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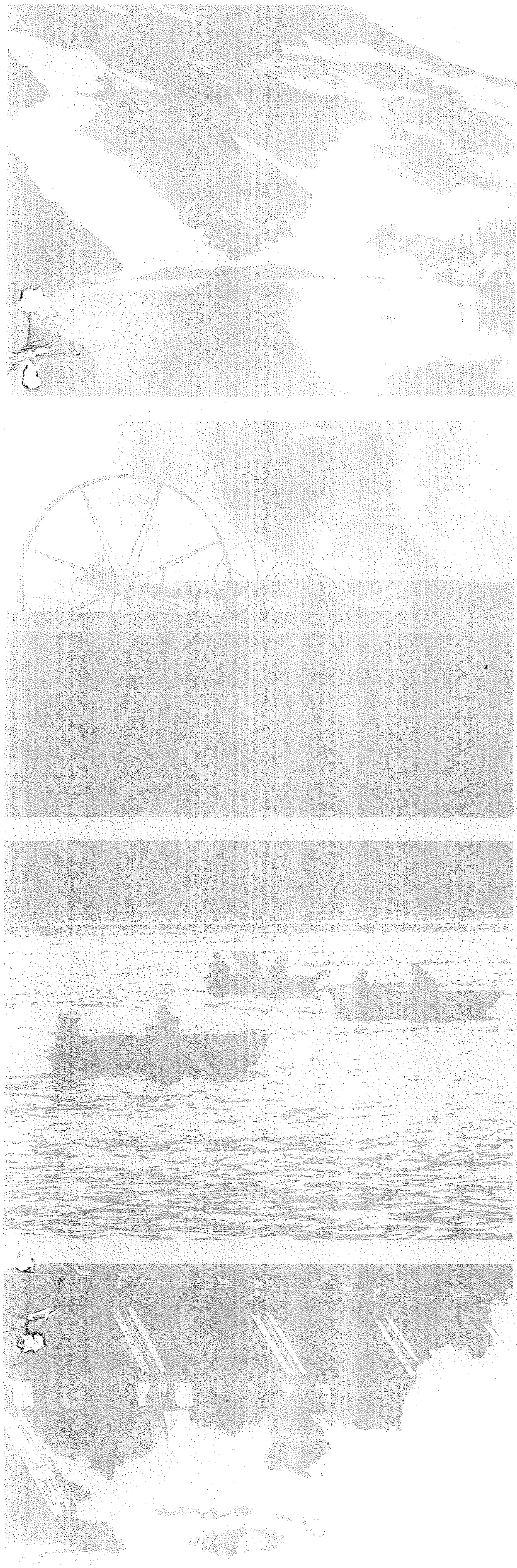

FISHERY ASSESSMENT OF THE UPPER SPOKANE RIVER

by
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Assistant Environmental Scientist
and
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Research Assistant

STATE OF WASHINGTON
WATER RESEARCH CENTER
WASHINGTON STATE UNIVERSITY

Pullman, WA 99164-3002 June, 1982

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Project Completion Report to
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SUMMARY

The objective of this study was to provide baseline information on the upper Spokane River fishery in order to assess future changes. The specific objectives were to: 1) determine the number, species and age structure of trout and trout populations in the upper Spokane River; 2) estimate the number of other fish species; 3) determine the food habits of salmonids in the upper Spokane River; 4) estimate angler harvest; 5) provide data for minimum flow recommendations.

The direct count of fish by snorkeling (1980) resulted in an average of 17.9 salmonids per counter mile from Post Falls (RM 102) to Sullivan Road (RM 87.6) and was composed primarily of rainbow trout. The count from Sullivan Road to RM 86.2 was 384.6 salmonids per counter mile and was composed of about equal numbers of rainbow trout and brook char. From RM 86.2 to RM 84.7 the count was 75.1 fish per counter mile and composed ot equal numbers ot rainbow trout and brook char. From RM 84.7 to RM 80.2 (Upriver Dam) the count was one fish per counter mile.

The population estimate (1980) derived from a mark recapture technique was 8,268 salmonids (95% confidence interval 5,780 to 10,576) from RM 100 to RM 84.7. A mark-recapture effort was repeated in 1981 in two sections of the river and the results were comparable to the 1980 data. The population estimates corresponded in numbers and ratio of fish to the results of the snorkel counts.

An upstream movement (21%) was observed from marked rainbow trout subject to a high flow.

The growth of rainbow trout in the upper Spokane determined from annual increments of growth appears neither exceptionally slow nor rapid.

The annulus ages and corresponding lengths are 0-9.8 cm, 1-19.2, 2-27.9, 3-36.7, 4-42.3, 5-52.1, 6-61.0. The brook char growth was equivalent to rainbow growth.

The estimated density of longnose dace sampled by electroshocking a riffle area was $0.16/m^2$. The abundance of longnose suckers is about twice that of the salmonids.

Anglers spent an estimated 28,737 hours during the 1980 fishing season and 28,998 hours during the 1981 season on the upper Spokane River.

The average catch per effort was .133 fish per hour in 1980 and .102 in 1981.

The angler harvest of salmonids on the upper Spokane River was 3,772 in 1980 and 2,893 in 1981.

A comparison of salmonid stomach contents and substrate samples indicated that salmonids fed selectively on *Hydropsyche sp.* (caddisfly), *Ascellus sp.* (sowbug) and *Baetis sp.* (mayfly). Chironomids were avoided or not available.

The stage-discharge-velocity relationship for four bridge stations are presented. Low flows during the study period were higher than the agreement flow of 300 CFS.

ACKNOWLEDGEMENT

We express gratitude to the following people and organizations for assistance in this study:

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INTRODUCTION

The upper Spokane River has been managed by the Washington State Department of Game as a wild trout fishery with no supplemental stocking. In the late 1970's they observed that the catch rate was low, but, because of its proximity to the city of Spokane, it received heavy angler effort in spite of the low catch rate. In 1979, the Game Department imposed a one fish limit to prevent overharvest. Also in 1979, the Department of Game and sport fishing organizations expressed concern to the Washington Department of Ecology over the possible deleterious effects of a proposed sewage treatment plant at Harvard Road on this wild trout fishery. There existed, however, little data on this fishery from which to determine future impact. The objective of this study was to provide the baseline information to assess the impact of the Liberty Lake sewage treatment plant and increasing urbanization of the Spokane Valley.

The specific objectives of the study were:

1. To estimate the number, species and age structure of trout and trout populations in the upper Spokane River.

2. To estimate the number of other fish species.

3. To determine the food habits of salmonids in the Spokane River.

4. To estimate angler harvest.

5. To provide data for minimum flow recommendations.

II. STUDY AREA

The study area (Figs. 1 and 2) includes the Spokane River from the downstream side of the dam at Post Falls, Idaho (RM 102.0) to Upriver Dam (Spokane Dam) (RM 80.2) near the eastern city limits of Spokane. The river is the outflow of Lake Coeur d'Alene and the discharge is controlled by tributary inflow (St. Joe River and Coeur d'Alene River) to the lake and the operation of the Post Falls Dam by the Washington Water Power Company for power generation. Upriver Dam also has a power generating facility but the three mile long reservoir has relatively little storage capacity.

The mean annual flow for the years 1953 to 1968 in the upper river was 6921 cfs with a mean high flow of 22,000 and mean low flow of 495 cfs. The record low flow was 88 cfs in 1967. The flow during the study period of 1980-1981 is compared with the mean flow in Figure 3. The timing of peak flow is highly variable and is dependent on climatic events which cause rapid snow melt at low and midrange elevations. High elevation snowmelt generally occurs in June.

The Spokane River basin has a complex geological history which is reviewed in Crosby _et._ _al._, 1971. The basin is composed of highly porous, poorly sorted glacial deposits. The river at various locations contributes a measurable amount of water to the groundwater or increases measurably from groundwater flow to the river (Bolke and Vaccaro 1979). A large amount of groundwater flow to the river was observed between RM 87.6 (Sullivan Road) and RM 86.2 (Kaiser Intake) and at RM 80.2 (Upriver Dam).

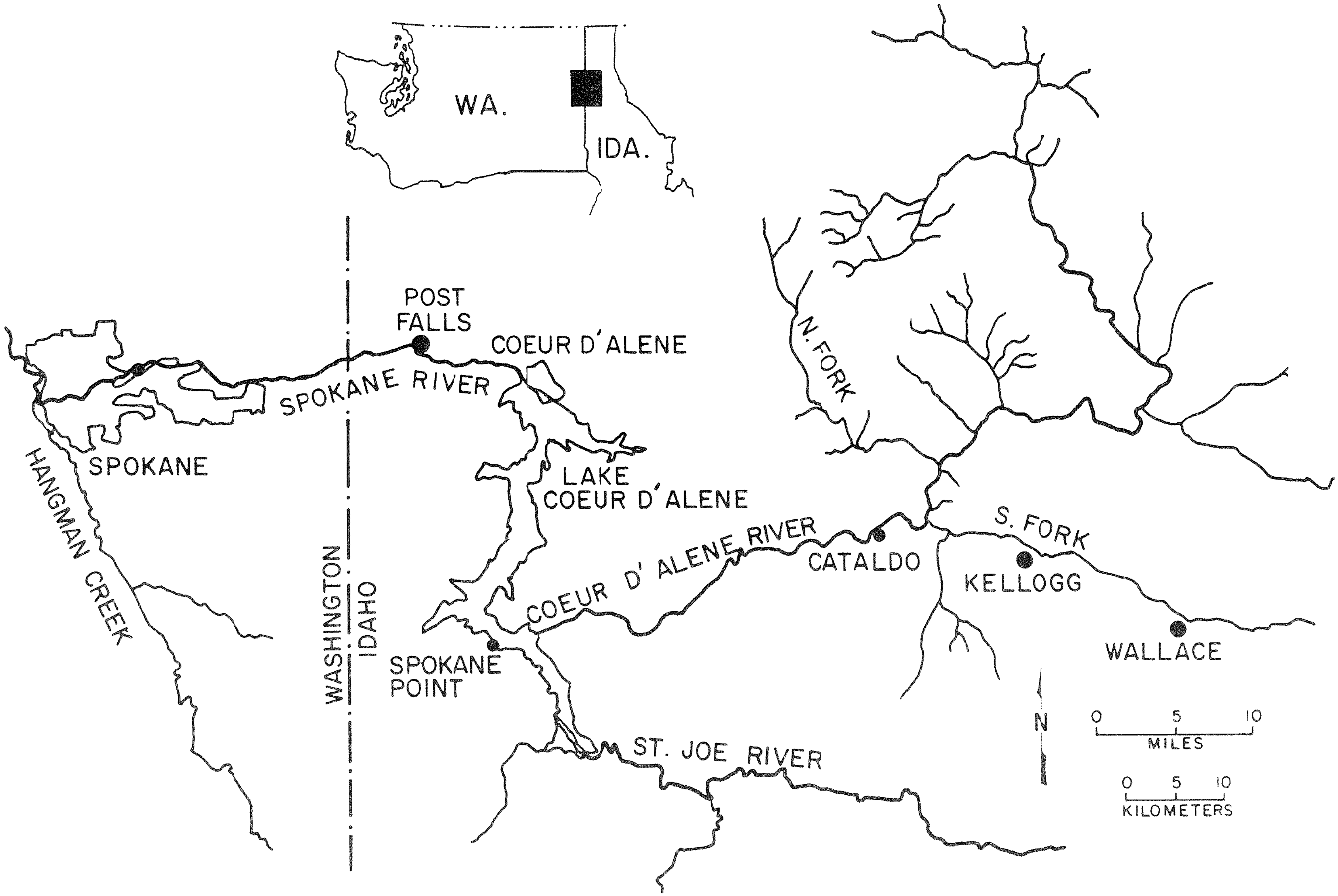

Figure 1. The Coeur d'Alene - Spokane River drainage.

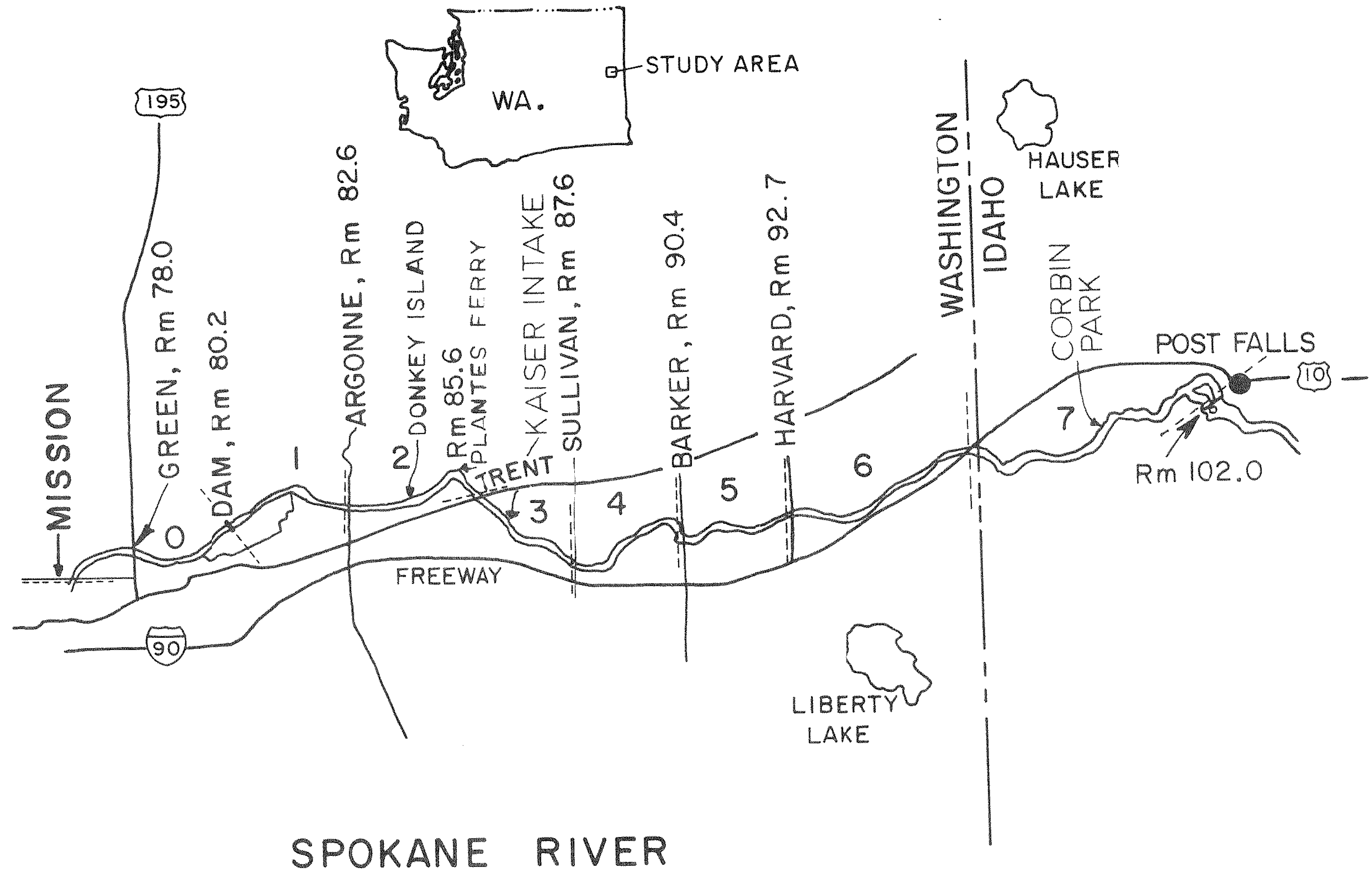

Figure 2. The fishery study section of the upper Spokane River with study reach (0-7) boundaries indicated by dashed lines.

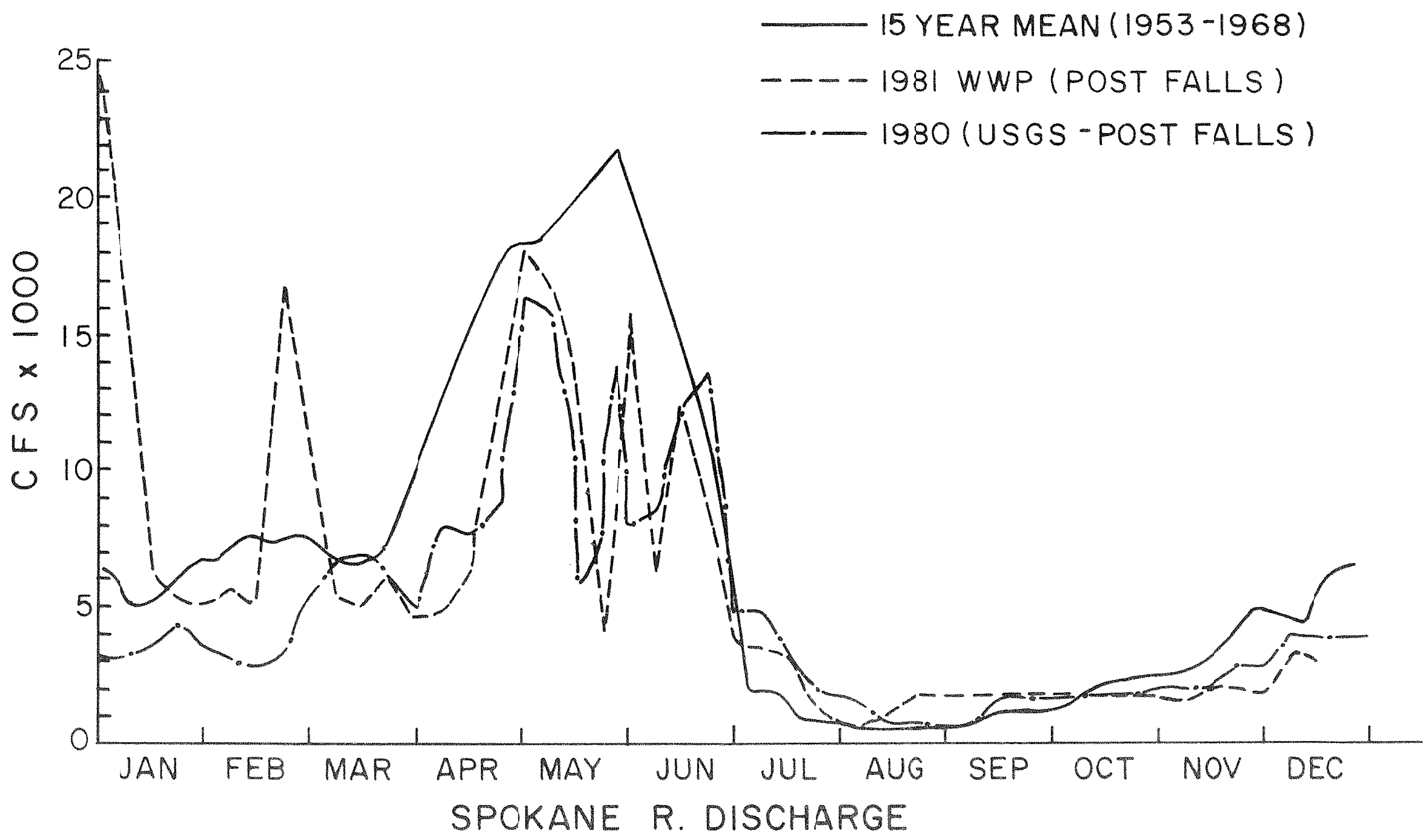

Figure 3. Discharge of the Spokane River near Post Falls.

The river substrate is typically composed of granitic rocks (cobble) from RM 120 to RM 90.4 and from RM 84.7 to RM 80.2. The substrate from RM 90.4 to RM 84.7 is composed of rock and boulders with boulders prevalent in midchannel. Columnar basalt is observed only at RM 84.7 as pillars in the river channel and as a wall on the north bank. Gravels and sand are found only in quiescent areas behind boulders or on inside corners of river bends. Upriver Reservoir is well scoured and has no observed sediment deposition.

The river drops 155 ft. in elevation from Post Falls (RM 102) to the head of the reservoir at approximately Plantes Ferry (RM 84.7) or 9.5 ft./mile. The Barker Road Bridge (RM 90.4) is an approximate dividing point in river slope. The elevation change between Post Falls (RM 102) and the Barker Road bridge is 90 ft. or 7.8 ft./mile. The elevation drop between the Barker Road bridge and Plantes Ferry is 65 ft. or 13.5 ft./mile.

The river narrows from the Barker Road bridge downstream to the head of the reservoir. The mean river width (low flow) measured from aerial photographs (Aerial Mapping Co., Boise, ID) is 255 feet between RM 96.2 (Stateline) and Barker Road bridge and 183 feet between Barker Road and Plantes Ferry.

The river does not exhibit a typical riffle (rapids)-pool morphometry. Deep pools (>12 ft.) are present at the USGS gauging station (RM 100.6-Reach 7), Corbin Park (RM 100.0-Reach 7), Stateline (RM 96.2-Reach 67), Kaiser Intake (RM 86.2-Reach 3) and Plantes Ferry (RM 84.7-Reach 2). Most of the river between riffles is shallow (5-6 ft.) at low flow and is of moderate velocity (≈1 ft/sec). The riffle-pool or riffle-run ratio also increases from Barker Road downstream to the Kaiser Intake from 26.1% (miles riffle/miles pool or run) to 36%. This high percentage of riffle area, the steeper gradient and midchannel boulders all cause the river from Barker Road to the Kaiser Intake to be quite turbulent even at low flows.

The locations by river mile of some prominent landmarks on the river are given in Table 1.

The river was divided into study sections or reaches in order to evaluate different parameters by area. Some reaches were divided in subsections (Table 2).

Table 1. River mile location of some Spokane River landmarks.

Landmark	River Mile	(Km)
Post Falls Powerhouse	102.0	(164.2)
USGS Gauging Station (Idaho)	100.6	(161.9)
Corbin Park	100.0	(160.9)
Pleasant View Bridge	98.7	(158.8)
State Line Bridge	96.2	(154.8)
Harvard Road Bridge	92.7	(149.2)
Barker Road Bridge	90.4	(145.5)
Flora Road	89.1	(143.4)
Sullivan Road Bridge	87.6	(141.1)
Railroad Trestle	87.1	(140.2)
Kaiser Aluminum Intake (Euclid)	86.2	(139.0)
Trent Railroad Trestle	85.6	(137.3)
Plantes Ferry Park (Myrtle Point)	84.7	(136.3)
Donkey Island	83.4	(134.2)
Argonne Road	82.6	(132.9)
Boulder Beach	81.4	(131.0)
Upriver Dam	80.2	(129.0)
Greene Street	78.0	(125.5)

Table 2. Spokane River Reaches and Subsections With River Miles.

		River Miles
Reach 1	Upriver Dam to Argonne Road	2.4
Reach 2	Argonne to Trent Railroad Trestle	3.0
	2A Argonne to Donkey Island	.8
	2B Donkey Island to Plantes Ferry	1.3
	2C Plantes Ferry to Trent Railroad Trestle	.9
Reach 3	Trent Railroad Trestle to Sullivan Road	2.0
	3C Trent Railroad Trestle to Kaiser Intake	.6
	3B Kaiser Intake to Railroad Trestle	.9
	3A Railroad Trestle to Sullivan Road	.5
Reach 4	Sullivan Road to Barker Road	2.8
Reach 5	Barker Road to Harvard Road	2.3
Reach 6	Harvard Road to Stateline	3.5
Reach 7	Stateline to Post Falls	5.8
	7A Stateline to Pleasantview Road	2.5
	7B Pleasantview to Corbin Park	1.3
	7C Corbin Park to Post Falls	2.0

METHODS

A. Population Parameters

1. Snorkel Counts

Visual counts of fish provide an estimate of relative fish abundance and distribution. Four separate snorkel counts were conducted in the upper Spokane River in 1980. From July 15 to July 18 we counted from Post Falls to Upriver Dam (reaches 7 to 1). This count included the use of SCUBA in the deep pool below Stateline and a transect across Upriver Reservoir. No fish were observed during these SCUBA transects so SCUBA was not used again. From July 29 to July 31, 1980 we made one count in reach 6, one count in reach 5 and three counts in reach 4. The multiple counts in reach 4 were run to determine the variability of repeated counts within relatively constant count conditions. The counters were shifted so each of the three counters counted one run at mid-channel, north shore, and south shore. From August 11 to August 15, 1980 we made one count in reaches 7 to 1, one count from Upriver Dam to Mission Street and two additional counts in reach 5 with five and eight counters. The multiple counts in reach 5 were used to find a maximum fish count with an increasing number of counters. Plans to conduct a count with eleven counters were cancelled because of problems with the distribution of eight counters. One snorkel count was conducted in study reach 3 on November 13, 1980. The count scheduled for July 1981 was cancelled in reaches five through one because of high turbidity in the river caused by dredging at Harvard Road. In September 1981, we counted from Post Falls to Upriver Dam (reaches seven through one).

The counts included only age 1 and older fish (fish in the second growing season) except for the August 1980 counts which included young of the year fish.

The counts were tallied on plastic counters strapped to the snorkelers wrist. The counters floating near each shore were over water four to six feet deep. In high velocity water the counters moved closer to shore. The midchannel counter followed the thalweg (line of highest velocity). Several rapids were considered too dangerous to snorkel, especially for the midchannel counter, and so these rapids were not surveyed. For the July and August 1980 counts the snorkelers carried river maps in waterproof bags and noted the location of fish as they were counted.

2. Population Estimates-Salmonids

A population estimate was derived by a mark-recapture technique (Ricker 1968) using electroshocking gear and serially numbered jaw tags. Confidence intervals were calculated by methods given in Davis (1964) and Ricker (1968).

Several methods of electroshocking were tried on the Spokane River from June to September, 1980. These included: 1) night electroshocking in a 16-foot aluminum boat; 2) daytime electroshocking with 6-foot and 12-foot aluminum boats, and 3) night electroshocking with a 12-foot boat and 7.5 HP outboard motor. These methods were inefficient because no fish were captured or because of logistical problems. We then used a technique using the motor, drifting, and walking the boat to cover all (or most) of a reach in a night. We used the motor only if the starting or ending point had a long run or pool. While drifting one person sat in the front of the boat using a dead man switch for the electroshocker and netting the fish as they approached the anode. A 60 watt reflector lamp was clamped to the gunwale for illumination. The netted fish were placed in a 30 gallon barrel carried in the boat. The oarsman in the stern was responsible for navigation. When a sufficient number of fish had been collected we put into shore to tag the fish. The fish were individually anesthetized with MS222 (tricainmethansulfonate), weighed, measured for fork length and tagged with a serially numbered jaw tag. Scale samples, for age and growth, were taken from a sample of fish in each reach. Tagged fish were placed in a small enclosure constructed of rocks and open on the upstream end. The fish were observed until they recovered from the anesthetic and swam away. Stomach samples were taken from the few fish that did not recover. Generally, it was possible to work one reach in a night (dusk to dawn). In reach 7 (Idaho) we worked only from Corbin Park to Stateline because of the difficult access at Post Falls and the very heavy rapids just above Corbin Park. In addition, the 3.8 miles from Corbin Park to Stateline was the maximum we could work in one night.

The use of a fyke net in reach 5 and fyke and gill nets in reach 1 to collect fish was unsuccessful.

The major capture effort began on September 8, 1980 and continued through September 19. The recapture efforts were conducted in October, 1980 and April, 1981. Another capture effort was conducted in September, 1981 only in reach 5 and 3.

3. Age and Growth - Salmonids

Age and growth determinations were made according to procedures given in Ricker (1968), Everhart, Eipper and Youngs (1975), Alvord (1954), Cooper (1951) and Shirvell (1980).

Scale samples were taken from angler caught fish and a sample of fish taken during the mark-recapture sampling. Scales from rainbow trout were taken from the area above the lateral line and below the dorsal fin. Brook char scales were taken from the caudal peduncle. All scales were air dried in labeled envelopes. The scales were cleaned with an alcohol-water mixture when necessary and impressions of the scales were made on acetate slides using a heat press. The annuli were counted by the use of a scale projector (rainbow trout) or a binocular dissecting microscope (brook char). The scales were analyzed independently by two people and atypical scales were discarded. Age determined by scale analysis was confirmed by standard length-frequency plots.

The annual growth rate was measured as the difference in size between succeeding age classes and by the recapture of individual tagged fish.

4. Estimate of Abundance - Non-salmonids

The abundance of longnose dace (Rhinichthys cataractae) was estimated by electroshocking shallow riffle areas along eight 30 by 12-foot transects in the Barker Road area. This density estimate was expanded to a river estimate by multipling by the area of shallow riffles.

The abundance of longnose sucker (*Catostomus catostomus*) was estimated by comparing the number of suckers stunned by the electroshocker to the number of salmonids captured in 1980 and 1981.

B. Angler Census-Sampling Design and Analysis

The study design was based on Malvestuto *et al.* (1978) who allocates sampling effort randomly and proportionately to expected fishing effort. Randomly allocating effort within sampling strata reduces sampling bias. Allocating sampling effort according to expected effort increases precision. Since variance tends to increase with the mean, allocating more samples to times of greater fishing activity reduces the confidence interval by reducing t and increasing n according the following equation:

$$\text{Confidence interval of } \bar{X} \; (C.I._{\bar{X}}) = \bar{X} \pm t_{\alpha,d.f.} \frac{S}{\sqrt{n}}$$

where $C.I._{\bar{X}}$ is the confidence interval around a mean,

$\bar{X}$ is the sample mean,

t is the students t probability value given α (probability of type I error) and d. f. (degrees of freedom),

S is the standard deviation of $\bar{X}$ and n is the number of samples

The 1980 creel census effort was allocated after consulting with Ray Duff, Washington Department of Game, Spokane Regional Fishery Manager. The Washington Fishing Season (April 20 to September 30) was divided into eight strata and 80 angler counts were assigned to days within these strata. The season was divided by flow regime (high flow = April 20 to June 30, low flow = July 1 to September 30). Within each flow regime we also divided the time into weekends or weekdays. These days were further divided into AM or PM. The AM count period started at one half hour before official sunrise and continued for eight hours. The PM count started eight hours prior to dark (official sunset time + one half hour). The number of check days and percentage effort is given in Table 3. The counts were also separated by river reach.

Some discrepancy from the planned allocation occurred because of the Mt. St. Helens eruption and illness of the census worker.

In 1981, seventy-seven check days were randomly assigned in proportion to the angling effort observed in 1980 with an increased number of counts assigned to weekend PM periods for low flow and high flow. All weekend days (or holidays) except one were sampled in 1981 due to the large number of anglers on weekends and because only an AM or PM could be assigned to a weekend day.

In 1980, the census worker alternated the starting point and the count/interview priority. The travel time per count trip was approximately two hours. Interview trip time depended on the number of anglers. The worker also made a count during the interview trip (some anglers were visible but not accessible for interview). In 1981 the census worker completed 3 trips per count period - two count trips and one interview/count trip. The starting point and the sequence of counts and interview were randomly chosen for each count period.

Each angler was asked (1) the time fishing started, (2) anticipated quitting time, (3) the hours spent on the previous trip, and (4) whether any fish had been caught. Any fish caught and retained were measured for

Table 3. Angler census effort for 1980 and 1981 in number of check days and percent (%) for the upper Spokane River.

	Weekday AM	Weekday PM	Weekend AM	Weekend PM
1980 High Flow (59%)	7(11)	12(19)	8(13)	10(16)
1980 Low Flow (41%)	8(13)	7(11)	6(10)	5(8)
1981 High Flow (43%)	5(6)	9(12)	4(5)	15(19)
1981 Low Flow (57%)	5(6)	12(16)	7(9)	20(26)

length, scales were taken for age determination and, when present, the stomach was removed for later analysis of contents.

The angler harvest per reach and time strata were determined by calculating the mean of angler numbers in each reach and time strata. Each count was treated as an independent count. The mean angler count for each reach-time strata was multiplied by the number of total hours in each time strata to obtain total angler hours per reach-time strata. The total angler hours were then multiplied by the catch per effort (CPE = fish per hour) to obtain a harvest estimate. The confidence interval was based on the standard deviation of the counts in each reach-time strata. Each limit was carried through as a separate estimate (multiplied by hours per period then by CPE). The CPE was calculated for each reach-flow period and not by weekend-weekday or AM-PM. Two CPE estimates were made for each reach-flow period. One estimate was based on the number of fish caught for period of time at the interview time. The other CPE estimate was based on number of fish caught per time in the angler's previous trip.

C. Food Habits

A total of 102 salmonid stomachs were collected from anglers and electroshocking mortalities. They were preserved in 10% formalin or 95% ethanol. In the laboratory the stomachs were opened and the organisms present were identified and counted. When large numbers of small organisms were present we counted these by subsampling.

Strauss' (1979) linear index was used to determine the presence of selective feeding. This index (L) is the unweighted difference in proportion of organisms present in the stomach (Ri) to organisms present in the river substrate (Pi). The index is calculated as L = Ri - Pi with positive values indicating fish preference and negative values indicating avoidance or inaccessibility. A value near zero indicates neither preference or avoidance. The substrate proportion (Pi) of organisms was calculated from all samples (multiple-plate and rock basket) collected in reaches two through six from April through September of 1980 and 1981 (Funk et al., 1982). The confidence interval (C.I.) for L was calculated as

$$C.I. = \pm t_{N_P + N_R - 2, .05} \left(\frac{S2(L)}{N_P + N_R}\right)^{.5}$$

where

$$S^2(L) = \frac{Ri(1-Ri)}{N_R} + \frac{Pi\ (1-Pi)}{N_p}$$

N_R is number of samples to calculate Ri

N_p is number of samples to calculate Pi

Oligochaeta, Colenterata and Turbellaria were not included in the calculation of Pi.

D. Minimum Flow Data

The procedure for determining minimum flows for salmonids generally is (1) determine the flow regime for a river, (2) relate depth, area and velocity to flow, and (3) determine minimum and optimum flow based on velocity preference, depth preference, and spawning area available.

Flow in the Spokane River is well-documented. In our study section Washington Water Power records daily discharge from the Post Falls dam and the U.S.G.S. maintains a gauging station two miles downstream from the dam (RM 100.6). Our measurements of bed profile and depth change with flow were confined to bridges at Stateline, Harvard Rd., Sullivan Road and Argonne Road because of the high water velocity. Velocity profiles were measured at each bridge station over several flows with a Price meter. We observed apparent depth preference during our snorkel counts and measured the velocity in the river in areas where we observed fish during the fall 1981 snorkel counts with a velocity meter described by Gessner (1955).

RESULTS

A. Population Parameters

1. Snorkel counts

The snorkel counts were a rapid method of determining relative abundance and distribution of fish in the upper Spokane River.

In 1980, there was a general increase in abundance (fish per counter mile) from reach seven to a maximum in reach three between Sullivan Road to the Kaiser intake (Figure 4). The abundance then decreased from Kaiser intake to Plantes Ferry and practically no fish were observed from Plantes Ferry to Upriver Dam. From Upriver Dam to Mission Street (Reach 0) the abundance was comparable to Reach 4. Reach 0 is stocked with rainbow and brown trout and from Greene Street downriver is open for angling all year with an eight fish limit. In 1981, the counts were equivalent in Reaches 7 through 4 and maximum density was again observed in the section from Sullivan Road to Kaiser intake. No fish were observed from Plantes Ferry to Upriver Dam.

As a comparison, Reid (1971) counted an average of 116 salmonids (rainbow and cutthroat trout) per counter mile in the upper St. Joe River (Marble Creek to Falls Creek) in 1967, 1968, and 1969. The St. Joe study section, however, was stocked during the study years at a rate of 8,200 rainbow per river mile. Cutthroat trout (not stocked) were counted at 3.2 per counter mile.

The abundance and distribution of fish in the river appears to be closely related to the amount of groundwater inflow. The groundwater enters as cold (8-10C) springs from Sullivan Road to the Kaiser intake and the flow of this water is large enough to influence midsummer temperature in the reach. On July 13, 1980 (1700 hr.) we measured a drop in water temperature from 23 to 19C (74 to 67F) through this reach. Large numbers of fish were observed congregated along the shoreline in areas where these springs enter the river. Brook char especially seemed to prefer these areas as the maximum abundance of brook char occurred in this reach of the river (Figure 4).

The multiple counts in Reach 4 to determine the precision of counts (Table 4) showed a wide confidence interval of ±7.6 around the mean number of fish per counter mile ($\bar{X}$ = 8.2) at α =.1. This is in part due to the small sample size (3) but is also largely influenced by the high variation in the count of the midchannel counter. Omitting the midchannel counter from the calculations gives a mean and confidence interval of 8.5 ± 3.4. Reach 4, as explained previously, is an extremely turbulent reach and has several rapids that were considered too dangerous to snorkel through in midchannel. It was also observed that at low flows the fish are distributed closely around the heads and tails of the rapids. The midchannel count in this turbulent reach is largely a function of how closely the midchannel counter felt he could safely approach the head of the rapids or enter in the tail. If the multiple counts had been repeated during August the variance would have probably decreased because of lower flows (lower velocity in the rapids) and more experienced counters.

The coefficients of variation (C.V. = S ÷ $\bar{X}$) in the multiple counts (.45 and .20) are equivalent to multiple counts of whitefish in the Similkameen River, B.C. (.42 to .18) (Northcote and Wilkie 1963). The data presented by Northcote and Wilkie (1963) also show a strong

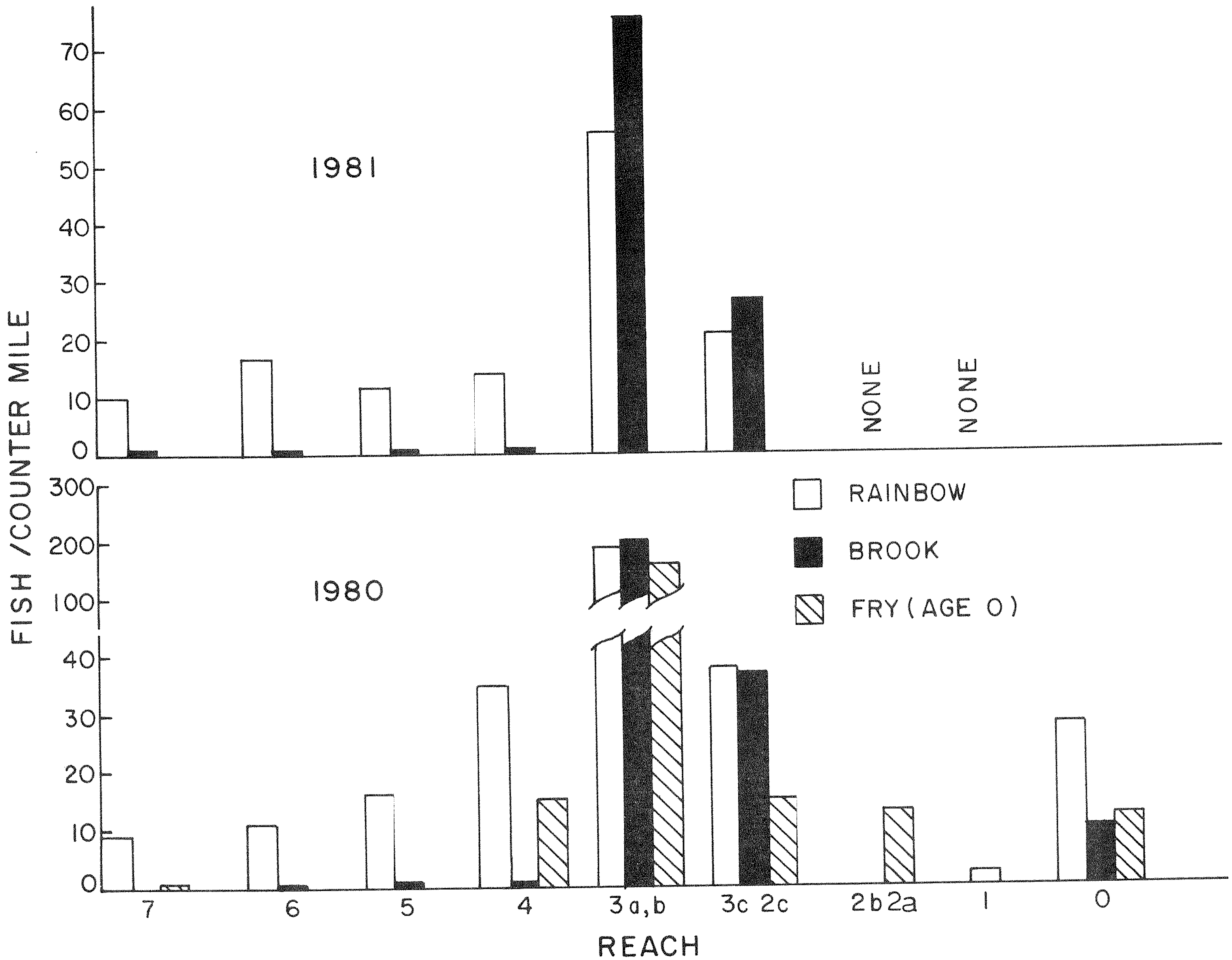

Figure 4. A comparison of snorkel counts among study reaches in the upper Spokane River.

TABLE 4. Multiple snorkel counts of salmonids in study reach four to determine precision of fish counts

Count No.	Counter	Fish Count	Total Fish Count	Fish/ Counter Mile	Fish/ Counter Mile (shore count)
1	North shore	19			
1	Mid-channel	13	55	6.5	7.5
1	South shore	23			
2	North shore	30			
2	Mid-channel	6	48	5.7	7.5
2	South shore	12			
3	North shore	39			
3	Mid-channel	46	104	12.4	10.4
3	South shore	19			
		$\bar{X}$ =		8.2	8.5
		S =		3.66	1.67
Confidence Interval (α=.1)		=		± 7.6	± 3.4

positive dependence (r = .95) of the variance on the mean count. The practical implication of this dependence is that in order to maintain a constant error of the mean the number of counts allocated to a study reach should be proportional to the fish density in that reach.

On August 12 and 13, 1980 we tried to obtain an estimate of actual numbers of fish in reach 5 by counting with 3, 5 and 8 counters on separate counts. Reach 5 was chosen because the additional snorkelers were inexperienced and reach 5 is a relatively easy reach to snorkel (low turbulence). Theoretically, the total number of fish with increasing numbers of counters should reach some asymptotic value. In practice, however, managing eight counters spread across the river and subject to the problems of varying velocities and poor communication proved to be too difficult, therefore the planned counts with additional counters were cancelled. The total number of fish counted increased directly with the number of counters (Table 5) and considering the river width and visibility approximately 30 counters would be needed for a complete count. Although the total number of fish counted increased directly with the increase in counters, the number of fish counted per counter remained relatively constant (Table 5). Considering the relative consistency of fish count per counter, the August 1980 count data was expanded to obtain a population estimate by multiplying mean count per reach by mean river width per reach and dividing by eight (Table 6). Eight feet was the approximate lateral width of visibility during the counts. The estimates are highly dependent on visibility and increasing the count width from eight feet to ten feet reduces the population estimate to 16,638.

The dredging of the river bed at Harvard Rd. for the natural gas pipeline caused a cancellation of the planned July 1981 counts below

Table 5. Snorkel counts of salmonids in the Spokane River (Harvard Rd. to Barker Rd.) with three, five and eight counters.

Date	Counters	Total Fish Counted	Fish/Counter Mile
August 12, 1980[a]	2	71	15.4
August 12, 1980	3	117	17.0
August 13, 1980	5	177	15.4
August 13, 1980	8	270	14.7

[a]Mid-channel count omitted

Table 6. Population estimate for total salmonids from August 1980 snorkel counts by reach

Reach	Mean Count	(River Width ÷ 8)	Total Fish
7	52.7	31.9	1,681
6	38.3	31.9	1,222
5	36.7	31.9	1,171
4	94.3	22.9	2,159
3ab	500	22.9	11,450
3c2c	127.6	22.9	2,922
2ab	0	33.2	0
1	4	47.7	191
			20,796

Harvard Rd. due to the high turbidity. The suspended solids concentration immediately below Harvard Rd. at this time was 13.7 mg/L and visibility in the water was less than one foot. The suspended solids remained high through 1981 and may have caused the 1981 counts to be lower than 1980 counts in reach 5 through 2 (Figure 4). The mean suspended solids concentration in reach 5 through 2 in September 1981 was 4.1 mg/L compared to 1.5 mg/L in the August 1980 count period.

Since the counts are so highly dependent on visibility, future counts should include some measurement of visibility. Suspended solids were used in this study because the data were available from the water quality study being conducted concurrently (Funk et al., 1982). Visibility, however, is also affected by the size of suspended particulates and color of the water. The best reference measurement for any future counts is probably an underwater Secchi disk measurement.

There was a relatively even distribution of salmonids throughout the upper part of reach 5, the site of the treatment plant outfall (Figure 5) during the August 1980 snorkel counts.

No fish were observed in the November, 1980 count in reach 3.

2. Population Estimate-Salmonids

In the initial collecting effort from June 22 to June 24, 1980 (Table 7) it became apparent that in trying to collect all the fish we were missing some of the salmonids. On June 24 and thereafter we collected only the salmonids.

The high density of longnose suckers (Catostomus catostomus) in this reach was not observed in later, low flow collecting efforts although

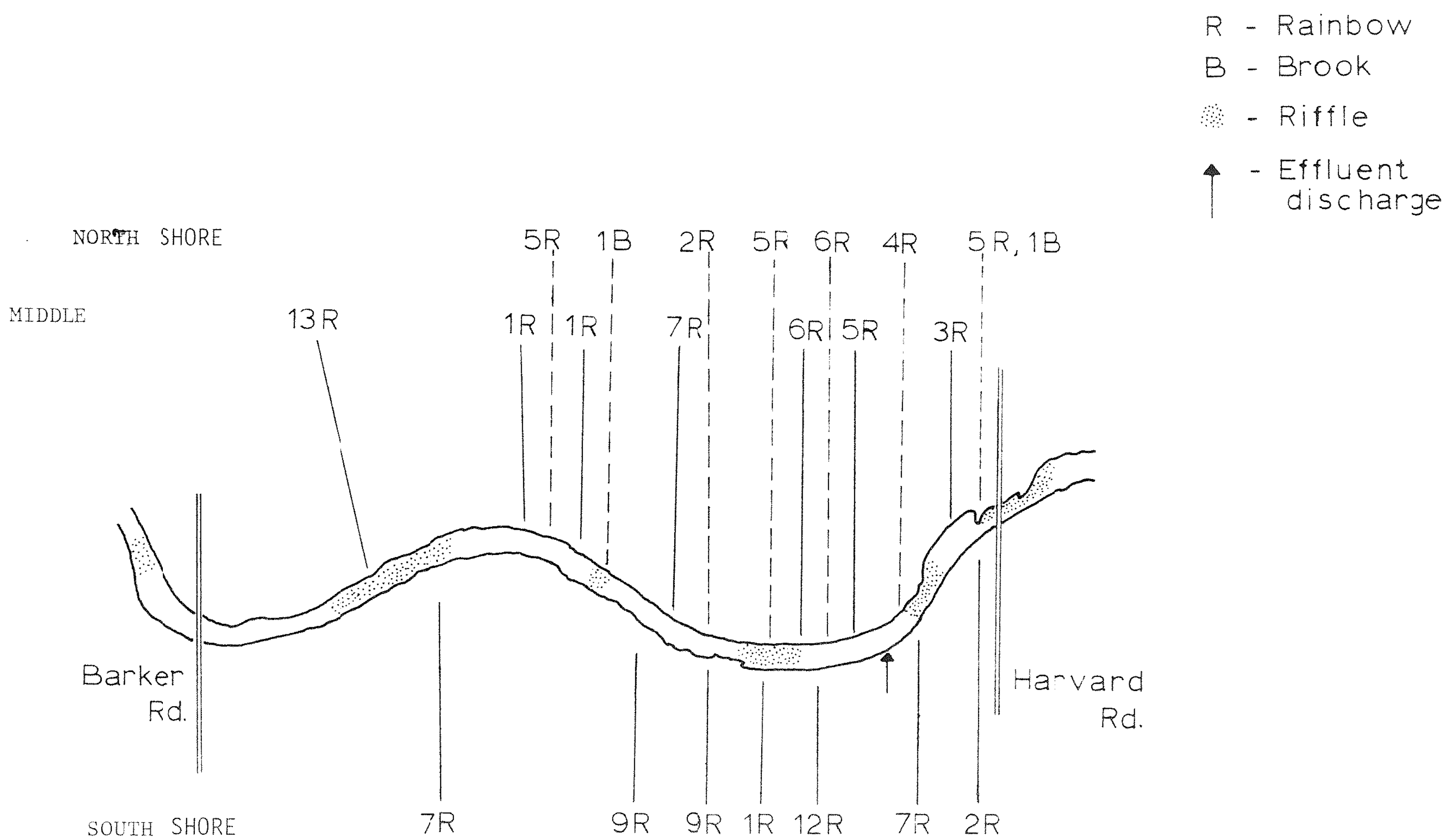

Figure 5. Distribution of salmonids observed by snorkeling in study reach five.

Table 7. Results of preliminary electroshocking effort on upper Spokane River.

June 22, 1980 Reach 2a

Longnose sucker - 98

Yellow perch - 6

Kokanee - 3

Rainbow trout - 1

June 23, 1980 Reach 2b

Longnose sucker - 26

Yellow perch - 2

Rainbow trout - 2

June 24, 1980 Reach 2b

Rainbow trout - 5

Book char - 3

large numbers were observed in the upper reaches while snorkel counting and electroshocking.

Yellow perch (Perca falvescens) were collected frequently in reach 1 and 2 at high flow but infrequently at low flows in these and other reaches.

The kokanee (Oncorhynchus nerka) collected at this time were in poor physical condition and had probably passed over the Post Falls Dam during the spring high flow. Only one other kokanee was captured during the rest of the study and it was captured in reach 7.

The unsuccessful July 1980 daytime collecting efforts were conducted in reach 3 because of the high concentration of fish observed there. It's possible that a daytime effort would be successful in the river with a more powerful shocking unit, however, this would mean a larger generator and larger boat which would sacrifice mobility. Frequently, it was necessary to line the boat or completely unload and carry the boat and gear around some rapids in reach three and four. A larger boat and generator would have made it impossible to work these reaches. We also frequently had to climb the steep river banks with the gear at the start or stop point. Another one or two crew members would have been necessary with larger gear.

From September 8 to September 19, 1980, 515 salmonids were captured, tagged and released from Corbin Park to Plantes Ferry (Table 8). No fish were captured in the remainder of reach two and reach one. The recapture sampling was conducted from October 8 to October 16. We captured 557 salmonids which included 36 (6.5%) recaptures. The combined salmonid population estimate from Corbin Park to Plantes Ferry based on this data was 8,268 (Table 9). Our observations from the snorkel counts and the

Table 8. Numbers of salmonids marked and recaptured for a population estimate on the upper Spokane River.

9/8 - 9/19/80

	Number Caught		Number Recaptured	
Reach	Rainbow	Brook	Rainbow	Brook
7	61[a]	0		
6	43	2		
5	28	1		
4	69	41		
3	65	182		
2	10	13		
1	0	0		
Total	276	239		

10/8 - 10/16/80

	Number Caught		Number Recaptured	
Reach	Rainbow	Brook	Rainbow	Brook
7	115[a]	7	7	0
6	18	2	4	0
5	57	2	2	0
4	78	19	2	3
3	53	141	2	15
2	16	19	1	0
Total	367	190	18	18

[a] includes one cutthroat trout

Table 8. Continued

4/4 - 4/9/81

Reach	Number Caught: Rainbow	Number Caught: Brook	Number Recaptured (all tags): Rainbow	Number Recaptured (all tags): Brook
7	64[a]	6	2	1
6	93	3	3	0
5	86[a]	5	2	0
4	44	11	1	0
3	18	11	0	3
2	21	3	0	0
1	1	0	0	0
Total	335	44	8	4

9/14 - 9/18/81

			all tags	
7	7	0	0	0
6	18	8	0	0
5	14	0	1	0
4	36	0	1	0
3	21	56	0	1
2	1	14	1	0
1	0	0	0	0
Total	97	78	3	1

10/21 - 10/22/81

			(Sept. 81 tags only)	
5	88	5	1	0
3	192	90	4	8

[a] includes one cutthroat trout

Table 9. Population estimate for salmonids in the upper Spokane River.

$$\hat{N} = \frac{M(C + 1)}{(R + 1)}$$

where $\hat{N}$ = population estimate at the time of sampling

M = number of fish initially marked

C = number caught in second sample

R = number of recaptures in sample C

Fall 1980

Reach	N Rainbow	N Brook	N Combined	Approximate 95% C.I.	Fish/River Mile
7[a]	937	-	991	368 - 1,614	261
6	198	-	225	54 - 396	64
5	560	-	599	204 - 1,232	260
4	1,863	236	1,888	455 - 3,322	674
3	1,213	1,786	2,909	1,668 - 4,150	1,455
2[b]	90	-	426	0 - 982	473
2-7			8,268	5,780 - 10,576	

April 1981 (Combined)

	N Combined	Approximate 95% C.I.
M = 1072		
C = 391		
R = 12		
$N = \frac{1072\ (392)}{13} =$	32,325	15,129 - 49,521

[a]Corbin Park to Stateline only

[b]From Trent Road to Plantes Ferry only

Table 9. Continued

1981 Creel Census (tagged fish observed)

Reach 1-7

	N Combined	Approximate 95% C.I.
M = 1451		
C = 92		
R = 2		
$N = \frac{1451\ (93)}{3} =$	44,981	0 - 95,275

1981 Estimate (Sept. - Oct. 1981 mark and recapture)

Reach	N Rainbow	N Brook	N Combined	Approximate 95% C.I. (Combined)	Fish/River Mile
3	827	616	1747	899 - 2,596	874
5			658	0 - 1,515	286

1980 angler harvest indicated that this estimate was probably too low. The necessary conditions to prevent bias in the Petersen estimator are that;

1. MC 3n (initial number tagged X number taken for second sample 3 times the population estimate),

2. marked and unmarked fish have the same mortality,

3. marked fish and unmarked fish do not differ in catchability,

4. marked fish do not lose their marks,

5. marked fish become randomly mixed with unmarked fish,

6. all marks are recognizable and

7. recruitment to the population is negligible between time of marking and time of recapture (Ricker 1968).

Violations of most of these conditions, however, results in an overestimation of N. A low estimate would result if the fish tagged initially were more susceptible to recapture because of near shore feeding habits.

From April 4 to April 9, 1981, a second recapture effort was conducted (Table 9). The number of fish collected in reaches three and four was especially low, primarily because of the difficulty of electroshocking these reaches during higher flows. The overall recapture rate (3%) from all previous tags was also lower than the previous fall effort. The combined population estimate from the spring data (32,325) was much higher than the fall estimate but because of the low recapture rate the confidence interval was extremely wide (Table 9).

The data from the 1981 creel census was examined as a check on the population estimate. Of 92 fish examined by the creel census worker only two were tagged. The population estimate based on this limited sample was 44,981. The use of all tag returns as R and the harvest estimate as

C was not possible because there is no estimate of the percentage of angler returns.

In 1981, another mark recapture effort was conducted, but we were only able to capture 175 in our initial capture sample (September). We judged this to be too few fish to conduct another major recapture effort. The October recapture effort, then, was only conducted in reaches 3 and 5. The combined salmonid population estimates for reach 3 and 5 based on September 1981 tags are 1,747 and 658 respectively (Table 9). The 95% confidence interval for the reach 3 estimate is 899 to 2,596. The best estimates for population number appear to be the fall mark-recapture estimates and the best reach estimate is for reach 3 based on percentage tag recovery. The 1981 combined estimate for reach 3 was about 1200 fish lower than the 1980 estimate, however, the confidence intervals of 1980 and 1981 overlap. The difference may have been real and reflected a high mortality of 1980 spawned fish which entered the sampling in 1981.

The fall 1981 combined estimate for reach 5 of 658 was practically the same as the fall 1980 estimate (599).

It was initially determined that the period from early September to early October would be the optimum time for conducting the mark-recapture work. The first consideration was to avoid the high flows which are dangerous and inconvenient. It was preferred to work with water temperature below 20C to avoid the combination of temperature and handling stress which would cause mortality. We also wanted to complete our work before the water temperature dropped to 10C and the brook char spawning began.

It was apparent, however, that the collecting efforts were much more efficient at a water temperature of 10C than at higher temperatures. In

September 1980, for example, 247 fish were collected in reach 3 in three nights of effort. The water temperature during this time was 18.5 to 16.0 C. In October 1980 with a water temperature of 11 C, 194 fish were collected in one night in the same reach. The same phenomena occurred in 1981 with temperatures of 17 C in September and 10 C in October. The large October increase in 1981, however, was due mainly to numbers of rainbow trout captured. The reason for the large difference in capture rates is apparently the increased feeding activity of the rainbow at temperatures of around 10 C and the brook char using the near shore gravel deposits for spawning. In the October capture efforts rainbow trout were frequently caught with longnose dace in their mouths or gullet, an obvious indication of feeding activity not observed in the September sampling. This activity probably caused the fish to be in the near shore area and more vulnerable to capture. The brook char captured in October were in spawning condition. The males had developed extreme coloration, the larger males had developed hooked jaws, and occasionally milt was excreted during handling. The females were swollen with eggs. The brook char were typically caught near gravel deposits and near inflowing groundwater.

The optimum period for obtaining the largest sample, then, occurs during the spawning time for the brook char. We experienced other problems, however, with the October sampling times. The early morning (from 0200) temperature at this time of year in the Spokane region are generally below freezing on clear nights and our sampling and measuring gear became ice covered. The temperature differential between the cold air and the 10 C water creates a dense fog especially on the rapids which in turn caused extreme difficulty in observing the rocks during our drifts. The periphytic algae also appears to increase rapidly at this time in reaches 3 and 4 and caused great difficulty in walking even with special boot soles. Falling in the water during electroshocking is dangerous even with the precaution of a dead-man switch.

The use of numbered jaw tags allowed us to determine the amount of fish movement in the river from the period of June 1980 to December 1981. Overall it appears as if there was little movement (14%) in the river, however, by examining only those fish subject to a high flow (exclude those fish tagged and recaptured during a low flow period) 14 of 66 rainbow (21%) exhibited an upstream movement. Of these 14 rainbow, 9 moved from downstream into reach 7 or a 14% movement from downstream into reach 7. One rainbow (1.5%) exhibited significant downstream movement (2 reaches) (Table 10).

Twelve recaptured brook char had been exposed to high flow and 3 (25%) exhibited upstream movement and 1 (8%) exhibited downstream movement.

A one reach movement upstream was considered a real move because in the process of capturing and tagging fish they were displaced up to one half mile downstream. Fish captured in the last riffle area of reach 6 were tagged and released below the Harvard Road bridge (reach 5). This probably accounts for the three rainbow that appeared to have moved from reach 6 to 5.

There was no significant ($\alpha = .1$) size difference between those fish that moved and those that did not move.

The overall percentage of tag returns from anglers during the 1981 fishing season was low (7-9%). Of 643 rainbow tagged in the fall of

TABLE 10. Movement of marked fish in the upper Spokane River

RAINBOW TROUT

Same Reach

TAGGED					RECAPTURED				
TAG #	DATE	LENGTH (cm)	WEIGHT (g)	REACH	REACH	DATE	LENGTH (cm)	WEIGHT (g)	ANGLER[1]
234	09-15-81	15.0	-	5	5	10-23-81	-	-	X
291	04-09-81	14.7	-	3	3	10-23-81	24.1	-	X
522	09-16-81	20.0	-	7	7	10-15-81	~26.7	-	X
709	10-15-80	18.3	-	4	4	08-30-81	~27.9	-	X
763	10-15-80	22.8	-	4	4	04-07-81	23.5	-	
788	10-15-80	17.9	77.2	4	4	06-24-81	~33	-	X
1002	06-24-80	30.8	-	2	2	09----81	~33	-	X
1059	10-13-80	22.0	-	7	7	11-12-80	~24	-	X
1071	10-13-80	21.4	128.0	7	7	04-05-81	21.9	-	X
1156	10-14-80	23.8	166.5	5	5	10-23-81	31.0	-	
1179	10-13-80	22.0	139.7	7	7	12-01-80	~25.4	-	X
1254	04-04-81	25.5	201.8	7	7	08-08-81	~33	-	X
1266	09-17-80	17.8	63.2	3	3	10-23-81	18.2	-	
1502	06-23-80	40.2	-	2	2	06-29-81	~48	-	X
1527	09-11-80	26.9	-	5	5	04-06-81	28.6	-	
1708	10-09-80	32.6	-	6	6	05----81	36.7	-	X
1746	10-14-80	27.6	259.3	5	5	07-19-81	~34.3	~340	X
1747	10-13-80	29.5	335.8	7	7	11-12-80	~35.6	~453.6	X
1756	10-15-80	31.2	377.2	4	4	09-17-81	32.4	407.3	
1989	10-16-80	31.8	438.2	2	2	09----81	~30	-	X
2001	10-09-80	28.2	-	6	6	04-06-81	30.0	-	
2022	09-10-80	38.0	-	5	5	06-21-81	~39.4	-	X
2027	09-17-80	32.9	560.	6	6	07-22-81	~34.3	-	X
2078	09-15-80	29.4	~336.0	7	7	10-19-81	~38.1	-	X
2081	09-16-80	26.9	~224.0	7	7	10-25-81	~30.5	-	X
2084	09-15-80	29.1	~356.0	7	7	05-11-81	-	~340.2	X
2097	09-12-80	35.1	-	3	3	05-01-81	~40.6	0	X
2102	10-13-80	30.2	-	7	7	04-05-81	31.1	-	X
2105	10-14-80	33.0	507.2	5	5	----81	~48.3	-	X
2107	10-09-80	28.0	284.2	6	6	09-30-81	~33.0	-	
2152	10-13-80	27.5	239.2	7	7	10-23-80	~30.5	-	
2162	10-14-80	30.5	410.9	5	5	09-15-81	32.7	449.9	
2165	10-15-80	38.2	631.7	4	4	06-15-81	~41.9	~794	X
2245	04-06-81	30.0	-	5	5	07-18-81	30.5	340	X
2256	04-07-81	33.4	427.4	4	4	04-30-81	34.3	-	X
2271	04-06-81	33.0	-	5	5	10-23-81	34.0	-	
2274	04-09-81	29.1	372.0	2	2	----81	-	~680	X
2723	10-16-80	41.2	865.0	2	2	05-20-81	~43.2	-	X
2745	04-06-81	38.6	-	6	6	05-19-81	~41.9	-	X
2773	10-13-80	38.0	673.8	7	7	06-16-81	~43.2	~454g	X
2784	09-15-80	35.8	~448.0	7	7	05-07-81	44.5	907.2	X
2797	09-08-80	31.4	-	6	6	04-06-81	33.0	-	X
1081	10-08-80	34.3	440.7	3	3	06-13-81	-	-	X
1119	04-04-81	25.7	-	7	7	08-06-81	-	-	X
1195	10-14-80	26.0	246.9	7	7	05-03-81	-	-	X
1850	04-07-81	28.4	322.1	5	5	10-23-81	-	-	X
1974	04-05-81	24.5	-	7	7	10----81	-	-	X

TABLE 10. (Continued)

	TAGGED				RECAPTURE				
TAG #	DATE	LENGTH	WEIGHT	REACH	REACH	DATE	LENGTH	WEIGHT	ANGLER
One Reach Upriver									
501	09-16-80	18.6	-	6	7	10-19-81	~30.5	-	X
585	09-11-80	18.5	-	4	5	09-09-81	~45.7		X
804	09-17-81	15.6	-	3	4	10-23-81	-	-	X
1089	09-17-80	23.5	-	4	5	04-06-81	26.5	252.31	X
1130	10-14-80	22.0	146.0	5	6	04-06-81	23.0		
1571	09-17-80	24.8	168.	6	7	07-08-81	~32	-	X
1841	09-15-81	23.8	-	6	7	11-22-81	~25.4	-	X
1844	04-06-81	27.1	-	6	7	07-08-81	~32	-	X
1913	10-16-80	32.9	487.6	2	3	09-17-81	33.3	422.5	
2772	04-09-81	54.8	188.9	2	3	08-03-81	~56	-	X
One Reach Downriver									
1575	09-17-80	23.6	168	6	5	09-11-81	~28.0	-	X
2201	04-05-81	29.5	-	6	5	--	-	-	X
2721	04-06-81	40.5	-	6	5	07-28-81	~43	~680	X
Two Reach Upriver									
1066	10-14-80	24.4	214.6	5	7	01-24-81	~30.5	-	X
1174	10-14-80	20.8	137.4	5	7	08-07-81	24.0	-	X
1778	10-14-80	26.1	-	5	7	11-09-81	~35.6		X
1848	04-06-81	28.0	-	5	7	09-18-81	~38.1		X
2254	09-17-81	30.9	-	3	5	10-23-81	31.0	-	
Two Reach Downriver									
1873	04-06-81	26.4	-	5	3	10-23-81	-	-	X
Three Reach Upriver									
696	09-17-80	19.7	168.0	4	7	06-25-81	~25	-	X
1603	09-18-80	27.8	-	4	7	05-14-81	~33	-	X
Four Reach Upriver									
1595	09-10-80	26.8	-	3	7	11-30-80	~32	-	X
Five Reach Upriver									
1504	06-24-80	35.5	-	2	7	03-10-81	-	-	X

TABLE 10. (Continued)

	TAGGED				RECAPTURE				
TAG #	DATE	LENGTH	WEIGHT	REACH	REACH	DATE	LENGTH	WEIGHT	ANGLER
				BROOK TROUT Same Reach					
105	09-10-80	17.0	-	3	3	05-02-81	22.9	-	X
166	10-16-80	16.9	55.1	3	3	07----81	∿20	-	X
550	09-12-80	20.5	-	3	3	09-20-80	∿25	-	X
707	10-08-80	19.0	69.6	3	3	05-18-81	22.0	-	X
730	04-09-81	16.1	42.5	3	3	10-23-81	20.0	-	
860	09-17-81	14.2	34.8	3	3	10-23-81	14.5	-	
929	10-16-80	17.0	-	3	3	04-09-81	17.2	-	
1158	09-17-81	20.0	-	3	3	10-23-81	20.2	-	
1513	09-09-80	27.3	-	3	3	04-09-81	28.0	-	
1888	09-17-81	22.5	-	3	3	10-23-81	23.0	-	
1942	04-05-81	26.5	-	7	7	06-11-81	∿29	-	X
1982	09-17-81	21.0	-	3	3	10-23-81	21.0	-	
2009	09-10-80	28.8	-	3	3	04-09-81	28.9	-	
2262	09-17-81	30.2	-	3	3	09-20-81	31.8	-	
1940	04-04-81	20.4	-	7	7	07-15-81	-	-	X
				One Reach Upriver					
1684	10-08-80	32.0	-	3	4	05----81	-	-	X
				One Reach Downriver					
1784	10-15-80	21.0	294.8	4	3	10-23-81	31.4	-	
1888	09-17-81	22.5	-	4	3	10----81			
				Two Reach Upriver					
1196	10-14-80	18.4	72.6	5	7	04-15-81	19.0	-	
				Two Reach Downriver					
2005	09-09-80	38.2	-	3	1	05-09-81	∿39	-	X
				Three Section Upriver					
570	09-12-80	19.0	-	4	7	03-14-81	∿20	-	X

[1] Recapture data from angler returns is approximate except for location.

1980, thirty-two tags (5%) were returned and four percent of the spring 1981 tags were returned. Seven of 429 (2%) fall 1980 brook char tags and two of 44 (5%) spring tags were returned. Shetter (1968) also reported an overall tag return of 10% and observed the return from fish tagged in the spring was about twice as high as that for fish tagged in the fall. He attributed the difference to overwinter mortality.

3. Age and Growth - Salmonids

The scale analysis was conducted on fish sampled in the fall of 1980 and 1981 (Table 11). The back calculation to previous annuli show the fish growth is negligible between the time of the fall collection and the formation of a new annulus. The length-age relationship was verified by plotting the length-frequency of electroshocked fish also collected in the fall months. The length-frequency for rainbow trout (Figure 6) shows a smaller second peak for both age I, age II fish and possible age III fish. Plotting the data by month (September and October), year (1980 and 1981) and reaches (3 and 7) fails to remove the bimodality.

The length age relationship becomes very tenuous for age classes above IV because of the small number of these fish sampled.

The rainbow trout in the Spokane River show neither extremely fast or slow growth based on comparative growth rates given in Wydoski and Whitney (1979).

Some difficulty was experienced in reading scale annuli from brook char because of the small size of the scales, a large amount of scale regeneration and indistinct annuli. The length frequency plot (Figure 7) becomes indistinct after age class II and the scale analysis was based on only two samples. Brook char are considered to be a short lived fish compared to other salmonids. The combination of high natural mortality

Table 11 . Average length of rainbow trout and brook char in the fall of 1980 and 1981 with age determined by scale annuli count.

RAINBOW

ANNULUS Age	Growth Seasons	Length cm (inches)	N	std. deviation	Back calculated length[b]
0	[a](1)	9.8(3.9)	15	.79	8.9(3.5)
1	(2)	19.2(7.6)	31	2.71	19.6(7.7)
2	(3)	27.9(11.0)	51	3.37	27.4(10.8)
3	(4)	36.7(14.4)	27	4.50	36.8(14.5)
4	(5)	42.3(16.7)	6	3.25	41.9(16.5)
5	(6)	52.1(20.5)	1	-	47.0(18.5)
6	(7)	61.0(24.0)	1	-	51.1(20.1)
		BROOK			
0	[a](1)	11.1(4.4)	2	-	11.4(4.5)
1	(2)	18.8(7.4)	31	2.44	19.6(7.7)
2	(3)	25.4(10.0)	28	3.52	24.9(9.8)
3	(4)	36.7(14.4)	2	-	31.8(12.5)

[a]Collected length only - no scale analysis

[b]From regression of scale length to fish length and Walford plot

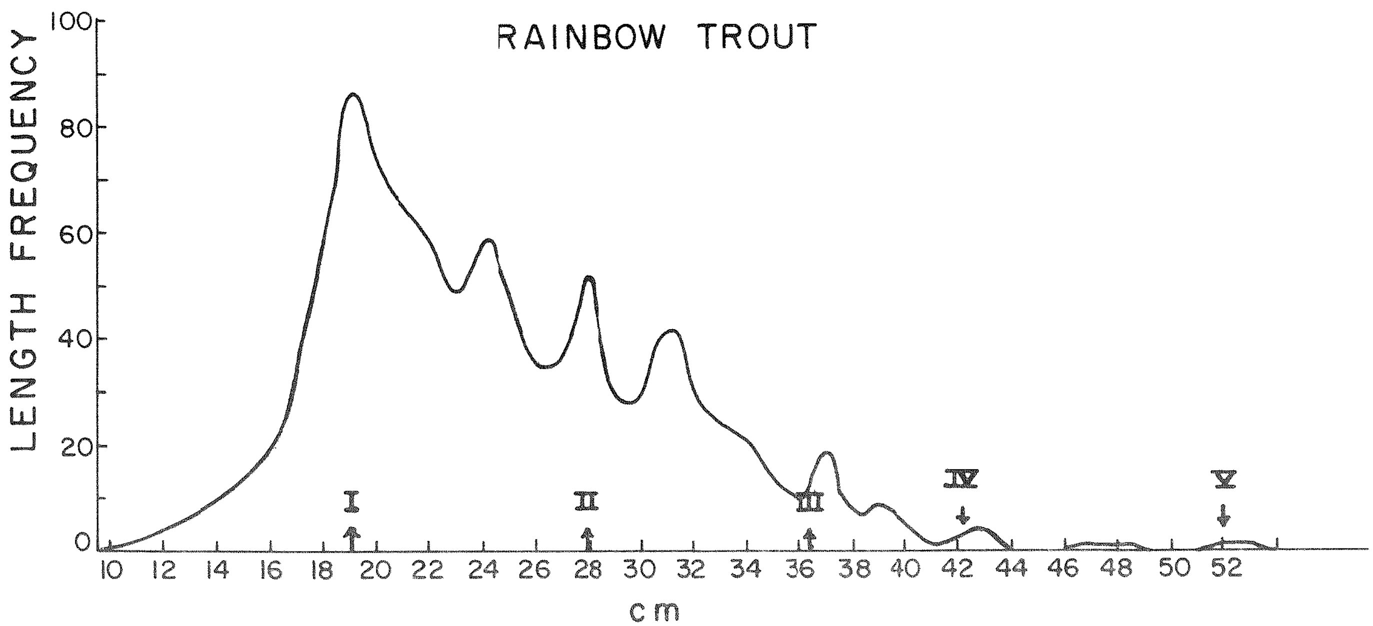

Figure 6. Length-frequency distribution of rainbow trout in the upper Spokane River.

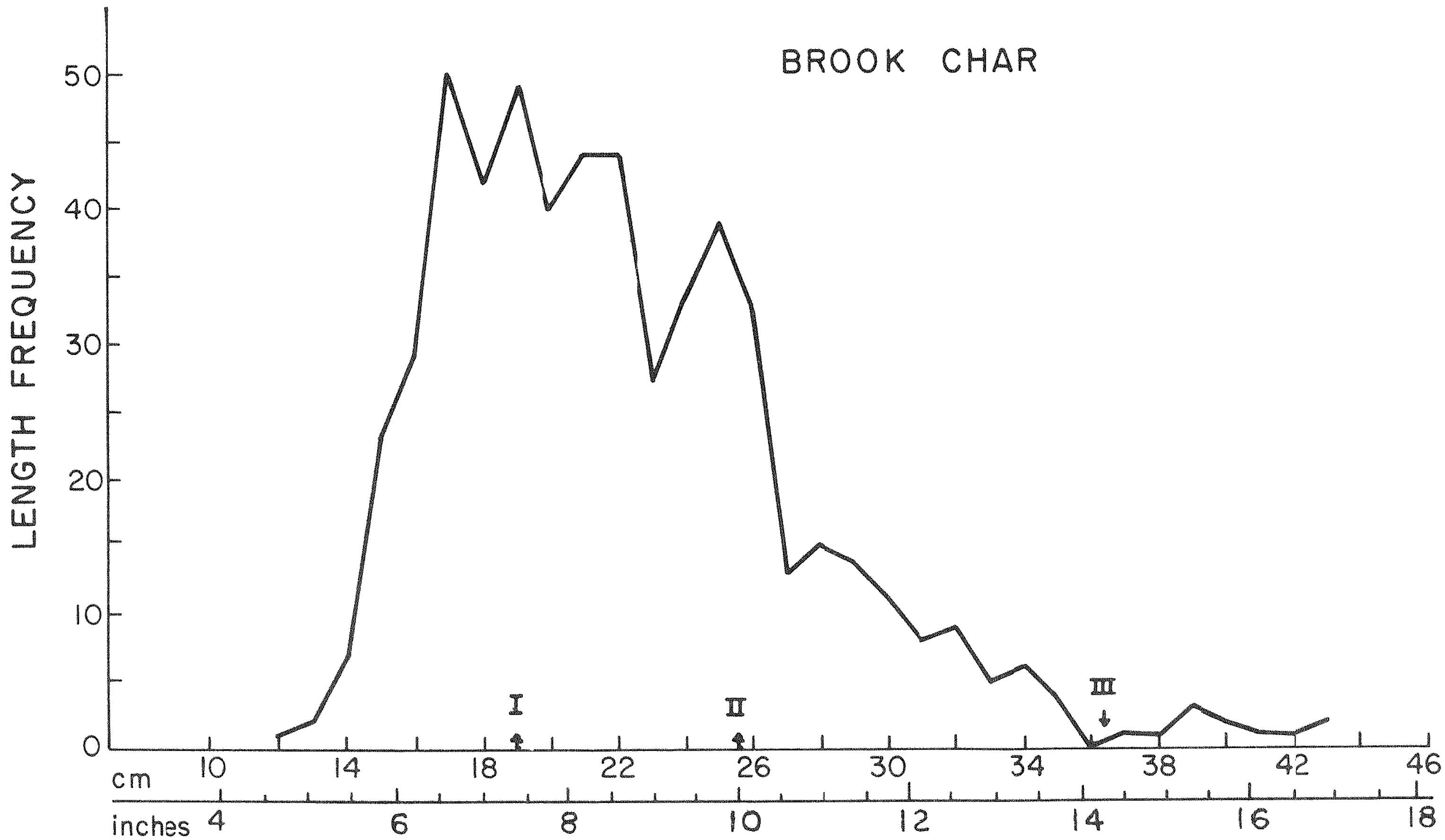

Figure 7. Length frequency distribution of brook char in the upper Spokane River.

and angling mortality is illustrated by the sharp decline in numbers of fish from age class II to age class III.

The brook char exhibit exceptional growth in the Spokane River when compared to growth in other waters (Wydoski and Whitney 1979). The growth in the Spokane River is equivalent to limestone creeks and lowland lakes. This fast growth is apparently related to the groundwater inflow around reach 3 because the brook char population is generally confined to reach 3. The cooler water temperature of reach 3 may prevent mid-summer stress and subsequent growth reduction.

The length-weight relationship for rainbow (Figure 8) and brook char (Figure 9) exhibit no exceptional characteristics.

4. Abundance of non-salmonids

We observed during the snorkel counts and electroshocking large numbers of longnose dace (Rhinichthys cataractae) and longnose sucker (Catostomus catostomus).

The longnose dace were found in the shallow rapids areas with estimated water velocities of four to six feet per second. The dace we observed generally ranged from 5 to 7.5 cm (2 to 3 inches). The primary food of the longnose dace is reported to be blackfly larva (Simulidae) (Gerald 1966) which are also found in the fast flowing rapids areas. The estimated abundance of longnose dace was $0.16/m^2$ (S.D. - .08) in two riffle areas near Barker Road. Our estimates of abundance may be low because when shocked, dace frequently remained in the rock interstitial area. Our estimate of abundance for the river is 46,000 dace.

Longnose suckers were observed during the daytime, feeding in high velocity water, however, during the night time electroshocking they were

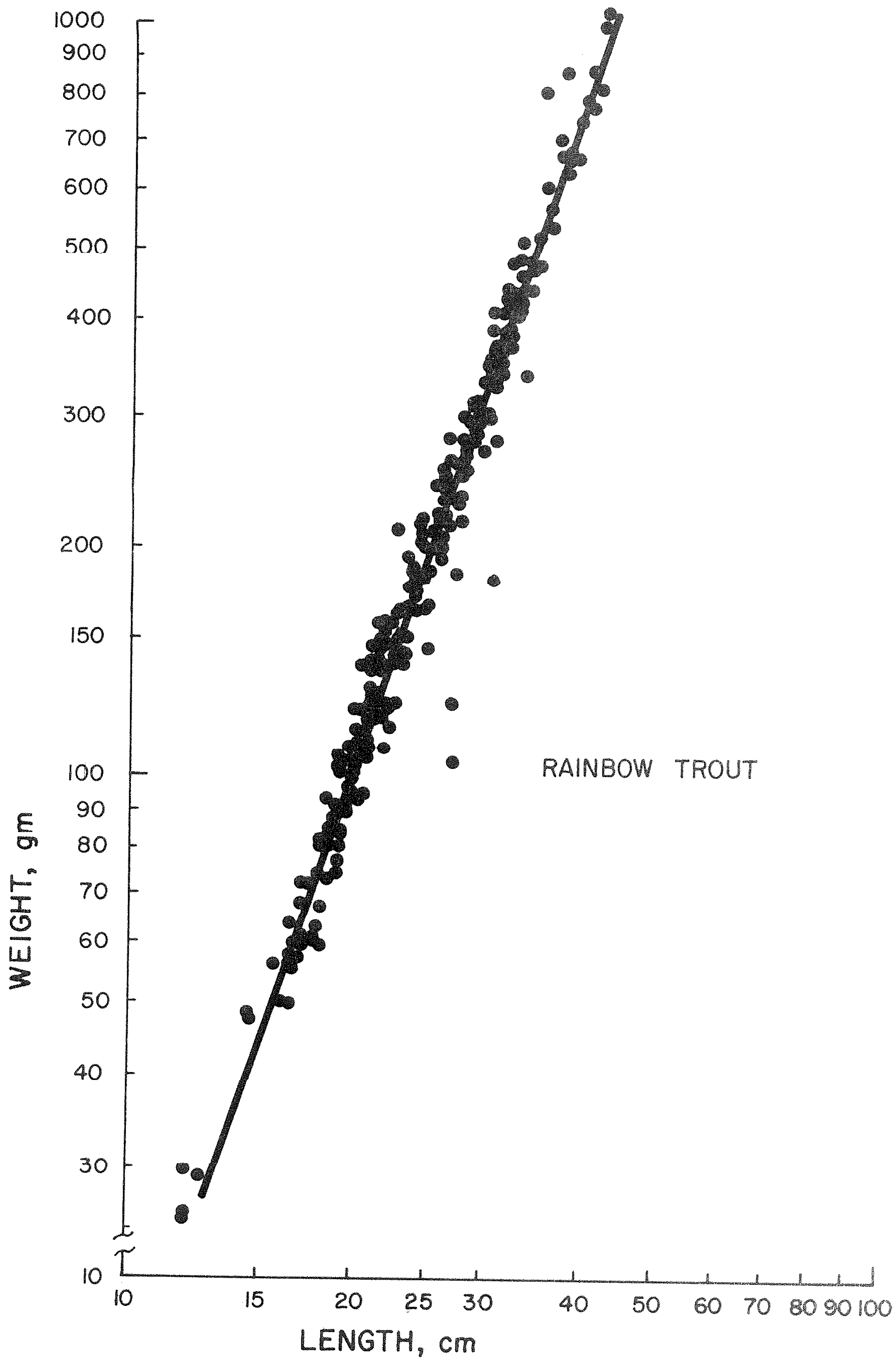

Figure 8. Length-weight relationship for rainbow trout in the upper Spokane River.

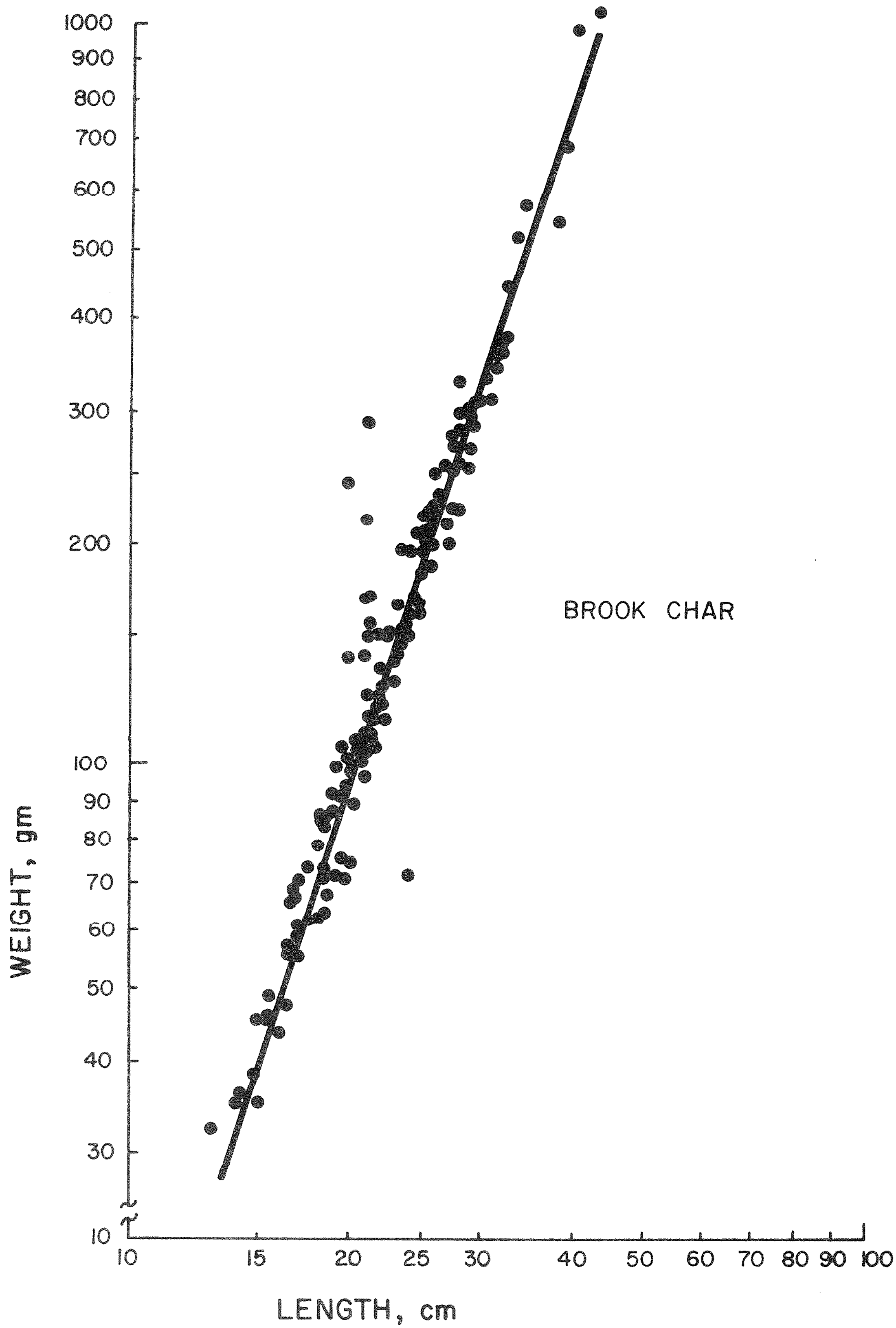

Figure 9. Length-weight relationship for brook char on the upper Spokane River.

most often found in the slower moving eddies and backwaters. There were also some apparent seasonal differences in distribution between study reaches. In the spring of 1980 large numbers of suckers were observed in the lower section of reach 2 and in reach 1, however, very few were observed in these areas during the fall electroshocking. Very few sucker fry were observed which indicates the fry may inhabit the deeper slower reaches of the river such as Upriver Reservoir.

In June 1980 in reach 2, we captured 41 suckers for every resident salmonid captured. In reaches 7 through 4 in September of 1981, we observed 3 suckers stunned for 10 salmonids, however, we did not electrofish in the eddies and backwaters. A subjective estimate of the sucker population based on snorkel observations is approximately 2 times the number of salmonids except for reach 3 which is approximately 1:1.

The other non-salmonid fish which we occasionally saw in the snorkel counts or during electroshocking were yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*) and catfish (*Ictalurus sp.*).

Several species of fish common in upstream and Columbia River drainages but notably absent in the upper Spokane River are the mountain whitefish (*Prosopium williamsoni*), northern squawfish (*Ptychocheilus oregonensis*), speckled dace (*Rhinichthys osculus*) and the torrent sculpin (*Cottus rhotheus*) (Simpson and Wallace 1978, Wydoski and Whitney 1979).

B. Angler Census

1. Angler effort

Mean angler counts were higher for the high flow period in 1980 and 1981 but because of the longer low flow period (July 1 to September 31) compared to the high flow period (third Sunday of April to June 30) angler effort measured as hours expended per period was approximately evenly divided between high flow and low flow (Table 12). Anglers spent an estimated 28,737 hours (90% confidence limits 15,147 to 42,608) during the 1980 fishing season and 28,998 (19,083 to 39,210) hours in the 1981 season on the upper Spokane River.

Table 12. A comparison of total mean angler counts and hours for high flow and low flow periods on the upper Spokane River.

1980	Angler Counts	90% Confidence Limits	Angler Hours	90% Confidence Limits
High Flow	65.3	35.8-95.3	14,955	7,950-22,121
Low Flow	41.8	22.3-61.2	13,782	7,197-20,487
1981				
High Flow	75.0	55.2-95.3	16,806	12,015-21,750
Low Flow	36.3	22.0-50.9	12,192	19,083-39,210

Among the count strata (Weekday AM, Weekday PM, Weekend AM, Weekend PM) most effort was expended (77-78%) during the PM count strata (Table 13). Angler counts were generally about 2.5 times higher during the weekend then during weekdays.

Among study reaches the largest effort as percent of the total was expended in reaches 7 and 3 (Table 14). Compared on the basis of river mile, however, reach three receives the most pressure and reach 4 receives the least pressure.

Table 13. Angler effort (as percent total hours) among time strata in the upper Spokane River.

High Flow	1980	1981
Weekday AM	4	4
Weekday PM	24	25
Weekend AM	7	6
Weekend PM	17	23
Low Flow		
Weekday AM	4	9
Weekday PM	24	19
Weekend AM	7	4
Weekend PM	13	10

Table 14. A comparison of angler hours by study reach as percent of total and hours per river mile (rm) on the upper Spokane River.

	Reach						
1980	1	2	3	4	5	6	7
%	10	7	16	3	1	16	38
hr/rm	1153	627	2279	299	1370	1290	1901
1981							
%	8	8	21	6	12	14	30
hr/rm	1013	819	2986	617	1571	1138	1520

2. Catch Per Effort (CPE) Estimates

The one fish limit in the Washington stretch of the Spokane River presented a special problem with estimating CPE. Although Malvestuto (1978) determined the CPE based on incomplete trips is an unbiased estimator of trip CPE, this is probably valid only in a fishery with a multiple fish limit and a high probability of success. It was anticipated in the design of the angler census that the CPE for the Washington portion of the river would be much too low if it was based only on incomplete trips because if a successful fishermen left the river immediately after catching a fish the probability of the creel census worker intercepting a successful fisherman was reduced. As explained previously, two estimates of CPE were made. One estimate was based on incomplete trip (day of angler contact) and the other was based on the previous trip effort and catch.

The results (Table 15) indicated the trend that was anticipated i.e.: the previous trip CPE was generally much higher than contact CPE. Reach 7 (Idaho section) was used as a data check because of the six fish limit in this reach. As expected, the census worker encountered many more successful fishermen in the this reach than in reaches 1 through 6 (Tables 16 and 17). If incomplete trip CPE is an unbiased estimator of trip CPE and previous trip CPE is an unbiased estimator of contact day CPE then in reach 7 the contact CPE should be equivalent to the previous trip CPE. It was observed, however, that in reach 7 the previous trip CPE was greater than contact CPE indicating bias in one or both of the estimators. The problem then is determining which is the best estimate of true CPE. In a lake this is easily done by concurrent checks of the roving census worker with access point data on fishermen leaving the lake

Table 15. A summary of previous trip CPE and contact day CPE for 1980 and 1981 on the upper Spokane River

1980	Reach							
Contact CPE	1	2	3	4	5	6	7	$\bar{X}$
High Flow	.029	.077	.193	.064	.048	.154	.123	.098
Low Flow	-	-	.021	.21	.05	.017	.185	.097
Previous CPE								
High Flow	.128	.259	.258	.148	.133	.228	.194	.193
Low Flow	.132	.267	.239	-	.110	.097	.293	.190
1981								
Contact CPE								
High Flow	.037	.053	.046	.054	.100	.055	.061	.058
Low Flow	-	-	.066	-	.088	.052	.123	.082
Previous CPE								
High Flow	.078	.078	.162	.194	.113	.088	.215	.133
Low Flow	-	.270	.214	.292	.579	.087	.276	.286

Table 16. Catch per effort (CPE) by contact day and previous trip information (1980).

Contact Day CPE

	Reach						
High Flow	1	2	3	4	5	6	7
Hours	69.2	52.1	46.7	15.7	125.6	97.6	171
Fish	2	4	9	1	6	15	21
CPE	.029	.077	.193	.064	.048	.154	.123
Low Flow							
Hours	31.7	12	47.5	4.7	19.9	59.8	129.6
Fish	0	0	1	1	1	1	24
CPE	-	-	.021	.21	.05	.017	.185

Previous Trip CPE

High Flow							
Hours	39	61.8	66	40.5	157.8	131.6	227.1
Fish	5	16	17	6	21	30	44
CPE	.128	.259	.258	.148	.133	.228	.194
Low Flow							
Hours	45.5	15	71.2	13	63.5	113	150.1
Fish	6	4	17	0	7	11	44
CPE	.132	.267	.239	-	.110	.097	.293

Table 17. Catch per effort (CPE) by contact day and previous trip information (1981).

Contact Day CPE

	Reach						
High Flow	1	2	3	4	5	6	7
Hours	107.1	112.6	172.6	37.3	190.7	145.8	244.7
Fish	4	6	8	2	19	8	15
CPE	.037	.053	.046	.054	.100	.055	.061
Low Flow							
Hours	19.7	26	76.2	4.8	34.0	77.6	146.7
Fish	0	0	5	0	3	4	18
CPE	-	-	.066	-	.088	.052	.123

Previous Trip CPE

	1	2	3	4	5	6	7
High Flow							
Hours	116	102.5	203.3	93	159	170	223
Fish	9	8	33	18	18	15	48
CPE	.078	.078	.162	.194	.113	.088	.215
Low Flow							
Hours	5.0	37	70	24	38	80.5	185
Fish	0	10	15	7	22	7	51
CPE	-	.270	.214	.292	.579	.087	.276

(Malvestuto 1978). This technique is not possible in a river system with almost unlimited access so a verification of trip CPE to completed trip CPE is practically impossible. Because there is no way to statistically evaluate bias in sampling we are left only with a subjective analysis of possible bias. In reach 7 with the six fish limit the census worker intercepted a good sample of successful fisherman and there is no indication that incomplete trip CPE is not a good estimator of completed trip CPE. A review of the census data, however, indicated that a large percentage of fishermen were fishing the river for the first time even in the later low flow period. These fishermen are included in the contact CPE but not in the prior trip data. Fishermen who fished the river infrequently were also not included in the prior trip data because of their uncertainty of previous trip time. The prior trip CPE then only includes those fishermen who fish the river frequently and are familiar with the best locations, times and techniques and consequently have a higher CPE than the "average" fisherman. The best estimate for CPE in reach 7 is probably the contact day CPE and so was used to calculate harvest.

In reach one through six there is the previously mentioned possible bias because of the one fish limit which reduces the probability of the census worker intercepting successful fishermen. The previous trip CPE, however, is subject to the same bias as in reach 7 and includes only fishermen who fish the river frequently and probably have a higher success rate (CPE). In the absence of any indication of the relative magnitude of negative and positive bias the previous trip and contact day data were combined for reaches one through six. There was also no

Table 18. Catch per effort by combining previous trip and contact day effort and catch (Reach 7 by contact day).

1980

High Flow	Reach 1	2	3	4	5	6	7	total
Hours	108.2	113.9	112.7	56.2	283.4	229.2	171	1074
Fish	7	20	26	7	27	45	21	153
CPE	.065	.176	.230	.125	.095	.196	.123	.142
Low Flow								
Hours	77.2	27	118.7	17.7	83.4	172.8	130	627
Fish	6	4	18	1	8	12	24	73
CPE	.078	.148	.152	.056	.096	.069	.185	.116
HF + LF[1]=	.070	.170	.190	.108	.098	.142	.149	.133

1981

High Flow	1	2	3	4	5	6	7	total
Hours	223.1	215.1	375.9	130.3	349.7	315.8	244.7	1854.6
Fish	13	14	41	20	37	23	15	163
CPE	.058	.065	.109	.153	.106	.073	.061	.088
Low Flow								
Hours	24.7	63	146.2	28.8	72	158.1	146.7	639.5
Fish	0	10	20	7	25	11	18	91
CPE	<.04	.159	.137	.243	.347	.070	.123	.142
HF + LF[1]=	.052	.086	.117	.170	.147	.072	.084	.102
$\bar{X}$ by reach (1980 + 1981)	.060	.115	.139	.150	.123	.104	.093	.114

[1]CPE used for calculating harvest

indication of a consistent difference between high flow and low flow CPE so the data was combined over flow (Table 18) for all reaches.

There was little variation of CPE among flow or year. The CPE for reach one (reservoir) is consistently low and probably reflects the low numbers of fish observed there. The overall CPE of about 0.1 means the average fisherman spends ten hours fishing per fish caught and with an average trip length of about three hours the average angler is successful in one out of four trips.

3. Angler Harvest

The estimated angler harvest of salmonids in 1980 was 3,772 (90% confidence limits 2,038 to 6,034) and 2,893 (1,878 to 3,925) in 1981.

The catch was approximately evenly divided between high flow and low flow periods in both 1980 and 1981.

Compared by reach (Table 19), the catch was highest in reaches three and seven and lowest in reach one. The total angler harvest by reach for

Table 19. Angler harvest in the upper Spokane River by study reach.

	Reach						
	1	2	3	4	5	6	7
1980	114	320	867	91	315	632	1433
90% C.I.	85-305	133-507	433-1299	13-183	162-485	337-1268	875-1987
1981	128	211	700	293	532	287	742
90% C.I.	79-176	130-299	487-911	145-433	330-745	185-393	522-958
Catch/r.m.	101	171	784	137	368	263	375

1980 and 1981 divided by the number of river miles for each reach (Table 19) shows the relatively high harvest in reach three over the two year period. The angler harvest in reach three is composed of 40% brook char (Figure 10) which accounts for most of the difference in catch per river mile between reach three and some other reaches such as reaches five and seven. Cutthroat trout or cutthroat-rainbow hybrids make up ten percent of the catch in reach seven.

C. Food Habits

Salmonids in the Spokane River fed selectively (positive L values) on *Hydropsyche sp.*, *Asellus sp.* and *Baetis sp.* (Table 20, 21). Chironomids were avoided or not available (negative L value). The selectivity index values were not significant (=.01) for other organisms indicating neither selection or avoidance. Some of the factors causing a bias of L discussed by Strauss (1979) are: 1. the assumption that the samples represent the true composition of the prey population, 2. the assumption that all organisms are equally accessible to the fish 3. the assumption that predation by fish does not alter the abundance of prey items and 4. different rates of digestion of prey items. The largest source of error or bias is probably due to error in determining the true composition of the prey population. The relative magnitude of this error is illustrated by Funk *et al.* (1982) in a comparison of numbers of invertebrates collected with replicate samples of three types of samplers.

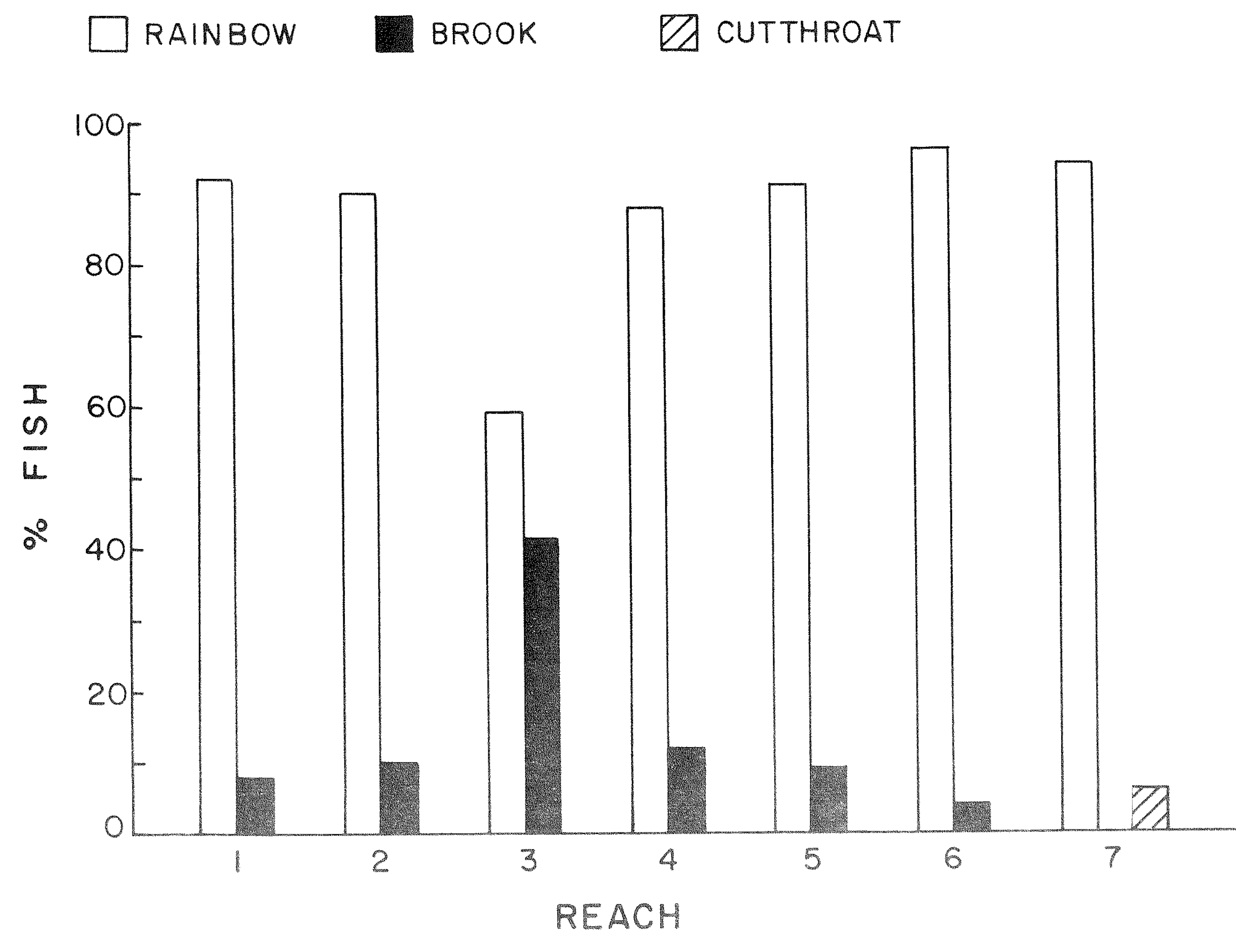

Figure 10. A comparison of the percent composition of angler catch in the upper Spokane River (1980 and 1981)

Table 20. Taxonomic classification of organisms found in substrate samples and stomachs of Spokane River trout.

Phylum
- Class
  - Order
    - Family
      - Genus species

Mollusca
- Gastropoda (Snails)
  - Pulmonata
    - *Physidae

Arthropoda
- Insecta
  - Ephemeroptera (Mayflies)
    - Baetidae
      - *Baetis sp.*
  - Tricoptera (Caddisflies)
    - -Glossosomatidae
    - Hydropsychidae
      - *Hydropsyche*
      - *Cheumatopsyche*
    - Limnophilidae
      - *Dicosmoecus*
      - *Onocosmoecus*
    - *Leptoceridae
      - +*Ceraclea*
    - Polycentropodidae
      - +*Polycentropus*
    - +Rhyacophilidae
    - Hydroptilidae
      - +*Oxyethira*
      - +*Agraylea*
  - Plecoptera (Stoneflies)
    - Perlodiadae
      - +*Isogenus*
      - +*Archynopteryx*
  - Lepidoptera (moths)
    - Pyralidae
      - *Paragyractis*
  - Diptera
    - Simuliidae
      - *Simulium*
    - *Chironomidae
    - +Tipulidae
      - *Antocha*
    - Tabanidae
      - *Chrysops*

Table 20. Continued

Phylum
    Class
        Order
            Family
                Genus species

        Coleoptera
            Dytiscidae
                **Dytiscus*

       *Hemiptera
            Nepidae
                -*Nepa*
           -Notonectidae

        Odonata
           *Zygoptera (suborder-damselflies)
            Aeshnidae
                -*Aeshna*

           -Cordulegastridae
          -*Gomphidae

       +Hymenoptera
       +Homoptera

   +Oligochaeta

Coelenterata
    Hydrazoa
        Hydroida
            Hydridae
                +*Hydra*

    Crustacea
     Subclass
     Malacostraca
      *Isopoda (sowbugs)
           **Asellus*

    Arachnoidea
        Trombidiformes
            +Hydracarina

Platyhelminths
    Turbellaria
        Tricladida
            +Planaridae

Pisces
    Osteichthyes
        Cyprinidae
        *Rhinichthys cataractae

*Present in bottom samples and fish stomachs
+Present in bottom samples only
-Present in stomachs only

Table 21. Food selection index (L) for salmonids in the upper Spokane River.

Organism[1]	Numbers in Stomach $\bar{X}$	Substrate[2] $\bar{X}$	Ri[3]	Pi[4]	L=Ri-Pi
Hydropsyche sp.	34.23	280.76	.511	.180	.331
Asellus sp.	5.59	.001	.083	0	.083
Baetis sp.	12.94	185.21	.193	.119	.074
Dicosmoecus sp.	1.73	3.76	.026	.002	.024
Paragyractis sp.	1.54	1.53	.023	.001	.022
Glossosomatidae	.86	.001	.013	0	.013
Physidae	.43	.18	.006	0	.006
Hemiptera	.11	.18	.002	0	.002
Chrysops sp.	.06	.29	.001	0	.001
Rhinichthys cataractae	.10	.16	.001	0	.001
Onocosmoecus sp.	.04	3.61	.001	.002	-.001
Hydracarina sp.	0	.97	-	.001	-.001
Rhyacophilidae	0	1.55	0	.001	-.001
Tipulidae	0	1.71	0	.001	-.001
Arcynopteryx sp.	0	4.0	0	.003	-.003
Leptoceridae	.01	9.0	0	.006	-.006
Ceraclea sp.	0	15.32	0	.010	-.010
Antocha sp.	.31	28.0	.005	.018	-.013
Simulium sp.	.19	26.71	.003	.017	-.014
Cheumatopsyche sp.	.16	53.74	.002	.034	-.032
Chironomidae	8.54	940.53	.128	.603	-.475

[1]See Table 20 for the taxonomic classification

[2]In numbers per m^2

[3]Percentage of food organisms in stomachs

[4]Percentage of organisms in river substrate

D. Minimum Flow Data

The methodology for determining acceptable minimum stream flows is primarily for small ungauged streams which are wadable at low flows (Bovee and Milhous 1978). A methodology for large rivers using a boat is given by White (1976). However, in most of the upper Spokane River the water at low flow is too deep or fast to wade and too shallow to travel in a boat. Therefore, the data collection was confined to bridge sites.

Within the study section, discharge is measured by the Washington Water Power Company (WWP) as release from the Post Falls dam (RM 102) and by the U.S. Geological Survey (USGS) at a gauging station (RM 100.6). The USGS discharge data for water year 1980 was three percent greater than the WWP data. This difference may be due to a small amount of groundwater inflow between the dam and the gauging station or a small measurement error. The lowest flows in the Spokane River generally occur in August as a result of low flows from the Coeur d'Alene and St. Joe rivers and evaporation from the lake.

The critical flow in the upper Spokane River appears to be the midsummer low flows. During 1980 the low flow of 720 CFS occurred from August 2 to August 14 (Washington Water Power 1980, USGS 1980). In 1981 low flow occurred from August 23 to September 4 at about 620 CFS (Washington Water Power 1981). Historical extreme low flows of about 100 CFS occurred in 1967 and 1973 (USGS 1980).

One method of estimating optimum and minimum flows is the "Montana Method" (Tennant 1976) which is based on average annual discharge (flow). The minimum base flow regime rating suggested by Tennant is from excellent at 50% of the average annual flow to poor (minimum) at 10% of the average annual flow. The Montana Method is empirically based on observed changes of width, depth and velocity with changes in flow. Tennet observed that width, depth and velocity changed most rapidly from zero to ten percent than at any greater incremental increase in flow. He noted that in general a 10% annual flow covered 60 percent of the substrate, the depths averaged one foot and velocities averaged 0.75 feet per second and concluded that 10% annual flow is a critical low flow. The average annual flow of the Spokane River is about 6000 CFS and so the minimum instantaneous flow to protect aquatic life in the upper Spokane River based on the Montana Method is 600 CFS.

The IFG (Instream Flow Group) incremental methodology (Bovee and Milhous 1978) determines the area useable by fish at different life or activity stages (spawning, incubation, fry, juvenile and adult). The incremental analysis is conducted in four steps: 1) A series of physical and hydraulic measurements are made in the stream. These measurements are made across several transects in a critical or representative reach of stream; 2) a computer model simulates conditions of velocity and depth at different flows; 3) a composite index is calculated for each flow based on the depth and velocity preference of a particular species of fish; and 4) a weighted usable area for the reach is calculated for different flows by multipling the area of step 2 by the index number of step 3. This weighted useable area is a measure of attractiveness of a stream reach at different flows and may be used to identify critical flows for different life stages. A critical review of the IFG methodology is given in Smith (1979).

The IFG methodology was not used because of the difficulty in collecting the transect data even at low flows. The measured stage-discharge-velocity relationship for four bridge stations are presented in Figures 11 through 14. There was considerable inaccuracy in the velocity measurements because of the turbulence caused by the bridge pilings, however, the measured mean velocities were within 20% of velocities calculated by (discharge ÷ area) except at Harvard Road which had a negative flow (eddy) on the north side at lower flows.

The attempts to determine actual velocity preference of the Spokane River salmonids was unsuccessful because of the difficulty of maintaining position for taking measurements and because the apparatus used was found to be extremely inaccurate and imprecise in calibrated flume tests. In lieu of these measurements the probability of use curves developed by the IFG (Bovee 1978) were used to compare flows and stations (Table 22). Although these curves were developed for use in the incremental analysis described above they still provide a useful index when used with average velocity and maximum water depth.

Table 22 indicates that overall conditions improve as flows decrease primarily because the mean velocity approaches the preferred velocity as flows decrease. The real amount of area of preferred velocity may, however, be decreasing. Temperature and substrate are less than optimum for fry at some flows.

The observations made during the snorkel counts show that the river near the Stateline Bridge is not utilized by salmonids at low flow even though the mean velocity is near optimum and the depth is sufficient (according to the probability curves). No fish were observed in the high velocity water at the Sullivan Road Bridge which agrees with the low preference coefficient. No fish were observed while snorkeling or captured by electroshocking at the Argonne Road Bridge even though

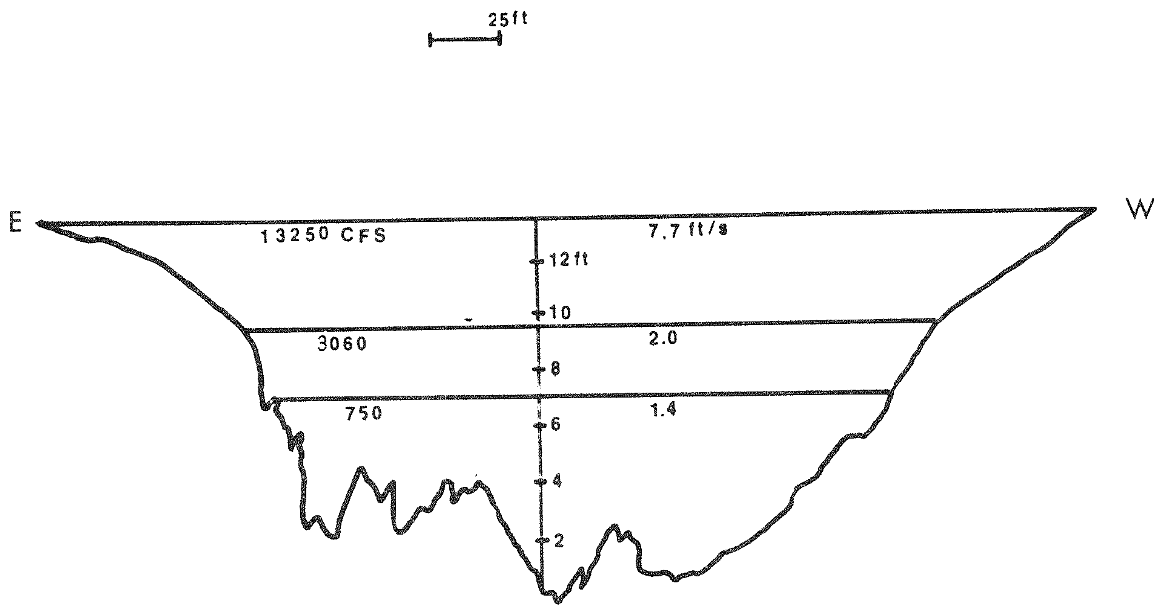

Figure 11. Stage-discharge-velocity relationship for the upper Spokane River at Stateline Bridge (RM 96.2).

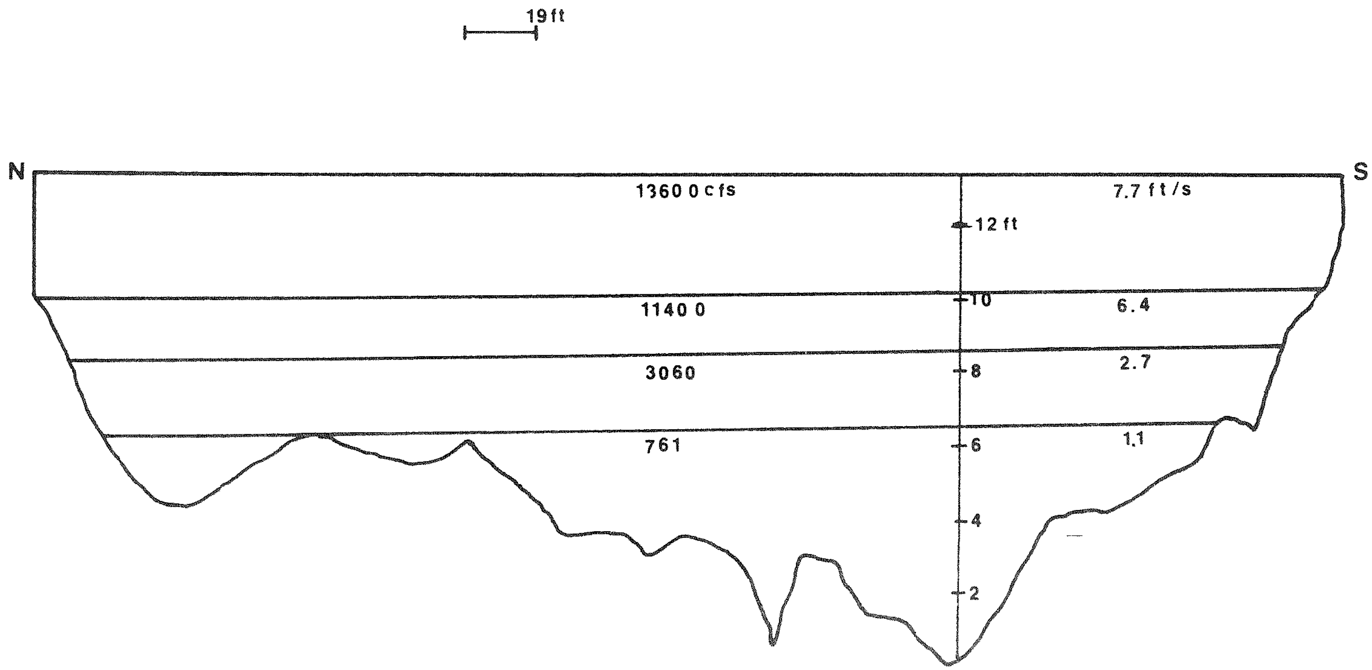

Figure 12. Stage-discharge-velocity relationship for the upper Spokane River at Harvard Road Bridge (RM 92.7).

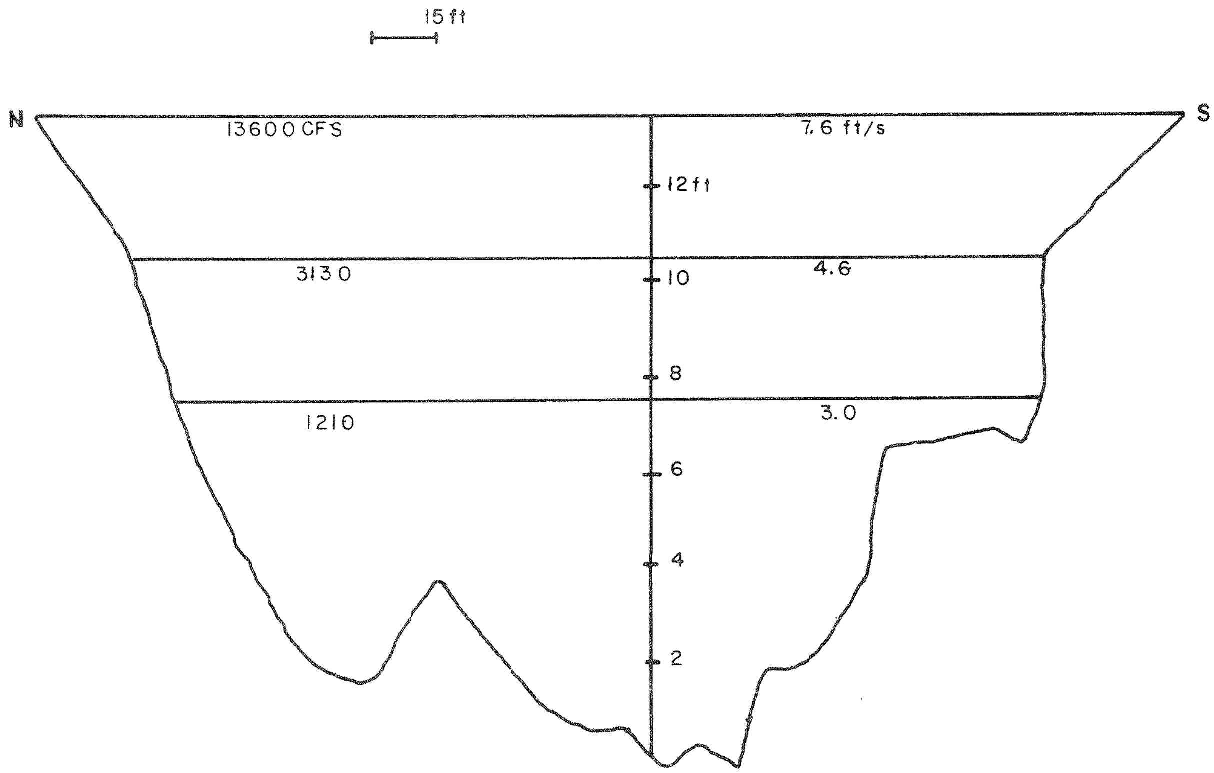

Figure 13. Stage-discharge-velocity relationship for the upper Spokane River at Sullivan Road Bridge (RM 87.6).

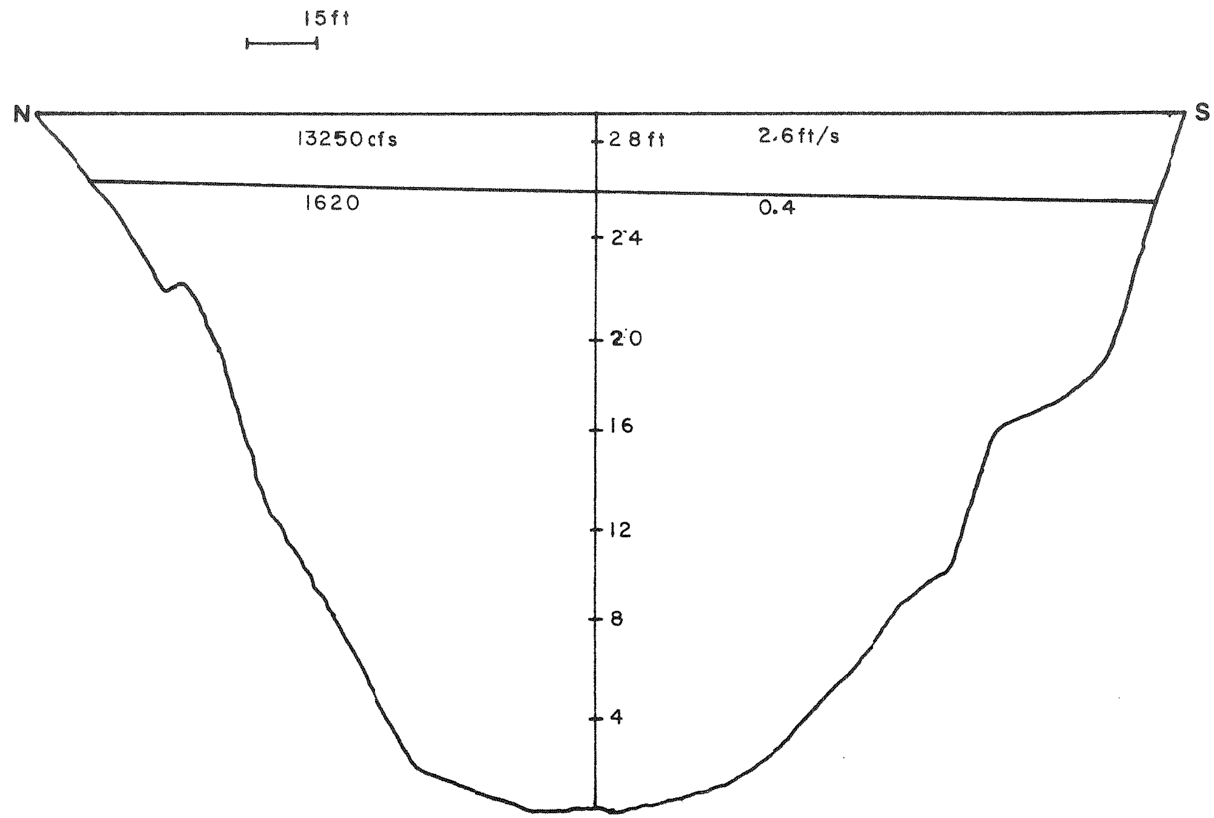

Figure 14. Stage-discharge-velocity relationship for the upper Spokane River at Argonne Road Bridge (RM 82.6).

TABLE 22. Probability of use factors for rainbow trout in the upper Spokane River. The factors vary from 1 (most preferred) to 0 (least preferred).

STATELINE

Flow	Velocity	Depth	Substrate	Temperature	Product[1]
		Rainbow Adult			
13,250	<.01	1.0	1.0	1.0	<.01
3,060	.6	1.0	1.0	1.0	.6
750	1.0	1.0	1.0	1.0	1.0
		Rainbow Fry			
13,250	<.01	.02	.3	1.0	<.01
3,060	.24	.02	.3	1.0	<.01
750	.6	.02	.3	1.0	<.01

HARVARD ROAD

Flow	Velocity	Depth	Substrate	Temperature	Product[1]
		Rainbow Adult			
13,600	<.01	1.0	1.0	1.0	<.01
11,400	<.01	1.0	1.0	1.0	<.01
3,060	.1	1.0	1.0	1.0	.1
761	.96	1.0	1.0	.88	.8
		Rainbow Fry			
13,600	<.01	.02	.3	1.0	<.01
11,400	<.01	.02	.3	1.0	<.01
3,060	<.01	.02	.3	1.0	<.01
761	.7	.02	.3	.2	<.01

Table 22. Continued

SULLIVAN ROAD

Flow	Velocity	Depth	Substrate	Temperature	Product[1]
			Rainbow Adult		
13,600	<.01	1.0	1.0	1.0	<.01
3,130	<.01	1.0	1.0	.96	<.01
1,210	<.01	1.0	1.0	1.0	<.01
			Rainbow Fry		
13,600	<.01	.02	.16	1.0	<.01
3,130	<.01	.02	.16	.96	<.01
1,210	<.01	.02	.16	1.0	<.01

ARGONNE ROAD

Flow	Velocity	Depth	Substrate	Temperature	Product[1]
			Rainbow Adult		
13,250	.1	1.0	1.0	1.0	.1
1,670	.4	1.0	1.0	1.0	.4
			Rainbow Fry		
13,250	<.01	.02	.3	1.0	<.01
1,670	1.0	.02	.3	1.0	<.01

1. Product of the four coefficients

conditions appear favorable from the preference coefficients. Our other snorkeling observations indicate that as flows decrease the rainbow trout tend to become less dispersed in the river and they tend to group more closely on the rapids.

In recent proceedings before the Federal Energy Regulatory Commission, the Washington Water Power Company suggested a license stipulation of 300 cfs minimum flow be maintained at Post Falls Dam. This minimum flow was supported by the Idaho Department of Water Resources in the licensing proceedings. Considerations in determining minimum flows were the protection of the instream resources in the Spokane River and the desire to maintaining a stable water elevation in Lake Coeur d'Alene for recreation.

To properly determine the effect of low flows and specifically the 300 cfs minimum flow in the Spokane River, controlled flows over a relatively short period of time should be observed and measurements made on fish dispersion, substrate exposed, and heat gain. The controlled flows might be at 1800 cfs (30% mean annual flow) 600 cfs (10%) and 300 cfs (5%). The critical reach for low flows is between Post Falls and Sullivan Road. Downstream of Sullivan Road, low flow and high temperature conditions are alleviated by groundwater inflow.

The difficult aspect of determining suitable minimum flows (assuming no critical point such as lethal temperature is reached) is in equating physical measurements to the biological factors. For example, if a decreased of flow from 600 CFS to 300 CFS resulted in a decrease of wetted substrate or preferred holding area of fish by some significant amount, what then would be the resultant loss of fish production. If this loss could be determined, then an administrative decision would be necessary to determine if that lost fish production would be more valuable than the loss of recreation if Coeur d'Alene Lake were drafted to provide a higher flow.

DISCUSSION

The primary objective of the fishery study was to provide baseline data for determining future changes in the salmonid fishery of the upper Spokane River. Rather than concentrating all the effort into one parameter such as a population estimate several aspects have been examined. Combined with the physical, biological and chemical analyses by Funk et al. (1982), these parameters should permit an assessment of future impacts.

The direct (snorkel) counts are a rapid method of determining fish abundance. Although the results of snorkel counts are not frequently reported in the literature some fish and game agencies such as Idaho are doing snorkel counts routinely to determine long term trends of fish abundance (Goodnight 1980). Trend analysis must be conducted over several years for validity and considering the low cost of snorkel counts we hope more data can be collected on the Spokane River. The snorkel counts are also very useful in determining distribution of fish and specifically in the Spokane River the data may be used to determine changes in distribution in study reach five, the site of the new treatment plant outfall. The snorkel count data is relatively imprecise (as is most environmental data) but the largest yearly variability is probably caused by differences in visibility. This difference in visibility may be accounted for by a Secchi disk reading.

Electroshocking as a method of capturing fish is most efficient in small streams and the relatively large variance in this study is due primarily to the size of the Spokane River. About 75% of the salmonid population in the upper Spokane River resides between Barker Road and

Plantes Ferry. Population estimates in the future conducted only in these reaches (4,3,2) would sacrifice only a small loss of information at a greatly reduced cost. The electroshocking is conducted most efficiently in October but may cause some disruption of brook char spawning.

Age and growth data provide an indicator of change and may be gathered from fish collected by electroshocking or from anglers. It is difficult to determine the cause of change, however, unless combined with an estimate of population size.

The angler census data provides an indirect measure of fish abundance. With a relatively constant effort (number of angler hours) a decrease or increase in CPE indicates a decline or increase in fish numbers. A constant CPE with an increase in the angler effort indicates an increasing fish population. The difficulty of determining bias in determining CPE in the Spokane River has been discussed but another apparent problem is the low CPE found on the Spokane River. The low CPE reduces the probability of intercepting successful fishermen and for some combinations of flow and reach no estimate of CPE could be made because no successful fishermen were contacted.

The assumption in the food selectivity index is that a change in the composition of the benthos will cause a change of fish production. Our data indicates a low preference or availability of the chironomidae, the numerically largest group of organisms present in the benthos. Any water quality changes which cause an increase in the abundance of this group and a decline of other organisms may cause a loss of fish production.

Although it was not an objective of this study to define the factor(s) which may be limiting fish production it appears that the

Spokane River is under a moderate ecological stress. Funk et al. (1982) have determined diversity indices for the aquatic invertebrates at several locations and with several sampling methods. The indices fall in the range which indicates moderate pollution. The stonefly, Pteronarcys californica, common in the St. Joe and upper Coeur d'Alene rivers (Bailey 1982b) was not collected in two years of sampling of the upper Spokane River and only one genus of ephemeroptera (mayfly) was collected. Several fish species, as mentioned previously, are also notably absent in the upper Spokane River. The parameters which may be causing this apparent stress are high zinc concentrations, high midsummer temperature or a reservoir effect.

The zinc concentration in the upper Spokane River is declining (Yake 1979) but during the study period the mean annual soluble zinc concentration at Harvard Road was 93 ug/L (Funk et al. 1982). The maximum concentration of zinc recommended by the Environmental Protection Agency (1980) for protection of aquatic life (at 25 mg/l hardness) is 47 ug/L (24 hour average) with no instantaneous concentration exceeding 101 ug/L. The 96 hour LC 50 of hatchery rainbow trout in Spokane River water is 112 ug/L (Bailey 1982a). Obviously, the salmonids in the Spokane River have adapted by acclimation or through genetic change to high zinc concentrations. The adaptation of the salmonids does not preclude stress due to the zinc. The absence of northern squawfish (Ptychocheilus oregonensis) is probably not due to zinc toxicity. Andros and Garton (1980) found squawfish to be more resistant to zinc than salmonids. No information was found on the toxicity of zinc to the other fish species absent from the upper Spokane River.

The invertebrates also appear to be highly resistant to zinc on the basis of acute assays (Warnick and Bell 1969, Nehring 1976). Warnick and Bell (1969), however, observed that maximum response of invertebrates is not measured in a 96 hour test.

Maximum temperature in the upper Spokane River occurs in late July and in August at about 23C from Harvard Road to Sullivan Road (Funk _et al_. 1982). The actual maximum daily temperature may be several degrees higher than that indicated by Funk _et al_ because of the diurnal fluctuation and time of measurement. Black (1953) found 50% mortality in 24 hours of rainbow trout (Kamloops var.) at 24.0C when the fish were acclimated to 11C. In a natural system with slowly increasing temperature and lower nighttime temperatures the critical temperature would be several degrees higher, however, the high temperature or the combination of temperature and zinc may be a factor in the reduced diversity of fish and invertebrates in the Spokane River.

The reduction in diversity of invertebrates and fish in the upper Spokane River may also be due to the influence of Lake Coeur d'Alene (reservoir effect). Spence and Hynes (1971a, b) studied invertebrates and fish populations above and below an impoundment with hypolimnitic discharge. Their observations closely parallel our observations of reduced diversity and dominance of certain organisms in the river below the impoundment. Ward and Stanford (1979) have also noted the same phenomenon on other rivers with surface reservoir discharges. The major evidence that the reduced diversity in the upper Spokane River is caused by the reservoir effect and not from zinc toxicity is the presence of salmonids. A review of the literature indicates that salmonids are more sensitive to zinc than most other fish or invertebrates. The actual mechanism of the reservoir effect is not defined, but is probably a shift in the thermal regime and a change in the food source from terrestrial detritus to lake plankton.

We view the upper Spokane River as an extremely valuable natural resource. It provides high quality recreational opportunities near a large urban center and we hope this work helps to maintain these uses.

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APPENDIX

This appendix contains miscellaneous data from the snorkel counts and creel census.

Table A-1. Direct counts of trout and char in the Spokane River observed by snorkeling

7/15/80 (1430-1700) Reach 6 - Stateline to Harvard Road

North	-	2 Rainbow	1 Brook
Midchannel	-	7 Rainbow	0 Brook
South Shore	-	7 Rainbow	2 Brook

7/16/80 (0750-0925) Reach 5 - Harvard Road to Barker Road

North	-	9 Rainbow	0 Brook
South	-	14 Rainbow	4 Brook

7/16/80 (1020-1235) Reach 4 - Barker Road to Sullivan Road

North	-	40 Rainbow	31 Brook
South	-	16 Rainbow	7 Brook

7/16/80 (1505-1620) Reach 3 - Sullivan Road to Kaiser Intake.

North	-	21 Rainbow	110 Brook
South	-	12 Rainbow	58 Brook

7/16/80 (1635-1745) Reach 3 and 2-Kaiser Intake to Plantes Ferry Park

North	-	16 Rainbow	21 Brook
South	-	8 Rainbow	11 Brook

7/16/80 (1745-1830) Reach 2-Plantes Ferry Park to Donkey Island

North	-	3 Rainbow	
Midchannel	-	2 Rainbow	1 Brook
South	-	0	

7/18/80 (0830-0915) Reach 1 - Upriver Reservoir at Boulder Beach

North	-	0
Midchannel	-	0
South	-	0

7/18/80 (1115-1530) Reach 7-Post Falls to State Line

North	-	9 Rainbow	
Midchannel	-	11 Rainbow	
South	-	14 Rainbow	1 Brook

Table A-1. (Continued)

7/29/80 Reach 6 State Line to Harvard Road

North - 9 Rainbow 0 Brook
Midchannel - 3 Rainbow 0 Brook
South - 3 Rainbow 0 Brook

7/30/80 Reach 5 - Harvard Road to Barker Road

North - 9 Rainbow 0 Brook
Midchannel - 6 Rainbow 0 Brook
South - 13 Rainbow 0 Brook

7/30/80 Run #1 Reach 4 - Barker Road to Sullivan Road

North - 19 Rainbow 0 Brook
Midchannel - 13 Rainbow 0 Brook
South - 21 Rainbow 2 Brook

7/31/80 Run #2

North - 26 Rainbow 4 Brook
Midchannel - 6 Rainbow 0 Brook
South - 12 Rainbow 0 Brook

7/31/80 Run #3

North - 31 Rainbow 8 Brook
Midchannel - 46 Rainbow 0 Brook
South - 14 Rainbow 5 Brook

8/14/80 Reach 7 - Post Falls to State Line

North - 45 Rainbow 0 Brook 11 Fry
Midchannel - 48 Rainbow 0 Brook 0 Fry
South - 65 Rainbow 0 Brook 0 Fry

8/11/80 Reach 6 - State Line to Harvard Road

North - 36 Rainbow 2 Brook 0 Fry
Midchannel - 46 Rainbow 0 Brook 0 Fry
South - 33 Rainbow 0 Brook 0 Fry

8/12/80 Reach 5 - Harvard Road to Barker Road

North - 27 Rainbow 2 Brook 0 Fry
Midchannel - 36 Rainbow 0 Brook 0 Fry
South - 47 Rainbow 0 Brook 0 Fry

8/13/80 Reach 5

Counter 1	37 Rainbow	0 Brook	0 Fry
2	38 Rainbow	0 Brook	0 Fry
3	36 Rainbow	0 Brook	0 Fry
4	37 Rainbow	0 Brook	0 Fry
5	29 Rainbow	0 Brook	0 Fry

Table A-1. (Continued)

8/13/80 Reach 5

Counter 1	10 Rainbow	0 Brook	1 Fry
2	21 Rainbow	0 Brook	0 Fry
3	14 Rainbow	0 Brook	0 Fry
4	64 Rainbow	0 Brook	0 Fry
5	46 Rainbow	0 Brook	0 Fry
6	80 Rainbow	0 Brook	0 Fry
7	24 Rainbow	0 Brook	0 Fry
8	11 Rainbow	0 Brook	0 Fry

8/11/80 Reach 4 - Barker Road to Sullivan Road

North	- 85 Rainbow	0 Brook	87 Fry
Midchannel	-110 Rainbow	0 Brook	1 Fry
South	- 88 Rainbow	1 Brook	30 Fry

8/12/80 Reach 3ab - Sullivan Road to Kaiser Intake

North	- 180 Rainbow	409 Brook	388 Fry
Midchannel	- 18 Rainbow	1 Brook	0 Fry
South	- 537 Rainbow	355 Brook	217 Fry

8/14/80 Reach 3C, 2C Kaiser Intake to Plantes Ferry

North	- 86 Rainbow	178 Brook	34 Fry
Midchannel	- 46 Rainbow	1 Brook	0 Fry
South	- 63 Rainbow	9 Brook	42 Fry

8/14/80 Reach 2b - Plantes Ferry to Donkey Island

North	-		
Midchannel	- 0 Rainbow	0 Brook	17 Fry
South	-		

8/15/80 Reach 1 - Upriver Reservoir near Boulder Beach

North	- 0 Rainbow	0 Brook	0 Fry
South	- 0 Rainbow	1 Brook	0 Fry

8/15/80 Reach 0 - Upriver Dam to Mission Street

North	- 158 Rainbow	40 Brook	69 Fry
Midchannel	- 12 Rainbow	31 Brook	45 Fry
South	- 162 Rainbow	46 Brook	30 Fry

Table A-1. (Continued)

7/20/81	Reach 6 - Stateline to Harvard Rd.		
	North	31 Rainbow	0 Brook
	South	22 Rainbow	1 Brook
9/8/81	Reach 7 - Post Falls to Stateline		
	North	80 Rainbow	0 Brook
	South	43 Rainbow	3 Brook
9/9/81	Reach 6 - Stateline to Harvard Rd.		
	North	62 Rainbow	1 Brook
	South	47 Rainbow	0 Brook
9/9/81	Reach 5 - Harvard Rd. to Barker Rd.		
	North	27 Rainbow	0 Brook
	South	27 Rainbow	4 Brook
9/10/81	Reach 4 - Barker Rd. To Sullivan Rd.		
	North	37 Rainbow	3 Brook
	South	40 Rainbow	1 Brook
9/10/81	Reach 3ab - Sullivan Rd. To Kaiser Intake		
	North	87 Rainbow	129 Brook
	South	58 Rainbow	70 Brook
9/10/81	Reach 3c, 2c - Kaiser Intake to Plantes Ferry		
	North	43 Rainbow	92 Brook
	South	29 Rainbow	1 Brook
9/11/81	Reach 2b - Plantes Ferry to Donkey Island		
	North	0 Rainbow	0 Brook
9/11/81	Reach 1 - Old Pump House to Dam		
	North	0 Rainbow	2 Brook (fry)

Table A-2. A comparison of August 1980 and September 1981 direct counts (fish/counter mile) of Rainbow Trout (Salmo gairdneri Richardson) and Brook char (Salvelinus fontinalis Mitchill) in the upper Spokane River.

	1980	1981
Reach 7 - Post Falls to State Line (5.8 miles)		
Rainbow	9.1	10.6
Brook	0	.3
Total	9.1	10.9
Fry	.6	-
Reach 6 - State Line to Harvard Rd. (3.5 miles)		
Rainbow	11.0	15.6
Brook	.2	.1
Total	11.2	15.7
Fry	0	-
Reach 5 - Harvard Rd. to Barker Rd. (2.3 miles)		
Rainbow	15.9	11.7
Brook	.3	.9
Total	16.2	12.6
Fry	0	-
Reach 4 - Barker Rd. to Sullivan Rd (2.7 miles)		
Rainbow	34.9	14.3
Brook	.1	.7
Total	35.0	14.7
Fry	14.6	-
Reach 3ab - Sullivan Rd. to Kaiser Intake (1.3 miles)		
Rainbow	188.5	55.8
Brook	196.1	76.5
Total	384.6	132.3
Fry	155.1	-
Reach 3c, 2c - Kaiser Intake to Plantes Ferry (1.7 miles)		
Rainbow	38.2	21.2
Brook	36.9	27.4
Total	75.1	48.6
Fry	14.9	-

Table A-2. (Continued)

	1980	1981
Reach 2b - Plantes Ferry to Donkey Island (1.3 miles)		
Rainbow	0	0
Brook	0	0
Total	0	0
Fry	13.1	-
Reach 1 - Upriver Reservoir (.3 miles)		
Rainbow	0	0
Brook	1.7	0
Total	1.7	0
Fry	0	2
Reach 0 - Upriver Dam to Mission Street (4.0 miles)		
Rainbow	27.7	-
Brook	9.8	-
Total	37.5	
Fry	12.0	

The 1980 creel census opinion and residence data are compiled and summarized in Table A-3. The results as percentage of respondents are separated by reach and then as total. The overall impression of the quality of fishing was evenly divided between good, average, and poor. In reach 1 (reservoir) the majority (53%) rated the fishing as poor. In reaches 4 and 6 there was an approximately even split between good and poor. The percentage of people who rated the quality of fishing good or excellent is surprisingly high considering the catch per effort estimate of .133 fish per hour.

The second question was asked to see if people were aware that the upper Spokane is a wild trout fishery. Forty five percent know that there was no stocking of the upper river and the rest guessed the percentage of stocked fish was quite low.

On the impression of water quality, 73% rated the river as good and saw no specific water quality problems (Question 4).

The fishermen in the upper river in Washington were evenly divided between Spokane City and Spokane County residency. In the Idaho reach, 85% were Idaho residents and 15% from Washington or other states.

During the 1981 census anglers in Washington were asked their opinion of the one fish limit. Of the 340 anglers who responded 221 (65%) had no opinion, 31 (9%) were strongly opposed, 43(13%) were opposed and 45 (13%) agreed with the limit.

Table A-3 . Fisherman opinion survey (%) or the upper Spokane River (1981).

Question 1. Quality of fishing: excellent, good, average, poor

REACH

1				2				3				4				5				6				7				TOTAL			
E	G	A	P	E	G	A	P	E	G	A	P	E	G	A	P	E	G	A	P	E	G	A	P	E	G	A	P	E	G	A	P
6	16	25	53	2	33	34	31	7	53	20	21	0	42	5	53	5	27	28	39	11	40	16	33	4	31	31	34	6	34	26	35

Question 2. What percent of fish are stocked in the upper Spokane River: 100-50%, <25%, 0.

100-50	<25%	0%
3	52	45

Question 3. What is your impression of water quality in the upper Spokane River: Excellent, Good, Average, Poor.

E	G	A	P
6	73	17	5

Question 4. What is the major water quality problem:

None	Trash	Sewage	Industrial	Algae	Flow	Boats	Ash	Oxygen	Mines
72	12	4	5	1	3	1	2	<1	<1

Question 5. What is your place of residence: Spokane, Spokane County, WA, ID, other.

Reach 1-6					Reach 7				
City	County	WA	IDA	Other	City	County	WA	IDA	Other
44	48	5	1	2	2	2	3	85	9

Creel Census Schedule

Spokane River 1980

April	21	am
	25	pm
	26	am
	27	am
	28	am
	29	am
	30	pm
May	1	pm
	3	am
	4	am
	7	pm
	8	am
	9	pm
	10	pm
	11	pm
	15	pm
	16	am
	17	am
	18	pm
	20	am (Ash Fallout)
	22	am (Ash Fallout)
	24	pm (Ash Fallout)
	25	pm (Ash Fallout)
	26	pm (Ash Fallout)
	28	am (Ash Fallout)
	29	pm
	31	pm
June	1	pm
	7	pm
	8	pm
	9	pm
	10	pm
	11	am
	12	pm
	13	am
	14	pm
	15	pm
	17	pm
	21	pm
	22	am
	25	pm
	26	pm
	27	am
	28	am
	29	am
July	3	pm
	4	pm
	5	am
	11	pm
	12	am
	13	am
	16	am
	17	pm
	19	pm
	23	pm
	25	pm
	27	pm
	29	am
	31	pm
August	2	pm
	4	am
	5	pm
	9	pm
	10	pm
	18	am
	20	pm
	23	pm
	24	pm
	31	pm
Sept.	1	pm
	3	am
	6	am
	7	am
	15	am
	20	am
	21	am
	23	pm
	24	am
	26	am
	27	pm

Census Sheet - Spokane River 1980

Date ______________ Time start __________ at Post Falls/Dam Time end ____________

Reach	Fishing	Unsure
1. Dam to Argonne	______	______
2. Argonne to Trent	______	______
3. Trent to Sullivan	______	______
4. Sullivan to Barker	______	______
5. Barker to Harvard	______	______
6. Harvard to State Line	______	______
7. State Line to Post Falls	______	______
TOTAL	______	______

Date ______________ Time start __________ at Post Falls/Dam Time end ____________

Reach	Fishing	Unsure
1. Dam to Argonne	______	______
2. Argonne to Trent	______	______
3. Trent to Sullivan	______	______
4. Sullivan to Barker	______	______
5. Barker to Harvard	______	______
6. Harvard to State Line	______	______
7. State Line to Post Falls	______	______
TOTAL	______	______

Interview Sheet - Spokane River 1980

Date________________ Location______________________ Time______________

Time started fishing ______________________

Anticipated time of finish ____________________

Number of fish caught __________________

approximate sizes ____

Fishing method ____

Sex M________ F_________ Age-Child_____ Teen______ Adult_______

<u>Previous Trip</u>

Hours fished ________________

Number fish caught __________________

<u>Biodata</u>

Fish length _______________

Fish weight _______________

Stomach Code Number _______________________
reach-date-number

1. What is your impression of quality of fishing on the river?
   excellent ____________ good_________ average__________ poor__________
2. What percentage of fish in the river are stocked?
   100-75%________ 75-50%________ 50-25%________ 25 or less_________ 0_________
3. What is your impression of water quality in the river?
   excellent ____________ good ________ average__________ poor__________
4. What do you feel is the major water quality problem ____________________
   ____
5. Is your residence in City_____Spokane County_____Washington_______Idaho_____
   other state_______

1981 Creel Census Schedule - Spokane River

Date	Time Start	Time End	Start At[1]	Sequence[2]
4/19	1200	1943	URD	C C I
4/20	1200	1944	URD	I C C
4/25	0544	1200	PFD	C C I
4/26	1251	2051	PFD	C C I
4/28	1253	2053	PFD	C C I
5/2	1259	2059	URD	C I C
5/3	1300	2100	URD	C C I
5/6	1303	2103	URD	C C I
5/9	1306	2106	URD	I C C
5/10	1307	2107	URD	I C C
5/14	1311	2111	PFD	C C I
5/15	1312	2112	URD	C C I
5/16	1327	2127	PFD	C I C
5/17	1328	2128	URD	C I C
5/21	1332	2132	PFD	I C C
5/24	0458	1200	URD	I C C
5/25	1336	2136	PFD	C I C
5/26	0457	1200	URD	I C C
5/27	1338	2138	PFD	C C I
5/28	1339	2139	URD	C C I
5/30	1340	2140	URD	C I C
5/31	1341	2141	PFD	I C C
6/1	1342	2112	PFD	C C I
6/2	0454	1200	URD	C C I
6/6	1346	2146	URD	C I C
6/7	0452	1200	URD	I C C
6/11	0451	1200	URD	I C C
6/13	1349	2149	URD	I C C
6/14	1350	2150	URD	C C I
6/15	0451	1200	URD	C C I
6/17	0451	1200	URD	C C I
6/20	0452	1200	PFD	C C I
6/21	1352	2152	URD	C C I
6/23	1352	2152	PRD	I C C
6/27	0453	1200	PFD	I C C
6/28	1352	2152	URD	C C I
7/2	1352	2152	PFD	I C C
7/4	1352	2152	PFD	I C C
7/5	0458	1200	URD	C I C
7/6	0459	1200	URD	C I C
7/11	1349	2149	PFD	C I C
7/12	0503	1200	PFD	C I C
7/17	1345	2145	URD	C I C
7/18	1344	2144	URD	C C I
7/19	1343	2143	URD	C C I
7/20	0510	1200	URD	C C I
7/22	0512	1200	PFD	C C I
7/23	1339	2139	PFD	I C C
7/25	1337	2137	PFD	I C C
7/26	1336	2136	URD	C I C

1981 Creel Census - Spokane River (continued)

Date	Time Start	Time End	Start At[1]	Sequence[2]
7/30	0520	1200	PFD	C I C
7/31	0521	1200	PFD	I C C
8/1	1330	2130	URD	C C I
8/2	1316	2116	PRD	C C I
8/7	0528	1200	URD	C C I
8/8	1306	2106	PFD	I C C
8/9	0530	1200	PFD	C C I
8/12	1301	2101	PFD	C C I
8/15	1254	2054	PFD	C I C
8/16	1255	2055	PFD	C C I
8/18	1252	2052	URD	C C I
8/20	1248	2048	URD	C I C
8/22	1246	2046	URD	I C C
8/23	0600	1200	URD	C C I
8/25	1241	2041	URD	I C C
8/28	1236	2036	PFD	C C I
8/29	0606	1200	PFD	C C I
8/30	1231	2031	URD	I C C
9/2	1229	2029	URD	C I C
9/5	1222	2022	URD	I C C
9/6	0614	1200	PRD	C I C
9/12	1203	2003	PFD	I C C
9/13	1201	2001	PFD	I C C
9/17	1200	1954	PFD	I C C
9/18	1200	1953	PFD	C C I
9/19	1200	1952	PFD	C C I
9/20	1200	1949	URD	C I C
9/22	1200	1946	PFD	C I C
9/26	1200	1939	URD	I C C
9/27	1200	1938	URD	C C I

[1]PFD = Post Falls Dam
URD - Upriver Dan

[2]C = Count trip
I = Interview trip

Count Sheet - Spokane River 1981

Date ________________ Time Start ______ ______ ______

Weather ____

Reach

1. Dam to Argonne			
2. Argonne to Trent			
3. Trent to Sullivan			
4. Sullivan to Barker			
5. Barker to Harvard			
6. Harvard to State Line			
7. State Line to Post Falls			

Date ________________ Time Start ______ ______ ______

Weather ____

Reach

1. Dam to Argonne			
2. Argonne to Trent			
3. Trent to Sullivan			
4. Sullivan to Barker			
5. Barker to Harvard			
6. Harvard to State Line			
7. State Line to Post Falls			

Interview Sheet - Spokane River 1981

Date __________ Location __________ Time __________

Time started fishing __________ anticipated finish time __________

Number and species of fish caught   Rainbow_____ Brook_____ Cutthroat_____

Other _____

Previous Trip

Date __________ Time Start _____ End_____ Where__________

No. and species caught Rainbow _____ Brook _____ Cutthroat _____

Caught any tagged fish? Yes/No and Number __________

Biodata

Species __________ Length __________ Stomach code __________
Reach/Date/No.

Date __________ Location __________ Time __________

Time started fishing __________ anticipated finish time __________

Number and species of fish caught   Rainbow_____ Brook_____ Cutthroat_____

Other _____

Previous Trip

Date __________ Time Start _____ End_____ Where __________

No. and species caught Rainbow _____ Brook _____ Cutthroat _____

Caught any tagged fish? Yes/No and Number __________

Biodata

Species __________ Length __________ Stomach code __________
Reach/Date/No.

Table A-4. Fishermen counts for the Upper Spokane River (1980).

I. Upriver Dam to Post Falls

High Flow

April				May				June			
Weekday		Weekend		Weekday		Weekend		Weekday		Weekend	
am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
5	20	18		0	29	7	22	2	28	2	26
3	17	9		13	19	29	27	2	12	6	25
7				0	8	6	29	4	20	18	41
					2	9	22	0	22	14	27
					7				44	24	57
					9				35	25	22
									14		34
									11		
									29		

Low Flow

July				August				September			
Weekday		Weekend		Weekday		Weekend		Weekday		Weekend	
am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
0	15	8	28	2	3		23	3	2	6	12
6	15	7	22	4	20		2	7	2	14	35
3	25	19	13	0	22		27	4	11	3	
4	28	9	12	1	30		11	7		11	
3	23	10	4	0			6	0		12	
2	12	9	7				8	0		3	
	19	6					20	1		12	
	17	21					14	0			
	10						4	0			
	1						10	0			
	6						48				
	3						20				
	1										

Table A-5. A summary of angler counts by month and by flow on the Upper Spokane River (1980).

I. Upriver Dam to Post Falls

High Flow

	April				May				June			
	Weekday		Weekend		Weekday		Weekend		Weekday		Weekend	
	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
N	3	2	2		3	6	4	4	4	9	6	7
$\bar{X}$	5	18.5	13.5		4.3	12.3	12.8	25	2	23.9	14.8	33.1
S	2				7.5	9.9	10.9	3.6	1.6	11.2	9.4	12.3
S^2	4				56.3	97.5	118.9	12.7	2.7	124.4	88.2	151.8

Low Flow

	July				August				September			
	Weekday		Weekend		Weekday		Weekend		Weekday		Weekend	
	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
N	6	13	8	6	5	4		12	10	3	7	2
$\bar{X}$	3	13.5	11.1	14.3	1.4	18.8		16.1	2.2	5	8.7	23.5
S	2	9	5.6	9.1	1.7	11.4		12.8	2.9	5.2	4.6	--
S^2	4	81	31.8	82.7	2.8	128.9		163.1	8.4	27	21.2	--

High Flow

	Weekday		Weekend	
	am	pm	am	pm
N	10	17	12	11
$\bar{X}$	3.6	19.2	13.9	30.2
S	4.0	11.1	8.8	10.6
S^2	16.3	123	77.2	111.8

Low Flow

	Weekday		Weekend	
	am	pm	am	pm
N	21	20	15	20
$\bar{X}$	2.2	13.3	10	16.3
S	2.4	9.6	5.2	11.7
S^2	5.7	91.6	26.6	136.9

II. Up River Dam to Stateline

High Flow

	Weekday		Weekend	
	am	pm	am	pm
N	10	17	12	11
$\bar{X}$	1.4	13.1	8.8	22
S	1.8	7.6	6.3	8.9
S^2	3.2	57.6	39.5	79

Low Flow

	Weekday		Weekend	
	am	pm	am	pm
N	21	20	15	20
$\bar{X}$	1.2	9.3	5.1	8.7
S	1.6	7.4	4.2	5.6
S^2	2.5	55.4	18.0	31.3

Table A-5 . Continued

II. Upriver Dam to Stateline

High Flow

April				May				June			
Weekday		Weekend		Weekday		Weekend		Weekday		Weekend	
am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
0	15	3		0	21	4	16	1	20	1	23
2	12	16		5	16	22	21	1	12	5	13
4				0	6	4	17	1	19	8	25
					0	7	16	0	17	8	22
					5				31	12	45
					7				10	15	16
									8		28
									6		
									17		

Low Flow

July				August				September			
Weekday		Weekend		Weekday		Weekend		Weekday		Weekend	
am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
0	10	2	9	2	1		20	1	1	3	5
4	10	2	8	1	20		1	5	1	5	15
2	15	13	5	0	20		15	0	7	0	
4	18	8	11	0	25		9	1		7	
3	15	7	2	0			1	0		9	
2	11	4	6				5	0		0	
	8	2					8	1		2	
	7	13					11	0			
	2						4	0			
	0						7	0			
	5						20				
	2						12				
	8										

Table A-6. Average lengths of fish from Spokane River Creel Census (1980).

Reach

	#1		#2		#3			#4
	Rainbow	Brook	R	B	R	B	C	R
N =	1	1	1	3	3	7	1	1
$\bar{x}$ length cm inches =	10.4	7.5	13.8	8.6	9.8	8.6	10.2	17.3

	#5		#6		#7		
	R	C	R	C	R	B	C
N =	6	1	15	1	34	1	8
$\bar{x}$ length cm inches =	12.7	10.0	13.6	10.6	11.4	7.2	10.2

Table A-7. Miscellaneous Creel Census Data (1981).

Mean anticipated trip length = 2.6 hours

Mean previous trip length = 2.9 hours

<u>Mean length of fish caught</u>

<u>Reach 1-6</u>

37 Rainbow - 26.8 cm (10.6 in)

10 Brook - 24.0 cm (9.4 in)

<u>Reach 7</u>

32 Rainbow - 31.9 (12.6 in)

Table A-8. Mean fishing trip length (hours) based on anticipated trip length and previous trip by month and reach (1981).

1. Anticipated trip length (total anticipated hours ÷ no. fishermen)

Period	Reach 1	2	3	4	5	6	7	$\bar{X}$ by month
April-May	2.1	2.3	2.3	3.3	2.6	2.5	3.0	1.8
June	3.0	1.6	4.0	2.0	3.1	3.5	2.8	3.0
July	2.1	3.4	2.8	1.9	3.0	2.8	2.5	2.7
August	2.0	2.3	2.9	9.75	2.6	2.3	4.0	3.2
September	4.0	1.0	2.3	1.8	1.9	2.0	2.4	2.3
Average by reach =	2.4	2.3	2.8	3.2	2.7	2.7	3.0	

2. Previous trip length

Period	Reach 1	2	3	4	5	6	7	
April-May	3.2	3.8	1.9	2.9	2.3	2.8	2.6	2.6
June	2.0	2.8	3.9	2.0	3.1	3.0	2.7	3.1
July	1.0	2.6	2.3	1.8	2.7	3.5	15.2	4.4
August	.4	-	2.5	3.5	3.0	2.6	2.2	2.1
September	-	2.0	1.6	1.5	2.0	2.0	2.5	2.1
Average by reach =	2.6	3.2	2.3	2.6	2.5	3.0	3.6	