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Shepard et al. 1984b

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LIFE HISTORIES OF WESTSLOPE CUTTHROAT AND BULL TROUT IN THE UPPER FLATHEAD RIVER BASIN, MONTANA

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INTRODUCTION

This report presents life history and habitat requirement information for westslope cutthroat and bull trout populations in the upper Flathead River Basin, which includes Flathead Lake, the mainstem Flathead River above Flathead Lake, North Fork of the Flathead River, Middle Fork of the Flathead River and tributaries to these waters. The South Fork of the Flathead River, Stillwater River, Whitefish River and Swan River drainages were not included in this study. The information presented in this report is a synthesis of data collected primarily during a five-year baseline fisheries study (1978 to 1982) of the upper Flathead Basin funded by the Environmental Protection Agency and conducted by the Montana Department of Fish, Wildlife and Parks (MDFWP). We also incorporated information collected during other MDFWP studies funded by the Bureau of Reclamation, Bonneville Power Administration and USDA Forest Service. The following reports were used as primary reference sources and are not cited individually in the text: Montana Department of Fish Wildlife and Parks (1979), Graham et al. (1980), Fraley et al. (1981), Leathe and Graham (1981), McMullin and Graham (1981), Fraley and Graham (1982), Leathe and Graham (1982), Shepard et al. (1982), MDFWP (1983a), MDFWP (1983b), MDFWP (1983c), Shepard and Graham (1982), Shepard and Graham (1983a), and Pratt (1984). These reports should be consulted if more detailed information on a particular aspect of these investigations is needed.

Other fisheries studies presently being conducted by MDFWP include a basin-wide micro-hydro cumulative impact study in the Swan River drainage funded by the Bonneville Power Administration and a study evaluating the impacts of timber harvest in Coal Creek, a tributary to the North Fork of the Flathead River, funded by the USDA Forest Service, Flathead National Forest.

Life history and habitat information were organized by life-stage, beginning with embryonic development and continuing through tributary residence, juvenile emigration, Flathead River-Flathead Lake residence, and concluding with mi'gration of adult spawners back to the spawning grounds. Growth information is presented by species. We also included information regarding our present knowledge of sculpin and mountain whitefish life histories. This report does not address kokanee, the dominant sport fish in the basin in terms of harvest and angler use, because this information is presently being collected in two separate studies being conducted by MDFWP under contract to the Bonneville Power Administration. Life history information for kokanee will be presented at the conclusion of these two studies.

WESTSLOPE CUTTHROAT TROUT

STOCK ASSESSMENT

Behnke (1979) recognized three commonly occurring life history patterns of westslope cutthroat throughout their native range. Resident fish spend their entire life within a tributary stream. Fluvial cutthroat trout rear up to three years in tributary streams emigrate to a river to grow to maturity, and return to their natal tributary to spawn. Adfluvial cutthroat trout spawn and rear in tributary streams but move into lakes to mature. Growth of fish is generally more rapid in rivers and lakes than in tributary streams; consequently, adults from fluvial populations are usually larger than resident adults and adfluvial adults often grow larger than fluvial adults within the same system.

Presently, the downstream emigration of juveniles is the only way to distinguish between resident and migratory (either fluvial or adfluvial) forms of juvenile cutthroat trout. Averette and MacPhee (1971) also concluded that behavioral rather than morphologic differences were the only way to separate resident and adfluvial cutthroat trout in the St. Joe River drainage, Idaho. They stated that to be able to group these different life history forms into discrete stocks required proof of genetic isolation via temporal or spatial isolation during spawning. Since they found both life history forms spawning in the same sections of many lower St. Joe tributaries, they concluded no evidence existed that showed discrete spawning. We presently have no evidence from either electrophoretic analyses or spawning ground surveys to conclude genetic isolation has occurred for the three life history forms (other than above physical migration barriers) in the upper Flathead Basin. Genetic mixing may occur frequently enough to prevent stock differentiation and migratory behavior is based on social and environmental cues in conjunction with genetic codes. For example, during years of lower than average streamflows, juvenile progeny from resident parental stock may migrate downstream seeking more favorable growing environments in response to increased competition for food and space (Chapman and Bjornn 1969). Generally, mature adults (age IV and older) of each life history form can be differentiated based on size with the largest adults (>350 mm) being adfluvial, medium sized adults (approximately 250 to 350 mm) being fluvial and small adults (<250 mm) indicating resident fish.

EMBRYONIC DEVELOPMENT

Terminology used in this report is defined as follows:

Alevin - a small fish which has just hatched, still has a yolk sac and does not actively feed.

Embryo - fertilized egg.

Emergence - fry leave the gravel.

Fry - a small fish which has recently absorbed the yolk sac and begun actively feeding.

Hatch - process between egg and alevin stage.

Hatch Duration - time period from the hatching of the first egg until the last egg hatches.

Incubation - period of egg development.

Swim up - fry swim up from the streambed after emergence by gulping air to fill their swim bladder.

Temperature Units - (°C) number of degrees above freezing multiplied by the number of days above freezing.

Embryonic development of both cutthroat and bull trout is affected by water temperature, concentrations of dissolved oxygen and streambed composition. Water temperature affects timing of incubation, duration of hatch and embryo survival. Increased fine sediments within the streambed can prevent oxygenated water from reaching embryos, trap metabolic wastes within interstitial spaces surrounding the embryos, and form a physical barrier preventing fry emergence. The information presented below originated from both fish culture research, laboratory experiments and field observations.

Egg Deposition through Hatching

After eggs have been deposited in the gravels and fertilized, the embryos required 310 temperature units to hatch (Smith et al. 1983). The incubation period for cutthroat embryos in the upper Flathead River basin extends from mid-May through August depending on time of spawning and water temperature.

Egg survival has been related to the age of spawning adults, temperature of water where adults reside before spawning, genetic variation within the stock and amount of fine sediment present in the substrate. Mature two and three year old cutthroat trout have less viable gametes than mature four and five year old fish (Smith et al. 1983, Daryle Hodges, Murray Springs Hatchery, Eureka, Montana, personal communication). Adult cutthroat trout held in cool (2-4°C) water temperatures produced more viable eggs than those held in a constant water temperature of 10°C (Smith et al. 1983). Genetic variability is necessary for the production of viable eggs (Allendorf and Phelps 1980). In laboratory studies, embryo survival to hatching was generally less than 50 percent when the percentage of fine sediment (material less than 6.35 mm) within the redd exceeded 20 percent (Idaho Cooperative Fisheries Research Unit, University of Idaho, Moscow, unpublished data).

Hatching through Fry Emergence

After hatching, alevins remained within the interstitial areas of the streambed gravels until they accumulated an additional 110 to 150 temperature units before absorbing the yolk sac and emerging as fry (Daryle Hodges, Murray Springs Hatchery, Eureka, Montana, personal communication). Heimer (1969, 1970) estimated that survival of westslope cutthroat trout eggs to fry emergence ranged from 30 to 34 percent in tributaries to Priest Lake, Idaho.

Fry emerged from the streambed from early July to late August in upper Flathead River Basin tributaries. Cutthroat trout in the St. Joe River, Wolf Lodge Creek and Coeur d'Alene Lake drainages, Idaho emerged earlier (Table 1). Fry were approximately 20 mm long at emergence in tributaries to the Flathead River and Lake Coeur d'Alene (Table 1).

STREAM RESIDENCE

Resident and migratory stocks of cutthroat trout were indistinguishable as juveniles and were combined in the following discussion. Resident adult cutthroat trout were often observed alongside migratory juveniles in streams in the basin. Aggressive behavior was frequently displayed by resident adult cutthroat trout toward smaller juvenile cutthroat and bull trout.

Species distributions, habitat use, and food habits are described by size group. Habitat used by juvenile fish was analyzed for fish smaller than 100 mm and fish larger or equal to 100 mm. Food habits were analyzed for fish smaller than 110 and larger or equal to 110 mm. Comparative data was often available only by age of fish rather than size of fish and is reported as such. An age 0 fish was in its first summer of life, and age I fish had completed one full year and was in its second summer of life.

Distribution in Streams

Cutthroat trout were observed in 89 (97%) of the 92 tributaries surveyed in the upper Flathead basin, and were the only trout species present in 28 (30%) of the surveyed tributary streams. Only eight (9%) of the streams were inaccessible to other trout due to permanent or seasonal barriers to fish movement. Densities of cutthroat trout in Flathead River tributaries were generally higher than those reported for other drainages, except Wolf Lodge Creek, Coeur d'Alene, Idaho (Table 2).

Cutthroat trout densities were highest in small streams (low stream order), and backwaters or side channels of larger streams (Tables 3 and 4). High densities of juvenile cutthroat trout were observed in several small streams characterized by low gradient and associated with small high mountain lakes. Hartman and Gill (1968) also reported cutthroat in "small level streams" some of which were associated with lakes. However, when other species were present, cutthroat trout were observed in areas of moderate to high gradients. Griffith (1970) believed interspecific interactions between cutthroat and brook trout resulted in a longitudinal distribution for these two species within streams with cutthroat trout inhabiting the high gradient headwater areas and brook trout inhabiting the low gradient regions.

High densities of cutthroat trout were found in upper reaches of tributary drainages (Table 4). Many of these cutthroat appeared to be residents. Averett and McPhee (1971) reported resident cutthroat trout predominated upper basin tributary populations and migratory cutthroat trout were more dominant in lower tributary and mainstem populations in the St. Joe River drainage, Idaho.

Table 1. Time of year, water temperature during incubation and fry size at emergence for westslope cutthroat trout in the Flathead River, St. Joe River, Wolf Lodge Creek and Priest Lake drainages.

Emergence period	Incubation temperature	Size at emergence	Drainage	Source
July-August	2-10°C	23 mm	Flathead River	Johnson 1963 This study
June-July	2-13°C	--	St. Joe River	Averett and McPhee 1971 Mauser 1972
June	9-17°C	20 mm	Wolf Lodge Creek	Lukens 1978
August[a/]	13-21°C	--	Priest Lake	Bjornn 1957

a/ Fry emergence completed.

Table 2. Densities of age I and older cutthroat (fish/100m^2) observed in pools of tributaries to river drainages in Montana and Idaho.

Drainage	Cutthroat/ 100 m^2	Tributaries used in average	Source Citation
Flathead River	17.7	89	This Study
S.F. Clearwater River	14.3	3	Shepard 1983
Lemhi River	3.0	1	Horner 1978
St. Joe River	1.4	9	Thurow and Bjornn 1977
Lochsa River	0.8	6	Graham 1977
Selway River	1.1	8	Graham 1977
Coeur d'Alene Lake	26.1	6	Lukens 1978

Table 3. Mean densities (fish/100 m²) and standard deviations (S.D.) of cutthroat and bull trout by stream order.

Stream order [1/]	Number of surveyed reaches	Cutthroat Mean	Cutthroat S.D.	Bull trout Mean	Bull trout S.D.
2	45	8.3	15.6	0.9	2.2
3	98	5.0	6.0	0.6	1.3
4	36	1.4	2.2	0.4	0.8
5	5	0.7	0.8	1.0	1.2

1/ Stream order refers to the location of the stream in the drainage and its relative size. First order streams have no tributaries, second order streams begin where two first order streams join, and so on.

Table 4. Mean densities (fish/100 m²) and standard deviations (S.D.) of cutthroat and bull trout by stream reach.

Stream reach [1/]	Number of surveyed reaches	Cutthroat Mean	Cutthroat S.D.	Bull trout Mean	Bull trout S.D.
1	88	4.3	7.0	0.5	1.2
2	56	5.1	10.8	0.7	1.9
3	27	7.2	12.3	1.0	1.8
4	11	5.3	8.1	6.5	1.0
5	2	0.5	0.4	0.1	0.1

1/ Stream reaches were homogenous portions of a stream with respect to channel gradient, relative size, and adjacent land form. Stream reaches were numbered from the mouth upstream.

Cutthroat trout were most frequently found in habitat units (e.g. pool, riffle or run) smaller than 200 m^2 and 100 m^3. Densities of cutthroat trout were higher in pool habitats than in any other habitat type (Table 5). Shepard (1983) found densities of cutthroat trout larger than 50 mm were significantly higher ($p<0.1$) in pool than riffle, run or pocketwater habitats in tributaries to the South Fork of the Clearwater River, Idaho. Cutthroat trout densities were higher in pools because fish used the entire water column (depth) by "stacking up" where suitable water velocities and cover existed.

Habitat Used

Small (<100 mm) Cutthroat

Cutthroat trout fry and fingerlings were found along stream margins in both main stream channels and small side channels. Small groups of fry were observed in low velocity areas within pools, while solitary individuals were seen along the fringes of fast water (runs and riffles). In tributaries to the Flathead River, fry and fingerlings were more abundant in pools and runs than riffles or pocketwaters (Table 5). Glova and Mason (1974) reported larger numbers of young coastal cutthroat (*Salmo clarki clarki*) in riffles and glides than in pools when coho (*Oncorhynchus kisutch*) were present. When coastal cutthroat were alone they were evenly distributed between pools, glides, and riffles.

Within habitat units, cutthroat trout selected areas of homogeneous depths and velocities. Young cutthroat trout used shallow areas, approximately 0.3 m deep, where water velocities were less than 0.15 mps. In other drainages, cutthroat trout were found in areas with water depths between 0.05 and 0.50 m where water velocities were 0.11-0.36 mps (Table 6). Juvenile cutthroat trout usually maintained a fixed position in the water column, 0.1-0.4 m above the streambed where water velocities were between 0.02 and 0.46 mps (Table 6). Small juvenile cutthroat trout were generally within 0.2 m of overhead cover. This cover could be provided by overhanging brush, undercut banks, water depth, large substrate or a broken water surface. When other fish species or older cutthroat trout were present, juvenile cutthroat trout were consistently closer to cover. Hansen (1977) also found cutthroat trout used the same types of habitat.

Cutthroat trout fry held near the water surface in shallow water areas using partially submerged twigs, overhanging branches and shade as cover Fingerlings were distributed throughout the water column and were associated with submerged cover.

Large (100-200 mm) Cutthroat Trout

Larger juvenile cutthroat trout were most numerous in main channel pools. Run and pocketwater habitats were used more than shallow riffle areas (Table 5). The preference exhibited by cutthroat trout for pools has been reported by other researchers (Horner 1978, Shepard 1983). Shepard (1983) found significantly higher densities of cutthroat trout larger than 50 mm in pools than in run, pocketwater or riffle habitats. He also found that cutthroat trout densities were higher in runs than in pocketwaters or riffles.

Table 5. Densities (fish/100m²) of cutthroat trout age 0, age I, age II, age III, all cutthroat and age I and older cutthroat observed in pools, runs, riffles and pocketwaters of the upper Flathead River Basin.

	Habitat Units			
Age	Pools (394)	Runs (637)	Riffles (574)	Pocketwater (188)
0	1.4	1.3	0.6	0.5
I	1.7	1.4	0.4	0.7
II	4.7	2.2	0.4	2.1
III	11.3	3.5	1.2	2.3
All cutthroat	19.1	8.4	2.6	5.6
Age I and older	17.7	7.1	2.0	5.1

Table 6. Average depth and velocity of the focal point selected by juvenile westslope cutthroat trout of various sizes (>100, <100 mm) or ages living in tributary streams (N = number of tributaries surveyed).

(N)	Depth selection (m)	Velocity selection (m)	Fish size/age	Citation
37	0.31	0.10	<100 mm	This Study
27	0.29	0.10	Fry	Griffith 1970
26	0.46	0.11	I+	Griffith 1970
56	0.43	0.10	I+	Hansen 1977
55	0.62	0.22	100-200 mm	This Study
37	0.49	0.14	II+	Hansen 1977
7	0.50	0.21	III+	Hansen 1977
44	0.50	0.11	II+	Griffith 1970
16	0.46	0.12	III+	Griffith 1970

Cutthroat trout moved into faster and deeper water as they grew. Everest (1969) and Hansen (1977) reported the same type of response. Individuals maintained a constant position in water 0.4-1.2 m deep where water velocities were 0.09 to 0.24 mps. Westslope cutthroat trout in North Idaho streams used similar types of areas (Table 6).

Debris (both over the water's surface and partially submerged) was used extensively as cover by cutthroat trout 100 mm and longer. Larger debris (logs, rootwads or branches at least 10 cm in diameter) were preferred by larger cutthroat trout. Often this large debris created pools by catching streambed material above it and forming a plunge pool. Complex cover in the form of debris jams, rootwads, substrate and undercut banks has also been reported to be important for cutthroat trout in other areas and may be a particularly important component of winter habitat (Griffith 1979, Hansen 1977, Bustard and Narver 1975).

Cutthroat trout developed social hierarchies in pools. Social hierarchies were maintained beneath overhead cover in deep water areas where cutthroat trout were "stacked" vertically in the water column. Territorial behavior was usually exhibited in the presence of visually isolating cover types.

Food Habits

Cutthroat trout were opportunistic feeders. The most common insects in the benthos were usually the most common items in the diet. Dipterans (true flies) and Ephemeroptera (mayflies) were the most common items in the diet of fish 110 mm and smaller. Trichoptera (caddisflies) and Plecoptera (stoneflies) were also consumed. Winged insects were rare in the stomachs of small cutthroat trout.

Cutthroat trout used a wider diversity of food items as they increased in size. Individuals larger than 110 mm frequently used caddisflies in addition to trueflies and mayflies. Mayflies most commonly ingested were Ephemerellidae, Baetidae and Heptageniidae. The free living caddisflies Rhyacophilidae and retreat building Hydropsychidae were common in the diet. Limnephilidae, a small case building caddis was also present in cutthroat trout stomachs. Stoneflies, beetles (Coleoptera), ants (Hymenoptera) and spiders (Arachnida) were also eaten. Winged insects became an important component in the diet as cutthroat trout increased in size.

EMIGRATION OF JUVENILES

Juvenile westslope cutthroat and bull trout initiated a migratory life history pattern by leaving tributaries and moving downstream into the North and Middle Forks of the Flathead River. The majority of juvenile westslope cutthroat trout leaving tributary streams continued moving downstream to the lower Flathead River and Flathead Lake. Some cutthroat trout remained in the rivers year round. It appeared the upper Middle Fork of the Flathead River (above Bear Creek) supported a larger riverine population of westslope cutthroat trout than either the lower Middle Fork or the North Fork. The following summarizes age composition of emigrating juveniles and timing and duration of their migration.

Age Composition

Most juveniles emigrated from tributary streams primarily at age II and III (Table 7). The age composition of juveniles passing through downstream traps located near the mouths of tributaries corresponded closely to migration classes assigned using scales from cutthroat trout captured in the lower Flathead River and Flathead Lake (Table 7). Migration classes determined from scale analyses for cutthroat trout captured in the North and Middle Forks of the Flathead River showed a higher percentage of migration class I fish (21 and 22 percent, respectively) than those observed leaving tributaries (4 percent). The age composition of Challenge Creek emigrants corresponded closely to migration classes assigned using scale analyses taken from fish captured in the Middle Fork of the Flathead River, suggesting that Challenge Creek supports a fluvial spawning population.

These data were compared to research on cutthroat trout in other lake-river systems (Table 8). Fish which migrated at ages II and III predominated the populations, although a larger percentage of fish migrating at age I were collected in the rivers (Table 8). Age I fish may contribute a higher percentage to riverine populations as a result of displacement from tributaries.

Timing

Juvenile cutthroat trout emigrated from Middle Fork Flathead River tributaries primarily during June and from North Fork tributaries during June and July (Table 9 and Appendix A). Juvenile cutthroat may have moved out of tributary streams in May and June but our traps were inefficient or inoperable during high water.

The timing of juvenile emigration from upper Flathead River tributaries was similar to that reported for other migratory populations of westslope cutthroat. Lukens (1978) reported that juvenile westslope cutthroat emigrated from Wolf Lodge Creek into Lake Coeur d'Alene, Idaho from early May through mid-July. Juvenile westslope cutthroat emigrated from Young Creek into Lake Koocanusa, Montana as early as March, with the majority leaving during June and July and another peak was observed in September and October (May 1972, May and Huston 1974, May and Huston 1975). The juvenile westslope cutthroat trout emigration from Hungry Horse Creek to Hungry Horse Reservoir, Montana extended from June to August, peaking between July 1 and July 20 (Huston 1969, 1972, 1974). Thurow and Bjornn (1978) reported juvenile cutthroat emigrated primarily during the spring from tributaries to the St. Joe River, Idaho.

Several researchers have reported cutthroat trout moving downstream during the fall (Bjornn and Mallet 1964, Chapman and Bjornn 1969, Thurow 1976, May and Huston 1974, 1975, May 1972). Many of these researchers believed cutthroat trout emigrated from tributaries during the fall in search

Table 7. Percent (number) of cutthroat trout in each migration class trapped leaving tributaries to the Flathead River and computed from scale samples collected from the North Fork, Middle Fork, lower Flathead River and Flathead Lake for the time period 1976 to 1981.

Location	Years of migration	Type of Data	Percent (number) of cutthroat by age class at migration			
			I	II	III	IV
Coal Creek	1977	Trap	1 (2)	36 (83)	38 (86)	25 (57)
Akokala Creek	1976-1977	Trap	T (1)	20 (47)	56 (132)	24 (56)
Red Meadow Cr.	1977, 1979	Trap	1 (3)	28 (62)	60 (135)	11 (24)
Whale Creek	1977, 1978	Trap	5 (4)	33 (28)	56 (48)	6 (5)
Trail Creek	1977, 1979	Trap	2 (4)	58 (129)	33 (74)	7 (15)
Mainstem North Fork	1977, 1979	Trap	5 (2)	50 (20)	37 (15)	8 (3)
Challenge Creek[1/]	1980	Trap	21 (33)	38 (60)	41 (65)	0 (0)
Geifer Creek	1981	Trap	0 (0)	50 (45)	49 (44)	1 (1)
Tributary Average			4 (49)	37 (474)	47 (599)	12 (161)
North Fork of Flathead River	1980	Scales	21 (27)	33 (44)	39 (50)	6 (8)
Middle Fork of Flathead River	1980	Scales	22 (41)	33 (58)	42 (78)	3 (6)
Lower Flathead River	1980	Scales	6 (14)	57 (142)	34 (86)	3 (8)
Flathead Lake	----	Scales	4 (15)	43 (148)	49 (170)	4 (15)

1/ A small tributary to Granite Creek, a large Middle Fork Flathead River tributary.

Table 8. Percent composition of migration classes in westslope cutthroat trout populations sampled from lakes, rivers and tributaries in Montana and Idaho.

Location	Age at migration 1	2	3	4	Source
Tributaries to Flathead River[1/]	4	37	47	12	This study
North Fork Flathead[2/] River	21	33	39	6	This study
Middle Fork Flat-[2/] head River	22	33	42	3	This study
Lower Flathead[2/] River	6	57	34	3	This study
Flathead Lake[2/]	4	42	49	5	This study
Priest Lake, Idaho[2/]	--	38	57	5	Bjornn 1957
Upper Priest Lake[2/] Idaho	6	35	58	--	Bjornn 1957
Hungry Horse Res-[2/] ervoir, Montana	6	74	19	1	Huston 1972
Lake Koocanusa,[2/] Montana	7	60	33	--	May et al. 1983
Lower St. Joe[2/] River, Idaho	26	67	7	--	Averette & MacPhee 1971
Upper St. Joe[2/] River, Idaho	--	17	68	5	Rankel 1971
St. Joe River,[2/] Idaho	--	40	59	1	Johnson 1977
Kelly Creek,[2/] Idaho	--	30	70	--	Johnson 1977

1/ Migration classes based on the age of emigrating juveniles passed through downstream traps.
2/ Migration classes based on interpreting growth patterns from scale analysis.

Table 9. Number of days trapping occurred, number of juvenile cutthroat passed downstream through traps, and number of trapped juvenile cutthroat per trap-day by month from North Fork tributaries during 1976 to 1980 and from Middle Fork tributaries during 1981.

	May	June	July	August	September	October
North Fork Tributaries (1976-1980)						
Trap Days	29	42	443	424	264	131
Number of Fish	67	271	2233	541	126	5
Fish/Trap Day	2.31	6.45	5.04	1.28	0.48	0.04
Middle Fork Tributaries (1981)						
Trap Days	--	33	78	62	14	--
Number of Fish	--	82	31	16	3	--
Fish/Trap Day	--	2.48	0.40	0.23	0.21	--

of suitable overwinter cover. Trail Creek, a North Fork Flathead River tributary, was the only tributary trapped during this study where relatively high numbers of juvenile cutthroat trout emigrated during the fall (Appendix A). Bjornn (1971) believed fall-winter outmigrations from Big Springs Creek, Idaho may have been related to winter carrying capacity of upstream areas. Bustard and Narver (1975) found that cutthroat trout preferred to overwinter in sidepools containing rubble substrates and bank cover. Some salmonids entered interstitial spaces within the streambed as water temperatures fell below 7°C (Everest 1969, Mauser 1972, Morrill 1972). Trail Creek's lower reach (which is isolated from upper Trail Creek by a segment of dry channel located approximately 13 km above its mouth) may not provide adequate overwinter habitat and fish numbers may exceed the capacity of winter habitat.

There was also evidence that juvenile cutthroat trout migrated upstream into Trail Creek from the North Fork Flathead River during the spring. Johnson and Bjornn (1978) described movement patterns of westslope cutthroat trout in the North Fork Clearwater River and St. Joe River drainages, Idaho to consist of movement into upper areas of the drainage and into tributaries during the spring and early summer, little movement over the course of the summer, and then downstream movement in the fall in tributaries and the mainstem rivers. This movement pattern was also reported for juvenile steelhead in the Clearwater River drainage, Idaho (Reingold 1964).

Once juvenile cutthroat moved into the North and Middle Forks of the Flathead River their movements were not as well documented. From 1979 to 1982, we tagged 2,781 juvenile cutthroat trout. Twenty-one of these tagged fish were recaptured, a return rate of only 0.8 percent. A summary of tag return data indicated that juvenile cutthroat trout generally moved in a downstream direction (Figure 1 and Appendix B).

The time juvenile cutthroat trout spent migrating downriver through the North and Middle Forks to the mainstem Flathead River and Flathead Lake was variable. It appeared that some juvenile fish entered the Middle and North Forks from tributaries during the spring and early summer and moved rapidly down river to the junction of the North and Middle Forks. They then spent one to two months moving downriver to the Flathead Lake-River estuary. Other juveniles moved downriver slowly, spending from one to two months in the mainstem North and Middle Forks.

FLATHEAD RIVER - FLATHEAD LAKE RESIDENCE

When addressing juvenile to subadult and subadult to adult life stages of westslope cutthroat and bull trout in the upper Flathead River basin, we combined Flathead River and Flathead Lake residence because fish apparently used these two areas seasonally during their growth from juveniles to adults. The character of the 36 km portion of the Flathead River immediately above Flathead Lake changes during the year due to the fluctuating pool level (vertical fluctuations of approximately 3 m) caused by the impoundment of Flathead Lake by Kerr Dam. This 36 km portion of the river is functionally similar to an estuary and we refer to it as such. The Flathead River below the confluence of the South Fork (74 km above Flathead Lake) is considered partially regulated due to the contribution of the regulated South Fork.

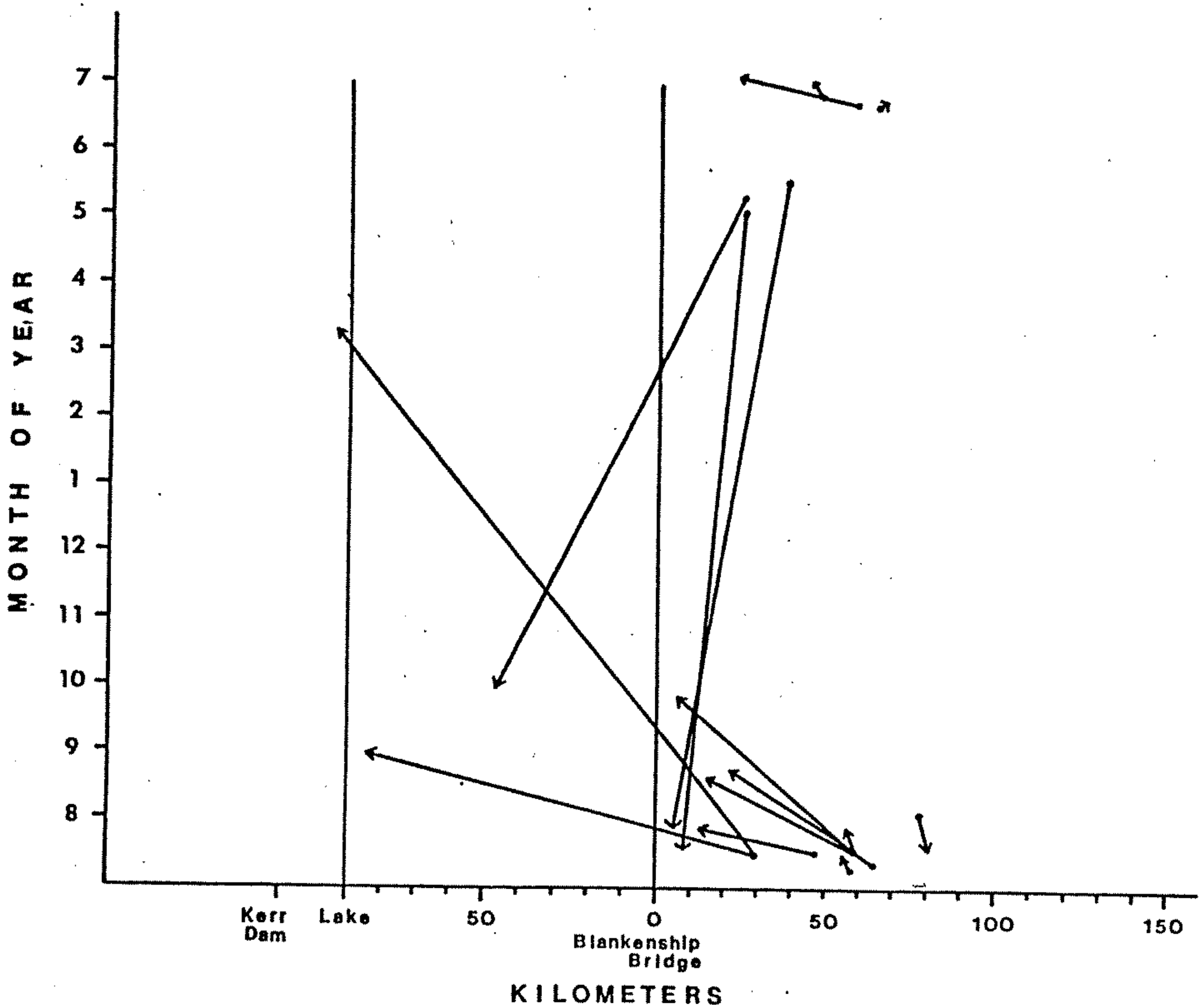

Figure 1. Movement of juvenile cutthroat (less than 225 mm) in the upper Flathead River Basin, returns within one year 1962-1981.

Daily water levels in the South Fork and Flathead River below the South Fork are controlled by Hungry Horse Dam and can fluctuate vertically as much as 2.5 meters. These releases help keep the lower Flathead River from freezing over. Juvenile, subadult and adult cutthroat trout used both the lower Flathead river and Flathead Lake because they provided a more stable environment and available food resources which allowed fish to grow at faster rates than in tributaries.

Seasonal Movement

The majority of the downstream migrating juvenile cutthroat trout probably arrived at the confluence of the North and Middle Forks from late August through September. Some juvenile cutthroat trout were present in the lower Flathead River (near Kalispell) throughout the year. Our data indicated that some juvenile cutthroat trout remained in the river during the first winter they arrived, and possibly longer, before entering Flathead Lake. Juvenile, subadult and adult cutthroat trout appeared to inhabit the lower portion of the Flathead River during the winter months, probably in response to availability of macroinvertebrates. Catch per effort information provided from electrofishing showed that juvenile cutthroat trout abundance in the lower river increased during the fall and winter in both 1979 and 1980, before declining again in the early spring. We also have tag return data indicating some adult cutthroat trout moved up into the lower river from Flathead Lake during January through April, prior to the spawning season.

Food Habits

Westslope cutthroat trout in Flathead Lake depended on terrestrial insects during the spring, summer and fall months. Sixty-four percent of the cutthroat trout stomachs sampled during the winter were empty (six times the number of empty stomachs found during the other three seasons). A small sample of cutthroat trout (eight fish) captured in the lower Flathead River during January, 1981 were found to have full stomachs containing primarily riverine aquatic insects.

Results from other studies of cutthroat trout food habits in lakes revealed that cutthroat trout consumed many different types of prey. Food habits of cutthroat trout generally related to prey type, abundance and availability as well as the species composition of the fish community. Westslope cutthroat trout fed mostly on *Daphnia*, terrestrial insects and aquatic Diptera in Lake Koocanusa, Montana, with *Daphnia* eaten exclusively throughout the winter (McMullin 1979). McMullin (1979) also reported that westslope cutthroat trout ingested very few *Daphnia* in Hungry Horse Reservoir, Montana, but depended primarily on terrestrial insects and aquatic Diptera. In lakes of northern Idaho, cutthroat trout fed almost entirely on terrestrial and aquatic insects (Bjornn 1957, Jeppson and Platts 1959). Zooplankton was found to be an important food item for cutthroat trout in many western lakes (Benson 1961, Antipa 1974, and numerous studies summarized by Carlander 1969).

Lake Distribution

Cutthroat trout were found to be distributed throughout Flathead Lake. Concentrations of cutthroat trout were occasionally encountered during the spring months in the northeast portion of the lake, where the Flathead and Swan rivers enter the lake. The spring concentrations were believed to be related to increased food availability in the form of dense Dipteran hatches. Small concentrations of cutthroat trout were occasionally observed near kokanee spawning areas. Cutthroat trout may have been feeding on kokanee eggs at that time. Cutthroat trout were captured most frequently in floating gill nets set during the spring, fall and winter. The lower numbers of cutthroat trout captured in summer floating gill net sets was probably related to avoidance of high surface water temperatures (>20°C). McMullin (1979) observed that westslope cutthroat trout preferred temperatures less than 18°C, while Bell (1973) reported the preferred temperature range of cutthroat trout to be 9.5 to 12.9°C. Floating gill net catches of cutthroat trout were associated with the presence or absence of emerging Dipterans in the spring. In areas where Diptera were hatching, large numbers of cutthroat were captured in floating gill net sets, indicating the ability of cutthroat trout to key on this available food source.

ADULT SPAWNING MIGRATION

Adult cutthroat trout abundance was found to increase in the lower mainstem as early as October. Adult cutthroat trout abundance was noticeably higher in the Kalispell area of the mainstem by December in both 1979 and 1980. Adults appeared to hold in the area of the Flathead River near the mouth of the Stillwater River prior to migrating upstream to spawn. During the early spring (March and April) adults moved slowly upriver traveling the 7 km between the mouth of the Stillwater River to the Steel Bridge in 40-49 days. No similar adult cutthroat trout holding areas were found in the Flathead River above Kalispell.

Early movement into the lower river and the long holding period exhibited by adult cutthroat trout may be related to food availability discussed previously. Adult fish may build up energy reserves by moving into the food rich river during the winter to feed in preparation for the subsequent spawning migration. Although we have no evidence to indicate that there was any difference between sizes or ages of early versus late migrating spawners, adult cutthroat trout which moved into the lower river early tended to migrate further upstream than later arrivals.

Of all adult cutthroat trout (fish larger than 350 mm) tagged in the mainstem Flathead River from 1961 through 1981, 173 were recaptured. Ninety-six of the recaptured fish were recaptured in the mainstem. Of the 77 adult cutthroat trout which left the mainstem, 41 (53%) were recaptured in the North Fork drainage, four (5%) were recaptured in the Middle Fork drainage, three (4%) were recaptured in the Stillwater River drainage, 27 (35%) were recaptured in Flathead Lake, and one each were recaptured in the Whitefish river and Swan River drainages (Figure 2, and Appendix B). The distribution of recaptures may not accurately reflect the true distribution of movement because of differential probabilities of recapture due to both variable angling effort and tag return compliance between drainages. Adult-sized fish

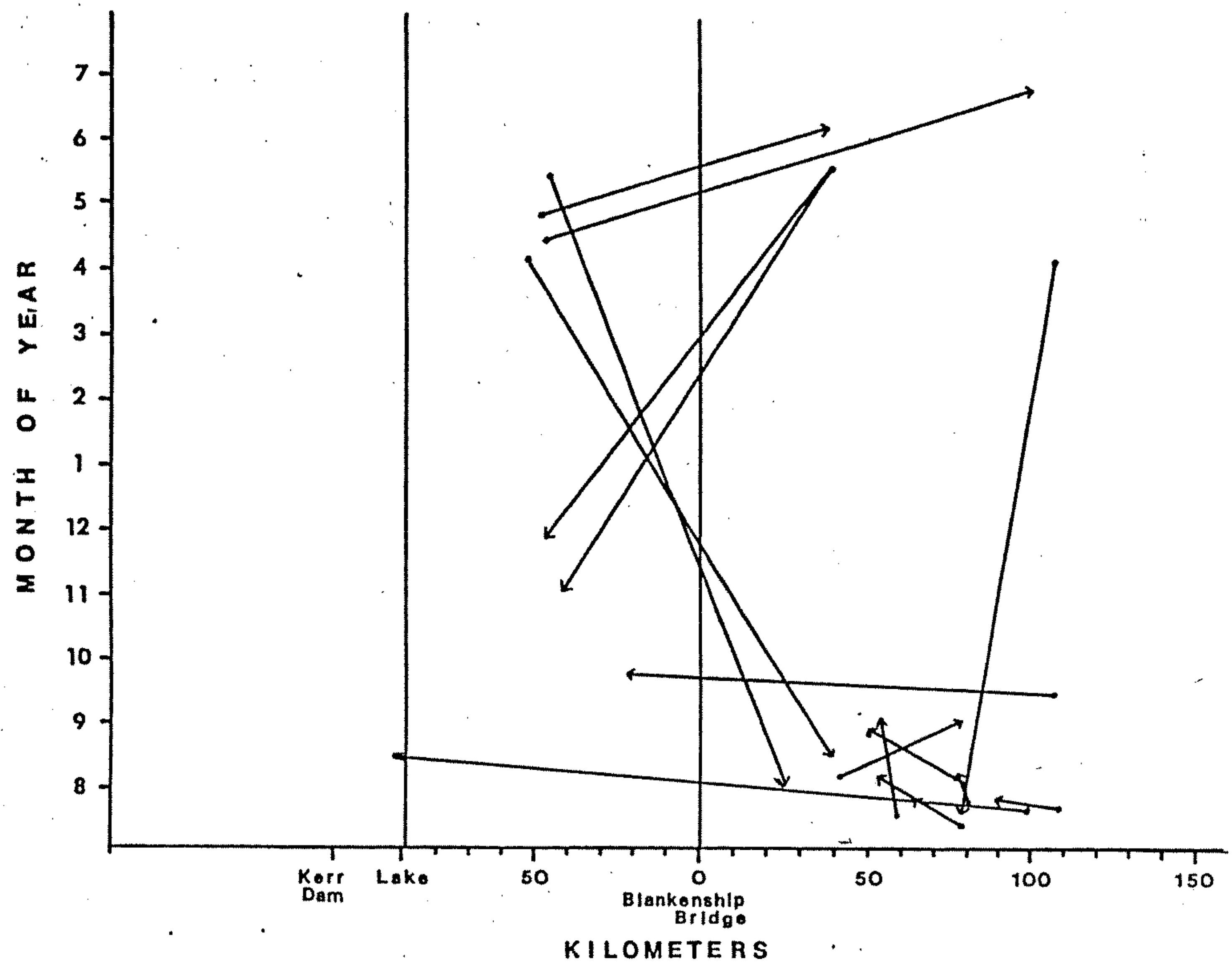

Figure 2. Movement of cutthroat greater than 225 mm in the upper Flathead River Basin, returns within one year 1962-1981.

tagged in the upper portion of the basin were generally recaptured down river from their tagged location (Figure 2). It can be inferred that adult cutthroat trout moved upstream from Flathead Lake and the mainstem Flathead River to waters throughout the upper basin for spawning. The North Fork drainage obviously provided important cutthroat trout spawning habitat (Appendix B, Table B-5).

Adult cutthroat trout moved slowly into the lower mainstem during the fall and winter, began moving rapidly upriver sometime in the spring, and after spawning was completed, moved rapidly back downstream to the mainstem of the Flathead River by mid-summer.Adult cutthroat trout tagged in the mainstem and recaptured in the North Fork drainage were caught in May, June and July, with the latest recapture occurring on 19 July. We believe the majority of fish recaptured were spent adults returning to the mainstem and Flathead Lake because most of these fish were recaptured after 15 June when river flows and turbidities were more conducive for angling. The fastest and furthest upstream movement recorded for an adult westslope cutthroat was 212 km in 87 days, an average of 2.44 km per day. This fish moved upstream to McLatchie Creek in the Canadian portion of the North Fork.

SPAWNING

Timing and Distribution

Migratory adult cutthroat trout (those that grow to maturity in waters other than their natal tributaries) moved into tributaries to the upper Flathead River during the spring when streamflows were high. Spawning occurred during May and June (Table 10). Adults left the tributaries soon after spawning, usually by the beginning of July. Previous fishery investigators studying the North Fork drainage of the Flathead River reached similar conclusions (Block 1955, Johnson 1963). Huston et al. (1984) believed water temperature and streamflow were important cues triggering westslope cutthroat trout spawning movement and redd construction in tributaries to Lake Koocanusa, Montana.

Resident westslope cutthroat trout were also found to spawn in May and June. Most resident adults probably spawned within a short distance of their summer residence and in most cases probably within their "home" pool (Miller 1957).

The distribution of westslope cutthroat trout spawning within the upper Flathead Basin is not well known; however, spawning activity has been documented in several small and intermediate sized tributaries within the upper basin. Johnson (1963) also reported higher numbers of juveniles in small versus large Flathead Basin tributaries and speculated that adult cutthroat selected these small tributaries for spawning to reduce the mortality associated with a shifting streambed which can occur in large tributaries. Scott and Crossman (1973) stated that cutthroat spawned only in "small, gravelly streams". Lukens (1978) believed that a large number of spawning adult westslope cutthroat moved upstream from Lake Coeur d'Alene into small first order (in some cases intermittent) streams to spawn.

Table 10. Characteristics of westslope cutthroat spawning including time of year, size of spawner, sex ratio and fecundity of migratory or resident stocks observed in river drainages of Montana and Idaho.

Drainage	Timing of spawning activity	Life-history pattern	Length of spawners (mm) Average	(range)	Sex ratio (M:F)	Fecundity	Source
Flathead River, Montana	May-June	Migratory	---	(349-450)	1:2.2	---	This study
Flathead River, Montana	May-June	Migratory	---	(356-432)	---	---	Block 1955
Flathead River, Montana	May-June	Resident (Langford Cr)	---	(160-256)	---	183[1/]	Johnson, 1963
		Migratory	371	(305-490)	1.0:2.0	1,482	
		Migratory (Mud Lake)	293	---	1.0:0.6		
Young Creek, Lake Koocanusa, Montana	May-June	Migratory	351	(292-437)	1.0:1.6	---	May & Huston, 1983
Hungry Horse[3/] Reservoir, Flathead drainage, Montana	Late May-late June	Migratory	371	(226-472)	1.0:3.8	1,000	Huston 1972
Wolf Lodge Creek, Lake Coeur d'Alene Idaho	May-June	Migratory	335	(254-365)	1.0:2.7	---	Lukens 1978
St. Joe River, Idaho	May-June	Migratory	303[2/]	(228-366)	---	---	Averette & MacPhee 1971

Table 10. (Continued).

Drainage	Timing of spawning activity	Life-history pattern	Length of spawners (mm) Average	(range)	Sex ratio	Fecundity	Source
Priest Lake Idaho	April-June	Migratory	---	---	1.0:5.6	---	Bjornn 1957
Bond Creek, St. Joe River, Idaho	Before May 25	Migratory	347	(256-430)	1.0:1.6	---	Thurow & Bjornn 1978

1/ From one 160 mm female.
2/ Fork length.
3/ 1963 to 1968 and 1970 and 1971 spawning runs.

Characteristics of Adults

The minimum size at maturity of westslope cutthroat trout captured in Flathead Lake during this study was 349 mm. We assumed that adult cutthroat trout which follow an adfluvial life-history pattern were generally larger than 350 mm. Block (1955) and Johnson (1963) reported similar minimum sizes for migratory adult cutthroat trout in the Flathead Basin (Table 10). Huston (1973, 1972, 1969) and Huston et al. (1984) reported similar sizes for migratory adults in Hungry Horse Reservoir, and Lake Koocanusa (Table 10). Migratory adults in the Lake Coeur d'Alene, Idaho system were slightly smaller (Lukens 1978).

The sex ratio of mature cutthroat in Flathead Lake averaged 1:2.2 (males:females) which was similar to average sex ratios reported in other areas of Montana and Idaho (Table 10). No fecundity estimates were conducted for cutthroat trout during this study; however, we assumed fecundities were similar to those reported by Johnson (1963) and Huston (1972). Approximately 1,000 eggs per westslope cutthroat female were collected at the Murray Springs Hatchery from 1980 to 1982 (files, Murray Springs Hatchery, Eureka, Montana). These fish were Hungry Horse Reservoir (which impounded the South Fork Flathead River) stock.

During this study, no conclusive data were collected to identify homing ability, repeat spawnings or spawning mortality associated with adfluvial spawning adults. Huston et al. (1984) found that approximately 70 percent of the 1977 spawning run into Young Creek from Lake Koocanusa homed accurately. Huston (1972, 1973) identified 24 percent of the 1970 spawning run into Hungry Horse Creek from Hungry Horse Reservoir as being repeat spawners and believed alternate year spawning was occurring. Huston et al. (1984) documented 0.7 to 2.9 percent of the 1974 to 1977 westslope cutthroat trout spawning runs into Young Creek were repeat spawners. An estimated ten to twenty percent of the spawning adults ascending Young Creek were believed to be repeat spawners (personal communication, Bruce May, MDFWP, Kalispell, Montana). Data on gonad condition of mature sized (>350 mm) westslope cutthroat trout captured in gill nets set in Flathead Lake suggested alternate-year spawning was prevalent. The potential for spawning mortality is high. Huston et al. (1984) found that post-spawning mortality ranged from 27 to 60 percent between 1970 and 1977 in Young Creek, a Lake Koocanusa tributary.

Physical Characteristics of Spawning Sites

Cutthroat trout spawned over streambed areas composed predominantly of gravels ranging in size from 2 to 50 mm (Table 11). Size of redds averaged 0.9 to 1.0 m long by 0.4 to 0.45 m wide for migratory cutthroat and 0.6 m long by 0.32 m wide for resident cutthroat. Average water depths over redds ranged from 17 to 20 cm and average water velocities ranged from 0.30 to 0.37 mps. Adult cutthroat trout which moved from Lake Koocanusa into Young Creek generally spawned at the lower end of pools in water averaging 25.6 cm deep, over a streambed consisting primarily of gravel (25 to 76 mm in size) (files, Montana Department of Fish, Wildlife and Parks, Kalispell, Montana). Scott and Crossman (1973) reported that cutthroat trout redds were approximately 0.30 m in diameter and eggs were covered by 150-200 mm of gravel.

Table 11. Characteristics of resident and migratory westslope cutthroat trout redds including redd size (disturbed area), water depth, velocity and streambed composition.

Drainage	Life-history pattern	Mean water depth over redd (m)	Mean velocity over redd (m/sec.)	Mean disturbed area (m^2)	Stream composition: Cobble/ boulder (>50mm)	Stream composition: Large Gravel (16-50)	Stream composition: Small Gravel (2-16)	Stream composition: Sand (<2)
Challenge Cr., Flathead River	Resident	0.17	0.30	0.19	3	37	40	20
Montana	Migratory	0.17	0.34	0.45	5	38	43	14
Young Creek,1/ Lake Koocanusa, Montana	Migratory	0.27	0.25	---	---	---	---	---

1/ From data on file, Montana Department Fish, Wildlife and Parks, Libby Field Station, Libby, Montana.

GROWTH

Scale samples were used as the primary method to estimate growth. Cutthroat trout emerged as fry at a length of approximately 20 mm and grew 20 to 40 mm during their first year. Scales first formed on cutthroat trout at lengths of 38 to 44 mm. Scales were not found to cover the entire body surface until fish were 63-68 mm (Brown and Bailey 1952). Cutthroat trout that had not formed scales or had only one or two growth rings (circuli) by the beginning of their first winter did not form annuli (yearly growth marks).

An estimated 61 percent of the cutthroat trout sampled for age-growth analysis from the upper Flathead basin had not formed a first year annulus, similar to results from the North fork Clearwater and Upper St. Joe rivers, Idaho (Table 12). A smaller percentage (30-40%) of scales examined from cutthroat trout collected in the mainstem Flathead River and Flathead Lake were missing a first year annulus, comparable to percentages of missing annuli observed in the lower St. Joe and Salmon River basins. The difference between the percentages of cutthroat trout missing a first annulus in Flathead River and Lake versus the upper portion of the basin may be caused by one or more of the following reasons: 1) the presence of slower growing resident cutthroat trout contributing to the sample from the upper basin; 2) colder water temperatures in upper basin tributaries slowing growth; and 3) the contribution of cutthroat trout reared in the Whitefish and Stillwater river systems to the sampled population from the main river and lake.

Growth of cutthroat trout in upper Flathead tributaries was generally similar between tributaries and differences were likely caused by differences in thermal regimes (Appendix C). Juvenile cutthroat trout grew to average lengths of 45-63 mm, 90-110 mm, 130-150 mm by the end of their first, second and third years of stream residence, respectively (Table 13 and Appendix C). Growth appearred to be slower in the present study for North Fork tributaries than growth described by Johnson in the early 1960's, especially between ages II and III (Table 13). This difference may have been due to consistent bias in scale reading, the difference between scale length-body length relationships used during the two studies, or a change in growth rates.

After emigrating from natal rearing tributaries cutthroat trout grew an average of 89 to 119 mm compared to an average of 40 to 60 mm for similar years in tributaries (Table 14). After the initial burst of growth the first year after emigration from tributaries, yearly growth slowed slightly to average between 44 to 90 mm. Growth appeared to slow as fish reached sexual maturity (age V and older).

Table 12. Characteristics of scales and length at scale formation for westslope cutthroat trout in river drainages of Montana and Idaho during their first year.

Fish length (mm)		First annulus				
		Number circuli				
At scale formation	At first annulus	Without	With	% Missing	Drainage	Source
38-43	54	≤7	>7	61-69	Flathead (North and Middle Forks)	This Study
---	64	≤7	>7	29-43	Flathead (main river and lake)	This Study
42-46	69	3-9	---	---	St. Joe	Averett & MacPhee 1971
---	52	---	---	40.3	St. Joe	Rankel 1971
---	72	6-12	---	0.0	St. Joe	Averett 1963
---	66	---	---	64	N.F. Clearwater and St. Joe	Johnson & Bjornn 1978
---	60	3-12	12-17	30.5	Salmon	Mallett 1963
35[a]	85	---	---	---	Priest	Bjornn 1957
---	73	<7	---	0.0	Coeur d'Alene	Lukens 1979

a/ Based on an estimate.

Table 13. Back-calculated lengths at annulus formation of westslope cutthroat trout in the upper Flathead basin and other rivers and tributary streams in Montana and Idaho (adapted from Lukens 1978).

Drainage	(N)[a/]	Age 1	2	3	4	5	6	7
Rivers								
Mainstem Flathead River (1981)	250	55	103	157	242	305	336	381
Main rivers of Flathead drainage (1963)	559	56	119	196	287	333	378	---
North Fork Flathead River (1977-80)	197	54	97	138	166	214	---	---
Middle Fork Flathead River (1979-80)	183	60	110	164	223	275	---	---
South Fork Flathead River (1981)	113	59	108	155	206	273	323	---
Salmon River (1963)	474	60	100	174	254	322	371	---
St. Joe River (1971)	347	66	101	153	212	251	306	---
Tributaries								
North Fork Flathead tributaries (1963)	106	58	114	178	216	244	302	---
North Fork Flathead tributaries (1977-81)	1,820	54	100	145	189	247	---	---
Middle Fork Flathead tributaries (1980-81)	880	54	100	149	205	254	293	---
Hungry Horse Cr. (1969-72, 74)	1,239	73	121	162	---	---	---	---
Young Creek (1974)	92	49	109	160	---	---	---	---
St. Joe tributaries (1963)	161	72	142	216	---	---	---	---

Table 13. (Continued).

Drainage	(N)	1	2	3	4	5	6	7
Wolf Lodge Cr. (1978)	324	73	111	136	185	---	---	---
Kelly Creek (1977)	208	66	101	153	212	251	306	---
Priest and Upper Priest Lake tributaries (1957)	232	85	129	171	201	254	---	---
Lakes								
Flathead Lake (1962-81)	573	64	120	189	261	311	350	382

a/ N equals sample size for age 1. Age 2 through 7 sample sizes were likely lower.

Table 14. Mean calculated total length growth increments (millimeters) for westslope cutthroat trout that entered Flathead River and Flathead Lake after spending one to four years in tributary streams. Fish were collected during the years 1962 through 1982.

		Length increments (mm) between annuli						
tributary	(n)	I	II	III	VI	V	VI	VII
Flathead River								
1	(14)	56	89	90	--	--	--	--
2	(142)	57	53	119	58	35	28	--
3	(86)	50	41	53	99	56	33	49
4	(8)	56	40	46	54	100	45	41
Flathead Lake								
1	(15)	56	98	76	55	61	39	--
2	(148)	65	56	99	63	46	33	--
3	(170)	61	49	50	95	55	39	39
4	(15)	64	53	47	49	91	44	--

BULL TROUT

STOCK ASSESSMENT

Most bull trout in the Flathead Basin are adfluvial. Possible exceptions were found in Hay Creek and several streams draining large lakes in Glacier Park. Hay Creek flows through a boggy meadow near its mouth and may be difficult for adfluvial adult bull trout to ascend during most years. Kintla, Logging, Harrison, Cyclone, and McDonald creeks may provide spawning and rearing habitat for bull trout which mature in lakes within each of those drainages.

EMBRYONIC DEVELOPMENT

Terminology used in this portion of the report is defined in the WESTSLOPE CUTTHROAT TROUT section.

Egg Deposition through Hatching

Bull trout required approximately 350 temperature units (°C) after fertilization to hatch (Weaver and White 1984). This was similar to the incubation period for Dolly Varden (380 temperature units) documented by Armstrong and Blackett (1980). Hatching is completed after 100-145 days, usually at the end of January (Weaver and White 1984, Allan 1980, Blackett 1968, Heimer 1965) (Table 15). Laboratory investigations reported incubation periods of 126 days at 2°C and 95 days at 4°C (McPhail and Murray 1979).

Table 15. Temperature units, days required, and approximate dates for eye up, hatch, and emergence of bull trout embryos and alevins in field and laboratory conditions (adopted from Weaver and White 1984).

Stage of development	Temperature units (°C) from fertilization	Number of days from fertilization	Approximate date
Field			
Eye up	200	35	October 17
Hatch	350	113	January 3
Emergence	634	223	April 22
Laboratory			
Eye up	366	42	November 1
Hatch	504	62	November 21
Emergence	825	103	January 1

Approximately 40-50 percent of deposited bull trout eggs survived through hatching in excavated redds (Blackett 1968, Allan 1980). McPhail and Murray (1979) reported egg to fry survival varied in different water temperatures. They found 0-20, 60-90 and 80-95 percent of the eggs survived to hatching in water temperatures of 8-10, 6, and 2-4°C, respectively.

Sediment affects bull trout egg survival as it does other salmonids. The preliminary work of Weaver and White (1984) demonstrated that approximately 15 percent of the fertilized bull trout eggs survived to hatch in laboratory channels with a spawning substrate containing 30 percent material less than or equal to 6.35 mm in diameter (Table 16).

Table 16. Number and percentage survival of bull trout embryos in various substrate mixtures in laboratory channels (unpublished data, Montana State Cooperative Fisheries Research Unit, Bozeman, Montana).

Gravel mixture ≤6.35 mm : >2.0 mm	Percentage of surviving embryos[a]
50 : 29	0
40 : 23	1
30 : 18	21
20 : 12	38
10 : 6	48
0 : 0[a]	38[b]

[a] Based on number of eyed eggs placed in channel estimated from percent of eyed eggs alive in Heath trays.

[b] One control channel had 17.5 percent of planted embryos, which could not be accounted for.

Hatching to Fry Emergence

The period of hatching to fry emergence may be divided into two periods for bull trout: 1) alevin growth and 2) fry growth prior to emergence from the gravels. Anadromous Dolly Varden and bull trout alevins required at least 65-90 days to absorb their yolk sacs. Unlike cutthroat trout, bull trout remained within the interstices of the streambed as fry for up to three weeks before filling their air bladders (McPhail and Murray 1979). Parr marks developed and feeding began while fry were still in the gravel. Bull trout reached lengths of 25-28 mm before emerging from the streambed and filling their air bladders.

STREAM RESIDENCE

Habitat used by juvenile fish was analyzed for fish smaller than 100 mm and fish larger or equal to 100 mm. Food habits were analyzed for fish smaller than 110 and larger or equal to 110 mm. Comparative data was often available only by age of fish rather than size of fish and is reported as such. An age 0 fish was in its first summer of life, and age I fish had completed one full year and was in its second summer of life.

Distribution in Streams

Bull trout were present in 63 (71%) of the 89 surveyed tributaries, but their distribution within these streams was often limited. Bull trout were present in only 50 percent of the stream reaches where fish were observed. Most streams containing bull trout also supported cutthroat trout. Two exceptional areas supporting only bull trout were Paola Creek and a section of Kintla Creek above a barrier falls.

Accessibility of stream reaches to spawning adults influenced, but was not the only factor limiting the distribution of bull trout. Juvenile bull trout were found in areas inaccessible to spawning adults in Yakinikak, Challenge, Dodge, Skyland, Basin and Bowl creeks. Apparently juveniles moved upstream for rearing in these streams.

Water temperature also appeared to influence juvenile bull trout distribution in the Flathead River Basin. Streams such as Akokala and Camas creeks supported populations of cutthroat trout but were not used by bull trout even though they were accessible and contained apparently suitable habitat. Maximum monthly water temperatures in July and August approached 19°C in Akokala Creek and 25°C in Camas Creek compared to 15 to 18°C in other streams where bull trout were present. Reaches containing high densities of juvenile bull trout were frequently influenced by cold perennial springs. Higher bull trout densities were observed in areas where water temperatures were 12°C or less. Bull trout distribution in other drainages were also believed to be influenced by cold perennial springs (Oliver 1979, Allan 1980).

Bull trout densities were usually lower than cutthroat trout densities in Flathead tributaries. This was attributed in part to underwater census techniques often being less efficient for bull trout (Shepard and Graham 1983). However, higher densities of bull trout were observed in Flathead tributaries than other drainages where underwater censusing was used (Table 17), but were lower when compared to electrofishing estimates (Table 18).

Bull trout were observed more frequently in third and fourth order tributaries to the upper Flathead River, although densities of juvenile bull trout were highest in second and fifth order streams (Table 3). Platts (1979) reported bull trout abundance increased as stream order decreased in tributaries to the South Fork Salmon River, Idaho and bull trout were not seen in any fifth order streams.

Juvenile bull trout used all sizes of pools, riffles, runs, and pocketwaters in streams in the upper Flathead drainage. Bull trout numbers increased, but densities did not, as the size of habitat units increased. Most age classes were found in similar densities in pools, runs, riffles and pocketwater (Table 19). Juvenile bull trout in Flathead tributaries appeared to be more ubiquitous in their use of habitat features than juvenile bull trout and Dolly Varden in other drainages (Table 20).

Table 17. Mean density of bull trout observed by snorkeling in tributaries to the Flathead and Idaho river drainages. Includes only those tributaries where bull trout were observed (N = number of tributaries).

N	Mean density Age I+ fish/100m²	Range of densities fish/100m²	Drainage	Source
63	1.3	0.1-7.1	Flathead	This study
3	0.22	0.05-0.65	Salmon	Sekulich 1978
2	0.003	<0.01	Saint Joe	Thurow and Bjornn 1977
5	0.49	0.10-2.17	Lochsa	Graham and Bjornn 1976
3	0.34	0.19-0.63	Selway	Graham and Bjornn 1976
1	0.89	----	Bear Valley Cr.	Petrosky, unpub. data
2	0.03	0.16-0.01	Salmon	Konopackey, unpub. data

Table 18. Mean densities of bull trout estimated from electrofishing in the Flathead and the Toboggan, MacKenzie and Wigwam drainages of British Columbia.

N	Mean estimated density fish/100 m²	Range of estimated density fish/100m²	Drainage	Source
7	5.4	0.1-15.5	Flathead	This study
3	11	1-31	Toboggan	Tredger 1979
3	14	1-39	MacKenzie & Hill	Ptolemy 1979

Table 19. Mean densities of age 0, age I, age II, age III, all bull trout and age I and older bull trout in pools, runs, riffles and pocketwater of the upper Flathead River basin (1979-1981).

Age	Habitat unit: Pools (394)	Runs (637)	Riffles (574)	Pocketwater (188)
0	0.3	0.3	0.1	0.1
1	0.6	0.5	0.5	0.1
2	1.6	0.4	0.3	0.4
3	0.4	0.2	0.1	0.2
All bull trout	5.2	2.2	1.8	1.2
Age 1 and older	4.6	1.7	1.3	1.1

Table 20. Flow pattern or habitat units used by juvenile bull trout and Dolly Varden in streams of Montana, British Columbia and Alaska.

Flow pattern	Drainage	Citation
All habitat units	Flathead, MT	This study
Rolling or broken flow	Wigwam, B.C.	Oliver 1979
Pools	MacKenzie, B.C.	McPhail & Murray 1979
Runs	Toboggan, B.C.	Tredger 1979
Shallow riffle (age I)	Price of Wales Island Alaska	Cardinal 1980
Pools (age II, III)	Prince of Wales Island Alaska	Cardinal 1980
Side pools, eddies	Hood Bay Cr., Alaska	Blackett 1968
Riffles, pools	Hood Bay Cr., Alaska	Armstrong and Elliott 1972
Riffles	Sukunka, B.C.	Stuart and Chrislott 1979
Riffle-glide	MacKenzie, Hill Creeks B.C.	Ptolemy 1979

Habitat Used

Small (<100 mm) Bull Trout

Small juvenile bull trout (<100 mm) were most often observed closely associated with instream cover in the form of streambed material (cobble and boulders) and submerged fine debris. These cover types provided small pockets of slow water (average velocity of 0.09 mps) allowing fish to hold positions with little energy expenditure (often immediately above the streambed) near high velocity, food bearing water. Juvenile bull trout and Dolly Varden were reported to use similar cover types and water velocities by researchers working in other drainages (Tables 21 and 22). Small juvenile bull trout were able to use any site above the wetted stream bottom where suitable cover was available. Their use of streambed material for cover permitted them to use a much wider range of sites than cutthroat trout utilized.

Small bull trout were located immediately above, on, or within the streambed (mean distance above the streambed = 0.03 m). Turning over streambed material was often the only way to locate small bull trout. Oliver (1979) and Griffith (1979) also reported finding bull trout within the streambed.

When bull trout densities were compared to streambed composition for all reaches surveyed in the Flathead drainage, the highest densities were observed in streams with a streambed predominated by gravel and cobble. However, at the microhabitat level, small bull trout were generally observed over small sized substrate (silt and sand) which had accumulated behind water velocity obstructions used as cover. A comparison of streambed compositions used by juvenile bull trout in the Flathead with that used by juvenile bull trout in other drainages was difficult due to the different methods used to describe substrate composition; however, since substrate appeared to be an important habitat component, we presented a comparison using broad size classes (Table 23).

Large (100-200 mm) Bull Trout

Juvenile bull trout 100 mm and longer were associated with the stream bottom, using dispersed instream cover and small pockets of slow water. As bull trout grew they used faster water (0-0.12 mps) and were located higher in the water column (0.08 m above the streambed) in deeper water (0.45 m mean depth). Little comparative data was available for bull trout 100 mm and larger (Table 22). Griffith (1979) observed age II bull trout in water slower than 0.5 mps and less than 0.5 m deep in Silverhope Creek, British Columbia.

Larger juvenile bull trout were associated with large submerged debris, which may be dispersed or in complex pooling structures (debris jams) similar to areas where cutthroat were observed. Bull trout 100 mm and larger were either directly under cover or in open areas (often not associated with the

Table 21. Cover used by juvenile bull trout and Dolly Varden in streams of Alaska, Montana and British Columbia.

Species	Cover type	Drainage	Source
Dolly Varden	Debris (coarse, undercut banks, fine obstructive)	Tye-one-ohn, AK Little Toad Three Mile	Cardinal 1980
	Substrate	Silverhope, B.C.	Griffith 1979
	Debris	Toboggan, B.C.	Tredger 1979
Bull trout	Undercut banks	MacKenzie, B.C.	Ptolemy 1979
	Fine debris, substrate	Flathead, MT	This Study
	Substrate	Wigwam, B.C.	Oliver 1979

Table 22. Depth and velocity used by juvenile bull trout in the Flathead and general depth and velocity measures of juvenile bull trout in streams of British Columbia, adopted from Griffith 1979.

	Depth (m)	Velocity mps	Bull trout age/size	Drainage	Source
General measures	0.2-0.4	0.10	fry	Toboggan, B.C.	Tredger 1979
	0.1-0.3	0.10-0.30	fry	MacKenzie, B.C.	Ptolemy 1979
	0.5-0.7	0.11-0.13	I+	MacKenzie, B.C.	Ptolemy 1979
	0.2-0.5	0.15-0.50	I+	Silverhope	Griffith 1979
	0.4-1.2	0.30	1+ & II+	Toboggan, B.C.	Tredger 1979
Microhabitat measures	0.08-0.80 $\bar{x} = 0.33$	0.00-0.27 $\bar{x} = 0.09$	<100	Flathead	This study
	0.16-0.94 $\bar{x} = 0.45$	0.00-0.45 $\bar{x} = 0.12$	$\geq$100	Flathead	This study

Table 23. Substrate associated with juvenile bull trout in British Columbia and the Flathead.

Age	Drainage	Substrate			Citation
		Fines	Gravel	Cobble	
Unspecified	Flathead		Gravel & cobble		This study
Unspecified	Toboggan	15-25	60	5-25	Stuart & Chislett 1979[1/]
Fry	MacKenzie & Hill	3-30	65	0-70	Ptolemy 1979[1/]
1-2	Toboggan	25	70	5	Tredger 1979[1/]
1	Silverhope	15	50	25	Griffith 1979
2	Silverhope	---	---	65	Griffith 1979
Fry	Wigwam and Ram		Sand & gravel		Oliver 1979
1-3	Wigwam and Ram		Rubble & boulder		Oliver 1979
Microhabitat					
Fry-1	Flathead		Sand & gravel		This study
2-3	Flathead		Gravel & cobble-boulder		

1/ Adapted from Griffith 1979.

streambed) of pools. Individuals directly under cover held their positions even during disturbances. Bull trout in open areas of pools reacted quickly to disturbances by moving under cover.

Food Habits

Bull trout less than 110 mm were opportunistic feeders. Ephemeroptera (mayflies) and Diptera (true flies) were the most abundant aquatic insects in benthic samples and the most common food item in bull trout stomachs. Chironomids, a type of true fly, were the most abundant and frequently used food item. Heptagenid and Baetid mayflies were also commonly used foods.

Juvenile bull trout greater than 110 mm were more piscivorous. Sculpins and other bull trout have been identified in juvenile bull trout stomachs. Fish were increasing consumed during the fall months. Horner (1978) also found bull trout to be highly piscivorous.

EMIGRATION OF JUVENILES

Juvenile bull trout initiated a migratory life history pattern by leaving tributaries and moving downstream into the North and Middle Forks of the Flathead River. Virtually all juvenile bull trout moved downstream through the Flathead River to Flathead Lake. The following will summarize the age composition of emigrating juveniles and the timing and duration of their migration.

Age Composition

Juvenile bull trout emigrated from upper Flathead River tributaries primarily at age II (49%) with smaller percentages outmigrating at age I or III (18 and 32%, respectively) (Table 24). Juvenile bull trout were also found to emigrate from rearing areas in tributaries from ages I to III in systems draining into large lakes in Idaho and British Columbia (Bjornn 1957, Oliver 1979, McPhail and Murray 1979). Oliver (1979) found that juveniles in Ram Creek, a small tributary to Wigwam River, in the Kootenay River drainage, British Columbia, emigrated at age I and II (primarily age II), while juveniles emigrated from the Wigwam River primarily at age II and III.

Bjornn (1957) was able to recognize migration classes using scales from bull trout in the Priest Lake drainage of Idaho. Migration classes for bull trout captured in Flathead Lake were difficult to assign by identifying changes in growth from scale samples. This difficulty may be related to the wide variety of growth environments and food utilized by juvenile bull trout during their migration to Flathead Lake.

Timing

Juvenile bull trout emigrated from tributaries to the North and Middle Forks of the Flathead River primarily during June and July (Table 25 and Appendix A). Timing of emigration was similar to cutthroat juveniles. Since we were unable to effectively trap during high spring flows, we could not document the numbers of juvenile bull trout emigrating during May and early June. Oliver (1979) reported that juvenile bull trout emigrated continuously

Table 24. Percent of age I, II, III and IV bull trout emigrating from tributary streams.

Location	Years of migration	Type of data	Percent (number) of bull trout by age class of migration I	II	III	IV
Red Meadow Cr.	1973, 79	Trap	6 (3)	76 (42)	18 (10)	0 (0)
Trail Creek	1977, 79	Trap	34 (41)	43 (52)	19 (23)	3 (4)
Geifer Creek	1981	Trap	0 (0)	37 (26)	63 (45)	0 (0)
Average			18 (44)	49 (120)	32 (78)	2 (4)

Table 25. Number of days trapping occurred, number of juvenile bull trout passed downstream through traps, and number of trapped juvenile bull trout per trap day by month from North Fork tributaries during 1976 to 1980 and Middle Fork tributaries during 1981.

	June	July	August	September	October
North Fork tributaries (1976-1980)					
Trap days	42	443	424	264	131
Number of Fish	42	709	340	116	6
Fish/trap day	1.00	1.60	0.80	0.44	0.04
Middle Fork tributaries (1981)					
Trap Days	43	74	62	14	---
Number of Fish	60	28	19	8	---
Fish/Trap Day	1.40	0.38	0.26	0.57	---

throughout the summer-fall season in the Wigwam drainage, British Columbia. Using circumstantial evidence, McPhail and Murray (1979) suggested two downstream migrations of juvenile bull trout: 1) a spring migration of newly emerged fry, and 2) a fall migration of "larger 1+ and 2+ individuals".

Juvenile bull trout movement through the Flathead River system to Flathead Lake is not well understood. We tagged 618 juvenile bull trout during the study and only two (0.3%) were recaptured. Very few juvenile bull trout were observed during underwater counts (or captured by anglers) in the North and Middle Forks. We speculated that the majority of the outmigrating juvenile bull trout moved quickly downstream through the river system during the summer. When juvenile bull trout were observed in the two forks they were often found along the river margins.

FLATHEAD RIVER - FLATHEAD LAKE RESIDENCE

Seasonal Movement

Limited data suggested juvenile bull trout probably moved downriver into the mainstem Flathead River during the same time period as juvenile cutthroat, from August through September. Juvenile bull trout appeared to inhabit the partially regulated portion of the river throughout the year before moving into Flathead Lake. It is possible that some bull trout reside to maturity in the lower river. Fourteen bull trout 200 to 400 mm tagged in the main river were recaptured. Ten of these fish were recaptured in the main river (9 moved less than 4 km), three were recaptured in the lake and one moved up into the North Fork of Flathead River (Appendix B).

Food Habits

Bull trout were found to be highly piscivorous and opportunistic predators, eating whatever species of fish available. Bull trout in Flathead Lake fed primarily on fish (fish were found in approximately 91 percent of the bull trout stomachs which contained food). The three whitefish species were the most important year-round food item. Food habits varied seasonally with the most important food items being kokanee during the spring, yellow perch in the winter and lake and mountain whitefish during the summer and fall. Scavenging fish viscera discarded by anglers may be an important summer food source for bull trout in Flathead Lake. Approximately 40 percent of the bull trout stomachs examined were empty. Bjornn (1957) observed a similar percentage of empty stomachs from bull trout captured in Priest and Upper Priest Lakes, Idaho.

Small bull trout (<300 mm) in Flathead Lake fed extensively on slimy sculpins, while larger bull trout (>550 mm) used kokanee and whitefish almost exclusively for food. On the average, bull trout were able to consume prey that were approximately 43 percent of their own length. Bull trout in other inland Northwest lakes were found to feed primarily on fish. Bjornn (1957) found that bull trout fed heavily on kokanee salmon in Priest Lake, while whitefish were more heavily utilized in Upper Priest Lake, probably because kokanee were less abundant in Upper Priest Lake. More recently, mysids were found to be the most important bull trout prey item in Priest Lake, probably due to the decline of kokanee and whitefish populations (Rieman and Lukens 1979). In Lake Pend Oreille, Idaho bull trout fed mostly on kokanee salmon (Jeppson and Platts 1959).

Subadult bull trout captured by electrofishing in the Flathead River were frequently found in areas of high yearling whitefish density, suggesting whitefish may be an important food item of bull trout in the Flathead River. Horner (1978) found that bull trout were highly predacious in Big Springs Creek, Idaho with nearly 100 percent of their stomachs containing fry.

Lake Distribution

Catches of bull trout in gill nets were generally largest in the north end of Flathead Lake during 1980 and 1981 agreeing with earlier findings of Hanzel (1970). Bull trout catches during August were highest in sinking nets set in water deeper than 14 m corresponding to the lower end of the thermocline with temperatures of 15°C or less. Summer distribution of bull trout in Flathead Lake appeared to be dependent upon availability of prey in the form of whitefish and water temperatures, but this relationship did not hold through the fall. Bull trout continued eating whitefish even though peamouth were the most abundant prey species at the depth (and temperature) zone inhabited by bull trout.

ADULT SPAWNING MIGRATION

Migration of adult bull trout into the mainstem Flathead River from Flathead Lake began in April and peaked during May and June when river flows were high. Adult bull trout spawners apparently moved slowly upriver through the spring and early summer, arriving at the North and Middle Forks sometime in late June through July. We believe adult bull trout held in the mainstem North and Middle Forks, probably near the mouths of their spawning tributary destinations, for up to a month. During this time, feeding was believed to be limited, although anglers reported capturing a few adult bull trout whose stomachs contained fish (personal communication, Lee Secrest, Polebridge, Montana).

Adults entered the tributary streams from late July through September with the majority moving into tributaries during August. These adults held in areas of the creeks with abundant cover (deep pools, log jams, undercut banks, etc.). Dunn (1981) found that large pools with abundant cover were important holding areas for adult steelhead trout in Wooley Creek, California. Adult bull trout appeared to migrate primarily during the night in Flathead River tributaries similar to adult bull trout in tributaries to the Upper Arrow Lakes (McPhail and Murray 1979).

After spawning was completed, adults remained on the spawning grounds for a very short time, then moved rapidly out of the tributaries. Upon reaching the river, adults moved rapidly back down to the lower river and lake. There was some evidence from anglers to indicate adult bull trout may initiate feeding on spawning concentrations of mountain whitefish during their migration back down to the lake (personal communication, John Fraley, Montana Department of Fish, Wildlife and Parks, Kalispell, Montana).

Three of six adult bull trout (>450 mm) tagged in the lower mainstem of the Flathead River were recaptured in the North Fork, but all were recaptured more than eight months after the tagging date. Seventeen adult bull trout tagged in the North Fork drainage and one tagged in the Middle Fork drainage were recaptured in the mainstem Flathead River, while 28 adults tagged in the North Fork drainage and two tagged in the Middle Fork drainage were recaptured in Flathead Lake (Figures 3 through 5 and Appendix B). The longest documented movement was 223.6 km by an adult bull trout which was tagged 31 August, 1976 moving out of Howell Creek, a North Fork tributary in Canada, and recaptured 22 January, 1978 in Flathead Lake at Blue Bay. The longest movement documented in the Middle Fork drainage was 207.6 km by an adult bull trout which was tagged 4 September, 1980 in Granite Creek (a Middle Fork Flathead River tributary) and recaptured on 19 July, 1981 in Flathead Lake near Big Arm.

SPAWNING

Timing and Distribution

Adult bull trout in the upper Flathead River spawned during a relatively short time period in the fall, primarily in September and October. Other populations of inland bull trout in the Northwest have been reported to spawn at a similar time of year (Table 26). Timing of spawning activity in the upper Flathead River basin was believed to be initiated in response to several environmental cues including water temperature, photoperiod and streamflow. We found that bull trout spawning activity began when maximum daily water temperatures dropped below 9°C. Spawning was generally completed by mid-October. Spawning activity of anadromous Dolly Varden and other non-anadromous bull trout populations occurred at water temperatures between 5 and 9°C (Blackett 1968, Leggett 1969, Needham and Vaughan 1952, McPhail and Murray 1979).

Adult bull trout consistently used specific spawning grounds within the upper Flathead River basin. Of 185 stream reaches covering 750 km of Flathead tributaries surveyed, bull trout redds were located in only 48 reaches covering 215 km (28%). Areas selected for spawning were large streams characterized by high stream order (higher stream order indicates larger tributaries closer to the mainstem rivers), low D-90 measurements (D-90 is defined as the diameter of a stone in the streambed which is larger than 90 percent of all streambed material), low channel gradient, and a larger percentage of gravel and cobble in the streambed.

Adult bull trout also appeared to select areas: 1) directly influenced by groundwater recharge; 2) in low gradient areas at interfaces between high gradient and low gradient portions of a stream channel; and 3) where the stream split into multiple channels. High gradient-low gradient channel interfaces and multiple channel areas were characteristics of an aggrading stream channel. Aggrading areas were also characterized by recently deposited, loosely compacted gravels resulting from annual peak streamflow events. These conditions provided ideal spawning habitat.

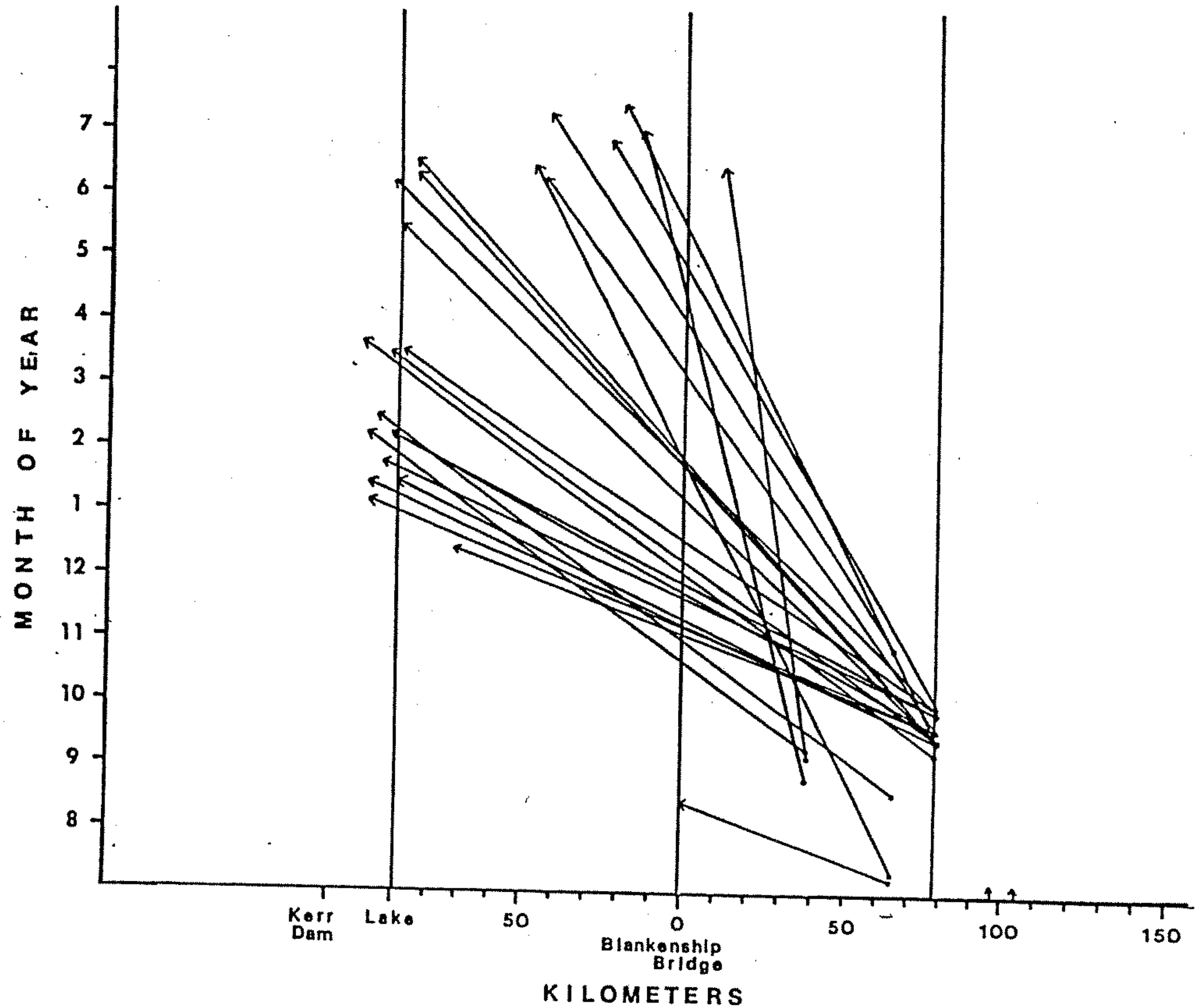

Figure 3. Movement of adult bull trout from U.S. tributaries of the North Fork Flathead River, returns within one year 1962-1981.

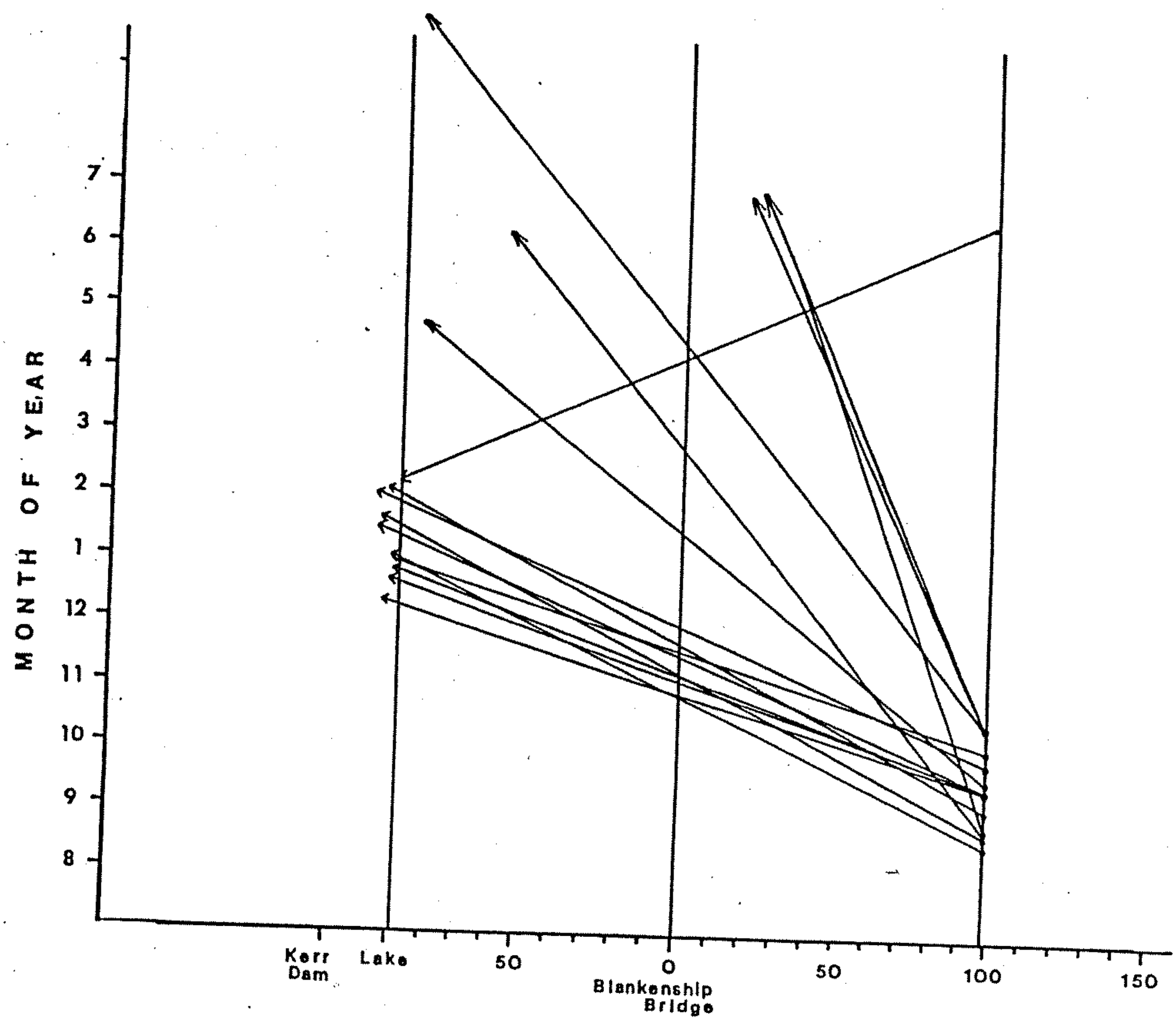

Figure 4. Adult bull trout movement from Canadian tributaries of the North Fork Flathead River, returns within one year 1962-1981.

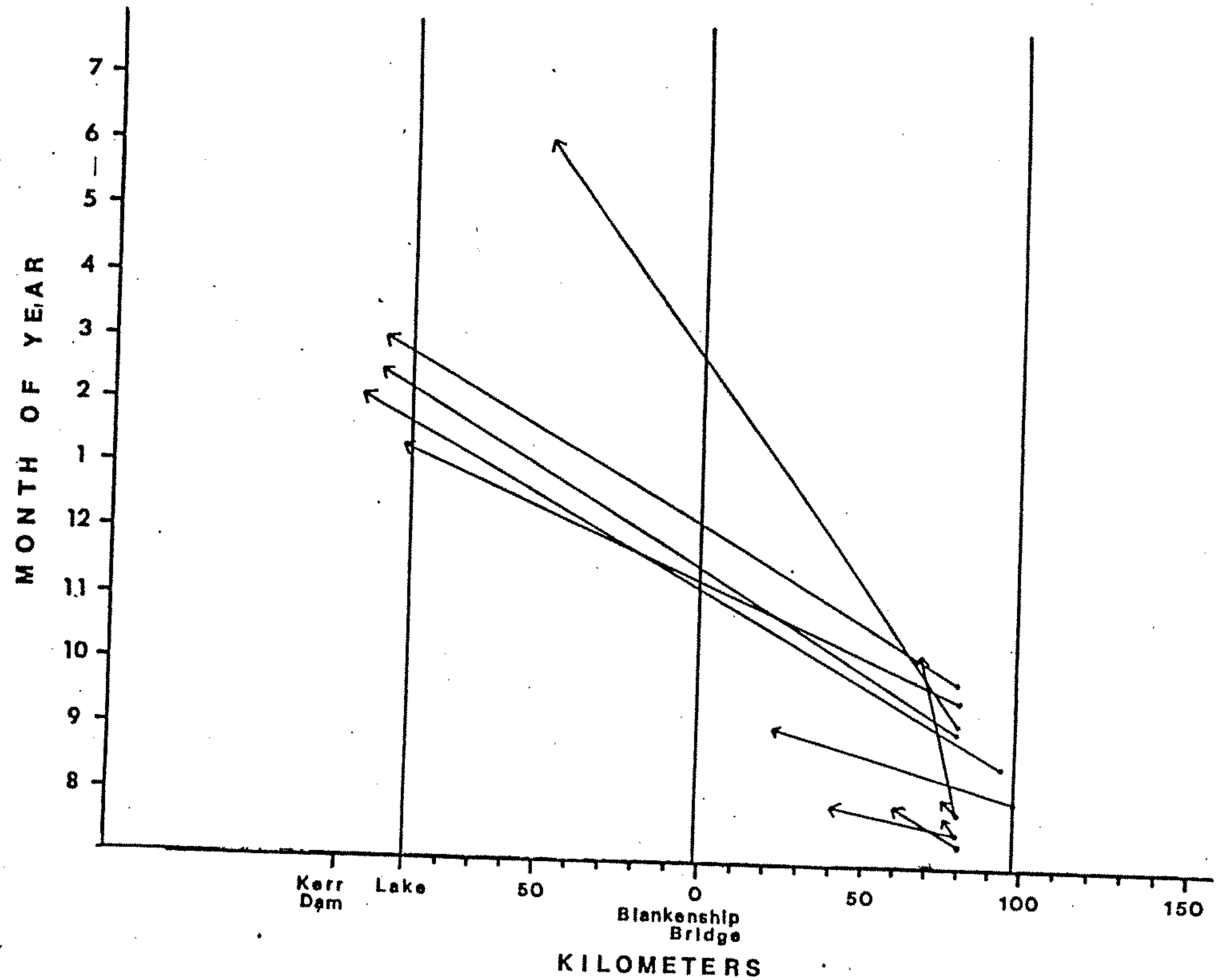

Figure 5. Bull trout movement in the Middle Fork Flathead River, returns within one year 1962-1981.

Table 26. Characteristics of bull trout spawning, including time of year, size of spawner, sex ratio and fecundity observed in river drainages of Montana, Idaho and British Columbia.

Drainage	Timing of spawning activity	Length (mm) Average	Range	Sex ratio (Male:Female)	Fecundity (eggs/female)	Source
Flathead River, Montana	September 9- October 10	611	(406-876)	1.0:1.1	5,482	This study
Wigwam River & Ram Creek, British Columbia	mid-September[2/] to mid-October	518[1/]	(290-730)	---	---	Oliver 1978
MacKenzie Creek, Upper Arrow Lakes, British Columbia	September 14 to October 29	443	(290-587)	1.0:0.8	1,443	McPhail & Murray 1979
Meadow Creek, Duncan River, Kootenay Lake, British Columbia	September 15 to October 11	515[1/]	(79)[3/]	1.0:1.1	---	Leggett 1969
Clark Fork River, Pend Oreille Lake, Idaho	September 18 to October 20	598	(445-745)	---	3,821	Heimer 1965

1/ Fork length

2/ Timing of spent adults migrating downstream.

3/ Standard deviation.

McPhail and Murray (1979) listed low channel gradient and a streambed composed of walnut sized gravel as requirements for bull trout spawning in MacKenzie Creek, British Columbia. Allan (1980) and Heimer (1965) reported spawning bull trout used areas influenced by groundwater and concluded groundwater provided a stable environment for incubating embryos during .pa winter months when harsh environmental conditions normally exist. Brook trout, another inland charr, also spawn directly over areas of upwelling groundwater or in spring-fed tributaries (Webster and Eiriksdottir 1976, Carline 1980).

Characteristics of Adults

Adult bull trout in the upper Flathead River basin were larger than adult bull trout from other drainages (Table 26). Due to their larger size, fecundity rates were also higher than any reported. The sex ratio of adult bull trout entering Flathead River tributaries was estimated to be 1.0:1.1 (males:females), similar to sex ratios reported for populations in British Columbia and Idaho (Table 26). Mature adults were from five to nine years of age. We recorded the presence of "precocious" male bull trout (215 mm in length and three years of age) in Coal Creek, a tributary to the North Fork of the Flathead River. Allan (1980) recorded the presence of juvenile bull trout that matured in their natal tributaries in the Clearwater River drainage, Alberta.

Spawning behavior of adult bull trout has been described in detail by several researchers (Needham and Vaughan 1952, Block 1955, Leggett 1969, Blackett 1968, McPhail and Murray 1979, Allan 1980). Spawning bull trout in Flathead tributaries exhibited similar behavior patterns. Generally, the female selected the spawning site and the male defended it. It was possible that spawning pairs formed during the migration upstream. We hypothesized that pairing may have occurred at the mouths of tributary streams as numerous bull trout moved into our upstream traps as pairs. McPhail and Murray (1979) also reported bull trout moving upstream in pairs in MacKenzie Creek, British Columbia.

We believed repeat spawning occurred for some bull trout in the Flathead; however, we also found a number of mature-sized bull trout in Flathead Lake during summer and fall sampling indicating that at least some adults did not spawn every year. Allan (1980) reported that 27 percent of the adult bull trout tagged in Timber Creek, Alberta returned to spawn the following year. He also documented the return of one female three years in succession.

Physical Characteristics of Spawning Sites

Bull trout generally spawned in runs or tails of pools. Measurements of bull trout redds in upper Flathead River tributaries revealed that the average area of disturbed streambed was larger than redds measured in Alberta and British Columbia (Table 27). This size differential was probably related to the larger size of adult bull trout in the upper Flathead River basin. The average water depth over redds recorded during this study was 0.28 m (range: 0.15 to 0.35 m), illustrating bull trout in the Flathead system spawned in relatively shallow water when compared to other studies (Table 26).

Table 27 Characteristics of bull trout redds including redd size (disturbed area), depth of egg deposition, water depth, velocity and streambed composition observed in river drainages of Montana, Idaho and British Columbia.

Drainage	Mean water depth over redd (m)	Mean velocity over redd(m/sec)	Mean disturbed area (m^2)	Streambed Composition (%) Cobble and larger	Large gravel	Small gravel	Sand	Depth of egg deposition	Source
				(>50 mm)	(16-50)	(2-16)	(<2mm)		
Flathead River (Montana)	0.28 (0.15-0.35)	0.29 (0.24-0.61)	2.3	18	30	39	13	.10-.20	
Flathead River (Montana)	0.30	----	3.72	Predominantly medium-coarse gravels				.20	Block 1955
				(>60 mm)	(33-59)	(2-32)	(<2mm)		
Clearwater River (Alberta)									
Sawmill Springs	0.24	0.52	0.69	5	12	72	10	.03-.18	Allen 1980
Timber Creek	0.58	0.44	0.62	4	14	70	9		
				(>75 mm)	(26-75)	(1.5-25)	(<1.5mm)		
Mackenzie Creek, Upper Arrow Lakes (British Columbia)	——	0.57-0.64	0.50	0	31	61	8	.10-.16	McPhail & Murray 1979
				(>50 mm)		(10-50)	(<10mm)		
Wigwam River and Ram Creek, Kootenai River (British Columbia)	0.34	0.43	1.47	20		50	30	.17-.25	Oliver 1979
				(>50 mm)	(25-60)	(2-25)	(<2mm)		
Lake Pend Oreille, Clark Fork River, (Idaho)	----	——	——	0	5	85	10	.08-.15	Heimer 1965
				(>50 mm)	(10-50)		(<10 mm)		
Kootenay Lake, Meadow Creek, Duncan River, (British Columbia)	0.73-0.84	0.04-0.61		29	59		12	.10	Legget 1969

Water velocities (measured at 0.6 depth at the front edge of the redd depression) ranged between 0.24 to 0.61 mps. Eggs were covered with 0.10 to 0.20 m of gravel. These findings were consistent with water velocities and egg deposition depths reported for bull trout redds investigated in other drainages (Table 27). The composition of the streambed in Flathead tributary spawning areas was also similar to that measured in spawning grounds used by bull trout in other drainages (Table 27).

GROWTH

Juvenile bull trout grew to average lengths of 71 mm, 117 mm, and 171 mm at age I, II and III, respectively, in the North Fork drainage, and 51 mm, 96 mm and 152 mm in the Middle Fork drainage (Table 28). Early growth of juvenile bull trout is slower in the Middle Fork drainage, probably due to environmental factors. Middle Fork tributaries appeared to be more productive than North Fork tributaries (Table 29). The thermal regimes for Middle Fork tributaries were similar to North Fork tributaries for mean monthly maximum temperatures, but mean monthly minimums were lower in the summer months for several North Fork tributaries (Table 30). Perhaps bull trout growth was enhanced in cooler North Fork tributaries. McPhail and Murray (1979) found that bull trout fry grew to larger sizes at lower temperatures and grew largest at 4°C.

Annual growth increments calculated using scale samples from bull trout collected from Flathead Lake averaged 68 mm the first year and 62 mm the second year (Appendix C, Table C-6). After the second year, incremental growth increased to an average of 74 mm between the second and third years, indicating that a portion of the fish emigrated from tributaries to a more favorable growth environment. After the third year, average incremental growth increased again to 88 mm a year and remained reasonably consistent up to age eight (range 88 to 95 mm per year) reflecting increased growth following the movement of fish from the tributaries into Flathead Lake and the shift in diet from invertebrates to fish (Table 31).

Table 28. Back-calculated lengths at annulus of bull trout during their first four years from lake and riverine collections from drainages in Montana, Idaho and British Columbia.

Drainage	Year	I	II	III	IV
Lakes					
Flathead	1963-81	68 (929)	130 (929)	204 (926)	292 (851)
Flathead	1963	71 (289)	140 (289)	208 (289)	323 (245)
Hungry Horse Reservoir		72 (212)	144 (212)	225 (185)	324 (130)
Priest Lake	1957	71 (61)	114 ---	183 ---	310 ---
Upper Priest Lake	1957	66 (41)	102 ---	155 ---	239 ---
Lake Koocanusa		67 (162)	123 (162)	212 (157)	309 (96)
Rivers & Streams					
North Fork Flathead	1955	76 (80)	150 (51)	234 (44)	335 (43)
North Fork Flathead	1977-1982	71 (820)	117 (478)	171 (109)	317 (30)
Middle Fork Flathead	1981-1982	51 (456)	96 (407)	152 (234)	284 (52)
Upper Basin combined	1977-1982	65 (870)	108 (594)	160 (220)	288 (61)
Toboggan Creek	1979	48 (44)	99 (37)	165 (20)	229 (5)

Table 29 . Chemical parameters of the lower reaches of major tributaries of the North and Middle Forks of the Flathead River in October, 1980. Total alkalinity and conductivity were measured in the field. BDL indicates the value for the parameter is below the detection limit.

Creeks	TP	TOC	SO_4^--N	NO_3^--N	Mg^{++}	Ca^{++}	K^+	Na^+	Total alkalinity	Conductivity
North Fork drainage										
Camas	.011	1.36	.67	BDL	2.7	10.0	.24	.73	35	40
Anaconda	.007	1.20	.87	BDL	1.7	5.8	.29	1.8	19	33
Logging	.008	1.04	.63	BDL	1.7	6.4	.17	1.0	23	25
Bowman	.004	.89	.83	.023	5.7	21.0	.23	.85	68	122
Akokala	.010	1.02	.67	BDL	3.7	13.8	.30	1.2	47	65
Ford	.014	1.67	.43	BDL	5.5	24.7	.56	2.0	85	105
Starvation	.003	.54	1.3	0.56	6.5	24.9	.26	1.3	83	100
Kishenehn	.005	.46	5.1	<.01	7.3	24.9	.39	1.6	70	112
Sage	.006	.71	3.4	<.01	7.8	29.4	.50	1.8	92	115
Coal	.007	.65	1.1	.018	6.8	20.5	.26	1.2	73	82
Hay	.004	.70	1.0	BDL	9.5	26.6	.32	1.1	100	148
Red Meadow	.005	.98	.87	<.01	6.1	23.5	.21	.87	79	132
Moose	.004	1.02	1.0	BDL	8.4	20.6	.32	1.0	78	90
Couldrey	.005	.63	.93	BDL	6.8	27.7	.26	.97	91	105
Howell	.004	.71	1.8	BDL	9.0	48.7	.30	.53	149	170
Cabin	.011	1.60	3.2	BDL	10.9	39.5	1.4	1.5	135	170
Middle Fork drainage										
Strawberry	.004	.87	13.3	BDL	15.0	52.8	.64	2.3	146	240
Trail	.004	.76	4.7	BDL	15.3	45.7	.46	1.3	158	210
Gateway	.003	.54	21.4	.023	19.4	59.3	.73	1.8	163	275
Bowl	.003	.80	3.9	BDL	11.4	38.5	.56	1.6	145	195
Clack	.002	.77	1.9	BDL	10.1	41.7	.17	.18	140	200
Cox	.006	.83	5.3	BDL	7.5	29.5	.12	.74	102	145
Morrison	.006	.82	10.6	BDL	11.3	50.1	.51	1.5	138	220
Granite	.003	.65	1.3	<.01	10.8	33.1	.46	1.1	118	160
Ole	.003	.70	1.1	.018	6.3	19.8	.32	1.0	73	110
Stanton	.004	1.14	.90	0.36	7.7	26.8	.22	.49	103	295

Table 30. Monthly minimum and maximum water temperatures of six North Fork and four Middle Fork tributaries.

Month	North Fork tributaries	Middle Fork tributaries
July		
Mean minimum	5.6	6.8
Mean maximum	12.7	13.5
August		
Mean minimum	7.9	10.1
Mean maximum	15.8	15.8
September		
Mean minimum	4.9	8.0
Mean maximum	12.5	11.8

Table 31. Bull trout growth (millimeters) in various waters.

		Total length (mm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	IX
Flathead Lake										
This study (1963-1981)	mm	68	130	204	292	384	472	567	658	731
	(n)	(929)	(929)	(926)	(851)	(601)	(290)	(102)	(28)	(4)
Block (1955)	mm	76	150	234	335	457	566	691	780	---
	(n)	(80)	(51)	(44)	(43)	(41)	(31)	(15)	(1)	---
Rahrer (1963)	mm	71	140	208	323	452	594	724	876	---
	(n)	(289)	(289)	(289)	(245)	(203)	(80)	(14)	(1)	---
Hungry Horse Reservoir[a/] 1953 & 1972	mm	72	144	225	324	429	513	594	671	---
	(n)	(212)	(212)	(185)	(130)	(60)	(28)	(5)	(3)	
Lake Koocanusa[b/]	mm	67	123	212	309	390	482	518	---	---
	(n)	(162)	(162)	(157)	(96)	(37)	(11)	(1)		
Priest Lake[c/]	mm	71	114	183	310	424	516	605	---	---
	(n)	(61)								
Upper Priest Lake[c/]	mm	66	102	155	239	358	462	546	612	---
	(n)	(41)								

a/ Huston 1974.
b/ May et al. 1979
c/ Bjornn 1961

CONTRASTING SURVIVAL STRATEGIES

EMBRYONIC DEVELOPMENT

Because spawning occurs at different times of the year cutthroat and bull trout are exposed to different environmental conditions during their early life stages. Fall egg deposition and overwinter incubation subjects bull trout eggs to a harsh environment of cold temperatures and low flows. Bull trout appeared to select areas of groundwater recharge in upper Flathead River tributaries which may minimize the effects of harsh winter temperatures and the formation of anchor ice. Heimer (1965) reported high survival and relatively rapid development of bull trout eggs in areas influenced by groundwater in the Clark Fork River. In contrast, cutthroat embryos in tributaries to the Flathead River system incubated for a short period of time during the spring during variable streamflows and water temperatures. Johnson (1963) suggested cutthroat may spawn in small tributaries to avoid streambed movement which can occur in large tributaries during peak flow events.

Early survival may be enhanced by: 1) large size at emergence, 2) rapid growth to reach a size to avoid predation, 3) protective coloration, and 4) species distribution. Bull trout seem to maximize fry size at emergence. Mann and Mills (1979) state, "nevertheless in most species it is likely that the larvae from the largest eggs are best equipped to survive under difficult conditions". Large eggs and alevin size is typical of fishes with long cold incubation periods (Mann and Mills 1979) like bull trout. Fry which hatch in early spring may be subjected to an initial period of limited food availability and starvation (Mann and Mills 1979). Bull trout size at emergence is maximized by the unusual habit of remaining in the gravel and feeding after yolk sac absorption. They also develop parr marks unusually early which provides them with criptic coloration to avoid predation (Balon 1980).

Cutthroat trout were 10 mm smaller or two-thirds the size of bull trout when they emerged from the gravels. Cutthroat trout used low gradient areas of small streams for spawning and rearing. These areas may compensate for the selective disadvantage of small fry size by providing shallow nursery areas less accessible to predators.

STREAM RESIDENCE

Distribution in Streams

Juvenile cutthroat and bull trout used the space available in streams differently. Bull trout were found closely associated with the streambed near submerged cover forming pockets of low velocity water. Cutthroat trout were found throughout the water column beneath overhead types of cover. Therefore, bull trout used the streambed as habitat, while cutthroat trout used the water column.

Social Order

The habitat used by juvenile cutthroat and bull trout provides a basis for describing, in general terms, the social structure each species adopts. Bull trout are territorial, defending a fixed site with a focus consisting of a small pocket of low velocity water near the streambed. Cutthroat trout formed dominance hierarchies throughout the water column of pools.

Social structure may influence potential fish production by minimizing aggressive behavior (Chapman 1966, Noakes 1978). Visual isolation, a characteristic of fixed site territoriality, reduces this aggression (Noakes 1978, Chapman 1966). When visual isolation is not available, fish densities can be maintained at higher levels by the formation of dominance hierarchies (Noakes 1978). Cutthroat trout densities may be maintained at higher levels than bull trout because cutthroat form dominance hierarchies, while bull trout did not. Increasing juvenile bull trout production in streams would require increasing visual isolation since usable space, in the form of streambed surface area, is fixed. Bull trout would be very susceptible to any loss of wetted streambed area.

Social order has also been related to feeding strategies (Gerking 1959, Noakes 1978). Cutthroat trout fed on drifting insects on the water's surface or in the water column. Optimum feeding areas for cutthroat trout were toward the head of pools near complex currents in the middle of the water column where drifting insects were readily available. Juvenile bull trout foraged along the stream bottom; therefore, optimum feeding sites were near the streambed surface close to the food source.

Fish Size and Spatial Segregation

Intraspecific interactions were also minimized by spatial segregation of different size fish. Smaller cutthroat and bull trout usually used shallower, slower water than older fish. Objects providing cover for small fish did not provide adequate cover for larger individuals.

Spatial segregation and social order minimized intra- and interspecific interactions between juvenile trout. Small cutthroat trout were separated from small bull trout by their use of the water column and from other cutthroat trout by their use of shallower areas. Larger juvenile trout of both species were separated by vertical spacing in the water column and their use of cover. Positions used by bull trout in the water column tended to maximize their concealment and minimize their use of energy. Cutthroat trout held positions in the water column and probably used more energy to maintain their feeding positions and were less concealed than bull trout.

As bull trout grew in size, they moved up into the water column and used pools more often increasing the potential for interaction with cutthroat trout. Where resident adult cutthroat trout were present alongside juvenile bull trout, aggressive encounters were frequently observed. If juvenile bull trout were conspicuous in pools, they were chased by resident adult cutthroat trout until they retreated under cover.

EMIGRATION OF JUVENILES

Juvenile cutthroat and bull trout appeared to emigrate from tributary streams at similar ages and during the same times of year. Information on movement of juveniles in the Flathead River was sketchy, making it difficult to assess any possible interaction which may have occurred during migration. We believe juvenile bull trout moved quickly downstream (through the upper river system) while a portion of juvenile cutthroat trout remained in the two forks of the river for longer time periods (up to a year). The only juvenile bull trout located in either the North or Middle forks of the Flathead River were found along the river margins (near shore) in the Middle Fork.

Segments of the cutthroat trout population appeared to be fluvial. Bull trout did not seem to exhibit this type of fluvial life history pattern in the Flathead, but do did so in other river systems (Armstrong[1] and Morrow 1980). Where large lakes are present, bull trout usually follow an adfluvial life history pattern. For the highly piscivorous bull trout, the advantage gained by migrating into a large lake with abundant prey must outweigh the disadvantages of moving long distances to and from spawning and rearing habitat. Conversely, the insectivorous cutthroat trout exhibited all three life history patterns, possibly indicating no overriding advantage was gained by following one of the three potential life-history patterns.

FLATHEAD RIVER - FLATHEAD LAKE RESIDENCE

Cutthroat trout depended on terrestrial and aquatic insects for food. Limited winter sampling of cutthroat trout in Flathead Lake indicated that when insects and types of zooplankton usually preferred as food were unavailable, the fish starved. Some cutthroat trout may move up into the lower river from Flathead Lake to take advantage of the constant supply of aquatic macroinvertebrates that were available throughout the winter. Cutthroat trout food preferences also dictated their distribution in Flathead Lake vertically as well as horizontally. Water surface and shoreline areas throughout the lake were used by cutthroat during the entire year except in the summer months when warm surface water temperatures forced cutthroat to seek cooler deeper waters.

Bull trout in Flathead Lake had a consistent food source in the form of fish and were not compelled to seek food in the Flathead River during the winter months. During the fall, when pygmy whitefish concentrated in the lower Flathead River, bull trout in the lower river used them for prey. Bull trout in Flathead Lake were found vertically throughout the water column during the spring, winter and fall when the lake was homothermous. During the summer bull trout were found in moderately deep water and fed on mountain and lake whitefish. Cutthroat and bull trout juveniles appeared to use the river as a staging area before entering the lake, while adults used the river seasonally because of the increased food available and as a staging area prior to their upstream spawning migrations.

ADULT SPAWNING MIGRATION

Adult cutthroat trout completed their spawning migration in a relatively short time period (two to three months), while adult bull trout spent as long as seven months traveling to and from spawning areas. Cutthroat trout spawning migrations coincided with peak spring streamflows allowing cutthroat trout to use smaller streams for spawning and perhaps enhancing their ability to pass partial barriers and move higher upstream into tributaries than adult bull trout. Cutthroat trout spawners were less available to anglers during most of their spawning migration due to high turbid spring flow conditions.

SPAWNING

Timing and Distribution

Spawning westslope cutthroat and bull trout were found to be temporally and possibly spatially segregated. Bull trout spawned during the fall and cutthroat spawned during the spring. Spatial segregation of spawning has not been well documented, but it appears the majority of bull trout spawning occurred in large tributaries or in the lower reaches (nearest the rivers) of small tributaries. Limited data suggested cutthroat spawned in small tributaries and headwater areas which may have been related to the fact that spawning gravels in small streams were less likely to be disturbed by high spring flows (Johnson 1963). This spatial segregation could also be a result of the differential accessibility into streams during high spring versus low fall discharges.

Characteristics of Adults

Adult bull trout were much larger than migratory adult cutthroat trout; however, they were not in natal tributaries at the same time so no interaction occurred at the spawning grounds between migratory adults of the two species.

MANAGEMENT IMPLICATIONS

RECREATIONAL FISHERY

Several studies were conducted to evaluate the recreational fishery in Flathead Lake, mainstem Flathead River, and the North Fork Flathead River during 1981 (Graham and Fredenberg 1983, Fredenberg and Graham 1982, Fredenberg and Graham 1983, Sutherland 1982). Kokanee made up ninety-two percent of the angler harvest in Flathead Lake. Cutthroat trout made up two percent and bull trout one percent of the Flathead Lake angler harvest. The average length of bull trout caught in Flathead Lake was 574 mm and anglers released approximately half of the bull trout caught because of an 18 inch (457 mm) minimum size limit. The average length of westslope cutthroat trout caught by anglers in Flathead Lake was 320 mm. The estimated harvests of cutthroat trout, bull trout, and kokanee in the mainstem Flathead River were 8,557, 1,827, and 76,830 fish, respectively. The kokanee harvest included the popular snag fishery which harvested the bulk of kokanee. The average lengths of westslope cutthroat and bull trout caught in the mainstem were 280 and 581 mm, respectively. An estimated 16,381 cutthroat trout and 404 bull trout were harvested from the North Fork Flathead River.

During 1981, Sutherland (1982) estimated that approximately 740,000 recreational visitor days were spent on Flathead River and Lake associated with water based recreation with an estimated total net value of five million dollars. These estimates are considered conservative because of the assumptions and techniques used to generate them. Approximately 342,600 of these days and 1.74 million dollars were attributed to fishing. This included the kokanee fishery which accounted for approximately 90 percent of the total. More importantly, the study estimated the preservation values of water based recreation as reflected in preservation of water quality at 96 million dollars.

Management of the fishery in the Flathead basin depends upon maintaining high quality water, preserving habitat used for spawning, rearing and maturation, and controlling the harvest to ensure adequate recruitment for maintaining fish populations.

COAL DEVELOPMENT IN CANADA

Development of coal reserves in the Canadian portion of the Flathead River could have significant impacts on fish resources in the basin. Howell Creek has consistently supported 10 percent of the known bull trout spawning for the entire basin. Montana Department of Fish, Wildlife and Parks biologists prepared comments on the probable impacts of coal development on fish resources in the basin. These comments focused on problems foreseen with increased sedimentation, nutrient enrichment, heavy metals pollution and increased human activity. Sage Creek Coal received approval in principle for its Stage II application in early 1984 from the provincial government of British Columbia.

OIL AND GAS

Oil and gas exploration in the Flathead drainage has been steadily increasing, especially in the North Fork area. Presently, no sites have been developed commercially, although drilling of exploratory wells has begun. Shell Canada is planning to develop carbon dioxide wells in the upper north Fork Flathead River to provide for enhanced oil recovery from existing oilfields in Northern Alberta. Their proposal calls for about 25 wells, 30 kilometers of new road, 50 kilometers of upgraded roads, 80 kilometers of infield gathering pipelines, and a processing facility. Construction is anticipated to begin in 1986 and be completed by 1989.

Potential impacts from these developments include increased sedimentation from roads, increased access and human population resulting in increased fishing pressure, pipline construction causing increased sedimentation and the possibility of pipeline failure, and potential dissruption of groundwater aquifers during drilling.

FOREST MANAGEMENT ACTIVITIES

Forest management activities (including logging, roading, oil and gas exploration and any other activity which disturbs the land surface) in the upper Flathead basin could potentially affect the capability of tributary streams to produce fish which recruit to the Flathead Lake and River fishery. Our studies have documented the importance of these tributaries in providing spawning and rearing habitat for westslope cutthroat and bull trout in the basin. Forest management activities can impact this habitat by altering flow and temperature regimes, increasing sedimentation rates, changing rates of organic debris recruitment, and altering primary productivity rates and sources. Shepard and Graham (1983b) found that the streambed of Coal Creek (a North Fork tributary) contained a significantly higher percentage of fine sediment than three neighboring drainages. The Flathead National Forest allows a 50 percent increase in sediment over natural levels produced off Forest Service lands during forest development in all sensitive fishery tributaries, and allows a 100 percent increase in non-sensitive tributaries even though many of these non-sensitive tributaries support fish (Forest Service, USDA 1983). Water yields in streams draining Forest Service lands are allowed to be increased from 5 to 10 percent, depending on the stability of the stream channel and the use of the stream. Several streams, most noteably Big Creek (a North Fork tributary), would have water yield increases above the "acceptable" 5 to 10 percent level according to the Forest Service Plan (Forest Service, USDA 1983).

Streamflow and Water Temperature

Canopy modification within a drainage can significantly alter the timing and quantity of water flowing from that drainage (Gibbons and Salo 1973, Chamberlin 1982). Opening up areas on north-facing slopes will trap snow and cause it to melt over a longer time period, dampening peak flows and augmenting late summer flows. Conversely, removing timber from a south-facing slope can increase peak flows and reduce water available for late summer flows. Water yields generally increase with increasing canopy removal and these increases are as permanent as the changes in the forest hydrologic system that cause them (Harr et al. 1979). Augmenting late summer streamflows may benefit trout populations by increasing the available usable space within the stream. Managing the forest to augment late summer flows can increase peak flows and dramatically change stream channels. Reducing late summer flows would reduce the amount of living space available for juvenile trout and impede access to spawning areas by fall spawning bull trout.

The cumulative impact of reducing late summer streamflows in several tributaries to the North Fork Flathead River could decrease summer river flows. This river segment has been designated as a scenic and recreational river under the National Wild and Scenic Rivers Act. Floating is a popular use of the river, and recreational use of the river has been increasing. Lower summer river flows could have a significant impact on the floatability of the river.

Removal of streamside vegetation increases maximum water temperatures in direct proportion to the surface area of the stream exposed (Gibbons and Salo 1973). We have data suggesting that juvenile bull trout may prefer cooler maximum summer water temperatures than cutthroat trout. Removing large areas of forest canopy within a tributary drainage may increase water temperatures which could shift the species composition from one favoring bull trout to one favoring cutthroat. Streamside vegetation also helps insulate the stream during winter months, moderating low water temperatures and reducing the formation of anchor ice (Gibbons and Salo 1973).

Sedimentation

Inorganic sediment normally originates from non-point sources (Murphy et al. 1981). Gibbons and Salo (1973) reviewed 25 articles on the production of sediment as it related to logging and roading and found that logging roads were the major source of man-caused stream sediments.

Effects on Spawning and Incubation

The fact that excessive amounts of fine sediment has a detrimental effect on salmonid embryo survival has been well documented and summarized by Cordone and Kelly (1961), Gibbons and Salo (1973), Iwamoto et al. (1978) and Reiser and Bjornn (1979). Fine sediment levels in Coal Creek were significantly higher than levels in Big, Whale and Trail creeks, suggesting that land management activities in Coal Creek may be degrading bull trout spawning habitat. More detailed information is needed for determining the origin and transport rate of sediment to Coal Creek, so measures can be implemented to reduce sediment input to the stream. The relationship between streambed composition and bull trout embryo survival needs to be developed to better predict the impacts of sedimentation on bull trout recruitment. Ongoing research which addresses this question is presently under way at the Montana State University Cooperative Fisheries Research Unit.

Effects on Juvenile Rearing

Deposition of sediment onto the streambed can affect salmonid rearing habitat by:

1) modifying the complexity of habitat and decreasing the interstitial spaces used by aquatic macroinvertebrates which supply the bulk of the food resource for juvenile salmonids (Reiser and Bjornn 1979, Bjornn et al. 1977, Gibbons and Salo 1973);

2) reducing pool volume which may reduce summer and overwinter rearing habitat for juvenile salmonids (Bjornn et al. 1977, Reiser and Bjornn 1979); and

3) blanketing cobble and boulder substrate preventing the use of interstitial spaces within the streambed by overwintering juvenile salmonids (Everest 1969, Bustard and Narver 1975, Bjornn et al. 1977).

Leathe and Graham (1983) found a significant non-linear negative relationship ($r=-0.75$; $p<.10$) existed between the density of juvenile bull trout and the percentage of fine sediment in several tributaries to the Swan River, Montana.

A reduction in pool volume caused by the deposition of sediment may also reduce the number of adult bull trout which spawn in a particular tributary. Adult bull trout were frequently observed holding in deep water provided by pools after they entered spawning tributaries to the Flathead River. These large fish (up to 8 kg) may remain in tributaries for as long as two months. The majority of that time is probably spent hiding either in deep pools or under log jams. Dunn (1981) found that pool volume was the most important holding pool characteristic influencing summer steelhead numbers in holding pools of the 13 variables he tested. We believe pool volume may be as important for holding adult bull trout.

Instream and Streambank Cover

Vegetation manipulation along streambanks can change the amounts of large debris recruited to the stream channel over time. Generally, large quantities of debris enter the stream channel immediately following harvest activities. Organic debris are an important component in headwater streams. They influence channel morphology by creating plunge pools, trapping gravels, adding nutrients, and providing cover (Brown 1974, Meehan et al. 1977, Bryant 1980, Boussu 1954). If too much large size debris (trees and stumps) enter the stream channel, debris jams capable of diverting the stream channel may result (Meehan et al. 1969, Bryant 1980). In severe cases, large debris jams accompanied by extremely high streamflows may move the entire debris jam down the stream course in a phenomenon termed "flush-out" (Brown 1974). Flush-outs can be particularly damaging to fish habitat.

Primary Productivity

Murphy et al. (1981) and Hunt (1979) recently suggested that removal of streambank vegetation may improve the ability of a stream to support fish by increasing primary productivity. We are concerned that long-term sources of allochthonous (derived outside the stream channel) nutrient sources would be sacrificed by cutting riparian vegetation. This vegetation contributes the coarse particulate matter (CPOM) used by macro-invertebrate shedders which provides the bulk of the nutrients available in headwater tributary streams (Cummins 1973, Meehan et al. 1977).

OTHER SPECIES

SCULPINS

Stock Assessment

Two species of sculpins, slimy (Cottus cognatus) and shorthead (Cottus confusus), were present in the two forks of the Flathead River and their tributaries (Table 32). The slimy sculpin is the most widely distributed sculpin in North America (Lindsey 1956). In contrast, the distribution of the shorthead sculpin is limited. It is considered a rare and endangered species in Canada (Maughan 1976) and a species of special concern in Montana (Holton 1980).

Both species were prevalent in the North Fork, but were infrequently observed in the Middle Fork. The lack of sculpins in the Middle Fork may have been an artifact of sampling bias. Sculpins were difficult to observe snorkeling; and snorkeling was the primary method used to collect fish information in the Middle Fork drainage, while both snorkeling and electrofishing were used in the North Fork drainage.

Spawning and Early Development

Sculpins spawned in the spring, probably late in April or May. Many gravid, but few ripe females, were found in mid and late April. Glasser et al. (1981) reported shorthead sculpins spawned in mid-April. Craig and Wells (1976) reported slimy sculpins spawned in May.

Individuals of both species were mature at three years of age. A few two year olds were collected but none were mature. Glasser et al. (1981) and Petrosky and Waters (1975) found mature slimy sculpins that were two to three years old. Slimy sculpins in Alaska did not mature until they were four years old (Craig and Wells 1976).

The smallest mature sculpins observed were 50 mm males and 75 mm females. Other researchers have noted similar minimum sizes for mature sculpins (Table 33). Shorthead sculpins up to 116 mm and seven years of age have been observed in reproductive condition in the Flathead. Craig and Wells (1976) report slimy sculpins up to seven years of age.

Fecundity is related to fish size in sculpins, as it is with other fishes. Although no egg counts were conducted during this study, fecundity information was available from the literature (Table 33).

Adhesive eggs were laid in clusters on the underside of rubble to boulder size substrate. The areas selected were free of silt. Siltation has been known to reduce slimy sculpin production (Petrosky and Waters 1975).

Egg incubation has not been studied for either slimy or shorthead sculpins. Information was available for Cottus bairdi (mottled sculpin). Eggs hatch within 30-40 days if incubated at $48-50^{\circ}F$ (Bailey 1952), or within 20 days if incubation temperatures are between $55-59^{\circ}F$ (Hann 1927).

Table 32. Distribution of sculpins, mountain whitefish and brook trout in tributaries of the North and Middle Forks of the Flathead. + = present, - = absent.

Drainage	Sculpin	Mountain Whitefish	Brook trout
North Fork			
Canyon	-	+	-
McGinnis	-	+	-
Kimmerly	+	-	-
Big	+	+	-
Langford	+	-	-
Hallowatt	+	-	-
Werner	-	-	-
Kletomus	-	-	-
Skookoleel	-	-	-
Nicola	-	-	-
Camas	+	+	-
Dutch	+	+	-
Anaconda	+	+	-
Logging	+	+	-
Coal	+	-	-
Cyclone	+	-	-
Dead Horse	-	-	-
South Fork Coal	?	-	-
Mathias	?	-	-
Quartz	+	+	-
Cummings	+	-	-
Hay	+	+	-
Moran	+	+	-
Bowman	+	+	-
Akokala	+	+	-
Parke	+	-	-
Longbow	-	-	-
Red Meadow	+	+	-
Moose	+	-	-
Whale	+	+	-
Shorty	-	-	-
Ford	-	-	-
Kintla	-	+	-
Starvation	+	+	-
Trail	+	+	-
Ketchikan	-	-	-
Yakinikak	-	-	-
Tuchuck	-	-	-
Kishenehn	+	+	-
Spruce	+	-	-
Sage	+	+	-

Table 32. (Continued).

Drainage	Sculpin	Mountain Whitefish	Brook trout
Cauldrey	+	+	-
Burnham	+	?	-
Howell	+	+	-
Cabin	+	+	-
Commerce	+	-	-
Middlepass	+	-	-
Packhorse	+	+	-
Forsey	+	+	-
McEvoy	+	+	-
Middle Fork			
McDonald	-	+	-
Lincoln	-	+	+
Walton	-	+	+
Deerlick	-	+	+
Harrison	-	+	+
Nyack	-	+	-
Coal	+	+	+
Pinchot	-	+	+
Stanton	-	+	+
Tunnel	-	-	-
Muir	-	-	-
Paola	-	-	-
Park	-	+	-
Dickey	+	-	+
Ole	-	+	+
Essex	-	-	-
Bear	+	+	+
Geifer	+	+	+
Skyland	-	-	-
Charlie	-	-	-
Long	-	+	-
Bergsicker	-	-	-
Twenty-five Mile	-	-	-
Granite	-	+	-
Challenge	-	+	-
Dodge	-	-	-
Lake	-	+	-
Miner	-	-	-
Morrison	-	+	-
Puzzel	-	-	-
Lodgepole	+	+	-
Whistler	-	-	-
Schafer	-	+	-
Dolly Varden	+	+	-
Argosy	-	-	-
West Fork Schafer	-	-	-

Table 32. (Continued).

	Sculpin	Mountain Whitefish	Brook trout
Calbick	-	-	-
Cox	-	+	-
Clack	-	+	-
Bowl	+	+	-
Basin	+	+	-
Strawberry	+	-	-
Trail	-	-	-
South Fork Trail	-	-	-
Gateway	-	-	-
East Fork Strawberry	-	-	-

Table 33. The length at maturity, fecundity and relationship between fecundity and fish length for slimy and shorthead sculpins.

Species	Citation	Length at maturity (mm)	Fecundity (no. of eggs)	Fecundity equation
Slimy	Petrosky and Waters 1975	43-111	59-645	Eggs = 10.1x (length)
Slimy	Craig & Wells 1976	68-99	59-339	----
Slimy	Vanvilet 1964 1/	---	82-1291	
Shorthead	Glasser et al 2/ 1981	---	---	F = 14.15 (S.L. - 531)
Shorthead	Peden 1982 (Flathead)	---	128-690	----
Shorthead	(Flathead)	20-116	---	----

1/ Adapted from Craig and Wells 1976

2/ Adapted from Peden 1982.

Other species of sculpins hatch at sizes as small as 3.0 mm, and are 9-15 mm before they resemble adult fish (Richardson and Washington 1980, Bailey 1952).

Habitat

Sculpins were observed in the middle and lower reaches of North and Middle Fork tributaries. They were rarely present in headwater streams. Peden (1982) reports shorthead sculpins were rarely found above an elevation of 1,372 m (4,500 feet). In contrast, Maughan (1976) found shorthead sculpins in headwaters in areas over 976 m (3,200 feet) elevation. Maughan (1976) found shorthead sculpins in areas not used by other species of Cottus, however, in Coal Creek (a tributary to the North Fork of the Flathead River) slimy and shorthead sculpins have been observed in the same portion of the stream. Peden (1982) did not notice any zonation of the two species. In several areas we noted exclusive use of a stream by a single species of sculpin. In areas where the species coexisted, like Coal Creek, hybridization (confirmed with electrophoretic analysis) did occur (unpublished data, MDFWP, Kalispell, Montana).

Sculpins were characteristically found in most habitat units of any size stream in regions with large clean substrate. Although a few were found along the fringes of pools, most individuals were in the fast water areas of riffles, runs and pocketwater. Bailey and Bond (1963) reported sculpins in riffle areas. Peden (1982) noted sculpins used riffles and areas of complex flow patterns which were not necessarily associated with the broken water of riffles.

Slimy sculpins preferred cool waters, selecting water 11-13°C and did not survive in water 20°C (Symons et al. 1976).

Age and Growth

Sculpins collected during this study grew at similar rates as those collected by Peden (1982) and Glasser et al. (1981) (Table 34). By the end of their first year, sculpins were between 30 and 39 mm. Between the first two years, the sizes of fish could distinctly place individual fish in the I and II+ age classes. The size of sculpins in all other age classes overlapped (Table 34). Average sizes of age II, III and IV shorthead sculpins in Trail Creek were 55, 68 and 84 mm, respectively. Although few were collected, slimy sculpins seemed to grow at a similar rate. Slimy sculpins in Alaska grew at rates similar to Flathead sculpins, although both grew slower than growth reported for other populations of slimy sculpins (Craig and Wells 1976).

Food Habits

Sculpins fed primarily on benthic insects. Limited stomach analyses demonstrated sculpins used mayflies (primarily Baetidae and Heptageniidae) and stoneflies. In other areas, dipterans, particularly chironomids, were the predominant food item in the diet of slimy sculpins, particularly young fish (Petrosky and Waters 1975, Craig and Wells 1976). Older sculpins utilized mayflies (Petrosky and Waters 1975).

Table 34. Average length of shorthead and slimy sculpins from the Flathead and ranges of lengths observed for all sculpins aged during this study, compared to collections of Glasser et al. 1981, Peden 1982, and Craig and Wells 1976.

	I	II	III	IV	V	VI	VII
Flathead							
Shorthead	34	55	68	84	101	110	111
Slimy	--	46	61	78	---	---	---
Combined	31-39	46-64	53-84	73-110	94-105	110[1]	106-116
Flathead (in Canada)							
Combined (Peden 1982)	35-39	45-51	60-70	---	---	---	---
Clearwater							
Shorthead (Glasser et al. 1981)	30-35	41-47	54-56	66	77	---	---
Chandalar							
Slimy (Craig & Wells 1976)	28-44	45-59	54-79	55-87	74-95	83-107	99-104

Fish have been observed occasionally in sculpin stomachs. Both cutthroat fry and other sculpins were observed in stomachs. Sculpins have been reported as predators on eggs and fry of many salmonid species, however, in the 15 studies reviewed by Moyle (1977), only 0.6 percent of the sculpins had ingested salmonid eggs or fry. Sculpins will feed on fry or eggs, but do not seem to limit trout production (Moyle 1977). The role of sculpins as forage for trout has been demonstrated in both lake and stream habitats (Moyle 1977).

Parasites

Sculpins collected in the North Fork and Coal Creek frequently contained large parasitic worms within their body cavity (Ligula). The worms were so large the abdomens of parasitized fish were noticeably distended.

WHITEFISH

Stock Assessment

Three species of whitefish were present in the upper Flathead basin; mountain (*Prosopium williamsoni*), lake (*Coregonus clupeaformis*) and pygmy (*Prosopium coulteri*). The mountain whitefish was widely distributed in lake and riverine habitats of the upper basin (Table 35). Lake and pygmy whitefish were found only in Flathead Lake and their life history will not be reviewed here.

Spawning and Early Development

Mountain whitefish spawn in the fall from October through December (Scott and Crossman 1973, May and Huston 1975, Daily 1971). Spawning distribution of mountain whitefish has not been documented in the upper Flathead River basin. Fish movements and fry distribution provide a general view of the probable spawning distribution. Whitefish were observed primarily in the main forks of the Flathead River during October and probably spawned in the river and in large tributaries. Whitefish fry were observed in side channels of the North Fork and several tributaries in the basin. Fry were observed in Dolly Varden, Akokala and portions of Hay creeks. In the Kootenai River drainage, mountain whitefish deposited their eggs in the main river and several tributaries during October, when water temperatures dropped to 5°C (May et al. 1983). Davies and Thompson (1976) associated declining water temperatures with pre-spawning movements.

Whitefish congregate in large pools of the river before spawning (Davies and Thompson 1976). In the Kootenai River, three year and older whitefish broadcasted their eggs over gravels 25 to 200 mm in diameter, generally in riffle areas with depths of 0.15 to 0.61 m and velocities of 0.27-0.78 mps (May and Huston 1975).

Stream Residence

Whitefish distribution in streams was limited. Whitefish were observed in 39 percent of the streams and 28 percent of the reaches surveyed (Table 35). Whitefish 152 mm and larger were found in 37 percent of the surveyed

Table 35. Distribution of whitefish by size class (less than 152 mm and 152 mm or larger), expressed as number (percent) of total reaches or tributary streams sampled in the upper Flathead Basin.

	Total	Whitefish <152 mm	Whitefish >152 mm	Any size Whitefish
Reaches sampled	185	19(10%)	48(19%)	52(28%)
Streams sampled	92	24(26%)	34(37%)	36(39%)

streams. Small whitefish (<152 mm) were located in only 26 percent of the streams and 10 percent of the reaches surveyed. Fry were rarely observed in streams.

Whitefish were most often observed in the lower portions of larger tributaries characterized by highest stream order and lowest stream reach (Table 36). Whitefish were more frequently seen in Middle Fork tributaries than in North Fork tributaries. In both the North and Middle Fork drainages, whitefish were more common in the streams draining Glacier National Park. This distribution may be explained by the warmer temperatures of Glacier National Park streams, many which flow from large lakes.

It appears that streams were used seasonally by whitefish. April electrofishing surveys in tributary streams of the North Fork did not locate any whitefish. We believe whitefish moved into the lower portion of tributary streams to feed during peak river discharges. Whitefish moved out of tributaries during August. Over one hundred whitefish per day have been trapped moving downstream out of tributaries during the month of August. Similar whitefish movements were documented in the Sheep River drainage in Canada (Davies and Thompson 1976) which were also attributed to a food seeking response.

Table 36. Mean density and range of densities of whitefish observed in stream reaches 1-5 and stream orders 2-5 in surveyed sites within tributaries to the North and Middle Forks of the Flathead. Numbers in parentheses indicate number of sites where whitefish were observed.

Reach			Order		
Reach number	Mean density	Densities range	Order	Mean density	Densities range
1	1.7(33)	0.1-16.9	5	5.6(4)	1.3-16.9
2	0.9(16)	0.1- 2.6	4	1.1(21)	0.1- 4.3
3	0.9(4)	0.4- 1.4	3	0.9(29)	0.1- 1.6
4	---(1)	1.2	2	---(1)	0.1
5	---	---	---	---	---

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APPENDIX A

Summary of results for downstream trapping of juvenile westslope cutthroat and bull trout in upper Flathead River tributaries from 1976 to 1981.

Cutthroat - Akokala Creek
1976-1977

	June	July	August	September	October
Trap Days	13	39	37	24	—
Number of Fish	130	258	12	1	—
Fish/Trap Day	10.00	6.61	0.32	0.04	—

Cutthroat - Coal Creek
1977

	June	July	August	September	October
Trap Days	—	31	31	30	20
Number of Fish	—	381	79	12	0
Fish/Trap Day	—	12.29	2.55	0.40	0.00

Cutthroat - Trail Creek
1977-1979-1980

	June	July	August	September	October
Trap Days	7	76	62	47	20
Juvenile Fish	27	422	97	73	48
Juvenile Fish/ Trap Day	3.86	5.55	1.56	1.55	2.40

Cutthroat - Red Meadow Creek
1976-1977-1979-1980

	June	July	August	September	October
Trap Days	17	16	72	60	39
Juvenile Fish	114	663	45	1	0
Juvenile Fish/ Trap Day	6.70	10.87	.62	.02	—

Cutthroat - River Trap
1977-1979-1980

	June	July	August	September	October
Trap Days	—	27	58	36	12
Juvenile Fish	—	107	174	23	3
Juvenile Fish/ Trap Day	—	3.96	3.00	.64	.25

Dolly Varden - Red Meadow Creek
1976, 1977, 1979

	June	July	August	September	October
Trap days	15	83	72	60	39
Number of Fish	19	143	42	2	0
Fish/Trap Day	1.27	1.72	0.58	0.03	0.00

Dolly Varden - Trail Creek
1977, 1979

	June	July	August	September	October
Trap Days	5	62	62	46	20
Number of fish	22	273	106	47	0
Fish/Trap Day	4.40	4.40	1.71	1.02	0.00

Dolly Varden - Whale Creek
1977

	June	July	August	September	October
Trap Days	1	31	31	30	20
Number of Fish	1	22	59	11	0
Fish/Trap Day	1.00	0.71	1.90	0.37	0.00

Dolly Varden - Big Creek
1977

	June	July	August	September	October
Trap Days	—	31	31	30	20
Number of Fish	—	25	49	2	2
Fish/Trap Day	—	0.81	1.58	0.07	0.10

Dolly Varden - Coal Creek
1977

	June	July	August	September	October
Trap Days	—	31	31	30	20
Number of Fish	—	33	7	7	2
Fish/Trap Day	—	1.06	0.23	0.23	0.10

Dolly Varden - Giefer Creek
1981

	June	July	August	September[1]	October
Trap Days	27	21	—	—	—
Number of Fish	55	11	—	—	—
Fish/Trap Day	2.04	0.52	—	—	—

Dolly Varden - Bear Creek
1981

	June	July	August	September	October
Trap Days	30	31	31	7	—
Number of Fish	3	9	11	3	—
Fish/Trap Day	0.10	0.29	0.35	0.43	—

APPENDIX B

Summary of tag return information illustrating movement of westslope cutthroat and bull trout in the upper Flathead River Basin.

Appendix B1. Cutthroat moving into or out of tributaries of the North and Middle Forks.

Drainage (km)	Mark	Recapture	Length	Tag type	Tag color	Tag number	Movement (km) Within sector	Out of sector	Total movement	Direction
North Fork										
Big Creek (24)	9-14-60	6-25-61	---	1	6	561	11	--	11	down
	9-14-60	8-10-61	---	1	6	562	3	--	3	down
	9-11-59	7-18-60	---	1	6	287	24	47	71	down
	5-9-80	9-3-80	107	4	6	1,078	24	23	47	down
	5-4-80	7-20-80	108	4	6	1,025	16	--	16	down
	5-14-80	7-29-80	246	2	3	2,760	24	47	71	down
Coal Creek (39)	5-15-80	7-23-80	158	4	6	1,157	31	--	31	down
	7-16-62	3-6-63	193	1	6	1,130	39	94	133	down
	7-16-62	8-29-63	203	1	6	1,126	39	3	42	down
	4-25-77	6-5-77	297	2	1	1,899	39	49	86	up
	4-6-76	8-13-77	328	2	1	1,124	39	53	92	up
	5-20-80	11- 80	393	2	3	2,771	39	42	81	down
	5-20-80	11-29-80	395	2	3	2,770	39	47	86	down
Moran Creek (46)	7-20-62	7-6-63	193	1	6	1,234	34	--	34	up
	7-16-62	7-28-63	201	1	6	1,113	<1	--	<1	up
Hay Creek (46)	6-25-80	7-1-80	151	4	6	95	4	--	4	up
Akokala Creek (54)	7-8-61	6-30-62	---	1	6	464	19	--	19	up
Red Meadow Cr. (59)	7-15-80	9-25-80	172	4	4	38	52	--	52	down
	7-10-80	7-19-80	174	2	3	1,257	5	--	5	down
	7-14-80	8-21-80	179	4	4	29	45	--	45	down
	7-18-80	7-30-80	192	4	6	470	5	--	5	down
	6-24-80	7-10-80	203	4	4	149	31	--	31	down
	7-20-79	9-3-79	236	2	3	2,517	5	--	5	down

Appendix B1. (Continued)

Drainage (km)	Mark	Recapture	Length	Tag type	Tag color	Tag number	Movement (km) Within sector	Out of sector	Total movement	Direction
Moose Creek (64)	7-12-80	8-16-80	146	4	4	444	42	--	42	down
	6-25-80	7-1-80	151	4	6	95	1	--	1	up
Kintla Creek (79)	8-2-62	9-1-62	229	1	2	636	39	--	39	up
	7-23-79	9-6-79	287	2	3	2,532	2	--	2	up
Trail Creek (80)	7-21-80	8-4-80	185	4	6	526	2	--	2	up
	8-3-79	8-23-79	264	2	3	2,535	27	--	27	down
	7-11-79	7-26-79	272	2	3	2,511	15	--	15	down
	7-11-79	8-5-79	284	2	3	2,513	27	---	27	down
1/	7-23-79	9-6-79	287	2	5	2,532	2	--	2	down
Starvation Cr. (82)	4-14-77	6-28-77	394	2	1	1,777	82	47	129	up
Cauldrey Cr. (100)	7-18-76	8-12-76	353	2	3	5,000	100	88	188	down
Howell Creek (108)	4-7-76	7-17-76	353	2	1	1,165	108	47	155	up
	9-13-76	9-19-76	360	2	3	5,002	29	--	29	down
	7-23-76	7-24-76	421	2	3	5,001	108	23	131	down
Middle Fork										
Bear Creek (71)	7-29-57	8-2-57	---	1	0	328	<1	--	<1	down
	8-1-57	8-1-57	---	1	0	333	16	--	16	down
Strawberry & Trail Creeks	9-10-60	10-20-61	---	1	6	397	32	--	32	down

1/ These fish were recaptured in Kintla Lake (km 3.8 of Kintla Creek).

Appendix B2. Bull trout moving into or out of tributary streams from (to) another river sector.

Drainage (km)	Mark	Recapture	Length	Tag type	Tag color	Tag number	Movement (km) Within sector	Out of sector	Total movement	Direction
Coal Creek (39)	8-23-54	7-1-55	554	1	0	50542	38.6	14.4	53.3	down
	7-10-77	7-8-78	584	2	4	59	38.6	--	38.9	down
	9-7-77	2-10-78	584	2	1	1835	38.6	109.3	147.9	down
	9-7-77	6-15-78	531	2	1	1839	19.6	--	19.6	down
Red Meadow Cr. (59)	10-27-77	8-9-79	518	2	1	1987	4.5	--	4.5	down
	7-23-80	7-27-80	164	4	6	578	4.5	--	4.5	down
Whale Creek (66)	7-9-77	6-14-78	533	2	4	12	66.0	46.6	112.6	down
	10-29-77	7-12-78	792	2	1	1863	66.0	22.5	88.5	down
	8-20-75	2-20-76	612	1	0	2363	66.0	98.0	164.0	down
Trail Creek (80)	9-6-52	3-8-53	---	1	0	50095	80.4	115.8	196.2	down
	9-21-53	6-12-55	589	1	0	50354	80.4	46.6	127.0	down
	9-14-54	1-15-56	749	1	0	118	80.4	109.4	189.8	down
	9-15-54	6-12-55	693	1	0	120	80.4	85.2	165.6	down
	9-15-54	7-15-55	635	1	0	121	80.4	--	80.4	down
	9-17-54	6-22-55	699	1	0	124	80.4	85.2	165.6	down
	9-18-54	12-13-54	673	1	0	133	80.4	72.4	152.8	down
	9-19-54	5-19-55	826	1	0	134	80.4	88.4	168.8	down
	9-19-54	1-25-55	762	1	0	135	80.4	75.9	156.3	down
	9-28-54	3-15-55	780	1	0	175	80.4	88.4	168.8	down
	9-28-54	1-27-55	729	1	0	176	80.4	98.1	178.5	down
	9-21-54	1-2-55	660	1	0	50551	80.4	109.3	189.7	down
	9-21-54	2-9-56	617	1	0	50556	80.4	109.3	189.7	down
	9-22-54	7-4-56	602	1	0	50563	25.7	--	25.7	down
	9-30-54	2-4-57	587	1	0	50571	80.4	98.1	178.5	down
	9-30-54	6-27-55	617	1	0	50572	80.4	24.1	104.5	down
	9-30-54	7-14-56	660	1	0	50579	80.4	22.6	103.0	down

Appendix B2. (Continued).

Drainage (km)	Mark	Recapture	Length	Tag type	Tag color	Tag number	Movement (km) Within sector	Out of sector	Total movement	Direction
Trail Creek (cont.)	9-30-54	6-5-55	551	1	0	50602	80.4	93.3	173.7	down
	10-4-54	2-8-55	688	1	0	50590	80.4	94.9	175.3	down
	10-7-54	5-20-59	594	1	0	50597	80.4	56.3	136.7	down
	10-12-54	2-1-56	556	1	0	50606	80.4	98.1	178.5	down
	9-13-78	1-20-79	686	2	3	2410	80.4	98.1	178.5	down
	9-15-77	3-15-78	737	2	1	1852	80.4	98.1	178.5	down
Kishenehn Cr. (85)	10-16-53	9-18-55	749	1	0	39	85.2	--	85.2	down
	10-17-53	11-17-53	744	1	0	42	85.2	93.3	178.5	down
Cauldrey Cr. (100)	9-22-76	4-29-77	760	2	3	4111	99.7	83.6	183.3	down
	9-28-76	2-3-77	645	2	3	4133	99.7	109.3	209.0	down
	10-15-76	9-26-77	546	2	3	4196	99.7	83.6	183.3	down
	9-13-76	12-12-76	674	2	3	4453	99.7	115.8	215.5	down
	9-14-76	1-14-77	750	2	3	4466	99.7	109.3	209.0	down
	9-16-76	12-23-76	600	2	3	4475	99.7	93.3	193.0	down
	8-13-76	6-18-78	710	2	3	4861	99.7	22.5	122.2	down
	8-23-76	6-11-77	660	2	3	4895	46.6	--	46.6	down
	9-3-76	2-4-77	710	2	3	4998	99.7	109.2	209.0	down
	8-12-76	1-2-77	710	2	3	5005	99.7	98.1	192.8	
Howell Creek (108)	6-22-76	2-8-77	569	2	3	4802	107.7	94.9	202.6	down
	8-23-76	6-8-77	495	2	3	4894	107.7	46.7	154.4	down
	8-31-76	1-22-78	480	2	3	4946	107.7	115.8	223.5	down
	9-8-76	5-30-78	685	2	3	4969	107.7	101.3	209.0	down
	9-13-76	2-17-79	810	2	3	4455	107.7	109.4	217.1	down
	9-15-76	7-7-79	214	2	3	4469	107.7	109.4	217.1	down
	9-15-76	12-23-76	748	2	3	5004	107.7	101.3	209.0	down
	10-3-76	7-3-77	670	2	3	4993	54.7	--	54.7	down
	10-3-76	1-2-77	619	2	3	4150	107.7	98.1	205.8	down
	10-15-76	7-3-77	647	2	3	4478	67.5	--	67.5	down
	10-23-76	5-31-78	673	2	3	4055	107.7	109.4	217.1	down

Appendix B3. Distance cutthroat and bull trout moved after being tagged in the main river, North Fork, Middle Fork or Lake, Flathead River Basin, Montana.

	Distance moved (miles)					
	None	2-47	48-95	96-144	145-192	193-240
Cutthroat						
Main River	62	134	69	21	3	3
North Fork	29	68	25	12	2	1
Middle Fork	26	30	10	10	1	1
Lake	1	2	--	--	--	--
TOTAL	118	234	104	43	6	5
Percent	23	46	20	8	1	1
Bull trout						
Main River	6	12	4	--	1	--
North Fork	21	9	6	7	22	16
Middle Fork	14	29	7	--	3	1
TOTAL	42	54	19	8	31	19
Percent	24	31	11	5	18	11

Appendix B4. Percentage (number of fish) of the tag returns in which fish had moved 2-47 km, 48-95 km, 96-144 km, 145-192 km, 193-240 km, or had not moved.

	N	Distance moved in river (km)					
		None	2-47	48-95	96-144	145-192	193-240
Cutthroat	(510)	23% (118)	46% (234)	20% (104)	8% (43)	1% (6)	1% (5)
Bull trout	(173)	24% (42)	31% (54)	11% (19)	5% (8)	18% (31)	11% (19)

Appendix B5. Cutthroat trout (225-614 mm) marked in Flathead River between November and May 1952-1982 which were returned, listed by section of the basin and month of return. Percent of each month's return is presented for each basin section.

Month	Section of the basin								Monthly total
	North Fork		Middle Fork		Main River		Lake		
	N	(%)	N	(%)	N	(%)	N	(%)	
January	--	--	--	--	--	--	--	--	--
February	--	--	--	--	2	(100)	--	--	2
March	--	--	--	--	7	(78)	2	(22)	9
April	--	--	--	--	19	(95)	1	(5)	20
May	8	(32)	--	--	10	(40)	7	(28)	25
June	28	(57)	2	(4)	15	(14)	4	(8)	49
July	16	(28)	5	(9)	27	(25)	9	(16)	57
August	1	(4)	6	(25)	9	(38)	8	(33)	24
September	--	--	--	--	8	(7)	--	--	8
October	--	--	--	--	4	(4)	1	(20)	5
November	--	--	--	--	8	(7)	--	--	8
December	--	--	--	--	--	--	--	--	--
	Contribution of each basin sector								
Number of recaptures	53		13		109		32		207
% recaptures	(26)		(6)		(53)		(15)		

APPENDIX C

Age-growth information for westslope cutthroat and bull trout in the Upper Flathead River drainage.

Appendix C1. Back-calculated length at annulus for cutthroat trout collected in different years and in different portions of the upper river basin.

	Year	I	II	III	IV	V	VII
North Fork Drainage	1977-1981	55 (2,107)	100 (1,917)	144 (1,192)	186 (287)	242 (18)	
	1977	58 (743)	106 (729)	152 (466)	195 (135)	248 (5)	
	1980	51 (795)	94 (749)	133 (470)	171 (115)	227 (9)	
Middle Fork Drainage	1980-1981	55 (880)	101 (792)	153 (499)	213 (136)	264 (19)	293 (3)
	1980	58 (428)	103 (386)	153 (276)	221 (92)	275 (17)	
South Fork Drainage	1981	58 (199)	106 (199)	152 (180)	202 (97)	256 (19)	323 (1)
TOTAL		55 (3,096)	100 (2,908)	146 (1,871)	194 (520)	251 (56)	301 (4)
North Fork River	1977& 1980	54 (197)	97 (191)	138 (129)	166 (35)	214 (3)	
	1977	58 (70)	112 (64)	147 (22)			
	1980	52 (127)	90 (127)	135 (107)	166 (35)	214 (3)	
North Fork tributaries	1977-1981	54 (1,820)	100 (1,726)	145 (1,063)	189 (252)	247 (15)	
	1977	58 (673)	105 (665)	152 (444)	195 (135)	248 (5)	
	1979	54 (288)	101 (249)	153 (169)	203 (34)	265 (4)	
	1980	51 (668)	94 (622)	132 (363)	173 (80)	234 (6)	
	1981	55 (191)	97 (190)	143 (87)	213 (3)		
Middle Fork River	1980	60 (183)	110 (183)	164 (167)	223 (85)	275 (17)	

Appendix C1. (Continued).

	Year	I	II	III	IV	V	VI
Middle Fork tributaries	1980-1981	54 (880)	100 (792)	149 (499)	205 (136)	254 (19)	293 (3)
	1980	57 (245)	98 (203)	138 (109)	195 (7)		
	1981	53 (632)	101 (586)	153 (387)	207 (126)	253 (16)	
South Fork River	1981	59 (113)	108 (113)	155 (107)	206 (69)	273 (11)	323 (1)

Appendix C2. Back-calculated length at annulus for cutthroat trout, listed by tributary, in the North Fork portion of the Flathead River basin.

Creek name	Year	Age I	II	III	IV	V
Langford Creek	1980	56 (148)	103 (148)	147 (84)	197 (26)	250 (4)
Coal Creek	1977	60 (250)	108 (245)	151 (151)	189 (61)	173 (1)
	1979	57 (25)	102 (14)	136 (4)	174 (3)	
	1981	56 (78)	101 (78)	145 (59)	213 (3)	
Cyclone Creek	1981	55 (113)	94 (112)	142 (28)		
Logging Creek	1980	46 (33)	88 (30)	136 (9)		
Moran Creek	1980	51 (78)	88 (76)	116 (32)		
Hay Creek	1980	49 (113)	91 (108)	134 (82)	166 (29)	225 (1)
Akokala Creek	1977	56 (214)	103 (213)	149 (166)	188 (49)	189 (2)
Red Meadow Creek	1977	52 (68)	100 (68)	146 (43)	197 (12)	
	1979	52 (223)	101 (195)	153 (134)	194 (19)	184 (2)
	1980	50 (127)	100 (123)	138 (76)	172 (12)	
Moose Creek	1980	50 (159)	86 (136)	117 (79)	144 (13)	178 (1)
Whale Creek	1977	64 (82)	118 (80)	175 (52)	238 (6)	329 (1)
Trail Creek	1977	54 (59)	98 (59)	147 (32)	254 (7)	362 (1)
	1979	58 (40)	101 (40)	161 (31)	223 (12)	347 (2)
	1980	45 (81)	90 (80)	126 (17)	173 (2)	

Appendix C3. Back-calculated lengths of cutthroat trout, listed by tributary, from the Middle Fork portion of the upper river basin.

Creek name	Year	Age I	II	III	IV	V
Essex Creek	1981	53 (90)	96 (82)	146 (46)	201 (7)	
Park Creek	1981	60 (54)	110 (52)	156 (44)	208 (13)	
Ole Creek	1981	49 (94)	100 (94)	154 (90)	207 (33)	287 (4)
Muir Creek	1981	51 (83)	100 (59)	145 (42)	206 (8)	
Bear Creek	1981	63 (90)	118 (89)	172 (82)	222 (37)	273 (4)
Geifer Creek	1981	55 (119)	105 (108)	149 (45)	199 (4)	
Challenge Creek	1980	56 (158)	99 (125)	138 (65)		
Dodge Creek	1981	46 (102)	82 (102)	130 (38)	182 (24)	228 (8)
Basin Creek	1980	57 (78)	94 (69)	130 (35)	177 (4)	

Table C4. Incremental growth of cutthroat (growth per year for each age class) determined from back-calculated lengths at annulus for fish collected from different portions of the basin during different years between 1962-1981.

Portion of Flathead drainage	N	Growth increment period 0-1	1-2	2-3	3-4
Lake (62-81)	573	64	56	69	72
Mainstem (81)	250	55	48	51	90
Main portions (63)	559	56	63	77	91
North Fork (77-80)	197	54	43	41	28
Middle Fork (79-80)	183	60	50	54	59
North Fork tributaries (63)	106	58	56	64	38
North Fork tributaries (77-81)	1820	54	46	45	44
Middle Fork tributaries (79-81)	880	54	46	49	56

Table C-5. Back calculated lengths at annulus formation of bull trout in the upper Flathead Basin (1968-1981).

Drainage	Total length (mm) at annulus								
	I	II	III	IV	V	VI	VII	VIII	IX
Adults and Juveniles									
Upper Flathead (1968-81)	66 (1,814)	121 (1,538)	196 (1,161)	292 (927)	385 (669)	475 (349)	566 (129)	667 (32)	731 (4)
Flathead Lake (1968-81)	68 (931)	129 (931)	204 (928)	291 (853)	384 (603)	472 (291)	566 (102)	658 (28)	731 (4)
North Fork of the Flathead River drainage (1975-1981)	73 (533)	117 (306)	165 (60)	301 (12)	440 (8)	538 (7)	574 (3)	---	---
Middle Fork of the Flathead River drainage (1980-1981)	52 (349)	100 (300)	165 (172)	297 (61)	399 (57)	488 (50)	567 (24)	655 (4)	
Juveniles Only									
North Fork drainage	73 (525)	117 (298)	155 (52)	228 (4)	---	---	---	---	---
Coal Creek	75 (145)	124 (62)	202 (23)	323 (14)	---	---	---	---	---
Red Meadow Creek	65 (145)	113 (113)	168 (29)	360 (7)	---	---	---	---	---
Trail Creek	74 (473)	119 (264)	158 (46)	228 (4)	---	---	---	---	---
Whale Creek	56 (52)	98 (34)	139 (6)	---	---	---	---	---	---

Table C6. Incremental growth (growth between years) of bull trout during their first four years determined from back-calculated lengths at annulus, collected from various parts of the Flathead Basin.

Area	Year	Incremental growth			
		0-1	1-2	2-3	3-4
Lake	1963(Rahrer)	69	68	115	129
Lake	1963	68	62	72	86
Lake	1968	68	57	67	73
Lake	1980	59	60	67[1]	75
North Fork	1955(Block)	76	74	84	101
North Fork	1977-1981	72	45	53	148
Middle Fork	1981	49	44	51	127