2$30.87, **$p<.001$).** This indicates that a large proportion (87%) of the variation in spawner length could be attributed to differences in spawning and incubation gauge heights in the Flathead River as affected by discharges from Hungry Horse Reservoir. Length of 1983 female kokanee spawners averaged 364 mm, close to the 362.6 mm predicted by the river gauge height model (Table 11). Predicted length for 1984 female kokanee spawners in the Flathead drainage is 337 mm.

Flathead Lake levels have also affected kokanee year class strength from 1966-1983 (Decker-Hess and Clancey 1984). The addition of the number of days of lake elevation less than 2885 feet during the incubation period raised the r of the gauge height model from 0.87 to 0.93. The relationship between female kokanee length, Flathead River gauge heights, and Flathead Lake levels is illustrated in Figure 8.

Unexplained variation in kokaneeyear class strength maybe related to other factors not included in the models. Other factors may affect incubation success (Wickett 1962), growth of kokanee in Flathead Lake (Goodlad et al. 1974), or differential recruitment from other spawning areas to the lake population. Quadrennial or cyclic dominance may also be affecting year class strength of Flathead kokanee (Fraley and McMullin 1983).

Age composition of the river system kokanee run does not appear to have affected spawner lengths from 1970-1983 (Table 12). During the 1981-1983 period, kokanee spawner lengths were the

Table 10. Mainstem Flathead River flow variables and Flathead System female kokanee length from 1966-1983.

Spawn year	Water years in 3 year average	Actual female kokanee length	Incubation-spawning gauge height difference (ft)	Weighted 3 year moving average (ft)
1966	1962-64	283	1.53	2.06
1967	**1963-65**	263	3.16	2.44
1968	1964-66	266	2.39	2.20
1969	1965-67	303	0.99	0.65
1970	1966-68	314	-1.54	-0.36
1971	1967-69	324	-0.14	-0.29
1972	1968-70	324	0.76	-0.14
1973	1969-71	297	-1.35	0.22
1974	1970-72	307	1.78	0.23
1975	1971-73	309	-0.27	0.41
1976	1972-74	305	-0.04	0.06
1977	1973-75	314	0.52	-0.43
1978	1974-76	323	-2.07	-0.97
1979	1975-77	337	-0.97	-0.87
1980	**1976-78**	**351**	0.46	-0.48
1981	1977-79	361	-1.22	-0.94
1982	**1978-80**	370	**-1.97**	**-2.31**
1983	1979-81	364	-3.86	-2.06

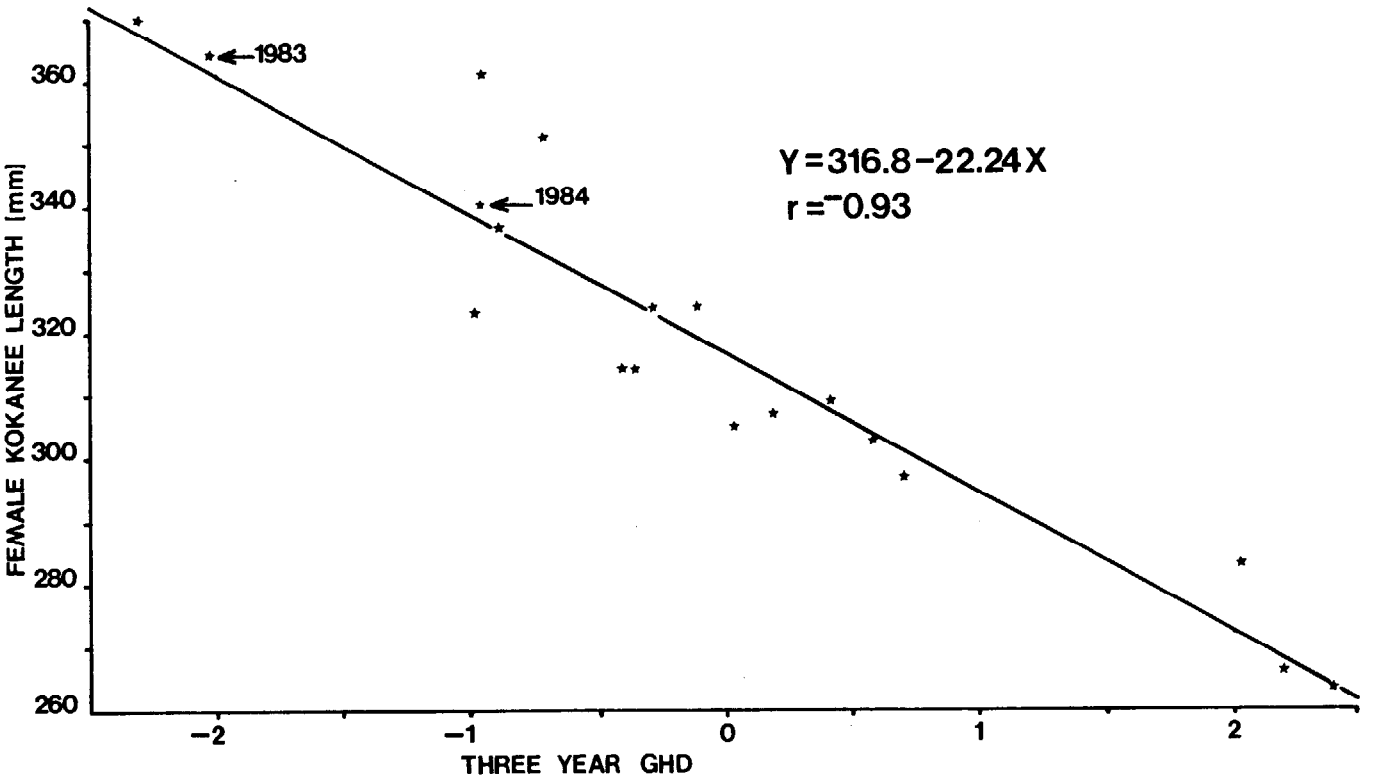

Fig. 7. Relationship between female kokanee spawner length and the three year average in gauge height difference (ft) in the years that produced them from 1966-1983.

Table 11. Actual Flathead drainage female kokanee spawner length, lengths predicted from the river gauge height model and residual errors, 1966-1983.

Year	Actual female spawner length (mm)	Predicted female spawner length (mm)	Residual error (mm)
1966	283	271.0	12.0
1967	263	262.5	0.5
1968	266	267.9	-1.9
1969	303	302.3	0.7
1970	314	324.8	-10.8
1971	324	323.2	0.8
1972	324	**319.9**	**4.1**
1973	297	311.9	-14.9
1974	307	311.7	4.7
1975	309	307.7	1.3
1976	305	315.4	-10.4
1977	314	326.3	-12.3
1978	323	338.4	-15.4
1979	337	336.1	0.9
1980	351	327.5	23.5
1981	361	337.7	23.3
1982	370	368.2	1.85
1983	364	362.6	1.4
1984	---	337	---

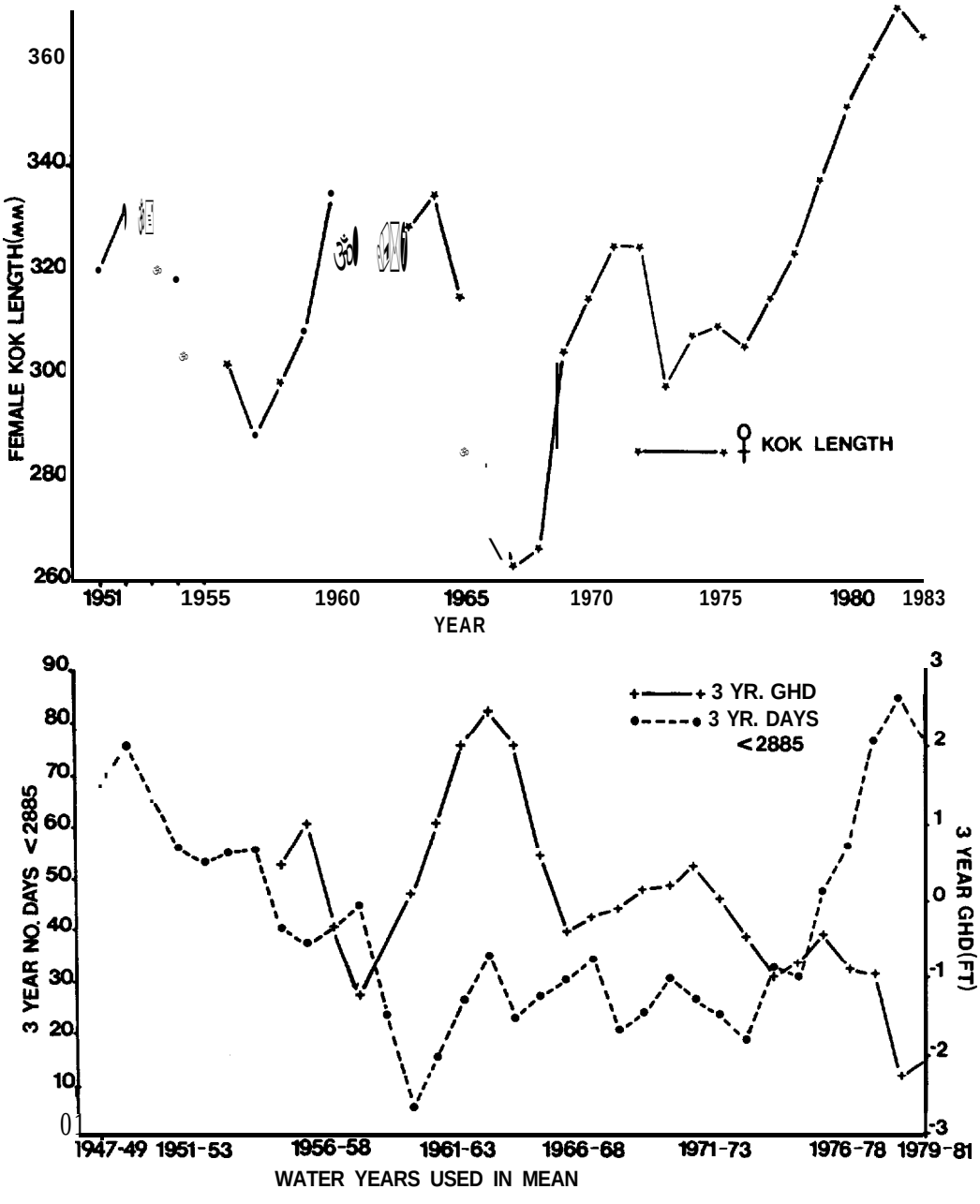

Fig. 8. Relationship between female kokanee length, Flathead River spawning - incubation gauge height difference, and number of days Flathead Lake levels were below 2885 feet during the kokanee incubation period for spawn years 1951-1983.

Table 12. Length (mm) and age data for kokanee salmon collected in Flathead River system spawning areas from 1970-1983.

Year	No. fish			Average length[1]			% Age II+[2]			% Age III+			% Age IV+		
	Male	Female	Comb	Male	Female	Comb	Male	Female	Comb	Male	Female	Comb	Male	Female	Comb
1983	116	140	256	376	361	369	3	1	2	88	96	92	9	3	6
1982	107	106	213	381	367	374	2	1	2	79	89	84	19	10	14
1981	85	120	205	373	356	364	0	0	0	82	95	89	18	5	11
1980	47	69	116	371	343	357	0	0	0	36	65	51	64	35	49
1979	92	102	194	345	328	336	0	0	0	85	98	92	15	2	8
1978	175	143	318	333	312	321	0	0	0	85	95	90	15	5	10
1977	321	309	630	323	310	316	4	1	2	89	94	92	7	5	6
1976	253	145	398	312	300	306	6	6	6	81	71	76	13	23	18
1975	114	123	237	315	302	308	0	0	0	56	69	63	44	31	37
1974[3]	114	78	192	315	302	308	0	0	0	60	72	66	40	28	34
1973	44	22	66	305	292	298	2	14	8	82	73	78	16	13	14
1972	49	27	76	333	318	325	0	0	0	32	37	34	68	63	66
1971	99	112	211	333	320	327	0	23	11	29	69	49	33	8	20
1970	74	83	157	325	310	318	0	0	0	34	31	33	66	69	67

[1] Combined length is an average of the mean male and mean female lengths.
[2] Combined age structure is an average of the mean male and mean female age structure.
[3] Figures from 1970-1973 are McDonald Creek fish only.

largest recorded; yet only 6-14% of the run was composed of older (IV+) fish.

FRY EMERGENCE AND EMIGRATION

Fry Abundance and Emergence Timing

The timing of kokanee fry emergence and kokanee fry abundance is critical in the determination of the relative importance of Flathead River system spawning areas as areas of recruitment to the Flathead Lake population. Kokanee fry emigraticn was intensively monitored in three river system spawning areas (Figure 9). Fry emigration was monitored on a limited basis in the Middle Fork of the Flathead River and at several points on the main stem Flathead River.

McDonald Creek

Kokanee fry emergence and emigration in McDonald Creek extended from mid-January to mid-June, 1984 (Appendix C). A major fry emigration peak occurred during the third week of April: peak emigration occurred two to four weeks later during other years of the study (Fraley and McMullin 1983). Lesser peaks of fry emigration occurred in early April and mid-May. Emergence trap catches indicate similar emergence timing in McDonald Creek (Figure 10).

Emigrating fry were distributed vertically and laterally throughout the water column. Average numbers of kokanee fry cap turedin top, middle and bottom nets set vertically in the water column were 17.4, 16.0 and 10.1 per 100 m^3 water filtered.

An estimated 13.1 million fry emigrated from McDonald Creek in 1983. The number of emigrating fry was 76% oftheestimatedegg deposition calculated from spawner and fecundity counts. The rate was inflated due to an underestimate of potential egg deposition. The snorkel counts of adult spawners used to estimate potential egg deposition are trend point estimates and may not represent the total number of spawners which entered McDonald Creek during the 1983 spawning period. Egg to fry survival rates in McDonald Creek of 22% and 69% were calculated for 1982 and 1983. Kokanee fry survival may be inversely related to spawner density in McDonald Creek. The high survival rates during 1983 and 1984 occurred during years of low spawner trend counts (30,000-34,000), while the lower figure calculated in 1982 resulted from a trend count of nearly 100,000 spawners.

Survival in McDonald Creek was high when compared to other natural salmon spawning areas. Jeppson (1960) reported a seven percent egg to fry survival rate in Sullivan Spring Creek, Idaho which was considered a high quality kokanee spawning ground. Survival rates comparable to the 1983 McDonald Creek figures have

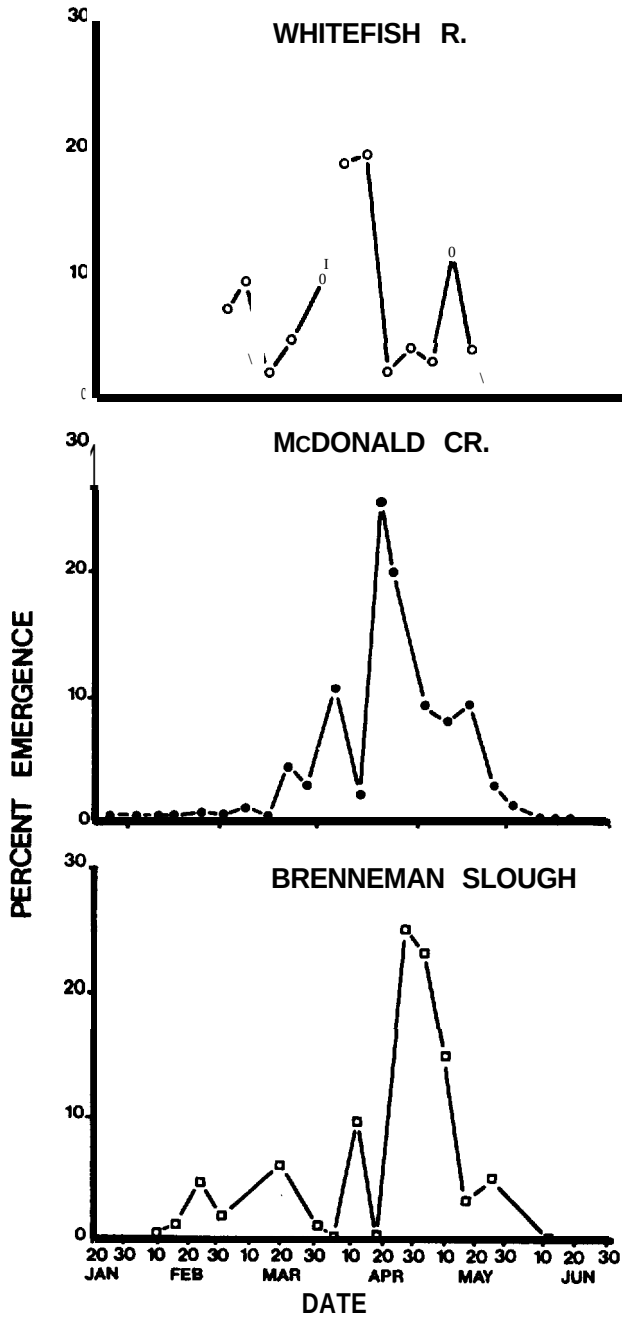

Fig. 9. Kokanee emigration in three river system spawning areas.

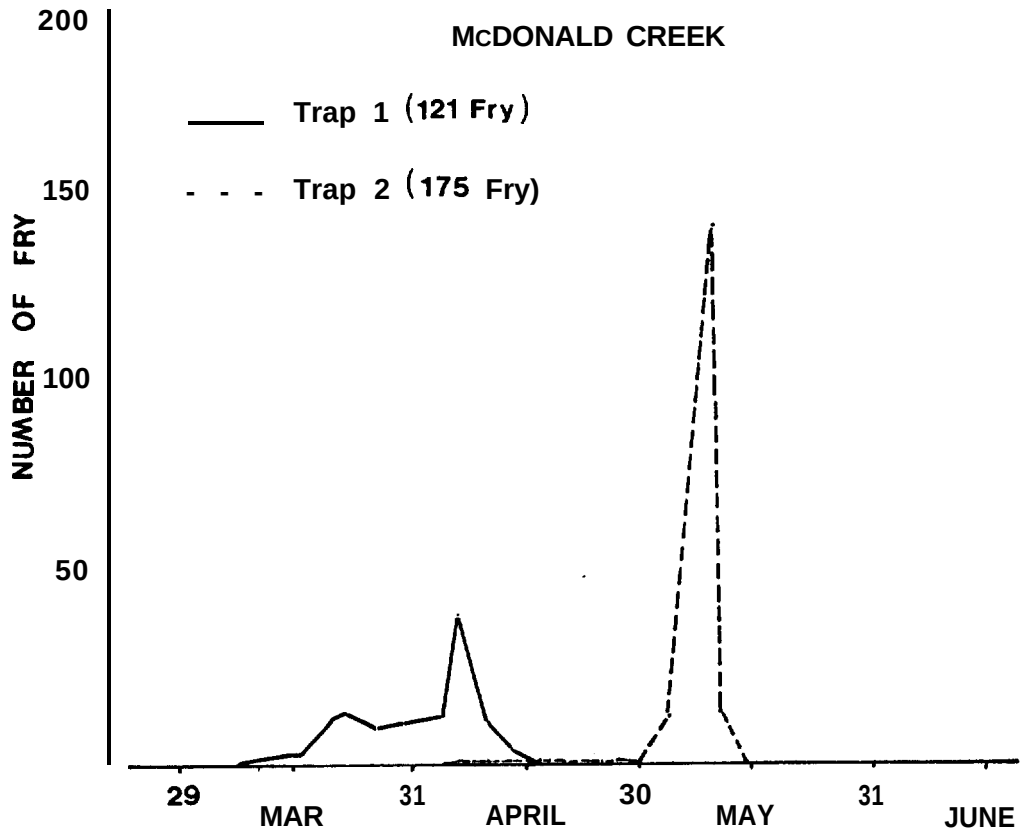

Fig. 10. Number of fry captured in emergence traps in McDonald Creek during the spring of 1984.

been reported for salmon in several spawning channels in Japan the U.S.S.R., Washington (Bakkala 1970) and British Columbia (R.A. Lindsay, British Columbia Ministry of Environment, pers. comm.). Royce (1959) reported a 75 percent egg to fry survival for silver salmon in a coastal California stream.

Fry emergence from kokanee redds at the upper end of McDonald Lake peaked in late May, as indicated by biweekly towing from April-June. Emergence in upper McDonald Creek didn't begin until early June and appeared to be completed by late June. Kokanee that spawned in upper McDonald Creek and along the upper lakeshore may have been part of the McDonald Lake population,

Brenneman's Slough

Fry emigration occurred in a series of peaks in Brenneman's Slough, a main stem spring area which corresponds roughly to the pattern of adult kokanee migration into the slough (Appendix C). The major emigration peak occurred in early May. An estimated 37,198 fry emigrated from the area during the spring of 1984, representing 19.2% of the total potential egg deposition. The egg to fry survival rate calculated for Brenneman Slough for 1983 was 13.7%, when an estimated 31,511 fry emigrated.

Whitefish River

The major kokanee fry emigration peak in the Whitefish River occurred in mid-April, with a secondary peak in mid-May (Figure 9). Number of fry emerging from two redds into emergence traps also peaked in mid-April.

An estimated 66,254 fry emigrated from the Whitefish River above Rose Crossing Bridge. This represents 10.4% of the total potential egg deposition, based on redd and fecundity counts. Egg to fry survival in the Whitefish River &ring 1983 was 4.5%.

Main stem Flathead River

Emigration of kokanee fry in the Flathead River past Kalispell peaked in mid-April (Appendix c). Initiation of runoff and debris prevented further sampling after early May. Emergence trap catches at spawning area 39 in the main stem also peaked in mid-April (Figure 11). Kokanee fry emergence timing was early in 1984 due to early initiation of spawning in the fall of 1983.

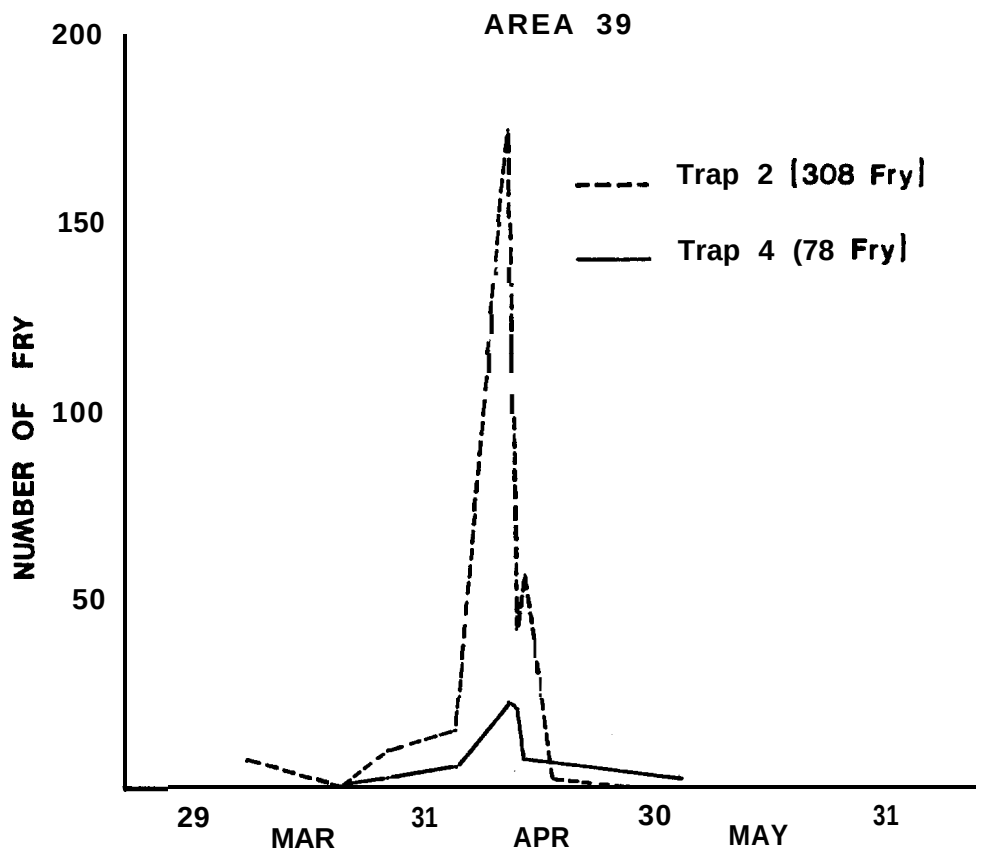

Fig. 11. Numbers of fry captured in two of four emergence traps at Area 39 in the main stem Flathead River during the spring of 1984.

Middle Fork of the Flathead

Fry emigration in the Middle Fork of the Flathead River peaked in late March (Appendix C). The majority of the fry passing the Middle Fork sampling station above West Glacier probably emigrated from redds located near the mouth of Deerlick Creek.

Fry Movements

Kokanee fry emigration was monitored from McDonald Creek downstream through the river system during two fry staining experiments. These experiments were conducted to determine the timing of fry recruitment to Flathead Lake. Knowledge of timing of fry arrival to the lake could prove critical in any future studies on younger age classes of kokanee. A total of 14,500 kokanee fry captured in McDonald Creek were stained and released on 28 March and their movements were monitored at sampling sites downstream (Figure 12). A total of 512 of the fry were recaptured at stations 8, 34 and 55 km downstream from McDonald Creek. The fry apparently left the creek in a concentrated group, beginning at dusk, and began passing the eight km station after 3 hours of travel time. The leading edge of the stained fry group passed the 34 km point after 10 hours of swimming time. The fry appeared to hold in the area for the daylight period, then began moving and passed the 55 km point four hours after darkness for a total travel time of 14 hours. Attempts to track the fry in the lower, slow moving 30 km of the river to Flathead Lake, were unsuccessful. Flows during this experiment averaged 871, 920 and 3834 cfs in the Middle Fork, North Fork and main stem Flathead River.

A second group of 40,500 fry were captured and stained in McDonald Creek on 23 April. The fry left the creek in a concentrated group beginning at dusk (2000 hrs) as indicated by nets set in the creek. They reached the 8km point after two hours of travel and the 34 km point after six hours (Figure 13). The first stained fry reached the 55 km point by 0500, after 8 hours of travel, slightly faster than the calculated flow time. After apparently holding in the area during the daylight hours, the fry continued to pass the 55 km point until 2400 hours the second night. The first fry reached the 96 km point by the end of the second night of travel. The majority of the fry passed the 96 km point on the third night of travel from McDonald Creek.

Stained fry covered the distance between the 55 km and 96km points at a rate approximately twice that of the current speed, measured at several points along the length of the section. The fry were more scattered at the 96 km point, as one was captured two nights after the majority passed. Flows during this experiment averaged 3,870, 4,416 and 11,134 cfs in the North Fork, Middle Fork, and main stem Flathead River.

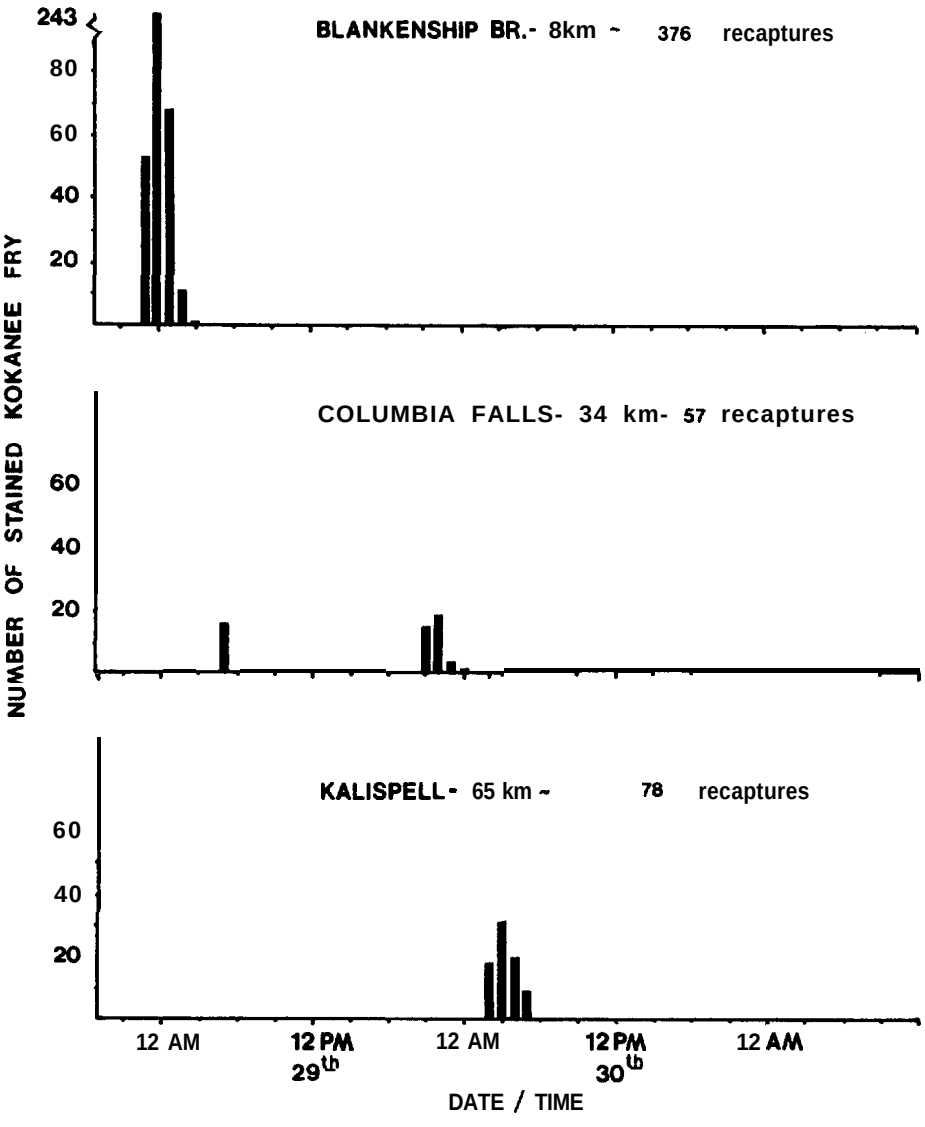

Fig. 12. Number of recaptured stained fry at sample sites 8km, 34km, and 55km below McDonald Creek at 28-30 March 1984. Successive peaks show the downstream movement rate of the group of stained fry.

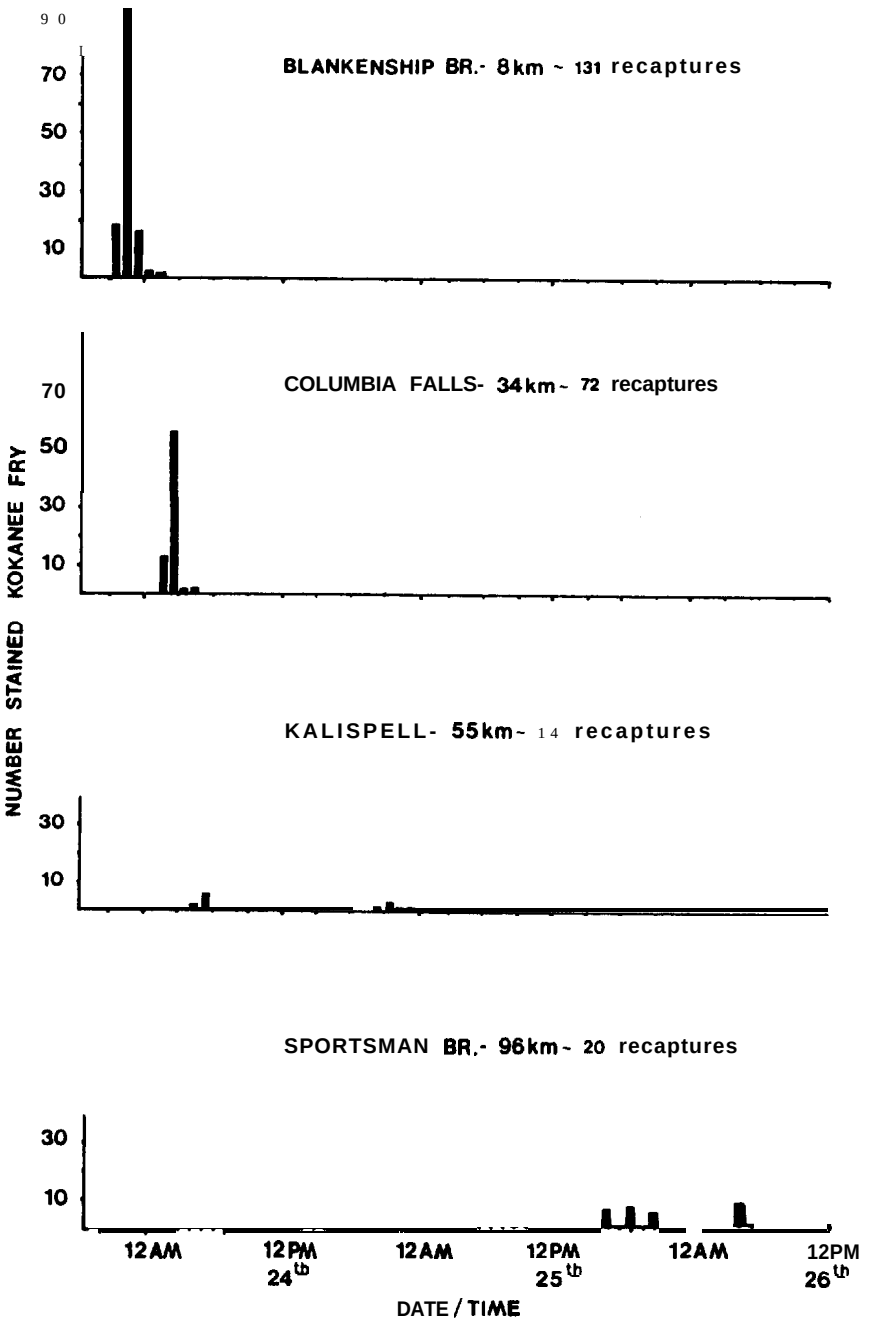

Fig. 13. Number of recaptured stained fry at sample sites 8km, 34km, 55km, and 96km below McDonald Creek on 23-26 April, 1984. Successive peaks show the downstream movement rate of the group of stained fry.

Movement rates of kokanee fry were as rapid ok more rapid than estimated flow rates in the Flathead River System. The fry apparently hold their position in the flow and actively swim through eddies and back currents. Hartman etal. (1962) reported that sockeye fry actively migrated downstream faster than the current.

POPULATION RECOVERY

Flow Recommendations for Population Recovery

The goal for the management of the Flathead drainage kokanee fishery is a balanced number of fish, approximately 330 mm in length (Graham et al. 1980). This level of recovery would provide a main stem run similar to that of 1975 when an estimated 165,000 fishspawned in the Flathead River. Recovery of the main stem run will enhance recruitment to the Flathead Lake fishery and provide a dependable fishery for adult kokanee in the river system. The overall management goal is also directed toward maintaining a diversity of spawning areas.

Management of seascnal and daily flow levels in the Flathead River below the South Fork is critical to the recovery of the kokanee population. A flow regime in the main stem, which would enhance kokanee reproduction, was recommended to the Northwest Power Planning Council in 1981 and implemented by the Bonneville Power Administration and Bureau of Reclamation during the 1982 and 1983 spawning years (NWPPC 1982). The flow recommendations included a stable discharge of 3,500-4,500 cfs for kokanee spawning from 15 October through 15 December, and a minimum flow of 3500 cfs for egg incubation and alevin development from 15 December through 30 April. These flows will eliminate most incubation mortality due to dewatering, and should result in the recovery of the main stem run to levels observed prior to the late 1970's.

Timing of the Population Recovery

Timing of the recovery of the main stem kokanee population could vary substantially, depending on the level of natural reproductive success for each year class of fish (Figure 14). Recovery of the population from its present depressed level could not occur at a fry to adult return rate of l.0%, assuming 20% egg to fry survival. At a 2.0% fry to adult return rate and no harvest, a fishable main stem population would be reached by1993 and over 150,000 spawners would return annually by 1997. The maximum assigned level of 330,000 spawners would be reached by 2003. A fry to returning adult survival rate of 3.0% could result in a fishable population by 1989, and by 1997 a maximum assigned level of 330,000 spawners would be reached.

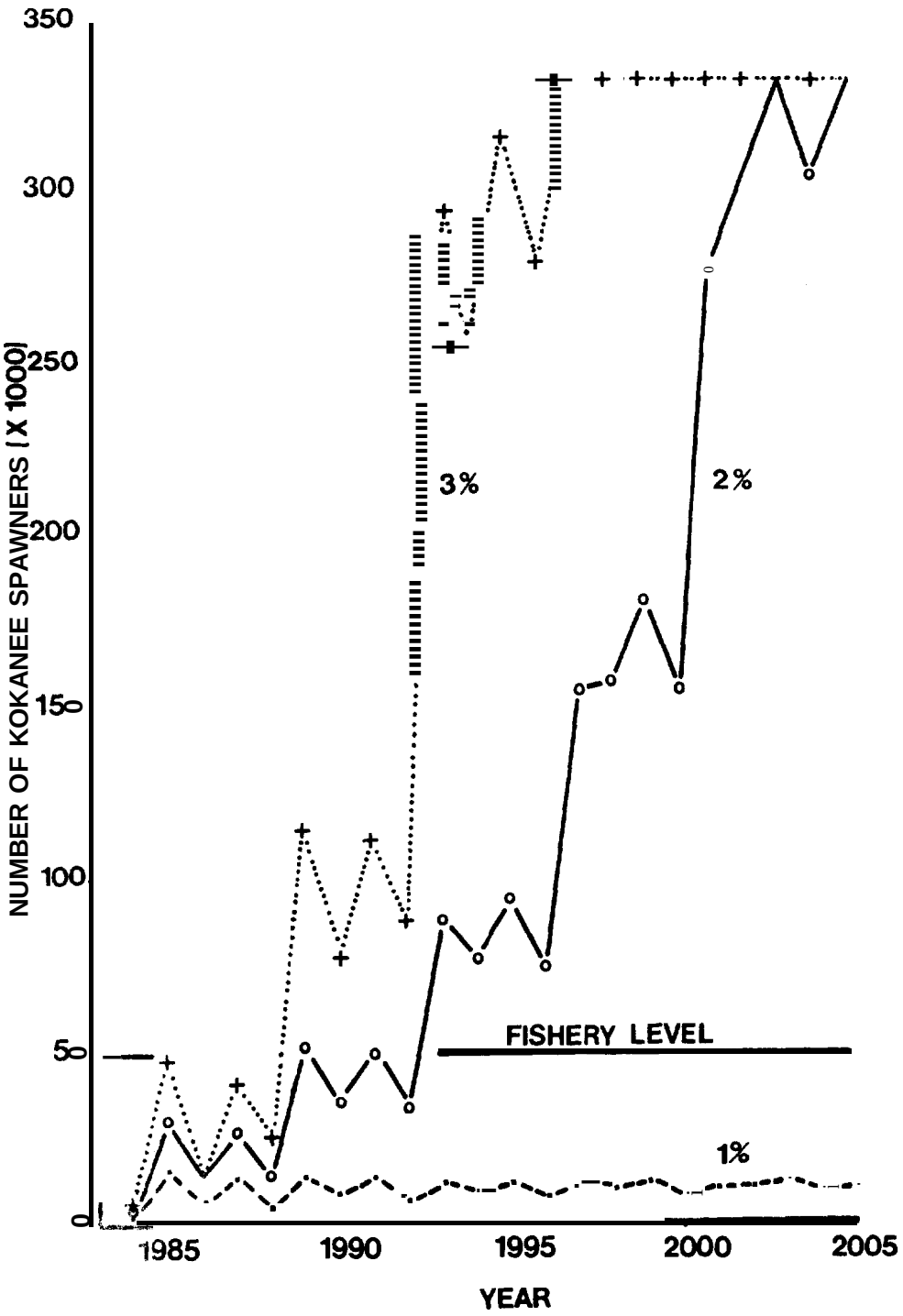

Fig. 14. Projected growth of the main stem kokanee population at 20 percent egg to fry survival, and one, two, and three percent fry to adult returns (no angler harvest).

The main stem kokanee population is expected to recover with an average of 20% egg to fry survival and 2.0% fry to adult survival, based on egg to fry survival studies in the Flathead, and on values in the literature. These rates would result in a doubling of numbers in each successive four year cycle of spawners for an overall return rate of 2.0 adults per spawner. Due to the present density of spawners, reproductive success in the early years of the recovery could be substantially greater. Mean estimates of returning adults per spawner reported for Seagoing salmon in streams of Alaska and British Columbia ranged from 1.7 to 3.0 and averaged 2.3 over a 40 year period (Bakkala 1970).

Management of Harvest Rates

A spawning run of 50,000 kokanee spawners in the main stem was estimated as the minimum population that could support a harvest without impairing the recovery rate of the population. With little OK no harvest, the population should be safely above the 50,000 fish level by 1993. The rate at which the main stem population is harvestedfrom that point would greatly affect the Kate Of population growth and recovery (Figure 15). A desirable harvest rate for management of the main stem kokanee population would be one that could be adjusted based on the number of spawners that return each year. This shifting harvest rate could begin at 10% when the minimum fishery level of 50,000 fish is reached, and increased to 50% at the assumed maximum population level of 330,000 spawners (figure 16, Table 13). With this shifting harvest rate, the main stem population would increase to over 200,000 spawners after four OK five generations and to over 300,000 spawners by 2007. This harvest management strategy would allow for a reasonable balance Of population recovery and angler harvest.

The kokanee snag fishery was converted to a lure fishery with a reduced limit of 10 fish during the 1983 spawning run. The purpose of these regulation changes was to reduce the harvest rate to below 10% as outlined inthe harvest management strategy. An estimated 1022 kokanee were harvested from an estimated main stem preharvest population of 17,301 for a harvest rate of 5.0%. The lure fishery regulations were effective in reducing harvest rates of the main stem run from the traditional 40 to 50% experienced during the snag fishery. The lure fishery will remain in effect until the population recovers to the level where it can again support the 40 to 50% harvest rates of the past.

CONCLUSIONS AND FUTURE WORK

The kokanee spawning run in main stem Flathead River has been reduced to an average of only 16% of the total recruitment to Elathead Lake from 1979-1983. This decline was largely due to the effects of the operation of Hungry Horse Dam on kokanee spawning and success and angler harvest. The main stem kokanee run has

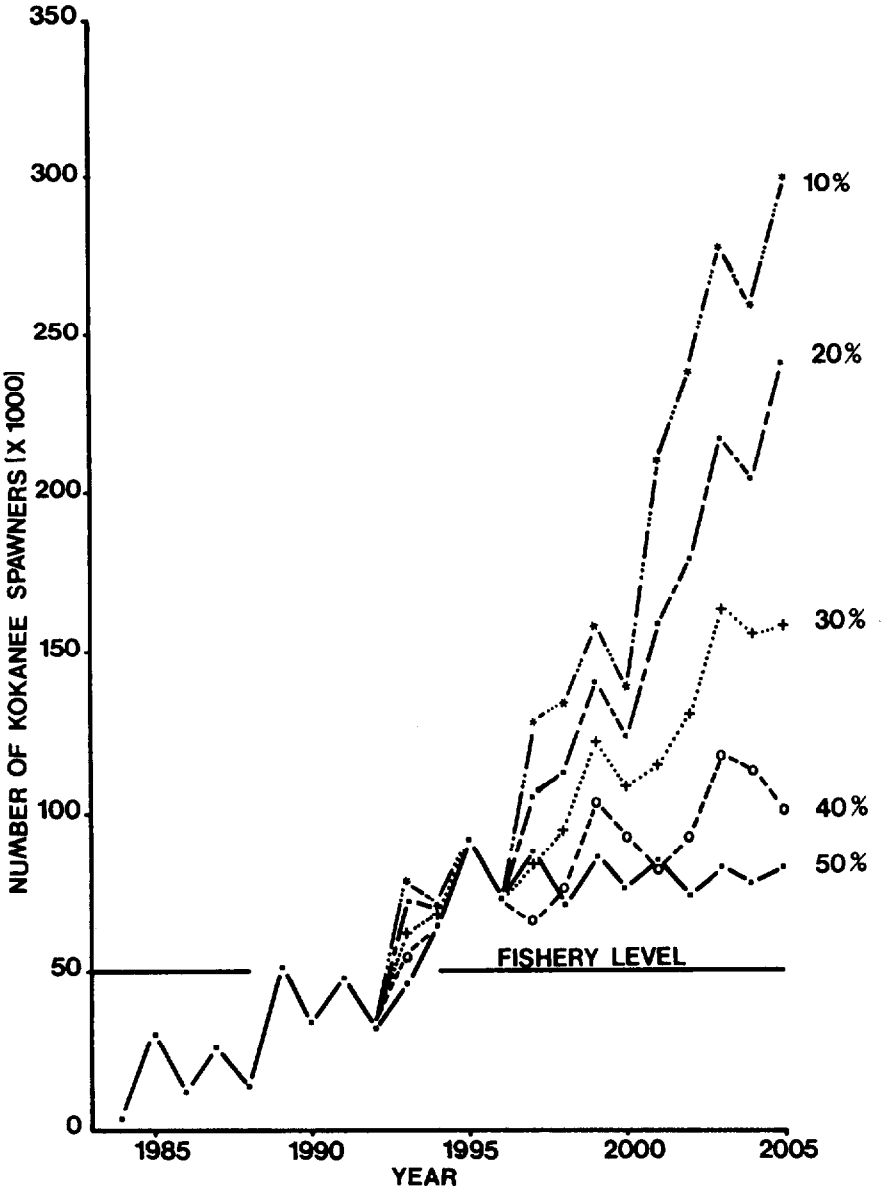

Fig. 15. Projected growth of the main stem kokanee run at 20% egg to fry survival, 2% fry to adult survival and 10%, 20%, 30%, 40% and 50% harvest rates.

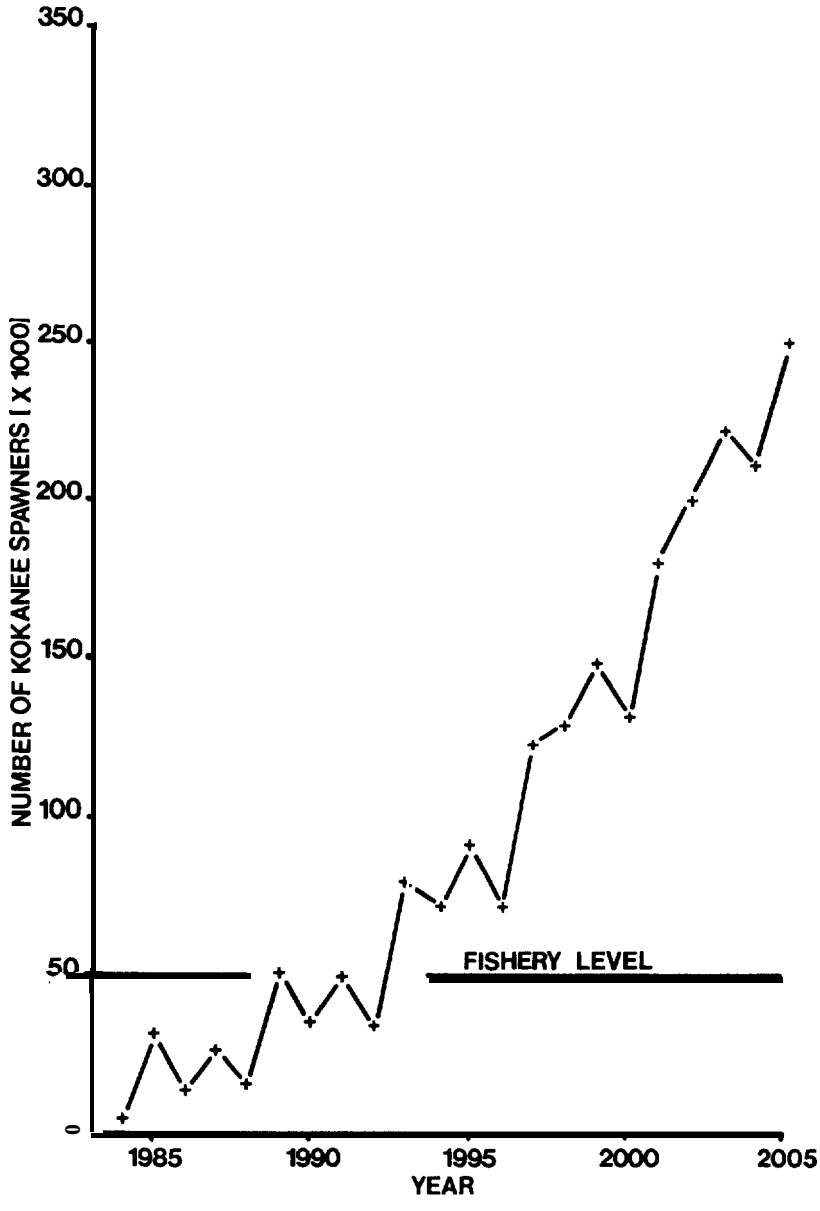

Fig. 16. Projected growth of the main stem kokanee run at 20% egg to fry survival, 2% fry to adult survival and a 10-50% shifting harvest rate from 50,000 - 330,000 spawners.

Table 13. Hypothetical harvest management plan for the main stem Flathead River kokanee run.

Projected preharvest population level	Estimated time period	Mean Harvest rate	Mean number of kokanee harvested
o-50,000	1984-1972	0[1/]	0
50,000-100,000	1993-1996	0.14	11,473
100,000-200,000	1997-2001	0.24	34,093
200,000-300,000	2002-2008-	0.39	95,749
>300,000	2009-2033	0.50	162,235

1/ **The restricted lure fishery may result in a minimal harvest of** 6% **or less.**

declined from an estimated 165,000 post-harvest spawners 325 mm in length in 1975, to an average of only 9,400 post-harvest spawners averaging 380mm over the last five years.

Implementation of the recommended spawning (3,500-4,500 cfs) and incubation (3,500 cfs) flows in the main stem should result in the recovery of the kokanee spawning run to levels similar to 1975 (330,000 preharvest spawners), which is the management goal of the study.

The recovery period could vary, depending on natural fluctuations in the survival rates of kokanee eggs and fry. Average conditions of 20% egg to fry survival, 2.0% fry to returning adult survival, and a l0-50% shifting harvest rate after the population reaches 50,000 fish would result in recovery approaching the management goal of over 300,000 spawners by 2008, or after six generations of kokanee. If no harvest was allowed, population recoveryapproachingthe management goal would occur by the mid 1990's.

Work during the next year of the study willconcernthe continued evaluation of the effects of the controlled flows on kokanee reproductive success. Additional die1 spawning studies will be conducted to evaluate possible fine tuning of the daily timing of the flow releases from Hungry Horse Dam. Studies will also focus on refining the average values for natural kokanee reproductive success which are critical in projecting and managing the recovery of the main stem spawning run

Afinalresearch reportwillbepreparedbythe end ofFY1985 (September 30, 1985). At that time, all results from the study will be compiled and analyzed and any daily and seasonal adjustments of the present Flathead River flow recommendations will be made. Evaluation of the river flows will continue through the 1985, 1986 and 1987 spawning years in a much reduced form, not requiring a project biologist on the river portion of the study. Final study recommendations for both the river andlakeportionsof the study will be made by March, 1988.

LITERATURE CITED

Alvord, W. 1975. History of the Montana Fish and Game. Montana

Bakkala, R.G. 1970. Synopsis of biological data on the chum salmon, *Onchorhynchus keta (Walbaum)* U.S. Fish and Wildlife Service (Circular 315). **89 pages.**

Church, W., and M. Nelson. 1963. Red salmon spawning ground surveys in the Nushagak and Togiak districts Bristol Bay, 1962. Alaska Department of Fish and Game, Informational Leaflet-34. 8 pages.

Decker-Hess, J. and P. Clancy. 1984. Impacts of water level fluctuations on kokanee reproduction in Flathead Lake. Annual report to the Bonneville Power Administration Contract DE AI79-83BP39641, Project No. 81S-5. Montana Department of Fish, Wildlife and Parks, Kalispell, Montana, USA.

Domrose, B. 1975. Notes on kokanee redd examination and fry emergence in relation to Hungry Horse Reservoir discharge. Montana Department of Fish, Wildlife and Parks, Kalispell, Montana 4 pages.

Fish and Wildlife Service. 1968. A review of all fishery data obtained from waters of the McDonald Fishery Management Unit for the fifty-year period from 1916 through 1966. U.S.D.I. Fish and Wildlife Service, Glacier National Park, Fishery Management Program. Review Report No. 7.

Foerster, R.E. 1944. The relation of lake population density to size of young sockeye salmon *(Onchorhynchus nerka).* Journal of the Fisheries Research Board of Canada. 6:267-280.

Fraley, J.J., and P.J. Graham. 1982. The impact of Hungry Horse Dam on the fishery of the Flathead River. Completion report submitted to the Bureau of Reclamaticn. Montana Department of Fish, Wildlife and Parks, Ealispell, Montana, USA.

Fraley, J.J., and S.L. McMullin. 1983. Effects of the operation of Hungry Horse Dam on the Kokanee Fishery in the Flathead River System. Annual report to the Bonneville Power Administration, Contract DE AI79-83BP39641, Project No. 8lS-5. Montana Department of Fish, Wildlife and Parks, Ealispell, Montana, USA.

Fredenberg, W. and P.J. Graham. 1982. Census of kokanee fishermen on the Flathead River. Report submitted to the U.S. Environmental Protection Agency Montana Department of Fish, Wildlife and Parks, Ealispell, Montana, USA.

Gibson, H. 1973. Lake Pend Oreille kokanee spawning trends. Idaho Department of Fish and Game, Project F-53-R-8, Job IV-c.

Goodlad, J.C., T.W. Gjernes, and E.L. Brannon. 1974. Factors affecting sockeye salmon (*Oncorhynchus nerka*) growth in four lakes of the Fraser River system. Journal of the Fisheries Research Board of Canada 31:871-892.

Graham, P.J., S.L. McMullin, S. Appert, K.J. Fraser, and P. Leonard. 1980. Impacts of Hungry Horse Dam on aquatic life in the Flathead River. Annual report to the Bureau of Reclamation. Montana Department of Fish, Wildlife and Parks, Kalispell, Montana, USA.

Graham, P.J., D.A. Hanzel, and R.E. Schumacher. 1981. Kokanee management in the Flathead system. Montana Department of Fish, Wildlife and Parks, Kalispell, Montana, USA.

Graham, P.J. and W. Fredenberg. 1982. Flathead Lake fisherman census. Report submitted to the US. Environmental Protection Agency. Montana Department of Fish, Wildlife and Parks, Kalispell, Montana, USA.

Hanzel, D.A. 1975-76. Measure annual trends in recruitment and migration of kokanee populations and identify major factors affecting trends. Project No. F-33-R-10, Job No. Ib. Job Performance Report. Montana Department of Fish and Game, Kalispell, Montana,USA.

Hanzel, D.A 1977. Angler pressure and gamefish harvest estimates for 1975 in the Flathead River system above Flathead Lake. Montana Department of Fish, Wildlife and Parks, Kalispell, Mcntana,USA.

Hartman,W.L., C.W. Strickland, and D.T. Hoopes. 1962. Survival and behavior of sockeye salmon fry migrating into Brooks Lake, Alaska. Transactions of the American Fisheries Society 91:133-139.

Jeppson, P. 1960. Evaluation of kokanee and trout spawning areas in Pend Oreille Lake and tributary streams. Idaho Department Fish and Game, Job Progress Report F3-R-10.

Johnson, W.E. 1965. On mechanisms of self-regulation of population abundance in *Oncorhynchus nerka*. Mitt. Intern. Verein. Limn. 13:66-76.

McMullin, S.L.and P.J.Graham. 1981. The impact of Hungry Horse Dam on the kokanee fishery of the Flathead River. Report submitted to the Bureau of Reclamation. Montana Department of Fish, Wildlife and Parks, Kalispell, Montana, USA.

McNeil, W.J. 1963. Tests of efficiency of hydraulic sampler for collecting salmon eggs. Manuscript Report 1963. U.S.D.I. Fish and Wildlife Service, Bureau of Commercial Fisheries. 3 pages

Montana Fish and Game Commission Report. 1918. Flathead Fish Hatchery Report.

Montana Fish and Game Commission Report. 1934. Flathead Fish Hatchery Report.

Neilscn, J.D. and G.H. Geen. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Transaction of the American Fisheries Society 110:554-556.

Neuhold, J.M., and K.H. Lu. 1957. Creel census method. Utah State Department of Fish and Game, Publication No. 8, Salt Lake City, Utah, USA. 36 pages.

Northwest Power Planning Council. 1982. Columbia River Basin Fish and Wildlife Plan. Portland, Oregon.

Phillips, R.W., and K.V. Koski. 1969. A fry trap method for estimating salmonid survival from egg deposition to fry emergence. Journal of the Fisheries Research Board of Canada 26:133-141.

Royce, W.F. 1959. On the possibilities of improving salmon spawning areas. Transactions of the North American Wildlife Conference 24:356-366.

Stober, Q.J., R.E. Marita, and A.J. Hamalainen. 1978. Instream flow and the reproductive efficiency of sockeye salmon. Fisheries Research Institute, University of Washington, Seattle, Washington, USA. 124 pages.

Ward, F.J., and L.A. VerHoeven. 1963. Two biological stains as markers for sockeye salmon fry. Transaction of the American Fisheries Society 92:379-383.

Wickett, W.P. 1962. Environmental variability and reproduction potentials of pink salmon in British Columbia. Pages 73-86 In: H.R. MacMillan Lectures in Fisheries, Symposium on Pink Salmon 1960. University of British Columbia, Vancouver, Canada.

APPENDIX A

Kokanee redd counts in spawning areas on the mainstem Flathead River, 1979-1983.

Redd counts for the South and Middle Forks of the Flathead River, Beaver and Deerlick Creeks, and the Whitefish River during 1983.

Table 1. Numbers of kokanee redds counted in late November of 1979, 1980, 1981, 1982 and 1983 in areas of the Flathead River below the South Fork. See Appendix E and Praley and Graham (1982) for locations and descriptions of spawning areas.

Area Number	River km	Number of kokanee redds observed 1979	1980	1981	1982	1983
1 [1/]	37.0	425	136	341	180 [4/]	278
1A	37.0	- -	- -	- - -	60	0
2	41.42	5	0	12	0	0
3	42.0	7	1	0	0	0
4	42.2	0	25	67	9	0
5 [1/]	42.5	0	0	14	0	0
6 [1/]	43.4	60	11	0	0	0
7	44.3	0	6	30	16	0
8	45.0	0	0	133	47	0
9	45.5	0	15	218	0	7
10	46.7	0	0	517	0	19
11	47.9	0	0	165	0	0
12	48.0	0	0	254	0	0
13	40.3	22	0	0 [4/]	60	0
14	48.8	0	0	151 [4/]	0	0
15	49.0	0	0	9	0	0
16	49.4	119	12	106	0	0
17	50.0	359	0	118	0	0 [5/]
18	50.5	10	0	0	0	2 [5/]
19	52.0	0	3	174	0	6 [5/]
20	52.2	55	0	604	0	130 [5/]
21	52.4	0	13	226	0	24
22	54.4	100	0	176	17	0
23	55.3	100	7	31	0	0
24	55.5	200	1	13	0	0 [2/]
25	59.8	290	5	363	0	124 [2/]
26	60.2	0	0	3	0	0
27	60.3	150	0	494	0	368 [5/]
28 [2/]	60.7	0	1	51	0	60 [1/]
29 [2/]	60.8	250	0	375	0	197 [1/]
30	61.0	25	0	94	22	103 [1/]
31	61.5	25	0	23 [4/]	0	25 [1/]
32	65.0	0		735 [4/]	0	199
32A	65.5	0	8	413	0	10 [5/]
33 [1/]	66.0	0	0	11	0	36 [5/]
34 [1/]	66.5	20	0	160	67	123
35 [1/]	67.6	50	0	146 [3/]	0	25
36 [1/]	68.5	330	231	0 [3/]	0	0
37 [1/]	67.7	100	0	495	0	1302
38 [1/]	68.5	100	0	288	0	260
39A	69.0	- -	---		- -	30
39B [2/]	69.4	---	- - -	---	- - -	108
39 [2/]	69.5	0	0	1083	560	1852
39c	70.1	---	- - -	---	- -	742
40	70.6	0	0	76	0	231
41	70.9	0	0	92	65	8
41A	72.0	0	0	0	12	0
42	73.7	0	0	0	12	222
42A	73.7	---	- - -	- - -	- - -	192
TOTAL		2,802	467	7,853	1,528	6,683

1/ Spring influenced .
2/ Limited groundwater or spring influence.
3/ Beaver dammed during 1981.
4/ Redds found after late November redd count.
5/ Early November count used because they exceeded late Nov. counts.

Table 2. Number of kokanee redds in the South Fork of the Flathead River from Devil's Elbow to Highway 2 on 29 October 1981, 12 November 1982 and 7 November 1983.

Spawning area description	Area	River km	Number of redds 1981	1982	1983
300-400 m above Highway 2	1	1.5	45	100[1/]	805
Whelp Creek area	2	2.6	90	0	0
Left bank of big bend across from Whelp Creek	3	3.2	140	25	9
U.S.G.S. gauge area (left and right banks)	4	5.5	2	43	859
Devil's Elbow	5	6.3	---[2/]	32	184
TOTALS			277	200	1857[3/]

1/ Redds found after November count.
2/ No count.
3/ An .additional 297 redds were found in the South Fork below the Highway 2 bridge.

Table 3. Number of kokanee redds counted in the upper Middle Fork of the Flathead River on 20 and 22 October, 1981, 25 October, 1982, and 1 November 1983.

Spawning area description	Area	River km	Number of redds 1981	1982	1983
Run above golf course	13	8.6	25	0	42
Run below new W. Glacier bridge	14	9.1	35	0	0
New W. Glacier bridge	15	9.6	51	0	0
Run below old W. Glacier bridge	16	10.7	307	0	3
First run below canoe dump rapids	17	12.0	360	0	6
Last tunnel	18	12.8	95	0	0
Second hole below Lincoln Cr.	19	16.0	10	0	0
	19A	0	0	9	0
Between Deerlick and Harrison Cr.	20	21.9	7	0	9
Mouth Deerlick Creek	21	22.4	66	44	60
		TOTAL	956	53	120

Table 4. Number of kokanee redds counted in the lower Middle Fork of the Flathead River on 20 and 22 October, 1981, 26 October, 1982, and 20 October, 1983.

Spawning area description	Area	River km	Number of redds 1981	1982	1983
First run and pool of canyon	1	2.2	140	244	10
Second run/pool	2	2.6	230	122	4
Third run	3	2.9	246	0	19
Fourth run	4	3.2	170	40	10
Fifth run	5	3.5	62	0	0
First hole in canyon	6	3.8	62	46	0
Sixth run	7	4.5	23	0	0
Second hole of canyon	8	4.8	250	0	0
Third hole of canyon	9	05.1	14	57	0
Hole at tail of USGS cable	10	5.9	40	4	0
Below first house on hill	11	6.9	119	60	139
Below McDonald Creek	12	7.4	4	125	252
		TOTAL	1,360	698	434

Table 5 . Number of redds counted in Beaver and Deerlick creeks on 4 December 1981, 3 December 1982, and 5 December 1983.

Spawning area description	Area	Creek km	Number of redds 1981	1982	1983
Deerlick Creek					
Mouth of Deerlick Creek to Moccasin Creek river access	1	D-.5	48	9	1
Hwy 2 Bridge to Dalimata Bridge	2	1.0-1.5	11	1	0
Gas line crossing to Hwy Dept. shed	3	2.0-3.0	143	14	0
Beaver Creek					
Run below ford crossing to beginning of creek (including side channel by ford)	1	3.0-4.0	516	18	0
TOTAL			718	42	1

Table 6. Number of kokanee redds counted in the Whitefish River on 19 October 1981, 22 October 1982, and 24 October 1983.

Spawning area description	Area	River km	Number of redds 1981	1982	1983
Rose Crossing to Birch Grove Bridge	1	6.0-9.5	265	289	103
Birch Grove Bridge to Tetrault Bridge	2	9.5-13.0	48	421	272
Tetrault Bridge to Hodgson Crossing	3	13.0-15.0	41	127	118
Above Hodgson Crossing	4	15.0-15.5	59	36	37
TOTAL			413	873	530

APPENDIX B

Characteristics of the fall, 1983 kokanee fishery in the Flathead River system.

Tables 1-16

Table 1. Total number of angler party interviews and completed trip party interviews on Sections MSl-MS4 of the Flathead River from 27 August to 15 October, 1983.

	River Section				
	MS1	MS2	MS3	MS4	Total
Number of Interviews					
Shore	13	29	7	32	81
Boat	75	10	7	4	96
Total	88	39	14	36	177
Number of Completed Trips					
Shore	4	5	2	14	25
Boat	37	3	1	1	42
Total	41	8	3	15	67
Percent Completed Trips	47	21	21	42	38

Table 2. Percent kokanee anglers in sections MSl, MS2, MS3 and MS4 of the Flathead River and section MFl of the Middle Fork from 27 August to 15 October, 1983.

	Total Interviews	Kokanee Fisherman	% Kokanee Fisherman
MS 1	89	75	84
MS2	39	7	18
MS 3	15	3	20
MS 4	36	20	56
MF 1	19	18	95

Table 3. Angler residence from 179 party interviews conducted on Sections MS-MS4 of the main stem Plathead River from 27 August through 15 October, 1983.

Angler residence	Number of parties	Percent of parties
Kalispell	116	65
Other Flathead county	47	26
Lake County	2	1
Missoula County	0	0
Other Western Montana	1	1
Eastern Montana	2	1
USA non-resident	8	5
Foreign (Canada)	3	2

Table 4. Catch rates (number of kokanee per hour) for all anglers interviewed on the mainstem Flathead River from 27 August to 15 October, 1983. The number of kokanee caught is in parentheses.

Date	Catch rate (no. kokanee/hour) MS1	MS2	MS3	MS4	
		All Anglers			
8/27 - 8/31	.72 (78)	0	0	0	
9/l - 9/14	.44 (88)	0	0	1.81 (68)	
9/15 - 9/30	.57 (30)	0	0	1.28 (45)	
10/l - lO/l5	0	0	0	.79 (13)	
TOTAL	.53 (196)	0 -	0	1.48 (126)	.56 (322)
		Kokanee Anglers			
8/27 - 8/31	.80 (78)	0	0	0	
9/l - 9/14	.49 (88)	0	0	2.91 (67)	
9/l5 - 9/30	.75 (30)	0	0	1.80 (45)	
10/l - lO/l5	0	0	0	.79 (13)	
TOTAL	.57 (196)	0 -	0	2.09 (125)	.72 (321)

Table 5. Mean number of hours (weighted mean) per completed angler trip by time period on Sections MSl-MS4 on the main stem Flathead River and Section MFl on the Middle Fork of the Flathead River, 27 August to 15 October, 1983.

	Mean hours/completed angler trip					
	Mains tem					Middle Fork
Time period	MS1	MS2		MS4	Total	MFl
8/27 - 8/31						
shore	4.7	4.0		-	4.5	-
Boat	6.7	-		-	6.7	-
Combined	6.2	4.0		-	6.0	-
9/1 - 9/14						
Shore	4.0	2.3	6.0	3.2	3.3	-
Boat	**4.1**				4.1	-
Combined	**4.1**	2.3	6.0	3.2	3.8	-
9/15 - 9/30						
Shore			1.3	2.8	**2.4**	**6.1**
Boat		**4.8**	10.0	10.0	**4.4**	**7.0**
Combined	**1.9**	**4.8**	4.2	4.0	3.6	6.1
10/1 - 10/15						
Shore		2.5		-	2.5	3.0
boat				-		
Combined		2.5		-	2.5	3.0
TOTAL						
Shore	4.5	2.7	2.8	3.1	3.2	5.8
Boat	4.4	4.8	10.0	10.0	**4.7**	7.0
Combined	4.5	3.5	4.6	3.5	**4.2**	5.9

Table 6. Number of parties using each terminal tackle type on Sections Ml-MS4 on the Flathead **River,** 27 August through 15 October, 1983.

	River Section				
	MSl	MS2	MS3	MS4	Total(X)
Bait	7	13	3	5	28 (16)
Fly	**0**	**9**	**4**	**9**	22 (12)
Lure	11	10	4	**0**	25 (14)
Combination	71	7	4	22	104 (58)
TOTAL	89	39	15	36	179 (100)

Table 7. Total number of angler party interviews and number of completed trip angler party interviews on Section MFl of the Middle Fork of the Flathead River from 27 August **to 15 October, 1983.**

	Shore	Boat	Combined
Number of interviews	17	2	19
Number of hours	69	9	78
Number of completed trip interviews	11	1	12
Number of hours	63.5	7	70.5
Percent completed trips	65	50	63
Percent Hours - Completed trips	92	78	90

Table 8. Catch rates (number of kokanee per hour) for shore and boat fishermen on Sections MS1-MS4 on the mainstem Flathead River and Section MF1 on the Middle Fork of the Flathead from 27 August to 15 October, 1983.

	Catch Rates (kokanee/hour)											
	Mainstem Flathead River										Middle Fork	
	MS1		MS2		MS3		MS4		All Sections		MF1	
Date	Shore	Boat	Shore	Boat	Shore	Boat	Shore	Boat	Shore	Boat	Shore	Boat
8/27 - 8/31	.14	.85	0	0	0	0						
9/1 - 9/14	0	.49	0	-	0	-	1.81	-				
9/15 - 9/30	0	.71	0	0	0	0	1.45	0			1.10	2.22
10/1 - 10/15			0	-	-	-	0	1.18	-	-	0	-
TOTAL	.03	.61	0	0	0	0	1.59	.59	.63	.50	.97	2.22

Table 9. Estimated shore fishing pressure by time period on Sections MS1-MS4 of the Flathead River. The 95% confidence limits are in parentheses.

		Total	Estimated shore fishing pressure by section				
			Mainstem Flathead River				
Time Period	Days	daylight hours	MS1	MS2	MS3	MS4	Total
8/27 - 8/31	5	67.5	17 (± 33)	219 (± 165)	67 (± 132)	0	303
9/1 - 9/14	14	189	201 (± 109)	579 (± 305)	260 (± 165)	394 (± 290)	1434
9/15 - 9/30	16	195.2	174 (± 102)	336 (± 169)	65 (± 54)	239 (± 130)	814
10/1 - 10/15	15	168	21 (± 41)	210 (± 322)	21 (± 41)	42 (± 82)	294
Total	50	619.7	412 (± 159)	1344 (± 503)	413 (± 222)	674 (± 328)	2844 (± 659,

Table 10. Estimated boat fishing pressure by time period on Sections MSl-MS4 of the Flathead River. The 95% confidence limits are in parentheses.

Time Period	Days	Total daylight hours	Estimated boat fishing pressure by section				
			Mainstem Flathead River				
			MS1	MS2	MS3	MS4	Total
8/27 - 8/31	5	67.5	1201 (±778)	540 (±630)	202 (±281)	0	1943
9/1 - 9/14	14	189	2000	0	0	0	2000
9/5 - 9/30	16	195.2	877 (±421)	260 (±243)	172 (±217)	239 (±187)	1548
10/1 - 10/15	15	168	0	0	0	42 (±82)	42
Total	50	619.7	4077 (±1299)	800 (±675)	374 (±355)	281 (±204)	5532 (±1520)

Table 11. Total estimated fishing pressure (hours) by time period on Sections MS1-MS4 of the Flathead River. The 95% confidence limits are in parentheses.

Time Period	Days	Total daylight hours	Estimated fishing pressure (hours) by section Main Stem Flathead River				
			MS1	MS2	MS3	MS4	Total
8/27 - 8/31	5	67.5	1218 (±779)	759 (±651)	270 (±310)	0	2247
9/1 - 9/14	14	189	2200 (±958)	579 (±305)	260 (±165)	394 (±290)	3433
9/15 - 9/30	16	195.2	1050 (±433)	596 (±296)	237 (±224)	477 (±228)	2360
10/1 - 10/15	15	168	21 (±41)	210 (±322)	21 (±41)	84 (±116)	336
Total Pressure	50	619.7	4489 (±1309)	2145 (±842)	788 (±419)	955 (±387)	8377 (±1657)
Percent Pressure -			54	26	9	11	100
Pressure (hours) Per Km			125	113	74	41	94

Table 12. Estimated monthly kokanee harvest by shore anglers only on the four sections of the mainstem Flathead River during 1983. The 95% confidence limits are in parentheses.

Time Period	Estimated numbers of kokanee harvested				
	MS1	MS2	MS3	MS4	Total
8/27 - 8/31	2	0	0	0 .	2
9/1 - 9/14	0	0	0	713	713
9/15 - 9/30	0	0	0	346	346
10/1 - 10/15		0		0	D
Total	2	0	0	1059	1062 (±836)

Table 13. Estimated monthly kokanee harvest by boat anglers only on the four sections of the mainstem Flathead River during 1983. The 95% confidence limits are in parentheses.

Time Period	Estimated numbers of kokanee harvested				
	MS1	MS2	MS3	MS4	Total
8/27 - 8/31	1020	0	0		1020
9/1 - 9/14	977	0	0		977
9/15 - 9/30	626	0	0	0	626
10/1 - 10/15		0		50	50
Total	2623	0	0	50	2672 (+1346)

Table 14. Estimated kokanee harvest by shore and boat fishermen on the lower Middle Fork of the Flathead River during 1983. The 95% confidence limits are in parentheses for totals.

Time Period	Estimated numbers of kokanee harvested		
	Shore	Boat	Total
8/27 - 8/31			
9/1 - 9/14			
9/15 - 9/30	228	271	500 (+366)
10/1 - 10/15	0		0
Total	228 (+191)	271 (+312)	500 (+366)

Table 15. Total estimated fisherman pressure in hours exerted by kokanee anglers from shore and in boats on the lower Middle Fork of the Flathead River from 27 August to 15 October, 1983. The 95% confidence intervals are in parentheses.

Time Period	Days	Total daylight hours	Estimated fishing pressure. (hours)		
			Shore	Boat	Total
8/27 - 8/31	5	67.5	0	0	0
9/1 - 9/14	14	189	0	0	0
9/15 - 9/30	16	195.2	207 (±107)	122 (±92)	329 (±141)
10/1 - 10/15	15	168	42 (±66)	0	42 (±66)
Total	50	619.7	249 (±126)	122 (±92)	371 (±156)

Table 16. Estimated kokanee harvest by all anglers on the four sections of the mainstem Flathead River during 1983. The 95% confidence limits are in parentheses.

Time Period	Estimated numbers of kokanee harvested				
	MS1	MS2	MS3	MS4	Total
8/27 - 8/31	1022	0	0		1022
9/1 - 9/14	977	0	0	713	1690
9/15 - 9/30	626	0	0	346	972
10/1 - 10/15		0		50	50
Total	2625 (±1341)	0	0	1109 (±843)	3734 (±1584)

APPENDIX C

Estimated numbers of kokanee fry emigrating, flow, and water temperatures in five river system spawning areas during late winter and spring, 1984.

Figures l-5

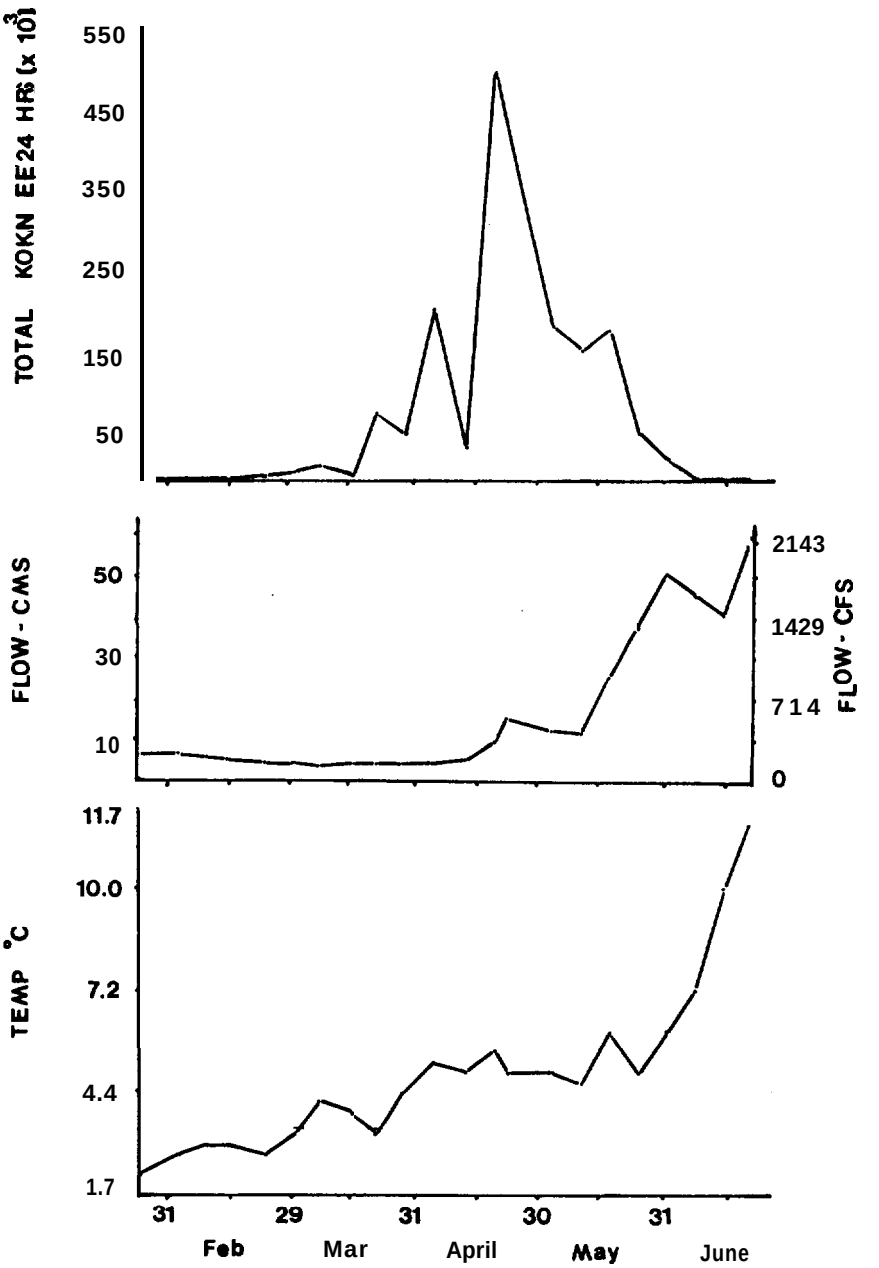

Fig. 1. Estimated numbers of kokanee fry emigrating, flow, and water temperature in McDonald Creek during late winter and spring, 1984.

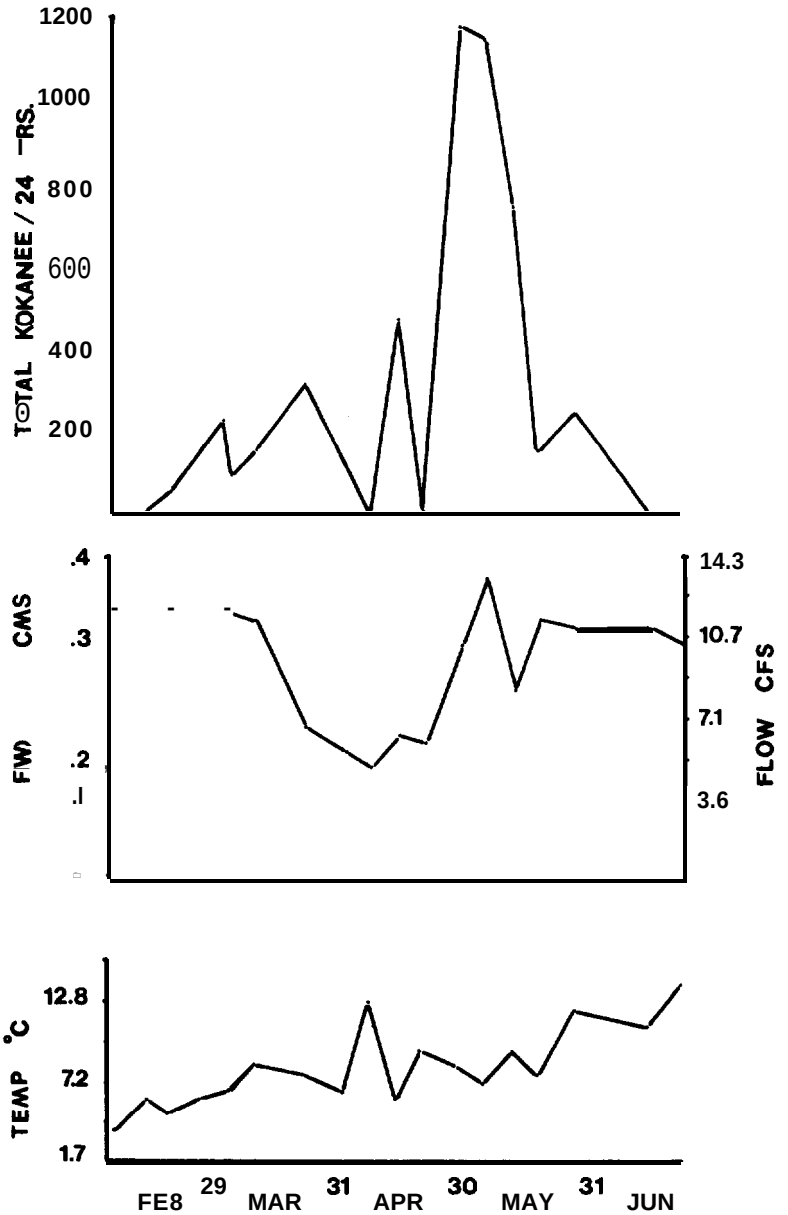

Fig. 2. Estimated numbers of kokanee fry emigrating, flow, and water temperature in Brenneman Slough during late winter and spring, 1984.

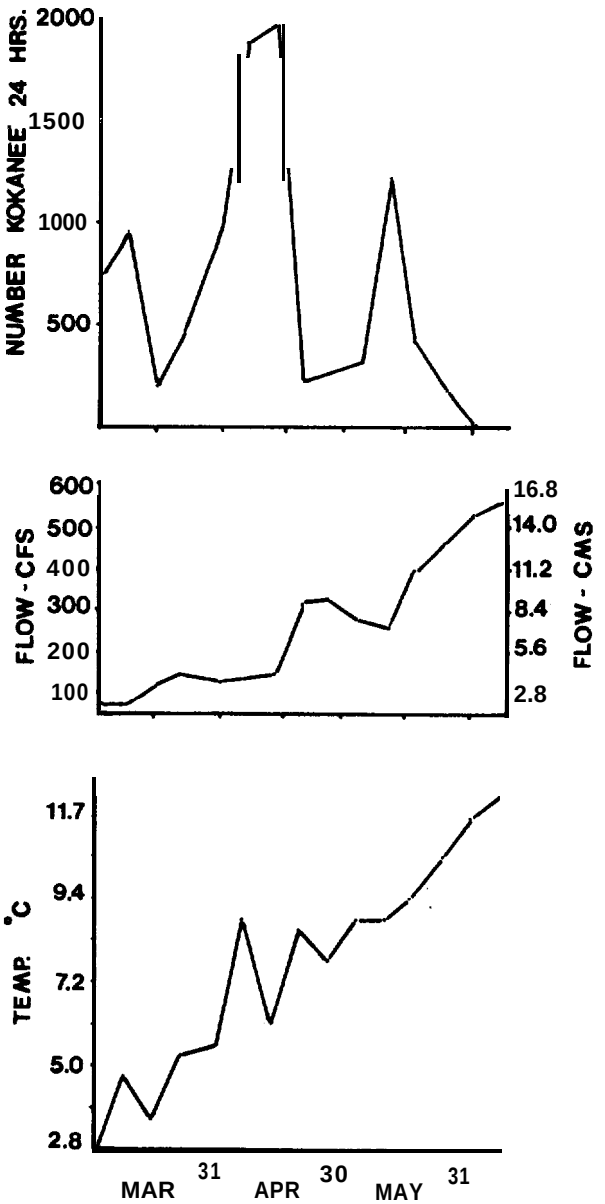

Fig. 3. Estimated number of kokanee fry emigrating, flow, and water temperature in the Whitefish River during spring, 1984.

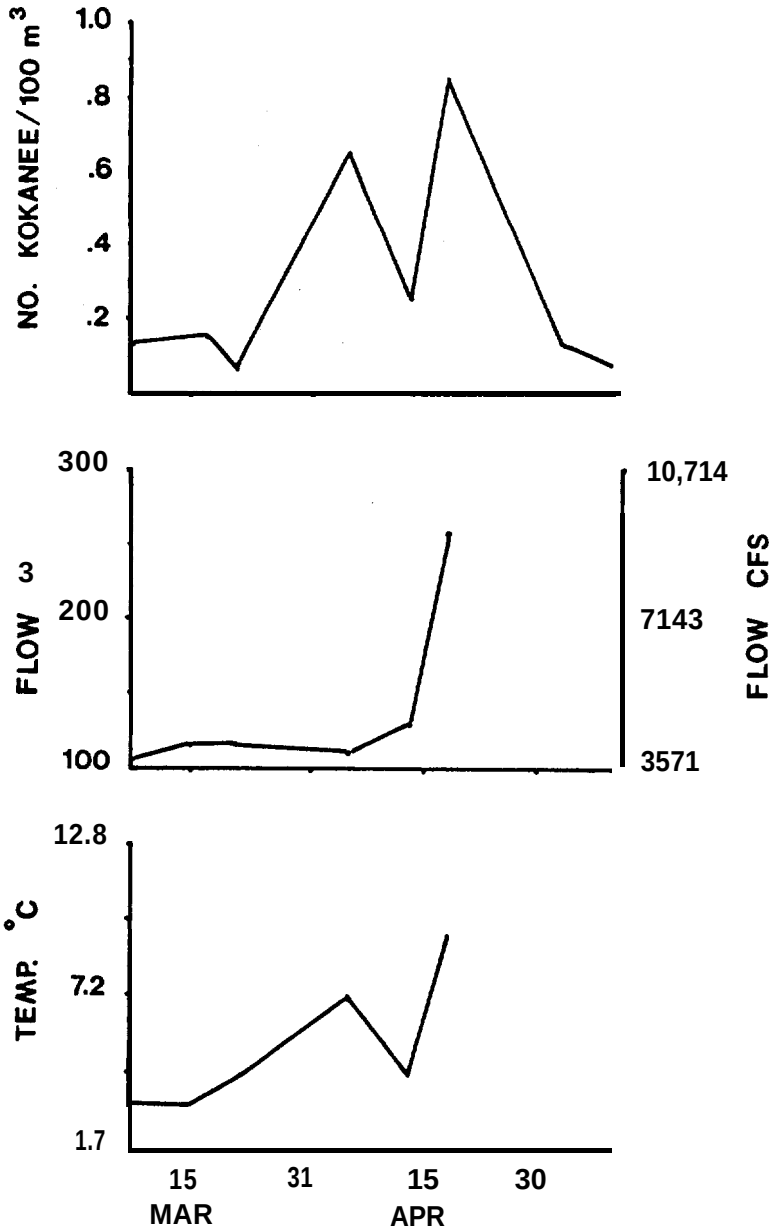

Fig. 4. Number of kokanee fry/l00$_m^3$ of water filtered, flow, and temperature in the main stem Flathead River near Kalispell during 1984.

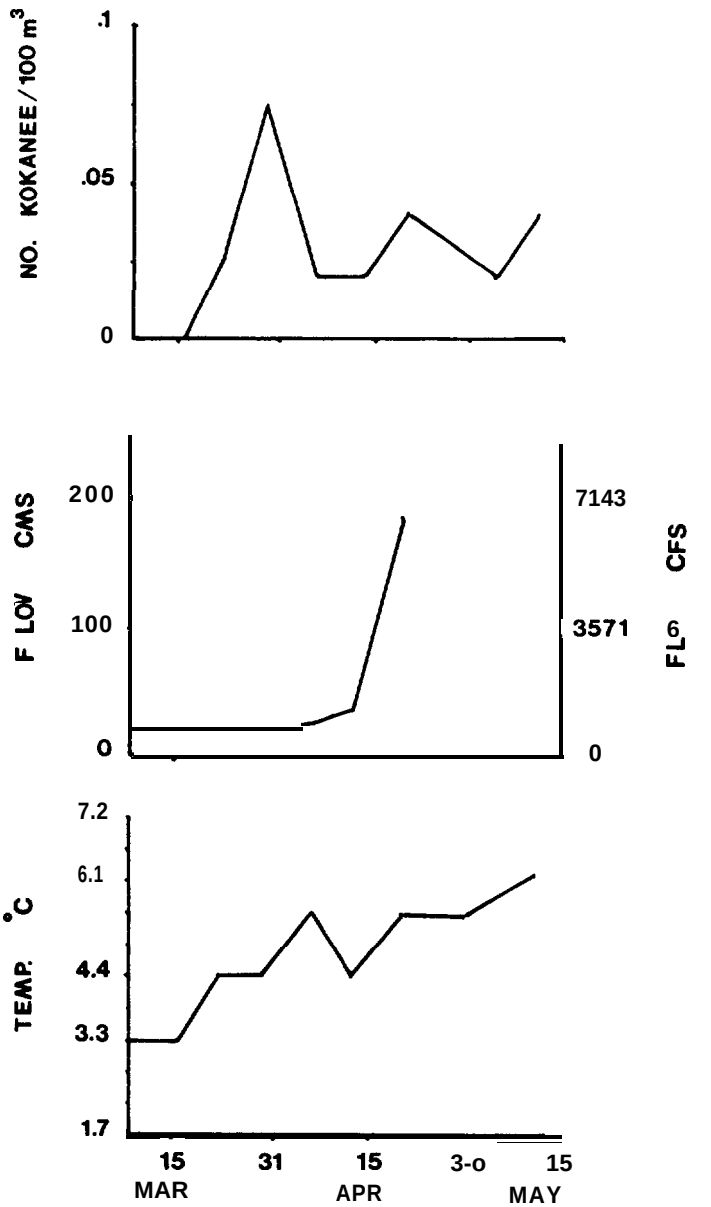

Fig. 5. Number of kokanee fry/l00$_m^3$ of water filtered, flow and water temperature in the Middle Fork River during spring, 1984.